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THE WASPS OF THE GENUS *PLENOCULUS* (HYMENOPTERA: SPHECIDAE, LARRINAE)

BY

FRANCIS X. WILLIAMS
Research Associate
California Academy of Sciences

My study of these small wasps was begun many years ago and has extended, with interruptions, up to 1959. About 850 specimens of *Plenoculus* were assembled for study.

I wish to extend my thanks to the many entomologists and to the institutions with which they may be connected, for the very generous assistance given me. Mr. P. H. Timberlake, Associate Entomologist, Emeritus, University of California, Citrus Experiment Station, Department of Biological Control, Riverside, California, has made available the large collection of *Plenoculus,* which he obtained chiefly in southern California. A great deal of material, also from desert regions and elsewhere, has come from the collections of the California Insect Survey, Division of Entomology and Parasitology, University of California, at Berkeley, and the University of California at Davis, with Drs. P. D. Hurd and R. M. Bohart and their associates doing the collecting. Dr. George D. Butler, Jr., of the Department of Entomology, University of Arizona; Dr. Howard E. Evans, of the Department of Entomology, Cornell University; and Dr. R. R. Dreisbach, of Midland, Michigan, have likewise loaned considerable and interesting material. Dr. Herbert F. Schwarz, of the American Museum of Natural History, has donated several specimens of *Plenoculus.* Finally, Dr. Karl V.

Krombein, of the Division of Insect Identification and Parasite Introduction Laboratories, U. S. Department of Agriculture, Washington, D. C., has been unfailingly helpful in the loan of specimens, including the entire material of *Plenoculus davisi davisi* Fox from his own collection and also that from the collection of the U. S. National Museum. He has also compared specimens, and in his useful correspondence has made helpful suggestions and given references to pertinent literature. The excellent drawing of the head of *Plenoculus gillaspyi* Krombein (fig. 33) is the work of Mr. Arthur D. Cushman, of the U. S. National Museum. Through the courtesy of Dr. Krombein, I was able to study an important collection of *Plenoculus* and *Solierella* made by Dr. W. R. M. Mason in the Colorado and Mojave deserts. The author has also made collections of *Plenoculus,* chiefly in the Colorado desert. The collection of the California Academy of Sciences was also very helpful. The facilities made available by both the California Academy of Sciences, San Francisco, and the San Diego Society of Natural History Museum are here gratefully acknowledged.

In the Synoptic Catalog of Hymenoptera of America North of Mexico (Muesebeck, Krombein, Townes, and others, 1951, U.S.D.A. Monograph No. 2), and the first supplement to this Catalog for 1958, prepared under the direction of Dr. Krombein, a total of seven species and one subspecies are listed. In the Old World, two species have been described, one from Transcaspia, U.S.S.R. (as *Pavlovskia tadzhika* by Gussakovskij), the other from Portugal and Spain, by Andrade. In the present paper ten species and four subspecies of *Plenoculus* are described as new, while two forms of *Plenoculus* previously listed as valid are here regarded as mere color forms. This brings the total, as here accepted, to 17 species and 5 subspecies, as follows:

1. *Plenoculus sinuatus,* new species . . . . Page 7
2. *Plenoculus gillaspyi* Krombein . . . . " 8
3. *Plenoculus hurdi,* new species . . . . " 10
4. *Plenoculus timberlakei,* new species . . . . " 11
5. *Plenoculus cuneatus,* new species . . . . " 12
6. *Plenoculus cockerellii* Fox . . . . " 15
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17. *Plenoculus beaumonti* Andrade . . . . " 44

Genus **PLENOCULUS** Fox.

Plenoculus Fox, 1893. Psyche 6:554. Genotype *Plenoculus davisi* Fox.
Pavlovskia Gussakovskij, 1935. Trav. Fil. Acad. Sci. URSS, Tadjikistan, 5:424. Type: *Pavlovskia tadzhika* Gussakovskij. Monobasic and original designation.

Plenoculus may be characterized as follows: Mandibles distinctly emarginate on the lower side (59, 60), or more rarely they are stepped down from near the base so that there is little or no opposing elevation beyond (26A), with or without a tooth within just basad of the blade, malar space lacking or very short; maxillary palpi with six segments, labial palpi with four; the male with clypeal margin with or without a brush of rather incurved hairs far to each side; eyes entire within, converging toward the vertex; ocelli perfect; antennae originating immediately behind the clypeus. Prepectus tolerably well defined; legs stout, moderately to strongly spinose, female with a fore tarsal comb (80), weaker in the male, intermediate tibiae with a single apical spur; metasternum grooved; marginal cell truncate and rather weakly appendiculate; three submarginal cells, the second pedicillate, first and second submarginal cells each receiving a recurrent vein; submedian cell shorter than median on externo-median nervure; in the hind wings the discoidal vein originates well beyond the transverse-median vein; anal lobe short, not at all reaching to opposite apex of submedian cell. The pygidial area is subtriangular, shining and more or less punctate, the margins sharp or with a fine carina. Male with or without transverse tubercles or rugosities on sternites 3–6.

Plenoculus is separable from *Solierella,* its rather close relative, by a number of characters. In *Plenoculus* the mandibles are strongly excavate or, in fewer cases, stepped down beneath; in *Solierella* the mandibles are occasionally weakly excavate beneath, much less often they are strongly stepped down (*Solierella albipes* [Ashmead], *Solierella prosopidis* Williams); the female of *Plenoculus* has a good foretarsal comb which together with the stout, rather squat form of the wasp points to a fossorial habit, the bristles forming this comb being well developed on the long basal tarsal article; in some species of *Solierella,* particularly some of the larger ones, while they are not known to be fossorial, a tarsal comb of rather fine long bristles may exist, but these bristles do not occur strongly on the basal article of the foretarsus; *Plenoculus* has the more strongly spinose legs. As far as known the members of the genus *Plenoculus* lack the strong frontal and clypeal carinae so often present in *Solierella.* An important separating character in *Plenoculus* is the well-defined pygidial area, particularly in the female, and in the male the lateral lobes of the aedeagus, while occasionally pointed on one side, are not dentate or serrate as is characteristic of *Solierella.*

The species of *Plenoculus* are broadly separated into two groups by Fox (1893, 1897) . . . "those having the clypeus strongly emarginate and dentate *(davisi, propinquus),* and those in which the clypeus is neither emarginate nor dentate *(cockerellii, parvus*[1]*).*" However, the discovery in recent years of additional species including the males of the "*cockerellii*" group *(Pl. cockerellii, Pl. mexicanus, Pl. timberlakei,* and *Pl. cuneatus),* as well as the bringing to light of other species, i.e., *Pl. gillaspyi* Krombein (probably), *Pl. hurdi, Pl. sinuatus, Pl. boregensis,* and *Pl. palmarum,* and a restudy of *Pl. parvus* Fox, reveal that all of these forms possess one or more characters, in one or both sexes, that are common to these two original groups, tend to bridge the gap between them. On the other hand, the prey of *Plenoculus cockerellii,* as first discovered by P. H. Timberlake in southern California, consists of very small caterpillars, probably pyraloideans, and it is quite likely that the remaining three species of the "*cockerellii*" group also prey on caterpillars. As far as known, the species of the "*davisi-propinquus*" group (no prey records on *Pl. propinquus*) store their nests with small heteropterous bugs, and occasionally aphids.

This at least is a notable biological difference between these two *Plenoculus* groups.

Nothing seems to be known concerning the nature of the prey of the intermediate or more or less morphologically bridging group of *Plenoculus* species.

KEY TO THE SPECIES OF PLENOCULUS[2, 3]

Females—antennae with 12 segments; abdomen with 6 tergites visible 1
Males—antennae with 13 segments; abdomen with 7 tergites visible 16

1. Anterior margin of the clypeus not produced in the middle, but sinuate, with one or two inconspicuous teeth far to each side (33, 35); mandible without a tooth on the inner margin (except in *Pl. sinuatus* where it is very small) 2

   Anterior margin of the clypeus gently outbowed to cuneate in the middle, or the clypeus may be broadly subtruncate, or more sloping, emarginate mesad and with lateral teeth or angles 4

---

[1] Dr. Karl V. Krombein has critically examined, with modern equipment, the type of *Plenoculus parvus* Fox (1897), female, and finds that it has two small teeth on each side of the clypeus. This species, which is related to my *Pl. palmarum,* thus belongs in an intermediate position.

[2] The number in parentheses refers to figures in this paper.

[3] This key has its difficult parts and is not entirely satisfactory. Some of the species considered are weak species.

2. Mandibles with a small basal notch or tooth on the inner margin; edge of clypeus broadly polished; red and white markings present..*Pl. sinuatus*, new species

Mandibles without a basal tooth on the inner margin; edge of clypeus not broadly polished; red and white markings absent 3

3. Median emargination of the clypeus somewhat wider; distance between the inner margin of the antennal sockets much greater than the distance between the outer margin of the antennal sockets and the inner margin of the compound eyes at a point opposite, the ratio being approximately 3.5 to 2.2 (34) ....*Pl. hurdi*, new species

Median emargination of the clypeus narrower, this emargination being partially filled by a thin transparent lamella; distance between the inner margin of the antennal sockets and between their outer margin and the opposing eyes nearly the same (33) ....*Pl. gillaspyi* Krombein

4. Anterior margin of the clypeus outbowed or subconic, more rarely sharply conic; no median notch or emargination 5

Anterior margin of the clypeus truncately or subtruncately produced and with a median notch or emargination 12

5. Clypeus gently outbowed, and toothed laterad; mandibles notched beneath (59, 60) and with an inner tooth 6

Clypeus without teeth; mandibles more stepped-down near the base beneath than notched there (26A), and with no inner tooth 7

6. Clypeus with two teeth on either side; abdomen black except at tip...*Pl. parvus* Fox

Clypeus with three teeth on either side; abdomen red ....*Pl. palmarum*, new species

7. Clypeus gently outbowed, although slightly transverse apically (26), its color diluted white and reddish; pronotum with a creamy yellow tegumentary band; mid tarsi with rather long dense pale bristles (27); much silvery pile ....*Pl. boregensis*, new species

Clypeus reddish to black, gently outbowed or subconic in outline, more rarely pointed; pronotum without tegumentary band; mid-tarsal bristles brownish, stouter and shorter 8

8. Mandibles evenly, or very nearly evenly, curved (17, 22); pale leg markings present or absent 9

Mandibles distinctly crooked or elbowed before the middle, this character is best seen in unworn specimens; pale leg markings present.................... 10

9. Clypeal outline cuneate or wedge-shaped in its median portion; ocelli arranged in distinctly less than a right-angle triangle; pale leg markings present ....*Pl. cuneatus*, new species

Clypeus gently outbowed; ocelli forming a triangle at least as great as a right-angle triangle; pale markings absent..................*Pl. timberlakei*, new species

10. Clypeus gently outbowed, cuneate, or more rarely sharply conic; pale femoral marks present 11

11. Clypeus gently outbowed to conic; mandibles moderately slender. Southwest United States; Baja California and Guerrero, Mexico......*Pl. cockerellii* Fox

Clypeus subconic, sometimes with an inconspicuous ridge; mandibles very slender (13). Tropical Mexico, E. and W. ....*Pl. mexicanus*, new species

12. Anterior margin of the clypeus deeply incised mesad, and depressed about this incision, the sides of which are more or less rounded to the first angle or tooth, of which there are three (55, 85) 13

Clypeus less deeply incised mesad, little or not depressed there and with two to five teeth on each side of the median incision (54, 62, 63, 67) 14

13. Generally larger species, up to 6–7 mm. long; abdomen black or red and black; the disc of the pygidium dark and smooth and hardly affected by its punctuations. Distribution: From the Rocky Mountains to the Pacific Coast .... *Pl. propinquus* Fox

Smaller, to about 5 mm.; abdomen red; disc of pygidium roughened by its heavy punctation. Colorado Desert .... *Pl. deserti*, new species

14. Clypeus generally with four strongly developed teeth on each side of the rather narrow median emargination; abdomen red with increasingly large black marks from base to apex (84). California, chiefly in the Upper Sonoran Zone .... *Pl. boharti*, new species

Clypeal margin with from two to five teeth on each side of the median incision, but sometimes these teeth are largely reduced to mere crenulations (67, 69); abdomen usually without the color pattern as described above, or the abdomen is black 15

15. Clypeal dentition delicate, of three or four teeth on each side of the median notch; truncation of the marginal cell usually quite narrow (5). A small highly polished black, or more rarely with the abdomen red, species with no clear yellow markings. Colorado Desert, California; Picacho Pass, Pinal County, Arizona .... *Pl. stygius*, new species

Clypeal dentition normally of four teeth on each side of the median notch, but it may be variable; abdomen more commonly black .... *Pl. davisi* and subspecies

16. Sternites 3–6 smooth; clypeus without a hair brush on either side (14A, 23) 17

Sternites 3–6 more or less transversely tuberculate, or at least the area is gently undulate; clypeus produced subtruncate mesad, with a hair brush on either side (43, 44, 56) 23

17. Mandibles with a tooth within; clypeus subtruncate (37) 18

Mandibles without a tooth within, or the tooth is very small and placed on a ridge posterior to the blade (31); clypeus rounded out to subcuneate in the middle 19

18. Inner tooth of mandibles strong; article 13 of antennae not gently curved; uncal lobes slightly acuminate on the ventral side but with a tuft of bristles near their apex (71) .... *Pl. palmarum*, new species

Inner side of mandibles with a moderate tooth at the base of the blade (30); article 13 of the antennae gently curved; uncal lobes without a tuft of bristles near the apex; produced portion of clypeus truncate .... *Pl. sinuatus*, new species

19. Clypeus produced mesad as a low, evenly rounded lobe (28); articles 3 and 4 of the antennae subsequal; uncal lobes acuminate ventrad in profile (29B) .... *Pl. boregensis*, new species

Clypeus a little more strongly produced mesad; uncal lobes as viewed from above strongly conelike in profile (72) 20

20. Clypeus rather narrowly produced mesad, where it is cuneate, with a lateral extension from its depressed sides (20); seventh antennal segment lobed apically on the outer side and provided with one or more longer hairs (21) .... *Pl. timberlakei*, new species

Clypeus without a lateral extension from depressed sides; antennae without modification 21

21\. Produced portion of the clypeus narrowly subtruncate mesad, a tooth at either side of the thin margin (24, 25); antennae rather stout, not slender at the base, article 3 not longer than 4 .... *Pl. cuneatus*, new species
Clypeus without teeth, gently rounded out subcuneate; antennae rather slender basad, article 3 slightly longer than 4 22

22\. Clypeus not carinate (14A) .... *Pl. cockerellii* Fox
Clypeus delicately carinate; mandibles more slender than in *Pl. cockerellii* (23) .... *Pl. mexicanus*, new species

23\. Scape of the antennae almost always dark concolorous; clypeus very rarely clear yellow 24
Scape pale beneath; clypeus commonly clear yellow (dull yellow in *Pl. stygius*) 26

24\. Clypeus blackish; margin of the produced portion multidentate (61, A and B); volsellar armature feeble .... *P. boharti*, new species
Clypeus mesad dull yellowish or yellowish red, the base often black, more rarely it is all black, this produced portion often somewhat depressed for the apical portion, which may be gently bilobed; volsella usually with some strong spines or teeth 25

25\. Larger; clypeus generally dirty yellow; abdomen black or black and red; volsella with 2–3 short stout thorns (81, 82) .... *Pl. propinquus* Fox
Smaller; clypeus dark or blackish; abdomen orange red; volsella with about 8 strong spines. Colorado Desert, California .... *Pl. deserti*, new species

26\. Polished black; the pale markings are dull yellow to pale yellowish brown; volsellar ridge with about 5 stout bristles (90). A desert species .... *Pl. stygius*, new species
Abdomen black, black and red or entirely red; pale markings almost always creamy yellow; volsella generally with inconspicuous bristles. Widely distributed and variable .... *Pl. davisi* Fox, and subspecies

Plenoculus sinuatus Williams, new species.

(Figures 30, 32, 35.)

Female, holotype. Length, 5.25 mm. Black; head and thorax subopaque, abdomen rather shining; clypeus apically, mandibles except apex, scape beneath at apex, tarsi, and abdomen reddish; pronotal lobes, tegulae basad and basal wing sclerites, femora 1 and 2 in part beneath to apex, and tibiae 2 and 3 in part creamy white, femora 3 at apex and tibiae 2 and 3 with some reddish brown. Head relatively wide; clypeus very short, its margin sinuate, being shallowly emarginate mesad where it is polished, broadly and steeply developed and with a very few large punctures, while posterior to this emargination it is transversely tumid, and there is a small clypeal tooth near the inner base of the mandibles; mandibles slender, crooked, provided with rather long, sparse, erect hairs, well emarginate beneath, and within with a small tooth at the base of the blade; antennae moderately stout, article 3 slightly longer than 4, 12 more curved on one side, and tapering, with articles 10, 11, and 12 slightly reddish on the underside; ocelli forming slightly more than a right-angle triangle, interocellar line less than the postocellar line.

Punctation of dorsulum fine, subcoriaceous, bristles of fore tarsal comb as long as to longer than the segments from which they arise. Disc of propodeum a rather broad, mainly coriaceous triangle, rounded apically, the pleurae with fine oblique striae, the posterior face with a grooved depression in its upper two-thirds. Spurs and leg bristles generally pale brown, venation pale testaceous. Marginal cell not broadly truncate, somewhat exceeding the third submarginal cell. Pygidium rather narrowly triangular, narrower than usual at apex, polished, with sparse larger and smaller punctures, the sides slightly constricted preapically. Vestiture white pile, dense on face, portions of thorax and bordering the disc of the propodeum, silvery abdominal bands not conspicuous.

MALE, allotype. Length, 4.25 mm. Marked much like the female, but the clypeus is entirely blackish, the last antennal segment rather contrastingly brownish, and the generally red abdomen dark apically; the creamy white tibial stripes are distinct and the scape all dark. The disc of the clypeus is slightly convex, its margin slightly rounded truncate, its shoulders strong, and there are no lateral hair tufts; the mandibles with a moderate tooth within; antennae moderately stout, article 2 (Pedicel) less than one and one-half times as long as thick; 3 longer than 4, 13 gently curved and about as long as 11 plus 12; ocelli in about a right-angle triangle. Mesopleurae with a small ventral tubercle. Abdominal venter smooth. Terminalia with the aedeagal lobes pointed ventrad, much as in *Pl. boregensis,* but differs from that species in having a group of three bristles below the middle of the parameres (32).

HOLOTYPE, female. In fresh condition, Borego, San Diego County, California, April 27, 1954 (P. D. Hurd). ALLOTYPE, male, topotypical, May 13, 1954 (F. X. Williams), on low *Euphorbia.* PARATYPES, 1 female, Palm Springs, Riverside County, California, July 29, 1952 (P. H. Timberlake), on *Eriogonum trichopes;* 1 male, Borego, April 27, 1954 (P. D. Hurd); 1 female, 3 miles north of Scissor's Crossing, San Diego County, IX, 8, 1955 (J. C. Hall). The male paratype has the clypeus partly reddish.

DISCUSSION. This species is readily separated from the next two species by means of the table and illustrations.

Plenoculus gillaspyi Krombein.

(Figure 33.)[4]

Plenoculus gillaspyi KROMBEIN, 1938. Ent. Soc. Amer. An. 31:468. Female. Round River, Williamson County, Texas, October 10, 1935, on *Baccharis salicina.* (J. E. Gillaspy.)

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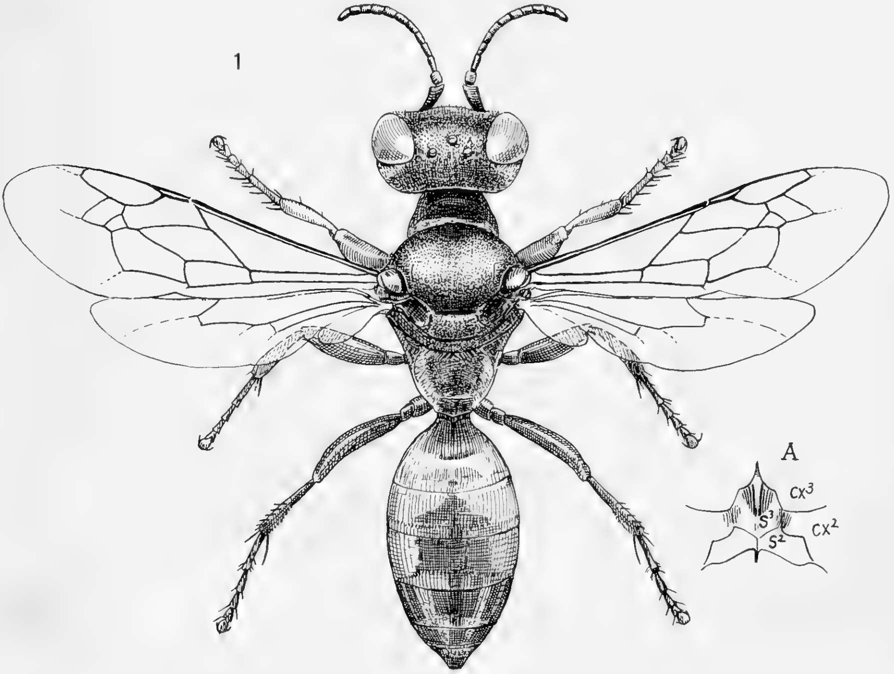
[4] Drawn by Arthur D. Cushman.

This species, of which there is but one specimen known, was taken at what is apparently the western edge of the Lower Humid Austral Zone. It measures 4.70 mm. long. Except for the red apically on the mandibles and tegulae, it is all black. The sculpture is quite fine; the clypeus is very short (i.e., from base to anterior edge), being emarginate in the middle. The distance between the inner margin of the antennal sockets is equal



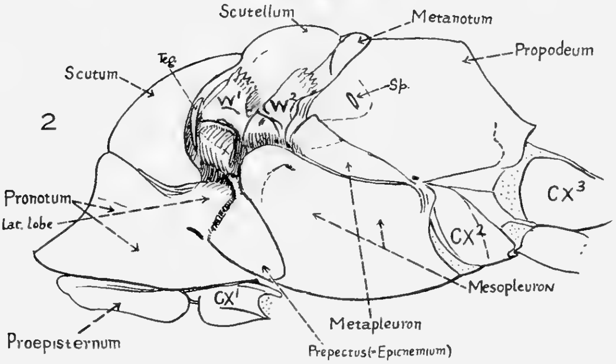


Figure 1. *Plenoculus propinquus.* Female. Length 6.2 mm. From Riverside, California. At A, thoracic sternites 2 and 3 of a male from Nevada.

Figure 2. *Plenoculus timberlakei.* Female. Thorax, from side. From five miles south of Palm Springs, California.

to the distance between the inner margin of the compound eye and the outer margin of the antennal sockets.

DISCUSSION. Obviously, this species is rather closely related to *Pl. hurdi,* new species.

Plenoculus hurdi Williams, new species.

(Figure 34).

FEMALE, holotype. Length, 4.75 mm. Head and thorax subshining, abdomen shining, sculpture very fine. Black; there are no pale markings, the mandibles are nearly uniformly black, the tibial spurs pale, the tarsi nearly black, the venation blackish brown, and the apex of tergites 1–3 very narrowly testaceous. The head is wide, chiefly finely reticulate or coriaceous and the preoccipital carina rather narrowly obsolete dorsad. The clypeus is short, and the anterior margin sinuate and is strongly tumid, rounded and polished along the shallow median emargination, and has an inconspicuous tooth over the base of the mandibles. The mandibles are quite slender, somewhat crooked before their middle length, broadly excavate beneath and with no inner tooth; the antennae are moderately stout, the flagellum subfusiform, articles 3 and 4 subequal; the ocelli in somewhat less than a right-angle triangle. The disc of the propodeum rounded, very finely reticulate, its median trough shallow, commencing well beyond the base, not infringed upon by silvery pile, its pleurae coriaceous, the posterior face with some transverse striae and a narrow median cleft expanding toward the dorsum. Tarsal comb bristles shorter than the diameter of the segments from which they arise. Abdomen generally very finely reticulate. The disc of the pygidium is entirely black, polished and with moderately fine punctures, it is rather narrow with the sides nearly straight. Vestiture: The moderate silvery pile has evidently been obscured by the effects of moisture.

HOLOTYPE, female. In unworn condition, Teotihuacan Pyramid, Mexico, July 6, 1951 (P. D. Hurd). PARATYPE, 1 female, also in fine condition (collection, University of California at Davis), Teotihuacan, Mexico, July 21, 1956 (Rand and K. Dreisbach).

DISCUSSION. This species is most nearly related to *Pl. gillaspyi* Krombein described from Round River, Williamson County, Texas. It differs from *Pl. gillaspyi* in its wider clypeal emargination, and in the fact that the distance between the inner margin of the antennal sockets is much greater than the distance between the outer margin of the antennal sockets and the inner margin of the compound eye, the ratio being approximately 3.5 to 2.2, or a coefficient of 6.29.

Named for Dr. Paul D. Hurd of the Department of Entomology, University of California, Berkeley, who with his fellow entomologists has collected so much material in this genus of wasps.

Unfortunately, the labrum of the holotype was damaged through my dissection, but in the paratype, the labrum shows as a dark brownish, almost opaque hair-fringed strip that is closely appressed to or fused with, the clypeus and stretches inconspicuously across its median emargination.

Plenoculus timberlakei Williams, new species.

(Figures 2, 11, 19–22, 31, 38, 47, 49, 52, 77.)

Female, holotype. Length, 6 mm. Shining except disc of propodeum. Black, mandibles reddish beyond base to near apex, antennae from apex of scape onwards, brownish, all tibiae reddish apically with yellow base, tegulae transparent testaceous, bases of principal veins more or less creamy yellow, spines honey yellow, abdomen red. Frons coriaceous, vertex finely punctate; clypeus evenly rounded out mesad; mandibles evenly curved, with a notch or step-down beneath near base; antennae short, subclavate, article 3 longer than 4; ocelli in slightly more than a right-angle triangle; preoccipital carina interrupted dorsad; scutum and scutellum with rather fine separate punctures, postscutellum more finely and closely punctured, mesopleurae with some fine obscure wrinkles posteriorly. Disc of propodeum coriaceous, with fanning basal carinulae and a shallow, more or less cross-carinulate median groove, the pleurae generally polished and with some carinulae and punctures, posterior face polished, with a narrow obcuneate groove and a few transverse carinulae. Tibiae and tarsi, except for the more lightly armed fore tibiae, with rather numerous short stout bristles. Tergite 5 with strong well-spaced punctures. Pygidium well margined, the disc sparsely punctured and somewhat constricted subspatulate apically. Vestiture: rather sparse silvery pile, the specimen being rather worn.

Male, allotype. Length, 3.8 mm. Head and thorax rather densely clothed with silvery pile; abdomen banded with silvery pile. Black; clypeus except base of produced portion and most of the sides, mandibles except apex, fore femora beneath except at base, all tibiae except in part beneath, pale yellow to brownish yellow; tegulae translucent, base of wings more or less creamy; antennae yellowish brown, excepting the first 6–7 segments above; abdomen reddish. Clypeus rather narrowly produced mesad, apically cuneate, the area at the base of this production is well depressed and gives rise on each side to a short outcurved process upon which the mandibles when folded seem to rest. Mandibles without inner tooth in line with the blade. Antennae stout, fusiform-clavate, the pedicel constricted basally, article 7 lobed apically on outer side above and provided with one longer and several shorter hairs, shorter hairs being present also on 2–6; preoccipital carina interrupted dorsad. Disc of propodeum opaque, with fanning basal and some transverse carinulae, no obvious median groove, but there is a slightly depressed area at apex of the disc; pleurae opaque, with fine carinulae; posterior face with transverse carinulae and a median incision that widens dorsad. Second submarginal cell with a short petiole. Abdomen finely punctate, not tuberculate beneath. Aedeagus as in *Pl. cockerellii.*

HOLOTYPE and ALLOTYPE (Citrus Experiment Station, Riverside); holotype, 5 miles south of Palm Springs, California, June 28, 1941, on *Dalea spinosa;* allotype, Beaver Dam, Arizona, June 20, 1939, on *Eriogonum trichopodum;* PARATYPES, 2 females, Beaver Dam, Arizona, June 20, 1939, on *Eriogonum trichopodum;* 2 males, 6 miles south of Palm Springs, Colorado Desert, California, June 8, 1930, on *Eriogonum trichopodum;* 2 females, 4 miles south of Palm Springs, June 25, 1941, on *Dalea spinosa.* Not considered a paratype is a female dissected for study and bearing the label: 6 miles south of Palm Springs, Colorado Desert, California, June 8, 1930. All these specimens were collected by P. H. Timberlake. Not considered paratypes are 2 females, Palm Springs, June 25 and 28, 1941 (E. C. Van Dyke).

DISCUSSION. In the female the evenly curved mandibles, the pygidium somewhat spatulate at tip and the lack of pale femoral markings will serve to distinguish *Pl. timberlakei* from *Pl. cockerellii,* while the curiously developed clypeus and the somewhat modified antennae will serve that purpose in the male.

Plenoculus cuneatus Wiliams, new species.

(Figures 10, 17, 18, 24, 25.)

FEMALE, holotype. Length, 4.5 mm. Shining, except disc of propodeum. Black; rim of median portion of clypeus, mandibles except at darker base, and apex of scape narrowly beneath, dull reddish brown; tibiae and tarsi in part reddish; antennae dull brownish beneath, the apical segment a little paler; tegulae and basal portion of wings, particularly along the costa, prothoracic lobes apically, fore femora for apical half beneath, a small spot apically on intermediate femora, the very tip of hind femora, and all tibiae above, largely creamy yellow; abdomen all red. Sculpture of head and thorax largely obscured by the generous silvery pile. The frons evidently coriaceous

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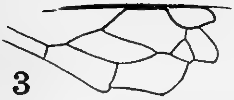
Figure 3. *Plenoculus cuneatus.* Male. To show part of the venation of the forewing. From Glendale, Nevada.

Figure 4. *Plenoculus cockerellii* ?. Male. From Tucson, Arizona.

Figure 5. *Plenoculus stygius.* Female, holotype. From Palm Springs, California.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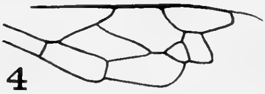
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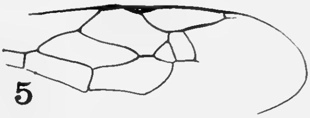
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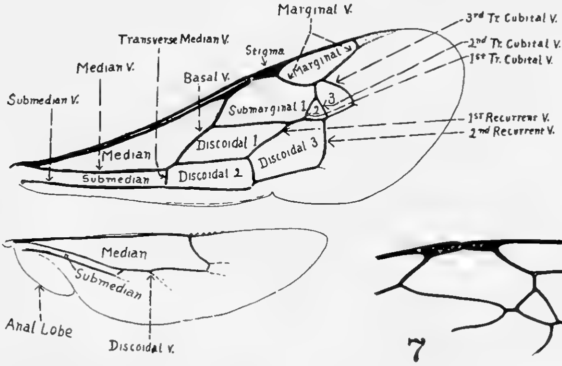

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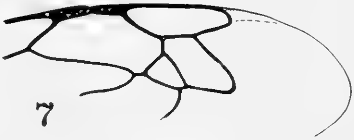
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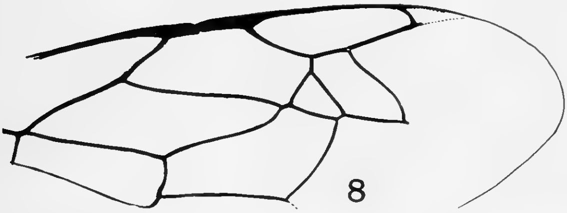
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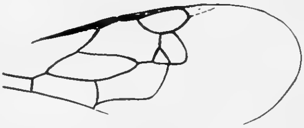
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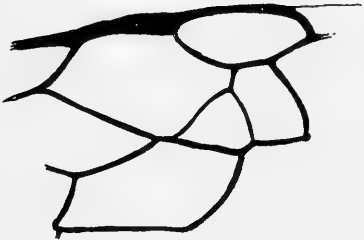
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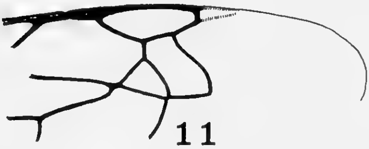
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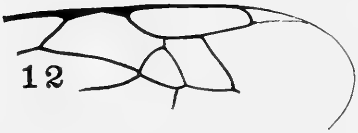
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Figure 6. *Plenoculus davisi (=P. apicalis)*. Male, type series. From Northwestern Kansas.

Figure 7. *Plenoculus davisi*. Male. From Gavilan, California.

Figure 8. *Plenoculus davis transversus*. Female. Holotype. From Tulare County, California.

Figure 9. *Plenoculus palmarum*. Male. From Palm Springs, California.

Figure 10. *Plenoculus cuneatus*. Holotype. Female. From Imperial County, Calif.

Figure 11. *Plenoculus timberlakei*. Female. From near Palm Springs, California.

Figure 12. *Plenoculus davisi*. Probably a female. From Morongo Valley, Calif.

or granular. Clypeus with the well-bossed median portion chiefly shining, curving into its cuneate and well-rimmed extension; mandibles almost evenly curved, rather broadly notched beneath; antennae short, subclavate, article 3 longer than 4, article 12 subconic; ocelli forming a triangle intermediate between an equilateral and a right-angle triangle; preoccipital carina complete dorsad. Scutum and scutellum strongly and closely punctate. Disc of propodeum rather closely hedged by dense silvery pile, the median line delicate and interrupted, the pleurae reticulate-striate, the posterior face subopaque and with a shallow median area. Comb of the basal article of the foretarsus consisting five bristles which are nearly twice as long as the diameter of this basal article. Other leg bristles moderate. Marginal cell of forewings somewhat shorter than usual in the female, and its apex is broadly and obliquely subtruncate and extending apically fully as far as does the third submarginal cell. The third transverse-cubital vein is outbowed and not sinuate. Abdomen broad, the tergites shining, the tergites 1–4 very fine, chiefly hair punctured, the usual large scattered punctures on tergite 5, the 6th tergite (pygidium) widely triangular, slightly constricted apically and provided with large scattered punctures, the bounding carinae low, hardly raised. The apices of tergites narrowly and obscurely pale yellowish, that of tergite 1 rather strongly banded by silvery pile.

MALE, allotype. Length, 4 mm. somewhat less shining than the female. Markings about as in the female, except that the disc of the clypeus almost entirely, the mandibles basally, the scape beneath and the legs to a greater degree, are creamy yellow. The antennae have the first three articles dark brown above, becoming much lighter for the last ten articles, and beneath articles 2 and 3 are dark, and all the remainder lighter than above. The venation generally, testaceous and the abdomen all red. The clypeus is not carinate, its median portion is moderately bossed, drawn out mesad, and with a tooth before its rather narrowly truncate apex. The clypeal margin is wide and rather bristly for its lower sides. Mandibles well notched beneath, almost evenly curved, not toothed within. Antennae stout and subclavate, viewed dorsally article 3 is very little longer than 4 and narrower than the subquadrate pedicel (article 2), the pedicel however, as viewed from the side is subtriangular, but constricted basally; from the side the basal articles trend obliquely, and all the flagellum except articles 12 and 13 are rounded out below with a total crenulate effect. Article 13 is tapering and nearly as long as 11 plus 12. Ocelli in very slightly more than an equilateral triangle. Preoccipital carina complete dorsad. Disc of propodeum subopaque, finely reticulate, a short median carina and an apical depression, the disc hedged by silvery pile. Marginal cell short, the third submarginal cell extending about equally toward apex of wing. Tergites with fine dense punctures, with silvery pile bands on apices of 1–4; tergites 6 and 7 with quite sparse larger punctures. Terminalia of the *Pl. cockerellii* type. No examination was made of the terminalia of the allotype of *Pl. cuneatus.*

Holotype, female, and allotype, male, from Pinto Wash, Imperial County, California, May 5, 1958 (F. X. Williams), on *Euphorbia polycarpa* var. *hirtella*. Paratype: 2 females and 3 males, same data as type material. Specimens not considered paratypes: 1 male, Thousand Palms, Riverside County, California, April 23, 1955 (W. R. M. Mason); 1 male, Borego, San Diego County, April 25, 1954 (P. D. Hurd), on *Croton californicus,* and 1 male in the U. S. National Museum (No. 1119, B 29), from Glendale, Nevada, October 3, 1929, on *Chrysothamnus paniculatus,* and collected by David E. Fox.

Discussion. This distinct species is readily separated from *Pl. timberlakei,* its nearest relative, in the female by its cuneate clypeal margin, the narrower ocellar triangle, the generally shorter marginal cell and the presence of femoral and tibial markings; the male of *Pl. cuneatus* is differentiated by the form of the clypeus and the unmodified antennae.

Plenoculus cockerellii Fox.

(Figures 4, 14, 15, 16, 42, 48, 50, 51, 70, 80.)

Plenoculus cockerellii Fox, 1893, Proc. Acad. Nat. Sci. Phila., 45:538. Female. Las Cruces, New Mexico (T. D. A. Cockerell).

Female. *Plenoculus cockerellii,* as represented by a specimen in the U. S. National Museum, and taken in the type locality in 1928, by Cockerell, is about 6 mm. long. It is black with the clypeus and mandibles largely reddish, the antennae brownish with the apex of the last article paler, the first and second femora with pale creamy white apically beneath, the legs are generally darker and lighter reddish, and the abdomen red. The clypeus is evenly rounded out, the antennae rather short and subclavate, article 3 plainly longer than 4; the ocelli form about a right-angle triangle, and the preoccipital carina is entire above; the tibial spines are moderate; tergite 5 is without large deep punctations; the pygidium is very little constricted before the apex, the disc of which is evenly flattened. The punctation is fine, or the sculpture largely coriaceous.

Male (hitherto undescribed). Subopaque. It is black with the clypeus and mandibles, except their apex and lower tooth, brownish yellow, the antennae with the scape beneath lemon yellow, articles 3–6 dull yellowish beneath, the last articles being honey yellow; the margin of the prothoracic lobes and the base of the wings are creamy yellow, the tegulae are in part translucent, the rest creamy yellow; most of the fore femora beneath and the apex of all the femora, tibiae, except a stripe beneath, and the tarsi, creamy yellow; the abdomen is reddish, obscurely black above and beneath at middle length. The clypeus is rounded out, slightly wedge-like mesad, with a slightly prominent translucent rim (the clypeus and mandibles are somewhat worn down); mandibles slightly elbowed, not dentate within; antennae rather slender for the basal part of the flagellum, articles 3 and 4 subsequal from above; ocelli forming very slightly more than a right-angle triangle; vertex finely granulate, preoccipital carina entire dorsad; thoracic notum finely and closely punctate; disc of propodeum finely granulate and with a shallow trough that has some transverse striae, the pleurae in part smooth and in part finely striate, the posterior face shining and with a triangular depression above. Vestiture is of silvery pile forming bands on the abdomen. Terminalia with the lobes of the aedeagus, as seen from above, extending cone-like laterally.

This description of the male is based on somewhat worn specimens from: Four miles east of Eden, Riverside, California (P. H. Timberlake). Males from La Paz, Baja California, Mexico, are much darker. And intermediates occur elsewhere.

Specimens studied: ARIZONA—Cochise County: 17 miles east of Douglas, 2 females, August 8, 1958 (R. M. Bohart); Willcox, 2 males, 1 female, August 14, 1958 (D. D. Linsdale); Madera Canyon, Santa Rita Mts., 1 female, July 31, 1958 (R. M. Bohart). Graham County: San Carlos, 1 female, July 15, 1955 (N. J. Nerney), swept/l alfalfa. Maricopa County: Wickenburg, 1 female, August 25, 1927 (Cornell Univ., Lot 542, sub. 334). Pima County: Sabino Canyon, 1 female, July 17, 1954 (R. M. Bohart). Tucson, 1 male, May 30, 1920 (F. X. Williams, doubtfully this species); 10 females and 1 male, July 17, 1955 (G. D. Butler), *Wislezenia*. Pinal County: Eloy, 10 miles south, 1 female, July 3, 1953 (T. R. Haig). CALIFORNIA—Riverside County: Cathedral City, 1 female, October 8, 1946 (P. H. Timberlake), on *Euphorbia polycarpa*. Four miles east of Eden, 2 males, April 17, 1937 (P. H. Timberlake), on *Eriogonum thomasi*. Palm Springs, 3 females, June 24, 29, 1954 (P. H. Timberlake), on *Dalea spinosa*. Twenty-nine Palms, 1 female, August 9, 1946 (P. H. Timberlake), on *Wislezenia refracta;* one female (carrying a pyralid caterpillar), September 5, 1946 (P. H. Timberlake). Thousand Palms, 2 males, April 16 and 23, 1955 (W. R. M. Mason). San Diego County: Borego Desert, 1 female, April 27, 1954 (P. D. Hurd); 1 female, April 27, 1954 (M. Wasbauer), on *Croton californicus;* 1 female, May 26, 1954 (F. X. Williams), 1 female, April 27, 1955 (R. O. Schuster). NEW MEXICO—Dona Ana County: Las Cruces: 3 females, August, 1928 (Cockerell) (Ckll. 4870 and Ckll. 4877, Collection U. S. National Museum). Albuquerque (desert), 5 males, June 15, 1956 (R. and K. Dreisbach). Hidalgo County: Rodeo, 2 females, August 21, 26, 1958 (R. M. Bohart); 18 miles north of Rodeo, 7 females, August 19, 25, and 26, 1958 (R. M. Bohart). TEXAS—El Paso County: El Paso, 1 female, July 24, 1914 (J. C. Bradley), Cornell U. Lot 684, sub. 35 (labeled, *Plenoculus cockerelli* Fox ♀, J. C. Bradley, 1923. Comp. with type). Llano County: Not far from Austin, 1 female, June 12, 1941 (J. E. Gillaspy) Col. Univ. Calif., Berkeley). MEXICO—Baja California: La Paz, 1 female, October 12, 1954 (F. X. Williams); 33 females and 4 males, October 8, 1955 (F. X. Williams). Guerrero: Mexcala, 1 female, June 29, 1951 (P. D. Hurd).

Discussion. Easily separated from *Pl. timberlakei* by its elbowed mandibles, this character being more obvious in the female, and by the unmodified clypeus and antennae in the male. However, *Pl. cockerellii* shows considerable variation over its wide range. A female from Las Cruces, New Mexico, has a good deal of reddish about the mandibles. clypeus and femora; those from La Paz, Baja California, are considerably darker, with some of the California examples intermediate between the two. The pale femoral markings seem always present. The female from Llano County, Texas, and several from Arizona (Cochise, Graham, and Pima counties) have the clypeus drawn out wedge shaped (figs. 15, 16). Males may be quite dark, and in material from the same locality and collected on the same date one specimen has the clypeus quite black while another may have the clypeus of an old ivory color. Sometimes the clypeus shows a weak median ridge, as in the five males from Albuquerque, while a male from Tucson has the mandibles narrowly cleft within.

Plenoculus mexicanus Williams, new species.

(Figures 13, 23.)

Female, holotype. Length, 5.5 mm. Black; vertex and dorsulum shining, disc of propodeum subopaque. Clypeus narrowly reddish margined, mandibles red, darker apically, scape black and obscure reddish, pronotal lobes dull reddish, the first and second pair of femora with a creamy yellow stripe beneath, tibiae and tarsi mainly reddish brown; abdomen red, with much blackish apically up to the second tergite; pygidium dark red. Head wider than high; clypeus with the median portion rather gibbous and drawn out subcuneate, with scattered punctures except rather narrowly mesad, thus giving it a subcarinate aspect; mandibles very slender, distinctly elbowed at the basal third, feebly and widely excavate beneath, the bordering notch low, no inner tooth, the blade being quite low and forming in profile only a gentle convexity; antennae stout, article 3 longer than 4; ocelli arranged in about a right-angle triangle; preoccipital carina complete dorsad but not reaching the gular suture below. Dorsulum very closely punctate; disc of propodeum finely and transversely aciculate, narrowly depressed apically, posterior face with a narrow wedge-like depression; marginal and submarginal cells extending equally apically. Fifth tergite with the usual large punctures; pygidium slightly compressed subapically, with a few strong punctures. Pile silvery.

MALE, allotype. Length, 4 mm. Head, thorax, except the largely creamy yellow pronotal lobes, and the abdomen, except a little reddish laterally at the base, black. Clypeus red apically, mandibles creamy yellow basad, reddish apically; scape beneath and the last five or six articles increasingly brownish; tegulae and axillary sclerites pale yellowish brown; first and second pairs of femora beneath from apex, all tibiae widely above, and the tarsi, creamy yellow. Clypeus rounded subcuneate mesad, with a fine low, more or less divided carina; mandibles slender and elbowed, though less so than in the female, well excavated beneath; antennae fusiform, slender at the base, articles 3 and 4 subsequal, article 13 tapering; ocelli forming less than a right-angle triangle. Dorsulum and disc of the propodeum nearly opaque. Terminalia of the *Pl. cockerellii* type. Vestiture of silvery pile, forming bands on the abdomen.

HOLOTYPE, female, and ALLOTYPE male, from Acapulco, State of Guerrero, Mexico, July 1, 1951 (H. E. Evans). PARATYPES, all from Mexico, as follows: 5 females from Acapulco, date as above; 1 female, Tecolutla, State of Veracruz, June 19, 1951 (H. E. Evans); 4 females and 1 male from Veracruz, June 20, 1951 (H. E. Evans); 1 male and 16 females, Acapulco, July 1, 1951 (P. D. Hurd); 16 females, Veracruz, June 20, 1951 (P. D. Hurd); 3 females, Tecolutla, June 19, 1951 (P. D. Hurd), and 1 male, Alpuyeca, Morelos, Mexico, July 3, 1951 (P. D. Hurd).

DISCUSSION. *Plenoculus mexicanus* differs consistently from *Pl. cockerellii* in its more slender and more crooked mandibles, particularly in the female. In the male of *Pl. mexicanus,* of which sex only four specimens have been collected, the abdomen may be almost entirely black.

Figure 13. *Plenoculus mexicanus.* Female. Holotype. Jaws and clypeus. From Acapulco, Mexico.

Figure 14. *Plenoculus cockerellii.* Female. From La Paz, Baja California, Mexico. At A, clypeus of male. Same locality.

Figure 15. *Plenoculus cockerellii.* Female. From Llano County, Texas.

Figure 16. *Plenoculus cockerellii.* Female. From Tucson, Arizona.

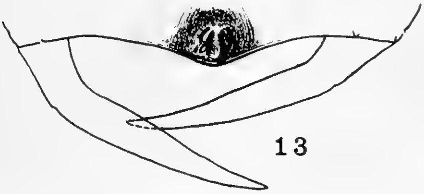
Figure 17. *Plenoculus cuneatus.* Female. Holotype. From Imperial County, Calif.

Figure 18. *Plenoculus cuneatus.* Female. Holotype. Ocellar triangle.

Figure 19. *Plenoculus timberlakei.* Female. Holotype. Five miles south of Palm Springs, Riverside County, California.

Figure 20. *Plenoculus timberlakei.* Male. Beaver Dam, Arizona.

Figure 21. *Plenoculus timberlakei.* Male. Antenna from side.



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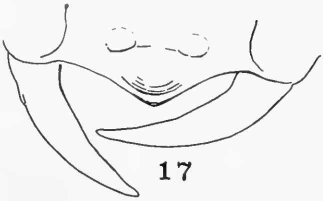

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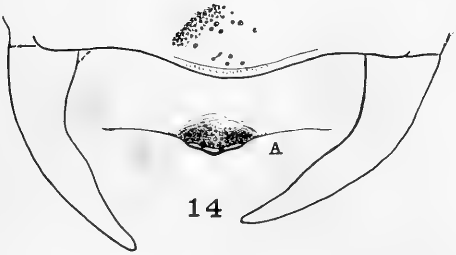

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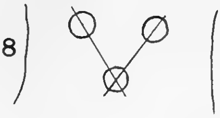

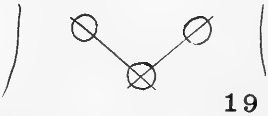

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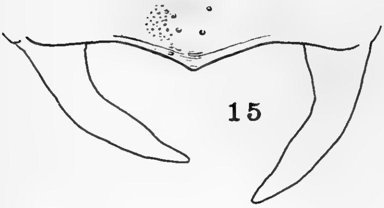

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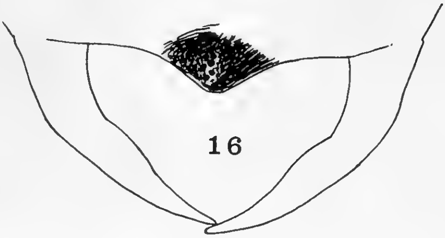

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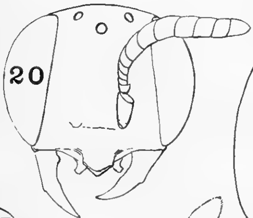

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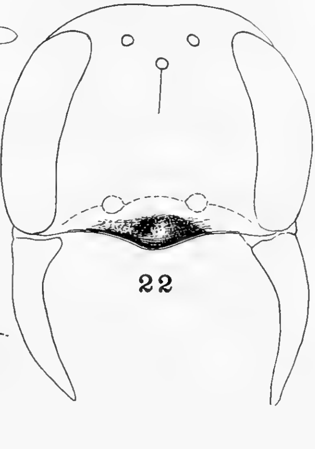

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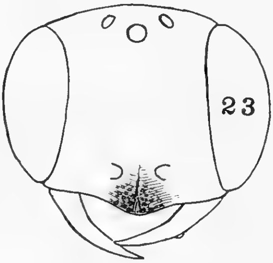

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Figure 22. *Plenoculus timberlakei.* Female. From near Palm Springs.
Figure 23. *Plenoculus mexicanus.* Male. Allotype. From Acapulco, Mexico.
Figure 24. *Plenoculus cuneatus.* Male. Clypeus. From Glendale, Nevada.
Figure 25. *Plenoculus cuneatus.* Male. From Borego, San Diego County, Calif.

Plenoculus boregensis Williams, new species.

(Figures 26, 27, 28, 29.)

FEMALE, holotype. Length, 6 mm. Black; clypeus diluted white, its margin narrowly, except wedge-like mesad, reddish; mandibles reddish, the apices darker; scape of antennae pale yellow beneath; above, the flagellum is reddish brown to dusky brown; base of pronotum, outer portion of its lobes, tegulae, largely so; axillary sclerites and basal wing veins, creamy white; fore femora postero-ventrad and mid femora ventrad, creamy white from apex to near base; posterior trochanters and femora reddish, all tibiae reddish with yellowish white dorsad; tarsi reddish brown; abdomen reddish, shining, the apical margins of tergites 1–4 whitish, that on tergite 1 the most distinct. Vestiture: dense appressed silvery pile on head and thorax, conspicuous also on femora, and in certain lights it shows as three stripes on the mesonotum, and as narrowing bands at the apex of tergites 1–4. Clypeus gently rounded outwardly, this lobe very slightly roughened and moderately gibbous; mandibles very slender, stepped down at basal third beneath rather than emarginate, and with no inner tooth; antennae subclavate, the flagellum rather fusiform, article 3 distinctly longer than 4, 12 about half again as long as thick and tapering rather sharply (collapsed ?); ocelli in slightly more than a right-angle triangle. Exposed disc of propodeum much narrowed by the invading pile, opaque, and with a line-like groove that widens and flattens apically. Foretarsal rake particularly well developed for *Plenoculus,* the pale bristles extending to nearly twice the width of their respective segments; mid-tarsi with a rather dense row of long bristles; the bristles on the posterior tarsi moderate. Wing venation mostly pale testaceous, the long third submarginal cell extending apically fully as far as the marginal cell. Abdomen relatively broad; pygidium broadly triangular, the sides well carinate, the apex narrow, and the disc with a few large punctures.

MALE, allotype. Length, 4 mm. Black; clypeus, mandibles at base, scape beneath, large spot on forecoxae, femora 1 and 2 beneath and at apex, apex of femora 3, tibiae and tarsi, base of wings to well along the costal margin, creamy white; scape of antennae above and pedicel in part and base of article 3 nearly black; otherwise the flagellum is orange yellow; last tergite reddish. Clypeus gently rounded outward, no hair tuft on either side; mandibles slender, well excavate beneath, but with no inner tooth; antennae slender, subclavate, the pedicel thicker than, and fully as long as, the third antennal article which is about as wide as long and very little shorter than the fourth; the clavate portion of the antennae with no article, except the thirteenth, longer than wide, article 13 one and one-half times longer than 12 and tapering on one side from half its length; ocelli forming less than a right-angle triangle. Pronotum distinctly depressed mesad. Disc of propodeum narrowly exposed, depressed mesad, and with some transverse regulae; the pleurae tessellate, shining; the posterior face with a subfusiform depression. Marginal cell rather narrowly truncate, slightly exceeding the third submarginal. Abdomen smooth ventrad. Terminalia: uncal lobes sharply pointed dorsad (as facing the last visible ventral segment); a row of spines, short, heavy and spike-like, on each volsella. Vestiture: abundant silvery pile, as in the female.

Holotype, female, Borego, San Diego County, California, April 30, 1954 (M. Wasbauer), on *Croton californicus.* Allotype, male, topotypical, April 25, 1954 (P. H. Timberlake), on *Croton californicus.* Paratype, 1 male, topotypical, April 25, 1954 (M. Wasbauer), on *Croton californicus.* All three specimens are in fine condition.

Discussion. *Plenoculus boregensis* belongs nearest the *Pl. cockerellii* group, although the terminalia of the male of *Pl. boregensis* are quite different. I consider this species our finest example of *Plenoculus.* The yellow tegumentary band on the pronotum of the female seems distinctive among wasps of this genus.

Plenoculus boregensis perniger Williams, new subspecies.

Male, holotype. About 3 mm. long. Head, thorax, and abdomen shining black. Mandibles blackish at base, thence reddish; antennae black, femora black, tibiae with some creamy white, all tarsi, except apex of last article, pale; venation of forewings generally dark testaceous, paler at base; the very tip of abdomen slightly reddish. Clypeus rounded out mesad, and except for its thick shining rim it is roughened. Mandibles not slender, slightly crooked, with a very slight notch within. Antennae thick, subclavate, article 3 as long as the pedicel and narrowed basad, article 4 very slightly shorter than 3, article 13 tapering and a little longer than 1½ the length of 12. Ocelli forming a little less than a right-angle triangle. Vertex coriaceous; dorsulum finely and closely punctate; disc of propodeum widely exposed, finely granulate. Marginal cell of forewings rather narrowly truncate and exceeding the third submarginal cell. Some patches of silvery pile. Terminalia as in *Pl. boregensis boregensis;* the parameres with the usual fringing bristles, a row of stronger erect bristles from the concave surface, and a row of shorter volsellar bristles, lobes of aedeagus acuminate on their ventral side (facing the last visible ventral segment).

Holotype, male, Thousand Palms, Riverside County, California, April 7, 1955 (W. R. M. Mason). Paratypes, 4 males. Two other males not considered paratypes, topotypical, early to late April, 1955 (W. R. M. Mason).

Female, unknown.

DISCUSSION. This species differs from the nominate species chiefly in its black clypeus and abdomen. The largest of the series is 3.40 mm. long.

Plenoculus parvus Fox.

Plenoculus parvus Fox, 1897, Ent. News, 8:71–72. Type, female, Las Cruces, New Mexico (Cockerell, 5173).

FEMALE. The original description is as follows:

> Anterior margin of clypeus subtruncate in the middle, not incised or dentate; the flagellum strongly clavate; the first joint longer than the second, dorsum and scutellum finely and closely punctured; middle segments microscopically striated, not impressed above, posterior face more distinctly transversely striated; with a deep longitudinal central furrow; legs tolerably spinose, tarsal comb feebly developed; pygidial area with large sparse punctures, not margined or carinated laterally. Black; mandibles except apex, legs except coxae and extreme tip of abdomen, red; scape beneath and tegulae yellowish; flagellum beneath testaceous; entire insect clothed more or less with silvery pubescence, especially the head in front and the thorax on sides and beneath; apical margins of abdominal segments narrowly testaceous; wings hyaline, strongly iridescent, nervures testaceous. Length 3 mm.
>
> This is the smallest species of *Plenoculus*, and is not closely related to any of the others.

DISCUSSION. I am obliged to Dr. Karl V. Krombein for his additional findings from an examination of this unique female type, principally that there are two teeth at each lateral angle of the clypeus and that the pygidium is delimited, though rather weakly, by a carina.

Plenoculus palmarum Williams, new species.

(Figures 9, 36, 37, 71, 73, 78.)

MALE, holotype. Length, 3.8 mm. Black; antennae brownish yellow, duskier toward base; forepart of clypeus reddish brown; mandibles, except teeth and apex, yellow; fore and mid-femora at apex beneath, all tarsi and

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Figure 26. *Plenoculus boregensis*. Female. Holotype. At A, mandible, from outer side. Borego.

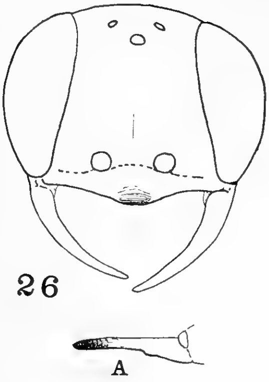
Figure 27. *Plenoculus boregensis*. Female. Mid tarsus. Borego.

Figure 28. *Plenoculus boregensis*. Male. Clypeal outline. Borego.

Figure 29. *Plenoculus boregensis*. A., pygidium of female; B., male, extremity of aedeagal lobes, ventral and lateral views. Borego.

Figure 30. *Plenoculus sinuatus*. Male. Allotype. Mandible somewhat inclined from side. Borego.

Figure 31. *Plenoculus timberlakei*. Male. Allotype. Mandible. To show low tooth, T, behind blade, B. Beaver Dam, Arizona.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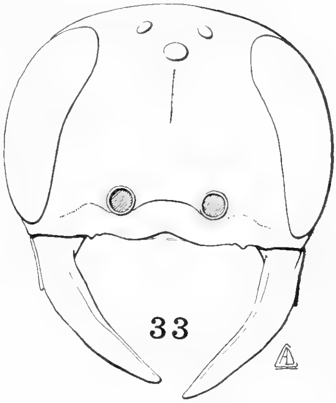
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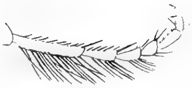
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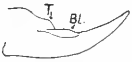
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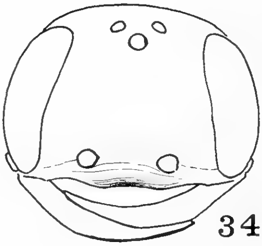
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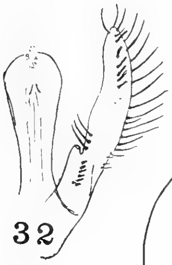
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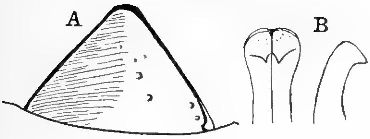
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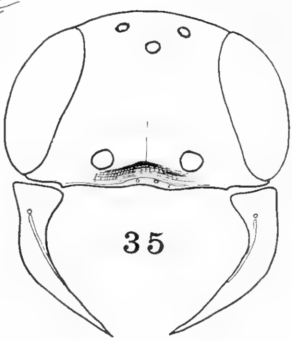
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Figure 32. *Plenoculus sinuatus.* Male. Allotype. Terminalia in part. From Borego.

Figure 33. *Plenoculus gillaspyi.* Female. Type. From Williamson County, Texas. Drawn by Arthur D. Cushman.

Figure 34. *Plenoculus hurdi.* Female. Holotype. From Teotihuacan, Mexico.

Figure 35. *Plenoculus sinuatus.* Female. Holotype. From Borego.

tibiae, pale yellowish to yellowish brown; tegulae and basal venation nearly white; first three abdominal segments orange. Produced portion of clypeus subtruncate, no clypeal side whiskers; mandibles with a fang-like tooth within; antennae stout, the segments short, the thirteenth tapering; ocelli in slightly less than a right-angle triangle. Dorsulum shining, finely punctate; metapleurae above with some well-marked carinulae extending to near spiracle. Exposed disc of propodeum narrow, tongue-like, there being an imperfect bounding carina hedged in by silvery pile; there are also a few transverse and an imperfect longitudinal carina; posterior face with some fine carinulae and a narrow wedge-like cleft expanding to apex of the disc. Marginal cell very short. Abdomen smooth beneath. Lateral lobes of the aedeagus somewhat cuneate beneath, and apically above are provided with a tuft of bristles. The pile is silvery and abundant.

Female, allotype. Length, 4 mm. Body shining. Black; clypeus for apical portion, mandibles except apex, scape of antennae beneath at base, and flagellum beneath, fore and middle femora beneath beyond base, creamy white; posterior femora reddish brown apically; tibiae and tarsi pale yellowish brown, but tibiae in part whitish dorsad; pronotal lobes apically, tegulae, axillary sclerites, and base of wings, creamy white; venation testaceous, abdomen entirely red; legs with spines on the palest areas whitish, otherwise spines and spurs pale brown. Head rather wide; produced portion of clypeus gently lobed, narrowly rimmed and with three teeth on each side, the innermost tooth quite small; mandibles with a fang-like tooth within at base of blade; antennae moderately stout, article 3 slightly longer than 4, article 12 gently tapering; ocelli in about a right-angle triangle. Dorsulum with close punctures. Exposed disc of propodeum narrowing from base, and with two longitudinal carinulae and some shorter basal ones; pleurae finely reticulate; posterior face with its depression in its upper portion. Marginal cell rather short, exceeding the third submarginal. Disc of pygidium broadly triangular, tapering slightly at apex, its bounding carinae not strong, the disc with a few punctures. Vestiture silvery pile in the usual places.

Holotype, male (Citrus Experiment Station, Riverside), Palm Springs, Riverside County, California, April 24, 1938 (P. H. Timberlake), flying over ground. Allotype, female, Borego, San Diego County, April 29, 1955 (F. X. Williams). Paratypes, 2 males, Borego, April 29, 1954 (P. H. Timberlake), on *Euphorbia polycarpa;* 1 female. Borego, April 27, 1954 (P. D. Hurd). Other specimens not considered paratypes: 1 female, Blythe, Riverside County, April 24, 1955 (W. R. M. Mason); 3 males, Pinto Wash, Imperial County, California, April 28, 1958, and 12 males and 4 females, topotypical, May 5, 1958 (F. X. Williams), all at plants of *Euphorbia polycarpa hirtella.*

Discussion. This small, stoutly-built species has the labrum gently bilobed in both sexes. It is evidently related to *Pl. parvus* Fox, of which only the female is known. The abdomen of *Pl. palmarum* is entirely red, and there are three teeth on either side of the low clypeal lobe, while in *Pl. parvus* there are but two such on either side.

Plenoculus propinquus Fox.

(Figures 1, 46, 55, 56, 81, 82.)

Plenoculus propinquus Fox, 1893, Proc. Acad. Nat. Sci. Phila., 45:537–538. Female, Colorado. *Ashmead*, 1899, Psyche, 8:337–339. Male and key to spp.

Plenoculus propinquus var. *rufescens* Cockerell, 1898, Proc. Davenport Acad. Sci., 7:144. Reported from Arizona, California, Colorado, New Mexico, Idaho, and now from Nevada, Oregon, Washington, and Utah.

Specimens examined: CALIFORNIA—Kern County: Randsburg, 1 male, May 1, 1952 (R. M. Bohart). Pumpkin Center, 1 male, July 30, 1956 (E. I. Schlinger). Lassen County: Halleluja Junction, 1 male, July 4, 1951 (R. C. Bechtel); 3 females and 1 male, July 11, 1957 (R. M. Bohart). Monterey County: *San Lucas,* 1 male, August 20, 1933, on flowers of *Eriogonum gracile* (P. H. Timberlake). Los Angeles County: Clairmont, 3 females "PomC" (Baker). Glendale, 1 male, June 8, 1952 (E. I. Schlinger); 2 miles east of Lancaster, September 14, 1956 (E. I. Schlinger). Orange County: Yorba Linda, 1 female, August 15, 1920, on flowers of anise (P. H. Timberlake). Riverside County: Banning, 1 male, June 26, 1952 (J. W. MacSwain). Four miles east of Eden, 1 male, April 17, 1937, on *Larrea divaricata* (P. H. Timberlake); Riverside, 8 females and 3 males, distributed in April, June, July, September, and October, and the years 1927, 1928, and 1929, on *Euphorbia marginata;* 4 males and 3 females, comprising 6 specimens collected in June and 1 in September, during the years 1926, 1927, 1932, and 1941, on *Eriogonum gracile;* 1 female and 1 male, September, 1924, on annual *Eriogonum;* 1 female digging in loose soil. All collected by P. H. Timberlake; 3 females, August 7 and 10, 1956 (J. C. Hall and E. I. Schlinger). San Bernardino County: One mile east of Cajon Junction, 8 males, August, 1956 (E. I. Schlinger). Ventura County: Santa Paula, 3 males, June 5, 1927, on or near ground (P. H. Timberlake). COLORADO—Alamosa County: Great Sand Dunes, 6 females, July 20–21, 1954 (H. E. and M. A. Evans). One female, No. 2276 Colorado; Boulder, 1 female, August 5, 1908; 1 male, August 4, 1908 (S. A. Rohwer, Det. S. A. Rowher), Collections U. S. National Museum. Limon, 1 female, August 25, 1951 (R. R. Dreisbach). NEVADA—Churchill County: Fallon, altitude 4,000 feet, 4 males, May 29, 1930 (E. L. Bell), Acc. 30540, American Museum of Natural History, Minden, 2 females, August 24, 1952 (R. M. Bohart). Washoe County: Sparks, 1 female, July 18, 1953. OREGON—Deschutes County:

Tumalo Reservation, near Bend, 2 males, June 22–23, 1954 (E. I. Schlinger). UTAH—North fork Duchesne River, 1 female, July 13–14, 1927 (Cornell University Lot 542, sub. 305). Morgan County: Pine View, Ogden Canyon, 1 female, July 21, 1922 (E. P. Van Duzee). WASHINGTON—Grant County: Columbia River, near Vantage, 1 male, August 27, 1954 (H. E. and M. A. Evans).

Discussion. The female of *Pl. propinquus* averages about 6 mm. long. It is black or with the basal part of the abdomen reddish, and the anterior tibiae in front yellowish brown. The clypeus is deeply cleft mesad, almost with a stoved-in effect. The disc of the propodeum is finely granulate, with a few carinulae and a shallow median sulcus. The male has a rather gibbous clypeus, often shallowly cleft mesad or bluntly produced there, and its color is more or less pale yellowish or old ivory and sometimes sharply dark at the extreme base. With rare exceptions the scape is dark beneath. The 2–3 stout volsellar thorns appear to be its best character.

Plenoculus deserti Williams, new species.

(Figures 85, 87.)

Male, holotype. Length, 4 mm. Black; disc of clypeus anteriorly yellowish red; mandibles same color except base and apex; no pale ventral stripe on scape; a stripe on fore tibiae, on fore tarsi generally, a rather obscure stripe behind on the posterior tibiae, and an obscure basal and apical mark on middle tibiae, all pale dull yellowish; middle and posterior tarsi brownish, tegulae yellowish; venation testaceous, the costa and other veins forming the marginal cell, darker; abdomen orange red. Produced portion of clypeus with acute lateral angles, the low wide median lobe polished and somewhat downcurved apically; a pale clypeal tuft far to either side; mandibles excavate beneath and with a strong tooth within; antennae rather slender, articles 3 and 4 subsequal, 13 curved on one side; frons and vertex subopaque a line forward from anterior ocellus, the ocelli forming barely less than a right-angle triangle, the space between the fore ocellus and each posterior one tumid. Dorsulum closely punctate, the meso- and metapleurae shining, the mesopleurae beneath with a small tubercle; disc of propodeum subopaque, broad and subtruncate, bounded apically by a curved carina, the disc is reticulate and with fanning and transverse carinulae, the median trough widens apically and is polished there, propodeal pleurae shining and very finely striate, posterior face shining, transversely striate and with a broad subcordate depression. Abdomen with very fine reticulations. Aedeagus of the *Pl. davisi* type, but with about 8 strong volsellar spines. Vestiture moderate silvery pile.

Female, allotype. Length, 5 mm. Head and thorax generally subshining, the punctation finer than in the male. Black, the clypeus reddish except at base, only the posterior tibiae with a pale dirty yellow stripe posteriorly, tarsi largely brownish; venation as in holotype; abdomen reddish with a darker ill-defined median blotch on tergite 2. Produced portion of clypeus subtruncate, mostly bare and shining with a very few large punctures, strongly emarginate and rather depressed mesad, the margin sloping down from this emargination and provided with an angle and two teeth at each side; mandibles stout, emarginate beneath and toothed within; antennae rather slender, segments 3 and 4 subequal, the slightly reddish segment 12 slightly longer than segment 11; ocelli forming very little less than a right-angle triangle, the line forward from the anterior ocellus about as long as the diameter of that ocellus, the space between the fore ocellus and each posterior ocellus rather tumid; head texture subcoriaceous. Length of spines of the fore tarsal comb up to about 1.3 the thickness of the segment from which they originate. Disc of propodeum generally opaque except the apical part of the very shallow median trough, and with very fine recurved striae; propodeal pleurae shining with exceedingly fine striate-reticulate surface; posterior face shining, with a V-shaped depression. Abdomen with tergites showing very fine reticulations and the usual strong punctures on the apical ones. Disc of pygidium subtriangular, not pinched apically, the sides being nearly straight, the discs with rather sparse though strong punctures having the effect of roughening its surface.

Holotype, male, in good condition, Borego, San Diego County, April 20, 1955 (F. X. Williams). Allotype, female, topotypical, April 2, 1953 (P. D. Hurd). Paratypes likewise from Borego are, 2 males, April 25, 1954 (P. D. Hurd), on *Croton californicus;* 1 female, April 9, 1955 (F. X. Williams); 3 females, March 15, 1957 (F. X. Williams). Specimens not regarded as paratypes are, 1 male (with clypeus and mandibles black), Picacho Pass, Arizona, September 13, 1954 (P. H. Timberlake), on *Euphorbia albomarginata;* 1 male and 1 female, Thousand Palms, Riverside County, March 28 and April 25, 1955 (W. R. M. Mason); 1 male, Fish Creek mountains, 300 feet, Imperial County, California, April 20, 1955 (W. R. M. Mason).

Discussion. *Plenoculus deserti* seems to be the Colorado Desert representative of *Pl. propinquus* Fox. It differs from the latter in its generally smaller size; in the male in the slightly different clypeus and in the more numerous and more spinelike volsellar armature; in the female in the more roughened pygidial disc. And admittedly, this rather weak species may be difficult to separate from some specimens of the desert *Pl. davisi* Fox.

Plenoculus boharti Williams, new species.

(Figures 40, 61, 83, 84.)

FEMALE, holotype. Length, 4.5 mm. Frons subopaque, thoracic dorsum somewhat shining. Black; mandibles widely orange mesad, legs nearly black, fore femora at extreme base in part reddish, hind tibiae suffused with orange red, tarsi obscurely brownish, tegulae testaceous apically; abdomen red with a large central black spot on tergite 1, a still larger one on tergite 2, with tergite 3 almost entirely black, and the remaining tergites blackish. Frons densely and minutely punctate, less densely so on vertex which is shining; clypeus with the disc gently convex, the anterior part shining and with some large deep punctures, the margin slightly arcuate and with four strong teeth on each side of the rather narrow median emargination; antennae subclavate, rather stout, article 3 appearing slightly longer than 4; ocelli forming very slightly more than a right-angle triangle. Dorsulum very finely punctate. Disc of propodeum short, almost coriaceous, slightly depressed and very minutely cross-wrinkled for its apical half, the pleurae with very fine longitudinal striae, shining; posterior face chiefly smooth, with a shallow subtriangular depression from the upper part of which a pair of diverging carinulae arise. Legs moderately spinose; venation rather heavy, the marginal cell ending very slightly beyond the third submarginal cell, the second transverse-cubital and the second recurrent vein interstitial in one wing, nearly so in the other wing. Abdomen broad, the tergites generally reticulate, the fifth however with the usual large punctures; pygidium of the

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Figure 36. *Plenoculus palmarum.* Female. Paratype. From Borego.

Figure 37. *Plenoculus palmarum.* Male. From Palm Springs.

Figure 38. *Plenoculus timberlakei.* Female. Head, to show dorsally interrupted preoccipital ridge.

Figure 39. *Plenoculus davisi.* Male, with red abdomen. Ocellar triangle. From Plumas County, California.

Figure 40. *Plenoculus boharti.* Female. Holotype. From Campo, California (U.S. N.M.).

Figure 41. *Plenoculus davisi.* Female. From Midland County, Michigan.

Figure 42. *Plenoculus cockerellii.* Female. From Douglas, Arizona.

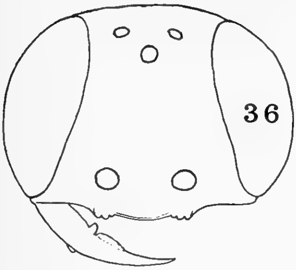
Figure 43. *Plenoculus davisi,* male, with red abdomen. Abdomen, from side, to show ventral ridges or undulations. From Big Bear Valley, San Bernardino Mountains, California.

Figure 44. *Plenoculus davisi.* Male (of Fig. 43). Abdomen, from beneath, to show ridges.

Figure 45. *Plenoculus davisi.* Female. Pygidium. From Olmsted County, Minn.

Figure 46. *Plenoculus propinquus.* Female. To show bilobed labrum. From Riverside, California.

Figure 47. *Plenoculus timberlakei.* Female. To show labrum very slightly emarginate mesad.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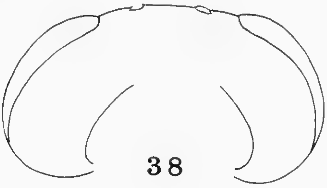
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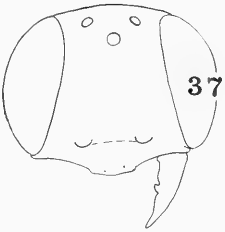
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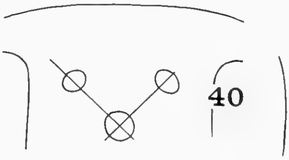
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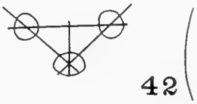
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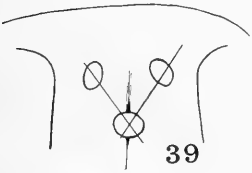
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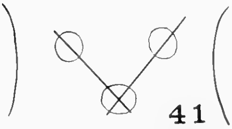
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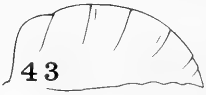
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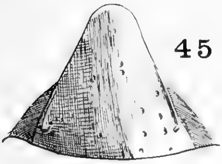
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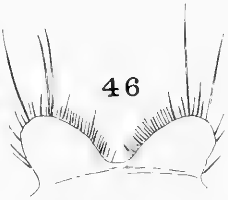
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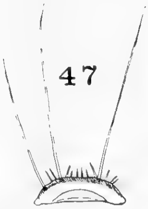
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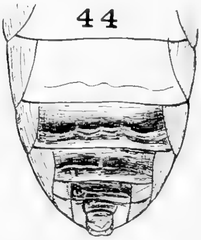
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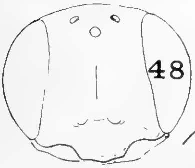
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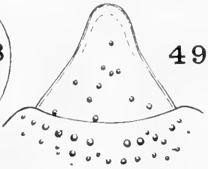
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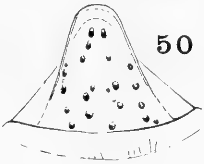
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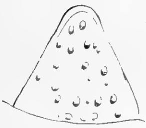
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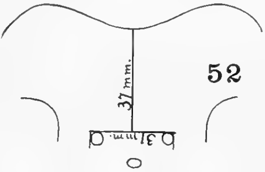
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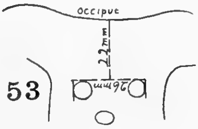
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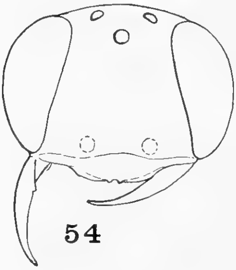
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Figure 48. *Plenoculus cockerellii* (?) male. From Tucson, Arizona.

Figure 49. *Plenoculus timberlakei*. Female. Pygidium. From Beaver Dam, Ariz.

Figure 50. *Plenoculus cockerellii*. Female. Pygidium. From Douglas, Arizona.

Figure 51. *Plenoculus cockerellii*. Female. From Eloy, Arizona.

Figure 52. *Plenoculus timberlakei*. Female. To show ocellar-occipital ratio.

Figure 53. *Plenoculus davisi*. Female, with red abdomen. To show ocellar-occipital ratio. From Mill Creek, San Bernardino County, California.

Figure 54. *Plenoculus davisi gracilis*. Female, holotype. The pale clypeus has unusual dentition. Six miles west of Indio, California.

usual triangular form, not constricted subapically, shining, with rather sparse strong punctures except mesad.

MALE, allotype. Length, 5 mm. Black; mandibles distad of broad part, reddish; extreme base of fore tibiae and a stripe posteriorly on the hind tibiae and their spurs, reddish brown; tarsi dark brown; abdomen red, with a transverse blackish spot on tergites 2 and 4, beyond it is blackish; a pair of small dark spots on sternite 2. Head with exceedingly fine close punctures, more scattered behind the posterior ocelli where it is shining; clypeus with the lateral hair tufts pale brown, clypeal disc moderately convex, the anterior part roughly sculptured though shining, the produced margin only gently arcuate and armed with four strong teeth; antennae rather stout, with the scape all dark, articles 3 and 4 subequal, 13 not bent; ocelli in slightly less than a right-angle triangle; a shining, slim fusiform line from the fore ocellus to between the bases of the antennae. Dorsulum shining, very finely and closely punctate, the pleurae striato-punctate and with a polished bossed area. Disc of propodeum widely exposed, shining, longitudinally and divergingly striato-punctate, the apex obcuneately depressed mesad, the pleurae striato-punctate, the posterior face largely shining, transversely striate and with a V-shaped depression mesad. Venation heavy, testaceous. Abdomen gently undulate ventrad except at base, above mostly reticulate. Terminalia as in *Pl. davisi davisi* (compared with a *Pl. davisi* from Midland County, Michigan, see fig. 79); laterodistal bristles of the parameres strong, other bristles weak or wanting. Vestiture: Sparse, some of it may have been rubbed off.

HOLOTYPE, female (U. S. National Museum Collection, Type No. 58464, from K. V. Krombein Collection), from Campo, San Diego County, California, April 27 1939 (R. M. Bohart). ALLOTYPE, male, Glencliff Camp, near Buckman Springs, San Diego County, May 7, 1953 (F. X. Williams).

Thus, the holotype and allotype were taken from localities scarcely 15 miles apart. PARATYPES, California, as follows: LOS ANGELES COUNTY: Pasadena, 3 males, May 14, 1944 (K. W. Cooper), in the Karl V. Krombein Collection (U. S. National Museum Collection), 44e14. Tanbark Flat, San Gabriel Mts., 3 males, July 11, 1952; July 5 and 12, 1956 (R. M. Bohart); 1 male, July 13, 1952 (J. W. MacSwain); 1 male and 1 female, June 17, 1 female, June 20, 1956 (R. C. Bechtel). MONTEREY COUNTY: Arroyo Seco Camp, 3 females, June 6, 1956 (R. M. Bohart), 2 females, June 5, 1957 (R. M. Bohart). Other specimens not considered paratypes are: 1 male, Sequoia National Park, Tulare County, California (R. C. Bechtel), and 1 male, Samuel Spr., Napa County, California (R. M. Bohart).

DISCUSSION. The male of *Pl. boharti* is identified by its blackish clypeal disc whose edge is multidentate, more rarely, crenulate, and emarginate mesad much as in the female, by the entirely dark antennal scape and the red and black abdomen. The male from Sequoia National Park and the one from Samuel Springs have the hind tibiae and tarsi pale reddish.

The female, on the other hand, except for the not-altogether-constant red-and-black color pattern of the abdomen and the frequently stronger protuberant clypeal teeth, seems inseparable from females with the abdomen entirely black from the same locality, that I regard as a rather dark form of *Pl. davisi.* Associated with these "*davisi*"-type females are typical pale-marked males of *Pl. davisi.*

Plenoculus stygius Williams, new species.

(Figures 5, 62, 90.)

Female, holotype. Length, 3.5 mm. Shining, the sculpture very fine. Black; mandibles except base and apex, margin of produced portion of clypeus, the legs beyond femora, yellowish brown; the tarsi in part duskier; antennae brownish beneath; tegulae brownish except at apex; apex of pygidium reddish. Head coriaceous; clypeus short, smooth and thick along middle part of margin, the dentition rather minute and consisting of three teeth on each side of the rather wide and shallow emargination; antennae subclavate; ocelli forming very slightly more than a right-angle triangle. Dorsulum finely and closely punctate; disc of propodeum coriaceous, under certain lights with minute transverse wrinkles and a shallow median trough, the pleurae polished, exceedingly fine reticulate-punctate, posterior face of propodeum nearly smooth, with an inverted tear-shaped depression. Foretarsal comb not strong, leg bristles pale. Truncation of marginal cell very narrow. Tergites under lower magnification appearing smooth, but under × 80 magnification with very fine transverse striae, and with a few strong punctures on tergite 5. Pygidium triangular, very little constricted apically, the disc with a few strong punctures. The silvery pile while not generally outstanding, is conspicuous on the pronotum, mesopleurae, and above on either side of the disc of the propodeum.

Male, allotype. Length, 3.2 mm. Much like the female but the sculpture is not quite so fine, although the propodeal pleurae appear smooth and polished under moderate magnification. In addition to the pale yellowish brown tibiae and tarsi, the clypeus is dull yellow, as is also the scape beneath, the antennae being generally dull brownish above, paler beneath. There is the usual hair tuft at each side of the clypeus that is angled laterad and with a low median lobe. Antennae subclavate; ocelli forming a little less than a right-angle triangle. Abdomen with sternal cross ridges; each volsella with five stout bristles.

Holotype, female (Citrus Experiment Station, Riverside), from Palm

Springs, Riverside County, California, May 11, 1935 (P. H. Timberlake), on *Euphorbia polycarpa;* Allotype, male, Borego, San Diego County, May 12, 1955 (F. X. Williams), on a mat *Euphorbia.* Paratypes: 1 female, Palm Springs, Riverside County, May 11, 1935 (P. H. Timberlake), on *Euphorbia polycarpa;* 1 female, 6 miles south of Palm Springs, Colorado Desert, California, June 8, 1930, on *Eriogonum trichopodum,* and 1 male near Palm Springs, June 8, 1930, on *Croton californicus,* both specimens collected by P. H. Timberlake; 4 males, Borego, San Diego County, April 29 and May 12, 1955 (F. X. Williams); 1 male, Borego Valley, San Diego County, dunes, April 18, 1957 (R. M. Bohart). Other specimens not considered paratypes: 4 males, Borego, May 12, 1955 (F. X. Williams); 6 females and 1 male, Thousand Palms, Riverside County, California, one in March, the rest in April, 1955 (W.R.M. Mason); 1 female, Blythe, Riverside County (W.R.M. Mason); 1 female, Cronise Valley, San Bernardino County, California, April 29, 1956 (M. Wasbauer). One female, Picacho Pass, Pinal County, Arizona, September 13, 1954 (P. H. Timberlake), "flying over the ground." On the same mount as one of the California females taken by Timberlake is its prey, a small mirid bug.

Discussion. Obviously this little desert dweller is closely related to *Pl. davisi* Fox, but a combination of characters, at times somewhat variable, separates it from *Pl. davisi.* The more obvious distinctions in *Pl. stygius* are its highly polished condition, the lack of any pale clear yellow markings, the more delicate clypeus dentition, the rather sac-like marginal cell, its narrow truncation that extends well beyond the third submarginal cell, and additionally in the male, the generally stouter volsellar spines.

Occasionally *Pl. stygius* has the abdomen orange red, as in the above listed female from Blythe, and the one from Cronise Valley.

Plenoculus davisi Fox.

(Figures 6, 7, 8, 12, 39, 41, 43, 44, 45, 53, 54, 57–60, 63–69, 74, 75, 76, 79, 86, 88.)

Plenoculus davisi Fox, 1893, Psyche, 6:554–555; 1893, Proc. Acad. Nat. Sci. Phila., 45:537. Male and female. Michigan, Montana.

Plenoculus abdominalis Ashmead, 1899, Psyche, 8:339. Male. Arizona (Prescott).

Plenoculus apicalis Williams, 1914 (1913), Kansas Univ. Sci. Bul., 8:175. Male and female. (Biol., l. c., 207–208, pl. 30, fig. 120.) Distribution: Transcontinental in the United States. Canada, British Columbia (Vernon). Mexico, Baja California Norte; Sinaloa (Mazatlan); Durango (Nombre de Dios), Nayarit (San Blas).

The original description of this species is as follows:

Plenoculus davisi ♀.—Anterior margin of clypeus deeply incised, armed with five teeth on each side, the outer and inner tooth is generally the largest, the others being in some specimens indistinct; front very finely granulated, with a long, distinct medial impressed line, which originates in a strong fovea, before the anterior ocellus and extends down between the base of the antennae; ocelli forming a triangle; on each side of anterior portion of vertex there is a curved furrow, running from each hind ocellus to the inner eye-margin; first joint of flagellum possibly a little shorter than either second or third, which are a little longer than any of the following joints, except the last; dorsulum and scutellum with very fine, close punctures, both strongly convex; suture between dorsulum and scutellum strong; metathorax above very finely granulated, rather strongly furrowed down the middle, the extreme base generally with a transverse series of small fossae, sides and posterior face very finely striated; abdomen finely and closely punctured, the pygidial area triangular, with large, sparse punctures, its lateral ridges not well defined; black; clypeus, except apex, tegulae, four anterior tibiae on outer side, except apical portion, yellowish; tarsi and apical margins of the abdominal segments testaceous; wings hyaline, iridescent; nervures testaceous, apical abdominal segment more or less rufous; head, thorax and abdomen more or less covered with silvery pile, which is most dense on the face, clypeus, mesopleurae and metathorax. Length 5–6 mm.

Var. legs, except anterior tibiae entirely black.

♂. Anterior margin of clypeus slightly produced medially; antennae shorter than in the ♀ and subclavate; clypeus entirely, scape beneath, tegulae, tubercles, apex of femora, the tibiae, except inner side of the two anterior pair, and the tarsi, bright yellow. Length 4½–5 mm.

Agricultural College, Michigan (June and July). Collected by Mr. Gager C. Davis, to whom it is dedicated; Montana (Morrison). Coll. Amer. Entom. Society.

Distribution. Over five hundred specimens of what I consider to be *Pl. davisi* have been examined. The great majority of these are listed here, with their distribution as follows:

ARIZONA—Cochise County: Douglas, 1 female, August 8, 1955 (R. R. Dreisbach). Maricopa County: Tempe, 2 males, August 3, 1917 (Cornell University, Lot 542). Pima County: Tucson, 1 male, May 30, 1920 (F. X. Williams). Dateland, 1 female, April 12, 1955 (Butler and Werner).

CALIFORNIA—Alpine County: Hope Valley, 4 females and 1 male, July 9 and 18, 1948 (J. W. MacSwain and P. D. Hurd). Contra Costa County: Antioch, 1 male, June 4, 1949 (F. X. Williams); 1 male and 1 female, July 8, 1954 (P. D. Hurd); Danville, 2 males, June 21 and 23, 1949; 2 females, August 6 and 10, 1949 (F. X. Williams). El Dorado County: Echo Lake, 1 male, July 23, 1955 (E. I. Schlinger); Lake Fontanillis, 8500 feet, 1 female, July 21, 1955 (E. I. Schlinger); two miles south of Meyers, 2 females, July 24, 1955 (E. I. Schlinger). Imperial County: Gordon's Well, 3 miles west, 1 male, July 14, 1956 (E. I. Schlinger); Pinto Wash, 3 females and 13 males, May 5, 1958 (F. X. Williams), either on *Euphorbia polycarpa hirtella* or *Eriogonum inflatum;* Fish Creek Mts., 300 feet, 2 males, March, 1 female, April, 1955 (W. R. M. Mason). Inyo County: Westgard Pass Plateau, 1 female, May 27, 1937 (C. A. Hamsher). Kern County: Randsburg, 1 male, May 1, 1921 (R. M. Bohart). Lake County: Midlake, 1 female, May 30, 1955 (E. I. Schlinger). Lassen County: Bridge Creek Camp, 6 females, July 9, 1949 (J. W. MacSwain); Summit Camp, 1 female, July 28, 1949 (P. D. Hurd); Westwood, 2 males, July 9, 1949 (P. D. Hurd); McCoy Flat, 3 females, July 8, 1949 (J. W. MacSwain and P. D. Hurd). LOS ANGELES COUNTY: Mt. Wilson Trail, Branigan, 1 female, August 10, 1915 (P. H. Timberlake); Claremont (Baker), 1 female (PemC); Chrystal Lake, 1 male, June 29, 1950 (F. X. Williams); 1 female, July 9, 1952 (R. M. Bohart); eight miles east of Lancaster, 1 male, September 1, 1956 (E. I. Schlinger); Pasadena, 1 male, May 14, 1944 (44E14) (USNM) (K. W. Cooper, Coll.); Tanbark Flat, 1 male, June 17, 1956 (R. M. Bohart). MONTEREY COUNTY: Arroyo Seco Camp, 38 males and 6 females, August 6, 1956, and June 5, 1957 (R. M. Bohart); San Lucas, 1 male, August 20, 1935 (P. H. Timberlake), on *Eriogonum gracile*. NAPA COUNTY: Samuel Springs, 1 female and 2 males, May 9, 1953 (E. I. Schlinger, R. M. Bohart); 1 female, May 28, 1953 (R. C. Bechtel); 1 female, May 29, 1953, and 1 female, May 24, 1956 (E. I. Schlinger). NEVADA COUNTY: Sagehen Creek, near Hobart Mills, 1 female, May 29, 1 male, June 25, 1954 (R. M. Bohart); 3 females, July 2 and 9, 1954 (E. I. Schlinger, R. M. Bohart); 1 male, July 25, 1956 (R. M. Bohart). PLACER COUNTY: Lake Tahoe (6225 feet), 1 female, July 15, 1949 (E. G. Linsley); Carnelian Bay, Lake Tahoe, 2 males and 1 female, July 22, 1957 (R. M. Bohart). PLUMAS COUNTY: Bucks (5070 feet), 1 male, July 23, 1937 (F. X. Williams); Joinsville, 1 female, August 26, 1956 (R. M. Bohart). RIVERSIDE COUNTY: Andreas Canyon, Palm Springs, 1 female, April 24, 1932 (P. H. Timberlake), on *Eriogonum polifolium;* Palm Springs Station, 1 female, June 26, 1952 (J. W. MacSwain); Perris, 3 miles west of, May 14, 1956 (U.S.N.M.) (U. N. Lanham, Coll.); Mt. Wilson Trail, Branigan, 1

Figure 55. *Plenoculus propinquus*. Female. From Riverside, California.

Figure 56. *Plenoculus propinquus*. Male. From Riverside. Clypeal dentition of A, male from Santa Paula, California; B, male from Eden, California.

Figure 57. *Plenoculus davisi transversus*. Female. Holotype. From Three Rivers, Tulare County, California.

Figure 58. *Plenoculus davisi*. Female. Andreas Canyon, Palm Springs.

Figure 59. *Plenoculus davisi transversus*. Female. Holotype. Mandible. From outer side.

Figure 60. *Plenoculus davisi*. Female. The mandible is worn down.

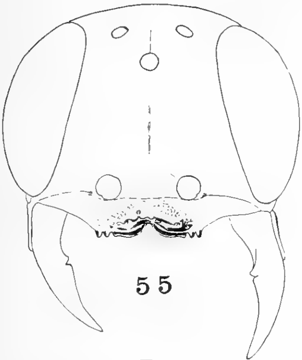
Figure 61. *Plenoculus boharti*. Female. Holotype. From Campo, San Diego County, California (U.S.N.M. collection). At A, clypeal dentition of *Pl. boharti*, male, allotype, from near Buckman's Springs, San Diego County, California; at B, is the clypeal dentition of a male paratype from Tanbark Flat, San Gabriel Mts., Calif.

Figure 62. *Plenoculus stygius*. Female. Holotype. The head has been rotated so that the lower side of the face is more forward than the vertex. From Palm Springs, California.

Figure 63. *Plenoculus davisi*. Female, with red abdomen. From Riverside, Calif.

Figure 64. *Plenoculus davisi*. Female. From Sergeant's Bluff, Iowa.

Figure 65. *Plenoculus davisi*. *Male*. From Riverside.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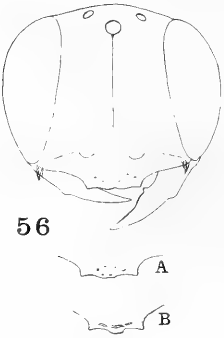
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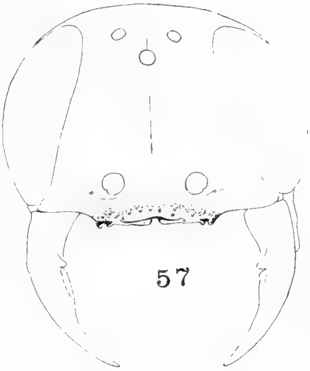
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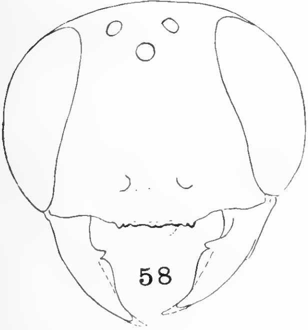
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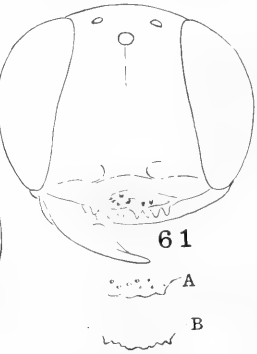
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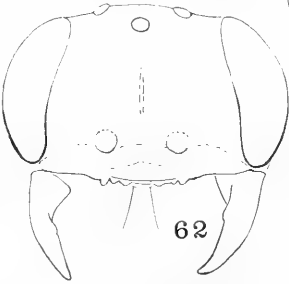
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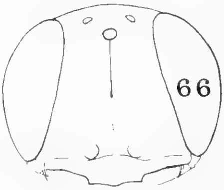
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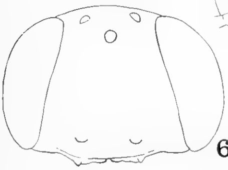
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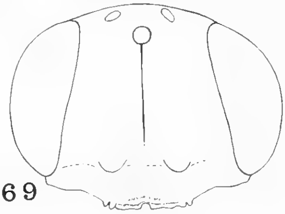
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Figure 66. *Plenoculus davisi.* Male, with red abdomen. From Plumas County, California.

Figure 67. *Plenoculus davisi.* Female, with red abdomen. Clypeus probably worn down. From Imperial County, California.

Figure 68. *Plenoculus davisi.* Female. From northwestern Kansas.

Figure 69. *Plenoculus davisi.* Female. From Olmsted County, Minnesota.

female, August 10, 1915 (P. H. Timberlake); One Thousand Palms, 1 female, April 10, 1957 (P. H. Timberlake), on *Eriogonum reniforme;* Blythe, 1 female, April 24, 1955 (W. R. M. Mason); Thousand Palms, 13 males, April, 1955 (W. R. M. Mason); Riverside, 1 female, September 26, 1924, on annual *Eriogonum,* 1 female, October 15, 1926 on *Eriogonum reniforme,* 1 male, August 7, 1926, on *Helianthus annuus,* 1 female, May 14, 1926, and 1 female, September 8, 1927, on *Euphorbia albomarginata,* and 1 male, May 12, 1950, on *Eriogonum fasciculatum,* all of these collected by P. H. Timberlake; The Gavilan, 1 male and 1 female, May 31, 1937, 1 female, June 2, 1938 (P. H. Timberlake), all on *Eriogonum fasciculatum.* SAN BERNARDINO COUNTY: Big Bear Valley, 6700–6800 feet, 2 males, August 11, 1933, on *Eriogonum wrighti,* and September 14, 1934, on *Eriogonum;* Camp Baldy, 2 males, June 26, 1956 (R. M. Bohart); Dollar Line Trail, San Bernardino Mts., 1 male, July 11, 1956 (R. M. Bohart); Cronise Valley, 2 females, April 29, 1956 (P. D. Hurd, M. Wasbauer), *Heliotropus curassavicus, Prosopis;* twelve miles east of Mentone, San Bernardino Mts., 3 males and 3 females, July 11, 1956 (R. C. Bechtel); Mill Creek, 6000 feet, 1 female, August 28, 1936 (P. H. Timberlake); Morongo Valley, 1 male, May 7, 1939 (P. H. Timberlake), on *Eriogonum fasciculatum;* Valley of the Falls, 1 female, August 18, 1945 (P. H. Timberlake), on flowers of *Chrysothamnus;* Verdemont, 1 male, May 17, 1946 (P. H. Timberlake), on *Chorizanthe parryi;* Helendale, 1 female, May 16, 1955 (W. R. M. Mason); Redlands, 1 male (R. F. Cole). SAN DIEGO COUNTY: Borrego (or Borego), 10 males and 4 females, April 1 and 2, 1953 (P. D. Hurd); 9 males, 3 females, most with label "*Croton californicus,*" last part April, 1954 (P. D. Hurd); 2 males, April 25, 1954 (M. Wasbauer), on *Croton californicus;* 4 males and 2 females, April, May, 1955, and 1957 (F. X. Williams); Borrego Dunes, 1 male, April 18, 1957; Borrego, Palm Canyon, 1 male and 1 female, April 19, 1957 (R. M. Bohart); two miles north of Warner Springs, 1 female, July 8, 1956 (R. M. Bohart), on *Croton californicus;* Green Valley, 5 miles south of Cuyamaca, 1 female, August 8, 1951 (P. H. Timberlake), on *Hugelia virgata.* SAN LUIS OBISPO COUNTY: Black Lake, 1 female, July 29, 1955, and 2 females, August 29, 1955 (R. M. Bohart). SAN JOAQUIN COUNTY: Tracy, 1 female, June 7, 1949 (J. W. MacSwain). SANTA CRUZ COUNTY: Felton, 1 male, May 15–19, 1907, 300–500 feet (Bradley), Cornell U. lot 684, sub. 39, det. J. C. Bradley, 1923; 2 females, same locality, May 20–25, 1907 (J. C. Bradley); Glenwood, 1 female, May 27, 1908 (J. Chester Bradley). SHASTA COUNTY: Hat Creek, 1 female, June 23, 1955 (J. W. MacSwain), 1 female, May 28, 1956 (J. W. MacSwain); Moose Camp, 1 female, July 14, 1957 (E. I. Schlinger); Snow Mt. Road, 1 female, June 23, 1955 (J. W. MacSwain). SIERRA COUNTY: Independence Lake, 2 females, July 17 and 20 (R. M. Bohart); 1 female, July 27, 1956 (R. M. Bohart). SONOMA COUNTY: Cloverdale, 1 male, August 26, 1953 (E. I. Schlinger). TEHAMA COUNTY: Four miles north of Paynes Creek, 1 female, May 21, 1955 (R. M. Bohart). Tulare County: Three Rivers, 3 miles west of, 1 female, May 10, 1938 (P.H. Timberlake), flying over ground *(= Pl. davisi transversus).* Tuolumne County: Dardanelles, 1 female, June 26, 1951 (C. A. Downing). Ventura County: Santa Paula, 2 males and 2 females, June 5, 1927 (P. H. Timberlake). Yolo County: Davis, 32 males and 50 females, collected from June 7 to September, 1953, 1956, and 1957 (Collectors: R. M. Bohart, R. C. Bechtel, J. C. Downey, A. T. McClay, and E. I. Schlinger), a female of one of these specimens is mounted with its prey, the nymph of a heteropterous bug (R. C. Bechtel, collector); Elkhorn Ferry, 4 females and 60 males, August 1, 1956 (R. M. Bohart).

COLORADO—Alamosa County: Great Sand Dunes, 1 female, July 20–21, 1954 (H. E. and M. A. Evans).

CONNECTICUT—East Hartford, 1 male, September 4, 1947 (H. E. Evans); Poquonock, 1 male, June 27, 1905 (H. L. Viereck) (=*Pl. davisi atlanticus* Viereck) (Col. U.S.N.M.).

FLORIDA—Welaka, 1 male, May 1–4, 1955 (H. E. and M. A. Evans) *(= Pl. davisi atlanticus).*

IDAHO—Hollister, 1 female, No. 6, July 27, 1932, *S. pestifer* (David E. Fox) (Col. U.S.N.M.); Jerome, 1 female, June 27, 1932 ("Pole 20, trap 2, Wind Van Trap").

INDIANA—1 female, No. 2177 (1933).

IOWA—Sergeant Bluff, 3 females and 3 males, August 3, 1933 (C. N. Ainslie); Sioux City, 1 male, May 25, 1931 (C. N. Ainslie).

KANSAS—Clay County: 4 males, August 9, 1952 (Lin). Graham County: 1 male, August 16, 1912 (F. X. Williams); Grant County: 1 female, August 18, 1952 (Acc. No. 8021, H. E. Evans, Coll.). Phillips and Morton Counties: 22 males and 15 females, August, 1912 (F. X. Williams). Pottawatomie County: 1 female and 1 male, June, 1950 (H. E. Evans).

MICHIGAN—Crawford County: 1 male, June 24, 1953. Gladwin County: 1 male, June 14, 1953. Midland County: 1 male, June 27, 1953. Otsego County: 1 male, June 24, 1955. All R. R. Dreisbach, Collection. Washtenaw County: Ann Arbor, 1 male, July 28, 1950 (U. N. Lanham); Gladstone County and Newago County: 10 females, 1951, 1953 (R. R. Dreisbach); Midland County: 1 female, 1 male, June 9, 1936 (R. R. Dreisbach) (Det. K. V. Krombein, U.S.N.M.).

MINNESOTA—Olmstead, 2 females (C. N. Ainslie) (Det. Stevens, U.S. N.M.).

MONTANA—*Plenoculus davisi davisi* Fox "type" (Det. K. V. Krombein, U.S.N.M.).

NEVADA—Fernley, 1 male, August 5, 1953 (R. M. Bohart); Mt. Rose, 6,500 feet, 1 male, June 14, 1957 (R. M. Bohart).

NEW JERSEY—Clementon, 1 male, May 24, 1902 (J. C. Bradley).

NEW MEXICO—HIDALGO COUNTY: 2 males, Rodeo, August 26, 1958 (R. M. Bohart).

NEW YORK—Ithaca, Kite Hill, 14 males, July 1 and 2 (P. P. Babiy); Kite Hill Campus, Ithaca, and Ithaca, 7 males and 1 female, August 19, 1929, June 15, 1937 (P. P. Babiy); June 26, June 29, 1935 (K. V. Krombein); 1 female, 6 miles from Ithaca, August 11, 1955 (with biological note) (H. E. Evans); Minetto, 3 females, June 27, 28, 1955 (H. E. Evans).

NORTH CAROLINA—Kill Devil Hills, 1 female, July 1, 1954 (K. V. Krombein) (U.S.N.M.).

NORTH DAKOTA—Beach, 2 females, July 19, 1923 (C. N. Ainslie) (U.S.N.M.) (Det. Stevens).

OREGON—Bend, 1 female, August 19, 1953 (R. M. Bohart).

TENNESSEE—Memphis, 1 male, July 16, 1914 (J. C. Bradley); 1 female, June 4, 1918 (Cornell U., Lot 684, Sub. 36 and 37, Det. J. C. Bradley, 1923, *Plenoculus davisi* ♂ Fox).

TEXAS—McDade, 1 male, June 11, 1935 (J. E. Gillaspy) (Krombein Collection, and compared by Dr. Krombein with the type of *Pl. abdominalis* Ashmead).

UTAH—North Fork Duchesne River, 1 male, July 13–14, 1927 (Cornell U., Lot 542, Sub. 305); Logan, 1 female, July 1, 1955 (R. M. Bohart); Roosevelt, 5,000 feet, 1 female, July 27, 1953 (R. Dreisbach).

WYOMING—Powder River, 1 female, August 1, 1950 (R. R. Dreisbach and K. K. Schwab).

CANADA—BRITISH COLUMBIA: Vernon, 1 female, July 14, 1947 (H. B. Leech). Tunneling in sand. The burrow stored with immature Aphidae.

MEXICO—DURANGO: Nombre de Dios, 1 male and 1 female, August 1, 1951 (P. D. Hurd). BAJA CALIFORNIA: La Paz, 1 female, October 7, 1955 (F. X. Williams). NAYARIT: San Blas, 2 males, July 20, 1951 (P. D. Hurd). SINALOA: Mazatlan, 1 female, October 7, 1955 (F. X. Williams).

DIAGNOSES OF THE SUBSPECIES *Plenoculus davisi*

Abdomen red and black; clypeus black in both sexes, almost squarely truncate in the male, usually very low subcuneate in the female, and with a median cleft and poorly developed teeth or none; in the male the aedeagus the volsellar ridge is weakly armed............*Plenoculus davisi mojavensis* Williams, new subspecies (86, 88).

Abdomen chiefly reddish; head relatively wide; produced portion of clypeus truncate, its median emargination narrow and with two teeth far to each side (57), female ....*Plenoculus davisi transversus* Williams, new subspecies.

Abdomen red, clypeus pale creamy yellow, its produced portion subtruncate, the narrow median emargination with a bordering tooth (54) ....*Plenoculus davisi gracilis* Williams, new subspecies, female.

Abdomen black; differs from *Plenoculus davisi* Fox in having the basal tergites reticulate instead of punctate, and the pubescence thin on the sides of the propodeum, the pile being heavier in the nominate species..*Plenoculus davisi atlanticus Viereck.*

Plenoculus davisi mojavensis Williams, new subspecies.

(Figures 86, 88.)

FEMALE, holotype. Length, 5 mm. Rather shining. Black; mandibles reddish brown from a little before notch to near apex; fore tibiae except beneath, foretarsi, mid-tarsi, and the hind tarsi in part, brownish; venation testaceous; abdomen with first 2¾ tergites reddish orange, the remainder black. Silvery pile sparse (the insect is rather worn). Clypeus widely subcuneate, notched mesad in the small indication of a truncation, behind which it is shining and transversely tumid. Labrum deeply bilobed, as is usual with species belonging to the *Pl. davisi* complex; mandibles well notched; blade on inner side relatively short; antennae rather slender, articles 3 and 4 subequal, 12 about 1.75 longer than 11; ocelli in a right-angle triangle, an incised line anteriorly from fore ocellus. Head very finely sculptured, almost coriaceous. Pronotum not notched mesad; dorsulum very finely and closely punctate; disc of propodeum reticulate and with a few fine transverse and some basal carinulae, depressed mesad particularly toward apex, posterior face with an inbowed obcuneate area formed by a fine line from each side of the disc of the propodeum, this area hardly depressed. Venation delicate, marginal cell long, somewhat exceeding the subtruncate third submarginal; pedicel of second submarginal cell quite short. Abdominal tergites generally very finely striate-reticulate, fifth tergite with the usual sparse coarse punctures. Pygidium of the usual rather narrowly triangular form, the two carinae straight, the disc very finely tessellate and with some large coarse punctures particularly well to each side of the middle line.

MALE, allotype. Length, 4.6 mm. Marked about as in the holotype, but with tibiae and tarsi generally dull yellowish brown and the orange red of the abdomen extending into tergite 4. The sculpture is less fine than in the female. The shining black clypeus is drawn out truncate mesad, the lateral angles are sharp, the disc with moderate punctures, and there is a low median lobe from the truncation. The antennae are rather slender for the basal part, article 3 slightly longer than 4, its length nearly twice that of its expanded apical diameter, article 13 about 1.50 the length of 12; ocelli in about a right-angle triangle. Frons very finely reticulate, almost coriaceous; vertex finely reticulate-punctate. Pronotum, and mesonotum anteriorly, slightly notched mesad, dorsulum finely and closely punctate. Disc of propodeum widely exposed, wrinkled-reticulate, the furrow shining apically, posterior face with the obcuneate area poorly defined and in part finely grooved mesad. Venation as in holotype. Apical sternal rugosities strong. Terminalia: parameres as in the *Pl. davisi* group; aedeagal lobes rounded, hardly angulate on one side; volsellar ridge apparently unarmed. Vestiture: the silvery pile is not conspicuous, although the specimen is in fresh condition.

HOLOTYPE, female, ALLOTYPE male, and 4 PARATYPE males, from Apple Valley, San Bernardino County, 20–V–1955; a fifth male paratype is topotypical, 10–V–1955 (W. R. M. Mason). Apple Valley lies in the southern part of the Mojave Desert and just north of the San Bernardino Mountains. Other paratypes are from Arizona, Cochise County, Wilcox, 3 males, August 11, 14, 1958; Apache, 5 miles southeast, 1 female, August 11, 1958 (R. M. Bohart); and from New Mexico, Hidalgo County, Rodeo, 1 male, 2 females, end of August, 1958 (R. M. Bohart).

DISCUSSION. The female is best differentiated by its clypeus which at most is very greatly cuneate, and cleft (86), and the male by its black clypeus.

Plenoculus davisi transversus Williams, new subspecies.

(Figures 8, 57, 59.)

FEMALE, holotype. Length, 6.5 mm. Head and thorax subopaque; general punctation fine. Black; mandibles except apex yellowish brown; clypeus reddish along margin; apex of fore femora narrowly and a good deal of hind tibiae, dull brownish yellow; abdomen reddish, somewhat darker apically.

Figure 70. *Plenoculus cockerellii.* Male. Aedeagus. From Riverside County, Calif.

Figure 71. *Plenoculus palmarum.* Male. Paratype. From Borego.

Figure 72. *Plenoculus cockerellii* (?). Male. Aedeagus. From Tucson, Arizona.

Figure 73. *Plenoculus palmarum.* Male.

Figure 74. *Plenoculus davisi (=apicalis).* Male. Last visible ventral segment. From northwestern Kansas.

Figure 75. *Plenoculus davisi (=apicalis).* From northwestern Kansas.

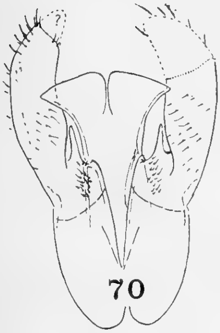
Figure 76. *Plenoculus davisi (=apicalis).* Male. Antenna. From northwestern Kansas.

Figure 77. *Plenoculus timberlakei.* Female. From Palm Springs.

Figure 78. *Plenoculus palmarum.* Male. Disc of propodeum.

Figure 79. *Plenoculus davisi.* Male. Aedeagus. From Midland County, Michigan.

Figure 80. *Plenoculus cockerellii.* Female. Fore tarsal comb. From Douglas, Ariz.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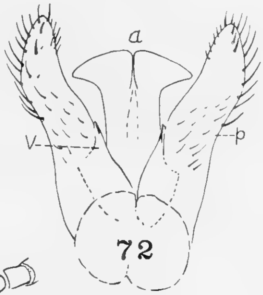

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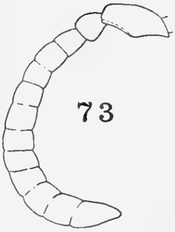
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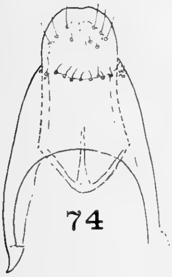
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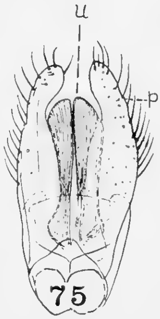

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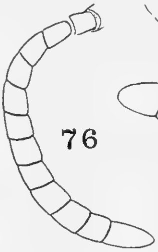
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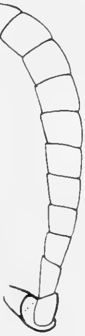
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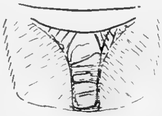
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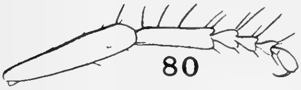
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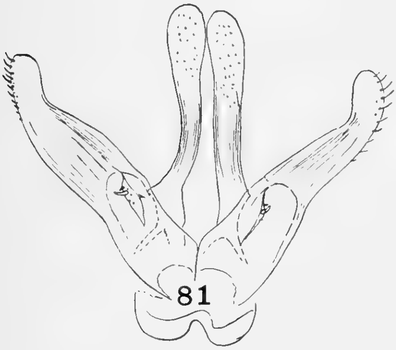
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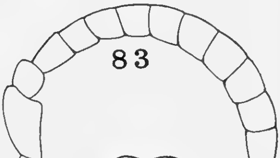
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Figure 81. *Plenoculus propinquus.* Male. Aedeagus. Note the larger and the smaller volsellar tooth. From Santa Paula, California.

Figure 82. *Plenoculus propinquus.* Male. One paramere, to show three volsellar teeth. From Nevada.

Figure 83. *Plenoculus boharti.* Female. Holotype. From Campo, San Diego County, California.

Figure 84. *Plenoculus boharti.* Female. Holotype. To show dorsal abdominal pattern. White representing the red coloration.

Produced portion of clypeus truncate, with a narrow median emargination and two teeth far to each side, the clypeus short, its smooth anterior portion bordered by some large punctures; antennae rather slender, article 3 longer than 4; ocelli in a right-angle triangle, the smooth area between the posterior ocelli and the compound eyes shining. Disc of propodeum with basal fanning carinae and some recurved transverse wrinkles; the pleurae generally, very finely longitudinally striate; posterior face of propodeum shining about the V-shaped depression, elsewhere finely transversely striate. Fifth tergite rugosely punctate except apically. Pygidium rather narrowly triangular, with scattered strong punctures. Vestiture of silvery pile.

HOLOTYPE, female (Citrus Experiment Station, Riverside), three miles west of Three Rivers, Tulare County, California, May 10, 1938. Flying over ground (P. H. Timberlake). PARATYPE, 1 female (U. S. National Museum), three miles west of Perris, Riverside County, California, May 14, 1948 (U. N. Lanham). This specimen is in fine condition and agrees well with the holotype.

DISCUSSION: The relatively wide head of *Pl. davisi transversus,* the character of the clypeus and the relatively slender mandibles are its important characters.

Plenoculus davisi gracilis Williams, new subspecies.

(Figure 54.)

FEMALE, holotype. Length, 4.8 mm. Black; generally shining, finely sculptured; mandibles except apex, clypeus, scape beneath, tegulae, axillary sclerites, venation at base, fore femora beneath at apex, tibiae above, pale creamy yellow, tibiae beneath and tarsi generally, pale brownish; flagellum beyond base yellowish brown beneath; abdomen red. Produced portion of clypeus subtruncate, generally quite thin, median emargination narrow, with a tooth bordering either side; mandibles slender, with a strong tooth; psammophore fairly strong; antennae rather stout, articles 3 and 4 subequal, article 12 tapering obliquely; ocelli in slightly less than a right-angle triangle, each posterior ocellus about 1½ times its diameter from the compound eye. Exposed disc of propodeum broadly tongue-shaped, very finely and shallowly reticulate, median furrow short, weak, pleurae and posterior face delicately reticulate, depression on posterior face rather wide. Tarsal comb strong; marginal cell extending well beyond third submarginal. Pygidium broad, slightly constricted apically and with very few punctures. Vestiture: rather dense silvery pile on head and thorax; bristles pale to silvery.

HOLOTYPE, female, 6 miles west of Indio, Riverside County, California, April 30, 1949 (E. G. Linsley, J. W. MacSwain, and R. F. Smyth), *Melilotus.*

The pale clypeus and the clypeal dentition are its chief subspecific characters.

Three other specimens somewhat resemble this subspecies in their somewhat darker and more straight-edged clypeal projection, but they are regarded as aberrant forms of *Pl. davisi* with the abdomen red. Two of these specimens are from Cronise Valley, San Bernardino County, California, the third is from Borego Valley, San Diego County.

Plenoculus davisi atlanticus Viereck.

Plenoculus atlanticus Viereck, 1902. Ent. News, 13:74. ♂. N. syn.

Plenoculus davisi atlanticus Viereck, changed status. (See Synoptic Catalog Hymenoptera of North America North of Mexico, under direction of Muesebeck, Krombein, and Townes, 1951:941.)

Plenoculus davisi Fox of Catalog, in part. *Pl. atlanticus* not a syn. (*teste* Krombein, 1955. Ent. Soc. Wash. Proc. 57:146). (See also First Supplement 1958:187, under direction of Dr. Karl V. Krombein, to above Catalog, 1951.)

Dr. Krombein (*l. c.*, 1955) has shown that *Pl. atlanticus* is a valid subspecies. It ranges from Connecticut south to North Carolina; it occurs in Florida, and is also found in Texas (McDade).

Plenoculus davisi atlanticus Viereck differs most importantly from *Pl. davisi davisi* Fox in that the silvery pubescence delimiting the propodeal area is very sparse (usually quite dense in the nominate race), the two basal tergites are reticulate in *Pl. davisi atlanticus,* very commonly punctate in our eastern *Pl. davisi davisi,* and there are transverse arched carinae on the posterior two-thirds of the disc of the propodeum in *Pl. atlanticus* and which are lacking in the nominate race.

I am indebted to Dr. Karl V. Krombein for this data which he secured in the first place in comparing *Pl. atlanticus* Viereck type male with *Pl. davisi* Fox (2 paratypes), in the collection of the Academy of Natural Sciences of Philadelphia.

At least in the Far West, most specimens of *Pl. davisi* that I have seen have the basal tergites reticulate or tessellate, and often with some very fine cross striations, but with the silvery pubescence moderately well to very well developed on the sides of the disc of the propodeum.

NEW SYNONYMY

Plenoculus abdominalis Ashmead.

Plenoculus abdominalis Ashmead, 1899, Psyche, 8:339, ♂. From Prescott, Arizona.

From Ashmead's description and from the study of a male specimen that was compared with the type of *Pl. abdominalis* by Dr. Krombein, and loaned to me, I have concluded that *Pl. abdominalis* is merely a color phase of *Pl. davisi davisi;* such color phases commonly occur in the Colorado Desert, and elsewhere in the two Sonoran Zones.

Plenoculus apicalis Williams.

Plenoculus apicalis WILLIAMS, 1914 (1913), Kans. Univ. Sci. Bul. 8:175. ♀ ♂ Kansas.

So also have I made this purported species of *Plenoculus* a synonym of *Pl. davisi davisi.* The writer has examined Kansas specimens taken by Lin (1952) and Evans (1950, 1952), and these, together with the specimens collected by me in 1912, show that in the same general region in Kansas what has been called *Pl. apicalis* range in color of abdomen from chiefly reddish to almost wholly black.

My description of this wasp from Kansas would apply equally well to some of the California specimens of *Pl. davisi davisi.*

OLD WORLD SPECIES

Plenoculus tadzhika (Gussakovskij).

Pavlovskia tadzhika GUSSAKOVSKIJ, 1935, Trav. Fil. Acad. Sci. URSS, Tadjikistan, 5:424.

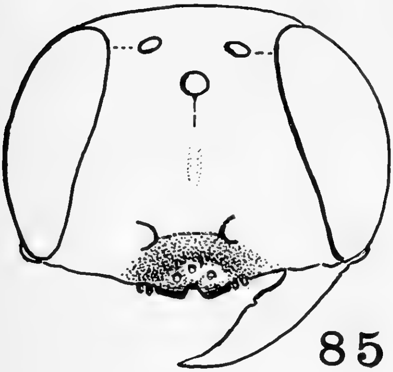
This Transcaspian (U.S.S.R.) species is represented by a single male specimen. From Gussakovskij's two figures and his description in Latin, it corresponds pretty well to *Plenoculus,* although the venation of the hind wings seems not typical for the genus.

I am not familiar with Gussakovskij's genus *Ptygosphex* with which he likens *Pavlovskia.*

Plenoculus beaumonti Andrade.

Plenoculus beaumonti ANDRADE, 1957. Mem. e Estudos Mus. Zool. Univ. de Coimbra, No. 247:2–7, Figs. 1–9. Male and female. Portugal, Setúbal district (Andrade): Albufeira Lagoon (Andrade). Spain (Cadiz province): Chiclana (Beaumont).

This species belongs in the *Pl. davisi* group. In the female of *Pl. beaumonti* the "Median sclerite of the clypeus widely emarginate, its anterior edge with three teeth at each side (fig. 1); . . .". This emargination is angular rather than rounded. The male has the "Paramera of the genitalia with a cluster of spines below (fig. 5) . . ."



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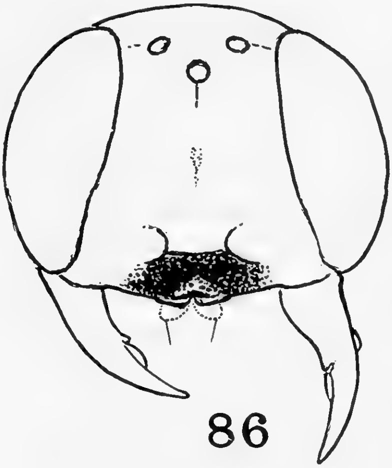

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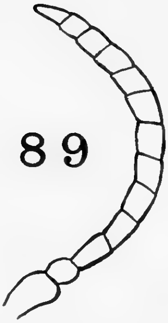

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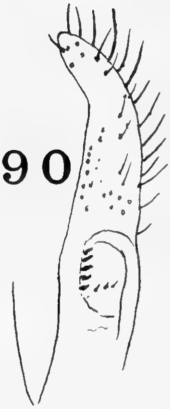

Figure 85. *Plenoculus deserti.* Female. Paratype. From Borego Desert, Calif.

Figure 86. *Plenoculus davisi mojavensis.* Male. Holotype. Apple Valley, San Bernardino County, California.

Figure 87. *Plenoculus deserti.* Allotype. Male. Clypeal production. Borego.

Figure 88. *Plenoculus davisi mojavensis.* Paratype. Male. Apple Valley.

Figure 89. *Plenoculus cockerellii.* Male. Antenna, from side (free hand), La Paz, Baja California, Mexico.

Figure 90. *Plenoculus stygius.* Allotype. Male. One paramere showing 5 heavy volsellar spines. Borego Desert.

BIOLOGY OF *PLENOCULUS*

Not much has been recorded on the habits of *Plenoculus.* In California, where the writer is best acquainted with these wasps, both directly and through the collections of other entomologists, they are most abundant in the spring in desert and semidesert regions, particularly when there have been sufficient well-timed rains to ensure an abundance of plant growth. Autumn rains may also bring out these wasps. *Plenoculus* species patronize many kinds of flowers, of which those of *Eriogonum* spp., *Croton californicus,* and the prostrate or decumbent little *Euphorbia polycarpa* var. *hirtella* and *Euphorbia albomarginata* seem the most important. Among other wasps associated with *Plenoculus,* particularly as observed on the euphorbias, are species of *Solierella,* the spider-hunting little *Nitelopterus, Tachysphex,* and some of the Nyssoninae. Thus, the entomologist, in collecting the desired wasps on the euphorbias, may assume a very lowly posture, even to seating himself on the sand in the heat of the desert sun before one of these plants to secure the wasp visitors. It is important to obtain good series of these wasps both at flowers and at their nesting sites so that both sexes are represented, for the association the sexes may otherwise be difficult.

Occasionally *Plenoculus* females are captured with their prey, as noted in the following records:

Plenoculus stygius Williams, new species. A female taken by P. H. Timberlake in the Colorado Desert, California, had a small mirid bug as its prey. This is mounted with the wasp.

Plenoculus davisi Fox. A female taken by R. C. Bechtel, in Davis, Yolo County, California, had a quite small heteropterous bug as her prey which is mounted on the same pin with the wasp.

Plenoculus davisi Fox. A female taken by Hugh B. Leech, at Vernon, British Columbia, was noted tunneling in the sand. The burrow was found to be stored with immature aphids.

Plenoculus cockerellii Fox. A female wasp carrying a small caterpillar resembling a pyralid was collected by P. H. Timberlake at Twenty-nine Palms, Riverside County, California, September 5, 1946. At La Paz, Baja California, Mexico, October 8, 1955, I found a loose colony of several dozen of these little wasps along a road a few miles from town. The area occupied was about 6 × 20 feet of a shallow sandy ditch. Here were some low plants, including a small *Euphorbia.* Many *Pl. cockerellii* females were digging their burrows in the gritty sand, and they showed great energy in throwing out the sand behind them. Some five or six of the wasps were seen flying to their burrows, each with a slender inert pyralid caterpillar held longitudinally beneath her body so that the prey projected fore and aft. A burdened wasp would alight immediately before her burrow, deposit the caterpillar, enter the tunnel, turn about therein and emerge to drag in the caterpillar. Several of these slim little moth larvae were secured. They were somewhat reddish, striped, and with a conspicuous cervical shield, and suggested relationship with the caterpillar carried by a *Pl. cockerellii* female at Twenty-nine Palms, Riverside County, and taken by Mr. Timberlake, I did not succeed in digging out any of the wasps' burrows. Four of the relatively small male wasps were taken as they flew after the females or perched nearby. Small tachinid and bombyliid flies showed interest in the nesting activities of these wasps.

Plenoculus davisi Fox (= *Pl apicalis* Williams). In Phillips County, Kansas, during late August, 1912, I observed some of these wasps nesting in a sandy spot, and storing their burrows with mature as well as immature capsid bugs, probably *Psallus seriatus* (Reuter), that were easily carried on the wing. The nest holes were left open while the wasps were afield. The nests apparently contained several cells, each of which contained several paralyzed bugs.

GENERAL COMMENTS ON *PLENOCULUS*

The study of the systematics of *Plenoculus* presents difficulties. Perhaps the most obvious of these is the variation in form and detail, particularly in the female, of the anterior part of the clypeus, the variation in the terminalia of the male (those of the female were not studied), and the presence of population groups that seem hardly meriting of subspecific rank. Size and color may be useful in helping determine species, but they are not wholly reliable. The female disc of the pygidium (sixth tergite) may vary somewhat in the same species, and its form and punctation is a useful diagnostic character in only a few species, and the male genitalia, to the extent they have been studied by me, serve to separate groups rather than species. Sculpture has a useful purpose in classification but, as in the genus *Solierella,* it must be used with caution.

Data up to the present show that *Plenoculus* is poorly represented in the Old World (Portugal, Spain, and Transcaspia in the U.S.S.R.). In North America, *Plenoculus* is transcontinental in the United States, and ranges northward from at least the southern part of Canada (one specimen from Vernon, British Columbia, others from states bordering on Canada) to well into the tropics of Mexico. Southwestern United States, with emphasis upon the tolerably well-known California deserts, appears to be the area of their greatest development. Of the fourteen species of *Plenoculus* which we have recognized for the United States, only the transcontinental *Pl. davisi davisi* Fox and its subspecies *Pl. davisi atlanticus* Viereck occur east of the Mississippi River, while but four others reach or nearly reach to the Rocky Mountains. These four are *Pl. propinquus, Pl. parvus, Pl. gillaspyi,* and *Pl. cockerellii.* The remaining ten species, and four subspecies are chiefly desert insects. *Plenoculus propinquus* seems less xerophytic, while *Pl. davisi,* as studied chiefly from California specimens, is abundant in the Upper and Lower Sonoran Zones and sometimes extends into the Canadian Zone of the mountains where it is sparse.

Plenoculus wasps having the abdomen wholly or in part orange red were noted chiefly in the desert regions of southern California. Desert species which on the contrary have the abdomen entirely or nearly entirely shining black are represented by *Pl. stygius* and *Pl. boregensis perniger,* the former being more prevalent. At least in the Upper Sonoran Zone, *Pl. davisi* has the abdomen more commonly orange red in the male sex; indeed, in some populations it seems to be exclusively a male character. In a population of *Pl. davisi* taken chiefly by Dr. R. M. Bohart, at Davis, Yolo County, California, most of the males have the abdomen black; the few females taken there also have the abdomen black.

Based on scanty material of *Pl. davisi,* specimens with the abdomen orange red do range eastward to the Rocky Mountains and beyond, as exemplified by *Pl. davisi* (=*apicalis* Williams) in Kansas, where there is a transition from the orange red to the black abdomen that seems to characterize this species more or less beyond this parallel.

Evidently a dry Sonoran climate is more selective in *Plenoculus* (and perhaps to a slightly lesser degree in *Solierella,* its first cousin) for an orange-colored abdomen and also lends to a greater diversity of species than does a humid climate. The exceptions to this general statement however, leave much to be explained.

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quency of fogs, rather than lower temperatures and higher atmospheric dampness . . . .”

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INTERPOPULATION VARIATION IN THE COLUBRID SNAKE *NATRIX PRYERI* FROM THE RIUKIU ISLANDS, WITH DESCRIPTION OF A NEW SUBSPECIES

BY

EDMOND V. MALNATE
Academy of Natural Sciences, Philadelphia

and

HAROLD E. MUNSTERMAN
Natural History Museum, Stanford University

Introduction

Studies by one of us (Munsterman) of the reptile fauna of the Riukiu Islands and by the other (Malnate) in the systematics of the Asian species of the snake-genus *Natrix* quite naturally crossed at the species *Natrix pryeri*. *Natrix pryeri* is isolated in its relationship with its congeners and is the sole representative of *Natrix* inhabiting the Riukiu Islands. Under these circumstances the combination of our resources in a single report on the species should, it is hoped, be of greater value than that which would have resulted from our individual efforts.

Natrix pryeri was described by Boulenger in 1887. Little attention has been paid the species although the number of specimens available for study has increased in the intervening years since its discovery (unfortunately, ecological and natural history data did not increase to the same degree). For this study 84 specimens have been examined; data on 25 additional specimens have been obtained from literature and colleagues. These 109 examples are distributed through the Riukiu island chain (from north to south) as follows: Amami, 31; Kikaiga, 3; Okinawa, 52; Miyako, 2; Ishigaki, 9; Iriomote 1 (5 specimens are labeled "LooChoo Islands," without more specific data; four specimens in the collections of the Senckenberg Museum are labeled "Miyama," a locality unknown to us; two specimens are of questionable derivation). Wall (1905) examined 57 specimens, mostly from Okinawa, in the collection of A. Owston, Yokohama, Japan, but made only the briefest possible mention of the species in his notes. The present whereabouts of this collection is unknown.

SYSTEMATIC DISCUSSION

Natrix pryeri (Boulenger).

Tropidonotus pryeri BOULENGER, 1887, Proc. Zool. Soc. London, 1887, p. 149, pl. 18, fig. 3 (type locality: Loo Choo Islands, herein restricted to Okinawa); 1893, Cat. Snakes Brit. Mus. (N. H.), vol. 1, p. 250.

Natrix pryeri, STEJNEGER 1907, U. S. Nat'l Mus. Bull. 58, p. 284, pl. 20, figs. 247–249; Maki, 1931, a monograph of the snakes of Japan, p. 40 pl. 10, text-figs. 15–16.

SCUTELLATION. Rostral broader than high, narrowly visible from above. Internasals subrectangular, longer than wide, rarely long as wide; internaso-rostral contact (ratio between contact of a single internasal with the rostral and that of an anterior nasal with the rostral) less than 1 or 1. Prefrontals as wide as long or slightly wider (fused in two specimens), slightly longer than internasals, in contact with supraoculars. Frontal longer than wide l/w = 1.4–1.8 [mean 1.6; 20 specimens]), longer than its distance from snout tip, equal to or slightly longer than length of interparietal suture. Parietals longer than combined width, posterior angle acute. Nasals divided, nostril between two plates. Loreal longer than high, rarely as long as high. Preoculars 1, rarely 2; postoculars 3, rarely 4 or 2. Anterior temporals 2, rarely 1; posterior temporals 2, frequently 1, rarely 3. Supralabials 8, rarely 9 or 7; fourth and fifth (rarely fifth and sixth, fourth only, or third and fourth) border orbit; seventh largest. Infralabials 10, rarely 9 or 11; 5 (rarely 6) border anterior chin-shields. Posterior chin-shields longer than anterior pair, separated from one-third to entire length by small scales. Dorsal scales in 19–19–17 rows, keeled, those of outer row less strongly so; apical pits prominent throughout body length; number of scale rows reduced by loss of fourth scale row (between 60.2–68.1% [mean 63.9%] of head and body length [11 males]; 58.1–81.4% [mean 65.1%; 23 females]). Ventrals 167–188 (172–188 [mean 178.9; 34 males]; 167–182 [mean 174.1; 52 females]); anal plate divided; subcaudals 94–133 (102–133 [mean 117.2; 19 males]; 94–126 [mean 113.2; 28 females]).

Color. Dorsum grayish or brownish. Anterior part of body with series of elongate, dark lateral blotches which meet in opposition or slightly alternate at vertebral line; blotches separated by broad yellowish interspaces; scales of interspaces sometimes have dark tips, or interspaces may be reduced to sharply defined, dark-edged, light vertical bars extending from ventrals to or near to vertebral line. On posterior portion of body light areas are reduced to dorsolateral series of light spots on the fourth through sixth scale rows; dark blotches are also reduced forming small black spots below each light one and sometimes also evident as paired squarish black spots or irregular transverse bars across back. Irregularly on dorsum dark scales may be finely edged with white. Head blackish or light brown, usually mottled or marbled with gray or white (marbling may be obscure or lacking); paired parietal light spots commonly present but often obscure; short postparietal light streak present, may be reduced to a spot at end of interparietal suture. Supralabials whitish, sutures between first to sixth shields edged with black; on larger (older) specimens supralabials anterior to eye may have suffusion of dark color across upper edges; broad band present from eye across seventh and eighth supralabials to angle of jaw, there joining forward extension of first body blotch; light color of seventh supralabial is confined to lower anterior corner of shield; on eighth supralabial light color is restricted to a central spot. Nape black; well-defined yellowish nuchal crescent present on each side, these joining at vertebral line and extending posteriorly onto neck for varying distances forming Y-shaped mark; this mark may be reduced to a light spot at angle of jaw and a very short-branched "Y" vertebrally or may rarely be absent. Infralabials whitish, a few anterior shields with narrow black edges. Venter yellowish, dorsal color encroaching onto outer edges of ventrals; a series of small, black spots present along lateral edge of belly, these usually irregular or absent anteriorly, becoming stronger posteriorly and subcaudally, sometimes forming continuous line.

Measurements and proportions. Total length: largest male, 987 mm., plus (tail docked); largest female, 1095 mm. Tail/total length ratio: 0.273–0.345 (0.273–0.337 [mean 0.306; 18 males]; 0.284–0.346 [mean 0.311; 23 females]). Head length/body length ratio: 0.037–0.053 [mean 0.044; 46 specimens]; head length/width ratio: 1.7–2.3 [mean 1.97; 50 specimens]; snout (tip to level of midorbital point) 30–38% of head length (32–38% [mean 35.6%; 19 males]; 30–38% [mean 33.5%; 35 females]); eye diameter, if projected forward from anterior rim of orbit usually reaches midnostril point, distance varying from middle posterior nasal to middle anterior nasal (ratio eye diameter/head length: 0.15–0.23 [mean 0.177; 54 specimens]).

DENTITION. Maxillary teeth 23–29 (32 counts), last two teeth strongly enlarged (occasionally only slightly larger than preceding teeth). Palatopterygoid series of teeth 35–45 (11–17 palatine plus 25–30 pterygoid teeth [9 specimens]), gradually decreasing in size posteriorly. Dentary teeth 22–35 [12 specimens], subequal or somewhat larger anteriorly.

HEMIPENES. Hemipenes unforked, short, extending to level of fifth-eighth subcaudals; spinous, distal spines small, basal spines stouter; one strongly enlarged basal spine, followed distally by small group of stout spines; organ base furrowed. Sulcus spermaticus single, extending to organ tip, lips spinous.

DISTRIBUTION. Known only from the Riukiu Islands (Oshima group: Edateku, Kakeroma, Kikaiga, Amami, Uke, Tokuna, Okierabu; Okinawa group: Okinawa; Miyako group: Miyako; Yaeyama group: Ishigaki, Iriomote).

NATURAL HISTORY. The topography of the Riukiu Islands varies from relative flatness to low mountains. The Oshima group is the most rugged (greatest elevation, 2,300 feet); Okinawa is mountainous in the north (highest peak, 1,557 feet), plateau-like in the south; Miyako is low and flat; the Yaeyama Islands are mountainous with limited tableland (maximum elevation, 1,680 feet).

Vegetation is subtropical. Broadleaf trees are found at sea level; evergreens are characteristic of the mountain slopes. The lowlands are extensively cultivated, the chief crops being rice, sweet potatoes and sugar cane. The flora of the northern islands is most closely related to that of southern Japan, while the southern islands are rich in subtropical elements related to those of Formosa.

Professor Kazuo Koba *(in litt.)* informs us that on Amami and Okinawa *N. pryeri* is common in the rice fields and grasslands near the hills, and also is found in the forests. "*Natrix pryeri* and *Liopeltis* [= *Opheodrys*] *semicarinata fritzei* are most common species among the snakes of Amami-ôshima." Examination of the stomach contents of all specimens seen yielded frogs only, *Rana limnocharis* being the only species identified.

Wall *(op. cit.)* notes four females with eggs. Two contained three eggs, one five and one six. The eggs varied in size from 0.9 to 1.8 inches long by 0.5 inches in diameter. Two eggs were found in the ovaries of one female examined, another contained four. These were approximately of the size noted by Wall.

SEXUAL VARIATION. As indicated in the descriptive data for the species sexual variation is not highly developed in *N. pryeri.* Average differences in some characters are defined. The number of ventrals and subcaudals average higher in males; females appear to attain a somewhat greater length; the fourth scale row on the body extends for a greater mean length on females. Except for the higher number of ventrals in males these characteristics are typical variations found between the sexes in colubrid snakes. Peculiarly, the proportionate length of the tail is about equal in both sexes.

In addition to these variations, male *pryeri* exhibit certain characters not found in females. The scales of the snout (occasionally all dorsal head scales) are tuberculate on males of over 375 mm. body length (lower limit estimated on the basis of two males, 383 and 414 mm. body length, which show the character poorly defined). On some males the scales of the anal region may bear swollen keels or the apical scale pits in the same area may be much more pronounced (visually, they appear to be swollen or tuberculate in form) than elsewhere on the body. It is presumed that these characters are related to sexual activity but without knowledge of the courtship and mating habits of the species verification is impossible.

GEOGRAPHICAL VARIATION. Differentiation of the populations of *N. pryeri* inhabiting the various islands of the Riukiu archipelago is evidenced by their variation. Interpopulation variation can best be presented by considering each population in turn, from north to south. Standard scale characters and proportions are shown in table I and the interpopulation variation in certain of these is illustrated on the accompanying graph (fig. 1). Other characteristics observed are noted below.

Amami. A distinguishing characteristic of the Amami population is the strongly defined marbling of the head with light gray in contrast with other populations wherein the marbling is either obscure (dark gray) or absent. Males from Amami show a strong development of the apical pits in the anal region (swollen keels on these scales have not been noted). The fact that 8 of 13 specimens examined have the posterior chin-shields separated their entire length by small scales is of unknown significance but in no other population is this feature so predominant. A further peculiarity of this character is that the specimens on which it occurs are all males, and those individuals with less than complete separation (½ to ¾) are all females.

Kikaiga. The population of *N. pryeri* occurring on this island is known from three specimens only. These are generally lighter in ground color than the other populations; verification that this is a natural condition and not the result of preservation techniques is desirable. It is reasonable to assume that additional data will associate the Kikaiga population with that of Amami.

Okinawa. There is a strong tendency in this population toward increase in the number of posterior temporals. Half of the specimens studied (26 of 52) have two posterior temporals on both sides of the head, an additional eight have two on one side only. Two posterior temporals occur in only five

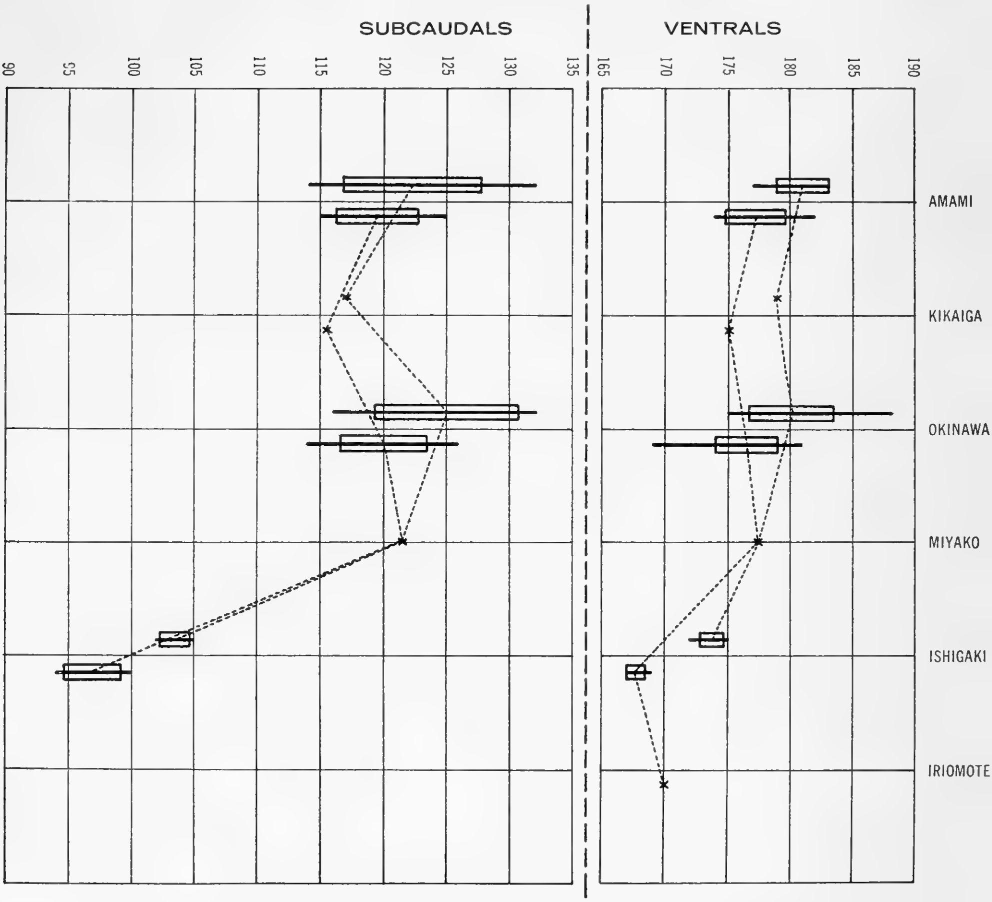

Figure 1. Known variations of ventrals and subcaudals (sexes separate), within populations of *Natrix pryeri*. Dotted line connects means of the same sex in each population. Open boxes show one standard deviation from the mean.

other specimens throughout the remainder of the range. In addition, it is noted that among the specimens with a single posterior temporal only one is a male showing the condition on one side only; all the others are females. The significance of this is unknown. In this population the nuchal crescent shows consistent reduction. Many individuals have only a light spot at the angle of the jaw and the forks of the Y may be reduced or even lost. Lateral spotting on the ventrum also shows reduction, being absent on the anterior portion of the belly to a greater extent (one-half) than in any other population. Okinawan males have swollen keels and pronounced apical pits on the scales of the anal region.

The four specimens in the Senckenberg Museum (numbers 17629–32) labeled "Miyama" have not been seen by us but certain data of scutellation have been supplied by Dr. Klemmer. Three are adult females, one is of unknown sex. Ventrals and subcaudals (in the three females) number 176–183 and 119–125 (2 only), respectively. Temporals are noted as being 2 + ?, 3 + 2, 2 + 4, 4 + 3; preoculars 1, postoculars 3, supralabials 8 in all individuals. On the basis of the scale counts, especially the high number of temporals, it is assumed that the specimens are from the Okinawa group.

Miyako. Natrix pryeri is known from this island by only two specimens. In addition to the data shown in the chart it is reported to us by Dr. Klemmer *(in litt.)* that the ventral spotting on these specimens is very distinct on all ventrals.

Ishigaki. The pattern of the Ishigaki population is unusual and most distinctive; the light interspaces on the anterior portion of the body, broad in other populations, are reduced to narrow, dark-edged vertical bars; the head and occipital region are uniformly light-colored, in great contrast with the very dark head usual to the species elsewhere. In this population are found the lowest ventral and subcaudal counts of the species; also, both characters exhibit stronger sexual differentiation than in any other population (available data show no overlap of counts between the sexes in either character). Male specimens of *N. pryeri* from Ishigaki have been noted to bear swollen keels and strongly produced apical pits on the scales of the anal region.

Maki (1931) lists Ishigaki in the range of *N. pryeri* (the "Tshigaki" listed in his chart of scutellation ?) but the count of ventrals (183) and subcaudals (115) are both high for the Ishigaki population as otherwise known to us. Maki makes no comment as to pattern (an obvious and noteworthy distinction). We do not include this specimen in our description of the population.

Iriomote. Known only from a single specimen described by Stejneger *(op. cit.)*. Stejneger describes the anterior light interspaces as "vertical bars" and thus suggests a similarity between this population and that of Ishigaki. In this regard mention must be made here of a specimen (CAS 21920) reportedly from Ishigaki. In its dorsal body pattern it compares well with Ishigaki specimens and Stejneger's Iriomote example. The head, however, is dark, marbled with dark gray; the supralabials are heavily mottled with dark; the nuchal crescent is reduced to light spots at the angles of the jaws. On the ventrum there is a heavy development of melanophores: the chin and throat are mottled with black; the ventral spots are boldly developed, beginning at the gulars, and the area between them and the sides is strongly suffused with the dark flank color; the subcaudal surface is heavily powdered gray. Scutellation is generally normal except that the ventral count (165) is the lowest known (unfortunately, the tail is docked and a subcaudal count cannot be determined); two posterior temporals are pres-

TABLE I

Sex	*Amami*	*Kikaiga*	*Okinawa*	*Miyako*	*Ishigaki*	*Iriomote*
M	177–183 (13) 181.0 ± 2.11	179 (1)	175–188 (18) 180.2 ± 3.37	176–179 (2) 177.5	172–175 (4) 173.8 ± 1.09	
F	174–182 (18) 177.3 ± 2.36	174–176 (2) 175	169–181 (31) 176.5 ± 2.46		167–169 (5) 167.6 ± 0.80	170 (1)

TABLE II

M	114–132 (6) 122.2 ± 5.54	117 (1)	116–132 (10) 125.0 ± 5.67	118–125 (2) 121.5	102–105 (3) 103.3 ± 1.25	
F	115–125 (11) 119.6 ± 3.20	115–116 (2) 115.5	114–126 (13) 120.1 ± 3.43		94–100 (4) 97.0 ± 2.24	

TABLE III

M	.309–.320 (5) .3116	.308 (1)	.298–.337 (10) .3184		.273–.286 (3) .2807	
F	.304–.326 (10) .3117	.311–.346 (2) .3285	.302–.338 (10) .3207		.284–.287 (3) .2850	

TABLE IV

M	62.7–68.1 (3) 64.5	62.2 (1)	60.2–66.6 (3) 64.0		63.6–65.2 (4) 64.8	
F	62.3–69.2 (5) 66.1	64.4–64.5 (2) 64.5	58.1–81.4 (13) 65. 9		61.8–65.9 (3) 63.9	

TABLE V

	Amami	*Kikaiga*	*Okinawa*	*Miyako*	*Ishigaki*	*Iriomote*
Labials	8/10 (24) 9–8/10 (1) 8/10–11 (1)	8/10 (3)	8/10 (43) 9–8/10 (1) 7–8/9–10 (1) 8/9–10 (1) 8/10–9 (1)	8/? (1)	8/10 (7) 9/10 (1) 8/10–11 (2)	8/10 (1)
Oculars	1, 3 (28) 1, 4-3 (1) 2, 3 (1) 1, 3–2 (1)	1, 3 (3)	1, 3 (47) 1–2, 3 (1) 2, 3 (1) 1, 3–4 (1)	1, 3 (1)	1, 3 (8) 1, 2–3 (1) 1, 3–4 (1)	1, 3–4 (1)
Temporals	2, 1 (27) 2, 2–1 (3) 2, 2 (1)	2, 1 (3)	2, 2 (24) 2, 2–1 (6) 2, 1–2 (2) 2, 1 (15) 1–2, 2 (1) 1, 1 (1) 2, 2–3 (1)	2, ? (1)	2, 2 (1) 2, 1 (8) 1, 1 (1)	2, 1 (1)

Table I.[1] Summary of variation in ventral counts in populations of *Natrix pryeri.*

Table II. Summary of variation in subcaudal counts in populations of *Natrix pryeri.*

Table III. Summary of variation in tail ratio in populations of *Natrix pryeri.*

Table IV. Summary of variation in persistence of the fourth scale row on the body in populations of *Natrix pryeri.* Figures are percentages of body length in which fourth scale row is present.

Table V. Summary of variation in head scales in populations of *Natrix pryeri.*

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[1] *Note:* In Tables I–II the mean and standard deviations from the mean are shown. In Tables III IV only the mean is shown. The numbers in parentheses in all tables indicate the number of specimens from which variation was determined.

ent. The maxillary teeth number 31, the highest count recorded. On the basis of these data it may be assumed that this specimen came from the Yaeyama group but more likely Iriomote rather than Ishigaki.

Analysis of the interpopulation variation in *N. pryeri* demonstrates the development of certain patterns in the linear distribution of the species through the archipelago (see fig. 1 and tables 1–5).

1) Subcaudals are highest on Okinawa (means: male, 125.0; female, 120.1), are somewhat reduced on the more northern Amami (male, 122.2; female, 119.6), much reduced on the southern Ishigaki (male, 103.3; female, 97.0).

2) Ventrals appear to be correlated with the above, although the pattern is not so strongly defined (means: male, 180.2; female, 176.5, on Okinawa; male, 181.0; female, 177.3, on Amami; and male, 173.8; female, 167.6, on Ishigaki). Range of variation in ventrals seems to demonstrate the pattern more prominently (see figure 1).

3) Tail/total length ratio appears to follow the same trend (means: male, 0.318; female, 0.320, on Okinawa; 0.312 (both sexes), on Amami; male, 0.281; female, 0.285, on Ishigaki).

4) The length of the snout as a percentage of the head length varies in the same manner (means: male, 35.9; female 35.1, on Okinawa; male, 35.1; female, 32.9, on Amami; male, 34.8; female, 32.0, on Ishigaki).

5) Items 3 and 4 above are probably correlated with total length which shows a comparable trend but not so clearly demonstrated. The largest known specimens are from Okinawa, those from Amami and Ishigaki being smaller.

Overlying these broadly defined patterns are prominent local variations.

a) The strongly developed marbling of the head in the Amami population.

b) The predominance of two posterior temporals, and reduction of the nuchal pattern in the population inhabiting Okinawa. (The former may represent the pattern of variation outlined above.)

c) The peculiar pattern developments in the Ishigaki population: reduction of the anterior light dorsal areas and the development of a light head coloration.

Thus, two types of variation are associated with the distribution of *N. pryeri:* a basic variation in certain characters, presumably older and perhaps related to the initial dispersal of the species; and, local differentiations occurring in other characters, related to the discontinuities of distribution established by geophysical factors, and possibly due to the isolation of small units of the species continuum (Sewell Wright effect). It is not possible to demonstrate adaptive or nonadaptive variations in the populations; however, it is assumed that both are involved.

Differentiation among most populations of *N. pryeri* is not great, except in regard to the inhabitants of Ishigaki. The unusual pattern developed in this population is combined with low ventral counts and an extremely low number of subcaudals. The history of the Yaeyama group is one of isolation, at times considerably greater than at the present (Hanzawa, 1935). In spite of the physical isolation of this population complete genetic isolation is not a certainty. Similarities in basic scutellation is believed to demonstrate a close association among populations in the past, if not in the present. *Natrix pryeri* on Ishigaki is sufficiently distinct to warrant systematic recognition; however, because of the considerable overlap in scale characters among all populations and because the degree of genetic isolation cannot be fixed recognition is limited to the subspecific level.

At the moment it is impossible to recognize the subspecies as occurring elsewhere than on Ishigaki; however, Iriomote has through its history been closely associated with Ishigaki (Hanzawa, *op. cit.*), and it may well be shown later that *N. pryeri* in the whole Yaeyama group should be considered a single taxon.

The population of *N. pryeri* inhabiting Ishigaki may be designated:

Natrix pryeri ishigakiensis Malnate and Munsterman, new subspecies.

Natrix pryeri (part ?), MAKI, 1931. A monograph of the snakes of Japan, p. 40.

DIAGNOSIS. A form of *N. pryeri* distinguished by a uniform, light-colored head; reduction of broad anterior light interspaces to narrow, dark-edged vertical bars; much reduced subcaudal count; shorter tail. Presently known only from Ishigaki.

HOLOTYPE. CAS 21913; adult male, collected on Ishigaki-shima, Yaeyama group, Riukiu Islands, by Victor Kühne, 25 May to 2 June, 1910.

PARATYPES (8). CAS 21914, 21917, 21919, males; CAS 21912, 21915, 21916, 21918, 21921, females; all collected on Ishigaki-shima, Yaeyama group, Riukiu Islands, by Victor Kühne, 25 May to 2 June, 1910.

DESCRIPTION OF HOLOTYPE. Rostral edge visible from above. Internasals longer than wide, internasorostral contact ratio equals one. Prefrontals wider than long, slightly shorter than internasals, in contact with supraoculars. Frontal longer than its distance from tip of snout, equal in length to interparietal suture, length/width ratio 1.4. Parietals as long as combined width, posterior angle acute. Nasals divided. Loreal longer than high. Preocular 1, postoculars 3. Anterior temporals 2, posterior temporals 1. Supralabials 8, fourth and fifth border orbit, sixth largest. Infralabials 10, 5 border anterior chin-shields, sixth largest. Posterior chin-shields much the longer pair, separated entire length by small scales. Dorsal scales in 19–19–17 rows, strongly keeled, outer row slightly less so; apical pits present throughout body length;

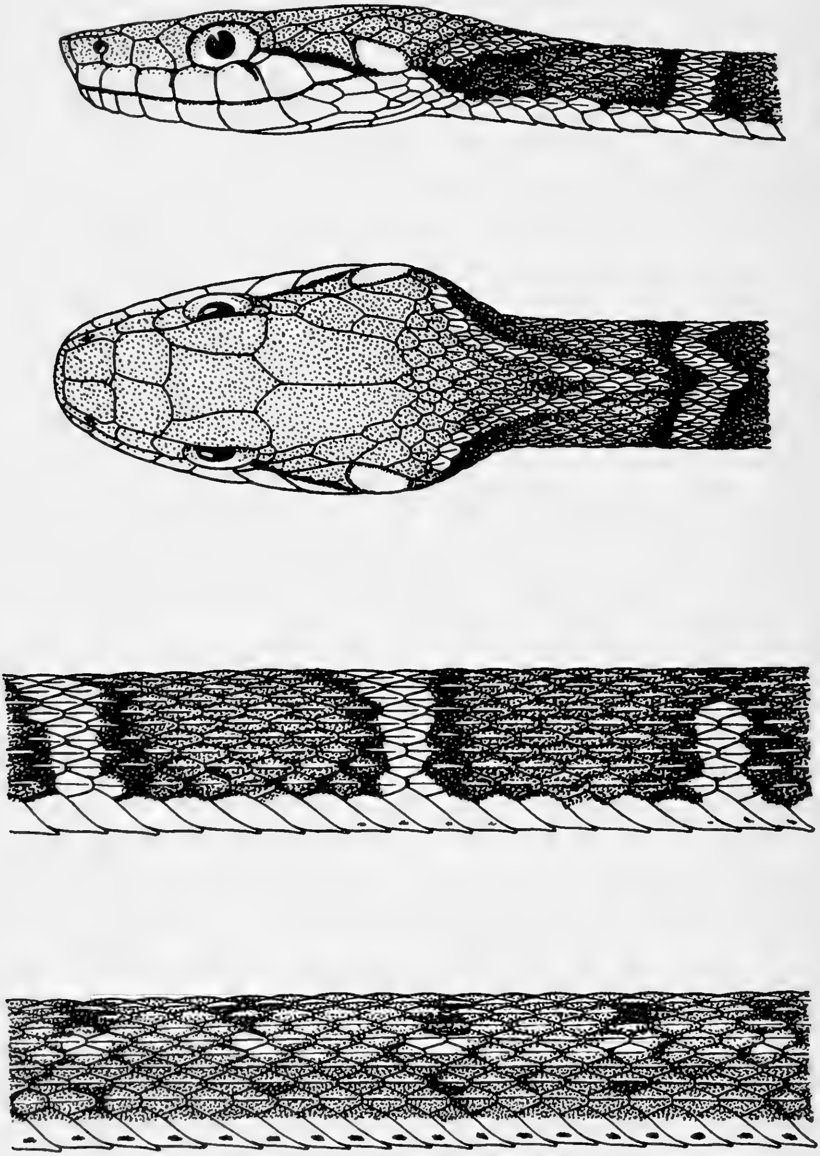

Figure 2. Holotype of *Natrix pryeri ishigakiensis*, CAS 21913. Dorsal and lateral aspects of the head, and lateral view of an anterior and posterior portion of the body.

fourth scale row present for 63.6% of head and body length. Ventrals 174; anal divided; subcaudals 102.

Anterior body with broad dark (gray) blotches, black-edged; separated by narrow (1½ scales wide) vertical, light bars extending from ventrals to vertebral line; first pair meet, forming ring, second and third pairs encircle vertebral dark spot, fourth pair separated partially by vertebral dark spot; reduction of vertical light bars begins with fifth pair, starting first at vertebral line and more posteriorly from ventrals also; posterior half of body with light color reduced to series of dorsolateral spots on fourth to sixth scale rows; dark color bordering blotches anteriorly, reduced posteriorly to dark spots below dorsolateral light series and irregular transverse bars across back; dark dorsal scales with light keels. Chin and throat immaculate; series dark spots along outer edges of ventrals beginning at about thirty-fifth ventral (few scattered small spots anterior to this point), increasing in prominence posteriorly, irregular under tail; outer edges ventrals and subcaudals suffused with dark color of flanks. Head uniformly pale above to nuchal crescent; supralabials white, second to fifth with narrow, short, dark streaks at posterior sutures; dark streak from postoculars to lip at juncture of seventh to eighth supralabials; eighth supralabial white, finely edged dark; nuchal crescent narrow, well-defined, dark along posterior edge, each side extending posteriorly on neck for short distance before converging, a dark spot in angle of "Y" thus formed.

Measurements and proportions. Total length 932 mm.; tail 254 mm. Tail/total length ratio: 0.273. Head length/body length ratio: 0.043; head length/width ratio: 1.9; snout 38% head length; eye diameter, projected forward, reaches midnostril point (eye diameter/head length ratio: 0.17).

Dentition. Maxillary teeth 24–25, in continuous series, last two strongly enlarged. Palato-pterygoid series of teeth 15 plus 30, gradually decreasing in size posteriorly in the series. Dentary teeth 30–30, somewhat larger anteriorly.

Hemipenes. Hemipenes unforked, extend to level of sixth subcaudal plate; organ spinous, distal spines small, the spines increasing in size basally on organ; one enlarged basal spine; basal area of organ furrowed. Sulcus spermaticus not forked, extending to organ tip; lips spinous.

Variation. Variation in scale characters in the paratypes is summarized in table I (see Ishigaki). In pattern they are typical except for minor variations. In CAS 21914 all of the light vertical bars are separated vertebrally, and there is a series of small, dark, light-edged, diamond-shaped figures along the vertebral line on the neck; in CAS 21912 the vertical bars alternate on each side of the body.

DISCUSSION. Interpopulation variation exhibited by *Natrix pryeri* appears to be closely correlated with the geological history of the Riukiu archipelago. Hanzawa *(op. cit.)* has summarized the geological history of the islands (see also, Inger, 1947). The main points outlined by Hanzawa are followed here as a guide to interpreting the pattern of variation set forth above.

The ancestral stock of *N. pryeri* is presumed to have arrived in the Riukiu Islands from the Asian continent via Formosa. Dispersal through the islands probably took place during a period of maximum land emergence, such as occurred during the late Pliocene when the Riukiu archipelago formed one continuous island narrowly separated from the mainland. Competition in the new region may have been present originally (two other forms of *Natrix* have attained Formosa, *N. sauteri,* a form related to *N. pryeri,* and *N. piscator,* an extremely vagile form). Such competition as may have existed apparently was not an effective deterrent, for it is evident that "pro-*pryeri*" (or "*pryeri*") spread throughout the region to the exclusion of its congeners. Submergence of the Riukiu Cordillera and subsequent emergence, to a lesser degree than in Pliocene times, certainly must have initiated breaks in the previously continuous population. Again, in the early-middle Pleistocene, inundation of some subaerial land masses resulted in the isolation of populations of *N. pryeri* on Amami, Okinawa, and in the Yaeyama group. Subsequent emergence united the islands in each group permitting the populations to expand to a limited degree. More recently, slight raising of sea level has produced the contemporary geography of the Riukius and isolated *N. pryeri* on several of the islands.

In the outline above, time of dispersal of "pro-*pryeri*" stock through the Riukiu Islands is highly problematical. However, a late Pliocene dispersion at a time when a continuous land mass was available, is thought to be the most logical for a terrestrial animal such as *N. pryeri.* Emergence of land during early Pleistocene times was nearly as great, with the islands of each group united. At such a time waifing could have proved highly successful as a means of dispersion. The occurrence of *N. pryeri* on Miyako must be attributed to waifing, presumable from the Yaeyama group. In the past, low-lying Miyako is believed to have been drowned with each submergence, and thus would require recolonization with each emergence. The closeness of the Yaeyama group (approximately 60 miles to the south) and the prevailing wind and current directions (south to north) virtually precludes colonization by waifing from any source other than the Yaeyama group. (Unfortunately, the Miyako population is very poorly known and its relationships cannot be determined.)

It is not possible to determine exactly what factors influenced the development of the genetic systems represented by *N. pryeri pryeri* and the divergent *N. p. ishigakiensis.* Four stages are definable in their evolutionary history: 1) initial dispersion; 2) extreme reduction and isolation of at least three subpopulations; 3) moderate dispersal and expansion of these; 4) recurrence of reduction and isolation (contemporary conditions). In spite of this history of expansion and contraction, and continuous or near-continuous and isolated populations, genetic divergence has not been great (assuming that phenotypic variation is an expression of genetic variation), except in the southern population where isolation is greatest. Interisland variation may be the result of random genetic drift in small isolated populations (the Sewell Wright effect). Populations on Okinawa and Amami are presumed to be relatively large, those on Miyako, Ishigaki, and Iriomote may be smaller. The greater genetic divergence in the more isolated (from other *N. pryeri* populations) southern islands could reflect random drift. Drift may have been effective in establishing the characteristics of the gene pool of the various populations during the periods of isolation. With expansion, particularly in the northern populations where the pools may have been at least partially combined, natural selection pressure would be effective in maintaining certain limitations to the enlarged pools. In the northern populations *(N. pryeri)* random drift would seem to have been rendered virtually impotent by ease of immigration between the islands leaving natural selection as the primary factor acting upon the evolving populations. In the south *(N. p. ishigakiensis),* whether or not the populations are smaller, drift may have had considerable effect in producing the gene pool on which natural selection is now a maintaining force. Dobzhansky and Pavlovsky (1957) have demonstrated the probability that both random drift and natural selection interact to produce new genetic systems in isolated populations. In the species *N. pryeri* each of these factors may have contributed to establishing and maintaining divergence; however, each appears to have played a somewhat more important role in different areas of distribution.

Natrix pryeri is related to a group of *Natrix* in eastern Asia including *N. vibakari* in Japan, and *N. craspedogaster, N. popei* and *N. sauteri* in southern China. The characteristics of *N. pryeri* suggest that it is a primitive type, in correlation with its isolated, peripheral geographical position. It cannot successfully be derived directly from any of its contemporaries. Although it is closest to *N. craspedogaster* it is presumed to have arisen from a prototype of the group which perhaps ranged broadly in eastern Asia.

Acknowledgments

This study could not have been accomplished were it not for the cooperation of many colleagues. Special mention is due Dr. Alan E. Leviton, of the California Academy of Sciences. In addition to loaning us the largest series of *N. pryeri* specimens available, he was also extremely generous in calling

our attention to the exceptional variation exhibited by the specimens from Ishigaki.

For their permission to study specimens in their care we wish also to thank: Mr. Charles M. Bogert, American Museum of Natural History; Mr. J. C. Battersby, British Museum (Natural History); Mr. Neil D. Richmond, Carnegie Museum; Dr. Robert F. Inger, Chicago Natural History Museum; Mr. Arthur Loveridge and Dr. Ernest E. Wililams, Museum of Comparative Zoology, Harvard College; Dr. Doris M. Cochran, United States National Museum, Smithsonian Institution. Dr. Konrad Klemmer, Senckenberg Natural History Museum, has provided data on specimens in his charge. Professor Kazuo Koba, Kumamoto University, has been most helpful in supplying natural history data on his collections of *N. pryeri* from Okinawa and Amami. Dr. Theodosius Dobzhansky, Columbia University, has been helpful in reaching an understanding of the genetic factors involved. Mr. Charles O. Culver, Philadelphia, assisted in translating references. Without the good offices of Mr. Roger Conant, Dr. Alan E. Leviton, and Dr. George S. Myers the study would have been impossible. To all of these people we are sincerely grateful for their interest, patience and cooperation.

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FURTHER RECORDS OF NEOTROPICAL TABANIDAE (DIPTERA) MOSTLY FROM PERU

BY

CORNELIUS B. PHILIP

U. S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana.

A previous report (Philip, 1958) provided records and descriptions of species taken chiefly by a California Academy of Sciences expedition to the west coast of South America. The present is a supplemental report on material taken in part by Drs. E. S. Ross and E. I. Schlinger on a subsequent trip in 1954–55. Many of the records below, referred to simply as Tingo Maria, were by these collectors from Monson Valley, Peru. Again, it will be evident that studies of types in European museums[1] as well as comments generously offered by Drs. G. B. Fairchild and I. M. Mackerras, facilitated many nomenclatural decisions. The following abbreviations are used: BMNH for British Museum (Natural History), Paris for Museum National d'Histoire Naturelle, Paris, VNM for Vienna Naturhistorisches Museum, Turin for University of Turin Museum, CAS for California Academy of Sciences, and AMNH for American Museum of Natural History. Collections of L. L. Pechuman, G. B. Fairchild, and the author are indicated by respective initials.

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Scaptia grisea (Jaennicke).

On the basis of study of the types in Seckenberg Museum, Frankfurt, which I also saw, Krober (1930b) correctly synonymized this and *S. jucunda* (Jaennicke) from Chile, though the latter originally had page priority. On the basis of the description, I had considered this to be the intermediate form of the following *S. atra,* but comparison of specimens reveals minor but distinctive differences in *S. grisea* of which I have not seen other examples.

The respective types, and paratypes labelled "von Hayden" and "Valparaiso, Bayerhoffer" do not reveal on what basis the describer separated these two names. But Krober's selection of *S. grisea* will stand under the Rules as the correct name, though only *"jucunda"* carries Jaennicke's hand-written label. The fronts of these are wider (index 1:1.8) than in *S. albithorax* (Macquart), and are more divergent basally than my *S. atra (leucothorax)* specimens, while the snouts are definitely more produced than in any of my series and there are more pale hairs basally on the abdomen. The palpi, however, are the same in both. Cell R_5 is narrowed but not closed in any of the types of *S. grisea (jucundus).* It appears probable that additional specimens will turn up to confirm this as a separate species.

On the other hand, Professor I. M. Mackerras has indicated that *S. limbithorax* (Macquart), which Krober *(op. cit.)* assumed was a related Neotropical species described from *patria ignota,* should actually apply to a New South Wales species with practically parallel frons, of which he loaned me a specimen.

Scaptia atra (Philippi).

Krober (1934) did not recognize this Chilean species and placed it with question under *Esenbeckia.* The black body, but ash-gray front and pale hairs behind the head and on mid and hind tibiae, leave little doubt that this is the melanistic extreme of Chilean specimens previously assigned to the much paler *Listrapha (= Scaptia) leucothorax* (Ricardo). Complete intergradation occurs without morphological differentiation.

In a series of one male and seventeen females in CAS, there is complete intergradation from the dark *S. atra* through specimens with mixed black and white to completely white notal vestiture that encroaches on the pleura in combination with either black or white (or mixed) beards. A study of variants on a geographic basis would have to be made with adequate series to determine if available names could be applied as subspecies. While *S. atra* was described with closed first posterior cell, this is variable even on different wings of the same specimen in the series studied. This character is observed to vary in certain other species of *Scaptia* in Chile.

The male of *S. atra* has not previously been described.

Allotype ♂, 14 mm. Readily associated with females having entire notum and scutellum and upper occiput white-haired; white hairs on squamae and the basal third of middle tibia, but strangely enough the hind tibia is entirely black-haired like the remainder of the insect including its face. Apical palpal segment cylindrical in basal half with flattened outer face in the distal half. Proboscis shorter than thorax. Cell R_5 narrowed but not closed. No spur vein.

"L. Verde, X. 1937, Chile, Dr. Reed." In CAS.

Veprius presbiter Rondani.

An examination of the recently discovered type, loaned through courtesy of Professor Mario Salfi of the University of Naples, reveals that this species, for which the genus is monotypic, has long been misidentified. This name was recently synonymized with *Tabanus carbo* Macquart by Fairchild (1956). Mackerras (1955) had reassigned *Veprius* as a subgenus of *Mesomyia* in the Tribe Bouvieromyini of the Chrysopinae on the basis of similarly misidentified specimens supplied by the writer.

The type is moldy but recognizable as the male of the later-described *Chaetopalpus coracinus* (Philippi) from Chile, a species which, after Philippi's time, was shown to be congeneric with *"Tabanus ?" annulicornis* Philippi. In describing the latter with question under *Tabanus,* Philippi (1865) made the peculiar statement that he had considered proposing the genus *Chaetopalpus* for this but changed his mind; however, the name has since been accepted for both of the above species. The doubt concerning validity of this generic name is now not of consequence since *Veprius* becomes the prior name. However, this requires radical transfer of *Veprius* to the Tribe Pangoniini in the Pangoniinae as revised by Mackerras (1954) and leaves *Mesomyia carbo,* new combination, without needed subgeneric assignment; a new subgenus is proposed below.

Since the name *Veprius* was derived from the Latin for "thorn bush," it is also more appropriately applied to the shaggier species in *Chaetopalpus* (as might have been suspected) than to *M. carbo.* Philippi alluded to the different, fiery-red eyes when he described *C. coracinus.*

Mesomyia (Coracella) Philip, new subgenus.

Subgenotype *Mesomyia (Coracella) carbo* (Macquart).

The subgeneric characters can be quoted from Mackerras (1955, "subgenus *Veprius*") "banded eyes, which are only faintly hairy, shining subcallus and face, unenlarged first antennal segment, and broadly Tabanus-like habitus." The eyes (relaxed) show a brown band on a bright green ground (though Philippi described them as "fiery red" in life) and the hairs are visible only under magnification higher than that of a hand lens. There is no postocular rim and frontal callosities of females are keel-like.

The Australian subgenus *Vepriella* Mackerras has some characters in common. A specimen of the subgenotype *M. (V.) frontalis* (Ricardo) is available through kindness of Dr. Mackerras. It differs in having a definite postocular rim, entirely pollinose subcallus and face, bare eyes with coloration reversed with two blue or green bands, frontal callosity quadrate and touching the eyes, and clear wings. Mackerras describes the style of *Vepriella* male genitalia as more slender and with a "projecting, subapical ventral lobe" not present in "*Veprius*" (= *Coracella*).

A specimen of each sex of *M. carbo* in the writer's collection is dusted with plant pollen which reveals flower-visiting habits. Both sexes of *M. rubricornis* (Krober), new combination, from Chile are also available which enables description of the previously unknown female. The male agrees closely with the type in BMNH compared by me in 1953. Except for the bright orange-red flagellums, the two species look very much alike. However, the subcallus and face here are entirely dull, blackish brown pollinose in both sexes, so that the subshiny condition in *M. carbo* is only of specific value. The eye coloration and microscopic hairs are the same for both species.

Mesomyia (Coracella) rubricornis (Krober), allotype ♀, 15 mm. Compared to *M. carbo,* the bright orange antennal plates are larger and as tall as long, disc-like, the first three annuli are also orange, the apical one blackish-brown. The frontal callosity is black and much narrower, only a little widened below, and reaches upward nearly to the anterior ocellus. The notum has a dull, dark-bluish sheen with three narrow blackish stripes. Most cells of the wings have hyaline streaks as also seen in some *M. carbo.*

Angol, Chile, 8 December, 1956. T. Garcia. In collection CBP.

I do not know the third species from Chile, *Mesomyia (Coracella) rufopilosus* (Bigot), new combination, which Fairchild (1956), following Krober (1934), also placed in "*Veprius*" and described as having "hind tibial spurs, bare subepaulet and subcosta, fleshy labella, and pilose holoptic eyes." The wings are described as nearly clear.

Esenbeckia schlingeri Philip, new species.

A robust species of the "*translucens*" group with thorax and most appendages yellow, but abdomen and femora dark.

Holotype ♀, 16.5 mm. Eyes bare. Front yellow polinose with darker central stripe from vertex to base which margins a narrow yellow keel and expands to envelop most of the subcallus above antennae (index 1:3.3); face and cheeks of same sooty-brown pollinosity. Beard straw yellow with sparse black hairs along ocular margins and in sutures on either side of the antennae, and on both palpal segments. Antennae and palpi yellow, the former of usual shape and with black hairs basally, but the terminal annulus unusually attenuated, longer than in either *E. translucens* Macquart or *E. chagresensis* Fairchild. Apical palpal segments more slender than in either of those species, and proboscis relatively longer, palpi a little less than half its length (again showing difficulties of recognizing *Ricardoa*). Theca and labellae sclerotized, rather slender, the former not thickened as in *Proboscoides*.

Thorax and scutellum yellowish-brown, covered with short, fine, pale hairs. Pleura, coxae, and femora dark, smoky brown, entirely black-haired. Tibiae and tarsi yellow with short black hairs. Wings yellow fumose, especially anteriorly; cell R_5 closed at the margin, spur veins longer than stems. Subepaulets bare.

Abdomen with tergite 1 yellow-brown pollinose, concolorous with thorax; remainder of tergites subshiny, chocolate brown with blackish incisures from tergite 3 caudad, covered with sparse black hairs except for pale ones narrowly on the incisures. Venter similar, but colors more intense, making the yellow first sternite more contrasting to the almost blackish remainder.

"Peru: Monson Valley, Tingo Maria, XI–29–1954. E. I. Schlinger and E. S. Ross." In CAS.

Paratypes, 2 females, same data but 28 September and 21 October, in close agreement. In CAS and collection CBP.

The longer proboscis, relatively shorter and more slender palpi, black hairs on facial sutures, basal palpal segments, chest and coxae, and lack of black hairs on notum and scutellum differentiate this from both *E. translucens* and *E. chagresensis;* the latter also has more conspicuous pale incisures on the abdomen, and tibiae are darker. *E. translucens* has a more prominent frontal callosity, and labellae are larger, and more fleshy along the lower margin.

Study of the type of *E. diaphana* (Schiner) from Colombia in VNM proves it to relate more closely to the slender *illota* group than to the above species. The following *E. ecuadorensis* Lutz and Castro has more strikingly banded abdomen and different proboscis.

Esenbeckia ecuadorensis Lutz and Castro.

Five females of this species in University of Michigan Museum of Zoology are labeled "Ecuador: nr Quevada Los Rios Prov., V–VI–1955, F. L. O'Rourke." Mouth parts are slender, but rigid, theca and labella sclerotized but more slender than in *Proboscoides*.

Esenbeckia gertschi Philip

Since description of this species (1954), a female has been found in

AMNH collections bearing the same data as the holotype male. It is readily associated with the sharply-dark, extreme bases of the wings, reddish, yellow-haired, short palpi, bicolored legs, and predominantly yellow-haired abdomen of the holotype.

ALLOTYPE ♀, 17 mm. Frons and subcallus buff-pollinose (including the well-outlined keel), parallel in upper half, moderately divergent below, index 1:2.9, though the upper portion gives frons a narrower appearance. Face brown, thinly dusted with yellow pollen, slightly swollen under antennae. Latter reddish-orange, inconspicuous yellow hairs on first two segments, the terminal annulus much elongated. Palpi slender, acuminate, about one-third length of proboscis, the broad bare areas on sides occupying about two thirds their lengths. Beard and thoracic vestiture straw yellow.

Notum, scutellum, and pleura blackish, unlined; narrowly reddish above wing bases and antealar tubercles. Femora blackish, tibiae reddish, each with concolorous hairs. Wings subhyaline with yellow costal cells, but sharply deep brown basad of the humeral cross vein and in cell first M. Allula subhyaline and venation as in holotype. Abdomen entirely yellow-haired. Tergite 1 dull reddish-yellow pollinose; remainder of abdomen subshiny, broadly deep reddish on sides of tergite 2, and grading into blackish-brown behind and on the venter.

"6 mi. N. E. El Salto Dgo. Dist., Dgo. Mex. 8500 ft. August 10, 1947. D. Rockefeller Exp., Gertsch." In AMNH.

In key to females (Philip, 1954) this would run to couplet 6 where it separates on dark halteres, and dark but yellow-haired abdomen. This is a much more robust species than either *E. tepicana* or *E. abata* also in couplet 6.

An equally robust, somewhat similar-appearing female was taken at the same time and place but differs in lack of basal wing infuscation, narrower front, less divergent below, entirely dark legs with black hairs on tibiae and abdominal segments from 3 caudad. This female agrees with a syntype of *E. seminuda* Coquillett and with the type of *E. nigronotata* Macquart in Paris Museum as discussed by Philip (1954).

Proboscoides fairchildi Philip.

A female was taken by Schlinger and Ross at Yurac near Tingo Maria, 16 November, 1954.

Triceratomyia mcintyrei Bequaert.

A female of this peculiar *Fidena*-like species with long triramous antennae was taken by Schlinger and Ross in Ecuador "N. of Puyo, Napo-Pastaza, 253 m., 9 Feb., 1955." Subepaulets and eyes are bare.

Chrysops laeta sublaeta Philip.

Twenty-nine females were taken by Schlinger and Ross at Tingo Maria on various dates from 23 September to 9 December, 1954, plus one near Puyo, Napo-Pastaza, Ecuador, 953 m., 9 February, 1955. These all have the characteristic heavy wing pattern with straight outer margin of the crossband beyond discal cell, and apical spot connected and sometimes even filling cell R_1. The yellow marking on tergite 2 is hourglass-shaped, and that on tergite 3 usually crosses the segment. However, all but one have yellow frontal and facial callosities, the former with a narrow to rather wide, dark, upper margin; in one, the entire disc is dull brown. It appears, therefore, that the important character differentiating *C. l. sublaeta* from the typical form (see Philip, 1955) is the heavier wing pattern, but that the color of the callosities is variable.

Chrysops leucospila Wiedemann.

Nine females, which show little variation, were also taken at Tingo Maria between 10 October and 23 December. All have small yellow triangles on tergites 2 to 4 but in two specimens there is an additional smaller spot on tergite 5, and in one, the triangle is present only on tergite 2. The type seen by the author in 1953 in VNM is dirty, which condition obscures the abdominal triangles. Otherwise a specimen from Goyaz, Annapolis, Brabil, agrees with this as well as with the type of synonym *C. guttula* Wiedemann also in VNM.

Chrysops calogastra Schiner.

A female from Tingo Maria, 11 November, only 6 mm. in length, differs from a Canal Zone specimen compared by the author with the type in VNM only in having heavier wing and abdominal patterns and dark margins on the facial sutures and apodemal pits. Apical spot around the apex of wing is but little paler than crossband, basal infuscation in the respective basal cells occupies a little less than half of the first and nearly a third of the second cells, and the median, equilateral triangle on tergite 2 does not reach half way across segment. The pleura are entirely plumbeus without the golden patches beneath the wing bases. This represents a melanistic variant of *C. calogastra.*

Another female from Tingo Maria in the same month is obviously related to the above in the extensive apical spot but differs in the following critical characters.

Chrysops rossi Philip, new species.

A small, predominantly blackish species with a row of very small yellow triangles on tergites 2 to 4; apical spot extends around apex of wing and the infuscation of both basal cells occupies more than half their lengths.

HOLOTYPE ♀, 7.5 mm. Eyes (relaxed) with very heavy dark pattern, only median frontal spot not contiguous to ocular margin, shaft and upper frontal spots joined at vertex, arrowhead broadly joined to median spot, and possibly to lower occipital margin (indistinct on revival). Frons taller than broad, yellow pollinose, a transverse black spot at vertex surrounding the three ocelli, callosity broad and shallow, yellow on disc, upper margin brown. Face, bare protuberant, yellow-orange. Lateral pollinose stripes reaching bases of palpi. Cheeks bare, reddish-brown, darker behind. Antennae thin, reddish, style almost black; basal annulus subequal to pedicel in length, scape a third longer than either. Palpi reddish.

Thorax and scutellum entirely subshiny black, thinly dusted anteriorly with plumbeus pollen, and with golden pollen in a small spot on pleura under wing bases. Sparse, short, black hair with a few inconspicuous appressed yellow ones on notum. Coxae also subshiny black, which color extends onto bases of first two pairs of femora, and two thirds of hind pair; two hind pairs of tibiae blackish, tarsi mostly pale, straw yellow; remainder of legs dull reddish brown. Wings with pattern as in the melanistic *C. calogastra* above, infuscation intense, apical spot a little less so and encircles entire apex of wing and leaves hyaline "sickle" broken but with a connected spot across vein R_{2+3}, a round spot below fork in cell R_5, and another in cell M_1; the small spots at outer and inner ends of quadrate spot at fork seen in *C. calogastra* are missing here so that crossband and apical spot are broadly joined across fork; apical margin of cell M_2 is smoky, crossband fills cell M_3 to margin and most of cell CU_1 except for a small triangular spot along anterior margin; two basal cells predominantly infuscated with about a third of each hyaline toward the tips, anal cell a little less than half infuscated apically, and anal area smoky. Halteres black.

Abdomen, including incisures subshiny black with small yellow spots on extreme upper, outer corners of tergites 1 and 2, a small yellow taller-than-broad triangle on hind margin of tergite 2, reaching less than a third of the way across, and a smaller inconspicuous one on 3 and 4. Sternite 1 and anterior margin of 2 yellow. Remainder of venter black and black-haired with inconspicuous sparse yellow hairs caudad.

Peru: Monson Valley, Tingo Maria, 23 November, 1954, Schlinger and Ross. In CAS.

The much darker, heavier body and wing patterns, especially in the basal cells, make it unlikely that this is merely a melanistic variant of *C. calogastra* though the relationship is obvious.

Stenotabanus pequiensis Fairchild.

This and the similar *S. xenium* Fairchild, belong to the anomalous group which is intermediate with *Tabanus* because of some setae on the subepaulets, but with otherwise *Stenotabanus*-like facies.

Seven females of this and five of *S. xenium* were taken by Schlinger and Ross at Tingo Maria between 18 September and 2 December. Another specimen of the latter in AMNH was taken on 3 June, 1939, at Huanuco, Tingo Maria, by Wyotkoski.

Stenotabanus obscurus Krober.

The type from Venezuela is intact in VNM and I have a specimen from Ecuador in close agreement except for somewhat taller frontal callosity. Another specimen from Ecuador agrees structurally, but also agrees with Krober's (1929) variety of *S. flavofemoratus* from Peru with more reddish femora, style and abdomen. Specimens from one locality in Bolivia show similar variation but in two, the middorsal expansion of the pale incisure on tergite 2 plainly crosses the tergite, though such spots are indefinite on the following tergites.

Similar variation and intergradation occur among 40 females taken 18 September to 3 November, 1954, in Tingo Maria, except that at most there is only an indistinct pale-haired triangle in the middle of tergite 2. In ten of the darkest variants, the abdomen, style, and halteres are almost black. The remainder could be assigned to variety *S. flavofemoratus* though gradations in color are a matter of degree or intensity with the palest forms having entirely red antennae and legs, and pale-brown halteres. All are structurally alike except the frontal indexes vary between 1:4 and 1:5.3. Krober describes the type of *S. obscurus* as about 1:3.5, but I measured it at 1:4. Though Krober keys the species with wings absolutely hyaline, there is perceptible tinting anteriorly in the type, as well as in most of this series of specimens. Eyes have two green bands on a purple ground in relaxed specimens.

Stenotabanus taeniotes (Wiedemann).

This genotype is representative of several later-described species that have a prominent, pale middorsal stripe on reddish to brown abdomens. The validity of such species as *S. pallipes* Krober with its slightly wider front, and *S. pseudotaeniotes* Krober will depend on variation found in adequate series. Krober (1929) overlooked the relationship here of *S. fulvistriatus* (Hine) from Central America. There is also confusion regarding identity of the type of *S. taeniotes,* whether in Vienna or Frankfurt. Until this confusion regarding variation can be resolved, it appears best to assign the oldest name to a series of 8 males and 14 females taken at Tingo Maria between 21 October and 11 December, 1954. The frontal indexes of the females vary between 1:2.9 and 1:3.3, the femora and style may be entirely red or with brownish shades, and upper margin of callosity may be tridentate, squared, or rounded.

Two syntypes, labeled type and paratype, "Brasilia, Freireiss," "56," were seen in Frankfurt and Dr. Eli Franz has written that Wiedemann's type series originated from the Senckenberg Museum, so that the specimen in VNM labeled "taeniotes" in his handwriting, but not type contrary to Krober (1929), could have been from the original series. To remove any doubt on this important species, genotype of *Stenotabanus,* the intact Frankfurt specimen labeled "type," subsequent to Wiedemann, is herewith designated as lectotype; frons is slightly convergent below, index 1:5.75.

Stenotabanus albilinearis Philip, new species.

A slender, blackish species with single white serrated line on the abdomen, metallic brassy hairs on thorax, dark red antennae, bicolored legs, and dark brown to blackish palpi.

HOLOTYPE ♀, 9.0 mm. and wings 9.0 mm. Eyes bare with two green bands on a purple ground (relaxed). Frons slightly widened above (index 1:4.0), yellow pollinose with two wide blackish bands, one at vertex which surrounds a small, low subshiny tubercle with vestigial anterior ocellus; basal callosity smooth, rather protuberant, piceous, a little taller than broad and touching eye margins its full length, tridentate at top, middle prong extended upward as a narrow median keel two-thirds the height of frons. Subcallus buff-pollinose above, with a brown band below which crosses on either side of the antennae onto upper corners of cheeks. The latter and face creamy-pollinose, beard concolorous, short, sparse. Antennae dark brick-red with black hairs on basal segments, plate with a low, obtuse, dorsal angle basally, and a little longer than style. Palpi dirty brownish, first segment almost black, entirely black-haired; but little shorter than proboscis.

Thorax and scutellum black, unlined but with narrow pale margins above wing bases, notum covered with indistinct, short, black hairs and sparse, appressed, brassy hairs. A black line margins notum across tubercle in front of each wing. Pleura broadly creamy-pollinose and pilose above, darker below and on chest. Coxae and femora black. Tibiae bright straw-yellow to whitish, but black on the distal halves of fore pairs, and on tips of two hind pairs, vestiture concolorous. Wings tinted with a distinct apical cloud beyond stigma; cell R_5 wide open, short spurs present. Halteres blackish, subepaulets bare.

Abdomen black, the median whitish line to fifth segment composed of narrow, truncated triangles, apices of those on tergites 4 and 5 just reaching anterior margins. Incisures of all but first two tergites and of all sternites narrowly whitish. Sternite 2 with a brownish cast and wider suffusion of pale hairs behind.

Peru: Monson Valley, Tingo Maria, 10 October, 1954, Schlinger and Ross. In CAS.

PARATYPES ♀'s: 5, same data except dates between 21 October and 2 December, 1954. In CAS, and collections CBP and GBF. In close agreement, frontal indexes vary between 1:3.7 to 1:4.3 with mean of 1:3.9, callosity may be rounded across top, and palpi may be almost black. The combination of dark palpi, red antennae, trianguliferous line on black abdomen, and brassy-haired thorax is distinctive. *S. obscuremarginatus* Krober of Brazil has discontinuous triangles on a browner abdomen, paler fore coxae and palpi, antennae darkened apically, and a wider frons.

Stenotabanus sexannulatus (Enderlein).

This contrastingly patterned, small, compact insect was made the genotype of the unnecessary *Styposelaga* Enderlein. A female from Yurac, 67 miles east of Tingo Maria, 16 November, 1954, permits some additional notes. Notum and scutellum are densely covered with appressed, iridescent, greenish and silver, scalelike hairs. Scutellar integument is gray apically with intermixed white hairs best seen from the side. Frontal index 1:4.0 and there is a quadrate, shining black spot across the vertex enclosing a low tubercle with three vestigial ocelli. The incisural band on tergite 2 widens to a low triangle which reaches only half way across the segment.

Another female from Monson Valley, Tingo Maria, 29 November, 1955, is obviously a melanistic variant. Palpi and pleura are blackish, beard is mixed black and yellow, and incisural bands are a little narrower. Frons is a little wider, index 1:3.7 and the spot at the vertex is smaller.

It appears highly probable that *T. incipiens* Walker from Amazonos, Brazil, is an earlier name, and the headless type in BMNH agrees with the first specimen above. *Stenotabanus maculifrons* Hine from Guatemala cannot be separated by the description and will need type comparison to decide on synonymy.

Stenotabanus macroceras Philip, new species.

Opportunity is provided here to describe another distinctive South American species from Venezuela. This is slender with dark thorax, reddish-brown abdomen, unusually elongate antennae, and tinted wings with faint clouds and short spur veins at forks.

HOLOTYPE ♀, body 9 mm., wings 10.5 mm. Eyes ostensibly bare. Frons with parallel sides (index 1:4.0), brown pollinose with a small dark spot at vertex but no vestigial ocelli; basal callosity brownish black, protuberant, triangulate in shape due to a broadly tapered point less than half way to vertex and no median line above. Subcallus pale brown, paler above. Face and cheeks gray pollinose, beard short, sparse, whitish. Antennae reddish basally with black hairs, black beyond the low, but sharp dorsal tooth which is situated on basal fourth of plate, the latter unusually long and slender, twice as long as style which is also a third longer than two basal segments combined; whole structure is subequal to frons in length. Palpi slender, hardly swollen at "knees," blunt-tipped, about two-thirds length of rather long proboscis.

Notum and scutellum blackish, unlined, with sparse brown hairs, and appressed brassy to greenish ones; antealar tubercles pale brown. Pleura and coxae gray pollinose and whitish pilose. Femora and distal half of fore tibiae, and all tarsi dark brown, remainder of legs reddish with pale hairs. Wings tinted, costal cells yellow; cell R_5 wide open. Halteres pale brown. Subepaulets with a few scattering setae.

Abdomen with first four segments reddish-brown, darker caudad, covered with mostly black hairs. Tergites 1 and 2 with small median dark integumental spots and median patches of straw-yellow hairs on incisures; on remaining tergites, similar patches widen along incisures. Venter colored similarly but with predominantly pale hairs and more prominent pale incisures.

Rancho Grande nr. Maracay, Venezuela, 13 May, 1946. In AMNH.

ALLOTYPE ♂, 10 mm. Similar to female except for usual sexual differences, and readily associated. Head a little wider than thorax, enlarged facets brown with sparse short hairs, sharply demarcated in upper two-thirds of eye area, a posterior margin of small facets extends upward but tapers out just before vertex. Tubercle small but visible at eye level. Frontal triangle yellow pollinose, smoky in the apex. Face and cheeks also yellow pollinose with more abundant yellow hairs. Palpi small, ovoid, blunt, about one-half longer than thick. Yellow and metallic brassy hairs on notum longer than in female and a series of dark brown median spots above and below on first four segments of the brighter reddish abdomen, more prominent than in any females.

Same data as holotype, but dated 27 April, 1945. In AMNH.

PARATYPES: ♂ and 4 ♀'s, same data but females dated 5 to 17 May. In CAS and collection CBP. Each sex in close agreement with above. The paratype male lacks median spots on tergites 3 and 4.

The long antennae are unusual for *Stenotabanus* and the sparsely setulose subepaulets place the species in the anomalous group intermediate with *Tabanus* and with interesting divergence suggestive of the distinctive *Nea-*

vella Oldroyd of the African East Coast. The last has bare subepaulets and elongate antennae, but antennae and frons of females have fundamentally different proportions and shapes. Eye pattern of *S. macroceras* was not clear-cut on revival, but in two specimens appeared to consist of a heavy median purple stripe, and an equal green one below it, both outwardly bent upward in most unusual right-angled curves to reach upper eye margin; upper area green, and lower margin widely purple extending around the outer "corner" of eyes beyond the distal strong bend in adjoining green stripe.

Phaeotabanus aphanopterus (Wiedemann).

A female from Rio Ucayali, Peru, 28 November, 1923, Harvey Bassler, in AMNH, appears to be this, though legs are dark brown rather than rust-red, pleural vestiture is yellow and the entirely brown wings fade but slightly along the margins. Abdomen is yellow-brown without the lilac-reddish sheen described by Krober (1930a). Thorax is blackish with appressed brassy hairs and there are some golden hairs on the incisures of tergites 2 to 4. Fairchild has commented on the need for recognizing *Phaeotabanus* as a full genus. The present species agrees with the genotype, *P. litigiosus* (Walker), in having bare supepaulets and no tubercle at the vertex in the female, though labellae are relatively larger. The syntype of *P. aphanopterus* from Brazil in VNM is intact though a little moldy; another in Frankfurt, now headless, is wrongly labeled "type." Since a third is reported in Berlin Museum, the VNM specimen labeled "Brasilia, Coll. Winthem," No. 3737 is designated as lectotype. It has bare subepaulets, no visible ocelli.

Phaeotabanus aphanopterus var. **obscuripilus** Krober.

A female taken at Pucalipa, Peru, x–2–54, by Schlinger and Ross and another from Rio Ucayali, xi–28–23, Harvey Bassler (AMNH) extend the range considerably. The former (in CAS) agrees in detail with the type in BMNH from British Guiana except for absence of spur veins. The subepaulets are contrasting bright orange, nonsetulose, which removes the group from *Tabanus* proper.

A male from Tingo Maria, x–10–54 (also CAS) differs in only minor respects. The hairs of the abdomen are less appressed, and pale incisures below not as prominent. This also agrees with description of *Ph. nigriflavus* Krober (type in Hamburg from French Guiana now destroyed) which is undoubedly a synonym.

A syntype each of Wiedemann's typical form are listed in Frankfurt, Berlin, and Vienna. The one in Frankfurt is now headless. The one in Vienna, "Brasilien Coll. Winthem" No. 3737, may be designated lectotype. It is intact but a little moldy.

Tabanus (Taeniotabanus) callosus Macquart.

One female from Peru by Schlinger and Ross, I–3–55, at Colonia Perene, Rio Perene, N.E. La Merced. A variant from Tingo Maria, x–27–54 (in manuscript of Dr. G. B. Fairchild as sp. No. 3).

Tabanus missionum Macquart.

In Paris Museum of Natural History there are 5 syntype specimens representing two species from Brazil having superficial resemblance to each other. Three of one are in better condition than the other two but represent a small species of the difficult *Taeniotabanus* group with rather narrow fronts and small callosities, and with no spur-veins at the base of vein R_4. Macquart's reference to the fore legs sometimes being bicolored and the annuli black were the only statements referable to these, whereas the other important characters of large brown callosity and spur-veins refer to two specimens related to *Stenotabanus* or *Dasybasis*. It is necessary, therefore, to select a lectotype and is appropriate to refer the name to these latter insects which will be more readily recognized. The syntype with clearest abdominal pattern is selected and redescribed.

LECTOTYPE ♀, 11 mm. Frons, broad, parallel-sided, index 1:2.2; yellow pollinose, a small, low brownish tubercle at the vertex. No median callus, but a broader than tall, brown, rugose basal callosity touching the eye margins. Subcallus yellow, face gray, beard white. Antennae yellow with yellow hairs, the flagellums missing. Palpi missing. Eyes sparsely pilose under high magnification, bare for key purposes.

Thorax black, discolored and cracked; pleura with pale hairs. Legs red with straw-yellow hairs. Wings clear, veins bright yellow, subepaulets bare, cell R_5 open, short spur veins present.

Abdomen worn, but with a characteristic wide black, longitudinal line, and the sides and venter yellow.

Labeled "des Missiones" (probably Argentina).

A syntype is in agreement and has slender elongate, pale-haired, pale-yellow palpi, and callosity is darker brown. Antennae also broken. No pale markings are evident in the median stripe of either.

Six females in Pechuman collection from Tandil and General Pacheco, Buenos Aires Prov., R. A., 15–23 March, 1951, are better preserved than either of the types. Size 9.5–12.5 mm. The largest is closest with entirely pale-haired scape and pedicel (flagellums missing), palpi and legs. The callosity is reddish laterally with a dark brown disc, rectangular, touching eye margins and with a small median extension above. The appendages of the other three have some black hairs, frons may be a little narrower, and callosities vary in shape and color to entirely black and subtriangular. The flagellums are black, slightly reddish basally in two, no dorsal angles, and style equal to plate in length. In one there are dark shadows on fore coxae and basal half of hind femora; fore tibiae are darkened apically in all, and short spur veins are present.

This species is peculiar in having a single purple crossband on relaxed eyes. In one specimen in which the abdomen is partially greased, the median stripe is obscure, in all others it is contrasting, and in two unrubbed specimens there are suggestions of narrow, pale-haired median lines on the black stripes. It is likely that the meagerly described *Tabanus confirmatus* Brethes is a synonym.

Dicladocera neosubmacula Krober.

One female from Tingo Maria, 18 September, 1954, appears to be this species. Wing pattern is reduced to heavy vein marginings basally and below stigma, much as in *D. hoppi* Enderlein. However, the body is dull reddish-brown, less compact, and lacks the blackish enameled appearance of the latter and of the *D. macula* complex, though frontal and abdominal features show relationships. Since there is only one type of *D. submacula* (Walker), seen by Fairchild (1956) and the writer in BMNH, the reasons for Krober (1934) synonymizing this *pro parte* under both *D. macula* (Macquart), and his *D. "neo-submacula* nov. nom." are not apparent. The type of *D. submacula* is smaller and has some vestiture straw-yellow in color compared to the type of *D. macula* (Macquart) (also in BMNH) with orange hairs, but the synonymy appears correct, though Fairchild disagrees. In any event, *D. neosubmacula* Krober is distinct from either and has, moreover, completely nonsetulose basicostas. The writer has seen five syntypes of *D. argyrophora* (Schiner) in VNM and agrees with Krober that they differ from *D. macula* (Macquart) only in orange vestiture extending from beard onto chest, upper fore coxae, pleura, and humeral lobes.

A female of *D. hoppi* (Enderlein) from Arica, Chile, Cuya Farm, November,1949, determined Barretto, is available for comparison with *D. neosubmacula.* It is a much larger, and blacker, shining species. Since this sex has not been described, this specimen may be assigned as allotype of *D. hoppi.* Length 17.5 mm. Eyes black, unbanded, with short sparse hairs which are more evident than in *D. neosubmacula.* Frons parallel-sided, index 1:3.4, sooty-gray pollinose, a small, bare black spot at vertex but no vestiges of ocelli. Callosity drop-shaped, brown, widely separated from eyes. Sparse hairs laterally on subcallus. Face and cheeks sooty-gray pollinose with black and brown hairs intermixed. Antennal hook not reaching end of plate. Palpi gray-black, black-haired, rather slender. A few yellowish hairs on thorax, but vestiture here and of legs largely brown and black intermixed. Abdomen enameled blackish with dark brown shadings on sides and venter. Wings and other characters as described and figured for the male by Krober (1940). Except that the wings have more subhyaline parts, and markings are reduced, antennal hook is shorter, and the vestiture of beard, pleura, chest, and fore coxae is darker, the species might be considered only a dark variant of *D. macula.* The subepaulets, likewise, are covered with sparse setulae only on upper half.

Dicladocera scutellata (Macquart).

The synonymy of this and *D. macula* (Macquart) is complicated, and further confused when Krober (1934) wrongly placed *D. scutellata* in synonymy with the later *D. macula.* There is variation in the color of the vestiture of head and thorax in series of both. A specimen from Minas Geraes, Brazil, agrees with two syntypes of the former in Paris Museum (from "Patrie ignota") except for darker beard which is variable in series, but differs from the *D. macula* type in BMNH ("? New Grenada") in more robust, enameled appearance, darker wings especially basally, and much broader frons with heavier keel; patches of white hairs on outer corners of sternites 3 and 4 in *D. macula* have not been seen in *D. scutellata.*

A female each from Colombia and Peru, compared with *D. macula,* also agreed with types of *D. auribarbis* (Macquart) and *D. submacula* (Walker) in BMNH, and *D. argyrophora* (Schiner) in VNM except for minor variations in color of vestiture. These also agree with a specimen compared with *D. satanica* (Bigot) by Fairchild, but differ from *D. castanea* (Bigot) (Fairchild correspondence) which the writer neglected to compare. Fairchild (1956) states that if a specimen determined by Krober in BMNH agrees with types in Berlin of *D. neosubmacula* (Krober) then this is distinct from the above.

A male and four females of *D. scutellata* in Senckenberg Museum, Frankfurt, studied through kindness of Dr. Elli Franz, labeled "Passa Quarto an Camp Blütiu, 4/3,20 Zikàn" show variations in color of beard from brown to yellow. The undescribed male may be taken as allotype.

ALLOTYPE ♂, 17 mm. Agrees with female in hooked antennae, red scutellum with shadow at base, dark legs and venter, and yellowish-tinted wings. The eyes are bare, facets sharply enlarged in the upper two-thirds, palpi elongate, cylindrical, blunt, without apical nipple, and basal three tergites predominantly reddish-brown. Fore tarsal claws subequal.

Dicladocera tinctipennis Philip, new species.

A robust species with brick-red, patternless abdomen, black antennal plates with long hooks, black femora, and uniformly tinted wings with setose subepaulets.

Holotype ♀, 18 mm. Eyes bare. Frons pale brown pollinose, parallel-sided (index 1:7.2), a darker, sparsely pollinose spot at vertex but no ocelli; callosity reddish, ovoid, bidentate below, separated from the eyes, and rather abruptly narrowed above into a narrow, reddish keel to upper third of frons. Subcallus, face and cheeks brown pollinose with concolorous hair below. Antennae with two basal segments reddish with black hairs, flagellums entirely black, teeth reaching to the end of plates, and longer than styles. Palpi elongate, pale brown, black-haired, slightly thickened basally and blunt apically. Labella large and fleshy.

Notum and scutellum dark brown pollinose over blackish integument, clothed with sparse black and yellow pile; antealar tubercles and pleura reddish with black and yellow pile. Coxae grayish-yellow pollinose with mostly yellow hairs. Femora black, tibiae reddish, mostly black-haired; hind-tibial fringe prominent. Wings with costal cells and veins yellow, membrane pale yellow without intensified pattern; cells R_5 wide open, no spur-veins. Halteres yellow, knobs paler and brighter.

Abdomen uniformly brick-red, with indistinct median dark spots below; almost entirely black-haired with a few scattering yellow ones.

"W. Ecuador, Mindo. 1913. Hammon." In BMNH.

Paratypes, 6 ♀'s, same data, in BMNH and collection CBP.

This was first questioned as a possible variant of *D. unicolor* Lutz of Brazil, also with tinted, but not pictured wings. That species, however, has reddish legs and antennae, and paler thorax.

Stypochela inca Philip, new species.

A medium-sized, plain brownish species with pictured wings, bare eyes and subepaulets, and reddish antennae and legs.

Holotype ♀, 15 mm. Eyes without bands (relaxed). Frons reddish-brown pollinose, parallel-sided (index 1:5.0); callosity reddish, drop-shaped, widely separated from eyes, and gradually narrowed into a median keel which reaches upper fourth of frons. Subcallus, face, and cheeks reddish-brown pollinose, beard blackish in front, pale behind, face in profile a little more snout-like than in preceding. Basal segments of antennae black-haired; plate slender, tooth unusually long and reaching end of second annulus, style dark brown. Palpi dark red with black hairs, long and slender, half as long as the proboscis, which has smaller and smoother labella than the preceding. Proboscis a little longer than height of head.

Thorax and scutellum reddish-brown, with four narrow gray stripes anterodorsally, and clothed with black and brown hairs. No pallid hairs under wing bases, but patches of whitish hairs in front of halteres. Legs unicolorous reddish with concolorous hairs. Wings brown, paler from apex around hind margin, and with a contrasting hyaline band across inner cross veins; a blunt outward extension of brown envelops the fork. No spur veins, cells R_5 wide open. Halteres yellow, paler on knobs.

Abdomen unicolorous reddish brown with inconspicuous black and some brown hairs posteriorly; venter also with a perceptible grayish bloom.

Peru, Monson Valley, Tingo Maria, 3 November, 1954, Schlinger and Ross. In CAS.

PARATYPES, 15 ♀'s, same locality and collectors, between 23 September and 11 December, 1954; in collections CAS, CBP, LLP, and GBF. Three were taken at light. All in close agreement with the holotype; frontal indexes of ten between 1:4.1 to 1:5.6 (mean 4.99).

Close inspection is required to separate this species from *S. peruviana* (Bigot) six specimens of which were taken at Nanegalito, Ecuador, 27 October, 1956, by Mr. R. W. Portman (identified by Dr. G. B. Fairchild). Eyes in the latter, however, are distinctly hairy under a hand lens; unworn specimens have a patch of bright yellow hairs below the wing base and also in front of halteres, the hyaline crossband is narrower and subcallus is more protuberant in profile. Panama specimens of *D. badia,* also with hairy eyes, are close to *D. peruviana,* but in those, infuscation in basal cells is more dilute, subcallus flatter, callosity more sharply outlined, and there are patches of whitish hairs in front of and above the halteres. *D. peruviana* was overlooked when Krober described his *D. badia,* but the types of both have been seen by Fairchild (1956) and the writer in BMNH, and assigned to *Stypochela* later by Fairchild (1958).

Dichelacera (Catachlorops) auripilis Philip, new species.

A medium-sized, dark brown species with extensive golden pile over head, thorax, and venter, red callosity and appendages, and contrasting, irregular, dark crossband on wings; a golden-haired triangle in middle of fourth abdominal segment.

HOLOTYPE ♀, 14. 5 mm. Eyes bare. Frons golden-yellow pollinose, a little darker at the vertex but no ocelli, distinctly convergent above (index 1:4.5); callosity large, protuberant, yellowish-brown, ovoid, narrowly separated from the eyes and gradually tapered into a heavy, reddish median keel which attenuates at the upper third of the frons. Subcallus, face, and cheeks golden pollinose with some gray shadows, face receding; beard sparse, golden-yellow. Antennae brick-red, style blackish, black-haired basally, the tooth reaching to end of first annulus. Palpi very slender, elongate, deep red with black hairs. Labellum fleshy but rather small.

Notum dark brown with three faint reddish lines anteriorly, scutellum reddish, the whole clothed with sparse black, and conspicuous golden-yellow hairs. Pleura and coxae grayish-yellow with bright yellow pile. Legs yellowish-red with rufous hairs. Wings hyaline in apex and hind margin, yellow in discal cell, pale yellow across basal and anal cells; the inner margin of crossband starts at proximal end of stigma and crosses middle of discal cell into middle of cubital but does not reach hind margin; extensions of outer margin along veins R_{2+3}, and longer along R_5 nearly to the wing margin, receding along middle of cell R_5 to base of, but missing, cell M_1, and continuing across cells M_2 and M_3 to middle of cubital cell. Cell R_5 wide open, no spur veins. Subepaulets bare. Halteres brown, yellow on knobs.

Abdomen subshiny, reddish-brown on tergites 1 to 3, dark with a large flat, golden-haired triangle which crosses tergite 4[2]; otherwise brown thereafter; entirely black-haired, except for triangle and a few yellow hairs on extreme edges and in middle of tergite 3. Venter reddish with golden hair.

"Colombia: 18 mi. SW Mocoa Narino, 1910 m., 3 March, 1955, Schlinger and Ross." In CAS.

The description of the smaller *D. ecuadoriensis* Enderlein omits the distinctive frontal characters and apparently includes a wing picture related to this, but there are white hairs on beard and chest, the notal hairs are brownish not golden, and the tergal incisures have yellow hairs in that species. Dr. Fairchild writes that his specimen of *D. ecuadoriensis,* though worn, shows suggestions of pale triangles on tergites 2 to 4 and has frons less divergent below compared to this. Wing picture and abdominal triangle obviously are derived from common ancestral stock with *D. caloptera* (Schiner), the type of which in VNM is in close agreement with a Venezuela specimen which has shorter antennal tooth, white-haired abdominal triangle, and is a much darker insect.

Rhabdotylus venenata (Osten Sacken).

Though the original description includes two specimens with some variation, the author entertained "no doubt about their specific identity." Examination of these two, however, shows these differences to have specific significance. The Panama specimen, representing the form which occurs southward into Brazil as recognized at present, is herewith designated as lectotype. It is more robust (16 mm.), front 1:4, antennae, including style, red, face and cheeks golden-yellow pilose and pollinose, palpi orange with mostly yellow hair, femora bright yellow-orange with concolorous hair, and abdomen with greenish shades basally.

The other, smaller, darker specimen from Guatemala appears to be *R. viridiventris* Macquart with pale beard and bicolored fore tibiae.

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[2] This triangle with its conspicuous golden hairs was entirely obscured by "greasing" until the specimen was cleaned in ethyl acetate.

Stypommia abdominalis Philip, new species.

A delicate brown species with abdomen unusually abbreviated compared to the long wings, appendages orange to yellow, and with golden-haired abdominal incisures widened to form median triangles which are probably easily lost by wear.

Holotype ♀, 8.5 mm., wings 11 mm. Eyes bare; green, unbanded (relaxed). Frons yellowish-brown pollinose, sides parallel (index 1:4.3), three vestigial ocelli in a flat, thinly pollinose, small triangle below vertex. Callosity taller than broad, smooth and bulging, subovoid, dark blackish-brown, separated from eyes and prolonged above in a thin median keel reaching halfway to vertex. Subcallus golden-yellow pollinose. Face and cheeks buff pollinose, the beard sparse, straw-yellow. Tentorial pits deep, blackish. Antennae orange, not darkened apically, with concolorous hairs, plate as in *Stenotabanus* without dorsobasal prominence, subequal in length to style, and half again longer than tall. Palpi slender, yellow, about equal to antennae in length, covered with yellow and brown hairs intermixed. Proboscis, including fleshy labella, yellow, but little longer than palpi.

Thorax and scutellum brown, paler around anterior margin to include antealar tubercles; covered with brown and appressed brassy hairs. Pleura, chest, and coxae pale grayish-yellow pollinose and pilose. Legs bright yellow with mostly concolorous hairs. Wings yellowish tinted, deeper along costal margin, and a smoky tinge at apex. Fork and outer cross veins with clouds; spur vein moderate. Halteres brown. Subepaulets with a few sparse hairs.

Abdomen dull brown above covered with mostly black hairs, incisures with yellow hairs which widen into median triangles, accentuated in certain lights when viewed from front. Abdomen ends before the tip of the discal cell of the folded wing. Venter deep yellow with yellow hairs.

"Peru: Monson Valley, Tingo Maria, 27–X–1954, Schlinger and Ross." In CAS.

This is near *Stypommia flavescens* Krober, but differs from a specimen of *S. flavescens* (which agrees with Krober's description except for a slightly narrower front) with same locality data in having a darker dorsum and frontal callosity, pleura more grayish, style more chunky, apical annulus not darkened, and suggestions of middorsal triangles on abdomen which probably would not show in worn specimens. The generic placement might better be in *Stenotabanus* in its broad sense, but cannot be decided at present. Krober (1930) suggested that *Tabanus flavescens* Thunberg might be the same. However, I examined Thunberg's type on loan through kindness of Professor Bertil Kullenberg, Uppsala, and found it was a *Dichelacera*.

Tabanus quadripunctatus Fabricius.

There is question whether this represents a southern extension of *Hybomitra (Tylostypia)* or a parallel development in the Neotropics from elements related to *Stypommia*. I am inclined to agree with Fairchild (correspondence) that this species does not belong in the boreally elaborated *Hybomitra,* which avoids the taxonomic complications involved in deciding date of validation of *Poeciloderos,* one of several generic and subgeneric names proposed for this species and its synonyms.

From Tingo Maria, are two females of the typical dark form, 10 October and 16 November, 1954, and two males of the pallid form heretofore assigned to variety *amabilis* Walker, 2 November and 11 December. Fabricius' type female in Copenhagen is intact except for missing palpi, and agrees with a Colombia specimen having predominantly dark abdomen and three rows of pale spots. I have confirmed the synonymy of *Tabanus punctipennis* Macquart and *T. nigropunctatus* Bellardi with this typical form by study of the respective types in Paris and Turin. From notes and a drawing of the abdominal pattern furnished by Professor Kullenberg, the type of *T. elegans* Thunberg in Uppsala Museum evidently is an intermediate color phase in which the double geminate spots are joined across the anterior margin of tergite 2 and reach the hind margin, but the sublateral pale spots are large and barely touch the incisure behind.

Tabanus quadripunctatus is extremely variable in frontal structures of females, including distinctness of ocellar tubercles, narrowing or closure of cells R_5 at wing margins, and color patterns of abdomens; the latter show both melanistic and albinistic extremes. To the variation with closed cell R_5, Enderlein (1924) gave the name *dasyphyrtina* under his *Hypopelma quadripuncta* (sic). Krober (1934) catalogued this and *T. maculipennis* Macquart (preoccupied) as synonyms of the supposed pallid form *H. amabilis* which he figured in 1931. The type of the last in BMNH, however, is also the dark form. This leaves the pallid form without a name. Although there is complete intergradation between the two forms, a name for the pallid extremes serves a useful purpose and is herewith proposed.

Tabanus quadripunctatus amabilinus Philip, new variety.

Holotype ♀, 12 mm. Differs from the typical form in predominantly gray-pilose notum with a blackish transverse band across the middle connected to four narrow, black lines in front and three behind, lateral margins widely reddish. Tergite 1 on posterior half is pale pinkish with white pile, and two small submedian brown spots depend from the anterior black band. Tergite 2 is entirely pinkish with white pile, a pair of small, isolated brown spots submedially, and larger diagonal dashes on the sides. Spots on following tergites are similar in location to those of typical form but larger and more abundantly white-haired.

Andrelandia, Minas Geraes, Brazil, January, 1938, B. F. Gomes; determined as "*T. quadripunctatus* F." by A. V. Martins of Instituto Ezequiel Dias, Minas Geraes, Brazil. In collection CBP through courtesy of Dr. Martins.

ALLOTYPE ♂, 15 mm. Like the female but notum is almost entirely dark with four small, indefinite patches of pale scales and abdomen above and below is more strikingly whitish; all dark spots reduced, those on tergite 1 and sides of tergite 2 absent.

Peru: Tingo Maria, 2 November, 1954. Schlinger and Ross. In CAS.

PARATYPES, ♀, same data as holotype, and ♂ same data as allotype (in collection CBP); ♂, ♀, Rio Suarez Santander, Colombia, 900 m., 11–28 August, 1946, L. Richter (in AMNH); ♀, Campinas, Brazil, 14 April 1948, G. Bouvier (determined as *T. punctipennis* Macquart by Castro); and ♀, Pyrenopolis, Goyaz, Brazil, 28 December, 1936 (determined as *P. 4-punctatus f. amabilis* by Fairchild) (in collection GBF).

Tabanus (Taeniotabanus) stenocephalus Hine.

Two males from Monson Valley, 21 October and 3 November, 1954, agree closely in structure of head and color pattern with a topotypic male from Guatemala, compared with the syntype male, except that palpi and under parts including vestiture are much more yellow. Eyes are bare, and juncture of upper and lower facets is indiscernible.

Tabanus (Taeniotabanus) carneus Bellardi.

From Monson Valley between 18 September and 23 December, 1954, 23 males and three females of this widespread species were taken. The only divergence from the lectotype male (Philip, 1954) in Turin Museum is a tendency in a few males for increasing apical production of the palpi to a definite downward produced, blunt nipple in two specimens. Intergradation is complete in this character, but the majority of the males agree in having ovoid, moderately swollen palpi without terminal production in the lectotype. The females are typical *T. carneus* with completely reddish legs and scutellums, and broad, even abdominal lines.

Tabanus (Taeniotabanus) pungens Wiedemann.

A male, 16 November, and a female, 11 December, also from Tingo Maria, are assigned to this species. The former has dark fore coxae, femora, and scutellum, while the female has these parts reddish, differences which Fairchild (1942) has accepted in keying these sexes under synonyn *T. angustivittus* Krober. It appears not unlikely that coloration of these parts may vary in the female, and I have applied the oldest name to the complex for which Fairchild (1956) has provided the synonymy under *T. desertus* Walker.

The types of both *T. pungens* and *T. desertus* in VNM and BMNH, respectively, are worn and somewhat discolored; the latter has been broken and repaired. A female from Panama is in fair agreement with each except that *T. pungens* has brown rather than red fore coxae and hind femora (the mid femora are red), and scutellum is red only apically but blackish on base. While frons and size of callosity are in agreement, upper margin of latter in *T. pungens* has a low tridentate appearance due to small upward extensions of two upper corners, which are usually rounded in most specimens.

The same minor differences occur between *T. pungens* and a Mexican specimen in good agreement with the type of *T. propinquus* Bellardi in Turin, except for the entirely red scutellum of the last. *Tabanus sallei* Bellardi, also from Mexico, is obviously the male of the same species and agrees with the type in Turin, in having entirely dark scutellum, fore coxae and femora as discussed above. The red on the sides of the abdomens of both males is a little more extensive than in the Tingo Maria male but they agree in other characters.

I have not seen females which are like the males in having all dark scutellums, fore coxae, and femora, but it seems likely that they should occur considering the extensive distribution from Mexico to Peru and Brazil.

Tabanus (Taeniotabanus) claripennis Bigot.

As Fairchild (1956) has shown, the well-known *T. hookeri* Knab is a synonym. A female taken at Angol, 31 December, 1950, by Ross and Michelbacher is the first recorded for Chile. It is small, 10 mm., and the writer has seen another small (9 mm.) female from British Guiana which confuses placement in Fairchild's (1942) keys, though the wide front differentiates it from the *T. callosus* group. *Tabanus ameghinoi* Brethes, from northern Argentina, is a synonym.

Leucotabanus exaestuans Linné.

A male was taken by Schlinger and Ross in Tingo Maria, December 11, at light (determined by G. B. F.).

Tabanus (Macrocormus) sorbillans complex.

Specimens from Satipo, Peru (in collection LLP) have cell R_5 closed and with petiole as long as the spur vein. A female in AMNH from the same place has this cell narrowed but open to width equaling the base of cell M_1 at the discal cell in one wing and just closed at the margin in the other. This condition was described for the type of *Bellardia rubrofemorata* Krober. Material before me from Peru and other South American localities is insufficient to determine variation in this respect but when adequate, will affect assignment of names in the *T. sorbillans* complex, which unfortunately is not represented in the Tingo Maria collections under study here.

Tabanus rubripes Macquart is considered close by Fairchild (1956) "but distinct."

It appears probable that *T. testaceus* Macquart from Brazil as redescribed by Krober (1930) is a variant also. Krober reported the type in BMNH, but it was not seen by either Fairchild or myself in 1953. The type listed by Fairchild (1956) as in Paris Museum and also seen by me from Cayenne (Macquart's type locality), is not a *Macrocormus* with wing spurs, and because it has wide open cells R_5, doubts are raised about the real identity of *T. testaceus,* though this is preoccupied in any event.

Tabanus (Lophotabanus) lophus Philip, new species.

A large, lilac-brown species with dark antennae, reddish legs, long wing spurs, and the "ocular spot" prominent but confined to the praescutellum.

HOLOTYPE ♀, 19 mm. Eyes bare, relaxed, two narrow purple bands on a bluish-green ground. Frons narrow (index 1:9.0), buff-brown pollinose, with a peculiar, small, bare, rugose spot in apex of a v-shaped patch of black hairs at vertex; callosity and keel red, former finely wrinkled, ovoid, with rounded lower corners; contiguous to eye margins in middle and tapered gradually above into a keel which reaches nearly three-fourths the height of frons and is a little expanded in the middle. Subcallus buff pollinose. Face and cheeks whitish pollinose and pilose. Antennae with basal segments and inner face of plate pale brown, scape swollen and hoodlike with abundant black hairs; plate long and slender, dorsobasal tooth low but acute, outer face dark brown, style blackish and about half as long as plate. Palpi creamy, long, somewhat thickened basally and tapered to a blunt point, black-haired with mostly white hairs on basal segment.

Thorax lilac-brown with gray pollinosity and three narrow, indefinite lines anteriorly, covered with sparse black and appressed silvery hairs; praescutellum brownish black with a dense patch of coal-black hairs flanked on either corner by white hairs. Scutellum gray-brown, not darkened basally, broadly pinkish around hind margin with black hairs on the disc, and silvery-white hairs around entire margin which continues forward to form patches above wing insertions. Pleura, chest, and coxae whitish-pollinose and pilose, a few intermixed brown hairs above. Legs pinkish with abundant white hairs; inner surfaces of fore femora, upper surfaces of the hind tibiae, outer, distal fifths of fore tibiae, and tarsi with brown to black hairs; a few black hairs distally in hind-tibial fringe and on dorsums of the femora. Wings pale yellowish, accentuated along radial vein margins; cell R_5 narrowed at the wing margin; spur veins longer than their stems. Halteres pale yellow. Subepaulets setulose.

Abdomen lilac-brown with wide gray incisures, black hairs over all, including the incisures, except for silvery-white hairs on the extreme lateral margins and in a median row of equilateral triangles which reach about halfway across tergites 1 to 5; 6 and 7 entirely black-haired. Venter pink, thinly dusted with white pollen; white hairs over all with sparse median patches of black hairs as viewed from front; sternite 7 with coarse black hairs.

Peru: Monson Valley, Tingo Maria, at light, 11 December, 1954, Schlinger and Ross. In CAS.

ALLOTYPE ♂, 15 mm. Like the female in body colors and black spot restricted to the praescutellum, but equilateral triangles on tergites 4 and 5 nearly crossing segments, lateral white hair patches confined to hind corners, and black hairs on venter more extensive. Head wider than thorax, facets moderately enlarged but sharply demarcated and brown in upper two-thirds of eye area. Tubercle in occipital notch small, ovoid, situated below the eye level. Beard white with sparse brown hairs on upper genae. Antennae dark red, style blackish. Palpi ovoid with indistinct terminal nipples. Wings not as tinted as in female probably because somewhat teneral. Thorax paler, probably for the same reason.

Rio Suarez, Santander, Colombia, 900 m., 11–28 August, 1946, L. Richter. In AMNH. Determined as *T. xipe* Krober by J. Bequaert.

PARATYPE females: 2, Restrepo, Dept. Meta, Colombia, 500 m., 1936, J. Bequaert (in collections CBP and GBF), and 1, Villavicencio, Meta, Colombia, 13 June, 1941 (determined respectively as *T. xipe* by J. Bequaert and Fairchild); 5, Villavicencio, Meta, Colombia, various dates from April to August (in collections GBF and CBP); 1, Maracaju, Matto Grosso, Brazil, April, 1937. All in close agreement with the holotype; 16 to 19 mm. Two have more reddish antennal plates, and in three more worn specimens, the abdominal triangles appear flatter with suggestion of very narrow, pale incisures. *T. albocirculus* Hine (probable synonym *T. xipe* Krober) averages smaller and is usually more reddish, especially the antennae in the females, its "ocular spot" encroaches broadly onto the scutellum, abdominal triangles are usually shallower and broader, merging into pale incisures, and frons of females are narrower (1:10.0 to 1:11.2 in six specimens). Unfortunately, the type of *T. xipe* was destroyed in Hamburg, but I have seen four "cotypes" (paratypes)from "Surinam" and "Paramaibo" inVNM which also differ in these respects. *T. oculus* Walker (synonyms *T. albonotatus* Bellardi, *T. bipartitus* Walker; I have a homotype from Mexico compared with types of all three) is at once distinguished from *T. lophus* by closed and petiolate cell R_5, red antennae and larger "ocular spot." *Tabanus pseudoculus* Fairchild is a smaller insect, also with larger spot, pale hairs of most parts including beard, creamy-yellow, broader frons, more reddish antennae, and wing veins not margined with brown. *Tabanus albopruinosus* Krober is a large species from Brazil with body color, dark antennae, and praescutellar black spot resembling *T. lophus* but the frons is much narrower (1:14), white hairs are reduced to lower sides of two hind pairs of femora, and bases of tibiae (mid tibiae of *T. lophus* are entirely white-haired), and pleura yellow-haired. There is no sign of rounded, sublateral, abdominal spots in *T. lophus*, and no mention is made of spur veins in *T. albopruinosus*. The writer saw the type and "cotype" females of the latter in VNM but had no specimens for comparison. *Tabunus fumomarginatus* Hine, also from Brazil (Amazonas), has larger scutellar spot, no spur veins, and darker fore femora.

The writer has seen *T. albocirculus* from Trinidad, British Guiana, Venezuela, Colombia, and Para and Matto Grosso, Brazil. Revived eye patterns of three Brazilian and five Panamanian females of *T. albocirculus* showed blue and green banding in an unusual pattern in which three green bands and the green lower border alternated with three purple bands and the upper border purple; the upper purple band short while green and purple ones below it bend around it outwardly and upward at a 90° angle to meet the upper purple border before the outermost angle of the eye. The median bands in two relaxed *T. lophus* above do not have these strong upward bends toward the outer angles of the eyes.

The specific name, *T. lophus*, refers to the frontal keel for which the subgenus was named, though this is not even a special feature of either the new species or the subgenus.

Tabanus (Lophotabanus) flavicorpus Philip, new species.

A rather large, bright yellow-bodied species with mostly yellow hairs, a conspicuous, dense, dark brown-haired spot on praescutellum and anterior half of scutellum, and single row of tall, pale triangles on the abdomen.

HOLOTYPE ♀, 18 mm. Eyes bare (relaxed), apparently plain green without bands. Frons slightly widened above (index 1:7.0), yellow pollinose with a darker median patch, short yellow and black hairs at vertex without a bare spot underneath. Basal callosity pale red, small, only half again taller than broad, ovoid, widely separated from eyes, corners rounded below, and tapered above into a narrow, reddish median keel which reaches to nearly three-fourths height of frons. Subcallus buff pollinose, face and cheeks gray-buff with pale yellow hairs. Antennae bright red, the style dark brown; scapes swollen and hood-like, taller than plates and covered with dark brown setae; plates two-thirds longer than tall at acute basal tooth, strongly excavated dorsally, style short, equal to height of plate. Palpi slender, elongate, tapered to a blunt point, deep yellow, covered with pale yellow and brown hairs, entirely yellow-haired basally. Theca reddish, labella brown, fleshy.

Thorax pale reddish-brown, unlined, sparsely covered with pale yellow and reddish hairs intermixed, antealar tubercles with coarse dark brown hairs and a dense patch of the same color on praescutellum and a patch of straw-yellow ones on either side. Scutellum reddish on disc, widely gray-margined behind, with a dense median patch of coarse dark brown hairs on the anterior half, pale-haired around the margin. Pleura yellow with sparse gray pollen and pale yellow hairs. Legs yellow with concolorous hairs, darker reddish on tarsi, fore tibiae but little darker on the tips. Wings tinted yellow, paler behind, veins pale brown, cell R_5 wide open, no spur veins. Halteres bright yellow on the knobs. Subepaulets setulose.

Abdomen pale burnt-sienna above, bright reddish-yellow, almost orange, below. Mostly with rufous hairs on dorsum, last three tergites predominantly brown-haired; a median patch of creamy hairs on tergite 1, and a middorsal row of tall, almost equilateral pale yellow triangles on tergites 2 to 5, first two reaching over half-way across, the last two almost across, the respective tergites. Extreme edges and entire venter bright golden-haired except for coarse dark brown hairs on sternite 6.

Rio Maranon, Peru, 28 August, 1923, Harvey Bassler. In AMNH.

The entirely unbaded eyes and entirely yellow-brown to reddish appearance with almost no really black hairs, especially on the scutellar patch are unlike any species known to me in *Lophotabanus*. *T. fumomarginatus* Hine is a darker insect with darkened fore femora and pale abdominal incisures.

Tabanus basivittus Walker.

None of this species was taken at Tingo Maria, but that it must be common in some parts of Peru is attested by a series in AMNH from "Middle Rio Ucayali" and "Lower Rio Tapiche," July to December, and in USNM from Iquitos, March–April. Two females were also taken by Schlinger and Ross at Pucalipa, 2 October, 1954. The better known *T. viduus* Walker, *T. bitinctus* Walker and possibly *T. marginenevris* Macquart are synonyms according to Fairchild (1956); I have specimens compared with types of the first two. In unworn specimens, the black patch of hairs flanked on either side by decurved whitish patches under the scutellum on tergite 1 are plain and characteristic on an otherwise inornate, dark brown species with tinted wings.

This species is close to *T. impressus* Wiedemann from which it is distinguished by open cell R_5, distinctly wider frons, and more obvious patch of black hairs on the prescutellar ridge. A specimen from Brazil compared with the types of each shows that *T. piceus* Thunberg (seen through kindness of Professor Bertil Kullenberg of Uppsala) is an earlier name for *T. impressus* Wiedemann.

Stypochela neominos Philip, new species.

A robust blackish-brown species with pictured wings, reddish legs, ostensibly bare, unicolorous eyes, and setose subepaulets.

Holotype ♀, 20 mm. Eyes without perceptible hairs, unicolorous (relaxed). Frons parallel-sided, index 1:4.3, buff-pollinose with a peculiar sooty-

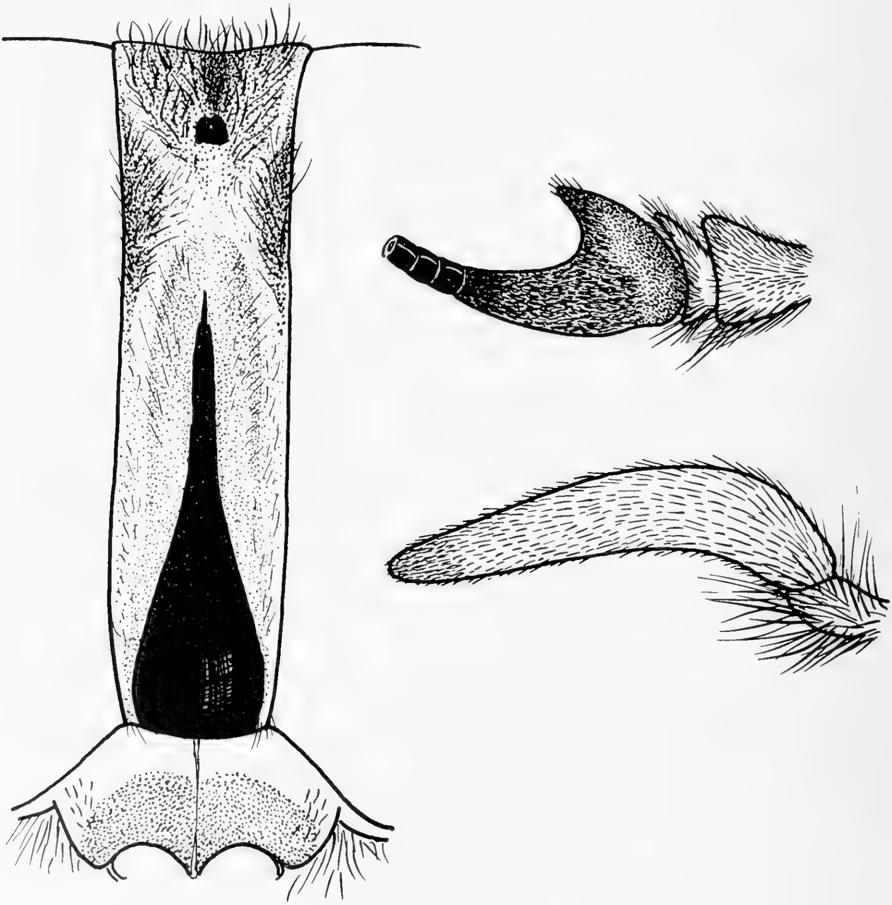

Figure 1. *Stypochela neominos*. Front, antenna, palp.

grey patch in the upper third that mostly disappears in dorsal view, in middle of which well below the vertex is a small raised tubercle; basal callus widely separated from eyes, chestnut-brown, merging gradually above into a darker keel which attenuates in the upper third. Subcallus with indistinct sublateral hairs, brown, with gray pollinosity along eye margins which continues along cheek margins also. Face and cheeks sooty-gray with brown hairs. Antennae black with black hairs, pedicels brown; the acute teeth reach a little over half way to base of styles. Palpi reddish with black hairs, long, slender, hardly tapered, with blunt ends. Labella fleshy.

Thorax brownish-red on dorsum with three wide black stripes, the median one fading at level of wing bases, scutellum dark on disc with reddish margins; invested with sparse black and some coppery hairs. Pleura dark brown with blackish pile, patches of pale pile above and below wing insertions and on tegulae. Wings with infuscation basad of stigma, apex tinted faintly with paler areas in medial and cubital cells, and R_3; a pale spot in discal and apices of two basal cells. Cell R_5 open, subepaulets setulose. No spur veins. Legs bright reddish with similar hairs, most of fore femora, basal half of hind pair, and tarsi brownish.

Abdomen bluish-black with black hairs, a few inconspicuous, reddish hairs mesally on incisures 4 and 5.

"Yungas de la Paz, Bolivia. 1000 m." H. Rolle. In BMNH, labeled *Dasyrhamphis minos* Schiner, det. Krober, 1929.

PARATYPE females: 3, Bolivia, El Palmar, Chapare Cockabamba, 1000 m., 10–18.i.1958, Monros and Wygodzinsky; 1, Argentina, Quebrada, Caiuzo, Tucuman, 8.iv.1948, Golback. In collections Tucuman Nac. Univ. and CBP. In good agreement with holotype. Two show more definite median patches of orange hairs on tergites 4–5, and the Tucuman specimen has entirely reddish femora.

This was compared with the two syntypes of *S. minos* on loan from VNM through courtesy of Professor Max Beier. The latter differ in being smaller, scapes are reddish, plates shorter and less excised, beard black, and golden-hair patches on tergites 4 and 5 are larger and more conspicuous which is not a difference of wear. The generic relationships of this group remain to be refined and there is obvious similarity to *Dasychela* spp. which Bequaert and Renjifo-Salcedo (1946) preferred to restrict to species with bare or only a few setae on subepaulets, and hairy eyes, and since referred to *Stypochela* by Fairchild (1958).

Chelommia crassicornis (Wiedemann).

The type in the Kiel collection of Fabricius now at Copenhagen still carries the mistaken label "rufiventris" as called to attention by the describer in differentiating it from Fabricius true type in the Copenhagen collection from India. *Chelommia crassicornis* is obviously Neotropical and probably is the prior name for one of the variants of *T. albibarbis* Wiedemann discussed by Fairchild (1956) under *T. alboater* Walker. Eyes of the type are shrunken as though removed from spirit originally, front very narrow (1:12.0), and agrees with the type of *T. albibarbis* in the Copenhagen collection, in long, slender keel, black, strongly excised plate with acute tooth, slender palpi, red scutellum, red-brown femora, strongly tinted wings, and remains of some sublateral, white-hair spots on reddish abdomen, but differs only in pale-yellow beard, and moderately constricted, but not closed cell R_5.

Available specimens of the group are insufficient to assess the specific value of this last character and I am loathe to assign this old specimen of uncertain preservation to any of the more recently described species. This was, at one time, listed as an unrecognized Nearctic species.

However, I believe *T. alboater* to be a distinct, darker species with almost clear wings, costal cells lightly tinted, and cells R_5 but little narrowed. Three females from Mt. Duida, Venezuela, agree with types of *T. alboater* (which lacks flagellums) and synonym *T. atricornis* Bigot. Scutellums and abdomens brownish black, plates more slender than in the "*crassicornis-albibarbis*" variants, the teeth a little sharper and less produced and with less "hump" on lower margin. The dark type of *T. angustifrons* Macquart, also from Venezuela in BMNH, is soiled but has similar clear wings and head characters, and would have priority if found to be the same.

Chelommia albibarbis (Wiedemann).

A specimen from Caripito, Venezuela, is in good agreement with type but better preserved because of mild greasing of type which accentuates the red of abdomen; cell R_5 is closed at wing margin but not short petiolate as in type. Scutellums and femora reddish. The type of synonym *T. senior* Walker also agrees including cells R_5 closed at wing margin, though the antennae are broken.

None of the above were included in Barretto's (1949) review but have obvious relationships, though whether assignment to *Chelommia* Enderlein or *Chelotabanus* Lutz at the generic or subgeneric levels is proper, remains to be settled. His *C. amazonensis* may be a variant of *C. albibarbis* as suggested by Fairchild (1956), and appears to differ chiefly in more slender plate with longer tooth, slightly thicker palp, and uniformly infuscated wing.

Four females, taken by Schlinger and Ross at Pucalipa, Peru, with *T. basirittus*, differ from the Venezuela homotype of *C. albibarbis*, only in moderately narrowed rather than closed cells R_5, black, not reddish, frontal keels, and darker scapes, pedicels and palpi. The notums and scutellums are slate-gray to blackish with brownish tinges on the edges; much of the notums and all of the scutellums are reddish in typical specimens of *C. albibarbis*. Nevertheless, the shapes of frons, antennae, and palpi, and close agrement in abdominal patterns above and below suggest these to be no more than subspecific differences. Infuscation of the wings, accentuated subcostally and along vein margins, is the same. The pale hairs of the venter are confined to narrower sublateral stripes which widen along the incisures, and the hind tibiae are entirely black-haired with heavy outer fringes.

One is denuded, which, if a few white, scattering hairs on abdomen were overlooked, might be confused with *T. discus* Wiedemann also with worn abdomen, as Krober may have done, but the more uniformly tinted wings, dark beard and pleural hairs, and red antennae of *T. discus* should be distinctive.

Family Pelecorrhynchidae

The following have been transferred to a family of their own, the Pelecorrhynchidae, but are in the literature as Tabanidae.

Pelecorrhynchus xanthopleura (Philippi).

This striking species from Chile has not been recorded since the original inadequate description about which there has been some doubt on account of the variability of hair color in such species as *P. elegans* (Philippi). However, comparison with specimens of *P. longicauda* (Bigot) leaves little doubt that one of each sex has recently been received in material from Chile which permits augmenting description.

Female, 20 mm. Agrees with *P. longicauda* closely in large, blackish appearance, with two admedian notal lines, squamal tufts, and the wings almost orange, head relatively small, and front a little taller than wide. The terminal, abdominal segments can obviously be extended as in *P. longicauda*. The lateral, transverse, gray streaks on sternite 2 agree also, but those on tergites 2 and 3 are much smaller and round, less than the diameter of the hind tibiae. The beards, propleural and notopleural tufts are bright, golden yellow. In Michigan State University from "Pitrufquen," Feb. 21, 1955, Neiva.

The presumed male in CAS from 50 km. E. San Carlos, Nuble, Dec. 26, 1950, Ross and Michelbacher, differs only in small spots on segments 2 to 4 above and below. The eyes are barely contiguous.

Pelecorrhynchus vulpes (Macquart).

The male has not been described and one in Michigan State University from Angol, 29.xi.1958, A. Urjate (?), can be designated as allotype. Length, 17 mm. Unicolorous orange-brown and robust like the female, and even more shaggy, rufous-orange-haired. Eyes contiguous, enlarged facets well-marked and occupying the upper two-thirds with no occipital margin of small facets. Ocellar tubercle with three ocelli prominent and raised above eye level. Frontal triangle small, the antennal bases separated by a little less than their diameters from the eyes and from each other. In profile, head more rounded and face more bulging than female. Antennae and palpi about same shape and length in both sexes, palpi short and stubby, broad dorso-lateral grooves at tips of those of female. Pale creamy tufts of hairs beneath the wing bases of both. There are no described closely related species.

SUMMARY

Described as new are the following Tabanidae: *Esenbeckia schlingeri, Chrysops rossi, Stenotabanus albilinearis, Stypochela inca, Stypommia abdominalis, Tabanus (Lophotabanus) lophus,* and *T. (L.) flavicorpus* (holotype females from Peru); *Stenotabanus macroceras* (holotype female from Venezuela); *Tabanus quadripunctatus amabilinus* (holotype female from Brazil (=*amabilis,* author's not Walker); *Dicladocera tinctipennis* (holotype female from Ecuador); *Dichelacera (Catachlorops) auripilis* (holotype female from Colombia); and *Stypochela neominos* (holotype female from Bolivia). *Coracella,* new subgenus, is erected for *Mesomyia carbo* (Macquart) from Chile. New synonymy includes: *Diatomineura leucothorax* Ricardo equals the older *Scaptia atra* (Philippi); *Chaetopalpus coracinus* (Philippi) equals the older *Veprius presbiter* Rondani (not of authors); *Tabanus pungens* Wiedemann is the earliest name for *T. desertus* Walker, *T. propinquus* and *T. sallei* Bellardi, and *T. angustivittus* Krober; *T. impressus* Wiedemann equals the older *T. piceus* Thunberg. Variation in and systematics including lectotype establishment of some other Neotropical species is discussed, particularly of species taken in Peru by the California Academy of Sciences Expedition.

ADDENDUM

This opportunity is taken to call the attention to emendations which are needed in a previous paper on Neotropical Tabanidae (Philip, 1958, *Pan-Pacific Entomologist,* 34:63–76). Page 63, line, 30, distinct, not "direct"; p. 64, line 6, delete "1" in "cross veins"; p. 71, line 23, correct "*Listraphia*"; p. 75, replace line 25 with ". . . tergite 2 than on the following three tergites. The other two . . ."; p. 76, line 25, complete "General . . . ," and line 41, replace "*Chaetopalpus annulincornis*" with *Tabanus anachoreta.*

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MANTLE CAVITY, HABITS, AND HABITAT IN THE BLIND LIMPET, *LEPETA CONCENTRICA* MIDDENDORFF[1]

BY

C. M. YONGE
University of Glasgow

INTRODUCTION

The tribe Patellacea (Docoglossa) comprises three families, the Acmaeidae, Patellidae, and Lepetidae, better considered in this order than with the more specialized Patellidae first as in Thiele (1931). In the first of these there is a single aspidobranch ctenidium turned on its side and directed to the right with the addition, in the genus *Lottia,* of secondary pallial gills. In the Patellidae these gills alone occur, there being no ctenidium. The ring of gills is interrupted anteriorly in *Patina (Helcion), Nacella,* and *Cellana* but is complete in *Patella.* Details of the structure and of the ciliary currents in both ctenidia and pallial gills are given elsewhere (Yonge, 1947) where the various means of detecting the presence of suspended matter by osphradia and sensory streaks are described, and also the manner in which this is accumulated and finally removed. In *Acmaea (Patelloida) tessulata* and *A. virginea* both exhalant current and collected sediment pass back along the pallial grooves which they leave in the mid-line posteriorly.[2] But the pres-

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[1] From the Friday Harbor Laboratory, University of Washington.

[2] This is not true of many Pacific species of *Acmaea* where the greater water movements apparently ensure cleansing of the pallial grooves (personal observations at Pacific Grove).

ence of the secondary gills in the pallial grooves makes this impossible in other genera. In *Lottia gigantea,* which lives intertidally on exposed and usually steeply sloping or precipitous rocks, cleansing is largely the work of water movements (Abbott, 1956). In *Patina* the bulk of the waste material is embedded in mucus secreted by a glandular streak around the margin of the foot. In this state it is carried to the front of the foot by ciliary action. Material which collects on the mantle margins is carried to the right side of the head and there removed in the relatively weak exhalant current. In *Patella,* where a glandular streak occurs along the side of the foot in young individuals only, sediment is conveyed by cilia to the middle of the right side where it accumulates on the side of the foot for periodic expulsion, in a manner reminiscent of the expulsion of pseudofaeces in bivalves, by sudden contraction of the shell muscles (Yonge, 1947).

It will be noted that in these limpets—all of them intertidal in habitat—creation of a respiratory current by either ctenidium or pallial gills produces the need for mechanisms to rid the mantle cavity of matter carried in suspension in this current. In the Lepetidae, however, neither ctenidium nor secondary gill is present while these limpets are sublittoral in habitat. It follows that the nature of the ciliary currents, never previously observed, within the nuchal cavity and pallial grooves becomes a matter of some interest.

Family Lepetidae

Apart from the absence of any form of respiratory outgrowth, members of this family are characterized by lack of eyes, by a radula which possesses a median tooth absent in the Acmaeidae, and by the lateral prolongation of the head into a pair of labial processes (fig. 2). The few species of the two constituent genera, *Lepeta* Gray 1847 and *Propilidium* Forbes & Hanley 1849, are sublittoral inhabitants of cold and polar seas, especially in the Northern Hemisphere. Although *Lepeta caeca* Müller, the northern blind limpet, which occurs on both sides of the North Atlantic, is probably the best known species, repeated attempts to obtain this by dredging in the Clyde Sea area (where it has been recorded) proved fruitless. It was therefore particularly gratifying, while working at the Friday Harbor Laboratory of the University of Washington during the summer of 1959, to find that the closely related *L. (Cryptoctenidia) concentrica* Middendorff was common in the waters around the San Juan Islands. It is a pleasure, at this point, to record gratitude to Dr. R. L. Fernald, Acting Director of the Laboratory, to Dr. Dixy Lee Ray, and to other colleagues and fellow workers.

Lepeta concentrica Middendorff

Shell. Summarizing the description by Oldroyd (1927), the shell is depressed and conical with the apex directed forward and the anterior slope about one-third or less the length of the shell. The surface of this is usually light brown and bears faint radiate striations. The outline is oval but a little narrower in front; the anterior slope is slightly concave and the posterior slope convex. The edges of the shell are smooth and the inside is polished with the anterior terminations of the muscle scar very slightly behind the apex and with the posterior region much nearer to the margin of the shell. A length of about 20 mm., a breadth of 16 mm., and a height of 8 mm. are attained.

Distribution. Oldroyd reports the presence of this species from Icy Cape in the Arctic to Puget Sound and also in the Okhotsk Sea. Around the San Juan Islands it is common on suitable bottoms, certainly down to 25 fathoms as reported by Oldroyd and probably deeper. Like all members of this family, it is exclusively sublittoral. It never occurs in numbers together and was most characteristically taken in dredgings in some 45 meters in Griffin Bay off the southeast of San Juan Island. Here the bottom is of dense mud on the surface of which smooth, rounded stones about 7 cm. in greatest diameter apparently occur in some numbers. The upper surface of these bears a variety of encrusting organisms, notably bryozoans, balanoids, and serpulids, and with them there was usually found one and very occasionally two of these limpets (see fig. 1). In these depths there is no algal growth so that the limpets must feed largely, if not exclusively, on the organic detritus which will settle continuously out of the water in such regions of mud deposition. Steady deposition of food is clearly essential owing to the small area of feeding surface—not more than about 30 sq. cm. in most cases—available to any one limpet, because the surrounding mud represents an impassable barrier to such animals. Clearly on more extensive rocky surfaces they will not be so confined, but there will also be less deposition on these so that a wider feeding range will be necessary.

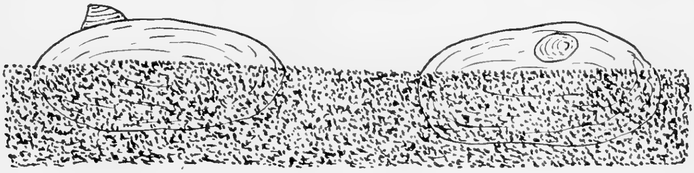

Figure 1. *Lepeta concentrica*, habitat on stones lying on mud at about 45 meters depth in Griffin Bay, San Juan Island, showing isolation of individual limpets. × ½.

EXTERNAL STRUCTURE. Examination of the animal from the ventral aspect (fig. 2) reveals the great simplicity of external structure. The mantle is fringed with a single row of minute and evenly distributed tentacles, not comparable with the pallial tentacles in *Patella* and notably smaller than those in *Acmaea* (Yonge, 1947). The head bears a pair of short, rather stout tentacles without eyes. Laterally it is extended into the distinctive pair of labial processes which will sweep the surface of the rock on either side of the mouth as the animal moves and feeds. They may have sensory powers or could perhaps push food toward the mouth, but if so by muscular and not ciliary action because the head is not ciliated. The slitlike mouth opens repeatedly to expose the radula.

The nuchal cavity is shallow and contains only the openings of the anus and of the kidneys, situated together on papillae on the right side. Ctenidium, osphradia, and also, as noted by Thiem (1917), the senory streaks present in other Patellacea are absent. In justification of an earlier surmise (Yonge, 1947), the loss of these sensory structures has been found to be accompanied by loss of ciliation throughout the nuchal cavity.

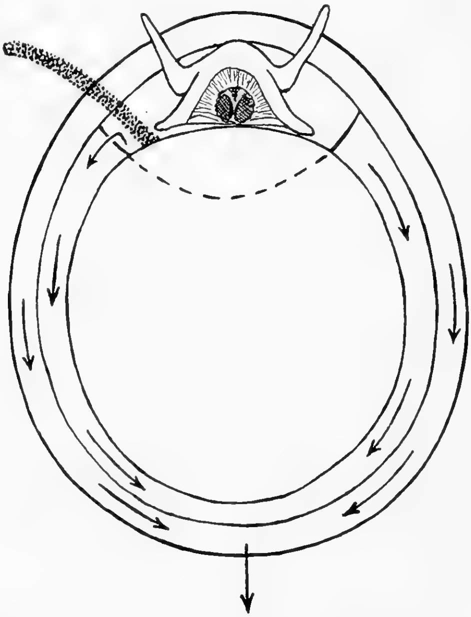

Figure 2. *Lepeta concentrica*, ventral aspect showing head with labial processes and tentacles (no eyes), foot, pallial grooves and extent, indicated by broken line, of nuchal cavity containing anus and renal openings. Arrows indicate direction of ciliary currents in pallial grooves; faecal rod emerging from nuchal cavity on right side. × 4.

In the absence of secondary gills, the pallial grooves are featureless. The usual blood vessel runs around the mantle, a little distance from the margin. Ciliation both on the mantle (except around the head) and on the sides of the foot is well developed and, as indicated by the arrows in figure 1, material is carried rapidly to the midline posteriorly where the groove is shallowest and there, consolidated in mucus, it is passed out.

While disposal of sediment from the pallial grooves thus follows the same course as in *Acmaea tessulata* and *A. virginea* (Yonge, 1947), this is not true for the faeces. The small faecal pellets characteristic of these species of *Acmaea* (Moore, 1931) are conveyed along the right pallial groove for similar posterior expulsion. In *L. concentrica,* however, the faeces in the form of long, slightly curved rods are pushed directly out from the right side of the head, as shown in figure 2. These rods have a diameter of 0.5 mm. and are often over 1 cm. long; they are mud colored and appear to be almost entirely composed of minute particles of sand. They are produced in very great quantity.

Behavior. Specimens of *L. concentrica* were observed in the aquarium and also in bowls of sea water under the binocular dissecting microscope. They differ in behavior from intertidal Acmaeidae and Patellidae in two important respects. When exposed to air on the surface of a stone they invariably move down below water level, and they also move about more continuously and more rapidly. There is every indication that they are engaged primarily in collecting detritus rather than in scraping the rock surface. When moving, the shell margins are just clear of the rock surface by perhaps as much as 0.5 mm. The minute pallial tentacles may be just visible in some areas, but the cephalic tentacles are not usually to be seen except when the animal is viewed as it moves over the curved edge of a stone. The long faecal rods are continuously being extruded on the right side of the head, indicating corresponding activity in feeding. The only discernible current, and that only gentle, emerges from under the shell posteriorly.

Discussion

While retaining the form and general habit of the other Patellacea, the Lepetidae have exploited the possibilities of life in the sublittoral (in some cases to considerable depths). This has followed the loss of the ctenidium but, unlike the Patellacea, without the appearance of secondary gills. The apparent loss in respiratory efficiency may well have been made good by the possibilities of uninterrupted respiration under conditions of continuous submergence. In any case the loss of respiratory currents, whether caused locally by a ctenidium or more generally by pallial gills, has the major and probably all important compensating advantage of removing the problem represented by the need for disposing of sediment entering with such currents. Now that sediment is no longer carried into the nuchal cavity or the pallial grooves, the osphradia and the sensory streaks needed for its detection (Yonge, 1947) disappear. The nuchal cavity is devoid of cilia while ciliation in the pallial grooves is adequate to clear these of any sediment raised as the animal moves.

With the sublittoral habit and the habit of feeding on organic deposits (doubtless including bottom diatoms, etc.) may be correlated the loss of sensory equipment represented by the disappearance of the eyes and reduction of both cephalic and pallial tentacles. The characteristic labial processes may possibly aid in collection of food which, in the form of constantly settling deposits, needs to be widely scooped up by the continuously moving animal.

The Lepetidae may thus be regarded as a group of archaeogastropod which, like the Patellidae, are to be derived, as originally suggested on purely morphological grounds by Thiem (1917), from the more primitive, because still ctenidial-bearing, Acmaeidae. But whereas both groups have lost the ctenidium, in the Patellidae this has been replaced by secondary gills which, with the elaboration of better methods for ridding the mantle cavity of sediment, increase efficiency in the intertidal habitat, while in the Lepetidae it is loss of this structure accompanied by change in habits which has made sublittoral life possible, under conditions, moreover, where there is much deposition of sediment (see fig. 1).

The course of evolution within the Acmaeidae and Patellidae, involving change in conditions in the mantle cavities of *Acmaea (Patelloida), Lottia, Patina,* and *Patella,* has been outlined and illustrated elsewhere (Yonge, 1947, fig. 23). The present study would derive the Lepetidae also from the Acmaeidae. Palaeontological evidence supports these conclusions. According to Wenz (1938), the Acmaeidae appeared in the middle of the Triassic to be followed by the Patellidae near the end of the Jurassic and by the Lepetidae at the beginning of the Miocene.

The sublittoral habit in limpets is not common. The great majority of archaeogastropod limpets, i.e., the Fissurellidae and the Patellacea, are intertidal. So also are the marine pulmonate limpets such as *Siphonaria* (Yonge, 1952, 1960) and *Trimusculus* (Yonge, 1958, 1960), and also *Hipponix* (Yonge, 1953, 1960) among mesogastropods. Apart from some mesogastropod ciliary-feeding Calyptaeidae and Capulidae, the only gastropod limpets (i.e., excluding the monoplacophoran *Neopilina*) occurring in deep water appear to be members of the Cocculinacea, such as *Addisonia,* in which the ctenidium extends back along the right pallial groove (Dall, 1889). Although possessing an aspidobranch ctenidium, in all other respects these animals are mesogastropods with the means of internal fertilization and direct development. They live in great depths and for that reason have never, unfortunately, been examined in life. Strictly speaking, therefore, the Lepetidae appear as the only exclusively sublittoral group of truly archaeogastropod limpets.

Summary

The family Lepetidae, as exemplified by *L. concentrica* here examined, is composed of forms which are characteristically adapted for life in the sublittoral where they invariably occur.

Lepeta concentrica feeds on detritus which involves continual movement over the feeding surface which may not exceed 30 sq. cm. This indiscriminate feeding may explain the loss of eyes and reduction of pallial and cephalic tentacles. The characteristic labial processes may be concerned with drawing food toward the mouth.

Neither ctenidium nor pallial gills occur. Correlated with the absence of indrawn sediment, osphradia and sensory streaks present in other Patellacea are lacking. The shallow nuchal cavity is unciliated; in the pallial grooves particles are carried posteriorly.

The position of the Lepetidae within the Patellacea (Docoglossa) is considered. Loss of the ctenidium present in the more primitive Acmaeidae, together with change in habits, accounts for their movement into the sublittoral which they are the one group of the Archaeogastropoda successfully to exploit.

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FURTHER OBSERVATIONS ON *HIPPONIX ANTIQUATUS* WITH NOTES ON NORTH PACIFIC PULMONATE LIMPETS[1]

BY

C. M. YONGE
University of Glasgow

INTRODUCTION

The observations on mesogastropod and pulmonate limpets here recorded represent continuation of earlier work on *Hipponix antiquatus* (Linnaeus) and on *Trimusculus (Gadinia) reticulata* (Sowerby) (Yonge, 1953, 1958) carried out in California, while examination of *Siphonaria alternata* Say at Bermuda (Yonge, 1952) forms the basis for the notes on two north Pacific siphonariids. Acknowledgments for assistance are gratefully made to Dr. L. R. Blinks and Dr. D. P. Abbott of the Hopkins Marine Station, Pacific Grove, where the bulk of the work was done; to Mr. James A. McLean, of Stanford University, who collected specimens of *Williamia vernalis* by diving and provided information about this and other species; to Dr. R. L. Fernald, Acting Director of the Friday Harbor Laboratory, who collected the specimens of *Siphonaria thersites* from San Juan Island which were examined in the Department of Zoology, University of Washington; and to Mr. W. J. Eyerdam of Seattle for shells of this species collected by him in Alaska.

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[1] From the Hopkins Marine Station, Pacific Grove, and the Department of Zoology, University of Washington.

HIPPONIX ANTIQUATUS (LINNAEUS)

Although far from uncommon from mid-tidal levels downward on exposed rocky shores, *H. antiquatus* often demands careful search owing to its habit of living in narrow, often overhung, crevices. Earlier study (Yonge, 1953) had emphasized the very specialized sedentary habit with secretion of a ventral "valve" cemented to the substratum. Surprisingly it is not a ciliary feeder like the related Calyptraeidae and Capulidae, but gropes for food, largely fragments of calcareous algae, by means of the proboscis. In the course of the present observations, animals were seen to extend the proboscis well beyond the margins of the shell and actively to search for and to swallow such fragments. All animals previously examined in 1949, were females and the tentative conclusion was reached that *H. antiquatus* is a protandrous hermaphrodite in which "owing to the sedentary habit and to the rough water in which it lives, cross fertilization may be impossible and it appears more probable that spermatozoa produced during the male phase are stored in the receptaculum for fertilization of eggs produced in the subsequent female phase." Such a condition is known to exist in the bivalve wood borer, *Xylophaga dorsalis* (Purchon, 1941).

HABITS. Important additional information about the habitat and numbers of this species was provided by the effects of the great storm which struck the coast of central California on February 16, 1960. Coinciding with spring tides this did extensive damage and granite blocks of great size and weight were displaced on the exposed northwestern side of Point Cabrillo where the Hopkins Marine Station is situated. The floor and roof of often extensive but previously inaccessible crevices into which a hand could not have been inserted, were exposed together with a rich and characteristic fauna of largely attached animals. The more varied fauna, to be mentioned later when discussing *Trimusculus,* covered the roof, i.e., occupied the previous undersurface of the turned boulders. But the uncovered floor (never the roof) was usually thickly covered with either the shells of living *H. antiquatus* or with recent scars. Adjacent animals often touched one another. Thus 45 animals were counted in an area 25 by 20 cm. and 59 animals or recent scars in another area some 15 cm. square. The shells ranged from 8 to 20 mm. in greatest aperture diameter although this is an indifferent criterion of either size or age because the height varies greatly.

PRESENCE OF MALES. Revelation of the large populations within this protected and, clearly for these animals, ideal habitat raised again the question of the presence of males. These, however, could certainly not be mobile, as they are in the Calytraeidae or in *Capulus,* beause all specimens of *A. antiquatus* were cemented. Representative samples were taken from these areas and examination soon revealed the presence of males.

As shown in figure 1, these individuals possess a penis which comes off, as in other Mesogastropoda, at the base of the right cephalic tentacle. What is unusual is the length and bifid end of this organ in *A. antiquatus*. Even when still very wrinkled and clearly capable of much further distension, it may extend beyond the margin of the shell (fig. 1). It may also contract into a rounded mass within the mantle cavity. The seminal groove extends along the posterior side of the penis and so along that surface of the posterior terminal bifurcation, opening at the tip of this. The function of the anterior limb must remain conjectural until the process of copulation has been observed which requires examination of colonies of attached individuals. Possibly it attaches to the margin of the shell of an adjacent female while the functional tip of the penis enters the oviduct.

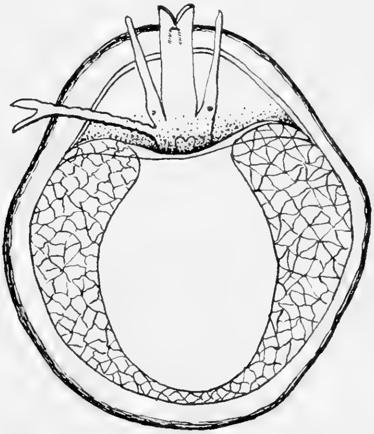

Figure 1. *Hipponix antiquatus*, male, viewed from ventral aspect after removal of under "valve." Note presence of extensile, bifid penis on right side. × 14.

Of 89 animals examined, 13 were males (one with only a rudimentary penis) and 76 females. The former ranged in aperture length from 6.0 to 10.0 mm.; the latter from 7.0 to 20.0 mm. There is thus evidence that the animals are protandric hermaphrodites. Part of the length overlap is certainly due to the extremely variable shape of the shells. The disparity in numbers between the sexes may be due to the time of year: 23 out of the 76 females were carrying egg capsules with young in all stages of development. Fertilization of many animals must therefore have occurred and many former males may have lost the penis in the process of sex change.

Revelation of the presence of these dense colonies of *H. antiquatus* in the protection of deep crannies helps in the understanding of the mode of life of this and allied species. Settlement must take place almost immediately after hatching when the young crawl vigorously; their behavior being such as to keep them in darkness and on the floor of the rock cleft. The presence of an unusually long penis will enable the attached male to fertilize adjacent females in the same manner that the hermaphrodite acorn barnacles fertilize each other. It is not unusual to find isolated specimens of *H. antiquatus* but it does not seem possible that they can either fertilize in the male phase or be fertilized in the female phase. However, the presence of these dense and well protected colonies will ensure the continuance of the population.

TRIMUSCULUS RETICULATUS (SOWERBY)

Further information about the habitat, and also abundance, of this pulmonate limpet of which the mantle cavity and habits have previously been described (Yonge, 1958) was also provided by the effects of the storm on February 16, 1960. What had formed the upper surfaces of these low and extensive crannies were found richly covered with encrusted animals. These included the barnacles, *Tetraclita squamosa rubescens* and *Balanus nubilis,* a variety of serpulids, and, among Mollusca, *Chama pellucida* (which, unlike *Pseudochama exogyra,* does not settle among weeds on more exposed rock faces), *Pododesmus macroschisma,* and *Hinnites multirugosus,* the last two being by no means confined to such an environment. But the most characteristic member of this roof fauna was *T. reticulata.* It is just as confined to the roof of these crevices as *Hipponix* is to the floor. And, like that species, it occurs in compact colonies with shells often in contact. In one area some 30 by 12 cm. there were 51 animals, in another, 22 by 12 cm., 47 were counted. The limpets varied in diameter from 8 to 28 mm.

Internal fertilization is just as essential to these hermaphrodite pulmonates as to mesogastropods such as *Hipponix.* But a gregarious habit might seem less important because *T. reticulata* is certainly mobile, moving actively in aquaria where it crawls up to the water level and above, there respiring in air (Yonge, 1958). Despite this power of movement, the colonies exposed on the upper surfaces of overturned rocks persisted unchanged for certainly six weeks after exposure although this must involve death in the heat of summer. While intertidal species of *Acmaea* so exposed out of their normal environment would quickly have dispersed, behavior in *T. reticulata* is apparently restricted to upward movement (hence their concentration on the roof of crevices) and away from water and, possibly, light. This unnatural exposure on a flat surface in the upper intertidal region provokes no reaction. There is no upper surface on which to move, water seldom reaches them, and there is no gradient of illumination.

Presumably, the young which crawl out of the egg masses (not yet observed) go normally to maintain or swell the existing colony in the particular rock crevice. This specialized habit, resembling—apart from the retention of mobility—that of *Hipponix,* is in sharp contrast to the less ecologically restricted habit of most Siphonariidae (Yonge, 1958).

Siphonariidae

These highly successful pulmonate limpets are extremely abundant in the Southern Hemisphere especially in the Indian Ocean and the western Pacific. Few species occur in the Northern Hemisphere. Around North America, *Siphonaria alternata* Say and *S. pectinata* Linnaeus occur along southern Atlantic shores, the former extending to Bermuda where it is abundant intertidally on the pitted aeolian limestone (Yonge, 1952). It grips firmly, has a stout shell, and possesses all the adaptations of an intertidal limpet. On the Pacific Coast, *S. thersites* Carpenter ranges from the Aleutian Islands to the Straits of Juan de Fuca, *S. brannani* Stearns from Santa Barbara to Laguna Beach, while the allied *Williamia vernalis* Dall occurs along the entire coast of California with *W. peltoides* Carpenter along the southern half of this, extending into the Gulf of California (Oldroyd, 1927: Keen, 1937).

Two of these species, *S. thersites* and *W. vernalis,* were examined in life and proved of great interest because of the contrast they present to conditions in *S. alternata,* itself probably broadly representative of the great majority of the siphonariids.

Siphonaria thersites Carpenter

The specimens examined were collected by Dr. R. L. Fernald on the rocky shore near Kanaka Bay on the western, more exposed, shore of San Juan Island where they live high on the shore associated with *Fucus.* Compared with *S. alternata* and certainly the great majority of other species of the genus, the thin and asymmetrically coiled shell with the apex near the posterior end is very small (fig. 2). It is flattened and caplike with the characteristic siphonal extension on the right side and appears to be perched on top of the column of the relatively massive foot (fig. 3). The animal cannot be contained within it. The head is small, without tentacles but with minute eyes marginally on the upper surface. The limited overhang of mantle and shell implies that there is effectively no pallial groove. The characteristic siphonariid siphon, with the anus opening on it, projects to the level of the widened shell margin on the right side. The surface of the tall foot is covered with some six rows of white glands which, on mechanical stimulus, produce a very copious densely white and viscid secretion. They also occur on the head and the siphon. These glands occur in all siphonariids examined and are probably repugnatorial, indeed in *A. thersites* they appear to represent the sole means of defense.

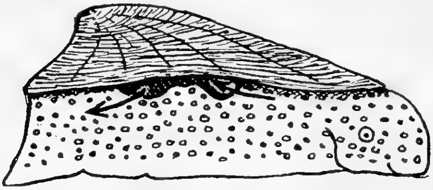

Figure 2. *Siphonaria thersites*, viewed from right side, showing siphon with arrows indicating inhalant and exhalant currents, also glands on sides of foot and on head. × 14.

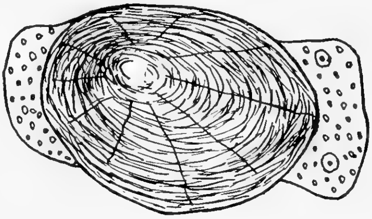

Figure 3. *Siphonaria thersites*, viewed from above when crawling, showing extension of head in front and foot behind the small asymmetrical shell. × 14.

Outside the mantle cavity the surface is unciliated, precisely as in *S. alternata*. A slow current enters the mantle cavity by the anterior, inhalant, opening and leaves by the exhalant opening on the posterior side of the siphon. Within the cavity there is precisely the same arrangement of organs as described in *S. alternata* (Yonge, 1952). The filaments of the secondary gill hang down from the roof but the respiratory current is largely produced by dense cilia on an underlying ridge on the floor of the cavity. These secondarily acquired but undoubtedly highly efficient respiratory organs possibly represent a major factor in the success of the Siphonariidae. The much more restricted *Trimusculus* has no such gills (Yonge, 1958).

The habitats of *S. thersites* are most interesting. Alike at San Juan Island and in Alaska it occurs on *Fucus*. It feeds on this, excavating rounded depressions and discharging long faecal threads of fucoid materials from the anus as it does so. The animal is active for a limpet; it crawls quickly along *Fucus* or on a glass surface groping with the broad, rather suckerlike head. The general appearance is shown in figure 3. There is a tendency to move up the sides of an aquarium. It appears that this species occurs in cracks in rocks during the summer so achieving protection from high insolation. Probably it emerges to feed on *Fucus* by night. The unusual reduction of the shell and accompanying greater mobility may therefore be associated with the mode of life, the animal feeding on *Fucus* high on relatively exposed shores where protection is needed both against the heat of the sun in the summer and also from storms. It may even hibernate under such conditions at the northern end of its range.

Siphonaria thersites may therefore be regarded as a siphonariid of specialized and restricted habitat. This could account for its far northern distribution.

Williamia vernalis Dall

The obvious difference between the shell in this genus and in the closely related *Siphonaria* is the absence in the former of a siphonal projection. The shell in *W. vernalis* is smooth and perfectly symmetrical with a backward pointing apex some one-third of the distance from the posterior end. The shell is reddish brown with lighter colored rays radiating from the apex (see Oldroyd, 1927, for full description).

The appearance of the animal when viewed ventrally is shown in figure 4. Although Mr. McLean states that fully grown animals are blue, the young specimens examined, the largest with a shell aperture 5.5 mm. long by 4.0 mm. wide, were all bright red. This pigmentation occurs on the sides of the foot, on the top of the head, and on the mantle although there it forms radiating bands alternating with lighter areas, six on each side, in which the white glandular patches are conspicuous. Equally numerous on all surfaces, they

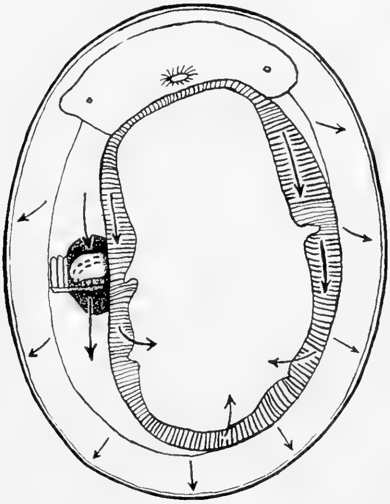

Figure 4. *Williamia vernalis*, viewed from ventral aspect showing head with small mouth, foot (sides shaded) and large pallial opening, with siphon (bearing anus) on right side. Marginal pallial gills shown. Arrows indicate inhalant and exhalant currents also cleansing currents in pallial grooves (rejection via posterior surface of foot). × 24.

are obscured in the pigmented areas. The mantle is more extensive than in *S. thersites* (although not more so than in *S. alternata*), the shell which it secretes being pulled down completely over the animal. Indeed the head barely projects beyond this when moving. The wide and deep pallial grooves so formed differ from those of the other two species in being ciliated. As indicated by the arrows in figure 4, particles are carried rapidly backward within the groove and along the sides of the foot and then rejected by way of the sole of this posteriorly. Peripherally there is an outward movement of particles along the mantle margin.

The head has the typical siphonariid appearance, flattened, without tentacles, and with a pair of minute eyes. The pallial opening is wide and much internal structure can be seen without dissection; the most marginal of the pallial gills can be seen from the ventral view (fig. 4). The width of the inhalant and exhalant openings through which powerful currents pass may explain the absence of a siphonal extension to the shell in this genus. The disposition and mode of functioning of the pallial organs are the same as in *S. alternata*.

The habits and habitat of *W. vernalis* are in interesting contrast to those of *S. alternata* and *S. thersites*. The first of these is midtidal (Yonge, 1952), the second, as reported above, is a specialized inhabitant of the upper shore. *Williamia vernalis*, on the other hand, occurs very low on the shore, to be collected only at low spring tides and, more suitably, by diving in the shallow sublittoral. It occurs there on the shells of *Tegula brunnea*, sometimes dead and inhabited by hermit crabs, or on those of *Astrea gibberosa*, as well as on rocks, but probably always associated with the presence of red coralline algae on which it appears to feed. In movement the broad head lobes move actively from side to side as the animal explores the surface over which the radula scrapes. From his observations while collecting, Mr. McLean considers that *W. vernalis* requires a protected environment. The delicate shell would indicate this but most of all the presence of powerful cleansing currents in the pallial grooves. This provides evidence that this limpet lives in regions where water movements are too weak to ensure cleansing, in contrast to conditions in *Lottia gigantea* (Abbott, 1956) and in the majority of local intertidal species of *Acmaea* (personal observations) where cleansing is brought about by water movements. And this is also true of the two species of *Siphonaria*.

SUMMARY

Overturning of major boulders in the upper tidal region on Point Cabrillo, Pacific Grove, by a major storm on February 16, 1960, revealed dense colonies of *Hipponix antiquatus* on the floor of previously inaccessible crevices. The presence of nonmotile males having an unusually extensile and

bifid penis was established but all the larger animals were female, indicating protandry. Maintenance of this attached species is probably ensured by the existence of these dense, well protected colonies.

Equally dense colonies of the pulmonate limpet *Trimusculus reticulatus* occurred on the roof of these crevices. This concentration appears to be the result of behavior and ensures cross-fertilization and protection from desiccation.

Siphonaris thersites lives associated with *Fucus* on the upper shore in the north Pacific. Mobility due to reduction of the shell enables it to find protection from insolation within cracks in the rocks.

Williamia vernalis is an inhabitant of the low intertidal and shallow sublittoral. Absence of the siphonal extension of the shell in this genus may be due to the wider opening into the pallial cavity. The presence of cleansing cilia in the pallial grooves indicates life in sheltered areas of still water.

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REVISION DER CHILENISCHEN MISOLAMPINI: GATTUNGEN *HELIOFUGUS* GUÉRIN UND *MYRMECODEMA* GEBIEN (= MYRMECOSOMA GERMAIN) (COLEOPTERA: TENEBRIONIDAE)

Von

HEINZ FREUDE

Entomologische Abteilung der Zoologischen Staatssammlung München

Schon vor längerer Zeit trug mir Herr Hugh B. Leech, Associate Curator of Insects an der California Academy of Sciences, die Bearbeitung der Tenebrionidae der Ausbeuten Ross-Michelbacher aus Chile an mit dem Endziel, eine Tenebrionidenfauna Chiles zu veröffentlichen. Ich sagte damals unter der Bedingung zu, daß mir genügend Zeit gelassen würde, weil ich gerade mit der monographischen Bearbeitung der Monommidae der Welt beschäftigt war und ohnehin durch meine vielseitige Berufstätigkeit an der Zoologischen Sammlung des Bayerischen Staates in München so stark in Anspruch genommen bin, daß ich mit sehr langen Zeitspannen rechnen muß. Herr Leech kam mir in dieser Hinsicht in außerordentlich verständnisvoller Weise entgegen, wofür ich ihm ganz besonders danken möchte. Inzwischen hat mein glücklicherer Kollege, Herr Hans Kulzer vom Museum G. Frey in Tutzing, bereits einige Gruppen südamerikanischer Tenebrioniden bearbeitet und das diesbezügliche Material der Ausbeuten Ross-Michelbacher mit einbezogen. Weiter ergab sich, daß viele Gattungen der amerikanischen Tenebrioniden noch keinerlei grundlegende zusammenfassende Bearbeitung erfahren haben. Das erschwert die Aufgabe wesentlich und es bleibt mir nichts weiter übrig, als zunächst die erforderlichen Gattungsrevisionen vorzunehmen. Diese sind deshalb so schwierig, weil es ohne Studium der Typen, nur anhand der meist unzureichenden Beschreibungen, in der Regel unmöglich ist, eine Art sicher zu deuten. Vielfach sind aber die Typen nicht mehr vorhanden oder nicht zu erhalten, was eine Bearbeitung zusätzlich erschwert wenn nicht überhaupt unmöglich macht. Im Falle des Verlustes der Typen kann nur die Aufstellung eines Neotypus eine sichere Arbeitsunterlage geben. Mit dieser Arbeit soll nun meinerseits wenigstens ein erster Baustein zu der großen Aufgabe beigetragen werden und ich hoffe, daß diesem bald weitere folgen werden.

Meine Methode, späteren Bearbeitern die zeitraubende und oft schwierige Literaturbeschaffung zu ersparen und die Urbeschreibungen mit abzudrucken, möchte ich auch hier anwenden und bin überzeugt, daß solche Arbeitserleichterung einst dankbar begrüßt werden wird.

Für Unterstützung meiner Arbeit insbesondere durch Material ist es mir eine angenehme Pflicht, außer Herrn Leech noch einer Dame und einigen Herren meinen verbindlichsten Dank zum Ausdruck zu bringen. Es sind: Fräulein Dr. C. von Hayek und Herr Keeper Dr. Riley vom British Museum; Herr Konsul a.D. G. Frey und sein Mitarbeiter, Herr H. Kulzer; Herr Direktor Dr. Zoltan Kaszab am Museum Budapest; Herr Prof. Dr. G. Kuschel, Santiago; Herr Chefarzt Dr. G. H. Nick, Sao Paulo; Herr Prof. Dr. H. Sachtleben, Direktor des Deutschen Entomologischen Instituts, dem ich besonders für seine Literaturhilfe danken möchte und sein Mitarbeiter, Herr Prof. Dr. Machatschke; Herr Sous-Directeur. Dr. A. Villiers und Herr Assistent Dr. Guy Colas am Museum Paris.

Nachdem die Arbeit bereits abgeschlossen war, erhielt ich noch reiches und besonders interessantes Material mit guten Fundortangaben von Herrn Louis E. Peña, Santiago, dem ich ganz besonders dafür danken möchte. Es zwang mich, die Arbeit zu erweitern und neu zu gestalten. Vor allem zeigte es, daß mit dem bisher in den Museen befindlichem Material nur ein geringer Teil des Artenbestandes erfaßt worden war und daß Tiere ohne genaue Fundorte keine sicheren Schlüsse zulassen. Selbst das mir nun vorliegende Material reicht noch nicht aus, um umfangreichere Rassenkreise zu erkennen, was nach dem alten Material wegen der nahen Verwandtschaft der Arten zunächst leicht schien.

Chile ist durch seine riesige geographische Breitenausdehnung und die im gesamten Gebiet vorhandenen beträchtlichen Höhendifferenzen faunistisch ganz besonders reich und interessant, aber auch schwer überschaubar. Es müßte in jahrelanger, systematischer Sammeltätigeit Material aus allen Regionen zusammengetragen werden, um ein einigermaßen lückenloses Bild zu erhalten. Die Ausbeuten von Ross-Michelbacher und Peña mit seinen Mitarbeitern lassen ahnen, welcher Reichtum der Fauna, speziell auf dem

Gebiete der Coleoptera, vorhanden sein muß. Große Serien von den einzelnen Fundorten lassen die Variationsbreite erkennen und ermöglichen dadurch sichere Schlüsse auf rassische Verwandtschaftsbeziehungen. So kann ich die chilenischen Sammler nur bitten, in ihrem Eifer, der schon gute Erfolge gebracht hat, unvermindert fortzufahren und bedaure lebhaft, daß ich nicht selbst die Gelegenheit habe, an Ort und Stelle mitzutun.

HELIOFUGUS Guérin

Die Gattung *Heliofugus* ist mit Ausnahme des weit über Südamerika verbreiteten *H. sulcatus* Guérin auf Mittelchile, etwa von Coquimbo bis Llanquihue, und das benachbarte Argentinien beschränkt. Sie wurde aufgestellt von Guérin in "Voyage de la Coquille. Zoologie. Tom. II, Part. II, 1re Div., 1830, p. 96."

Urbeschreibung: **Genre Héliofuge, Heliofugus. Guér.** Le Mélasome qui a donné lieu à l'établissement de ce nouveau genre vient encore du Chili; il ressemble beaucoup aux Misolampes; mais il en diffère cependant par le quatrième article des antennes, qui, d'après Latreille, est égal au troisième dans les Misolampes, tandis que, dans notre insecte, cet article est beaucoup plus court. Dans les Misolampes, la lèvre inférieure est prèsque carrée, à peine plus large à l'extrémité, aussi longue que large; tandis que, dans le genre Héliofuge, elle est transversale, ou beaucoup plus large que longue, étroite à la base et plus large à l'extrémité. Voici les caractères que nous assignons à notre nouveau genre:

Labre arrondi, saillant, transversal, inséré sur une troncature du bord antérieur de la tête.

Mandibules fortes, peu saillantes, bidentées à l'extrémité.

Mâchoires courtes, ayant le lobe externe grand, arrondi, cilié; l'externe très-petit, étroit, terminé par un onglet peu visible et cilié.

Palpes maxillaires assez longes, de quatre articles, le premier court, le second deux fois plus grand, le troisième plus court, et le dernier grand, fortement sécuriforme.

Lèvre inférieure transversale, un peu plus large en avant, avec la languette très-saillant, arrondie, et laissant l'insertion des palpes labiaux à découvert.

Palpes labiaux assez courts, de trois articles, les deux premiers presque égaux, le dernier un peu en hache, arrondi.

Antennes de onze articles, le premier assez grand, le second court, le troisième de la longueur des deux premiers réunis, le quatrième de moitié moins long que celui qui le précède; tous ces articles cylindriques et un peu renflés vers l'extrémité, ainsi que le cinquième et le sixième; les articles suivants aplatis, s'élargissant jusqu'au dernier, qui est un peu plus grand, arrondi et très-obtus au bout.

Zu dieser Beschreibung ist lediglich zu bemerken, daß die Abflachung der Antennenglieder 7-10 durch deren Verbreiterung bedingt ist, während ihre Dicke gleich bleibt. Nur das Endglied verflacht sich zur Spitze.

Die Bezeichnung der Mandibel als 2-zähnig erweckt falsche Vorstellungen. Sie sind 2 gerundete, kneifzangenartig wirkende chitinige Schneiden, die nur als Abschluß je einen kleinen vorspringenden Zahn besitzen.

Ergänzend zu Guérins Beschreibung hat Brême in Revue Zool. 1842, p. 112, folgendes festgestellt:

A ces charactères nous croyons devoir ajouter les suivants. Epistome très-saillant et séparé de l'Epicrâne par une suture, comme dans les genres précédents [= Sphaerotus Kirby und Zophius Brême, der Verf.]. Thorax globuleux tronqué en avant, et rétréci postérieurement. Corps en ovale allongé; Elytres se prolongeant légèrement en arrière. Pattes médiocres. Cuisses un peu renflées. Tibias grossissant vers l'extrémité, qui est soyeuse en-dessous, ainsi que le dessous des tarses; crochets petits.

Was Brême über den Thorax sagt, unter dem das Halsschild bezw. der Prothorax zu verstehen ist, trifft höchstens sehr bedingt zu. Der Prothorax ist allgemein vorn nur abgestutzt, wenn man bei seitlicher Ansicht die schräge Begrenzung gegen den Kopf hin meint, die oben wesentlich weiter vorn liegt als unten und den Prothorax schräg abgeschnitten erscheinen läßt, was aber Brême kaum gemeint haben dürfte. Der Vorderrand des Halsschildes ist nur selten abgestutzt, bei Arten wie *H. collaris* und *H. cryptocephalus* sogar schildförmig vorgewölbt und auch sonst meist konvex. Dagegen ist die Basis des Halsschildes meist ± abgestutzt und höchstens leicht konvex. Weiter ist die Körperform, d. h. die des Körpers ohne Prothorax und Caput, nicht immer langoval, sondern zuweilen ziemlich kurzoval-haselnussförmig.

Unglücklicherweise hat Solier in Gay: Hist. fisica y polit. de Chile (V), 1851, p. 227-228, dieselbe Gattung nochmals unter dem Namen *Euschatia* beschrieben, deren Synonymie bereits von Lacordaire in den Genera des Coléoptères 1859 festgestellt wurde. Soliers Beschreibung lautet:

Urbeschreibung: **Euscatia.—Euschatia.** Mentum parvum, antice in trapezium dilatatum, margine antico in medio in lobum latum, breve et truncatum producto. Labium exsertum, antice dilatatum et subtruncatum. Palpi maxillares articulo apicali compresso, valde dilatato et valde securiformi. Palpi labiales, articulo ultimo inflato ovato et apice truncato. Antennae, articulis quinque ultimis compressis, et in claven oblongam dilatatis; 2-6 conicis; tertio alteris valde longiore; septimo conico, oblongo; 8-10 transversis; ultimo suboblongo, subcylindrico, sed apice rotundato. Tibiae omnes tenues, ad apicem laeviter clavatae.

Barba pequeña, evasada en trapecio anteriormente y prolongada en el medio del borde anterior, el lobulo corto, ancho y truncado. Lengüeta saliente, evasada anteriormente en trapecio, subtruncada, con los ángulos fuertemente redondeados. Palpos maxilares terminados por un artículo grande, dilatado, comprimido y notablemente securiforme. Ultimo articulo de los palpos labiales hinchado, ovoide pero fuertemente truncado en el extremo. Antenas de once artículos, de dos á seis cónicos, oblongos ú oblongiúsculos, y de los cuales el tercero es casi tan largo como los dos siguientes reunidos; de siete á once, comprimidos, dilatados, y formando una porrita oblonga; el séptimo cónico oblongo; de ocho á diez transversales, undécimo levemente oblongo, subcilindrico y redondeado en el extremo. Todos los tibias son delgados, ligeramente espesados en forma de porrita y semejantes muy probablemente en los dos sexos. A los menos son semejantes entodos los individuos que he podido observar. Cuerpo encogido en la base de los elitros con borde marginal muy redondeado.

Este género es bien distinto del precedente [= *Oligocara* Gay et Solier, der Verf.] por la forma de su barba; por su lengüeta no profundamente escotada y por la forma de los tibias anteriores. Se compone de cinco especies.

Agassiz hat in seinem Nomenclatoris Zoologici Index Universalis 1846 den Namen *Heliofugus* in *Heliophygus* umgeschrieben. Er ist durch die sprachliche Unzulänglichkeit des halb griechisch halb lateinischen Namens dazu bewogen worden. Auch Philippi wendet sich gelegentlich der Beschreibung von *H. cryptocephalus* (s. d.) in einer Anmerkung gegen diese "vox hybrida." Artikel 19 der Internationalen Regeln für die Zoologische Nomenklatur besagt, daß die ursprüngliche Schreibung eines Namens beizubehalten ist, falls nicht ein Schreib- oder Druckfehler oder ein Fehler in der Transkription ersichtlich ist. Keiner der erwähnten Fehler liegt hier vor, und selbst solche werden heute in der Regel belassen, weil man auf dem Standpunkt steht, daß ein Name nicht unbedingt einem Wortsinn entsprechen muß (Artikel 32). Fairmaire hat nun in seiner Monographie in den Ann. France (5) 5, 1875, die korrigierte Schreibweise von Agassiz übernommen. Da es sich nur um ein etwas abgeänderte Schreibweise des Gattungsnamens handelt, habe ich keine Veranlassung, seine Arten als unter einem anderen Namen beschrieben anzusehen.

Allgemein ist von der Gattung noch zu sagen, daß ihre Vertreter matur schwarz gefärbt sind, teils glänzend, teils ± matt, nur die Mundwerkzeuge, Antennen und Tarsen können heller sein. Die Elytren haben entweder 9 scharf eingeschnittene und in der Tiefe maschinennahtartig fein punktierte Furchen oder eine entsprechende Reihenzahl von Punkten, die gröber oder feiner bis fast obsolet, ungleich oder annähernd gleich groß, unregelmäßig oder regelmäßig gestellt sein können. Eine Scutellarreihe kann vorhanden sein oder fehlen, zuweilen sogar individuell. Die spärliche Behaarung der Unterseite ist meist abgerieben, nur bei *H. sulcatulus* ist sie kräftig und dicht und sind Kopf und Halsschild auch oberseits deutlich bewimpert. Allgemein stärker bewimpert sind die Tibien auf der Innen- und die Tarsen auf der Unterseite.

Die ♂♂ haben dickere Hintertibien mit einer Bürste abstehender Haare auf deren Innenseite. Dieser Geschlechtsdimorphismus wird bei kleineren Arten ± undeutlich.

Genotypus ist *H. arenosus* Guérin, der gleichzeitig mit der Gattung als einzige Art beschrieben wurde. Guérin erwähnt im Anschluß daran noch eine 2. Art, die bereits von ihm im Magasin de Zoologie veröffentlicht worden sei. Diese als H. "striatus" bezeichnete Art aus Montevideo erschien aber erst 1834 unter dem Namen H. "sulcatus" (s. d.).

Die Gattung *Heliofugus* Guérin läßt sich in 4 Untergattungen einteilen, welche hauptsächlich durch die eigenartige Halsschildform gekennzeichnet sind:

1. Collariheliofugus, *subgen. nov.:* Halsschild schutenförmig, Kopf ± verdeckt. Subgenotypus ist *H. collaris* Germain. Zur Untergattung gehört noch *H. cryptocephalus* Philippi.
2. Rugosiheliofugus, *subgen. nov.:* Halsschild quer rechteckig, Ecken abgerundet, wenigstens an den Seiten grob grubig punktiert. Unterseite einschließlich der Beine grob runzlig punktiert, Tibien verrundet vierkantig.

Subgenotypus ist *H. sulcatulus* Gemminger. Hierher gehört noch *H. neuqueni,* spec. nov.

3. INSCUTOHELIOFUGUS, *subgen. nov.:* Halsschild kugelig gewölbt. Elytrennaht vorn stark vertieft, Scutellum unsichtbar. Subgenotypus ist *H. kuscheli,* spec. nov.
4. HELIOFUGUS, *sensu stricto:* Halsschild nicht schutenförmig, nicht grubig punktiert und nicht kugelig. Unterseite meist schwach skulpturiert. Tibien nahezu stielrund. Hierher alle übrigen Arten.

EINZELBESCHREIBUNG DER ARTEN

1. **Collariheliofugus** Freude, *subgen. nov.*

Heliofugus (Collariheliofugus) collaris (Germain).

Anal. Univ. Chile, 12, 1855, p. 404.
Urbeschreibung: '59. *Euschatia collaris*
An Eusch. laticollis Sol. (ex Gay.)

Oblongo-elongata, nigra; nitida; capite quadrato a prothorace tecto, porfunde et dense punctato, haud transverse striato, interstitiis punctorum elevatis et reticulatis; prothorace vix latiore quam longo, basi leviter truncato, marginibus lateralibus et margine antico valde dilatatis et leviter reflexis, supra dense punctatis, disco circuliforme, marginato, profunde punctato et postice leviter convexo, elytris nitidioribus, striis profundis et punctulatis aequaliter impressis, interstitiis laevibus, convexis; abdomine longitrorsum leviter plicato. Long. 8 lin., lat. 4 lin. [= 16,8 mm. und 8,4 mm., der Verf.]

Der Typus befindet sich im Museum Paris.

Die Art ist durch ihren schutenförmigen Halsschild leicht kenntlich und unterscheidet sich von dem nächstverwandten *H. cryptocephalus* Philippi durch breiter aufgebogenen Vorder- und Seitenrand sowie gröbere Punktierung desselben. Das Mesosternum ist stärker beulenartig aufgewölbt.

Die meisten mir vorgelegenen Exemplare trugen nur den Fundort "Chile." An spezielleren Fundorten waren vertreten "Rancagua, Prov. Colchagua, und Temuco(?)." Unter dem Material befanden sich auch Originalstücke von Germain.

Heliofugus (Collariheliofugus) cryptocephalus Philippi.

Stettin. Ent. Zeit. 25, 1864, p. 348-349.

Urbeschreibung: (**Heliofugus** +) (**Euschatia**) **cryptocephalus Ph.** H. niger, sat nitidus; capite sub prothorace recondito, grosse rugoso-punctato; sulco inter epistomum et frontem obsoleto; prothorace parum convexo, punctulato, semiorbiculari, postice abrupte angustato, margine, anguste limbato, antice haud dilatato neque reflexo; elytris striato-punctatis, interstitiis vix convexis, sub lente fortiore tenuissime et distanter puncticulatis. Longit. 7 lin. [= 14,7 mm, der Verf.], latit. prothor. 2⅔, elytrorum 3½ lin. [= 5,6 mm und 7,3 mm, der Verf.]—Patria: Andes prov. Colchagua.

Die Körpergestalt und der unter dem vorderen Rand des Halsschildes verstecke Kopf sind wie H. (Euschatia) collaris Ph. Germ. Annal. de la Univ. 1855 p. 404. Der Kopf ist matt, zwar auch noch grob, aber doch viel feiner punctirt als bei der genannten Art; ich sehe keine Spur von Naht zwischen Epistom und Stirn. Das Halsschild ist ebenfalls wenig gewölbt und beinahe kreisförmig, aber doch von anderer Gestalt, es ist vorn schmaler und erreicht seine größte Breite erst in 5/6 seiner Länge, während es bei collaris vorn breiter ist und schon in der halben Länge seine größte Breite erreicht; es ist sehr fein punctirt, während es bei collaris grob punctirt ist. Sein vorderer Rand ist nicht breit schaufelförmig aufgeworfen, sondern einfach mit einem dünnen, aufgerichteten Saum versehen. Die Zwischenräume zwischen den Furchen der Flügeldecken sind fast ganz flach, während sie bei collaris stark gewölbt sind. Bei Euschatia laticollis Sol. soll das Halsschild latera attenuata et subparallela haben, was bei unserer Art nicht zutrifft, auch soll die Länge 9 Linien [=18,9 mm, der Verf.] betragen. Eu. sulcata Sol., die einzige Art, von der er sagt: margine antico prothoracis supra caput leviter producto, soll grobe Punkte auf dem Halsschild haben, deren Zwischenräume Runzeln bilden; beide Arten fehlen dem Museum noch.

+) Der Name Heliofugus, offenbar von ἥλιος und fugere abgeleitet, ist vox hybrida und nicht viel besser, als wenn Jemand Lichtfugus oder Lightfugus oder Soleilfugus sagen wollte, hat aber die Prioritat vor Euschatia. Die Sonne meidend heisst φυξήλιος, also Phyxelius.

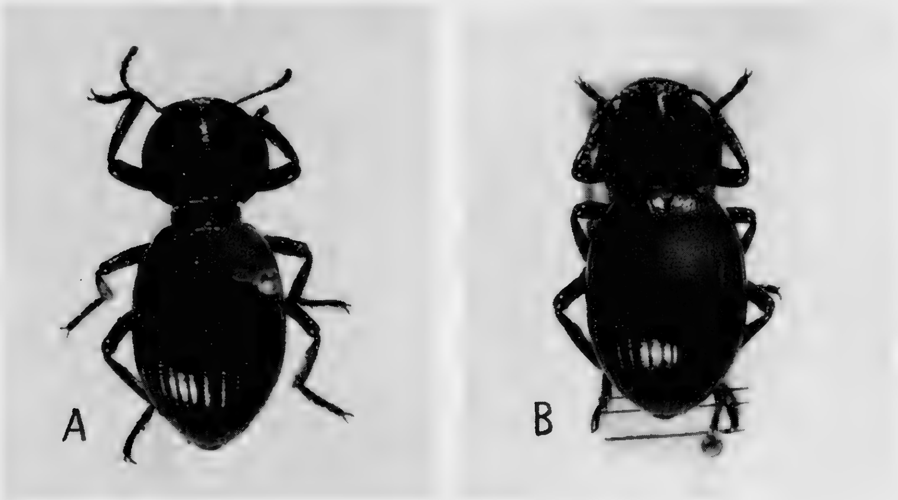

Abb. 1. a. *Heliofugus cryptocephalus cryptocephalus* Philippi. Chile, leg. Steinheil, Sammlung Haag-Ruthenberg, in der Zool. Staatssammlung München. b. *Heliofugus cryptocephalus curicoensis,* subsp. nov. Holotypus. Chile, Prov. Curico, El Coigual, 1400-1600 m., III. 1955, leg. L. E. Peña.

Die Sammlung Philippi und mit ihr der Typus der Art befindet sich im National Museum in Santiago de Chile. Ein Studium dieses Typus erübrigte sich aber, da die Beschreibung Philippis eindeutig ist und die Art gut gegen *H. collaris* abgrenzt. Auf die Unterschiede zwischen beiden wurde bereits bei *H. collaris* hingewiesen. Besonders hervorzuheben sind der schmale Vorder- und Seitenrand des Halsschildes und dessen feine Punktierung.

Fotografien von Marianne Bischoff, München.

Mir lagen nur wenige Exemplare der Art vor und alle nur mit der Patriaangabe "Chile." Philippi nennt die Anden von Colchagua als Fundort der Typen. Da mir auch Material von *H. collaris* Germain von Colchagua vorlag, könnten beide Arten nebeneinander vorkommen. Von Herrn Peña erhielt ich nun Material aus den Anden von Curico, das sich als eigene Rasse von *H. cryptocephalus* herausstellte.

Heliofugus (Collariheliofugus) cryptocephalus curicoensis Freude, *subsp. nov.*

Sie unterscheidet sich von der Nominatrasse durch kürzeres Halsschild, das den Kopf nicht vollständig verdeckt und weniger stark schutenförmig vorgezogen ist. Es ist aber noch deutlich vorn aufgebogen und etwa halbkreisförmig gerundet, die Vorderecken sind aber oft wenigstens angedeutet. Im übrigen entspricht sie völlig der Nominatform.

Von dieser interessanten Subspecies lag mir eine riesige Serie von 601 Exemplaren vor, alle von einem Fundort. Sie gestattete mir eine ausgezeichnete Uebersicht über die Variationsbreite dieser Rasse. Länge 17,5 - 11,5 mm., Breite der Elytren 8,0 - 5,5 mm., des Halsschildes 6,0 - 4,0 mm. Halsschildlänge 5,1 - 3,2 mm. Intervalle flach bis mäßig gewölbt. Halsschildvorderecken stumpfwinklig verrundet bis vollständig verrundet. Hinterecken meist abgeschrägt stumpfwinklig bis vollständig verrundet. Elytren etwas breit bis langoval, Seiten stärker oder flacher gebogen.

Holotypus, ♂, 14,5 × 6,5 mm., und Allotypus, ♀, 17,0 × 7,0 mm., von Chile, El Coigual, 1400-1600 m., III.1955, leg. L. E. Peña, befinden sich in der Sammlung Peña, Santiago.

Paratypoide vom gleichen Fundort, I., III. oder IV.55, alle leg. Peña, in der Sammlung Peña und in der Zoologischen Staatssammlung München.

2. **Rugosiheliofugus** Freude, *subgen. nov.*

Heliofugus (Rugosiheliofugus) sulcatulus (Gemminger)

= *H. sulcatus* (Solier), nomen praeoccupatum Die Urbeschreibung von *H. sulcatus* (Solier) (*Euschatia*) befindet sich in Gay: Hist. fisica y polit. de Chile, 1851, p. 230-231.

Urbeschreibung: **Euschatia sulcata.** E. nigra, nitida; capite dense punctato-rugoso; tergo prothoracis rugoso, valde punctato, subquadrato, in medio longitrorsum gibboso, postice abrupte et oblique-angustato, marginibus lateralibus leviter arcuatis, reflexis, margine antico in medio supra caput leviter producto; elytris nitidioribus et sulcis punctatis valde impressis, interstitiis planatis levissimis.—Long. 6 lin. ½ à 7 lin. ¼; lat., 3 lin. ½ à 4 lin. [=13,6–15,2 mm; 7,3–8,4 mm, der Verf.].

De un negro brillante sobre todo en los elitros. Cabeza muy densamente puntuada y rugosa. Tergum del protórax poco transversal, con bordes, laterales subparalelos, pero levemente arqueados, despues encogidos oblicuamente cerca de la base y alzados de manera que forman un surco marginal; está cubierto de puntos mas gruesos, pero menos apretados que en la cabeza, intérvalos entre estos puntos levantados en forma de arrugas; este tergum está inclinado de cada lado de modo que forma en el medio unn arista longitudinal muy obtusa; borde anterior levemente avanzado sobre la cabeza. Elitros marcados de surcos bastante hundidos y teniendo cada uno una ringlera de puntitos hundidos; intérvalos planos y muy lisos.

Se halla en Santa Rosa, etc.

Gemminger nahm in Coleopt. Hefte, VI., 1870, p. 123, wegen Praeokkupation des Namens durch *H. sulcatus* Guérin die Emendation vor.

Nachstehende Art- oder Gattungsnamen ändere ich, wie folgt, ab: Heliophygus sulcatus Sol. (Cat. p. 2008) wegen sulcatus Guér. Mag. Zool. 1834. Mélas. p. 27. t. 113 in sulcatulus.

Die Art ist durch die grob punktierte und stark behaarte Unterseite sowie das verrundet rechteckige, quere Halsschild, das ebenfalls stark grubig punktiert und deutlich bewimpert ist, von allen bisher bekannten Arten der Gattung scharf getrennt, weshalb mir eine eigene Untergattung angebracht erschien.

Der Holotypus befindet sich im Museum Paris. Solier gibt als Patria Santa Rosa an. Vermutlich ist damit Santa Rosa de los Andes in Aconcagua gemeint, nicht Santa Rosa in der Provinz Tarapaca. Das alte Material der Museen enthielt zwar nur Exemplare mit der Patriaangabe "Chile" mit Ausnahme eines Exemplars vom Museum Berlin, welches von Dr. Puelma gesammelt die Angabe "Santiago, Chile" trug. Diese wurde durch neuere Funde von Herrn Peña aus der Provinz Santiago bestätigt, welche folgende genaueren Ortsbezeichnungen tragen: Q. Macul, Manzano, Rio Molina (Favellones), El Canelo (Cord. Santiago), Co. San Ramon, La Engorda (Los Valdes) und Cristobal.

Heliofugus (Rugosiheliofugus) neuqueni Freude, *spec. nov.*

Patria: Argentinien, Prov. Neuquen. 14,3 × 6,8 mm.

Schwarz, Mundwerkzeuge, Oberlippe, Antennen und Bein ± braun-rot. Kopf grob punktiert. Halsschild stark quer, nicht ganz doppelt so breit wie lang, mit stark gebogenen, fein, aber hoch gerandeten Seiten, die in der Mitte kurz annähernd parallel verlaufen, so daß der Halsschild wie ein Rechteck mit abgestutzten Ecken erscheint. Die dadurch entstandenen 6 Ecken wieder leicht verrundet. Wölbung stark dachförmig, der First ist eine verrundete, nahezu unpunktierte Längsschwiele, die Seitenflächen sind grob punktiert, unbewimpert. Scutellum mittelgroß, quer dreieckig. Elytren länglich oval, hinten leicht zugespitzt, mit je 9 feinen, punktierten Längsfurchen, die 6. durchweg, die 2. am Absturz vertieft. Intervalle oben ziemlich flach, an den Seiten und am Absturz deutlich gewölbt, nur äußerst fein und zerstreut punktiert.

Unterseite einschließlich der Beine grob punktiert, Abdomen gerunzelt. Tibien deutlich verrundet vierkantig, die Schenkel weniger deutlich. Die distale Hälfte der Schienen beim ♂ auf der Unterseite mit dichter Haarbürste. Auch die Unterseite der Tarsen polsterartig goldgelb behaart.

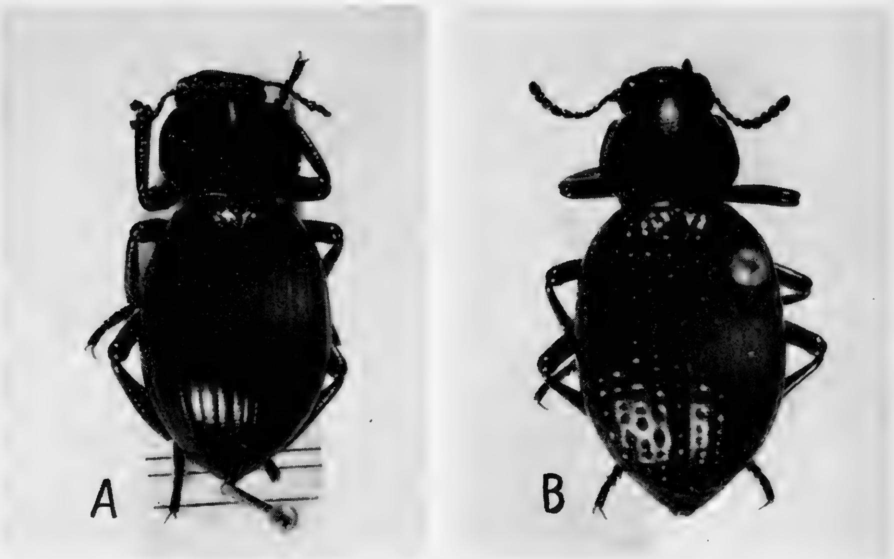

Abb. 2. a. *Heliofugus neuqueni,* spec. nov. Argentinia, Prov. Neuquen, Piedra del Aqua, 29.I.55, in der Zool. Staatssammlung München. b. *Heliofugus impressus impressus* Guérin. 30 km. W. of Puranque, Osorno, Chile, 16.I.51, leg. Ross-Michelbacher, in der California Academy of Sciences.

Holotypus, ♂, von Argentinien, Prov. Neuquen, Piedra del Aqua, 28.I. 55. (? leg. Petrovski).

Die Art erhielt ich erst kurz vor Abschluß dieser Arbeit, leider nur in einem Stück, sie ist aber so charakteristisch, daß an ihrer Artberechtigung nicht zu zweifeln ist. Verwandtschaftlich gehört sie zweifellos zu *H. sulcatulus* Gemminger und damit in das Subgenus *Rugosiheliofugus.* Von *H. sulcatulus* Gemminger ist sie durch schlankere Gestalt, stärker dachförmigen Halsschild, der in der Mitte unpunktiert ist, und fehlende Bewimperung auf Kopf und Halsschild leicht zu unterscheiden.

3. **Inscutoheliofugus** Freude, *subgen. nov.*

Heliofugus (Inscutoheliofugus) kuscheli Freude, *spec. nov.*

Patria: Chile? (ohne Fundort).

Holotypus 11,0 × 5,5 mm. Allotypus 12,0 × 6,0 mm.

Schwarzglänzend, Oberseite kahl, Unterseite, Antennen und Mundwerkzeuge ± bräunlich. Tibien auf der Innenseite distalwärts zunehmend goldgelb bewimpert. Kopf orthognath (senkrecht zur Körperachse), mit unscharfer, aber deutlicher querer Stirnfurche, etwas dicht, nicht runzlig, eingestochen punktiert. Halsschild lackglänzend, hoch, fast halbkugelig gewölbt, besonders bei Ansicht von vorn, viel feiner und etwas weniger dicht punktiert als der Kopf. Vorderwinkel deutlich stumpfwinklig, etwas vorgezogen, Hinterwinkel ziemlich verrundet, Seiten stark gerundet, Basis gerade oder leicht konvex.

Scutellum wegen der an dieser Stelle stark vertieften Elytrennaht nicht sichtbar. Elytren langgestreckt, um die Hälfte länger als breit, fast zylindrisch, hinten gemeinsam verrundet zugespitzt. Mit 9 schwach vertieften Reihen mittelfeiner, etwas ungleich großer Punkte in unregelmäßigen Abständen, die am Apex vor ihrer Vereinigung aufhören. Intervalle sehr flach gewölbt, äußerst fein und entfernt punktiert, am Grunde–nur bei starker Vergrößerung sichtbar–fein netzartig chagriniert. Ohne Scutellarreihe. Epipleuren vorn breit, nach hinten gleichmäßig verschmälert.

Unterseite, besonders das Abdomen, sehr fein und entfernt punktiert. Zwischen den 3 letzten sichtbaren Abdominalsterniten sind, wie bei allen *Heliofugus,* glatte Gelenkhäute erkennbar. Die kürzeren und kräftigeren Hintertibien der ♂♂ sind innerseits etwas gefurcht und ihre distalen beiden Drittel mit einer Haarbürste versehen.

Holotypus, ♂, und Allotypus, ♀, wahrscheinlich von Chile (ohne Fundort), befinden sich im Nationalmuseum in Santiago de Chile. Ich widme die Art meinem lieben Freund und Kollegen, Herrn Prof. Dr. Guillermo Kuschel, Santiago.

Durch ihren halbkugelig gewölbten Halsschild und die langgestreckten, fast dattelförmigen Elytren ist die Art eindeutig gekennzeichnet. Sie steht ziemlich isoliert in der Gattung. Am ehesten lassen sich zufolge der Halsschildbildung noch Beziehungen zu *H. sulcatus* Guérin vermuten.

Leider lagen mir nur die beiden fundortlosen Exemplare vor und da keine unmittelbaren verwandtschaftlichen Beziehungen zu einer anderen Art festzustellen sind, ist auch keine vermutliche Lokalisation möglich. Die Wahrscheinlichkeit spricht für ein etwas isoliertes und oekologisch eigenartiges Gebiet, das aber im Hinblick auf den ± nahestehenden *H. sulcatus* Guérin nicht einmal unbedingt in Chile liegen müßte. Hoffentlich gelingt es bald, dieses Rätsel durch neues Material zu lösen.

4. **Heliofugus** *sensu stricto.*

Heliofugus (Heliofugus) sulcatus Guérin.

Magasin de Zoologie, Insectes, Paris, 1834, Mélasomes, p. 27.

Urbeschreibung: J'ai établi un nouveau genre très voisin des Misolampus, avec un insecte du Chili, rapporté par les naturalistes de l'expédition autour du monde, commandée par le capitaine Duperrey. Ce genre, auquel j'ai donné le nom d'Heliofugus, a été décrit dans la partie zoologique de ce Voyage, et figuré à la pl. 4, fig. 6 de son Atlas. Voici une autre espèce que M. Auguste de Saint-Hilaire a rapportée de Monte-Video.

Heliofugus sulcatus, Nob. (pl.113, f.1). Il est long de 11 à 13 millimètres et large de 6 à 7; son corps est entièrement noir en dessus et en dessous; la tête est petite; le corselet est à peu près aussi long que large, globuleux, arrondi, un peu plus large que la tête; les élytres sont arrondies, au moins trois fois plus larges que le corselet, bombées; elles ont chacune dix stries longitudinales, profondes et lisses; les pattes sont médiocres et noires.

Der Holotypus befand sich ohne jede Kennzeichnung in der Collection Sedillot im Museum Paris, in welche die Sammlung Guérin übergegangen war. Da kein weiteres Exemplar in dieser Sammlung vorhanden war, welches zu dieser Art gehört, besteht wohl kein Zweifel daran, daß es wirklich der Holotypus ist, trotzdem geringfügige Abweichungen von den Angaben Guérins festzustellen sind. Die stark schematisierte Abbildung zeigt eine merkwürdige Konkavität im Bereich der vorderen 2/5 des Seitenrandes, die bei keiner Art mit kugeligem Halsschild in dieser Weise beobachtet werden konnte. Nur der Holotypus von *H. proximus* (Solier) hat eine solche Konkavität, kommt aber wegen seiner schlankeren Gestalt nicht in Betracht.

Die Art ist sehr charakteristisch durch die am Apex vertieften Punktfurchen und stark gewölbten Intervalle. Die Nahtstreifen sind deutlich schmaler als die 2. Intervalle. Eine Scutellarreihe fehlt. Der Halsschild ist stark gewölbt querelliptisch, mit nur angedeuteten Vorder- und Hinterecken und obsolet entfernt punktiert. Kopf sehr fein, aber deutlich, mäßig dicht punktiert.

Die Möglichkeit eines Irrtums kann mich nicht davon abhalten, das fragliche Exemplar der Collection Sedillot als den Holotypus festzulegen, da ein hoher Grad von Wahrscheinlichkeit für die Richtigkeit der Annahme spricht. Der Vorteil dieses Entscheidens für die systematische Arbeit überwiegt die Bedenken um ein Vielfaches.

Diese Art fällt durch ihre weite Verbreitung völlig aus dem engen Rahmen der übrigen Arten. Mir lag Material vor aus Uruguay—Minas, Montevideo und C. Penitente; Chile; Colombia Plata; Rio Parana, (wohl Argentinien). Ob die Art wirklich bis Colombien nach Norden verbreitet ist, müßte allerdings durch neuere Funde belegt werden. Gebien gibt in seinem Katalog merkwürdigerweise nur Chile an, obwohl die Art aus Montevideo beschrieben wurde.

Die Ausbildung der Elytren zeigt Aehnlichkeit zu der von *H. sulcatulus* Gemminger weshalb ich *H. sulcatus* Guérin im Anschluß an jene Art stelle.

Heliofugus (Heliofugus) impressus Guérin.

Magasin de Zoologie, Insectes, Paris, 1834, Mélasomes, p. 27.

Urbeschreibung: Heliofugus impressus, Nob. Cet insecte est long de 14 millimètres et large de 7. Il ressemble beaucoup au précédent [*sulcatus* Guér., der Verf.]; mais il est un peu plus allongé. Sa tête est lisse, rétrécie en avant; les antennes sont de la longueur de la tête et du corselet, aplaties au bout. Le corselet est un peu plus large que long, ponctué, luisant, un peu plus étroit en arrière. Les élytres sont ovales, terminées en pointe arrondi; elles ont chacune en dessus sept lignes longitudinales d'impressions ou de gros points très distants entre eux. Les pattes sont de grandeur moyenne. Cet insecte vient du Pérou.

In der Collection Sedillot des Museums Paris befinden sich 2 Exemplare, die zwar nicht als Typen bezeichnet sind, in denen wir aber sicher solche vermuten dürfen. Die Größe des ♀ stimmt genau mit der in der Urbeschreibung gemachten Angabe überein, es ist deshalb als Holotypus anzusehen. Das größere ♂ hat Guérin höchstwahrscheinlich gleichfalls vorgelegen. Ich fasse es deshalb als Allotypus auf.

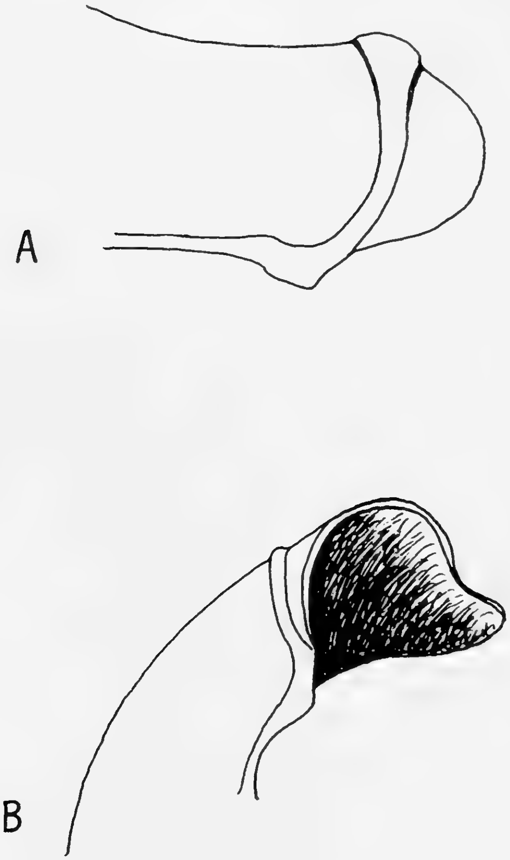

Abb. 3. *Heliofugus impressus punctatus* (Solier). Linke Mandibel, a. von links vorn, b. von schräg rechts oben.

Kopf und Halsschild sind nur matt-glänzend, die Elytren haben einschließlich des Seitenrandes und der Nahtreihe 9 Punktreihen; offenbar hat Guérin die Außenreihen jeder Elytre nicht mitgezählt. Charakteristisch für das Typenexemplar, aber zweifellos individuell, ist der Seitenrand des Halsschildes, der zur Basis gerade verengt, bereits etwas hinter der Mitte gerundet umbiegt und nach vorn unregelmäßig kleinwellig geschwungen sich weniger stark verengt, aber in annähernd gerader Richtung verläuft. Die Vorderecken sind deutlich, aber breit verrundet. Auf der linken Elytre befinden sich 2 feine Punkte als Andeutung eines Scutellarstreifens, der normalerweise fehlt. Kopf und Halsschild sind mittelfein, etwas dicht, aber sehr flach punktiert. Sie zeigen bei starker Vergrößerung eine sehr feine, gleichmäßig körnige Mikroskulptur und sind schon aus diesem Grunde nicht stark glänzend. Auch die Elytren haben eine Mikroretikulierung.

Heliofugus impressus ist die problematischste Art der Gattung. Sie ist sowohl in der Form des Halsschildes als auch in der Elytrenpunktierung sehr variabel. Da mir aber verschiedene, sehr einheitliche Serien von jeweils einem Fundort vorlagen, muß ich die stärkeren Differenzen doch irgendwie als subspezifischer Natur deuten, nur reicht das Material mit genauen Fundorten nicht für deren geographische Abgrenzung aus. Es macht auch den Anschein, als ob die Rassen nicht rein flächenmäßig geographisch abgegrenzt wären, sondern daß andersgeartete, möglicherweise Höhenstufen berücksichtigende Areale vorliegen. Die Form des Halsschildes scheint individuell zwischen schmaler und stärker gewölbt und breiter und etwas weniger gewölbt zu variieren, dagegen deutet die Stärke der Punktreihen auf subspecifische Unterschiede.

Die Subspecies *H. i. impressus* hat sehr grobe bis mässig feine, weit und etwas unregelmäßig gestellte Punktreihen. Von ihr lag mir besonders reiches Material vor, besonders auch aus den Ausbeuten von Ross-Michelbacher, sodaß mir genauere Fundortangaben möglich sind. Außer altem Material mit der Patria "Chile" waren folgende Fundorte vertreten: Corral, Chile, 16.X.13, leg. R. H. Beck; 30 km. West of Purranque, Osorno, Chile, 16.I.51, Ross-Michelbacher; 10 Miles North East of Pucon, Chile, 12.I.51, Ross-Michelbacher; 20 km. East of Temuco, Chile, 8.I.51, Ross-Michelbacher; 10 Miles North West of Villarica, S. Chile, 10.I.51, Ross-Michelbacher; West of Angol, Chile, 3.I.51, Crest of Sierra Nahuelbuta, Elev. 1200 m., Ross-Michelbacher; 22 km. East of Temuco, Chile, 28.I.51, Ross-Michelbacher; Cordillere de Nahuelbuta, Pichinahuel, 12.-20.II.1953, 1400-1600 m.; Caramavida, 5.-10. II.53; Rinihue, II.48; Contulmo, Prov. Concepcion, 1904-5, Schönemann leg.

Auch vom benachbarten Argentinien, Neuquen, Hua-Hum, Lago Lacar, 3.XII.1946, Hayward leg., waren Exemplare vertreten (Museum Budapest).

Von Herrn Peña erhielt ich noch Material von Pto. Varas, Llanquihue, I.1924, leg. Atanasio; Pirehueico, Cord. Valdivia, XI.53, leg. E. Wolff; Neltume, Valdivia, I.48, leg. Peña; Rinihue, Valdivia, I.48, leg. Yrarras; Neuquen, Argentina, 12.I.52, XII.53; T. Rio Blanco, Curacautin, 6-18.II.43, 1050-1500 m., leg. L. E. Peña, und XII.47, leg. Wagenck; Caramavida, Nahuelbuta (W), Arauco, 25-31.XII.53, 750 m., leg. L. E. Peña; Butamalal, Nahuelbuta (O), 1100-1400 m., 12-25.II.53, leg. L. E. Peña; Pichinahuel, 12-20.II.53, leg. L. E. Peña. Constitucion, Costa de Maule, 27.XI.53, leg. L. E. Peña.

Allgemein gesehen nimmt die durchschnittliche Punktgröße von Süden nach Norden ab. Differenziertere rassische Gliederung war anhand des vorgelegenen Materials noch nicht möglich. Besondere Schwierigkeiten hierin bereitet das Gebiet der Nahuelbuta.

Die Subspecies *H. i. punctatus* (Solier) wurde in Gay: Hist. fisica y polit. de Chile (V), 1851, p. 228-229, als eigene Art beschrieben.

Urbeschreibung: **Euschatia punctata.** (Atlas zoologico.—Entomologia, Coleópteros, lám. 20, fig. 3.) E. nigra; tergo prothoracis lateribus inferne valde inflexo, antice supra caput producto, punctulato; elytris punctis magnis, oblongis et in seriebus dispositis, impressis.—Long., 5 lin. ⅓ à 6 lin. ¾; lat. 3 lin. à 3 lin. ½. [= 11,2 - 14,1 mm.; 6,3 - 7,3 mm., der Verf.] De un negro poco brillante, oblonga y ovalada. Cabeza finamente puntuada con la sutura del epístome marcada de un surco bien expresado. Tergum del protórax convexo, fuertemente encorvado hácia la base lateralmente, encogido por delante y por detrás, arqueándose en los bordes laterales, finamente puntuado, y con el borde anterior avanzado por encima de la cabeza. Elitros marcados de ringleras de gruesos puntos hundidos y oblongos, la primera de estas ringleras es libre; la segunda se reune posteriormente con la quinta, la tercera y la cuarta, las mas cortas, se reunen entre si posteriormente, la sexta y la séptima, situadas la una en el borde marginal y la otra en la parte lateral, son libres y vienen á concluir en un pliegue levantado longitudinal, posterior y poco marcado. Cada flanco está costeádo por un surco marcado de una ringlera de puntos mas pequeños y mas aproximados; intérvalos entre las estrías planos y casi lisos.

De las provincias centrales, Santiago, etc.

Esplicacion de la làmina.

Lam. 20, fig. 3.—Animal aumentado.—a Tamaño natural.—b Barba y len gueta.c Quijada.—d Cabeza.—c Antena.

Fairmaire stellte in seiner Monographie die Art synonym zu *H. impressus* Guérin und beschrieb seinerseits eine Art *H. punctatostriatus.* Solier bringt zwar in seiner Urbeschreibung von *H. punctatus* den Hinweis "elytris punctis magnis," die dazugehörige Abbildung deutet aber eher auf mittlere Punkte in mehr gefurchten Reihen, welches Merkmal für *H. punctatostriatus* Fairmaire zutrifft. Für diese Deutung sprechen auch die stark nach unten gebogenen Halsschildseiten. In der Collection Marseul des Pariser Museums, die die Sammlung Solier enthält, befindet sich nun kein Exemplar von *H. i. impressus* Guérin, wohl aber 1 Exemplar von *H. punctatostriatus,* das in der Form der Abbildung von *H. punctatus* entspricht, wenn auch auf der Abbildung die Punktreihen stärker furchig wiedergegeben sind. Es ist jedenfalls sehr wahrscheinlich, daß wir in diesem Exemplar den Holotypus von *H. punctatus* (Solier) vor uns haben. Demnach ist *H. punctatostriatus* (Fairmaire) als Synonym von *H. punctatus* (Solier) anzusehen. Der Vollständigkeit halber hier noch die Urbeschreibungen von *H. punctatostriatus* und auch *H. tenuipunctatus* Philippi, welche Art bereits von Fairmaire (1875) synonym zu *H. punctatostriatus* gestellt wurde. Den Holotypus dieser Art, der sich in National Museum Santiago befindet, konnte ich dankenswerterweise studieren und seize Identität mit punctatus (Solier) bestätigen.

Heliofugus (Heliofugus) punctatostriatus (Fairmaire et Germain).

Col. Chilensia 1861, p. 5.

Urbeschreibung: **Euschatia punctato-striata.**—Long. 12 à 15 mill.—Ovato-oblonga, aterrima, nitida, convexa, prothorace tenuiter sat dense punctato, lateribus ante basin obliquis, elytris striatis, striis parum impressis, sat grosse parum dense punctatis, interstitiis vix convexis; ♀ oblongior elytris vix striatis, striarum punctis minoribus, interstitiis planatis.

Heliofugus (Heliofugus) tenuipunctatus Philippi.

Stettin. Ent. Zeit. 25, 1864, p. 349.

Urbeschreibung: **Heliofugus tenuipunctatus** Ph. H. niger; prothorace lateribus valde inflexo, tenuissime punctulato; elytris striato-punctatis, punctis minutis; interstitiis planiusculis. Longit. 7 lin. [= 14,7 mm, der Verf.], latit. prothor. 2½, elytrorum 3½ lin. [= 5,2 mm und 7,3 mm, der Verf.]

Ex andibus prov. Colchaguae!

Das Museum besitzt ein einziges Exemplar. Das Halsschild hat ganz dieselbe Form wie H. impressus Guér. (Euschatia punctata Sol.) und Eu. proxima Sol., unsere Art unterscheidet sich aber auf den ersten Blick von beiden durch punktirt-gestreifte Flügeldecken, die also wie bei H. collaris und cryptocephalus beschaffen sind, nur sind die Punkte der neuen Art weit feiner. Der Kopf hängt senkrecht herab und ist von oben nicht zu sehen. Die Naht, welche das Epistom begränzt, ist sehr deutlich, wenn auch fein; die Punctirung des Kopfes ist fein, die Punkte stehen einzeln in der Mitte, gedrängt an dem Rändern und sind auf dem Scheitel gröber. Das Halsschild hat sehr feine, oberflächliche Punkte.

Von *H. i. punctatus* (Solier) lag mir verhältnismäßig reiches Material vor, allerdings meist ohne genaue Fundorte. Neben solchen von Chile, Valdivia, Santiago fanden sich einzelne Exemplare von Pemehue, Tolhuaca, Rio Cipresе. Die Fundortangabe Montevideo beruht zweifellos auf einem Irrtum. Von Ross-Michelbacher wurden 2 Exemplare 50 km. East of San Carlos, Nuble, Chile, am 26.XII.50 gesammelt. Von Herrn Peña erhielt ich noch folgende Belege: Recinto, Cord. Nuble, XI.52, leg. M. Rivera; Las Trancas, Cord. Nuble, 5-16.XII.51, leg. L. E. Peña; Termas de Chillan, Cord. Chillan, 19.XII.55, leg. L. E. Peña; Estero de Leiva, Cord Parral, 8-12.I.53, leg Barros-Peña; El Coigual, Cord. Curico, 1400-1600 m, 11-13.I.55, leg. Peña-Barros. Diese genauen Fundorte lassen vermuten, daß sich die Subspecies *H. i. punctatus* nördlich an die Subspecies *H. i. impressus* anschließt. Uebergangsstücke sind vorhanden.

Eine weitere Subspecies möchte ich als *H. i. cribricephalus* subsp. nov. bezeichnen. Sie ist besonders ausgezeichnet durch ihre kräftige, punktgrubige Kopfpunktierung. Die Elytrenpunktierung sowie die Halsschildform ist wie bei *H. i. impressus* oder *H. i. punctatus.*

Holotypus, ♂, von Chile, Coll. Oyarzun, befindet sich in der Zoologischen Staatssammlung München.

Allotypus, ♀, von Chile, befindet sich in Museum G. Frey in Tutzing. Beide Exemplare waren von Gebien für *H. cribriceps* (Fairmaire) gehalten worden, ein Vergleich mit dem Typus dieser Art zeigte aber, daß es sich um etwas anderes hadeln muß.

Die individuelle Variation innerhalb dieser Rasse muß ebenfalls beträchtlich sein. Her Holotypus ist stark glänzend und hat eine kräftigere Punktierung der Elytrenreihen als der mattere Allotypus. Möglicherweise handelt es sich bei beiden Vertretern sogar noch um getrennte Rassen. Leider tragen sie keinen genauen Fundort, sodaß sie vorerst nicht zu lokalisieren sind. Sie dürften aber ihre Verbreitung in der Nähe von *H. laticollis* (Solier) haben, dessen Verwandtschaft mit der "*impressus*"-Gruppe gerade durch *H. i. cribricephalus* deutlich wird.

Heliofugus (Heliofugus) laticollis (Solier).

In Gay: Hist. fisica y polit. de Chile (V), 1851, p. 230.

Urbeschreibung: **Euschatia laticollis.** E. nigra; capite dense punctato, stria transversa leviter impresso; tergo prothoracis latiore, parum convexo, valdè transverso, punctulato, antice et postice angustato, lateribus attenuatis et sub parallelis, margine antico flexuoso; elytris sulcis tenuiter punctatis, impressis, interstitiis convexiusculis laevigatis.—Long., 9 lin.; lat., 4 lin. [= 18,9 mm; 8,4 mm, der Verf.]

De un negro poco brillante, ancha y poco convexa. Cabeza con puntuacion apretada

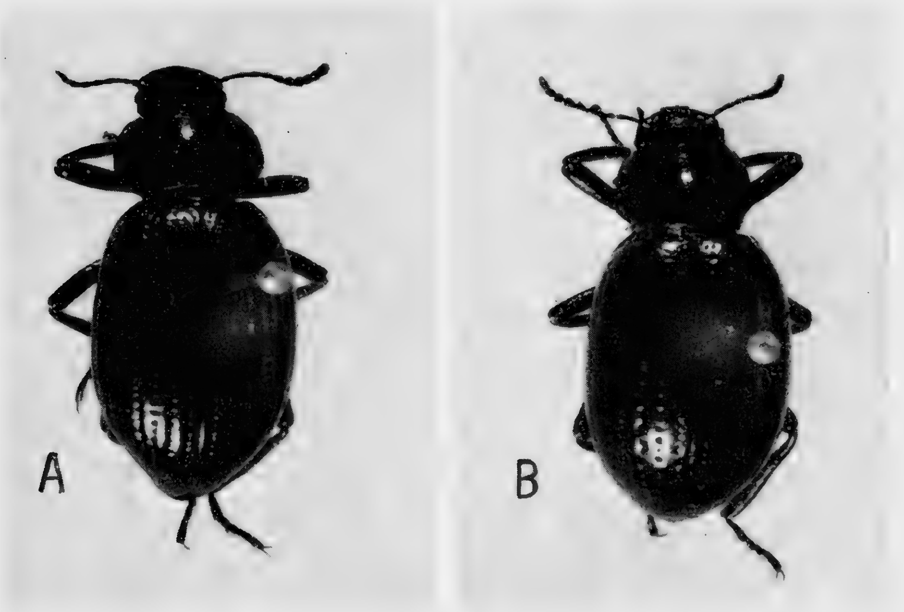

Abb. 4. a. *Heliofugus laticollis* (Solier). Neo-Holotypus. Chile, leg. Steinheil, Sammlung Haag-Ruthenberg, in der Zoll. Staatssammlung München. b. *Heliofugus impressus cribricephalus,* subsp. nov. Holotypus. Chile, Coll. Oyarsun, in der Zool. Staatssammlung München.

y bien marcada aunque bastante fina. Sutura posterior del epístome marcada por una estría transversal muy fina; suturas laterales obliteradas. Tergum del protórax poco convexo, muy ancho, muy transversal, finamente puntuado, encogido hácia adelante y hácia atrás pero con bordes laterales subparalelos en el medio, adelgazados y finamente alzados en rodete pequeño; borde anterior flexuoso. Elitros marcados de surcos bien distintos per poco hondos, y ofreciendo cada uno una ringlera de puntitos hundidos; intérvalos leve-monte convexos y casi lisos. Estos surcos se obliteran posteriormente antes de reunirse.

Esta especie muy escasa vive en las provincias centrales.

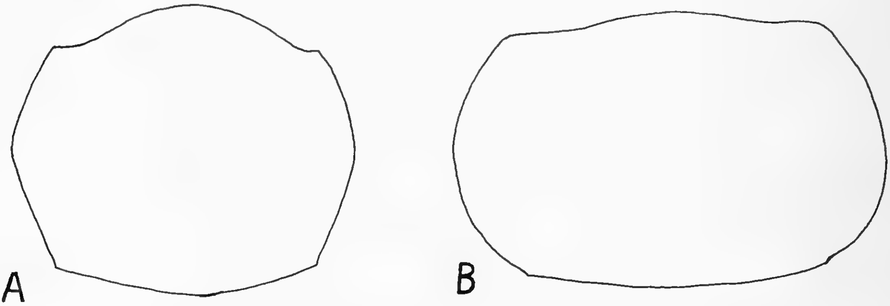

Abb. 5. Halsschild-Umrisse von a. *Heliofugus impressus impressus* Guérin, b. *Heliofugus laticollis* (Solier).

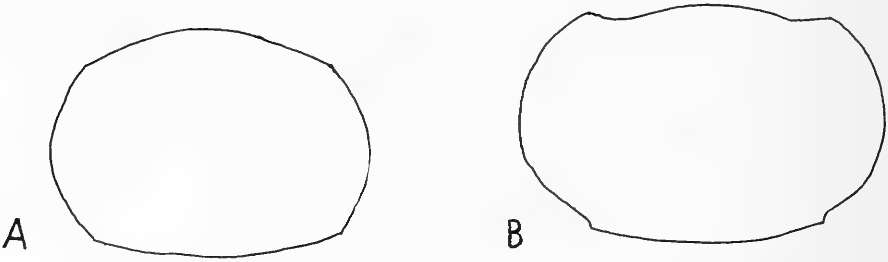

Abb. 6. Halsschild-Umrisse von a. *Heliofugus sulcatus* Guérin, b. *Heliofugus barossi*, spec. nov.

Der Typus, welcher sich in der Sammlung Marseul des Pariser Museums befinden müßte, ist leider nicht mehr vorhanden, ebensowenig ein anderes Exemplar dieser Art. Deshalb sehe ich mich genötigt, einen Neotypus aus den Beständen der Zoologischen Staatssammlung München auszuwählen, was auch im Hinblick darauf zu verantworten ist, weil sich hier die Sammlung Haag-Ruthenberg befindet, welche sehr viel authentisches Material enthält. Ich erkläre zum Neotypus ein ♂ der Sammlung Haag-Ruthenberg von Chile, leg. Steinheil. Dieser lebte von 1830-1879, war also bei der Veröffentlichung der Art immerhin bereits 21 Jahre alt. Das Exemplar bleibt zwar um 2,9 mm. hinter der Größenangabe Soliers zurück, mir ist aber noch kein Exemplar untergekommen, welches das Maß von 18,9 mm. wirklich erreicht hätte. Entweder war der Originaltypus wirklich ein Riese oder die Messung ungenau. Vielleicht auch spielte die Präparationsweise eine Rolle (Kopf besonders weit vorgestreckt?). Im übrigen aber trifft die Beschreibung gut auf das Exemplar zu, nur daß die Halsschildseitenränder in der Mitte nicht deutlich parallel abgeflacht sind.

Die Art hat die Elytrenreihen etwa wie *H. i. punctatus* (Solier), ist aber durch den fast doppelt so breit wie langen Halsschild und die kräftige Punktierung desselben wie auch besonders des Kopfes so wesentlich von jenem verschieden, daß nur die in gewisser Hinsicht vermittelnde Subspecies *H. i. cribricephalus* ihre engere Verwandtschaft mit dem Rassenkreis des *H. impressus* erkennen läßt. Vermutlich handelt es sich um eine ursprüngliche Randrasse von diesem, welche inzwischen zu artlicher Selbständigkeit gelangt ist.

Außer allgemein mit Chile bezetteltem Material lag mir nur 1 Exemplar aus Valparaiso vor. Dieses macht wahrscheinlich, daß sich *H. laticollis* nördlich an die "*impressus*"-Gruppe anschließt. Die geographisch-oekologischen Verbreitungsverhältnisse dieser Gruppe sensu lato, insbesondere auch bezüglich der verschiedenen Höhenlagen, an Ort und Stelle gründlich zu untersuchen, wäre eine dankbare Aufgabe für einen Koleopterologen oder Doktoranden.

Heliofugus (Heliofugus) cribriceps Fairmaire.

Heliophygus, Ann. Soc. Ent. France 1875, p. 196.

Urbeschreibung: Long. 20. mill.—Oblongus sat convexus, niger, nitidus, capite subopaco, dense ac grosse punctato, subruguloso, antennis piceis, prothorace valde transverso, margine antico arcuato, lateribus antice tantum arcuatis, basi oblique truncatis, lateribus evidenter marginato, sat dense sat grosse punctato, elytris ovatis, apice obtuse acuminatis, punctis grossis substriatis, intervallis planis, pectore rugoso-punctato, abdomine tenuiter punctato.

Oblong, assez convexe, d'un noir brillant, avec les antennes d'un brun un peu roussâtre. Tête presque mate par sa ponctuation forte, serrée, un peu rugueuse; l'impression arquée antérieure peu distincte. Corselet fortement transversal, assez court, convexe, les côtés arrondis seulement en avant, coupés ou même un peu sinués obliquement en arrière, avec les angles postérieurs formant une très-petite pointe; bords latéraux étroitement mais visiblement marginés; ponctuation assez forte et assez serrée, les intervalles très-finement réticulés; bords postérieurs très-finement marginés, interrompus de chaque côté par une très-petite strie. Elytres ovalaires, obtusément acuminées, à lignes de gros points qui sont parfois confluents ou réunis par un ligne fine, ce qui forme des espèces de stries. Poitrine ponctuée, rugueuse, surtout au milieu. Abdomen finement ponctué. Valvidia [= Valdivia, der Verf.].

Communiqué obligeamment par M. Fr. Bates.

Ressemble assez au sulcipennis; en diffère par les points bien moins grands élytres, la forme générale plus oblongue, plus convexe, la tête à sillon antérieur moins marqué, le corselet moins densément ponctué, moins arrondi sur les côtés; la couleur est aussi plus brillante.

Der Holotypus befindet sich in der Collection Fairmaire im Museum Paris. Der Druckfehlerteufel hat dem Autor bei der Veröffentlichung arg mitgespielt, oder die Beschreibung muß in einer unguten Stunde erfolgt sein. Schon die Größenangabe beruht offensichtlich auf einem Druckfehler, denn der Typus mißt nur 10 mm. statt 20 mm. Die Beschreibung paßt an sich gut zum Typenexemplar, nur bezüglich der Unterbrechung des feinen Halsschildhinterrandes ist die Einschränkung zu machen, daß sich diese nur auf der rechten Seite findet, also eine individuelle Variante darstellt.

Beim Vergleich mit *H. sulcipennis* Germain sollen die Elytrenpunkte "moins grands" sein, was schon nach der Beschreibung ("punctis grossis") unwahrscheinlich ist. Auch kann man das Halsschild nicht als "moins densément ponctué" bezeichnen, denn beide sind annähernd gleich punktiert, *H. cribriceps* eher etwas dichter.

Schließlich ist auch noch der Fundort verdruckt worden und "Valdivia" wurde zu "Valvidia" entstellt.

Trotzdem das Typenexemplar nur die Patriaangabe "Chili" trägt, ist an seiner Identität kaum zu zweifeln, einmal wegen des Vergleichs mit dem gleichgroßen *H. sulcipennis,* zum anderen wegen der sonst nirgends zu beobachtenden Unterbrechung des Halsschildhinterrandes.

In der Elytrenpunktierung erinnert die Art am ehesten an *H. i. impressus* und *H. i. punctatus,* ist aber kleiner, höher und gleichmäßiger gewölbt, hat kürzeren, gröber und weniger dicht punktierten Halsschild. Von dieser etwas problematischen Art lag mir noch 1 Exemplar aus dem Nationalmuseum Santiago de Chile vor, nur 8,6 mm., Kopf etwas weniger kräftig punktiert, aber sicher zu *H. cribriceps* gehörig, leider ohne Patria.

Heliofugus (Heliofugus) penai penai Freude, *spec.* et *subsp. nov.*

Patria: Chile: Prov. Alhue.

18,0-16,5 × 9,0-8,0 mm.

Schwarz, fettgländzend, unbehaart; Mundwerkzeuge, Antennen- und Tarsenenden ± bräunlich, Tibien und Tarsen goldgelb bewimpert. Kopf kräftig punktiert, zwischen den Augen grob und nur dort gelegentlich zusammenfließend, ohne scharfe Stirnquerfurche. Halsschild gut 1½ × so breit wie lang, in der Mitte kräftig gewölbt, seitlich breit abgeflacht und etwas aufgebogen. Vorder- und Hinterrand annähernd gerade, nur neben den Ecken leicht konkav geschwungen, zur Mitte unscharf gerandet, Seitenränder mittelstark nach oben fein gekielt. Vorderecken stumpf, schwach vorgezogen, Seitenrand breit nach außen bogig, in der Mitte ± parallelseitig abgeflacht, vor den rechteckig-scharfen Hinterwinkeln kurz konkav geschwungen. Punktierung mittelstark und mäßig dicht, in der seitlichen Abflachung meist kräftiger und dichter, wenig tief. Scutellum breit dreieckig, quer aufgewölbt. Elytren oval, hinten gemeinsam leicht verrundet zugespitzt, glatt, etwas abgeflacht, mit vertiefter Naht. Die 9 Punktreihen sind äußerst fein, nicht furchig, die Punkte stehen in etwas ungleichen Abständen. Eine Scutellarreihe ist vorhanden, angedeutet, oder kann ganz fehlen. Die Elytrenreihen werden vor der Basis und vor der Vereinigung am Absturz obsolet. Der feine Seitenrand ist von oben gesehen nur vorn und hinten sichtbar. Intervalle fein netzartig chagriniert und äußerst fein zerstreut punktiert.

Unterseite vorn grob, hinten fein punktiert und seitlich ± gerunzelt. Beine lang, fein, etwas entfernt punktiert, Tibien innenseits apikalwärts zunehmend stark goldgelb bewimpert. Tarsen auf der Unterseite mit dichten Tomentpolstern.

♂♂ an der Innenseite der Hinter- und Mitteltibien abgeflacht und mit kräftiger Haarbürste versehen.

Holotypus, ♂, 18 × 9 mm., und Allotypus, ♀, 17 × 8 mm., von Pichi, Alhue (Santiago), 6-8.XII.47, Coll. Peña-Baross, befinden sich in der Sammlung Peña, Santiago.

Paratypen vom gleichen Fundort in derselben Sammlung und der Zoologischen Staatssammlung München.

Ich widme die Art ihrem Sammler, meinem verehrten Kollegen, Herrn Louis E. Peña, Santiago, dessen reiches Material meine Bearbeitung dieser Gattung wesentlich förderte.

Heliofugus (Heliofugus) penai ohigginsi Freude, *subsp. nov.*

Von dieser Art *H. penai* liegt mir eine Serie aus der Provinz O'Higgins vor, welche sich durch kleinere Gestalt (16,5-13,5 × 8,0-6,0 mm.), weniger breites, schwächer abgeflachtes Halsschild ohne aufgebogenen Rand und meist undeutliche Hinterwinkel, aber weniger stumpfe Vorderwinkel unterscheidet. Gelegentlich sind die Elytrenreihen kräftiger und es tritt eine schwache lederartige Runzelung auf.

Holotypus, ♂, 16,5 × 8,0 mm., von Co. Poqui, O'Higgins, 1500 m, 20-24. III.51, Coll. L. E. Peña, in der Sammlung Peña, Santiago de Chile.

Paratypi, alles ♂♂, vom selben Fundort, in der gleichen Sammlung und der Zoologischen Staatssammlung München.

Der Holotypus hat auf der linken Elytre hinter der Schulter swischen der 4.-7. Punktreihe einen traumatischen Quereindruck.

Diese Subspecies gleicht im Halsschild *H. laticollis* (Solier), ist aber durch die vertiefte Elytrennaht und die feinen Punktreihen grundlegend von dieser verschieden. Trotzdem dürfte sie ihr und damit auch der "*impressus*"-Gruppe verandtschaftlich noch am nächsten kommen, denn bei *H. impressus* besteht eine Tendenz zur Reduktion der Elytrenpunkte und in sehr vereinzelten Fällen ist auch eine Vertiefung der Naht zu beobachten, aber nie in so ausgesprochener Form.

Heliofugus (Heliofugus) colasi Freude, *spec. nov.*

Patria: Chile.
9,0 × 4,5 mm.

Schwarz, Mundteile, Antennen und Tarsen ± rotbraun, oben unbewimpert, halbmatt.

Kopf vorn abgestutzt, an den Augen am breitesten, nach hinten verengt, mit feiner, aber tiefer Querfurche, die die Stirn vorn konkavbogig abgrenzt. Punktierung scharf eingestochen, ziemlich dicht. Halsschild breit queroval, mäßig gewölbt, Seiten stark bogig, fein gerandet, zur Basis nicht konkav, Vorderwinkel verrundet, Hinterwinkel kaum angedeutet, Vorderrand und Basis konvex. Punktierung wie die des Kopfes, etwas weniger dicht und zur Mitte feiner.

Scutellum breit dreieckig, glatt. Elytren etwa haselnußförmig, mit je 9 vertieften, maschinennahtartig punktierten Längsfurchen. Der Holotypus besitzt assymetrisch auf der linken Seite einen Punkt als Andeutung eines Scutellarstreifens. Intervalle an den Seitenrändern der Elytren stärker gewölbt, zerstreut sehr fein punktiert, mit äußerst feiner netzartiger Mikroskulptur. Epipleuren vorn breit, gleichmäßig nach hinten verschmälert. Unterseite und Beine kräftig punktiert, Abdominalsternite seitlich entfernter und feiner. Zwischen den 3 letzten sichtbaren Sterniten bernsteinfarbene Intersegmentalhäute. Beine aus den Punkten goldgelb behaart, zum Tibienende stark und dicht. Tarsen einschließlich des Klauengliedes unten mit goldgelben Tomentpolstern.

Holotypus, Chile, Germain leg., in Coll. Marseul im Museum Paris. Meinem verehrten Kollegen am Museum Paris, Herrn Dr. Guy Colas, zum Dank für sein liebenswürdiges Entgegenkommen gewidmet.

Die Art steht verwandtschaftlich *H. sulcipennis* Germain am nächsten, ist durch ihr sehr breites, nur flach gewölbtes Halsschild leicht von dieser zu unterscheiden.

Heliofugus (Heliofugus) sulcipennis (Germain).

Anal. Univ. Chile, 12, 1855, p. 404.

Urbeschreibung: 60. **Euschatia sulcipennis.** Oblongo-ovata, nigra, nitidula; capite quadrato punctato, punctis anticis minoribus et densioribus; thorace subtransverso, punctato, longitrorsum convexo, basi truncato, angulis rectis lateribus leviter arcuatis, margine antico truncato, subemarginato, angulis subobtusis; elytris laxe et tenuissime punctulatis, sulcis, punctatis, angustis et profundis, aequaliter impressis, interstitiis complanatis; segmenti abdominis punctulatis et longitrorsum tenuiter rugatis; ore antennis, tarsisque rufopiceis.

Long. 4½ lin., lat. 2½ lin. [= 9,4 × 5,2 mm, der Verf.]

Der Holotypus der Art benfindet sich im Museum Paris.

Außer weiteren Originalexemplaren von Germain (Cotypen?) und Exemplaren mit dem allgemeinen Fundort "Chile" lag mir je 1 Exemplar von

Chillan und Aculco (?) vor, welch letzterer Fundort, wenn damit Aculco in Mexico gemeint sein sollte, sicher als falsch bezeichnet werden muß.

Die Art gehört zu den kleineren Vertretern unter 11 mm. mit gefurchten Elytren. In den Furchen befinden sich maschinennahtartige, regelmäßige Punkte.

Als Subspecies zu *H. sulcipennis* ist *H. brevipennis* Fairmaire anzusehen.

Heliofugus (Heliofugus) sulcipennis brevipennis Fairmaire.

Heliophygus, Ann. Soc. Ent. France, 1875, p. 197-198.

Urbeschreibung: Long. 11½ mill.—Ovoideus, antice attenuatus, mediocriter convexus, omnius niger, nitidus; capite sat grosse dense punctato, antice striata arcuata, utrinque obsolete foveolato, antennis gracilioribus, prothorace transverso, lateribus arcuatis, basi obsolete sinuatis, sat grosse sat dense punctato, elytris ovatis, basi truncatis, apice obtuse acuminatis, profunde striatis, striis tenuiter punctatis, usque ad apicem impressis, intervallis subplanis; subtus nitidior, laevis.

Ovalaire, légèrement oblong, un peu élargi en arrière, d'un noir brillant. Tête fortement et densément ponctuée, un peu mate, ayant en avant une forte impression transversale se terminant de chaque côté en une fossette. Corselet court, transversal, arrondi sur les côtés, qui sont fortement obliques à la base, un peu redressés en avant, avec les angles antérieurs obtusément droits; bord antérieur médiocrement arqué au milieu; ponctuation médiocrement forte, assez serrée. Elytres courtes, assez larges, s'énlargissant après le milieu, assez brusquement rétrécies en arrière, à stries fortement marquées et médiocrement ponctuées, les quatrième et cinquième plus courtes que les autres, ne se réunissant pas. Poitrine finement punctuée. Abdomen très-lisse.

Santiago; un seul individu.

Cette espèce est bien distincte par la forme des élytres, qui sont courtes, larges et peu convexes; le corselet est bien plus large et moins convexe que chez le punctatosulcatus.

Der Holotypus befindet sich im Museum Paris.

Im Vergleich zur Subspecies *H. s. sulcipennis* ist *H. s. brevipennis* breiter, mit flacheren, stärker vortretenden Halsschildvorderecken.

Heliofugus (Heliofugus) barrosi Freude, *spec. nov.*

Patria: Chile: Alhue, Pichi.

14,0-10,5 × 6,0-4,5 mm. Holotypus 11,0 × 4,5 mm.

Schwarz, ± glänzend, Mundwerkzeuge und Antennenenden zuweilen bräunlich, Tibien und Tarsen blaßgelb behaart. Kopf mittelstark, ziemlich tief und dicht punktiert, höchstens neben den Augen runzlig, Stirnquerfurche deutlich. Halsschild gleichstark, aber weniger tief und nicht ganz so dicht punktiert; stark quer, Basis breit. Seitenrand stark gebogen, zu den verrundeten Vorderecken schwach, hinten stärker und vor den scharfen, fast rechteckigen Hinterwinkeln kurz konkav geschwungen verengt. Vorderrand etwas konvex, Hinterrand fast gerade. Querwölgung besonders beim Holotypus ziemlich stark, zu den Seiten hin abgeflacht. Scutellum breit, gerundet dreieckig, Spitze ± vertieft. Elytren länglich oval, etwa haselnußförmig, mit

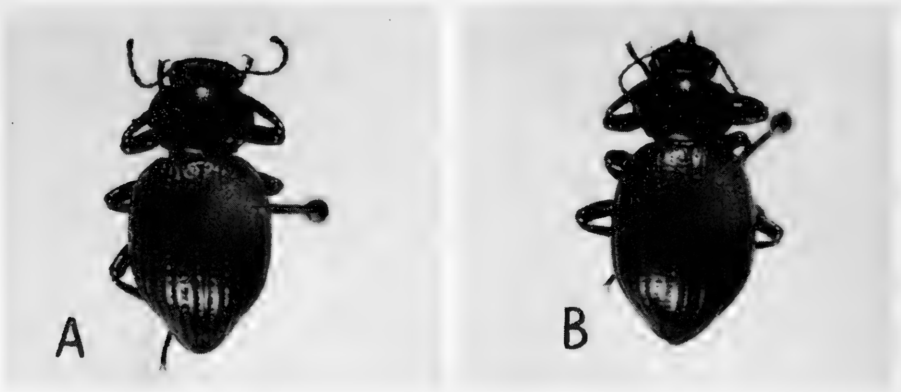

Abb. 7. a. *Heliofugus barossi,* spec. nov. Holotypus. Pichi, Alhue, Santiago, 6-8.XII. 47, Coll. Peña-Barros, in Sammlung Peña, Santiago. b. *Heliofugus ventriosus ventriosus,* spec. nov. Holotypus. Co. Poqui, O'Higgins, 1500 m., 20-24.III.51, Coll. L. E. Peña, in Sammlung Peña, Santiago.

je 9 Reihen ziemlich kräftiger, zuweilen feinerer und gelegentlich durch feine Längsrille verbundener, etwas ungleicher Punkte, die in teils unregelmäßigen Abständen voneinander stehen. Reihen zum Absturz etwas vertieft. Intervalle mäßig, aber deutlich, gewölbt, auf dem Diskus gelegentlich, flach; fein, wenig dicht punktiert. Scutellarstreifen meist deutlich, aber dem Holotypus fehlt er. Abdomen fein, nach hinten zunehmend dichter punktiert. Beine kräftig und ziemlich dicht punktiert, Tibien auf der Innenseite gelblich bewimpert, Tarsen mit dichten Bürstensohlen.

Holotypus, ♂, Allotypus, ♀, und 1 Paratypoid von Pichi, Alhue (Stgo.), 6-8.XII.47, Coll. Peña-Barros, in der Sammlung Peña.

2 Paratypoide gleicher Daten sowie ein weiterer von Alhue, 8.XII. (ohne Jahr und Sammler), befinden sich in der Zoologischen Staatssammlung München. 1 Paratypoid von Chile, Quillota, XII.97, im Museum Frey, Tutzing.

Ich widme die Art Herrn Barros, einem verdienstvollen Sammler und Mitarbeiter Herrn Peñas.

Sie ähnelt etwas *H. laticollis,* ist aber wesentlich kleiner und hat ein weniger dicht punktiertes Halsschild mit deutlicheren Vorderecken.

Heliofugus (Heliofugus) ventriosus Freude, *spec. nov.*

Patria: Chile: Prov. O'Higgins.

12,0-7,9 × 6,2-4,3 mm., Holotypus 11,5 × 5,4 mm., Allotypus 11,2 × 4,5 mm.

Schwarz, schwach glänzend, am Grunde äußerst fein netzartig chagriniert, mäßig breit, Elytren nach hinten etwas bauchig verbreitert, dann gemeinsam verrundet zugespitzt. Kopf dicht, mittelstark punktiert. Die bogige Stirnfurche deutlich, aber wenig scharf.

Halsschild weniger dicht, mittelstark punktiert, zur Mitte schwächer; mäßig gewölbt, Seiten flacher. Vorderrand schwach konvex bis gerade, Vorderecken leicht oder nicht vorgezogen, verrundet gewinkelt. Seitenrand mäßig gebogen, vor den fast rechtwinkligen Hinterecken kurz konkav geschwungen. Größte Halsschildbreite vor der Mitte. Basis schmaler als der Vorderrand, meist geringfügig breiter als die Elytrenbasis oder die halbe Abdomenbreite. Scutellum ± breit dreieckig. Elytren mit je 9 Reihen feiner bis mittelstarker, nicht ganz gleichmäßig großer Punkte in schwach unregelmäßigen Abständen, die andeutungsweise rinnig verbunden sind. Punkte am Absturz feiner. Die fein und wenig dicht punktierten Intervalle oben ± flach, seitlich und am Absturz deutlich gewölbt. Die Nahtregion ist zuweilen leicht vertieft. Die Reihen enden am Absturz frei oder laufen unregelmäßig zusammen. Eine Scutellarreihe ist meist angedeutet. Antennen, Palpen, Tarsen schwarz, nur die Endglieder der beiden erstgenannten distalwärts aufgehellt. Schenkel und Schienen kräftig punktiert, kurz bewimpert, letztere innen distalwärts zunehmend dicht goldgelb bewimpert. Die ♂♂ haben kräftigere Hintertibien mit wenig deutlicher Wimperbürste.

Holotypus, ♂, und Allotypus, ♀, von Co. Poqui, O'Higgins, 1500 m, 20-24.III.51, Coll. L. E. Peña befinden sich in der Sammlung Peña.

Paratypoide vom gleichen Fundort und Datum in der Sammlung Peña und der Zoologischen Staatssammlung München.

Im ganzen lagen mir 31 Exemplare der Art vor. Sie erinnert sehr an *H. proximoides,* ist etwas feiner punktiert, mit dunklen Antennen und mit am

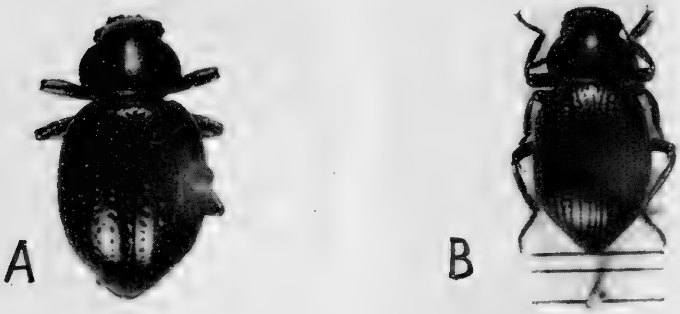

Abb. 8. a. *Heliofugus ventriosus nancaguensis,* subsp. nov. Holotypus. Nancagua, 15.III.1946, leg. I. Guzman, in Sammlung Peña, Santiago. b. *Heliofugus leechi,* Spec. nov. Holotypus. Chile, Prov. Curico, El Coigual, 1400-1600 m., IV.1955, leg. L. E. Peña, in Sammlung Peña, Santiago.

Absturz feiner werdenden Punktreihen. Subspezifische Verwandtschaft beider ist möglich.

Heliofugus (Heliofugus) proximoides Freude, *spec. nov.*

Patria: Chile.

10,2-9,8 × 5,2-4,8 mm.

Schwarzglänsend, Oberseite kahl; Mundpartie, gelegentlich auch Antennen und Beine ± bräunlich. Kopf meist kräftig punktiert, Stirn durch eine nach vorn konkave Furche abgegrenzt. Halsschild quer, Vorderrand und Basis etwa gleich breit, Seitenrand stark bogig, vor den Hinterecken nur schwach konkav geschwungen, Vorderrand leicht konkav, Vorder- und Hinterecken deutlich, wenn auch nicht scharf. Punktierung wie die des Kopfes. Gelegentlich treten seitlich hinter der Mitte grubige Vertiefungen auf. Scutellum kurz, breit dreieckig-herzförmig. Elytren etwa haselnußförmig, hinten gemeinsam stumpf verrundet zugespitzt, mit je 9 Punktreihen. Diese aus kräftigen Punkten, ± regelmäßig und durch eine feine Rille verbunden. Intervalle ± flach, nach außen und zum Apex meist gewölbt, kaum sichtbar fein entfernt punktiert, deutlich fein netzartig chagriniert. Selten sind Andeutungen einer Schildchenreihe vorhanden. 1.-3. Reihe endet hinten frei. Epipleuren glatt, vorn etwas breit, allmählich nach hinten verengt. Die Sternite vorn etwa wie der Halsschild, das Abdomen meist feiner und schwächer punktiert. Zwischen den letzten 3 sichtbaren Sterniten treten bräunlichgelbe Intersegmentalhäute vor. Beine kräftig punktiert.

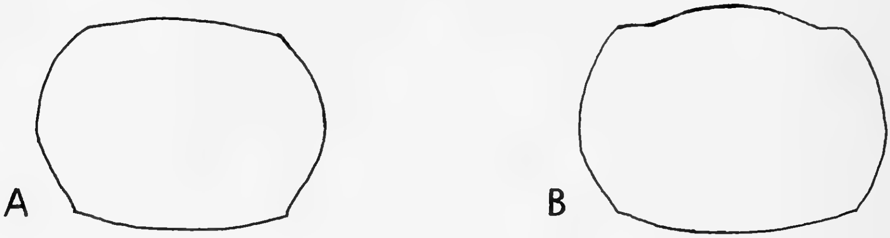

Abb. 9. Halsschild-Umbrisse von a *Heliofugus proximus proximus* (Solier), b. *Heliofugus leechi leechi,* subsp. nov.

Holotypus, Chile, Steinheil leg., in der Sammlung Haag-Ruthenberg der Zoologischen Staatssammlung München.

Paratypoide gleichen Fundorts und Sammlers, weiter Boucard leg., in der Zoologischen Staatssammlung München und im British Museum. 1 Paratypoid von Chile. Coll. Fairmaire, im Museum Paris.

Im Vergleich mit dem sehr ähnlichen *H. proximus* fällt die breite Halsschildbasis und entsprechende Elytrenbreite auf. Die Reihenpunkte der Elytren sind meist durch eine feine Rille verbunden. Die Halsschildbasis ist breiter als die halbe Abdomenbreite.

Aus Nancagua, Prov. Colchagua, lagen mir 2 Exemplare der Art vor, welche dunkle Antennen mit nur hellen Spitzen des letzten Gliedes hatten. Da bei anderen Arten die Färbung der Antennen nicht unbedingt art- oder auch nur rassenspezifischen Charakter zeigt, kann ich diese Exemplare als Paratypoide und Colchagua oder eine Nachbarprovinz als Patria der Art ansehen. Genaue Funddaten der Exemplare: Nancagua, 15.III.1946, leg. I. Guzman. Herr L. E. Peña, in dessen Sammlung sie sich befinden, überließ mir liebenswürdigerweise eines davon für die Zoologische Sammlung des Bayerischen Staates.

Heliofugus (Heliofugus) proximoides rotundangulus Freude, *subsp. nov.*

Von Süd-Chile lag mir 1 Exemplar von *H. proximoides* mit völlig verrundeten Halsschildhinterecken vor, welches mir einer eigenen Rasse anzugehören scheint.

Holotypus von Süd-Chile, leg. G. H. Schwabe (Nr.662), befindet sich im Deutschen Entomologischen Institut.

Heliofugus (Heliofugus) leechi Freude, *spec. nov.*

Patria: Chile: Cordillere Curico.

11,0-6,5 × 5,5-3,2 mm.

Schwarz, matt bis schwach fettglänzend, am Grunde fein netzartig chagriniert; mäßig breit; Labrum meist braun, durch glatte, gelbbraune Haut von der Stirn getrennt. Stirnnaht trapezförmig-bogig, ± scharf. Kopf und Halsschild ziemlich fein aber deutlich, an den Seiten und auf dem Kopf etwas kräftiger punktiert. Halsschild nicht ganz anderthalb-mal so breit wie lang, ziemlich stark gewölbt. Vorderrand deutlich konvex, Vorderecken verrundet gewinkelt, kaum vorgezogen. Seiten gleichmäßig etwas stark gebogen, in oder hinter der Mitte am breitesten, zur Basis nicht konkav verengt. Die Hinterecken treten nur schwach in Erscheinung. Basis so breit wie der Vorderrand, etwas breiter als die Elytrenbasis. Selten treten in der Mitte jeder Halsschildseite ± tiefe Gruben auf. Scutellum ± breit dreieckig. Elytren etwas schlanker oder breiter haselnußförmig. Die Punkte der 9 Reihen sind feiner oder kräftiger, oberflächlich gesehen ziemlich gleichmäßig und meist durch feine Rinnen verbunden, genau besehen aber in den Abständen und auch in der Größe etwas unterschiedlich. Eine Scultellarreihe ist meist in wenigen Punkten vorhanden, kann aber fehlen. Die zerstreut fein punktierten Intervalle sind oben ± flach, seitlich und am Absturz mehr gewölbt. Antennen, Palpen und Tarsen meist dunkel, können aber ± aufgehellt sein. Schenkel und Schienen kräftig und dicht punktiert, letztere innen distalwärts zunehmend länger goldgelb bewimpert. Die ♂♂ mit etwas kräftigeren Hinterschienen und einer wenig deutlichen Bürste auf deren Innenseite.

Holotypus, 9,2 × 4,6 mm., ♂, und Allotypus, 9,0 × 4,4 mm., ♀, von Chile, Prov. Curico, El Coigual, 1400-1600 m, IV. und III.1955, leg. L. E. Peña, in der Sammlung Peña, Santiago.

Paratypoide gleicher Daten, weiter vom X. und XI.1954, leg. M. Rivera, weiter von Buchen, Cord. Curico, 1300 m, VIII.1954, leg. M. Rivera, in der Sammlung Peña und der Zoologischen Staatssammlung München. Es lagen mir 129 Exemplare der Art vor. Sie ist ähnlich *H. quillotaensis,* hat aber das Halsschild zur Basis weniger verengt sowie Kopf, Halsschild und Beine dichter und kräftiger punktiert.

Heliofugus (Heliofugus) leechi maulensis Freude, *subsp. nov.*

Nachträglich erhielt ich von Herrn L. E. Peña eine Serie von *H. leechi* von der Kuste der Provinz Maule, die ich wegen der etwas stärkeren, ungleichmäßigeren und weniger dichten Punkte der Elytrenreihen als *Heliofugus leechi maulensis* bezeichnen möchte. Holotypus von Tregualemo, Maule, 10-20.II.59, Coll. L. E. Peña. Von den 16 Paratypoiden der gleichen Serie überließ mir Herr Peña liebenswürdigerweise Belegexemplare für die Zoologische Staatssammlung München.

Heliofugus (Heliofugus) quillotaensis Freude, *spec. nov.*

Patria: Chile: Prov. Valparaiso, Umgeb. Quillota.

10,8-8,0 × 5,4-4,3 mm.

Die Variationsbreite in der Größe dürfte aber der von *H. leechi* entsprechen.

Schwarz, mäßig glänzend, die Elytren mehr als das Halsschild, am Grunde fein netzartig chagriniert; mäßig breit. Stirnnaht bogig, ziemlich scharf. Kopf und Halsschild fein, mäßig dicht, ziemlich scharf eingestochen punktiert, Halsschild-Seiten kaum stärker. Halsschild-Vorderrand leicht konvex bis gerade, Vorderecken schwach vorgezogen, verrundet winklig. Seitenrand mäßig gebogen, zur Basis stärker, aber kaum konkav verengt. Größte Halsschildbreite in oder hinter der Mitte. Hinterecken höchstens stumpfwinklig vorspringend. Basis schmaler als der Vorderrand, aber breiter als die Elytrenbasis. Scutellum breit dreieckig. Elytren länger oder kürzer haselnußförmig, oberseits etwas abgeflacht, hinten gemeinsam verrundet zugespitzt. Mit je 9 Reihen mittelstarker bis feiner Punkte, die annähernd, aber nicht völlig gleichmäßig in Größig und Abstand sind, zum Absturz feiner. Eine Scutellarlinie kann vorhanden sein oder fehlen. Die 3. und 4. laufen schon zu Beginn des Absturzes zusammen, die Vereinigungen am Absturz sind aber nicht regelmäßig, was allgemein gilt. Beim Allotypus z. B. unterbleibt sie auf der linken Elytre. Die zerstreut fein punktierten Intervalle sind oben fast flach, seitwärts und am Absturz stärker gewölbt. Antennen, Palpen, Tarsen dunkel oder zum Ende aufgehellt. Schenkel und Schienen nur sehr punktiert, letztere auf der Innenseite distalwärts zunehmend goldgelb bewimpert.

Holotypus, ♂, 9,2 × 4,8 mm., und Allotypus, ♀, 10,8 × 5,4 mm., von Chile, Quillota, XII.1897, im Museum G. Frey, Tutzing.

Von Herrn Peña erhielt ich 2 Exemplare von Perales, welche sich geringfügig unterscheiden, aber vermutlich im Rahmen der Variationsbreite, sodaß ich sie als Paratypoide ansehe.

Paratypus, ♀, von Perales, Valparaiso, I.1926, befindet sich in der Sammlung Peña, Santiago.

Paratypus, ♀, von Perales, Marga-Marga, IX.24, leg. P. Atanasio, in der Zoologischen Staatssammlung München.

Die Art ist nächstverwandt zu *H. biobioensis*, ich kann beide aber noch nicht zu einem Rassenkreis zusammenfassen, weil die Zwischenglieder fehlen. Sie unterscheidet sich von dieser durch deutlichere Halsschild-Hinterecken und regelmäßigere, dichtere und weniger grobe Punkte der Elytrenreihen, ihr Apex ist länger zugespitzt.

Heliofugus (Heliofugus) biobioensis Freude, *spec. nov.*

Patria: Chile: Prov. Bio-Bio.

Holotypus 8,8 × 4,7 mm.

Schwarz, etwas glänzend, Halsschild weniger; am Grunde fein netzartig chagriniert; etwas breit. Stirnnaht bogig, wenig scharf. Kopf und Halsschild fein, mäßig dicht punktiert, Halsschild-Seiten nicht stärker. Halsschild um die Hälfte breiter als lang, gleichmäßig und ziemlich stark gewölbt. Vorderrand schwach konvex, Vorderecken leicht vorgezogen, verrundet winklig. Seitenrand stark, gleichmäßig gebogen, nach vorn wie hinten gleichstark verengt, ohne deutlich konkaven Schwung vor den sehr stumpfwinkligen Hinterecken. Basis etwa gleich dem Vorderrand und so breit wie das halbe Abdomen. Scutellum breit dreieckig. Elytren haselnußförmig, etwas nach hinten verbreitert und gemeinsam verrundet zugespitzt, oberseits leicht abgeflacht, mit je 9 Reihen mittlerer bis kräftiger Punkte, teils fein rinnig verbunden, deren Abstände verschieden sind. Am Absturz werden die Punkte etwas feiner. Eine Scutellarreihe ist beim Holotypus links mit 3, rechts mit 2 Punkten angedeutet, kann aber wohl auch fehlen. Die sehr fein und zerstreut punktierten Intervalle sind oben flacher, seitlich und am Absturz stärker gewölbt. Antennen, Palpen und Tarsen dunkel, Endglieder an den Spitzen etwas aufgehellt (mit Ausnahme der Tarsen); umfangreichere Aufhellungen sind aber denkbar, Punktierung der Schenkel und Schienen fein, letztere innerseits distalwärts zunehmend stärker goldgelb bewimpert. Holotypus von Chile, Bio-Bio, 1893-1894, v. Kiesling leg., in der Zoologischen Staatssammlung München.

Auf die vermutlich nähere Verwandtschaft mit *H. quillotaensis* wurde dort bereits hingewiesen und auf die Unterschiede aufmerksam gemacht. Die Elytrenpunktierung ist viel gröber, mehr wie bei *H. proximoides*.

Heliofugus (Heliofugus) fairmairei Freude, *nom. nov.*

Heliophygus sulcipennis Fairmaire, Ann. Soc. Ent. France, V, 1875, p. 195-196.

Urbeschreibung: 7. **H. sulcipennis.**—Long. 8½ à 10½ mill.—Ovato-oblongus, parum convexus, niger, nitidus; antennis tarsisque obscure ferrugineis, capite dense fortiter punctato, antice utrinque foveolato, et transversim impresso, prothorace valde transverso, lateribus rotundato, basi constricto, margine antico valde arcuato, fortiter dense punctato, angulis posticis obtusis acutiusculis, elytris valde lineato-punctatis, fere striatis.

Oblongue, légèrement ovalaire, un peu convexe, mais aussi un peu déprimée, en dessus, d'un noir brillant, avec les antennes et les tarses roussâtres. Tête densément et assez fortement ponctuée, ayant en avant une légère impression tout à fait transversale, formant de chaque côté une petite fossette. Corselet très-transversal; côtés arrondis, surtout en avant, fortement oblique en arrière, avec les angles postérieurs obtus, mais bien peu marqués; ponctuation grosse, assez serrée. Elytres oblongues-ovalaires, tronquées à la bases, obtusément acuminées, à lignes de très-gros points ou petites fossettes formant des stries plus ou moins marquées; intervalles plans ou à peu près, lisses.

Chili.

Ressemble en petit au proximus; en diffère, outre la taille, par la forme plus oblongue, la tête plus fortement ponctuée, la suture du chaperon non distincte, remplacée par une impression transversale les antennes et les tarses plus franchement roux, le corselet plus fortement ponctué, et les élytres à fossettes moins fortes, plus nombreuses et plus serrées.

Holotypus von Chile, Coll. Bates, als "type von *Heliofugus sulcipennis* Fairm." bezeichnet, befindet sich im British Museum.

Die Art ist nicht identisch mit *H. sulcipennis* Germain, deshalb ist eine Umbenennung wegen Praeokkupation notwendig. Dem Autor zu Ehren nenne ich sie *H. fairmairei* nom. nov. Im Gegensatz zu Germains *H. sulcipennis* ist die Art durch grobpunktierten Kopf und Halsschild ausgezeichnet.

Zunächst lag mir nur ein weiteres Exemplar dieser Art von Chile, Steinheil leg., Sammlung Haag-Ruthenberg, in der Zool. Staatssammlung vor. Nun

Abb. 10. a. *Heliofugus fairmairei,* nom. nov. El Canelo, Santiago, 20-23.X.47, Coll. L. E. Peña, in Sammlung Peña, Santiago. b. *Heliofugus coquimboensis,* spec. nov. Holotypus. Talinay, Coquimbo, 20-22.IX.47, Coll. L. E. Peña, in Sammlung Peña, Santiago.

erhielt ich eine größere Serie durch Herrn Peña, die durchweg aus der Provinz Santiago stammt, wodurch die Patriafrage der Art gelöst ist. Die einzelnen Fundorte sind: El Canelo, Cordillere Santiago, leg. L. E. Peña (26.XI. 54, 23.III.47, 20-23.X.47, 20.XI.51 und XI-XII.52); Penalolen, Santiago, 20. VI.53 und 10.X.53, leg. L. E. Peña; Q. Macul, Santiago, 1950 m, 12-16.VIII.47 und 18.IX.46, leg. L. E. Peña; Ely Peumo, Rio Maipo, Santiago, X.51 und I.53; Guayacan, Santiago, 2.XII.52; La Obra, Santiago, 18-23.XII.53, coll. L. E. Peña; Vom National Museum Santiago erhielt ich noch 2 Exemplare ohne Patria.

Heliofugus (Heliofugus) arenosus Guérin.

In Voyage de la Coquille.—Zool. Tome II, Part. II, 1re Div., 1830, p. 96-97, pl. IV, fig. 6.

Urbeschreibung: **Heliofuge Des Sables, Heliofugus arenosus. Guer.**—Ater, ore, apice, antennarum tarsisque rufo-brunneis; thorace cordato, globoso; elytris striato-punctatis, postice acuminatis.—L. 10 mill., l. 4 m.—Atlas, Ins. pl. IV, fig. 6.

Il est tout noir en dessus et en dessous; sa tête est arrondie, tronquée en avant, ayant un sillon transversal près du bord antérieur, avec les palpes, les mâchoires et l'extrémité des antennes ferrugineux. Celles-ci sont de la longueur de la tête et du corselet réunis. Le corselet est un peu plus large que long, très-arrondi sur les côtés, un peu plus étroit en arrière, bombé et très-finement ponctué, vu à la loupe. L'ecusson est excessivement petit, transversal et arrondi, Les élytres sont allongées, plus larges que le corselet, presque parallèles et peu arrondies sur les côtés, jusqu'aux deux tiers de leur longueur, terminées ensuite brusquement en pointe, soudées et embrassant les côtés de l'abdomen; elles ont chaucune neuf stries assez profondes et ponctuées. Les pattes sont de grandeur moyenne, assez grêles, sans épines; les tarses sont simples, avec un duvet ferrugineux en dessous. L'insecte grossi est représenté dans notre planche IV, figure 6. La figure 6A représenté sa tête vue en dessous; on la voit en dessus avec les antennes grossies; à la figure 6B. Enfin les nos 6C et 6D représent un tarse antérieur et un tarse postérieur grossis.

Cet insecte vient de la Conception, au Chili.

Nous possédons une autre espèce du même genre, qui a été trouvée à Monte-Video; c'est notre Heliofugus striatus, publié dans le Magasin de Zoologie.

Bezüglich des im Nachsatz genannten *H. striatus* habe ich bereits früher (vor der Einteilung in Subgenera) festgestellt, daß es sich um die erst später unter dem Namen *H. sulcatus* Guérin veröffentlichte Art handelt.

Der Typus von *H. arenosus* Guérin wäre in der Collection Sedillot zu erwarten gewesen, ist aber im Museum Paris nicht vorhanden und zweifelsohne verloren gegangen. Leider fand sich in den Sammlungen des Pariser Museums auch kein anderes Exemplar dieser Art, welches zum Neotypus erklärt werden könnte. So habe ich mich entschlossen, ein Exemplar aus der Sammlung Haag-Ruthenberg, Chile, Chevrolat leg., das sich in der Zoologischen Sammlung des Bayerischen Staates in München befindet, als Neotypus zu bestimmen. Weitere Exemplare mit dem allgemeinen Fundort Chile befinden sich im British Museum, dem Museum Frey, Tutzing, dem Nationalmuseum Santiago de Chile und der Zool. Staatssammlung München. 1 Exemplar von Concepcion, P. Herbst leg., Coll. Kraatz, im Deutschen Entomologischen Institut. Durch Herrn Peña erhielt ich folgende genauen Fundorte: Tregualemu, N. Costa, Nuble, 6-9.XII.1953, Coll. L. E. Peña; Chovellen, Costa de Maule, 5.XII.1953, Coll. L. E. Peña; Curanipe, Costa de Maule, 4.XII.1953, Coll. L. E. Peña.

Die Art unterscheidet sich von *H. proximus* durch geraden Halsschild-Vorderrand und im Durchschnitt schlankere Gestalt.

Die Art *Heliofugus parvus* (Solier) wurde von Gebien in seinem Katalog synonym zu *H. arenosus* Guérin gestellt. Da auch der Typus dieser Art verloren gegangen ist, konnte die Synonymie nicht überprüft werden. Die Wahrscheinlichkeit spricht dafür, daß Gebien recht hat und mich dünkt es schon im Hinblick auf den Verlust des Typus als die beste Lösung des Problems. Der Vollständigkeit halber hier noch die Urbeschreibung aus Gay: Historia fisica y politica de Chile V., 1851, p. 229-230.

Urbeschreibung: **Euschatia parva.** E. nigra; tergo prothoracis minus convexo, punctulato, postice valde angustato, subcordato, et cum margine antico subtruncato; elytris sulcis, oblongo-punctatis, impressis.—Long. 3 lin. ¾ à 4 lin. ¼; lat., 1 lin. ¾. [7,8 - 8,9 mm; 3.6 mm, der Verf.].

De un negro mate. Cabeza finamente puntuada y con la sutura del epistome marcada por una impresion transversal; suturas laterales del mismo simplemente arqueadas por una estria. Tergum del protórax finamente puntuado, notablemente encogido posteriormente y subcordiforme; pero menos convexo que en la especie precedente [= *proximus* (Sol.), der Verf.], y con borde anterior subtruncado. Elitros marcados de surcos bien expresados, aunque poco hondos, y ofreciendo cada uno una ringlera de puntos hundidos, mediocres y oblongos; estos surcos se reunen posteriormente como las ringleras de puntos de las dos especies precedentes. Esta especie habita las cercanias de Concepcion.

Heliofugus (Heliofugus) coquimboensis Freude, *spec. nov.*

Patria: Chile: Coquimbo.

7,0-12,0 × 3,35-5,4 mm.

Schwarz, matt-fettglänzend, Grund fein netzartig chagriniert; ziemlich schlank. Kopf und Halsschild fein, mäßig dicht, ± obsolet bis deutlich punktiert. Stirnquerfurche deutlich, aber wenig scharf, bogig bis trapezförmig. Halsschild nicht ganz doppelt so breit wie lang, mäßig hoch gewölbt, Vorderrand schwach konvex bis gerade; Vorderecken winklig verrundet, kaum nennenswert vorgezogen. Seitenrand gleichmäßig gebogen oder kurz vor der Mitte leicht gewinkelt, nach vorn weniger verengt als zur Basis, vor dieser mit meist deutlichem konkavem Schwung. Hinterwinkel über 90°, deutlich. Basis schmaler als der Vorderrand, aber breiter als das halbe Abdomen. Scutellum breit dreieckig. Elytren langoval, Seiten schwach gebogen, zum Apex verengt und gemeinsam stumpf verrundet zugespitzt, oben ± abgeflacht; mit 9 Reihen mittlerer, etwas ungleich großer und entfernter, rinnig zusammenfließender Punkte, die am Absturz fein werden. Eine Scutellarreihe fehlt vollständig und die 1. Reihe tritt oft ziemlich nahe an die Naht und weicht auch dem Scutellum nur schwach aus. Meist laufen 3. und 4. Reihe schon vor dem Absturz zusammen, gelegentlich auch 4. und 5. oder 3.-5. Intervalle ±

obsolet punktiert, oben flach, seitlich und am Absturz ± gewölbt. Antennen, Palpen, Tarsen dunkel bis ± aufgehellt; Holotypus 3 Antennenendglieder heller. Beine fein, ± obsolet punktiert, Tibien innen distalwärts zunehmend goldgelb bewimpert. Die ♂♂ haben kräftigere Hintertibien mit einer schwer erkennbaren Bürste aufgerichteter, kurzer und feiner gelber Wimpern an der Innenseite.

Holotypus, ♂, 11,0 × 4,8 mm, und Allotypus, ♀, 8,0 × 3,9 mm, von Talinay, Coquimbo, 20-22.IX.47, Coll. L. E. Peña, in der Sammlung Peña. Paratypoide vom gleichen Fundort, davon einer vom 12.IV.52, leg. Wagenck., in der Sammlung Peña, Santiago, und der Zool. Staatssammlung München.

Im ganzen lagen mir 68 Exemplare vor.

Weiter lagen mir noch 6 Paratypoide von Fray Jorge, Coquimbo, 4-5.XI. 1957, Coll. L. E. Peña, und von Fray Jorge Forest, Coquimbo, 11.XII.50, Ross-Michelbacher (California Academy of Sciences) vor, im ganzen eine Serie von 76 Exemplaren.

Die Art erinnert in der Gestalt an *H. arenosus*, hat aber viel breiteres Halsschild.

Heliofugus (Heliofugus) rossi Freude, *spec. nov.*

Patria: Chile: Nahuelbuta.

9,5-7,7 × 4,6-3,5 mm.

Schwarz, mäßig glänzend, am Grunde fein netzartig chagriniert, Elytren matter; nur Endglieder der Antennen und Palpen zur Spitze bräunlich. Kopf und Halsschild ± fein, aber ziemlich scharf punktiert, Kopt dichter. Stirnfurche meist wenig scharf, aber deutlich grubig vertieft. Halsschild mäßig gewölbt, nicht ganz um die Hälfte breiter als lang, etwas herzförmig, Vorderrand deutlich konvex, Vorderecken nicht vorgezogen, ziemlich verrundet, Seitenrand stark gebogen, zur Basis stärker verengt und vor den Hinterwinkeln deutlich konkav, so daß diese, wenn auch über 90°, ziemlich scharf vortreten. Basis leicht konvex, so breit wie die Elytrenbasis. Größte Halsschildbreite vor der Mitte. Scutellum etwas breit dreieckig. Elytren breiter oder schlanker haselnußförmig, mit 9 Reihen verschieden großer, etwas entfernt stehender Punkte in ziemlich ungleichen Abständen; nur gelegentlich ist eine Verbindungslängsrille angedeutet. Eine Scutellarreihe ist nur selten vorhanden. Die etwas groß, aber sehr flach punktierten Intervalle auch am Absturz nicht deutlich gewölbt. Prosternum gröber, Abdomen fein, entfernt punktiert, nur die beiden letzten sichtbaren Sternite dicht.

Schenkel und Schienen scharf eingestochen mittelstark punktiert. Holotypus, ♂, 8,0 × 4,1 mm., und Allotypus, ♀, 8,3 × 3,8 mm., von W. of Angol, Chile, Crest of Sierra Nahuelbuta, 1200 m, I.3.51, Ross-Michelbacher Coll., in der California Academy of Sciences.

Paratypoide gleicher Daten in der California Academy of Sciences und der Zoologischen Staatssammlung München.

Paratypoide von Pichinahuel, Cord. Nahuelbuta, Arauco, 1200 m, 14-18. II.56, Coll. L. E. Peña; und I.59, leg. G. Barria, in Sammlung L. E. Peña.

Pichinahuel, 12-20.II.1953, Coll. L. E. Peña; Caramavida, Nahuelbuta (W), Arauco, 750 m, 25-31.XII.53, Coll. Peña; Caramavida, Nahuelbuta, Arauco, 720-1100 m, 11.I.1954, Coll. L. E. Peña; Cherquenco, I-II.1954, T. Ramirez leg. in der Sammlung Peña, Santiago, und der Zoologischen Staatssammlung München.

Die Art ähnelt *H. proximus* (Solier), ist glänzender, hat breiteres, zur Basis stärker verengtes Halsschild; die Reihenpunkte der Elytren stehen entfernter und die Intervalle sind flacher und feiner punktiert.

Heliofugus (Heliofugus) proximus (Solier).

(In Gay: Historia fisica y politica de Chile V, 1851, p. 229.)

Urbeschreibung: **Euschatia proxima.** E. nigra; tergo prothoracis convexo, punctulato, postice valde angustato, subcordato et antice subtruncato; elytris punctis mediocribus, oblongis et in seriebus dispositis impressis.—Long., 3 lin. ½ à 5 lin.; lat., 1 lin. ¾ à 2 lin. ⅓. [= 7,3 - 10,5 mm; 3,6 - 4,9 mm, der Verf.]

De un negro casi caido. Cabeza finamente puntuada, epístome corto, marcado en la sutura posterior por un hundimiento transversal, sus suturas laterales no so distinguidas mas que por una fina estría. Tergum del protórax corto, convexo, pero poco encorvado lateralmente hácia abajo, finamente puntuado, muy encogido hácia la base, subcordiforme y de borde anterior subtruncado como la base. Elitros marcados con ringleras de puntos hundidos bastante gruesos y oblongos. Estas ringleras se reunen posteriormente como en la precedente, y cada flanco está igualmente costeado por un surco marcado de una ringlera de puntos hundidos mas pequeños que los del dorso y de los costados, y mas apretados.

Esta especie se halla en Santiago, la Araucania, Concepcion, etc.

Abb. 11. a. *Heliofugus proximus* (Solier). Estero Leiva, Cord. Parral, X-XII.1953, Coll. Villalobos, in Zool. Staatssammlung München. b. *Heliofugus rossi*, spec. nov. W. of Angol. Chile, Crest of Sierra Nahuelbuta, 1200 m., leg. Ross-Michelbacher, 3.I.51, in der California Academy of Sciences. Holotypus.

In der Sammlung Marseul des Pariser Museums befinden sich 2 typische Exemplare, das eine von Santiago (Holotypus), das andere von Concepcion (Paratypus). Ersteres mißt 8,5 mm., das andere 11,0 mm. Der Holotypus ist offenbar eine Kümmerform mit etwas eckig verrundeten Halsschildseiten, die sich auch nach vorn ein Stück gerade verengen. Außerdem fehlen ihm die sonst deutlichen Punkte der Schildchenreihe. Die übrigen Merkmale stimmen aber zwischen beiden Exemplaren und der Beschreibung so gut überein, daß ich beide Typen nicht als spezifisch verschieden ansehen kann. Die Art ist im wesentlichen durch den stark verengten, herzförmigen Halsschild ausgezeichnet.

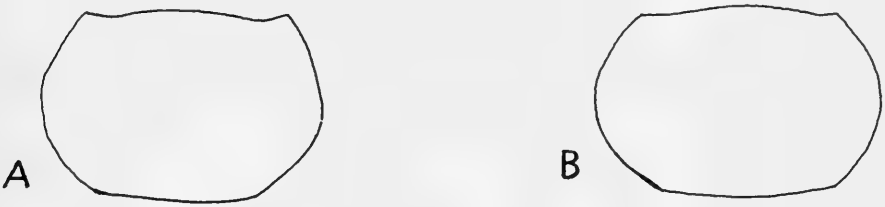

Abb. 12. Halsschild-Umrisse von a. *Heliofugus quillotaensis,* spec. nov., b. *Heliofugus bibioensis,* spec. nov.

An neuerem Material lagen mir aus der Sammlung Peña vor: 2 Exemplare von Estero Leiva, Cord. Parral, X-XII.1953, Coll. Villalobos, und eines von Santiago, Coll. L. E. Peña.

Heliofugus (Heliofugus) proximus punctatosulcatus Fairmaire.

Ann. Soc. Ent. France 1875, p. 197.

(als *Heliophygus*)

Urbeschreibung: 9. **H. punctatosulcatus.**—Long. 8 mill. Ovatus, supra planiusculus, niger, nitidus, capite densissime sat tenuiter punctato, antice leviter impresso, inter oculos sulco transverso brevis, prothorace convexo, subcordato, sat dense sat fortiter punctato, elytris breviter ovatis, striatis, striis fortiter punctatis, intervallis convexiusculis, sutra leviter depressa.

Ovalaire, un peu déprimé en dessus, d'un noir brillant, dernier article des antennes roussâtre. Tête à ponctuation assez fine, très-serrée; au bord anterieur un faible impression transversale formant de chaque côté une petite fossette; entre les yeux un court sillon transversal. Corselet transversal, très-convexe, fortement arrondi sur les côtés, qui son sinués à la base; angles postérieurs droits, pointus; bord antérieur fortement arqué, avec les angles arrondis; ponctuation médiocrement forte, assez serrée; de chaque côté, avant le bord postérieur, un petit sillon transversal. Elytres courtes, larges, obtusément acuminées, à stries assez profondes, très-grossement ponctuées, les intervalles à peine convexes. Pattes finement ponctuées.

Chili; un seul individu.

Cette espèce ressemble, par la forme courte des élytres, à l'H. sulcatus (1); mais elle en diffère notablement par la ponctuation du corselet et des élytres.

In der Anmerkung 1 wird die Urbeschreibung von *H. sulcatus* Guérin-Méneville abgedruckt.

Den Typus unicus, der sich in der Collection Fairmaire des Museums Paris befindet, konnte ich studieren. Er ist fettglänzend und in der Halsschildmitte weniger dicht punktiert. Ein als *H. proximus* determiniertes Exemplar der Collection Fairmaire hat zwar die Gestalt von *H. proximus,* aber die kräftigere Kopf- und Halsschild- punktierung von *H. p. punctatosulcatus* und demonstriert dadurch die Zusammengehörigkeit der beiden Rassen. Die kleinen Querfurchen zwischen den Augen und an der Halsschildbasis halte ich für individuell, da sie bei anderen Vertretern, die m. E. zweifellos zu dieser Subspecies gehören, nicht vorhanden sind.

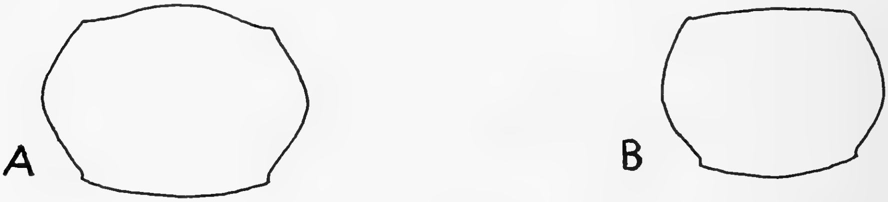

Abb. 13. Halsschild-Umrisse von a. *Heliofugus rossi,* spec. nov., b. *Heliofugus arenosus* Germain.

Abb. 14. Halsschild-Umrisse von a. *Heliofugus sulcipennis* Germain, b. *Heliofugus germaini,* spec. nov.

Im Vergleich zur Nominatform *H. proximus* (Solier) ist *H. p. punctatosulcatus* kürzer und breiter, glänzender und hat stärker punktierten Kopf und Halsschild.

Außer wenigen Exemplaren mit dem Fundort "Chile" lag mir erfreulicherweise 1 Exemplar vor, das 50 km E. of San Carlos, Nuble, Chile, 26.XII. 50 von Ross-Michelbacher, erbeutet wurde.

Heliofugus (Heliofugus) germaini Freude, *spec. nov.*

Patria: Chile (Concepcion).

8,5 × 4,8 mm. (Holotypus), – 10,0 × 4,8 mm.

Schwarz, etwas glänzend, Antennen, Taster und Tarsen bräunlich-rötlich. Kopf etwas quer, vorn konvex gerundet, mit scharfer, nach vorn konkaver Stirnnaht. Die Seitenrandkante buchtet die Augen vorn nur schwach ein. Punktierung rundlich eingestochen, etwas ungleich, mäßig dicht, Grund fast matt. Halschild quer, schwach herzförmig, vorn leicht doppelbuchtig, fast gerade. Seiten stark gebogen, hinten stärker eingezogen als vorn und mit seicht, nicht immer deutlich konkavem Schwung. Basis schwach konvex. Punktierung ähnlich der des Kopfes, seitlich etwas kräftiger. Seiten fein gerandet. Elytren etwa haselnußförmig, nach hinten verrundet zugespitzt, ± breit, Basis etwas konkav, so breit wie die Halsschildbasis, dahinter stark bogig erweitert, mit 9 fein gerinnten Reihen in der Stärke wie im Abstand ziemlich gleicher Punkte und einer kurzen Schildchenreihe am quer-dreieckigen Scutellum, die nur selten fehlt. 1. und 2. Punktreihe enden frei, die übrigen gleichfalls oder sie laufen unregelmäßig zusammen. Der feine Seitenrand ist von oben nur an den Schultern und am Apex sichtbar. Intervalle meist deutlich gewölbt, glänzend, sehr fein, mäßig dicht und etwas unregelmäßig punktiert. Abdomen glänzend, Punktierung vorn mäßig dicht, hinten dichter und feiner.

Abb. 15. a. *Heliofugus germaini,* spec. nov. Allotypus. Chile, Cord. Parral, Fundo Malcho, X.1956, leg. L. E. Peña, in Sammlung Peña. b. *Myrmecodema michelbacheri,* spec. nov. Holotypus. Fray Jorge Forest, Coquimbo, Chile. 11.XII.50, leg. Ross-Michelbacher, in der California Academy of Sciences.

Holotypus, ♂, Chile, Germain, Sammlung Haag-Ruthenberg, in der Zool. Staatssammlung München.

Paratypoide von Germain und Coll. Bates, einige sine patria, im British Museum. 1 Exemplar als type von *H. rufitarsis* Fairmaire bezeichnet, welcher Name wohl nomen nudum ist.

Paratypoide von Concepcion, Chile, Reed leg., in der California Academy of Sciences, von Chile, Oyarzum leg., in der Zool. Staatssammlung München.

Allotypus, ♀, und Paratypoide von Chile, Cord. Parral, Fundo Malcho, X.1956, leg. Peña; X.1956 und IV.57, leg. L. E. Peña; und I.58, leg. M. Rivera, in Collection L. E. Peña.

Chile, Cord. Nuble, Las Trancas, 5-16.XII.51, leg. Peña; Recinto, Cord. Nuble, XI.1952, leg. M. Rivera; Linares, 5-17.I.47, leg. Barros; Estero Leiva, Cord. Parral, X-XI.1953, Coll. Villalobos; Estero de Leiva, Cord. Parral, 8-12. I.1953, leg. Barros-Peña; in der Sammlung Peña, Santiago, und einige davon in der Zoologischen Staatssammlung München.

Die Verbreitung der Art erstreckt sich demnach über die Cordillere von Linares, Nuble und Concepcion.

Heliofugus germaini ähnelt der Subspecies *H. p. punctatosulcatus* hat aber feinere, gleichmäßigere, vorn ebenfalls vertiefte Punktreihen und vorn in der Mitte höher gewölbtes Halsschild mit mehr verrundeten Vorderecken. Besonders auffallend sind die hellen Antennen.

Bestimmungstabelle der Gattung Heliofugus Guerin

1′ Halsschild vorn abgeflacht oder sogar schutenförmig aufgebogen und halbkreisförmig gerundet 2

1″ Halsschild vorn entweder mit deutlichen Ecken oder stärker quergewölbt (Ecken nach unten eingeschlagen) 3

2′ Halsschild grob punktiert, breit und stark aufgebogen. (Colchagua) .... *H. collaris* Germain

2″ Halsschild fein punktiert, mehr abgeflacht als aufgebogen. (Colchagua, Curico) .... *H. cryptocephalus* Philippi

a′ Halsschild weniger quer (6:7), auch seitlich stärker abgeflacht, Vorderecken völlig verrundet. (Colchagua) .... *H. cryptocephalus cryptocephalus* Philippi

a″ Halsschild stärker quer (6:8), seitlich mehr herabgebogen. Vorderecken verrundet, aber ihre Lage meist noch angedeudet. (Curico) .... *H. cryptocephalus curicoensis,* subsp. nov.

3′ Halsschild ausgesprochen kräftig-grob punktiert, höchstens mit geglättetem Mittellängsstreifen 4

3″ Halsschild höchstens mittelstark punktiert 6

4′ Elytren mit Längsrillen, die in der Tiefe maschinennahtartig fein punktiert sind 5

4″ Elytren mit etwas kräftigen Reihen in Größe und Dichte ungleichmäßiger Punkte. (Santiago) .... *H. fairmairei,* nom. nov.

5′ Halsschild stark dachförmig, mit geglätteter Längsmitte. Elytren oval. (Neuquen) .... *H. neuqueni,* spec. nov.

5″ Halsschild auch in der Mitte grob punktiert, weniger ausgeprägt dachförmig. Elytren breitoval. (Santiago—Aconcagua) .... *H. sulcatus* Gemminger

6′ Halsschild kugelartig gewölbt, lackglänzend. Scutellum unsichtbar. (Patria?) .... *H. kuscheli,* spec. nov.

6″ Halsschild anders. Scutellum deutlich 7

7′ Elytrenreihen nur nadelrissig fein angedeutet. (Santiago–Higgins)...... *H. penai,* spec. nov.

  a′ Größer (18,0-16,5 mm). Halsschild stärker verbreitert, am Seitendrande etwas aufgebogen, kräftiger punktiert, Vorderrand fast gerade (Cord. Santiago)...... *H. penai penai,* spec. et subsp. nov.

  a″ Kleiner (16,5-13,5 mm). Halsschild weniger stark abgeflacht, nicht aufgebogen, weniger stark punktiert, Vorderrand deutlich konvex. (Cord. O'Higgins)...... *H. penai ohigginsi,* subsp. nov.

7″ Elytrenreihen kräftiger punktiert oder deutlich gerinnt...... 8

8′ Elytren mit Längsrinnen, die maschinennahtartig gleichmäßig ± fein punktiert sind 9

8″ Elytren mit ungleichmäßig punktierten, ± gerinnten Punktreihen...... 14

9′ Halsschild sehr flach gewölbt, fast queroval, Ecken nur angedeutet. (Patria?)...... *H. colasi,* spec. nov.

9″ Halsschild stärker gewölbt...... 10

10′ Halsschild queroval, aber hochgewölbt, Ecken völlig verrundet. Elytrenreihen scharf und tief eingeschnitten. (Uruguay-Chile)...... *H. sulcatus* Guérin

10″ Halsschild mit deutlichen, wenn auch abgerundeten Ecken...... 11

11′ Halsschild stark, etwas walzenförmig gewölbt, Vorderrand wulstig, stark konvex. Elytrenreihen extrem fein punktiert. (Nuble und die nördlich anschließenden Provinzen.)...... *H. impressus punctatus* (Solier)

11″ Halsschild nicht walzenförmig. Elytrenreihen kräftiger punktiert...... 12

12′ Halsschild nach hinten stärker verengt, etwas herzförmig, Vorderrand kaum konvex. Elytrenintervalle ziemlich gewölbt, Rinnen deshalb etwas tief und in der Tiefe fein punktiert. (Cordillere von Linares–Concepcion)...... *H. germaini,* spec. nov.

12″ Halsschild hinten kaum stärker verengt als vorn, nicht herzförmig, Vorderrand ausgesprochen konvex. Elytrenintervalle ± flach, Reihen kräftiger punktiert...... 13

13′ Etwas glänzend. Halsschild stärker gewölbt (Seiten nicht abgeflacht). Elytrenreihen mehr rinnig, dichter und feiner punktiert. (Nuble–O'Higgins?)...... *H. sulcipennis* Germain

  a′ Halsschildvorderecken stark nach unten eingezogen. Abdomen langoval. (Nuble)...... *H. sulcipennis sulcipennis* Germain

  a″ Halsschildvorderecken flacher, deutlicher vortretend. Abdomen breiter oval. (Santiago)...... *H. sulcipennis brevipennis* Fairmaire

13″ Matt. Halsschild flacher gewölbt (Seiten leicht abgeflacht). Elytrenreihen mehr kräftig punktiert als gerinnt. (Curico)...... *H. leechi,* spec. nov.*

14′ Die Hintertibien sind innenseits nach dem 1. Drittel flach ausgekehlt und mit einer starken Haarbürste versehen. (Große Arten, etwa 10-17 mm.)...... 15

14″ Die Hintertibien ohne flache Auskehlung und ohne starke Bürste...... 18

15′ Halsschild flacher gewölbt, Vorderrand schwach konvex...... 16

15″ Halsschild stärker gewölbt, Vorderrand stark konvex...... 17

16′ Halsschild hinter der Mitte am breitesten. Punktreihen aus ziemlich gleichmäßigen, dichter gestellten Punkten. (Valparaiso?)...... *H. laticollis* Solier

16″ Halsschild vor der Mitte am breitesten. Punktreihen aus ungleich großen Punkten in unregelmäßigen Abständen. (Valdivia)...... *H. cribriceps* (Fairmaire)

17′ Kopf und Halsschild sehr fein punktiert, ± matt. Punktreihen der Elytren sehr grob und ungleich. (Concepcion–Valdivia)...... *H. impressus impressus* Guérin

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* Siehe auch *H. leechi maulensis* auf S. 26a.

17″ Kopf und Halsschildseiten mittelstark punktiert, ± glänzend. Punktreihen der Elytren kräftig, aber gleichmäßiger. (Patria?) .... *H. impressus cribricephalus,* subsp. nov.

18′ Halsschild flach gewölbt, breit (1½ × so breit wie in der Mitte lang, trotz konvexem Vorderrand). Punktierung ziemlich kräftig. (Alhue–Santiago) .... *H. barossi,* spec. nov.

18″ Halsschild stärker gewölbt, weniger breit, feiner punktiert 19

19′ Halsschild herzförmig, zur Basis deutlich stärker verengt als nach vorn, Basis ziemlich schmal 20

19″ Halsschild nicht herzförmig, zur Basis kaum stärker verengt als nach vorn, Basis ziemlich breit 23

20′ Schenkel und Schienen ziemlich kräftig, etwas dicht punktiert. (O'Higgins) .... *H. ventriosus,* spec. nov.

20″ Schenkel und Schienen fein und spärlich punktiert 21

21′ Halsschild glänzen. Elytrenreihen aus entfernt stehenden, längsrissigen und ungleichen Punkten. (Nahuelbuta) .... *H. rossi,* spec. nov.

21″ Halsschild matt, höchstens seidenglänzend. Reihenpunkte der Elytren weniger entfernt und nicht längsrissig 22

22′ Halsschild auch stärker längsgewölbt, Vorderrand kräftig konvex, Vorderecken stark abgerundet. (Santiago–Concepcion) .... *H. proximus* (Solier)

  a′ Punkte der Elytrenreihen sehr unregelmäßig in Größe und Abstand voneinander. (Santiago–Concepcion?) .... *H. proximus proximus* (Solier)

  a″ Punkte der Elytrenreihen weniger unregelmäßig, etwas dichter gestellt und meist stärker gefurcht. (Nuble) .... *H. proximus punctatosulcatus* (Fairmaire)

22″ Halsschild nur schwach längsgewölbt, Vorderrand fast gerade, Vorderecken sehr deutlich, wenn auch verrundet. (Concepcion, Maule) .... *H. arenosus* Germain

23′ Halsschild-Vorderrand annähernd gerade, Vorderecken ziemlich scharf, wenn auch die Spitze abgerundet (von der Seite gesehen fast rechtwinklig) 24

23″ Halsschild-Vorderrand stärker konvex, Vorderecken wenig vortretend (von der Seite gesehen stumpfwinklig verrundet) 26

24′ Halsschild-Hinterwinkel durch kleinen konkaven Schwung ziemlich scharf. Gestalt schlanker oval (Coquimbo) .... *H. coquimboensis,* spec. nov.

24″ Halsschild-Hinterwinkel fast vollständig verrundet 25

25′ Elytren mit ± gerinnten Reihen annähernd gleichmäßiger, etwas dichter gestellter Punkte. (Quillota) .... *H. quillotaensis,* spec. nov.

25″ Elytren mit Reihen sehr ungleicher Punkte in verschiedenen Abständen, nur am Absturz deutlich gerinnt. (Bio Bio) .... *H. biobioensis,* spec. nov.

26′ Elytrenreihen aus ungleich entfernten, unregelmäßigen und verschieden großen Punkten. (Colchagua–Südchille?) .... *H. proximoides,* spec. nov.

  a′ Halsschild-Hinterwinkel deutlich. (Colchagua) .... *H. proximoides proximoides,* spec. et subsp. nov.

  a″ Halsschild-Hinterwinkel völlig verrundet. (Südchile?) .... *H. proximoides rotundangulus,* subsp. nov.

26″ Elytrenreihen aus annähernd gleichen, regelmäßigeren Punkten (Curico–Maule) .... *H. leechi,* spec. nov.

  a′ Elytrenreihen aus dichtgestellten, kräftigen Punkten in feinen Längsrillen. (Curico) .... *H. leechi leechi,* spec. et subsp. nov.

  a″ Elytrenreihen aus weniger dichtgestellten, mehr längsrissigen Punkten. (Maule) .... *H. leechi maulensis,* subsp. nov.

NB: Die Verbreitungsangaben können selbstverständlich noch nicht als vollständig und endgültig angesehen werden, bieten aber doch gewisse Anhaltspunkte.

MYRMECODEMA GEBIEN

Myrmecodema Gebien (*Myrmecosoma* Germain: Ann. Univ. Chile, 12, 1855, p. 403.)

Gattung *Myrmecodema* Gebien wurde von Germain als *Myrmecosoma* aufgestellt und mußte von Gebien wegen Praeokkupation des Namens durch die Anthicidengattung *Myrmecosoma* Mannerheim (1848) umbenannt werden.

Urbeschreibung: **Myrmecosoma** (moluridae.) Novum genus. Corpus elongatum: mentum transversum, postice leviter angustatum, antice truncatum; labium trapeziforme, antice dilatatum et truncatum, palpis articulo ultimo praecedenti longiore, cylindrico apice subtruncato; maxillarum lobis apice rotundatis, pilosis, inermibus, et palpis elongatis, articulo secundo longo, conice, penultimo brevi conico, ultimo valde dilatato apice oblique et late truncato; mandibulae crassae apice leviter bifidae; labrum transversum, antice truncatum, angulis subrotundatis, epistomum antice leviter productum et truncatum; caput postice productum, prothoracem latitudine subaequans; oculi vix transversi, haud lunatis; antennae filiformes versus apicem leviter incrassatae, atriculo secundo minore, tertio longiore, alteris conicis latitudine leviter crescentibus, ultimo suboblongo praecedenti haud minore; prothorax subcylindricus, longior quam latus, antice et postice angustatus, carina laterali fere nulla; elytra oblongo-ovata basim coarctata prothorace parum latiora; femora apice clavata, tibiae haud triangulares, fere fili, formes.

Die Vertreter der Gattung fallen durch ihre besonders schlanke, fast cylindrische Form auf und sind mir bisher nur aus Chile bekannt geworden. Genotypus ist *Myrmecodema nycterinoides* (Germain), die als einzige Art bei der Urbeschreibung des Genus veröffentlicht wurde und 95 Jahre alleinige Vertreterin blieb.

In seinem 1. Tenebrionidenkatalog, den Gebien 1910-11 im Rahmen des Coleopterorum Catalogus von Junk-Schenkling veröffentlicht hat, erscheint die Gattung noch als *Myrmecosoma* Germain unter den Physogasterinae. Das erklärt auch, weshalb wir sie in der Gattungstabelle der amerikanischen Misolampinae, welche Gebien in der Stettin. Ent. Zeit. 89, 1928, p. 219-220, zusammengestellt hat, vergeblich suchen. Sie käme dort neben *Mytis* Champion zu stehen, von der sie leicht durch ihre cylindrische, viel schlankere Gestalt abzugrenzen ist. Erst im neuen Katalog (Mitt. Münchn. Ent. Ges. 1942-1944) stellt Gebien sie zu den Misolampini und benennt sie in *Myrmecodema* um.

Myrmecodema nycterinoides (Germain).

Ann. Univ. Chile, 12, 1855, p. 404.

Urbeschreibung: Elongatus, cylindricus niger, laxe pubescens; capite crebre punctato, supra suturam epistomi depresso; prothorace basi subtruncato in medio leviter sinuato, antice truncato, lateribus vix carinatis tergo dense punctato ad basim leviter marginato et aliquando fossula parum profunda notato; elytris oblongis convexis; humeris valde rotundatis, sutura haud elevati, utroque elytro, carinis quatuor angustis, ante basim junctis, et versus apicem abbreviatis, notato, carina breviore, interstitiis punctis tenuissimis laxe impressis et punctis marjoribus biseriatis ornatis interstitiis, serierum aliquando convexiusculis; abdomine subnitido, profunde punctato; pedibus piceis ore, antennis, tarsisque rufis. Long. 5¼ lin., lat. 1⅓ lin. [= 11,0 mm und 2,8 mm, der Verf.]

Die Art ist besonders ausgezeichnet durch die 4 ziemlich scharfen Kiele in den Intervallen 3, 5, 7 und 9. Bemerkenswert ist weiter die ziemlich dichte und kräftige Punktierung der gesamten Epipleurenbreite.

Myrmecodema nycterinoides ist überall in den Sammlungen vertreten. Um so verwunderlicher ist, daß erst 1950 ein 2. Art veröffentlicht wurde.

Myrmecodema kochi Kulzer.

Ent. Arbeiten Mus. Frey, I, 1950, p. 29-30.

Urbeschreibung: Von der Gattung **Myrmecodema** Gebien (Mitt. Münch. Ent. Gesell. XXXII.-XXXIV. p. 402 (781) Tenebr. Catalog), aufgestellt von Germain als Myrmecosoma in (Anales Univ. Chile XII. 1855. pp. 403 und 404.) ist bisher nur eine Art und zwar nycterinoides Germain bekannt. In der Sammlung Frey befindet sich ein Tier, auf das die Gattungsdiagnose vollkommen paßt und das auch in der äußeren Form mit M. nycterinoides übereinstimmt.

Länglich cylindrisch, matt schwarz, kaum sichtbar behaart, nur am Prothorax sind einzelne spärliche längere schwarze Haare vorhanden.

Kopf dicht grob, Clypeus und die Umgebung fein spärlich punktiert. Clypeus nicht niedergedrückt wie bei nycterinoides. Augen klein und rund, vorne nicht eingedrückt, sehr weit voneinander entfernt, weiter als Clypeus Vorderrand. Fühler fadenförmig. Die ersten Glieder schwarz, dann immer heller werdend. Zweites Glied kurz, drittes länger als viertes. 4-8 [soll heißen 5-8, der Verf.] gleich lang, kürzer als 4. 9-10 wieder etwas kürzer. Alle Glieder sind walzenförmig. Unterseite des Kopfes wie in der Gattungsdiagnose, nur ist das Kinn hinten nicht verengt.

Halsschild etwas länger als breit, cylindrisch. Größte Breite vor der Mitte, nach hinten mehr verengt. Basis und Vorderrand gerade abgestutzt. Vorderrand in der Mitte ungerandet, Basis deutlich gerandet. Der Prothorax ist fast cylindrisch, die Oberseite von der Unterseite nur durch eine feine Seitenrandkante getrennt. Sonst ist der Uebergang unmerklich. Noch walzenförmiger als bei nycterinoides. Scheibe sehr fein, Unterseite etwas kräftiger punktiert. Prosternum hinten niedergedrückt.

Flügeldecken länglich, gewölbt. An der Basis gleich breit wie der Hinterrand des Halsschildes. In der Mitte am breitesten, nach hinten stärker als nach vorne verengt. Schulter ganz verrundet. Die Reihen regelmäßig fein, die äußeren etwas gröber punktiert. Zwischenräume glatt, unpunktiert und nicht gewölbt, ohne jede Spur von Rippen. *M. nycterinoides* hat vier kräftige Rippen. Marginallinie kräftig und regelmäßig punktiert. Epipleuren ziemlich breit, von vorne nach hinten allmählich immer schmäler werdend, glatt, unpunktiert.

Mesosternum grob, Hinterleib feiner punktiert, sehr spärlich behaart, matt schwarz. Die Schenkel sind am Ende keulenförmig verdickt, einfach, die Schienen nicht gekantet, gerade, im letzten Drittel gelb behaart.

Ich war anfangs unsicher, ob auf Grund der starken Rippenbildung bei *nycterinoides* die neue Art überhaupt in diese Gattung gehört, aber die Gattungsmerkmale sind so charakteristisch und die Form des Körpers ist so typisch, daß wohl kaum ein Zweifel bestehen kann.

Länge 12 mm. Breite 4,5 mm. Ein Stück in coll. Gg. Frey.
Patria: Chile.

Myrmecodema michelbacheri Freude, *spec. nov.*

Patria: Chile: Coquimbo.

Länge 11-12 mm., Breite 2,7-3,8 mm.

Schwarzbraun, sehr schlank, etwas zylindrisch. Kopf ziemlich grob, mäßig dicht, eingestochen punktiert, zum konvexen, durch eine Querdepression abgegrenzten Vorderrand feiner. Antennen erreichen die Halsschildbasis nicht, ihre Glieder mit Ausnahme des kurzen 2. und verlängerten 3. annähernd gleichlang, Endglied länglich oval. Die letzten 4-5 Glieder heller gelbbraun, pubeszent. Endglied der Kiefertaster stark beilförmig. Augen rundlich-oval Halsschild im Vergleich zum Kopf feiner, aber dichter und gleichmäßig scharf eingestochen punktiert, um etwa 1/5 länger als breit, in der Mitte am breitesten, nach vorn und zur Basis verengt, vor der Basis mit undeutlichem konkavem Schwung des Seitenrandes. Vorn ungerandet, seitlich fein, zur Basis stärker und diese selbst ziemlich kräftig kielförmig gerandet. Vor der Basismitte oft mit einem schwachen flachen Eindruck. Alle Ecken ziemlich stark abgerundet. Scutellum breit dreieckig, wie der Halsschild punktiert. Elytren mit 10 mittelstarken, deutlichen und ziemlich scharfen Punktreihen, die Punktstellung einzelner kann ziemlich unregelmäßig sein, sodaß einzelne Punkte aus der Reihe tanzen. Auch einige unregelmäßige Punkte der Schildchenreihe sind vorhanden. Intervalle meist schwach gewölbt und undeutlich punktiert. Apex ziemlich breit abgerundet. Epipleuren schmal und allmählich zum Apex verengt, mit einer feinen Punktreihe am Innenrand oder zerstreut punktiert. Kopfunterseite und Thoraxsternite kräftig punktiert, Abdomen zum Apex abnehmend feiner und entfernter, aus den Punkten ± deutlich bewimpert (oft abgerieben). Der Prosternalfortsatz schiebt sich bandförmig zwischen die Vorderhüften und ist der Wölbung des Prosternum angeglichen, an der Basis schwach verbreitert und abgestutzt. Auf dem Mesosternum in seiner Verlängerung meist ein glatter Längskiel. Zwischen den 3 letzten Abdominalsterniten ist eine schmale gelbe Gelenkhaut sichtbar. Schenkel keulig verdickt, die vorderen kurz, die hinteren lang, wie die schlanken Tibien fein punktiert und kurz altgoldfarben bewimpert. ♂ innerseits der Hintertibien mit einer etwas abgeflachten Längspartie und schwacher Haarbürste auf dieser. Tarsen der Geschlechter nicht deutlich verschieden, oberseits fein und spärlich bewimpert, unterseits mit dichten, altgoldfarbenen Tomentpolstern der Glieder 1-4, bezw. 1-3 der Hintertarsen. Penis lang und schlank, stielrund, allmählich zugespitzt, von der Seite gesehen sensenblattförmig. Der ductus ejaculatorius mündet vor der Spitze. Die ♀ Begattungstasche hat 2 lange, schwach s-förmig gekrümmte Stützstäbe (nach Verhoeff radii ventrales), die radii recurrentes setzen in stumpfem Winkel an deren proximalen Enden an.

Holotypus, ♀, Fray Jorge Forest, Coquimbo, Chile, 11.XII.50, Ross-Michelbacher leg., befindet sich in der California Academy of Sciences.

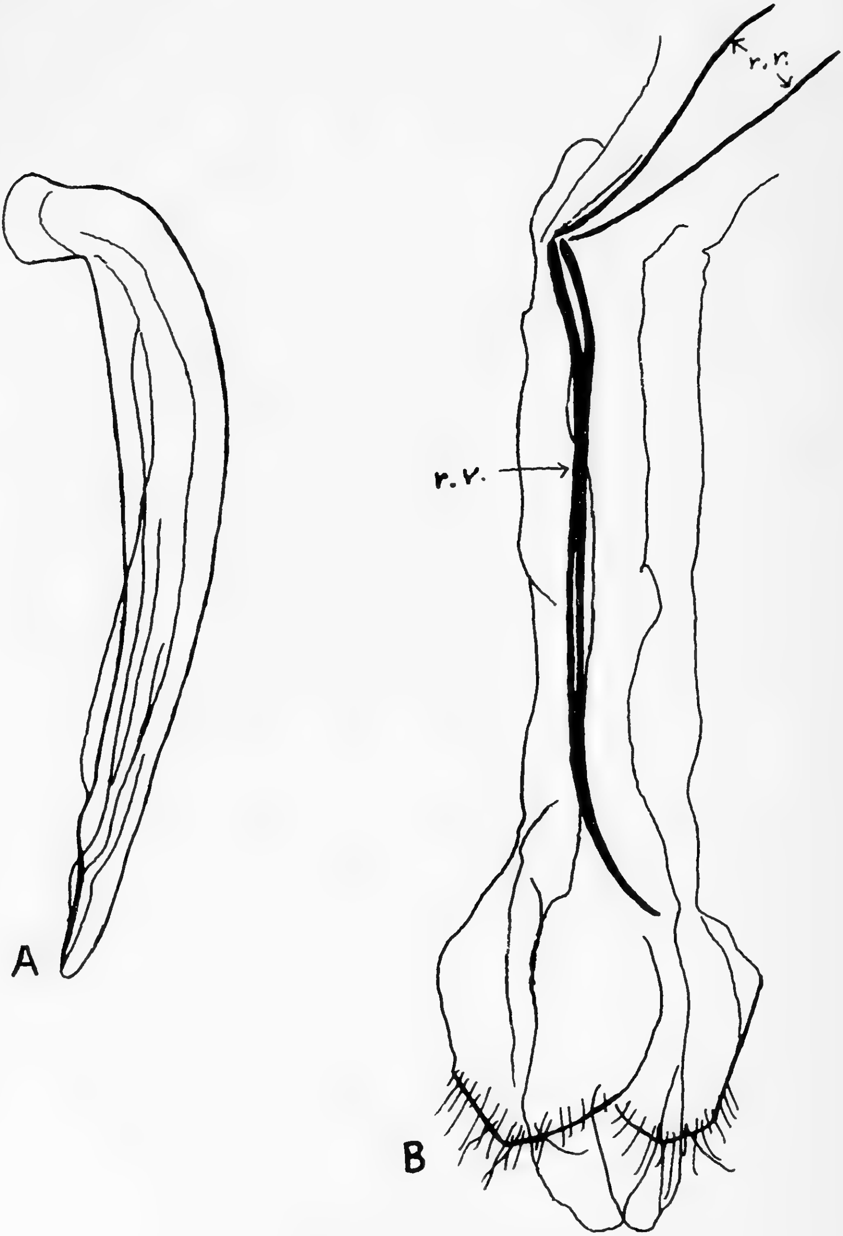

Abb. 16. *Myrmecodema michelbacheri*, spec. nov. a. Aedeagus. b. Begattungstasche, r.v. = radii ventrales, r.r. = recurrentes.

Allotypus, ♂, von Fray Jorge, 18.IX.47, L. Peña leg., sowie 1 Paratypoid von Talypay (?), 20.IX.47, L. Peña leg., im Museum G. Frey, Tutzing.

1 ♂ Paratypoid von Fray Jorge, Ovale, Chile, 11.XII.50, Ross-Michelbacher leg., in der Zoologischen Staatssammlung.

Ich habe die Art zu Ehren eines der verdienstvollen Sammler genannt. Sie ist sehr ähnlich *M. kochi* Kulzer und ich war geneigt, sie als Rasse derselben anzusehen. Ihr Vorkommen in benachbarten Provinzen könnte darauf hindeuten. Die Stützstäbe der Begattungstasche des Holotypus von *M. kochi*, eines ♀, sind aber weit stärker und einseitig gekrümmt und die radii recurrentes setzen in spitzem Winkel an, so daß ich daraus auf 2 verschiedene Arten schießen muß. Ein Vergleich der Penes ist noch nicht möglich, da von *M. kochi* bisher nur das eine Exemplar bekannt ist, er verspricht allerdings auch wenig Differenzierung, da der von *M. michelbacheri* ohne Besonderheiten ist.

Beide Arten sind anhand der Halsschild- und Elytrenpunktierung leicht zu unterscheiden.

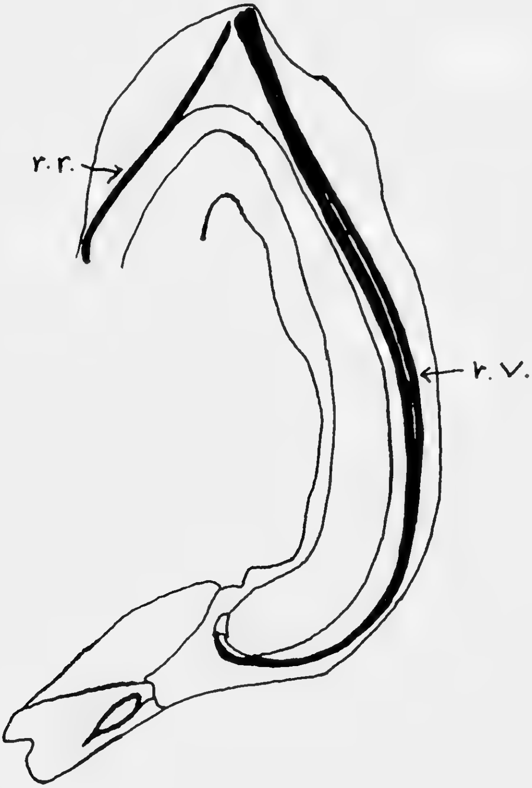

Abb. 17. *Myrmecodema kochi* Kulzer. Begattungstasche, r.v. = radii ventrales, r.r. = recurrentes.

BESTIMMUNGSTABELLE DER GATTUNG MYRMECODEMA-GEBIEN

1′ Intervalle 3, 5, 7 und 9 gekielt .... *M. nycterinoides* (Germain)
1″ Alle Intervalle ungekielt 2
2′ Halsschildober- und Unterseite obsolet punktiert, Elytrenreihen fein punktiert .... *M. kochi* Kulzer
2″ Halsschildober- und Unterseite dicht und ziemlich kräftig punktiert, Elytrenreihen kräftig .... *M. michelbacheri,* spec. nov.

Systematische Uebersicht

HELIOFUGUS Guérin

1. *Collariheliofugus,* subgen. nov.
   Heliofugus collaris (Germain)
   Heliofugus cryptocephalus cryptocephalus Philippi
   Heliofugus cryptocephalus curicoensis, subsp. nov.
2. *Rugosiheliofugus,* subgen. nov.
   Heliofugus sulcatulus Gemminger
   Heliofugus neuqueni, spec. nov.
3. *Inscutoheliofugus,* subgen. nov.
   Heliofugus kuscheli, spec. nov.
4. *Heliofugus,* sensu stricto.
   Heliofugus sulcatus Guérin
   Heliofugus impressus impressus Guérin
   Heliofugus impressus punctatus (Solier)
   Heliofugus impressus cribricephalus, subsp. nov.
   Heliofugus laticollis (Solier)
   Heliofugus cribriceps Fairmaire
   Heliofugus penai penai, spec. et subsp. nov.
   Heliofugus penai ohigginsi, subsp. nov.
   Heliofugus colasi, spec. nov.
   Heliofugus sulcipennis sulcipennis (Germain)
   Heliofugus sulcipennis brevipennis Fairmaire
   Heliofugus barrosi, spec. nov.
   Heliofugus ventriosus ventriosus, spec. et subsp. nov.
   Heliofugus proximoides proximoides, spec. et subsp. nov.
   Heliofugus proximoides rotundangulus, subsp. nov.
   Heliofugus leechi leechi, spec. et subsp. nov.
   Heliofugus leechi maulensis, subsp. nov.
   Heliofugus quillotaensis, spec. nov.
   Heliofugus biobioensis, spec. nov.
   Heliofugus fairmairei, nom. nov.
   Heliofugus arenosus Guérin
   Heliofugus coquimboensis, spec. nov.

Heliofugus rossi, spec. nov.
Heliofugus proximus proximus (Solier)
Heliofugus proximus punctatosulcatus Fairmaire
Heliofugus germaini, spec. nov.

MYRMECODEMA Gebien

Myrmecodema nycterinoides (Germain)
Myrmecodema kochi Kulzer
Myrmecodema michelbacheri, spec. nov.

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(Die Quellen der Urbeschreibungen sind bereits jeweils bei deren Wiedergabe vermerkt.)

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FIRST RECORDS OF THE ECHENEIDID FISH *REMILEGIA AUSTRALIS* (BENNETT) FROM CALIFORNIA, WITH MERISTIC DATA

BY

W. I. FOLLETT and LILLIAN J. DEMPSTER
Department of Ichthyology
California Academy of Sciences

During October 1958, nine specimens of the widely distributed but rarely collected whalesucker, *Remilegia australis* (Bennett), were taken from blue whales, *Sibbaldus musculus* (Linnaeus),[1] captured at 37° 20′ North Latitude, 123° 00′ West Longitude (about 20 miles south of the Farallon Islands), off San Mateo County, California. These are apparently the first authentic records of this species of Echeneididae from California. (A "California specimen" referred by Gudger (1926:18) to *Remilegia australis* could not have been of that species, since the specimen was stated to have only "18 lamellae.")

Eight of these specimens (California Academy of Sciences no. 26663), 126 to 380 mm. in standard length, were removed from 65- to 70-foot blue whales captured October 12; the ninth specimen (California Academy of Sciences no. 26664), 262 mm. in standard length (pl. 1, upper fig.), was taken from an 81-foot male blue whale captured October 16.

During September 1959, eight additional specimens were taken from

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[1] In using this name for the blue whale, we follow Grinnell (1933:213), Miller and Kellogg (1955:667), and Hall and Kelson (1959:837).

blue whales captured off central California: Three specimens (California Academy of Sciences no. 26766), 136 to 186 mm. in standard length, 10 to 12 miles off Santa Cruz; four specimens (Dale W. Rice field no. 146), 105 to 134 mm. in standard length, and one specimen (Dale W. Rice field no. 150), 399 mm. in standard length, 20 to 30 miles west of the Farallon Islands.

Although the whalesucker has been known for 120 years, there are only about 20 published records of specimens collected. Perhaps for this reason, *Remilegia australis* has been regarded as a rare species: "possibly the rarest form of the Echeneididae" (Gudger, 1926:10); "very rare" (Ui, 1932:253); "a rare species known from very scattered spots on the globe" (Whitley, 1949:23); "very rare" (Kamohara, 1958:61); "probably the rarest of the Remoras" (Smith, 1958:320). Krefft (1953:280) said that this species was only seldom found but that it was not at all rare on the coast of Peru, where he had seen it in the water several times on slain whales.

SYNONYMY

Several recent authors have referred this species to the genus *Remora* Gill, 1862. However, pending further study, we prefer to follow prevalent usage, which recognizes *Remilegia* Gill, 1862, as a distinct genus.

Echeneis australis BENNETT, 1840, vol. 2:273 ("Australasian remora"; original diagnosis; type locality not indicated). GILL, 1864:60 (type of *Remilegia* Gill; *Echeneis scutata* Günther a synonym); 61 (critical notes). WAITE, 1915:340 (synonymy; counts; measurements; description; color; references; critical notes; size; specimen from Adelaide, South Australia); pl. 11 (disc); 1921:160 ("sucker fish"; synonymy; record); fig. 263; 1923:185 ("sucker fish"; characters in key; diagnosis; record; two figs.). KAMOHARA, 1950:237 ("oukoban"; *Echeneis scutata* Günther a synonym; description; color; size; distribution; Tosa Province, Japan), GRAHAM, 1953:341 (figs., copied); 342 (reference). MATSUBARA, 1955:1211 (*Echeneis scutata* Günther a synonym; generic name misspelled *Echelis*).

Remora australis. BENNETT, 1840, vol. 1:165 ("sucking-fish"; size; observed at Raiatea, Society Islands). MCCULLOCH, 1929: 382–383 (synonymy; distribution; Australia). MASSMANN, 1957:157 ("whale sucker"; specimen from Gloucester Point, Chesapeake Bay, Virginia). MAHNKEN and GILMORE, 1960:134 ("whale-sucker"; size; color; behavior; observed in Gulf of Mexico, Lat. 28° 10′ N. [misprinted "S"], Long. 93° 20′ W.); pl. 1 (fish clinging to *Stenella plagiodon*). AMERICAN FISHERIES SOCIETY COMMITTEE ON NAMES OF FISHES, 1960:48 ("whalesucker"; distribution).

Remilegia australis. GILL, 1864:61 (reference; critical notes; *Echeneis scutata* Günther a synonym). LÜTKEN, 1875:42 (synonym of *Echeneis scutata* Günther). JORDAN and EVERMANN, 1898:2268 (generic name only; characters in key); 2270–2271 (description; distribution; record; synonymy). EVERMANN and MARSH, 1900:301 (generic name only; characters in key). GUDGER, 1926:10 (characters; record); 18 ([misidentification]); 22 (references). NICHOLS, 1930:370 (generic name only [misprinted *Remilegea*]; hosts; not recorded from Porto Rico). DE BUEN, 1934:398 (*Echeneis scutata* Günther a synonym); 402 (characters in key; generic allocation). BREDER, 1936:42–43 (size; brief description; color; specimen, in Bingham Oceanographic Collection, Yale University, New Haven, Connecticut, from between Panama and Lower California). WOODS, 1942:192 (brief description; size; count; distribution; records; reference; specimen, in Field Museum of Natural History, Chicago, Illinois, from within 50 miles of Corpus Christi, Texas). CARL and WILBY, 1945:29 ("whale sucker"; host; reference; specimens from Vancouver Island erroneously recorded as *Remora remora;* distribution; size; specimens in Provincial Museum, Victoria, British Columbia, and in University of British Columbia; "record appears to be the first for the Pacific Ocean"). CLEMENS and WILBY, 1949:42 (characters in key); 329 ("whale-sucker"; description; counts; color; size; diagnosis; hosts; records; specimens in Provincial Museum, Victoria, British Columbia); fig. 246. WHITLEY, 1947:149 (specimen from Bicton, near Fremantle, Western Australia); 1948:29 (record); 1949:22 (fig. of disc; specimen from Cape of Good Hope); 23 (diagnosis; color; records; distribution; hosts; size). KREFFT, 1953: 278–281 (synonymy; references; size; host; description; measurements; color; parasite; distribution; specimens, in Institut für Seefischerei, Hamburg, Germany, from off Peru, Lat. 6° 12′ S., Long. 82° 05′ W., and Lat. 10° 20′ S., Long. 80° 24′ W.); fig. 2 (lateral aspect); fig. 3 (dorsal aspect); fig. 4 (dentition). MATSUBARA, 1955:1211 ("ōkoban"; description; color; size; measurements; counts; "until now we had no record in Japan"; specimen, in Saito's collection, probably from coast of northern Japan); fig. 463a (disc); fig. 463b (lamina). HUBBS, 1956:70 (*Remora scutata* a synonym). MAUL, 1956: 9, 16 (generic name only; references); 12, 13 (specific name only; *scutata* a synonym); 18 (generic name only; characters in key). KAMOHARA, 1958:61 (*"ōkoban"; Echeneis scutata* Günther a synonym; distribution; Kochi Prefecture, Japan). SMITH, 1958:319–320 (synonymy; counts; measurements; description; color; size; host; distribution; "not before in the South Western Indian Ocean"; "the first specimen . . . from South Africa"; specimen from Algoa Bay, South Africa); fig. 1 (dorsal and lateral aspects). TORTONESE, 1958:336 (Mediterranean). MYERS, 1960:78 (known from north coast of New Guinea).

Echeneis scutata GÜNTHER, 1860a:401, 402, pl. 10B (original diagnosis; type locality, Ceylon); 1860b:381 (reference; description; measurements; size; color; distribution; specimens, in British Museum (Natural History), London, England, from Ceylon and India). GILL, 1862:239 (characters; *Remilegia*, new genus); 1864:60, 61 (synonym of *Echeneis australis* Bennett). LÜTKEN, 1875:28 (characters in key); 30 (reference); 31 (specimen in Copenhagen Museum); 32 (host); 42–43 (*Remilegia australis* a synonym; distribution; hosts; reference; critical note; size; description; measurements; color; specimen from Atlantic Ocean, Lat. 10° N., Long. 39° W.); 4, 5 (French abstract). GÜNTHER, 1880:461 (bulkiest species of *Echeneis;* size); 1886:326 (bulkiest species of *Echeneis;* size). PERUGIA, 1881:17 (references; description; color; specimen, in Collezione Centrale dei Vertebrati Italiani in Florence, Italy, from Adriatic Sea); colored pl. 2. FABER, 1883:232 (record). CARUS, 1893:661 (diagnosis; distribution; record; accidental at Trieste). NINNI, 1912:77 (reference; record). JORDAN, 1919:316 (orthotype of *Remilegia*). MCCULLOCH, 1929:382 (synonym of *Remora australis*). UI, 1932:253 ("ohokoban"; specific name misprinted *sucatata;* diagnosis; color; size; Kishu, Japan). DE BUEN, 1934:398, 399 (references; occurrence in Mediterranean doubtful; synonym of *Remilegia australis;*

distribution). MATSUBARA, 1955:1211 (synonym of *Echeneis australis* Bennett; type of *Remilegia* Gill; generic name misspelled *Echelis*). KAMOHARA, 1958:61 (synonym of *Remilegia australis*).

Remilegia scutata. GILL, 1862:239 (characters; *Remilegia*, new genus).

Remora scutata. CADENAT, 1953:680–683 (references; host; distribution; measurements; counts; description; color; characters; comparisons; specimen, in Laboratoire de Biologie Marine de l'Institut Français d'Afrique Noire, Gorée, from off N'gor, Sénégal, French West Africa); fig. 11; fig. 12 (disc). MUNRO, 1955:268 ("Ceylonese remora"; characters in key; reference; diagnosis; color; size; Ceylon); pl. 52. HUBBS, 1956:70 (synonym of *Remilegia australis*).

Echeneis naucrates [not of Linnaeus, 1758:261]. GÜNTHER, 1860b:384 (synonymy, in part: *Echeneis australis* Bennett only).

Remora remora [not of Gill, 1862:239]. HALKETT, 1913:96 (in part: Sechart, British Columbia; specimen in Provincial Museum, Victoria, British Columbia). SCHULTZ and DELACY, 1936:138 (in part: Vancouver Island record).

METHODS OF COUNTING

All counts of the dorsal, anal, and caudal fins were taken from radiographs. In the dorsal and anal fins, the last two ray elements are counted as one ray. In the caudal fin, all branched rays plus the adjacent unbranched ray in each moiety of the fin are regarded as principal rays, and all other unbranched rays are regarded as procurrent. (See Hubbs and Lagler, 1958: 19–21.)

All rudimentary gill-rakers are counted, and the gill-raker in the angle of the arch is included in the count of the lower limb, as by Hubbs and Lagler (1958:24).

CHARACTERS

Except as stated below, the characters of our specimens correspond well to those noted in the literature (see SYNONYMY, *supra*). Our data, presented in table I, do not suggest any distinction between the 17 specimens taken from blue whales and a specimen (Scripps Institution of Oceanography no. 59–74) taken from a whitebelly dolphin.

DISCAL LAMINAE. Modally 26 pairs, ranging from 25 to 28. The specimen with 28 pairs of laminae—one more pair than previously recorded for this species—is shown in plate 1, lower figure.

The published counts range from 24 (Bennett, 1840:273) to 27 (Günther, 1860a:401).

The number of denticles on the last pair of laminae ranges from 124 (61 on the left lamina, 63 on the right) to 358 (184 on left, 174 on right), being roughly correlated with the size of the specimen (as in other genera of Echeneididae; see Maul, 1956:11, 48).

TABLE 1

Standard length, disc length, and selected counts of 18 specimens of Remilegia australis

CAS=California Academy of Sciences; DWR=Dale W. Rice; SIO=Scripps Institution of Oceanography. Figures at left of hyphen represent count of left side of specimen; figures at right of hyphen represent count of right side of specimen.

Character	*DWR 146*	*DWR 146*	*DWR 146*	*CAS 26663*	*DWR 146*	*CAS 26766*
Standard length, mm	105	122	126	126	134	136
Disc length, mm	52	60	62	61	69	69
Counts						
Discal laminae	27	26	26	25	25	26
Dorsal soft-rays	25	24	24	25	25	26
Anal rays, total	25	23	23	25	25	25
Pectoral rays	24–24	24–24	24–24	23–23	23–23	23–23
Pelvic rays	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5
Caudal rays:						
Principal	9+8	9+8	9+8	9+8	9+8	9+8
Procurrent[1]	13/14	14/14	14/14	13/14	12/13	14/15
Gill-rakers:[2]						
1st arch:						
Anterior	2+17–2+16	2+15–2+16	3+14–2+15	2+17–2+14	2+19–2+17	2+18–3+17
Posterior	1+18–1+17	1+17–1+19	1+17–1+17	2+16–1+17	1+17–1+16	1+18–1+18
2nd arch:						
Anterior	2+18–2+18	2+16–2+16	2+16–2+17	2+16–2+17	2+17–2+16	2+17–2+17
Posterior	2+16–2+17	1+16–2+17	1+16–2+20	2+18–2+16	2+16–2+17	1+19–2+19
3rd arch:						
Anterior	3+17–2+17	2+17–2+16	2+17–2+17	2+16–2+17	3+19–3+18	2+18–2+20
Posterior	1+16–1+17	1+16–1+17	1+17–1+16	1+15–1+17	1+18–1+16	1+17–1+16
4th arch:						
Anterior	1+17–2+20	2+17–2+16	2+17–1+18	2+16–2+17	2+18–1+17	2+18–2+17
Posterior	1+13–1+14	1+13–1+14	1+13–1+16	1+12–1+13	1+13–1+13	1+13–1+14
Branchiostegals	10–10	10–10	10–10	9–9	10–9	10–10
Denticles on last pair of laminae	61–63	74–72	73–77	79–81	80–83	89–87
Vertebrae	12+15=27	12+15=27	12+15=27	12+15=27	12+15=27	12+15=27

[1] Figures at left of diagonal represent count of upper series; figures at right of diagonal represent count of lower series.

[2] All rudimentary gill-rakers are counted, and the gill-raker in the angle of the arch is included in the count of the lower limb.

TABLE I—Continued

Standard length, disc length, and selected counts of 18 specimens of Remilegia australis

CAS=California Academy of Sciences; DWR=Dale W. Rice; SIO=Scripps Institution of Oceanography. Figures at left of hyphen represent count of left side of specimen; figures at right of hyphen represent count of right side of specimen.

Character	*CAS 26766*	*CAS 26663*	*SIO 59–74*	*CAS 26766*	*CAS 26663*	*CAS 26663*
Standard length, mm	146	157	167	186	222	234
Disc length, mm	72	79	83	96	109	118
Counts						
Discal laminae	26	26	27	26	25	26
Dorsal soft-rays	23	26	26	25	23	25
Anal rays, total	25	26	24	25	24	25
Pectoral rays	23–22	24–24	24–24	23–23	24–22	23–23
Pelvic rays	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5
Caudal rays:						
Principal	9+8	9+8	9+8	9+8	9+8	9+8
Procurrent[1]	13/14	15/14	14/14	14/15	14/15	14/13
Gill-rakers:[2]						
1st arch:						
Anterior	2+15–2+17	2+17–2+17	1+16–2+17	2+17–2+17	2+15–2+15	2+17–2+17
Posterior	1+16–1+16	1+17–2+17	1+18–2+16	1+19–2+17	2+16–1+19	2+18–1+19
2nd arch:						
Anterior	2+17–1+16	2+17–2+17	2+17–2+15	2+19–2+17	2+17–2+20	2+19–3+19
Posterior	2+17–2+17	2+18–2+20	2+16–2+17	2+20–2+20	2+18–2+19	1+18–2+17
3rd arch:						
Anterior	2+17–2+16	2+18–2+17	2+16–2+16	2+19–2+19	2+18–2+17	2+18–2+17
Posterior	1+16–1+17	1+17–2+18	1+16–1+18	1+17–1+17	1+17–1+17	1+16–1+18
4th arch:						
Anterior	2+17–2+17	2+17–2+17	2+17–2+17	2+17–2+19	2+16–1+17	2+18–2+16
Posterior	1+13–1+14	1+13–1+14	1+12–1+13	1+13–1+13	1+12–1+13	1+13–1+13
Branchiostegals	10–9	10–10	10–10	10–10	10–10	10–10
Denticles on last pair of laminae	86–85	90–88	87–85	98–104	126–124	134–138
Vertebrae	12+15=27	12+15=27	12+15=27	12+15=27	12+15=27	12+15=27

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1. Figures at left of diagonal represent count of upper series; figures at right of diagonal represent count of lower series.
2. All rudimentary gill-rakers are counted, and the gill-raker in the angle of the arch is included in the count of the lower limb.

TABLE I—Continued

Standard length, disc length, and selected counts of 18 specimens of Remilegia australis

CAS=California Academy of Sciences; DWR=Dale W. Rice; SIO=Scripps Institution of Oceanography. Figures at left of hyphen represent count of left side of specimen; figures at right of hyphen represent count of right side of specimen.

Character	*CAS 26663*	*CAS 26664*	*CAS 26663*	*CAS 26663*	*CAS 26663*	*DWR 150*
Standard length, mm	250	262	286	297	380	399
Disc length, mm	123	127	141	155	191	201
Counts						
Discal laminae	25	26	26	26	28	26
Dorsal soft-rays	25	25	25	24	25	26
Anal rays, total	23	25	24	24	24	25
Pectoral rays	21–23	24–23	23–24	24–23	24–23	23–23
Pelvic rays	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5	I, 5–I, 5
Caudal rays:						
Principal	9+8	9+8	9+8	9+8	9+8	9+8
Procurrent[1]	15/14	15/15	13/14	13/13	13/14	14/13
Gill-rakers:[2]						
1st arch:						
Anterior	1+16–2+15	2+16–2+16	2+14–2+16	2+19–2+17	2+16–2+17	2+17–2+16
Posterior	1+17–1+19	2+16–1+18	2+18–2+17	1+17–1+17	1+19–1+18	1+17–1+17
2nd arch:						
Anterior	2+17–1+19	2+18–2+17	2+17–2+17	2+18–3+16	2+20–3+17	2+18–2+17
Posterior	2+22–2+18	2+18–2+17	2+19–2+19	2+17–1+17	2+19–2+19	1+18–1+17
3rd arch:						
Anterior	2+17–2+18	2+17–2+18	2+16–2+16	2+17–2+20	2+17–2+18	2+18–3+17
Posterior	2+17–1+16	1+16–1+16	1+17–1+15	1+14–1+15	1+15–2+15	1+16–2+17
4th arch:						
Anterior	2+19–2+16	2+18–2+17	2+17–2+16	2+15–2+17	2+17–2+18	2+17–2+18
Posterior	1+14–1+14	1+12–1+12	1+12–1+13	1+11–1+13	1+13–1+12	1+15–1+14
Branchiostegals	10–10	10–10	10–10	10–10	10–10	10–10
Denticles on last pair of laminae	122–121	119–125	142–140	129–122	111–126	184–174
Vertebrae	12+15=27	12+15=27	12+15=27	12+15=27	12+15=27	12+15=27

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1. Figures at left of diagonal represent count of upper series; figures at right of diagonal represent count of lower series.
2. All rudimentary gill-rakers are counted, and the gill-raker in the angle of the arch is included in the count of the lower limb.

DORSAL SOFT-RAYS. Modally 25, ranging from 23 to 26.

The published counts range from 20 (Smith, 1958:319) to 22 (Günther, 1860a:401); possibly they do not include some of the anterior rays, which—because of the thick integument of this fish—may have been overlooked.

ANAL RAYS. Modally 25, ranging from 23 to 26. Pending further investigation, we regard the two anterior elements, which are embedded in thick integument, as unbranched rays rather than as spines.[2]

The published counts range from 21 (Günther, 1860a:401) to 24 (Bennett, 1840:273).

PECTORAL RAYS. Modally 23, ranging from 21 to 24. The uppermost ray is invariably unbranched. We have not expressed the pectoral formulae in terms of branched and unbranched rays because, in the absence of alizarin preparations, the branching of the lowest rays in the smaller specimens does not appear satisfactorily determinable.

The published counts range from 1/20 (Cadenat, 1953:681) to 24 (Waite, 1915:340).

PELVIC RAYS. I, 5.

When Bennett (1840:273) wrote "Ventral 5," he had surely overlooked the concealed spine. When Günther (1860b:382) said of *Echeneis scutata,* "the ventrals are . . ., as in all the species of the genus [*Echeneis*], composed of one spine . . . and four soft rays," he apparently used the word "four" by inadvertence, since in his diagnoses of two other species which he referred to the genus *Echeneis,* he noted that the ventrals were composed of one spine and five soft-rays (Günther, *op. cit.*:377, 383).

CAUDAL RAYS. Principal: 9+8. Procurrent: modally 13 in the upper series and 14 in the lower series, ranging from 12 in the upper series and 13 in the lower series to 15 in the upper and 15 in the lower.

Since all our specimens have 17 principal caudal rays, it seems probable that the count of 20 by Bennett (1840:273) included the longest procurrent ray in one moiety of the caudal fin and the two longest procurrent rays in the other moiety. Counts of 13+6 and 19–20 were noted by Waite (1915:340; 1923:185).

GILL-RAKERS. First arch (anterior aspect): modally 2+17, ranging from 1 to 3 on the upper limb and from 14 to 19 on the lower limb. The gill-rakers of the upper limb are small, round structures, which are difficult to discern because they are masked by the long gill-rakers at and immediately below the angle of the arch. Frequencies of counts of the gill-rakers on the anterior and posterior aspects of all arches are presented in table II.

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[2] In the order Echeneiformes, according to Berg (1940:495), there are "no spines in second dorsal and anal."

TABLE II

Frequencies of gill-raker counts in 18 specimens of Remilegia australis[1]
(Both sides counted)

	Upper limb			Lower limb											
	1	*2*	*3*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
First arch:															
Anterior	2	32	2	....	....	....	3	6	9	15	1	2	....	....	....
Posterior	27	9	....	....	....	....	....	....	7	15	8	6	....	....	....
Second arch:															
Anterior	2	31	3	....	....	....	....	1	7	17	5	4	2	....	....
Posterior	7	29	....	....	....	....	....	....	6	11	7	7	4	....	1
Third arch:															
Anterior	....	32	4	....	....	....	....	....	7	15	9	3	2	....	....
Posterior	32	4	....	....	....	....	....	4	12	14	6	....	....	....	....
Fourth arch:															
Anterior	4	32	....	....	....	....	....	1	6	19	7	2	1	....	....
Posterior	36	....	....	1	7	18	8	1	1	....	....	....	....	....	....

[1] All rudimentary gill-rakers are counted, and the gill-raker in the angle of the arch is included in the count of the lower limb.

The published counts are 4+14 (Waite, 1915:341), 1 at angle and 14 on lower limb (Cadenat, 1953:681), 2+1+14 (Matsubara, 1955:1212), and 0+15 (Smith, 1958:319).

BRANCHIOSTEGAL RAYS. Modally 10–10; 9–9 in one specimen, 10–9 in two specimens.

In the original description of *Echeneis australis,* Bennett (1840:273) noted, "Branchiostegous rays 10." The original diagnosis of the genus *Echeneis* included the character "Membr. branch. radiis X" (Linnaeus, 1758:260). Günther (1860b:376), however, regarded "branchiostegals seven" as a character of the genus *Echeneis* (to which he referred the present species; *op. cit.*:381, as *Echeneis scutata*). This statement of Günther's may have been accepted by those authors who noted seven branchiostegals as a character of the family Echeneididae (*e.g.,* Gill, 1883:565; Jordan and Gilbert, 1883:416; Jordan and Evermann, 1898:2266; 1905:494; Evermann and Marsh, 1900:301; Meek and Hildebrand, 1928:895; Fowler, 1959:498).

BRANCHIOSTEGAL MEMBRANES. In all our specimens, the left branchiostegal membrane overlaps the right. This asymmetry is in accordance with the general rule for all fishes in which the branchiostegal membranes are not united with each other or with the isthmus (Hubbs and Hubbs, 1945:279; Crossman, 1960:368).

SIZE. Our specimens range from 105 to 399 mm. in standard length.

The smallest example that we have found mentioned in the literature is the 46-mm. specimen recorded by Lütken (1875:42). The largest of which we have found a published record is the 23-inch specimen mentioned by Günther (1860b:382); possibly this specimen provided the basis for the statements that this species attains a length of 2 feet and a weight of 8 pounds (Günther, 1880:461; 1886:326) and that it attains a length of 600 mm. (Kamohara, 1950:237; Smith, 1958:320).

DISC LENGTH. Averaging 0.50 standard length; ranging from 0.48 standard length to 0.52 standard length.

A disc length of 0.5 standard length was recorded by Woods (1942:192) and a disc length of 0.46 standard length, by Smith (1958:319). The disc length has been recorded as 2⅓ in total length (Günther, 1860a:401; Perugia, 1881:17) and as 2⅖ in total length (Lütken, 1875:42).

COLOR. In life, one specimen—the only one that we obtained alive—was blue with a narrow white margin on each fin. This specimen, which is shown in plate 1, upper figure, was photographed immediately after it had been preserved in formalin and before any observable change had occurred in the life colors. After months in alcohol, this specimen and 15 others are dark slaty blue and one specimen is brown. In life, the specimen from a whitebelly dolphin (see HOSTS, *infra*) was reported to have been light slate gray with some hint of bluish background; after preservation in alcohol it has darkened to a bluish brown.

The life colors of the whalesucker have been recorded as brown (Günther, 1860a:401; 1860b:381; Lütken, 1875:43); dark brown with white edge on dorsal and anal fins (Matsubara, 1955:1212); brownish (Kamohara, 1950:237); uniform violet (Perugia, 1881:17); uniform dark slaty blue, edges of fins lighter, disc brown (Waite, 1915:341); dark slaty-blue (Whitley, 1949:23); deep marine blue (Cadenat, 1953:682); bluish white (Cadenat, 1953:682); grayish white (Ui, 1932:253); uniform slate gray, margins of dorsal and anal and tips of tail white (Breder, 1936:43); uniform gray (Mahnken and Gilmore, 1960:134); almost black, margins of dorsal, anal, and pectoral and upper and lower margins of caudal white (Smith, 1958:320).

HOSTS

Our 17 specimens were all taken from blue whales, *Sibbaldus musculus*. The specimen (Scripps Institution of Oceanography no. 59–74) from off San Roque Rock, Baja California, was taken from a whitebelly dolphin, *Delphinus bairdii* (John E. Fitch, personal communication).

Published records mention the following cetaceans as hosts of the whalesucker: dolphin (Lütken, 1875:42); sulphur bottom whale [blue whale] (Carl and Wilby, 1945:29); *Delphinus delphis* (?) (Cadenat, 1953:680);

sperm whale, *Physeter* (Krefft, 1953:278); porpoise (Smith, 1958:320); spotted porpoise, *Stenella plagiodon* (Mahnken and Gilmore, 1960:134). One individual was attached to an oar (Perugia, 1881:17).

DISTRIBUTION

The present specimens were collected off California and Baja California.

Remilegia australis appears to be of world-wide distribution in temperate and tropical seas. It is known from as far north as Vancouver Island, British Columbia (Lat. 49° N.), and as far south as the Cape of Good Hope (Lat. 34° S.).

The localities from which we have found this species recorded may be listed as follows:

Pacific Ocean: Society Islands (Bennett, 1840, vol. 1:165). New Guinea (Myers, 1960:78). Japan (Ui, 1932:253; Kamohara, 1950:237; 1958:61; Matsubara, 1955:1211). British Columbia (Halkett, 1913:96). Between Lower California and Panama (Breder, 1936:42). Peru (Krefft, 1953:278).

Atlantic Ocean: Gulf of Mexico (Woods, 1942:192; Mahnken and Gilmore, 1960:134). Chesapeake Bay (Massmann, 1957:157). Mid-Atlantic (Lütken, 1875:42). Adriatic Sea (Perugia, 1881:17). French West Africa (Cadenat, 1953:680).

Indian Ocean: South Africa (Whitley, 1949:22; Smith, 1958:320). India (Günther, 1860b:381). Ceylon (Günther, 1860a:401). Western Australia (Whitley, 1947:149). South Australia (Waite, 1915:340).

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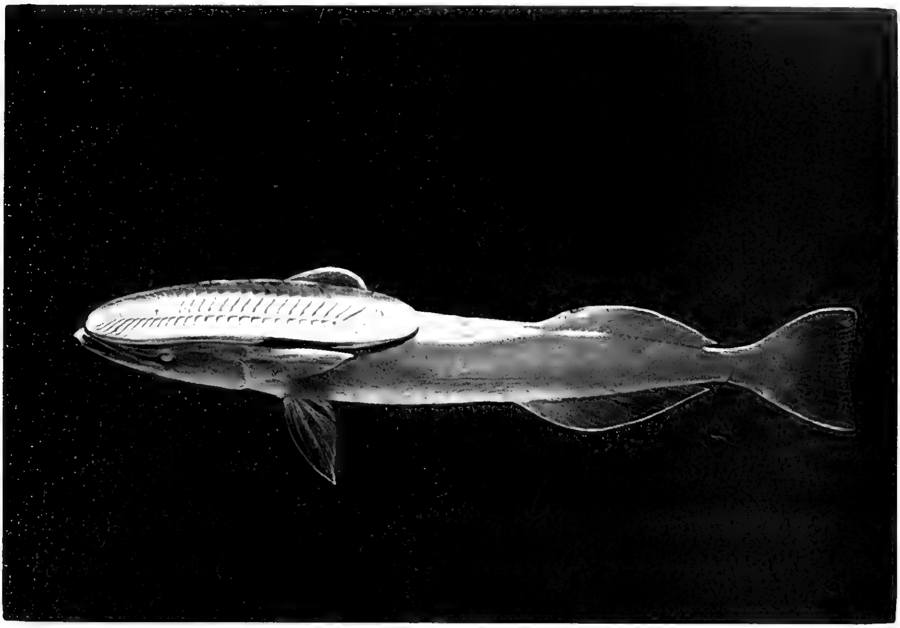
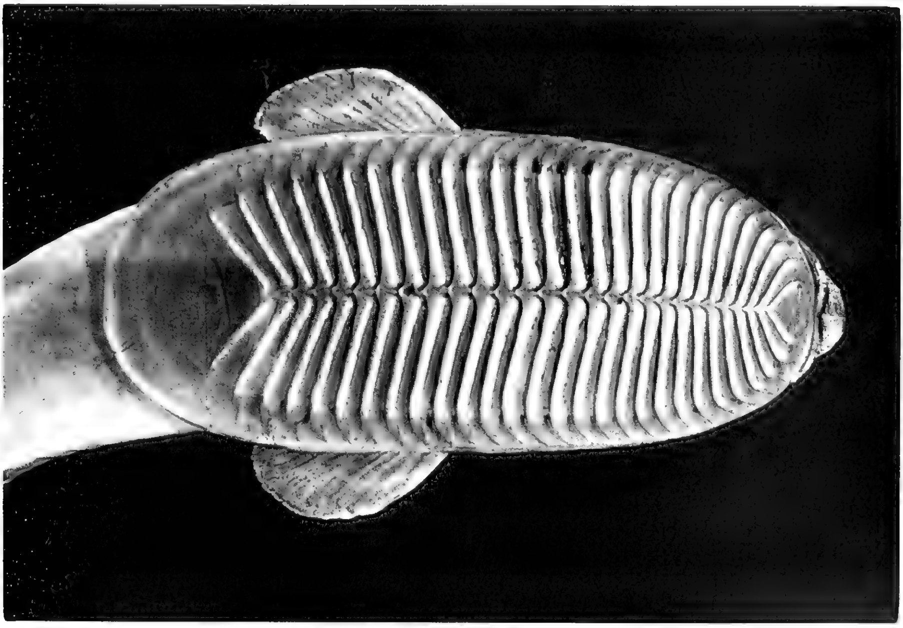
Plate 1

Upper figure. *Remilegia australis* (Bennett), whalesucker (CAS 26664), standard length 262 mm., from a blue whale captured October 16, 1958, off San Mateo County, California. Kodachrome by W. I. Follett.

Lower figure. Disc of a 380-mm. specimen of *Remilegia australis* (CAS 26663) with 28 pairs of laminae—one more pair than previously recorded for this species. Kodachrome by W. I. Follett.





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ON SOME EARTHWORMS OF EISEN'S COLLECTION[1]

BY

G. E. GATES

University of Maine, Orono

Gustav Eisen, pioneer of oligochaetology in North America, and for whom three genera and several species were named, collected in California and Mexico, and also during 1880–1903, while he was on expeditions to Central American republics. Most of his material was lost at the time of the San Francisco earthquake in 1906. Fortunately, a few lots survived the disaster. The present contribution reports on those belonging to the California Academy of Sciences. This material was received by the author more than ten years ago. All of it is more or less softened. Some specimens were so macerated that even identification to family was impossible. Others were identifiable, but disintegrated more or less completely during dissection. The study of worms in such delicate condition is tedious and the results are not always commensurate with the time expended. However, some of the material has provided information of considerable interest.

The author's thanks are extended to Dr. Robert C. Miller for loan of the material. Especially appreciated is his understanding of the fact that a study of some of these specimens would result in their destruction.

ON CERTAIN BLOOD VESSELS OF EARTHWORMS

Vascular organs were not mentioned in many of the specific descriptions, and in others only the location of the last hearts and the condition of the dor-

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[1] From research financed by the National Science Foundation.

sal trunk (whether double or single) were stated. Such inadequate treatment of essential structures is doubtless responsible for part of the artificiality of the classical system. Much more information must be obtained before taxonomic and phylogenetic importance can be evaluated, but data even now available suggest that certain vessels can provide characters for definition of more natural taxa, and of course for a better understanding of evolution.

Dorsal and ventral trunks are more likely than not to be complete, but abortions of short portions are known to be noteworthy in the octochaetid *Eutyphoeus.* Extra-esophageal trunks, free in coelomic cavities of a pre-intestinal region of the body, may prove to be uniformly median to or lateral to the segmental commissures and the hearts in some genera and this is even true in some families. Posterior portions of these trunks, by their associations with the esophagus and other major vessels, are expected to provide a greater diversity of taxonomic characters. Latero-parietal trunks (*cf.* Gates, 1939), in contrast to the extra-esophageals, are on the body wall throughout nearly all of their lengths, rising into the coelom only in some anterior segment to pass up toward the esophagus. Again, association with the gut or other major vessels may provide important characters. These trunks, like the subneural, often are empty or nearly so throughout most of their lengths, and then may be almost if not quite unrecognizable in field-preserved material. Posterior latero-parietals in *Eutyphoeus,* as well as in the octochaetid *Eudichogaster,* do pass back to the hind end of the body and, according to evidence now available, are present only when a subneural is absent. Anterior latero-parietals, possibly even two pairs, have been detected only in *Sparganophilus* in which a subneural appears to be lacking. The subneural has been thought to end in the vicinity of xiii–xiv, but probably is complete and continued to a bifurcation at the anterior end of the body.

Almost a century ago the segmental commissures or hearts that connect dorsal and ventral trunks were designated as laterals by Perrier. Hearts that connect supra-intestinal and ventral trunks he called intestinals. The term "latero-intestinal" was later coined by Bourne for hearts that open above into dorsal and supra-intestinal trunks. The supra-intestinal trunk of early authors long has been more properly called the supra-esophageal, and substitution of esophageal for intestinal in the Perrier-Bourne terminology (Gates, 1939, pp. 153–154) provided a more accurate characterization that was not so different as to require a glossary.

Latero-esophageal hearts have been identified by various authors as dorso-esophageals, true intestinals, intestinals, dorso-supra-intestino-ventrals, and esophageals. Lateral hearts have been designated as dorso-ventrals and esophageals. Esophageal hearts have been called intestinals, supra-intestino-ventrals. The terms lateral and esophageal have also been used for any heart, regardless of its dorsal connections. Unfortunately, the meaning of a particular characterization is not always determinable from the text or figures. Doubtless some of the confusion is attributable to the fact that one of the two dorsal bifurcations of a latero-esophageal heart is often empty. When strongly contracted, or in poor preservation, an empty bifurcation may be very difficult to identify. Possibly only in *Sparganophilus* are hearts present in an intestinal region of the body, but in that genus the vessels are lateral.

Family ACANTHODRILIDAE

This family now comprises the Acanthodrilinae of the classical system (*cf.* Gates, 1959), the holonephric genera of the Diplocardiinae (*cf.* Pickford, 1937), and the holonephric genera with tubular prostates of ectodermal origin that previously were in the Megascolecinae.

The classical Acanthodrilinae probably did not constitute a natural group as Stephenson seems to have suggested when he wrote (1930:819) that "convenience is best served" by placing therein all genera ineligible for admission to other megascolecid subfamilies. Recent additions (Gates, 1959) to the family admittedly were for convenience only. Not until much more information about previously neglected somatic anatomy is available will a more natural arrangement of genera into subfamilies or families be possible.

Genus **Plutellus** Perrier, 1873.

This classical genus includes species with one gizzard, in v, vi, or vii, that may be vestigial or well developed, sometimes even in two segments, v–vi or vi-vii and then really two. Species without calciferous glands or with glands of unknown structure which may be 2 pairs in xiv–xv or xv–xvi, 3 pairs in x–xii, or xi-xiii, 4 pairs in x–xiii or xii–xv or xiii–xvi, 5 pairs in ix–xiii. Species with an intestinal origin in xiv, xv, xvi or xvii, with hearts in x–xi, x–xii, x–xiii, the last pairs latero-esophageal, lateral, or even esophageal. By definition, the two prostates open to the exterior in xviii but in some species the prostatic pores are in xix or xx. Male gonoducts open to the exterior in xviii near the prostatic pores or pass into prostatic ducts within the body wall, just above the parietes, at various more ental levels to the end of the duct or even into the gland itself.

Plutellus, accordingly, is a congeries which has in common only the two characters of its family and in addition the lumbricin arrangement of the setae. The distribution, as incongruous as the morphology, comprises Ceylon, India, Burma, Australia, Tasmania, New Caledonia, New Zealand, Auckland Islands, Queen Charlotte Island, a Pacific coastal strip of the United States, Guatemala, and a northern portion of South America. The type species, supposedly from Pennsylvania, may not even be American. The andry is unknown and the holotype, though still in existence, seems never to have been re-examined nor has the species been recognized elsewhere. Until *P. heteroporus* is more adequately characterized and some at least of its relationships are determined, perhaps more especially to North American species, the status of Eisen's *Argilophilus* is likely to remain uncertain. Accordingly, the commonly accepted classical generic name is retained for the two species considered below.

Plutellus papillifer (Eisen, 1893).

Plutellus papillifer, GATES, 1941, Proc. California Acad. Sci. 23, p. 443.

Colony Mill, Tulare County, California, 5415 feet, May 18, 1904, 0–1–0. Chas. Fuchs.

Tamalpais, Marin County, California, 0–2–10.

Tamalpais Station, Marin County, California, 1–2–18.

Eisen collection, no. 595, 0–0–2 (anterior fragments of 18 and 24 segments).

EXTERNAL CHARACTERISTICS. Diameter 6–7 mm. (fragments), 4–5 mm. (other specimens). Segments, 139–147, 161 (Colony Mill). Prostomial tongue open posteriorly but with a transverse furrow (several specimens) slightly behind the anterior margin of segment i. Ventral setae of ii are lacking (fragments) and follicle apertures either are closed or are now unrecognizable. Setae in preclitellar segments are ornamented near the tip with fine, transverse serrations.

Clitellum in xiii–xviii, anterior border indistinct, often apparently in xii, definitely at eq/xii (1 specimen) or much nearer 11/12 (1 specimen), in a third worm possibly at 11/12. The clitellum is protuberant (relaxed worms) or concave like a waist (some relaxed and contracted specimens).

Spermathecal pores at *B* (see notes to key below), except as indicated to the contrary in the section on polymorphism, at 7/8–8/9.

Female pores in a transversely elliptical area of epidermal thickening in *BB* which is opaque and protuberant except in one fragment where it is wholly translucent and depressed.

Male fields more or less distinctly demarcated, reach into xvii, as well as xix and are centered in *AB*. Each is longitudinally placed, widest at eq/xviii where a slight protuberance bears the male pore and follicle apertures. The epidermis in an anterior portion (mostly in xvii) and in an equisized posterior portion (mostly in xix) appears to be thicker but without translucence.

Genital markings are located as follows: 8/9 (14 specimens), 9/10 (33), 10/11 (34), 11/12 (33), 12/13 (32), 13/14 (4), 14/15 (34), 15/16 (33), 16/17 (24), 17/18 (3), 18/19 (1), 19/20 (33), 20/21 (28), 21/22 (8), 22/23 (1), 23/24 (1). A central portion of each marking is translucent except on specimen no. 17 which has two discrete translucent areas in each of the markings from 12/13 posteriorly.

INTERNAL ANATOMY. Septa 5/6 and those following are funnel-shaped and so large that the gizzard is back at the level of the eighth segment, 6/7–10/11 increasingly thickened posteriorly, 11/12–12/13 decreasingly so, subsequent septa also slightly strengthened as is the horizontal subesophageal mesentery in x–xiii. A special longitudinal muscle band at mD is unrecognizable, but behind the clitellum in these relaxed worms a spindle-shaped gap in the longitudinal musculature extends a quarter of the way through each segment from the intersegmental levels between.

Gizzard large, strong, with thickened cuticular lining, in v (30 specimens). The ventral typhlosole always is obvious in x-xiv even in the fragments in which the mucosa has disintegrated. Low longitudinal ridges on inner wall of gut in x–xiv are irregularly interrupted. Esophageal valve short, at region of insertion of 16/17. Intestinal origin in xvii (20 specimens) and recognizably so even when the valve is relaxed. Typhlosole rudimentary but very gradually increasing in height through xxi to region of xxvi–xxviii, ending as follows: in 101st of 139 segments, 107th of 145 segments, 108th of 143 (abnormal worm), 144 and 146 segments, 110th of 147 segments, leaving 35–38 metameres atyphlosolate.

The dorsal trunk is complete, traceable in five worms to the brain underneath which it bifurcates, the branches passing ventrally along the circumpharyngeal nervous connectives. A supra-esophageal trunk is present in x–xiii. Extra-esophageal trunks always are median to the hearts and segmental commissures. Posterior lateroparietal vessels small, recognizable only in xviii–xiv of three specimens, pass up to the gut just in front of 14/15 but are not traceable to any of the major trunks. Segmental commissures of v–ix lateral, those of v in front of the gizzard, traceable to the ventral trunk only in viii-ix except in one worm and then in vii-ix. Last hearts in xiii (30 specimens).

Nephridia avesiculate, present from ii, in preclitellar segments of contracted specimens coiled in long and tight spirals.

Holandric and metagynous (except as noted below), male funnels rather small, plicate. Male gonoducts without epididymis, apparently united just in front of 12/13, passing into the prostate gland or somewhat more ectally and then at the junction of the duct and gland, sometimes with variation from one side to the other of the same worm. Seminal vesicles medium-sized or smaller, vertically placed on the posterior faces of the septa, acinous, not filling the coelomic cavities of xi-xii. Lumen of prostate glands slit-like in cross section, in the ducts much smaller and circular in section. Ducts 2 + mm. long, a slenderer ental portion with one or two u-shaped loops.

Penisetal follicles conspicuously protuberant into coelomic cavities and reaching to the middle of the prostatic duct or (an early aclitellate worm) to a level three-fourths of the way up the duct.

Spermathecae large, in contact with the ventral parietes back to the septum and then up on its anterior face, the appearance of a slight curvature presumably due to a greater elongation of the anterior wall of the duct. Ovaries fairly large, fan-shaped, with numerous short egg strings. Mature ova distinguished, in present condition of these specimens, by an obvious opacity that is lacking elsewhere in the gonad.

GENITAL POLYMORPHISM. Three specimens are of athecal morphs, even rudiments of spermathecae lacking as was demonstrated by removing the longitudinal musculature from the interior of the body wall. Each specimen is of a different morph. One worm (no. 33) has a small ovary but no female funnel on the right side of xiv and a testis but no male funnel on right side of xii. Differences between the other specimens are in genital markings and penial setae. The markings of no. 31 are at 9/10–10/11 and 14/15–20/21. Ventral follicles of xviii are only slightly larger than in adjacent segments. Shape and ornamentation of the setae are unknown as only middle fragments of setal shafts were found. (Each fragment was enclosed in a sleeve of cuticle that extended for some distance beyond the jagged edges, the setae possibly broken as the follicles were pulled out of the parietes.) Genital markings of no. 32 are at 9/10–12/13, 14/15–16/17, 19/20–20/21. Penial setae are as usual in sexual specimens.

First order intermediate morphs (*cf.* Gates, 1956, for terminology) are represented in the present lots by five individuals. One of these (no. 34) has four very small spermathecae that protrude into the coelomic cavities just enough to permit distinguishing the duct and ampulla. The spermathecal duct is slender and shorter than the ampullary rudiment. Penial setae of this worm are as usual. Ovaries and prostates are mature though a clitellum is as yet unrecognizable. A more advanced stage of evolution was shown by six of the seven worms previously examined (Gates, 1941, p. 449) in which ental ends of rudiments were just recognizable at the parietes. No indications of the differentiation of the duct and ampullary portions were recognized. In such evolutionary lines all spermathecae appear to have been simultaneously and equally affected. Whether further growth had been inhibited at an early stage of development or whether initial invagination had been too long delayed remains to be learned.

Two specimens lacked one of the posterior spermathecae, that on the left side. No rudiments were present at the sites of the missing organs. A quadrithecal individual, in which the right posterior spermatheca is shorter as well as slenderer than the others and without differentiation into duct and ampulla, may provide a somewhat earlier evolutionary stage.

Three worms are bithecal. One of the antero-bithecal (spermathecal pores at 7/8 only) individuals is juvenile. Spermathecae (of no. 36) are rudimentary and only slightly protuberant into the coelom. The prostates are fairly large but obviously are juvenile as are the testes, ovaries, and gonoducal funnels. Genital markings are not distinguishable (anlage possibly not visible because of poor condition?). The penisetal follicles, however, have attained adult size and the penial setae have the usual shape, size and ornamentation. The other antero-bithecal worm (no. 29) is adult but follicles of the ventral setae in xviii protrude only slightly into the coelom. The setae are penial but shorter and slenderer than usual and with somewhat coarser ornamentation. The postero-bithecal worm (no. 30) appears to be normal except for the absence of the anterior spermathecae.

Four worms are pseudo-intermediate morphs, so-called because they are not evolving in the direction of any of the major standard morphs such as A, R, and AR. Three worms (nos. 14, 24, 28) have an extra spermatheca on the right side of vii. The other (no. 25) has the extra organ on the left side. Each extra-spermatheca is normal (as are the other structures) except in no. 14 where the ampulla is only about one-quarter the usual size. Genital markings are located as follows: at 8/9–11/12, 14/15–15/16, 19/20–20/21 (no. 14), 9/10–12/13, 14/15–15/16, 19/20–20/21 (no. 24), 8/9–12/13, 14/15–16/17, 19/20–21/22 (no. 25), 9/10–12/13, 14/15–16/17, 19/20 (no. 28).

Addition of extra organs to a normal complement is much less common than deletion in genital polymorphism. The number of genital markings in these morphs of *P. papillifer* averages somewhat higher than in normally quadrithecal worms. Certainly there is little indication of deletion of markings, and in some lines markings may have been added.

No indications of any trend toward elimination of prostates or of precocious abortion of testes were detected. Aside then from reduction and elimination of spermathecae, reduction (and possibly elimination) of penial setae, the evolutionary trends that were noted are toward increase in number of spermathecae and of gonads. The extra gonads represent a return to an ancient ancestral condition, but addition to the spermathecal battery appears to be a change never before made in the ancestry of *P. papillifer.*

The ovaries seem to have matured precociously in an aclitellate specimen and may have done so in several clitellate individuals. The testes in some clitellate worms are very large, bushy, each of the numerous long digitiform lobes showing only the same early stage of spermatogenesis. Perhaps some modification in a system of endocrine control had delayed the initiation of male gametogenesis until it was too late for the sperm to be matured prior to breeding.

Abnormality. All organs of the left side from the first spermatheca back to the prostates are two segments behind their normal locations. Displacements are due to intercalations of two metameres by halving of two mesoblastic somites at levels in front of the eighth (*cf.* Gates, 1960). Metamerism is abnormal in the region in front of what normally would have been 9/10. Genital markings are at 9/10–12/13, 15/16–16/17, 20/21–21/22.

REPRODUCTION. Iridescence on the male funnels of the Tulare specimen proves that sperm had been matured. Iridescence within the seminal chambers in the spermathecal ducts shows that copulation had been completed even though a clitellum is lacking. Reproduction in this specimen presumably could have been biparental. Maturation of sperm, even profusely, does not, however, guarantee that reproduction is biparental (*cf.* Gates, 1957). Even after copulation reproduction may be parthenogenetic.

Spermatozoal iridescence was lacking on the male funnels and in the spermathecae of 29 specimens regardless of the condition of clitellum and ovaries. The breeding season for *P. papillifer* is unknown, and even if it were, collection dates are lacking for most of these worms. Mere absence of spermatozoa, in these circumstances, scarcely provides trustworthy evidence as to method of reproduction in most quadrithecal individuals.

Evolution of genital polymorphism obviously is well advanced in *P. papillifer*. This sort of polymorphism in earthworms appears, so far as now known, only when reproduction has become parthenogenetic. Individuals of athecal and of some of the intermediate morphs must reproduce parthenogenetically. Male sterility is anticipated in some of the quadrithecal worms with normal anatomy.

REMARKS. Most of the specimens probably had been scoured, then anesthetized and preserved in a relaxed state. All now are more or less softened. The worms from which the anterior ends had broken off probably had been suddenly killed and preserved in such strong alcohol as to make them brittle.

Flocculent masses of corpuscles filled the coelomic cavities of most segments in the anesthetized worms. These masses may mask structures such as nephridia so that preservation is not as good as is needed for some studies. Presence of quite some amounts of the flocculent material in the coelom of v–vi was, in the present case, advantageous as it enabled easy recognition of the delicate septum 5/6 and its insertion on the gut just behind the gizzard. The septum is, however, attached at several points to the anterior margin of the gizzard which might, in less fortunate conditions, have been thought to be in vi (*cf.* notes on several species of *Ramiellona* below).

Except as indicated to the contrary above, the external characteristics and internal anatomy of each worm are as in previous specimens (Gates, 1941).

Hearts, of course, never were found in xiv. Possibly much distended anterior portions of the posterior latero-parietal trunks rising from the body wall of xiv were mistaken by Eisen for hearts.

Relationships with *P. marmoratus* remain to be worked out.

Plutellus marmoratus (Eisen, 1893).

Eisen Collection, 0–0–2. (No further data.)

External characteristics. Length, 80–83 mm. Diameter, 4 mm. Segments, 140, 167. Setae, $AA =$ or $< BC$, DD ca. $= \frac{1}{2}C$ anterior to clitellum, posteriorly $AA > BC$ or CD, $DD < \frac{1}{2}C$. Dorsal pores unrecognizable. Clitellum on xiii–xix/2 or xix. Females pores at *A*, midway between 13/14 and eq/xiv, within a transversely elliptical presetal tumescence in *BB*. Male fields distinctly delimited, reaching to presetal secondary furrow of xix and the postsetal of xvii, median margins especially tumescent.

Genital markings small and not quite as wide as *AB*, circular, each with a single greyish translucent central area, centered about at *A*, paired, at 9/10, 15/16 (1 specimen only), 16/17, 19/20.

Internal anatomy. Gizzard probably in v (2 specimens) but 5/6 very delicate, possibly incomplete and apparently attached (but not inserted) or perhaps only adherent at several points to anterior margin of the gizzard. Gut valvular in xvi–xvii, and there scarcely if at all thicker than the distended dorsal blood vessel, gradually widening in xviii–xx, normal intestinal width attained only in xxi. Typhlosole rudimentary in xix–xxiii, fairly high and simply lamelliform from region of xxiv–xxvi posteriorly, ending abruptly in 110th of 140 and 127th of 167 segments.

Last hearts in xiii (2). Nephridia avesiculate, ducts pass into parietes at *C, D* or, occasionally, dorsal to *D* by a distance about equal to *CD*.

Spermathecae fairly large, erect in coelomic cavities and reaching up to dorsal parietes. Duct much shorter than ampulla, wider entally and there with a considerable protuberance (almost reniform) from anterior and median face or from anterior half and in which a number of small seminal chambers are visible.

Reproduction. Iridescence on the male funnels of each specimen shows that sperm had been matured. Seminal chambers of two spermathecae of one specimen and all chambers of the other specimen contain sperm. Spermathecal ampullae are filled with a loose coagulum. As sperm are matured and then exchanged during copulation reproduction is assumed to be biparental. The worms may have been collected toward the end of breeding period.

Remarks. The specimens were macerated and fell apart during the dissection. The coelomic cavities of x–xi were filled with a compact coagulum that came away with difficulty from the male funnels. The tips of penial setae are lacking or softened and deformed.

Except as indicated to the contrary above these worms are like *P. papillifer.*

Family OCTOCHAETIDAE

This family now comprises the Octochaetinae of the classical system (*cf.* Gates, 1959), the meronephric genera of the Diplocardiinae, and the meronephric genera having tubular prostates of ectodermal origin that were previously in the Megascolecinae.

The octochaetids of Mexico and Central America have been referred, in the past, to seven classical genera: *Eodrilus, Acanthodrilus, Trigaster, Dichogaster, Howascolex, Ramiellona,* and *Ramiella.* Consideration of *Trigaster* and *Dichogaster* is deferred to a subsequent occasion. All of the other octochaetids belong in *Ramiella.* The necessity for placing a Central American endemic (Gates, 1957) in an Indian genus provided yet another demonstration of the artificiality inherent in a system based primarily on esoteric phylogenies.

Eisen's collection now provides some reason for believing that further information with regard to taxonomically important somatic characters of American, as well as of Indian species, will enable at least two American genera to be morphologically distinguished from *Ramiella.* Although the American taxa cannot be so defined at present, resurrection of the first available name may obviate some nomenclatural changes in the future.

Howascolex by definition is "purely meganephridial" in an anterior portion of the body. Meganephridial, in the classical system, implied that excretory organs are two per segment only and also that each has a preseptal funnel as well as a coiled postseptal body with an epidermal nephropore in the same metamere as the loops. This is the condition that characterized the Eudrilidae, Glossoscolecidae, Lumbricidae, Ocnerodrilinae, Acanthodrilinae, and some of the Megascolecinae which were all defined (Stephenson, 1930) as meganephridial. Other excretory systems have several pairs to several hundred micronephridia per segment. In more highly evolved meronephric systems, some micronephridia were found to be as large as, or even larger, than meganephridia. To indicate whether a large excretory tubule was or was not one of several meronephridia in a segment, some qualification was needed, and the primitive condition (one pair per segment) became known as purely meganephridial. American species, so far as can be determined, are meronephric and without holonephridia (as they should be called) in any region of the body. Accordingly, these species are excluded by definition from *Howascolex* in which there are "true meganephridia" (Stephenson, 1930:843).

Genus **Ramiellona** Michaelsen, 1935

The word *Ramiellona,* a modification of *Ramiella* which is based on a Hindu patronymic (Ram), by itself hints at the difficulties encountered while attempting to define, in the classical manner, an American taxon so as to distinguish it from an unrelated group of species endemic in the Indian peninsula. Similarities, expressed in the usual classical manner, actually are as follows: lumbricin setae, acanthodrilin male terminalia, one esophageal gizzard in a single segment, micronephridial. *Ramiella* lacks calciferous glands which means only that no pouches are constricted off from the gut. *Ramiellona* accordingly was distinguished by the presence of calciferous folds within esophageal widenings in xii and some of the preceding segments. Mention of esophageal widenings or of foldings of the inner wall cannot be expected in older descriptions as even highly evolved calciferous glands were derogated taxonomically. However, one Indian species, *Ramiella nainiana* Gates, 1945, does have in viii–xii (*cf.* descriptions below) folds between which calcareous granules were found. For the present, then, the two genera are distinguishable only by their geographical distributions.

The Guatemala specimens probably were quickly killed in the field and preserved in a strongly contracted state. Most are folded, twisted, or coiled. During their stay in alcohol their tissues were browned with the resultant loss of optical differentiation. Soaking in a solution of picric acid did improve matters somewhat, but not enough in several instances to permit characterization of the genital markings. The softening, usually associated with long stay of earthworms in any of the standard preservatives, obviates certainty as to the number of intestinal caeca and sometimes even as to presence or absence of these structures. The nephridia, of course, are in poor condition and microscopic structure was not determinable. Portions of the esophagus almost certainly are deformed in some individuals as a result of strong contraction. Extremes of deformation probably are recognizable, but states that seem more normal may not be recognizable after slight relaxation. Even before deterioration has set in, field preservation may not be good enough to permit detection of taxonomically important characters in the excretory system.

Ramiellona guatemalana Gates, new species.

Guatemala, vicinity of Totenicapan, highlands of Huehuetenango, May-Nov. 1902. 15–19–3. G. Eisen.

External characteristics. Length 140–190 mm. Diameter 5 mm. Segments, 287, 294, 320. Prostomium, prolobous (30 specimens), recognizable from dorsal side (3), visible in buccal cavity from anterior end (27), so deeply retracted as to be invisible from exterior (7). Peristomium soft, with many longitudinal creases, some part (except in 3 specimens) withdrawn into the anterior end. Two furrows on the peristomium, next to mD, sometimes appear to be deeper than the others and then may look like margins of a tanylobous tongue. A deep transverse furrow, however, always demarcates the prostomium from the real anterior margin of i. Pigmentation unrecognizable (alcoholic preservation). A postsetal secondary furrow is present from iv posteriorly, a presetal secondary from viii. These secondaries in the preclitellar region, may be as deep as the intersegmental furrows so that recognition of the latter becomes difficult. Tertiary furrows behind the clitellum, slight, often apparently incomplete but scarcely distinguishable from the secondaries. Toward the hind end the segments are very short and without secondary annulation. Nephropores unrecognizable and doubtless microscopic. First dorsal pore at 12/13 (22), ?12/13 (2), ?13/14 (5), unrecognizable until behind clitellum (2 specimens).

Setae lacking in ii–iii (20 specimens), also absent in iv (7), *a* and *b* alone present on right side of iv (3), *c* and *d* often lacking on v or v–vi, at first very small and very closely paired. In front of the clitellum, $AB = CD$, $AA < BC$, DD ca. $= \frac{1}{2}C$, near the 37th segment CD becomes wider than AB, the lateral ranks very gradually becoming more irregular but only in region of the 150th segment beginning to get well into the dorsum. The size of the setae as well as the protuberance from the epidermis increases posteriorly and as the quincuncial arrangement is attained, but decreases again in the last 4–6 setigerous segments. The enlarged posterior setae are rather spindle-shaped, their tips ornamented with about 15 rather widely and irregularly interrupted circles of very fine serrations. Ventral setae of xvii and xix penial, usually markedly protuberant. Ventral setae of xviii present (37 specimens), seemingly displaced slightly toward mV, ornamented distally with short transverse rows of fine serrations at 15–20 circumferential levels, a shorter terminal portion curved slightly to one side.

Clitellum saddle-shaped, reaching down nearly to *B*, on xiv–xix.

Spermathecal pores transversely slit-like when closed, nearly circular when open and then filled with a plug of hard coagulum or revealing internally smooth and glistening anterior as well as posterior lips in contact with each other, in *AB* at 7/8–8/9. Female pores minute, in setal annulus of xiv, just in front of or slightly anteromedian or anterolateral to *a*. Male pores somewhat larger, transverse slits, in seminal grooves and just at 17/18. Prostatic pores immediately lateral to apertures of penisetal follicles, usually unrecognizable except when traction on adjacent epidermis separates the margins, about at equators of xvii and xix. The penial setae at first appear to emerge from a single aperture on each side of xvii and xix, but after they have been pulled out, a dividing membrane can be seen to reach down almost to the level of the external surface of the epidermis. Seminal grooves with tumescent margins, well lateral to *B*, curve mesially in xvii and xix to the prostatic pores. An equatorial portion of xvii and xix, about at *AB* on each side, seems to be somewhat tumescent and is protuberant in a rather conical manner, follicle apertures at the apex. Seminal grooves and genital markings provide boundaries for a median male field that usually is slightly depressed.

Genital markings unpaired and median, transversely placed, the anteriormost often about reaching m*BC*, size decreasing posteriorly, along intersegmental furrows as follows: 16/17 (15 specimens), 19/20 (11), 20/21 (12), 21/22 (4). Posterior markings perhaps develop later than the one at 16/17 as they are lacking on the younger specimens. Each marking probably has one transverse row of circular areas. The equatorial annulus of xx and xxi (4 specimens), between the genital markings, is conspicuously protuberant, apparently somewhat tumescent and with a distinctive white opacity that is especially obvious because of the alcoholic browning in adjacent areas.

INTERNAL ANATOMY. Septa 5/6–9/10 large, funnel-shaped, posteriorly directed, 5/6 muscular, 6/7–9/10 thickly muscular, 10/11 slightly muscular, 11/12 obviously thicker, 10/11–11/12 united peripherally except ventrally in a middle portion of *CC* and organs of xi unrecognizable in a dissection from the dorsal side until after the apparently very thick septum 10/11 has been separated into its constituent parts. A special longitudinal muscle band at mD is present from 11/12 or 12/13 and is very distinct. Large and strong muscle bands from the posterior margin of the gizzard are inserted in the parietes of xi or xii. Diagonal muscle bands, with median parietal insertions near nerve cord, are present in xvi–xix; two in xvi on each side that are wide provide a useful marker for the segment, sometimes only one is present on each side but then it is much wider, covering the parietes from 15/16 to 16/17. A transverse muscle band from the gut in xiii passes, on each side, straight laterally to a parietal insertion.

Gizzard large and strong, with a thickened cuticular lining, in v (8 specimens), but because of the size of the septal funnels about at the level of viii–ix as indicated by intersegmental furrows externally. Postgizzard portion of esophagus narrow, high up in the coelomic cavities, little if any longer than the gizzard, or at most shorter than the section in i–v. Esophagus deeply constricted by 7/8–12/13, apparently with five pairs of sacs, the first two or three pairs gorged with blood so as to appear black, the last two pairs always white, the first two pairs apparently opening widely into the esophagus, the next three pairs more nearly constricted off, but without stalks and opening through smaller circular apertures. Calciferous lamellae numerous, thin, high, with free margins centrally, in viii–xii and possibly reaching very slightly into vii. Lower and rounded longitudinal ridges are present on the inner wall of the esophagus in xiii–xiv. Intestinal origin in region of insertion of septum 14/15, apparently just in front of the insertion (4 specimens) or just behind (4)—septa 14/15–15/16 often in contact mesially and adherent to each other, an anterior portion of the intestine with insertions of one or both septa sometimes drawn back into the interior of the gut, the adjacent portion of the intestine then bulged forward. Intestinal caeca small, paired, arising just lateral to the level of the secondary typhlosole (which is indicated externally by a deep red band) and immediately behind the septa, in Rxxiii–xxvi (1 specimen), xxiv–xxvi (1), xxiv–xxvii (1), xxv–xxvi (1), xxv–xxviii (1), (xxiv–xxv?) xxvi–xxx (1) xxv–xxx (1), unrecognizable (1). Typhlosole rudimentary from xvi to region of xxii–xxiv, thence posteriorly fairly large, thicker distally and with three longitudinal ridges on its ventral face, ending abruptly in 162d of 287, 176th of 294, 168th of 320 segments. Lateral typhlosoles low but simply lamelliform, beginning and ending abruptly, uninterrupted, just median to the caecal apertures, from the region of xxii–xxiv to xxx–xxxii. Supra-intestinal glands lacking.

Dorsal blood vessel single throughout, complete, bifurcating just behind or under the brain, the branches passing ventrally along the circumpharyngeal nervous connectives to unite and become the ventral trunk (2 specimens). Ventral trunk complete, in front of 4/5 joined by three pairs of blood-filled vessels and then bifurcating over the subpharyngeal ganglia (3 specimens, in one of which the branches are traceable only a short way up the nervous connectives). Extra-esophageal trunks recognizable from ii, large and filled with blood anteriorly, median to segmental commissures, empty and not traceable posteriorly. Supra-esophageal trunk bound closely to gut in viii–xii, with a large branch to each calciferous gland of viii–xi, bifurcating anteriorly in xii. Commissures of vi–x lateral, traced to the ventral trunk except in vi, each joined just before opening into the ventral trunk by one or two vessels as large as itself. Commissures of v lacking or unrecognized. Hearts of xi–xii latero-esophageal, anterior bifurcation of a heart of xii continuous with posterior bifurcation of the supra-esophageal. Subneural trunk not found (7 specimens) and probably lacking. Latero-parietal trunks not found.

Excretory system meronephric. A longitudinal band of closely crowded micronephridia is somewhat lateral to mV on each side in iii–iv. Two ducts emerge together from the anterior margin of the cluster, but separate almost at once and disappear from view on parietes of ii and iii. Smaller clusters of nephridia are present on the anterior faces of 4/5–11/12 or 12/13. One cluster usually is recognizable way up on the septum alongside the gut. Another cluster joins the duct which runs downward on the septum, near the ventral parietes. Nephridia are at the parietes from one of segments xii–xv but at first the loops are vertical against anterior faces of the septa, from xx posteriorly the tubules are arranged in a transverse row at the middle of each segment. At least five longitudinal ranks appear to be present on each side of the body (crowding and poor condition of the organs obviating more precise characterization). The median nephridium on each side in a posttyphlosolar region of the body is no larger than some others in the same segment, but it does have a preseptal funnel.

Metandric (7 specimens), testes of xi bushy, male funnels large and plicate, the testicular chamber (formed by peripheral union of 10/11–11/12) containing more or less coagulum but no seminal vesicles. Male funnels of x rather small but plicate (no testes in x). Seminal vesicles finely acinous, one pair, filling the coelomic cavity of xii, at maximal development bulging pockets of 12/13 back into xiii or xiv or (1 specimen) rupturing 12/13 and penetrating into xiii where a number of the lobes are separated off (owing to maceration?). Male gonoducts without epididymis but sometimes shortly looped in xiii–xvi, with thick wall (presumably muscular but without sheen), slightly narrower in xvii and there lateral to prostatic ducts, passing down into the parietes in front of *a* of xviii. Slender ducts from male funnels of x are traceable (1 specimen) back to junctions with other ducts in xii. Prostates tubular, coiled in xvii and xix, distending septa or reaching into xix and xx–xxii, ducts with muscular sheen and 2–3 mm. long. A thick muscular sac containing follicles of functional penial setae projects conspicuously into the coelomic cavities just median to each prostatic duct. Reserve penial setae often occur in a membranous sac that passes back from the apex of the muscular sac. Penial setae red or with some greenish color in an ectal portion of the largest shafts, thick, 2–4 mm. long. Shaft nearly straight or in a slight arc like a parenthesis. Distally the shaft narrows abruptly or gradually, the tip band-like, curved over to one side and at low magnification often seemingly hook-shaped. The margins of the band usually are slightly curved toward each other, but when the narrowing is abrupt the short tip may have a shape more or less like that of the bowl of a spoon. Ornamentation is of 30 or more circles of fine serrations, irregularly and frequently interrupted. The teeth, on the tip, are fewer, coarser, and with pointed distal ends well away from the shaft.

Spermathecae fairly large, to 5 mm. long, reaching up to the level of gut on the anterior faces of the septa, adiverticulate and without external demarcation into duct and ampulla. The duct is the anterior vertical portion passing straight down through the body wall and is thicker than the ampulla. The narrow lumen of the coelomic portion of the duct curves over posteriorly. The long ampulla gradually narrows entally. The rather thickish wall is provided with numerous closely crowded annular ridges. The seminal chambers, 6–8, are in the thicker anterior wall of the duct. Ovaries fan-shaped, with several short egg strings, usually hidden against ventral parietes by muscle bands. Oviducal funnels slightly folded, readily recognizable.

Reproduction. Iridescence on the male funnels of three aclitellate and one clitellate specimens is brilliant. Iridescence also is recognizable in the spermathecal seminal chambers of the aclitellate worms, but was not distinguishable in two spermathecae of a clitellate specimen. Reproduction, inasmuch as sperm are matured and then exchanged in copulation, is assumed to be biparental.

Growth stages. Juvenile 2 mm. thick. The epidermis in *AB* at equators of xvii and xix appears to be slightly tumescent. The tips of the red setae are just distinguishable in a central depression of the tumescence. The testes (xi only, none in x) are bushy but seminal vesicles had not as yet appeared. The spermathecae just protuberant into coelom, slender but already bent over toward the posterior septa. The ventral follicles of xvii and xix are protuberant into coelom just enough so that they can be grasped with the fine forceps. Each follicle contained three red setae, one a mere tip, a second about half the length of the longest which has a ribbon-like and flat tip. The male funnels are recognizable in x as well as in xi, but are much smaller in x.

Larger juveniles possess more prominent tumescences in xvii and xix, but still lack seminal grooves.

More mature worms, with distinct seminal grooves, were listed as aclitellate. One such has no genital markings and may not have been mature enough for them to be recognizable. Testes, with early stages of spermatogenesis, are unusually large in one early aclitellate with quite juvenile prostates, male funnels and seminal vesicles.

Aclitellate worms with sperm in the spermathecae showed no signs of a clitellum having regressed, but the seminal vesicles are dark. Epidermal evidences of clitellar regression could have been unrecognizable because of alcoholic browning, but contrariwise the dark appearance of the vesicles could be due to the browning by alcohol and so not evidence for postsexual regression.

Autotomy. Three worms obviously are very recent posterior amputees. Two to seven circumferential constrictions, always at intersegmental levels, are recognizable, on several other specimens, in the terminal forty millimeters of the body. At some of those constrictions the body wall already had been ruptured on one side or the other. The species obviously autotomizes readily, perhaps rapidly and sometimes extensively. The stimulus to the rupturing, in the present instances, may have been provided by grasping the worm posteriorly to drop it into the preservative. Individuals of species that do autotomize readily never have done so, in the author's experience, in killing alcohol regardless of the strength employed. Autotomy then can be avoided by seizing the worm near the anterior end.

An anterior rupture through which spermathecae protrude (aclitellate specimen) is likely to have been produced by the instrument used for digging (or perhaps ploughing) up the worms. Eight anterior fragments probably were broken off in that way.

Ingesta. Earth, reddish. No bits of plant matter were recognized under the binocular.

Abnormality. Spiral metamerism involving segments xi–xvi (1 specimen).

Parasites. Large, blood filled blisters of the intestinal wall in region of xvi–xxx contain two parasites each for which it is hoped identification can be obtained.

Remarks. Parietal insertions of some of the anterior septa almost certainly are displaced from their proper intersegmental levels. Two adjacent membranous septa sometimes adhere to each other so completely as to result in erroneous enumerations. Painstaking manipulation and repeated checks against fixed-position organs and against external annulation often were necessary. Even so, certainty as to the segment of intestinal origin was not achieved.

Some coelomic cavities were completely filled by a coagulum. No glands were recognized in the body wall above the genital markings.

Several characters, including retraction of the prostomium, location of the first dorsal pore, quincuncial arrangement of the setae, genital markings —identically located and each with a transverse row of circular areas, the trifid typhlosole, the ten ranks of nephridia in a postclitellar portion of the body, suggest relationships with the Salvadorean *R. lasiurus.* Differences, however, are numerous and as follows: prostomium prolobous (epilobous), clitellum saddle-shaped and on xiv–xix (annular on xiii–xx), muscularity of 5/6 (septum not mentioned), gizzard in v (vi), calciferous sacs in viii–xii (ix–xiii), segmental commissures and hearts in vi–xii (vii–xi), presence of a testicular chamber (not mentioned), metandric (holandric ? with seminal vesicles in xi ?), spermathecae adiverticulate (with a sessile, rosette-shaped diverticulum). Guatemalan worms also appear to be slightly larger and to have more segments. Some of these supposed differences may be of little or no taxonomic significance (*cf. R. lasiurus* below) and the more important ones now appear to be those relating to the clitellum and to the spermathecal diverticulum.

To facilitate further discussion of relationships in this difficult group there are subjoined certain notes on those species of which no material has been available for study. Each of these forms, with one exception, is known only from the original specimens secured at a single locality.

Ramiellona balantina Gates, new species.

Guatemala, vicinity of Totenicapan, highlands of Huehuetenango, May-Nov. 1902, 0–3–0. G. Eisen.

EXTERNAL CHARACTERISTICS. Length, 116 mm. Diameter, 6 mm. (largest specimen). Segments 111 (old posterior amputee), 197, 203. Pigmentation not determinable (alcoholic preservation and considerable browning). Prostomium prolobous (2 specimens), withdrawn but visible from the anterior end or unrecognizable (third specimen). A postsetal secondary furrow is present from vi or vii posteriorly, a presetal secondary from viii or ix. Secondary furrows behind the clitellum, slight and scarcely distinguishable from the tertiaries. Setae possibly lacking in ii as well as iii (part only?), *a* and *b* of xvii–xviii present, *a* and *b* of xix penial, very small and very closely paired in preclitellar region, AB ca. $= CD$, $AA < BC$, DD ca. $= \frac{1}{2}$C throughout much of the body, toward the posterior end AB and CD somewhat wider but only slightly smaller than AA, the *d* rank becoming somewhat above mL, all more protuberant and probably somewhat larger. Setae in the region of cxx ornamented with irregular interrupted circles of fine serrations, a short portion of the tip curved to one side so as to have a hook-shape. Nephropores unrecognizable and apparently microscopic. First dorsal pore, at 12/13 (2), ?13/14 (1).

Spermathecal pores, fairly large, centered about at A, one pair, at 7/8 (3 specimens). Female pores minute, just in front of *a* and hence in equatorial annulus of xiv (1). Male pores, somewhat larger, in seminal grooves, lateral to B at 18/19 (3). Prostatic pores at ends of the seminal grooves, just lateral to apertures of penisetal follicles, at eq/xix. The penial setae at first appear to project from a common aperture but after they have been drawn out a vertical membrane can be seen to reach down almost to the level of the external surface of the epidermis. Seminal grooves, lacking in the smallest specimen, pass from the prostatic pore anterolaterally to 18/19 (larger worm) or to 17/18 (largest specimen). Ventrum of xix to mBC markedly tumescent (3), reaching greatest elevation at A where there is a half-collar of special protuberance that is open laterally just beyond the penial setae.

Genital markings unpaired, transversely placed, recognizable only on the largest specimen and there at 15/16–17/18, 19/20–21/22. Each marking probably has one transverse row of circular areas.

INTERNAL ANATOMY. Septa 5/6–9/10 large, funnel-shaped, posteriorly directed, 5/6 muscular, 6/7–9/10 thickly muscular, 10/11 muscular, 11/12 thickly muscular, 10/11 and 11/12 united peripherally except ventrally in region of BB so that organs of xi are unrecognizable in a dissection from the dorsal side until after an apparently very thick septum 10/11 has been separated into its constituent parts. Special longitudinal muscle band at mD quite distinct. Large muscle bands from the posterior margin of the gizzard pass back to parietes in region of x–xii. A strong band from the lateral face of gut, on each side of xiii, has a parietal insertion laterally in xiv. Diagonal parietal bands, strong and wide, have median insertions near the nerve cord in xviii, but similar bands are lacking in xvi–xvii.

Gizzard large and strong, with thickened cuticular lining, in v (3 specimens) but about at level of viii–ix as indicated by intersegmental furrows externally, so elongated in one worm that its anterior opening is dorsal and its posterior aperture is ventral. Postgizzard portion of esophagus narrow, high up in coelomic cavities, little if any longer than the gizzard, deeply constricted at insertions of 7/8–12/13, the portions in viii–ix thin discs of nearly circular outline between compressing septa, a somewhat larger but equally thin disc in x obviously bilobed. Calciferous lamellae with free margins centrally, in viii–xii, of xi–xii within nearly spheroidal unstalked sacs all four of which at first appeared to be in xii as separating tissues are very thin. Intestinal origin in the region of insertion of 14/15, seemingly (3 specimens) just in front of 14/15. Intestinal caeca small, recognizable only with difficulty, in xxiv–xxv (3), possibly a smaller caecum in xxvii (1). Typhlosole rudimentary but lamelliform in xvi to region of xxii, thence posteriorly with widened ventral portion bearing three longitudinally lamelliform ridges, ending abruptly in 123d of 197 segments but in the amputee becoming rudimentary in the 94th segment and unrecognizable behind the 108th. Lateral typhlosoles low but lamelliform, uninterrupted, in xxii–xxviii. Supra-intestinal glands lacking.

Dorsal blood vessel single throughout. Extra-esophageal trunks empty and unrecognizable except anteriorly. Supra-esophageal trunk distinguishable only in xi–xii. Subneural trunk not found (2 specimens) and probably lacking. Lateroparietal trunks unrecognizable. Segmental commissures of vi–x lateral, traceable to ventral trunk only in x. Hearts in xi–xii, latero-esophageal.

Excretory system meronephric. A longitudinal band of closely crowded micronephridia parallels the nerve cord on each side of the body in iii–iv. Smaller clusters of micronephridia are present on the anterior faces of septa 4/5–11/12 or 12/13. Nephridia from xiii posteriorly, on the parietes, behind xx in at least four (possibly 5 or 6?) longitudinal ranks, the tubules transversely placed at the equator of each segment. The medianmost nephridium on each side, toward the hind end, has a preseptal funnel. Stomate nephridia of one specimen obviously are thicker than the astomate tubules of the same segment.

Metandric (3 specimens), testes (present only in xi) bushy, the testicular chamber with little or no coagulum but reaching forward (because of a ventral pocket of 10/11) on floor of x nearly to 9/10 (largest specimen). Male funnels all plicate, those of x smaller, those of xi (the largest specimen) within the anterior pocket of the testicular chamber. Seminal vesicles finely acinous, one pair in xii. Male gonoducts without epididymis, united on each side in front of 12/13, seemingly with a muscular sheath though the sheen is unrecognizable, passing down into the parietes in the region of 18/19. Prostates in younger specimens obviously juvenile and coiled in xix, probably adult in the largest worm where they reach into xx. Ducts about 2 mm. long, muscular, looped. Penisetal follicles within two thick, muscular sacs conspicuously protuberant into coelomic cavity of xix. Membranous sacs passing back from the apex into xxiii, each containing a large and a small reserve seta as well, sometimes as a mere tip of a third. Penial setae (functional), 2 + mm. long, thick, sometimes widest at ectal end which sometimes appears to be rather bulbous and abruptly narrowed to a terminal spine. The latter, usually softened, reveals under high magnification the shape of a spoon bowl. Shafts of reserve setae lack the bulbous widening at the tip and may narrow gradually to a thin band. Ornamentation is of frequently and irregularly interrupted circles of fine serrations, the teeth slightly larger and rising slightly away from the shaft on the narrowed tip.

Spermathecal duct vertical, thick, wider entally, adherent to the posterior face of 7/8, with a rather flat dorsal surface. Ampulla of about the same size as the duct, on the ventral parietes, ovoidal, narrowing to a very short but still fairly thick neck that passes to the posterior face of the duct. The wall of the ampulla is opaque (not membranous) and without obvious ridges. The lumen is wide distally and filled with coagulum, but in the neck it is very small as in the duct. Six slight white rounded protuberances on the dorsal face of the duct anteriorly mark the sites of distended seminal chambers. One or two additional chambers may be present down deeper so as to be unrecognizable externally. Ovaries fan-shaped.

REPRODUCTION. Iridescence on the male funnels of the largest worm is brilliant. The seminal chambers, in one spermatheca, are filled with a material in which iridescence is readily recognizable. Although there is no clitellum, the worm must have copulated. Reproduction, as sperm are matured and exchanged in copulation, is assumed to be biparental.

INGESTA. Earth, fine textured, dark, of a reddish brown color, without macroscopically recognizable plant fragments.

PARASITES. Six nematodes, red except at each end, were found in the coelomic cavity of xii (1 worm). Several small white cysts are present on an anterior portion of the intestine.

REMARKS. Protuberances from xix presumably can be inserted into the large spermathecal pores to function as temporary intromittent organs.

The short seminal grooves of the less mature worm are slight and may not have attained full development in depth as well as in length.

An esophageal typhlosole at mV, as in the previous and the next species, was not recognized.

Somatic anatomy indicates close relationships to species that are designated hereinafter as the "*guatemalana*" group. The major difference from others of the group (and which probably would have been considered very important in the classical system) is that the genitalia have undergone the metandric and the balantin reductions. The present species, accordingly provides one more demonstration that genital anatomy is liable to more rapid evolutionary modification than the somatic. The persistent male funnels of segment x show that advent of metandry was recent. Holandric individuals or even a holandric subspecies may be found. The balantin reduction of the ancestral acanthodrilin male terminalia is much rarer than the microscolecin and is as yet little known.

The peristomium, with numerous longitudinal wrinkles, is flaccid, a condition that appears not to be wholly attributable to postmortem softening, especially in view of the firmness of the prostomium. Apparently under way in the "*guatemalana*" group is an evolutionary derogation of the first segment which can be expected to result, perhaps in some hitherto uncollected species, in disappearance of intersegmental furrow ½. With loss of the setae of the next metamere, i and ii would be indistinguishable and all fixed-position organs would appear to be one level in front of their usual locations. Just such a change appears to have been completed in two megascolecid Indian genera, *Tonoscolex* Gates, 1933 and *Nelloscolex* Gates, 1939. A similar process is well under way in at least one species of the American glossoscolecid genus *Pontoscolex* Schmarda, 1861, in which 1/2 has disappeared but setae of ii still are present. The prostomium in *P. corethrurus* (Müller, 1856) seemingly has disappeared, but in *Tonoscolex* and *Nelloscolex* was retained. Retention of the prostomium now seems more likely to characterize more advanced stages of peristomial derogation in Central America.

Male apertures in the supposedly ancestral, acanthodrilin genitalia of the classical system are at eq/xviii, midway between the anterior and posterior prostatic pores which are at eq/xvii and eq/xix. Although all four glands appear to be equally developed (and presumably synchronously) in the "*guatemalana*" group, the male apertures are further anteriorly, at 17/18 and hence closer to the openings of the first pair of glands. Disappearance of the anterior prostates supposedly involves union of male and posterior prostatic pores. That has not happened in *R. balantina* where the male openings do not even get into xix, but are at 18/19 and so are at the same distance from the remaining prostatic pores as they previously were from the anterior pair.

Ramiellona strigosa Gates, new species.

Guatemala, vicinity of Totenicapan, highlands of Huehuetenango, May-Nov. 1902, 0–5–1. G. Eisen.

External characteristics. Length, *ca.* 97 mm. Diameter 3–3½ mm. Segments, 181, 203, 208. Prostomium prolobous, just recognizable from dorsal side (2 specimens), visible only from anterior end (4). Peristomium soft, with numerous longitudinal creases, some part withdrawn into anterior end (6). A postsetal secondary furrow is present from v, a presetal secondary from viii or ix. Tertiary furrows behind the clitellum, slight, often apparently incomplete and scarcely distinguishable from the secondaries. Setae present from ii, small, closely paired, *DD* ca. = ½C throughout, *AB* = *CD*, *AA* < *BC* anterior to clitellum, behind the clitellum *AA* > *BC*, toward posterior end *AA* and *BC* only a little larger than *AB* and *CD*, ventral setae of xvii and xix penial, ventral setae of xviii present (6 specimens) and median to seminal grooves. Nephropores unrecognizable and doubtless microscopic. First dorsal pore at 12/13 (6), in the clitellate worm a functional pore present at 13/14.

Clitellum dark red, intersegmental furrows obliterated, dorsal pores occluded, setae unrecognizable, probably at maximum tumescence, saddle-shaped, reaching down to *B* except in xvii–xix and there only to m*BC*, on xiv–xix, extending halfway through xx and slightly into xiii but in each of those segments much thinner and not so dark.

Spermathecal pores with rather irregular margins, not minute, centered about at *B*, two pairs, at 7/8–8/9 (6 specimens). Female pores minute, in setal annulus of xiv, slightly anteromedian to or just anterior to *a* (3). Male pores in seminal grooves, apparently at 17/18 (3, but location could not be confirmed by tracing male gonoduct through the musculature). Seminal grooves well lateral to *B*, pass mesially in xvii and xix onto conspicuous protuberances at apices of which are prostatic pores and follicle apertures.

Genital markings unpaired, transversely placed, each with a single transverse row of circular areas, at 10/11, 11/12 and 20/21 (2 specimens), 11/12 and 20/21 (1), in *BB* posteriorly, reaching into *BC* anteriorly, unrecognizable and presumably not yet developed (3 specimens). Areas of translucence and of about the same size, slightly depressed, may be present, on some specimens at 16/17, 18/19 and 19/20.

Internal anatomy. Septa 5/6–11/12 funnel-shaped and posteriorly directed, funnels of 5/6–9/10 especially large, 5/6 membranous but complete, 6/7–9/10 or 10/11 rather thickly muscular, 11/12–12/13 slightly strengthened. Special longitudinal muscle band at mD very distinct. Diagonal muscle bands broad, with median parietal insertions near nerve cord, present in xvi.

Gizzard large and strong, about at the level of viii–x as indicated by intersegmental furrows externally but actually in v (5 specimens). Postgizzard portion of esophagus slender, fairly high up in coelom, deeply constricted at the septal insertions. Calciferous lamellae fairly high and with free margins centrally, in viii–xii. Small, lateral sacs seemingly are present in each of vii–x, the sacs opening widely into esophageal lumen. Sacs in xi–xii more distinctly constricted off, though unstalked, and protruding slightly above and slightly below the median portion of gut. Intestinal origin in the region of the insertion of 14/15, almost certainly just behind 14/15 (1 specimen), apparently so but possibly not (the other four). Intestinal caeca indistinct, in xxiii–xxiv (3 specimens), apparently just in front of the septa, and in one worm recognizable only on the left side, in (xxiii?) xxiv–xxviii (1), xxiv–xxviii (1). Typhlosole rudimentary till region of xxii–xxiv, then abruptly enlarged, widened ventrally and there with three low but lamelliform and longitudinal ridges, with obvious vertical ridges on the lateral faces dorsally for a number of segments, ending abruptly in 110th of 181 or 111th of 203 segments, still recognizable at 98th segment of one of the anterior fragments. Lateral typhlosoles low but lamelliform, beginning and ending abruptly, in xxiii–xxviii. Supra-intestinal glands lacking.

Dorsal blood vessel single throughout, bifurcating just behind or just under the brain. Ventral trunk complete, bifurcating just over the subpharyngeal ganglia. Extra-esophageal trunks median to segmental commissures, filled with blood anteriorly but empty and unrecognizable posteriorly. Supra-esophageal trunk visible only in xi–xii. Subneural trunk unrecognizable and presumably lacking. Lateroparietal trunks unrecognizable. Segmental commissures of vi–x lateral, none found in v. Hearts of xi–xii, latero-esophageal (5 specimens).

Excretory system meronephric. A longitudinal band of closely crowded micronephridia is somewhat lateral to mV on each side of the body in iii–iv. Smaller clusters of nephridia are present on the anterior faces of septa 4/5–11/12 or 12/13. Nephridia are on the parietes from xiii posteriorly and behind the clitellum the loops are transversely placed. Nephridia almost certainly are in three longitudinal ranks on each side posteriorly, one rank about in *BC*, the other two further laterally. The medianmost tubule on each side in post-typhlosolar segments has a preseptal funnel.

Holandric. Seminal vesicles finely acinous, paired in xi and xii, in one worm smaller vesicles but with typical lobulation also present in ix. Male gonoducts of a side without epididymis, united just in front of 12/13, thence back apparently provided with a muscular sheath, zigzagged or shortly looped in xiv–xvi, slightly slenderer in xvii where they are lateral to the prostatic ducts, passing down into the parietes in the region of the insertion of 17/18 (but not traceable through the musculature). Prostates tubular, coiled in xvii and xix, the posterior pair sometimes extending into xx or xxi. Ducts muscular, 1–2 mm. long. Penial setae to 1½ mm. long, slenderer than in the other species, shaft curved in an arc like the parentheses but somewhat asymmetrically, narrowing rather gradually toward ectal end to a thin and flat band with both margins curved over on concave side of shaft. Ornamentation of two longitudinal ranks of transverse serrations, one rank on the upper side of the shaft as it lies naturally on the slide and the other on the lower side. The serrations comprise 2–7 teeth of variable size and shape, some of a more or less triangular shape, others thorn-like. The functional setae are yellow and with each there is associated one small reserve seta.

Spermathecae with a main axis that is 2–3 mm. long, slightly and gradually narrowed entally, usually posteriorly directed on the ventral parietes and then upward on the anterior faces of the septa. One spermatheca turns mesially and anteriorly to pass into the segment next in front. The duct is much shorter than the ampulla which has on its inner wall numerous closely crowded annular ridges. Diverticulum a large, nearly circular dorsoventrally flattened disc on the parietes of the segment next in front of that containing the main axis and reaching well toward or even to the anterior septum, with a number of small seminal chambers. Ovaries fan-shaped and with several egg strings.

REPRODUCTION. Iridescence is recognizable on the male funnels but is slight on those of the clitellate worm. Iridescence also is recognizable in the seminal chambers of the spermathecal diverticula of aclitellate specimens. Reproduction, inasmuch as sperm are matured and exchanged in copulation, is assumed to be biparental.

REMARKS. A posterior portion had been torn off from three worms. Some intestinal caeca may have become unrecognizable because of softening and alcoholic browning in three of the dissected specimens. The penial setae usually were broken, without ectal portions or with tips softened, and obviously more or less deformed.

Only one calciferous sac is present in x of one specimen, no slightest trace of a sac is recognizable on the other side. Hearts of xi (1 specimen) and xii (another worm) at first appeared to be absent. The associated septum, in each case, was adherent to the gut in front of the hearts as if normally inserted there. The male gonoducts of one worm, though in contact in xii, obviously do not unite until well into xiii.

As the spermathecal pores are not minute they may, when fully open, be large enough to permit insertion of protuberances of the male field functioning as temporary intromittent organs.

A testicular chamber was not recognized, possibly because the peripheral union of the bounding septa became unrecognizable as the worms were opened and pinned out.

These specimens appear to differ from the type of *R. eiseni* (*cf.* below) as follows: Saddle-shape of clitellum (annular but thinner ventrally) that reaches to xx/2 (instead of only slightly into xix). Absence of genital markings at 14/15, 15/16, 21/22–25/26, and possibly also presence of a transverse row of circular areas within each marking. Presence of calciferous sacs, especially in xi–xii. Presence of intestinal caeca. Presence of seminal vesicles in xi and occasionally in ix. Orientation and location of the spermathecal diverticulum, *i.e.*, flattened on the parietes of the preceding segment (not vertically placed on the anterior face of the duct and perhaps in the same segment as the main axis of the organ). Individual variation as to number of genital markings is, of course, to be expected, but such very little data as now are available suggest specific uniformity as to shape and size of the clitellum in this genus. Intestinal caeca should have been recognizable if present in the type of *R. eiseni*, as it was well preserved, but they may have been overlooked or even considered to be unworthy of mention. Possibly some deformation or a peculiar reaction to preservation rendered the calciferous sacs unrecognizable. (For other comments see notes on *R. eiseni* below.)

Somatic characters show that *R. strigosa* belongs in the "*guatemalana*" group to which *R. eiseni* probably will have to be added. Possibly only early stages in development of the testicular chamber, or none at all, are to be found in a holandric section of the group.

Ramiellona mexicana Gates, new species.

Mexico, Dos Rios, Tehuantepec, January, 1900, 0–1–1. P. M. King (Eisen collection).

External characteristics. Length, 96 mm. (aclitellate worm), 116 mm. (clitellate specimen which lacks a posterior portion presumably torn off before preservation). Diameter, 7 mm. (clitellate worm). Segments, 253 (aclitellate), 195 + (clitellate). Pigmentation not determinable (alcoholic preservation, specimens browned). First segment soft, longitudinally furrowed, almost wholly withdrawn into the interior but intersegmental furrow 1/2 recognizable just behind the anterior end of body. Prostomium presumably to be considered prolobous, also withdrawn out of sight but firm (not soft like peristomium), much wider than long, with a deep groove marking off a circular area at center of which is a deep pit. Secondary furrows two per segment behind clitellum. Setae unrecognizable on ii and probably lacking, small, very hard to see even when tips are protuberant from the epidermis, ventral setae paired and in regular ranks but dorsal setae in irregular ranks in preclitellar segments, posteriorly all ranks irregular and arrangement becoming quincunxial. Apertures of ventral follicles of viii–ix about at same level as spermathecal pores and hence only slightly behind intersegmental furrows, not in line with *a* and *b* ranks of other segments. Nephropores unrecognizable and apparently microscopic. First dorsal pore at 11/12 (2 specimens).

Clitellum saddle-shaped, dark red, reaching down to *B*, on xiv-xxii. A median region between the ventral borders of the clitellum is slightly depressed. The same region, in xv–xx of the aclitellate worm, is deeply depressed and so that the floor is invisible.

Spermathecal pores minute, superficial, obviously behind 7/8 and 8/9, unpaired and median. Female, male, and prostatic pores unrecognizable, the female pores possibly at *A*. Seminal groves unusually fine, shaped like parentheses, between equators of xvii and xix, at *B*. Slight tumescences at each end of the grooves may contain prostatic pores.

Genital tumescences areas of slight epidermal thickening, without distinct boundaries, paired in vii around apertures of *ab* follicles, unpaired and reaching beyond *B* in viii and ix where the posterior intersegmental furrows are irregularly met. A tumescence in each of segments xxvi–xxxii (clitellate worm) reaches laterally on both sides to *B* and anteroposteriorly to the intersegmental furrows.

INTERNAL ANATOMY. Septum 4/5 membranous, 5/6–9/10 rather thickly muscular and funnel-shaped, 10/11–11/12 slightly strengthened. Septal insertions on the parietes do not correspond to the intersegmental furrows, 9/10–14/15 crowded together so that the coelomic cavities of ix–xiv are short.

Gizzard large and strong, with thick cuticular lining, in v. Four wide and strong muscle bands from the posterior end of the gizzard dorsally pass back at least to 12/13. Other and more numerous bands from the septa to the parietes are shorter. Esophagus deeply constricted at the septal insertions and markedly moniliform through ix–xiv, in each of those segments short (especially so in xiv) and, relative to width of body, narrow. A thick typhlosolar ridge is present at mV. Thin, vertical, and presumably calciferous lamellae with free median and dorsal margins are attached to floor and lateral walls but leave slightly roughened roof of the gut free. Intestinal origin seemingly in xvi (but possibly in xv?). Typhlosole very rudimentary or lacking until about xxx, thence fairly high, lamelliform but with slight vertical ridges on lateral faces, ending effectively in 132d segment (clitellate worm) though a very small and round rudiment is recognizable in the next twenty metameres. Caeca and lateral typhlosoles were not recognized and may be absent. Supra-intestinal glands lacking.

Dorsal blood vessel single throughout, traceable anteriorly to the brain and presumably complete (though bifurcations to ventral trunk were not recognized). Ventral trunk not visible in front of ix. Supra-esophageal trunk double in part and apparently not continuous, recognizable only in xii–xiii. Extra-esophageal trunks median to segmental commissures, recognizable only in vi–viii. No subneural trunk. Latero-parietal trunks unrecognizable. Segmental commissures of v–x lateral (both specimens), those of v anterior to the gizzard, those of the other segments on anterior faces of the septa, traceable to the ventral trunk only in ix–x. Hearts of xi–xiii (both specimens) rather small but obviously latero-esophageal.

Excretory system meronephric. A large horseshoe-shaped cluster of micronephridia is present on the anterior face of 4/5. A fairly thick duct, recognized only on one side of one specimen, passes forward on the parietes into segment ii. Very small clusters of micronephridia are present on the parietes in iii, v, and posteriorly. Nephridia of postclitellar segments seemingly in six longitudinal ranks on each side. The median-most tubule on each side, in posterior segments of the body, is much thicker than the others and is provided with a slightly glistening preseptal funnel.

Holandric, testes manicate. Male funnels large in aclitellate worm but smaller in the other, plicate. Male gonoducts very slender, looped or zigzagged just behind the funnel septa, not traceable after reaching the parietes. Seminal vesicles vertical bodies on posterior faces of septa 10/11 and 11/12, medium-sized or smaller, acinous, and with many lobules. Prostates two pairs, coiled in xvii and xix. Ducts slender but with muscular sheen, ca. 4 mm. long. Lumen in glands slit-like in cross section, much smaller and circular in the ducts. Penial setae and enlarged setal follicles were not found in xvii–xix. Parietes covered, in xv–xx, by numerous diagonal muscle bands presumably responsible for depression or grooving of ventrum in the clitellar region.

Spermathecae long enough to reach up above gut, rather slenderly club-shaped, without external or internal indication of demarcation into ampulla and duct, very much narrowed in the parietes. The anterior spermatheca (both specimens) reaches forward into vi and has two diverticula. Two spermathecae are present in ix or anteriorly, each with its own diverticulum, the ducts (both specimens) united within the parietes. The diverticulum which passes to the anterior face of the duct at the parietes is short and rather digitiform. The axial lumen, located on the side of the diverticulum next to duct, opens into six discrete seminal chambers. Ovaries small, fan-shaped, with numerous short egg strings.

The ventral follicles of vii–ix are very thick but protrude only slightly into the coelomic cavities. Setal shafts without nodulus, curving slightly to one side near ental end. An ectal portion of each seta (clitellate specimen) is lacking as is ornamentation on the remaining portions.

Reproduction. Spermatozoal iridescence on the male funnels is limited to a peripheral region central to which the funnels are very dark, not black but with a reddish tinge. The color does not appear to be due to blood. Iridescence is unrecognizable in the spermathecae. Nevertheless, there are in the ampullary coagulum small bundles of fine threads that may be spermatozoa.

Small, spindle-shaped to ovoidal bodies of a definite red color are scattered through the coagulum that fills the seminal chambers of the spermathecal diverticula. If, as seems possible, these red bodies contain sperm, then a massive aggregation may have been present on the male funnels. Reproduction, in absence of evidence to the contrary, is assumed to be biparental.

INGESTA. Soil.

REMARKS. These worms had been crowded into a too-short container. The epidermis of xiv, because of the folding over of the specimen, had been creased and then cracked so that the females pores could not be found. The gut of one worm may have been ruptured during study of external characteristics. The second specimen was dissected before examination of external characters, but the gut already was ruptured in the region of xxx.

Some sort of genital markings probably are present in *BB* of the clitellar region, but even after soaking in picric acid solution optical differentiation was too poor to permit any attempt at characterization.

Clitellar tumescence is unrecognizable externally on the worm called aclitellate though some thickening of the epidermis is noticeable at the mid-dorsal incision. Sperm obviously had been matured and the worm almost certainly had copulated. Accordingly, one more must be added to the lengthening list of specimens that have matured sperm and copulated though aclitellate.

No indications of existence of a testicular chamber were recognized, but absence cannot be asserted.

Some of the somatic anatomy obviously is like that of the "*guatemalana*" group: Retraction of the prostomium and derogation of the peristomium associated with loss of setae at least in ii. Small size and close pairing (ventral ranks only) of setae anteriorly. Location of the first dorsal pore. Presence of all septa from 4/5, enlargement into posteriorly directed funnels of 5/6–9/10, marked muscularity in 6/7–9/10. Primitive location of gizzard, in v. Postgizzard portion of esophagus short and slender. Presence of calciferous lamellae in ix–xii. Presence of an intestinal typhlosole. Hearts of x lateral, of xi–xii latero-esophageal. Absence of a subneural vessel.

Differences from the "*guatemalana*" group are as follows: Anterior dislocation of the apertures of the ventral follicles of viii–ix. Development of tumescences (associated with intraparietal glands?) around the apertures of the ventral follicles in vii-ix, enlargement of those follicles (and development of copulatory setae?), abortion of ventral follicles in xvii–xix. More posterior intestinal origin. Presence of hearts in xiii (and of segmental commissures in v?). Union of the spermathecae midventrally. Minute size of spermathecal pores. Some of those differences have been found elsewhere within generic limits and now seem likely to be of minor taxonomic importance.

Evolution of the calciferous portion of the esophagus and of the excretory system in the anterior segments has been proceeding in ways that were not involved in the ancestry of the "*guatemalana*" group. Common origin with that group now appears to have been sufficiently remote to require generic distinction when adequate characterization of structure is possible.

Ramiellona eiseni (Michaelsen).

Eodrilus eiseni Michaelsen, 1911, Zool. Jahrb. Syst. 30, 559.

This species was erected on a single specimen from Huehuetenango. The importance attached to somatic organization in the classical system is shown by the characterizations of two systems: excretory organs meganephric, dorsal blood vessel single, last hearts in xii. The meganephry required the species to go in an Acanthodriline genus but micronephridia were later found (Pickford, 1937) in a small piece (now in the U.S.N.M.) of the body wall from the type. Pickford's transfer to *Howascolex* was qualified by a "?" because of absence of calciferous sacs. A widening of the gut in xii-xiii was attributed by Michaelsen to flattulence, but might have been due to distention by ingesta that was passing through at time of preservation. Poor preservation may have been responsible for failure to detect calciferous lamellae (the gut of earthworms sometimes is in very poor condition even though peripheral anatomy seems to be well preserved.)

The species obviously is holandric, presence of sperm on male funnels fortunately having been recorded. Absence of seminal vesicles in ix and/or xi is unusual as their disappearance would be expected to follow rather than to precede metandry. Spermathecal pores were said to be small but what that means is unknown as size usually was not mentioned. Location of male pores also was not stated. Except for absence of calciferous sacs, *P. eiseni* now seems to be close to *R. strigosa*. If that is correct, both species probably share with others of the group certain unrecorded characters.

Ramiellona irpex (Michaelsen).

Eodrilus irpex Michaelsen, 1911, Zool. Jahrb. Syst., 30:555.
? Acanthodrilus irpex Michaelsen, 1925, Mitt. Zoll. Mus. Hamburg, 41:76.

Eodrilus irpex was erected on a single specimen from Huehuetenango that was provided (like the type of the previous species) by Eisen. Size of spermathecal pores, location of male pores, intestinal caeca, typhlosole and even the andry were not mentioned in the description. The species may be metandric but with retention of anterior male funnels as in *R. tecumumami* and *R. guatemalana,* or holandric but with only one pair of seminal vesicles as in *R. eiseni*. A supposedly meganephridial excretory system, as in *R.*

eiseni, was found (Pickford, 1937) to be micronephridial, *i.e.,* meronephric but nothing is known about the tubules of the preclitellar region of the body where generic peculiarities are likely to be more obvious. Calciferous lamellae are present in xii but in viii–xi are within paired, dorsally directed and discrete glands with slender stalks that open into the gut close to mD. The spermathecae are much like those of *R. balantina.*

Acanthodrilus irpex was described from a specimen from Mexico which is larger than the Guatemalan worm and has paired genital markings. Segment number is more than twice that of the type, but a clitellum had not been developed. No information as to internal organization was recorded though the worm presumably was opened to enable generic identification. In view of the external differences conspecificity with the type requires confirmation.

Ramiellona tecumumami (Michaelsen).

Eodrilus tecum-umami MICHAELSEN, 1911, Zool. Jahrb. Syst., 30:550.

This species was erected on specimens from Huehuetenango that were provided by Eisen. Size of spermathecal pores, location of first dorsal pore and of male pores, intestinal origin, and caeca were not mentioned. In the usual classical manner, location of the last pair of hearts is all that was recorded about the vascular system. As in case of the two preceding species, a supposedly meganephridial excretory system was later found (*cf. R. vulcanica* below) to be micronephridial. Unfortunately, no further information as to the type or other specimens was vouchsafed. Omissions in the list of differences between *R. tecumumami* and *R. vulcanicus* warrant assumptions that spermathecal pores are large, that the male pores are in seminal grooves at level 17/18, that calciferous lamellae are present and especially large in xi–xii, that intestinal caeca are present, that there are vascular commissures or hearts in viii-xii. Spermathecae appear to be erect in coelomic cavities. Spermathecal pores are median to *A*, more so at 8/9. A continuation of the process that apparently is under way can be expected to result in median union of the paired organs, first at 8/9 rather than at 7/8 as in *R. mexicana.*

Ramiellona stadelmanni Michaelsen.

Ramiellona stadelmanni MICHAELSEN, 1934, Mitt. Zool. Mus. Hamburg, 45:53.

This species is known only from the original description of two internally macerated specimens from Honduras. Reproductive apertures (except the female pores) and seminal grooves were not seen. Septum 5/6, the intestinal origin, and intestinal caeca were not mentioned. One part of the setal formula appears to be incorrect, in

$$AA = \frac{5}{6} - \frac{6}{6} AB,$$

BC presumably should be read for AB as setae are closely paired anteriorly.

Whether the spermathecal pores are minute or merely unrecognized because of strong contraction is unknown but no porophores or special protuberances are shown in a figure of the male field. Presence of seminal vesicles in xi–xii usually is associated with holandry which is assumed in order to include this species in the key below. Relationships indicated by the genital markings, calciferous portion of the gut, the large hearts of xi–xii, and other structure, in absence of information about insertion of 5/6 (which may have been membranous and destroyed in pinning out or even in handling the specimen), is believed to warrant assuming that the gizzard is in v. Intestinal caeca (as in some of the author's specimens), possibly even calciferous sacs, may have been unrecognizable because of the internal maceration.

Ramiellona americana (Gates).

Ramiella americana GATES, 1957, Breviora, 75:1.

This species was erected on a single, probably incomplete, specimen supposedly from Guatemala. The esophagus is slender behind the gizzard but if calciferous sacs and lamellae are present in this species they had become unrecognizable because of internal maceration. Spermathecal pores are large enough to admit protuberances functioning as temporary intromittent organs. The lateral typhlosoles, intestinal caeca, lateral hearts of x, latero-esophageal hearts of xi-xii, the testicular chamber and the spermathecae suggest relationships to a "*guatemalana*" group of species. From that group, however, *R. americana* is set apart by the nephridia of the anteriormost portion of the body.

Ramiellona lasiura (Graff).

Howascolex (Graceevelynia) lasiurus GRAFF, 1957, Senckenbergiana, 38:129.

This species was erected on 3 specimens (2 juvenile) from Salvador. The description is in the best classical tradition. Accordingly, though the typhlosole was well characterized, information as to size of spermathecal pores, GM glands and lateral typhlosoles, kind of hearts, trunks of the circulatory system, nephridia of the preclitellar region, testicular chambers, etc., is not to be expected. Gonads were not seen and perhaps also the gonoducal funnels as the latter were not mentioned. The number of seminal vesicles also is unknown. Possibly masses of coagulum (which have been mistaken for vesicles in the past) were what was seen in segment xi. A single pair of vesicles, in xii, usually is indicative of metandry but in *R. eiseni* is associated with holandry. Hence, the andry is unknown, but to enable inclusion of *"lasiura"* in the key, metandry is assumed. Inability to recognize gonads and perhaps also the enteric insertion of septum 5/6 may have made recognition of axial location of certain organs difficult (though level of entrance of spermathecae into the parietes should have provided one good clue). If the gizzard is in v rather than in vi, other organs also will prove to be located as in *R. guatemalana* and a testicular chamber may well be present. Restriction of hearts to vii–xi and presence of calciferous sacs in ix–xiii certainly require confirmation.

Ramiellona sauerlandti (Graff).

Howascolex (Graceevelynia) sauerlandti Graff, 1957, Senckenbergiana, 38:131.

This species was erected on 2 specimens (1 juvenile) from Salvador (*cf.* comment on description of *R. lasiurus*). Male pores, gizzard, calciferous sacs, intestinal origin and hearts appear to be as in *R. guatemalana.* Perhaps, then, the typhlosole which was not characterized also is of the same sort and associated with intestinal caeca. Spermathecal pores were not recognized and may be minute—protuberances in region of prostatic pores apparently lacking. Except for presence of hearts in xi–xii, nothing is known of the vascular system and the anterior nephridia are not characterized. Male funnels are said to be in xi–xii which in itself is very unlikely but becomes even more so when seminal vesicles are in xi–xii. A *lapsus calami* doubtless is responsible for an erroneous location of the testes. The holandry then suggests relationships with *R. strigosa* and *R. stadelmanni.*

Ramiellona vulcanica (Graff).

Howascolex (Graceevelynia) tecumumami vulcanicus Graff, 1957, Senckenbergiana, 38:127.

This form was erected on 6 specimens (5 subadult) from Salvador. As usual, information as to the vascular system and nephridia of a preclitellar region is lacking. The level of insertion of septum 5/6 on the gut apparently was not determined as the gizzard was said to be in v or vi (v in *R. tecumumami*). Graff examined the type of this species and found the excretory system to be micronephridial, *i.e.,* meronephric but did not record other important information that could have been obtained at the same time.

Among the differences between the Salvador and Guatemala worms respectively, are the following: Length 140 to 180 mm.—440 to 1000 mm. Diameter, 7 to 9 mm.—9 to 12 mm. Segments, 260—360 (+ ?). Spermathecal pores, in *AB* (possibly not minute)—median to *A* (possibly minute). Genital markings, present at 16/17 and 19/20—lacking. Septum 10/11, lacking—present. Intestinal caeca, present—lacking (?). Penial setae, 2.6 mm. long—4 to 4.5 mm. long. Spermathecae, with a large round diverticulum on the ampulla (?)—adiverticulate but with seminal chambers sometimes recognizable in a small, transverse protuberance near ental end of duct. More information is needed about important somatic anatomy to determine relationships of the two forms not only to each other but also to the rest of the species whether holandric or metandric.

Discussion

Certain species do or probably do share with "*guatemalana*" many if not all of the following characters: Peristomium, flaccid and usually more or less retracted into anterior end. Prostomium, prolobous, not flaccid though usually retracted. (Associated with the retraction there seems to be a tendency to abort the setal follicles in the anteriormost segments.) Setae, small and closely paired, at least anteriorly, ventral setae of xviii retained, ventral couples of xvii and xix penial. First dorsal pore in region of 11/12–12/13. Spermathecal pores, in *AB* at 7/8–8/9, not minute, large enough for insertion during copulation of temporary protrusions from the male field. Male pores, at 17/18 and in seminal grooves that are lateral to *B*. Genital markings, unpaired, median, at intersegmental furrows, usually if not always with a single transverse row of small circular areas. Septa, present from 4/5, 5/6–9/10 funnel-shaped, 6/7–9/10 thickly muscular, 10/11–11/12 peripherally fused except ventrally to form a testicular chamber. Gizzard, in v. Calciferous lamellae, in viii–xii, in sacs (4 species) that are somewhat more distinctly constricted off from the gut in xi–xii. Intestinal origin, near insertion of 14/15. Intestinal caeca, paired, from dorsum in some of xx–xxx. Typhlosole widened ventrally and with three longitudinal ridges. Lateral typhlosoles present in region of xx–xxx. Hearts, of x lateral, of xi–xii lateroesophageal. Dorsal blood vessel, single throughout and complete. Extra-esophageal trunks median to hearts and segmental commissures. No subneural trunk. Nephridia of iii–iv (presumably astomate) closely crowded in two longitudinal bands parallel to the nerve cord. Astomate micronephridia on anterior faces of septa in next eight segments in each of which there is one pair of nephridial ducts.

Some such uniformity of structure must be shared by species so closely related as to belong in a monophyletic genus. However, some of the characters just listed may not be available to define even the genus in which *R. guatemalana* belongs. Calciferous sacs of xi–xii, for instance, distinguish four species of a "*guatemalana*" group from *Ramiella* but other species, obviously of the same group, seemingly have no sacs. The excretory system in the first few segments of *R. americana* and *R. mexicana* provides differences from the "*guatemalana*" group that may be significant at generic level but not necessarily so from the unknown structure in most species of *Ramiella*. The calciferous section of the gut appears to deny close relationship between *R. americana* and *R. mexicana* as well as of both to the "*guatemalana*" group. Most divergent, possibly, is *R. irpex* which certainly is generically distinguishable by its calciferous glands alone from *Ramiella*. Nothing is known, however, about an anterior portion of the excretory system in *R. irpex*. Relationships of the latter to other American species accordingly are uncertain.

Ramiellona obviously is a congeries, as a whole morphologically indistinguishable from *Ramiella* and presently incapable of segregation into natural generic units. The group may well prove to be a most important constituent of the native earthworm fauna in a region from the isthmus of Tehuantepec to Nicaragua.

Eisen long ago suggested that exotic species were replacing the natives in Mexico and Central America. If, as elsewhere, endemics are haemerophobic they should be sought in undisturbed soils, especially in jungles (which must exist even today in considerable areas) and preferably near or at end of the rainy season when mature individuals are most likely to be easily obtainable.

KEY TO SPECIES OF RAMIELLONA

1.	Stalked calciferous glands lacking	2
	Slender stalks of calciferous glands pass to gut close to mD in viii–xi	*R. irpex*[2]
2.	Spermathecal pores paired	3
	Spermatheca pores unpaired, at mV	*R. mexicana*
3.	Holandric[3]	4
	Metandric	7
4.	Spermathecae adiverticulate	5
	Spermathecae diverticulate	6
5.	Clitellum annular, genital markings paired	*R. sauerlandti*
	Clitellum saddle-shaped, genital markings unpaired	*R. stadelmanni*
6.	Spermathecal diverticulum dorsoventrally flattened in preceding segment	*R. strigosa*
	Spermathecal diverticulum vertical and on anterior face of duct	*R. eiseni*
7.	Setae in lumbricin arrangement posteriorly	8
	Setae in quincuncial arrangement posteriorly	11
8.	Spermathecae without a posterior growth curvature	9
	Spermathecae with a posterior growth curvature[4]	10
9.	Spermathecal pores median to *A*[5]	*R. tecumumami*
	Spermathecal pores in *AB* or centered at *A*	*R. vulcanica*
10.	Quadriprostatic, quadrithecal	*R. americana*
	Biprostatic, bithecal	*R. balantina*

11. Clitellum, saddle-shaped, on xiv–xix, spermathecae adiverticulate .... *R. guatemalana*
Clitellum annular, on xiii–xx, spermatheca with rosette-shaped diverticulum........................ *R. lasiura*

Note, there is no couplet 12.

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2. Guatemalan and Mexican worms referred to *R. irpex* may be specifically distinct.
3. Andry of some species is unknown, compare notes above on *R. irpex* and *R. lesiura*.
4. In this state the ampulla appears to be an outgrowth from the posterior face of the duct.
5. *A*, *B*, *C*, *D* are meridians of longitude passing across apertures of *a*, *b*, *c*, *d*, setal follicles respectively. mD and mV, respectively, indicate mid-dorsal and midventral. eq indicates equator. C is the abbreviation for circumference (U in German). *AB* is the meridional space between *A* and *B*.

Family MEGASCOLECIDAE

This family was recently redefined (Gates, 1959) to exclude all genera except those with racemose prostates of the pheretima sort.

Genus **Pheretima** Kinberg, 1867

Pheretima diffringens (Baird, 1869).

Guatemala, Totenicapan, 0–3–2. (Doubtless collected by Eisen during his explorations, possibly in May–Nov., 1902.)

The prostate glands are lacking, in one of the clitellate worms, but the prostatic ducts are well developed. The dissected individual (and probably the others also) is of an intermediate morph evolving in direction of the anarsenosomphic stage. Reproduction is parthenogenetic.

The species is of Asiatic origin and may have been introduced to Guatemala by the Spaniards.

Family GLOSSOSCOLECIDAE

This family is now restricted in accordance with Michaelsen's later classifications (*cf.* Gates, 1959).

Genus **Pontoscolex** Schmarda, 1861

Pontoscolex corethrurus (Müller, 1857).

Guatemala, Totenicapan, 0–0–2. (Doubtless collected by Eisen during his explorations, possibly in May–Nov., 1902.)

Two unlabelled tubes, but part of the Eisen collection, almost certainly are of the same species and may have been collected at the same time. Specimens were in an advanced stage of maceration.

Seminal vesicles, when recognizable, small and coiled up in xii.

Spermatozoal iridescence is lacking on male funnels and spermathecae are juvenile or if larger are empty in worms with clitellum at maximal tumescence.

Reproduction is parthenogenetic.

The species is of American origin, but is likely to have been introduced to Guatemala, possibly after the Spanish conquest.

Family SPARGANOPHILIDAE

Genus **Sparganophilus** Benham, 1892

Sparganophilus eiseni Smith, 1895.

Eisen collection, 0–1–16. (No further data.)

EXTERNAL CHARACTERISTICS. Length, to 140 mm. Diameter, in clitellar region, to 2 mm. Segments, 210 (posterior amputee?), 231, 257. Anus dorsal (four specimens) or terminal (posterior amputees). Prostomium, zygolobous (14 specimens). Peristomium with a transverse furrow in *DD* immediately in front of the equator (14 specimens) and often at the equator a ring of very small spots some of which occasionally look much like tips of setae. Setae *c* and *d* dorsal throughout, ventral setae of clitellar segments with nodulus much nearer ectal end and, further ectally, three to seven irregular circles of very small teeth. Clitellum, red, covering xvi–xxv, intersegmental furrows 16/17–24/25 obliterated, dorsal setae of those segments lacking. The anterior and posterior margins are not distinguishable externally but the red coloration extends through xv and xxvi, often into xiv and through xxvii but 14/15, 15/16 and 26/27 are not obliterated and the epidermis is less thickened. Tubercula pubertatis, broad bands just lateral to *B* in which the red clitellar coloration is lacking, extend from 17/18 or eq/xviii to eq/xxiii or to 23/24. A median portion of the band is translucent, the lateral portion of a brilliant white opacity which is often continued as a narrower strip to eq/xvii and eq/xxiv. Apertures of genital glands (sometimes called prostates), on very small white protuberances, always just lateral to *b*, on xvi–xvii (16 specimens), xxiv–xxvii (14), xxiv–xxvi (1), xxv–xxviii (1).

INTERNAL ANATOMY. Last hearts in xi (5 specimens). Anterior lateroparietal trunks, two pairs. The larger of each pair passes up on the anterior face of 13/14 (1 specimen) or 14/15 (4) to join the dorsal trunk.

Nephridia are lacking in xii and anteriorly but are present in xiii, probably also in xiv though very small, larger in xv–xxvii, much larger still from xxviii. Nephridial vesicles are lacking and the very slender duct passes into the parietes in *AB*, close to or almost at *A*.

Male funnels, large and plicate. Seminal vesicles, medium sized or smaller, in xi–xii, filled with very dark and almost black matter.

Spermathecal duct longer than the ampulla, with muscular sheen, slightly narrower in entalmost portion. Ovaries, narrow, discoidal, terminating distally in a single egg string (5 specimens) which may contain as many as five ova. Ovisacs, small, lobed, on posterior face of 13/14.

REMARKS. Nephropores and male pores are unrecognizable. Except as otherwise indicated above, external characteristics and anatomy are as in Florida specimens (Gates, 1943, p. 94).

Spermatozoal iridescence is lacking (5 specimens) on male funnels and in spermathecal ampullae which appear to be shrunken. Only two mature ova are left in one ovary which has an eggless egg string. These worms may have been preserved at or near the end of the breeding season.

The genitalia of earthworms are now known to be liable to rapid evolutionary modification. The ovaries obviously are the most conservative of the reproductive organs. Accordingly, the similarity of sparganophilid and lumbricid ovaries may prove to be of importance in estimating relationships of a family so divergent that consideration of its phylogeny alone was omitted by Stephenson (1930) in his monograph.

Family LUMBRICIDAE

Genus **Bimastos** Moore, 1893

Bimastos parvus (Eisen, 1874).

Guatemala, Totenicapan, 0–0–3. (Doubtless collected by Eisen during his explorations, possibly in May–Nov., 1902.)

Diameter, *ca.* 1.5 mm. Clitellum (xxiii?) xxiv–xxx (2 specimens), xxiii–xxx (1).

The species is exotic in Guatemala but its original home, usually thought to be in North America, is unknown.

Genus **Dendrobaena** Eisen, 1874

Dendrobaena rubida (Savigny, 1826).

Guatemala, Totenicapan, 2–0–8. (Doubtless collected by Eisen during his explorations, possibly in May–Nov., 1902.)

Diameter, *ca.* 1.5 mm. Clitellum (xxv) xxvi–xxxi (xxxii?), three specimens, xxvi–xxxi five specimens. Tubercula pubertatis, in xxix–xxx, just lateral to *B*, distinctly outlined but TP glands lacking at least in coelom (3 specimens). Atrial glands are present (3 specimens) but there are no supraparietal glands associated with the genital setae (*a* and *b*) of xvi. Athecal (2 specimens), rudimentary spermathecae opening at 10/11 (1 specimen). Spermatozoal iridescence on male funnels is slight.

The species is of European origin and may have been taken to Guatemala by the Spaniards soon after colonization began.

California Earthworms and Their Method of Reproduction

The earthworm fauna of California comprises more than twenty species, precise enumeration impossible because of uncertainty as to status of several taxa. Even if all endemics (indicated by asterisk in the list below) are valid species, which now seems unlikely, the lot will constitute less than a third of the number present in the state. Natives once were "most common" (Eisen, 1894, p. 41) but by the end of the century (Eisen, 1900, p. 249) finding them in gardens and other places where earthworms are mostly likely to be sought had become "almost impossible." Nearly forty years later, efforts to secure material from sites recommended by Eisen (1900, p. 249–250), undisturbed soil in gulches and mountain meadows, under rotten stumps and decaying leaves in the forest, yielded only seven specimens (Gates, 1941) of a single indigenous species. If Eisen's prophecy that eventually few if any native species will be left is not already fulfilled, conservation, at least as museum specimens and from as many sites as possible, ought to be provided at once. Native species are protected in Australia and export, even for scientific study, is restricted. In California, the competitive exotics are widely distributed by organic gardeners and anglers, by the latter perhaps in the very places most likely to harbor native remnants. How massive that distribution may have become during the last twenty or so years can only be guessed but it is noteworthy that in 1958 expenditure of a little time and money already had revealed Californian addresses of 207 individuals or firms engaged in raising or distributing exotic earthworms, or both.

Among the factors favoring exotic supremacy, according to Eisen, are much longer breeding periods and resistance to human disturbance of habitats. Much remains to be learned about seasonal activity, in California, of every kind of earthworm but endemics of many areas rather generally are believed to be haemerophobic. Exotics, and more especially the European lumbricids, obviously are not haemerophobic and even are called haemerophilic.

More recently parthenogenesis has been thought to favor colonization of new areas. However, biparental reproduction is obligatory (OB, in the list) for five introduced lumbricids including the one raised by most "earthworm farmers." Biparental reproduction is very probable (pB) in one European and in two of three Asiatic exotics. Seven exotics admittedly are parthenogenetic (P), as very probably (pP) are four others, but only one of the eleven now seems likely to be as common as the sexual peregrines.

Acquisition of the ability to reproduce parthenogenetically often has been followed, in earthworms, by evolution of genital polymorphism. Atheeal morphs of three European exotics are known and may be present in California. Sperm are matured and then exchanged during copulation by individuals of one thecal morph of *D. rubida* in which parthenogenesis is facultative. One California endemic (*Plutellus papillifer*) also is polymorphic but whether parthenogenesis is possible in individuals that mature and exchange sperm remains to be determined. Another endemic (*Plutellus umbellulariae*) with 2, 3, or 4 pairs of spermathecae may have evolved a similar sort of polymorphism. Sperm are matured and exchanged by individuals of some morphs but of which ones was not recorded. Spermathecae are, of course, much more likely to be deleted than added. The ancestral hermaphroditic morph, then, may be octothecal. Nevertheless, a sexthecal morph of the usually (and presumably normally) quadrithecal *rosea* was found by McKey-Fender in Oregon.

Biparental reproduction is very probable in worms that mature and exchange sperm but there is at present no evidence to prove that it is obligatory in any native species.

List of California Earthworms

(Endemics are marked by asterisks)

Ocnerodrilidae	*Ocnerodrilus occidentalis*	pP
Acanthodrilidae	*Microscolex dubius*	pP
	Microscolex phosphoreus	pP
	**Plutellus collinus*[6]	
	**Plutellus fenderi fenderi*[6]	pB
	**Plutellus marmoratus*	pB
	**Plutellus papillifer*	pP and pB
	**Plutellus sierrae*[6]	
	**Plutellus umbellulariae*[6]	pB and P?
Octochaetidae	*Dichogaster bolaui*	
	Dichogaster saliens	pB
Megascolecidae	*Pheretima californica*	pB
	Pheretima diffringens	P
	Pheretima hawayana	pB
Sparganophilidae	**Sparganophilus smithi*[6]	
	**Sparganophilus sonomae*[6]	
Lumbricidae	*Eiseniella tetraedra*	P
	Eisenia foetida	OB
	Eisenia hortensis	pB
	Eisenia rosea	P
	Dendrobaena octaedra	P
	Dendrobaena rubida	P and B
	Bimastos parvus	pP
	Allolobophora chlorotica	OB
	Allolobophora trapezoides	P
	Allolobophora turgida	OB
	Lumbricus rubellus	OB
	Lumbricus terrestris	OB
	Octolasium lacteum	P
(Eudrilidae)	*Eudrilus eugeniae*[7]	

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[6] Known only from the original description or material.

[7] Unrecorded as yet from natural habitats but known to have been distributed to earthworm farmers in California.

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PYRGOMORPHIDAE (ORTHOPTERA : ACRIDOIDEA) COLLECTED IN AFRICA BY E. S. ROSS AND R. E. LEECH, 1957–1958, WITH DESCRIPTIONS OF NEW SPECIES

BY

D. KEITH McE. KEVAN

McGill University, Department of Entomology, Macdonald College,
Province of Quebec, Canada

Through the kindness of Dr. E. S. Ross and Mr. D. C. Rentz, of the California Academy of Sciences, I have had the opportunity of examining a collection of Pyrgomorphidae assembled in Africa during 1957 and 1958 by Dr. Ross himself, in collaboration with Mr. R. E. Leech. Since this material contains a number of interesting specimens and records, an account is presented of the species comprising the collection. The specimens, including types of new species, are in the possession of the California Academy, except for a few duplicates which I have retained for further study.

Maura marshalli Bolívar, 1904.

Belgian Congo: 5 miles W. of Tshinsenda, 1330 m., Stop 380, 8.II.1958, 1 ♀. Northern Rhodesia: 44 miles S.W. of Hyimba, 570 m., Stop 433 [?[1]],

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[1] The specimen is labelled "St.434" which apparently refers to a locality 12 miles E. of Rufunsa, 1060 m., 2.III.1958.

1.III.1958, 1 ♀; 5 miles N. of Kapiri Mposhi, 1320 m., Stop 384, 9.II.1958, 1 ♂.

A common species of southern central Africa. It is found in two main color variants: one with the dorsum of the head and pronotum yellowish-orange, the tegmina black; and the other with a more mottled, paler, less distinctive coloration. The females above belong to the first type, the male (as is normally the case) is brachypterous and of the second color form. The male is presumably conspecific with the females, but the whole genus is badly in need of revision.

Maura lurida (Fabricius, 1781).

KENYA: Tanganyika border, Namanga, 1300 m., Stop 245, 19.IX.1957, 1 ♀.

A species widely distributed in tropical Africa.

Maura antennata Bolívar, 1912.

BELGIAN CONGO: Upemba Park, Munowe, 1400 m., Stop 337, 18.I.1958, 2 ♀♀.

A fairly common Central and East African insect, but possibly not a valid species, being in all probability a brachypterous form of another. This specimen has a testaceous, immaculate frons as in *M. flavifrons* Bolívar, 1894.

Maura fitzgeraldi Dirsh, 1954.

NORTHERN RHODESIA: Abercorn, 1600 m., Stop 404, 16.II.1958, 1 ♀.

Described from a single male from Abercorn. Until the genus is revised, it is impossible to be certain of the status of this species. It may merely represent the micropterous condition of another. Many species of *Maura* appear to be variable in color pattern and in tegmen length.

Dictyophorus (Dictyophorus) spumans (Thunberg, 1787).

SOUTHERN RHODESIA: 12 miles S. of Chipinga, 970 m., Stop 466, 19.III.1958, 2 ♂♂ [1 ab. *calceatus* (Bolívar, 1904)]. UNION OF SOUTH AFRICA: Transvaal, Klaserie, 600 m., Stop 492, 28.III.1958, 1 ♀ [ab. *calceatus*]; Natal, 3 miles N.E. of Ubombo, 300 m., Stop 507, 6.IV.1958, 1 ♂ [ab. *calceatus*].

A very variable species common and widely distributed in southern Africa.

Dictyophorus (Tapesiella) laticinctus (Walker, 1870).

BELGIAN CONGO: 50 km. S. of Tshela, Stop 6, 26.VII.1957, 1 ♂, 2 ♀ ♀; 56 km. N. of Matadi, Stop 7, 27.VII.1957, 2 ♀ ♀.

Known from several places in Central Africa.

Dictyophorus (Tapesiella) griseus (Reiche et Fairmaire, 1850).

BELGIAN CONGO: 27 miles S. of Kapona, 1400 m., 14.I.1958, 1 young nymph; Nasoni, 28 miles N. of Kasaji, 1070 m., Stop 361, 31.I.1958, 1 ♀ [f. *fuscoroseus* (Sjöstedt, 1923)]. KENYA: Rift Valley, Nairobi-Magadi road 25 miles N. of Magadi, Stop 251, 22.XI.1957, 1 ♂ [f. *intermedius* (Sjöstedt, 1923)]. TANGANYIKA: 1 mile N. of Megeta, 800 m., Stop 225[2], 15.XI.1957, 2 nymphs; 4 miles N. of Kolo, 114 miles N. of Dodoma, 1700 m., Stop 238, 17.XI.1957, 1 ♂ [f. *intermedius*]. NORTHERN RHODESIA: 8 miles S.W. of Ndola, 1310 m., 9.II.1958, 1 young nymph. SOUTHERN RHODESIA: 10 miles S.W. of Shabani, 1050 m., Stop 472, 21.III.1958, 1 ♀ [f. *fuscoroseus*].

A very variable species extremely widely distributed in tropical Africa.

Parapetasia (Loveridgeacris) impotens (Karsch, 1888).

KENYA: Kwale, 450 m., 207, 5.XI.1957, 1 ♂, 1 nymph.

A rather localized species occurring in northeastern Tanganyika and southeastern Kenya.

Taphronota ferruginea (Fabricius, 1781).

BELGIAN CONGO: Bunyakiri (Kavumu-Walikale Route), 1100 m., Stop 114, 7.IX.1957, 1 ♀ (typical red hind tibiae).

A common and widely distributed West African species.

Taphronota sp., aff. *T. corallipes* Sjöstedt, 1929.

BELGIAN CONGO: Irangi, Luhoha R., 900 m., Stop 117, 10.IX.1957, 2 ♂ ♂, 3 ♀ ♀.

This material possibly belongs to a new species, but until the genus is revised, it is impossible to be certain. It bears a strong resemblance to *T. corallipes* from Middle Congo, but the hind tibiae are entirely black and the head and pronotum marked as in *T. ferruginea*.

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[2] The locality on the data label does not coincide with this stop number.

Taphronota subverrucosa Saussure, 1899.

Taphronota occidentalis Karsch, 1893, Berl. ent. Z. 38:83 [*nec*, 1892, *ibid*. 37:70].[3]
Taphronota subverrucosa Saussure, 1899, Abhandl. Senckenb. Ges. 21:644.
Taphronota amaranthina, Bolívar, 1904, Bol. Soc. esp. Hist. nat. 4:395, 400 (new synonymy).

BELGIAN CONGO: Lwiro River Falls, 47 km. N. of Bukavu, 2000 m., Stop 107, 1 ♂, 1 ♀.

The "*subverrucosa-calliparea*" group of species is in need of revision. It seems possible that *T. subverrucosa* may prove to be the widely distributed West African subspecies of *T. calliparea*. The above synonymy has been determined by a comparison of types and will be discussed fully elsewhere. The present specimens are rather atypical in that the tubercles on the metazona of the pronotum are strongly exaggerated.

Taphronota sp., aff. *T. calliparea* (Schaum, 1853).

KENYA: Kaimosi Mission, 27 miles N.E. of Kisumu, 1650 m., Stop 267, 29.XI.1957, 1 ♂.

This is the typical form found in the Central African Lakes region. The tegmina are shorter than in typical *T. calliparea* and the wings redder. It is possible that this form represents an intermediate to *T. subverrucosa* of West Africa.

Taphronota calliparea (Schaum, 1853).

P[oecilocera] cincta BURMEISTER, 1838, Handb. Ent. 2:623, no. 7.
Poecilocerus callipareus SCHAUM, 1853, *Ber. Akad. Wiss. Berlin*, 1853:778, no. 16.

The earliest name for this species is *Poecilocera cincta* and fuller explanation of this will be given when the genus is revised. It is sufficient for the present to say that I am satisfied that *P. cincta* of Burmeister and *Poecilocerus callipareus* of Schaum are synonyms and that the former is neither a synonym nor an homonym of *Gryllus cinctus* Fabricius, 1793 (which has been referred to the genus *Phymateus*). Neither is it a synonym of *Gryllus thaelephorus* Stoll'h, 1813 (= *Taphronota ferruginea* Fabricius), as was also thought to be the case by Burmeister, so that the name "*cincta*" was perhaps valid for this species. Schaum was, however, quite logical and deliberate in renaming Burmeister's material and even although the name *Poecilocera*

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[3] *T. occidentalis* Karsch, 1892, is another rather similar West African species which occurs in the Cameroons and southeastern Nigeria. It is recognizable by, among other characters, the presence of a distinct, pale, quadrate spot on the postero-inferior area of the lateral pronotal lobe. Owing to an error in type labelling in the Berlin Museum, one of Karsch's 1893 specimens was selected by me (1955:79) as the single type. This selection is invalid since it does not refer to a specimen included by Karsch in his original 1892 description; the two are not conspecific. A correct type selection is as follows: ♂ (lectotype), Kamerun, Buea, 1.I–10.IV.1891 (Preuss, S.) [Berlin Museum]. There is also one ♀ syntype with the same data.

cincta had not been based upon a misidentification of Fabricius' species, the revised Rules adopted in London in 1958 include a Statute of Limitations aimed at preventing the resurrection of names which have remained buried and unused for fifty years and thus "*callipared*" must be retained.

Kenya: Teita Hills, 3 miles E. of Maktau, Stop 201, 1.IX.1957, 2 ♂♂.
Northern Rhodesia: Abercorn, 1600 m., Stop 404, 16.II.1958, 1 ♂, 1 ♀.
Southern Rhodesia: 12 mi. S. of Chipinga, 970 m., 19.III.1958, 1 ♂.

This is an extremely widely distributed species in southern and eastern Africa. It varies considerably in size, tegmen length, wing color, etc. Southern specimens tend to be larger with proportionately longer tegmina and wings. This is true of the above Rhodesian specimens.

Rutidoderes concolor Kevan, new species.

(Figure 1.)
"*Peristegus squarrosus* L., Varietät," Sjöstedt, 1929, Ark. Zool. 20A(15):7.

Type. ♂, Belgian Congo: Tshibati (Lwiro), 32 miles N. of Bukavu, 1950 m., Stop 291, 17.XII.1957 (E. S. Ross & R. E. Leech). [California Academy of Sciences.]

A large species, the type being quite as large as any male of the generitype, *R. squarrosus* (Linné, 1771), and much larger than those of the only other described species, *R. cinctus* (Sjöstedt, 1929). It conforms closely with these species in the shape of the head and pronotum. The latter has the thorn-like tubercles extremely long and prominent exactly as in *R. squarrosus*. It differs chiefly in the venation and in coloration. The external male genitalia do not appear to be distinctive.

tegmina. Very broad (broader than in the other species), broadly rounded apically with fine, close venation, quite different from what is found in the other species and resembling that of *Taphronota* (except *T. ståli*); four instead of two rows of cells between most of the main veins; color dark olive green, suffused dark purplish in the costal field and toward the apex, without any trace of the tessellation found in *R. squarrosus* and *R. cinctus*.

hind wings. Very broad, more discoidal but with similar venation to that of the other species (*i.e.*, with only two rows of cells between the main veins); color almost uniform deep crimson-red, without the black tessellation of the other species, although the cells of the anterior and apical parts of the wings are darker crimson.

general coloration. Head, bases of antennae, and ventral side brownish-olive; eyes chestnut; apical two-thirds of antennae blackish; pronotum dull olive-green; legs olive with yellowish-olive maculations; abdomen without the distinctive rings of color found in *R. squarrosus* and *R. cinctus*.

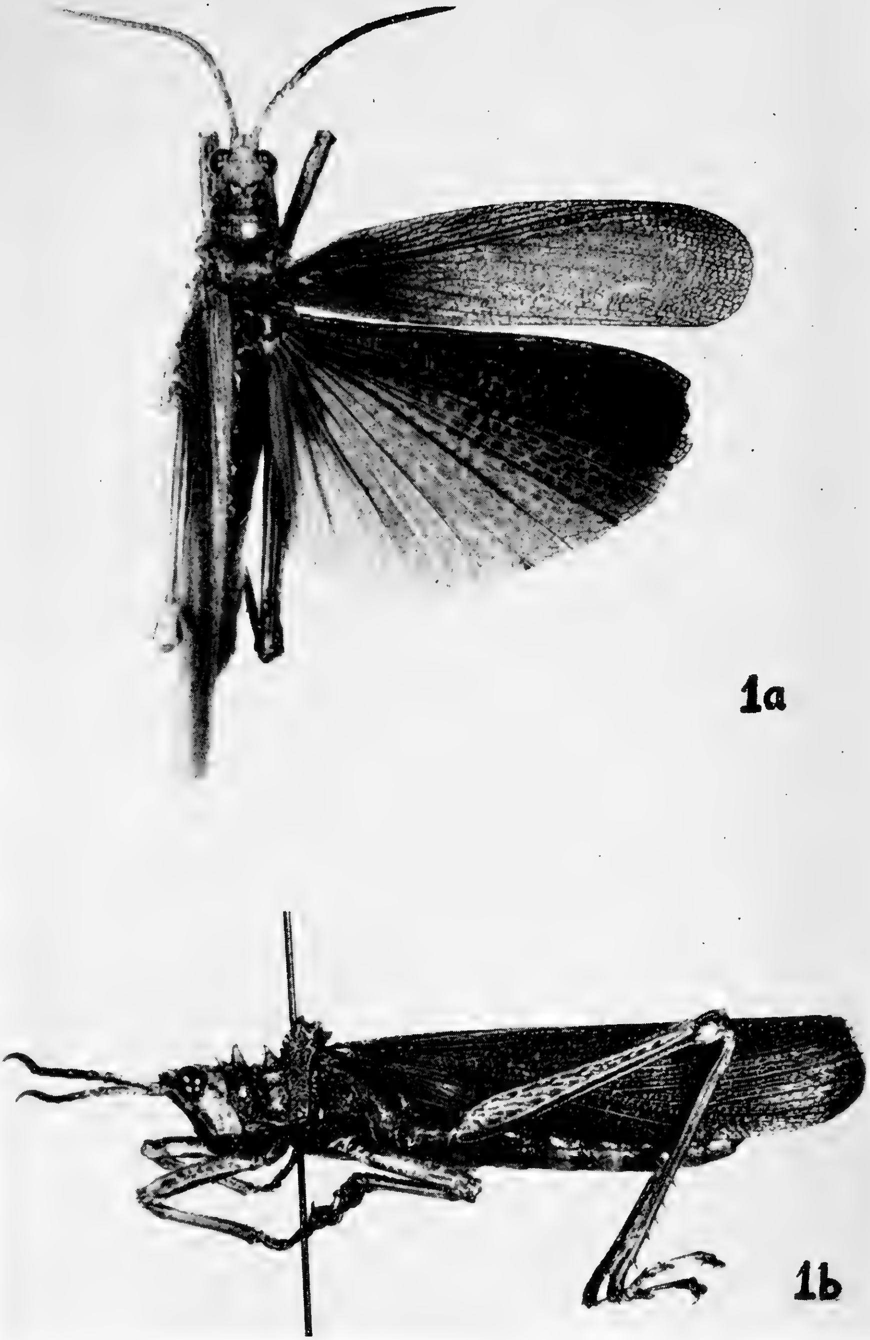

Figure 1. *Rutidodores concolor*, new species, ♂ type × 1¾ (approx.); (a) dorsal; (b) lateral. [Photos: S. K. Banerjee.]

MEASUREMENTS. Length 40.5, antenna 20, head (dorsal) 4.0, pronotum 7.9, tegmen 36.3 x 9.8, hind femur 19.8 mm.

PARATYPE. ♂, BELGIAN CONGO: N.W. [Lake] Tanganyika, 1910 (*Grauer*). Agrees well with the type but is slightly smaller; hind wings with rather more cells darker. Measursements: Length 37, antenna 19, head 4.0, pronotum 7.9, tegmen 34.5 x 9.7; hind femur 19.0 mm.

Phymateus (Phymateus) viridipes Stål, 1873.

KENYA: 38 miles S.E. of Kitale, 1950 m., Stop 163, 17.X.1957, 1 ♀; Rift Valley, Nairobi-Magadi Road, 25 miles N. of Magadi, Stop 251, 22.XI.1957, 1 ♀. UNION OF SOUTH AFRICA: Natal, Ekombe Forest, 39 miles N. of Kranskop, 1520 m., Stop 518, 10.IV.1958, 1 ♂.

A very common species in eastern and southern Africa; often occurring in large numbers and occasionally injurious to crops.

Phymateus (Phymateus) iris Bolívar, 1884.

ANGOLA: 14 miles S.E. of Hengue, 1720 m., Stop 619, 29.V.1958, 2 ♀♀.

This species seems to be confined to Angola where it appears to be not uncommon.

Phymateus (Phymateus) aegrotus (Gerstaecker, 1869).

KENYA: Teita District, 11 miles S. of Maktau, 1000 m., Stop 202, 2.XI.1957, 3 ♂♂, 2 ♀♀; Tanganyika border, Namanga, 1300 m., Stop 245, 19.XI.1957, 2 ♂♂; Athi River, 1500 m., Stop 248, 20.XI.1957, 5 ♂♂.

A common species in northern Tanganyika, Kenya, and the Somalilands; often occurring in large numbers and occasionally injurious to crops.

Phymateus (Maphyteus)[4] baccatus Stål, 1876.

SOUTHERN RHODESIA: 14 miles W. of Fort Victoria, 1050 m., Stop 471, 21.III.1958, 1 ♂; 10 miles N.E. of Filabusi, 1100 m., Stop 473, 22.III.1958, 1 ♀; 2 miles N.W. of Balla Balla, 1100 m., Stop 474, 22.III.1958, 1 ♀, 1 nymph; Khama Ruins, 14 miles W. of Bulawayo, 1275 m., Stop 475, 22.III.1958, 1 ♂, 1 ♀. UNION OF SOUTH AFRICA: Transvaal, Dwarsrivier, 27 miles S. of Louis Trichardt, 1000 m., Stop 485, 26.III.1958, 1 ♂, 1 ♀, 10 miles E. of Pietersborg, 1200 m., Stop 486, 26.III.1958, 1 ♂. SOUTH WEST AFRICA: 10 miles S. of Rehoboth, 1350 m., Stop 577, 7.V.1958, 2 ♀♀; 10 miles S. of

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[4] I prefer to continue to recognize *Maphyteus* Bolívar as a subgenus of *Phymateus* Stål on the basis of the broad, almost subcycloid hind wings, tapering tegmina and coarse venation, rather than on the unsatisfactory characters originally used to separate the two.

Windhoek, 1850 m., Stop 579, 8.V.1958, 1 ♂, 1 ♀; 14 miles S.E. of Omaruru, 1160 m., Stop 561–2, 10.V.1958, 1 ♂; 2 miles N.W. of Outjo, 1250 m., Stop 587, 14.V.1958, 1 ♀.

A common species in the drier parts of southern Africa.

Phymateus (Maphyteus) leprosus (Fabricius, 1793).

Union of South Africa: Cape Province, Sandflats, 280 m., Stop 530, 18.IV.1958, 2 ♂♂.

A very common species in South Africa, often occurring in large numbers and frequently injurious to crops.

Zonocerus variegatus (Linné, 1758).

Belgian Congo: 36 miles N. of Uvira, 1000 m., 22.VIII.1957, 1 nymph; 24 miles S. of Mambasa, 950 m., Stop 137, 1.X.1957, 3 ♂♂ (1 macropterous), 8 ♀♀; Epulu, 950 m., Stop 138, 3.X.1957, 2 ♀♀.

A very common species (sometimes injurious) in west and central Africa.

Zonocerus elegans (Thunberg, 1815).

Tanganyika: 36 miles S.E. of Sumbawanga, Stop 397, 1590 m., 13.II. 1958, 6 ♂♂, 4 ♀♀. Nyasaland: Chiromo, 100 m., 2.II.1958, 1 ♀; 16 miles S. of Kasunger, 1600 m., 23.II.1958, ♂ ♀. Northern Rhodesia: Kafue, 960 m., Stop 443, 8.III.1958, 1 ♀. Southern Rhodesia: Bikita Mines, 1200 m., Stop 468, 18.III.1958, 1 ♀. Union of South Africa: Transvaal, Dwarsrivier, 35 miles S. of Louis Trichardt, Stop 485, 25.IV.1958, 1 ♀.

A very common species in southern and eastern Africa where it replaces *Z. variegatus*. It is also frequently injurious to crops.

Occidentosphena ruandensis (Rehn, 1914).

Belgian Congo: Tshibati (Lwiro), 32 miles N. of Bukavu, 1950 m., Stop 291, 17.XII.1957, 6 ♂♂, 5 ♀♀; Lwiro River Falls, 47 km. N. of Bukavu, 2000 m., Stop 107, 26.VIII.1957, 4 ♂♂, 5 ♀♀.

This species is known from a number of localities in the eastern Congo, Ruanda-Urundi and S.W. Uganda.

Parasphena naivashensis Kevan, 1948.

Kenya: 17 miles S.E. of Nakuru, 1900 m., II.XII.1959, 1 ♂, 1 ♀.

This species is known only from the Rift Valley of Kenya. The specimen in the Paris Museum recorded by Bolívar (1922) from Naivasha under the name *P. pulchripes* (Gerstaecker) has now been examined and proves to belong to this species, as suggested by Kevan (1948).

Parasphena teitensis Kevan, 1948.

KENYA: Teita Hills, 3 miles E. of Maktau, Stop 201, 1.XI.1957, 1 ♀. This species occurs only in the Teita Hills.

Parasphenula obscura Kevan, new species.

(Figures 2, 3.)

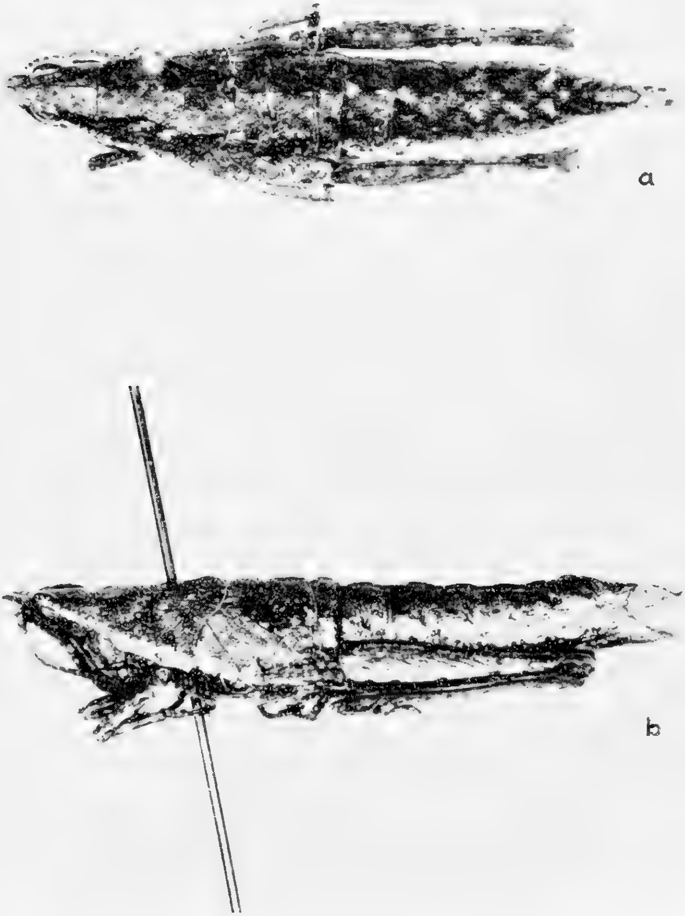

Figure 2. *Parasphenula obscura*, new species; ♀ type × 3 (approx.); (a) dorsal; (b) lateral. [Photos: S. K. Banerjee.]

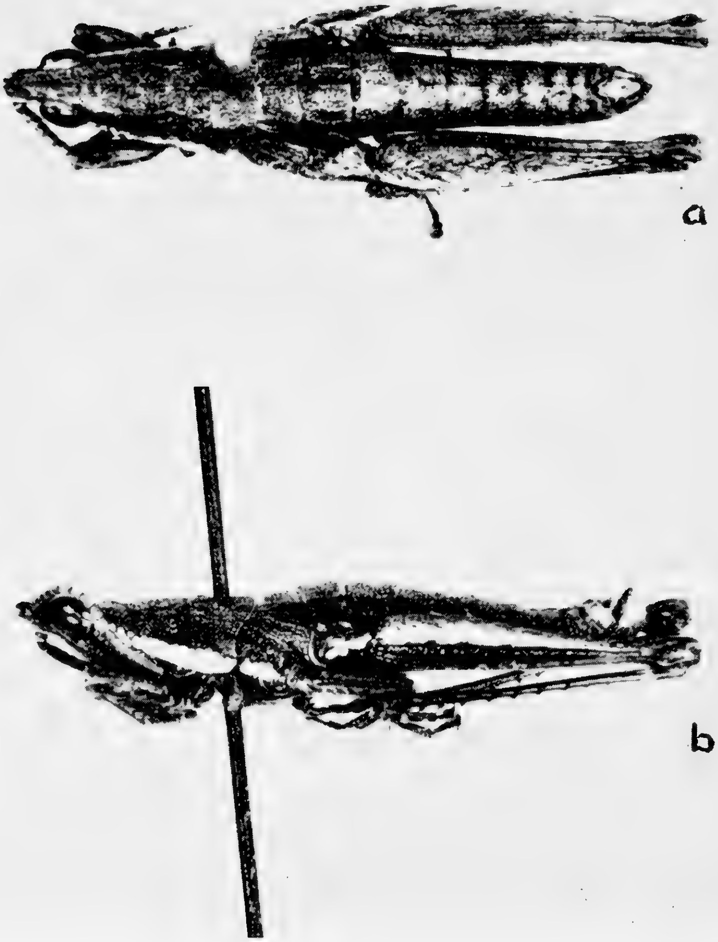

Figure 3. *Parasphenula obscura*, new species, ♂ allotype × 4½ (approx.); (a) dorsal; (b) lateral. [Photos: S. K. Banerjee.]

TYPE. ♀, N.E. NORTHERN RHODESIA: Abercorn, 1600 m., Stop 404, 16.II. 1958. (E. S. Ross & R. E. Leech.) [California Academy of Sciences.]

HEAD. About two-thirds as long as pronotum. Antennae about as long as the pronotum, basal segments strongly flattened. Eyes oval, about one and three-quarter times as long as broad, posterior margin somewhat truncated; interocular space about equal to the breadth of an eye. Fastigium of vertex about as long as wide with lateral margins subparallel and apex parabolic. Median carinula distinct, reaching the occiput. Vertex rugose with a few small tubercles near the eyes. Frontal profile strongly oblique, distinctly and evenly concave. Frontal ridge strong, compressed between the antennae, parallel-sided and evenly sulcate throughout to the clypeus. Lateral frontal carinae strong, slightly sinuous. Frons granular with a pair of small tubercles about equidistant from the lateral carinae and the clypeal suture, slightly nearer to the frontal ridge. Clypeus and cheeks with a few small scattered tubercles. Oblique row of tubercles from behind the eye to the anterior margin of pronotum distinct, forming a double row.

THORAX. Pronotum fairly typical for the genus. Pronotal disc almost twice as long as wide, granular-rugose with a few scattered pustules; anterior margin almost truncate; posterior margin strongly biarcuate; median carina distinct, particularly in the anterior and posterior thirds; lateral carinae indistinct, sinuous, diverging to the metazona, subparallel in the prozona and metazona; anterior transverse sulcus faint, placed at about one-third of the pronotal length; second sulcus sinuous, more distinct at about the middle of the disc; typical sulcus straight, fairly distinct, placed about two-thirds of the distance along the pronotum. Lateral pronotal lobes somewhat concave in the middle with scattered pustules; anterior margin straight, oblique; inferior margin slightly sinuous; posterior margin widely excavated; infero-posterior angle irregular; dorso-lateral impressions distinct but ill-defined and with a raised granulated ridge below them running diagonally upward toward the posterior end of the lateral carina of the disc; callous ridge above the inferior margin of the lateral lobe comprised of numerous small, more or less distinct granular tubercles. Mesonotum all but concealed beneath the pronotum; metanotum slightly shorter than the metazona of the pronotum, similarly sculptured but virtually without granular pustules. Prosternal tubercle transverse and slightly sulcate along its apex. Meso- and metasterna strongly granular; mesosternal lobes a little longer than wide, their interspace more than twice the width of a lobe; metasternal pits directly behind the inner angles of the mesosternal lobes; metasternal interspace very short and wide.

TEGMINA AND WINGS. Tegmina not quite reaching the posterior margin of the first abdominal tergum, strap-like, with costal margins straight, posterior margins slightly convex and apices tapering to a rounded point. Hind wings scale-like.

LEGS. Covered with granular pustules but otherwise unremarkable. Hind femora about five times as long as wide.

ABDOMEN. Segments all similarly sculptured to the metanotum; median carina strong throughout. First abdominal tergum very similar to metanotum but slightly longer than the metazona of the pronotum and bearing a few distinct granular pustules at the lateral margins. Tympana of moderate size, distinct and lying in large, shallow depressions. Tenth abdominal tergum deeply excised to base. Epiproct narrowly triangular with apex rather blunt and a transverse sulcus before the middle. Cerci conical, short and stout, falling considerably short of the apex of the epiproct. Ovipositor valves fairly elongate, the dorsal valves scarcely crenulated at the base (fig. 4).

COLORATION. Generally fuscous; granules and tubercles testaceous. Antennae blackish, suffused reddish; eyes chestnut; lateral pronotal lobes blackish in the middle. Pleura, sternum and apex of abdomen locally suffused reddish. Abdomen ventrally testaceous, mottled fuscous and with a pair of irregular ventro-lateral fuscous stripes; abdominal segments laterally with an oblique, black macula which is broken up and less distinct on the posterior segments. Tegmina fuscous; hind wings reddish. Hind femur with the lower part of the exterior face testaceous; dorsal aspect with patches of blackish suffusion; exterior-ventral face blackish. Hind tibiae and tarsi dirty pinkish; blackish apically.

MEASUREMENTS. Length 31, head 4.1, pronotum 5.6, tegmen 3.2, hind femur 11.2 mm.

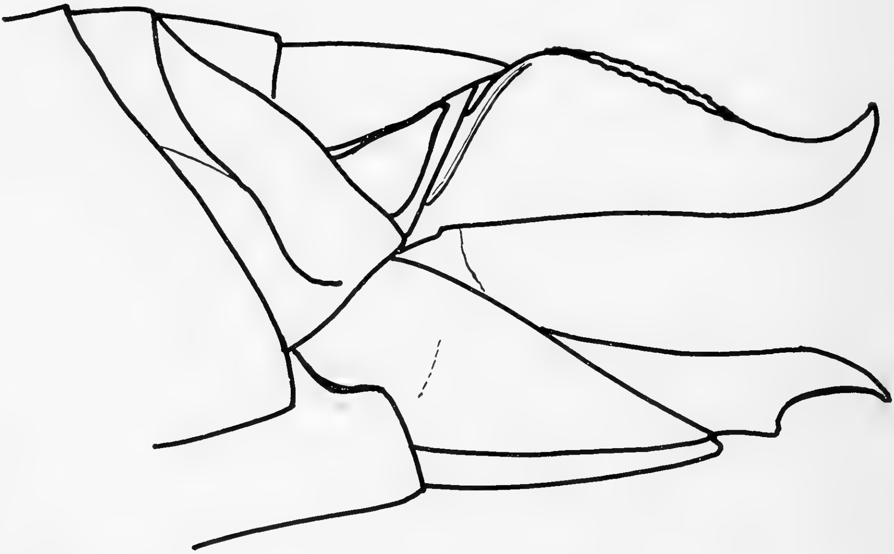

Figure 4. *Parasphenula obscura*, new species; ♀, ovipositor, lateral.

Allotype. ♂; same data as type [California Academy of Sciences].

Agrees with the type except for being smaller and more slender, and in the following details. The head is a little more than two-thirds as long as the pronotum; the antennae are almost as long as the head and pronotum together; the interocular space is narrower and the fastigium more rounded apically; granular pustules are fewer and less distinct, those of the callous inferior border of the lateral pronotal lobes running into one another; the meso- and metasternal interspaces are much narrower, the former being barely one and a half times as wide as a lobe; the tegmina (which are suffused blackish) extend just beyond the hind margin of the first abdominal tergum; the black maculae on the sides of the abdomen are large and distinct; the cerci are longer and narrower, reaching almost to the apex of the epiproct; and the tenth abdominal tergum is not deeply excised to the base, but has a distinct, narrow, rounded median notch (fig. 5a). The subgenital plate is subacute with a somewhat truncated apical profile (fig. 5b).

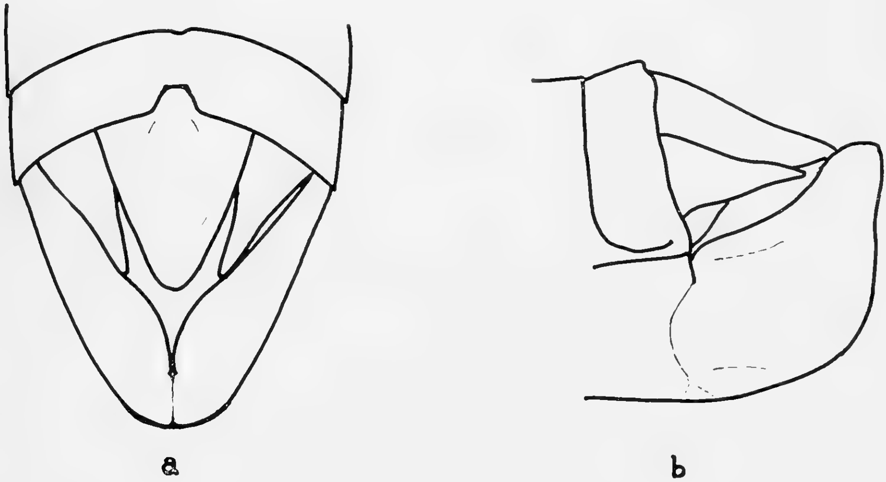

Figure 5. *Parasphenula obscura*, new species; ♂, external genitalia; (a) dorsal; (b) lateral.

measurements. Length 18.5, head 3.2, pronotum 3.8, tegmen 2.8, hind femur 9.3 mm.

Paratypes[5]. N.E. Northern Rhodesia: 2 ♀ ♀, same date as type; 1 ♀, Kalambo Falls, 22 miles N.W. of Abercorn, 1200 m., Stop 405, 18.II.1958 (E. S. Ross & R. E. Leech); 2 ♀ ♀, Abercorn, 21.XII.1953 [coll. ?]; 1 ♂, 1 ♀, Abercorn, 24.XII.1953, [coll. ?]. S.W. Tanganyika: 1 ♂, Lake Chila.

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[5] Only those collected by Ross and Leech are from the California Academy of Sciences; the others are in the British Museum or in my own collection.

Mbuga, 30.XI.1950 [coll.?]; 1 ♂, Ufipa, XI.1954 (Fitzgerald); 1 ♂, Ufipa, Mlonge Boma, 28.II.1956 (R. F. Chapman); 1 ♂, Ufipa, Nkundi, 5.III.1956 (R. F. Chapman); 2 ♂♂, Tatanda, 3 miles S. of Sumbawanga, 50 m., Stop 403, 16.II.1958 (E. S. Ross & R. E. Leech). There is also a nymph, presumably of this species, from the same area of S.E. Tanganyika; Mbizi Mt., 13. VIII.1948 (G. Burnett).

The majority of these specimens agree closely with the type and allotype, although most of them are rather smaller. The length and exact shape of the tegmen and fastigium of the vertex and the degree of rugosity and granulation of the integument are all subject to slight variation. Four of the males are rather differently coloured from the remainder. One of the Sumbawanga males is more uniform brown; the other greenish with a brown dorsal stripe, brown patches on the lateral pronotal lobes and distinctly pinkish-red hind tibiae. The Mlonge specimen is purple with tegmina and the row of tubercles from behind the eye across the inferior margin of the lateral pronotal lobe all light green. The Nkundi male is light green with black antennae, pink hind tibiae and fuscous fore and middle legs, the infero-external face of the hind femora also being fuscous. The rows of tubercles behind the eyes in this last specimen are bright yellow and those on the inferior margins of the lateral pronotal lobes pale testaceous. The fastigium is also rather long and narrow and the tegmina very slightly broader than in the other material, but I can see no good reason for considering it to belong to a distinct species.

This new species is the most southerly of the genus so far known—presuming *"Parasphena" nigropicta* Bolívar to belong to a different genus, see Kevan (1956). It seems to be closest to the Ethiopian *P. montana* (Uvarov, 1934) and the N. Kenya *P. grandis* Kevan, 1956, conforming with the former in size and the shape of the ovipositor, but differing in being more slender, in the sculpturation and in having much larger tegmen scales. *P. grandis* is geographically the nearest species. It agrees with *P. obscura* in general appearance and in the larger tegmen scales, but it is a very much more robust insect with a coarser ovipositor.

Cawendia glabrata Karsch, 1888.

This species was not collected by Dr. Ross or Mr. Leech, but I take this opportunity of establishing a further synonymy in the genus. A recent reexamination of the type of *C. grossa* Ramme leads me to believe that this is indeed a synonym of the above, as previously suggested (Kevan, 1956). Thus: *Cawendia grossa* Ramme, 1929, *Mitt. zool. Mus. Berlin*, 15:280, pl. IV, fig. 7. = *Cawendia glabrata* Karsch, 1888, *Ent. Nachr.* 14:345, new synonymy.

The known distribution of this species in the Congo may now be further extended to include R. Kanzenze-Lualaba (Brédo), 2 ♂♂ [in Brussels Museum].

Afrosphena rhodesiensis Kevan, 1956.

BELGIAN CONGO. 10 miles W. of Mitwasba, 1570 m., Stop 334, 16.I.1958, 1 ♂; Parc d'Upemba, Lusinga, 1800 m., Stop 336, 17.I.1958, 1 ♂, 3 ♀ ♀; Parc d'Upemba, Muye, 1570 m., Stop 336, 17.I.1958, 3 ♀ ♀.

Previously known only from Kipundu in Northern Rhodesia. Now also known elsewhere in the Congo although not previously recorded: Kalulu (? E. Katanga), 6.V.1939, 2 ♀ ♀ (H. J. Bredo)—Brussels Museum.

Chirindites odendaali Ramme, 1929.

In the original description and in subsequent references the name of this species is spelled *oldendaali,* but the collector's name was Odendaal (so far as I am aware, no such name as Oldendaal exists) and I again, therefore, use the recent emendation *"odendaali"* (see Kevan, 1961b).

SOUTHERN RHODESIA: Umtali Heights, 1420 m., Stop 455, 13.III.1958, 1 ♀ (small); Chirinda Forest, 18 miles S. of Chipinga, 1110 m., Stop 465, 18.III.1958, 4 ♂ ♂ (all ab. *marshalli* Ramme, 1929), 1 ♀ (brownish). MOZAMBIQUE: 27 miles E. of Villa Manica, 700 m., Stop 456, 31.III.1958, 1 ♂ (very large), 1 ♀ (large).

This species is now fairly well known from the eastern borders of Southern Rhodesia with Portuguese East Africa.[6] It is extraordinarily variable, not only in size and coloration (see Kevan, 1956), but also in the shape of the fastigium of the vertex. The Villa Manica specimens have very broad, parallel-sided fastigia and the Chipinga female a rather acutely pointed one, but intermediates are known from various localities and the shape of the fastigium seems to be merely an individual character. It seems probable that environment may have some effect on coloration and possible that altitude affects size; specimens taken at lower altitudes mostly seem to be larger than those taken at greater elevations. A genetical and environmental study of this species would probably prove most interesting.

Pyrgomorphella arachidis Dirsh, 1951.

TANGANYIKA: N.E. base of Mt. Meru, Stop 191, 29.X.1957, 1 ♀. NYASALAND: 7 miles S. of Cholo, 940 m., 25.II.1958, 1 very young nymph (? this species).

This species is fairly widely distributed in northern Tanganyika and southern Kenya. It has been recorded as injuring ground-nuts.

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[6] In the Paris Museum I have recently seen a specimen from Vallée du Revoué, Env. d'Andrada, 1905 (*G. Vasse*), which further extends the known range of the species in Mozambique.

Pyrgomorphella albini (Chopard, 1921).

This species was not collected by Dr. Ross or Mr. Leech, but I take this opportunity of publishing further records since *P. albini* is little known.

KENYA: Masai Reserve, Narok, 28.I.1914 (Capt. A. O. Luckman), 1 ♂; Masai, Piyon, between Mt. Suswa and L. Magadi, 22.V.1946 (D. K. McE. Kevan), 1 ♀.

There are also two old records of *Parasphena* (now *Parasphenella*) *dubia* Bolívar, 1904 from Tanganyika, N. of Mt. Meru and Ngare na Nyuki (Sjöstedt, 1909). Kevan (1948) suggested that these were probably referable to a species of *Pyrgomorphella* and a recent examination of the material shows that the specimens belong to the above species.

Pyrgomorphella rugosa Key, 1937.

The only reported specimen of this species is the unique damaged male type. It is, therefore, interesting to record the following from the present collection:

UNION OF SOUTH AFRICA: Cape Province, 3 miles S.E. of Calitzdorp, 275 m., Stop 545, 24.IV.1957, 1 ♂, 2 ♀ ♀.

Since the type lacks hind legs, the measurements of the present male example may be given:

Length 13.5, head 2.7, pronotum 2.9, tegmen 3.0, hind femur 6.8 mm. The tegmina are a little longer than in the type, reaching the anterior margin of the second abdominal tergum.

The female has not hitherto been described. It agrees well with the original description of the male, but is larger and more robust. The mesosternal interspace is fully twice the width of the mesosternal lobe. The epiproct is narrowly triangular, parabolic at the apex; the cerci are very short triangular in lateral view (almost as wide at the base as they are long); the ovipositor valves are moderately slender, their apices strongly curved, the dorsal valves being distinctly crenulated above.

The specimen selected to present the female of the species ("nealotype") has the following measurements:

Length 20.5, head 3.2, pronotum 4.2, tegmen 5.3, hind femur 9.3 mm.

The genus *Pyrgomorphella,* as at present recognized, is undoubtedly heterogeneous, but it is not possible to revise it completely at the present time.[7] However, *P. rugosa* possesses certain interesting characters which mark it off from other species and which may eventually make it desirable to erect a new genus to contain it. These characters are, particularly, the shape of the frons and the sculpturation of the pronotum, both of which are

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[7] See also *Plerisca*, p. 243.

somewhat reminiscent of the anomalous monotypic genus *Phymella* Uvarov, 1922. The heads of both *P. rugosa* and *Phymella capensis* Uvarov are of the characteristic *Pyrgomorphella* shape with the dorsal profile strongly convex and the frons strongly concave, but both have a strong, deep transverse impression crossing the frons below the median ocellus, giving the frontal profile a characteristic interrupted appearance.[8] This is remarked on and figured by Key in his original description of *P. rugosa*. The head of *Ph. capensis* is strongly tuberculate, unlike that of *P. rugosa,* and Uvarov, in his original description, mentions a transverse row of tubercles below the ocellus; this lies above the transverse impression. The fastigium of the vertex in both species is also rather similar, being more or less parallel-sided and very blunt apically, giving the fastigium a rather square appearance. The sculpturation of the pronotum in *P. rugosa* has been described and figured by Key. He notes the way in which the median and lateral carinae are broken up and exaggerated between the transverse sulci, and also the presence of various additional callosities and tubercles. Although the sculpturation is not exaggerated to the fantastic degree exhibited by *Phymella,* it bears a certain basic resemblance to the condition found in that genus when the two are compared. Both species also have somewhat similar, reduced, ovate tegmina. These similarities between *Pyrgomorphella rugosa* and *Phymella capensis* confirm the suggestion of Kevan (1959:22) that *Phymella* is perhaps most closely related to *Pyrgomorphella*. Whether it now deserves tribal status of its own (the tribe Phymellini was erected by Kevan, *l.c.*) is, in spite of its extraordinary appearance, perhaps debatable.

Plerisca peringueyi Bolívar, 1904.
(Figure 6.)

Plerisca rubripennulis (Key, 1937), new combination.

Plerisca senecionicola (Key, 1937), new combination.

Although no material was collected by Dr. Ross and Mr. Leech, I take this opportunity of referring to these three South African species, all of which occur in Cape Province.

Owing to the lack of material, the genus *Plerisca* Bolívar, 1904, was omitted from my recent paper on micropterous African Pyrgomorphidae (Kevan, 1956), but in the provisional key to the genera given, *Plerisca* would be included with *Pyrgomorphella* Bolívar, 1904. At the time of description (Bolívar, 1904:442), the genus was placed near *Parasphena* Bolívar, 1884, but it is much nearer to certain species at present included in *Pyrgomorphella*. Bolívar (1909:26) indirectly separated the two genera on the basis of

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[8] This transverse impression is absent or faint in other described species of *Pyrgomorphella,* but is developed to a slight degree in an undescribed Somali species.

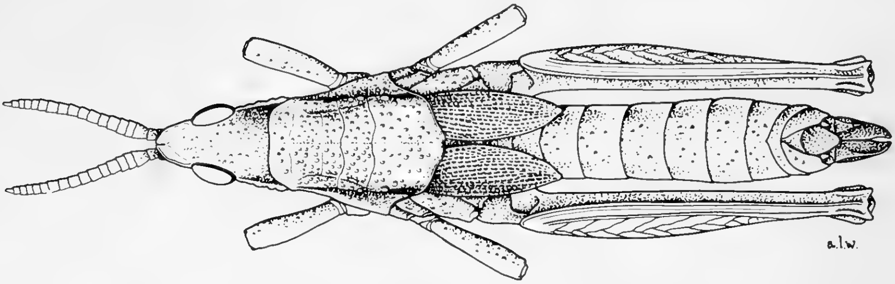

Figure 6. *Plerisca peringueyi* **Bolívar, ♀ type × 4⅓ (approx.). [Drawing by A. L. Wallers, Courtesy of Dr. V. M. Dirsh.]**

untenable antennal and pronotal characters, but the similarity of *Plerisca* and *Pyrgomorphella* is very close. Until the latter is revised (the need for this is great), *Plerisca* may be distinguished by the following combination of characters:

Head less strongly convex dorsally and frons less concave; pronotal sculpturation weak; posterior margin of pronotal disc rather angularly produced and notched medially, not biarcuate, truncated (with or without a median notch), or evenly rounded; tegmina ovate or ovate-lanceolate.

Pyrgomorphella rugosa Key has similarly shaped tegmina and posterior pronotal margin, but differs in the shape of the head and in the rugose pronotum; and certain Palaearctic species, such as *Pyrgomorphella serbica* (Brunner von Wattenwyl, 1882), have ovate-lanceolate tegmina, but are probably more closely related to *Pyrgomorpha* Serville, 1839.

I am indebted to Dr. V. M. Dirsh of the Anti-Locust Research Centre, London, for comparing the types of *Pyrgomorphella rubripennulis* Key, 1937, and *Pyrgomorphella senecionicola* Key, 1937, with that of *Plerisca peringueyi* Bolívar, 1904, and for confirming that all three are congeneric. I am also grateful to him for providing me with a figure of the type of the last-mentioned species which has not previously been illustrated (fig. 6). Through the kindness of Dr. H. Gisin of the Natural History Museum, Geneva, I have subsequently been able to see this type (the only locality given on the label is "Cap. b.Esp.") which I have compared with paratypic and other topotypic material of *P. rubripennulis* from Grahamstown, eastern Cape Province. Although the two species are very similar, I agree with Dr. Dirsh that they are probably not synonymous. *Plerisca peringueyi* differs from *P. rubripennulis* in that the head is a little wider dorsally and the frons less oblique and somewhat less concave in profile, and that the posterior margin of the pronotal disc is rather less produced. The tegmina of the type of the former, also, are almost contiguous and the carinula of the vertex virtually lacking, but the latter, in *P. rubripennulis,* varies considerably in its degree of development and the tegmina vary much in shape and size. Some specimens have tegmina almost as in the *P. peringueyi* type although not actually contiguous, some even longer, though narrower, and others smaller; males frequently have contiguous tegmina. The carinula of the vertex and the tegmina are thus probably unreliable as a means of distinguishing between the two species.

The following new nomenclatorial combinations are involved: *Pyrgomorphella rubripennulis* Key, 1937, *Ann. S. Afr. Mus.,* 32:151, 157, pl. XVII, figs. C, H. = *Plerisca rubripennulis* (Key, 1937), new combination; and *Pyrgomorphella senecionicola* Key, 1937, *Ann. S. Afr. Mus.,* 32:150, 154, pl. XVII, figs. D, G = *Plerisca senecionicola* (Key), new combination.

At least two other species of *Plerisca,* as yet undescribed, are known to me from single females. One is from the Transvaal and the other from eastern Ethiopia.

Pyrgomorpha dispar semlikiana (Rehn, 1914).

The above name is discussed by Kevan (1961a).

Belgian Congo: Camp de l'Epulu, 950 m., Stop 138, 3.X.1957, 1 ♂. Angola: Luanda, 18.VII.1957, 1 ♀

Apparently widespread in the West African zoogeographical region.

Pyrgomorpha granulata Stål, 1875.

Northern Rhodesia: 33 miles E. of Mazabuka, 1180 m., Stop 442, 7.III.1958, 1 ♀. Union of South Africa: Transvaal, 15 miles W. of Pangola, 550 m., Stop 502, 3.IV.1958, 1 ♂.

Common in southern Africa.

Pyrgomorpha cylindrica Bolívar, 1904.

A provisional determination only. The specimens below agree fairly well with the types, but the extent of the synonymy is not yet known.

Belgian Congo: 52 miles S.E. of Kilembe, Stop 57, 8.VIII.1957, 1 ♀. Park Upemba, Muye, 1570 m., 17.I.1958, 1 ♂. Tanganyika: 36 miles S.E. of Sumbawanga, 1590 m. [Stop 397], 13.II.1958, 1 ♂, 1 ♀.

Apparently fairly widespread in tropical Africa.

Tanita loosi Bolívar, 1904.

Species of *Tanita* are for the most part difficult to determine with certainty in the present confused state of the genus, the very limits of which are uncertain, but type material of the species referred to here have been seen recently.

Belgian Congo: 19 miles S.E. of Kiembe, 8.VIII.1957, 1 ♂; 39 miles N.E. of Lusambo, 12.VIII.1957, 1 ♀; 60 miles S. of Albertville, 1320 m., Stop 318, 13.I.1958, 1 ♀.

Tanita subcylindrica (Bolívar, 1882).

Belgian Congo: 32 miles W. of Kinda, 1000 m., 2.II.1958, 1 ♀. Tanganyika: 1 mile N. of Megeta, 800 m., Stop 225, 15.XI.1958, 1 ♂, 2 ♀♀.

This species is very like the next, but is more slender with a slightly more oblique frons and longer hind femora. The type is lost but specimens from the type series have been examined. It was described from Angola.

Tanita picturata (Karsch, 1888).

Belgian Congo: 43 miles N.W. of Kolwezi, 1100 m., Stop 358, 30.I.1957, 1 ♀.

This specimen appears to agree reasonably well with the type which was described from northern Angola.

Tanita lineaalba (Bolívar, 1889).

Belgian Congo: 39 miles E. of Lusambo, Stop 73, 12.VIII.1957, 1 ♀; Upemba Park, Munowe, 850 m., Stop 339, 18.I.1958, 1 ♀.

A species known from Angola and the southern Congo. The Lusambo specimen is smaller and less clearly marked than the Munowe example which compares well with syntypic material.

Atractomorpha aberrans Karsch, 1888.

Belgian Congo: Irangi, Luhoha R., 900 m., Stop 117, 9.IX.1957, 1 ♂, 1 ♀; 39 km. S. of Walikale, 700 m., Stop 293, 14.IX.1957, 1 ♂, 1 ♀; the same, 22.XII.1957, 1 ♂, 1 ♀; Camp de l'Epulu, Stop 138, 21.X.1957, 1 ♀; 45 miles S. of Albertville, 1350 m., 12.I.1958, 1 ♂, 1 ♀.

A common species throughout the West African zoogeographical region.

Atractomorpha acutipennis gerstaeckeri Bolívar, 1884.

A recent revision of the genus *Atractomorpha* indicates that *gerstaeckeri* is but a subspecies of the Malagasy *A. acutipennis* (Guérin-Méneville)—see Banerjee & Kevan (1960).

GABON: Port Gentil, Stop 8, 12.VII.1957, 1 ♂. BELGIAN CONGO: 37 miles E. of Kamituga, 675 m., Stop 91, 17–18.VIII.1957, 2 ♂♂; 39 miles N.E. of Lusambo, 12.VIII.1957, 1 ♂; Kama Mission, 14.VIII.1957, 1 ♂; Bunyakiri (Kavumu-Walikale Route), 1100 m., Stop 114, 7.XI.1957, 1 ♀; Irangi, Luhoha R., 900 m., Stop 117, 9–10.IX.1957, 4 ♂♂, 2 ♀♀. KENYA: Kaimosi Mission, 27 miles N.E. of Kisumu, 1600 m., Stop 267, 29.XI.1957, 1 ♂. TANGANYIKA: 82 miles S.W. of Morogoro, 530 m., 15.XI.1957, 1 ♀. UNION OF SOUTH AFRICA: Cape Province, Port St. John's, sea level, Stop 520, 13.IV. 1958, 1 ♂, 2 ♀♀.

Common and widely distributed in tropical and southern Africa.

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FLORA AND VEGETATION OF CLIPPERTON ISLAND[1, 2]

By

MARIE-HÉLÈNE SACHET

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[1] Publication authorized by the Director, U.S. Geological Survey.

[2] Contribution from the Scripps Institution of Oceanography, New Series.

INTRODUCTION

One of the loneliest, most isolated and smallest islands in the Pacific Ocean is Clipperton Island (10° 18′ N, 109° 13′ W). The nearest land, about 600 nautical miles to the NNE is the coast of Mexico. Clipperton is one of the few oceanic islands, and the only coral island, in the Eastern Pacific. The nearest atoll, Pukapuka in the Tuamotu Archipelago, is 2300 miles to the southwest. Although uninhabited, Clipperton has been seriously influenced by short-lived human settlements. The flora is poor and the vegetation meager, yet Clipperton's unique location and the history of its plant life make its study very worthwhile and raise a number of interesting questions. Birds and other animals were collected and observed in the last century, but the plants received little attention until very recently. The geography will be elaborated in separate papers (Sachet, in press), and only a brief description of the features pertinent to botany will be given here.

During the international Geophysical Year and as part of this program, Scripps Institution of Oceanography carried out a number of research cruises, and in the summer of 1958 had several ships in the Eastern tropical Pacific studying the Equatorial Counter Current (Expedition Doldrums). One of the ships stopped at Clipperton and left a number of biologists, including myself as botanist, for a survey of life on the atoll. This is how I came to spend two and a half weeks on this little-known island (Aug. 7–26, 1958). The all-too-short visit was most enjoyable and rewarding and I take this opportunity to express my appreciation for this chance to Scripps Institution of Oceanography and to its director, Dr. Roger Revelle, and to thank the many persons who helped me during the voyage and the stay on the island and in the study of the material collected. Particular credit must go to Professor Carl L. Hubbs, of Scripps, who originally suggested this survey of Clipperton and from whom the invitation to participate was received. The French government gave us the necessary authorization to land and stay on the island. For permitting me to join the expedition and encouraging me to study the material collected I wish to thank my superiors in the U.S. Geological Survey and in the Pacific Science Board, National Academy of Sciences—National Research Council. A grant from the Academy's Joseph Henry Fund was much appreciated. Miss Evelyn L. Pruitt's assistance in securing photographs and her support of atoll research through the Geography Branch of the Office of Naval Research are gratefully acknowledged. For the identification of specimens I am indebted to Mrs. M. L. Farr and to Messrs. E. Balech, P. Bourrelly, E. Yale Dawson, Francis Drouet, F. R. Fosberg, Mason Hale, C. W. Hesseltine, P. L. Lentz, H. A. Miller, E. H. Moore, Jr., John A. Stevenson, H. K. Svenson, and R. D. Wood. Dr. Fosberg also gave me much help in interpreting the data collected and in preparing this paper. Messrs. E. C. Allison, R. W. Becking, A. S. Hambly, C. F. Harbison, W. L. Klawe, Conrad

Limbaugh, H. E. Maude, and R. E. Snodgrass gave me unpublished information or helped me study some of the material assembled. Dr. Elizabeth McClintock, Mr. Allison, Professor L. Emberger, Professor Hubbs, and Dr. Philip Ross read the manuscript and made many valuable comments and editorial suggestions. To all my most sincere thanks.

Where the top of the highest peak of the newly described submarine Clipperton Ridge (Menard and Fisher, 1958) reaches the surface of the sea, an egg-shaped coral reef supports a narrow, low, uninterrupted land strip of limestone debris, while a small volcanic rock (Clipperton Rock), 29 m. high, rises near the south point. The circumference of the land is about 12 km., and the long, NW–SE, axis of the island is 4 km. long. The ribbon of land varies in width from 45 m. to 400 m. (much of it about 200 m. wide), and encloses a lagoon of almost fresh water.

The seaward outline of the atoll ring is very even, but the inner edge of the land strip projects into the lagoon in several small points or peninsulas. One of these, about halfway along the northeast side, is triangular Green Point (Pointe Verte).[3] In the southeast the short Isthmus (Isthme) stretches parallel to the land strip. At its western free tip rises the volcanic Clipperton Rock (Rocher Clipperton), and from its northern coast the low rocky Thumb Point (Pointe du Pouce) extends northward into the lagoon. West of the Rock lies another short peninsula, the Hook (Le Crochet). Between the Hook, the Isthmus, and the land strip, the lagoon forms a long and narrow arm, Rock Bay (Baie du Rocher). On the southwest side of the island, two rocky points called North and South Pincers (Pince Nord, Pince Sud) enclose shallow Pincer Bay (Baie de la Pince). Along it rises a grove of coconut palms among which the ruins of a U.S. Weather Station, occupied in 1944–1945, are partly hidden. The lagoon is deep (10 to 20 meters and more) in places but is divided by very shallow reefs. A few small islets occur in it, some near the Rock, and the five Egg Islands along the northwest side.

Cross-sections of the atoll rim show comparable profiles everywhere. Above the intertidal reef-flat lined by sand beaches or pebble or cobble strands rise white ridges of unconsolidated limestone fragments, reaching a maximum elevation of 4 meters. Everywhere the tops of these ridges are also the highest points of the ocean-lagoon profiles and from there the land slopes down to the lagoon. Beyond the shorter lagoonward sides of the ridges, where coral pieces are stained dark gray or black by microscopic algae, the land consists of flat or very gently sloping surfaces ending in small "cliffs" or low muddy shores at the lagoon edge. The sediments forming these surfaces are derived from the skeletons of lime-secreting organisms, mostly corals, and consist of sands

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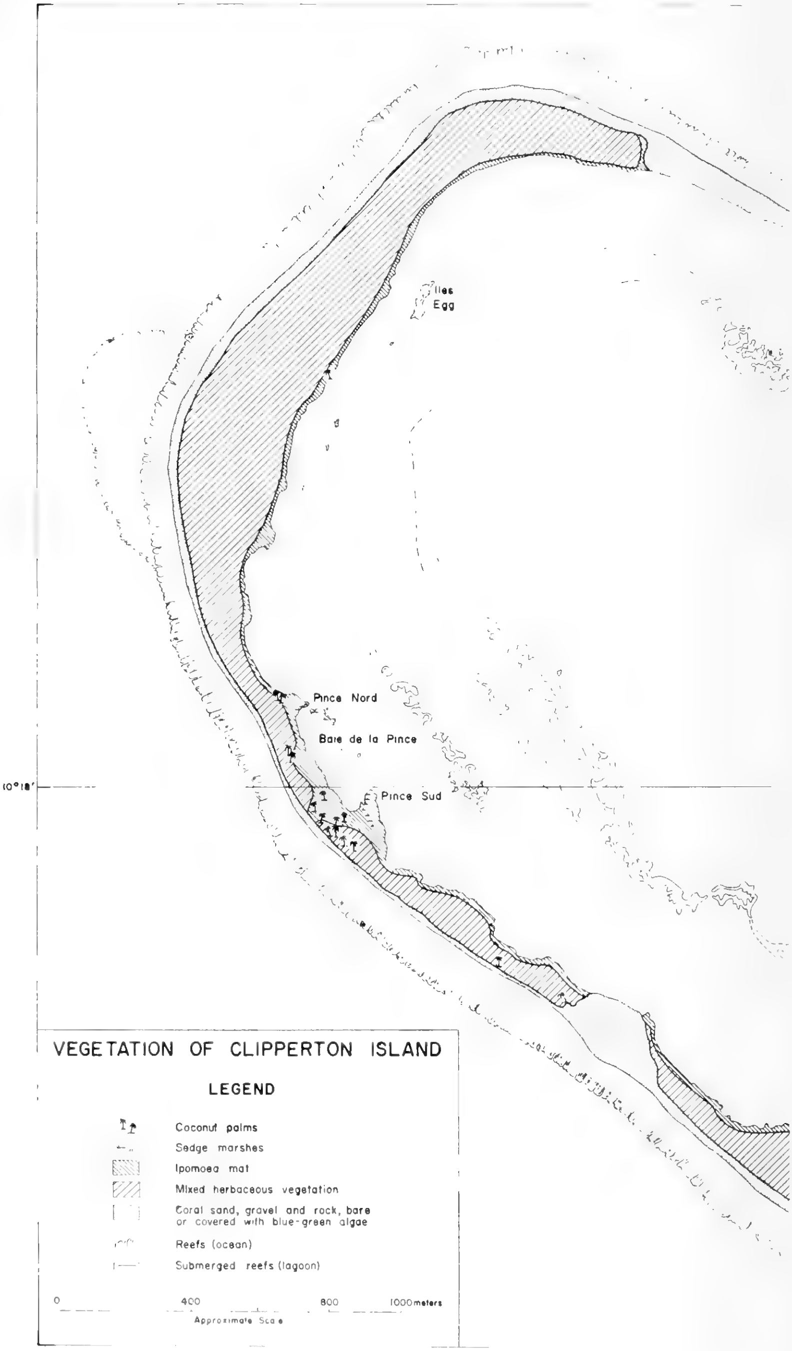
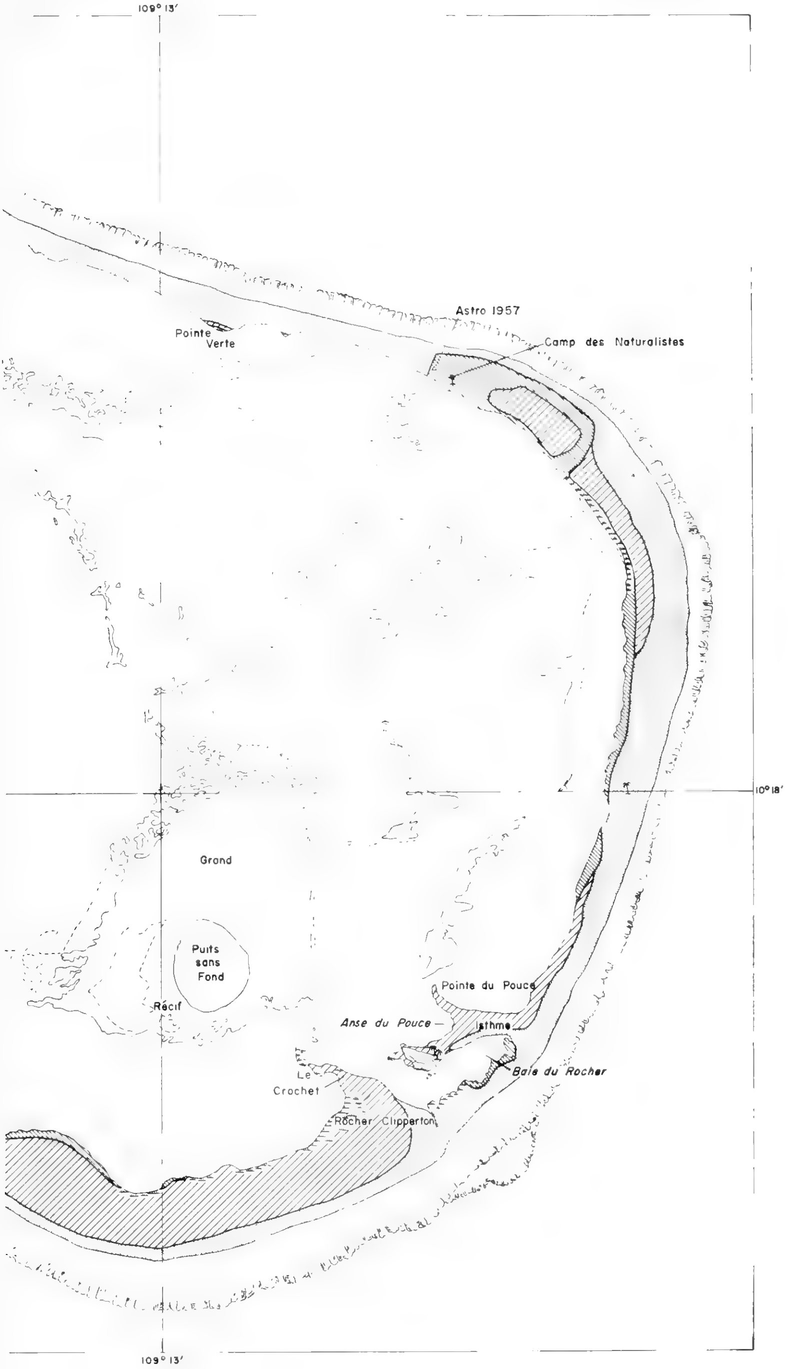
[3] These names, used on the accompanying map, have been submitted for approval to the Service Hydrographique of the French Navy.


Iles
Egg
Pince Nord
Baie de la Pince
Pince Sud
10°18'
VEGETATION OF CLIPPERTON ISLAND
LEGEND
Coconut palms
Sedge marshes
Ipomoea mat
Mixed herbaceous vegetation
Coral sand, gravel and rock, bare or covered with blue-green algae
Reefs (ocean)
Submerged reefs (lagoon)
0
400
800
1000 meters
Approximate Scale


109° 13′
Astro 1957
Camp des Naturalistes
Pointe Verte
10° 18′
Grand
Puits sans Fond
Récif
Pointe du Pouce
Anse du Pouce
Isthme
Baie du Rocher
Le Crochet
Rocher Clipperton
109° 13′

and gravels, loose or consolidated into rock. In the consolidated sediments the limestone pieces are bound by a phosphatic cement derived from the guano of the numerous sea birds that live on the atoll. In some cases, the coral fragments are themselves partly phosphatized. These phosphatic conglomerates form flat pavements, often interrupted by concentric step-like ledges that parallel the shores. Sand and coral fragments in varying mixtures may be scattered in a thin layer over the rock or form deeper beds.

In most areas on Clipperton the surface soils are very immature—coral sand and gravels only slightly discolored by organic matter. In some areas the soil is of phosphatic gravel, derived apparently from the indurated phosphatic rock, but in many places the surface is of only slightly modified recently deposited material.

On the broad northwest corner are large areas of phosphatic silt with slight admixture of coral gravel, this especially scattered in a thin layer over the surface. The silt is differentiated into a brownish or brownish-gray upper layer as much as 15 cm. thick lying on a pale creamy white layer, more compact, of undetermined thickness. These are both almost entirely calcium phosphate but the percentages of both P_2O_5 and CaO are somewhat lower in the darker upper layers, perhaps indicating some profile development. Similar silty material underlies the gravel sheet on the northeast side, at least in some places. Judging by the similarity of the material in some old stockpiles on the west corner near the lagoon, the silt may be one of the kinds of phosphate that were mined commercially. Therefore its present extent is probably much more restricted than it must once have been.

Otherwise no significant profile development was observed in any well drained site except in the coconut groves where a thick surface horizon of partly decomposed litter and humus had accumulated on the coral. Crab holes are abundant and doubtless there is a continual stirring up and turnover of the soil material, making any incipient horizons less distinct. Earthworms are locally abundant. Drainage seems generally excellent except on ground lying at about lagoon level. Here the soil is, in its upper layer at least, a dark highly organic silty mud. The soil, generally calcareous and phosphatic, may be locally enriched by small amounts of material from the volcanic Rock and of drifted pumice and extraneous rocks carried in drift trees.

Clipperton Rock (fig. 1) forms an irregular pyramid about 29 m. high. At the end of the Isthmus the east face rises as a great triangular wall. Walking around the base, one discovers that the Rock is not a solid mass but is traversed by roughly parallel passages oriented SSE–NNW. It is mostly gray with a dark reddish tinge, and mottled with white trickles of guano and patches of dark or gray-greenish lichens. Every small rock projection or cleft is occupied by nesting boobies and noddies. The volcanic rock is a trachyte,

Figure 1. Clipperton Rock and sedge marsh at base of Hook. Arrangement of sedge species about a small pond. *Eleocharis mutata* in center of photo (growing in water); *Eleocharis geniculata* in front (growing in wet mud); a few small plants of *Hemicarpha micrantha* among stones in foreground.

and under the accumulation of bird guano, has been phosphatized for an unknown depth, at least 30 or 50 cm. It remains very hard and compact. No plants grow on the Rock except for the lichens and a few algae.

The area of the tropical Pacific in which Clipperton Island lies is one of variable surface currents. During the winter, the North Equatorial Current flows westward past the island, and the Equatorial Countercurrent south of it. During the summer months, the Equatorial Countercurrent runs farther north and in some years may bathe the atoll in its eastward flow. This pattern of water circulation is complicated by transverse currents, by tidal currents and by storm waves.

Clipperton Island has a seasonally humid tropical climate. Very few data have ever been collected, and information has to be extrapolated from what is known of the surrounding ocean. The northeast trade-wind is the dominant wind for much of the year but during the summer months winds from the southwest or west become more important, bringing squalls and storms. The air temperature in August 1958 ranged from 24° to 32°C, the temperature of surface seawater from 26° to 29°C (Limbaugh, unpublished data).

In the summer, rainfall is very high. During August 1958, it rained almost every day, and very heavy rains often lasted all night and all the following morning. A dry season has been reported for the first half of the year but no details, let alone precipitation data, are available. The area of ocean east of Clipperton and the central American coast have indeed a dry season in the spring. In the summer of 1958, the vegetation obviously was recovering from a severe dry spell, as will be described below. In May, 1958, the condition of the vegetation was even worse (Witold L. Klawe, personal communication). It must be kept in mind, however, that on an atoll with extremely porous soils and substratum, and intense evaporation, complete and prolonged dry conditions are not necessary to affect the plant life. Irregular rainfall suffices to cause effective drought for the vegetation.

In the area between Clipperton Island and the American coast, hurricanes travelling principally in a northwest direction are known to occur. Probably only a few of them ever hit the island. One did in October 1944 (P. G. Taylor, 1948). Even when the hurricanes pass well to the east, the storm waves may reach the low island. In the summer of 1958, evidences that a powerful storm

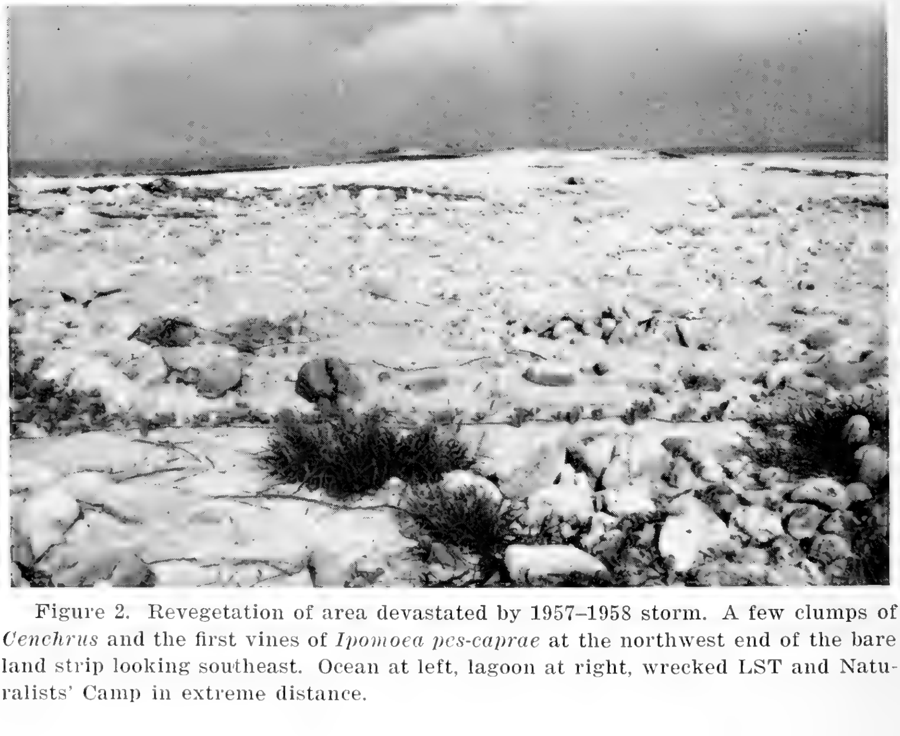


Figure 2. Revegetation of area devastated by 1957–1958 storm. A few clumps of *Cenchrus* and the first vines of *Ipomoea pes-caprae* at the northwest end of the bare land strip looking southeast. Ocean at left, lagoon at right, wrecked LST and Naturalists' Camp in extreme distance.

had recently affected Clipperton were obvious. An area of several hundred meters along the northeast side of the atoll (fig. 2) had perhaps been scoured out, and then had been completely covered by white coral gravel or sand, from ocean to lagoon, and the vegetation here had been totally eliminated (p. 297). The ocean shore had been undercut and eroded. Sea water had certainly poured into the lagoon. Comparison of photographs and notes made in November, 1957, and May, 1958, shows that the storm occurred between these dates. The hurricane season is from June to December with greatest frequencies in August to October, but other storms probably occur in most other months.

Most of the visitors to Clipperton Island have been impressed by the great colonies of sea birds nesting on it and flying over it. Their numbers have unfortunately diminished greatly but they are still the most obvious and striking part of the island's fauna. Great frigates, two kinds of boobies, two kinds of noddies, sooty terns, and a few fairy terns are the principal seabirds. Sooty terns and blue-faced boobies habitually lay their eggs on the ground and do so on Clipperton. The fairy terns use coral boulders, coconut fronds, and the ruins of the quonset huts. The common noddies, which usually build their nests on the ground or more often in bushes and trees, try on Clipperton to find perches on rocks, small cliffs, and abandoned equipment to protect their eggs and chicks from the pigs, but some make crude nests on the ground. The white-capped noddies favor cliffs or tall shrubs and trees, and on Clipperton crowd on the palm trees and on the Rock. They share the palms with the nesting frigate birds and some brown boobies, and the Rock with brown boobies. The latter also nest on lagoon "cliffs" and rocks.

Other sea birds, and various migrating shore birds were seen in small numbers in August, 1958, and may be more abundant at other times.

Ducks of many species were seen on the lagoon in November, 1901 (Beck, 1907), and perhaps still visit the island on their long winter trips to the southern hemisphere. In 1958, we were surprised to find many coots bobbing on the lagoon and nesting in the sedge beds. The presence of land birds had been observed in 1825 by Morrell (1832) and has been mentioned several times since. In August, 1958, an American land bird or two could be sighted almost every day: martin, cuckoo, yellow warbler, etc.

The bird population influences the plant life of the island in various significant ways: the birds probably brought to the island many of its plants, in mud on their feet, in their crops, or on their feathers. Possibly all the phanerogams, and even some algae (Proctor, 1959), found in and around the lagoon were brought by the ducks, coots, and shore birds. Sea birds are believed to eat only marine animals, but a number of species are known to swallow seeds, which can be found in their crops. The phosphatization of soil, coral conglomerates, and volcanic rock by guano has already been mentioned and the plants growing in such substrata are thus indirectly influenced by the presence of the birds. They damage the coconut palms, keep them from fruiting by crushing the young inflorescences, and may eventually kill some of them. No higher plant has any chance of establishing itself on Clipperton Rock while all the flat spots where a little soil might form, and many not very flat sites, are occupied by booby and noddy nests. These birds may help disseminate some plants such as *Heliotropium* by carrying fruiting twigs around.

In 1958, 58 pigs were roaming on Clipperton Island, feeding on plants, birds' eggs, crabs, and perhaps other animals. They had been introduced at the end of the 19th century, and were all killed in 1958 for the protection of the nesting birds.

The land crabs (*Gecarcinus planatus*) are another very obvious part of the Clipperton land fauna. In the past the island was described as red with them. In 1958, they were much less numerous, but could be seen everywhere hiding in cracks and holes under ledges and stones, or, in the late afternoon, scrambling over rocks on their way to the lagoon or the ocean. Land crabs are reported to go to the water periodically in order to release the larvae from the mature egg masses.

Among the other land invertebrates, the moths should be mentioned for their effect on the plant life. Larvae of various species were feeding on *Solanum, Cenchrus,* and *Corchorus.* The large morning-glory hawk moth (*Herse cingulata* according to Charles F. Harbison, entomologist of the 1958 party) was very abundant in the *Ipomoea pes-caprae* vegetation.

The other components of the Clipperton fauna seemed less directly associated with the plants.

HISTORY OF COLLECTIONS

The first plant collected on Clipperton Island was apparently a water plant from the lagoon gathered by Lt. Griswold in 1861 (Pease, 1868). It was deposited in the California Academy of Sciences, but was lost in the San Francisco Fire in 1906 when most of the collections of the Academy were destroyed. Later scientific expeditions, including the Academy's own (1905–1906), made no plant collections as far as is known. In 1935 the French training ship *Jeanne d'Arc* visited Clipperton and some plants were taken, but what became of them could not be ascertained. They are not in the Herbarium of the Muséum National d'Histoire Naturelle in Paris.

The first collection to be identified in the literature was gathered by Dr. Waldo L. Schmitt of the U.S. National Museum, on the Presidential Cruise of 1938. The algae were identified by Dr. W. R. Taylor (1939); the five phanerogams by Dr. E. P. Killip (1939). The specimens are in the U.S. National Herbarium.

Two small collections of phanerogams, made by Mr. Conrad Limbaugh in 1956 and by Mr. W. L. Klawe in 1958, were sent to Dr. F. R. Fosberg for identification, and deposited in the U.S. National Herbarium. Since the determinations have not been published, and I have worked with the specimens, I will list them here together with my own and those of Schmitt. I am not aware of any other collections, except for a few plants collected in 1958 by Charles F. Harbison, and deposited in the San Diego Natural History Museum.

During the 1958 survey, in 19 days of diligent search, 26 phanerogams were found on Clipperton Island. A few may have been missed, but not many. The cryptogamic collections are more likely to be incomplete. Some fungi, lichens, mosses, and land and fresh-water algae were collected and are listed below. There are no ferns or fern allies on the atoll, and no hepatics.

SYSTEMATIC ENUMERATION

FUNGI

Fungi had never been mentioned from Clipperton Island before the 1958 survey, when only a few were seen and collected, all from the coconut groves. Phanerogams on the island were carefully inspected for possible fungus diseases, and a few plants with spots were collected, but the spots were found to be sterile. The specimens were sent to the U.S. National Fungus collection, Mr. John A. Stevenson, Curator, and identified by the specialists there as indicated below. In addition, a number of fungi were cultured from soil samples submitted to Mr. C. W. Hesseltine, Head of the U.S. Agricultural Research Service Fermentation Laboratory, Peoria, Illinois, where the cultures will be kept alive.[4]

MYXOMYCETES

Dictydiaethalium plumbeum (Schumacher) Rostafiński

Coconut grove at base of east face of Clipperton Rock.

On old rotting coconuts, palm fronds and wood. *Sachet 342* (det. Dr. M. L. Farr).

PHYCOMYCETES

Cunninghamellaceae

Cunninghamella echinulata (Matruchot) Thaxter.

Isolated from soil sample 15.

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[4] Sample nos. are my own collection numbers, the equivalent numbers of the Fermentation Laboratory are as follows: SS-494 (Sachet 3); SS-495 (Sachet 5); SS-496 (Sachet 6); SS-497 (7a); SS-498 (11-1); SS-499 (14-1); SS-500 (15); SS-501 (20); SS-502 (21); SS-503 (22); SS-504 (26); SS-505 (31); SS-506 (32); SS-507 (34a).

Cunninghamella elegans Lendner.

Isolated from soil sample 21.

Mucoraceae

Absidia scabra Cocconi.

Isolated from soil samples 11–1, 31, 32.
This is a very rare species, according to Mr. Hesseltine.

Rhizopus arrhizus Fischer.

Isolated from soil samples 7a, 15, 20, 26.

Piptocephalidaceae

Syncephalastrum racemosum (Cohn) Schroeter.

Isolated from soil samples 5, 11–1, 14–1.

Ascomycetes

Eurotiaceae

Eurotium chevalieri Mangin.

Isolated from soil sample 3.

Sartorya fumigata Vuillemin.

Isolated from soil sample 7a.

Basidiomycetes

Telephoraceae

Corticium lactescens Berkeley.

Coconut grove at base of East face of Clipperton Rock.
On old rotting coconuts, palm fronds and wood. *Sachet 342* (det. P. L. Lentz) (with *Dictydiaethalium plumbeum* above, and traces of other forms).

Agaricaceae

A number of small mushrooms were found growing on dead coconuts, coconut fronds and wood in the grove at the base of the East face of the Rock (*Sachet 337*), and in the Southwest coconut grove (*Sachet 350*). They were not identified.

Fungi Imperfecti

Dematiaceae

Haplographium sp. ?

Isolated from soil sample 26.

Moniliaceae

Aspergillus flavus Link.

Isolated from soil samples 14–1, 20, 32.

Aspergillus flavus-oryzae group.

Isolated from soil sample 20.

Aspergillus fumigatus Fresenius.

Isolated from soil samples 11–1, 26, 31.

Aspergillus micro-virido-citrinus Constantin & Lucet.

Isolated from soil sample 34a.

Aspergillus niger series.

Isolated from soil sample 26.

Aspergillus phoenicis (Corda) Thom.

Isolated from soil sample 14–1.
This species is not common, according to Mr. Hesseltine.

Aspergillus sydowi (Bainier & Sartory) Thom & Church.

Isolated from soil samples 14–1, 26.

Aspergillus sydowi or **versicolor** (intermediate form).

Isolated from soil samples 3, 5, 6, 14–1, 21, 22.
A very interesting intermediate form.

Aspergillus terreus Thom.

Isolated from soil samples 14–1, 22, 26, 31, 32.

Aspergillus terreus new var. ?

Isolated from soil sample 21.

Aspergillus versicolor (Vuillemin) Tiraboschi.

Isolated from soil sample 31.

Aspergillus violaceo-fuscus Gasperini.

Isolated from soil samples 20, 21, 34a.

Geotrichum sp.

Isolated from soil sample 5.

Hyalopus sp.

Isolated from soil sample 3.

Paecilomyces sp.

Isolated from soil sample 31.

Penicillium chrysogenum Thom.

Isolated from soil sample 7a.

Penicillium citrinum Thom.

Isolated from soil samples 5, 14–1, 22

Penicillium commune Thom.

Isolated from soil sample 15.

Penicillium cyclopium Westling.

Isolated from soil sample 26.

Penicillium funiculosum Thom.

Isolated from soil sample 20.

Penicillium funiculosum series.

Isolated from soil samples 15, 20.

Penicillium lanosum Westling.

Isolated from soil sample 21.

Penicillium meleagrinum Biourge.

Isolated from soil sample 5 and 26?

Penicillium oxalicum Currie & Thom.

Isolated from soil sample 5.

Penicillium (near **P. piscarium** Westling).

Isolated from soil sample 20.

Penicillium sp.

Unidentified species of *Penicillium* were isolated from soil samples 3, 14–1, 15?, 26.

Trichoderma viride Persoon ex Fresenius.

Isolated from soil samples 14–1, 32.

Tuberculariaceae

Fusarium sp.

Unidentified species of *Fusarium* were isolated from soil samples 22, 31.

LICHENES

Lichens were given to Dr. Mason Hale of the U.S. National Herbarium, who identified them as follows:

Pyrenocarp lichen.

Encrusting pieces of volcanic rock piled up on shore. *Sachet 477.*

Buelliaceae

Rinodina sp.

On walls of passages inside Clipperton Rock. *Sachet 469.*

Pyxine sp.

On trunk of coconut palm. *Sachet 352.*
On dead coconut wood. *Sachet 479.*

ALGAE

All the algae collected during the 1958 survey were sent to Dr. E. Yale Dawson who has reported on them elsewhere (Dawson, 1959). While the majority of the marine forms were collected by the marine biologists, my collections included a few, but my algae were mostly of land and lagoon species. By far the greater number of these are Myxophyceae, or blue-green algae. Specimens of these were retained in his herbarium by Dr. Francis Drouet, who identified them. The Desmidiaceae, Oedogoniaceae, and Peridiniaceae were isolated and identified by Dr. P. Bourrelly. Sets of duplicate specimens were sent by Dr. Dawson to the U.S. National Herbarium and the Paris Museum.

The following list of land and lagoon algae is compiled from Taylor (1939), who based his report on collections made by Dr. Waldo Schmitt on July 21, 1938, and from Dawson (1959).

MYXOPHYCEAE

Chroococcaceae

Anacystis aeruginosa (Zanardini) Drouet & Daily.

Concentrated near lagoon shore. *Sachet 325* in part.

Anacystis montana (Lightfoot) Drouet & Daily.

Covering coral fragments and rocks everywhere on land. *Sachet 463* in part, *466* in part, *473* in part; *Limbaugh et al. 20009* in part.

Chroococcus turgidus (Kützing) Nägeli.

Lagoon, occasional among filamentous algae. *Schmitt 21* in part.
Lagoon. *Sachet 478* in part.

Gomphosphaeria aponina Kützing.

Lagoon, infrequent colonies among filamentous algae. *Schmitt 21* in part.

Microcystis flos-aquae (Wittrock) Kirchner.

Lagoon, infrequent among filamentous algae. *Schmitt 21* in part.

Chamaesiphonaceae

Entophysalis deusta (Meneghini) Drouet & Daily.

Surface of coral pebbles and consolidated rock. *Sachet 475* in part.

Forming thin layers or crusts on coral sand. *Sachet 305* in part, *308* in part.

In surface sand at top of beach. *Sachet 462* in part, *471* in part.

Entophysalis granulosa Kützing.

Lagoon. *Sachet 478* in part.

Stigonemataceae

Mastigocoleus testarum Lagerheim.

Surface of coral pebbles and consolidated rock. *Sachet 475* in part.

Forming thin layers or crusts on coral sand. *Sachet 305* in part, *308* in part.

Nostocaceae

Nostoc sp.

On dead coconut trunks and husks. *Sachet 467* in part (young plants).

Scytonemataceae

Scytonema hofmannii Agardh.

Covering coral fragments and rocks everywhere on land. *Sachet 463* in part, *466* in part, *473* in part; *Limbaugh et al. 20009.*

Rivulariaceae

Amphithrix violacea (Kützing) Born.

On coral rocks along lagoon edge. *Sachet 328* in part.

Calothrix crustacea Thuret.

In sand and crust along lagoon edge. *Sachet 474* in part.

In surface sand at top of beach. *Sachet 471* in part.

Surface of consolidated ledge. *Sachet 472* (with primordia of green algae).

Thin layer or crust in surface sand. *Sachet 305* in part, *308* in part.

Calothrix parietina (Nägeli) Thuret.

Lagoon. *Sachet 478* in part.

Calothrix stellaris Bornet & Flahaut.

Lagoon, on leaves of *Najas marina*. *Schmitt 21* in part.

Oscillatoriaceae

Lyngbya aestuarii (Mertens) Liebmann.

Lagoon, scattered trichomes in and among the masses of *L. versicolor*, back from landing place. *Schmitt 21* in part.

On coral rock in lagoon. *Sachet 478* in part.

Lyngbya semiplena (Agardh) J. Agardh.

On rocks in lagoon. *Sachet 478* in part.

Concentrated near shore of lagoon. *Sachet 325* in part.

Lyngbya confervoides Agardh.

On coral rocks along lagoon edge. *Sachet 328* in part.

Lyngbya guaymasensis Drouet.

Concentrated near shore of lagoon. *Sachet 325* in part.

Lyngbya lagerheimii (Möbius) Grunow.

Lagoon, scattered trichomes among the masses of *L. versicolor*. *Schmitt 21* in part.

Lagoon. *Sachet 478* in part.

Lyngbya versicolor (Wartmann) Gomont.

Lagoon, forming large masses, probably extremely abundant with other algae and *Najas marina*. *Schmitt 21* in part.

Lagoon. *Sachet 478* in part.

Microcoleus chthonoplastes (Flora Danica) Thuret.

In surface sand at top of beach. *Sachet 471* in part.

Plectonema nostocorum Bornet.

On surface of sand turning to sandstone, slab thrown up on top of beach. *Sachet 476* in part.

On dead coconut trunks and husks, *Sachet 467* in part.

Plectonema terebrans Bornet & Flahaut.

Forming thin layers or crusts on coral sand. *Sachet 305* in part, *308* in part.

Surface sand on top of beach. *Sachet 462* in part.

Schizothrix heufleri Grunow.

In surface sand at top of beach. *Sachet 471* in part.

Chlorophyceae

Desmidiaceae

Closterium parvulum Nägeli, forma.

Lagoon, infrequent in strainings from *Lyngbya* masses. *Schmitt 21* in part.

Closterium parvulum Nägeli.

Lagoon. *Sachet 478* in part.

Closterium parvulum near var. **majus** West.

Lagoon, frequent in strainings from *Lyngbya* masses. *Schmitt 21* in part.
Lagoon. *Sachet 478* in part.

Cosmarium clippertonensis Taylor.

Lagoon, very common in strainings from *Lyngbya* masses. *Schmitt 21* in part.
Lagoon. *Sachet 478* in part.

Cosmarium subprotumidum Nordstedt, forma.

Lagoon, common in strainings from *Lyngbya* masses. *Schmitt 21* in part.

Oöcystaceae

Oöcystis solitaria Wittrock approaching forma **major** Wille.

Lagoon, frequent among filamentous algae. *Schmitt 21* in part.

Oedogoniaceae

Oedogonium sp.

Lagoon, frequent among other algae. *Schmitt 21* in part.

Oedogonium sp.

Lagoon. *Sachet 478* in part.

Sphaerellaceae

Protococcus grevillei (Agardh) Crouan.

On surface of sand turning to sandstone, slab thrown up on top of beach. *Sachet 476* in part.

Characeae

Chara sp.

Scanty in lagoon, with *Lyngbya versicolor,* sterile. *Schmitt 21* in part. The specimen was examined in 1948 by Dr. R. D. Wood who identified it as a form of *Chara zeylanica* Klein ex Willdenow near *C. kenoyeri* Howe. *Chara* was especially looked for in 1958, but without success. However, among lagoon sediments collected in 1958 by E. C. Allison, oospores of a *Chara* were isolated and sent to Dr. Wood. He considers (personal communication) that they may be *C. zeylanica* and thus would represent the same plant as the sterile specimen collected in 1938. The plant may have been killed by the addition of sea water to the lagoon at the time of a storm.

The variable pantropic *Chara zeylanica* occurs widely in the Pacific Islands as well as throughout North and South America. The form of it known as *C. kenoyeri* Howe was described from Barro Colorado Island and according to Wood is found in the vicinity of Panama.

Pyrrophyceae

Peridiniaceae

Glenodinium sp.

Lagoon. *Sachet 478,* in part. A new species of *Glenodinium* was isolated by Dr. Bourrelly and is being studied and described by Dr. Balech. It is also represented in a collection by Limbaugh.

BRYOPHYTA

Musci (Mosses)

The presence of moss on Clipperton was noted by Limbaugh in 1956 and Klawe in 1958. I collected 3 species which were identified by Dr. Harvey A. Miller. Sets were kept at Miami University, Oxford, Ohio, others were sent to the U.S. National Herbarium, the Paris Museum, the herbarium of the New York Botanical Garden and the herbarium of the University of California.

Bryaceae

Bryum sp.

Sterile plants of a species of *Bryum* were extremely abundant on rocky pavements all around the island (see vegetation section). *Sachet 303* and *334* were collected on the northwest part of the atoll. Unfortunately most species of *Bryum* cannot be recognized when sterile. This one may be near *B. cuspidatum.*

Bryum argenteum Hedwig var. **lanatum** (Palisot de Beauvois) Bruch, Schimper & Gümbel.

This silvery moss (*Sachet 335*) was found only on a rocky pavement on the northwest part of the atoll, often mixed with the above. It is the variety with percurrent costa, typical of arid situations. It is a pantropic taxon.

Leucobryaceae

Octoblepharum albidum Hedwig.

Found only on a few coconut trunks inside the main southwest grove. *Sachet 351.* It formed a network of small star-shaped plants on the trunks together with some lichens of the genus *Pyxine.* This species is also pantropic.

PHANEROGAMIA

Except for a few unicates, to be deposited in the U.S. National Herbarium, several full or partial sets of Phanerogams were made and were sent to the following herbaria: U.S. National Herbarium; Laboratoire de Phanérogamie, Muséum National d'Histoire Naturelle, Paris; B. P. Bishop Museum; New York Botanical Garden; Rijksherbarium, Leiden; San Diego Natural History Museum; University of California, Berkeley; California Academy of Sciences; and Royal Botanic Gardens, Kew.

Some identifications were made and all were checked by Dr. F. R. Fosberg, whose help is deeply appreciated.

Potamogetonaceae

Potamogeton pectinatus Linnaeus.

Found only near one of the Egg Islands in the lagoon. *Sachet 326.*

This species is widely distributed in North and South America, Eurasia, and Africa, but is lacking in the Pacific Islands. It is most likely indigenous in

Clipperton, probably brought originally in the crops or on the feet of birds. Guppy (1906, p. 513) mentioned that seeds of *Potamogeton* are sometimes found in the crops of ducks. Several species of Anatidae (ducks) have been seen in great numbers in November on Clipperton Island (Beck, 1907) and *P. pectinatus* may well have been brought to the atoll by them.

Ruppia maritima Linnaeus.

Attached to rocks in shallow water along lagoon shore. *Sachet 327, Limbaugh 1, Klawe s.n.*

This is the short peduncled form. Setchell (1946, pp. 469–477) demonstrated that the type of this species is a form with short peduncle (contrary to previous typifications) and regarded var. *rostrata* Agardh as a synonym. He considered that the variations in fruit shape and relative length of peduncle and podogynes, beak, etc., are "reversible ecophenic" expressions of form and size.

The short peduncled plant is well represented along the west coast of America. It is not var. *pacifica* St. John and Fosberg which has a shorter rostrum, and is found farther west in the Pacific.

This is in all likelihood an indigenous plant on Clipperton. It is well adapted for distribution either in the crops or in mud on the feet of birds. It can stand a very high salt content in the water and also, in many coastal situations, endures great fluctuations in salinity.

Zostera marina var. **latifolia** Morong ?

No specimen of this species has been seen, but a photograph taken in 1943 by the Byrd party (Byrd, 1943, vol. 2, photo 15) shows large masses of drift on a lagoon beach, composed almost entirely of a coarse "sea-grass," different in appearance, and larger than any of the three species of phanerogams found in the lagoon in 1958. The plant cannot be identified with certainty from the photograph, but, according to F. R. Fosberg, the masses look very much like the drift of *Zostera marina* var. *latifolia* that sometime pile up on the shores of estuaries on the California coast. The lagoon water was reported by Byrd (1943, vol. 1, p. 22) to be brackish "70 grains of salt per gallon" (1200 ppm), in September 1943. On the Atlantic coast of the United States, *Zostera* grows in brackish water well up Chesapeake Bay and Setchell (1929, p. 430) recorded it from the Baltic and the Black Sea, which have low salinity in their surface waters, so it would not be impossible for this species to grow in the almost fresh water of Clipperton lagoon. Very likely this plant had disappeared or become dormant at the time of my visit (August, 1958), as the lagoon beach drift was then searched carefully for the previously reported

Chara (see p. 268) and no broad-leafed or coarse-stemmed aquatic similar to what is shown in the photograph was found. Here is an important indication that the flora of the island may change from time to time due to chance or environmental fluctuations.

Najadaceae

Najas marina Linnaeus var. **latifolia** A. Braun.

Very common in lagoon from shore to depths of 6 m. (acc. Limbaugh). *Sachet 304, 340; Schmitt 102; Klawe s.n.*

The species is almost cosmopolitan, in temperate and tropical regions. It is known from tropical America and as far north as California, but is absent from the Pacific Islands west of Clipperton. The variety is known from tropical South America (Rendle, 1899, p. 396), and is most probably indigenous in Clipperton, to which it was perhaps brought by birds.

Gramineae

Cenchrus echinatus Linnaeus (glabrous form).

One of the most abundant plants on the island. *Sachet 321; Schmitt 104; Klawe 1460, 1461.*

A common weed in tropical America and the Pacific Islands, possibly introduced to Clipperton by human agency, as it has been on many other atolls.

Dactyloctenium aegyptium (Linnaeus) Willdenow.

Common locally on coral sand. *Sachet 348; Limbaugh 2; Klawe 1452, 1454.*

Pantropic weed, extending into temperate regions (United States). Introduced to Americas and the Pacific Islands from Old World. Certainly not native to Clipperton.

Eragrostis amabilis (Linnaeus) Wight & Arnott.

Common locally on coral sand and rocks. *Sachet 316, 354; Klawe 1463.*

Pantropic weed, frequently introduced on coral islands and thriving there. Introduced to America from the Old World. Certainly not native to Clipperton.

Eragrostis ciliaris (Linnaeus) R. Brown.

Common locally. *Sachet 319; Limbaugh 4.*

A pantropic weed, undoubtedly introduced into Clipperton by man.

Cyperaceae

Eleocharis geniculata (Linnaeus) Roemer & Schultes.

Forming pure stands on wet mud around lagoon. *Sachet 312, 324.*

Warmest parts of America northward to California, Michigan, and Ontario, but widely distributed in Old World also, including Pacific Islands, in wet places. Probably carried around on the feet of wading birds and possibly thus introduced to Clipperton.

Eleocharis mutata (Linnaeus) Roemer & Schultes.

Forming dense beds around lagoon, growing in shallow water. *Sachet 317.* (det. H. K. Svenson).

Occurring in the West Indies, Central and South America, the Galápagos, and tropical Africa, according to Svenson. Possibly brought to Clipperton by birds, either in their crops or more likely in mud on their feet.

Figure 3. Sedge marsh of *Scirpus rubiginosus* on Clipperton Island, at base of Hook.

Hemicarpha micrantha (Vahl) Pax.

Scattered small plants on sand or drying mud. *Sachet 310, 311, 307* (det. H. K. Svenson).

North, Central and South America. Possibly brought to Clipperton in the crops or in mud on the feet of birds.

Scirpus rubiginosus Beetle.

Forming occasional patches (fig. 3) at edge of lagoon, in shallow water. *Sachet 318.*

Pacific coast of North America from Vancouver Island to Baja California, according to Beetle. Probably brought to Clipperton by water birds.

Palmae

Cocos nucifera Linnaeus.

A large grove of palms, together with smaller groups and isolated trees. *Sachet 353* (obtained with the help of Dr. Kenneth E. Stager).

Original home unknown, most likely spread all over the tropics by human agency. Certainly deliberately brought to Clipperton by man in recent years. First noted in 1897.

There appear to be two main varieties of coconut palms on the island: some have more oval, green nuts, and the rachis of the young frond is also green; others have a bright orange young rachis, and rounder large orange nuts. The lone palm opposite the Egg Islands is of the latter type.

Portulacaceae

Portulaca oleracea Linnaeus.

Local. *Sachet 345, 357; Klawe 1453, 1462.*

Small scattered plants are found, mostly on the east side of the island, the most important stand being near the lagoon, a little south of the landing place. For many days no flowers were seen until finally the stand was visited in the early morning when the yellow flowers were watched opening and wilting in the course of an hour.

This species is cosmopolitan and polymorphic, but the seeds of the Clipperton specimens are like those of the common tropical American form. It is widely introduced in connection with human activity, but also appears to be native in many areas. It is uncertain whether it is native or recently introduced on Clipperton.

Figure 4. Dead erect fruiting branches of *Brassica*. Vegetation in foreground mostly *Sida* with mat of *Ipomoea*.

Cruciferae

Brassica juncea Linnaeus.

Forming local colonies in various parts of the atoll, especially in the main coconut grove on the southwest, and on the northwest land strip. *Sachet 331.* Many dead old fruiting branches formed stands up to 1 m. high (fig. 4).

The species is from Asia and was probably deliberately introduced, as the greens are eaten (it is known as Chinese mustard and by other names). Probably brought to Clipperton by guano workers as it is recognizable in photographs taken in 1943. Another species of *Brassica* may have been present in the main coconut grove, but if so was not collected.

Leguminosae

Caesalpinia sp.

A single seedling from drift seed, on ocean beach. *Sachet 302.* Adult plants not found on island. Seeds of *C. bonduc* are common in beach drift on the island.

Canavalia sp.

Seedling growing among *Ipomoea pes-caprae* vines. *Sachet 347.*

Doubtless germinated from drift seed as not otherwise known from island.

Mucuna sloanei Fawcett & Rendle ?

Seedling vines growing at top of beach from drift seeds, *Sachet 349, 338;* also many seeds in drift. Placed here because of 3 veins rather than 4 at base of lateral leaflets. Not distinguishable with certainty from *M. urens* without mature racemes. Could be the "plant resembling sarsaparilla" of Morrell which made his men ill (see p. 286), as it has prurient hairs on the pods. This and related species are widely called "cowitch" because of the terrific painful itching caused by these hairs.

Tropical American and West African shore plant.

Phaseolus adenanthus G. F. W. Meyer ?

Sterile, *Sachet 332*; found only on the northwest side where it was mixed with *Ipomoea pes-caprae* vines. The specimen matches best those of this species but the tips of the folioles are unusually rounded at apex.

Widespread weed of tropical American origin. Cultivated, though not commonly so in United States. Possibly introduced as a cultivated plant, or else from drift seed.

Euphorbiaceae

Phyllanthus amarus Schumacher & Thonning.

Common, especially on the northwest and east sides of the island. *Sachet 323, 359; Schmitt 101; Klawe 1456.*

According to F. R. Fosberg and G. L. Webster, the specimens undoubtedly belong to this species. It is usually, but incorrectly, referred to *P. niruri* Linnaeus.

Phyllanthus amarus is probably of Caribbean origin but now is a pantropic weed. Doubtless accidentally introduced by man. Two variants are present, one with conspicuous pellucid leaf veins, the other the ordinary form.

Sapindaceae

Sapindus saponaria Linnaeus ?

Seedling in drift. *Sachet 339.*

Seed identical with that of *S. saponaria,* simple leaves probably a seedling character, especially in view of a statement by de Candolle (1824, p. 607):

"Frutex nascens, quem viv. in h. genes. video, foliis simplicibus elongatis fere Dodonaeam refert."

Judging from the size of the drift seeds found two forms are represented, f. *microcarpus* Radlkofer and probably, from the distribution, f. *inaequalis* (De Candolle) Radlkofer. The germinating seedling is of this latter form. It is well represented in tropical America along the west coast, in the Galápagos, and in Hawaii. Forma *microcarpus* is widely distributed in the Pacific Islands.

Malvaceae

Sida rhombifolia Linnaeus.

One of the most common plants on the island. *Sachet 315; Klawe 1457.*

Pantropic weed, extremely variable, but variation pattern obscure. Undoubtedly carried around by man, but attained a wide distribution in the Pacific very early. Doubtless introduced by man to Clipperton.

Tiliaceae

Corchorus aestuans Linnaeus.

Very common everywhere on island. *Sachet 346; Limbaugh 5; Klawe 1458.*

A common pantropic weed, doubtless carried around accidentally by man and probably thus introduced to Clipperton.

Sterculiaceae

Waltheria indica Linnaeus.

Only one small patch of this plant was found, near the south corner of the island. It was sterile but with some dead fruiting branches of the previous season. *Sachet 343.*

Pantropic weed, but probably of American origin; probably brought by man to Clipperton, but could have reached the island by other means.

Convolvulaceae

Ipomoea pes-caprae subsp. **brasiliensis** (Linnaeus) van Ooststrom.

Common all around the island. *Sachet 320; Limbaugh 6; Klawe 1459.*

This is the form usually found in America and the Pacific Islands, merging westward with the Indian Ocean form, which is ssp. *pes-caprae.*

Figure 5. Evidence of periodic dry weather on Clipperton Island, northwest land strip. "Trunk" of *Ipomoea pes-caprae*, in mixed herbaceous vegetation.

Most of the vines observed on the atoll were growing out of the ground or from a small root-stock. On the northwest part of the island, however, several plants were seen which possessed massive "trunks," large twisted woody stems 10–25 cm. in diameter and several dm. in length (fig. 5). From these, woody branches and the more common thick herbaceous vines emerged. This curious feature is interpreted as an indication of seasonal drought, the vines dying back in dry months to the thick stems and growing again in wetter seasons. A similar feature was observed by F. R. Fosberg (1955, p. 28) on Pokak Island, where *Ipomoea tuba* formed enormous stumps.

This plant was present on Clipperton at least as early as the 1938 visit of Schmitt, and probably had been there for a long time. It was likely introduced in drift, but a seed of it was once found in the crop of a fairy tern in the Marshall Is. (Fosberg, 1957, p. 234).

Ipomoea triloba Linnaeus.

Occasional on northeast, southwest, and south parts of the island. *Sachet 314, 341; Limbaugh 7.*

Only a few of the plants were in bloom and many of the vines seemed in rather poor condition.

Of tropical American origin, but now a pantropic weed, probably brought by man, but this is not certain.

Solanaceae

Nicotiana glauca Graham.

Scattered plants up to 1.5 m. tall occur on the northwest part of the island, *Sachet 329,* and south of the main coconut grove.

Very likely the species was introduced by the Mexicans and all the plants seen may have been planted. All were in very poor condition (fig. 6); many were dead, and others had dead limbs and only a few tufts of leaves at the tips of live branches. Altogether only a few flowers and some old fruiting twigs were seen.

The genus is American but this species is sometimes cultivated elsewhere as an ornamental. It is sometimes called tree tobacco and occasionally used for smoking in areas where the true tobaccos do not do so well, as in the dry areas of Mexico.

Solanum nigrum Linnaeus var. **americanum** (Miller) O. E. Schulz.

Occasional in various parts of island, especially on the northwest land strip, in the south corner and around the base of Clipperton Rock. *Sachet 309, 358; Schmitt 105; Klawe 1465, 1466.*

This species has a world-wide distribution, but the Clipperton material comes closest to the American variety. Possibly introduced by man, or earlier by birds.

Boraginaceae

Heliotropium curassavicum Linnaeus.

Occasional, especially abundant on sandy areas of east side of atoll. *Sachet 322, 356; Schmitt 103; Limbaugh 8; Klawe 1451.*

Clipperton Island specimens uniformly have very small linear to linear oblanceolate leaves, 6-15 mm. long, 1–2 mm. wide. A few basal leaves spatulate, 2 cm. long, 3–4 mm. wide toward apex. Specimens resembling these in leaf size: Mexico s.l. *Palmer 869* (US), which is more robust and has the leaves somewhat wider; Mexico, Sinaloa, Altata, *Rose 1369* (US), with leaves slightly larger and more spatulate; a similar one from same locality, *Rose et al. 14822* (US); one similar but with leaves a bit wider, from Jalisco, Nayarit, *Ferris 5729* (US). Various other specimens from Mexico and islands as well as several from Chile and one from Peru are somewhat similar. West Indian material is variable, some rather approaching the above, but not so extreme.

Tropical American except for occurrence on Hawaiian Islands. Probably a native plant, perhaps originally brought by birds or currents.

Figure 6. Introduced plants on northwest land strip. *Nicotiana glauca*, *Cocos*, and *Brassica* in the background.

Compositae

Conyza bonariensis (Linnaeus) Cronquist.

Forming pure stands on sandy areas near lagoon, opposite the landing place, and on the northwest side. Many seedlings covering the ground in the latter stand. *Sachet 313, Limbaugh 9.*

Common introduced plant throughout tropics and temperate zone; origin obscure, but probably American. May have been introduced by wind but more probably by man.

Eclipta alba (Linnaeus) Hasskarl.

Scattered over much of island in mixed herbaceous vegetation. *Sachet 336, 344; Klawe 1455; 1458a, 1464, 1467.*

American, but generally introduced in the tropics; probably brought to Clipperton by man.

DRIFT SEEDS

Seeds of land plants brought by ocean currents come to rest on beaches all over the world, although perhaps more noticeably in the tropics, where a greater number of plants produce large seeds. Drift seeds are found in abundance and are of great interest on the tropical oceanic islands, especially on the atolls, because a large proportion of the flora is of a strand character, and much of it has presumably arrived on the islands in drift. Under special circumstances, for instance after unusual weather conditions, immense quantities of drift seeds may be found on atolls. Such was the case on Canton Island in 1958, where Drs. O. and I. Degener filled many large bags with seed of many species (personal communication). Usually seeds are common on atoll beaches, but represent a limited number of species. On Clipperton in August, 1958, the numbers of seeds and of species found were quite small. Yet all members of the party were gathering them. Only a few handfuls were obtained of the larger foreign seeds. Of course, great numbers of small seeds of plants growing on the island, particularly of *Ipomoea pes-caprae,* were found in the drift. Coconuts also are carried across the lagoon, or perhaps around the island, and found in drift.

After an examination of drift from other islands, and of some of the numerous books and papers that discuss drift seeds, it appears, as could be expected, that the recognizable seeds from Clipperton are all of very common species; in fact, they are among the most common drift seeds listed by Guppy (1906, 1917), and among those that remained afloat longest in his experiments (1906, p. 531).

While the literature on drift seeds and their importance in plant dispersal is very rich, papers useful in their identification are uncommon. The most useful for the determination of Clipperton seeds were the studies of Guppy (1906, 1917), Ridley (1930), and Johnston (1949). The identities suggested by these works were checked in the herbarium. The following were collected between August 7 and 26, 1958.

Palmae

Several "seeds" or rather bony endocarps appeared to belong in this family and were sent to Dr. H. E. Moore, Jr., for comparison with material in the Bailey Hortorium.

Astrocaryum sp.

One large endocarp belongs to this American genus.

Cocoid palms.

Several other endocarps belong to cocoid palms from tropical America, but could not be identified.

Leguminosae

By far the greater number of drift seeds found on Clipperton are referable to this large family.

Caesalpinia bonduc (Linnaeus) Roxburgh.

The rounded gray seeds common on Clipperton and almost everywhere in drift are of this species.

Caesalpinia major (Medic) Dandy & Exell.

One seed, similar to the above but larger and pale brown, belongs here.

Canavalia rosea (Swartz) De Candolle.

Four bean-shaped seeds correspond very well with Johnston's description of this species.

Dioclea megacarpa Rolfe ?

Seeds of *Dioclea* spp., large circular, biconvex, and smooth with a long, thin attachment scar, are extremely common in drift everywhere, and are numerous on Clipperton Island. They are orange to brown. Tentative identifications to species were made with the help of Johnston's paper. Four seeds, larger than the other *Dioclea* seeds, lighter in color and with a narrow attachment scar may be of this species.

Dioclea reflexa Hooker?

Seeds of *Dioclea* are quite variable in size and shape and are not easily arranged in groups of similar individuals. Most of those from Clipperton are probably referable to *D. reflexa,* but some may be of other species.

Entada gigas (Linnaeus) Fawcett & Rendle.

The large, heavy, dark brown snuff-box sea beans are of this species. The plant is confined to the New World and Africa, but the beans of this and similar species are found all over the world.

Mucuna mutisiana (Humboldt, Bonpland & Kunth) De Candolle?

The rounded, minutely hammered seeds of *Mucuna* spp. of the *M. urens* group are dark dull brown, with a dark wide attachment scar, sometimes bordered by a lighter area. Several of those found on Clipperton matched well seeds of this species.

Mucuna sloanei Fawcett & Rendle.

Many of the Clipperton *Mucuna* seeds appear to be of this species.

Mucuna urens (Linnaeus) De Candolle?

One *Mucuna* seed, larger and flatter than the others, may belong here, but the attachment scar is somewhat wider than is described for this species by Johnston.

Strongylodon lucidus (Forster filius) Seemann?

One black seed, with a long, very thin attachment scar may be of this species. The scar is somewhat narrower than in the only seed available in the herbarium for comparison. This is a Pacific Islands species and is commonly found in drift; if the identification is correct this seed provides the only definite evidence of transport to Clipperton of a land plant from westward in the Pacific.

In 1956, Mr. Limbaugh collected seeds of *Caesalpinia bonduc, Mucuna* sp. and *Dioclea* sp. on Clipperton Island.

Sapindaceae

Sapindus saponaria Linnaeus.

A few spherical black seeds of two sizes appear to belong to forms of this species (see also p. 275). *Sapindus* drift seeds are common but "in scanty numbers" (Guppy, 1917, p. 157) in the Caribbean, much less so in the Pacific (one was recently identified from Eniwetok).

Convolvulaceae

Merremia tuberosa (Linnaeus) Rendle.

Two large rounded black seeds, with 2 furrows at right angle dividing one side into 4 sections, and with a large bean-shaped attachment scar on the other side, were recognized with the help of Guppy's work (1917, pp. 161–164). They are abnormal, single seeds of *Merremia,* replacing the usual 4. One specimen in the U.S. National Herbarium from Haiti, *Leonard and Leonard 12680,* includes such a seed in a wood rose attached to a good specimen of the plant. The plant is American and West African but the abnormal seeds drift as far as Scotland and the outlying islands and other parts of Northern Europe (Guppy, 1917, pp. 161–164), together with seeds of *Mucuna* and sometimes *Entada.*

A few drift seeds of some of the species listed above had germinated. Such seedlings of *Caesalpinia, Canavalia, Mucuna,* and *Sapindus* are mentioned in the preceding enumeration of Clipperton plants.

Unidentified drift trees were seen on the upper parts of beaches or beach ridges, and indeed have been reported repeatedly since 1711. One such tree contained a piece of volcanic rock embedded in its root system.

SUMMARY OF PHYTOGEOGRAPHICAL RELATIONSHIPS

Clipperton Island, the lone atoll of the Eastern Pacific, much nearer to the American mainland than to the nearest Pacific Islands to the west, has long intrigued biogeographers. Collections of marine animals and plants have revealed that both an American and a substantial Indo-Pacific element are represented in its fauna and flora. The proportions vary from group to group and change as each group becomes better known. Prior to recent collecting, the zoogeographic peculiarities of the atoll had been discussed on the basis of the molluscan fauna by Hertlein and Emerson (1953). Ekman (1953) occasionally referred to Clipperton in his general discussions of the tropical Pacific marine faunas.

A better understanding of the biogeographic relationships of Clipperton Island, based on more thorough collecting and correlated with increased knowledge of the ocean around it, was the principal object of the biological survey of 1958. Only a few of the animal groups have been identified and their geographic relationships discussed. Allison's study of *Conus* (1959) may be mentioned especially. No doubt the zoological work when completed will confirm and define more precisely the dual origin of the small atoll's fauna.

The small algal flora, which has been studied by Taylor (1939) and Dawson (1957, 1959), can be looked upon as the ultimate attenuation from west to east of the Indo-Pacific marine flora, with small admixture of American species. Dawson (1959, p. 5) writes: "The floral composition is almost entirely of species that are common and widely distributed throughout the Indo-Pacific region . . . the very low degree of species diversity, even for Pacific atolls is remarkable."

Unfortunately, the land plants are rather disappointing as a source of information, for the vascular flora is very small and a number of species are certainly, others probably, of human introduction. Many of the remaining plants are pantropic in distribution and could have come to the island from any direction. Some, such as *Heliotropium curassavicum,* the sedges, and perhaps *Portulaca oleracea,* are native and probably came from the east. The palm "seeds" in the drift undoubtedly came from tropical America.

The lagoon phanerogams, and perhaps some algae (Proctor, 1959), were most likely brought by migrating birds that travel along generally north and south flyways and seldom, if ever, visit central Pacific islands.

None of the species in the Clipperton land flora can unequivocally be regarded as having come from the Indo-Pacific region. In fact the complete absence of very widely distributed Pacific plants that are found on a great many atolls is extraordinary. *Scaevola sericea,* for instance, is known on islands, especially atolls, from the Tuamotus to the Hawaiian chain and from the western side of the Indian Ocean to Christmas and Henderson Islands. Of almost equally extensive occurrence are *Triumfetta procumbens, Pisonia grandis, Tournefortia argentea, Lepturus repens* and many others. All the species just mentioned tolerate seasonal dryness rather well and could certainly live under the climatic conditions of Clipperton Island. *Scaevola* and *Tournefortia* are probably disseminated in drift, the others by birds. Evidently Ekman's East Pacific Barrier (1953) is even more effective for land plants than for marine algae and animals. The present fragmentary state of the knowledge of the distribution of terrestrial nonvascular cryptogams, as well as the paucity of the known flora and lack of determinations in some groups, make speculations as to their phytogeography at present futile.

There is reason to believe, as will be shown below, that the present flora of Clipperton is of very recent origin and one might speculate on the possible presence of an Indo-Pacific element in the original flora. However, we know that native trees have never occurred on the island in 250 years of recorded history, and therefore, that a number of very common Pacific atoll species have never grown on it. We may never know whether any herbaceous Pacific species were ever present.

Man has already had much irreversible influence on the ecology of Clipperton. Still, the island continues to form a valuable small laboratory and periodic resurveys will be very fruitful, even in the study of the meager land flora, if the island remains uninhabited and is preserved from further interference.

TABLE I

POSSIBLE MEANS OF TRANSPORT OF LAND AND LAGOON PLANTS TO CLIPPERTON ISLAND

	Natural means				Human agency	
	Wind	Drift	On birds	In birds	Accidental	Deliberate
Fungi	?					
Lichens	?					
Microscopic algae	?			?		
Chara			?	?		
Mosses	?					
Potamogeton			?	?		
Ruppia			?	?		
Najas			?	?		
Cenchrus			?		?	
Dactyloctenium					?	
Eragrostis amabilis					?	
E. ciliaris					?	
Eleocharis geniculata			?	?		
E. mutata			?	?		
Hemicarpha			?	?		
Scirpus			?	?		
Cocos						x
Portulaca	?		?		?	
Brassica						x
Phaseolus					?	?
Phyllanthus					?	
Sida					?	
Corchorus	?				?	
Waltheria					?	
Ipomoea pes-caprae		x		?		
I. triloba					?	
Nicotiana						x
Solanum				?	?	
Heliotropium		x				
Conyza	?				?	
Eclipta	?				?	

HISTORY OF VEGETATION

While no record has been found of the discovery by John Clipperton of the Rock and Island that bear his name, it is generally believed to have occurred in 1705, during this pirate's crossing from Peru to China, of which there is no available account. The island may have been known earlier to Spanish navigators, although it lies far south of the galleon routes across the Pacific; unsatisfactory accounts and poor determinations of coordinates make it very difficult to identify many of the islands marked on ancient charts, and it is unlikely, in any event, that any recognizable description of the island written before 1705 will be discovered.[5] As far as known, then, the written history of Clipperton Island begins on April 3, 1711, when two small French ships, *La Princesse* and *La Découverte,* happened upon it (France, 1912). The Captain of *La Découverte,* Michel Du Bocage, and a passenger on *La Princesse,* Mr. De Prudhomme, wrote in their ship log and personal diary, respectively, excellent brief descriptions of the island and its Rock; it was named Ile de la Passion, as April 3 was Good Friday. The coordinates fit, as do the descriptions and a small sketch map (although this is wrongly oriented) furnished by Mr. De Prudhomme. There is no mention of openings to the lagoon, and none is indicated on the sketch, but the ships may not have come close enough to see them, if they existed then. Both writers mention low brush as the only visible vegetation of the island, and note the presence of large dead drift tree trunks. De Prudhomme used the word "raquettes" which brings to mind *Opuntia.* Species of this cactus grow in the Revillagigedo and Galápagos Islands and could have occurred on Clipperton.

The first recorded landing on the island took place over a hundred years later (in August, 1825), as a result of which a more detailed account of its vegetation and flora was published (Morrell, 1832): "It produces a little shrubbery and some coarse grass, among which I think fresh water might be found by digging. . . . Among the few vegetable productions of this island we found a plant resembling sarsaparilla, which badly poisoned several of the crew who handled it."

Sir Edward Belcher who sketched the first published map of the atoll as seen from the masthead of HMS *Sulphur* in May 1839 (Belcher, 1843) noted the absence of trees (except for large drift trunks) and remarked that the north side seemed covered with something like grass. His map and description indicate two openings into the lagoon, one at the north end of the northeast coast, and one southeast of the Rock, at the head of what is now Rock Bay. At the present time, these areas are relatively low, free of elevated consolidated rock and formed of coral sand or gravel; therefore they correspond well to possible sites of former openings.

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[5] For a detailed account of the known history of Clipperton, see Sachet, 1960.

The next well known visit to the island was that of Victor le Coat de Kerveguen, who took possession of it for the French Empire on November 17, 1858 (France, 1912). Several very difficult landings were made by swimming part of the way to the coast, and in his manuscript reports Le Coat de Kerveguen gave detailed descriptions of the island, accompanied by a sketch map and drawings of the Rock. He saw no trace of vegetation, but noted immense numbers of land crabs and birds. The lagoon was closed and its water salty, but how much so is not said.

Lt. Griswold visited Clipperton in August, 1861 (Pease, 1868) and found the lagoon closed, its water "*fresh* and *potable,*" much driftwood on the beach, but no vegetation: "I did not find the least sign of vegetable life upon the island. The only plant seen, grew in considerable quantities in the lagoon, which I pulled out of the water, where it was growing."

One might be tempted not to take these remarks literally. Many nonbotanists will report an area as totally devoid of vegetation just because there are no trees and tall bushes and what little herbaceous vegetation is present has not interfered with their walking or other activities. However, in the 1890's the Clipperton Island phosphate deposits (called "guano" by most authors) brought many visitors and even residents to the island, and accounts, both casual and scientific, became more numerous (Anonymous, 1893, 1897, Mexico [1911], Snodgrass and Heller, 1902); even photographs are available.

All these accounts imply or remark that there was no vegetation on the island at that time, and the photos (Wharton, 1898, Mexico [1911]) do not show any. In his manuscript diary, made available to me through the courtesy of Professor H. E. Maude and with the authorization of Mrs. Sydney Aris, John Arundel, who visited the island in August, 1897, indicated that there was no natural vegetation.

Snodgrass and Heller, two Stanford students who collected birds and other animals in November, 1898, wrote (p. 502): "No land plant is native to the island, and the birds and crabs are everywhere so abundant that no plant could possibly grow there unless artificially protected." Dr. Snodgrass (conversation, 1960) confirmed this statement, but told me that the guano workers had a small enclosed garden.

In the decade following 1890, both coconut palms and pigs were introduced on Clipperton. A photo probably taken in 1897 (México [1911], fig. 4) shows two small, healthy-looking palms, growing in a square enclosure perhaps 30 to 50 cm. high, and in front of them two large pigs. A long shed, probably where the phosphate rock was crushed and dried, forms the background of the photo. At that time the settlement was on the northeast side (U.S. Hydrographic chart no. 1680, 1897 ed., British Admiralty chart no. 1936, 1898, 1899 eds.) near the present Naturalists' Camp, and the first coconut palms shown in the photo were planted there. It is not known whether the present small group of palms in that location dates from that time, or, as seems more likely, was replanted from the later, larger groves of the southwest coast.

Despite political storms, phosphate collecting continued in the beginning of the 20th century. In August, 1905, the Schooner *Academy* of the California Academy of Sciences visited the island. Slevin (1931, p. 21) wrote of that visit: "We found Clipperton to be a real coral atoll without a sign of vegetation with the exception of a lone cocoanut palm growing by the house of the keepers and bearing about 20 nuts." The scientific party noted the abundance of land crabs. Absence of vegetation and astronomical numbers of land crabs are also recorded in a picturesque newspaper account by Edwords (1906). "Land crabs literally infest the island, in countless numbers, getting into everything unprotected, eating anything soft . . . they eat all the green plants and even burrow to get at the seeds . . .

"The Pacific Islands Co. brought a ship load of soil from the mainland to make a garden. It was spread and seed planted. Next morning the place was red with crabs, and not a vestige of seed or loam remained." He goes on to describe how the garden was later replanted "on stilts" and visited by means of a short ladder which had to be removed every time, as the crabs could climb it. With enough such precautions the garden flourished.

At the time of the first World War the island phosphate digging was discontinued and after the dramatic rescue in 1917 (Perrill, 1937; Morris, 1934) of the group of women who had been stranded there for several years without supplies, the island was abandoned to the pigs, birds, and crabs. Captain Perrill's navigator, R. E. Kerr (Morris, 1934) mentioned great numbers of birds and "millions of crabs" but added "no grass grows on the entire island." There is no information on conditions between 1917 and January, 1935, when the French training ship *Jeanne d'Arc* visited the island to repossess it for France, to whom it had been awarded after international arbitration a few years before. The descriptions of the island at that time, and the photos (Anonymous, 1935, La Veyrie, 1935, Gauthier, 1949, Lacroix, 1939), indicate that the vegetation was generally similar to what it is now: a sparse cover of spiny grass and low thickets, a creeping plant (*Ipomoea*) giving the island its light green color, and several groups of flourishing coconut palms. The low thickets, as well as Morrell's "shrubbery" probably refer to the type of suffrutescent herbs now common on the island.

To summarize: in 1711, 1825, and probably 1839 the island had a low cover of suffrutescent and/or grassy vegetation. By 1858 this had disappeared and between 1893 and 1917 was still nonexistent. In 1935 the low cover had re-established itself and it has persisted to the present. How the vegetation disappeared, why it did not re-establish itself for decades, and how it eventually did are the principal questions. They can only be answered by conjecture.

Such a possible reconstruction follows:

We have no reason to distrust Du Bocage and De Prudhomme, nor Morrell, in their mention of vegetation; indeed, except for Morrell's sarsaparilla (see *Mucuna sloanei,* p. 275) their descriptions fit remarkably well what can be observed on Clipperton today. We do not know, of course, when the crabs came to the island but very likely they were already part of the scant island fauna in 1711 and 1825. Even if they appeared later, it is difficult to believe that they could have destroyed entirely the natural vegetation of the atoll. While island biotas may be considered as unsaturated and unusually vulnerable to introductions, it seems unlikely that the land crabs would suddenly completely upset the ecological balance of an island.

Land crabs and/or hermit crabs are a normal component of atoll faunas and even in other treeless islands (such as the central Pacific atolls) they do not habitually succeed in eradicating vegetation, or in inhibiting its reappearance.

More probably the vegetation seen by the French navigators, Morrell and perhaps Belcher, was largely destroyed by a catastrophe and the crab population eating it as fast as it grew back, prevented its re-establishment. The catastrophic event may well have been the storm that closed the lagoon openings. At that time storm waves may have washed over much of the island and killed most of the plants. If the storm occurred after a dry spell, when the vegetation was mostly dry and many plants dead, the destruction would have been even easier. Both dry spells and storm waves are known to occur not infrequently on the island.

Re-establishment of the vegetation may also have been retarded somewhat by an increase in the number of birds and later by the exploitation of phosphate, which consisted in scraping off the surface of the land, a process not conducive to the establishment of a plant cover.

What then happened to bring back a better equilibrium between flora and fauna? Very possibly the introduction and multiplication of pigs. At the time of our visit in 1958 there were 58 of them on the island and from an examination of their droppings it was obvious that they ate crabs. Certainly the crabs were not as numerous as they had been at the turn of the century, and they found enough to eat around the island so that they never were a problem in the camp. The pigs may have eaten enough of them, after the island was abandoned, to give the vegetation a chance to take hold. By that time the flora had been increased by various introduced species.

In 1958, all pigs were killed, because they molested the birds.

What will happen next cannot be predicted, but is of great interest and observations should be made at every opportunity.

As late as 1917, the very end of the Mexican settlement, no vegetation was obvious to a visitor, but sources of introduced seeds from which the modern vegetation developed probably date back in part to the Mexican camp. They had a garden and very likely the supply ships brought weed seeds repeatedly. The crews of fishing boats who often stop for brief visits may have carried some weeds to the island. Various plants were observed in 1935, and in 1938 *Cenchrus, Phyllanthus, Heliotropium, Solanum,* and *Ipomoea pes-caprae* were growing on the island. *Brassica* is recognizable on the 1943 photos. P. G. Taylor (1948) mentioned spiny grass [*Cenchrus*], bright green creeper [*Ipomoea*], bushes near the Rock and clumps of wild tobacco, also a green plant the leaves of which could be eaten as vegetables [probably *Brassica*], and great masses of weeds in the lagoon. He was on Clipperton in September and October, 1944.

In December, 1944, a small weather station was established on Clipperton by the U.S. Navy, and it remained in operation until October, 1945. The men had a garden (Denniston, personal communication) and planted some coconut palms in rows as an avenue between the two lines of quonset huts. The ruined station is on the southwest side, in the large coconut grove. Great quantities of equipment, packing material, and evidently seeds of garden plants and perhaps even soil were brought to the island and very likely some of the weeds now found were introduced during that period. The U.S. Forces accidentally distributed many weeds in the tropical Pacific Islands, where, in some cases, the dates of the introduction can be pinpointed with great precision (Fosberg, 1957).

Since the station was abandoned, many fishermen, salvagers of abandoned equipment, and others have visited the island, as have crews of French Navy ships and of course parties of scientists. Chance introduction of weeds may have taken place during any of these short visits. All the while winds, currents, and birds are continuously bringing seeds, some of which germinate, and a very few of which may become established.

PRESENT CONDITION OF THE VEGETATION

The flora of Clipperton Island listed above does not include any trees or shrubs except the coconut, and the vegetation, except for the small groves of introduced coconut palms, is very low, mostly a few decimeters and often only a few centimeters high. While there are some bare places, the vegetation is mostly distributed rather evenly over the surface of the island and the cover is complete over large areas.

Most of the vegetation cannot be easily divided into well-defined types, and fails to reflect the varying characteristics of the substratum as might more mature vegetation. This is not too surprising if we are right in thinking that this vegetation is less than 50 years old and if we consider the pioneer nature of much of the weedy flora and the profound disturbances to which the island has been subjected in the recent past (pigs, phosphate scraping, storms, occupation during World War II, etc.).

The main vegetation types or plant communities discernible without detailed quantitative phytosociological analysis are described below, as they were observed in August, 1958, with as much explanation of their habitat relations as the data at hand will permit.

COCONUT GROVES. Only a very small fraction of the total land area is occupied by coconut palms. They form one large grove, two small groups of a few palms, and a number of isolated single palms with thickets of seedlings. The large grove, on the southwest side of the atoll, along Pincer Bay, consists of

Figure 7. Air view (1957) of main part of the coconut grove on southwest side of the atoll. From left to right: ocean, reef flat (with trace of a ruined pier), beach and beach ridge, land strip, lagoon. The ruins of the U.S. Weather Station are mostly hidden in the palms. Low open mixed herbaceous vegetation, with *Ipomoea* vines forming mat along lagoon shore and creeping across land strip at lower right.

several groups of trees separated by small open areas and by the ruined buildings of the American weather station (fig. 7). The larger and perhaps older group of trees is immediately south of the station; the palms grow so close together as to form a complete canopy, providing such dense shade that there is no undergrowth of other flowering plants. Walking between the trunks is easy except for climbing over the litter of fallen fronds and piles of nuts. The ground is covered by a thick layer of partially formed humus resulting from the decomposition of the litter. Winds are little felt inside this group of trees and presumably the interior is also protected against salt-spray. A few of the palm trunks are bright green with some algae or lichens and a moss, *Octoblepharum albidum,* that forms a network of little star-shaped plants. A few fungi of the family Agaricaceae grow on dead wood. These cryptogams are the only plants to be seen within the palm grove.

South, north, and east of this main group of trees, but still a part of the grove, are smaller clumps of palms surrounded and intermixed with young trunkless palms and seedlings of all sizes. They form quite impenetrable thickets. Adjoining and to the north of the main group, two rows of obviously planted palms form an avenue between the two rows of ruined quonset huts of the American station. Other palms around the buildings may also have been planted. All these palms look very healthy, bearing numerous great green fronds and many inflorescences and bunches of nuts in all stages of development. The mature nuts are quite large. Many birds, great frigates, fairy terns, and common noddies nest on the fronds and inflorescences of coconut palms and trickles of guano are everywhere; however, here they do not seem to damage the palms.

Along the narrow east face of Clipperton Rock is a small open grove of eleven palms, with seedlings and sprouting nuts, and with a decapitated dead trunk and several rotting stumps. A few lichens and fungi grow on some of the trunks and on dead wood. The litter is like that in the main grove, but less abundant. Again there is no undergrowth, perhaps because the pigs trampled and burrowed much in this area. Sea birds nest all over the palms, on the fronds, on the inflorescences which they crush and destroy, even on the root system of a tipped-over palm. These palms are much damaged by this activity and perhaps by other factors, and do not bear as abundantly as the others.

On the northeast part of the atoll, a small group of 5 palms (fig. 10) and a number of seedlings mark Naturalists' Camp and one more tree grows a short distance away on the lagoon shore. As mentioned earlier, the first phosphate diggers' houses and sheds were in this general area, and the first coconut palms were planted on this side of the atoll. A thick blanket of *Ipomoea pes-caprae* covers the ground under the palms, which are not very tall and bear some nuts and inflorescences.

A few isolated palms are scattered around the coral ring. There are two north of the main grove, on the lagoon shore at the base of North Pincer, two others some distance from each other south of the main grove, and one (fig. 6) on the lagoon shore opposite the Egg Islands. One more palm seen near Green Point in 1956 and 1957 was swept away by the storm which hit the northeast coast in late 1957 or early 1958. One of a number of drifted nuts, however, developed a seedling about 2 m. tall on the southeast side. The isolated palms near the main grove may have been planted but the others must have grown from nuts drifting across the lagoon or around the atoll after a storm. The isolated palms are healthy and bear many nuts, and are surrounded by thickets of seedlings and young palms.

Visitors to the atoll like to carry around germinated nuts and a number of seedlings were taken from the large grove to the northeast side in September, 1958.

Mixed herbaceous vegetation. The pioneer nature of plant life on Clipperton Island is evident from the fact that by far the greater part of the land

Figure 8. Mixed herbaceous vegetation on northwest land strip. Arrangement of plants in lines. The most conspicuous plants are *Sida*, some *Cenchrus* and some vines of *Ipomoea pes-caprae*.

area is covered by an ill-defined, variable assemblage of weedy species forming a low grassy or brushy cover. This is best developed on the northwest side of the land strip (figs. 4, 5, 6, 8, 9). It is from this area that this vegetation type is described in detail below. Its extensions elsewhere and its variants or derived discreet sub-units can be studied later.

On the northwest side, the most abundant species are *Cenchrus echinatus, Sida rhombifolia,* and *Corchorus aestuans.* They form a cover up to 30 cm. tall, with an admixture of such other plants as *Eclipta, Phyllanthus,* and *Solanum,* and locally the much taller *Brassica juncea* (fig. 4). Over large areas the cover is complete but some places are open or bare. The plants are often densely intermixed. A very curious feature of this vegetation is its arrangement in long narrow parallel lines (fig. 8) that roughly follow the shores of the land strip. This striated effect is very striking on air photos. On the ground, what may be seen are long narrow lines of taller, thickly packed plants, mostly of *Sida* and *Corchorus,* alternating with more open areas of lower vegetation. The substratum appears the same, with loose pieces of coral covering much of the soil. Occasionally, however, the ground forms slight furrows and ridges like windrows. It is well known of course that the same plants will grow taller, or in a slightly different arrangement, where the soil is deeper or the substratum of a different texture, and thus reveal invisible and unsuspected characteristics of the ground. The only plausible explanation is that the plants thus follow hidden features, including probably the trenches, now filled in, along which the phosphate workers scraped the top phosphate-rich rock. Arundel in his diary (see p. 287) several times mentions trenches, resulting from earlier phosphate collecting, which he observed on the west and northwest sides. Digging a cut perpendicular to the lines of plants would have been most interesting but unfortunately was not feasible. The arrangement of plants in this mixed herbaceous vegetation otherwise seems to be quite random, except for the few variants discussed below.

This part of the land strip is the widest and highest and appears least likely to be disturbed by storm waves. It is here that the curious "trunks" of *Ipomoea pes-caprae* (fig. 5) which must be many years old are growing (see p. 277). Here also, *Solanum nigrum* seemed to be coming back to life: individual plants, in August, 1958, showed short new leafy stems inside a sort of "basket" of taller white dead twigs (fig. 9). The few leaves of *Nicotiana* (fig. 6) also looked like new growth. All these taken together seemed to indicate that the island had only recently recovered from a severe dry season. The annual *Cenchrus* plants probably die during that season, and indeed large areas of dead plants were seen, but there, little new growth had developed as yet. Many of the other plants in this area also seemed to be recovering from the vicissitudes of a dry spell.

The mixed herbaceous vegetation that is best developed on the northwest

Figure 9. More evidence of periodic dry weather on Clipperton Island, northwest land strip. Plant of *Solanum nigrum* with white dead branches and shorter new stems.

side of Clipperton Atoll continues around along the southwest land strip but becomes generally much lower and sparser. The plants are often only a few centimeters high and form a sort of turf. However, in the main palm grove, between the groups of trees and the quonset huts, a few stands of *Sida* and *Brassica* reach 1 m. or more in height.

The species forming this vegetation do not grow on piled up coral gravel and the landward slope of the ocean beach ridge is mostly free of them. However, the top of the ridge is depressed in a shallow longitudinal trench where finer material may have accumulated and where mixed herbaceous vegetation forms a low continuous cover, with *Cenchrus* and *Corchorus* especially abundant. Inland from the ridge, a compacted road made by the tracked vehicles of the American Weather Station is covered with a low grassy vegetation.

Near the southern corner of the atoll and at the base of the Hook, the vegetation is mostly very sparse, with much ground exposed, and the mixed herbaceous type is represented by scattered clumps or short lines of *Sida* and *Solanum* (fig. 12) and small prostrate plants of *Heliotropium*.

Around the base of the Rock, the mixed herbaceous vegetation again includes a low grassy component, and taller plants of *Sida* and *Solanum*. Along the east face of the Rock, just outside the coconut grove, *Corchorus, Sida* and *Solanum* form a large patch more luxuriant here than elsewhere on the island and up to 1.5 m. tall.

Along the Isthmus and Thumb peninsula, the cover of mixed herbs is very low and forms a mosaic of grassy areas and patches where *Corchorus* and *Sida* are more abundant. Along the south side of the Isthmus, a pig trail was very noticeable through the grasses.

The mixed herbaceous vegetation that extends more or less completely along the north, west, and south sides of the atoll becomes less obvious along the east side, where it forms small discontinuous patches interrupted by bare areas or other vegetation, or is replaced by its own variants.

VARIANTS OF MIXED HERBACEOUS VEGETATION TYPE. In some areas, the mixture of species forming this ill-defined vegetation may contain up to 15 species, in varying amounts, but with no obvious dominants. Elsewhere some species become more conspicuous, or fewer plants are found growing together. In extreme cases, patches of single species may be found.

Cenchrus echinatus variant. *Cenchrus echinatus* is almost always present in the mixed herbaceous community. In some areas, such as near the north corner of the island, or some parts of the east side which have been recently disturbed by storms, it is the dominant plant in a vegetation of a few species, or may even occur alone. Patches of pure *Cenchrus* may be large areas of dried, dead-looking plants, or small areas of tall, green, luxuriant plants. These patches occur principally on areas of gravel that have suffered recent disturbance. *Cenchrus* behaves as an extreme pioneer in these bare spots, germinating readily, growing rapidly, and maturing seeds early. Being an annual it may die when the next dry period occurs, giving other less abundant perennial species a chance to increase and produce a more diverse vegetation in the next and later growing seasons.

Heliotropium curassavicum and *Conyza bonariensis* variants. These are the only two species of the mixed herbaceous vegetation that obviously prefer a certain type of substratum. Wherever there is a sandy area, they may be present in the mixed vegetation. Where the sandy areas are extensive, they may form pure patches. It is not known how stable these pure vegetation types may be; perhaps they are relatively short-lived.

Pure *Heliotropium* vegetation is best developed near the east corner of the island, a little south of the landing place. There a low, rather flat sandy area is covered with these bluish-gray plants only a few cm. tall. Other smaller patches of pure *Heliotropium* occur elsewhere.

Pure *Conyza bonariensis* vegetation occupies, on the northwest side of the landstrip, a rather flat, sandy area. *Conyza* plants here form a dense stand 50 cm. tall, with an abundant ground cover of small seedlings. Another much smaller patch grows on the northeast side, opposite the landing place, near the lagoon.

Ipomoea pes-caprae TYPE. A little north of the landing place on the northeast side of the atoll, the whole width of the land strip is covered by a blanket of the beach morning glory, *Ipomoea pes-caprae.* In August, 1958, the vines were blooming abundantly and also bore fruits of different ages, including mature ones. The long thick vines, with their characteristically "goat-foot shaped" leaves, bright green and slightly succulent, spread in all directions and generally completely hide the ground. Between the wrecked LST and Naturalists' Camp, the wrecked and abandoned boats from the LST that lie on the land strip are almost completely smothered by the purplish pink-flowered vines. This coast-to-coast blanket extends north past Naturalists' Camp for some 80 m., then ends abruptly. The lagoon shore, along this area, is a low rocky cliff 1 to 1.5 m. above water level, and the *Ipomoea* mat extends to and over the cliffs. On the ocean side, erosion has recently caused the edge of the land to recede and dead and broken vines hang over the low cliffs forming this edge. On the photos taken in November, 1957, the vines can be clearly seen creeping down toward the beach and the present condition is no doubt a result of the 1957–58 storm (*cf.* p. 257).

Beyond the *Ipomoea* blanket this storm had laid coral gravel or sand over the whole land strip and there is no vegetation, except a few isolated *Ipomoea* vines, which, together with a few clumps of *Cenchrus,* may indicate the beginning of the revegetation process (fig. 2). At the north end of the devastated area, *Ipomoea* is again present all the way across the island for a short distance, then gives way to the mixed herbaceous type over most of the width of the land strip.

Along the entire northwest side of the island and around to Pincer Bay the vegetation of *Ipomoea* covers the low rocky cliffs of the lagoon coast and extends varying distances inland from the lagoon edge. In places it forms a very dense layer of vines, 0.50 m. thick or more, that makes for slow walking. From this wide belt, some plants occur oceanward into the mixed herbaceous type, where the large "trunks" were seen (fig. 5) and where long vines creep among the other vegetation. Near the lone palm of the northwest side, the *Ipomoea* blanket is mixed with the thinner stringy stems of a bean, *Phaseolus adenanthus.* The two species compete for this area and in places *Ipomoea,* in others *Phaseolus,* appears to be winning in the struggle.

Near Pincer Bay, the *Ipomoea* type continues along the rocky lagoon coast while some vines cross the rather dry open land strip to the old weather station (fig. 7), where they form dense camouflage over some the ruined buildings, over some piles of sand, over phosphate rock, and over parts of the oceanside coral ridge.

South of the Bay the *Ipomoea* mat follows the rocky lagoon coast. Where the coast is very low, this type is replaced by sedge marshes. It is absent, for instance, in the area of the Hook. There are only two small patches on the Isthmus and a large one on the other side of Rock Bay, on the narrow southeast land strip.

Along the low southeast side of the atoll, this vegetation occurs again in close proximity to the sedge marshes (figs. 10, 11). The narrow sand bank that separates the marsh from the lagoon is covered with a luxuriant growth of *Ipomoea*. On the other side of the marsh, landward, a low flat of black mud is criss-crossed by dead *Ipomoea* vines; landward of that, on slightly higher dry ground, a belt of live vines forms the typical blanket as seen elsewhere. The same pattern, but on a smaller scale, was seen also near Green Point.

Figure 10. Vegetation of lagoon shore east side of Clipperton Atoll. Looking northwest toward Naturalists' Camp. Beds of *Eleocharis mutata* in ponded depression, center right. *Ipomoea pes-caprae* invading low sand bank. Masses of plant debris at edge of lagoon.

Figure 11. Same as figure 10, looking southeast.

The mudflats may have been inundated on the occasion of a storm and the water ponded behind the bank may have stagnated long enough to kill the vines. Some other plants are growing among the dead vines on these open flats, mostly small, scattered specimens of *Portulaca oleracea* and, near the landward edge, *Heliotropium*.

Great quantities of seeds of *Ipomoea* are present in the drift in various parts of the island, especially in the sandy area south of the landing place, where many have germinated and formed seedlings and short vines. The large caterpillars of the morning glory sphinx (*Herse cingulata*) were extremely numerous on the luxuriant *Ipomoea* vines in August, 1958, and had entirely defoliated large areas by September (Dr. A. S. Hambly, personal communication).

SEDGE MARSHES. In low wet places, generally along the lagoon shores, sedge marshes are very conspicuous. The different species of sedges seldom mix in these wet places, but form single-species beds, their distribution apparently limited by the degree of wetness of the area. This arrangement is shown by the striking zonation in a pond at the base of the Hook (fig. 1). In the middle of the pond, in water, grows a thick stand of *Eleocharis mutata*, a bright green sedge 60–80 cm. tall, with triangular stems topped by a pale brown spike. All around, in wet mud, is a strip of the small (15–20 cm. tall) light green *Eleocharis geniculata.* Scattered on drier spots at the outer edge of the marsh are small, gray-green plants of *Hemicarpha micrantha.* The last two species sometimes occur together in small drying places, as on Thumb Point. The *Hemicarpha* species is the only sedge that is occasionally found on high ground. It is the least abundant of the four sedges. The fourth species, *Scirpus rubiginosus,* forms small patches of tules, up to 2 m. tall, in wet mud (fig. 3) or in shallow water. The stems are round, dark dull green. Coots sometimes use them for their nests. *Scirpus* grows opposite the landing place on the lagoon shore, in a few places along Thumb Point Bay and the Hook, and in small areas scattered along the southwest shore, as well as on North Pincer.

The other species that grows in water, *Eleocharis mutata,* is by far the most common. It forms dense narrow strips in channels of water separated from the lagoon by dry sandy banks along much of the southeast shore (figs. 10, 11) and on the northeast shore at Green Point; elsewhere, the sedge beds line the shore itself. Just west of the pond mentioned above, where the land slopes almost imperceptibly to the lagoon, the sedges seem to hold the fine lagoon sediments with their roots, so that when the water-level rises and floods the low shore, the sedges appear to grow on a muddy bank separated from the shore by water. The aspect is similar on the strip of land between the ocean and Rock Bay, where *Eleocharis mutata* forms a scalloped fringe on root-held mud banks a little offshore in the Bay. Near the south corner of the island *Eleocharis* fills a small lagoon inlet. Along much of the southwest side of the atoll, small beds of *Eleocharis mutata* occur among low spots or in shallow muddy areas at the base of rocky cliffs. South Pincer also is lined with such a fringe and low areas on this peninsula are filled with this sedge, to form conspicuous darker green strips across the dominant *Ipomoea* vegetation.

Eleocharis geniculata does not grow in water but occurs commonly as scattered tufts on wet mud on the east side of the atoll and forms large beds immediately west of the Hook on damp mud flats. It is always landward of the *Eleocharis mutata* shore fringe.

Bryum TYPE. In areas where the consolidated phosphate rock is exposed in a flat pavement the vegetation is often a pure cover of an unidentified species of *Bryum* in the form of numerous small cushions. This type is well developed at the base of the Hook (fig. 12) and around the south part of the island, as well as in the northwest, where it forms large carpets on flat rocky ground among the mixed herbaceous type. In the latter area this green sterile species of *Bryum* is in places mixed with a conspicuous, but much less abundant, silvery species, *Bryum argenteum* var. *lanatum.* Small tufts of *Bryum,* with occasional lichens and blue-green algae, are scattered in such microhabitats as the small crevices and overhangs common on rough surfaces of much of the consolidated rock.

Figure 12. Open mixed herbaceous vegetation (mostly *Solanum* and *Sida*) at the base of the Hook. *Bryum* vegetation type in foreground, on consolidated phosphatic rock.

Blue-green algae type. While most descriptions of coral islands do not fail to mention the blinding whiteness of coral gravel and sand, much of the coral material on dry land is stained by microscopic algae; in fact, some of it is so dark that it looks more like fresh lava than coral. This condition obtains on Clipperton Island where the films of blue-green algae staining the otherwise bare coral fragments constitute one of the most extensive vegetation types. All expanses of dry sand are stained light green or rarely orange-pink to a depth of about 1 cm. by mixtures of blue-green algae, even in areas where sand has been recently deposited by the ocean. All the landward sides of beach ridges, as well as boulder fields extending landward and much of the consolidated phosphate rock ledges and pavements, are colored from dark gray to black by similar mixtures. Only the top fragments are stained, and only their upper surfaces and sides. The color generally becomes increasingly paler downward along the sides, and the undersides are white, with sometimes a well marked green line between the stained and the white parts, as observed by Newhouse on Raroia Atoll (1954, p. 46).

The thin crust formed on dry sand seems, as far as our samples show, to consist of the following species: *Plectonema terebrans, Mastigocoleus testarum, Calothrix crustacea,* and *Entophysalis deusta,* with occasional admixture of others. A thicker crust of compacted sand from the top of the beach contained mainly *Protococcus grevillei* and *Plectonema nostocorum. Anacystis montana* and *Scytonema hofmannii* are the principal species closely associated on the surface of black coral fragments. On the phosphatized consolidated rock the mixture includes the same species of *Calothrix, Mastigocoleus, Entophysalis, Anacystis,* and *Scytonema.*

Except for the rather constant association of *Anacystis* and *Scytonema* on black coral, the samples are too few to establish firm relationships between the mixtures and these substrata and environmental conditions. The composition, nature, and ecological effects of these widespread crust and film communities are much in need of further investigation and comparison over a wide range of situations on atolls and other calcareous land. In particular, the significance of this type of land vegetation in soil formation and nitrogen fixation in atoll ecology has often been suggested, but not studied in detail or demonstrated conclusively.

Lagoon vegetation. In 1861 Lt. Griswold found the lagoon of Clipperton Island full of a water plant which he collected. Since that time, many authors have contrasted the abundance of plants in the lagoon with their scarcity on land.

Time and facilities were not available to study in detail whether the flora of the lagoon is arranged in recognizable vegetation types, and what they are. Only some brief notes can be made at this time. On the northwest side of the land strip, the lagoon shore is rocky and rocks under water are covered with a very abundant fur of algal filaments several centimeters long, bluish-green or turning to brownish. A collection from here includes *Lyngbya confervoides* and *Amphitrix violacea.* This algal fur occurs in most areas where the rocky shore is bathed by the lagoon water. Along much of the eastern half of the island strong western winds during August, 1958, pushed to shore great beds of algae mixed with higher plants. These were found floating on the surface or deposited as decomposing masses on the beach and included several species of *Lyngbya* associated with other blue-green and green algae. Such material could be found to some extent all around the lagoon, but was especially conspicuous on the east side (figs. 10, 11).

Some of the higher plants are attached to rocks in shallow water: *Ruppia maritima* occurs in various areas and is especially abundant around one of the

Egg Islands. *Potamogeton pectinatus* was found only in that same area. *Najas marina,* by far the most abundant phanerogam in the lagoon, forms thick stands in the shallower areas, with long stems rooting at nodes. Detached stems float in great tangled masses in various parts of the lagoon and are thrown up on the shores, often in a partly decomposed state, together with algal and other debris. Conrad Limbaugh (unpublished note, 1957) reported that "this plant grows from the shore to depths of 20 feet, extending to the surface."

Two macroscopic aquatics, previously known from the lagoon, were not found in the 1958 survey. They are *Chara zeylanica,* collected in 1938, and a plant seen in 1943 photographs, possibly *Zostera marina* (see p. 270). Their absence suggests either a seasonal variation, or drastic changes in environmental factors, possibly resulting from storms, which may bring about irregular but important changes in the composition of the lagoon vegetation.

The bottom of the lagoon, in the deeper areas, was found by the marine biologists in their diving operations to be free of macroscopic plants (Allison and Hambly, personal communications). Limbaugh (*l.c.*) wrote: "On the bottom of the lagoon at depths of 20 to at least 60 feet, there exists a blue-green carpet which can be torn away, but which can be powdered by squeezing. I assume that this is a microalga."

Marine vegetation. While the surveys of the reef and the underwater slopes of Clipperton Island, including work on algae, were carried out by the marine biologists, and will be reported elsewhere, a few very general notes may be included here. A few species of algae grow on the reef flat and over certain corals (Taylor, 1939, Dawson, 1957, 1959), but they are nowhere very abundant. Large scattered boulders on the reef flat are conspicuously covered with algal growth, particularly with a species of *Ulva.* The same *Ulva,* together with a red alga (*Hypnea spinella*), is left on the beaches in great abundance by the receding tide. Other formations are the felt of algae, including various blue-green and green species, covering rocks in shallow water, and lining some tidal pools, the thin slimy covering on slabs, the turfs of *Jania* and *Hypnea* that occur "throughout the seaward reef areas and down to at least 78 feet" (Dawson, 1959, p. 5), and the microscopic algae growing inside living coral heads.

In general, however, the role of algae in the living reef and in the formation of the atoll foundations and rocks is relatively small. Very few pieces of algal skeletons can be found among the enormous masses of limestone gravel and boulders that are thrown up by the ocean in beach ridges or in gravel and boulder fields. Most surprising to the botanist is the lack of a marked algal ridge at the seaward edge of the reef. Allison (personal communication) believes that "coralline algae dominate the outer edge of the intertidal reef flat, where they are the active rock builders, though they don't flourish to the great extent noted on other Pacific atolls where an algal ridge is evident." The contrast indeed is remarkable with the wide, thick growth of calcareous red algae forming the bright pink "Lithothamnion ridge" so well developed on the windward ocean reefs of many atolls, particularly the Marshall Islands.

In this respect, as well as in the complete absence of native trees and in other characteristics, the vegetation of Clipperton Island is very peculiar, and quite distinct from that of atolls in the rest of the Pacific.

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REMARKS ON THE COLUBRID GENUS *CHILOMENISCUS* (SERPENTES: COLUBRIDAE)[1]

by

Benjamin H. Banta

California Academy of Sciences, San Francisco 18, California

and

Alan E. Leviton

California Academy of Sciences, San Francisco 18, California and
Division of Systematic Biology, Stanford University

In 1860, Cope established the genus *Chilomeniscus* to accommodate a single species, *C. stramineus.* Subsequently Cope described three more nominal species, and others have since brought the number to seven. Of these four are currently recognized: *C. cinctus, C. punctatissimus, C. savagei,* and *C. stramineus.* Recently the authors received on loan from the Chicago Natural History Museum one specimen belonging to this genus taken on Cedros Island, off the Pacific coast of central Baja California, Mexico. In attempting to place this specimen it was necessary to re-examine the status of other nominal species.

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REVIEW OF CHARACTERS

The nominal species of *Chilomeniscus* have been distinguished mainly by differences in color pattern, contact, or lack of it, between the rostral and prefrontals, and ventral and subcaudal counts. A review of these characters indicates that they are indeed useful in separating populations.

Of the above, the most prominent are differences in color pattern between *C. stramineus* (figure 1) and the other species. This species alone lacks alter-

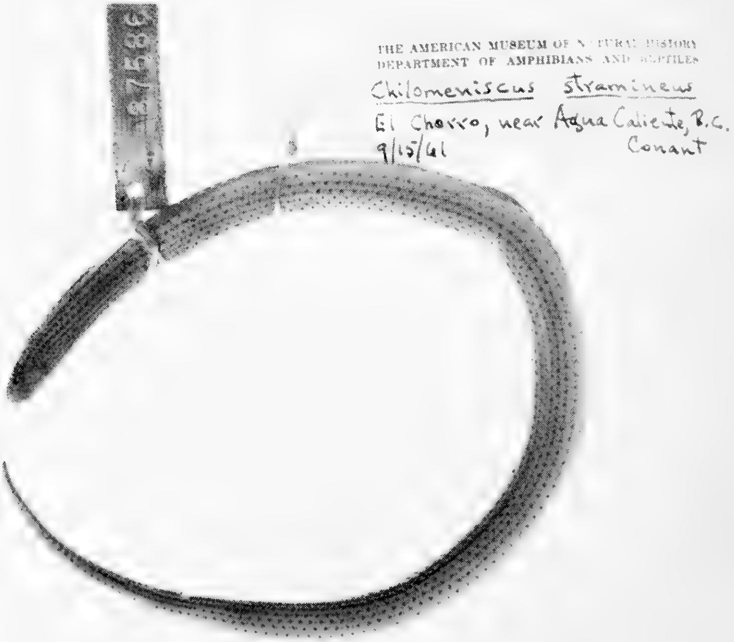

FIGURE 1. *Chilomeniscus stramineus stramineus* Cope (AMNH 87586), from El Chorro, near Agua Caliente, Baja California Sur, Mexico.

nating light and dark cross bars or rings. The dorsum is uniformly light brown, each scale bearing a minute dark spot, either at its apical or basal end. The other nominal species have distinct dark cross bars (figure 2).

Figure 2. *Chilomeniscus cinctus* Cope (AMNH 66338), from Guaymas, Sonora, Mexico.

These bars may or may not encircle the body (table 1). There is no evidence from the material at hand that populations may be distinguished on the basis of whether or not the dorsal bars extend onto the venter. Specimens drawn from the same population, collected at the same locality and at the same time, differ.

In a like manner the relative widths of the dark and light bands seem to vary independently. In general the light bands are narrower than the dark bands on the anterior portion of the body, about equal at and near midbody, and somewhat broader posteriorly. There are exceptions, but they are not numerous (table 2).

There is considerable variation in the number of dark bands, too. The greatest variation was found among the specimens forming the "Cape Region" sample from southern Baja California, the least among the specimens from Arizona. Specimens from Sonora (figure 2) have fewer cross bars than any of the others studied (table 3).

TABLE 1. *Summary of variation in the encirclement of the body by dark cross bands in* Chilomeniscus cinctus.

Locality	Number of individuals in which cross bands are confined to dorsum	Number of individuals in which cross bands encroach on or encircle venter	
		Posteriorly only	Entire body
Sonora	0	3	2
Arizona	13	14	8
Baja California Norte	1	5	8
Baja California Sur			
San Ignacio	2	2	3
Commondu	6	1	3
Cape Region[2]	8	0	0
Isla San Jose	1	0	0
Isla Cedros	0	0	1

[2] Cape Region includes that part of the peninsula of Baja California south of La Paz.

TABLE 2. *Summary of variation in the width of dark cross bands at midbody in* Chilomeniscus cinctus.

Locality	Light interspaces greater than, equal to, or less than dark bands at midbody		
	Greater than	Equal to	Less than
Sonora	0	1	6
Arizona	7	19	8
Baja California Norte	2	6	5
Baja California Sur			
San Ignacio	1	3	1
Commondu	3	3	4
Cape Region	3	3	2

TABLE 3. *Summary of variation in the number of dark cross bands on the body in* Chilomeniscus cinctus.

Locality	Male			Female		
	N	Mean	Range	N	Mean	Range
Sonora	2	16.0	14–18	3	16.0	15–17
Arizona	21	20.0	18–23	15	19.8	17–21
Baja California Norte	2	22.0	22	12	21.1	17–24
Baja California Sur						
San Ignacio	5	22.0	19–24	2	22.0	20–24
Commondu	5	26.0	21–39	5	28.2	22–34
Cape Region	2	26.6	20–33	5	24.0	20–28
Isla Monserrate				1	22	
Isla Magdalena				1	32	
Isla San Jose	1	25				
Isla San Marcos				1	24	
Isla Cedros	1	23		1	19	

It is noteworthy that occasionally specimens turn up that are intermediate in pattern between *C. cinctus* and *C. stramineus,* both cross bands and punctations being present (figures 3 and 4). The significance of these intermediates is not known. We have no evidence to indicate that they are hybrids. One species, *Chilomeniscus punctatissimus* (figure 4) has been distinguished from *C. cinctus* by the presence of small dark spots in the light interspaces. However, Linsdale (1932, p. 382) pointed out that some Baja California specimens of *C. cinctus* are similarly ornamented, and in this we concur.

In regard to color pattern, one problem yet to be solved is whether the populations differ in the presence or absence of red in the light interspaces. Specimens from Sonora, observed alive, have red pigment in the light interspaces; specimens taken alive in the La Paz and Todos Santos areas of southern Baja California, lack red pigments. Perhaps the presence or absence of red pigments may be significant; we do not know.

The rostral may or may not contact the prefrontals. *Chilomeniscus punctatissimus* and *C. savagei* (figure 5) have the rostral separated from the prefrontals by the internasals; the prefrontals are reduced and do not meet at the midline. In *C. stramineus* the rostral is also separated from the prefrontals by the internasals, though rarely this is not true. In six specimens of more than 50 the rostral did contact the prefrontals. In *C. cinctus* the internasals are reduced, prefrontals meet at the midline, and the rostral contacts the prefrontals. This condition also obtains in Cope's nominal species *C. stramineus fasciatus* (figure 6), and *C. ephippicus* (figure 7).

Ventral counts are subject to sexual dimorphism and to some extent geographical variation. Linsdale (1936, pp. 232–234) summarized the counts of a large sample of *C. stramineus* from Baja California. Several of his specimens were incorrectly sexed (we have checked each one!); with minor adjustments for this the following ranges were obtained: ventrals [♂] 107–114, [♀] 111–122; subcaudals [♂] 24–32, [♀] 25–30. Sexual dimorphism in ventral counts is obvious; it is not so clearly defined in subcaudal counts. In a like manner in a sample of 36 specimens of *C. cinctus* from Arizona: ventrals [♂] 108–119, [♀] 114–122; subcaudals [♂] 26–31, [♀] 22–27. It is evident that geographical comparisons in ventral and subcaudal counts must be made within sexes (tables 4 and 5).

Specimens of *C. savagei* have the highest ventral count known for the genus (134–136, 2 females). All other species range between 105 and 129 with males between 105–120 and females 111–129. One exception exists, a single male taken on Cedros Island (figure 8). It has 126 shields. *Chilomeniscus punctatissimus,* known from two females from Isla Partida (Sur)-Espiritu Santo, is characterized by having 119–121 ventrals and 23–25 subcaudals; these ranges are similar to both *C. stramineus* and *C. cinctus.* In

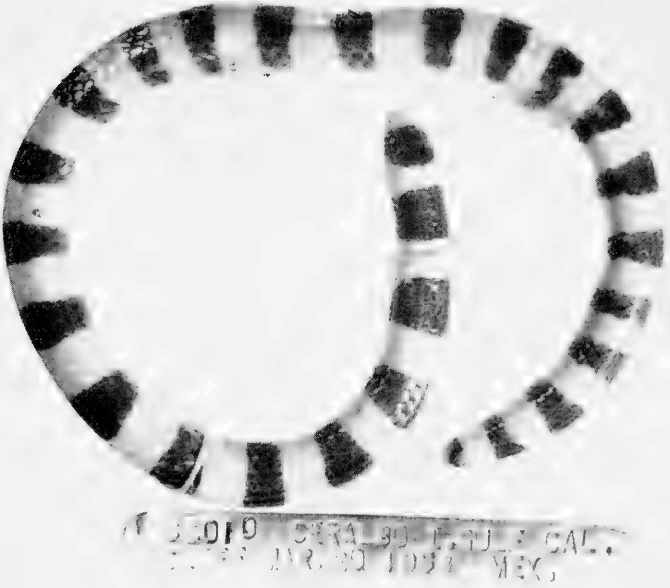

Figure 5. *Chilomeniscus savagei* Cliff (CAS 85010, Paratype), from Cerralvo Island, Gulf of California, Mexico.

1939, Hoard described *C. stramineus esterensis* (figure 9), distinguishing it from the nominal form by differences in ventral counts (♂ 114–123, ♀ 127–132). In this he seems entirely justified.

In summary, *Chilomeniscus stramineus* is easily distinguishable by color pattern; the Estero Salina population appears to be distinct on the basis of the higher ventral count, and Hoard's nominal subspecies is recognized. *Chilomeniscus punctatissimus* and *C. savagei* are both readily distinguishable from *C. stramineus* by color pattern, from *C. cinctus* by having reduced prefrontals not in contact at the midline and separated from the rostral by the internasals, and from each other by ventral counts.

Chilomeniscus cinctus is very variable. In color pattern the Sonora

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Figure 3. *Chilomeniscus stramineus esterensis* Hoard (LMK 30373), showing color pattern containing elements of both *C. stramineus* and *C. cinctus* patterns.

Figure 4. *Chilomeniscus punctatissimus* Van Denburgh & Slevin (CAS 49156, Holotype), from Isla Espiritu Santo, Gulf of California, Mexico.


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sample seems quite distinct in its lower number of dark cross bands, while the Commondu-Cape Region samples are more variable than any of the others and average more dark bands. The Arizona and northern Baja California samples (including that from San Ignacio), both represented by 15 or more specimens, are the most homogenous and are similar to each other. Additional material is needed from Sonora and central Baja California before the taxonomic implications of these apparent differences and similarities can be evaluated. Little importance is attached, at this time and based on available samples, to differences in ventral and subcaudal counts, though one specimen, taken on Cedros Island, deserves special note. This is the single male whose ventral count exceeds that of any other *C. cinctus* male and most "*cinctus*" females. However, a single female, also from Cedros, has a ventral count that falls well within the range for females from the mainland of central Baja California. In view of the marked sexual dimorphism in *C. cinctus*, this suggests that the Cedros male is abnormal in this character. If not, which remains to be seen after more collections are made, then the Cedros population should probably be accorded taxonomic recognition.

At the present time we recognize the following species and subspecies of *Chilomeniscus:*

Chilomeniscus cinctus Cope
Chilomeniscus punctatissimus Van Denburgh & Slevin
Chilomeniscus savagei Cliff
Chilomeniscus stramineus esterensis Hoard
Chilomeniscus stramineus stramineus Cope

Key to the Species of Chilomeniscus

1a. Rostral in contact with prefrontals; prefrontals broadly in contact at midline; internasals separated at midline; color pattern consists of an alternating series of dark and light cross bands .... *C. cinctus*

1b. Rostral usually not in contact with prefrontals; prefrontals not in contact at midline; internasals in contact at midline; color pattern variable.
  2a. Alternating dark and light bands on body, occasionally with some minute punctations in light areas.
    3a. Ventrals more than 130 .... *C. savagei*
    3b. Ventrals less than 125 .... *C. punctatissimus*
  2b. Uniform light brown on dorsum, without cross bands but with dark, longitudinally arranged, small spots, one to each scale.
    4a. Ventrals: ♂ 103–114, ♀ 111–122 .... *C. s. stramineus*
    4b. Ventrals: ♂ 114–123, ♀ 127–132 .... *C. s. esterensis*

Figure 6. *Chilomeniscus stramineus fasciatus* Cope [= *C. cinctus*] (USNM 12630, Syntype), from La Paz, Baja California Sur, Mexico.

Figure 7. *Chilomeniscus ephippicus* Cope [= *C. cinctus*] (USNM 8897, Holotype), said to have come from the Owens Valley, California.

Figure 8. *Chilomeniscus cinctus* Cope (CNHM 130286), from Isla Cedros, Pacific Coast of Baja California, Mexico.

Table 4. *Summary of variation in ventral counts in* Chilomeniscus cinctus.

	Male			Female		
Locality	N	Mean	Range	N	Mean	Range
Sonora	2	114.0	113–115	3	112.3	111–115
Arizona	21	114.8	108–119	15	118.9	114–122
Baja California Norte	2	117.0	114–120	12	121.6	112–129
Baja California Sur						
San Ignacio	5	113.8	109–117	2	121.0	120–122
Commondu	5	115.0	110–119	5	121.2	117–125
Cape Region	3	109.3	108–111	5	117.0	115–118
Isla Monserrate				1	128	
Isla San Jose	1	105				
Isla San Marcos				1	116	
Isla Cedros	1	126		1	125	

Table 5. *Summary of variation in subcaudal shields in* Chilomeniscus cinctus.

	Male			Female		
Locality	N	Mean	Range	N	Mean	Range
Sonora	2	27.5	26–29	3	25.7	24–28
Arizona	21	29.7	26–31	15	25.5	22–27
Baja California Norte	2	27.0	26–28	12	25.7	25–29
Baja California Sur						
San Ignacio	5	28.0	26–31	2	26.0	25–27
Commondu	5	29.8	26–33	4	27.0	26–28
Cape Region	3	29.0	27–31	5	26.6	26–28
Isla Monserrate				1	30	
Isla San Jose	1	25				
Isla San Marcos				1	33	
Isla Cedros	1	31		1	26	

Figure 9. *Chilomeniscus stramineus esterensis* Hoard (LMK 30370), from Estero Salina, Baja California, Mexico.

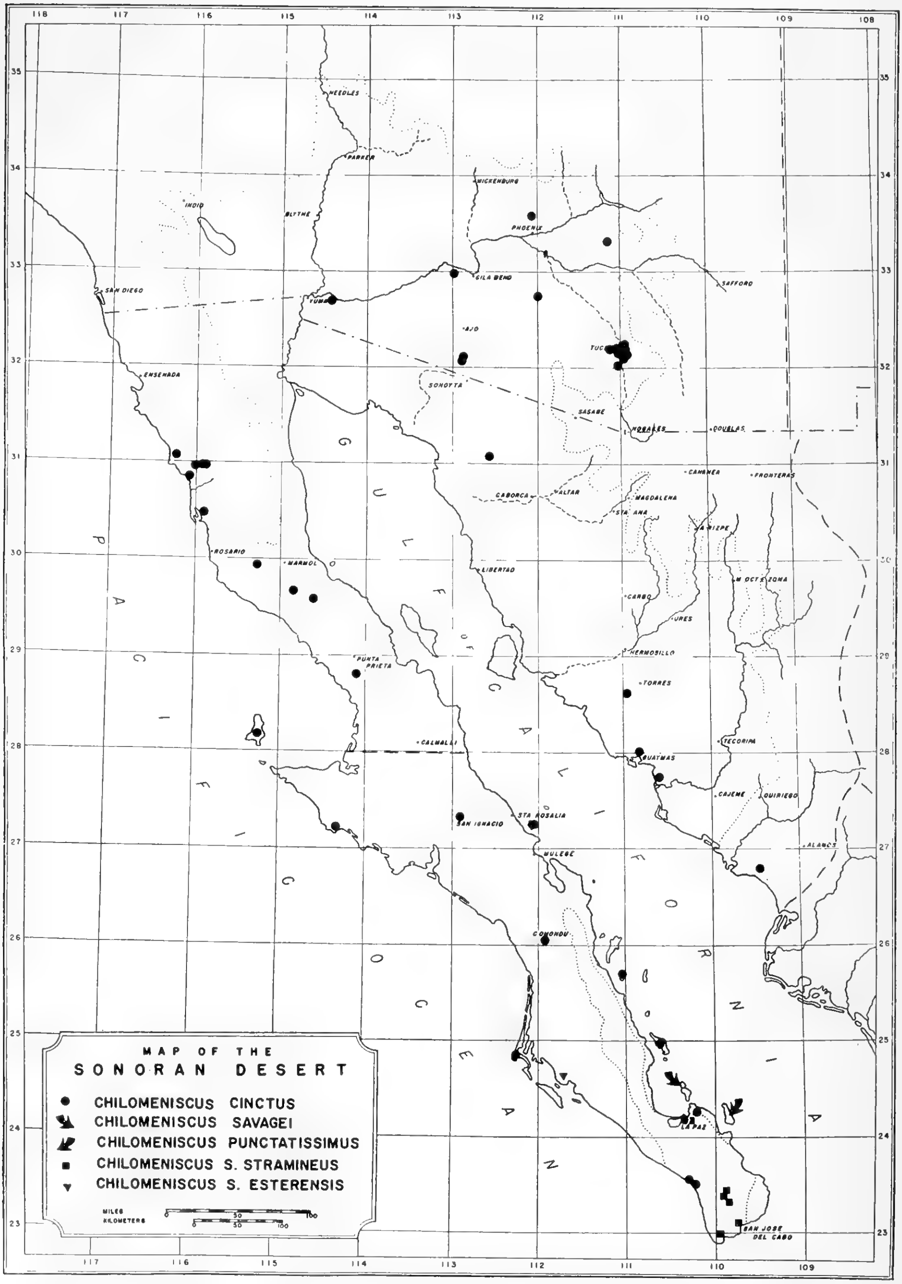

Figure 10. Distribution of *Chilomeniscus* in western North America. Note that the genus is largely confined to the Sonoran Desert region as defined by Shreve (1951) [as outlined by finely stippled border].

CHECK LIST

Chilomeniscus Cope

Chilomeniscus COPE, 1860, Proc. Acad. Nat. Sci. Philadelphia, 12:339 (type species *C. stramineus* Cope, by monotypy).

Chilomeniscus cinctus Cope.

Chilomeniscus cinctus COPE, 1861, Proc. Acad. Nat. Sci. Philadelphia, 13:303 (type locality near Guaymas, Sonora, Mexico; type in Museum of Comparative Zoology, Harvard University).

Chilomeniscus ephippicus COPE, 1867, Proc. Acad. Nat. Sci. Philadelphia, 19:85 (type locality Owens Valley, California; type in United States National Museum). The type locality of *C. ephippicus* is "Arizona Valley" (= Owens Valley), California. This is probably in error. No specimens of *Chilomeniscus* have since been reported from California although many areas in southern California, which could provide suitable habitats for this animal, have been more intensely collected than most any other area in the world. Much of William Gabb's material, probably including this specimen collected by G. H. Horn, was obtained in northern Baja California, and it may be that this specimen was obtained there. Cope (1875, p. 35) stated that *Chilomeniscus ephippicus* was from Owens Valley, California, but following in parenthesis added, "Sonora subregion." Yarrow, in 1882 (p. 86), reported on three specimens of this nominal species, two supposedly from "Arizona Valley," California, and one from Camp Mojave, Arizona. Based on our study we are unable to come to a definite conclusion as to the exact source of the type material of this form. Though we think it probably came from northern Baja California, we are not sure. We are certain, however, that it was not taken in California's Owens Valley.

Chilomeniscus stramineus fasciatus COPE, 1892, Proc. United States Nat. Mus., 14:595 (type locality La Paz, Baja California Sur, Mexico; syntypes [4] in the United States National Museum).

MATERIAL EXAMINED (94). ARIZONA: Tucson (LMK 32058; MVZ 57070; UMMZ 64069; USNM 15788–15790, 16806, 62545, 118570). 10 mi. S. Tucson (CM 19344–19345). 2 mi. N. Tucson (LMK 33383). 4 mi. N. Tuscon (LMK 34333). Verde Valley, near Tucson (LMK 44236). West of Tucson, on route 86 (MCZ 62379–62380). 7 mi. S. Tucson (UMMZ 70376). Xavier (LMK 32510, 32795). Casa Grande National Monument (LMK 34068). San Xavier Mission (LMK 34316). Cave Creek (CAS 17551). Cabali Mts. (CAS 33834). Santa Catalina Mts.[3] (CAS 34172). 20 mi. S. Ajo (CAS 81422). 8 mi. W. of Wellton (CAS 80689). Superior (MCZ 11976). Ajo road, 23 mi. from Mexican border (MCZ 62378). 2½ mi. W. Sahuarita, on west side of Santa Cruz River (MVZ 67187). Tucson Range (USNM 60975). 6 mi. W. Gila Bend (USNM 62341). Sycamore Canyon (USNM 62566). Pima County [without exact locality] (USNM 56322). Arizona [without exact

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[3] Prison Road, Santa Catalina Mts. (BYU 10162–10163).

locality] (CAS 33839–33840, LMK 27003). CALIFORNIA (see discussion under *C. ephippicus* above): Owens Valley (USNM 8897 [Holotype of *C. ephippicus*]). MEXICO: *Sonora*: Alamos (AMNH 64245). Guaymas (AMNH 66338). 20 mi. S. of Guaymas (AMNH 70692). About 40 mi. NW of Carborca, vicinity of Estacion Las Enchilayas (CNHM 74961–74962). East coast of Gulf of California, near Guaymas (MCZ 24 [Holotype of *C. cinctus*]). 20 mi. S. of Navajoa (MVZ 71365). 29 mi. S. Hermosillo (USC 942). *Baja California Norte:* Socorro (AMNH 64512, UMMZ 77068). Faraway Ranch, 30 mi. S. El Marmol (LMK 38663). 10 mi. S. Cataviña (LMK 42054). 11.2 mi. E. San Telmo (LMK 42324). 8.4 mi. E. San Telmo (LMK 42325). 12 mi. E. San Telmo (LMK 42737). San Antonio River, NE of Arroyo Seco (LMK 43378). About 10 mi. S. Punta Prieta (SDNHM 17390). San Antonio (CNHM 1129). San Quintin (CNHM 1125, USNM 37520). San Fernando (USNM 21539). Valle Trinidad (LMK 30371). *Baja California Sur:* Commondu (CNHM 25871–25872, MVZ 13776–13780, USNM 65825). San Ignacio (LMK 3828–3830, MVZ 10675, 13781, UMMZ 76461 [2]). Trail between Loreto and Commondu (USNM 67376–67377). La Paz (AMNH 14225, MCZ 37226, UMMZ 59792, USNM 12630 [2 syntypes of *Chilomeniscus stramineus fasciatus* Cope]). Bahia de los Muertos (CAS 91244). 5.3 mi. NW of Todos Santos (CAS 91401). Todos Santos (CAS 45981). Ballenas Bay (USNM 15158). Chametha Ranch (MCZ 36900). *Gulf of California*: Isla Monserrate (SDNHM 50173). Isla San Marcos (SDNHM 50174). Isla San Jose (SU 14035). *Pacific Coast of Baja California Islands*: Magdalena (USNM 37521). Cedros (MCZ 19731, CNHM 130286).

Chilomeniscus punctatissimus Van Denburgh and Slevin.

Chilomeniscus punctatissimus Van Denburgh and Slevin, 1921, Proc. California Acad. Sci., ser. 4, 11:98 (type locality Isla Partida Sur (Espiritu Santo), Gulf of California, Mexico; type in California Academy of Sciences).

Material examined (2): MEXICO: Isla Partida Sur (CAS 49156 [Holotype]). Isla Espiritu Santo (SDNHM 50175).

Chilomeniscus savagei Cliff.

Chilomeniscus savagei Cliff, 1954, Trans. San Diego Soc. Nat. Hist., 12:71 (type locality Cerralvo Island, Gulf of California, Mexico; type in Division of Systematic Biology, Stanford University).

Material examined (6): MEXICO: Isla Cerralvo (CAS 85010 [Paratype], 88626, 92994, 93014, SDNHM 44394, SU 14034 [Holotype]).

Chilomeniscus stramineus esterensis Hoard.

Chilomeniscus stramineus esterensis HOARD, 1939, Jour. Entomology and Zool., Pomona College, 31:45 (type locality Estero Salina, Baja California Sur, Mexico; type in San Diego Natural History Museum [formerly in personal collection of Dr. Laurence M. Klauber]).

MATERIAL EXAMINED (8): MEXICO: *Baja California Sur*: Estero Salina (opposite Isla Santa Margarita) (LMK 30364–30368, 30370 [Paratypes], 30372–30373).

Chilomeniscus stramineus stramineus Cope.

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1860. Notes and descriptions of new and little known species of American reptiles. *Proceedings of the Academy of Natural Sciences of Philadelphia,* 12:339–345.

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THIRD CONTRIBUTION TO THE HERPETOLOGY OF AFGHANISTAN

by

Alan E. Leviton

California Academy of Sciences, San Francisco 18, and
Division of Systematic Biology, Stanford University, California

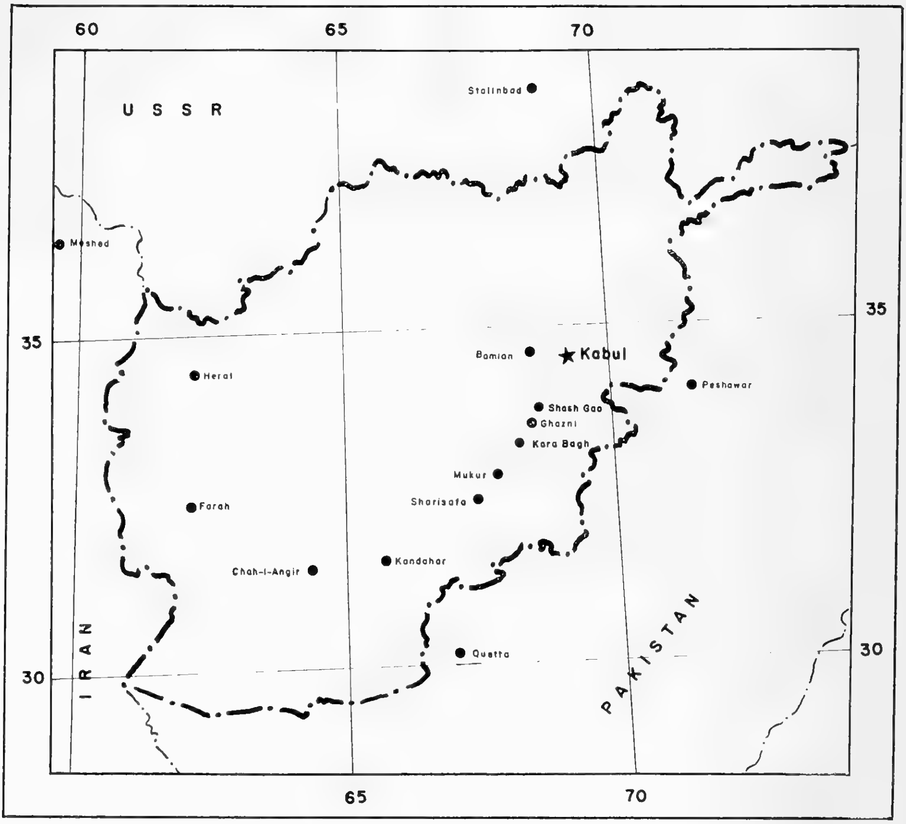
and

Steven C. Anderson

Division of Systematic Biology
Stanford University, California

Recently Mr. John Gasperetti, Field Associate of the California Academy of Sciences, presented a small number of amphibians and reptiles taken in Afghanistan to the Academy. These animals, taken during April and May, and August through October of 1961, constitute Mr. Gasperetti's third contribution to this little-known fauna. It supplements collections he made in 1950 and during March and April of 1961, already reported on by Leviton (1959) and Leviton and Anderson (1961).

The recent collection of 44 specimens was made in eastern Afghanistan. The following species are represented: *Bufo viridis, Rana sternosignata, Agama caucasica, Ablepharus pannonicus, Eremias guttulata watsonana, Ptyas mucosus, Coluber rhodorachis,* and *Alsophylax pipiens.* The latter species is recorded for the first time from Afghanistan. All specimens were taken between April 1 and May 11, and August 1 and October 20, 1961, between Kabul and Kara Bagh[1] at elevations varying between 1500 and 2600 meters.



AFGHANISTAN

Figure 1. Map of Afghanistan showing localities mentioned in the text. This map is the same as that published by the authors in 1961, but the position of Kara Bagh has been corrected (see footnote 1).

Systematic Notes

Bufo viridis Laurenti.

Material examined (13): Kara Bagh [April 1] (CAS 90759); Ghazni [April 15] (CAS 91603–91609); marshy area along Logar River, 7–8 km. south from Kabul [Oct. 20] (CAS 92337); Kabul [Aug. 9] (CAS 92325–92328).

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[1] In their earlier paper the authors located Kara Bagh about 35 km. north of Kabul. Mr. Gasperetti has indicated (personal communication) that this was in error and that the locality Kara Bagh is a group of villages about a third of the distance from Ghazni to Mukur (see map, figure 1).

The specimens taken in April range from 53–58 mm. snout-vent length. Of that series the four females contain ripe ova. Young (snout-vent length of 26–34 mm.) were collected in August, and a single male (59 mm.) was taken in October.

The dark blotches on the dorsum vary considerably among individuals; they are more pronounced in the females than in the males and the sexes are easily separable on this basis alone (figure 2).

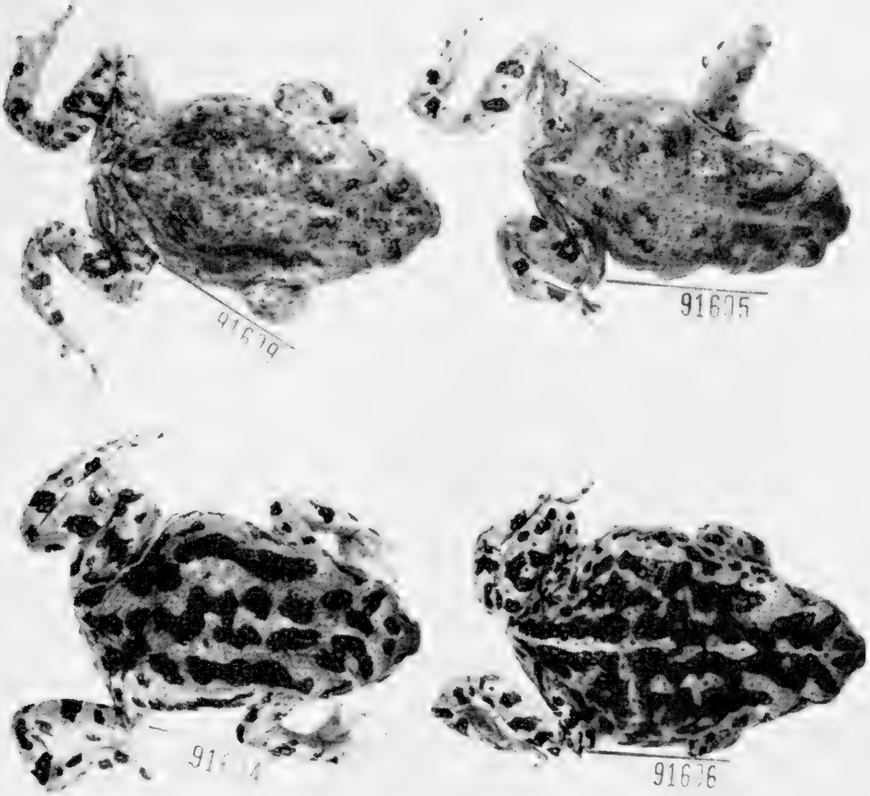

Figure 2. *Bufo viridis* showing differences in dark blotches between males (top) and females (bottom).

Rana sternosignata Murray.

MATERIAL EXAMINED (7): Marshy area along Logar River, 7–8 km. south from Kabul [Oct. 20] (CAS 92330–92336).

Seven specimens of this robust, aquatic ranid were taken (figure 3). The

FIGURE 3. *Rana sternosignata*, dorsal view.

males are most distinctive with their pronounced pectoral glands (figure 4) with minute and numerous asperites, which also cover the dorsolateral surfaces of the thumbs. The arms and legs are remarkably robust; the toes

Figure 4. *Rana sternosignata*, ventral view showing development of pectoral mammata.

fully webbed. The females lack pectoral mammata and other secondary sexual characteristics of the males.

One of the females, CAS 92331, contained masses of small eggs in the body. Stomach contents included remains of aquatic beetles and arachnids of unknown kinds.

These distinctive ranids, which are allied to the high-altitude ranids of western China and Tibet (*Rana boulengeri, R. phrynoides, R. pleuroden,* and *R. tibetanus*), resemble in body habitus the high-altitude South American semiaquatic leptodactylid frogs of the genus *Telmatobius* and other high altitude frogs such as *Scutiger* (Asian pelobatids). All are stout, with strong, short limbs, thick, somewhat tubercular and loose skin, large feet, and broad heads.

The largest male measures 125 mm. in snout-vent length, the largest female 82 mm.

Alsophylax pipiens (Pallas).

Material examined (3): Kabul [April 30 and May 11] (CAS 91613–91614); near Paghman River, 10 km. southwest of Kabul [Aug. 9] (CAS 92339).

This constitutes the first record of this species from Afghanistan (figure 5).

Over the years there has been a remarkable amount of confusion regarding this form. Pallas, in 1811, described *Lacerta pipiens.* In 1823, Lichtenstein (in Eversmann) referred a gecko, believed identical to Pallas', to *Ascalabotes pipiens,* and in 1832 Eichwald transferred Pallas' species to *Gymnodactylus,* basing his conclusion of generic affinities on specimens he obtained in the Transcaspian region. Fitzinger established the genus *Alsophylax* for Pallas' gecko after showing that the toes were not angularly bent as they are in *Gymnodactylus* [=*Cyrtodactylus* for the Asian species formerly assigned to *Gymnodactylus*]. It was not until 1912 that Bedriaga showed that the specimens Lichtenstein and Eichwald had before them were not the same as those seen by Pallas. *Alsophylax pipiens* (Pallas) is a non-tuberculate gecko which differs in this character from Lichtenstein's and Eichwald's tuberculate "*pipiens.*"

In 1915, Nikolsky illustrated a tuberculate gecko which he called *Alsophylax pipiens* Pallas but which is like *A. pipiens* of Lichtenstein, *et al.* Sometime earlier he had described *A. laevis,* illustrated in 1915 and obviously a non-tuberculate gecko, which we believe is close to, if not synonymous with *A. pipiens* of Pallas.

Pallas' species is *not* tuberculate, as indicated in the original description by the omission of any reference to that possible character; as pointed out by Bedriaga it also has enlarged subcaudal shields and is not uniformly

Figure 5. *Alsophylax pipiens* (Pallas), dorsal view. Note particularly the absence of enlarged tubercles on the dorsum.

granular below. This being the case we suspect it may well be necessary to revise our current views on the content of the genus *Alsophylax* (type species *Lacerta pipiens* Pallas, by original designation by Fitzinger, 1843). Of the

11 nominal species presently assigned to that genus at least 8 have both tubercles and granules on the dorsum, including those referred to as *A. pipiens* by Lichtenstein, Boulenger, Nikolsky, and others. In 1874, Blanford proposed the nominal genus *Bunopus* for *B. tuberculata* later referred to *Alsophylax* by Boulenger. We believe it desirable to reinstate Blanford's genus and refer to it those tuberculate species presently placed in *Alsophylax*, including *Ascalbotes pipiens* Lichtenstein (= *Gymnodactylus pipiens* Eichwald, *Alsophylax pipiens* Boulenger, Nikolsky, *et al.*), thereby restricting *Alsophylax* to include the nominal species *Lacerta pipiens* Pallas, *Gymnodactylus microtus* Blanford (perhaps!), and *Alsophylax laevis* Nikolsky (Chernov, 1959, p. 40, regards this form as a subspecies of *A. pipiens*). Under this arrangement the genus *Alsophylax* may be redefined as follows: Digits straight, not dilated or so angularly bent at any of the articulations as in *Gymnodactylus* (= *Cyrtodactylus* for Asian species), clawed, with transverse lamellae beneath, without a lateral fringe or denticulation of pointed scales. Dorsum with small, juxtaposed scales, without enlarged tubercles. Enlarged subcaudal shields present. Pupil vertical. Males with preanal pores.

Crossobamon may be distinguished from *Alsophylax* and *Bunopus* by possessing fringes along the lateral edges of the toes, and with *Bunopus* it may be distinguished from *Alsophylax* by the presence of scattered enlarged tubercules on the dorsum. Nikolsky's genus *Microgecko* (sometimes referred to the North African-Arabian genus *Tropiocolotes*) is also easily distinguished by its imbricate dorsal scales, rather than granules. *Tropiocolotes helenae* of Mertens (1956) should be re-examined to see if it is not in fact *A. pipiens* of Pallas.

Agama caucasica (Eichwald).

Material examined (11): Toward Ghazni, a few km. from Shash Gao [April 15] (CAS 91590–91598); near Paghman River, 10 km. southwest of Kabul, at 2100 M. [Aug. 1] (CAS 92329, 92338).

Immature specimens generally have dark reticulations on the under surfaces of throat and abdomen, these becoming more diffuse with age. All mature individuals are heavily infested with mites beneath the scales of both tail and body. Stomach contents include insect and plant material. Neither of the two mature females, taken in April, is gravid. One of the two males taken in April, and the large male (121 mm. in snout-vent length) taken in August, have clusters of callose preanal scales. The smallest specimen (38 mm. in snout-vent length) was taken in August, while the other young (39–47 mm. snout-vent length) were collected in April. Anderson (1962), after examining collections of *Agama nupta* obtained by him in southwestern Iran, in 1958, pointed out that "gravid females were collected in March, August, and October. This indicates that eggs are laid at least in the Spring and in the Autumn in this region." The collection of young specimens of *A. caucasica* in both April and August in east-central Afghanistan suggests a similar situation obtains as Anderson found in Iran.

Ablepharus pannonicus Fitzinger.

Material examined (2): 36 km. from Kabul, on road to Kandahar, at 2300 M. [April 10] (CAS 91610–91611).

Both specimens have three dark longitudinal dorsal stripes, a broader dark dorsolateral stripe, edged with white above, and a suffusion of blue on the undersides. Both have 21 longitudinal scale rows at midbody. The larger, CAS 91610, measures 36.1 mm. snout-vent length, and has a regenerated tail; the smaller measures 29.3 mm. snout-vent length, the tail measures 47.5 mm.

Eremias guttulata watsonana Stoliczka.

Material examined (6): 35 km. from Kabul, on road to Kandahar, at 2300 M. [April 30] (CAS 91612); toward Ghazni, a few km. from Shash Gao, at 2600 M. [April 15] (CAS 91599–91602); near Paghman River, 10 km. southwest of Kabul [Aug. 9] (CAS 92340).

The single female taken in April contains a few small eggs. One juvenile was obtained in August. It must be noted that of 16 specimens of this species collected by Gasperetti to date, 15 adults were taken during the months of January, February, March, and April. All but one female were found to be gravid. The one juvenile was taken in August. From previous investigations on Iranian reptiles (Anderson, 1962) it is thought that this juvenile must be about two months old (24.1 mm. snout-vent length), suggesting that the egg hatched in late May or early June. Perhaps these animals breed but once each year (see *Agama caucasica* for contrasting situation), laying their eggs in late winter or early spring, which then hatch in late spring or early summer (about 60 days incubation?).

In CAS 91599, the third supralabial on the right side is divided into two shields, one above the other. In CAS 91602, the sixth, rather than the fifth supralabial is the largest on the left side.

Snout-vent lengths: adults, 37.8–53.2 mm., juvenile, 24.1 mm; tail lengths: adults, 68.3–90.1 mm., juvenile, 40.6 mm. Dorsal scale rows, 42–47; ventral scale rows, 10; supralabials, 9–10; femoral pores, 11–13.

These specimens agree well with Gasperetti's previous series of 9 specimens from the Tarnak River area, near Kandahar (Leviton and Anderson, 1961), and do not differ significantly from 25 specimens from southwestern Iran (Anderson, 1962).

Coluber rhodorachis (Jan).

MATERIAL EXAMINED (1): 15 km. southwest of Kabul, on road to Kandahar, 2200 M. [Sept. 4] (CAS 92323).

A single specimen was taken by Gasperetti. It differs from others of this species previously reported on from Afghanistan in lacking the distinct blotches on the dorsum; rather they are small, irregular, dark patches.

Ptyas mucosus (Linnaeus).

MATERIAL EXAMINED (1): 40 km. from Kabul, along road to Kandahar, 2300 M. [Sept. 18] (CAS 92324).

A single, typical specimen of this species was taken. Only the skin and head were kept.

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INTERPRETATION OF THE INVERTEBRATE FAUNA FROM THE UPPER PLEISTOCENE BATTERY FORMATION NEAR CRESCENT CITY, CALIFORNIA

By

Warren O. Addicott
345 Middlefield Road, Menlo Park, California

This paper documents an assemblage of late Pleistocene invertebrates occurring as a basal fossiliferous lens on the Crescent City platform, an emergent wave-cut terrace on the northern California coast near the Oregon border. This is the only recorded late Pleistocene invertebrate fauna in northern California north of the San Francisco Bay district, although extensive areas of similar and probably contemporaneous wave-cut terraces occur along the coast between Crescent City and San Francisco. Fossils were collected from a sea cliff exposure west of Crescent City which is located near the southern edge of a broad marine terrace extending nearly thirty-five miles along the coast from the mouth of Smith River to a point south of Crescent City. The Crescent City fauna lived in a moderately shallow-water, nearshore-shelf environment of both rocky and sand-covered bottom. Subsequent redistribution and mixing by current or wave action brought together an assemblage of diverse ecological types. Composition of the assemblage, principally mollusks, indicates marine water temperatures not appreciably different from conditions offshore from Crescent City today. Study of topographic maps and the sailing chart of the area suggests that the fauna lived on or adjacent to a prominent northwesterly trending offshore reef which extended some seven or eight miles in a northwesterly direction from the late Pleistocene coastline.

Diller (1902) published an early account of Pleistocene terraces developed near Crescent City, in which comments by W. H. Dall concerning the stratigraphy and paleontology of Pliocene and Pleistocene deposits were presented. However, first mention of Pleistocene fossils from this area was made by Maxson (1933), who designated deposits capping the Crescent City platform as the Battery formation. Maxson did not describe or list the fauna, but did compare it with the upper San Pedro of southern California. Subsequently Back (1957), in a paper on the water resources of the Smith River plain (= Crescent City platform), noted the occurrence of four invertebrates from the Battery formation which were identified by Dr. Leo G. Hertlein.

A reconnaissance of sea-cliff exposures of the Crescent City platform and overlying deposits from Battery Point at Crescent City, northwestward some three and one-half miles to Point St. George, was made in November, 1958. The terrace platform was traced northwestward along the coast to a point where it passes beneath beach and sand dune cover near the north end of Point St. George. Fossils listed in table 1 were collected from a fossiliferous lens in sea cliffs at Crescent City. Although burrowing pelecypods, possibly *Zirfaea,* have made characteristic pockets in the terrace platform in several areas, no additional fossiliferous deposits were located in the Battery formation. However, in a subsurface study of the Battery formation made from records of wells drilled to this important local acquifer, Back (1957) states that fossil material has been recovered from basal gravels in at least one water well.

The terrace platform is eroded into rock of Mesozoic and Pliocene age. Mesozoic rocks consist principally of grey, massive, well-indurated sandstone with some pebble conglomerate. They have been identified as the Dothan formation of Jurassic age (Maxson, 1933). The Pliocene Point St. George formation is a light-grey, fossiliferous claystone containing abundant valves of *Macoma nasuta.* In the vicinity of Point St. George both formations strike northwesterly and dip toward the northeast. Dips measured in the Pliocene beds range from 12 to 20 degrees and are considerably more gentle than in the underlying Jurassic sandstone. Variation in elevation of the wave-cut terrace surface along sea cliffs west of Crescent City is largely a function of underlying rock type. On either end of Point St. George, which is formed of well-indurated Mesozoic sandstone, there is a lowering in elevation of the terrace surface where it crosses onto less resistant Pliocene claystone. Locally, this can amount to a change in elevation from around 50 feet to an average of about 20 to 25 feet. This slope has a definite northeasterly direction. It continues under the Smith River plain according to data from water wells and a seismic refraction survey in the area (Back, 1957). This inshore, northeasterly slope of the terrace platform and the southwesterly slope of the ocean floor from the nearshore zone of rocks and sea stacks, suggest that during late Pleistocene time the area from Battery Point to Point St. George was an offshore reef. The reef apparently extended several miles in a northwesterly direction from the late Pleistocene shore and may have measured up to a mile in width. Inspection of topographic maps suggests that the maximum shoreline angle of the late Pleistocene sea which eroded the Crescent City platform was between 80 and 120 feet with reference to present sea level. A portion of the highest reaches of this wave-cut terrace and the associated shoreline angle is preserved on Castle Rock located 3,000 feet offshore from the southern tip of Point St. George. This rock must have been partially emergent in late Pleistocene time, yet it was at least six miles from the shore line. Because the shoreline angle along the inner edge of the Smith River plain occurs rather uniformly at the same elevation, the apparent northeasterly slope of the terrace surface suggested by local data in the Crescent City area does not appear to be evidence of tilting or deformation of the terrace surface. Rather, it is a function of rock type and relative position from the shoreline angle.

The Battery formation is composed principally of grey, limonitic-stained sand with a basal gravel bed. In sea cliffs near the western edge of Crescent City, a basal boulder bed is developed above the beveled surface of Jurassic sandstone. Some yellow-grey sandy clay was observed in exposures in this area. The Battery formation is capped everywhere by a few feet of dark-brown soil. Scattered shell debris noted in terrace deposits at Battery Point near the foot of 6th Street was not suitable for collecting purposes. The assemblage listed in table 1 is from a sea cliff exposure on a small point near the west limits of Crescent City. This locality appears to be the same as that from which Back (1957) collected four different molluscs. The fossils occur in a lens or pocket of yellow-grey, gravelly, calcareous sand beneath a large sandstone boulder measuring nearly four feet in diameter. Most of the fossil material was badly broken and showed signs of considerable abrasion. The larger fragments and few whole specimens were fragile and extremely difficult to collect. A hundred feet or so west of this locality the terrace surface is channeled into an outcrop of dark grey to black shale. In this area, large fragile specimens of *Schizothaerus capax* were particularly abundant.

Along the boundary of the Coast Guard reservation on Point St. George, large shell mounds or kitchen middens were noted. Principal invertebrate constituents of the mounds were, in order of abundance, *Mytilus californianus, Protothaca staminea, Balanus* sp., and *Tegula funebralis.* Other forms observed were *Hinnites multirugosus, Thais lima, Thais lamellosa, Dendraster* sp., *Acmaea mitra, Acmaea* sp., and various bones.

TABLE 1. *Fossil invertebrates from the upper Pleistocene Battery formation at Crescent City, California.*

Pelecypoda

Macoma nasuta (Conrad)
Macoma irus (Hanley)
Mytilus californianus Conrad
Protothaca ruderata (Deshayes)
Protothaca staminea (Conrad)
Saxidomus giganteus (Deshayes)
Schizothaerus capax (Gould)
Zirfaea pilsbryi Lowe

Gastropoda

Acmaea persona Eschscholtz
Lepeta concentrica (Middendorf)
Margarites? sp.
Odostomia sp.
Thais lamellosa (Gmelin)

Cirripedia

Balanus cf. *B. nubilis* Darwin

Foraminifera

several unidentified species

This assemblage is dominated by large, thick-shelled pelecypods such as *Saxidomus giganteus*, *Schizothaerus capax*, and *Protothaca*. The fossiliferous lens, viewed in relationship to the basal gravels of the Battery formation in this area, unquestionably represents an assemblage brought together and modified by current or wave action. Its preservation as an isolated fossiliferous deposit within essentially barren outcrops of the Battery formation seems to be a direct result of the sheltered location in a pocket beneath a large boulder. Because of indications of considerable transportation, such as the badly fragmented and abraded condition of the shells, the apparently dominant thick-shelled pelecypods may not be truly representative of the fauna which existed at this locality during late Pleistocene time. They do represent a sand-bottom association which probably was developed upon a relatively smooth substrate of Point St. George claystone, a large area of which adjoins the fossil locality to the northwest. Invertebrates which characteristically inhabit areas of rocky ocean bottom along the open coast are represented by *Acmaea persona*, *Mytilus californianus*, *Margarites?* sp., *Lepeta concentrica*, and *Balanus* cf. *B. nubilis*. It is probable that the two ecological groups lived in close proximity, the rocky bottom forms living on the reef and the pelecypod association on a relatively flat sandy bottom adjoining the reef. This condition appears to be repeated today offshore from Crescent City. Water depth in the area during late Pleistocene time was no greater than about 80 feet judging from the apparent difference of elevation between the terrace platform and the shoreline angle.

Analysis of late Pleistocene water temperatures requires a relatively large number of species in order to be reliable. However, from the general aspect of the small association from the Battery formation it appears that marine water temperatures during the late Pleistocene were not significantly different from those occurring offshore today. With the exception of one gastropod, *Lepeta concentrica*, all species have geographic ranges along the Pacific Coast of North America which include the Crescent City area. The extra-limital species, according to Burch (1945), ranges as far south as the Puget Sound area in Washington, a few hundred miles to the north. It seems doubtful to the writer that this can be construed to indicate cooler water temperatures during the late Pleistocene than at present for two reasons. First, temperature data presented by Ricketts and Calvin (1948), show that the waters of Puget Sound, a vast protected inland body of marine water, are not significantly cooler than waters offshore from Crescent City in spite of the higher latitude. In fact, the northern California and Oregon coast is a well known area of seasonal upwelling of cold water which creates a strong anomaly in the northerly thermal gradient along the Pacific Coast. Second, there is the possibility that collecting has not been adequate to conclusively establish the southern endpoint of range of this gastropod.

The Crescent City fauna is the only recorded occurrence of marine late Pleistocene invertebrates between the San Francisco district (Arnold, 1903, Dickerson, 1922, Weaver, 1949, Johnson, 1962) and Cape Blanco in southern Oregon (Diller, 1903 and Martin, 1916). An identified fauna of more than 40 invertebrate species from the late Pleistocene terrace deposits at Cape Blanco (Addicott, in press), is similar in aspect to the fauna from the Battery formation at Crescent City. However, extensive collections from Tomales Bay, located 30 miles north of San Francisco, represent a protected coast environment with an element of warm water mollusks. Species comprising this element are restricted geographically to areas south of Point Conception today. Although there are many areas between the San Francisco district and Crescent City in which elevated marine terraces are well developed (Higgins, 1961), no marine fossils have been reported from them. There are, however, many indications of mollusk borings in the surfaces of wave-cut terrace platforms along the Sonoma County coast in northern California (Bauer, 1952). This is an anomalous condition with reference to the widespread, abundantly fossiliferous mantle of contemporaneous marine terraces along the southern California and Baja California coast described by Valentine (1961) and others. It also differs from shallow-water conditions offshore from the local area today, judging from the commonly occurring shells along northern California beaches cast up by heavy surf and storm waves. The probable explanation is that modification and redistribution of originally fossiliferous deposits by wave or current action was so extreme as to destroy most obvious traces of fossils or to concentrate them in local areas which are concealed beneath nonmarine deposits covering these terraces.

The age assignment of late Pleistocene for the Battery formation is based upon the modern aspect of the fossil assemblage, the apparent absence of deformation, and comparison with similar and probably contemporaneous emergent wave-cut terraces along the Pacific Coast from Mexico to Canada which locally, at least, can be demonstrated to be post lower Pleistocene.

LOCALITY DESCRIPTION

Exposure in sea cliff 600 feet west of the intersection of Modoc Street and Airport Drive at the western limits of Crescent City, Del Norte County, California (NW. quarter of the NE. quarter, section 30, T. 16 N., R. 1 W., Humboldt Base and Meridian, Crescent City quadrangle). Lens of fossiliferous sand overlying truncated surface of grey weathering, hard Mesozoic sandstone approximately 22 feet above sea level. Collected November, 1958, by the author.

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NEW AND RARE DIATOMS FROM OREGON AND WASHINGTON

By

H. E. Sovereign
7227 Sixth Avenue Northwest, Seattle 7, Washington, U.S.A.

During the examination of a large number of samples of diatom-bearing material collected from the inland waters of the Pacific Northwest, many forms were encountered which did not appear to have been described in the literature. As the listing of all of the forms found in the samples would result in a very large work, it has been thought expedient to describe the new ones and to include certain known ones which have seldom been mentioned in diatom literature.

The term "Pacific Northwest" as used in this paper includes the states of Oregon and Washington with narrow strips of adjacent Idaho and California. The Cascade Mountain Range divides the area into a relatively arid eastern part where, in general, irrigation is required for the successful annual production of crops, and a well watered western part where irrigation is not normally practiced. During the last glacial period the continental ice advanced into the northern part of the states of Idaho and Washington. The glaciated area is well supplied with lakes, bogs, and meadows which latter mark the sites of former lakes. South of the terminal line of the glacial ice, lakes are present but are relatively rare.

Many of the northern lakes of western Washington are acid or neutral in nature; most of the lakes of the arid part east of the Cascade Mountains are alkaline, sometimes exceedingly so. A large number of lakes of eastern Washington and Oregon have no normal outlet, the elevation of the water surface being controlled by evaporation. Where the alkalinity has been increased by evaporation, the salinity has also been correspondingly increased and many of the alkaline lakes support brackish or even marine forms. Some of the alkaline lakes of eastern Washington evaporate occasionally to complete dryness in the summer, yet as soon as winter's snows melt and some of the salts dissolve, one can find a diatom flora. The Columbia basins and plateaus extend from the Cascade Range eastward and form one of the largest areas of volcanic rock on the earth's surface, covering more than 200,000 square miles. The surface of the basalt has been warped downward into basins and upward to form plateaus. At the end of the glacial period melt water in inconceivable quantities from the diverted Columbia River flowed across the surface of the land in central Washington, removing not only all of the soil in its path and eroding the basalt surface, but actually plucking and sweeping away house sized pieces of rock. The basins thus formed vary in size from small ponds to lakes several miles in length.

Many of the lakes formed by plucking have no normal outlet and the water level is maintained by evaporation. The basalt rock, in general, is much fractured, and many of the basin lakes are fed by springs with water of about pH 9.0, the alkalinity being mainly due to carbonates.

Since the beginning of irrigation at the Grand Coulee Project in central Washington, seepage water from the canals and irrigated fields has much diluted several of the alkaline lakes, so much so that it will no longer be possible to duplicate the samples of diatom material collected from these lakes in the past.

Fossil diatom deposits ranging in age from late Miocene to post Glacial are common in the whole area. The Pacific Northwest has a great variety of habitats which support a large number of species of diatoms.

Cyclotella gamma Sovereign, new species.
(Figures 1, 2.)

HOLOTYPE, no. 3477 and paratype no. 3478 (California Academy of Sciences, Department of Geology Type Collection), from Lake Killebrew, Orcas Island, San Juan County, Washington. *p*H 7.4 to 8.8.

DESCRIPTION. Frustula rotunda, tympanoides, diametro 18–33 μ. Zona marginalis valvarum costis radialibus in interiore parte membrani 5–7 in 10 μ; poroidum in exteriore parte membrani super interioribus costis. Media pars valvae ½ diametrum valvae, uno vel pleuribus magnis foraminibus longe media valva.

Cells circular, drumshaped, 18 to 33 μ in diameter. The marginal zone of the valves has radial costae on the inner side of the membrane (like *Pinnularia*) 5 to 7 in 10 μ; on the exterior of the membrane are radial rows of poroids upon the interior costae.

Openings of the inner compartments of the costae form a small circular band crossing the costae. The median area is about half the diameter of the valve, is tangentially waved and one or more large pores are located at a distance from the center.

Achnanthes prava Sovereign, new species.
(Figures 3, 4.)

Holotype, no. 3479 (California Academy of Sciences, Department of Geology Type Collection), from Crescent Lake, Klamath County, Oregon, *p*H 8.0. Elevation 4840 feet above sea level. Fairly plentiful in the sample.

Description. Valvae ellipticae, 16–24 μ longae, 9–11 μ latae. Rhaphovalva, rhaphe recta, filiformis, area axialis lanceolata obliqua, area centralis rectangularis. Striae transapicales radiantes 24–27 in 10 μ. Aerovalva, area axialis modice lanceolata, striae radiantes 22–24 in 10 μ.

Valves elliptical 16 to 24 μ long by 9 to 11 μ wide. Raphe valve with straight threadlike raphe; axial area lanceolate, somewhat irregular in outline, with the axis at an angle of from 6 to 8 degrees from the axial line of the elliptical outline. Central area a transverse fascia normal to the oblique axis but not reaching to the margin of the valve. Striae radial 24 to 27 in 10 μ. Rapheless valve with axial area not oblique, slightly widened at the middle and somewhat irregular in outline. Striae radial 22 to 24 in 10 μ, sometimes changing direction abruptly at the transverse axis.

Frustulia rhomboides form **occidentalis** Sovereign, new form.

Holotype, no. 3480 (California Academy of Sciences, Department of Geology Type Collection), from Water Supply Spring, Crater Lake National Park, Oregon. *p*H 8.8 to 7.2. Elevation 6100 to 6500 feet above sea level. Also found at Wheeler and Munson Creeks, Crater Lake National Park.

Description. Differet a typo frustula longiore, strii plus remotis.

The form differs from the type only by its large size and coarser structure, 176 to 245 μ long by 30 to 32 μ wide. Transverse striae are 20 to 24 in 10 μ, longitudinal lines 18 to 22 in 10 μ. Classical descriptions of *F. rhomboides* (Ehrenberg) de Toni, give 160 μ as the maximum length. On a strewing from the water supply spring at Crater Lake National Park four specimens of type size were observed and 26 specimens of form *occidentalis.*

Neidium inconstans Sovereign, new species.
(Figure 13.)

Holotype, no. 3481 (California Academy of Sciences, Department of Geology Type Collection), from Finnel Lake, Adams County, Washington. *p*H 9.0. Elevation 1800 feet approximately.

Description. Valvae lanceolatae apicibus capitatis, 46–54 μ longae, 12–14 μ latae. Area axialis lanceolate angusta, area centralis rectangularis. Rhaphe recta, filiformis, striae plerum radiantes punctatae 12–14 in 10 μ.

Valves lanceolate with capitate ends, somewhat triundulate in outline, 46 to 54 μ long by 12 to 14 μ wide. Axial area very narrow lanceloate, central area an inclined transverse rectangle which does not extend to the valve margin. Raphe straight, threadlike, with central pores hooked in opposite directions. Striae in most individuals are radial, sometimes becoming convergent toward the poles; in some cases the striae bordering the central area are parallel to the inclined central area. Striae are plainly punctate and are crossed by a line near the margin, 12 to 14 in 10 μ.

Neidium Hitchcockii form **teres** Sovereign, new form.

(Figure 12.)

Holotype, no. 3482 (California Academy of Sciences, Department of Geology Type Collection), from Ozette Lake, Callam County, Washington. *p*H 6.8 to 7.0.

Description. Differet a typo valvis teretibus non undulatis, 41–65 μ longae, 15–18 μ latae. Striae transapicales 19–22 in 10 μ.

Valves linear with cuneate sharply rounded ends, 41 to 65 μ long by 15 to 18 μ wide. Striae 19 to 22 in 10 μ, puncta in striae rows 15 to 20 in 10 μ. The principal departure from the type shape is that the valves are not triundulate in outline but smooth. However, every gradation in shape from plainly triundulate to completely smooth margins can be found in the samples, form *teres* being the ultimate form of the variation.

Navicula contortula Sovereign, new species.

(Figure 7.)

Holotype, no. 3483 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. *p*H 7.2.

Description. Valvae lanceolatae cuneatis, 13–19 μ longae, 7–8 μ latae. Area axialis lanceolata angusta, area centralis parva. Rhaphe recta, filiformis. Striae radiantes 13 in 10 μ prope apices costa longitudinali brevissime interruptae.

Valves lanceolate with cuneate rounded ends, 13 to 19 μ long by 7 to 8 μ wide. Axial area narrow lanceolate, central area small. Rhape straight, threadlike. Striae radial throughout 13 in 10 μ at the middle. At each end of the valve are special structures on each side of the raphe which are dash shaped and parallel to the raphe, replacing the terminal pair of striae. The structure of *N. contortula* should be compared with *N. tecta* Krasske in A.

Schmidt Atlas, pl. 403, figs. 35–36 but the polar structure of *N. contortula* is much simpler than *N. tecta.*

Navicula evexa Sovereign, new species.
(Figures 5, 6.)

Holotype, no. 3484 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. *p*H 7.2.

Description. Valvae elliptico-lanceolatae, apicibus obtuse rotundatis, 14–26 μ longae, 5–6 μ latae. Area axialis recta angusta, area centralis parva. Rhaphe recta, filiformis. Striae in medio leniter radiantes, subapicibus ad lineam mediam fere perpendiculares 28 in 10 μ.

Valves elliptico-lanceolate, the longest individuals being linear-lanceolate; ends broadly rounded, 14 to 26 μ long by 5 to 6 μ wide. Axial area very narrow, central area very small. Raphe straight, threadlike, terminal pores comma shaped in a small polar area, central pores distant. Striae slightly radial becoming parallel at the valve ends about 28 in 10 μ, indistinctly punctate. *N. evexa* is superficially like *N. exilissima* Grunow but much larger and more coarsely striated.

Navicula Kincaidii Sovereign, new species.
(Figure 11.)

Holotype, no. 3485 (California Academy of Sciences, Department of Geology Type Collection), from Vidae Fall, Crater Lake National Park, Oregon. *p*H 6.8. Elevation 6500 feet.

Description. Valvae lineares constrictae in medio, apicibus cuneatis, 38–43 μ longae, 10–12 μ latae. Area axialis lanceolata angusta, area centralis rectangularis transversa. Rhaphe filiformis. Striae radiantes 10–15 in 10 μ in medio, apicibus 19 in 10 μ, delicatissime lineolatae.

Valves linear, transapically constricted with tapering bluntly rounded ends, 38 to 43 μ long by 10 to 12 μ wide in the middle. Axial area narrow lanceolate abruptly expanded to form a transverse central area which does not reach the margin. Raphe threadlike with widely spaced central pores turned to one side. Striae radial throughout 10 to 15 in 10 μ at the middle and about 19 in 10 μ at the ends, delicately lineolate about 30 in 10 μ. The striae in the central part of the valve are curved with the concave side toward the center of the valve.

Remarks. After having seen a specimen of this form, Dr. Friedrich Hustedt of Bremen, Germany, the present editor of the Schmidt Atlas der Diatomaceenkunde, sent me a pencil sketch made by A. Schmidt over 85 years ago.

NOTE: Magnification of the figures is 1000:1 unless otherwise stated.

FIGURE 1. *Cyclotella gamma* Sovereign, new species. (Internal view.) Holotype, no. 3477 (California Academy of Sciences, Department of Geology Type Collection), from Lake Killebrew, Orcas Island, San Juan County, Washington. Page 350.

FIGURE 2. *Cyclotella gamma* Sovereign, new species. (Partial exterior view.) Paratype no. 3478 (California Academy of Sciences, Department of Geology Type Collection), from Lake Killebrew, Orcas Island, San Juan County, Washington. Page 350.

FIGURES 3, 4. *Achnanthes prava* Sovereign, new species. Holotype, no. 3479 (California Academy of Sciences, Department of Geology Type Collection), from Crescent Lake, Klamath County, Oregon. Page 351.

FIGURES 5, 6. *Navicula evexa* Sovereign, new species. Holotype, no. 3484 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. Magnification 2000:1. Page 353.

FIGURE 7. *Navicula contortula* Sovereign, new species. Holotype, no. 3483 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. Magnification 2000:1. Page 352.

FIGURES 8, 9. *Navicula pseudosilicula* variety *olympica* Sovereign, new variety. Holotype, no. 3486 (California Academy of Sciences, Department of Geology Type Collection), from Mud Springs, Waterhole Camp, Olympic National Park, Clallam County, Washington. Page 358.

FIGURE 10. *Navicula rainierensis* Sovereign, new species. Holotype, no. 3487 (California Academy of Sciences, Department of Geology Type Collection), from Ohanapecosh Hot Springs, Spring "F," Mount Rainier National Park, Washington. Page 358.

FIGURE 11. *Navicula Kincaidii* Sovereign, new species. Holotype, no. 3485 (California Academy of Sciences, Department of Geology Type Collection), from Vidae Falls, Crater Lake National Park, Oregon. Page 353.

FIGURE 12. *Neidium Hitchcockii* from *teres* Sovereign, new form. Holotype, no. 3482 (California Academy of Sciences, Department of Geology Type Collection), from Ozette Lake, Clallam County, Washington. Page 352.

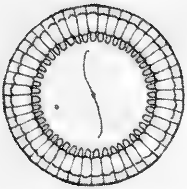
FIGURE 13. *Neidium inconstans* Sovereign, new species. Holotype, no. 3481 (California Academy of Sciences, Department of Geology Type Collection), from Finnel Lake, Adams County, Washington. Magnification 500:1. Page 351.

FIGURE 14. *Pinnularia pluviana* Sovereign, new species. Holotype, no. 3495 (California Academy of Sciences, Department of Geology Type Collection), from Finnel Lake, Adams County, Washington. Page 362.

FIGURE 15. *Pinnularia makahana* Sovereign, new species. Holotype, no. 3489 (California Academy of Sciences, Department of Geology Type Collection), from Shadow Lake, King County, Washington. Page 359.

FIGURE 16. *Pinnularia nubila* Sovereign, new species. Holotype, no. 3490 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. Page 360.

FIGURE 17. *Pinnularia convexa* Sovereign, new species. Holotype, no. 3488 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. Page 359.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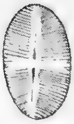
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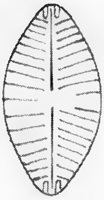
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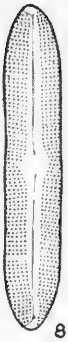
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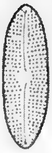
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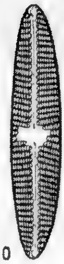
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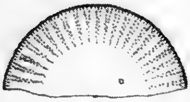
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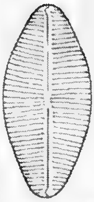
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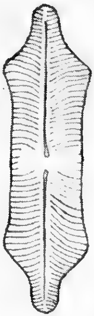
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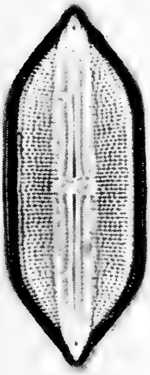
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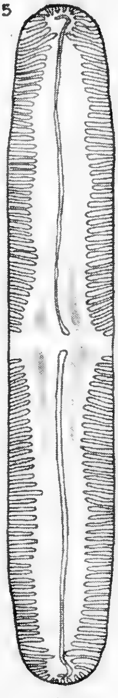
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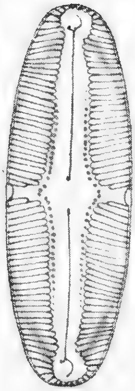
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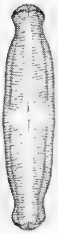
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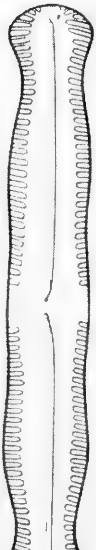
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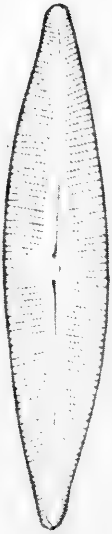
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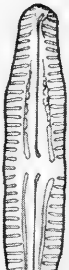
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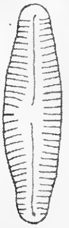
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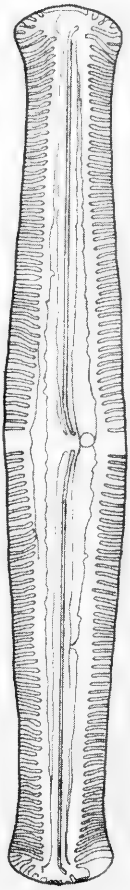
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FIGURE 18. *Pinnularia palousiana* Sovereign, new species. Holotype, no. 3491 (California Academy of Sciences, Department of Geology Type Collection), from near Vantage, Grant County, Washington. Early Pliocene fossil. Page 360.

FIGURE 19. *Pinnularia subpalousiana* Sovereign, new species. Holotype, no. 3492 (California Academy of Sciences, Department of Geology Type Collection), from Haney Meadow, 15 miles east of Liberty, Kittitas County, Washington. Page 361.

FIGURE 20. *Cymbella rainierensis* Sovereign, new species. Holotype, no. 3498 (California Academy of Sciences, Department of Geology Type Collection), from Mowich Lake, Mount Rainier National Park, Washington. Page 363.

FIGURE 21. *Cymbella couleensis* Sovereign, new species. Holotype, no. 3497 (California Academy of Sciences, Department of Geology Type Collection), from Deep Lake, Grand Coulee State Park, Grant County, Washington. Page 363.

FIGURES 22–24. *Denticula rainierensis* Sovereign, new species. Holotype, no. 3499 (California Academy of Sciences, Department of Geology Type Collection), from Ohanapecosh Hot Springs, Spring "F," Mount Rainier National Park, Washington. Page 364.

FIGURE 25. *Pinnularia obtusa* Sovereign, new species. Holotype, no. 3493 (California Academy of Sciences, Department of Geology Type Collection), from Stevens Pass, King County, Washington. Page 361.

FIGURE 26. *Pinnularia platycephala* form *ornata* Sovereign, new form. Holotype, no. 3494 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. Page 362.

FIGURE 27. *Pinnularia umbrosa* Sovereign, new species. Holotype, no. 3496 (California Academy of Sciences, Department of Geology Type Collection), from Shadow Lake, King County, Washington. Page 363.

FIGURES 28, 29. *Nitzschia dissapata* form *undulata* Sovereign, new form. Holotype, no. 3501 (California Academy of Sciences, Department of Geology Type Collection), from Lake Louise, Mount Rainier National Park, Washington. Page 365.

FIGURES 30–32. *Nitzschia perspicua* Sovereign, new species. Holotype, 3502 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. Page 365.

FIGURES 33–35. *Nitzschia bella* Sovereign, new species. Holotype, no. 3500 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. Page 364.

FIGURE 36. *Nitzschia bella* Sovereign, new species. Holotype, no. 3500. Magnification 2000:1. Page 364.

FIGURE 37. *Stenopterobia intermedia* form *undulata* Sovereign, new form. Holotype, no. 3503 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. Page 365.

FIGURE 38. *Stenopterobia intermedia* form *undulata* Sovereign, new form. Holotype, no. 3503. Magnification 2000:1. Page 365.

FIGURES 39, 40. *Surirella beadensis* Sovereign, new species. Holotype, no. 3504 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. Magnification 500:1. Page 365.

FIGURE 41. *Surirella parma* Sovereign, new species. Holotype, no. 3505 (California Academy of Sciences, Department of Geology Type Collection), from Water Supply Spring, Crater Lake National Park, Oregon. Magnification 500:1. Page 366.

FIGURE 42. *Gomphonema Hedini* Hustedt. Hypotype, no. 3506 (California Academy of Sciences, Department of Geology Type Collection), from Narada Falls, Mount Rainier National Park, Washington. Page 366.

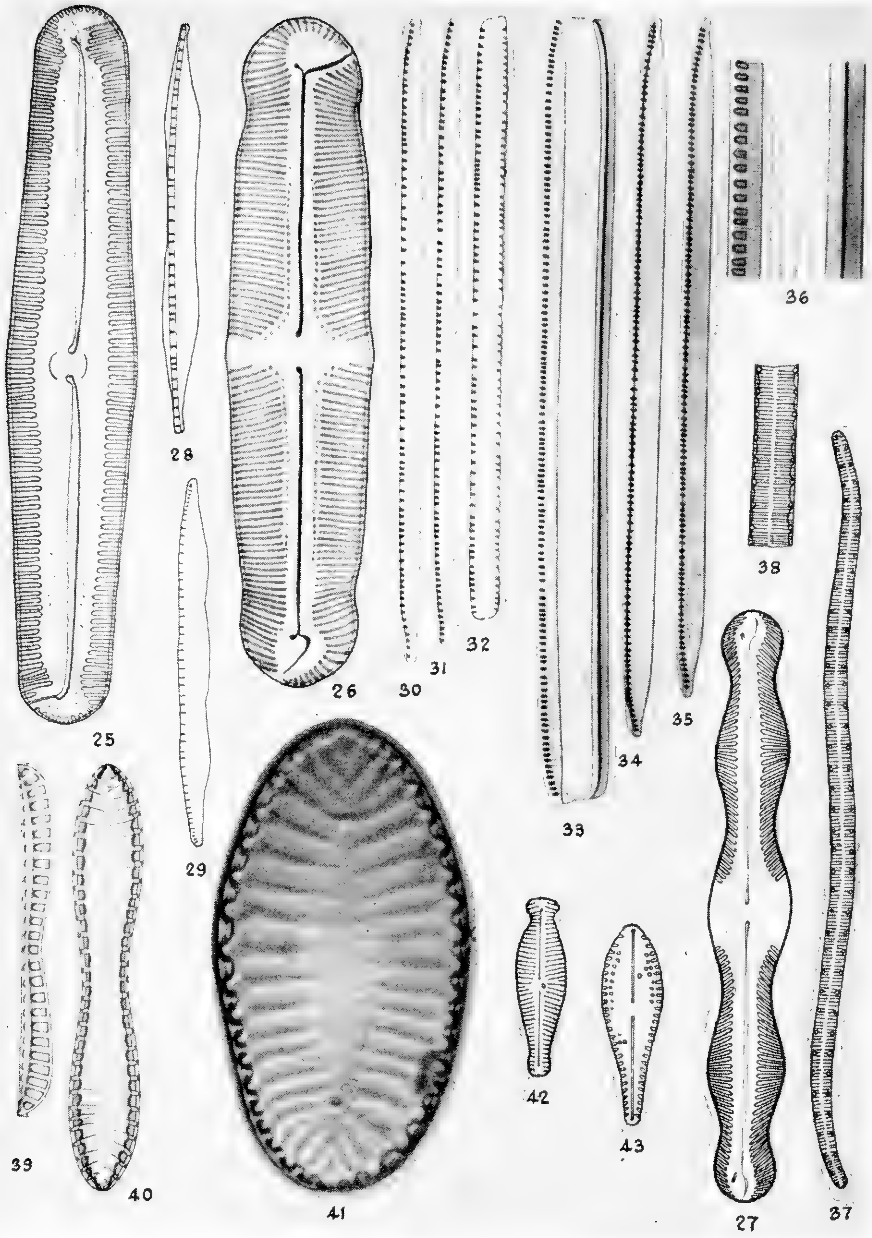

FIGURE 43. *Gomphonema Grovei* M. Schmidt. Hypotype no. 3507 (California Academy of Sciences, Department of Geology Type Collection), from Little Spokane River, Spokane County, Washington. Page 367.

The author is greatly indebted to Dr. Friedrich Hustedt of Bremen for making the drawings for the following figures: 8–10, 13–15, 20, 22–24, 27, 30 36, 39, 40.

Dr. Hustedt wrote that Schmidt's sketch was made from a slide in the collection of Weissflog of fossil material originating in Kamtschatka and was determined as a new species of *Stauroneis;* and it was given a name by Grunow which was never published. This is still another Asiatic form found in the Pacific Northwest.

Dedicated to Professor Trevor Kincaid who furnished me with my first collections of Pacific Northwest diatoms.

Navicula pseudosilicula variety **olympica** Sovereign, new variety.
(Figures 8, 9.)

Holotype, no. 3486 (California Academy of Sciences, Department of Geology Type Collection), from Mud Springs, Waterhole Camp, Olympic National Park, Clallam County, Washington. *p*H 6.8. Elevation 5500 feet.

Description. Valvae lineares, apicibus obtuse cuneatis, 21–47 μ longae, 6–8 μ latae. Area axialis anguste lanceolata, area centralis plus minusve irregulariter elliptica. Rhaphe recta, filiformis, vel flexis poris centralibus distantibus. Striae transapicales radiantes, interdum in apicibus ad lineam mediam perpendiculares 12–13 in 10 μ, distincte punctatae, punctis circum 20 in 10 μ.

Valves linear with cuneate rounded ends, margins slightly triundulate, 21 to 47 μ long by 6 to 8 μ wide. Axial area narrow lanceolate, central area irregular elliptical. Raphe threadlike, slightly curved, central pores distant. Striae radial infrequently becoming parallel at the ends, 17 to 19 in 10 μ, plainly punctate, the puncta spaced about 20 in 10 μ.

Remarks. According to Hustedt (1942), the type form is found in northern Europe and in the Alps. It is very triundulate in outline and has not been found thus far in the Pacific Northwest.

Navicula rainierensis Sovereign, new species.
(Figure 10.)

Holotype, no. 3487 (California Academy of Sciences, Department of Geology Type Collection), from Ohanapecosh Hot Springs, Spring "F," Mount Rainier National Park, Washington. Temperature 72° F., *p*H 7.2. Elevation 2100 feet.

Description. Valvae elliptico-lanceolatae apicibus obtusis rotundatis, 27–32 μ longae, 7–8 μ latae. Area axialis anguste linearis, area centralis plus minusve transapicaliter dilatata. Rhaphe rectis, filiformis, poris centralibus modice distantibus. Striae transapicales 12–13 in 10 μ, in media parte radiantes apicibus convergentes distincte lineolatae, lineolis circiter 29 in 10 μ.

Valves elliptico-lanceolate with bluntly rounded ends, 27 to 32 μ long by 7 to 8 μ wide. Axial area narrow linear, central area more or less transverse elliptical, somewhat asymmetrical. Raphe straight, threadlike, central pores somewhat distant. Striae radial at the center becoming convergent at the ends 12 to 13 in 10 μ, plainly lineolate with lineolations at about 29 in 10 μ.

Pinnularia convexa Sovereign, new species.
(Figure 17.)

Holotype, no. 3488 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. *p*H 6.7. Elevation 4250 feet. Locality is known locally as "Sheep Lake."

Description. Frustula valde convexa, in apicibus planis. Valvae ellipticae, 105–162 μ longae, 25–32 μ latae. Area axialis lanceolata, area centralis transapicaliter dilatata. Striae transapicales radiantes in medio in apicibus convergentes 5.9–6.6 in 10 μ, poris ornatis in area axialis.

Valves elliptical with broadly rounded ends, 105 to 162 μ long by 29 to 35 μ wide. Valve surface very convex and abruptly flattened at the poles, the very convex valve surface being lanceolate. Raphe slightly curved, threadlike, central pores wide apart, polar terminals comma shaped. Axial area lanceolate, central area a narrow transverse fascia. Costae radial at the center becoming convergent at the valve ends and going around the end of the valve leaving a circular polar area, spaced 5.9 to 6.6 in 10 μ near the middle of the valve. Circular ornata markings are located in the axial area.

Remarks. *Pinnularia convexa* is very similar to *P. divergens* var. *elliptica* Grunow, but differs in having a relatively wider axial area and much coarser costae spacing. The main difference, however, is in the sculpturing of the surface of the valves at the ends. Some fossil forms of *Pinnularia* from Lower Pliocene deposits show a tendency toward flattened valve ends but not to the extent shown on *P. convexa*. In both *P. convexa* and *P. divergens* the membrane is thickened on the margins at the transapical axis.

Pinnularia makahana Sovereign, new species.
(Figure 15.)

Holotype, no. 3489 (California Academy of Sciences, Department of Geology Type Collection), from Shadow Lake, King County, Washington. *p*H 6.8 to 7.2. Also found in other lowland lakes.

Description. Valvae lineari-triundulatae apicibus rotundatis capitatis, 57–81 μ longae, 11–12 μ latae. Area axialis latissime lanceolata, area centralis nulla. Rhaphe simplex, poris centralibus approximatis, fissuris terminalibus recurvatis. Striae transapicales breves, leniter radiantes apicibus convergentes 8–10 in 10 μ.

Valves linear with bluntly rounded ends, margins usually bigibbous or triundulate, 57 to 81 μ long by 11 to 12 μ wide. Axial area very wide lanceolate, generally about ¾ the valve width. Raphe simple, bent to one side to pores in a central nodule, terminal pores comma shaped. Costae marginal about 8 in 10 μ, radial in the middle where they are sometimes interrupted on one or both sides, becoming slightly convergent at the valve ends where they do not completely enclose the polar area. Resembles *P. acrosphaeria* Brébisson but is more closely marked and lacks the pebbled axial area.

Pinnularia nubila Sovereign, new species.
(Figure 16.)

Holotype, no. 3490 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. *p*H 7.6. Elevation 4250 feet.

Description. Valvae lineari-lanceolatae latissimae rotundatis, 82–100 μ longae, 14–15 μ latae. Area axialis latissima lanceolata, area centralis rectangularis, parva transversa. Striae transapicales leniter radiantes in medio apicibus convergentes 8–10 in 10 μ. Areis nubilis circum aream centralem.

Valves linear-lanceolate with broadly rounded ends, 82 to 100 μ long by 14 to 15 μ wide. Axial area very wide, generally more than ½ the valve width, central area formed by the omission of two or three costae, one more on the side opposite the central nodule than the other. Four symmetrically placed shadow marks surround the central area. Costae lightly radial at the center becoming somewhat convergent at the poles, 8 to 10 in 10 μ.

Pinnularia palousiana Sovereign, new species.
(Figure 18.)

Holotype, no. 3491 (California Academy of Sciences, Department of Geology Type Collection), from near Vantage, Grant County, Washington. Early Pliocene fossil. Also found in other diatomite deposits in Grant and Adams Counties, especially in the "Pot Holes" area near Vantage.

Description. Valvae lineari-lanceolatae apicibus capitatis rotundatis, 74–126 μ longae, 14–18 μ latae. Area axilis latissima, area centralis transapicaliter dilatata. Rhaphe recta inter costas longitudinales validas posita, filiformis; poris centralibus modice approximatis. Costae transapicales 9–10 in 10 μ in medio leniter radiantes apicibus convergentes.

Valves linear-lanceolate with broadly rounded capitate ends, 74 to 126 μ long by 14 to 18 μ wide. Axial area very wide, about one-half the width of the valve, somewhat wider at the middle of the valve. Raphe straight, threadlike, with central pores bent to one side toward a small central nodule, ends bent toward the same side in transverse elliptical polar areas. Costae 9 to 10 in 10 μ, short, lightly radial at the middle becoming convergent at the ends where they are sigmoid. Costae are interrupted in the middle to form a narrow transverse central area. There are ridges parallel to and on each side of the raphe which lies in shallow trough between them. The ridges are widest in the middle and taper toward the poles, sometimes not reaching the full length of the axial area.

Pinnularia subpalousiana Sovereign, new species.
(Figure 19.)

Holotype, no. 3492 (California Academy of Sciences, Department of Geology Type Collection), from Haney Meadow, 15 miles east of Liberty, Kittitas County, Washington. *p*H 6.2. Elevation 5500 feet. Also found in a few other high mountain lakes in Washington.

Description. Valvae lineares, aliquando leniter triundulatae, apicibus rostratis late rotundatis, 33–50 μ longae, 7–9 μ latae. Area axialis lata. Area centralis orthogonica transversa, aliquando asymmetrica. Rhaphe directa, filiformis, inter costis longitudinales validas posita, poris centralibus modice approximatis. Costae transapicales fere 9–10 in 10 μ, in medio leniter radiantes apicibus convergentes.

Valves linear, sometimes slightly triundulate, with broadly rounded rostrate ends, 35 to 50 μ long by 7 to 9 μ wide. Axial area lanceolate, widened at the center. Raphe straight, threadlike, central pores bent to one side and terminal pores toward the same side in small circular areas. Costae radial at the middle becoming convergent at the ends, about 9 in 10 μ; interrupted at the center on one or both sides. There are ridges in the axial area on each side of the raphe which lies in a shallow trough. The ridges are widest at the center of the valve and rarely extend to the ends of the axial area and are frequently interrupted. This species is similar in structure to *P. palousiana* but is specifically different in size, outline and details of ornamentation.

Pinnularia obtusa Sovereign, new species.
(Figure 25.)

Holotype, no. 3493 (California Academy of Sciences, Department of Geology Type Collection), from a rill in a boggy meadow at the summit of Stevens Pass, King County, Washington. *p*H 5.8. Elevation 4100 feet.

Description. Valvae lanceolatae apicibus obtuse rotundatis, 72–137 μ longae, 12–18 μ latae. Area axialis latissima lanceolata, maculata, area centralis non aucta. Rhaphe simplex, poris centralibus approximatis, fissuris terminalibus in contraris directiones recurvatis. Striae transapicales leniter radiantes, in apicibus ad lineam mediam fere perpendiculares, 8–9 in 10 μ.

Valves lanceolate with very broad rounded ends, 72 to 137 μ long by 12 to 18 μ wide. Axial area lanceolate, over half the valve width and lightly pebbled over its entire length; central area not developed. Raphe broad, simply inclined, central pores proximate and turned toward a central nodule; terminal pores in large polar areas and turned in opposite directions and extending to the valve margin. Costae slightly radial in the middle becoming parallel at the ends, 8 to 9 in 10 μ.

Pinnularia platycephala form **ornata** Sovereign, new form.

(Figure 26.)

Holotype, no. 3494 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. *p*H 6.7. Elevation 4250 feet. Also found in No Name Lake, Pend Oreille County, Washington. *p*H 7.7. Elevation 3250 feet.

Description. Differet a typo punctis ornatis in area axiali.

The form differs from the type in being relatively wider, the striae somewhat coarser, and by having a series of puncta in the axial area opposite the striae about two thirds the length of the valve forming the arrangement called "ornata" markings. Length 96 μ, width 21 μ, costae 10 in 10 μ. The diatom is very rare in samples wherever found.

Remarks. The commonly named "ornata" markings appear on several forms of *Pinnularia* but in no case can be considered as a specific feature or even the basis for a variety. Grunow evidently agreed with this idea as in Cleve's Synopsis of Naviculoid Diatoms, Part II, p. 79, is listed *P. divergens "Forma ornata* Grun." However on the facing p. 78 Cleve listed *P. legumen* "var. *ornata Cl."* about which he writes: "Central area a transverse fascia with a row of puncta on each side of the central nodule . . ."

Pinnularia pluviana Sovereign, new species.

(Figure 14.)

Holotype, no. 3495 (California Academy of Sciences, Department of Geology Type Collection), from Finnel Lake, Adams County, Washington. *p*H 9.0. Elevation 1800 feet approximately.

Description. Valvae lanceolatae, marginibus undulatis, apicibus rotundatis, 31–40 μ longae, 8–9 μ latae. Area axialis lanceolata, area centralis quadrata. Rhaphe recta, poris centralibus distantibus. Costae transapicales valde radiantes in media parte apicibus convergentes, 8–10 in 10 μ.

Valves lanceolate with broadly rounded rostrate ends, margins triundulate, 31 to 40 μ long by 8 to 9 μ wide. Axial area wide lanceolate, central area a broad transverse rectangle. Raphe straight, central pores distant and turned to one side, terminal pores comma shaped in large polar areas. Costae radial in the middle becoming convergent at the ends, 8 to 10 in 10 μ.

Pinnularia umbrosa Sovereign, new species.
(Figure 27.)

Holotype, no. 3496 (California Academy of Sciences, Department of Geology Type Collection), from Shadow Lake, King County, Washington. *p*H 6.5. Also found in Ozette Lake, Clallam County, Washington. *p*H 7.0.

Description. Valvae lineari-triundulatae apicibus rotundatis capitatis, 70–85 μ longae, 11–12 μ latae. Area axialis linearis, area centralis rectangularis transversa. Duo aeris nubilis circum arem centralem. Costae valde radiantes in media parte, apicibus convergentes 10–11 in 10 μ.

Valves linear triundulate with rounded capitate ends, 70 to 85 μ long by 11 to 12 μ wide. Axial area linear, central area large rectangular reaching to the valve margin. Raphe straight, simple, with comma shaped polar fissures. Costae strongly radial in the middle becoming strongly convergent at the poles, 10 to 11 in 10 μ. There are two shadow marks, one on each side of the middle area.

Cymbella couleensis Sovereign, new species.
(Figure 21.)

Holotype, no. 3497 (California Academy of Sciences, Department of Geology Type Collection), from Deep Lake, Grand Coulee State Park, Grant County, Washington. *p*H 8.8.

Description. Valvae naviculoidae, leniter asymmetricae, margine dorsali leniter convexa, margine ventrali plus convexa, apicibus rostratis rotundatis, 25–31 μ longae, 7–10 μ latae. Rhaphe recta, filiformis, non excentrica, fissuris terminalibus ad marginem dorsalem versis. Striae in media parte radiantes, apicibus parallelae, 10–13 in 10 μ.

Valves naviculoid, slightly asymmetrical, dorsal margin slightly convex, ventral margin more convex, with rostrate rounded ends, 25 to 31 μ long by 7 to 10 μ wide. Raphe straight, threadlike, not excentric, terminal fissures turned toward the dorsal margin. Striae radial at the middle becoming parallel at the poles, 10 to 13 in 10 μ.

Cymbella rainierensis Sovereign, new species.
(Figure 20.)

Holotype, no. 3498 (California Academy of Sciences, Department of Geology Type Collection), from Mowich Lake, Mount Rainier National

Park, Washington. *p*H 5.8 to 7.2. Also found in over a dozen high mountain lakes of the region.

DESCRIPTION. Valvae naviculoidae fere aequales, lanceolatae apicibus rotundatis, 42–79 μ longae, 13–16 μ latae. Area axialis lanceolata angusta, area centralis rhomboidalis. Raphae recta, fere in linea media. Striae radiantes, 9–11 in 10 μ, in apicibus densiores, delicatissime lineolatae.

Valves naviculoid, almost symmetrical in outline, lanceolate with rounded ends, 42 to 79 μ long by 13 to 16 μ wide. Raphe straight, almost on the median line. Axial area narrow lanceolate, central area rhomboidal. Striae lightly radial, at the middle 9 to 11 in 10 μ, closer at the ends, finely lineolate.

Denticula rainierensis Sovereign, new species.
(Figures 22–24.)

HOLOTYPE, no. 3499 (California Academy of Sciences, Department of Geology Type Collection), from Ohanapecosh Hot Springs, Spring "F," Mount Rainier National Park, Washington. Temperature 72° F., *p*H 7.4. Elevation 2100 feet. Also found in other springs of the area where the temperature reaches 100° F.

DESCRIPTION. Valvae lineari-lanceolatae apicibus acutis rotundatis, 12–15 μ longae, 2–3 μ latae. Costa transapicales 8–10 in 10 μ, lineas transapicales obscurae circiter 28–30 in 10 μ. Rhaphe excentrica ad margiem.

Valves linear lanceolate with acutely rounded ends, 12 to 15 μ long by 2 to 3 μ wide. Transapical costae 8 to 10 in 10 μ, transapical lines very difficult to see, about 28 to 30 in 10 μ. Raphe excentric along the margin.

Nitzschia bella Sovereign, new species.
(Figures 33–36.)

HOLOTYPE, no. 3500 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. *p*H 7.2.

DESCRIPTION. Frustula in facie connectivali visae lineares, apicibus cuneate rotundatis. Valvae lineares apicibus cuneate rotundatis, 180 to 230 μ longae, 7–9 μ latae. Carina magna, valde excentrica; punctis carinalibus 6–7 in 10 μ, striis 26–28 in 10 μ.

Cells in girdle view linear with slightly tapered ends. Valves linear with cuneate rounded ends, 180 to 230 μ long by 7 to 9 μ wide. Keel large, strongly excentric, not constricted in the middle, keel puncta coarse, 6 to 7 in 10 μ; striae fine, 26 to 28 in 10 μ, as shown in figure 36 only.

Nitzschia dissapata form **undulata** Sovereign, new form.
(Figures 28, 29.)

Holotype, no. 3501 (California Academy of Sciences, Department of Geology Type Collection), from Lake Louise, Mount Rainier National Park, Washington. Also found in Reflection Lake, Mount Rainier National Park, *p*H 6.1. Elevation 4860 feet. And also found in Bead Lake, Pend Oreille County, Washington. *p*H 8.8.

Description. Differet a typo valvae undulatae.

Differs from the type in having valve margins undulate, the number of undulations varying from two to three.

Nitzschia perspicua Sovereign, new species.
(Figures 30–32.)

Holotype, no. 3502 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. *p*H 7.2.

Description. Valvae lineares apicibus rostratis sub-capitatis, 65–93 μ longae, circiter 3 μ latae. Punctis carinalibus 8–10 in 10 μ, striae inconspicuae.

Valves linear with rostrate sub-capitate ends, 65 to 93 μ long by about 3 μ wide. Keel puncta 8 to 10 in 10 μ, striae invisible.

Stenopterobia intermedia form **undulata** Sovereign, new form.
(Figures 37, 38.)

Holotype, no. 3503 (California Academy of Sciences, Department of Geology Type Collection), from Lake Olallie, Skamania County, Washington. *p*H 6.7.

Description. Differet a typo valvae undulatis.

Differs from the type in having an undulating valve outline.

Remarks. Examples of *S. intermedia* (Lewis) Hustedt occur in the area which agree exactly with the description given by Hustedt (1930) but more commonly specimens will have wing canals spaced from 2½ to 3 in 10 μ instead of from 4 to 5½ in 10 μ. Many other examples of race differences exist in the Pacific Northwest.

Surirella beadensis Sovereign, new species.
(Figures 39, 40.)

Holotype, no. 3504 (California Academy of Sciences, Department of Geology Type Collection), from Bead Lake, Pend Oreille County, Washington. *p*H 7.2.

Description. Frustula in facie connectivali visae linearis apicibus rotundatis, in media parte concavis. Valvae panduriformes, apicibus rotundatis, 80–112 μ longae, 11–13 μ latae. Canaliculae alarum 23–28 in 100 μ, area media angusta lineari, striis transapicales delicatissimis, 24–26 in 10 μ.

Cells linear in girdle view with rounded ends, the cells strongly constricted in the middle by lowering of the valve surface. Valves panduriform with slightly pointed rounded ends, 80 to 112 μ long by 11 to 13 μ wide at the center and 15 to 17 μ at the widest part. Wing canals 23 to 28 in 100 μ; delicate striations here and there between the wing canals, 24 to 26 in 10 μ reaching to the narrow but distinct midfield area. Wing projections distinct, wing canals smaller than the windows.

Remarks. *S. beadensis* is superficially similar to *S. arata* Schmidt (Atlas, pl. 23, fig. 23), which averages larger and the valves in girdle view are not bowed in.

Surirella parma Sovereign, new species.

(Figure 41.)

Holotype, no 3505 (California Academy of Sciences, Department of Geology Type Collection), from Water Supply Spring, Crater Lake National Park, Oregon. *p*H 6.8. Elevation 6650 feet.

Description. Frustula in connectivali visae cuneata. Valvae forma mutabiles, ovatae vel oblongae, distincte alatae, 111–186 μ longae, 64–116 μ latae. Canaliculae alarum 11–15 in 100 μ, area media parum aucta.

Cells wedge shaped in girdle view. Valves very variable in outline varying from ovate to oblong, 111 to 186 μ long by 64 to 116 μ wide. Wings well developed, wing projections plain. Wing canals 11 to 15 in 100 μ, generally wider than the windows. The middle area is lanceolate but generally not well developed.

Gomphonema Hedini Hustedt.

(Figure 42.)

Gomphonema Hedini Hustedt in Hedin, Southern Tibet, vol. 6, pt. 3, Botany. Bacillariales aus Innerasien, p. 138, pl. 9, figs. 34, 35, 1922. Hustedt in Schmidt Atlas der Diatomaceenkunde, pl. 357, figs. 13, 14, May, 1925.

Hypotype, no. 3506 (California Academy of Sciences, Department of Geology Type Collection), from Narada Falls, Mount Rainier National Park, Washington. *p*H 7.2. Elevation 4572 feet.

Remarks. This species was described by Hustedt as widespread in the Central Asian Highlands and abundant east of Tso-ngombo at an elevation of 15,900 feet above sea level.

To account for the several Asiatic species of diatoms found as Recent in the Pacific Northwest, it is believed that the resting spores of many species are blown across the Pacific Ocean by the prevailing westerly winds and come to rest on the North American mainland. What is remarkable is that a species should land in a situation favorable to its propagation in the new locality.

Gomphonema Grovei M. Schmidt.
(Figure 43.)

Gomphonema Grovei M. SCHMIDT in Atlas der Diatomaceenkunde, plate 214, figures 13–18, March, 1899.

HYPOTYPE, no. 3507 (California Academy of Sciences, Department of Geology Type Collection), from Little Spokane River, Spokane County, Washington. *p*H 9.0. It was also found in Lake Washington, King County, Washington, and Sacheen Lake, Pend Oreille County, Washington.

REMARKS. The type locality for this fossil species is given as "Pitt River, Oregon" (Schmidt), and "Washington County (Etats-Unis)" (Tempère & Peragallo No. 627, 628), neither of which designations are definite; there is no Pitt River in Oregon and there are 19 states in the United States which have Washington counties. There are extensive and numerous beds of fossil freshwater diatoms of Miocene or Pliocene age in eastern Washington, eastern Oregon, and northern California. It is probable that M. Schmidt's specimen came from the California deposits. Goose Lake lies astride the Oregon-California border and on occasion has overflowed into the headwaters of the Pit River which lies entirely in California. The author has not had the opportunity to examine Tempère & Peragallo Sample no. 627, 628 (Diatomées du Mond Entier, p. 311), but has examined Sample no. 365, "Swan Lake, Klamath Cty.—Oregon," of this work. While not reported by Tempère & Peragallo in the analysis of this sample, *G. Grovei* has been found by the author in the original sample. Whether it was Recent or fossil is a matter of doubt. In general in southern Oregon east of the Cascades, it is nearly impossible to collect a Recent sample from lowland lakes or streams without finding it contaminated with fossil species washed in from the exposures of deposits which abound in that area. Distribution by winds is also highly probable.

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REMARKS ON THE ZOOGEOGRAPHY OF PHILIPPINE TERRESTRIAL SNAKES

By

Alan E. Leviton
California Academy of Sciences, San Francisco 18,
and *Division of Systematic Biology, Stanford University*

For more than thirty years interest in the Philippine herpetofauna lay dormant, a reawakening taking place within the past ten years as evidenced by the studies of Alcala (1962), Brown (1955–1962), Inger (1954), and the writer (1952–1962). The last studied the Philippine snakes, and as an outgrowth of that work re-evaluated the zoogeographic relations of the Philippine Islands on the basis of the distribution of these animals. Partial results of the systematic study are in press, and additional parts are in preparation. The present paper, therefore, incorporates results of as yet unpublished studies. Nomenclatural problems, especially name changes, presented in this paper are fully explained in the series now in press.

The writer is in debt to many people for their aid, especially for the loan of specimens for study. Their assistance is acknowledged elsewhere. For interest in and criticism of the present paper the writer is most especially indebted to Dr. George S. Myers of the Division of Systematic Biology, Stanford University, under whose sponsorship the original work was carried out. To Dr. Walter C. Brown of Menlo College, Menlo Park, California, who has been active in the Philippines since 1954, and Mr. Angel C. Alcala, Silliman University, Dumaguete, Philippines, the author wishes to express his thanks for permission to study collections they amassed in those islands between 1954 and 1959 and to include several of their new records in this paper (those species whose names are preceded by an asterisk [*]). Dr. Brown has papers in manuscript that deal with the zoogeography of several of the islands, particularly Negros, Bohol, and Palawan, in far more detail than they are treated here.

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INTRODUCTION

The zoogeographic relations of the Philippine Islands were discussed in considerable detail by Dickerson, and others, in 1928. Dickerson (1941), Mayr (1944), Myers (1951), Inger (1954), and Darlington (1958) have contributed additional material to the subject.

The present discussion is confined, insofar as that is possible and reasonable, to an analysis of the snake fauna. Several factors have dictated this approach. For one, I am thoroughly familiar with the systematics of only one group of Philippine animals. Inasmuch as the quality of one's zoogeographic conclusions depends on the correctness of the proposed systematic relationships of the animals involved, at least in large part, I am not in a position to render judgments regarding the probable zoogeographic relationships of animals I know little or nothing about. Secondly, I see no reason to repeat what has already been written regarding the distribution of other groups of animals. On the whole, the conclusions reached here do not differ markedly from those expressed more than thirty years ago by Dickerson and the authors who collaborated with him.

No attempt is made here to outline the geological history of the Philippine Islands. Dickerson (1924 and 1928b), Corby (1951), and Irving (1952) have already prepared such reviews, and much Philippine geology was incorporated into the works of van Bemmelen (1949) and Umbgrove (1938). Inger (1954) summarized the geological history of the Philippines in the introduction to his discussion on amphibian zoogeography. The work of Smith (1924) has been drawn upon for geological data on some of the small, obscure islands in the Philippines which are infrequently mentioned by others.

One point regarding the interrelationship between Philippine geology and the distribution of snakes in that region should be noted at this time. It is reasonably certain that the modern snake fauna of the Philippine Islands is a post-Miocene phenomenon. There is no evidence to indicate that Miocene and pre-Miocene Asian fauna could have entered the Philippines, most of the islands at that time being covered by shallow seas. However, periodic transgressions and regressions of the shallow inland seas during the Pleistocene, and the concomitant exposure of greater land masses, most profoundly affected the modern Philippine snake fauna, and I have drawn frequent attention to this matter.

GEOGRAPHICAL POSITION OF THE PHILIPPINE ISLANDS

The Philippine Islands comprise a group of some 7,100 islands, islets, and rocky crags, of which no more than 462 have areas greater than that of

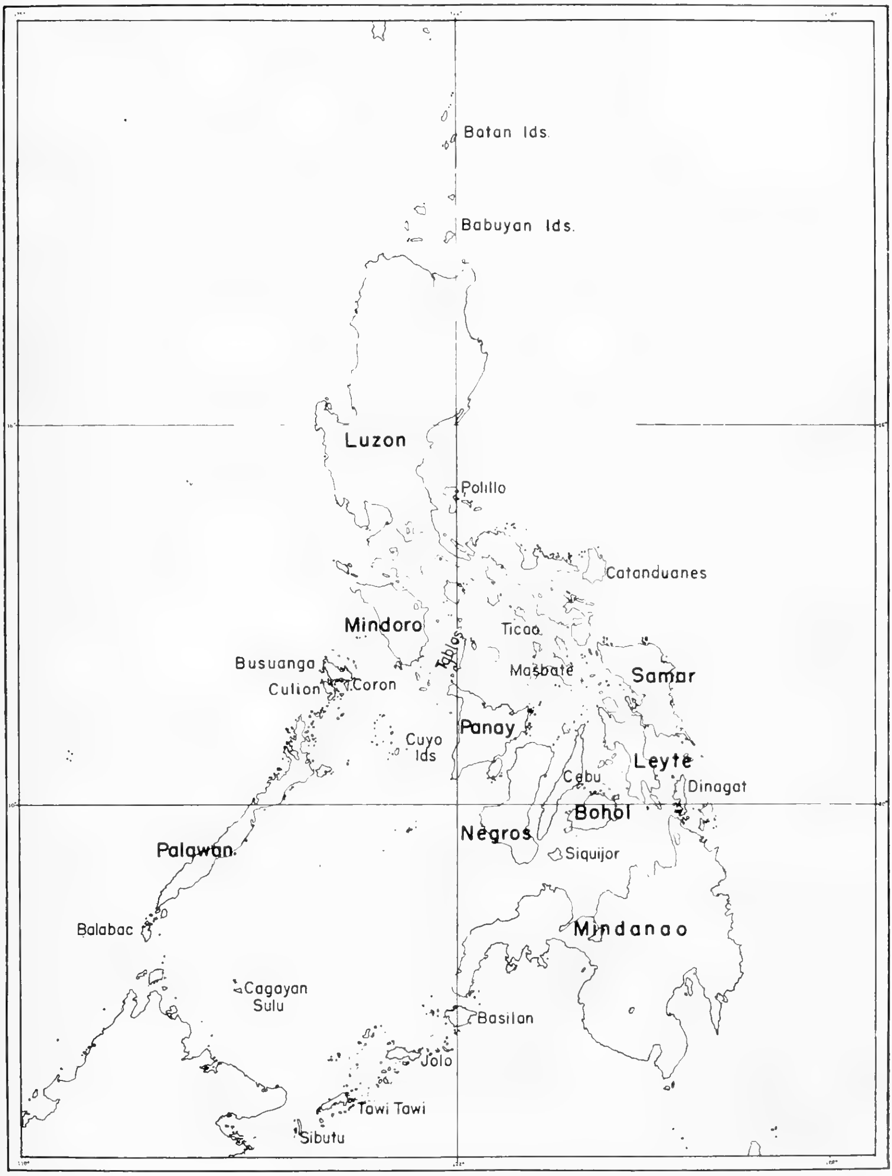

Figure 1. The Philippine Islands.

one square mile. The political boundaries of the Philippine Islands extend from Sibutu Island [4° 40′ N. Lat.] on the south to Y'Ami Island [21° 05′ N. Lat.] on the north side of the Bashi Channel, and from 116° 50′ to 136° 35′ E. Longitude. The eastern border of the archipelago is formed by the Mindanao Trench, which attains depths in excess of 35,000 feet. On the south is the Celebes Sea and the partially enclosed Sulu Sea, both of which reach depths in excess of 12,000 feet. The southern and northern portions of the China Sea, which forms the west flank of the Philippines, are shallow; however, depths in excess of 7,000 feet are reached off the west coast of Luzon Island.

There are eleven islands in the archipelago having areas of greater than 1,000 square miles. It has been estimated that there is a total of 114,830 square miles of subaerial land in the Philippines, 68 per cent of which is incorporated into the two islands of Luzon (40,814 square miles) and Mindanao (36,906 square miles).

The islands are mountainous, especially parts of Luzon, Mindanao, Mindoro, Negros, Palawan, and Panay, and elevations of 4,500 feet and more are not uncommon. All the principal peaks are volcanic in origin. However, some mountain ranges of folded sedimentary rocks have been identified, especially in a north-south belt extending through the central part of the archipelago.

Shallow submarine platforms (usually less than 50 meters below the surface) join many of the islands. These platforms and their attendant islands must have formed larger land masses during the Pleistocene when sea level was sufficiently lowered to expose them to subaerial erosion. The most prominent of these platforms include the Palawan shelf, the Sulu platform, the Mindanao platform, the western Visayan shelf, and the Camarines [= Luzon] platform.

Island connections have been altered, both in past and in the present, by block-faulting. Consequently, it is frequently difficult to determine whether several islands have been connected except by inferences based upon comparison of faunal elements.

The Philippine Islands are, according to Darlington (1957, p. 500), a fringing archipelago (*i.e.,* islands which have not been recently joined to nearby continental masses, but which nevertheless have received "fringes" of continental faunas). Many authors have partitioned the Philippines between two faunal regions. The southern islands of the Sulu and Palawan archipelagos have been assigned to the Oriental Region, while the northern islands have been placed in a transitional region which lies between the Oriental and Australian regions (Huxley, 1868; Dickerson, *et alii,* 1928). More recently, Mayr (1944) has assigned the entire Philippine Archipelago to the Oriental Region, while Inger (1954) suggests that the islands of the

Palawan chain "may be set off from the remainder of the archipelago by virtue of the absence of Papuan genera." There are few Papuan elements in the Philippine fauna, and those which have entered the islands probably did so by fortuitous means. On the other hand, the Malayan elements in the Philippines dominate the fauna, albeit they are neither so numerous nor so diversified as they are in western Indonesia and the Malay Peninsula. Furthermore, the Philippines do not represent a transitional region through which faunal elements are able to pass from one major faunal region to another, but rather the islands form a "dead-end street." Consequently, I am inclined to agree with Mayr and believe that the Philippines should be included within the Oriental Region.

COMPOSITION OF THE TERRESTRIAL PHILIPPINE SNAKE FAUNA

All but two families of Asian snakes have been reported from the Philippines. The two exceptions include the members of the family Uropeltidae, which are confined to Peninsular India, and those of the family Aniliidae, a single species of which enters western Indonesia. The families Typhlopidae (blind snakes) and Hydrophidae (sea snakes) and the aquatic colubrid genera *Hurria* and *Acrochordus* have been omitted from this report; nonetheless, they are represented in the Philippines.

Of the 69 genera of terrestrial snakes reported from Indonesia (many of which are of uncertain taxonomic status), 29 are known from the Philippines. Four genera[1] are endemic to the Philippines: *Myersophis, Oxyrhabdium, Cyclocorus,* and *Hologerrhum. Oxyrhabdium* is related to the genus *Xylophis,* a genus restricted to the Western Ghats in India. *Cyclocorus* and *Hologerrhum* are closely related to each other; they have no close relatives in southeastern Asia, Papua, or elsewhere, and may have originated in the Philippines from some early natricine ancestor.

Sixty-seven species of Philippine snakes (88 species and subspecies) are recognized in this paper. These may be divided into two general groups, those which are not endemic to the Philippines, and those which are restricted to the islands.

1. NON-ENDEMIC SPECIES. There are 32 non-endemic species represented in the Philippines either by subspecies found in Indonesia or by endemic subspecies related to populations which are found in Indonesia. Included among the non-endemic species are: *Ahaetulla prasina, Aplopeltura boa, Boiga angulata, Boiga cynodon, Boiga dendrophila, Boiga drapiezi, Calamaria everetti, Calamaria suluensis, Calamaria vermiformis, Chrysopelea*

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[1] After this paper had gone to press, a paper by Dr. Edward H. Taylor appeared in Copeia (1963, no. 2, pp. 429–433) in which he described a new genus and species of colubrid snake from Luzon Island, *Myersophis alpestris.* I have not seen the snake and do not feel qualified to comment upon this discovery at this time.

paradisi, Dendrelaphis caudolineatus, Dendrelaphis pictus, Dryocalamus subannulata, Dryocalamus tristrigatus, Dryophiops rubescens, Gonyosoma oxycephala, Liopeltis tricolor, Lycodon aulicus, Lycodon subcinctus, Maticora intestinalis, Naja naja, Natrix chrysarga, Ophiophagus hannah, Opisthotropis typica, Oligodon meyerinki, Oligodon vertebralis, Psammodynastes pulverulentus, Python reticulatus, Stegonotus mülleri, Trimeresurus wagleri, Xenopeltis unicolor, and *Zaocys carinatus.*

All of the species listed above are known to have western Indonesian-Malayan affinities. Many of the species are represented in the Philippines by distinct subspecies, as for example *Ahaetulla p. preocularis, Boiga d. divergens, Boiga d. latifasciata, Boiga d. multicincta, Calamaria v. grayi, Dendrelaphis c. luzonensis, Dendrelaphis c. terrificus, Maticora i. bilineata, Maticora i. philippina, Maticora i. suluensis, Naja n. philippina, Naja n. samarensis* and *Oligodon v. notospilus.*

In addition, a few species are also known from the Philippines which have been distinguished from closely related species listed above on the basis of a subjective evaluation of morphological differences. Several of these could be considered subspecies, as for example *Liopeltis philippina, Dryophiops philippina.* I regard these as good species, but differences in opinion regarding the taxonomic status of populations do exist among various workers. In any event, these species were derived from isolated populations of their Bornean relatives listed above among the non-endemic forms.

It must be noted that there are no species either of eastern Indonesian (Papuan) or Formosan origin in the Philippines.

II. ENDEMIC SPECIES. There are thirty-four endemic species in the Philippines: *Boiga philippina, Calamaria bitorques, Calamaria gervaisi, Calamaria joloensis, Calamaria mearnsi, Calamaria zamboangensis, Calliophis calligaster, Cyclocorus lineatus, Elaphe erythrura, Hologerrhum philippinum, Liopeltis philippina, Lycodon dumerili, Lycodon Mülleri, Lycodon tessellatus, Myersophis alpestris, Natrix dendrophiops, Natrix auriculata, Natrix lineata, Natrix spilogaster, Oligodon ancorus, Oligodon maculatus, Oligodon modestus, Oligodon perkinsi, Opisthotropis alcalai, Oxyrhabdium leporinum, Oxyrhabdium modestum, Pseudorabdion ater, Pseudorabdion mcnamarae, Pseudorabdion montanum, Pseudorabdion oxycephalum, Pseudorabdion taylori, Sibynophis bivattatus, Trimeresurus flavomaculatus Trimeresurus schultzei,* and *Zaocys luzonensis.*

The relationships of each of the above-named species will be discussed in some detail in the series of systematic papers now in press. With the exception of the genera *Cyclocorus, Hologerrhum, Myersophis,* and *Oxyrhabdion,* and the species *Lycodon dumerili, L. mülleri, Oligodon perkinsi,* and *Trimeresurus schultzei,* all have relatives existing at the present time in Borneo.

Cyclocorus and *Hologerrhum* are probably congeneric, and most likely they have evolved in the Philippines from some natricine-like ancestor. *Lycodon dumerili* and *L. mülleri* are very closely related and are probably relics of an early, widely distributed lycodontine snake from which the highly specialized species of *Lycodon* were subsequently derived. The affinities of the Palawan species *Trimeresurus schultzei* and the Calamianes endemic *Oligodon perkinsi* are not known. The latter may have been derived from a "*purpurascens*-like" ancestor, while the former may be related to the "*popeorum*" section of the genus *Timeresurus*. The genus *Oxyrhabdium* has no close relatives in the Indo-Malayan region. It is a very old genus related to the distant *Xylophis,* a genus of burrowing snakes restricted to Peninsular India.

It is very evident that, excepting the three genera *Cyclocorus, Hologerrhum,* and *Oxyrhabdium,* all the endemic species of Philippine snakes are related to western Indonesian species.

There are no endemic species in the Philippines which have eastern (Papuan) affinities, nor are there any genera or species having strictly Palearctic affinities.

FACTORS AFFECTING THE DISPERSAL OF PHILIPPINE SNAKES

Animals may have entered the Philippine Islands either by dispersal through a continuous and ecologically tolerable space, or by saltatory movements from one agreeable environment to another (Inger, 1954, p. 475). Insofar as the terrestrial snakes are concerned, it seems likely that the former has been most effective. Indeed, the very regular "immigrant pattern" of dispersal (Darlington, 1957, p. 485) of the Philippine snakes leads me to conclude that saltatory movements have had little effect on the fauna except for several of the smaller islands, not connected to any larger land mass (*e.g.,* Ticao, Sibuyan, Butan, Camiguin).

There are few problems in understanding the movements of animals through a continuous and ecologically agreeable environment, time to permit dispersal being the single most important factor. However, the mechanisms involved in the fortuitous dispersal of terrestrial snakes require a few words.

Because snakes move about with relative ease, lay eggs away from water, and can swim, it is frequently assumed that they can move with almost as much ease through a discontinuous environment as through a continuous biotope. We have very little data on the detailed ecological preferences of snakes beyond the obvious facts that some are obligate burrowers, some dwell on the ground and take refuge under logs or rocks or in holes at the bases of trees, others are arboreal or aquatic, and some appear to be able to live in a variety of situations. Nevertheless, where groups of snakes have been studied with care, it has been shown that they show definite ecological preferences, as for example *Leptodeira,* an inhabitant of the moist tropical forests, and its close ally *Hypsiglena,* whose species live at higher elevations and in drier environments (Duellman, 1958, p. 126).

We have little knowledge of the ecological factors which limit the distribution of snakes in the Philippines. However, the uniformity of the lowland tropical environment in this region would suggest that those factors would have a minimum effect and wherever continuous land masses exist snakes would soon fan out through the entire area. On the other hand, in an archipelago-type of environment, terrestrial snakes would have to cross a sea barrier in order to move from one land mass to another, and this raises some distinct problems.

Snakes can swim, but this does not necessarily mean, *ipso facto,* that they can cross salt water barriers. Sea snakes, and the colubrid snakes of the genera *Hurria* and *Acrochordus,* all of which enter salt water, have several morphological adaptations which secure the animals against the vicissitudes of that hyperisotonic solution. Nasal valves are present which close off the nostril passages. The nostrils are located on the top of the head and permit breathing while the snake is in the water. The rostral cleft is almost absent and this prevents water from entering the mouth. And the skin is thickened, especially the interstitial skin between scales, and serves as a protection against loss of body fluids or penetration of the body by salt ions.

The terrestrial Philippine snakes lack all of the above modifications. Thus, any individual entering the sea would be exposed to its effects. Consequently, I strongly doubt that a terrestrial snake could live for long if it had to journey many miles in the sea in order to pass from one island to another.

Rafting certainly provides a satisfactory means for transporting snakes from one island to another, especially in the Malayan tropics. The entire Malayan area is one of heavy rainfall, and rain in large quantities frequently falls in short periods of time. Rivers rise rapidly and become very turbulent. Portions of their banks are often torn away, float downstream, and out to sea. These rafts are then carried about in the prevailing currents, which in the case of the Philippines move northward on both sides of the archipelago. Should chance permit, the raft may touch at some distant island, and any animals trapped when the bank was torn away presumably could avail themselves of the new locality. I believe that such an explanation may account for the present distribution of snakes on Batan and Camiguin islands, especially for the ground-dwelling snake *Trimeresurus flavomaculatus.* The three arboreal snakes also known from those islands may have arrived via other means (see below).

Typhoons, or high winds, are occasionally effective in moving animals about. Inger (1954) has suggested that typhoons, which are not infrequent in the Philippines, probably have acted to disperse some elements of the amphibian fauna. Myers (1953, p. 21) has indicated that wind dispersal is available to smaller animals which may be carried aloft on pieces of vegetation, but that ground-dwelling animals probably would not be much affected. Three of the four species of snakes known from the remote Batan Island are light-weight arboreal snakes, and their presence on that island could possibly be the result of wind distribution. Dickerson (1928, fig. 6) has shown that an occasional typhoon tract will pass over northeastern Luzon, then veer almost due north, and pass over Batan and Camiguin islands.

Other factors which influence the distribution of terrestrial snakes include the size of the island, the width of the water barriers between islands, and man. Darlington (1957, p. 482) has discussed the effects of area as a limiting factor on the number of species which inhabit islands of different size. Unfortunately, the snake fauna of the islands of the Philippines has been unequally collected, the larger islands having attracted collectors more frequently than the smaller islands. Consequently, it is difficult at the present state of our knowledge of the distribution of Philippine snakes to be certain of the effects that island size has on the faunal composition.

In a like manner, it is not possible to evaluate the importance of distance between islands as a limiting factor in the distribution of Philippine snakes. As already mentioned, the regular distribution of snakes in the Philippines suggests that dispersal by saltatory movements, in which distance between islands would become a significant factor, probably has been of minor importance.

The effects that man has had on dispersing certain elements of the Philippine fauna can only be inferred. It is, of course, well known that certain reptiles are more likely than others to be transported about by man. The geckos of the genus *Gehyra* are prime examples. The present distribution of *Lycodon aulicus* may also be explained by allowing for a human agency in its dispersal. In the following discussion I have noted a few instances where man has probably been responsible for the occurrence of some snakes on certain islands.

On the whole, the Philippine snake fauna presents few problems to the zoogeographer. The distribution of these animals can be explained for the most part on the basis of former land connections for which geologic and hydrographic evidence provides a large measure of agreement.

ANALYSIS OF ISLAND FAUNA

In the following section the snake fauna of each of the Philippine islands from which terrestrial snakes have been reported and/or collected is reviewed. The purpose of this review is to focus attention on the inter-island relationships of the snake fauna. Each island is briefly described as to its geographical position. Pertinent facts about the geology and hydrography are included. A brief discussion of the snake fauna known to inhabit the island, with comments on the probable routes of dispersal, then follows.

BALABAC ISLAND

Ahaetulla prasina prasina
Aplopeltura boa
Boiga dendrophila multicincta
Chrysopelea paradisi
Dendrelaphis caudolineatus caudolineatus
Dryocalamus tristrigatus
Elaphe erythrura philippina
Gonyosoma oxycephala
Maticora intestinalis bilineata
Natrix chrysarga
Oligodon vertebralis notospilus
Ophiophagus hannah
Psammodynastes pulverulentus
Trimeresurus schultzei
Trimeresurus wagleri
Xenopeltis unicolor

Balabac Island (07° 56.6′ N. Lat., 117° 01.0′ E. Long.) lies between North Borneo and Palawan Island. The island is fairly small, about 125 square miles in area.

There are no endemic species or subspecies of snakes on Balabac. All the species are also known from Borneo and Palawan. There are a number of snakes which have been reported from both Palawan and Borneo but which have not been taken on Balabac. These include *Boiga cynodon, B. drapiezi, Calamaria everetti, Dendrelaphis pictus, Liopeltis tricolor, Lycodon subcinctus, Naja naja, Python reticulatus, Sibynophis bivittatus* (or related Bornean species *S. geminatus*) and *Zaocys carinatus*. Some, if not all, of these species may be expected to occur on Balabac. Perhaps the larger snakes, *Python reticulatus, Naja naja,* and *Zaocys carinatus,* might not be found there because the small size of the island may act to limit the potential food supply.

BANTAYAN ISLAND

Chrysopelea paradisi
Dendrelaphis caudolineatus terrificus
Lycodon aulicus capucinus

Bantayan Island (11° 13.0′ N. Lat., 123° 44.0′ E. Long.) lies at the north end of the Tañon Strait, to the northeast of Negros and northwest of Cebu. The island occupies an area of 45 square miles.

Bantayan rests upon the Visayan submarine shelf which lies at less than 50 meters depth and which joins Negros, Panay, Cebu, and Masbate islands.

Only three snakes have been collected on this island, all of which are widely distributed throughout the Philippines. The presence of *Dendrelaphis c. terrificus* relates this island to others lying south of Luzon on which a distinct subspecies of *D. caudolineatus* occurs.

BANTON ISLAND

Chrysopelea paradisi
Dendrelaphis caudolineatus terrificus

This small island (12° 56.5′ N. Lat., 122° 04.0′ E. Long.) of about 11 square miles in area lies in the Sibuyan Sea, about equidistant from Mindoro, Marinduque, and Tablas islands.

Only two species of snakes have been taken on the island. Both are widely distributed throughout the Philippines, *D. c. terrificus,* however, being found on the islands south of Luzon and Mindoro. Inasmuch as there is nothing known about the geological history of this island, and since hydrographic evidence does not suggest any reasonable chance of a subaerial land connection between this island and any of its neighbors, I suspect that the present fauna arrived via waif dispersal.

BASILAN ISLAND

Ahaetulla prasina preocularis
Aplopeltura boa
Boiga cynodon
Calamaria gervaisi hollandi
Calamaria vermiformis grayi
Chrysopelea paradisi
Cyclocorus lineatus nuchalis
Dendrelaphis caudolineatus terrificus
Lycodon dumerili
Natrix auriculata
Natrix dendrophiops dendrophiops
Natrix lineata
Oxyrhabdium modestum
Psammodynastes pulverulentus
Python reticulatus
Trimeresurus wagleri

Basilan Island is located immediately south of the Zamboanga Peninsula, Mindanao Island, between latitudes 6° 25′–6° 45.5′ N., and longitudes 121° 47.5′–122° 19.5′ E. The island occupies an area of about 495 square miles. There are many hills, but the most prominent is Basilan Peak, which reaches an altitude of 3320 feet. The narrow strait which separates Basilan from Zamboanga Province, Mindanao Island is a shallow submarine shelf, and it is very evident that Basilan must have been joined to Mindanao during parts of the Pleistocene. In a like manner, Basilan must also have been joined to the islands of the Sulu Archipelago to its southwest which also lie on the same submarine platform, now at less than 50 meters depth.

There are no unique species of snakes on Basilan. Taylor (1928, p. 217) indicated that the caecilian *Ichthyophis monochrous* occurs on Basilan but not on Mindanao. Recently, however, Inger (1954, p. 207) reported *I. monochrous* from Mindanao. Based on the distribution of reptiles and amphibians, Basilan may best be regarded as part of Mindanao.

Batan Island

Ahaetulla prasina preocularis
Lycodon mülleri
Natrix spilogaster
Trimeresurus flavomaculatus mcgregori

Batan Island (20° 25.2′ N. Lat., 121° 57.7′ E. Long.) lies about 130 miles north of Luzon Island between Taiwan and Luzon. It is separated from Taiwan by the deep Bashi Channel and from the islands to the south by the Balintang Channel. Both of these channels are more than 6000 feet deep thereby precluding any reasonable chance for a subaerial land connection between it and either Taiwan or the southern islands. The island occupies an area of 27 square miles.

It seems likely that Batan Island was populated by snakes which arrived by fortuitous means, either by rafting, wind dispersal, or in the course of human activities. The former probably applies in the case of *Trimeresurus f. mcgregori,* a subspecies endemic to the island.

The other species, all arboreal, could also have arrived at Batan Island by rafting, the prevailing current patterns in the China Sea favoring movement from Luzon northward. Or, they could have been carried there by high winds (see p. 376). The specimens of these species which have been taken on Batan suggest that the Batan populations are taxonomically indistinguishable from the Luzon populations, and therefore have only recently become established there.

Bohol Island

Ahaetulla prasina preocularis
Dendrelaphis caudolineatus terrificus
Gonyosoma oxycephala
Naja naja samarensis
Natrix auriculata
Natrix lineata
Oxyrhabdium modestum
Psammodynastes pulverulentus
Python reticulatus
Trimeresurus flavomaculatus flavomaculatus

Bohol Island (09° 38.0′ N. Lat., 123° 52.5′ E. Long.) lies to the north of Mindanao from which island it is separated by the Mindanao Sea. The island occupies an area of 1492 square miles. The highest peaks are located near the center of the island and reach altitudes of almost 2600 feet.

The island lies on a high submarine ridge which joins it to Leyte. Bohol is separated from Cebu by the Bohol Strait, having depths in excess of 500 meters. Most of the island is capped by late tertiary limestone, except where stream erosion has stripped away the cover to reveal the basement complex of crystalline rocks. From this it is concluded that the island was uplifted since the late Tertiary, probably in Pleistocene times.

There are no endemic species or subspecies of snakes on Bohol. All forms are identical to those found on Mindanao, Samar, and Leyte islands. There are, however, a number of snakes, lizards, and amphibians which inhabit those latter islands but not Bohol. Unfortunately, our knowledge of the Bohol fauna is based upon a few, small, recent collections. The fauna is poorly known, and at the present time it is not possible to evaluate the significance of the absence of certain groups of reptiles and amphibians from those collections. It is reasonably certain, however, that the known Bohol fauna is most closely related to that from Mindanao, Samar, and Leyte. In spite of the proximity of Cebu Island, there is no evidence to indicate that there has been any faunal interchange between those islands.

Bongao Island

Elaphe erythrura philippina
Oligodon meyerinki
Psammodynastes pulverulentus
Xenopeltis unicolor

Bongao Island (05° 01.5′ N. Lat., 119° 45.1′ E. Long.) is a member of the Tawi-Tawi group in the Sulu Archipelago. It is the southernmost island in the Tawi-Tawi group and is separated from Tawi-Tawi and Sanga Sanga by the very narrow and shallow Bongao Channel. To the west, and separated by a channel about 32 miles wide, lies Borneo; the Sibutu islands lie about 20 miles to the south.

The entire Tawi-Tawi group of islands is on a high submarine shelf, extending from Zamboanga southward, which lies within 50 meters of the surface. This high shelf terminates at the southern end of Bongao Island where there is an abrupt drop to depths of about 300 meters in the Sibutu Passage. Although geological evidence is lacking, the faunal picture clearly indicates that a continuous submarine shelf must have extended from Mindanao to Borneo. The present deep Sibutu Passage was probably formed through block faulting sometime after mid-Pleistocene.

Three of the four species of snakes known from Bongao are also known from North Borneo. *Elaphe e. philippina,* however, is known only from the Palawan Archipelago, and its occurrence on Bongao is unexpected. Unfortunately, I have not seen the specimens which were referred to that subspecies by Taylor (1922a, pp. 160–161). *Elaphe erythrura* has not been reported from Borneo. However, unless the Bongao specimens were introduced through human agencies, it seems very likely that the species will be found in Borneo.

BUBUAN ISLAND

Chrysopelea paradisi
Dendrelaphis caudolineatus terrificus
Liopeltis tricolor

This very small island (06° 20.9′ N. Lat., 121° 58.0′ E. Long.) is a member of the Tapiantana Group.

Only three species of snakes have been taken on this island. *Liopeltis tricolor* is well-known in Borneo and *Dendrelaphis c. terrificus* is widely distributed throughout the southern Philippines. *Chrysopelea paradisi* is widely distributed throughout the Malayan region.

The few snakes present on Bubuan relate this island to other members of the Sulu Archipelago, and thus, to Borneo and Mindanao. This is the northernmost locality for the Bornean *L. tricolor* in the eastern Philippines and the southernmost locality for *D. c. terrificus.*

BUSUANGA ISLAND

Ahaetulla prasina prasina
Dendrelaphis caudolineatus caudolineatus
Dendrelaphis pictus pictus
Elaphe erythrura philippina
Liopeltis philippina
Maticora intestinalis bilineata
Natrix chrysarga
Oligodon vertebralis notospilus
Psammodynastes pulverulentus
Sibynophis bivittatus

Busuanga Island (12° 05.0′ N. Lat., 120° 05.0′ E. Long.), a member of the Calamianes Group, lies near the northern end of the Palawan submarine shelf. It is the largest island of the group, 344 square miles in area.

There are no endemic species of snakes on Busuanga; all are known from islands to the south, especially Palawan. A single remarkable genus and species of discoglossid frog, *Barbourula busuangensis,* is known only from this island and Palawan. This frog is the sole representative of the Palearctic frog family Discoglossidae to occur in the Oriental Region and undoubtedly is a relic species which has been isolated on those islands for a long time.

Cagayan Sulu Island

Calamaria suluensis
Dendrelaphis pictus pictus

Cagayan Sulu (07° 01.0′ N. Lat., 118° 30.0′ E. Long.) is a small island, 26 square miles in area, which lies about 70 miles off the northeast coast of North Borneo. This island, together with its group of 13 surrounding islets, lies at the edge of the Bornean submarine shelf. The island is said to have several peaks, of which the highest is 837 feet and represents an extinct volcano (Smith, 1924, p. 244).

Only two snakes have been taken on Cagayan Sulu, both of which are known from Borneo.

Camiguin Island

Ahaetulla prasina preocularis
Chrysopelea paradisi
Dendrelaphis caudolineatus luzonensis
Trimeresurus flavomaculatus flavomaculatus

Camiguin Island (18° 55.7′ N. Lat., 121° 54.8′ E. Long.) belongs to the Babuyan Group and is located off the north coast of Luzon. The island is separated from Luzon by the Babuyan Channel, which is 100 to 500 meters deep. The highest peak on this island of 63 square miles is Camiguin Volcano which rises 2750 feet above sea level.

The snakes known from Camiguin are species and subspecies common on Luzon. *Dendrelaphis c. luzonensis,* however, is found only on Luzon and Camiguin.

There is no evidence to suggest how the snakes reached Camiguin. There may have been a land connection between it and Luzon, if the Babuyan Channel is of recent origin. If, on the other hand, the Babuyan Channel is an old structure, then rafting, wind dispersal, or accidental transport by human agencies could account for their presence on the island. In any event, the absence of geographic differentiation suggests the snakes have only recently become established there.

Catanduanes Island

Boiga angulata

This large island (13° 47.0′ N. Lat., 124° 16.0′ E. Long.) of 552 square miles area, lies off the southeast coast of Luzon. It lies on the broad, shallow Camarines shelf and undoubtedly has been joined to southeastern Luzon by subaerial land during parts of the Pleistocene.

A single snake has been taken on the island. The species is well known in the Philippines and has been reported from many of the larger islands, including Luzon, to which Catanduanes is obviously related by reason of its geographical and hydrographic position.

Cebu Island

Ahaetulla prasina preocularis
Calamaria gervaisi iridescens
Calliophis calligaster gemianulis
Chrysopelea paradisi
Cyclocorus lineatus lineatus
Dendrelaphis pictus pictus
Elaphe erythrura erythrura
Lycodon aulicus capucinus
Natrix dendrophiops negrosensis
Oxyrhabdium leporinum visayanum
Python reticulatus

This elongate island (10° 23.0′ N. Lat., 123° 53.3′ E. Long.), about 139 miles long and 20 miles wide, lies off the east coast of Negros Island, from which it is separated by the deep Tañon Strait. The mountains, which have a north-south trend, reach their greatest elevation in the central portion where Mt. Cabalasan attains an altitude of 3324 feet. Cebu lies on a very narrow shelf on its south, east and west sides, where there are abrupt drops to depths in excess of 500 meters. The northern portion of the island rests upon the shallow shelf which forms part of the broad, shallow submarine platform joining Cebu, Negros, Panay, and Masbate islands.

According to Dickerson (1928, p. 285) "Cebu was until late Pleistocene a string of coral islands which had but little connection with either the Visayan island to the west or the large Surigao island to the east."

There are no snakes unique to Cebu. Of the eleven species presently known from the island, seven are widely distributed throughout the Philippines. The four other species, *Calliophis c. gemianulis, Calamaria g. iridescens, Oxyrhabdium l. visayanum* and *Natrix d. negrosensis,* are identical to populations otherwise restricted to Negros and Panay. From this it seems reasonable to conclude that Cebu and Negros were joined together. The marked similarity of the fauna suggests that the islands were joined very recently, probably in the latest Pleistocene. Inasmuch as there are no endemic species of reptiles or amphibians on Cebu, it is doubtful that any of those animals were able to reach the island prior to that time. This would be in keeping with Dickerson's suggestion that Cebu was a series of small islands until late Pleistocene, and with McGregor's conclusion that Cebu probably was not joined to Negros during the Pliocene or most of the Pleistocene, based on the high degree of endemism among the birds.

CORON ISLAND

Ahaetulla prasina prasina
Dryophiops rubescens

Coron Island (11° 55.0′ N. Lat., 120° 14.0′ E. Long.) belongs to the Calamianes Group and lies to the immediate southeast of Busuanga. The island occupies an area of 27 square miles, is high and very rocky.

The two species of snakes reported from Coron are both well-known in Borneo. *Dryophiops rubescens* has not been taken on any other island in the Philippines, but it is reasonably certain that it will be found on Palawan unless it reached Coron by fortuitous means. *Ahaetulla p. prasina* has been taken on all the larger islands of the Palawan Archipelago, as well as Borneo.

CULION ISLAND

Ahaetulla prasina prasina
Boiga cynodon
Dendrelaphis pictus pictus
Elaphe erythrura philippina
Liopeltis philippina
Maticora intestinalis bilineata
Natrix chrysarga
Oligodon perkinsi
Sibynophis bivittatus

Culion Island (11° 50.0′ N. Lat., 119° 55.0′ E. Long.) is the second largest island in the Calamianes Group (150 square miles in area) and lies to the immediate south of Busuanga Island. Culion, Coron, and Busuanga form a compact group, the three islands being separated by narrow, shallow channels. From a zoogeographic standpoint the islands may be treated as a single unit.

Culion is, herpetologically, the best known of the Calamianes islands. Three species of snakes are known from Busuanga, two from Coron, and nine from Culion. Of the nine Culion species, *Oligodon perkinsi* appears to be endemic as is the frog genus *Barbourula* on Busuanga[2]. *Liopeltis philippina*, a species closely related to *L. tricolor* (known from western Indonesia and Palawan), has been taken on northern Palawan. I suspect that that species evolved in the Calamianes islands from an isolated population of *L. tricolor*. It probably entered Palawan during the last period of glacial maxima when the Palawan submarine shelf must have been exposed to subaerial erosion for its entire length. The remaining seven species and subspecies of Culion snakes are identical to those on Palawan.

Several fresh-water fish of the family Cyprinidae are found in the Calamianes islands. Four distinct species of cyprinid fish have been re-

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[2] Since this was written, specimens of *Barbourula* were taken on Palawan Island.

ported from Busuanga. Of these, one belongs to an endemic species of *Hampala,* and one to a distinct species, *Puntius ivis.* The two remaining species are found in Palawan.

Nine species of amphibians have been recorded from the Calamianes. Eight are known on Palawan. And one, *Rhacophorus a. appendiculatus,* reported from Culion on the basis of specimens obtained by Dr. Moellendorff, probably does not occur outside of the eastern Philippines (Inger, 1954, p. 376).

CUYO ISLAND

Lycodon aulicus capucinus

The largest of the Cuyo Islands, Cuyo (10° 51.1′ N. Lat., 121° 02.4′ E. Long.) lies about midway between northeastern Palawan and Panay islands. The island rests on the Palawan submarine shelf at the north end of the Sulu Sea. It is of volcanic origin with the highest point about 600 feet above sea level.

A single specimen of *Lycodon aulicus* has been collected on this isolated island. I suspect it was introduced there by man.

DINAGAT ISLAND

Oxyrhabdium modestum
Psammodynastes pulverulentus

Dinagat Island (10° 05.0′ N. Lat., 125° 35.0′ E. Long.) lies to the immediate north of the Surigao Peninsula, Mindanao. On the west, the Surigao Strait separates Dinagat and Leyte, and on the north, the Leyte Gulf separates the island from Samar. Mindanao and Dinagat are separated by a shallow channel five miles in width. The island occupies an area of 309 square miles. A chain of mountains extends from north to south. There are several peaks attaining altitudes in excess of 1700 feet; the highest point is at the north end of the island and rises 3300 feet above sea level.

Dinagat, Samar, and Leyte islands are joined to Mindanao by a shallow submarine shelf. This shelf lies well within 50 meters of the surface and undoubtedly was exposed to subaerial erosion at times of glacial maxima during the Pleistocene. At those times these islands and Bohol, which is connected to Leyte by a similar shallow submarine shelf, must have formed a continuous land mass, and there must have been relatively free movement of faunal elements from one island to another.

Two snakes have been reported from Dinagat. *Psammodynastes pulverulentus* is widely distributed throughout southeastern Asia. *Oxyrhabdium modestum* is known from Mindanao, Samar, Leyte, and Bohol (also doubtfully recorded from Negros).

Seven of the eight species of frogs Inger (1954, p. 512) records from

Dinagat are also found on Mindanao, Samar, and Leyte. Of these, three are restricted to those islands and four are widely distributed throughout the Philippines. Only one, *Rana macrodon visayanum,* known from the western Visayan islands but not from Mindanao or Samar, presents difficulties. Inger states that that frog occurs on Leyte as well as Dinagat. It is interesting to note that of the 16 frogs known from Leyte, this is the only frog not known to occur on Mindanao. Although Inger does not discuss this interesting anomaly, I believe it is reasonable to assume that *Rana m. visayanum* is not native to either Leyte or Dinagat. Taylor (1923, p. 523) has indicated that *Rana macrodon* is frequently sought after by the native inhabitants in the western Visayan islands as a source of food. I suspect that this frog may have been introduced into Leyte and Dinagat either accidentally or as a potential food source.

Jolo Island

Ahaetulla prasina preocularis
Calamaria joloensis
Chrysopelea paradisi
Dendrelaphis pictus pictus
Elaphe erythrura erythrura
Maticora intestinalis suluensis
Oligodon meyerinki
Ophiophagus hannah
Psammodynastes pulverulentus
Python reticulatus
Trimeresurus flavomaculatus flavomaculatus
Trimeresurus wagleri
Xenopeltis unicolor

The largest of the Sulu Islands, Jolo (06° 00.0′ N. Lat., 121° 09.0′ E. Long.) lies about midway between Basilan on the northeast and Tawi-Tawi on the southwest. Between Jolo, Basilan, and Tawi-Tawi are many small islands, some of volcanic origin and some merely raised coral reefs. Taken together, these islands represent the high points on the Sulu submarine platform, which extends from Zamboanga to Tawi-Tawi. According to Smith (1924, pp. 247–248) this platform has successively submerged and emerged, producing alternately a discontinuous and a continuous land mass extending from Mindanao to Borneo.

Jolo Island has an area of 345 square miles. There are several peaks, the highest of which, Mt. Bud Dajo, rises 2894 feet above sea level. The island is of volcanic origin. No active volcanoes are now present on the island, but there are extensive deposits of volcanic ash and tuffs presumed to be of late Pliocene and Pleistocene age.

The snake fauna of Jolo includes elements of the Mindanao and Bornean faunas. *Oligodon meyerinki,* related to the Bornean *O. octolineatus,* and

Xenopeltis unicolor are typical modern Bornean elements, while *Aheatulla p. preocularis, Elaphe e. erythrura,* and *Trimeresurus f. flavomaculatus* represent the typical Mindanao elements. Two species are thought to be endemic to Jolo, *Calamaria joloensis* and *Maticora i. suluensis.* The latter is very close to the Bornean *M. i. nigrotaeniata,* but the former does not appear to have any close relatives, either in Borneo or in the Philippines.

From the above it would seem that the island has been subject to several faunal invasions. The earliest, probably in late Pliocene or early Pleistocene, allowed the progenitors of the modern Mindanao-eastern Philippine fauna to enter those islands. During the later Pleistocene, modern elements of the Bornean fauna have passed northward toward Mindanao, and at the same time elements of the Mindanao fauna have moved southward.

The systematics of the Bornean species of *Calamaria* is too poorly known to permit speculation regarding the status of *C. joloensis.* At present, it appears to be a very distinct species and may represent either a relic form of an old invasion or a recently evolved unique species. On the other hand, a closely related but unknown species may yet be discovered in Borneo.

KALOTKOT ISLAND

Chrysopelea paradisi
Dendrelaphis caudolineatus terrificus

This small island (14° 54.5′ N. Lat., 122° 08.8′ E. Long.) lies off the east coast of Polillo Island. According to Taylor (1922b, p. 162) the island is about "3 kilometers long and is heavily forested."

Taylor states that he obtained three species of snakes on Kalotkot and eleven species of lizards. I have been able to establish the identity of only two of the snakes he obtained there and find they are identical to species found on Polillo. One very interesting fact is that *Dendrelaphis c. terrificus,* which occurs on Kalotkot and on Polillo, is not found on Luzon Island, but rather appears to be restricted to the islands of the southern and central Philippines. This interesting case of discontinuous distribution is discussed more fully under Polillo Island (p. 402).

LAPAC ISLAND

Dendrelaphis pictus pictus

Lapac (05° 32.0′ N. Lat., 120° 46.2′ E. Long.) is a small island, about 16 square miles in area, belonging to the Tapul Group in the Sulu Archipelago. The island is covered by deeply weathered volcanics (Smith, 1924, p. 247) including a basalt flow overlying a volcanic tuff (Corby, 1951, p. 308).

A single arboreal snake has been taken here. The species is widely distributed throughout the Philippines and western Indonesia.

LEYTE ISLAND

Ahaetulla prasina preocularis
Boiga angulata
Boiga cynodon
Calamaria vermiformis grayi
Chrysopelea paradisi
Dendrelaphis caudolineatus terrificus
Elaphe erythrura erythrura
Naja naja samarensis
Natrix auriculata
Oxyrhabdium modestum
Psammodynastes pulverulentus
Python reticulatus
Stegonotus mülleri
Trimeresurus flavomaculatus flavomaculatus
Trimeresurus wagleri
Zaocys luzonensis

Leyte (10° 50.0′ N. Lat., 124° 52.0′ E. Long.) is the eighth largest island in the Philippines and occupies more than 2780 square miles. The island lies between Luzon and Mindanao; it is almost in contact with Samar Island along the latter's southwest coast but is separated by a very narrow and shallow channel of water. The island is very mountainous, many of the peaks representing extinct volcanoes. Tertiary and later volcanics overlie much of the central portion of the island and limestones, marls, and shales, some of late Tertiary age, cover much of the southern portion. There is every reason to believe that the northern parts of Leyte have been exposed for most, if not all, of late Tertiary and recent times and that until recently, Samar and Leyte were joined by continuous dry land.

The fauna of Leyte is very similar to that on Samar and Mindanao. A number of species, including *Calamaria v. grayi, Naja n. samarensis, N. auriculata, O. modestum,* and *Stegonotus mülleri* are known only from those islands within the Philippines. *Zaocys luzonensis,* a species otherwise found only on Luzon and Polillo, was reported from Leyte by Boettger (1890, p. lxiii). However, this needs confirmation.

Inger (1954, p. 512) records 16 species of frogs from Leyte. Of these, twelve are also found on Mindanao, three are suspect of being endemic to the island, and one has been reported from Luzon and Polillo but not elsewhere. The latter record is for *Rana signata similis* of which Inger examined six specimens said to have come from Cabalian, Leyte (Inger, 1954, p. 323). I doubt that that subspecies of *Rana signata* is indigenous to Leyte and suspect that, barring accidental mislabeling of the specimens, the frogs were accidentally introduced into the island.

Data drawn from the distribution of other groups of animals clearly support the conclusions stated above regarding the faunal relations of Leyte, Samar, and Mindanao.

LUBANG ISLAND

Gonyosoma oxycephala
Natrix spilogaster

Lubang Island (13° 46.5′ N. Lat., 120° 11.5′ E. Long.) lies off the southwest coast of central Luzon opposite Batangas Province. It is separated from both Luzon and its southern neighbor, Mindoro, by deep channels. According to Smith (1924, pp. 258–260) the island is composed principally of igneous and metamorphosed sedimentary rocks with some coralline deposits along the coasts.

One of the two snakes reported from Lubang Island (*Gonyosoma oxycephala*) is widely distributed throughout southeast Asia. *Natrix spilogaster*, however, is found only on Luzon and Lubang islands. Inger (1954, p. 512) records two amphibians from the island, but again both are widely distributed forms. McGregor (1928, p. 205) suggests that Lubang Island belongs to the Luzon faunal province, based on the distribution of birds. On the other hand, Cooke, quoted in Dickerson (1928, pp. 269, 271, figs. 60, 61) indicates in his maps that Lubang properly belongs to a distinct Mindoro province. Insofar as snakes are concerned, Lubang, Mindoro, and Luzon should be combined into a single faunal district (see discussion of Mindoro, p. 394). The absence of numbers of amphibians and reptiles suggests that the present fauna on Lubang has probably been derived through fortuitous circumstances (rafting or accidental transport by man).

LUZON ISLAND

Ahaetulla prasina preocularis
Boiga angulata
Boiga cynodon
Boiga dendrophila divergens
Boiga philippina
Calamaria bitorques
Calamaria gervaisi gervaisi
Calliophis calligaster calligaster
Chrysopelea paradisi
Cyclocorus lineatus lineatus
Dendrelaphis caudolineatus luzonensis
Dendrelaphis pictus pictus
Dryophiops philippina
Elaphe erythrura erythrura
Gonyosoma oxycephala
Hologerrhum philippinum
Lycodon aulicus capucinus

Lycodon mülleri
Lycodon tesselatus
Maticora intestinalis philippinus
Myersophis alpestris (see footnote 1, p. 373)
Naja naja philippinensis
Natrix dendrophiops barbouri
Natrix spilogaster
Oligodon ancorus
Oligodon modestum
Ophiophagus hannah
Oxyrhabdium leporinum leporinum
Psammodynastes pulverulentus
Pseudorabdion mcnamarae
Python reticulatus
Trimeresurus flavomaculatus flavomaculatus
Trimeresurus wagleri
Zaocys luzonensis

Luzon (15° 00.0′ N. Lat., 121° 00.0′ E. Long.) is the largest island in the Philippine Archipelago, with an area of 40,420 square miles. It is characterized by great irregularity and diversity of form. The northern portion of the island is dominated by a central Cordillera and the western Zambales Mountains. A broad plain extends from the Tayabas Isthmus north to Manila Bay. It narrows in passing between the Zambales Mountains and the central Cordillera and extends northward to the Lingayan Gulf. A number of volcanoes (some recently active) dominate the landscape: Mt. Marivales, Mt. Arayat, Mt. Makiling, Mt. Taal, and others. To the south of the Tayabas Isthmus are the Bondoc and Camarines peninsulas, the former composed of folded sedimentary rocks, the latter studded with volcanoes (Iriga, Isarog, Mayon, *et al.*) except in the north where there are folded sedimentary rocks.

Dickerson (1928, pp. 92–96) has shown that in all probability the island was divided into at least three smaller islands during the Pleistocene: (1) the Zambales highlands, (2) most of northern Luzon and perhaps incorporating Polillo Island, and (3) the Camarines Peninsula, which was joined to Samar. The Manila Plain was inundated part of that time.

Thirty-four species and subspecies of snakes are known to occur on Luzon Island. Of this number, three species, *Boiga philippina, Calamaria bitorques,* and *Lycodon tessellatus,* all of questionable status, are confined to the island. *Natrix spilogaster,* also known from Lubang Island off the western Luzon coast, is otherwise confined to Luzon. Several other species are confined to Luzon and its immediate neighbors, *i.e.,* Mindoro, Polillo, the Batanes islands. These include *Boiga d. divergens, Calamaria g. gervaisi, Calliophis c. calligaster, Dendrelaphis c. luzonensis, Hologerrhum philippinum, Lycodon mülleri, Myersophis alpestris, Naja n. philippinus, Natrix* *d. barbouri, Oligodon ancorus,* and *Oxyrhabdium l. leporinum.* The remaining eighteen species and subspecies are widely distributed throughout the Philippines with the exception of *Cyclorus l. lineatus,* known elsewhere only from the Visayan Islands.

All endemic Luzon species, excepting those of the genera *Myersophis, Oxyrhabdium,* and *Cyclocorus,* are related to genera and species presently living in Indonesia. *Oxyrhabdium* apparently represents a very old group. Its closest relative, the genus *Xylophis,* is confined to the Western Ghats, in India. The genus *Cyclocorus* has no close relatives outside of the Philippines. A single widely distributed species is recognized within the islands, and I suspect that the genus had its origin in the Philippines.

Inger (1954, p. 513) recognizes twenty-two frogs from Luzon. Nine species and subspecies are either endemic to Luzon or are restricted to Luzon and its immediate neighbors. There are no unique genera of frogs on Luzon.

There is close agreement in the distributional picture of Luzon snakes and frogs and of the birds, insects, and land molluscs.

MASBATE ISLAND

Lycodon aulicus capucinus
Natrix dendrophiops negrosensis

Masbate (12° 15.0′ N. Lat., 123° 30.0′ E. Long.) is a moderate-sized island, 1571 square miles in area, located near the southwestern coast of southern Luzon and northwestern Samar. It is separated from those islands by the deep Ticao and Samar straits. To the southwest of Masbate is the shallow Visayan Sea which now separates Masbate from Panay, Negros, and northern Cebu. The highlands on Masbate extend from southeast to northwest along the northeastern coast. There are several mountains which attain elevations of about 2000 feet.

Masbate rests upon the shallow Visayan submarine shelf. The faunal evidence (see below) suggests that Masbate has been associated with Negros and Panay during the recent past.

Only two snakes have been collected on Masbate. Of these, *Natrix d. negrosensis* is a subspecies found only on Panay, Negros, and Cebu.

Inger (1954) does not list any amphibians from this island but I have seen some material not available to him at the time his report was prepared. The affinities of the frogs from Masbate seem to lie with the Negros populations. McGregor (1928, p. 202) suggests that Masbate is allied to Negros on the basis of its avian fauna, although there are about half as many species known from the islands are are known from Negros. In a like manner, Schultze (1928, p. 253, fig. 58 and p. 254) includes Masbate in the Visayan faunal district on the basis of similarities in Lepidoptera fauna, and Cooke (1892) indicates a similar relation for the land molluscs.

Mindanao Island

Ahaetulla prasina preocularis
Aplopeltura boa
Boiga angulata
Boiga cynodon
Boiga dendrophila latifasciata
Calamaria gervaisi hollandi
Calamaria mearnsi
Calamaria vermiformis grayi
Calamaria zamboangensis
Chrysopelea paradisi
Cyclocorus lineatus nuchalis
Dendrelaphis caudolineatus terrificus
Dendrelaphis pictus pictus
Elaphe erythrura erythrura
Lycodon aulicus capucinus
Lycodon dumerili
Maticora intestinalis philippina
Naja naja samarensis
Natrix auriculata
Natrix dendrophiops dendrophiops
Natrix lineata
Oligodon maculatus
Oligodon modestum
Oligodon vertebralis notospilus (?)
Ophiophagus hannah
Opisthotropis alcalai
Oxyrhabdium modestum
Psammodynastes pulverulentus
Pseudorabdion ater
Pseudorabdion taylori
Python reticulatus
Stegonotus mülleri
Trimeresurus flavomaculatus flavomaculatus
Trimeresurus wagleri

Mindanao (08° 00.0′ N. Lat., 125° 00.0′ E. Long.) is the second largest island in the Philippine Archipelago, occupying an area of more than 36,500 square miles. There are several mountain ranges and broad, flat stream valleys. Dickerson (1928, pp. 85–87) presents a summary of the Pleistocene history of Mindanao in which he demonstrates that Mindanao was divided into five islands in early Pleistocene. He (Dickerson, 1928, pp. 80–81) suggests that only the extreme eastern and extreme southwestern parts of Mindanao were uplifted during Miocene times. In the Pliocene, Dickerson (1928, p. 85) further suggests that western Mindanao was joined with Borneo via a Sulu bridge. Smith (1924, p. 218), in his concluding remarks, states that for the most part Mindanao is a young island, and "The great extent of comparatively recent volcanic extrusives and the considerable development of raised Pleistocene reefs gives one the impression that the dominant processes in Mindanao have been aggradational rather than degradational."

The snake fauna of Mindanao is composed of at least two Bornean elements and a small Luzon element. An older group of endemics, a few of which are also found on Samar, Leyte, and Bohol, include *Calamaria mearnsi, Lycodon dumerili, Natrix auriculata, Natrix d. dendrophiops, Oligodon maculatus, Pseudorabdion taylori,* and *Stegonotus mülleri.* The latter is a relic species found also in North Borneo. Neither *Calamaria mearnsi, Lycodon dumerili, Natrix dendrophiops,* nor *Natrix auriculata* appears to have close relatives in Borneo at the present time. *Oligodon maculatus* is a very distinctive species; it was probably derived from an isolated population of *O. purpurascens,* as was the Luzon species *O. ancorus.* Lastly, *Pseudorabdion taylori* appears to be allied to the Bornean species of *Pseudorabdion* formerly assigned to the genus *Agrophis* (Leviton and Brown, 1959). It seems likely that the species noted above evolved from ancestral Bornean populations which entered Mindanao during the Pliocene.

A second group of species and subspecies, also restricted to Mindanao, Samar, Leyte, and Bohol, of more recent origin and closely allied to populations now living in Borneo, includes *Ahaetulla p. preocularis, Boiga d. latifasciata, Calamaria v. grayi, Calamaria zamboangensis, Dendrelaphis c. terrificus, Maticora i. philippina, Naja n. samarensis,* and *Oligodon v. notospilus.* These probably are derivatives of Bornean populations which entered Mindanao during the Pleistocene by way of a subaerial land bridge that must have extended from Borneo, via the Sulu Archipelago, to the Zamboanga Peninsula. (See also Herre [1928] and Myers [1951] who have provided abundant evidence to indicate that Borneo and Mindanao were joined by subaerial land sometime in the Pleistocene in order to account for the present distribution of obligate fresh-water fish on Mindanao; I am in full accord with those authors, based on the distribution of the snakes.)

A few subspecies of snakes, related to populations on Luzon, are also recorded from Mindanao. These include *Calamaria g. hollandi, Cyclocorus l. nuchalis,* and *Trimeresurus f. flavomaculatus.* The latter form, although placed in the same taxonomic category as the Luzon population, differs slightly, suggesting incipient subspeciation. I suspect that *Cyclocorus l. nuchalis* was derived through insular isolation from *C. l. lineatus.* The latter probably entered Mindanao when the Camarines Peninsula was joined to Samar and Mindanao sometime during the Pleistocene. The differences between *Calamaria g. hollandi* and *C. g. gervaisi* suggest that they evolved independently from isolated populations of a common ancestor.

MINDORO ISLAND

Calamaria gervaisi gervaisi
Calliophis calligaster calligaster

Chrysopelea paradisi
Cyclocorus lineatus lineatus
Dendrelaphis caudolineatus luzonensis
Dendrelaphis pictus pictus
Dryophiops philippina
Elaphe erythrura erythrura
Lycodon aulicus capucinus
Lycodon mülleri
Naja naja philippinensis
Natrix dendrophiops barbouri
Oligodon ancorus
Ophiophagus hannah
Python reticulatus
Trimeresurus flavomaculatus flavomaculatus

This island (12° 50.0′ N. Lat., 121° 10.0′ E. Long.) lies to the southwest of Luzon Island. There are approximately 3759 square miles of land, excluding immediately adjacent islands (*e.g.*, Ilin, Ambulong, Buyallao, *et al.*), which together constitute Mindoro Province. The island is divided by a north-south trend of mountains, of which Mt. Halcon (8481 feet) in the north and Mt. Baco (8160 feet) in the center are the most prominent.

The island is separated from Luzon by the block-faulted Verde trough on the north, from the Palawan Archipelago by the Mindoro Strait on the southwest, and from other southern and eastern islands by the Tablas Strait.

The central and northwestern portions of Mindoro are composed of basement complex rocks, including andesites, granites, diorites, and other coarsely crystalline igneous rocks and some metamorphic rocks such as schists and slates. At the southern end are several limestones of mid- to late-Tertiary age (? Miocene and Pliocene) and some earlier limestones presumed to be of Mesozoic age because of the presence of fossil ammonites. The southwest coast is covered by a recent alluvium which evidently overlies late Tertiary limestones. Alluvium also covers much of the eastern coastal region. A small Mesozoic outcrop has been identified in the vicinity of Mt. Dumali, and a little late Tertiary limestone has been found in the vicinity of Varadero Bay. It is noteworthy that Verde Island and the immediately opposing shore of Luzon Island are covered by similar sediments and by extensive deposits of volcanic tuffs of relatively recent age.

Sixteen species and subspecies of terrestrial snakes are known from Mindoro. Not one is endemic to that island; all are known from Luzon. Six species and subspecies are endemic to Luzon and Mindoro and three to those islands and to Polillo and Batan. The seven remaining species are widely distributed throughout the Philippines and western Indonesia.

There are no species or genera of snakes common to Mindoro and the islands of the Palawan Archipelago which are not found in the eastern Philippines. This is likewise true for the amphibians (Inger, 1954, pp. 513–

514) and for insects (Schultze, 1928), but not for birds or primary fresh-water fish. According to Ripley and Rabor (1958, pp. 11–12) at least five species and subspecies of birds are common to Mindoro and Palawan and are not known from elsewhere. Herre (1928, p. 244) suggests that the single endemic cyprinid fish found on Mindoro, *Puntius hemictenus,* entered that island from Palawan. A distinctive species of timarau, *Bubalus mindorensis,* is known from Mindoro but not elsewhere in the Philippines. It is related to another species of *Bubalus* found in Sarawak, Borneo.

On the whole, the present fauna of Mindoro seems to be related to that on Luzon (although McGregor [1928] suggests otherwise based on bird distribution [see below]). The presence of a unique endemic species of *Bubalus* points to an early subaerial land connection between Mindoro and the Palawan islands. When this connection existed is in doubt. Dickerson (1928, p. 91) suggests that the Mindoro *Bubalus* was derived from an early Pleistocene or Pliocene ancestor, implying a possible land connection at that time.

The marked similarity in fauna between Mindoro and Luzon points to a relatively recent connection between those two islands, possibly in the late Pleistocene. As I have already indicated, the populations of snakes and frogs on Mindoro are taxonomically indistinguishable from those on Luzon. It is true that several genera of snakes known from Luzon, *e.g., Zaocys,* have not been taken on Mindoro. However, the latter island is very poorly known, and consequently negative evidence of this sort is of little significance.

The unique species of fresh-water fish, *Puntius hemictenus,* known from Mindoro, is related to species found on Palawan Island. No indigenous species of fresh-water fish is known from Luzon. Two fresh-water fishes have been recorded from central Luzon. One, *Oryzias luzonensis* (Herre) belongs to a secondary group of fresh-water fishes, according to Myers (1951). The other, a loach of the genus *Cobitus* appears to be a Chinese species. Professor Myers suggests (*in litt.*) that the latter may have been introduced. These facts have been interpreted to mean that Luzon and Mindoro have been disconnected for a longer period of time than Palawan and Mindoro. Evidence from other groups of animals does not bear this out. Therefore, I offer below an alternative explanation to account for the presence of a species of fresh-water fish on Mindoro but not on Luzon in the belief that Mindoro and Luzon were joined by a subaerial land-bridge more recently than Palawan and Mindoro.

If it be assumed that the fresh-water fish *P. hemictenus* was present on Mindoro at the time that Mindoro and Luzon were joined by dry land, then it could be expected that the fish might have reached Luzon. Luzon and Mindoro could only have been joined across the Verdes Island Passage which now separates northern and northeastern Mindoro and the Batangas-Cavite districts of southwestern Luzon. If, at the time Mindoro and Luzon were joined together, the Mindoro population of *Puntius* were to disperse into

Luzon, the fish would have had to enter the streams which drain the Batangas-Cavite area. The Batangas-Cavite district is overlain by thick deposits of volcanic tuff derived from intermittent periods of volcanic activity in that district during the late Pliocene and Pleistocene. It is evident that there must have been periodic destruction of the existing habitats, including the streams. There must have been considerable destruction of life, also. The chances for a small population of fresh-water fish to become established in this area of Luzon would be very small, if not nonexistent. The above factors probably would have had little effect on the dispersal of the numerically larger populations of animals on Luzon into Mindoro, however. Even if the Batangas-Cavite region were temporarily denuded of life because of volcanic activity, dispersal of faunal elements from immediately adjacent parts of Luzon into that region would continue during tranquil periods as soon as the necessary habitats reappeared. Thus, movements of animals from Luzon into Mindoro could also continue, albeit on an interrupted basis. From the above, then, it follows that periodic destruction of the available habitats of *Puntius* in the Batangas-Cavite district probably acted as the limiting factor in preventing the establishment of permanent population of that fish on Luzon.

One further point may be noted. Palawan may have received its complement of fresh-water fish during the Pleistocene when the Sundaland submarine shelf was exposed to subaerial erosion. At that time fresh-water fish probably passed from the Malay Peninsula into the islands of western Indonesia. In 1941, Dickerson discussed the effects of the last glaciation (Wisconsin) on the Sundaland shelf. He indicated that the Moelengraaf river and valley existed "in varying forms . . . during the earlier glacial phases of the Pleistocene." (Dickerson, 1941, p. 14.) From this it may be assumed that the fresh-water fish now found on Palawan, and which are represented by a number of endemic species, may have entered that island in early or mid-Pleistocene. At least one species of fish was then able to reach Mindoro, also in early or mid-Pleistocene. This latter conclusion is based on the fact that Mindoro lacks all the modern species of snakes and amphibians, except those which are widely distributed throughout the eastern Philippines, and I find it difficult to believe that one group of animals could have entered Mindoro to the exclusion of all other groups. Thus, it is assumed here that the progenitor of *Puntius hemictenus* entered Mindoro about the same time as the ancestors of the unique timarau.

As I have noted above, McGregor (1928) believes that Mindoro is very distinct from Luzon. This conclusion is, in large part, based on the absence of the large hornbills, or calaos, from Mindoro. I do not believe that McGregor's conclusions are entirely justified, however. I have already pointed out above that any faunal movements from Luzon to Mindoro would have had to pass through the Batangas-Cavite corridor. Periodic volcanic activity closed this route. Time would be required to re-establish favorable habitats for animals to reinhabit. In the case of the hornbills, they would have had to await the regrowth of the heavy dipterocarp forest climax. On the other hand, among the first animals to reinvade the Batangas-Cavite district would be the reptiles, many of which have wide ranges of ecological tolerances. These, then, would be the animals which could take advantage of a geologically temporary land connection between Luzon and Mindoro. In Dammerman's (1948) study of the fauna of Krakatoa, he showed that reptiles were among the earliest colonizers of that island following the 1883 explosion. On page 296, Dammerman also notes that ground snakes were the earliest colonizers of the slopes and surrounding areas of Mt. Jorullo, Mexico, which erupted in 1759. It is interesting to note that there are 12 species of ground snakes on Mindoro, and only two species of arboreal snakes. Most of the genera of arboreal snakes known from Luzon are absent, thus suggesting that the Batangas-Cavite corridor was not heavily forested at any time during which Mindoro and Luzon were joined together.

NEGROS ISLAND

Ahaetulla prasina preocularis
Boiga angulata
Calamaria gervaisi iridescens
Calliophis calligaster gemianulis
Chrysopelea paradisi
Cyclocorus lineatus lineatus
Dendrelaphis caudolineatus terrificus
Dendrelaphis pictus pictus
Dryophiops philippina
Elaphe erythrura erythrura
Gonyosoma oxycephala
Lycodon aulicus capucinus
Natrix dendrophiops negrosensis
Oligodon modestum
Ophiophagus hannah
Oxyrhabdium leporinum visayanum
Oxyrhabdium modestum[3]
Psammodynastes pulverulentus
Pseudorabdion mcnamarae
Pseudorabdion montanum
Pseudorabdion oxycephalum
Python reticulatus
Trimeresurus flavomaculatus flavomaculatus
Trimeresurus wagleri

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[3] A single specimen of this snake was presented to Dr. Walter Brown, in 1954, by a resident of Dumaguete, Negros Oriental, who stated he had collected the specimen in the vicinity of the town. This species is well known in the eastern Philippines. Although Dr. Brown and Mr. Angel Alcala have collected in the southern Negros area extensively on and off during the last eight years, no other specimen of this species has been found on the island. If the species now occurs there, which is doubtful, it must certainly have been accidentally introduced within recent years.

Negros Island (10° 00.0′ N. Lat., 123° 00.0′ E. Long.) is the fourth largest island in the Philippine Archipelago, occupying an area of more than 4900 square miles. The island lies to the northwest of Mindanao and is in close proximity to Panay and Cebu. It is bounded on the north by the shallow Visayan shelf which joins it to Panay, Masbate, and the extreme northwestern coast of Cebu.

Northern and southern Negros appear to have been subject to extensive volcanic activity. The landscape of both regions is dominated by volcanoes; in the north Mt. Canlaon rises to 8087 feet; in the south Cuernos de Negros attains an altitude of 6244 feet. Between the northern and southern districts is a central region in which extensive sedimentary deposits are most prominent. Limestones of Pliocene age have been found near the summits of the eastern mountains. The western shores of Negros have been built up partly by sediments derived from the eastern mountains and partly by the outpouring of lava, ash, and boulders, beginning in late Pliocene and continuing into recent times. During the Pliocene, and perhaps part of the Pleistocene, Negros Island was divided into two parts, separated by a submerged central region. The present island is, therefore, of comparatively recent origin.

During the Pleistocene, at least the northern portion of Negros must have been joined to Panay and Masbate by a subaerial land bridge when the shallow Visayan shelf was exposed. Northern Cebu must also have been a member of this complex, as I have already explained (see discussion of Cebu, p. 384).

The snake fauna of Negros includes at least seven species and subspecies of which one is endemic (*Pseudorabdion montanum*) to Negros and six are known only from the Visayan complex. The other seventeen species are widely distributed throughout the archipelago.

Of the six species and subspecies endemic to the western Visayan Island, all have their closest allies on Luzon. *Calamaria g. iridescens* is very close to *C. g. gervaisi; Calliophis c. gemianulis* and *C. c. calligaster* are found only on the Visayan Islands and Luzon, with a third subspecies restricted to Polillo; *Natrix d. negrosensis* is more similar to *N. d. barbouri* from Luzon than to *N. d. dendrophiops,* the Mindanao subspecies; *Oxyrhabdium l. visayanum,* found only in the western Visayan Islands, is related to *O. l. leporinum* from Luzon; and *Pseudorabdion mcnamarae* is most closely allied to *P. minutum* from Luzon (which has been tentatively referred to the synonymy of the former).

The Negros fauna, or more properly the western Visayan snake fauna, was derived largely from Luzon. Only one member of the southern Philippine snake fauna, not also found on Luzon, is present on Negros, *Dendrelaphis c. terrificus* (the occurrence of *Oxyrhabdium modestum* on Negros has already been questioned [see p. 398]).

On the whole, the frogs have a pattern of distribution similar to that of the snakes. A distinct subspecies of *Kaloula conjuncta,* most closely allied to the Luzon subspecies, occurs on Negros, and *Cornufer hazelae* appears to be restricted to Negros, Panay, and Luzon. A few frogs are allied to eastern or southern populations rather than the Luzon populations. Inger (1954, pp. 470–471) indicates that Negros shows about the same degree of faunal similarity to Mindanao as it does to Luzon and is, therefore, intermediate between the two.

Of the six subspecies of snakes endemic to the western Visayans which have their closest allies in Luzon, five are burrowing or at least secretive snakes. In view of the fact they are represented by distinct subspecies, it does not seem possible that their present distribution could be accounted for by recent accidental introduction by man, nor does it seem likely that the progenitors of so large a number of forms could have arrived by fortuitous rafting, or wind transport (which, incidentally, would be unlikely because prevailing storm paths do not pass from Luzon to the western Visayans). Furthermore, it is highly improbable that the ancestors of the Visayan species traveled across open water, for reasons I have already outlined (p. 376). Consequently, it would appear that there must have been a land connection between Luzon and western Visayan Islands. The fact that we are concerned with subspecifically distinct populations indicates a probable connection in the late Pliocene or early Pleistocene. From what is currently known of the geology and faunistics of the northern Philippines, the most probable connection between the two faunal regions would be across the present Ticao Strait. While there is no geological evidence to indicate the age of the strait, which probably is a dropped fault-block, it is known that there is considerable seismic activity at the present time. I suggest that the Ticao Strait assumed its present topographic attitude during the middle or late Pleistocene.

If I am correct in this assertion at least one heretofore unexplained problem, the fact that Ticao Island includes elements of both the modern Luzon and Visayan faunae, is explained (see discussion of Ticao Island, p. 407). Thus, I assume, a land connection existed between Ticao and Luzon thereby permitting elements of the Luzon fauna to enter the Visayan Islands. However, Ticao was joined to the western Visayans, via Masbate, and that island was joined to the more western islands of Panay and Negros only intermittently.

PALAWAN ISLAND

Ahaetulla prasina prasina
Aplopeltura boa
Boiga cynodon
Boiga dendrophila multicincta
Boiga drapiezi
Calamaria everetti

Chrysopelea paradisi
Dendrelaphis caudolineatus caudolineatus
Dendrelaphis pictus pictus
**Dryocalamus subannulata*
Dryocalamus tristrigatus
Elaphe erythrura philippina
Gonyosoma oxycephala
Liopeltis philippinus
Liopeltis tricolor
Lycodon aulicus capucinus
Lycodon subcinctus sealei
Maticora intestinalis bilineata
Naja naja miolepis
Natrix chrysarga
Oligodon vertebralis notospilus
Ophiophagus hannah
**Opisthotropis typica*
Psammodynastes pulverulentus
Python reticulatus
Sibynophis bivitattus
Trimeresurus schultzei
Trimeresurus wagleri
Xenopeltis unicolor
Zaocys carinatus

Palawan Island (10° 30.0′ N. Lat., 118° 30.0′ E. Long.) is a rugged, elongate island extending northeast from the northwest coast of Borneo. The island is more than 275 miles long, but only 5 to 30 miles wide. A chain of very rugged mountains, with peaks rising to more than 6000 feet (Mt. Mantalingajan attains an elevation of 6839 feet) extends the length of the island. A very broad, shallow submarine shelf extends to the northeast from the coast of north Borneo. The islands of the Palawan Archipelago, including Balabac, Palawan, and the Calamianes Islands, are all situated on this platform.

The geological history of Palawan is poorly known. Crystalline rocks predominate in the southern portion of the island, while limestones are found in the north. Faunal evidence, however, suggests that during the Pliocene and Pleistocene at least part of Palawan was joined to Borneo, and occasionally to the northern Calamianes Islands.

Thirty species and subspecies of snakes have been found on Palawan. Twenty-three species found on Palawan are taxonomically identical to populations from Borneo. Four Palawan species are known only from the Palawan Archipelago. Of these, three are related to Bornean populations. Only *Trimeresurus schultzei* is of unknown affinities.

Evidence drawn from other groups of animals suggests that Palawan and Borneo are very closely related. Herre (1928, pp. 244–246) and Myers (1951, p. 13) demonstrate very closely that Palawan and Borneo must have been joined by a subaerial land platform to account for the large number of obligate fresh-water cyprinid fish found there. In a like manner, the amphibians found on Palawan are most similar to Bornean populations.

PANAY ISLAND

Ahaetulla prasina preocularis
Calamaria gervaisi iridescens
Calliophis calligaster gemianulis
Dendrelaphis pictus pictus
Elaphe erythrura erythrura
Lycodon aulicus capucinus
Natrix dendrophiops negrosensis
Psammodynastes pulverulentus
Python reticulatus

This island (10° 42.0′ N. Lat., 122° 33.0′ E. Long.) lies to the immediate northwest of Negros to which it is intimately joined by the shallow Visayan submarine shelf. The central highlands attain altitudes of 6726 feet (Mt. Nangtud), 6722 feet (Mt. Malinae), and 5670 feet (Mt. Baloy), and some peaks on the western coasts are almost as high.

The geological history of Panay suggests that the island was partially inundated during the Miocene, Pliocene, and the Pleistocene. Dickerson (1928, p. 90) notes that there may have been two smaller islands during the Pleistocene, rather than one. From a zoological standpoint, however, it is most important to note that geologic and hydrographic evidence both point to a subaerial land connection between Negros, Panay, and, intermittently, Masbate during parts of the Pleistocene.

Panay is one of the least explored of the larger Philippine Islands. Only nine species of snakes have been reported from there; all are known from Negros, and at least three are restricted to those islands and Cebu.

McGregor (1928, p. 199, fig. 50, and pp. 202–203) has shown that the avian fauna of Negros and Panay are practically identical.

PAPAHANG ISLAND

Oligodon meyerinki

Papahang (05° 02.2′ N. Lat., 119° 47.4′ E. Long.) is a small raised coral reef at the south end of the Tawi-Tawi Group between Sanga Sanga and Bongao islands.

The single snake reported from Papahang is widely distributed throughout the southern Sulu Archipelago.

POLILLO ISLAND

Ahaetulla grasina preocularis
Boiga angulata

Boiga cynodon
Boiga dendrophila divergens
Calamaria gervaisi polillensis
Calliophis calligaster mcclungi
Chrysopelea paradisi
Cyclocorus lineatus lineatus
Dendrelaphis caudolineatus terrificus
Dendrelaphis pictus pictus
Elaphe erythrura erythrura
Hologerrhum philippinum
Lycodon mülleri
Natrix spilogaster
Psammodynastes pulverulentus
Python reticulatus
Trimeresurus flavomaculatus halieus
Zaocys luzonensis

Polillo Island (14° 50.0′ N. Lat., 121° 57.0′ E. Long.) lies about 25 kilometers off the east coast of Luzon. It is separated from that island by a deep channel, the Polillo Strait, which probably resulted from faulting (Dickerson, 1928, p. 115). The island occupies an area of about 297 square miles. Little is known of its geology. It rests upon the broad Camarines submarine shelf and must have been joined to the Camarines Peninsula in the Pleistocene during times of glacial maxima.

A heterogenous assemblage of snakes is present on Polillo. *Natrix spilogaster, Lycodon mülleri, Hologerrhum phillipinum, Cyclocorus l. lineatus,* and *Boiga d. divergens* are typically Luzon species. However, *Dendrelaphis c. terrificus,* the southern subspecies of *D. caudolineatus,* is found on Polillo rather than the Luzon form, *D. c. luzonensis.* Also, *Calamaria g. polillensis* is more closely related to *C. g. hollandi,* the Mindanao subspecies, than to *C. g. gervaisi,* from Luzon (although this similarity may be accounted for by parallel mutations in otherwise similar genetic systems). *Trimeresurus f. halieus* differs only slightly from the typical Luzon form and was probably derived from that population by insular isolation.

The amphibians known from Polillo are, for the most part, related to Luzon populations. A single endemic species, *Cornufer polillensis,* is found on the island. Inger (1954) gives no indication of the affinities of the species.

McGregor (1928, pp. 205–206) includes Polillo in the Luzon faunal district, having shown that the two share a number of endemic genera.

Based on the distribution of snakes, two faunal elements are found on Polillo. The Luzon element predominates. The Mindanao-Samar element is much smaller. The latter may have entered Polillo at a time when the Camarines Peninsula was joined to Samar and was separated from central and northern Luzon. Dickerson (1928, p. 120) has suggested that this occurred during the early and middle Pleistocene. If this be true, then those Mindanao-Samar faunal elements which were able to reach Polillo would have had an opportunity to become established before the Camarines Peninsula was again joined to Luzon (in late Pleistocene) and the numerically larger and more aggressive Luzon fauna entered that island. This may well account for the presence of *Dendrelaphis c. terrificus* on Polillo, rather than *D. c. luzonensis.*

SAMAR ISLAND

Ahaetulla prasina preocularis
Boiga dendrophila latifasciata
Calamaria vermiformis grayi
Calliophis calligaster calligaster
Chrysopelea paradisi
Cyclocorus lineatus nuchalis
Dendrelaphis caudolineatus terrificus
Dendrelaphis pictus pictus
Elaphe erythrura erythrura
Lycodon aulicus capucinus
Maticora intestinalis philippina
Naja naja samarensis
Natrix auriculata
Natrix lineata
Oligodon ancorus
Oxyrhabdium modestum
Psammodynastes pulverulentus
Python reticulatus
Stegonotus mülleri
Trimeresurus wagleri

Samar Island (12° 00.0′ N. Lat., 125° 00.0′ E. Long.) lies between Luzon on the north and Mindanao on the south. To the east, and separated by a very narrow channel, is Leyte. The island is the third largest in the Philippines, with more than 5300 square miles of area. There is no distinctive central Cordillera on Samar; the highest point among the relatively low hills rises 2789 feet above sea level. Because of the absence of marked topographic relief, rainfall is fairly evenly distributed over the entire island, which consequently is heavily forested. According to Dickerson (1928, p. 36) the island is a broad marine plain which was uplifted during the late Pleistocene, but it probably was exposed several times earlier in the Pleistocene during times of maximum recession of the seas.

Twenty species and subspecies of snakes are presently recorded from Samar. Of those, nine are found only on Mindanao and related islands, and two (both requiring confirmation) are known on Luzon. The ten remaining species and subspecies are widely distributed throughout the Philippines. There are no endemic species of snakes on Samar.

The amphibian fauna of Samar is not well known. Of the nine species and subspecies known to occur on the island, two are found only on Samar, Mindanao, Leyte, and Basilan, and six are widely distributed. A single nominal species, *Rhacophorus hecticus,* known only from the type specimen said to have come from Samar, is restricted to that island.

Several genera of both amphibians and snakes, present on Mindanao and Samar, do not enter Luzon. A few genera of amphibians, notably *Bufo, Chaperina,* and *Ichthyophis,* are found in Mindanao but not on Samar. In a like manner the snake genus *Aplopeltura* does not reach Samar.

It seems reasonable to conclude that Samar received most of its fauna from Mindanao. The absence of endemic species or subspecies suggests that the fauna entered not earlier than mid-Pleistocene, which is in agreement with what is known of the geological history of the island.

There are two lines of evidence to suggest that Samar was joined to Luzon during the later Pleistocene. For one, as I have already noted above, there are at least two snakes of the Luzon fauna which are presumed to have become established on Samar. These are *Calliophis c. calligaster* and *Oligodon ancorus.* That more Luzon species have not become established on Samar may have been a result of the fact that Mindanao and Samar were joined before Samar and Luzon, and the Mindanao fauna consequently became established and occupied the available habitats thereby preventing successful infiltration by the Luzon fauna.

The second line of evidence for a Samar-Luzon connection has already been discussed (see Polillo Island, p. 402). The fact that several Polillo snakes are more closely related to Mindanao populations rather than to Luzon forms suggests that their progenitors reached Polillo via a Samar-Camarines-Polillo bridge at a time when the Camarines Peninsula was separated from central Luzon during the mid-Pleistocene (Dickerson, 1928, p. 120).

Sibutu Island

Ahaetulla prasina prasina
Oligodon meyerinki

Sibuto (04° 46.4′ N. Lat., 119° 28.8′ E. Long.) is an elongate island, the largest of the Sibutu Group, which lies a few miles off the northeast coast of Borneo. Smith (1924, p. 247) states that the island is a raised coral reef and is flat except for one hill in the center.

Both snakes which have been collected on this island are known from other islands in the Sulu Archipelago and from North Borneo.

Sibuyan Island

Chrysopelea paradisi
Dryophiops philippina

Sibuyan Island (12° 25.0′ N. Lat., 122° 34.0′ E. Long.) lies a few miles to the east of Tablas and Romblon and is isolated from those islands by a deep channel. Plotting a series of isobath contours around Sibuyan indicates that the sides drop off very precipitously to reach depths in excess of 200 meters. According to Smith (1924, p. 200) the island has but one peak, an old volcanic stock which rises to a height of 6730 feet.

A single specimen of *Dryophiops philippina* has been taken on the island. This snake is known from Luzon and Mindoro, but not elsewhere. *Chrysopelea paradisi* is the only other snake to have been taken on this island. Inger (1954, p. 514) reports one frog from the island, *Rana erythraea*. McGregor (1928, p. 209) suggests that Sibuyan has been separated from all other islands for a very long time or has never been joined to any other island. I am inclined to agree.

Siquijor Island

Chrysopelea paradisi

Siquijor (09° 11.0′ N. Lat., 123° 34.0′ E. Long.) is a small island located off the southeast coast of Negros. It is separated from the surrounding islands, notably Negros, Cebu, Bohol, and Mindanao, by very deep channels, none of which is less than 175 meters deep. McGregor (1928, p. 202) states that the island is of recent origin, though I am unable to find geological evidence either to confirm or to refute that statement.

The single snake reported from Siquijor is widely distributed throughout southeastern Asia. Inger (1954, p. 514) records three frogs from the island, all of which are widely distributed. McGregor (1928, p. 202) states there are three endemic species of birds on Siquijor, but the island lacks a number of species found on neighboring Negros.

There is no clear indication of how the reptiles and amphibians reached Siquijor. The species known from the island could easily have been introduced. Nothing is known about the distribution of other groups of animals on this island. Based on his study of the birds, McGregor believes that it can be grouped with the Negros complex.

Sitanki Island

Dendrelaphis caudolineatus terrificus

This very small island (04° 39.5′ N. Lat., 119° 23.5′ E. Long.), a member of the Sibutu Group, lies within the Tumindao Reef, immediately to the west of the Tumindao Channel and Sibutu Island. Nothing is known of its geology but I suspect that it is a raised coral reef.

The single snake which occurs on Sitanki is a subspecies found in the Philippines as far south as Basilan Island at the north end of the Sulu Archipelago. It has not been taken on any of the Sulu islands and I doubt that it occurs there. It is most likely that the snake was accidentally introduced.

TABLAS ISLAND

Calamaria gervaisi gervaisi
Cyclocorus lineatus lineatus
Oligodon modestum

This island (12° 23.5′ N. Lat., 122° 02.0′ E. Long.) lies off the north coast of Panay and southeast of Mindoro. It is a long island with a north-south oriented series of mountains, the highest of which attains an elevation of 2165 feet. At the present time Tablas, and its immediate neighbor, Romblon, which together lie on a shallow submarine shelf, is separated from both Mindoro and Panay by channels exceeding 150 meters depth. There is no evidence to indicate that Tablas has been connected to either island, or to Luzon or Marinduque which lie to the north. Furthermore, there are extensive limestone deposits on the island suggesting marine planation perhaps in the late Pleistocene.

The known snake fauna of Tablas includes three snakes. *Calamaria g. gervaisi* occurs on Mindoro and Luzon; *Cyclocorus l. lineatus* on Luzon, Mindoro, and Negros; and *Oligodon modestum* on Negros, Luzon, and Mindanao. The latter species is best known on Negros, the other localities needing confirmation.

The frogs known from Tablas are all widely distributed species. From this and the above it seems probable that Tablas was populated by animals which arrived by rafting or other fortuitous means during very recent times.

TAWI-TAWI ISLAND

Oligodon meyerinki
Python reticulatus

Tawi-Tawi (05° 11.5′ N. Lat., 120° 02.0′ E. Long.) is the largest island in the Tawi-Tawi Group. It is about 34 miles long by 6 to 14 miles wide and occupies an area of 229 square miles. According to Smith (1924, pp. 246–247) the island is composed mostly of sedimentary rocks, but Corby (1951, pp. 308–309) remarks on the abundance of serpentines and the presence of reef limestones along the northwest coast. I have already remarked on the hydrographic position of the Tawi-Tawi Group (see p. 381).

The two snakes known from Tawi-Tawi are well known from elsewhere in the southern Sulu Islands and in North Borneo.

TICAO ISLAND

Dendrelaphis caudolineatus luzonensis

Ticao (12° 31.0′ N. Lat., 123° 42.0′ E. Long.) lies off the extreme southwest coast of southern Luzon between Luzon and Masbate. The island, which is 129 square miles in area, is separated from both Luzon and Masbate by deep channels. It is thought to have been joined with Masbate until late Pleistocene when vertical faulting produced the present graben separating the two islands. At the present time Ticao is connected with Masbate near the southern end of the island by a shallow submarine bridge, a part of the Visayan submarine shelf (Dickerson, 1928, pp. 113–114). There is no evidence to indicate the age of the Ticao straits. Before that graben had been formed Ticao may have been joined to Luzon, for reasons already given (see discussion of Negros Island, p. 398).

A single snake has been taken on Ticao Island. It seems noteworthy that this snake is a subspecies found elsewhere only on Luzon and Mindoro. There is no good evidence of a land connection between Ticao and Luzon during either Pliocene or Pleistocene although I have already indicated that the islands may have been joined at one time. McGregor (1928, p. 202) points out that Ticao, based on the distribution of birds, must be associated with the Visayan Islands. He does note, however, that some elements have "infiltrated" from Luzon.

INTERISLAND RELATIONSHIPS

From the preceding discussions, the following generalizations of the interisland relations may be proposed:

I. Luzon, Mindoro, Polillo, Marinduque, and the northern Batan and Camiguin islands form a logical faunal unit. Although Mindoro probably was joined to Palawan in the past, there are no Palawan elements in its herpetofauna. The reptiles and amphibians on Mindoro are clearly related to Luzon. The northern Batan and Camiguin islands, while they have not been joined to Luzon directly, nevertheless have received their fauna from that island, albeit by fortuitous means. Both Polillo and Catanduanes islands were joined to Luzon and their faunal relations clearly associate them with that island. This "Luzon" complex may be characterized by a number of "index" species, including among others: *Oligodon ancorus, Calliophis c. calligaster*[4], *Hologerrhum philippinum, Lycodon mülleri, Natrix spilogaster, Natrix d. barbouri,* and *Naja n. philippinensis.* Some, but not all, of these species are found on all the islands, with the exception of Luzon where they are all present. Nonetheless, two or more of the species are found on each island mentioned and are not found elsewhere in the Philippine Archipelago.

II. Panay, Negros, Cebu, Masbata, Bantayan, and probably Ticao and Siquijor islands form a faunal unit. Negros and Panay are particularly closely associated. Cebu, which received elements of the Negros-Panay fauna probably in the late Pleistocene, was before then an isolated series of raised

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[4] *Calliophis c. mcclungi,* from Polillo, differs from the nominate form in its lower ventral count. The color pattern is almost identical to the Luzon subspecies. On the other hand, *C. c. gemianulis* from the western Visayan islands has a very distinct color pattern.

coralline islets. These islands rest upon the shallow Visayan submarine platform which lies at depths of less than 50 meters.

Calliophis c. gemianulis, Calamaria g. iridescens, Natrix d. negrosensis, Oxyrhabdium l. visayanum are subspecies restricted to this general area. A number of species of *Pseudorabdion* are presently known only from Negros. However, the other islands of the western Visayan complex have not been as well studied as Negros and populations of *Pseudorabdion,* related to those on Negros, may yet be found elsewhere.

III. Samar, Leyte, Bohol, Dinagat, Mindanao, and Basilan are closely related. Bohol rests upon a shallow submarine shelf which joins it to Leyte. In a like manner Leyte and Samar are connected to Mindanao, by way of Dinagat, by a similar submarine platform. Basilan is separated from the Zamboanga Peninsula by a narrow and shallow channel of water. A drop in sea level of less than 20 meters would give rise to a continuous land mass extending from southern Basilan to northern Samar.

The islands listed here are characterized by several distinctive species and subspecies of snakes found nowhere else. These include: *Boiga d. latifasciata, Calamaria g. hollandi, Calamaria v. grayi, Cyclocorus l. nuchalis, Lycodon dumerili, Naja n. samarensis, Natrix auriculata, Natrix d. dendrophiops, Ntrix lineata, Oxyrhabdium modestum,* and *Stenogonotus mülleri.* Some, but not all, of the species and subspecies listed above occur on all the islands of the Mindanao complex. Basilan shares the greatest number of endemics with Mindanao, a total of eight, while Samar, Leyte, and Bohol, taken in combination, share seven (all known on Samar, five known from Leyte, and four from Bohol). Only two typically Luzon species, *Calliophis c. calligaster* and *Oligodon ancorus,* have been reported from Samar, but both need confirmation.

At least six species which occur on Mindanao have not been reported on other islands. These include *Calamaria mearnsi, Calamaria zamboangensis, Oligodon maculatus, Opisthotropis alcalai, Pseudorabdion ater,* and *Pseudorabdion taylori.* With the exception of *O. maculatus* they are secretive snakes. The affinities of *C. mearnsi* are not known. *Calamaria zamboangensis* may be conspecific with *C. brachyura* from Borneo. *Oligodon maculatus* is probably related to *O. annulifer* and *O. bipartita* from north Borneo. The relationship of *P. ater* are uncertain, but may be intermediate between *P. longiceps,* from western Indonesia and Malaya, and *P. oxycephalum* from Negros. *Pseudorabdion taylori* is probably related to the Bornean species *P. albonuchalis* and *P. Saravacensis.* And *O. alcalai* is close to *O. typica* from Borneo.

The fauna of none of the islands associated here with Mindanao has been collected as thoroughly as that of this island. All are much smaller, although Samar and Leyte are certainly large enough to support highly variable faunas. The faunas of Samar and Leyte are poorly known. For example, up to the time of this report, only five species and subspecies of snakes had been recorded for Samar Island; nineteen species and subspecies are now known. Future collecting will probably turn up additional species of snakes, most of which, I suspect, will have Mindanao affinities.

An additional factor must also be considered when comparing the total number of species shared between islands of a single faunal unit. Geological evidence suggests that Samar was, until the Pleistocene, covered by water. Mindanao, on the other hand, has not been completely inundated, at least since the Miocene, although many of the present large river valleys were drowned during parts of the Pleistocene. It is evident that the present fauna of Samar is of recent origin while Mindanao's fauna is older. It follows then that there has not been sufficient time for Samar to receive and to accommodate all the possible species and subspecies of snakes which are known to inhabit Mindanao, even assuming that ecological diversification and available habitats are as great on Samar as on Mindanao (which they are not!).

IV. The islands of the Sulu Archipelago, which extend from northeastern Borneo to, but not including, Basilan, form a single faunal unit. The largest of these islands, Jolo, supports the greatest number of species and subspecies. Most of the islands in the archipelago are either recently raised coral ridges or small volcanoes. Faunal elements from both Mindanao and Borneo may be identified on these islands, especially on Jolo.

A single species, *Oligodon meyerinki,* may be thought to characterize this group of islands. Of the thirteen snakes known from Jolo, one is endemic (*Calamaria joloensis*) and of uncertain affinities, two (*Ahaetulla p. preocularis* and *Trimeresurus f. flavomaculatus*) have Philippine affinities, and two (*Maticora i. suluensis* and *Oligodon meyerinki*) are mostly closely related to Bornean species. It seems clear that the Sulu Archipelago has not only provided a migration route for the Bornean fauna into the Philippines, but also has been used by Philippine faunal elements to disperse southward.

It is not surprising that elements of the Philippine fauna have not become established in Borneo as have elements of the Bornean fauna become established in the Philippines. Competition between the numerically large Bornean fauna and the smaller, closely related Philippine fauna would lead to the extinction of the latter.

The Sulu Archipelago, then, is a transitional region having a small fauna of which a part is Bornean and a part is Philippinean.

V. The Palawan Archipelago, including Balabac, Palawan, and the islands of the Calamianes Group belong to the Bornean faunal province. A few old endemic species are found on these islands, most especially the discoglossid frog *Barbourula,* and the snake *Oligodon perkinsi.* Twenty-five of the thirty-one species known from this Archipelago are identical to species known from Borneo. Of the six treated here as distinct species or subspecies, all but two are closely related to Bornean populations: *Sibynophis bivittatus* is probably only subspecifically distinct from *S. gemiantus; Liopeltis philippina,* which occurs on both Culion and northern Palawan, was probably derived from a population of *L. tricolor* which had been isolated on Culion Island, but which recently has re-entered Palawan; *Oligodon v. notospilus* is distinguished from the typical Bornean population by its lower ventral count; and *Maticori i bilineata* is distinguished by small differences in color pattern. Only *Oligodon perkinsi,* a species known from two specimens from Culion Island, and *Trimeresurus schultzei,* from Palawan, are of uncertain affinities and cannot be related to Bornean species.

ORIGIN OF THE PHILIPPINE SNAKE FAUNA

It is clearly evident that the Philippine snake fauna has been derived from western Indonesia and Malaya. Contrary to previously expressed views (Taylor, 1928, pp. 233–239), there are no genera or species of Philippine snakes which show affinity with strictly Taiwan, Papuan, or Celebesian genera.

Taylor (1928, p. 233) suggested a Taiwan origin for the Philippine species of *Calliophis* (formerly *Hemibungarus*) on the assumption that this genus was not known from the Indo-Malayan region. However, the genus is represented in Indonesia by a single species, *C. gracilis.* I have no doubt that *Calliophis* entered the Philippines a long time ago for the species which occurs there is very distinct. In addition, the genus has a disjunct distribution, with a number of very distinct species occurring at isolated places throughout the Oriental Region.

Although there is considerable floral evidence to suggest an early Tertiary connection of the northern Philippines with Taiwan (Merrill, 1928, pp. 157–166), there are no Taiwan reptile or amphibian elements in the Philippine fauna. Nor, indeed, are there any strictly Philippine amphibian or reptile elements in Taiwan.

Inger (1954, p. 492) has shown that the evidence for a Celebesian dispersal route for Philippine Amphibia is very weak. Insofar as the snakes are concerned, only two species of Philippine snakes, *Dendrelaphis c. terrificus* and *Elaphe erythrura,* have been identified in the Celebes. The latter species has been recorded from throughout the Philippines, including Palawan, and I suspect it will eventually be found in Borneo unless it has become extinct on that island because of competition with more aggressive Malayan species (*e.g., Elaphe melanura*). *Dendrelaphis c. terrificus* is not known from Borneo, although a closely related subspecies occurs there. I suspect that that snake was introduced into the Celebes by natives in the course of their local activities. I find it almost inconceivable that that snake could have entered the Philippines from the Celebes, or vice versa, without some other elements of the fauna also moving from one place to the other. At least 63 species of snakes are known from the Celebes. Of this number only 15 species are identical to species in the Philippines and of these, 13 are widely distributed throughout southeastern Asia.

Taylor (1928, p. 233) suggested that the snake genus *Stegonotus* had been derived from a Papuan ancestor because the genus was thought to be best developed in that region. There are eight species of lycodontine snakes in the Papuan region which have been assigned to the genus *Stegonotus* but which are more closely related to recognized species of *Lycodon.* The genus *Stegonotus* is a primitive lycodontine snake, and rather than being derived from the more highly specialized Papuan forms, I believe it is a relic of the ancestral stock from which the modern lycodontine snakes were derived. In my opinion, the Papuan lycodontine snakes were derived from the modern Asian lycodontine snakes. In support of this view, I would like to point out that the genus *Dinodon,* which is now restricted to the periphery of the Oriental Region in western and central China is closely related to *Stegonotus.* It, too, probably represents a relic of the early ancestral lycodontine stock.

Excluding Taiwan, the Papuan region and the Celebes as potential sources of the Philippine snake fauna, there remains only western Indonesia and Malaya to be considered. As I have pointed out earlier, with the exception of the genera *Myersophis Oxyrhabdium, Cyclocorus,* and *Hologerrhum,* all the genera of Philippine snakes are found in Borneo. This includes the genus *Stegonotus,* for which I have recently reported a specimen from the Mt. Kina Balu region of North Borneo (Leviton, in press). *Cyclocorus* and *Hologerrhum,* which I suspect are congeneric, may have originated in the Philippines, while *Oxyrhabdium* is an isolated relic whose closest relative lives in the Western Ghats of India.

SUMMARY

Eighty-seven species and subspecies of terrestrial snakes are now recognized in the Philippine Islands. Of this number, 58 species and subspecies (67 per cent) are endemic to those islands. All but four genera and their six included species and subspecies have present-day Indo-Malayan affinities.

Based on the distribution of the terrestrial snakes it is reasonable to suggest that the Philippines be divided into five faunal districts. Each district is characterized by several distinct endemic species which are found nowhere else in the Archipelago:

I. The Luzon district includes the islands of Luzon, Mindoro, Polillo, Catanduanes, Marinduque, and the northern Batan and Camiguin groups. These latter groups have not been joined to Luzon, but nonetheless they have received their small fauna from Luzon.

II. The western Visayan district includes the islands of Panay, Negros, Cebu, Masbate, Bantayan, and perhaps Ticao and Siquijor. Although there is considerable controversy about the placement of Cebu, I believe the fact that all the snakes known from the island are identical to populations known from Negros, clearly relates the two.

III. Samar, Leyte, Bohol, Dinagat, Mindanao, and Basilan are placed in the Mindanao district. These islands have been joined in the past when the extensive "Mindanao submarine platform" was exposed to subaerial erosion during the Pleistocene.

IV. The Sulu district is a transitional region. Elements of both Philippine and Bornean species, although few in number, have been found here. The small size of the existing islands, and periodic inundation of many of them, probably accounts for the scarcity of animal life (excepting Jolo). The present series of small disconnected islands rests upon a shallow submarine shelf which must have been exposed in the past to subaerial erosion and must have provided the main route of dispersal of Malayan faunal elements into the Philippines.

V. The Palawan faunal district is, in fact, a dismembered part of the Bornean faunal district. The snake fauna of the Palawan Archipelago is nearly identical to that of Borneo. There is evidence to indicate that Palawan may have been temporarily joined to Mindoro in the past. However, the snake fauna is quite dissimilar, suggesting that these islands must have been connected before Mindoro and Luzon were joined.

There is nothing in the snake fauna to indicate that any of the modern Philippine snakes were derived from Taiwan, the Papuan region, or the Celebes. Genera formerly thought to have been derived from one or the other of these areas have Malayan affinities.

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AMPHIBIANS AND REPTILES FROM IRAN

By

Steven C. Anderson

California Academy of Sciences, San Francisco 18,
and *Division of Systematic Biology, Stanford University*

INTRODUCTION

In 1958 the author was in Iran from late February through November. During this period a collection of amphibians and reptiles was assembled, largely from the areas of operation of the Iranian Oil Exploration and Producing Company. The principal collecting localities are indicated in figure 2. The numbers do not indicate the chronological sequence of the collection, as many of these localities were revisited several times during the year.

This paper constitutes a report on the collection made by the author, and on the geographic and ecological observations recorded. The herpetofauna of Iran, particularly that of Khuzistan Province, is incompletely known, and accurate distributional records are few. Probably the great majority of amphibians and lizards present in the foothill region of Khuzistan are represented in the present collection. The snakes are less well represented. Wall (1908) has reported on a collection of snakes from the same area.

GEOGRAPHY AND ECOLOGY

The foothills of the Zagros, between the high mountains and the coastal plain at the head of the Persian Gulf, provide the principal source of the present collection (figs. 3 and 4). From the coastal plain a series of ridges and valleys carved in the parallel series of anticlines and synclines provides a variety of habitat situations from 500 to 5,000 feet in elevation. This foothill belt is characterized by open and incompetent folding of strata, the strike being fairly consistent in a northwest-southeast direction. This gives rise to a series of parallel but broken ridges continuing into the higher elevations of the Zagros Mountains. The formations are limestones, marls, and gypsum.

The drainage of the central foothills of the Zagros is an intricate pattern of narrow, steep-sided gorges. Through these gorges the rivers run through the ridges toward the Mesopotamian lowlands. The principal drainage of this region is the Karun River which follows a tortuous course through the foothills onto the Ahwaz Plain, eventually joining the Shatt 'al Arab (formed by the confluence of the Tigris and the Euphrates rivers). In many areas there are no passages through the ridges, and the permanent streams, fed by many seasonal drainages, flow along the strike and cross from one syncline to another where gaps in the ridges occur. In the uplands much of the water flows underground through passages in the gypsum. These narrow tunnels and sinkholes contain water throughout the summer when the majority of the surface drainages are dry.

The environment of this foothill region has been severely altered by the transhumance of the local population. Probably within historical time the vegetation of this area was mixed woodland. The practice of uncontrolled deforestation for the manufacture of charcoal has completely denuded all but the least accessible slopes of the Zagros Mountains. This, coupled with overgrazing and centuries of constant cultivation, has resulted in severe erosion throughout southwest Iran.

The most striking aspect of the flora is the absence of woody vegetation other than occasional thorny shrubs and widely scattered small trees. This, in combination with the climatic factors, causes a striking contrast between the spring vegetation and that of the remainder of the year. From March until early June the hillsides are green, with numerous wildflowers on the slopes and along the many seasonal stream courses. All arable land is under cultivation at this season, the principal crops being wheat and barley. The length of the growing season is highly dependent on the winter and early spring rainfall, an extra week of daily rains greatly increasing the length of the spring season.

The length of the growing season has a profound effect on the fauna of the area, inasmuch as the availability of the principal prey species, small rodents and orthopterous insects, is strictly dependent on the amount of available vegetation. In the late spring and early summer there are great numbers of grasshoppers, and these decrease throughout the summer, some still remaining in the fall. Doubtless these form the bulk of the food supply for a great many species.

The long summer presents an extremely barren landscape, all the annual, herbaceous plants having disappeared. A few small thorny legumes and other sparse shrubs make up the entire summer flora. All but the major water courses are dry by mid-summer. There is a brief resurgence of growth in the late fall after the first rains in November, which is accompanied by an increase in the number of insects.

The early rains begin in November, and March generally marks the end of the rainy season. The spring temperatures are mild, neither the daily highs nor the daily lows being extreme. The summer temperatures become increasingly high, both the daily highs and the daily lows, there being very little cooling at night. The ground temperatures exceed 50°C. before midday and remain high until late in the afternoon, the barren ground readily absorbing the intense heat of the day and reradiating it at night, thus maintaining high air temperatures long after the sun has set. Temperatures remain high until October, at which time there is a considerable drop in the daily temperatures, particularly night temperatures. Figure 1 shows seasonal changes in mean daily high and low air temperatures as Masjid-i-Suleiman from February through November, 1958.

Localities 1–21 lie in the foothill belt.

The *Ahwaz Plain is* geographically an extension of the Mesopotamian lowlands. The plain rises in the north and east, and is deeply dissected

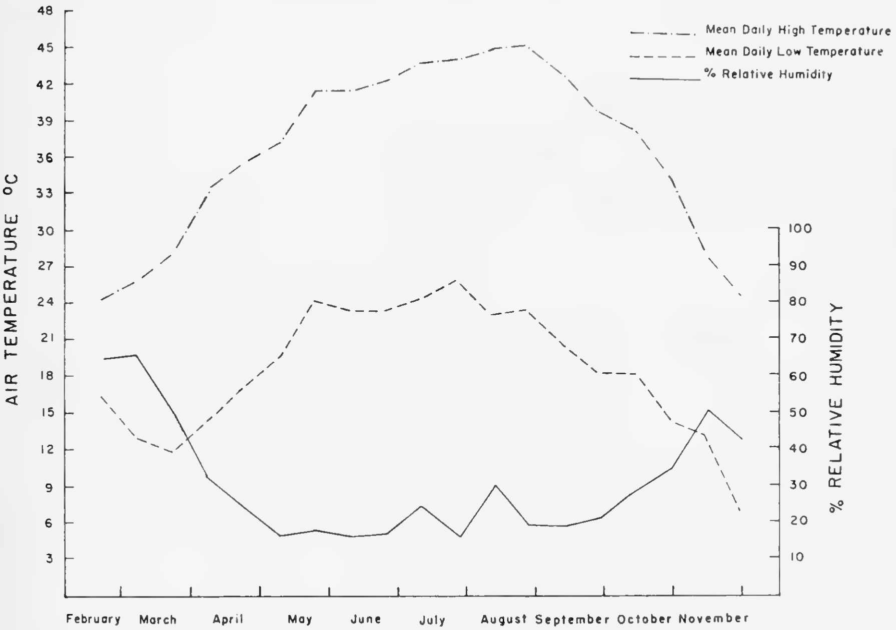


FIGURE 1. Mean daily temperatures and humidity for Masjid-i-Suleiman, Iran, in 1958. Based on data from the Masjid-i-Suleiman weather station.

in many areas. There are scattered areas of active dunes, as in the Dasht-i-Mishan.

Except for cultivation along the rivers, vegetation is very sparse, consisting of occasional low shrubs.

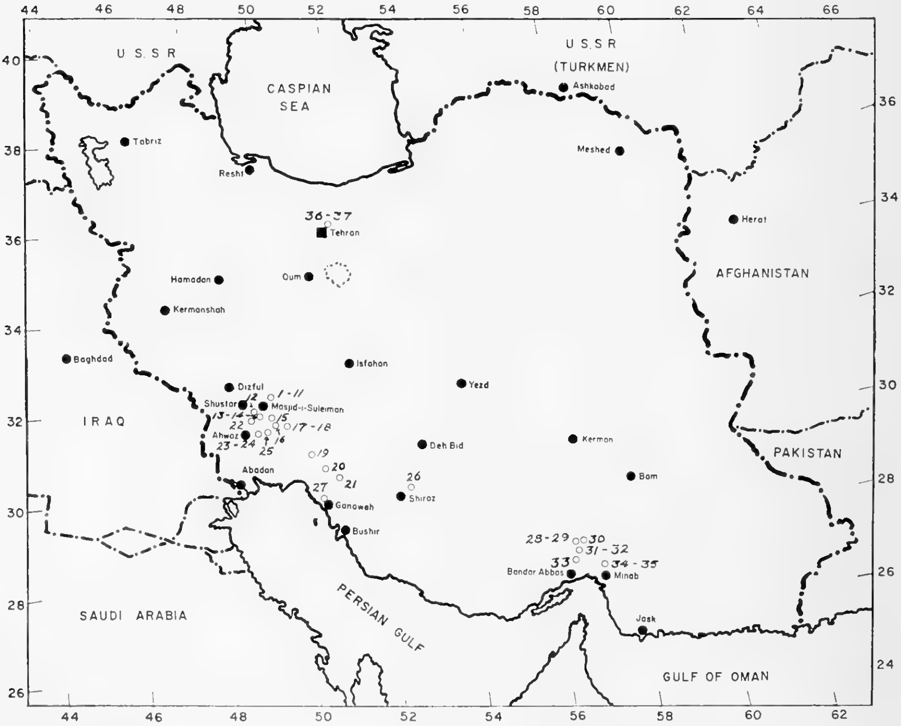
Both daily highs and lows are extremely high in summer, and the humidity is relatively high, particularly near the Persian Gulf and near the rivers, as compared with the drier foothill belt.

The total rainfall is less on the plain than in the foothills, but much of the precipitation may come in a few heavy rains. Adams (1962) indicates that the annual rainfall on the upper plain of Khuzistan is 200–300 millimeters. The drainages are often suddenly swollen, causing erosion and deeper dissection of the higher parts of the plain, and flooding of the land along the Karun River.

Localities 22–25 are on the Ahwaz Plain.

The Persian Gulf coast is characterized in most areas by a narrow coastal plain, the foothills often being quite close to the gulf. There is frequently a belt of coastal dues.

The flora is primarily a desert vegetation. In some places there are flat savannahs where there are numerous trees. There are many xerophytic



shrubs growing on the coastal plains and in the low coastal foothills (fig. 6). The primary agriculture is that of the date palm.

In the south, large anticlinal structures rise abruptly out of the coastal plain. Inland from the gulf the plain is deeply dissected into rugged badlands. In these areas of severe erosion, vegetation is extremely scanty.

Figure 2. Map showing the localities in Iran where amphibians and reptiles were collected.

1. Masjid-i-Suleiman, Khuzistan Province, 31° 57′ N., 49° 16′ E.
2. Naftak, staff housing north of Masjid-i-Suleiman, Khuzistan Province, 31° 58′ N., 49° 15′ E.
3. Masjid-i-Suleiman Airfield and vicinity, 31° 59′ N., 49° 15′ E.
4. Sar-i-Gach, Khuzistan Province, 31° 57′ N., 49° 21′ E.
5. Tul-i-Bazun, abandoned airfield, Khuzistan Province, 31°55′ N., 49° 25′ E.
6. Bard-i-Nishunde, Khuzistan Province, 31° 57′ N., 49° 21′ E.
7. Godar Landar, Khuzistan Province, 32° 01′ N., 49° 23′ E.
8. Zeloi, Khuzistan Province, 32° 13′ N., 49° 04′ E.
9. Lali, Khuzistan Province, 32° 15′ N., 49° 05′ E.
10. Lali Well No. 1, Karun River gorge, Khuzistan Province, 32° 14′ N., 49° 11′ E.
11. Sar-i-Naftak, near Tang-i-Golestan, Khuzistan Province.
12. Culvert on road between Masjid-i-Suleiman and Batwand, Khuzistan Province, 31° 55′ N., 49° 25′ E.
13. Lahabira Valley, Khuzistan Province, 31° 56′ N., 49° 09′ E.
14. Naft Sefid oil field, Khuzistan Province, 31° 40′ N., 49° 14′ E.
15. Yamaha, Khuzistan Province, 31° 47′ N., 49° 23′ E.
16. Haft Kel, Khuzistan Province, 31° 28′ N., 49° 30′ E.
17. Lake, 17 kilometers east of Haft Kel.
18. Champ Kure, Khuzistan Province, 31° 31′ N., 49° 50′ E.
19. Agha Jari, Khuzistan Province, 30° 43′ N., 49° 49′ E.
20. Gach Saran, 30° 20′ N., 50° 48′ E.
21. Chah Sefid, 30° 00′ N., 50° 52′ E.
22. Dar-i-Khazineh, Khuzistan Province, 31° 45′ N., 49° 08′ E.
23. Sand dunes on Ahwaz Ridge, Khuzistan Province, 31° 18′ N., 48° 45′ E.
24. Kurait, east of Ahwaz, Khuzistan Province, 31° 17′ N., 48° 49′ E.
25. Sand dunes on road between Ahwaz and Haft Kel, Khuzistan Province, 31° 16′ N., 49° 11′ E.
26. Persepolis, 29° 56′ N., 52° 49′ E. 5,500′.
27. Binak, at the foot of Kuh-i-Bang, 29° 44′ N., 50° 19′ E.
28. 35 miles north of Bandar Abbas, 27° 30′ N., 56° 18′ E.
29. East of Kuh-i-Ginau, 27° 33′ N., 56° 24′ E.
30. Khurgu, 27° 33′ N., 56° 27′ E.
31. Road just north of Shagu, 27° 17′ N., 56° 22′ E.
32. Dunes at Shagu, 27° 15′ N., 56° 25′ E.
33. Dunes on road from Bandar Abbas to Kerman, northeast of Bandar Abbas, 27° 12′ N., 56° 21′ E.
34. Date grove at Minab, 27° 09′ N., 57° 07′ E.
35. Dunes at Minab, 27° 09′ N., 57° 07′ E.
36. Foothills of Elburz Mountains, north of Tehran.
37. Hills east of Tehran on Ab Ali Road.

Although there are many species of desert shrubs, there is no immediate ground-cover other than spring grasses, which complete their growing season within a very few weeks.

There are a few small active dune areas inland from the coast, similar to other scattered dunes in southern Iran.

Localities 27–35 are in the coastal area.

LOCALITIES

The latitude and longitude of the localities were determined from U. S. Air Force Aeronautical Approach Charts and can only be regarded as approximations.

Masjid-i-Suleiman (localities 1 and 3). Lat. 31° 57′ N., long. 49° 16′ E. Field headquarters of the Iranian Oil Exploration and Producing Company. On many maps it appears as Maidan-i-Naftun. Wall (1908) refers to it as Maidan Mihaftan. The terrain is one of valley and ridge, typical of the foothill belt. Incompetent folding of the gypsum rock of the lower Fars formation has led to an erosion pattern of ridges of resistant rocks and strike-valleys cut in the more readily eroded layers.

Naftak (2). Lat. 31° 58′ N., long. 49° 15′ E. is a residence area about five kilometers to the north of Masjid-i-Suleiman proper, and is slightly higher in elevation. The road from Masjid-i-Suleiman to Naftak winds through low hills composed chiefly of gypsum.

Sar-i-Gach (4). Lat. 31° 57′ N., long. 49° 21′ E. A ridge to the east of Masjid-i-Suleiman composed principally of gypsum. It is crossed by a well-maintained, surfaced road, which serves the wells of the Masjid-i-Suleiman oil field and the water pumping station at Godar Landar.

Tul-i-Bazun (5). Lat. 31° 55′ N., long. 49° 25′ E. Near the top of the Sar-i-Gach ridge, a road runs south from the Sar-i-Gach road to an abandoned airstrip. Along this road are sinkholes in the gypsum which contain water throughout the year.

Bard-i-Nishunde (7). Lat. 31° 58′ N., long. 49° 21′ E. Site of a pre-Achaemenian ruin lying north of the road near the crest of Sar-i-Gach.

Godar Landar (7). Lat. 32° 01′ N., long. 49° 23′ E. A pumping station supplying Masjid-i-Suleiman with water from the Karun River. Across the river from the pumping station rises a steep conglomerate wall, composed of limestone pebbles and cobbles, to the high ridge of Kuh-i-Landar.

Zeloi (8). Lat. 32° 13′ N., long. 49° 04′ E. A plain west of the road between Masjid-i-Suleiman and Lali. There are streams and sinkholes in the gypsum. This was a former site of exploratory oil drilling and traversable roads still exist to some of the well sites.

Lali (9, 10). Lat. 32° 15′ N., long. 49° 05′ E. This is the northernmost oil field in the foothill area of Khuzistan. It is located in the hills through which flows the Karun River. There are considerable salt deposits in this region.

Sar-i-Naftak and *Tang-i-Golestan* (11). A surfaced road connecting Masjid-i-Suleiman with Batwand winds down the Sar-i-Naftak ridge,

FIGURE 3. Foothill region, March 1958. Zagros Mountains in the background. Foreground is typical habitat of *Agama nupta*, *Mabuya aurata septemtaeniata*, *Coluber rhodorachis*, and *Psammophis schokari*.

through Tang-i-Golestan, a steep-sided canyon. A small stream passes under this road through a culvert (12). Lat. 31° 55′ N., long. 49° 25′ E. At Batwand this road meets the newer Masjid-i-Suleiman–Ahwaz road.

Naft Safid (14). Lat. 31° 40′ N., long. 49° 14′ E. An oil field on the

FIGURE 4. Stream in the foothill region near Station 12 (fig. 2), April, 1958. Habitat of *Rana ridibunda* and *Hyla arborea savignyi*.

western slope of the foothill belt. The terrain is typical of the foothill region.

Yamaha (15). Lat. 31° 47′ N., long. 49° 23′ E. An abandoned site of exploratory oil drilling near the Tembi River in the foothills south of Masjid-i-Suleiman. A road runs from Yamaha, across the Tembi River, and through the Masjid-i-Suleiman oil field.

Haft Kel (16). Lat. 31° 28′ N., long. 49° 30′ E. An oil field south of Masjid-i-Suleiman. The road from Masjid-i-Suleiman to Haft Kel runs through typical foothill terrain, traversing a part of the Tembi River drainage. At one point the road emerges onto the small Yamaha plain. It crosses the Ab-i-Lashcar and minor intermittent streams. Haft Kel is near the edge of the foothills; the road from Haft Kel to Ahwaz soon drops onto the flat Ahwaz plain.

Near Haft Kel a road runs east into the Zagros Mountains. Seventeen kilometers east of the Masjid-i-Suleiman–Haft Kel road is a small lake (17) in an undrained depression in the hills. Shrinking to a fraction of its winter size, it provides, even in summer, a refuge for frogs, turtles, and ducks. In summer there is no sign of vegetation near the lake, other than a stand of dry brown reeds at its periphery.

The road into the Zagros leads ultimately to the village of Qal 'eh Tun, site of an old Bakhtiari fortress. From there a jeep track leads through stands of scrub oak to Malagha, a small village on a permanent stream, the Rud-i-Zard, at an elevation of 5,000 feet. Champ Kure (18), lat. 31° 31′ N., long. 49° 50′ E., is a government check station on this road.

Agha Jari (19). Lat. 30° 43′ N., long. 49° 49′ E. An oil field in the foothills at the edge of the coastal plain. There is a small active dune area on a ridge in the foothills near the number 3 production unit of the field.

Gach Saran (20). Lat 30° 20′ N., long. 50° 48′ E. The southernmost oil field in the foothill region. The Dugumbadan airfield and the living areas are on a small plain at the foot of a high ridge. The oil field is located in the foothills.

Chah Safid (21). Lat. 30° N., long. 50° 52′ E. A camp site on the road from Gach Saran to Ganaweh. It is approximately one mile from the junction of the Mishun road. The road traverses terrain of deeply incised gorges, most of which carry an intermittent flow of water. All of the gorges are subject to flood torrents following heavy rains.

Lahabira Valley (13). Lat. 31° 56′ N., long. 49° 09′ E. A valley in the foothills west of Masjid-i-Suleiman. Two to four miles wide, a thin alluvium covers the gypsum in much of the valley floor, through which flows Ab-i-Lashcar, a permanent stream. This stream is fed by seasonal drainages, and here and there are sinkholes in the gypsum.

Shustar. An old city on the Karun River in the relatively high eastern area of the Ahwaz Plain, and not far from the foothills. The road to Shustar passes through areas of low hillocks, ridges, and sandstone outcrops. Much of the vegetation along this road is that characteristic of the foothill region. Annual rainfall is about 300 millimeters (Adams, 1962).

Ahwaz. The capital of Khuzistan Province, and the commercial and distributional center. Ahwaz lies on the Karun River in the heart of the plain. Both the Iranian National Railway, running from Bandar Shapur and from Khorramshar to Tehran, and the road from Khorramshar to Tehran, pass through Ahwaz. The Karun River is navigable from the Shatt 'al Arab as far as Ahwaz.

Small dune areas (23). Lat. 31° 18′ N., long. 48° 45′ E. are located along the Ahwaz Ridge on the road between Ahwaz and the Ahwaz number 6 well location at *Kurait* (24), lat. 31° 17′ N., long. 48° 49′ E.

Dar-i-Khazineh (22). Lat. 31° 45′ N., long. 49° 08′ E. A small village on the plain near the road from Masjid-i-Suleiman to Ahwaz.

Khalafabad. A ferry crosses the Jarrahi River near the village of Khalafabad on the summer road from Agha Jari to the Ahwaz–Haft Kel road. The road crosses a broad flat plain, where, except for small cultivated areas near villages, the vegetation is sparse and xerophytic.

Sand dunes on the Ahwaz–Haft Kel road (25). Lat. 31° 16′ N., long. 49° 11′ E. The largest dune area visited was on the road between Ahwaz and Haft Kel. These dunes are composed of loose sand, transported and altered by the wind. A few shrubs grow on the dunes and on the sandy fringes. Some grasses and thorny shrubs are found in the "blow-out" depressions among the dunes, and the root systems have some stabilizing effect.

Persepolis (26). Lat. 29° 56′ N., long. 52° 49′ E. Ruins of the palace of the Achaemenian kings. It is on a terrace above a plain, in a large valley in the Zagros Mountains. The elevation is approximately 5,500 feet. It lies at the foot of high limestone hills. The hills are barren except for a few small shrubs. There is considerable agriculture on the plain.

Binak (27). Lat. 29° 44′ N., long. 50° 19′ E. Site of an exploratory well at the foot of Kuh-i-Bang on the Persian Gulf. There is a narrow strip of coastal dunes, on which grow a few shrubs. Kuh-i-Bang is an anticlinal structure, approximately one mile in length, rising out of the coastal plain. The vegetation of the plain is sparse. There is some date culture at Ganaweh on the coast to the southeast. A few low hills lie at the foot of Kuh-i-Bang and along the coast.

Bandar Abbas (28–33). An ancient seaport at the Strait of Hormuz. A road runs from Bandar Abbas to Kerman and Shiraz. East of the town, along the road to Kerman, there is a small active dune area (33), lat. 27° 12′ N., long. 56° 21′ E., much like the dune areas on the Ahwaz Plain.

Three prominent anticlinal structures rise out of the plain north of Bandar Abbas. These are Kuh-i-Ganau, Khurgu, and Kush Kuh. Between Bandar Abbas and Kuh-i-Ganau, the road passes through areas of savannah, sandstone outcrops, and low hills, emerging onto a higher, cobbled plain.

Here there is true desert vegetation (fig. 5). Many of the thorny, xerophytic shrubs of the plain extend onto the slopes of the mountains.

Although as a whole the area is quite arid, there are a few drainages where streams persist the year round. There is considerable date culture along these streams, even into the mountains to 3,000 feet.

Shagu (31), lat. 27° 17′ N., long. 56° 22′ E., is a small village, primarily a truck stop, a few miles north of Bandar Abbas on the road to Kerman. Just east of the village, on the road to Minab, there is a small active dune area (32), lat. 27° 15′ N., long. 56° 25′ E.

Minab (34, 35). Lat. 27° 09′ N., long. 57° 07′ E. The road from Shagu to Minab crosses a flat plain, many of the savannahs having numerous trees. Minab is a date-growing center. The Rud-i-Minab is the principal drainage. Minab is located at the edge of the coastal plain, there being much folded strata to the east, continuing into Baluchistan.

A small active dune area (35) lies north of the town, against a low ridge. The vegetation of the Minab area, other than the extensive date cultivation, consists of a few desert shrubs.

Figure 5. Terrain near Kuh-i-Ginau, southern Iran (Station 28 in fig. 2), April, 1958. Habitat of *Eremias guttulata watsonana*.

SYSTEMATIC AND ECOLOGICAL DISCUSSION

Class AMPHIBIA

Order Salientia

Family Bufonidae

Genus **Bufo** Laurenti

Bufo viridis Laurenti.

Bufo viridis Laurenti, 1768, Synops. Rept., p. 27, pl. 1, fig. 1.

Known range. Europe east of the Rhine and Rhone rivers; North Africa; southwest and central Asia, from the Mediterranean to Tibet and Mongolia; from below sea level near the Dead Sea to 15,000 feet in the Himalayas.

Material examined (14). Station 1[1] (CAS 86262[2] [II/27/58; ♂]; 86263 [III/2/58, ♀]; 86285 [III/19/58, ♂]; 86330 [IV/13/58, ♂]; 86641–86642 [♀ ♀]; 86643–86645 [♂ ♂] [XI/30/58]). Stream 15 km. north of Station 1 (CAS 86284 [III/10/58, ♂]). Station 2 (CAS 86324 [III/30/58, ♂]). Stream near Station 3 (CAS 86594 [IX/11/58, ♀]). Station 10 (CAS 86289 [III/20/58, ♂]). Stream near Station 17 (CAS 86327 [III/28/58, ♂]).

Remarks. The interorbital space is as wide as, or wider than, the upper eyelid in this series. There are numerous warts on the dorsum. The larger warts are surmounted by a prominent tubercle tipped with a black asperity, and this tubercle is surrounded by smaller, similar tubercles. The tubercles of nonbreeding females are reduced, and lack the asperity.

The toads are numerous in Khuzistan Province along stream courses in early spring, usually in the grass, rarely actually in the water. They were found occasionally under rocks on dry hillsides several hundred yards from water. Active in cultivated gardens throughout the summer, they were often seen at night in the grass near an outdoor light, feeding on insects attracted to the light. After rains in the late fall they were numerous on paved roads in the evening.

Bufo viridis was seen, but not collected at Persepolis in August.

On two occasions males were heard to make a bird-like warbling call along a stream in early March, several individuals participating in the chorus at dusk.

Strings of eggs were found in the streams in late February and early March. By early April most of the larvae had metamorphosed, the water along seasonal drainages by this time limited to intermittent pools diminish-

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[1] Station numbers refer to localities described on p. 6 of ms., and fig. 2.

[2] California Academy of Sciences catalog number.

ing in size. Two females and three males collected November 30, at Masjid-i-Suleiman appear to be in breeding condition.

Stomachs of toads collected in November contained ants and termites; CAS 86643 contained a centipede. The stomach of CAS 86285, collected March 19, contained terrestrial isopods, lepidopterous larvae, and other arthropods. There was also a calcareous mass, 6 mm. in diameter, in the stomach. Grass was present in the stomach of CAS 86289; this stomach contained no animal remains.

Bufo olivaceus Blanford.

(Figure 7.)

Bufo olivaceus Blanford, 1874, Ann. Mag. Nat. Hist., ser. 4, vol. 14, p. 35. (Type locality: Dasht River, Baluchistan [West Pakistan].)

Known range. Southeast Iran and western Pakistan; to 3,000′.

Material examined (33). Station 34 (CAS 86567–86568, 86570–86571, 86576, 86578, 86581–86582, 86584–86585, 86611–86613, 86615–86616, 86618 [♂♂]; 86560, 86569, 86572–86573, 86575, 86577, 86579–86580, 86583, 86595–86599, 86610, 86614, 86617 [♀♀] [X/21/58]).

Remarks. These specimens do not show as pronounced an occipital fold as shown in Blanford's illustration (1876, pl. 28, fig. 3). While Boulenger (1882) states that *B. olivaceus* lacks a tarsal fold, the present specimens possess a well-defined tarsal ridge of closely aligned tubercles.

The Minab series may be characterized as follows: Head and body depressed; snout projects slightly beyond mouth; crown lacks bony ridges; distance between eye and nostril on canthus rostralis equal to at least ⅔ the diameter of the eye; interorbital space equal to at least ¾ the length of the upper eyelid; distance between nostrils equal to ½, or only slightly greater than ½, the interorbital distance; tympanum distinct, the vertical diameter may be slightly greater than the horizontal diameter, the latter being ½ the diameter of the eye. Tongue in preserved specimens longer than wide.

First finger longer than second; toes more than ½ webbed, with the exception of the fourth, which is ⅓ webbed; toes with single subarticular tubercles; a well-defined tarsal ridge of closely aligned tubercles; inner metatarsal tubercle larger than outer metatarsal tubercle; palmar metacarpal tubercle considerably larger than thenar metacarpal tubercle.

Tibio-tarsal articulation reaches angle of mouth or slightly beyond.

A few small warts tipped with black asperities in the dorsal sacral and pelvic areas, slightly more numerous and more pronounced in females, and entirely lacking in CAS 86568 and 86613 (both males).

Paratoids often twice as long or longer than broad, frequently extending to sacral region.

Male with subgular vocal sac.

Pale olive above, white below; immaculate.

Male 56.5 mm. snout-vent length; female 58.0 mm.

These toads are distinct from Boulenger's (1891) description of *B. surdus* which lacks the tympanum (and the annulus typanicus, columella, and eustachian tube as well, according to Parker, cited by Schmidt, 1955) and which has bony ridges on the crown. Chernov compared one of the animals of the Minab series with Nikolsky's specimens of *B. persicus* (Carevsky, 1926, equated *B. surdus* with *B. persicus,* a view with which Schmidt, 1955, takes issue); he stated (personal communication) that the Minab toad is distinct from his specimens. It is clearly distinct from *B. luristanicus* Schmidt, which has much smaller paratoids, a tuberculate dorsal skin, shorter hind limbs, and the interorbital space narrower than the upper eyelid.

Blanford's specimens came from the Dasht River, which flows into the Gulf of Oman some 15 km. east of the Iran–Pakistan border, Bahu Kalat, just west of the border, and Ghistigan, Bampusht, also on the Iranian side of the border. Blanford (1876) states that at elevations greater than 3,000 feet *B. olivaceus* is replaced by *B. viridis.*

The present series was collected on a single October evening between 6 and 9 p.m. There were hundreds of these toads in and along irrigation ditches near a road running through a date grove (fig. 6). They were collected in the grass, in the mud, on the banks, and in the water of the shallow ditches, all within a distance of 100 yards. The majority were seen sitting or swimming in the water. Those on the banks and in the grass usually sought the water in their efforts to escape capture. These toads greatly outnumbered the representatives of *Rana cyanophlyctis* which were present in the same ditches. None were in breeding condition.

Most of the stomachs examined contained ants primarily, and often beetle larvae and termites. Several individuals had flatworms in the urinary bladder.

Family HYLIDAE

Genus **Hyla** Laurenti

Hyla arborea savignyi Audouin.

Hyla savignyi Audouin, 1827, Descr. Egypte, Rept., Suppl., p. 183, pl. 2, fig. 13. (Type locality: presumed to be Syria.)

Hyla arborea savignyi, Mertens, 1924, Abh. Ber. Mus. Magdeburg, Bd. 3, p. 356.

Figure 6. Date grove at Minab (Station 34 in fig. 2), October, 1958. *Bufo olivaceus* and *Rana cyanophlyctis* were collected in irrigation ditches of this grove.

Figure 7. *Bufo olivaceus.*

KNOWN RANGE. *Hyla arborea* ranges from Europe through North Africa and temperate Asia. The subspecies *H. a. savignyi* is the form of southwest Asia, meeting the typical form in Asia Minor and extending eastward through Iran, being found in the drainages of the Zagros and Elburz Mountains.

MATERIAL EXAMINED (21). Station 1 (CAS 86286 [III/20/58, ♀]). Stream on road to Station 9, 15 km. north of Station 1 (CAS 86295–86296 [♀♀]; 86297–86300 [♂♂] [III/10/58]). Stream on road to Station 9, 16.9 km. north of Station 1 (CAS 86312 [III/21/58, ♀]). Vicinity of Station 1 (CAS 86355 [♀]; 86356 [♂] [April, 1958]). Stream between Station 1 and Station 16 (CAS 86446 [VI/14/58, juv.]). Station 8 (CAS 86253–86255, 86257, 86259–86260 [♂♂]; 86256, 86258 [♀♀] [II/27/58]). Stream south of Station 9 (CAS 86304–86305 [III/20/58, ♂♂]).

REMARKS. These hylas are present in fair numbers along the seasonal stream courses in early spring. When collected, all were bright green, blending well with the grasses in which they were found. When placed in the dark, some became a darker, olive green, some a steel gray or gray-brown, others showing no change, although all were in the same container. Some became much paler when narcotized with chlorotone. Just-metamorphosed individuals were a light gray-green or tan.

In Khuzistan Province the eggs seem to be laid in late February and early March, metamorphosis being completed in March and April. No hylas were seen after mid-June. No intensive search was made for them, however. Water remains throughout the year in sinkholes and small caves in the gypsum formations, as well as in permanent streams. The water temperature is 22°–26°C. during the hottest part of the summer. A retreat is thus provided for the amphibians of the area.

CAS 86304 has a supernumerary forelimb attached to the right side of the pectoral girdle and innervated from the right side.

Family RANIDAE

Genus **Rana** Linnaeus

Rana ridibunda ridibunda Pallas.

Rana ridibunda PALLAS, 1771, Reise Rus. Reich., vol. 1, p. 458. (Type locality: Gurev, north coast of the Caspian Sea.)

Rana ridibunda ridibunda, MERTENS, 1925, Abh. Senck. Ges., vol. 39, p. 55.

KNOWN RANGE. The whole of Europe except northwest and central Italy; western Asia as far east as northern West Pakistan, Afghanistan, and eastern Turkestan (USSR); North Africa (Boulenger, 1891).

MATERIAL EXAMINED (59). Vicinity of Station 1 (CAS 86353 [♂]; 86354, 86359, 86364–86365 [♀♀] [April, 1958]). Stream 1.9 km. north of junction of road between Station 1 and Station 9 and road between Station 1 and Ahwaz (CAS 86307–86311 [III/21/58, ♂♂]). Stream 16.9 km. north of Station 1, on road to Station 9 (CAS 86313–86315 [III/21/58, juv.]). Fifteen kilometers north of Station 1, on road to Station 9 (CAS 86290, 86292 [juv.]; 86291 [♀]; 86293–86294 [♂♂] [III/10/58]). Station 2 (CAS 86363 [III/28/58, ♀]). Stream near Station 3 (CAS 86267 [III/14/58, ♂]). Pools near Station 3 (CAS 86619–86620, 86628 [♀♀]; 86621–86622, 86627 [♂♂] [Sept.–Oct., 1958]). Stream on road to Station 5 (CAS 86264–86265 [III/13/58, juv.]). Stream 9 km. above Station 7 (CAS 86261 [III/13/58, ♀]). Station 8 (CAS 86268–86272, 86274–86278, 86280–86282 [♀♀]; 86273, 86279, 86283 [♂♂] [III/12/58]; 86287 [II/27/58, ♀]). Stream south of Station 9 (CAS 86301–86302, 86306 [♀♀]; 86303 [juv.] [III/20/58]). Station 13 (CAS 86316–86319 [III/21/58, juv.]). Stream near Station 17 (CAS 86357 [♂]; 86358 [♀] [III/28/58]). Station 21 (CAS 86411 [♀]; 86412–86413 [juv.] [VI/8/58]).

Remarks. This frog is numerous in the foothill regions in all the permanent streams throughout the year, and in the seasonal drainages in the spring. Sinkholes and small caves in the gypsum provide retreats from the extreme summer heat and contain the only permanent water in many localities. During the day these frogs are found sitting in the water or in the vegetation along the banks of pools and streams.

Eggs are laid in late February and March, most metamorphosis being completed by early April. A few metamorphosing tadpoles were seen as late as May 23 in an area where the stream course was dry except for small, rapidly shrinking pools.

Unsuccessful attempts were made to induce ovulation in mature females in September. Ovaries showed little response despite injections of both amphibian and mammalian anterior pituitary.

These frogs may be an important part of the diet of many predators, since they are one of the few prey species available in large numbers throughout the year.

Seventeen of the 59 frogs in this series have a light vertebral stripe. In 40 of the 59 the tibiae do not overlap when the legs are at right angles to the body, and in several of these they do not even touch (a character independent of age or sex).

Rana cyanophlyctis Schneider.

Rana cyanophlyctis Schneider, 1799, Hist. Amph., vol. 1, p. 137.

Known range. Widely distributed from southern Arabia and eastern Iran to the Malay Peninsula, and from the Himalayas (to 6,000 feet) to Ceylon.

MATERIAL EXAMINED (6). Station 34 (CAS 86562 [♂]; 86561, 86563–86566 [♀ ♀] [X/21/58]).

REMARKS. The frogs of this series have a single white streak on the hinder side of the thighs, the dark pigment below this streak giving a mottled appearance rather than forming a distinct second dark streak. The interorbital space is only slightly narrower than the upper eyelid in these specimens.

Stomach contents included beetles, beetle larvae, a mole cricket, spiders, and other arthropod remains.

Class REPTILIA

Order CHELONIA

Family EMYDIDAE

Genus **Clemmys** Ritgen

Clemmys caspica caspica (Gmelin).

Testudo caspica GMELIN, 1774, Reise durch Russland, vol. 3, p. 59, pls. 10–11. (Type locality: Hircania, northern Iran.)

Clemmys caspica caspica, SCHMIDT, 1939, Field Mus. Nat. Hist., Zool. Ser., vol. 24, p. 89.

KNOWN RANGE. Iran, from the southern borders of the Caspian Sea to the Persian Gulf; Iraq; northern Arabia and Bahrein Island.

MATERIAL EXAMINED (7). Station 3 (CAS 86634 [III/14/58, ♀]) Station 17 (CAS 86629 [♀]; 86639 [♂] [X/26/58]; 86635 [♀]; 86636–86637 [juv.] [III/28/58]; 86638 [V/23/58, juv.]).

REMARKS. The carapace of CAS 86639 is misshapen, the left side much more depressed than the right, several shields having a shriveled appearance.

These turtles were collected at only two localities. Turtles, apparently of this species, were seen on a stream bank near Isfahan, and in streams near Persepolis. Presumably they are to be found wherever there is permanent water over successive years in the foothill regions.

In the small lake (75–100 meters in diameter) where most of these specimens were collected, there were hundreds of these turtles of all ages, as well as numbers of *Rana ridibunda*. This appears to be a permanent lake, but in summer diminishes to half its spring size. Reeds grow along its northern margin, and there is considerable aquatic vegetation in the lake itself.

One of the females laid an egg on June 4, and another on June 26. These eggs were about 40 mm. by 30 mm. The shells were brittle, and of a china-like texture. CAS 86629 and 86639 were found copulating on October 26, in the mud at the edge of the small lake.

Man may be the principal predator on the adults of this species. Although the flesh is apparently not eaten, the eggs are considered a potent ingredient in eye medicine. It is possible many turtles are killed for the eggs they contain, as eye ailments abound in southern Iran.

Order SQUAMATA

Suborder Sauria

Family Gekkonidae

Genus **Eublepharis** Gray

Eublepharis macularius (Blyth).

(Figure 8.)

Cyrtodactylus macularius Blyth, 1854, Jour. Asiat. Soc. Bengal, vol. 23, p. 737. (Type locality: Salt Range, Punjab.)

Eublepharis macularius, Anderson, 1871, Proc. Zool. Soc., p. 163.

Known range. Northwestern India, Pakistan, and Afghanistan to southern Turkmen (USSR), Iran, and Iraq.

Material examined (16). Road between Station 1 and Station 2 (CAS 86333 [IV/15/58, ♂, DOR]; 86360 [juv.]; 86361, 86366 [♀ ♀]; 86362 [♂] [IV/19/58]; 86381 [IV/28/58, ♂]; 86383 [V/13/58, juv.]; 86385 [V/21/58, ♀]; 86396, 86398 [♂ ♂]; 86397 [♀] [V/22/58]; 86416 [V/26/58, ♂]; 86507 [VIII/20/58, ♀]). Road between Station 1 and Batwand (CAS 86337 [IV/18/58, ♂, DOR]; 86382 [V/13/58, ♀]; 86384 [V/20/58, ♂]).

Remarks. Each dorsal tubercle is encircled by a single ring of slightly enlarged, juxtaposed dorsal scales.

In those specimens in which the tail has been rejuvenated, the tail is swollen just distal to the break, the rejuvenated portion lacking tubercles, and having smaller, less regular ventral scales.

Preanal pores are present in the females, although much less distinct than in the males.

The postanal sacs and deep axial pouches contain many small mites in all specimens.

All specimens were collected on surfaced roads between 8 p.m. and midnight. They were first seen in mid-April on roads along which collecting had been done during the same hours for the preceding six weeks. The lizards were fairly numerous on these roads until the end of May. None were seen from June until August 20, when a single specimen was collected.

These lizards were never encountered during the day, although many rocks were overturned in the area. Deep crevices in the gypsum probably provide a retreat during the day.

During the period that these lizards were seen on the roads, grasshoppers were also present on the roads in large numbers. Also on the roads at the same hours were scorpions, solpugids, and large spiders. Stomach contents included these animals as well as beetles and other arthropods. They have been reported to eat other lizards (Smith, 1935) and may prey on the various small geckoes of this region.

The foxes which abound in this area were observed eating lizards of this species which had been hit by automobiles, and probably prey regularly on them.

When captured, these lizards give a loud, prolonged squeek and attempt to bite. They often defecate, wrapping the short tail around the hand of their captor. This may occasionally enable them to drop the tail.

CAS 86361, 86366, 86385, 86397, 86507 contain eggs.

Air temperature recorded when these lizards were collected varied from 32.0° to 34.4°C. The road surface temperatures were 32.6° to 36.4°C., and were usually at least 2°C. higher than the surrounding soil temperatures, which ranged from 30.2° to 35.0°C.

The critical maximum temperature (as defined by Cowles and Bogert, 1944) was recorded for one individual (CAS 86507) and found to be 42.6°C. The lizard was placed on an asphalt surface which had a temperature of

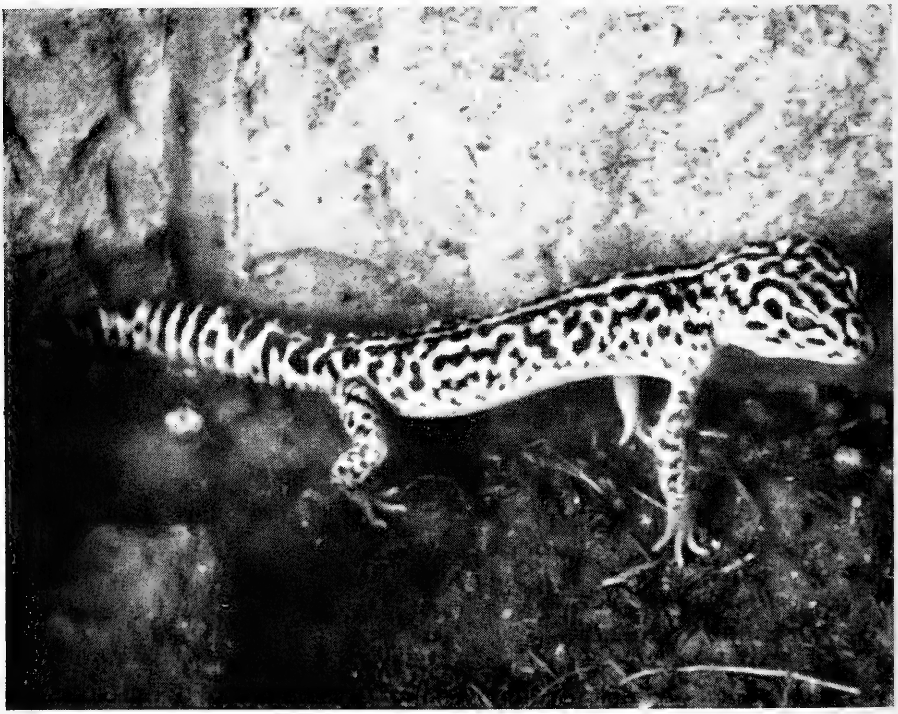

FIGURE 8. *Eublepharis macularius.*

48.6°C., in the direct sunlight. The air temperature was 44.6°C. The anal temperature at the start of the experiment was 35.6°C. The lizard was tethered so that it could not reach the shade which was visible a short distance away. The anal temperature at which all efforts to reach the shade became uncoordinated and ineffective was considered the critical maximum. Anal temperatures were taken with a Schulthize rapid-reading thermometer. The critical maximum temperature was reached four minutes after the initiation of the experiment. Efforts to reach the shade began immediately upon exposure of the animal to direct sunlight, and were unceasing until collapse. Considerable moisture was passed from the vent, and the mouth opened only when the animal was on the point of collapse. After the anal temperature was recorded, the animal was removed to the shade where it subsequently recovered. No paralysis was noted after recovery, but what, if any, other functional impairments resulted from exposure to high temperature was not determined.

Genus **Cyrtodactylus** Gray

Cyrtodactylus scaber (Hayden).

Stenodactylus scaber Hayden, 1827, in Rüppell, Atlas Reise Nörd. Africa, Rept., p. 15, pl. 4, fig. 2. (Type lcoality: vicinity of Tor, Sinai.)

Cyrtodactylus scaber, Underwood, 1954, Proc. Zool. Soc., London, pp. 469–492.

Known range. From Egypt to northwest India; Arabia, along the Persian Gulf.

Material examined (9). Station 1 (CAS 86431 [VI/23/58, ♂, on a wall]; 86513 [IX/7/58, juv.]; 86626 [Nov., 1958, juv., in a house]). On wall on a house near Station 3 (CAS 86532 [IX/10/58, juv.]; 86533 [IX/11/58, juv.]). Station 19, on wall of I.O.E.P.C. guest house (CAS 86481 [VIII/14/58, ♀]; 86482 [♀]; 86483 [♂] [VIII/15/58]). I.O.E.P.C. guest house at Station 24 (CAS 86558 [X/5/58, juv.]).

Remarks. There is a vertebral series of tubercles, smaller than the 10–12 rows of longitudinally and transversely arranged tubercles. This median row usually extends from the scapular to the pelvic region.

This species is the most common house-gecko in the foothill region. It was quite common on walls of houses from late June through November, becoming active during the late daylight hours. It was frequently seen at night just beyond the circle of light thrown by an outdoor fixture, darting forward occasionally to capture a moth or other insect attracted to the light.

Hatchlings were common in mid-August. One female laid two eggs, ovoid, white, and with brittle shells, in late August. These were 10.5 mm. long, the greatest width being 7 mm.

Cyrtodactylus agamuroides (Nikolsky).

(Figure 9.)

Gymnodactylus agamuroides NIKOLSKY, 1899, Ann. Mus. Zool. Imp. Acad. Sci. St. Pétersbourg, ser. 4, pp. 384–385.

KNOWN RANGE. Eastern Iran.

MATERIAL EXAMINED (1). Station 29 (CAS 86370 [IV/26/58, ♂]).

REMARKS. The single specimen was found under a rock by village boys.

Nikolsky (1899) designates no holotype specimen, nor type locality. The three syntypes are from Neizar in Seistan, Pendsch-Sara, and Duz Abad, eastern Kerman Province, Iran. The only record of this form subsequent to that of Nikolsky is by Wettstein (1951) who lists it from Kerman.

The present specimen differs from *C. kotschyi* in that the limbs are longer, the dorsal tubercles are approximately as broad as long, the abdominal scales are about 22–24 at mid-body (30 in *C. kotschyi*), and it has subquadrangular spots in three longitudinal series, with a less distinct lateral series, while *C. kotschyi* has angular transverse bars. It differs from *C. fedtschenkoi* and *C. longipes* in having the snout longer than the distance between eye and ear, fewer longitudinal rows of abdominal scales (28–30 in *C. fedtschenkoi*); scales of limbs are not keeled, dorsal tubercles are small, rounded, smooth to weakly keeled, subconical, rather than large and subtrihedral; there are but 4 preanal pores (28–36 preanal and femoral pores in *C. fedtschenkoi*); *C. fedtschenkoi* has dorsal crossbars. It is distinguished from *C. kermanensis* in that the diameter of the eye goes into the length of the snout only 1¼ times (2–2¼ in *C. kermanensis*), in that the mental shield is triangular rather than pentagonal, and in that it lacks strong keels on the dorsal tubercles. It is different from *C. zarudnyi* in having the first pair of chin shields in contact behind the mental; *C. zarudnyi* has triangular, strongly keeled tubercles, and lacks dark dorsal markings. It differs from *C. kachhensis* in having smaller, less strongly keeled tubercles, having regular infracaudal plates, and fewer longitudinal series of abdominal scales (30–40 in *C. kachhensis*). It is distinct in *C. caspius,* which has large, strongly keeled, trihedral tubercles, about 20 femoral and preanal pores, and indistinct dorsal crossbars. *Cyrtodactylus brevipes* has shorter limbs and imperfect longitudinal dusky bands on the dorsum, formed of arrowhead-shaped marks.

It does not differ significantly from Nikolsky's description of *Gymnodactylus agamuroides.*

At least eight species of *Cyrtodactylus* have been recorded from eastern Iran (*C. scaber, C. fedtschenkoi, C. kirmanensis, C. zarudnyi, C. longipes, C. caspius, C. brevipes,* and *C. agamuroides*). The types of these species should be examined to determine whether or not these are all specifically distinct forms.

Figure 9. *Cyrtodactylus agamuroides.*

Genus **Bunopus** Blanford

Bunopus tuberculatus Blanford.

Bunopus tuberculatus Blanford, 1874, Ann. Mag. Nat. Hist., ser. 4, vol. 13. p. 454. (Syntypes from Bahu Kalat, Mand, and near Bampur, southeastern Iran.)

Known range. Syria, Iraq, eastern Arabia, southern Iran, Afghanistan, Pakistan; to 3,000 feet.

Material examined (6). Station 25 (CAS 86492 [VIII/17/58, juv.]; 86524 [VIII/22/58, juv.]; 86536 [♀]; 86537 [♂] [IX/13/58]). Station 35 (CAS 86590–86591 [X/20/58, ♂♂]).

Remarks. Leviton and Anderson (1963) have demonstrated that Blanford's genus (*Bunopus*) of tuberculate geckoes is distinct from the non-tuberculate *Alsophylax* of Fitzinger.

In the present specimens the imbricate scales of the belly and lower surfaces of the limbs and tail have their posterior borders distinctly denticulated.

During the day these lizards were found in burrows among the roots of shrubs in the active sand-dune areas. They were active about 9:00 p.m. on the surface of the sand, particularly near the base of shrubs, on October 20 at Minab. Blanford (1876) collected this species in Baluchistan in houses and under rocks.

This species may be distinguished from *Cyrtodactylus heterocercus* (Blanford) and *Bunopus persicus* (Nikolsky) by the lack of postmental shields. The scales of the belly are smooth in *Bunopus tuberculatus*, but described as keeled in *B. persicus.*

Coloration in life: sandy gray above, the juveniles distinctly barred with chocolate-brown; six crossbars, broader than the interspaces, between the shoulders and pelvis, becoming broken and less distinct in adults. A brown crescent curves around the nape and passes through the eyes. There is dark pigment in the temporal areas, and in front of the eyes, the lips banded or spotted with brown. The hind limbs are crossbarred with brown, the forelimbs mottled. The tail is crossbarred above, flecked with brown below. The throat and belly are immaculate white.

Genus **Microgecko** Nikolsky

Microgecko helenae Nikolsky.

(Figure 10.)

Microgecko helenae NIKOLSKY, 1907, Ann. Mus. Zool. Acad. Imp. Sci. St. Pétersbourg, vol. 10, pp. 265–268, pl. 1, figs. 4, 4a. (Type locality: Arabistan [=Khuzistan], Iran.)

KNOWN RANGE. Khuzistan Province, southwest Iran. A doubtful record from southeast Iran (Mertens, 1956), and recorded from west Pakistan (Minton, 1962).

MATERIAL EXAMINED (1). Station 4 (CAS 86408 [V/13/58, ♂]).

REMARKS. This small gecko was first described from southwestern Iran by Nikolsky (1907). Mertens (1956) tentatively assigned a single, poorly preserved specimen from southeastern Iran to this species, regarding this specimen as congeneric with *Tropiocolotes Peters.* His specimen lacked dark crossbars on the dorsum. Minton (1962) includes *Tropicalotes helenae* (*sic*) in the fauna of west Pakistan, and states that it is common.

The present specimen agrees with Nikolsky's description of *Microgecko helenae* in all particulars except that the tail is slender and crossbarred throughout. Nikolsky's specimens were reported as having thick tails, the distal third being solid black. His illustration clearly shows that the tail is regenerated, and it is possible that all nine of his specimens lacked the original tail.

CAS 86408 has been described in detail in a previous paper (Anderson, 1961), in which I concurred with Mertens in placing *Microgecko* in the synonymy of *Tropiocolotes.* I now feel that while *M. helenae* Nikolsky and *T. steudneri* Peters are congeneric, they are probably generically distinct from *T. tripolitanus* Peters (the type species of *Tropiocolotes*).

This tiny gecko was collected on a surfaced road at 8:00 P.M. The road surface was 37.6°C., the surrounding soil 35.2°C., and the air 34.2°C. It was exceedingly agile, able to jump several inches.

Figure 10. *Microgecko helenae.*

Genus **Hemidactylus** Oken

Hemidactylus persicus Anderson.

Hemidactylus persicus Anderson, 1872, Proc. Zool. Soc. London, p. 378, fig. 2. (Type locality: probably Bushire, Iran, according to Blanford, 1876.)

Known range. Pakistan, Iran, Iraq, Arabia.

Material examined (9). Road between Station 1 and Station 2 (CAS 86499–86500 [VIII/20/58, ♀ ♀]). Road between Station 1 and Station 16 (CAS 86377 [V/12/58, ♀]; 86421 [VI/14/58, ♀]). Station 4 (CAS 86414 [♂]; 86415 [♀] [V/26/58]; 86424 [VI/24/58, ♂]; 86454–86455 [VI/13/58, ♀ ♀]).

Remarks. The females in this series contain ovarian eggs; CAS 86377 contains a large egg in each oviduct, the largest 13 mm.

The stomach of CAS 86455 contains grasshopper remains almost exclusively.

These lizards were found at night from May through August on the roads of the foothill region. The air temperatures were 31.4°–36.4°C., the road surfaces 35.4°–38.0°C., and the soil at the road edges 30°–35°C., the road surface usually 3°–5° higher than the surrounding soil.

This species occurs occasionally as a house gecko in this region, but less frequently so than *Cyrtodactylus scaber*.

Genus **Phyllodactylus** Gray

Phyllodactylus elisae Werner.

Phyllodactylus elisae Werner, 1895, Verh. Zool.-Bot. Ges. Wien, vol. 45, p. 14, pl. 3. fig. 1. (Type locality: ruins of Ninevah, near Mosul, Iraq.)

Known range. Western Iran and eastern Iraq.

Material examined (18). Station 4 (CAS 86432 [VI/24/58, ♂]). Station 12 (CAS 86339–86340, 86352 [IV/18/58, ♂♂]; 86435, 86437–86438 [♂♂]; 86436, 86439–86443 [VII/6/58]; 86525–86529 [VIII/22/58, ♂♂]).

Remarks. Stomach contents of this series seem to be exclusively spiders. There were many spiders in the culvert where these lizards were collected on several occasions. These geckoes are quite agile, and proved adept in avoiding capture in the dark culvert. The tails are extremely fragile, and although care was taken in collecting them, few were captured with complete tails. Several individuals were present on the stone walls of the culvert each time it was visited. A small trickle of water ran through the culvert in the summer. The lizards were usually in the middle, or darkest area of the culvert.

Family Agamidae

Genus **Agama** Daudin

Agama nupta de Filippi.

Agama nupta de Filippi, 1843, Giorn. Ist. Lomb. e Bib. Ital., vol. 6, p. 407. (Type locality: Persepolis, Iran.)

Known range. Pakistan, Afghanistan, Iran, Iraq.

Material examined (23). Station 1 (CAS 86250 [II/27/57, juv.]; 86321 [III/26/58, juv. ♂]; 86332 [IV/6/58, juv. ♂]; 86334–86335 [juv. ♂♂]; 86336 [juv. ♀] [IV/16/58]; 86512 [IX/7/58, juv.]). School building above road between Station 1 and Station 2 (CAS 86508 [VIII/20/58, juv.]). Road between Station 1 and Station 16 (CAS 86372 [V/12/58, ♂]). Road between Station 1 and Batwand (CAS 86434 [VII/6/58, ♀]). Station 3 (CAS 86531 [IX/4/58, ♂]). Station 6 (CAS 86502, 86510 [♀♀]; 86504, 86509 [♂♂] [VIII/21/58]). Station 7 (CAS 86252 [juv. ♂]; 86266 [♀] [III/13/58]). Station 9, above Karun River (CAS 86559 [X/11/58, ♀]). Station 19 (CAS 86623 [XI/4/58, ♂]). Station 26 (CAS 86474 [VIII/9/58, juv.]; 86476 [juv.]; 86477 [♂] [VIII/10/58]). Station 27 (CAS 86511 [IX/5/58, juv.]).

Remarks. The spines on the neck, around the ear, and the posterior temporal region are absent in the very young specimens. The scales become much more strongly keeled and mucronate with age, and the spines become increasingly pronounced. The occipital scales are relatively much larger in the young specimens than in older individuals.

The young have distinct dark crossbars in the area between the pectoral and pelvic girdles, these breaking up into less distinct reticulations as the animal matures.

Mites cluster in the folds on the neck, and under the imbricate scales of the adults.

These lizards were seen to eat both insects and herbaceous vegetation. The identifiable stomach contents were primarily orthopterous and coleopterous insects.

CAS 86266 and 86559 contained ovarian eggs, the largest measuring 3.5 mm. CAS 86502 and 86510 had eggs in the oviducts, measuring up to 26 mm. Thus gravid females were collected in March, August, and October, indicating that eggs are laid at least in the spring and in the autumn in this region.

The smallest juveniles (44 mm. snout–vent length) were seen in early September, but half-grown individuals were regularly observed from March through November.

This species is abundant in the foothill region, inhabiting rock outcrops where there are deep crevices. It is common on walls, cemetery monuments, and buildings. Almost always, one or more of these lizards are to be found living on and about each oil company staff bungalow at Masjid-i-Suleiman. These hang head down on the walls or screens and make brief forays onto the ground to capture insects. At night and during the hottest part of the day they retreat under the eaves.

These lizards were noted occasionally on the trunks of the few trees in the foothills. One was seen in a small gypsum cave. They are present in considerable numbers on the terrace of Persepolis, living in and about the ruins.

This is an extremely wary species, retreating quickly into a crevice (always close at hand) when alarmed. Observations (particularly of those living near buildings) indicate that the area of activity of an individual generally has a radius of less than fifty feet. The basking area, as indicated by the distribution of fecal pellets, is usually not more than five to ten feet in diameter.

From February through the summer a very definite shift in the periods of activity was observed. In late February and March this species was seen only at midday and early afternoon, when the air temperature was about 30°C. They were seen then basking on rocks, exposing the maximum surface area to the direct sunlight. In the afternoon they were raised on their forelegs, facing the sun so that the light rays would strike the head and belly, and the angle of reflection from the surface of the rock exposed them to the maximum reradiation. Later in the spring basking was initiated progressively earlier in the day and continued later into the afternoon. In the summer the lizards retired during the hottest hours, their activity restricted to the earliest daylight hours and to late afternoon in July and August. The anal temperature of a basking individual at 6:35 A.M. on August 20 was 27.2°C. when the air was 22.4°C. and the substrate 25.5°C. By mid-September they were again active until later in the morning and retired only during the midday heat, becoming active again early in the afternoon, when air temperatures were still over 40°C., and the rocks on which they were seen considerably higher. In mid-October they were active at midday.

Observations to determine the critical maximum temperature for this species were carried out with seven individuals (see p. 436). A critical maximum temperature between 43.8° and 48.5°C. was indicated (table 1).

During these observations the lizards became lighter in color, respiration became more rapid, and the mouth was open. Attempts to reach the shade were sporadic at first, becoming continuous as the anal temperature rose. The animal usually defecated when the anal temperature was between 37.0° and 42.6°C. Normal reactions were somewhat impaired before the actual critical maximum temperature was reached.

TABLE 1. *Summary of observations to determine the critical maximum temperature of* Agama nupta.

Sex	*Snout-vent length (mm.)*	*Air temp. (°C.)*	*Substrate temp. (°C.)*	*Initial anal temp. (°C.)*	*Time elapsed (min.)*	*Critical maximum temp.* (°C.)*
♂		41.0	50.0	33.5	9	48.5
♂	142	42.2	50.0	32.1	17	47.8
♂	158	41.6	50.5	30.4	17	46.8
♀	142	41.2	50.0	34.6	9	44.0
♀	136	41.0	49.6	33.6	11	44.6
juv.	64			34.8	4	43.8
juv.	62	41.8	48.6	34.8	6	46.8

*As defined by Cowles and Bogert (1944).

Agama agilis Olivier.

(Figure 11.)

Agama agilis OLIVIER, 1807, Voy. Emp. Otho., vol. 4, p. 394, pl. 24 (in atlas), fig. 2. (Type locality: vicinity of Baghdad, Iraq.)

KNOWN RANGE. Pakistan, Afghanistan, Iran, Iraq, Arabia, along the Persian Gulf. 0–6,000 feet.

MATERIAL EXAMINED (65). Station 1 (CAS 86251 [III/1/58, ♀]; 86320 [III/26/58, ♂]; 86328 [IV/7/58, ♀]; 86331 [IV/6/58, ♀]; 86466–86467 [VII/23/58, juv.]). Tang-i-Golestan, on road between Station 1 and Ahwaz (CAS 86338 [IV/18/58, ♂]). Road between Station 1 and Batwand (CAS 86348 [♀]; 86349–86351 [♂♂] [IV/18/58]). Road south of Shustar (CAS 86373 [IV/18/58, ♀]). Road between station 1 and Station 16 (CAS 86399–86400, 86402 [♂♂]; 86401, 86418 [♀♀] [V/23/58]). Station 4 (CAS 86447–86448 [juv.]; 86459 [♀] [VI/28/58]). Station 5 (CAS 86341–86346 [♂♂]; 86347 [♀] [IV/17/58]; 86389–86391 [♂♂]; 86392–86395, 86422–86423 [♀♀] [V/22/58]; 86425–86426 [VI/5/58, ♀♀]; 86456, 86458 [VI/28/58, ♂♂]; 86493–86497 [VIII/19/58, juv.]; 86498 [VIII/20/58, juv.]). Station 6 (CAS 86457 [VI/28/58, ♂], 86461–86462 [VII/4/58, ♂♂]). Road near Shustar (CAS 86464 [VII/18/58, ♀]). Road from Station 15 to Tembi River (CAS 86427–86429 [VI/20/58, ♂♂]). Tembi River, near Station 15 (CAS 86449 [VI/20/58, juv.]). Golf course at Station 16 (CAS 86556 [X/5/58, ♂]). Road near Station 17 (CAS 86403–86404, 86406 [♂♂]; 86405, 86419 [♀♀] [V/23/58]). Station 19 (CAS 86487 [VIII/16/58, juv. ♂]). Station 20 (CAS 86503 [VIII/23/58, juv. ♂]). Station 27 (CAS 86322 [Mar., 1958, ♂]; 86625 [XI/1/58, juv.]). Station 28 (CAS 86374 [IV/22/58, ♀]).

REMARKS. Taxonomic separation of the several geographic populations of this polymorphic species must await the examination of more material. The statistical significance of the variation in the scale rows of the various populations has been pointed out (Leviton and Anderson, 1961). Wettstein's (1951) designation of the subspecies *"agilis," "isolepis,"* and *"sanguinolenta"* is unacceptable, since he does not explain this partition on morphological grounds.

The present series from southwest Iran has a range of 76–95 (mean 86.1) scales around the body; six specimens from the Dasht-i-Margo Desert of Afghanistan (Leviton, 1959) have 72–76 (mean 74.8) scale rows; nine specimens from Kandahar, Afghanistan (Leviton and Anderson, 1961) have 60–74 (mean 65.0) rows; three specimens in the collection of the U.S. National Museum, designated as *Agama sanguinolenta,* have 56–66 (mean 59.7) scale rows. These last three specimens, from Turkestan (USSR), are otherwise indistinguishable from *A. agilis.*

Blanford (1881) remarks that two specimens from Persia in the Berlin Museum are distinguished from other Persian specimens by having smooth ventral scales, and having 80–85 scales round the body, the "common Persian form" having only 70–75. None of Blanford's (1876, 1881) specimens came from southwest Iran, and apparently the exact localities of the specimens in the Berlin Museum were not known. In many of the present specimens the keels on the ventral scales are indistinct.

CAS 86374, from southeastern Iran, has 67 scale rows, and is tentatively assigned to this species.

The measurements and scale counts for the present series and for the three *A. sanguinolenta* are presented in table 3. I wish to thank Dr. Doris Cochran of the U.S. National Museum for the loan of the three specimens of *A. sanguinolenta.*

Blanford (1881) states that the Central Asian specimens are distinguished from all the Persian examples by more strongly developed keels throughout, and that this coincides with Pallas' description of *Lacerta sanguinolenta,* and Eichwald's description of *Agama sanguinolenta.* He states that some of the largest males which he collected in the desert between Sind and Jaisalmir (northwestern India) have the strongly keeled and mucronate scales of *A. sanguinolenta.* He concludes that the form from "Persia, Baluchistan, and Sind" is the true *Agama agilis* of Olivier, and that the *A. sanguinolenta* of the countries north of Iran and east of the Caspian (with which *A. aralensis* is identified by Peters and apparently by Strauch) is a variety of *A. agilis* with more strongly keeled and spinose scales.

All females collected between March 1 and July 18, 1958, were gravid (no adult females were collected after July 18). CAS 86418 had eggs in both ovaries, even though a clutch of 8 eggs had been laid in captivity, and CAS 86464, which laid 12 eggs in captivity, had eggs in both ovaries. CAS 86419 had laid 6 eggs in captivity, and had eggs in the left ovary but none in the right; there was a single egg in the right oviduct. In 8 specimens the oviducts are greatly enlarged, but contain no eggs, the lizards having only small ovarian eggs. Some specimens had over 20 eggs in each ovary, the largest 6.5 mm. in diameter; the largest oviducal eggs were 11 mm. Captive females laid eggs between June 2 and July 26. These eggs were 13–15 mm. in diameter, the shells soft when laid, but hardening rapidly.

Juvenile specimens were not seen until late June, becoming increasingly numerous thereafter. Both newly hatched and half-grown juveniles were seen in late October and early November.

Stomach contents included grasshoppers, ants, beetles, and other arthropod remains.

In none of these specimens is there any indication of the tail having been regenerated.

This species was first seen in the foothills in early March, becoming very numerous by mid-April. Although often found within a few yards of *A. nupta,* their microhabitats do not overlap, *A. agilis* preferring small rock piles in relatively flat areas, and never seen on the ridges and outcrops frequented by *A. nupta.* During the hours of their activity, one of these lizards is to be seen on almost every one of the small piles of stones erected to mark the boundaries of grain fields. Occasionally they are seen in low thorny shrubs.

In some areas, where there are suitable rock piles, the lizards may be less than 50 feet apart.

This species was never encountered in active sand dune areas, but was collected near the beach at Binak, on the narrow coastal plain along the Persian Gulf.

Agama agilis is far less wary than *A. nupta,* and can be approached to within a few feet, particularly when basking, and collected by means of a noose.

Color and pattern changes, apparently correlated with changes in anal and ambient temperatures, were observed. During the earliest morning hours, when the lizards were basking, pressed close to rock or soil surfaces, and exposing a maximum surface area to the direct rays of the sun, they were dark in color, the dorsal pattern of interrupted crossbars very pronounced. The lowered albedo may permit greater heat absorption at the lower morning temperatures. The lizards were sluggish at this time, and could often be collected simply by picking them up. The broken pattern may serve to make them less conspicuous to predators in the hours when they are least wary, and shadows are long.

Anal temperatures when the lizards were basking and sluggish were 30.8°–40.4°C.; air temperatures were 29.8°–37.0°C., soil and rock surfaces 28.3°–39.2°C.

During the hottest hours of their activity they are extremely light in color, the males a light sandy color with no discernible pattern, the females showing some of the crossbars. Considerable orange pigment is seen on the tail at these times. The animals raise themselves on all four legs, well off the rock surfaces, and are tilted at an angle which exposes the minimum surface area to direct radiation. During these periods anal temperatures were 41.2°–45.2°C.; air temperatures were 38.0°–41.6°C., rock and soil temperatures 40.0°–50 +°C. During the hottest hours at which lizards were seen on rocks and in bushes, very little active foraging was observed. Sitting in low shrubs, away from the hot ground, may enable them to effectively lower the body temperature. One individual collected in a bush had an anal temperature of 38.0°C., while those on rocks in the vicinity had anal temperatures of 41.2°C. They were seen in bushes only during the hottest hours of their activity, sitting vertically so that the sun would strike the belly at a small angle.

Most foraging activity seems to take place when anal temperatures are between 38° and 42°C. The voluntary maximum temperature (as defined by Cowles and Bogert, 1944) appears to be about 44.8°C.

That the color change undergone by these animals is under nervous control is apparent when they are collected with a noose during the heat of the day. They are very light in color when seen sitting on the rocks; when noosed they darken almost instantly, and show much more contrast in the dorsal pattern. When taken in the hand from the noose they blanch within seconds to a color much lighter than when originally seen, the males becoming almost white, the pattern disappearing. The males are much darker on the throat and on the sides of the belly than on the dorsum, and these areas deepen in intensity, and have a blue cast when the lizards are held in the hand.

The seasonal shift in activity is very noticeable, and corresponds with that observed for *A. nupta*. Captive individuals placed in an outdoor observation enclosure were active throughout the midday hours in late September. The daily maximum temperatures were still high at this time, but there was no longer the prolonged heating of the substrate, an important factor in maintaining the high ambient temperatures of the summer months.

In observations to determine the critical maximum temperature (see p. 436), the lizards showed striking color and pattern changes. As anal temperatures rose, males faded gradually from a light gray with discernible crossbars, to nearly white as the critical maximum was approached, the pattern fading completely. The tail became increasingly orange as the animal grew lighter; the blue ventral areas, hardly visible at the start of the observations, became intensely blue. Females initially had dark brown to dark red-brown or orange-brown crossbars, which became much lighter, sometimes bright orange, as the temperature rose. A critical maximum temperature between 47.5° and 49°C. was indicated (table 2). One individual recovered

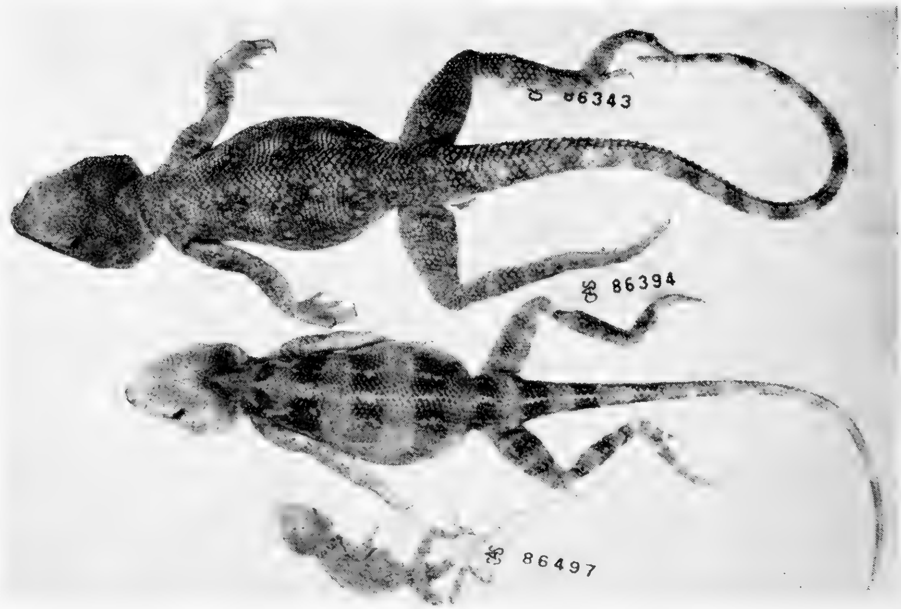

FIGURE 11. *Agama agilis.* Top to bottom: male, female, juvenile.

after having an anal temperature of 49.8°C., but coordination had probably failed before this temperature was reached.

Table 2. *Summary of observations to determine the critical maximum temperature of* Agama agilis.

Sex	*Snout-vent length (mm.)*	*Air temp. (°C.)*	*Substrate temp. (°C.)*	*Initial anal temp. (°C.)*	*Time elapsed (min.)*	*Critical maximum temp.*[3] *(°C.)*
♂	93	43.5	48.9	32.2	10	48.8
♂	92	43.8	51.0	36.6	7	49.0
♀	74	44.2	50.0	35.2	11	48.5
♂	82	38.2	45.0–49.4	35.6	12	48.4
♂	92	39.6	50.0	35.6	17	47.5

[3] As defined by Cowles and Bogert (1944).

Table 3. *Measurements (in mm.) and counts for specimens of* Agama agilis.

CAS number	*Sex*	*Scale rows*	*Upper labials*	*Lower labials*	*Preanal pores*	*Snout-vent length*	*Tail length*
86320	♂	82	16	18	12		
86322	♂					65	101
86338	♂	84	17/18	20/21	30		
86341	♂	82	16/18	17	21	83	134
86342	♂	82	17	19/18	24	84	126
86343	♂	81	18	18/19	10	86	141
86344	♂	85	20/18	19/20	20	84	140
86345	♂	86	19/20	19	18	90	133
86346	♂	86	18/19	18	25	87	138
86349	♂	80	17	16/18	26	82	127
86350	♂	92	15/17	16	28	91	145
86351	♂	82	15	17	11	84	122
86389	♂	81	17/16	17/16	28	89	143
86390	♂	82	16/18	19	25	88	135
86391	♂	90	18	19	20	84	141
86399	♂	88	16	18/17	28	94	139
86400	♂	86	18/17	19	43	93	144
86402	♂	81	16/14	16/15	25	89	142
86403	♂	84	16/17	17/16	24	83	146
86404	♂	86	16	17	24	79	130

TABLE 3 (cont.). *Measurements (in mm.) and counts for specimens of* Agama agilis.

CAS number	*Sex*	*Scale rows*	*Upper labials*	*Lower labials*	*Preanal pores*	*Snout-vent length*	*Tail length*
86406	♂	88	17	19/20	20	69	115
86427	♂	88	19/17	19	28	86	137
86428	♂	86	19	17	21	88	
86429	♂	84	17/18	16/18	29	90	146
86456	♂	82	16/17	19/18	52	93	149
86457	♂	87	18	18	17	94	
86458	♂	95	19/18	19	9	92	154
86461	♂	86	18/17	17	31	82	134
86462	♂	80	16/18	18	24	92	147
86487	♂	89	17	19/17	16	56	98
86503	♂	85	16	15	7	56	91
86556	♂	84	18/17	19/20	9	88	133
86251	♀	83	17/19	17/18	8	70	102
86328	♀	95	17/16	20/18	8	64	96
86331	♀	89	20/17	17/20	9	69	98
86347	♀	83	18	18/19	11	72	114
86348	♀	95	15/16	17/18	9	72	113
86373	♀	87	18/19	18/17	8	73	102
86392	♀	82	19/17	17/18	10	89	133
86393	♀	81	19	20	10	86	122
86394	♀	82	16/15	18/19	9	75	107
86395	♀	86		12/14	10	64	93
86401	♀	87	17/16	15/16	13	85	111
86405	♀	87	17/18	18	8	79	108
86418	♀	95	17/16	17	11	73	111
86419	♀	92	16	18/19	9	76	106
86422	♀	93	17/18	18	13	72	107
86423	♀	80	16	18/17	8	75	116
86425	♀	95	16/17	18/19	9	80	116
86426	♀	83	19/18	19	9	83	124
86459	♀	88	19/17	17/15	9	74	102
86464	♀	90	16/17	19/17	8	83	114
86447	juv.				8	33	47
86448	juv.				9	32	43
86449	juv.				10	32	53
86466	juv.					30	43
86467	juv.					29	43
86493	juv.	89	17	19/17	6	38	
86494	juv.	85	16	17/16	11	43	68

Table 3 (cont.). *Measurements (in mm.) and counts for specimens of* Agama agilis.

CAS number	*Sex*	*Scale rows*	*Upper labials*	*Lower labials*	*Preanal pores*	*Snout-vent length*	*Tail length*
86495	juv.	94	18/19	19/17	8	44	68
86496	juv.	90	20/18	19	10	38	53
86497	juv.	76	18/17	18	8	36	53
86498	juv.	88	16/15	16	10	40	65
86625	juv.	78 +	17/15	16/15			
Range		76–95 (86.1)	15–20	12–21	6–52	29–94	43–154
USNM number		*Data for specimens of* Agama sanguinolenta.					
14352		66	20	17/16	24	111	159
Caspi, Krasnowodsk							
14361		57	20/19	18/16	17	93	142
Turkestan							
37219	juv.	56	16/17	17	18	65	120
New Margelan, Turkestan							

Agama persica Blanford.

(Figure 12.)

Agama persica Blanford, 1881, Proc. Zool. Soc. London, p. 674, pl. 49 (syntypes came from Deh Bid and Kazerun, Iran, neither designated as the type locality).

Known range. Jordan; Iraq; Iran; Arabia, along the Persian Gulf.

Material examined (11). Station 23 (CAS 86534–86535 [IX/12/58, juv.]). Station 25 (CAS 86486 [juv.]; 86505–86506 [♂♂] [VIII/17/58]; 86521 [♀]; 86522–86523 [juv.] [VIII/22/58]; 86538–86539 [juv.]; 86540 [♂] [IX/13/58]).

Remarks. This series agrees well with Blanford's (1881) description. The preanal pores form a single row, occasionally with one or two additional pores in the row above or below, and are present in all adults. These specimens do not differ significantly from eight individuals from Arabia (Abqaiq, Qatif, and Dhahran). The ventral scales of the Iranian series are more strongly keeled than are those of the Arabian series, and the dorsal scales are more strongly mucronate, the apex of the mucro more upturned. There are 73–89 scales round the middle of the body in the Iranian lizards (mean 82.2), 73–82 in the Arabian series (mean 76.3). Blanford gives the range as 75–85 in his type series. Four of the five females of the Arabian series lack preanal pores.

I collected this species in only two localities, both active dune areas.

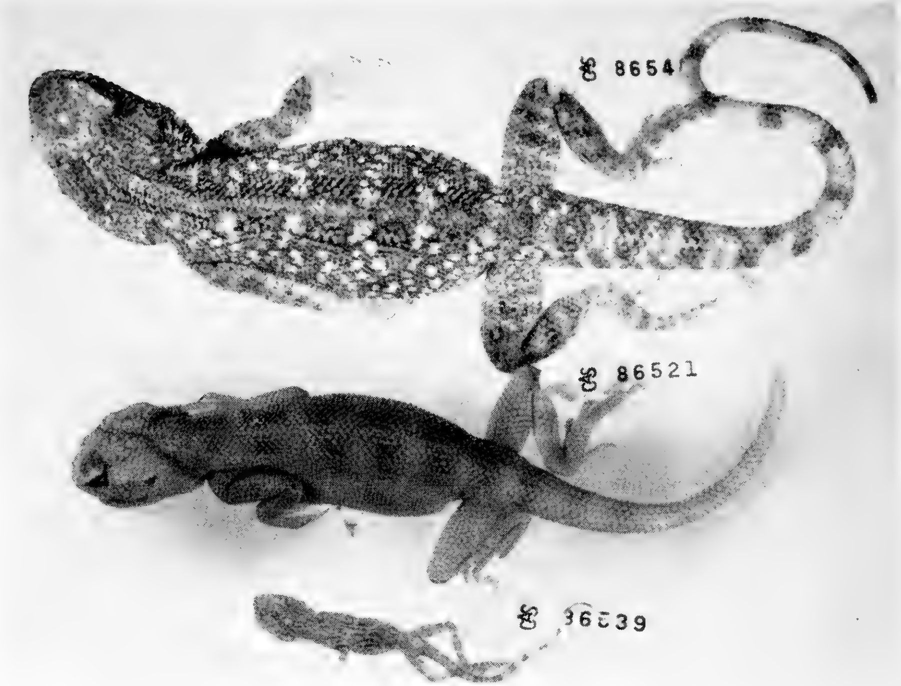

FIGURE 12. *Agama persica.* Top to bottom: male, female, juvenile.

Agama agilis was never observed in such a habitat. Active over the entire dune area, these lizards were most numerous on the fringes near low shrubs. Two were collected in a bush where they had apparently been feeding on the foliage, for one had leaves in its mouth. They were active on the dunes at midmorning in August. The anal temperature of one foraging individual was 40.8° when the air was 39.6°, and the sand 48.2°C. They were still active when the air had reached 42° and the sand well over 50°C.

Stomach contents included ants, beetles, and orthopterans.

The female, collected in late August, had 13 eggs in the left ovary, the largest 2 mm. in diameter.

These lizards are quite belligerent when cornered, leaping off the ground toward their pursuer, the mouth wide open, the dewlap extended.

In three observations to determine the critical maximum temperature (see p. 436), it appeared to be between 46.1° and 49.2°C. (table 4).

During these observations the lizards became much lighter in color; the pattern faded, the tail pattern becoming yellow, the blue areas on the throat and venter becoming more intensely blue. The mouth was opened wide, and the dewlap extended.

A male narcotized with chlorotone became much darker on the dorsal surface, the linked, diamond-shaped markings on the vertebral line becoming much less obvious, light crossbars appearing against the dark ground color, and a general light mottling appearing over the dorsum. The tail became much lighter. The light, sandy pattern of the belly faded completely. All of the blue areas became intense, the blue coloration diffusing high onto the maxillary region, over the snout, and lightly onto the temporal region. The sides of the belly and the chin became intensely blue, the dew-lap and throat becoming black.

Table 4. *Summary of observations to determine the critical maximum temperature of* Agama persica.

Sex	*Snout-vent length (mm.)*	*Air temp. (°C.)*	*Substrate temp. (°C.)*	*Initial anal temp. (°C.)*	*Time elapsed (min.)*	*Critical maximum temp.*[4] *(°C.)*
♂	99	43.6	51.2	34.0	7	46.1
♂	94	44.6	50.0	34.6	8	47.2
juv.	45	44.6	54.4	41.1	4	49.2

[4] As defined by Cowles and Bogert (1944).

Agama ruderata Olivier.

Agama ruderata Olivier, 1807, Voy. Emp. Othm. Eg. et Pers., vol. 2, p. 429, pl. 29, fig. 3 (syntypes from Iran and northern Arabia).

Known range. Israel; Syria; Turkey; Jordan; Iraq; Arabia; Iran; Afghanistan.

Material examined (1). Station 26 (CAS 86475 [VIII/9/58, juv.]).

Remarks. The single juvenile specimen was collected on the terrace of Persepolis. No *A. agilis* were seen in this region.

Genus **Uromastix** Merrem

Uromastix loricatus (Blanford).

Centrotrachelis loricatus Blanford, 1874, Proc. Zool. Soc. London, p. 660. (Type locality: Bushire, Iran.)

Uromastix loricatus, Boulenger, 1885, Cat. Liz. Brit. Mus., vol. 1, p. 409, pl. 32.

Known range. Iraq, Iran.

Material examined (6). Road between Station 1 and Ahwaz (CAS 86379 [Apr., 1958, ♂, DOR]). Road between Station 1 and Station 16 (CAS 86463 [V/23/58, juv.]); 86470 [VII/6/58, ♀]). Station 14 (CAS 86380 [April, 1958, ♂, DOR]). Station 15 (CAS 86468 [VI/20/58, ♀]). Near Station 22 (CAS 86469 [VII/6/58, ♂]).

Remarks. Both females have ovarian eggs, the largest 3 mm. in diameter.

These large lizards were seen from mid-April through mid-August on plains and in valleys where soil conditions permit excavation of the burrows in which they live. These burrows are often more than four feet in length, and more than one foot deep at their termination, and usually have two or more sharp bends. The lizards were most frequently observed basking on a mound of soil at the mouth of the burrow. They were often seen at midday during the summer when no other reptiles were active. They are easily alarmed, retreating quickly into the burrow. Occasionally they were seen foraging some twenty-five yards from the burrow. The burrows were often in areas where a low, hirsute herb (family Labiaceae) was growing. The leaves of these plants always showed that the lizards had fed on them where they occurred near the burrows. Fecal pellets in the basking area contained only this plant.

When threatened with capture, these animals whip the heavy, spiny tail laterally with rapid, violent strokes.

The juvenile specimen was collected at midday, when the surface of the road on which it was seen had a temperature of 57°C., the surrounding soil 57.5°C. When captured after considerable activity, the animal had an anal temperature of 45.8°C. A female captured June 20 was actively foraging in a plowed grain field at 9:25 A.M., when the air temperature was 35°, the soil 46.8°C. The anal temperature was 43.2°S.

A female collected at 3:40 P.M. on June 6, was active on a road having a surface temperature of 53.5°C., the surrounding soil 53.0°, and the air 47.5°C. When collected, the animal was nearly white, the bright orange areas of the back very pronounced.

Individuals basking in the early hours of the day were extremely dark in over-all coloration, those active in the hottest part of the day almost white, having large areas of bright orange across the dorsum. In captivity they demonstrated the ability to change from a very dark to a nearly white coloration, this change being correlated with temperature. This would seem to indicate a change in the albedo of the animal, allowing it to absorb more heat when temperatures are below the optimum for activity, and less when temperatures have exceeded this level.

Three captive adults showed signs of discomfort when anal temperatures rose above 44°C. They were very light in color at this temperature, respiration was rapid, their mouths were open, the tongues bright red.

Three adults recovered from experiments to determine the critical maximum temperature (see p. 436) after the anal temperature had risen to 49.1°–50.2 +°C. (table 5), apparently without suffering ill effects. They were observed for a relatively short period following recovery, however.

The general body color at the beginning of the observations was a light gray. They became gradually lighter as the temperature rose, becoming nearly white, the orange pigment in the thoracic area increasingly pronounced.

TABLE 5. *Summary of observations to determine the critical maximum temperature of* Uromastix loricatus.

Sex	*Snout-vent length (mm.)*	*Air temp. (°C.)*	*Substrate temp. (°C.)*	*Initial anal temp. (°C.)*	*Time elapsed (min.)*	*Critical maximum temp.*[5] *(°C.)*
♂	252	45.4	50 +	34.8	32	49.5
♀	220	45.4	50 +	34.5	24	50.2 +
♀	215	46.2	50 +	35.8	51	49.1

[5] As defined by Cowles and Bogert (1944).

Family VARANIDAE

Genus **Varanus** Merrem

Varanus griseus (Daudin).

Tupinambis griseus DAUDIN, 1803, Hist. Nat. Rept., vol. 8, p. 352. (Type locality: Egypt.)

Varanus griseus, BOULENGER, 1885, Cat. Liz. Brit. Mus., vol. 2, p. 306.

KNOWN RANGE. North Africa; Arabia and southern Asia to the Caspian Sea, and eastward through Afghanistan and Pakistan to the desert regions of northwest India, 0 feet–4,000 feet.

MATERIAL EXAMINED (2). Station 25 (CAS 86630–86631 [IX/13/58, juv.]).

REMARKS. This species was seen occasionally, always from a distance, in the foothill region. They were active in sand dune areas in August and September during the early daylight hours. They appear to forage systematically on the dunes over several hundred yards, entering one burrow after another in search of rodents and reptiles. One juvenile was tracked some 500 yards before it was found backing out of a burrow. When overtaken after a considerable chase, it stopped, hissing loudly, thrashed the tail from side to side, and ran directly at me. It had just eaten a lizard, the tail of which could be seen protruding from the throat.

The anal temperature of a foraging juvenile which had just entered a burrow was 38.5°, the air 31.8°, and the surface of the sand 45.4°C.

One captive individual was observed while it ate a dead mouse. The lizard braced itself on stiff forelegs, making short forward lunges with its body, the jaws maintaining a firm grip on the mouse. The prey was slowly worked farther into the throat in this manner until it was completely within the mouth and throat. There followed a series of contortions of the neck and body as the food was worked down the long throat.

Smith (1935) says that 15–20 eggs are laid, buried in the sand, or placed at the end of a burrow.

Family AMPHISBAENIDAE

Genus **Diplometopon** Nikolsky

Diplometopon zarudnyi Nikolsky.

Diplometopon zarudnyi NIKOLSKY, 1907, Ann. Mus. Zool. Acad. Sci. Petrograd, vol. 10, p. 277, figs. 1–3. (Type locality: Nasrie, Khuzistan, Iran.)

KNOWN RANGE. Iraq; southwestern Iran (Khuzistan Province); Arabia, along the Persian Gulf.

MATERIAL EXAMINED (1). Station 25 (CAS 86514 [VIII/22/58]).

REMARKS. The single specimen was found several inches below the surface of the sand. Whether it had been in a burrow or in loose sand was not determined.

Family LACERTIDAE

Genus **Acanthodactylus** Wiegmann

Acanthodactylus cantoris Günther.

Acanthodactylus cantoris blanfordi Boulenger.

Acanthodactylus cantoris, BLANFORD (in part), 1876, Zool. E. Persia, vol. 2, p. 163, pl. 26, fig. 3.

Acanthodactylus cantoris blanfordi BOULENGER, 1918, Bull. Soc. Zool. France, p. 154 (syntypes from Bam, Iran, and Mand, Pakistan).

KNOWN RANGE. The species ranges from northwest India through Pakistan and Afghanistan to western Iran and Arabia. The subspecies, *A. c. blanfordi*, is found in southwestern Pakistan and southeastern Iran.

MATERIAL EXAMINED (13). Station 32 (CAS 86600, 86602, 86604, 86607–86608 [♂♂]; 86601, 86603, 86605–86606, 86609 [♀♀] [X/23/58]). Station 33 (CAS 86588–86589 [X/18/58, ♂♂]). Station 35 (CAS 86592 [X/21/58, ♂]).

Acanthodactylus cantoris schmidti Haas.

Acanthodactylus cantoris schmidti HAAS, 1957, Proc. Calif. Acad. Sci., vol. 29, pp. 72–73. (Type locality: Dhahran, Saudi Arabia).

KNOWN RANGE. Dhahran, Abqaiq, Qatif, Shimal, and north of Tebuk, Saudi Arabia; Mesopotamian Plain, Khuzistan Province, southwestern Iran.

MATERIAL EXAMINED (25). Station 25 (CAS 86488, 86490 [♂♂]; 86491 [♀]; 86489 [juv.] [VIII/17/58]; 86515–86520 [VIII/22/58]; 86541–86542, 86544, 86547, 86549, 86551–86552 [♀♀]; 86543, 86545–86546, 86548, 86550, 86553–86555 [♂♂] [IX/13/58]).

Remarks. Boulenger (1921) gives the range of dorsal scale rows in *A. cantoris blanfordi* as 38–44, the ventrals as 12–14. The present specimens from southeastern Iran (Bandar Abbas, Shagu, and Minab) have 36–44 (mean 39.6) dorsals and 12–14 (mean 12.6) ventrals. They agree with Boulenger's description of this subspecies, the type series of which was collected by Blanford in southeastern Iran and southwestern Pakistan.

The specimens from southwestern Iran (Khuzistan Province) have 38–51 (mean 44.1) dorsals and 14–16 (mean 15.5) ventrals. The two series were compared with the paratypes of *A. c. schmidti* in the collection of the California Academy of Sciences (table 7). *Acanthodactylus c. schmidti,* from the northeast coast of Arabia, was found to have 38–54 (mean 44.8) dorsals, and 13–18 (mean 14.9) ventrals. Thus, the Khuzistan series appears to be closer to *A. c. schmidti* than to *A. c. blanfordi.* It is not possible to evaluate the biological significance of the several apparently distinct populations of *A. cantoris* on the basis of presently available material.

The following females contain ovarian eggs: CAS 86516, 86541, 86542, 86544, 86547, 86549, 86551, 86552, 86601, 86603, 86605, 86606, 86609. This indicates eggs are laid in late fall, and perhaps in the winter. The fact that no small juveniles were seen is additional evidence that hatching does not occur in spring and summer. Blanford (1876) found numerous young in November, and concluded that eggs probably hatch in the autumn.

Stomach contents include ants, termites, spiders, beetles, and blossoms. CAS 86516 has considerable sand, as well as insect remains in the colon.

This species was encountered only in active sand dune areas. Their tracks, characterized by the continuous mark left by the tail, are almost always to be seen in the morning in dune regions. These lizards run rapidly from bush to bush, exploring more slowly the area within the shade and protection of shrubs. They were never seen to burrow in the loose sand.

Anal temperatures of active lizards ranged from 38.0° to 41.8°C.; air temperatures during the periods of activity ranged from 27.4°, at which time activity was just beginning, to 42.0°C., the sand surface 34.0°–48.2°C. Above these air and sand temperatures, the lizards could be seen resting quietly in the shade of low shrubs. When sand surface temperatures were 50 +° in the sun, they were often about 35°C. in the shade of bushes. In summer (when these observations were made) the activity takes place only in the early morning and late afternoon, the animals retreating to burrows around the bases of shrubs during the hottest hours. On October 20, at 2:45 p.m., when the sand surface was over 50°C., and there were no lizards on the surface, the sand four inches below the surface was 41.8°C. A lizard was turned out of a burrow by digging at about that depth.

In three experiments to determine the critical maximum temperature for this species (see p. 436) a critical maximum of 47–49°C. was indicated (table 6). Observations were conducted in a metal box, the bottom of which was covered with sand. When first placed on the sand, these lizards performed the typical lacertid behavior of resting the weight on the elbow joint, while raising the forefeet off the sand surface. No attempts were made at burrowing.

TABLE 6. *Summary of observations to determine the critical maximum temperature of* Acanthodactylus cantoris.

Snout-vent length (mm.)	*Air temp. (°C.)*	*Substrate temp. (°C.)*	*Initial anal temp. (°C.)*	*Time elapsed (min.)*	*Critical maximum temp.[6] (°C.)*
47	42.5	59.6	37.6	3	47.0
43	44.6	57.0	35.8	3	49.0
47	44.6	55.5	39.0	3	49.0

[6] As defined by Cowles and Bogert (1944).

TABLE 7. *Measurements (in mm.) and counts for specimens of* Acanthodactylus cantoris.

CAS number	*Sex*	*Scale rows* *Dorsals*	*Scale rows* *Ventrals*	*Femoral pores*	*Snout-vent length*	*Tail length*
			Southeastern Iran			
86588	♂	36	13	20	39	84
86589	♂	41	13	22/21	47	
86592	♂	40	12	20/21	53	106
86600	♂	44	12	21/20	58	
86602	♂	40	13	20/22	49	99
86604	♂	37	12	26/23	43	
86607	♂	38	12	22/19	45	96
86608	♂	40	13	22	46	
86601	♀	40	12	19/21	51	
86603	♀	40	12	20/19	54	96
86605	♀	38	14	19	44	86
86606	♀	42	13	19/20	45	
86609	♀	39	13	18/19	39	
Range		36–44 (39.6)	12–14 (12.6)	18–26	39–58	84–106
			Khuzistan Province			
86488	♂	42	15	17/21	47	88

TABLE 7 (cont.). *Measurements (in mm.) and counts for specimens of* Acanthodactylus cantoris.

CAS number	Sex	*Scale rows* Dorsals	Ventrals	Femoral pores	Snout-vent length	Tail length
86490	♂	45	14	18/20	43	79
86543	♂	45	14	19/18	42	80
86545	♂	45	16	20/19	52	85
86546	♂	46	15	20	49	96
86548	♂	44	14	19/20	55	102
86550	♂	43	16	21/22	58	110
86553	♂	46	15	19/20	74	
86554	♂	39	15	21/20	80	159
86555	♂	39	16	21/20	85	
86491	♀	38	16	20	47	88
86541	♀	43	16	21/20	38	72
86542	♀	44	16	19/18	42	79
86544	♀	51	16	21/19	45	
86547	♀	44	16	19	52	
86549	♀	45	16	20/21	52	93
86551	♀	46	16	20/22	56	103
86552	♀	47	16	20/21	58	109
86489	juv.	46	16	22/20	36	
Range		38–51	14–16	18–22	36–85	72–159
		(44.1)	(15.5)			
		Dhahran (*paratypes of* A. c. schmidti *Haas*)				
84268		40	18	22		
84270	♀	46	14	18		
84530	♀	50	16	21/20		
84598		40	15	23		
84600		42	13	18/20		
84601	♂	43	14	20/19		
84603		40		20		
84604		38	16	20/22		
84605	♀	52	14	21		
84606		54	14	21		
84608		47	14	18/19		
84609	♀	45	16	20/22		
Range		38–54	13–18	18–23		
		(44.8)	(14.9)			

Genus **Eremias** Wiegmann

Eremias guttulata watsonana Stoliczka.

Eremias (Mesalina) watsonana STOLICZKA, 1872, Proc. Asiat. Soc. Bengal, p. 86. (Type locality: between Karachi and Sukkur, Sind.)

Eremias guttulata watsonana, SMITH, 1935, Fauna Brit. Ind., vol. 2, p. 389.

KNOWN RANGE. *Eremias guttulata* ranges from northeastern Africa, including Egypt, the Sudan, and Ethiopia, through southwest Asia and Arabia to northwest India. *Eremias g. watsonana* is known from Iran, Afghanistan, West Pakistan, and northwest India (Smith, 1935).

MATERIAL EXAMINED (25). Station 1 (CAS 86248 [III/2/58, ♀]; 86288 [III/19/58, ♀]; 86326 [♀]; 86329 [♂] [IV/7/58]; 86640 [XI/30/58, ♂]). Road between Station 1 and Station 16 (CAS 86323 [III/28/58, ♂]; 86386–86387 [V/23/58, juv.]; 86645 [VII/6/58, ♂]). Station 3 (CAS 86249 [III/14/58, ♂]). Station 4 (CAS 86452 [VI/28/58, juv.]). Station 6 (CAS 86453 [VII/4/58, juv.]). Road between Station 1 and Ahwaz (CAS 86465 [VII/18/58, ♀]). Station 8 (CAS 86325 [IV/2/58, ♀]). Station 11 (CAS 86444 [VII/6/58, juv.]). Station 15, near Tembi River (CAS 86430 [♂]; 86450–86451 [juv.] [VI/20/58]). Station 19 (CAS 86484–86485 [VIII/16/58, ♀ ♀]). Station 26 (CAS 86478 [VIII/10/58, juv.]). Station 29 (CAS 86368–86369 [IV/26/58, juv.]). Station 30 (CAS 86367 [IV/25/58, ♂]). Station 31 (CAS 86587 [X/18/58, ♂]).

REMARKS. In CAS 86368 the collar is distinct only at the sides of the throat. The scales of the tibia are not keeled in CAS 86484.

Females collected between March 2 and April 7, and on August 16 contain eggs (CAS 86248 and 86326 have eggs in the oviducts, the largest 9 mm. in diameter. CAS 86288, 86325, 86484, and 86485 contain ovarian eggs, the largest 3 mm. in diameter).

Hatchlings were seen from late April through November, half-grown individuals not appearing until late May or June. This indicates that eggs are laid in early spring and late summer (perhaps throughout the summer). Apparently hatching does not begin until midspring, and continues through early autumn (although perhaps no hatching occurs in midsummer). Adult size is attained by the following spring.

Stomachs contained ants and spiders.

This is the most common lacertid in the foothills of Khuzistan. It seems to prefer the less rocky areas, being abundant on hillsides, in valleys, and along stream courses. They are agile in avoiding capture, often making no attempt to seek safety under rocks close at hand. If hard pressed, they will run under a rock or down small holes in the soil.

They become active early in the day and remain active late in the evening, their small size and correspondingly greater surface area enabling them to rapidly reach optimum activity temperature. As air and substrate temperatures increase, activity is confined to the shade of rocks and small plants, quick dashes being made across areas of direct sunlight. As with the agamid lizards of the region, a shift in activity from midday in the spring to early morning and later afternoon in summer, and again to midday in the fall, was observed. Their small size, and their utilization of very small shaded areas gives them a longer period of activity than the larger species. The very young individuals are active earlier, and retreat to cover sooner in the hottest hours than do the adults. This species was found active about

TABLE 8. *Measurements (in mm.) and counts for specimens of* Eremias guttulata watsonana.

CAS number	*Sex*	*Scale rows*		*Upper labials*	*Femoral pores*	*Snout-vent length*	*Tail length*
		Dorsals	*Ventral*				
86249	♂	44	10	8	11	50	111
86323	♂	43	10	8	12	49	
86329	♂	43	10	9	12/11	51	108
86367	♂	45	9	8	13/14	44	
86430	♂	46	10	8	11	50	
86445	♂	46	10	9	13		
86587	♂	41	10	9/11	13	39	93
86640	♂	43	10	8	13	53	
86248	♀	44	10	8	12		
86288	♀	45	10	8	12/11	57	
86325	♀	46	10	9/8	11	53	
86326	♀	44	10	8	11	57	
86465	♀	42	10	8	11	39	75
86484	♀	43	10	9/8	12	41	78
86485	♀	39	10	7/8	11	38	80
86368	juv.	42	10	10	12	21	
86369	juv.	43	10	9	11	20	
86386	juv.	42	10	9	12	27	47
86387	juv.	47	10	9/10	12	25	46
86444	juv.	44	10	9	13		
86450	juv.	44	10	8	11	31	58
86451	juv.	44	10	8	12	30	64
86452	juv.	42	10	9	10	25	
86453	juv.	47	10	8	11	35	75
86478	juv.	44	10	9	11/12	26	54
Range		39–47	9–10	7–11	10–14	20–57	46–111

9:00 P.M. in mid-August in the light of a gas flare. The air temperature was 36.4°C., the ground surface 33.6°C.

This lacertid was never seen in active sand dune areas.

Genus **Ophisops** Ménétries

Ophisops elegans elegans Ménétries.

Ophisops elegans MÉNÉTRIES, 1832, Ct. Rais. Obj. Zool. Voy. Caucase, p. 63. (Type locality: near Baku, Caspian Sea.)

KNOWN RANGE. The species ranges through Turkey, Syria, Israel, Cyprus, Iraq, the Caucasus, northern Iran (south into the Zagros Mountains) and West Pakistan. *Ophisops e. elegans* is known from Syria, Iraq, Iran, and West Pakistan.

MATERIAL EXAMINED (4). Station 36 (CAS 86471 [VIII/1/58, ♂]). Station 37 (CAS 86472 [VIII/2/58, ♀]; 86473 [VIII/5/58, ♀]). Tang-i-Gurguda, near Gach Saran, at approximately 4,500 feet (CAS uncatalogued specimen [Autumn, 1960, ♀, collected by Howard T. Anderson]).

REMARKS. The occipital shield is somewhat wider than the interparietal in all of these specimens. In CAS 86471 the collar is distinct across the throat; in the others it is distinct only at the sides.

The three females contain ovarian eggs.

In the foothills near Tehran, the habits and habitat of this species appear to be similar to those of *Eremias guttulata watsonana* in southern Iran.

TABLE 9. *Measurements (in mm.) and counts for specimens of* Ophisops elegans elegans.

CAS number	*Sex*	*Scale rows*	*Longitudinal ventral plates*	*Upper labials*	*Femoral pores*	*Snout-vent length*	*Tail length*
86471	♂	32	8	9/8	14/11		
86472	♀	34	8	9/8	10	49	
86473	♀	32	8	8	10/9	46	91
Uncatalogued Specimen	♀	30	8	8	10/9	40	67

Family SCINCIDAE

Genus **Scincus** Gronovius

Scincus conirostris Blanford.

Scincus conirostris BLANFORD, 1881, Proc. Zool. Soc. London, p. 677, fig. 1. (Type locality: Tangyak, 7 mi. s. of Bushire, Iran.)

Known range. Southwestern Iran and eastern Iraq.

Material examined (2). Station 19 (CAS 86479 [♂]; 86480 [juv.] [VIII/16/58]).

Remarks. The present specimens agree with Blanford's original description. Scale counts are as follows: CAS 86479: 9 upper labials, 7 lower labials, 27 scale rows a mid-body; CAS 86480: 9 upper labials, 7/6 lower labials, 28 scale rows at mid-body.

Khalaf (1960) considers *S. conirostris* to be a subspecies of *S. scincus,* but fails to state why he does so, and cites no other authority. I have not compared *S. scincus* with *S. conirostris.*

I saw this species on a single occasion at only one locality. One was collected about one inch below the surface of the loose sand of an active dune. The track is characterized by the broad, undulating mark left by the tail. The second specimen was seen running across the sand, and rapidly buried itself at the base of a thorny shrub.

Observations to determine the critical maximum temperature for this species were carried out in a metal box, the bottom of which was covered with sand. Most attempts by the lizards to escape were launched against the side of the box, and few attempts were made at burrowing. They suffered no apparent ill effects after recovering from anal temperatures of 49.8° and 50.0°C. (table 10).

Table 10. *Summary of observations to determine the critical maximum temperature of* Scincus conirostris.

Sex	*Snout-vent length (mm.)*	*Air temp. (°C.)*	*Substrate temp. (°C.)*	*Initial anal temp. (°C.)*	*Time elapsed (min.)*	*Critical maximum temp.*[7] *(°C.)*
♂	82	42.1	57.4	31.2	9	49.8
juv.	51	43.4	58.6	37.0	4	50.0

[7] As defined by Cowles and Bogert (1944).

Genus **Mabuya** Fitzinger

Mabuya aurata septemtaeniata (Reuss).

Euprepis septemtaeniata Reuss, 1834, Mus. Senck., vol. 1, p. 47, pl. 3, fig. 1. (Type locality: Massaua.)

Mabuya aurata septemtaeniata, Mertens, 1924, Abh. Ber. Mus. Magdeburg, vol. 3, p. 377.

Known range. *Mabuya aurata* ranges from Abyssinia through southwest Asia to West Pakistan (Smith, 1935). *Mabuya a. septemtaeniata* occurs in Iraq, Iran, and the Persian Gulf coast of Arabia.

Material examined (3). Road between Station 1 and Station 16 (CAS 86388 [V/23/58, ♀]). Station 5 (CAS 86417 [VI/5/58, ♂]). Darrous, north of Tehran (CAS uncatalogued specimen [Autumn, 1960, juv., collected by Howard T. Anderson]).

Remarks. CAS 86388 contains ovarian eggs. The stomach of this specimen contains orthopteran and other arthropod remains, as well as a portion of its own tail. Weber (1960) found that stomach contents of specimens collected in Iraq consisted primarily of spiders. Smith (1935) states that *Mabuya aurata* is viviparous.

This species was seen on several occasions in the foothill region, from early March through late August, usually where rock crevices provided a ready retreat.

Table 11. *Measurements (in mm.) and counts for specimens of* Mabuya aurata septemtaeniata.

CAS number	*Sex*	*Upper labials*	*Lower labials*	*Scale rows*	*Snout-vent length*	*Tail length*
86388	♀	7	7/8	34	74	
86417	♂	8/7	7	33	80	119
Uncatalogued Specimen	juv.	7	8/7	37	37	58

Genus **Ophiomorus** Duméril and Bibron

Ophiomorus brevipes (Blanford).

(Figure 13.)

Zygnopsis brevipes Blanford, 1874, Ann. Mag. Nat. Hist., vol. 14, p. 33. (Type locality: Sa'adatabad, Sarjan, between Kerman and Shiraz, Iran.)

Ophiomorus brevipes. Boulenger, 1887, Bull. Soc. Zool. France, vol. 12, p. 525.

Known range. Eastern Iran; Turkmen (S.S.R.); Afghanistan.

Material examined (1). Station 35 (CAS 86593 [X/21/58, ♂]).

Remarks. This lizard was observed to move with snake-like movements beneath the surface of loose sand. The fresh tracks of this species were seen entering a burrow about 9:30 a.m., October 21.

Snout-vent length: 78 mm.

Figure 13. *Ophiomorus brevipes.*

Suborder SERPENTES

Family Colubridae

Genus **Coluber** Linnaeus

Coluber rhodorachis (Jan).

Zamenis rhodorachis Jan, 1865, in de Filippi, Viagg. Pers., p. 356. (Type locality. Iran.)

Coluber rhodorachis, Parker, 1931, Ann. Mag. Nat. Hist., ser. 10, vol. 8, p. 516.

Known range. Egypt to Somaliland; Sinai; Arabia; Syria; Iraq; Iran; Turkmen (S.S.R.); Afghanistan; Pakistan and northwest India to the western Himalayas.

Material examined (6). Station 1 (CAS 86409 [VI/8/58, ♂, DOR]; 86420 [VI/27/58, ♀]). Road between Station 1 and Station 16 (CAS 86371 [V/12/58, ♂]). Station 2 (CAS 86433 [VII/4/58, ♀]; 86624 [XI/1/58, juv.]). Station 18 (CAS 86586 [X/26/58, ♀]).

Remarks. Two upper labials (5th and 6th) enter the eye. CAS 86420 has eggs in the oviduct, the largest 39 mm. in diameter; CAS 86433 contains ovarian eggs, largest 9 mm.

CAS 86586 had unidentifiable snake remains in the stomach.

All of the specimens in this series have the crossbarred pattern. There is a pattern variation in the same region, in which the snake is a uniform brown to olive, with a single pink or orange vertebral stripe. A captive snake in the Masjid-i-Suleiman hospital was of this pattern.

This was the most frequently seen snake in the foothills. It appears to be strictly diurnal.

CAS 86409 was found dead on a road on a June evening. The mouth of this snake had been sewn firmly closed with heavy black thread. Inquiry of people familiar with local customs disclosed that this is fairly common practice, a snake with the mouth sewn shut being placed in someone's house or bed. This is considered a good joke on both the snake and the unsuspecting householder.

An active individual was collected June 27, at 7:15 A.M., when the air temperature was 31.4°, and the ground 33.4°C. One was collected at 6:30 P.M., on October 26, when the air was 25.2°, and the ground 23.0°C.

Leviton (1959) has pointed out that the separation of *C. rhodorachis, C. ventromaculatus,* and *C. karelini,* which broadly overlap geographically and ecologically, is based on nebulous and variable taxonomic characters. The characters of the present series are summarized in table 12.

TABLE 12. *Measurements (in mm.) and counts for specimens of* Coluber rhodorachis.

CAS number	*Sex*	*Upper labials*	*Lower labials*	*Scale rows*	*Ventrals*	*Caudals*	*Snout-vent length*	*Tail length*
86371	♂	9	10	19	233	139	459	185
86409	♂			19	228	134	733	297
86420	♀	9	10	19	230	51 +	808	145 +
86433	♀	9		19	232	132	665	260
86586	♀	9	10	19	240	137	455	188
86624	juv.	9	10	19	232	131		

Genus **Eirenis** Jan

Eirenis persica (Anderson).

Cyclophis persicus ANDERSON, 1872, Proc. Zool. Soc. London, p. 392, fig. 8. (Type locality: Bushire, Iran.)

Eirenis persica, STICKEL, 1951, Herpetologica, vol. 7, p. 128.

KNOWN RANGE. Northwest India; Pakistan; Turkmen (S.S.R.); Iran; Iraq.

MATERIAL EXAMINED (3). Station 1, in a house (CAS 86530 [VIII/30/58, ♀]). Road between Station 1 and Station 2 (CAS 86407 [V/25/58, ♀]). Station 4 (CAS 86410 [V/13/58, juv.])

Remarks. The black on the head extends from the nape through the prefrontals. There are no crossbars on the body, which is flesh-pink, the venter dark gray.

Both females contain eggs in the oviducts. CAS 86530 has a single elongate egg, 20 mm. long by 5 mm. wide.

These snakes were collected at night, one on May 13, at about 8:00 p.m., when the air was 34.2°, the surface of the road on which it was collected, 37.6°C., and the surrounding soil 35.2°C.

CAS 86350 has numerous mites under the ventral plates.

Table 13. *Measurements (in mm.) and counts for specimens of* Eirenis persica.

CAS number	*Sex*	*Upper labials*	*Lower labials*	*Scale rows*	*Ventrals*	*Caudals*	*Snout-vent length*	*Tail length*
86407	♀	7	8	15	210	73	288	73
86530	♀	7	8	15	202	72	418	108
86410	juv.	7	7/8	15	197	79	207	58

Genus **Telescopus** Wagler

Telescopus tessellatus tessellatus (Wall).

(Figures 14 and 15.)

Tarbophis tessellatus Wall, 1908, Jour. Bombay Nat. Hist. Soc., vol. 18, pp. 795–805. (Type locality: Maidan Mihaftan, 30 mi. e. of Shustar, southwestern Iran.)

Known range. The typical form of this species has been recognized only from the type locality and vicinity, in the western foothills of the Zagros Mountains, Khuzistan Province, Iran.

Material examined (2). Road between Station 1 and Station 16 (CAS 86376 [V/12/58, ♀). Station 4 (CAS 86460 [VI/24/58, ♂]).

Remarks. These specimens agree with Wall's description, which was based on a single specimen. His type locality is undoubtedly Maidan-i-Naftun, now more often referred to as Masjid-i-Suleiman.

Apparently these two specimens constitute the second recognition of the species. These specimens differ significantly from Schmidt's (1939) description of *Tarbophis martini* from Baghdad, Iraq, only in the greater number of ventral plates and subcaudals. In his specimens, the range for males was 226–232 ventrals, and 67–64 subcaudals; for females, 226–242 ventrals, 65–72 subcaudals. The scale counts for the present specimens are given in table 14. Wall's type had 243 ventrals and 75 subcaudals.

On the basis of Schmidt's description (I have not seen his type series) the difference between *T. tessellatus* Wall and *T. martini* Schmidt would seem to be, at most, subspecific. Schmidt states that *T. martini* is the Iraqi form referred to *iberus* by various authors.

Telescopus tessellatus tessellatus may be characterized as follows (based on Wall's description and my two specimens):

Head broad in temporal region, slightly wider than the length from snout to occiput; rostral scarcely visible from above, broader than high, in contact with six shields, the naso-rostral sutures longest; internasals as long as, or slightly longer than broad; prefrontals one and one-half times as long as internasals; frontal slightly longer than broad; single preocular touching frontal (or barely separated from frontal by prefrontal, as in CAS 86460); loreal enters eye, not twice as long as deep; two or three postoculars; 3d, 4th, and 5th upper labials enter the eye; nostril in semidivided, rectangular nasal; pupil vertical.

Dorsal scales smooth, in 21 rows at mid-body; apical pits singular; ventrals 241–251; subcaudals 75–78; anal entire in the three known specimens (5 of 8 of Schmidt's specimens of *T. martini* have the anal divided).

Light grayish-brown, the body with 39–52 dark brown, subrectangular mid-dorsal crossbars, which alternate with dark brown vertical lateral bars passing down to the angulation of the ventrals; the mid-dorsal crossbars do not always meet accurately on the midline, thus causing oblique or divided crossbars; interspaces one half as wide, to as wide as the crossbars; head brown; venter brownish-black; chin white.

One specimen was seen crawling onto a paved road about 8:00 p.m., on May 12. The air temperature was 34.0°, the road surface 34.6°, and the surrounding soil 32.0°C. A second snake was also found on a paved road, about 9:00 p.m., June 24. The air was 35.0°, the road 38.5°, and surrounding rock surfaces 36.9°C.

The species of *Telescopus* known from Iran may be distinguished as follows:

Dorsal scales in 19 rows at mid-body; ventrals 203–235; subcaudals 55–70
.... *T. fallax iberus*

Dorsal scales in 21 rows; ventrals 241–251; subcaudals 75–78............
.... *T. tessellatus tessellatus*

Dorsal scales in 23 rows; ventrals 266–280; subcaudals 76–84............
.... *T. rhinopoma*

Figure 14. *Telescopus tessellatus tessellatus.* Dorsal view.

Figure 15. *Telescopus tessellatus tessellatus.* Ventral view.

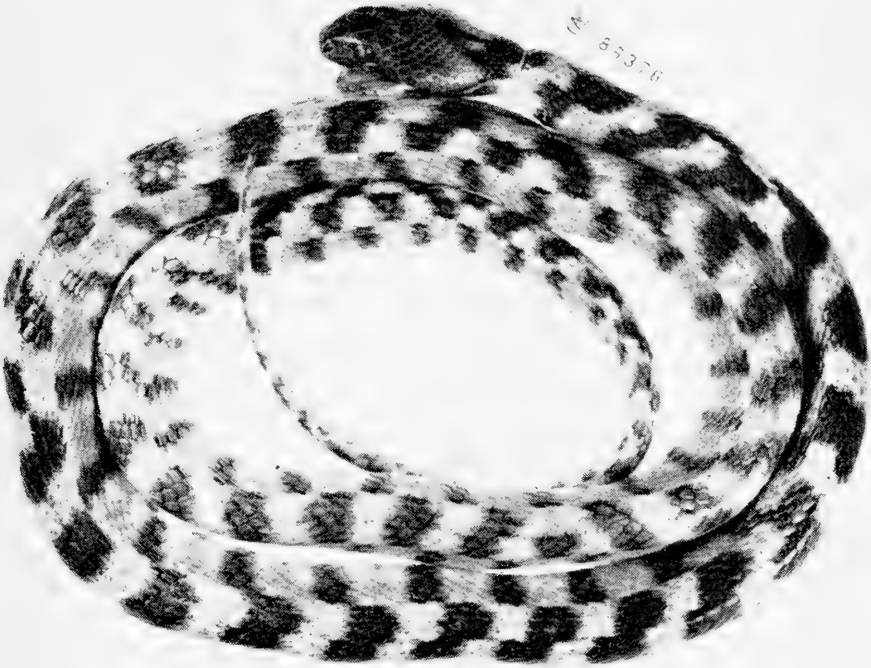
CA 85376

Table 14. *Measurements (in mm.) and counts for specimens of* Telescopus tessellatus tessellatus.

CAS number	*Sex*	*Scale rows*	*Ventrals*	*Caudals*	*Upper labials*	*Lower labials*	*Snout-vent length*	*Tail length*
86376	♀	21	241	75	8	11	770	150
86460	♂	21	250½	78	8	10/11	506	95
Type specimen (Wall, 1908)		21	243	75	8			

Genus **Psammophis** Fitzinger

Psammophis schokari (Forskål).

Coluber schokari Forskål, 1775, Descr. Anim., p. 14. (Type locality: Yemen.)
Psammophis schokari, Boulenger, 1896, Cat. Sn. Brit. Mus., vol. 3, p. 157.

Known range. Africa, north of the Sahara, through Arabia and southwestern Asia to Afghanistan, Pakistan, and northwest India.

Material examined (1). Station 1 (CAS 86375 [V/14/58, ♀]).

Remarks. The single specimen has 182 ventrals, 118 subcaudals, and 17 scale rows. Snout-vent length 492 mm., tail 227 mm.

This species was seen in the rocky foothills on several occasions from late February through early March, usually in the morning, basking on rock surfaces. This specimen was collected in a garden, near a house.

Family Elapidae

Genus **Walterinnesia** Lataste

Walterinnesia aegyptia Lataste.

Walterinnesia aegyptia Lataste, 1887, Le Naturaliste, p. 411. (Type locality: Egypt.)

Known range. From Egypt through Israel, Iraq, and Arabia, to the foothills of the Zagros Mountains of Khuzistan Province, Iran.

Material examined (3). Station 1 (CAS 86378 [V/11/58, ♂]; 86501 [IX/1/58, ♀]). Road between Station 1 and Station 2 (CAS 86557 [X/10/58, ♂, DOR]).

Remarks. Masjid-i-Suleiman, or Maidan-i-Naftun, as it appears on some maps, is undoubtedly "Maidan Mihaftan," Wall's (1908) type locality for *Atractaspis wilsoni*. Khuzistan is the modern name for Arabistan, the type locality for *Naja morgani* Mocquard. Both names have been shown to be synonyms for *Walterinnesia aegyptia* Lataste (Marx, 1953).

My three specimens were collected in and around gardens in the housing areas of the Iranian Oil Exploration and Producing Company.

A juvenile specimen in the hospital at Masjid-i-Suleiman has very narrow light crossbands.

CAS 86501 contains ovarian eggs. There are a few ants, but nothing else, in the intestine.

Family Viperidae

Genus **Echis Merrem**

Echis carinatus (Schneider).

Pseudoboa carinata Schneider, 1801, Hist. Amphib., vol. 2, p. 285. (Type locality: Arni. Based on a figure by Russell, 1796, Ind. Serp., vol. 1, pl. 2.)

Echis carinata, Wagler, 1830, Syst. Amph., p. 177.

Known range. Africa, north of the equator through southwestern Asia and Arabia to Turkmen (S.S.R.), Afghanistan, the whole of India south of the Ganges, except Bengal, and into the dry areas of Ceylon (Parker, 1932, and Smith, 1943).

Material examined (1). Station 32 (CAS 86632 [X/23/58, ♂]).

Remarks. This snake was seen crawling across a dune area at 9:00 a.m., October 23. The anal temperature was 37.5°, the air 33.5°, and the surface of the sand 38.5°C. It was not moving in the sidewinding fashion later observed in captivity. Tracks made by sidewinding were seen in all dune areas visited in Iran. When alarmed, this species has a characteristic locomotion which enables it to retreat, while keeping the head always toward its adversary. The body is positioned in a series of loops, the loops pressed together, so that as the snake moves, the lateral surfaces of the body are rubbed together. The obliquely arranged lateral scales, which have serrated keels, are thus rubbed together, producing a loud, continuous, hissing sound. The body moves cephalad, but the snake is able to retreat, the net movement being away from the source of danger. From this position the snake is able to strike about ⅔ the length of its body, the violence of the strike often carrying the entire animal forward.

This snake is extremely aggressive, striking violently on the least provocation.

The records of the Anglo-Iranian Oil Company describe a case of a laborer fatally bitten by a snake which was probably *E. carinatus*. The man reached his hand under a pipe to investigate a hissing sound he took to be a leak in the line, and was bitten. The symptoms demonstrated by this victim, haematuria, and haematemesis, seem to indicate that the capillary endothelium was attacked by the venom.

Genus **Pseudocerastes** Boulenger[8]

Pseudocerastes persicus (Duméril and Bibron).

Cerastes persicus DUMÉRIL and BIBRON, 1854, Erp. Gen., vol. 7, p. 1443, pl. 78b.
Pseudocerastes persicus, BOULENGER, 1896, Cat. Sn. Brit. Mus., vol. 3, p. 501.

KNOWN RANGE. Iran; Afghanistan; Pakistan.

MATERIAL EXAMINED (1). Station 27 (CAS 86633 [X/27/58, collected by W. O. Williams]).

REMARKS. This specimen has 156 ventrals, 42 subcaudals, and 23 scale rows at mid-body.

The snake was collected near an oil drilling rig, about 7:00 P.M.

Three types of locomotion were demonstrated by this snake in captivity: the most usual movement was lateral undulations of the body in "typical" snake fashion, only the head and neck raised from the surface of the ground; on one occasion it was seen to move forward in a straight line by moving the ventral plates; when sufficiently provoked, it would move with a sidewinding movement, the entire body touching the surface when sluggish and moving slowly, the body raised into the usual loops, and making the characteristic track when moving rapidly.

This individual was far less aggressive than the specimen of *Echis carinatus,* and could be prodded and moved about, seldon attempting to strike.

CHECK LIST OF AMPHIBIANS AND REPTILES REPORTED FROM IRAN

It is difficult to evaluate all of the records in the literature for the various species reported from within the political boundaries of Iran. Many taxonomic problems still exist, and these have been resolved in many different ways by previous authors. Unless one author were to have access to all of the specimens which have been collected in Iran, it would be impossible to decide with any assurance on the presence or absence of many forms. The present list includes several forms which have not been collected since their original discovery, and some of these may subsequently prove synonymous with other forms. In addition, many early locality records were far from precise, and many province names used by early collectors no longer have

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[8] Dr. Jean Guibé (personal communication) has recently compared the type of his *Pseudocerastes latirostris* with the description of *Eristocophis mcmahoni* Alcock and Finn (which was previously unavailable to him) and feels that they are synonymous. Neither Dr. Guibé, nor I, have seen the types of *E. mcmahoni* (which are in London and Calcutta), but on the basis of the description are agreed that separation of this form from the genus *Pseudocerastes* is probably not warranted.

the same connotation they once had. In a few cases I have included border records, particularly in southeastern Iran, in the region previously widely designated as Baluchistan. In any case, there is geographical, and probably ecological continuity between far southeastern Iran and that area of West Pakistan previously known as Baluchistan. I have not recognized many of the varietal and subspecific names used by previous authors.

Class **AMPHIBIA**

Order CAUDATA

Family Salamandridae

Neurergus crocatus crocatus Cope
Neurergus crocatus kaiseri Schmidt
Triturus cristatus karelini (Strauch)
Triturus cristatus longipes (Strauch)

Order SALIENTIA[9]

Family Bufonidae

Bufo luristanicus Schmidt
Bufo oblongus Nikolsky
Bufo olivaceus Blanford
Bufo persicus Nikolsky
Bufo surdus Boulenger
Bufo viridis arabicus Heyden
Bufo viridis viridis Laurenti

Family Hylidae

Hyla arborea savignyi Audouin

Family Ranidae

Rana cyanophlyctis Schneider
Rana ridibunda ridibunda Pallas

Class **REPTILIA**

Order CHELONIA

Family Emydidae

Clemmys caspica caspica (Gmelin)
Emys orbicularis (Linnaeus)

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[9] *Pelobates fuscus* was reported from Iran by Boulenger (1899) on the basis of a series of tadpoles from the region of Lake Urmia. This is the only record for this species from Iran; confirmation is required.

Family Testudinidae

Testudo graeca ibera Pallas
Testudo horsfieldi Gray
Testudo zarudnyi Nikolsky

Family Trionychidae

Trionyx euphraticus (Daudin)

Order SQUAMATA

Suborder SAURIA

Family Gekkonidae

Agamura persica (Duméril)
Alsophylax crassicauda Nikolsky
Alsophylax pipiens (Pallas)
Bunopus persicus (Nikolsky)
Bunopus tuberculatus Blanford
Ceramodactylus affinis Murray
Ceramodactylus doriae Blanford
Crossobamon eversmanni (Wiegman)
Cyrtodactylus agamuroides (Nikolsky)
Cyrtodactylus brevipes (Blanford)
Cyrtodactylus caspius (Eichwald)
Cyrtodactylus fedtschenkoi (Strauch)
Cyrtodactylus heterocercus (Blanford)
Cyrtodactylus kirmanensis (Nikolsky)
Cyrtodactylus kotschyi (Steindachner)
Cyrtodactylus longipes (Nikolsky)
Cyrtodactylus russowi (Strauch)
Cyrtodactylus scaber (Heyden)
Cyrtodactylus zarudnyi (Nikolsky)
Eublepharis macularius (Blyth)
Hemidactylus flaviviridis Rüppel
Hemidactylus persicus Anderson
Hemidactylus turcicus (Linnaeus)
Microgecko helenae Nikolsky
Phyllodactylus elisae Werner
Pristurus rupestris Blanford
Ptyodactylus hasselquisti (Donndorf)
Stenodactylus lumsdeni Boulenger
Teratoscincus bedriagai Nikolsky
Teratoscincus microlepis Nikolsky
Teratoscincus scincus (Schlegel)

Family Agamidae

Agama agilis Olivier
Agama caucasica (Eichwald)
Agama erythrogaster Nikolsky
Agama kirmanensis Nikolsky
Agama megalonyx (Günther)
Agama melanura (Blyth)
Agama microlepis (Blanford)
Agama microtympanum Werner
Agama nupta De Filippi
Agama persica Blanford
Agama rubrigularis (Blanford)
Agama ruderata Olivier
Calotes versicolor (Daudin)
Phrynocephalus helioscopus (Pallas)
? *Phrynocephalus interscapularis* Lichtenstein
Phrynocephalus luteoguttatus Boulenger
Phrynocephalus maculatus Anderson
Phrynocephalus mystaceus Pallas
Phrynocephalus ornatus Boulenger
Phrynocephalus persicus De Filippi
Phrynocephalus scutellatus (Olivier)
Uromastix asmussi (Strauch)
Uromastix loricatus (Blanford)
Uromastix microlepis Blanford

Family Varanidae

Varanus griseus Daudin
Varanus monitor (Linnaeus)

Family Amphisbaenidae

Diplometopon zarudnyi Nikolsky

Family Anguidae

Anguis fragilis colchicus Demidoff
Ophisaurus apodus (Pallas)

Family Lacertidae

Acanthodactylus cantoris blanfordi Boulenger
Acanthodactylus cantoris schmidti Haas
Acanthodactylus micropholis Blanford
Apathya cappadocica urmiana Lantz and Suchow

Family LACERTIDAE—Cont.

Eremias arguta (Pallas)
Eremias fasciata Blanford
Eremias guttulata guttulata (Lichtenstein)
Eremias guttulata watsonana Stoliczka
Eremias intermedia nigrocellata Nikolsky
Eremias lineolata (Nikolsky)
Eremias scripta (Strauch)
Eremias velox persica Blanford
Eremias velox strauchi Kessler
Lacerta brandti De Filippi
Lacerta chlorogaster Boulenger
Lacerta media Lantz and Cyrén
Lacerta muralis Merrem
Lacerta princeps Blanford
Lacerta saxicola defillipi (Camerano)
Lacerta strigata Eichwald
Lacerta viridis Linnaeus
Ophisops blanfordi Schmidt
Ophisops elegans ehrenbergi (Wiegman)
Ophisops elegans elegans Ménétries

Family SCINCIDAE

Ablepharus bivittatus Ménétries
Ablepharus grayanus Stoliczka
Ablepharus pannonicus Lichtenstein
Ablepharus persicus Nikolsky
Chalcides ocellatus ocellatus (Forskål)
Eumeces schneideri variegatus Schmidt
Eumeces taeniolatus Blyth
Eumeces zarudnyi Nikolsky
Mabuya aurata septemtaeniata (Reuss)
Ophiomorus blanfordi Boulenger
Ophiomorus brevipes (Blanford)
Ophiomorus miliaris (Pallas)
Ophiomorus persicus (Steindachner)
Ophiomorus tridactylus (Blyth)
Scincus conirostris Blanford

Suborder SERPENTES

Family TYPHLOPIDAE

Typhlops braminus (Daudin)

Family Typhlopidae—Cont.

Typhlops vermicularis Merrem
Typhlops wilsoni Wall

Family Leptotyphlopidae

Leptotyphlops hamulirostris (Nikolsky)
Leptotyphlops laticeps (Nikolsky)
Leptotyphlops macrorhynchus (Jan)

Family Boidae

Eryx elegans (Gray)
Eryx jaculus (Linnaeus)
Eryx johni (Russell)
Eryx miliaris (Pallas)
Eryx tataricus (Lichtenstein)

Family Colubridae

Boiga trigonata melanocephala (Annandale)
Coluber andreana Werner
Coluber caudaelineata (Günther)
Coluber dahlii (Fitzinger)
Coluber gemonensis (Laurenti)
Coluber jugularis asianus (Boettger)
Coluber karelini Brandt
Coluber ravergieri Ménétries
Coluber rhodorachis (Jan)
Coluber tyria Linnaeus
Coluber ventromaculatus Gray
Coronella austriaca Laurenti
Eirenis collaris (Ménétries)
Eirenis coronella (Schlegel)
Eirenis coronelloides (Jan)
Eirenis decemlineata (Duméril and Bibron)
Eirenis frenatus (Günther)
Eirenis iranica Schmidt
Eirenis meda (Cernov)
Eirenis modesta (Martin)
Eirenis persica (Anderson)
Eirenis punctatolineata (Boettger)
Eirenis rothi Jan
Elaphe dione (Pallas)
Elaphe hohenackeri (Strauch)

Family Colubridae—Cont.

Elaphe longissimus Laurenti
Elaphe quatuorlineata (Lacépède)
Lycodon striatus bicolor (Nikolsky)
Lytorhynchus diadema (Duméril and Bibron)
Lytorhynchus gaddi Nikolsky
Lytorhynchus ridgewayi Boulenger
Malpolon moilensis (Reuss)
Malpolon monspessulana (Hermann)
Natrix natrix persa (Pallas)
Natrix tessellata (Laurenti)
Psammophis lineolatus (Brandt)
Psammophis schokari (Forskål)
Ptyas mucosus (Linnaeus)
Rhynchocalamus satunini (Nikolsky)
Spalerosophis diadema diadema (Schlegel)
Spalerosophis microlepis (Jan)
Spalerosophis schirazianus (Jan)
Telescopus fallax iberus (Eichwald)
Telescopus rhinopoma (Blanford)
Telescopus tessellatus (Wall)

Family Elapidae

Naja naja oxiana (Eichwald)
Walterinnesia aegyptia Lataste

Family Viperidae

Agkistrodon halys (Pallas)
Echis carinatus (Schneider)
Pseudocerastes mcmahoni (Alcock and Finn)[10]
Pseudocerastes persicus (Duméril and Bibron)
Vipera lebetina (Linnaeus)
Vipera raddei Boettger
Vipera renardi (Christopher)

ZOOGEOGRAPHY

A detailed geographic analysis of the herpetofauna of Iran must await the availability of more material. Nevertheless, some general statements concerning distribution patterns can be made on the basis of available information.

Iran lies entirely within the Palearctic region. Geographically and eco-

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[10] See footnote, p. 472.

logically, it may be divided into more or less well-defined provinces. Of these geographical provinces, only the central plateau of Iran lies entirely within the political boundaries of the country. The folds of the Zagros Mountains, which border the plateau on the west and south, extend from the Anatolian highlands of eastern Turkey into southeastern Iran. The northern highlands, including the Elburz Mountains and folds of the Kopet Dagh, separate the central plateau from Russian Turkmen. These northern folds extend from the Zagros and Caucasus to the Hindu Kush of Afghanistan. The varied and broken terrain east of the plateau extends into western Afghanistan.

In the extreme north, the area bordering the Caspian Sea and the southern slopes of the Elburz Mountains has a moist climate, and is geographically and ecologically distinct from the rest of Iran.

Southwestern Iran includes the Ahwaz Plain, geographically an extension of the Mesopotamian lowlands. The western foothills of the Zagros Mountains, extending from southern Turkey and northeastern Iraq to the coastal areas of the Persian Gulf, form a border zone separating the Mesopotamian lowlands from the Zagros highlands.

The narrow coastal plain of the Persian Gulf connects the lowlands of southwestern Iran with the broken terrain of southeastern Iran and Baluchistan. The terrain of southeastern Iran is continuous into western Pakistan.

Certain wide-ranging Palearctic species are present in Iran. These species are characterized by their broad ecologic tolerances, and consequently are widely spread over most of the geographic provinces of Iran. These include *Bufo viridis, Hyla arborea, Rana ridibunda, Natrix tessellata,* and *Coluber gemonensis.* These species are absent from southeastern Iran.

Many elements of the Iranian herpetofauna have essentially a Mediterranean distribution. These fall into two categories: (1) species present in southern Europe, most of which are limited in their European distribution to the countries bordering the Mediterranean, and (2) North African species. Generally speaking, these elements are most prominent in western Iran, the number of species with Mediterranean affinities decreasing sharply east of the Zagros Mountains. Existing material is insufficient for a more precise numerical analysis of species in the various geographic provinces.

Species of the first category are distributed through Turkey, and include: *Testudo graeca, Cyrtodactylus kotschyi, Ophisaurus apodus, Coluber dahlii, Eirenis collaris,* and *Malpolon monspessulana.*

Typical of species distributed in North Africa, through the eastern borders of the Mediterranean, Syria, Arabia, Iraq, and Iran are: *Ptyodactylus hasselquisti, Mabuya aurata, Eumeces schneideri, Chalcides ocellatus, Leptotyphlops macrorhynchus, Lytorhynchus diadema,* and *Malpolon moilensis.*

Certain species present in southeastern Iran are more extensively distributed in southeastern Asia. Few of these species are present west or north of Iranian Baluchistan. Species more representative of the Oriental region than of southwest Asia are: *Rana cyanophlyctis, Calotes versicolor, Varanus monitor, Typhlops braminus, Eryx johni, Boiga trigonata,* and *Naja naja oxiana.*

A very few species, for the most part confined to the northeastern part of Iran, are representatives of the Central Asian fauna. *Eryx miliaris, Psammophis lineolatus, Vipera renardi,* and *Agkistrodon halys* fall into this category.

Most of the species inhabiting the area on the southern edge of the Caspian Sea are representatives of a Euro-Siberian fauna, and do not extend far into the more arid southern areas of Iran. *Triturus cristatus, Emys orbicularis, Lacerta strigata, Lacerta saxicola, Anguis fragilis, Natrix natrix, Elaphe longissimus,* and *Coronella austriaca* are examples of this fauna.

More prominent in the southern regions of Iran than in the northern areas are those species widely and continuously distributed from the arid regions of western India through southwest Asia to the deserts of the African continent. This element is represented by *Cyrtodactylus scaber, Hemidactylus flaviviridis, Agama ruderata, Varanus griseus, Eremias guttulata, Ablepharis pannonicus, Coluber rhodorachis, Spalerosophis diadema, Psammophis schokari, Vipera lebetina,* and *Echis carinatus.*

By far the most numerous elements in Iran are those species whose distribution is entirely confined to southwestern Asia. This area extends from the Red Sea and the Mediterranean on the west, through Afghanistan and western Pakistan on the east. On the north it is bounded by the Caucasus Mountains and the Trans-Caspian region. Certain species typical of this geographic region have their ranges variously extended into contiguous areas, *i.e.,* Egypt, Cyprus, Turkmen, or northwestern India. It is possible to further divide the southwest Asian species according to the centers of their ranges. The ranges of some center in the northeastern part of the region, *i.e.,* Afghanistan and northeastern Iran, some in Baluchistan, some in the southwest, Arabia and Iraq, and some in the highlands of the northwestern areas. Finally, some species are broadly distributed throughout most of southwest Asia. All of these categories overlap, and the significance of such distribution cannot be evaluated until more material is available.

Species widely distributed in southwest Asia include: *Clemmys caspica* (absent from the eastern portions of the region), *Eublepharis macularius, Hemidactylus persicus, Bunopus tuberculatus, Pristurus rupestris, Agama nupta, Agama agilis, Phrynocephalus maculatus, Acanthodactylus cantoris, Eremias brevirostris, Ophisops elegans, Typhlops vermicularis, Coluber ravergieri, Coluber ventromaculatus, Eirenis persica, Eirenis frenatus,* and *Pseudocerastes persicus.*

Species more or less restricted to the southwest, *i.e.,* Arabia, Israel, Jordan, Syria, Iraq, and southwestern Iran are *Trionyx euphraticus, Phyllodactylus elisae, Ceramodactylus doriae, Microgecko helenae, Agama persica, Uromastix loricatus, Uromastix microlepis, Diplometopon zarudnyi, Ophisops blanfordi, Scincus conirostris, Eryx jaculus, Eirenis coronella, Eirenis decemlineata, Eirenis rothi, Telescopus tessellatus,* and *Walterinnesia aegyptia.*

Representative of species having a southeastern distribution, *i.e.,* Pakistan, southern Afghanistan, and eastern Iran, are: *Bufo olivaceus, Agama melanura, Agama megalonyx, Agama rubrigularis, Phrynocephalus scutellatus, Phrynocephalus ornatus, Phrynocephalus luteoguttatus, Uromastix asmussi, Acanthodactylus micropholis, Ablepharus grayanus, Ophiomorus brevipes, Ophiomorus blanfordi, Ophiomorus tridactylus,* and *Telescopus rhinopoma.*

Northeastern species, those characteristic of northeastern Iran, Turkmen, and Afghanistan, are represented by *Testudo horsfieldi, Cyrtodactylus fedtschenkoi, Cyrtodactylus caspius, Teratoscincus scincus, Eremias lineolata,* and *Coluber karelini.*

Some southwest Asian species are distributed primarily in the northwestern highlands of the Zagros Mountains in Iran, northern Iraq, and Turkey. Some of these elements extend south in Iran along the Zagros Mountains. In this northwestern category are: *Neurergus crocatus, Testudo graeca ibera, Apathya cappadocica urmiana, Lacerta brandti, Eirenis collaris, Rhynchocalamus satunini,* and *Telescopus fallax iberus.*

Many endemic species have been recorded for Iran. The majority of these, however, are known from single specimens or from single localities. Until more material is forthcoming, or at least until the types of these species can be compared with more widely distributed related species, most must be regarded as having doubtful status. Little can be said of the significance of endemic forms in Iran until their affinities have been more extensively analyzed. Of particular interest in this regard are *Bufo olivaceus, B. persicus,* and *B. surdus,* known only from within narrow limits in eastern Iran and ecologically continuous areas to the east. Whether they are most closely allied to species to the east, or to *Bufo viridis* to the north and west, remains to be demonstrated. *Bufo luristanicus,* known only from the type, in the higher foothills of the Zagros Mountains in southwestern Iran, is said by Schmidt (1955) to be allied to *B. viridis,* with which it is sympatric. An unusually large number of species of *Cyrtodactylus* (as revived and redefined by Underwood, 1954) reportedly occur in Iran. Many of these are little-known endemics, which analysis may prove conspecific with more widely ranging forms.

It is noteworthy that the greatest number of endemics are reported from the central plateau region. A large proportion of the herpetofauna of that area, which includes eastern Kerman, Khorasan, Samnan Damghan, and eastern Tehran Provinces, is restricted to that region and adjacent areas of similar elevation in Afghanistan. Some of the species known only from this region are: *Bufo persicus, Testudo zarudnyi, Cyrtodactylus zarudnyi, Cyrtodactylus longipes, Agamura persica, Teratoscincus bedriagai, Teratoscincus microlepis, Agama kirmanensis, Agama erythrogaster, Eumeces zarudnyi,* and *Lycodon striatus bicolor.*

Apparently there is some degree of endemism in the south and central Zagros Mountains, but until the fauna of this region is more extensively collected, little can be said regarding the status of endemics.

Bufo luristanicus, Cyrtodactylus heterocercus, and *Telescopus tessellatus* have thus far been reported only from the western foothills of the Zagros Mountains.

Considering the herpetofauna of southwest Asia on the generic level, a few broad observations can be made. There are few amphibians in southwestern Asia. Those present belong to genera distributed widely in the Palearctic and are either widespread species with broad tolerances, or are little-known endemics of uncertain affinities.

Among the reptiles, certain genera are distributed principally in the arid regions north of the tropics, from North Africa to northwestern India, and occasionally extending into the steppes and high deserts of the USSR, northwestern China, and Mongolia. These genera have few or no representatives in tropical or moist-temperate regions. *Alsophylax, Bunopus, Teratoscincus, Phrynocephalus, Uromastix, Acanthodactylus, Scincus, Eryx, Eirenis, Lytorhynchus, Pseudocerastes,* and *Echis* illustrate this pattern. The monotypic genus *Diplometopon,* and the elapid genus *Walterinnesia,* known from Egypt to southwestern Iran, are two of the most narrowly restricted southwest Asian genera.

A number of genera are distributed continuously from the tropical areas of Africa through arid southwestern Asia and tropical southeastern Asia. A large proportion of these genera are most diverse in the tropics, with few species in the connecting arid region. This category is represented by *Testudo, Hemidactylus, Mabuya, Varanus,* and *Typhlops.*

Other genera, present both in tropical Africa and tropical Asia, are conspicuously absent from the Middle East. *Leiolopisma, Riopa, Python, Boiga,* and *Naja* are genera having this distribution pattern. *Boiga trigonata* and *Naja naja oxiana* extend slightly into the eastern part of southwest Asia, but there are no representatives of these genera west of Iran in Asia.

There are very few genera having representative species in southwest Asia, which are primarily tropical in numbers of species, but whose tropical distribution is limited only to Asia or exclusively to Africa. The genus *Agama* is found throughout tropical Africa, but is absent in the tropics of Asia. It has many species in southwest Asia, however. The tropical Asian genus *Calotes* has but one species (the widely distributed *C. versicolor*) entering the Middle East in the southeastern area.

Finally, some widespread Holarctic and Palearctic genera have representative species in southwest Asia. Few of these species are restricted to southwest Asia. Among the turtles, *Clemmys* and *Trionyx* each have a single species in the Middle East (both of these species restricted to this region). *Lacerta, Eumeces, Ophisaurus, Anguis, Natrix* (a genus also widespread in the Asian tropics), and *Agkistrodon* are each represented by one or a few species in southwest Asia. The genus *Vipera,* distributed widely in the tropics as well as in the Palearctic, has a few Middle Eastern species. *Coluber,* also found in both tropic and temperate regions of the world, contains many species in southwest Asia, most of them limited to this region.

There seem to be no species, and only one genus (*Trionyx*), showing a pattern of discontinuous distribution through the Middle East and tropical or temperate areas. There is, for instance, no evidence that any species is found in tropical Africa, eastern or tropical Asia, and in an isolated area or areas in southwest Asia. The genus *Trionyx* (represented in the Middle East by *T. euphraticus,* known only from the Euphrates River and its tributaries) is cosmopolitan.

There are, however, genera (but no species) found both in Africa and southeastern Asia, but absent in the connecting Middle East.

It appears that the arid region extending through southwestern Asia has been a distinct geographic unit long enough to have developed a characteristic herpetofauna at the species level, and to a lesser extent at the generic level, as the majority of species known from the Middle East are restricted to that area, while most of the genera are widely distributed.

Within the political boundaries of Iran there are diverse habitat situations, and each of the several geographically distinct regions has its characteristic fauna. The exact composition of these faunas cannot be elaborated within our present knowledge.

The uncontrolled cutting of woodland throughout the Middle East, a practice continuing practically unabated, has undoubtedly had a profound effect on the present distribution of the fauna. Recorded history indicates that forest and scrub were far more extensive in the recent past. The fact that remaining woodland seems to be living a marginal existence appears to indicate a change toward an increasingly arid climate. Closer examination of woodland faunas may reveal discontinuous distributions of herpetofaunal elements in southwestern Asia.

SUMMARY

One hundred seventy-seven species of amphibians and reptiles in sixty-five genera have been recorded from within the political boundaries of Iran. The actual number of species may prove to be somewhat less when problems of synonymy have been more extensively investigated. Thirty-three species, or 19 per cent of the known herpetofauna, are represented in the present

collection. The majority of these (21 species) were collected in the western foothills of the Zagros Mountains in southwestern Iran.

Relatively few collections have been made in Iran, and many species have been recorded from single localities. Many taxonomic problems must await the collection of further specimens and examination of typical material. Distribution is incompletely known for all species. Many of the early locality records are not precise, and require confirmation.

The aridity and prolonged hot season impose severe limitations on the fauna of the foothill region of southwestern Iran. The length of the growing season varies with the duration of the winter and spring rainy season. The vegetation is almost entirely herbaceous in this area, and is extensively grazed by sheep and goats. By late spring the hills are completely denuded. The large numbers of insects, which coincide with the blooming of herbaceous plants in the spring, dwindle through the summer. Grasshoppers and ants form the bulk of the food supply for many species throughout the summer.

Various behavioral adaptations enable the amphibians and reptiles to survive the long summer. Foraging activity begins in the early morning hours, diurnal lizards quickly reaching temperatures of normal activity by exposing a maximum surface area to the direct rays of the sun. As ambient temperatures rise, the period of activity is extended by utilization of small areas of shade (particularly the case with lacertids), brief dashes being made into direct sunlight. The agamid lizards may remain in the sun, but position themselves so that the sun's rays strike a minimum surface area, and at a small angle. *Agama agilis* ascends low bushes during extremely hot periods, and thus may escape much of the reradiated heat from the hot ground surface. The agamid lizards may benefit from changes in their albedo. They are dark in color when basking, and much lighter during the heat of the day. These color changes may supplement behavioral temperature regulation.

The reptiles retreat to shelter during the hottest hours. Deep crevices in limestone outcrops provide shelter for *Agama nupta, Mabuya aurata septemtaeniata,* and several of the snakes. *Agama agilis* and *Eremias guttulata watsonana* seek refuge under small rocks or in rock piles on level ground. The latter species also utilizes small holes and cracks in the hard-packed soil.

A few small streams persist throughout the summer, often only as intermittent pools. In many dry stream beds, moisture may be found a few inches beneath the surface. A moist, cool, microclimate is also maintained in small caves and sinkholes in the gypsum formations. These areas provide a summer refuge for the amphibians, and shelter nocturnal reptiles during the day. These cracks and crevices are also utilized by *Agama nupta* during the hottest hours, and presumably at night.

Several species of geckos and snakes are able to exist in the area due to their nocturnal habits, and the fact that temperatures do not drop below their normal activity range at night during the summer.

Dune-dwelling species are able to escape the severe midday temperatures by retreating to burrows a few inches below the sand surface.

Anal temperatures indicate that the normal activity range for most of the diurnal lizards of southwestern Iran is between 38.0° and 42.0°C. *Uromastix loricatus* was actively foraging at times when its anal temperature exceeded 43°C. *Agama agilis* was consistently found in direct sunlight, the anal temperature above 40°C. Critical maximum temperatures for most diurnal lizards are between 46° and 49°C. Both *Uromastix loricatus* and *Scincus conirostris* recovered from temperatures above 50°C. Cowles and Bogert (1944) found that the normal activity range of diurnal lizards of the deserts of the southwestern U.S. was approximately 35°–43°C., and that the lizards preferred temperatures of about 37°C. They found that lizards avoided temperatures above 40°C. Critical maximum temperatures were reported to be 43°–49°C.

As air and surface temperatures increased during the late spring and summer in southwestern Iran, a shift in the periods of reptilian activity was noted. During the moderate spring temperatures, activity was confined to the midday hours. By midsummer, foraging activity was noted only during the earliest daylight hours, and again in late afternoon.

A detailed zoogeographic analysis of the Iranian herpetofauna must await more extensive locality data, and the analysis of many systematic problems. Nevertheless, it is apparent that the several geographic and ecologic provinces of Iran are characterized by distinct differences in the composition of their faunas. Southwestern Iran and the northwestern highlands have a greater number of species with Mediterranean affinities than do the regions east of the Zagros Mountains. Southeastern Iran shares species with Pakistan and India, while elements of the Central Asia fauna are present in the northeast of the country. Apparently there is a relatively high degree of endemism on the central plateau of Iran. A European fauna prevails north of the Elburz Mountains on the south coast of the Caspian Sea. The majority of amphibians and reptiles known from Iran are restricted in their distribution to the Middle East.

Southwest Asia has apparently existed as a geographic unit long enough to have developed a characteristic herpetofauna, particularly at the species level.

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TWO NEW GENERA OF LEPTODACTYLID FROGS FROM COLOMBIA

By

Coleman J. Goin
University of Florida, Gainesville, Florida

and

Doris M. Cochran
United States National Museum, Washington, D. C.

Included among the novelties we have found in our studies on the frogs of Colombia are two diminutive specimens of leptodactylids that do not seem to be congeneric with each other or with other known leptodactylids. Since we believe it would be unwise to hold back descriptions of new genera until our report on the frogs of Colombia is published, we submit the descriptions of these two new ones at the present time.

Included in the unidentified material sent to us by our good friend Hermano Nicéforo María of Bogotá is a single specimen of a small leptodactylid from Páramo de La Rusia in Santander.

It seems proper that this genus be dedicated to this distinguished Colombian herpetologist who discovered the only known specimen.

Niceforonia Goin and Cochran, new genus.

Type species. *Niceforonia nana,* new species.

Diagnosis. A leptodactylid with a cartilaginous sternum; terminal phalanges terminating in an expanded knob but not distinctly T-shaped; tips of digits not expanded into distinct disks; no tympanum apparent;

pupil horizontal; maxillary teeth present; no odontoids on mandible; vomerine teeth in two small, distinct patches lying well behind the small choanae; tongue elongate, entire and free behind; fingers free of web, toes with but the merest vestige of web at the base; cranial derm free of skull; roof of skull not exostosed.

Niceforonia nana Goin and Cochran, new species.

(Figure 1.)

TYPE. Museo de La Salle 142, adult female, Colombia, Santander, Páramo de La Rusia, collected by Hno. Nicéforo María.

FIGURE 1. *Niceforonia nana*, type, Museo de La Salle 142, Colombia, Santander, Páramo de La Rusia. Actual length, 20.5 mm. × 3.

Description of type. No bony ridges on top of head. Vomerine teeth in 2 short, slanting, narrowly separated series far behind the choanae; tongue ½ as wide as mouth opening, elongate, broadly oval, its posterior border free and unnotched; snout moderate in length, rounded when viewed from above, slanting forward in profile, the upper jaw extending very slightly beyond the lower. Nostrils small, scarcely projecting, their distance from end of snout a trifle greater than their distance from eye. Canthus rostralis strong, curved; loreal region weakly concave, slanting outward to the upper lip. Eye rather small, but with very thick lids to give it additional prominence, its diameter about ⅘ its distance from tip of snout; interorbital diameter 1½ times that of upper eyelid, equal to interval between nostrils. Tympanum concealed. Fingers moderately long, with faint lateral ridges, free, their tips scarcely enlarged, first a little shorter than second, which equals the fourth, both of these extending to base of terminal phalanx of third; a distinct oval thumb pad present, also one at base of second finger; a rounded palmar callus; metacarpal tubercles well developed. Toes fairly long, with little trace of web, third longer than fifth, its tips reaching to middle of antepenultimate phalanx of fourth, the tips of all the toes slightly enlarged and flattened above; a distinct, oval, inner metatarsal tubercle, and a smaller, rounded, outer one; no apparent tarsal ridge; a series of heavy skinfolds on heel and knee. Body very stout, in postaxillary region much wider than greatest width of head. When hind leg is adpressed, heel reaches front of shoulder; when limbs are laid along the side, knee and elbow are widely separated; when hind legs are bent at right angles to body, heels are narrowly separated. Skin of upper parts finely granular, with narrow, interrupted, lateral, glandular line between posterior border of eye and sacrum; some heavy tubercles scattered over posterior third of back; sides heavily granular; venter smooth on throat, chest and anterior half of belly, becoming granular on posterior part of belly, on posterior femur and below vent; a short, thick, glandular ridge from lower posterior corner of eye, dropping behind corner of mouth, and continuing as a series of 2 or 3 small glands along side of neck, ending on proximal anterior part of humerus; a strong skinfold across the chest; a very distinct ventral disk.

Dimensions. Head and body, 20.5 mm.; head length (to end of upper jaw), 7 mm.; head width, 7.5 mm.; femur, 8 mm.; tibia, 7.5 mm.; foot, 8 mm.; hand, 5.5 mm.

Color (in alcohol). Dorsum seal brown to walnut brown, lightening on sides to wood brown; venter wood brown, immaculate except for some darker shadings between the granules on posterior belly; side of head immaculate fawn color, becoming a little darker near canthus; anterior femur seal brown on upper half, light wood brown on lower half; posterior thigh Mars brown with one or two paler spots; soles of feet and palms of hands pale wood brown, their tubercles and webs similar in color.

DISCUSSION. Just what the relationships of *Niceforonia* are is at present a moot question. In many ways it is structurally more like the forms of *Borborocoetes* which lack the tympanum.

When first examined the type specimen gives the impression of being immature, but there can be no doubt that it is an adult for it is a female packed with large ripe eggs.

The large unpigmented eggs (the individual eggs are approximately 2.00 mm. in diameter) probably indicate that *Niceforonia* is a terrestrial breeder. This would not be unexpected or inappropriate for a species living in the páramos. It may be that this species, the type of which was collected in the Páramo de La Rusia, is restricted to the páramos.

The other new form was collected 20 miles east of Pasto, Nariño. While the collector, E. S. Ross, gave no more precise data, this locality is certainly in a mountainous district and may well be on a páramos.

Trachyphrynus Goin and Cochran, new genus.

TYPE SPECIES. *Trachyphrynus myersi,* new species.

DIAGNOSIS. A leptodactylid with T-shaped terminal phalanges, a distinct tympanum; no vomerine teeth and rounded sacral diapophyses.

The combination of T-shaped phalanges and no vomerine teeth makes it readily separable from all forms except *Crossodactylus* and *Crossodactylodes.* The presence of a tympanum distinguishes it at once from *Crossodactylodes.* From *Crossodactylus,* which is perhaps its closest relative, it differs in having simple tips to the digits rather than having them furrowed above. It is not yet known if the males have the spines at the base of the first finger as in *Crossodactylus.*

Trachyphrynus myersi Goin and Cochran, new species.
(Figure 2.)

TYPE. California Academy of Sciences 85177, adult female, Colombia, Nariño, 20 miles east of Pasto, March 1, 1955.

DESCRIPTION OF TYPE. No bony ridges on top of head; no vomerine teeth; maxillary teeth weakly developed; tongue ¾ as wide as mouth opening, nearly circular, its posterior border free and not indented; snout broadly rounded when viewed from above, narrowly truncate in profile, the upper jaw extending slightly beyond the lower. Nostrils lateral, strongly projecting, their distance from end of snout about ½ their distance from eye. Canthus rostralis appearing sharp because of a glandular ridge along it from eyelid almost to nostril; loreal region flat, vertical, with the upper lip flaring sharply below it. Eye large, prominent, its diameter nearly as great as its distance from end of snout; interorbital diameter 1½ times that of upper eyelid, much greater than interval between the nostrils. Tympanum distinct, its greatest diameter ½ that of

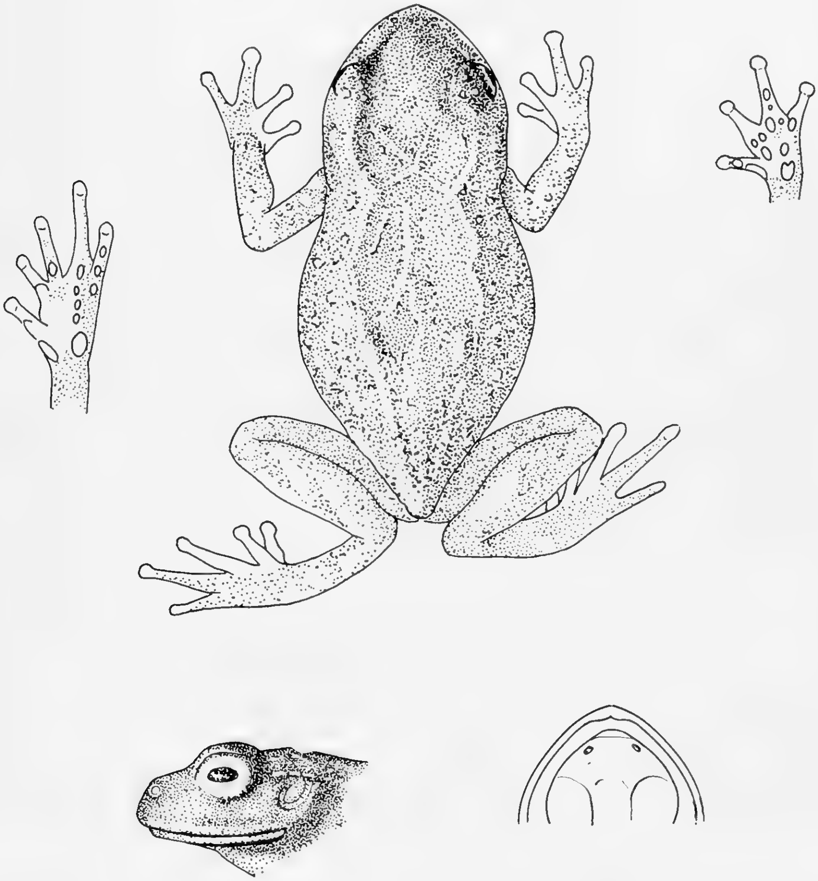

Figure 2. *Trachyphrynus myersi*, type, California Academy of Sciences 85177, Colombia, Nariño, 20 miles east of Pasto. Actual length, 22.0 mm. × 3.

eye, separated from eye by an interval equal to ½ its own diameter. Fingers fairly long, with disks on the three outer ones, the inner one not enlarged at tip, all with very faint lateral ridges, free, first shorter than second, fourth longer than either and reaching to base of penultimate phalanx of third, the disk of which covers ¼ the tympanum; an oval thumb pad present, and a cordiform palmar callus; metacarpal tubercles well developed. Toes long, barely webbed at the base, third and fifth subequal, their disks reaching to base of antepenultimate phalanx of fourth; disk of fourth toe covering about ⅓ of tympanum, hence a trifle larger than that of third finger; a large, blunt oval inner metatarsal tubercle and a smaller, rounded outer one; a weak inner tarsal ridge, enlarged into an oval gland just behind the inner metatarsal tubercle and ending before reaching heel; a row of 3 or 4 small elongate glands along outer tarsal border, ending with a small blunt heel tubercle. Body stout, in postaxillary region equal to greatest width of head. When hind leg is adpressed, heel reaches posterior border of tympanum; when limbs are laid along the side, knee and elbow are widely separated; when hind legs are bent at right angles to body, heels barely touch. Skin of upper parts with many spiny glandules and a network of glandular lines, the most prominent of which are the dorsolateral ones, an x-shaped pair behind head and several transverse ones on sacrum and across tibia; head with a small, pointed gland at tip of snout; venter coarsely granular on belly, faintly granular on chest, throat and lower thigh; a fine glandular ridge from posterior corner of eye above tympanum, ending behind it; no skinfold across chest; no ventral disk.

Dimension: Head and body, 22 mm.; head length, 8 mm.; head width, 8.5 mm.; femur, 8 mm.; tibia, 8.5 mm.; foot, 8 mm.; hand, 6 mm.

Color (in alcohol). Dorsum clove brown, the glandular lines olive-gray; a pair of large russet spots on upper surface of tibia between the diagonal glandular ridges; throat, chest and most of belly clove brown, excepting a narrow buff rim around lower jaw, and several large buff spots across posterior abdomen; lower limb surfaces buff with numerous brown marblings especially on lower thigh and arm, and a brown patch on heel and elbow; side of head with a large buff spot from edge of upper lip to eye; canthus, loreal region and posterior part of jaw dull clove brown; side of body uniform clove brown except for a very large buff to rose pink inguinal patch and a small axillary spot, both with irregular outlines; anterior and posterior thigh rose pink with a few brown marblings, the brown concentrated below anus in an irregular, dark postanal patch; palms of hands and soles of feet buff, the latter with some brown marblings on 3 outer toes.

Discussion. Since this individual, like the type of the preceding species, is a mature female containing large, unpigmented eggs, it is probable that this species is also a terrestrial breeder. Her abdominal eggs are, like those of *Niceforonia,* 2.0 mm. in diameter.

This species is named for Dr. George S. Myers.

Acknowledgments

We are indebted to Brother Nicéforo María for the privilege of describing the specimen he collected and presented to us, and to Dr. Alan E. Leviton for the privilege of borrowing and describing the specimen in the collection of the California Academy of Sciences. For comparing these new species with his Ecuadorian material, we are indebted to Dr. James A. Peters. To Mr. Paul Laessle we owe our thanks for the accompanying figures which are from his pen. The senior author's work on South American frogs is supported by a grant, G-13325, from the National Science Foundation, while the junior author's work on South American frogs is supported by a grant, GB-407(201D-294), also from the National Science Foundation.

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A NEW SPINE-THROATED GRASSHOPPER FROM THE WHITE MOUNTAINS OF CALIFORNIA (ORTHOPTERA: ACRIDIDAE: CYRTACANTHACRIDINAE)

By

Ashley B. Gurney
Entomology Research Division
Agricultural Research Service
U. S. Department of Agriculture

and

David C. Rentz
California Academy of Sciences
San Francisco 18, California

In this paper we describe a distinctive new species of grasshopper from the White Mountains in southern Mono County, California. The species represents a new genus most closely related to *Argiacris* Hebard, and less closely related to *Melanoplus* Stål. Our consideration of its generic relationships is a contribution toward a clarification of certain genera in the supertribe Melanoplini, briefly outlined by Rehn and Randell (1963).

The new grasshopper is of general interest because of its occurrence at elevations of 12,000–13,000 feet in that part of California which zoogeographically is part of the Basin and Range Province. Only a few other Acrididae in the United States breed successfully at this altitude, as noted by Alexander (1951). The altitudinal record for a United States orthopteron probably belongs to the decticine katydid *Acrodectes philopagus* Rehn and Hebard, which Morgan Hebard collected as high as 14,200 feet on Mt. Whitney, California, according to Rehn and Hebard (1920, pp. 258–263), and which Tinkham (1944, pp. 274–277) has vividly described finding there at about 12,800 feet, near ice and snow, in October.

The specimens of this interesting new grasshopper are a byproduct of biological studies conducted at high altitudes of the White Mountains during summer sessions of faculty and students from the University of California, at Berkeley. Nello Pace, Department of Physiology, University of California, Berkeley, Director of the White Mountains Research Station, has supplied data on climatic conditions on Mt. Barcroft; and Paul Manis, Operations Manager of the Station, arranged accommodations for the junior writer during his trips there. We are also indebted to J. A. G. Rehn and Harold J. Grant, Jr., Academy of Natural Sciences of Philadelphia, for reading this manuscript and making helpful suggestions. Figures 1 to 5 were drawn by Arthur D. Cushman, Entomology Research Division, U.S. Department of Agriculture; the other figures are by the senior author.

Agnostokasia Gurney and Rentz, new genus.

Generic description. General form much like *Argiacris,* differing as follows: (1) Aedeagus with fleshy exterior base short, the elongate aedeagal valves arising from a simple base, rather than from within a tall corolla-like base; (2) pronotal disk more strongly produced posteriorly; (3) male cercus elongate, weakly spatulate, not directed dorsally in apical half; (4) dorsal aedeagal valve not forked apically. Latter two characters probably of less fundamental nature than first two, and more subject to modification with inclusion of additional species.

Body dull, pubescent with short gray setae. Eyes in dorsal view broadly rounded at fastigium. Pronotum with disk posteriorly produced (obtuse angulate, male; broadly rounded, female); median carina poorly developed on prozona, distinct but very low on metazona; no definite lateral carinae, but shoulders evident on metazona. Prosternal process conical, not swollen at apex. Mesosternal interspace quadrate (male), moderately transverse

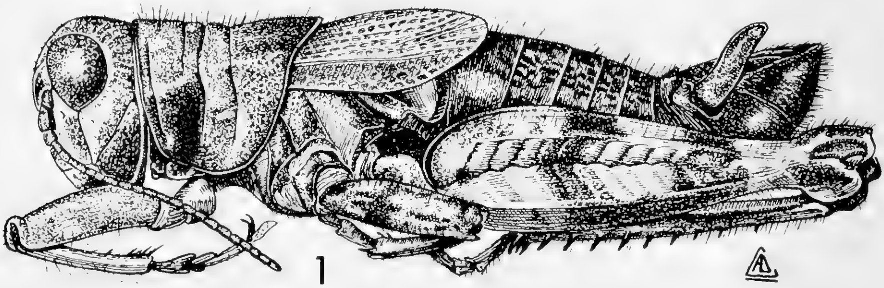
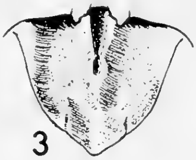
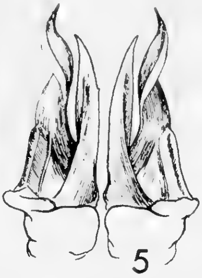
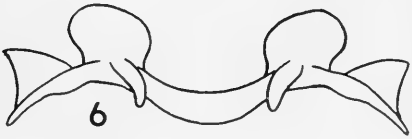


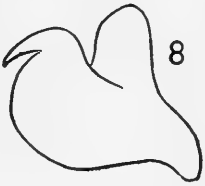
Figure 1. *Agnostokasia sublima,* new species; lateral view of male paratype.

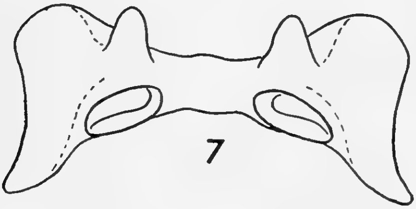
(female); metasternal interspace with narrowest width (posterior) about two-thirds distance between pits, thus lateral lobes clearly separated (male), posterior width about three-fourths distance between pits, metasternal interspace about twice as wide as long (female). Legs fairly robust (fig. 1);

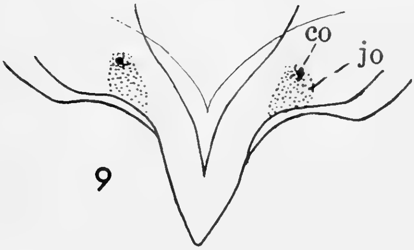












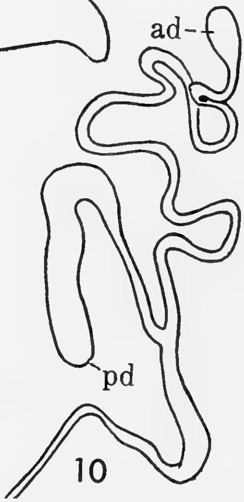


Figure 2. *Agnostokasia sublima*, new species; cercus; a male paratype.

Figure 3. Same; supraanal plate: male paratype.

Figure 4. Same; aedeagus of dry preparation, lateral view; a paratype.

Figure 5. Same; aedeagus of dry preparation, posterior view; a paratype.

Figure 6. Same; epiphallus, KOH preparation, anterior view; a paratype.

Figure 7. Same; epiphallus, KOH preparation, dorsal view; a paratype.

Figure 8. Same; epiphallus, lateral view; a paratype.

Figure 9. Same; subgenital plate, KOH preparation, dorsal view; a female paratype. *Co* = columella; *jo* = Jannone's organ.

Figure 10. Same; spermatheca, KOH preparation; from a paratype. *Ad* = apical diverticulum; *pd* = preapical diverticulum.

dorsal spines of hind tibia about 10 (lateral) — 11 (mesal). Tegmina short, broadly lanceolate. External tympanum well developed.

Furcula of male present, short; supraanal plate simple, with median longitudinal groove in basal half (male), with nearly complete curved transverse carina (female). Cercus elongate (male), very bluntly triangular (female). Ovipositor similar to that of *Argiacris,* apex of dorsal valve upturned, "scoop" well rounded.

Concealed male genitalia with aedeagus consisting of low exterior fleshy base (main stem), aedeagal valves slender, acute, not forked apically; epiphallus (figs. 6–8) with bridge simple, ancorae well developed and down-curved, lophi erect and not extending lateroposteriorly along posterior processes of epiphallus. Dorsal surface of female subgenital plate with thickened and pigmented area (Jannone's organ[1]) on each side of egg guide small; columellae (fig. 9, *co*) on each side single, very small, approximately round, and with several branches evident; spermatheca[2] elongate, with many convolutions, preapical diverticulum (fig. 10, *pd*) large and recurved, apical diverticulum *(ad)* distant from preapical one and moderately enlarged.

A more detailed formal description of the genus appears unnecessary at this stage in the continuing revision of generic and tribal concepts in this group. *Agnostokasia* apparently belongs to the Group Bradynotae, within the framework proposed by Rehn and Randell (1963, p. 11).

Agnostokasia superficially resembles some brachypterous species of *Melanoplus,* many of which, however, probably will not be found congeneric with the genotype, *M. femurrubrum* (De Geer), when a more thorough revision has been accomplished. In comparing *A. sublima,* new species with *M. femurrubrum,* the following generic differences have been noted,

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[1] Named and discussed by Agarwala (1952a, p. 149, fig. 10; 1952b) and earlier discussed by Jannone (1939, pp. 83, 85, fig. xxvii, 2); these organs were referred to as postvaginal sclerites by Rehn and Randell (1963) and Randell (1963).

[2] Spermathecae of Acrididae have been described by Slifer (1940) and Dirsh (1957).

FIGURE 11. *Melanoplus femurrubrum* (De Geer); dorsal view of head; male from Great Falls, Virginia.

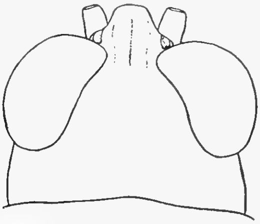
FIGURE 12. *Agnostokasia sublima,* new species; dorsal view of head; holotype.

FIGURE 13. *Argiacris militaris* (Scudder); posterior view of aedeagus, non-KOH preparation in glycerine; male from Galena Summit, Idaho.

FIGURE 14. Same; lateral view of aedeagus, non-KOH preparation in glycerine; male from Galena Summit, Idaho.

FIGURE 15. *Argiacris rehni* Hebard; posterior view of aedeagus, KOH preparation in glycerine; male from near Big Timber, Montana.

FIGURE 16. Same; lateral view of aedeagus, KOH preparation in glycerine; male from near Big Timber, Montana.



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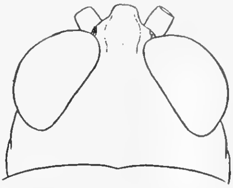

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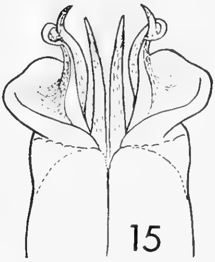

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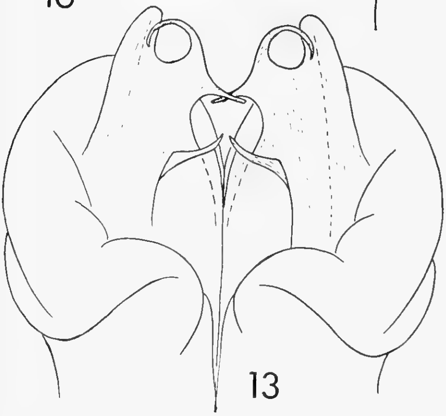

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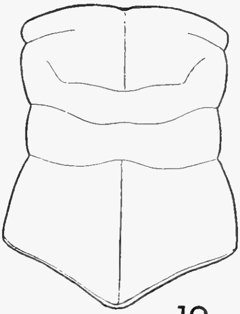

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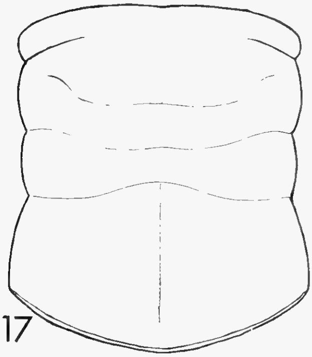

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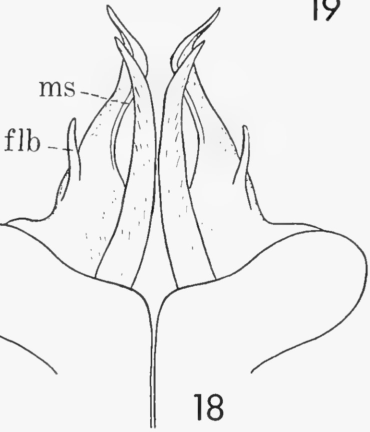

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Figure 17. Same; dorsal view of pronotum, male from near Big Timber, Montana.

Figure 18. *Agnostokasia sublima*, new species; posterior view of aedeagus, non-KOH preparation in glycerine; holotype. *Ms* = posterior marginal strip; *flb* = fingerlike lateral branch.

Figure 19. Same; dorsal view of pronotum; holotype.

here listed in what appears to be the order of relative importance: (1) The epiphallus of *M. femurrubrum* has a more specialized bridge, deeply emarginate posteriorly, and the lophi extend far along the posterior processes; (2) the aedeagus of *M. femurrubrum* is of a pattern very different from that of *A. sublima,* and it has a tall specialized "main stem," anteriorly extending dorsal aedeagal valves, and ventral valves which extend forward between the bases of the two halves of the "main stem" (see Gurney and Brooks, 1959, p. 13); (3) mesosternal and metasternal interspaces of *A. sublima* are markedly wider than those of *M. femurrubrum;* (4) at their dorsal extremities, the compound eyes are more sharply rounded in *M. femurrubum* (figs. 11, 12); (5) in *M. femurrubrum,* no sign of branching of columellae occurs; (6) mesal pair of apical spurs of hind tibia are shorter and more curved in *A. sublima* than in *M. femurrubrum.*

It is interesting that *Agnostokasia* occurs within the Basin and Range Province and that *Argiacris* occurs near the borders of that physiographic Province. *Argiacris* includes two species. The first is the genotype, *A. rehni* Hebard, described from Livington, Park County, Montana, and since collected at Olaf (near Twodot), Wheatland County, and near Big Timber, Sweet Grass County, Montana (material from last two localities in USNM). The second species is *Melanoplus militaris* Scudder, described from Soldier, Logan County, Idaho, and since found by Rehn and Hebard at Galena Summit, Sawtooth Range, Blaine County, Idaho. Mr. Rehn has suggested to us that the "Soldier" specimens probably were collected in mountains north of the town rather than in the unlikely habitat of the town's immediate vicinity. There has been no published assignment of *M. militaris* to *Argiacris,* but we are indebted to unpublished notes made in 1928 by the late Morgan Hebard, who suggested the possibility which we investigated.

There is close generic agreement in the external features of *M. militaris* and *A. rehni,* and the affinity appears evident in the concealed characters of the female subgenital plate, the male epiphallus, and especially the upright main stem of the aedeagus, with a corollalike apical portion bearing a forked dorsal aedeagal valve (figs. 13, 15). Therefore, we use the name *Argiacris militaris* (Scudder) (new combination). The genus *Argiacris* should not be confused with *Agriacris* Walker, a Neotropical romaleine genus. In an obvious lapsus, Hebard (1924, p. 101) misspelled the name of the Neotropical genus as *Argiacris.*

The generic name *Agnostokasia* is adapted from two Greek words, together meaning "unknown brother."

TYPE SPECIES. *Agnostokasia sublima,* new species.

Agnostokasia sublima Gurney and Rentz, new species.

(Figures 1–10, 12, 18, 19.)

Holotype. Male. Mt. Barcroft, 12,500 feet elevation, White Mountains, Mono County, California. July 21, 1961 (D. C. Rentz) [California Academy of Sciences].

Size medium for the group Bradynotae; most dorsal and lateral surfaces of body with conspicuous gray setae about 2 to 5 mm. long; tegmina abbreviate, lanceolate.

Head in dorsal view with ratio of interocular distance to width of a compound eye as 6:13; fastigium strongly declivent anteriorly and distinctly sulcate, marginal carinae of fastigium prominent between eyes; eyes moderately bulging; frontal costa in frontal view barely narrowed at junction with fastigium, weakly narrowed at median ocellus, extending only briefly ventrad of ocellus, in lateral view broadly rounded at level of antennal socket, weakly concave at median ocellus; antenna of 22 articles, reaching onto basal fourth of tegmen.

Pronotum with lateral carinae indistinct; median carina distinct but low on metazona, evident but obsolete on anterior half of prozona, absent on posterior half of prozona, cut by principal sulcus and two anterior sulci, ratio of prozonal length to metazonal length as 8:7; disk of pronotum dull, anterior half of lateral lobe weakly shiny; anterior margin of disk weakly rounded in dorsal view, scarcely emarginate medially; posterior margin of disk broadly produced (fig. 19), of about 140 degrees angulation; prosternal process strongly conical, blunt; mesosternal interspace quadrate, narrower than lateral lobe (as 2:3); distance between metasternal pits subequal to length of metasternal interspace.

Tegmina extending across about half of abdominal tergum 2, apically rounded lanceolate, not quite attingent along midline of body. Legs robust (fig. 1); hind tibial spurs short and stout, spines of lateral and mesal margins 10 and 11 on both legs.

Supraanal plate a little longer than basal width (as 16:15), lateral margins weakly elevated in basal half; longitudinal submedian ridges as in fig. 3. Furcula strong but brief. Cercus (figs. 1, 2) elongate, not mesally curved, with thin marginal areas along apical third, lateral surface broadly convex, mesal surface strongly concave.

Concealed genitalia (non-KOH preparation, preserved in glycerine) with main fleshy portion of aedeagus short, in posterior view seen as two longitudinally separated lobes, each broadened dorsally; aedeagal valves conspicuous, directed dorsoanteriorly; each dorsal aedeagal valve broad at base, anterior to ventral aedeagal valve, tapering toward acute apex, spirally twisted, with weakly sclerotized posterior marginal strip (fig. 18, *ms*) in distal two-thirds of length, a weak fingerlike lateral branch *(flb)* arising in basal third; each ventral valve moderately curved anteriorly and laterally, not spiralled, tapering to acute apex. Epiphallus with downcurved ancorae, lophi conspicuous with dorsal margins thickened and expanded.

COLORATION. General color gray, heavily spotted with brown and black. Head with bluish streaks among the black areas; face and clypeus with cream-colored pale areas; eyes and antennae brown. Pronotum dark, mostly blackish on prozona, with only a few pale spots, metazona browner. Tegmina grayish brown, with scant mottling. Femora cream colored, heavily marked with dark, ventral surface of front and middle femora pale; hind femur pinkish-red ventrally and spreading over lower part of mesal surface. Front and middle tibiae gray, with dark mottling. Hind tibiae mostly pinkish-red, briefly grayish-green at base, followed by a pale annulus divided by a narrow red band; spines of mesal margin pink at base, lateral margin dark throughout; hind tarsus streaked with pink at base. Dorsum of abdomen blackish, with delicate cream-colored mottling; cercus dark brown. Ventum of thorax dirty gray, of abdomen straw-colored.

MEASUREMENTS (in millimeters). Length of body, 16.5; pronotum, 4.1; hind femur, 9.5; front femur, 3.3; tegmen, 4.0. Greatest width of pronotum (posterior, including lateral lobes in perspective from above), 3.7; hind femur, 2.6; front femur, 1.0; tegmen, 2.1.

ALLOTYPE. Female, same data as holotype. [California Academy of Sciences.]

Head in dorsal view with ratio of smallest interocular distance to maximum width of a compound eye as 8:14; eye less globose than in male; fastigium barely sulcate; antenna reaching about two-thirds across lateral lobe of pronotum when extended. Median carina of prozona subequal to that of metazona (as 25:26); mesosternal interspace wider than long (as 15:8), subequal to width of a lateral lobe; ratio of distance between metasternal pits to length of metasternal interspace as 16:9, pits widely separated. Front and middle femora less robust than in holotype. Cercus triangular, apically blunt; dorsal ovipositor valve with "scoop" deeply, roundly concave. Dorsal surface of subgenital plate (fig. 9) and spermatheca (fig. 10) as described for genus.

COLORATION. Of same pattern as holotype, but with pale areas more conspicuous; head predominantly pale except for blackish spots on dorsum and occiput; dorsum of abdomen with cream-colored areas more extensive than dark areas; pattern of contrasting colors on lateral face of hind femur very conspicuous.

MEASUREMENTS (in millimeters). Length of body (slightly extended because of evisceration and filling with cotton), 25.0; pronotum, 5.1; hind femur, 11.2; front femur, 3.2; tegmen, 5.2. Width of pronotum, 5.4; hind femur, 3.3; front femur, 0.8; tegmen, 2.7.

Variation. The aedeagus of 9 male paratypes has been examined (4 preserved in glycerine, partly KOH preparations), and not one has a fingerlike lateral branch near the base of the dorsal valve such as occurs in the holotype. No other noteworthy structural variation has been observed. However, the condition of preparations is important for uniformity of observations. In the five dry preparations the aedeagal valves show some distortion; the apical portions of dorsal valves usually are directed differently from those preserved in glycerine (compare figs. 5, 18). The epiphallus is best seen following light treatment with KOH; otherwise, even when examined in fluid, the bridge will exhibit more contours. The color pattern is uniform, though some specimens are paler, others darker than the holotype and allotype.

Ten representative paratypes of each sex have been measured, with results as follows (in millimeters): Length of body, male (14.5–18.0, average 16.35), female (17.5–27.0, average 22.35); pronotum, male (4.0–4.4, average, 4.17), female (4.6–5.4, average 4.99); hind femur, male (9.0–9.4, average 9.15); female (9.7–11.5, average 10.69).

Specimens examined. 90 (42 males, 47 females, 1 juvenile. Holotype, allotype, paratypes). All from type locality except 3 males taken by J. Powell and labelled as taken at 13,000 feet instead of 12,500. All collected by D. C. Rentz except as noted. VII–1–61 (1 male, 1 female); VII–5–61 (6 males, 3 females), same (J. Powell) (2 females); VII–21–61 (29 males, 32 females, 2 mating pairs), same (J. Powell) (3 males, 4 females); VII–22–61 (1 male); VII–27–62 (D. C. Rentz and C. D. MacNeill) (1 juvenile male, 3 females). Paratypes will be deposited in the principal collections of Orthoptera.

Notes on distribution and biology. *Agnostokasia sublima* is known only from the slopes of Mt. Barcroft in the White Mountains of Mono County, California. The White Mountains are largely made up of Precambrian metamorphic rocks with granitic caps on the higher peaks. Mt. Barcroft and its adjacent slopes are granitic, and it was on these slopes among the arctic-alpine cushion-type perennials that the entire series of specimens was taken. On warm days, as for instance on July 5, 1961, when temperatures were in the mid-60's F., specimens of both sexes of *Agnostokasia* jump actively when approached, a habit different from the more slowly moving members belonging to the related genera *Hypsalonia, Hebardacris,* and *Bradynotes,* none of which have been found in the White Mountains, but which commonly occur at high elevations in the Sierra Nevada. The granite of Mt. Barcroft is quite dark, and the insect is so effectively protected by cryptic coloration that it can be detected only through its movements. No host-plant relationship was determined, but it seems likely that *A. sublima* subsists on the numerous short grasses found on the slopes.

In 1961 numerous adults of this grasshopper were seen in early July. Observations on July 27, 1962, when a few adults and several second and third instars were seen, suggested that the species had matured later in 1962 than in 1961, and we think that the unusual early summer warmth in 1961 was responsible. Selected data showing the nature of summer temperatures on Mt. Barcroft, given in table 1, were compiled by the Barcroft Laboratory of the White Mountain Research Station, Big Pine, California, on five-year mean values (in degrees F.) (August, 1952, through December, 1957). Certain data for 1961 and 1962 are included in parentheses for comparison, to show the greater warmth of June and July, 1961, as contrasted with 1962 and the five-year average.

Table 1. *Selected data showing the nature of summer temperatures at Mt. Barcroft.*

Month	Monthly av. max. temp.	Highest max. temp. of month	Monthly av. min. temp.	Lowest min. temp. of month	Monthly snowfall
May	34.4	50	18.8	—1	27.5″
June	45.7 (1961,50)	59	30.7 (1961,35)		
	(1962,45)		(1962,28)	13	4.9″ (1961,1)
					(1962,7)
July	54.0 (1961,55)		(1961,39)	27	0.4″ (1961,0)
	(1962,53)	62	39.3 (1962,34)		(1962,0)
August	53.0 (1961,45)	63	35.4 (1961,29)	27	0.6″ (1961,0)
	(1962,54)		(1962,36)		(1962,0)
Sept.	48.2	59	31.4	18	4.6″

The highest maximum daily temperature at Mt. Barcroft was 72°F., recorded on July 14 and August 8, 1953; the lowest minimum daily temperature was —32° F., recorded on March 6, 1956.

The specific name of this grasshopper is from a Latin word meaning uplifted or exalted, with reference to the lofty habitat.

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NEMERTEANS FROM CALIFORNIA AND OREGON

by

Diva Diniz Corrêa

Department of Zoology,
University of São Paulo, Brazil

INTRODUCTION

This paper is based principally on a collection of nemerteans made by me while on a John Simon Guggenheim Memorial Foundation Fellowship in the United States. I worked from March to August of 1958 at Pacific Marine Station, Dillon Beach, Marin County, California, where I was helped by Dr. Joel W. Hedgpeth, the director, Mr. Edmund H. Smith, and Dr. Ralph G. Johnson (University of Chicago). I stayed also for a short while at Scripps Institution of Oceanography, La Jolla, San Diego County, California, and took part in excursions in the San Diego area led by Dr. E. W. Fager of Scripps.

I am deeply indebted to Dr. J. W. Hedgpeth and to Dr. E. W. Fager for the kind hospitality conferred on me. Particular mention should be made of Mr. E. H. Smith and of Dr. R. G. Johnson for the great help they gave in collecting specimens.

During my stay at Allan Hancock Foundation, University of Southern California, Los Angeles, California, I had the chance to examine some of Coe's types of Pacific nemerteans deposited in the collection of that foundation. I am grateful to Dr. Olga Hartman for the use of the collection and her laboratory.

I wish to acknowledge to the Guggenheim Foundation, New York, and to the Brazilian National Research Council, Rio de Janeiro, my gratefulness for the financial help awarded to me.

I also wish to thank Dr. Hedgpeth for reading the manuscript and submitting it for publication.

The main papers relating to the nemerteans of the Pacific Coast of North America are those of Griffin (1898) and Coe (1901, 1904, 1905, 1940, 1944, and 1952).

The material, preserved as well as sectioned worms, is deposited in the Department of Zoology of the Faculty of Philosophy, Sciences and Letters of the University of São Paulo, P. O. B. 8105.

The systematic arrangement followed here is that of Hyman (1951). The present paper deals with the following 22 species:

Phylum RHYNCHOCOELA (Nemertini)

  Order Palaeonemertini

    Family TUBULANIDAE
    Genus *Tubulanus* Renier, 1804
      1. *T. polymorphus* Renier, 1804
      2. *T. sexlineatus* (Griffin, 1898)
      3. *T. cingulatus* (Coe, 1904)

    Family CARINOMIDAE
    Genus *Carinoma* Oudemans, 1885
      4. *C. mutabilis* Griffin, 1898

    Family CEPHALOTHRICIDAE
    Genus *Procephalothrix* Wijnhoff, 1910
      5. *P. spiralis* (Coe, 1930)

  Order Heteronemertini
    Family LINEIDAE
    Genus *Lineus* Sowerby, 1806
      6. *L. ruber* (Müller, 1771)
      7. *L. pictifrons* Coe, 1904

    Genus *Cerebratulus* Renier, 1804
      8. *C. montgomeryi* Coe, 1901
      9. *C. occidentalis* Coe, 1901
      10. *C. longiceps* Coe, 1901
      11. *C. albifrons* Coe, 1901

    Genus *Micrura* Ehrenberg, 1831
      12. *M. verrilli* Coe, 1901
      13. *M. wilsoni* (Coe, 1904)

Phylum Rhynchocoela (Nemertini)—Cont.

Order Hoplonemertini
  Family emplectonematidae
  Genus *Emplectonema* Stimpson, 1857
    14. *E. gracile* (Johnston, 1837)

  Genus *Paranemertes* Coe, 1901
    15. *P. peregrina* Coe, 1901

  Family amphiporidae
  Genus *Zygonemertes* Montgomery, 1897
    16. *Z. virescens* (Verrill, 1879)

  Genus *Amphiporus* Ehrenberg, 1831
    17. *A. cruentatus* Verrill, 1879
    18. *A. imparispinosus* Griffin, 1898
    19. *A. formidabilis* Griffin, 1898

  Family tetrastemmatidae
  Genus *Tetrastemma* Ehrenberg, 1831
    20. *T. nigrifrons* Coe, 1904
  Genus *Prostoma* Dugès, 1828
    21. ? *P. rubrum* (Leidy, 1850)

Order Bdellomorpha (= Bdellonemertini)
  Family malacobdellidae
  Genus *Malacobdella* Blainville, 1827
    22. *M. grossa* (Müller, 1776)

LIST OF LOCALITIES

1. Neighborhood of Dillon Beach (Second Sled Road), Marin County, California; intertidal zone. "Dillon Beach is a partly protected sandy beach on the southern shore of Bodega Bay, Marin County, at about 38° 15′ N. and 122° 58′ W. It is the site of a resort community situated on the bluffs overlooking the shore, and, in recent years, of the Pacific Marine Station, a branch of University of the Pacific. Many collection records in the literature of marine invertebrates refer to the rocky areas immediately north of the beach proper. To the south of Dillon Beach itself, beyond Sand Point, the promontory which marks the southern limit of Bodega Bay, are extensive areas of muddy sand and eel grass, known as High Clam Flat and Eel Grass Flats respectively. This area, lying within the limits of Tomales Bay, comprises one of the finest examples of the development of ecological communities of the Pacific Coast, with extensive aggregations of clams, worms, burrowing shrimps, and phoronids. Westward, across Bodega Bay, lies the bold

granite headland of Tomales Bluff, with its tidepools and sheltered crevices.

"In the 1890's when Dillon Beach could be reached from the nearby hamlet of Tomales via the narrow gauge railroad whose roadbed still leaves its traces on the landscape (Shaw *et al.*, 1949), zoologists paid frequent visits to the area, and Dillon Beach soon entered the literature as a type locality (Hedgpeth, 1951, p. 105)."

The worms live inside holdfasts of the large and abundant phaeophycean alga *Egregia menziesii* (see Ricketts and Calvin, 1956, p. 388, fig. a), in crevices of rocks, on alga straps, among mussel beds and other growths. The old holdfasts are the best for collecting the worms not only because they have numerous holes and interstices which are suitable places for the animals to hide, but also because they are more easily detached from the rocks. The best way to collect the worms is to bring old holdfasts to the laboratory and carefully open them in order to obtain complete animals. On shady days they crawl out of the holdfasts which makes it easier to collect them. The nine species collected from the neighborhood of Dillon Beach are *T. polymorphus* Renier, 1804; *T. sexlineatus* (Griffin, 1898); *C. occidentalis* Coe, 1901; *E. gracile* (Johnston, 1837); *P. peregrina* Coe, 1901; *A. cruentatus* Verrill, 1879; *A. imparispinosus* Griffin, 1898; *A. formidabilis* Griffin, 1898; *T. nigrifrons* Coe, 1904.

2. Shell Beach, Sonoma County, California, about 13 miles (24 kms.) north of Pacific Marine Station, just below the mouth of the Russian River. Intertidal zone. The same biotope as locality 1, except for *M. verrilli* which was found under roots of eelgrass, *Zostera marina* Linnaeus, attached to sandy bottom. The seven species obtained at Shell Beach are *T. polymorphus* Renier, 1804; *T. sexlineatus* (Griffin, 1898); *L. ruber* (Müller, 1771); *L. pictifrons* Coe, 1904; *M. verrilli* Coe, 1901; *M. wilsoni* (Coe, 1904); *E. gracile* (Johnston, 1837).

3. Clear Lake, Lake County, California. Under pebbles in shallow water. Collected in the early evening at sunset time. A single species, ? *P. rubrum* (Leidy, 1850), was taken here.

4. Southwest side of Sunset Bay, Charleston, Coos County, Oregon. Intertidal zone. Commensal in the mantle cavity of the lamellibranch *Siliqua patula* (Dixon) the "razor clam." Up to 80 per cent of these clams, according to canners, carry the worms. The percentage of clams so accompanied increases toward the north (Ricketts and Calvin, 1956, p. 195). *Malacobdella grossa* (Müller, 1776). *Cerebratulus albifrons* Coe, 1901, was found under stone at this locality, too.

5. Tomales Bay, Marin County, California. Intertidal zone. On mud and eelgrass flats a few steps south to Pacific Marine Station. Only *P. peregrina* Coe, 1901, was collected here.

6. Inner coast of Tomales Point, Marin County, California. Intertidal zone. In coarse sand at low tide. *Procephalothrix spiralis* (Coe, 1930) was found here.

7. White Gulch, Tomales Bay, Marin County, California. Dredged at about 18 feet (6 m.), from a substratum of medium sand associated with *Solen rosaceus* Carpenter, the "jackknife clam" and a sabellid polychaete. Collected by Dr. R. G. Johnson. The following four species were collected here: *T. cingulatus* (Coe, 1904) (coll. no. 1–58–1); *C. occidentalis* Coe, 1901 (coll. nos. 1–58–3, 4, 6, 11); *C. longiceps* Coe, 1901 (coll. nos. 1–58–17, 26); *C. albifrons,* Coe, 1901.

8. Outer coast of Tomales Point, Marin County, California. Intertidal zone. The same biotope as locality 1 except for *M. verrilli* which was found under roots of eelgrass. Five species as follows: *T. polymorphus* Renier, 1804; *T. sexlineatus* (Griffin, 1898); *C. montgomeryi* Coe, 1901; *M. verrilli,* Coe, 1901; *A. formidabilis,* Griffin, 1898.

9. La Jolla, San Diego County, California. Intertidal zone. Two species were collected here: *T. sexlineatus* (Griffin, 1898), probably from growths on rocks in the vicinities of Scripps Institution of Oceanography, and *C. mutabilis* Griffin, 1898, burrowing in sand close to the pier of the same institution. Collected by Dr. E. W. Fager.

10. Point Loma reef near Lighthouse, San Diego County, California. Intertidal zone. Only among algae. *Z. virescens* (Verrill, 1879), was taken here.

GENERA AND SPECIES

Tubulanus Renier, 1804.

References: Friedrich, 1936, p. 30. Coe, 1943, p. 226.

Body soft, cylindrical, delicate, capable of great contractibility; head often flattened dorsoventrally, triangle-shaped or disk-like, wider than the trunk and separated from it by a constriction; cephalic furrows distinct; eyes lacking; numerous epidermic glands; internal circular muscles well developed at level of anterior gut, often with two muscle crosses with external circular muscles; mouth immediately behind brain; median gut without diverticula; proboscis pore subterminal; proboscis short; proboscis sheath not longer than half of body length; nervous system completely situated between basement membrane and external circular musculature;

cerebral sense organs as epithelial pits or canals with structure simple; lateral sense organs present in esophageal region.

Tubulanus polymorphus Renier, 1804.

Principal references: Bürger, 1892, p. 140, as *Carinella polymorpha*; 1895, pp. 517–519, pl. 1, figs. 4, 10; pl. 12, figs. 3–4, 6, 9–13, 18: pl. 22, figs. 5–9, 21–22, 24–26; pl. 23, figs. 29, 31, 33; pl. 24, figs. 6, 9; pl. 26, fig. 3, pl. 27, figs. 5, 24, 48, 49, as *C. polymorpha*; 1904, p. 12. Coe, 1901, 1904, pp. 11–14, pl. 3, fig. 6; pl. 9, figs. 1–3; pl. 10, figs. 1–2, as *C. speciosa*; 1904, p. 115, as *C. rubra*; 1905, pp. 109–111, pl. 1, fig. 1; text figs. 2, 14, 24, as *C. rubra*; 1940, p. 256; 1944, p. 27. Friedrich, 1958, p. 4. Gontcharoff, 1955, p. 4. Griffin, 1898, p. 203, as *C. rubra*. Hylbom, 1957, pp. 548–549. Joubin, 1890, pp. 486–487, as *C. polymorpha*. Punnett, 1903, p. 11, as *C. polymorpha*. Ricketts and Calvin, 1956, pp. 147, 230, as *C. rubra*. Southern, 1913, p. 3. Wijnhoff, 1912, p. 409.

Material. Several worms from March to July, 1958. Localities 1, 2, 8. Rather common.

Distribution: Northern coasts of Europe; Mediterranean; Aleutian Islands, Alaska, British Columbia to Monterey Bay, California. Intertidal zone.

The living mature worms are up to 50–75 cm. long. Coe (1901, 1904, p. 12) gives a length up to 3 m. The maximum width is about 4–5 mm., behind the constriction between the head and the trunk. The anterior end is rounded. The proboscis pore is situated in its anteroventral, subterminal tip. The posterior end is slender. The color of the whole body is a deep, brilliant, uniform red. The worms, preserved in hot "Susa," have lost their bright appearance and acquired a uniform dull grayish color. A brown band appears around the body in preserved worms. In a specimen 50 cm. long the band begins about 15 mm. behind the tip of the head. It is about 5 mm. wide and distinct, fading away backward. A longitudinal line is present as a shallow groove on each side of the body, from the constriction to the posterior end. The large mouth, a longitudinal slit, bordered by a few villosities, lies behind the constriction on the ventral side. The lateral sense organs are situated shortly behind the brown band (Bürger, 1895, pl. 1, fig. 10).

The epidermis is thick and rich in glands throughout the body. The basement membrane, thin in the anterior part of the body, becomes thick posteriorly to the brain and there it shows fibers rather distinct which are crossed by fibers from the external circular muscles to the epidermis. Both circular layers, the external and the internal are thinner than the median longitudinal one. The muscular crosses between the two circular layers are

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Distributions or further occurrences for all the species treated here are from Coe, 1940, 1944, 1951, 1951a, 1952 and Corrêa, 1961.

very feeble. They are represented only by some thin fibers which pass from one layer to the other just beneath the dorsomedian longitudinal nerve. Some muscular crossing fibers occur also ventrally. The central plate of longitudinal muscles, situated between the digestive tract and the rhynchocoel, is thin. It extends from the mouth level backward. The cephalic glands are very highly developed. In front of the rhynchodaeum region they are more abundant dorsal to the blood lacuna. At the level of the proboscis pore and backward they are abundant, also all around the rhynchodaeum and blood lacuna. They fill most of the space of the tip of the head but do not reach far backward. The most posterior glands are situated far in front of the brain. Their secretion stains intensely with hematoxylin.

The proboscis pore is small. The rhynchodaeum is lined by a glandular and ciliated epithelium. Its glands are like the cephalic glands both in aspect and staining characteristics. The lumen of the rhynchodaeum is very narrow proximally and opens behind into an anterior rhynchocoelic pouch whose wall is without gland cells and cilia. The pouch is followed by the large rhynchocoel proper. The rhynchocoel wall is composed of an epithelium lining the cavity and a layer of circular muscles. Dorsally this layer contacts the external circular musculature and ventrally it contacts the longitudinal muscular plate. The proboscis wall is composed of a high external epithelium, a thin layer of circular muscles, a thicker layer of longitudinal muscles, and an internal epithelium. There are two longitudinal proboscidial nerves.

There is one large anterior blood lacuna subdivided by dorsoventral fibers and two large postcerebral ones, one on each side of the gut.

The nervous system is situated between the basement membrane and the external circular muscles. There is a ring of large anterior nerves originated from the ganglia and commissures. Backward run the dorsomedian nerve, the rhynchocoelic nerve, the proboscidial nerves, and the short esophageal nerves. The cerebral sense organs are highly developed. They lie immediately external to the dorsal ganglia and are innervated by the adjacent ganglion. They consist of a rounded mass of nerve cells surrounding a narrow, central canal, lined with a ciliated and sensory epithelium. The central canal leads ventrally and outward to open through the epidermis by a small pore.

Tubulanus sexlineatus (Griffin, 1898).

PRINCIPAL REFERENCES: COE, 1901, 1904, pp. 15–16, pl. 1, figs. 2–3, as *Carinella dinema*; 1904, p. 115, as *C. sexlineata*; 1905, pp. 111–114, pl. 1, figs. 2–3, pl. 15, figs. 90–92, as *C. sexlineata*; 1940, p. 256; 1944, p. 27. GRIFFIN, 1898, pp. 201–203, text fig. 15, as *C. exlineata*.

MATERIAL. Several worms from April to July, 1958. Localities 1, 2, 8, 9. Rather common.

Distribution. Alaska to southern California. Intertidal zone.

The living worms are up to 10 cm. in length and about 0.8 mm. in maximum width. Coe (1905, p. 114) gives 20 cm. as average size, varying from 7.5 cm. to 1 m. The ground color is dark reddish-brown with five very characteristic longitudinal white lines, three of which are on the back and two on the ventral side. All five longitudinal lines run nearly the whole length of the body. Of the three back lines one is median and the other two are lateral. A sixth medioventral line is shown as white spots on the anterior part of some of the worms. Besides the longitudinal lines there are also a great number of white rings, variable in width and situated at different distances from each other. The white rings are single or double lines. When double they have a brown ring between the pair. The anterior end has dorsally an irregular, transverse, white line and on both sides a black narrow groove which extends from the proboscis pore to the white line. The first trunk rings are somewhat irregular, sometimes present only dorsally. The fifth ring is broader than any of the remaining rings. Close to it there is on each side a shallow pit, the lateral sense organ. Several white spots occur on the dorsal and ventral sides in front of the first white ring and between the following four rings. The posterior end is yellowish-white both dorsally and ventrally. The large mouth is situated behind the constriction between head and trunk. The worms live in thin, transparent tubes, secreted by their epidermis.

The glandular epidermis is thick. The basement membrane is thin anteriorly and thick posteriorly to the brain. Before the brain there is an external layer of circular muscles, a thicker layer of longitudinal muscles, and a coat of circular muscles around the rhynchodaeum and blood vessels. Behind the mouth all three layers of muscles, the external circular, the median longitudinal, and the internal circular, are typical and complete. The muscular crosses between the two circular layers are almost completely wanting. A layer of central longitudinal muscles, the central plate, lies between rhynchocoel and anterior gut. Cephalic glands are absent in the present species as in other species of the genus *Tubulanus* (Bürger, 1897–1907, p. 409) and in most of the Palaeonemertini (Bürger, 1895, p. 229). Friedrich (1936a, p. 103) has found some differences between the dorsal and ventral glands of the rhynchodaeum epithelium of *T. Borealis* Friedrich, 1936. The same differences were also noted in *T. rhabdotus* Corrêa, 1954, where vacuolated cells occur besides stained glands (Corrêa, 1954, p. 15, pl. 2, fig. 8). The absence of true cephalic glands and the similarity between them and the vacuolated rhynchodaeal cells indicate a homology of both types. However I could not distinguish any difference in the rhynchodaeum glands in the present species, as I would expect owing to the absence of true cephalic glands.

The proboscis pore is situated subterminally, ventrally, at the anterior tip. The large rhynchodaeum is lined by a highly glandular epithelium. Anterior to the constriction between head and trunk the glands disappear and the rhynchodaeum passes to the rhynchocoel. A quite strong and complete muscular proboscidial septum is present in this region. Some of its fibers are retained in the anterior wall of the rhynchocoel. The rhynchocoel wall is composed of an epithelium, a distinct basement membrane, and a thick layer of circular muscles where a longitudinal nerve runs dorsally. Dorsally the circular muscles are thick layered because they contact the internal circular muscles of the body wall and ventrally they are thinner and touch the central plate of longitudinal muscles. Anteriorly to the nephridiopores, at the level of the stomach, there are longitudinal thickenings of the internal wall of the rhynchocoel, on both sides, close to the lateral blood vessels. They are the rhynchocoelic bodies described by Friedrich (1936a, p. 107) in *T. borealis* and by Corrêa (1954, p. 16) in *T. rhabdotus*. They are united to the lateral blood vessels by sometimes large canals. The rhynchocoelic bodies are covered by the rhynchocoelic epithelium and are composed of a mass of cells. As in *T. sexlineatus* there are no rhynchocoelic vessels, I follow the opinion of Friedrich (1936a, p. 108) about the nephridial function of the rhynchocoelic bodies. The proboscis wall is composed of an external epithelium, the external basement membrane, a thin layer of circular muscles, a thicker layer of longitudinal muscles, the internal basement membrane, and the flat internal epithelium. The two proboscidial, longitudinal nerves, are situated between the external basement membrane and the circular muscular layer. They arise independently from the ventral cerebral commissure and enter the proboscis at its attachment point.

The pre- and postcerebral vessels are true vessels, because they have defined walls with a muscular coat and epithelium (Hyman 1951, p. 488). In the precerebral part they are subdivided incompletely by dorsoventral muscular strands. Behind the mouth there is only one vessel on each side situated within the longitudinal musculature.

The nephridial system is situated in the first third of the body. It begins, on both sides of the body, with the well developed nephridial glands, a mass of minute tubules lined with a flattened epithelium. The glands project into the lumen of the lateral blood vessel along its lateral border. The nephridial glands pass through the vessel wall and continue as a longitudinal duct situated dorsolaterally to the blood vessel. The wall of the ducts is lined by a ciliated epithelium. Close to the level of the lateral sense organs the ducts pass outward through the epidermis and open by one dorsolateral nephridiopore on each side.

The nervous system is composed of two pairs of ganglia united dorsally and ventrally by commissures forming a nerve ring. It is situated between the basement membrane and the external circular musculature. The nerve ring gives origin to a large number of anterior nerves. The dorsomedian nerve belongs to them. From their thick origin they become slender forward and send branches into the epidermis. Backward run the dorsomedian nerve, the rhynchocoelic nerve, the two lateral nerve cords, the two proboscidial nerves, and the esophageal nerves. The cerebral sense organs are simple. They consist of a ciliated canal innervated by some fibers from the dorsal ganglia. The lateral sense organs are a pair of rounded pits situated dorsal to the lateral nerve cords in the epidermis outside the basement membrane. They are innervated by fibers from the lateral nerve cords.

Tubulanus cingulatus (Coe, 1904).

PRINCIPAL REFERENCES: COE, 1904, pp. 138–142, pl. 14, figs. 2–4, as *Carinella cingulata*; 1905, pp. 120–122, as *C. cingulata*; 1940, p. 255; 1944, p. 27.

MATERIAL. Several worms in June and July, 1958. Locality 7. Rather common.

FURTHER OCCURENCES. Alaska; Monterey Bay, California. Intertidal zone to 400 m. The present record links the distribution between Alaska and Monterey Bay, California.

The living worms are up to 15 cm. in length and about 2–3 mm. in maximum width. The ground color is deep brown with longitudinal white lines and thin white rings bordered with brown. The longitudinal lines are four in number, two are dorsolateral and the two other ventral, very near to the lateral margins of the body. Behind the constriction between the head and trunk there is a deep brown ring thinner on the ventral side and interrupted there by the large mouth. It is followed by a distinct white band which is the anterior limit of the white longitudinal lines. On both sides of the paler head there is a narrow, transverse, terminal, brown line. The space between the anterior rings is broader than the spaces between the more posterior rings. The proboscis pore is situated ventrally, subterminally on the head which is broader than the trunk. The lateral sense organs are well visible on the anterolateral border of the third white ring.

As the internal anatomy of *T. cingulatus* is quite similar to that of the preceding species, I give only a few divergent points.

The dorsoventral, precerebral musculature is much stronger. The muscular crosses between the external and internal circular muscles are quite strong, principally the dorsal one. True cephalic glands, which lie in the cephalic musculature or sometimes behind the brain, are absent. A difference is noted between the dorsal and ventral glands of the rhynchodaeum epithelium. Dorsally they are vacuolated cells and ventrally they are deep stained basophilous glands. At the limit between rhynchodaeum and rhynchocoel the former continues backward as a postventral blind sac.

OTHER SPECIES OF THE GENUS. The genus *Tubulanus* contains 29 species (Corrêa, 1954, pp. 21–25; Iwata, 1952, pp. 126–128; Friedrich, 1958, p. 3). Three of them are presented here and five more occur on the northeastern Pacific coast. They can be separated from *T. polymorphus*, *T. sexlineatus*, and *T. cingulatus* by the following external characteristics:

1. **Tubulanus pellucidas** (Coe, 1895). Recently redescribed by Corrêa (1961, pp. 4–5, figs. 1–4). Body filiform, small, about 20 mm. long and 0.3 mm. broad; whitish in color. Occurrences: Coasts of New England and southward to Miami, Florida and Pensacola, Florida on the Gulf Coast; Monterey Bay, California to San Diego, California. Intertidal zone.

2. **Tubulanus capistratus** (Coe, 1901). Long, slender, up to 1 m. long; color deep brown with three longitudinal white lines one of which is dorsal and one on each ventrolateral margin; a series of narrow white rings along the whole length of the body. Occurrences: Coast of Alaska to Monterey Bay, California; Japan. Intertidal zone.

3. **Tubulanus albocinctus** (Coe, 1904). Rather stout body about 30 cm. long; color deep red with a series of narrow white rings along the whole length of the body; longitudinal lines absent. Occurrence: Off the coast of southern California. Among red algae at depths of 100 to 200 m.

4. **Tubulanus frenatus** (Coe, 1904). Body long, 50 cm. or more; color pale yellowish or rosy with three longitudinal black lines one of which is dorsomedian and the other two are situated on or a little beneath the lateral margins; a series of narrow, black rings extends along the whole length of the body. Occurrence: Southern California. Intertidal zone.

5. **Tubulanus nothus** (Bürger, 1892). Small, 10 cm. long; color brownish-red with two longitudinal lateral lines, one dorsomedian and a series of white rings. Coe (1944, p. 27) is not sure about the identification of this species which was seen by him only in preserved specimens from Alaska. Occurrences: Coast of Alaska; South Africa; Mediterranean. Intertidal zone to 40 m.

Genus **Carinoma** Oudemans, 1885.

REFERENCE: FRIEDRICH, 1936, p. 31.

Anterior part of body in region of anterior gut with layer of external longitudinal muscles; brain and anterior course of lateral nerve cords between external circular and external longitudinal muscular layers, posteriorly these cords farther inward.

Carinoma mutabilis Griffin, 1898.

PRINCIPAL REFERENCES: COE, 1901, 1904, pp. 20–23, text figs. 1–2, as *C. griffini*; 1904, p. 115; 1905, pp. 144–153, pl. 12, figs. 76–80; pl. 13, figs. 81–82; pl. 14, figs. 83–87; pl. 15, figs. 88–89; 1940, p. 257, pl. 25, figs. 21–22; 1944, pp. 27–28. FRIEDRICH, 1956, pp. 3–5. GRIFFIN, 1898, pp. 204–205, text fig. 16.

MATERIAL. One worm. Locality 9.

DISTRIBUTION. British Columbia to Gulf of California. Intertidal zone to 40 m. Burrows on sandy shores of bays.

The preserved cylindrical worm was about 30 cm. long and 2–3 mm. broad. The rounded head is wider than the trunk. The color is uniformly grayish.

Unfortunately my single specimen of this little-known genus was not properly preserved and had been kept for a long time before it reached me. Consequently I can not give any details of the external or internal anatomy. The specific name was given only according to the occurrence. It is the only species of the genus on the Pacific coast of North America (Coe, 1940, p. 257).

Friedrich (1956, pp. 3–5) examined two specimens of the genus *Carinoma* collected on the coast of Chile by the Lund University Expedition 1948–49. He did not attempt to determine this material because the five hitherto-known species of *Carinoma* are not sufficiently described.

Genus **Procephalothrix** Wijnhoff, 1910.

REFERENCE: FRIEDRICH, 1936, p. 30.

Mouth far behind brain; internal circular musculature of body present in region of anterior gut; muscle crosses absent; brain and lateral nerve cords situated within longitudinal muscular layer; esophageal nerve unpaired; sense organs absent, in their place a nervous glandular tissue.

Procephalothrix spiralis (Coe, 1930).

PRINCIPAL REFERENCES: COE, 1905, pp. 153–154, as *Cephalothrix linearis*; 1930, pp. 101–103, text figs. 4–8, as *C. spiralis*; 1940, pp. 258–259, pl. 28, fig. 37; 1943, pp. 230–232, text figs. 19, 44; 1944, p. 28. VERRILL, 1892, pp. 442–443, pl. 36, figs. 4–5; pl. 39, figs. 10–15, as *C. linearis*.

MATERIAL. Several worms in July 1958. Locality 6. Very common.

DISTRIBUTION. New England; Alaska to San Diego, California. Intertidal zone to 20 m.

Alive, the filiform mature worms are up to 20 cm. long and 1–2 mm. wide. The color is variable from whitish to gray, pale yellow and light rosy often with pinkish, greenish, or salmon tinge posteriorly. They can be easily distinguished by the far-posterior position of the mouth and by the habit of fragmenting and coiling the body into a spiral. All the worms, collected in large numbers, were completely fragmented at their arrival in the laboratory. The head is very long and acutely pointed. Eyes are absent in the adults. A single pair of ocelli is present in larval stages and young adults (Coe, 1943, p. 231, textfig. 44).

Besides *P. spiralis,* a second species of *Procephalothrix, P. major* (Coe, 1930), is known on the Pacific Coast of North America. It can be separated from *P. spiralis* by its larger size, up to 1 m. in length and 5 mm. in width; by its ocher, or straw color; its more rosy color in front, and its grayish color behind; and by its slight tendency to coil into a spiral. Occurrence: southern California. Beneath stones in hard sand or clay fully exposed to surf. Intertidal zone.

Genus **Lineus** Sowerby, 1806.

Reference: Friedrich, 1936, p. 31.

Cephalic slits present; cutis not separated from musculature by connective tissue; layer of circular muscles dissolved in tip of head into radial and tangential fibers; dorsoventral muscles between intestinal pouches wanting; proboscis with two muscular layers: external circular and internal longitudinal; proboscis with two muscle crosses; cephalic blood lacuna uniform; blood vessels united at posterior end by a simple commissure.

Lineus ruber (Müller, 1771).

Principal references: Boie, 1952, pp. 188–222, text figs. 1–17. Coe, 1901, 1904, pp. 65–66, text fig. 16, as *L. viridis*: 1905, pp. 162–163, as L. *viridis*; 1940, p. 268, 1943, pp. 242–244, text figs. 33, 36, 48; 1944, p. 29. Friedrich, 1935, pp. 307–310, text figs. 8–9. Gontcharoff, 1951, pp. 149–235, pls. 1–7. McIntosh, 1873–74, pp. 188–190, pl. 5, fig. 2, as *L. sanguineus*. Southern, 1913, p. 9. Stephenson, 1913, pp. 25–27. Verrill, 1892, pp. 418–423, pl. 37, figs. 5–5b; pl. 38, figs. 6–6d; pl. 39, figs. 18, 22, as *L. viridis*; pp. 423–424, pl. 38, figs. 10–10a, as *L. sanguineus*. Wheeler, 1934, pp. 229–230, pl. 15, fig. 4, text fig. 6; 1940, pp. 31–32, figs. 5A–G. Wijnhoff, 1912, p. 416.

Material. Two worms in June, 1958. Locality 2. Uncommon.

Distribution. Circumpolar; Siberia; Northern coasts of Europe; Mediterranean; Madeira to South Africa; Greenland to Southern New England; Alaska to Monterey Bay, California. Intertidal zone to 10 m. Gontcharoff (1951, p. 155) is doubtful about the occurrence of the species in the Mediterranean. She has not collected it in Marseille and Banyuls, France.

The worms measured in life about 8 cm. in length and 1 mm. in maximum width. The color is brownish-red on the back and paler beneath. On the tip of the head there is one unpigmented zone. There are a few eyes, about 4–5 on each side, situated on the anterolateral margins.

The internal and external anatomy of the species was recently analyzed thoroughly by Friedrich (1935) and Gontcharroff (1951).

As far as I could see in my specimens, they belong to the *L. ruber* complex (Gontcharoff, l.c.) composed of *L. ruber*, *L. viridis* (Blainville, 1828), *L. sanguineus* (Rathke, 1799), and *L. pseudo-lacteus* Gontcharoff, 1951.

Lineus pictifrons Coe, 1904.

PRINCIPAL REFERENCES: COE, 1904, pp. 188–192, pl. 17, figs. 5–6; 1905, p. 169–171, pl. 3, fig. 36; 1940, p. 268; 1944, p. 28.

MATERIAL. One worm in July, 1958. Locality 2. Uncommon.

DISTRIBUTION. Puget Sound to coast of Mexico. Intertidal zone.

The worm was in life about 12 cm. long and 3 mm. wide. Body soft and flattened; head narrower than body; ocelli wanting. General color, deep brown or reddish both dorsally and ventrally. Posterior end paler. A series of numerous, transverse, yellow rings are present, as well as longitudinal yellow lines. The most anterior transverse markings encircle the body. The first one, situated at the posterior end of the longitudinal cephalic slits, is the widest. It is present only dorsally, as are the posterior ones. Almost all markings have a thickening on the median-dorsal line. The longitudinal lines are very thin, irregular and interrupted, except the median one which is rather conspicuous and connects all the thickenings of the transverse markings. The tip of the snout has a peculiar and characteristic yellowish band enclosing two orange colored spots.

OTHER SPECIES OF THE GENUS. Eight species of the genus *Lineus* are known on the Northeastern Pacific coast. Besides the two described here five more occur on the California coast. They can be separated by the following external characteristics:

1. **Lineus bilineatus** (Renier, 1804). Dark brown or olive with median-dorsal stripe of white or yellow extending the whole length of body and widening out on head to form a broad white marking; without transverse markings. Occurrences: Northern coasts of Europe; Mediterranean; Madeira; South Africa; Alaska to San Diego, California. Near low-water mark and below.

2. **Lineus torquatus** Coe, 1901. Dark reddish-brown or purple with a single narrow whitish band connecting posterior ends of cephalic furrows on dorsal side of head. Occurrences: Coast of Alaska to San Francisco Bay, California. Intertidal zone.

3. **Lineus rubescens** Coe, 1904. Small species, 10–15 mm. long; pink, rosy, or pinkish-red, sometimes with a tinge of blue; tip of head white both

above and below, sharply marked off from rosy color of body. Occurrences: Monterey Bay, California to San Diego, California. Near low-water mark and below.

4. **Lineus flavescens** Coe, 1904. Small species, 8–120 mm. long; yellowish, pale yellow with a tinge of orange, dull orange, ocher or yellowish-brown; margins of head pale or colorless; with 3 to 7 irregular red, purple, or black ocelli of which the most anterior are largest. Occurrences: southern California to Gulf of California, Mexico. Near low-water mark to 100 m. or more.

5. **Lineus vegetus** Coe, 1931. About 15 cm. long and uniformly reddish-brown except for the anterior tip which is pure white. Coe (1940, p. 266) separates *L. vegetus* from *L. ruber* on the basis of behavior and regenerative capacity. Occurrences: San Francisco Bay, California to Ensenada, Mexico. Intertidal zone.

Genus **Cerebratulus** Renier, 1804.

Reference: Friedrich, 1960, p. 57.

In general large animals with sharp lateral edges; with a small tail; diagonal muscular layer present; strong dorsoventral muscles; cutis set off against external longitudinal muscles; median gut with very deep lateral pouches; proboscis with external longitudinal muscles, circular muscles and internal longitudinal muscles, and two muscle crosses.

Cerebratulus montgomeryi Coe, 1901.

Principal references: Coe, 1901, 1904, pp. 80–82, pl. 6, figs. 1–2; 1905, pp. 200–201, pl. 3, figs. 38–39; 1940, p. 276; 1944, p. 29. Ricketts and Calvin, 1956, p. 230.

Material. One worm in May, 1958. Locality 8. Uncommon.

Distribution. Coast of Siberia; Bering Sea; Alaska to Monterey Bay, California; Japan. Intertidal zone to 600 m.

The worm was in life about 80 cm. long and 5 mm. wide. Coe (1905, p. 200) gives a length of up to three meters when fully extended. The color is both above and below bright pinkish red, fading toward the posterior tip. The tip of the head is white both dorsally and ventrally. The pointed head is variable in shape according to the state of contraction, flattened dorsoventrally, and well separated from the trunk by a constriction. It bears on each side a longitudinal slit extending backward as far as the anterior end of the mouth. Anteriorly these slits do not reach the proboscis pore. Ocelli wanting. The anterior portion of the body is cylindrical and the intestinal region is flattened. The posterior tip is sharply pointed. The caudal cirrus was lost. The body coils into a spiral both in life and in the preserved state.

The epidermis is highly glandular but flat. The epidermis of the cephalic slits is poor in glands and bears longer cilia than in the rest of the body. The basement membrane is thin. In front of the brain there is a dense net of muscular fibers around the rynchodaeum and haemal system, in which occur the voluminous cephalic glands. The longitudinal external muscles are diffusely distributed and the circular and internal longitudinal layer encircle the rynchodaeum and blood vessels. At the posterior level of the brain the layers of body musculature are complete. Beneath the epidermis there is a thick layer of glandular cutis followed by the thick external longitudinal muscles, the circular muscles, and the internal longitudinal muscles. Cutis and external longitudinal musculature are not separated by connective tissue. The layers of the body wall are interrupted ventrally at the esophagus level.

The postcerebral small mouth opens into a villous, ciliated and glandular esophagus. The gut is provided with lateral diverticula.

The proboscis pore is a longitudinal, subterminal, ventral slit. The rynchodaeum is lined by a ciliated epithelium. The rhynchocoel wall is composed of an epithelium, a layer of longitudinal muscles, and a thicker layer of circular muscles which are connected dorsally with the circular muscles of the body wall. The proboscis wall is composed of a high external epithelium, an external layer of circular muscles, a thicker layer of longitudinal muscles, an extremely thin layer of internal circular muscles, and the flat internal epithelium. Coe (1901, 1904, p. 81) describes an inner circular layer and later (1905, p. 200) recognizes it as absent. In fact the layer is present but very much interrupted. The muscular crosses between the two circular layers are very feeble.

Cerebratulus occidentalis Coe, 1901.

Principal references: Coe, 1901, 1904, pp. 76–77, pl. 6, fig. 3; 1905, pp. 197–198; 1940, p. 276; 1944, p. 29.

Material. Seven worms in June and July, 1958. Locality 1, 7.

Distribution. Alaska to San Francisco Bay, California. Intertidal zone to 120 m.

The largest worm was 8 cm. long alive and 3 mm. wide. The usual color is brown or reddish-brown anteriorly and lighter in intestinal region; ventral surface brownish with a median ocher stripe. The small, pointed head bears on each side a rather short longitudinal slit. Ocelli wanting. The mouth is large. The body is slightly rounded anteriorly and flattened posteriorly. The posterior tip is pointed and bears a very short tail about 1 mm. long.

The internal anatomy of the four species of *Cerebratulus* described here is quite uniform. In the present species the internal circular layer of proboscidial muscles is thicker than in *C. montgomeryi,* but the muscular crosses are also inconspicuous.

Cerebratulus longiceps Coe, 1901.

Principal references: Coe, 1901, 1904, pp. 77–79, pl. 5, figs. 4–7; 1905, pp. 199–200; 1940, p. 276; 1944, p. 29.

Material. Three worms in June and July, 1958. Locality 7. It is the first record of the species on the California coast.

Further occurrences. Alaska; Japan. Intertidal zone to 250 m.

The largest worm measured in life 30 cm. in length and 6 mm. in maximum width. The dorsal surface is dark brownish-black or purplish, much paler on the tip of the snout and on the borders of the cephalic furrows. The ventral surface is paler. The body is much flattened throughout its length, the anterior portion narrow and slender becoming wider posteriorly. The head is long, pointed, flattened dorsoventrally, directly continuous with the trunk, and with the tip often curved upward. The cephalic furrows are very long, remarkably deep and wide. They do not reach the proboscis pore anteriorly, and posteriorly they reach the anterior border of the long slit-like mouth. A white, 3 mm. long tail, was present.

Cerebratulus albifrons Coe, 1901.

Principal references: Coe, 1901, 1904, pp. 82–83, pl. 4, figs. 3–4; 1904, pp. 200–201, pl. 17, fig. 9; 1905, pp. 198–199; 1940, p. 274; 1944, p. 29.

Material. Two worms in July, 1958. Localities 4, 7.

Distribution. Alaska to San Diego, California. Intertidal zone to 100 m. or more.

The worms measured in life about 30 cm. in length and 5 mm. in maximum width. The color is uniform dark brown. The anterior end of the head is white, both dorsally and ventrally and extending backward as far as the anterior end of the mouth. The head is pointed and directly continuous with the trunk. It bears on each side a longitudinal slit. Ocelli wanting. The ribbon-like body is rounded anteriorly and flattened in intestinal region.

Other species of the genus. Nine species of *Cerebratulus* are known on the Pacific coast of North America. Besides the four species described here four more species occur on the California coast. They are:

1. **Cerebratulus marginatus** Renier, 1804. Length 50 cm. to 1 m.; brown to grayish or pale olive, paler beneath, with conspicuous paler or white

lateral margins. Occurrences: Circumpolar; Norway to Madeira; Greenland and Labrador to Cape Cod; Alaska to San Diego, California; Bering Sea; Japan. Sandy and muddy shores to depth of 100 m. Coe (1944, p. 29) does not list this species from the Mediterranean. It was collected by me in the Gulf of Naples (1952).

2. **Cerebratulus herculeus** Coe, 1901. Length 2 m. or more and width 25 mm.; dark reddish-brown. Occurrences: Bering Sea; coast of Alaska to central California and off the coast to depths of 60 m. or more.

3. **Cerebratulus californiensis** Coe, 1905. Small species, 10–15 cm. long; variable in color, pale yellow, light brown or chocolate brown; lateral margins thin and often paler; lateral nerve cords red. Occurrences: Puget Sound to Gulf of California. On muddy shores and in bays to depths of 35 m. or more.

4. **Cerebratulus lineolatus** Coe, 1905. Recently redescribed by Corrêa (1961, p. 14). Length 25 mm. to 20 cm.; pale gray, with numerous, fine, irregular and much interrupted dark olive-brown longitudinal lines extending the whole length of body both above and below, but more numerous and larger on dorsal surface than ventrally. Occurrences: Miami, Florida; southern California, Gulf of California, and West Coast of Mexico. Intertidal zone to 70 m. or more.

Genus **Micrura** Ehrenberg, 1831.

REFERENCE: FRIEDRICH, 1960, p. 59.

Cephalic furrows posteriorly widened as a pit from whose bottom parts cerebral canal; external longitudinal muscular layer of cutaneous-muscular tube stronger than circular and internal longitudinal muscular layers; dorsoventral and diagonal muscles lacking; post-cerebral or pre-esophageal dorsoventral and horizontal muscles lacking; pouches of median gut very shallow; coat of ganglionar cells of brain not separated by connective tissue from longitudinal external muscles.

Micrura verrilli Coe. 1901.

PRINCIPAL REFERENCES: COE, 1901, 1904, pp. 68–71, pl. 5, figs. 1–3; 1905, pp. 179–182, pl. 3, figs. 34–35; 1940, pp. 272–273; 1944, p. 29. GRIFFIN, 1898, pp. 214–215, as *Lineus striatus*. RICKETTS and CALVIN, 1956, p. 146, pl. 22, fig. 7.

MATERIAL. Ten worms from April to June, 1958. Localities 2, 8. Not uncommon. Unfortunately *M. verrilli* occurs not very frequently (Ricketts and Calvin, *l.c.*).

Distribution. Alaska to Monterey Bay, California. Intertidal zone and below.

The largest worm was 15 cm. long alive and 3 mm. in maximum width. The body is compact and rounded throughout, only ventrally slightly flattened. Cephalic furrows rather large. Ocelli wanting. Caudal cirrus whitish and slender. General color of body is pure ivory-white dorsally and ventrally with a series of sharply defined rectangular markings of deep purple covering the greater portion of the dorsal surface, separated from each other by silver-colored lines. At the lateral borders of the purple markings is a continuous longitudinal line of the same silver color. On the dorsal surface of the head there is a triangular marking of bright orange color followed by a white band.

Micrura wilsoni (Coe, 1904).

Principal references: Coe, 1904, pp. 195–198, pl. 16, figs. 10–11, as *Lineus wilsoni*; 1905, pp. 171–173, pl. 3, fig. 37, as *L. wilsoni*; 1940, p. 273; 1944, p. 29. Joubin, 1905, pp. 311–312, as *L. wilsoni*.

Material. One worm in April, 1958. Locality 2. Uncommon.

Further occurrences. Monterey Bay, California, to Gulf of California. Intertidal zone to 35 m.

The worm was 4 cm. long. Coe (1905, p. 172) gives a length of 7 to 15 cm. Body moderately slender, rounded anteriorly, flattened in intestinal region, but with rounded lateral margins. Head very long and slender, not distinctly marked off from body. Cephalic furrows very long. Mouth large, situated far behind tip of snout immediately behind brain. Proboscis pore sub-terminal. Ocelli wanting. Color of body deep brownish-black dorsally, slightly paler ventrally. Head bordered anteriorly by a narrow terminal band of white which extends back along the borders of cephalic slits, so that when the slits are open they appear white. White terminal border narrower on ventral than on dorsal surface and less conspicuous owing to the paler color of the ventral surface. The tail is short and white. Body encircled at irregular intervals by a series of very fine white rings often lying in slight constrictions through which spontaneous fission takes place.

Other species of the genus. Eight species of the genus *Micrura* are known on the Pacific coast of North America (Coe, 1944, p. 29). Besides *M. verrilli* and *M. wilsoni*, described here, four more species may occur in the intertidal zone of the localities where I collected. These can be separated from *M. verrilli* and *M. wilsoni* by the following external characteristics:

1. **Micrura alaskensis** Coe, 1901. Body long and moderately slender, at-

taining a large size for the genus, commonly 15–60 cm.; color salmon, gray, pale red, or light rosy brown, shading into lighter hues; light red or yellow or nearly white anteriorly; a cream colored stripe often situated in median ventral line; without transverse rings. Occurrences: Alaska to Ensenada, Mexico; Japan. Intertidal zone.

2. **Micrura nigrirostris** Coe, 1904. About 40–80 mm. long; dorsal surface bright blood-red, ventral surface paler; head with a narrow, but very sharp and conspicuous, transverse band of white near tip of snout; on the tip of head there is a small, rounded, black spot with a few minute whitish flecks. Occurrence: southern California. Low-water mark and below.

3. **Micrura olivaris** Coe, 1905. Length 7 to 15 cm.; body small and stout; color pale olive brown, grayish ocher with deeper olive in intestinal region and paler median dorsal stripe in esophageal region; without transverse rings; small black ocelli in an irregular row of 6–12 on each side of head. Occurrences: Monterey Bay, California and off San Francisco, California. Low-water mark to 120 m.

4. **Micrura pardalis** Coe, 1905. About 3 cm. long; color pale yellow dorsally covered with black or dark brown spots often somewhat elongated and arranged in irregular longitudinal lines; without tranverse rings; a single row, usually of 10 to 18 small ocelli, on each side of head. Occurrences: Monterey Bay, California to Ensenada, Mexico. Intertidal zone.

Genus **Emplectonema** Stimpson, 1857.

REFERENCES: FRIEDRICH, 1955, p. 172. CORRÊA, 1955, p. 68.

Long, filiform or flattened worms with short rhynchocoel; subepithelial glands often numerous, variously distributed or lacking; cephalic glands generally well developed but variable in length; muscular layers reach tip of head; dorsoventral muscles present; esophagus opens into rhynchodaeum; caecum absent but two long anterolateral intestinal pouches present; an esophageal caecum exceptionally present; gut with lateral diverticula; proboscidial septum of closed type; lateral nerve cords with one core of fibers; cerebral sense organs either small, far in front of brain, or large and shortly anterior to brain.

The genus *Emplectonema* was introduced by Stimpson (1857, p. 163) when he described *E. viride*, considered by him as new species. With the same name the species was described by Griffin (1898, pp. 207–209, figs. 17–18). *Borlasia camillea* Quatrefages, 1846, included by Stimpson (*l.c.*) in his *Emplectonema* is a synonym of *E. neesii* (Oersted, 1843) as was indicated by Bürger (1895, p. 544). As *E. viride* is identical with *Nemertes* *gracilis* Johnston, 1837 (Coe, 1901, pp. 23–25) the type of the genus *Emplectonema* is *E. gracile* (Johnston, 1837), not *E. neesii* (Oersted, 1843), as Verrill indicated (1892, p. 413).

The cephalic glands are abundant and very long in my worms from Naples (Corrêa, 1955, p. 69, pl. 2, fig. 6g) and in the worms from California. My observations do not agree with Yamaoka's (1940, p. 238) of the same species from Japan where the cephalic glands are said to be absent. Bürger (1895, p. 542) included their presence in his diagnosis of the genus but did not give any drawing of cephalic glands in *E. gracile*.

I deduce from figure 27, plate 15 of Bürger (*l.c.*) that the long intestinal caecum mentioned on page 543 corresponds to the anterolateral intestinal pouches of my terminology. Stephenson (1913, p. 13) gave the same interpretation. With Böhmig (1929, pp. 16–17, figs. 19–20) followed by Friedrich (1956, pp. 45–53, pls. 1–2), I call the intestinal caecum a median, ventral, sub-stomachic projection. This caecum is absent in *E. gracile*.

Emplectonema gracile (Johnston, 1837).

PRINCIPAL REFERENCES: BÜRGER, 1895, pp. 543–544, pl. 2, fig. 1; pl. 9, fig. 24; pl. 15, figs. 21–27; pl. 22, fig. 27; pl. 24, fig. 53; pl. 26, figs. 39–41; pl. 27, figs. 1a, 12, 18, 20; pl. 29, fig. 3, as *Eunemertes gracilis*. COE, 1901, 1904, pp. 23–25, pl. 8, fig. 3; text fig. 3; 1905, pp. 207–208, pl. 1, figs. 14, 14a, 15, 15a; text fig. 32; 1940, pp. 279–280, pl. 30, fig. 40; 1944, pp. 29. CORRÊA, 1953a, pp. 130–134, pl. 1, figs. 1–2; 1955, pp. 68–72, pl. 1, figs. 1–3; pl. 2, figs. 4–6. GRIFFIN, 1898, pp. 207–209, figs. 17–18, as *Emplectonema viride*. ISLER, 1901, p. 274. IWATA, 1954, p. 15. JOUBIN, 1890, pp. 585–586, pl. 31, figs. 15–16, 21, as *Nemertes gracilis*. RICKETTS and CALVIN, 1956, pp. 43, 170, 206. STEPHENSON, 1913, pp. 12–13, fig. 6. STIMPSON, 1857, p. 163, as *Emplectonema viride*. YAMAOKA, 1940, pp. 237–238, pl. 4, figs. 1–2; text fig. 14.

MATERIAL. Several worms from March to August, 1958. Localities 1, 2. Very common.

DISTRIBUTION. Northern coasts of Europe to Madeira; Mediterranean; Aleutian Islands and coast of Alaska to Ensenada, Mexico; Chile; Kamchatka to Japan. Intertidal zone to 100 m.

The largest worm measured in life up to 20 cm. in length and 1 mm. in width. The color of the back is uniform dark green. The ventral side is pale yellow or whitish. The color and aspect of the Mediterranean and California worms are not completely alike. The former are stronger and their color is paler than in the California worms (Bürger, 1895, pl. 2, fig. 1; Coe, 1905, pl. 1, fig. 14). The color is still present after preservation in hot "Susa." The head flattened dorsoventrally, wider and lighter than the trunk, contains numerous eyes distributed in two rows on each side: one anterolateral with 12–14 eyes and the other posterolateral with the same number.

Young worms have fewer eyes distributed irregularly. Cephalic furrows are not distinct. The worms have a tendency to coil into a spiral in life and during preservation.

The epidermis is high and rich in mucous glands. The worms make a mucous tube with the fine particles of mud existing between the mussel beds, their most common habitat. The basement membrane is thick and at certain levels thicker than the external circular muscle layer. The longitudinal muscles are high. Both layers reach the tip of the head. Anteriorly to the brain there is a dense muscular net where abundant dorsoventral muscular fibers occur. The cephalic glands are voluminous, distributed dorsally, ventrally, and laterally, reaching as far back as the posterior level of the stomach.

The esophagus opens into the rhynchodaeum. The stomach is large, long, and villous, and its ciliated epithelium is rich in cyanophilous glands. There are two long anterolateral intestinal pouches which join at the beginning of the gut on its sides.

The rhynchodaeum is surrounded by the cephalic glands. The proboscis septum belongs to the closed type. The rhynchocoel has about 1/3 of the body length. The rhynchocoel wall is composed of a flat epithelium, a layer of longitudinal muscles and a layer of circular muscles. There is a central, curved stylet surrounded by abundant diaphragmatic glands. The wall of the anterior proboscis chamber is composed of a high external epithelium, a layer of circular muscles, a thick layer of longitudinal muscles, and the flat internal epithelium.

In front of the brain there are two blood vessels united by a large commissure. Posterior to the brain there are three blood vessels, one dorsal, situated between the rhynchocoel, and the intestine, and two lateral ones. The dorsal vessel originates from the right lateral vessel.

The nephridia are well developed at the posterior level of the brain and the first part of the stomach.

There are two pairs of cerebral ganglia united by the commissures. The lateral nerve cords have only one core of fibers. The cerebral sense organs are situated ventrolaterally and far anteriorly to the brain.

Besides *E. gracile*, another species of *Emplectonema, E. bürgeri* Coe, 1901, is expected to occur on the mussel beds and other growths in the intertidal zone of the localities 1 and 2 where I have collected *E. gracile. Emplectonema bürgeri* can be separated from *E. gracile* by the following characters: it is up to 1 m. long; dark velvety brown above and creamy-white below; the base of the stylet is short, only a little longer than the central stylet; the latter is weak and straight. Occurrences: Alaska to Monterey Bay, California; Japan. Intertidal zone to 500 m.

Genus **Paranemertes** Coe, 1901.

REFERENCE: FRIEDRICH, 1955, p. 173.

Up to 50 cm. long, more or less stout; two to numerous eyes; subepithelial glands present, also behind the brain, sometimes reaching region of median gut; longitudinal musculature double layered in anterior part of body, internal and external layer separated from each other by a layer of parenchyma, farther behind the parenchyma disappears and the longitudinal muscular layer is uniform; cephalic glands large but not reaching beyond brain; esophagus opens into rhynchodaeum; caecum of median gut short but with paired pouches; rhynchocoel 1/2 or 1/3 of body length; lateral nerve cords with only one core of fibers; cerebral sense organs small, anterolaterally to brain.

Paranemertes peregrina Coe, 1901.

PRINCIPAL REFERENCES: COE, 1901, 1904, pp. 33–36, pl. 2, fig. 6; pl. 3, fig. 5; pl. 7, fig. 7; text fig. 7; 1905, pp. 220–224, pl. 1, figs. 7–9; pl. 16, figs. 95–96; pl. 17, fig. 103; pl. 24, fig. 192; pl. 25, figs. 189–199; text figs. 37–38; 1940, p. 286; 1944, p. 29. IWATA, 1954, p. 15. RICKETTS and CALVIN, 1956, pp. 146–147, 206. YAMAOKA, 1940, pp. 240–243, pl. 17 (in text 4), figs. 3–6; text figs. 17–19.

MATERIAL. Several worms from March to August, 1958. Localities 1, 5. This is one of the commonest and most widely distributed species of nemerteans on the Pacific coast. Very restless, frequently it was found on cloudy days crawling about on the beaches between tides. It occurs from low-tide level well up toward high-water in every habitat, under stones, among seaweeds, barnacles, mussel beds, and on seagrass in mudflats.

DISTRIBUTION. Commander Islands; Aleutian Islands; Alaska to Gulf of California, Mexico; Kamchatka to Japan. Intertidal zone and farther below.

The worms measured in life up to 20 cm. in length and 4 mm. in maximum width. The head is very variable in shape, commonly fan-shaped, flattened dorsoventrally, and a little wider than the adjoining portion of the trunk. The color is also very variable, but the commonest is uniform purplish or dark violet on the back and whitish-yellow on the ventral surface as well as on the margins. The width of the ventral yellow surface is in some worms only a narrow longitudinal stripe, the margins being also purple colored. The color is well preserved after fixation in hot "Susa." The purple head is bordered in front and laterally by the lighter color of the ventral surface. The same color occurs at the posterior border of the head as a small angular spot on each side. Numerous small eyes are arranged in groups on the head. Two groups are situated on the anterolateral margins and the other two are disposed in clusters just in front of the brain.

There is one transverse cephalic furrow, V-shaped, with its apex directed backward.

The glandular epidermis shows the purple pigment of the body in its deepest zone. Before the brain there is a dense muscular net besides the normal muscular layers underneath the epidermis. The cephalic glands are very abundant, scattered among the muscular net fibers and reaching the nephridial region backward. In the anterior part of the body the longitudinal muscles form an internal and an external layer separated by parenchyma. Farther behind the parenchyma disappears.

The esophagus opens into the rhynchodaeum. There are two anterolateral intestinal pouches which reach the posterior border of the brain. They unite under the stomach forming a short median caecum.

The rhynchodaeum opening is a subterminal slit situated ventrally to the frontal sense organ. The rhynchodaeum has a large lumen lined by a high epithelium. The strong proboscis septum, connected with the anterior muscular net, belongs to the closed type. The rhynchocoel reaches about 3/4 the length of the body. Its wall is composed of a flat epithelium, a layer of longitudinal muscles, and a layer of circular muscles. The wall of the anterior proboscis chamber is composed of a high external epithelium, a layer of circular muscles, a layer of longitudinal muscles, and a flat internal epithelium. The 14 longitudinal proboscidial nerves are located on the outer border of the longitudinal muscular layer. The central stylet is small, slender, and sharply pointed as are the accessory ones. All stylets have a braided appearance. The base is very small and pear-shaped. The number of accessory stylet pouches is 2, and each contains from 4 to 6 stylets.

There are a pair of long and large cephalic blood lacunae in the head joined anteriorly by an anastomosis. The three longitudinal postcerebral vessels are well developed, being two lateral and one dorsal, situated between the rhynchocoel and the gut. The nephridia occupy the region behind the brain and are situated above, below, or lateral to the lateral nerve cords. They are provided with numerous branches.

The brain is very simple. It is composed of two pairs of ganglia. The lateral nerve cords have only one core of fibers. The cerebral sense organs are small, simple, and lie well in front of the brain. They open into a slight furrow on the sides of the head, a little in front of them. A frontal sense organ is present.

KEY FOR THE SPECIES OF *Paranemertes*

1. Two ocelli..
P. biocellata Coe, 1944. No record is available of coloration in life. Occurrence: Biloxi, Mississippi. Burrowing in intertidal sand flats and in shallow water.

— More than 2 ocelli..........2

2. With transverse rings..........3

— Without transverse rings..........4

3. Transverse rings as very minute dark brown spots; 12 proboscidial nerves; number of ocelli not known. One can infer from the description of the species (Iwata, 1952, pp. 142–143) that it has more than 2 eyes as it resembles *P. peregrina* with many ocelli..........
P. incola Iwata, 1952. Bright chestnut brown anteriorly, yellow ventrally and marginally. Occurrence: Tomioka, Japan. Under stones near low water-mark.

— Transverse rings whitish; ten proboscidial nerves..........
..........*P. plana* Iwata, 1957. Pale brown with numerous whitish dots besides the rings. Occurrence: Sagami Bay, Japan. From 250 to 300 m. Collected by His Majesty the Emperor of Japan.

4. Stylets with braided appearance; 14 proboscidial nerves; 2 pouches of accessory stylets..........*P. peregrini* Coe, 1901.

— Stylets not braided in appearance: less than 14 proboscidial nerves; more than 2 pouches of accessory stylets..........5

5. Opaque white dorsally and ventrally; 9 to 10 proboscidial nerves; 4 pouches of accessory stylets..........
..........*P. pallida* Coe, 1901. Occurrence: Alaska. Intertidal zone.

— Not opaque white dorsally and ventrally; variable number of proboscidial nerves and pouches of accessory stylets..........6

6. Pale red dorsally and ventrally; 11 or 12 or 13 proboscidial nerves; 6 to 12 pouches of accessory stylets..........
....*P. carnea Coe*, 1901. Occurrences: Alaska to Puget Sound. Intertidal zone.

— Rosy or pinkish anteriorly, often tinged with yellow or orange, intestinal region gray or salmon; 10 to 13 proboscidial nerves; 2, 4, or 6 pouches of accessory stylets ....*P. californica* Coe, 1904. Occurrences: Monterey Bay, California to Ensenada, Mexico. In sandy and muddy flats.

BIOLOGICAL OBSERVATIONS AND EXPERIMENTS. The worms were maintained in sea-water at a temperature between 12 to 15° C. They endure better if some fragments of algae are added. These serve as shady shelter and substratum. In general the worms lasted for about 15 to 20 days under these conditions without food.

Their calm and uniform gliding is accompanied by movements of the tip of the snout to both sides or lifting it. Sometimes they contract rapidly, distend, and indulge in corkscrew and antiperistaltic movements. After about 30 minutes, all worms were sheltered under the pieces of algae.

Acephalous fragments (Friedrich, 1933; Eggers, 1924, 1936; Corrêa, 1953, 1953a) decapitated 5 cm. behind the anterior extremity, do not show any locomotion beyond muscular contractions which could produce a change of place. Only very strong stimuli could bring the peripheral nervous elements to give impulses to the cilia. Cephalic fragments, which contain the brain, behave like complete animals in regard to locomotion. Immediately after the cut, as the cilia continue to beat, they start a calm and uniform locomotion in a rectilinear path. After 24 hours they still are able to present the same sort of locomotion if the water is changed. The accumulation of mucus on the bottom of the dishes impedes the spontaneous gliding.

Paranemertes peregrina belongs to the locomotory type *a* (Corrêa, 1953, p. 548, 554). Spontaneous gliding depends on the brain. The threshold of stimulation of the nervous elements in the postcephalic part is much higher than that of the brain.

The worms are negatively phototactic. When in the nearest corner to the light source of square dishes they glide to the farthest corner. If they have the anterior end directed against the light source they turn round before they glide. The path is very seldom diagonal, as the worms are positively tigmotactic to the borders of the dish. Both paths, the diagonal and the bordering, took the same time to be performed. The same reaction was shown by complete worms and cephalic fragments.

Paranemertes peregrina represents excellent material for classes experiments on food intake in nemerteans, as was already described and illustrated by MacGinitie (1949, p. 162, f. 43). Besides being one of the commonest intertidal species of nemerteans on the California coast, they are voracious feeders (Coe, 1901, 1904, p. 36) and are easily fed in the laboratory with fragments of polychaetes.

Genus **Zygonemertes** Montgomery, 1897.

REFERENCE: FRIEDRICH, 1955, p. 154.

Many eyes, extended backward beyond brain, over and beside the lateral nerve cords, and, specially behind the brain more or less serially disposed; anterior part of body with numerous subepithelial glands (?); esophagus opens into rhynchodaeum; median gut without unpaired caecum directed forward, substituted by two long paired pouches (evidently *Z. capensis* Wheeler, 1934 and *Z. glandulosa* Yamaoka, 1940, with caecum); rhynchocoel reaching the posterior end, its wall double-layered; proboscis thick and short, anterior part of it with only one layer of circular muscles; base of central stylet long, cylindrical, posteriorly truncate, in front of the posterior end generally an annular furrow; lateral nerve cords with one fiber core; anal commissure dorsal to gut; cerebral sense organs large, immediately in front of or near the brain (?), clearly separated from it.

Zygonemertes virescens (Verrill, 1879).

PRINCIPAL REFERENCES: COE, 1905, pp. 214–216, pl. 22, figs. 141–144; 1940, pp. 295–

296, pl. 30, fig. 39; 1943, pp. 270–273; text figs. 63–64; 1944, p. 30; 1951, p. 329; 1951a, pp. 170–171, text figs. 16a–e. Corrêa, 1961, pp. 25–28. Montgomery, 1897, pp. 2–4, pl. 1, figs. 14–15, 23–24, 28. Verrill, 1892, p. 400, pl. 33, figs. 4–4e as *Amphiporus virescens; l.c.*, pp. 400–401, pl. 35, fig. 4; text fig. 4, as *A. agilis*.

Material. Three worms in September, 1958. Locality 10. Not common.

Distribution. Bay of Fundy, New England, and southward to Miami and Key Largo, Florida, and along the Gulf coast at least as far as Pensacola, Florida; Puget Sound to Gulf of California. Intertidal zone to 120 m.

The living mature worms are up to 3 cm. long and 1 mm. wide. The color is variable from white to yellow and green. There are numerous precerebral eyes disposed in irregular rows and postcerebral ones disposed in only one row on each side.

In living worms, flattened between slide and cover-slide, numerous generally sickle-shaped bodies appear, first described in *Emplectonema echinoderma* (Marion, 1830) (Bürger, 1895, p. 124, 216). At a first glance they seem to be calcareous corpuscles. Probably they are extra-cellular secretions, colorless or pigmented, originated from epidermal cells (Coe, 1943, p. 217). The sickle-shaped bodies can also be seen in clarified worms and in sections, as they do not dissolve in the liquids commonly used for preservation.

The large rhynchodaeal pore leads to a very narrow rhynchodaeum. The proboscis septum belongs to the closed type. The rhynchocoel reaches the posterior tip of the body. The proboscis is much shorter. The rhynchocoel wall is composed of an epithelium, a thick layer of longitudinal muscles, and a thin layer of circular ones. The proboscis wall is composed of a high external epithelium, circular muscles, a double layer of longitudinal muscles, circular muscles, and internal epithelium. There are ten proboscidial nerves. The central stylet is shorter than its base which is truncate and posteriorly lobate.

Other species of the genus. The genus *Zygonemertes* is quite uniform in its features. Besides size and color the best character to separate its eleven known species (Corrêa 1961, p. 26) is the number of proboscidial nerves. Two more species occur on the West coast of North America. They can be separated from *virescens* as follows:

1. *Zygonemertes thalassina* Coe, 1904. Closely related to *Z. virescens;* 12 proboscidial nerves. Occurrence: Alaska. Intertidal zone.

2. *Zygonemertes albida* Coe, 1904. Number of proboscidial nerves unknown; whitish, small, only up to 25 mm. long. Occurences: British Columbia to Ensenada, Mexico. Intertidal zone.

Genus **Amphiporus** Ehrenberg, 1831.

REFERENCE: FRIEDRICH, 1955, p. 154.

Generally large, stout forms; seldom none, 2 or 4 eyes, generally many to very many, distributed in groups; cephalic and subepithelial glands present or lacking; cutaneous-muscular tube with or without diagonal layers; dorsoventral muscles generally present; esophagus opens into rhynchodaeum; caecum with pouches of different length; without diverticula of esophagus, stomach or pylorus; rhynchocoel as long as body; nephridial apparatus probably always limited to a short stretch behind the cerebral ganglia; cerebral sense organs anterior to brain, maximally reaching under its anterior border, sometimes small, in the tip of the head, sometimes larger and nearer to the brain (the *A. pulcher*-group differs essentially in this point).

Amphiporus cruentatus Verrill, 1879.

PRINCIPAL REFERENCES: COE, 1904, pp. 154–155, pl. 20, figs. 1–6; 1905, pp. 246–247, pl. 1, fig. 13; text figs. 12, 20, 51–52; pp. 279–280, pl. 22, fig. 161, as *A. leptacanthus;* 1940, p. 299; 1943, pp. 279–281, pl. 3, fig. 1, text figs. 66–67; 1944, p. 30. VERRILL, 1892, pp. 399–400, pl. 33, figs. 7–8a; pl. 35, fig. 3, pl. 39, fig. 9.

MATERIAL. Two worms in April, 1958. Locality 1. Uncommon.

DISTRIBUTION. New England to Florida; Puget Sound to San Diego. California. Intertidal zone to 80 m.

The living, mature worms are up to 25 mm. in length. The head is slender, not wider than the rest of the body, with indistinct cephalic furrows. The color is whitish or pale yellow. There are only a few eyes, about 15, distributed irregularly in two rows, one on each lateral margin of the head. The size of the eyes is variable, the most anterior being the largest ones.

The rhynchocoel is almost as long as the body. The proboscis is also very long and thick. The slender and pointed central stylet is as long as the base. The base is irregularly cylindrical in shape. There are two pouches of accessory stylets each having two to four stylets.

The most striking feature of this small species of *Amphiporus* is the deep red color of the blood, easily seen by transparence through the large vessels in living animals. There are two precerebral vessels united anteriorly by a commissure and three postcerebral ones, two lateral and a dorsal one originated from the right lateral vessel at the level of the brain.

Amphiporus imparispinosus Griffin, 1898.

PRINCIPAL REFERENCES: COE, 1901, 1904, pp. 51–53, pl. 7, fig. 6; text fig. 13, as *A. leuciodus*; 1904, p. 115; 1905, pp. 247–249, pl. 16, figs. 99–100; pl. 25, figs. 195–

197; text fig. 53; 1940, p. 300; 1944, p. 30. GRIFFIN, 1898, p. 210, text figs. 19–20. PUNNETT, 1901, p. 95, as *A. leuciodus*.

MATERIAL. Several worms from March to August, 1958. Locality 1. It is one of the commonest nemerteans in the Dillon Beach area.

DISTRIBUTION. Coast of Siberia; Bering Sea; Alaska to San Diego, California and Ensenada, Mexico. Intertidal zone to 50 m.

The slender, elongated worms measured in life up to 20 cm. in length. The head is narrower than the following part of the body which is flattened posteriorly. The color is uniformly opaque white, sometimes with a pinkish or yellowish tinge. There are two groups of eyes on each side of the head. The anteromarginal groups form elongated rows of 10–12 eyes each, and the posterior groups, nearer the median line, have about the same number of eyes.

The glandular epidermis is moderately high. The basement membrane is thick. Both layers of muscles, the external circular and the thicker internal longitudinal one, attain the tip of the head. Before the brain there is a dense net of muscular fibers. The cephalic glands are not very abundant. They reach backward only the posterior level of the brain.

The large esophagus opens into the rhynchodaeum at the level of the cerebral sense organs. There are two large, branched, anterolateral intestinal pouches which reach forward as far as the brain region. They unite beneath the stomach and form a median caecum provided with lateral diverticula. Also the main gut is provided with diverticula.

The rhynchodaeum opens anteriorly by a large opening. It is lined by a high epithelium and contains a thick muscular coat in its most internal part. The strong proboscidial septum belongs to the closed type. The rhynchocoel is long, reaching almost the posterior end of the body. Its wall is composed of an epithelium, a layer of longitudinal muscles and a layer of circular muscles. The proboscis wall is composed of a high external epithelium, a layer of circular muscles, a thick layer of longitudinal muscles and a flat internal epithelium. There are 16 longitudinal proboscidial nerves, situated in the longitudinal muscular layer. The central stylet is almost as long as the very wide base. The number of pouches of accessory stylets was three in all specimens examined. The number of accessory stylets was 2–3 in each pouch.

There are two precerebral vessels united anteriorly by a commissure and lined by a high epithelium. Posterior to the brain there are three vessels, two lateral and a dorsal one. The nephridia are well developed.

The brain is composed of two pairs of ganglia united by a broad and short ventral commissure and a long and narrow dorsal commissure. The lateral nerve cords have only a core of fibers. The cerebral sense organs are composed of a series of chambers which open to the exterior by one lateroventral cerebral canal and aperture. They lie far in front of the brain. A frontal sense organ is present.

Amphiporus formidabilis Griffin, 1898.

PRINCIPAL REFERENCES: COE, 1901, 1904, pp. 54–56, pl. 3, fig. 1; pl. 7, fig. 5; pl. 11, fig. 3; text fig. 14, as *A. exilis;* 1904, p. 115; 1905, pp. 250–252, pl. 17, fig. 101–102; text figs. 13, 15, 23, 54, 1940, p. 300, 1944, p. 30. GRIFFIN, 1898, p. 211, text figs. 21–23. IWATA, 1952, pp. 144–146, text figs. 15–16.

MATERIAL. Several worms from March to August, 1958. Localities 1, 8. Very common.

DISTRIBUTION. Bering Island, Aleutian Islands, coast of Alaska and southward to Monterey Bay, California; Japan. Intertidal zone and below.

The slender worms measured in life up to 30 cm. in length and 2–3 mm. in maximum width. The commonest color is uniform opaque-white, sometimes pale yellowish-white. The intestinal canal, brain, and lateral nerve cords can be seen by transparence. The eyes, very small but extremely numerous, up to 250, are distributed in four clusters, two anterior and two posterior in the head.

Before the brain there is a dense muscular net. The cephalic glands are very well developed all around the rhynchodaeum. I could not see their posterior limits because there occur abundant submuscular glands at the brain level which show the same aspect as the cephalic ones.

The large esophagus opens into the rhynchodaeum. There are two branched anterolateral intestinal pouches which reach forward to the brain region. They unite beneath the stomach to form a branched and large median caecum.

The large rhynchodaeum is lined by a high epithelium. At its internal end it is coated by a thick muscular layer. The extremely strong proboscidial septum belongs to the closed type. The rhynchocoel is long, reaching almost the posterior end of the body. Its wall is composed of an epithelium, a longitudinal muscular layer, and a circular one. The proboscis is of moderate size. The wall of its anterior chamber is composed of an external epithelium, a layer of circular muscles, a thick layer of longitudinal muscles and a flat internal epithelium. There are about 25–30 proboscidial nerves situated within the longitudinal musculature. The central stylet is slender but its base is very massive. There are usually 6–12 pouches of accessory stylets each bearing 1–2 stylets.

The nephridia are remarkably long and well developed.

The brain is large. The lateral nerve cords have only one core of fibers.

The cerebral sense organs are situated far in front of the brain, ventrolaterally as well as their canal and opening. A frontal sense organ is present.

Other species of the genus. Eighteen species and one variety of *Amphiporus* are known on the Pacific coast of North America (Coe, 1944, pp. 30–31). Besides the three described here, eight more and the variety could occur in the intertidal zone of the localities where I collected. They can be separated by the following characteristics:

1. **Amphiporus angulatus** (Fabricius, 1774). Length 20 cm. or more; dark brown, reddish-brown or purplish-brown on dorsal surface, with paler margins and conspicuous angular whitish spots on each side of head, continuous with whitish ventral surface; a pair of elongated clusters of ocelli situated on the anterolateral borders of the head and a posterior group lies in or near the angular white spot on each lateral margin of head. Occurrences: Circumpolar; Greenland; Davis Strait; Labrador to Cape Cod; Bering Strait; Bering Sea; Aleutian Islands and Kamchatka to Japan; Alaska; British Columbia and southward to Point Conception, California. Intertidal zone to 150 m. or more.

2. **Amphiporus tigrinus** Coe, 1901. Length 10 cm.; color of various shades of lemon, yellow, and yellowish-brown; ocelli irregular in shape and variable in size arranged in two irregular and indistinctly separated clusters on each side of head. Occurrences: British Columbia and Puget Sound. Intertidal zone.

3. **Amphiporus bimaculatus** Coe, 1901. Up to 15 cm. long; dorsal surface, behind the head, deep red, brownish-red or brownish-orange, sometimes yellowish; head whitish with two angular or oval black or very dark brown spots placed symmetrically on dorsal surface; ventral surface pale reddish, or pale orange; ocelli arranged in an irregular, elongated cluster on each anterolateral margin. Occurrences: Sea of Okhotsky; Alaska to Ensenada, Mexico. Intertidal zone to 250 m.

4. **Amphiporus fulvus** Coe, 1905. Length 15 to 25 mm. or more; pale brownish anteriorly, deep brown in intestinal region, much paler beneath; head pale brown; color of body consists of innumerable minute dark brown spots scattered thickly over the ground color. Occurrence: southern California. Intertidal zone to 85 m.

5. **Amphiporus californicus** Coe, 1905. Length 10 to 25 mm. or more; deep red orange with an opaque white tinge, dark, dull yellowish red, or bright red; ventral surface duller and with more whitish. Occurrence: southern California. Intertidal zone to 80 m. or more.

6. **Amphiporus punctatulus** Coe, 1905. Between 35 and 50 mm. in length; in preserved specimens the whole surface of the body is dark mottled brown, the color consisting of innumerable dark dots which run together, forming irregular blotches; the mottling is less complete on the ventral surface. Occurrence: Catalina Island, California. Intertidal zone.

7. **Amphiporus rubellus** Coe, 1905. Length 25 mm. or more; pale orange, or pale red; much paler and usually grayish beneath. Occurrence: southern California. Intertidal zone to 200 m.

8. **Amphiporus flavescens** Coe, 1905. Up to 20 mm.; color very variable, usually whitish, or pale yellow; there are commonly 12 to 25 ocelli arranged in two groups on each side of head. Occurrences: Monterey Bay, California to Ensenada, Mexico. Intertidal zone.

9. **Amphiporus imparispinosus** Griffin, 1898 var. *similis* (Coe, 1905). Differs from the species in having two instead of three pouches of accessory stylets. Occurrences: Puget Sound to Ensenada, Mexico. Intertidal zone and below.

Genus **Tetrastemma** Ehrenberg, 1831.

Reference: Friedrich, 1955, p. 170.

Generally small, slender worms; tip of head with circular and longitudinal muscles as well as retractors; cephalic glands present, very variable in size, sometimes reaching far beyond brain; esophagus opens into rhynchodaeum; caecum of midgut present, with lateral pouches and two more pouches directed forward; pouches of midgut shallow, generally not branched; rhynchocoel as long as body (except *T. hansi* Bürger, 1893), without diverticula; precerebral septum (as far as known) closed; nephridia short, generally with one or two pores; lateral nerve cords with one fiber core; cerebral sense organs generally large situated in front of brain, exceptionally in cerebral region; generally dioecious (except *T. marioni* Joubin, 1890 and *T. caecum* Coe, 1901).

Tetrastemma nigrifrons Coe, 1904.

Principal references: Coe, 1904, pp. 159–164, pl. 15, fig. 7; pl. 16, figs. 6–9; pl. 17, fig. 1; pl. 20, fig. 16; pl. 21, figs. 15–23; 1905, pp. 289–293, pl. 2, fig. 26; pl. 18, figs. 111–115, text figs. 57–59; 1940, pp. 305–306; pl. 31, fig. 42; 1944, p. 31. Iwata, 1954, pp. 30–32, fig. 8 B 1–8; 1957, p. 27, pl. 1, fig. 14. Yamaoka, 1940, pp. 249–251, pl. 3, fig. 14; figs. 9–12; textfigs. 26–29, as *Prostoma nigrifons*.

Material. Two worms in May, 1958. Locality 1. Uncommon.

Distribution. Puget Sound to coasts of Mexico and Costa Rica; Japan. Intertidal zone.

Both worms were 30 mm. long. Variations in color and markings are so striking that several species appear to be represented by individuals which actually present all degrees of intergradation (Coe, 1905, p. 290). My worms had a whitish head with a large, quadrangular dark-brown dorsal marking and a purplish-brown trunk. Their coloration is close to that given by Coe (1904, 1905, 1940) for the variety "purpuratum." Four eyes are situated one on each corner of the head marking.

Other species of the genus. Besides *T. nigrifrons*, five more species of *Tetrastemma* could occur in the intertidal zone of the localities where I have collected. They can be separated by the following external characteristics:

1. **Testrastemma candidum** (Müller, 1774). Recently redescribed by Corrêa (1961, p. 40) is up to 20 mm. long and uniformly whitish or pinkish-white in color. Occurrences: Circumpolar; Greenland and Norway to Madeira; South Africa; Labrador to New England and southward to Miami and Key Largo, Florida; Alaska to Ensenada, Mexico. Intertidal zone.

2. **Tetrastemma bilineatum** Coe, 1904. Only 5 to 10 mm. long; general color creamy or grayish with two sharply defined brown stripes extending nearly along whole length of dorsal surface. Occurrence: San Diego, California. Intertidal zone.

3. **Tetrastemma quadrilineatum** Coe, 1904. Long 8 to 12 mm.; general color of body whitish with four longitudinal brown stripes, two of which are situated near lateral margins of body and the other two placed on dorsal surface. Occurrences: Monterey Bay, California to Ensenada, Mexico. Intertidal zone.

4. **Tetrastemma reticulatum** Coe, 1904. About 8 to 15 mm. long; ground color white with rectangular and longitudinal brown markings; head provided with a brown marking. Occurrence: southern California. Intertidal zone.

5. **Tetrastemma signifer** Coe, 1904. About 15 to 25 mm. long; general color of body deep reddish-brown or purplish except for the head which is white with a dark brown marking formed by a transverse, basal portion, from which two semicircular branches pass anteriorly. Occurrences: Monterey Bay, California to San Diego, California. Intertidal zone to 10 m.

Genus **Prostoma** Dugès, 1828.

Reference: Friedrich, 1955, p. 162.

In general small, up to 3.5 cm. long; none to six eyes; muscular-cutaneous tube without diagonal layer; tip of head with longitudinal muscles; cephalic glands short, only precerebral; midgut without or with very short unpaired blind pouch; only with two pouches directed froward; special pylorus tube not developed; true esophagus absent; rhynchocoel generally not reaching the posterior end, its wall musculature not crossed; blood vessels without brain commissures, the dorsal vessel arises from one of the lateral vessels; nephridia well developed, with many pores; cerebral sense organs before the brain, relatively simple; hermaphrodite.

? **Prostoma rubrum** (Leidy, 1850).

Principal references: Coe, 1940, p. 308; 1943, pp. 299–301, text fig. 75; 1959, pp. 366–367, text fig. 14. Cordero, 1943, pp. 125–134, figs. 1–2. Corrêa, 1951, pp. 257–264, pl. 1, figs. 1–5; pl. 2, figs. 6–11. Montgomery, 1896, pp. 436–438. Rioja, 1941, pp. 663–668, text figs. 1–4. Wijnhoff, 1938, pp. 219–230.

Material. Three worms in August, 1958. Locality 3. The species occurs in large numbers at that season (Coe, 1943, p. 299).

Distribution. New England to Georgia and Florida and westward to Ohio, Nebraska, Washington, and California; Xochimilco, Mexico and perhaps Caracas, Venezuela.

The living worms were up to 18 mm. long and 1.5 mm. wide. The anterior end is rounded and the posterior is pointed. The color of the three specimens was pale yellow or whitish. There are three pairs of small eyes disposed in two rows in front of the brain. An indistinct transverse cephalic furrow is present at the posterior level of the eyes.

The rhynchocoel is long as is also the proboscis. The central stylet is short. The base is pear-shaped and as long as the stylet. Two pouches are present, each containing 2–4 accessory stylets.

The unfavorable conditions of collecting and preserving made it impossible to obtain more information and a larger number of specimens.

In her synopsis of the genus *Prostoma*, Stiasny-Wijnhoff (1938) records 16 different names applied to freshwater nemerteans and gives their bibliography. Six species are recognized as valid in her revision, viz., *P. lumbricoideum* Dugès, 1828; *P. graecense* (Böhmig, 1892); *P. eilhardi* (Montgomery, 1895); *P. grande* (Ikeda, 1913); *P. padanum* Pierantoni. 1926; and *P. puteale* Beauchamp, 1932. Strangely enough, *P. rubrum* (Leidy, 1850) does not figure in Wijnhoff's list, although Coe (1940, 1943, 1959) revalidated this name for the specimens described from North America

(*P. aquarum-dulcium* Silliman, 1885, from New York State and *P. asensoriatum* Montgomery, 1896, from Pennsylvania) and Rioja, 1941, for specimens found in Xochimilco, in the vicinity of Mexico City, the most meridional known occurrence of the species. The South American specimens from Venezuela (Cordero, 1943) were not determined; they could belong to *P. rubrum* as the frontal sense organ was stated (p. 129) as absent. Friedrich (1955, p. 163) records *P. rubrum* in his list of species of *Prostoma*.

Wijnhoff (p. 6) considers the North American species and *P. graecense* as identical, but hesitated to introduce the corresponding change of the name because she had not seen North American material. As the name *P. asensoriatum* indicates, the American species has no supra-oral or frontal sense organ. In Montgomery's opinion (1896, p. 436) the cephalic glands of *P. asensoriatum* open individually, scattered on the frontal side. *Prostoma graecense*, however, has a frontal organ toward which the ducts of the cephalic glands converge (Böhmig, 1898, pp. 481, 536). Even Reisinger (1926, pp. 2–3), who unites all central European species under the name of *P. graecense*, maintains the North American species separated.

The living worms from California examined with regard to the presence of a frontal sense organ have shown it, and I confirmed it in preserved and cleared state as well as in sections. However, the sections were not good enough to reveal other very delicate characteristics of this species, *e.g.*, the ciliated epithelium in the esophagus and true layer of thick longitudinal muscles of the rhynchodaeum (Corrêa, 1951, pp. 259, 262). In the sections of the California worms I did not see the calcareous corpuscles in the parenchyma characteristic of *P. graecense*. Only further study of the California species of *Prostoma* could elucidate its exact systematic status.

Malacobdella blainville, 1827.

Reference: Friedrich, 1936, p. 44.

Posterior end of body with a sucker; buccal cavity villous, serving for food intake; intestine sinuous; midgut without lateral pouches; rhynchodaeum absent; proboscis without stylet.

Malacobdella grossa (Müller, 1776).

Principal references: Bürger, 1895, p. 597, pl. 18, figs. 1–5; pl. 23, fig. 39; pl. 27, figs. 21–23; pl. 28, figs. 25, 28, 39. Coe, 1940, p. 310; 1943, pp. 309–310, text fig. 79; 1944, p. 32. Gering, 1911, pp. 673–720, pl. 32, figs. 1–13; text fig. 1. Guberlet, 1925, pp. 1–13, pl. 1. Hammarsten, 1918, pp. 1–95, figs. 1–26, text figs. 1–18. Ricketts and Calvin, 1956, pp. 195–196. Riepen, 1933, pp. 323–496; text figs. 1–63 (the most complete work done on the species). Verrill, 1892, pp. 444–445, pl. 39, fig. 23, text fig. 9, as *M. obesa* and *M. mercenaria*.

Material. One worm in July, 1958. Locality 4. A second specimen was received from Dr. Liliana Forneris, Oceanographic Institute, São Paulo, (Brazil), collected during her stay at the University of Kiel (Germany), 1959. The latter worm was found in the mantle cavity of the lamellibranch *Arctica (Cyprina) islandica* (Linnaeus). Occurrence: Stoller Grund, Bay of Kiel, Germany. *Riepen* (1933) studied material from the same locality.

Distribution. Northern coasts of Europe, Mediterranean; Nova Scotia to Chesapeake Bay, Atlantic coast of North America and Puget Sound to California, Pacific coast.

The length of both present specimens, in preserved state, was about 15 mm. The maximum width, situated at the posterior half of body, was 5 mm. The body is short, broad, and thick. The anterior end is rounded and contains a large and excavated mouth, which serves as aperture for the atrium and proboscis. The posterior end is provided with a sucker. The worms cleared in clove oil showed atrium, esophagus, stomach, midgut, rectum, anus, brain, nervous commissures, lateral nerve cords, proboscis, rhynchocoel, and gonads.

The broad, villous atrium extends from near the tip of the head to the brain commissures where the proboscis opens into its dorsal wall. Posterior to the proboscis opening the digestive canal continues as esophagus without any change in size of lumen or in character of the lining epithelium of short ciliated cells. The esophagus is followed by the stomach. Its lumen is narrower, the ciliated epithelium is higher and the subepithelial glands in the parenchyma become more numerous. There is only a gradual transition in the lumen and epithelium of the esophagus and stomach and of the stomach and midgut. The midgut bends alternately to the left and right, forming at least six loops on the right and seven on the left side. The midgut terminates in the rectum which opens by the anus on the dorsal side of the sucker.

The rhynchocoel extends nearly along the whole length of the body, while the proboscis is much shorter reaching backward less than half that length. The unarmed proboscis fills most of the rhynchocoel and follows its coiling. The unusually long proboscidial retractor attains the posterior end of the rhynchocoel.

There are two much branched and convoluted lateral vessels united by three commissures, one anterior cephalic, one esophageal, situated on the dorsal side of the esophagus, from where the convoluted dorsal vessel arises, and one anal which unites the three vessels behind. The dorsal vessel lies between rhynchocoel and gut; the lateral vessels run on the sides of the body, close to the lateral nerve cords.

A single pair of nephridia extend from near the brain to the region of the stomach. The branched tubules lie in the parenchyma close to lateral nerve cords and lateral vessels. They unite posteriorly to form a pair of large efferent ducts which lead to the exterior on the ventrolateral surface of the body.

The long cerebral ganglia are widely separated by the broad atrium and connected by a small dorsal and a large ventral commissure. The ventral commissure passes between rhynchocoel and atrium and the dorsal one between rhynchocoel and body wall. Anterior, lateral, and posterior nerves arise from the ganglia. The lateral nerve cords are united posteriorly by a slender suprarectal commissure. Some other commissures and nerves arise from the cords along their course. Eyes and sense organs are wanting.

Both specimens, sexually mature females, had many ovaries situated on both sides of the body, irregularly scattered from the limit between esophagus and stomach to the rectal region. Each gonad has a dorsal opening.

The Order Bdellomorpha consists of a single genus, *Malacobdella*. Besides the here-described species, three more are known which can be separated by the somewhat modified Coe's key (1945, p. 67).

1. Commensal in marine lamellibranchs..2

— Commensal in fresh-water gastropods..................*M. auriculae* Blanchard, 1847. Occurrence: Chile. In the pallial cavity of *Chilina dombeyana* Brug.

2. Proboscis sheath nearly as long as body; posterior commissure of nerve cords on dorsal side of rectum..3

— Proboscis sheath only two thirds as long as body; posterior commissure of nerve cords in sucker..................*M. japonica* Takakura, 1897. Occurrence: Coasts of Japan. Commensal in the mantle cavity of *Spisula sachalinensis*.

3. Nephridiopores on dorso-lateral surfaces; gonads large, situated in a single row on each side of body..
M. minuta Coe, 1945. Occurrence: Off Point Loma, Southern California, at a depth of 40 m. Commensal in the mantle cavity of *Yoldia cooperi* Gabb.

— Nephridiopores on ventro-lateral surfaces; gonads relatively small and numerous, irregularly scattered..................*M. grossa* (Müller, 1776).

As the main purpose of this paper is to determine the intertidal species of nemerteans occurring along the California coast, I add a list of 11 more species not collected by me but recorded by Coe (1944, pp 27–32).

1. **Carinomella lactea** Coe, 1905. Recently redescribed by Corrêa, (1961, pp. 8–11, fig. 8). Length 50–100 mm.; general color of body milk-white, more or less translucent; after preservation a brown band appears about 5 mm. back from the tip of the head, which fades backward. Occurrences: Biscayne Bay, Miami, Florida; Monterey Bay, California to San Diego, California. Intertidal zone to 20 m.

2. **Baseodiscus punnetti** (Coe, 1904). Large species, 40–60 cm. long; general color deep brownish-red; anterior tip is much deeper brown, marked off from a narrow terminal and lateral white border; ocelli as an irregular longitudinal row of 40–60 or more on the anterolateral margins of head. Occurrences: Monterey Bay, California to Gulf of California, Mexico. Intertidal zone to 380 m.

3. **Zygeupolia rubens** (Coe, 1895). Rather slender, 5–8 cm., long; head pure white; esophageal region white or pale yellow; intestinal region from rose to pale yellow, light brown or chocolate-brown; white caudal cirrus present; cephalic furrows absent. Occurrences: New England and southward to North Carolina; Monterey Bay, California to Ensenada, Mexico. Intertidal zone to 50 m.

4. **Euborlasia nigrocincta** Coe, 1940. Up to 50–70 cm. long; there are two color varieties: the darker is rich purplish brown dorsally and ventrally; head white with fine red or brown dots except the tip; the paler is rosy with reddish brown or purplish dots dorsally; head white or pink; ocelli absent. Occurrences: San Francisco Bay, California; Monterey Bay, California to Ensenada, Mexico. Intertidal zone to 30 m.

5. **Nemertopsis gracilis** Coe, 1904. Commonly 10–15 cm. long; whitish with two longitudinal bands of deep brown along the whole length of body; four ocelli. Occurrences: Puget Sound to Ensenada, Mexico. Intertidal zone and below.

6. **Nemertopsis gracilis** var. **bullocki,** 1940. Differs from the typical form in having the longitudinal brown bands connected anteriorly and sometimes interrupted at intestinal region. Occurrence: coast of central California. Intertidal zone.

7. **Dichonemertes hartmanae** Coe, 1938. Small, 10–15 mm. long; pale red or yellowish with deep red blood; four ocelli; hermaphrodite. Occurrence: San Diego, California. Intertidal zone.

8. **Carcinonemertes epialti** Coe, 1902. Commensal on crabs of the genera *Portunus, Pugettia,* and *Euphylax.* Occurrences: Monterey Bay, California, to San Diego, California; Peru.

9. **Ototyphlonemertes spiralis** Coe, 1940. Minute, 3–5 mm. long; white, gray, straw color or yellow; ocelli absent; statocysts containing statolith with 8, 12, or 16 globules. Occurrence: San Diego, California. On sandy shores of bays.

10. **Prosorhochmus albidus** (Coe, 1895). Usually 10–15 mm. long; milk-white or creamy; four ocelli; two ocelli of same side united by a fine line

of dark pigment. Occurrences: Monterey Bay, California, to Ensenada, Mexico. Intertidal zone.

11. **Oerstedia dorsalis** (Abildgaard, 1806). Recently redescribed by Corrêa (1961, pp. 23–24). Up to 15 mm. long; color light cream irregularly spotted with brown of various shades and with considerable variations in shape and distribution; four ocelli. Ocurrences. Circumpolar; Norway to Mediterranean; Madeira; Nova Scotia to Miami, Florida and Key Largo, Florida; Puget Sound to Gulf of California. Intertidal zone and below.

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PHYLLOPHAGA SAYLORI, N. SP., FROM NUEVO LEON, MEXICO (COLEOPTERA: SCARABAEIDAE)

By

Milton W. Sanderson

Illinois Natural History Survey,
Urbana, Illinois

Jean Mathieu, Instituto Technologico y de Estudios Superiores in Monterrey, Nuevo Leon, Mexico, made a special search for *Phyllophaga galeanea* Saylor (1943: 28) on May 12 and 13, 1961, at its type locality, Galeana, Nuevo Leon. He examined various plants, including *Pinus* and *Juniperus,* suspected as possible hosts, but without success. Mr. Mathieu slept under the pines that night, and early next morning he noted a large species of *Phyllophaga* dropping from the high pine foliage to the forest floor. It is a new species in the *"ignava"* group, as defined by Sanderson (1958: 160, 172), and it is unique in several features among some 30 known species in that group.

This species is named in honor of Mr. L. W. Saylor, Head of the Material Department, Administrative Branch, Naval Supply Depot, Oakland, California. From 1934 to 1948, Mr. Saylor published some 35 papers on New World *Phyllophaga* in which he described many new species. He is especially to be credited, however, with breaking the taxonomic impasse which existed in the Central American and Mexican literature since the publication of the *Biologia* portion treating this genus. Until he began his studies for that area, it was virtually impossible to identify species from the literature. He illustrated male genitalia and prepared keys to several groups of species, making it possible to recognize a large proportion of the species in Mexico and Central America. The Saylor collection of *Phyllophaga* and other Scarabaeidae is now located at the California Academy of Sciences.

I am indebted to Jean Mathieu for the specific determination of the pine.

Phyllophaga saylori Sanderson, new species.

(Figures 1–7.)

HOLOTYPE. Male. Illinois Natural History Survey, collected 4 km. south of Galeana in Nuevo Leon, Mexico, at 6000 feet, May 13, 1961, by Jean Mathieu. Dropped from *Pinus teocote* about 5 o'clock in the morning. *General appearance.* A large plump brownish beetle, the posterior margin of the elytra (fig. 7) reflexed. *Length* 24 mm.; width 12.5 mm. *Head.* Antenna 10-segmented, 3-segmented club short, approximately equal in length to five preceding segments combined, and approximately equal in length to clypeus at middle. Clypeus evenly rounded to the slightly emarginate apex, apical margin strongly reflexed in anterior one-third, clypeal punctures shallow, generally closely placed, separated on the average by less than their own widths; frons similarly punctured but with irregular impunctate areas, especially adjacent to clypeo-frontal suture. Labrum exposed when viewed from above. Pronotum 1.6 times as wide as long, finely and very irregularly punctured, some punctures separated from others by from one to six times their widths; lateral margins broadly and faintly crenulate, nearly parallel in basal one-half; basal angle distinct, approximately 135 degrees, anterior angle not produced. *Elytra* rather strongly flared posteriorly, widest at about apical one-third, sutural costa very broad at middle, narrowed toward apex and scutellum, with irregularly scattered punctures; a large diagonal nearly impunctate costa arising near middle of base of elytron, expanded and extended toward sutural apex; apical margin of each elytron (fig. 7) strongly reflexed; entire lateral margin of elytron, except near sutural apex, with a conspicuous fringe of long hairs. *Abdomen.* Pygidium nearly evenly convex for most of its length, more strongly convex before apex, very irregularly and shallowly punctured, glabrous. Abdomen in lateral view (fig. 7) strongly convex to the narrowly transversely impressed posterior margin of the penultimate sternite; surface shining, nearly impunctate on disc, punctures dense in a median patch on posterior one-half of penultimate sternite; three abdominal sutures on disc slightly produced anteriorly at middle; last sternite flattened, about one-half length of penultimate. *Mestasternum.* Densely punctured toward sides, more sparsely punctured at middle, with long hairs not quite as long as greatest width of middle femur. *Legs.* Anterior tibia tridentate; each anterior tarsal segment with a ventral longitudinal carina, carinae of first four segments each terminating in a strong internal tooth; each tarsal claw with a long nearly median tooth (fig. 6); apical margin of posterior tibiae each with 22 and 24 strong setae; apical tibial spurs slender, longer spur a little longer than first posterior tarsal segment; posterior tibia without special modifications. *Genitalia* (figs. 1–3) asymmetrical, apical lobe of each paramere free, slender; one of the two lobes of paramere base (fig. 3) more expanded at apex than the other; aedeagus (fig. 2) bearing two strongly curved processes one one side, one longer than the other.

Paratypes. Eleven males and two females, all collected at the type locality, and except three males collected at light, under the same conditions. California Academy of Sciences; Instituto Technologico y de Estudios

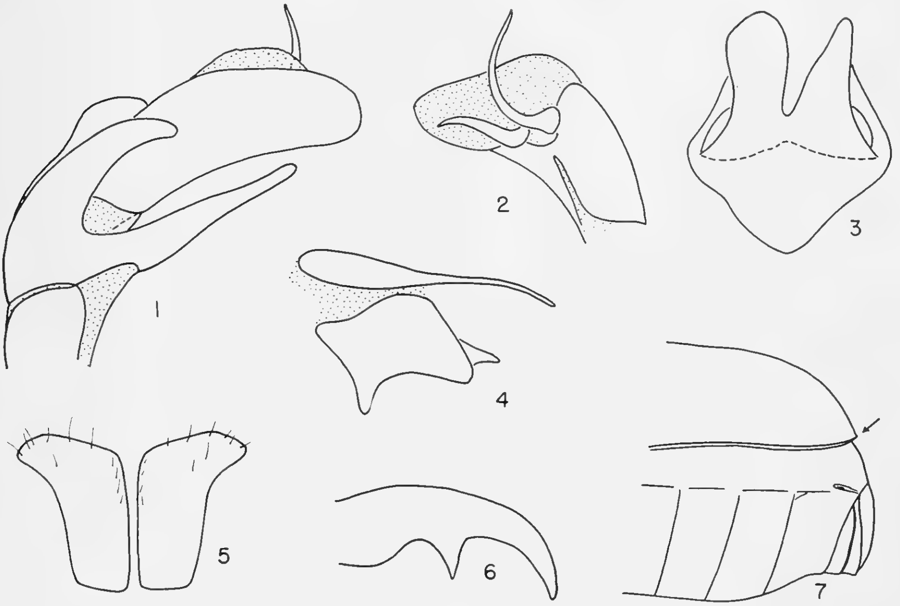

Figure 1. Left lateral view of male genitalia, *Phyllophaga saylori.*

Figure 2. Right lateral view of aedeagus of male genitalia, *Phyllophaga saylori.*

Figure 3. Dorsal view of asymmetrical base of parameres of male genitalia, *Phyllophaga saylori.*

Figure 4. Anal plates of female, *Phyllophaga saylori.*

Figure 5. Pubic processes of female genitalia, *Phyllophaga saylori.*

Figure 6. Tarsal claw of right foreleg of male, *Phyllophaga saylori.*

Figure 7. Lateral view of elytron and abdomen of male, *Phyllophaga saylori.* Arrow indicates reflexed elytral margin.

Superiores in Monterrey, Nuevo Leon; Illinois Natural History Survey. Males vary in color from light brown to dark brownish red; length 21 to 25 mm.; width 11 to 12.4 mm. The pronotum ranges from 1.67 to 1.90 times as wide as long, and the posterior tibial setae from 17 to 24. The female is similar to the male except as follows: antennal club shorter than clypeal length; pygidium deeply, narrowly grooved at apex; abdomen more pointed, last sternite longer, about two-thirds length of penultimate sternite. Pubic process of female genitalia divided (fig. 5); anal plates as in figure 4.

DISCUSSION. The genitalia of one dissected male are paler in color and less heavily sclerotized than other males, suggesting recent transformation from the pupal stage. The reflexed apical elytral margin, and the asymmetrical male genitalia will distinguish this species from all other known members of the "*ignava*" group. In size and appearance, *P. saylori* resembles *P. torta* LeConte (Mexico, United States), and *P. pleroma* Reinhard (Texas), both belonging to the "*ignava*" group. The symmetrical male genitalia will at once distinguish the two species from *P. saylori*.

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OSTEOLOGICAL CHARACTERISTICS AND AFFINITIES OF THE HEXAGRAMMID FISHES, WITH A SYNOPSIS[1]

By

Jay C. Quast
U.S. Bureau of Commercial Fisheries Biological Laboratory,
Auke Bay, Alaska

ABSTRACT

Representatives of hexagrammid genera are analyzed for skeletal features, and the findings compared with original and published data on other mail-cheeked fishes (suborder Cottoidei). Perciform groups suggested in the literature as possible mail-cheeked allies are also examined. Results indicate that the fish skeleton has numerous characteristics of taxonomic importance that have been used little or not at all. Examples include caudal structure, dorsal pterygiophore patterns, and ratios between dorsal fin spines, pterygiophores, and vertebrae. Taxonomic findings indicate that the present classification of mail-cheeked fishes, based on Regan's work of 1913, is in need of revision. The Hexagrammidae and Zaniolepididae are probably primitive offshoots of the cottid evolutionary line and the three groups should be placed in the same superfamily. The zaniolepidids are generally intermediate between the hexagrammids and cottids. The Anoplo-

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pomatidae (*Anoplopoma, Erilepis*) are sufficiently distinct from the scorpaenids and hexagrammid-cottids to warrant a separate superfamily. The mail-cheeked fishes may be an artificial assemblage containing at least three distinct evolutionary lines, scorpaenid, anoplopomatid, and hexagrammid-cottid. The findings are summarized in a synopsis.

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INTRODUCTION

The nine extant species of the family Hexagrammidae form an important element in the mail-cheeked fish fauna of the North Pacific Ocean. The phyletic position of the family within the mail-cheeked fishes (suborder Cottoidei) has been uncertain with considerable difference of opinion concerning where the family lines should be drawn. To investigate these and related questions, I undertook an osteological study of the family and its purported members and allies as part of my doctoral problem at the University of California at Los Angeles.

The mail-cheeked families listed by Berg (1940) and the Serranidae and Cirrhitidae are compared for features of cranium, axial skeleton, and appendicular skeleton. The Serranidae and Cirrhitidae are included because one or both of these families are usually mentioned by students of the phylogeny of the mail-cheeked fishes, e.g. Gill (1889), Jordan and Evermann (1898), and Regan (1913). The findings, as brought out in the discussion, indicate that considerable changes should be made in the arrangement of the families in the suborder and that the suborder is probably polyphyletic. To facilitate comparisons, the findings are summarized in a synopsis, with special emphasis on comparisons with the Hexagrammidae.

Taxonomic changes in several species follow the recommendations of Quast (1960): *Oxylebius pictus* and *Ophiodon elongatus* are in monotypic subfamilies under the Hexagrammidae; the Japanese *Agrammus agrammus* is placed in the genus *Hexagrammos;* and the nominal species *Hexagrammos superciliosus* and *H. lagocephalus* are synonymized under *H. lagocephalus.*

MATERIALS AND METHODS

Skeletal material included X-ray photographs, boiled fresh specimens, Clorox- or Purex-treated preserved material, and dissections (table 1). Dissection and study of skeletal material were sometimes facilitated by alizarin staining, with the specimens being dissected to the vicinity of the skeletal elements to aid stain penetration. Techniques of Green (1952) generally were followed except for storage of specimens in a 50 per cent isopropyl alcohol solution before fine dissections. Clearing in glycerine, was avoided when further examination was contemplated because of resultant slipperiness and irregularities of light refraction.

In skeletal preparations the entire fish was immersed in very hot, but not boiling, water with a detergent. Skeletal elements were removed as they loosened and were cleaned with a toothbrush. Care was taken not to cook the fish so extensively that neurocranial bones became separated or vertebral column and hypural fan became disarticulated. Jets of water and air were useful for removing soft tissues after cooking. When dry, some fatty bones were degreased by soaking for a week or more in toluene or xylene.

No one method of preparation is entirely satisfactory for material used in osteological studies, and two or more methods should be used on separate specimens of the same species when possible. Although dry skeletal preparations are superior for neurocranial study, dissections and alizarin stain-

Table 1.

Number of specimens examined

Symbols for the columns represent method of examination: X, X-ray; S, alizarin staining; C, cooked or Clorox-treated material.

	X	S	C
Holocentridae			
Holocentris suborbitalis	1		
Myripristis clarionensis	1		
Serranidae			
Alphestes galapagensis	1		
Alphestes multiguttatus	2		
Dermatolepis punctata			1
Diplectrum macropoma	1		
Epinephelus analogus			1
Mycteroperca jordani			1
Paralabrax auroguttatus	1		
Paralabrax clathratus		1	
Paralabrax nebulifer	1		
Paranthias colonus	1		1
Stereolepis gigas			1
Centrarchidae			
Micropterus salmoides	1		
Sciaenidae			
Micropogon altipinnis	1		
Cichlidae			
Cichlasoma dovii	1		
Pomacentridae			
Eupomacentrus beebei	1		
Cirrhitidae			
Cirrhitus marmoratus	1		
Cirrhitus rivulatus		1	1
Paracirrhites arcatus	1		
Scorpaenidae			
Dendrochirus chloreus		1	
Pterois antennata	1		
Scorpaena guttata	1		1
Scorpaena mystes	1		
Scorpaena sp.			1
Sebastiscus marmoratus	1		
Sebastodes chlorostictus	1		1
Sebastodes melanops		1	
Sebastodes paucispinis	1		

TABLE 1.—Continued

Scorpaenidae—Cont.	X	S	C
Sebastodes serriceps			1
Sebastolobus alascanus	1		
Sebastolobus altivelis	2	1	
Triglidae			
Prionotus albiostris	1		
Prionotus stephanophrys	1		1
Hexagrammidae			
Hexagrammos agrammus	16		1
Hexagrammos decagrammus	20		3
Hexagrammos lagocephalus[1]	38	1	1
Hexagrammos octogrammus	20		
Hexagrammos otakii	12		
Hexagrammos stelleri	24		
Ophiodon elongatus	19	1	2
Oxylebius pictus	39	1	1
Pleurogrammus monopterygius	10		
Zaniolepididae			
Zaniolepis frenata	4		
Zaniolepis latipinnis	6	1	1
Anoplopomatidae			
Anoplopoma fimbria	2	1	3
Erilepis zonifer	3		
Platycephalidae			
Platycephalus sp.		1	
Cottidae			
Artedius notospilotus	2		1
Chitonotus pugetensis			1
Clinocottus analis			3
Cottus bairdii			1
Enophrys bison			1
Hemilepidotus hemilepidotus	1		1
Icelinus sp.			4
Leptocottus armatus			2
Leiocottus hirundo	1		
Oligocottus sp.			2
Radulinus sp.			1
Scorpaenichthys marmoratus	1	1	2
Cyclopteridae			
Liparis dennyi	2		
Liparis florae	2		

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[1] Includes *H. superciliosus.*

ing, or clearing and staining, are more useful for other skeletal parts. Conventional X-rays are of little value for head structure or fine osteological detail.

Skeletal terminology follows Harrington (1955) for the neurocranium, and Starks (1901) and Merriman (1940) for vertebrae, ribs, and caudal skeleton. The term "pterygiophore," standardized by Eaton (1945), is employed for the median fin supports. Names and arrangements of taxonomic groups follow Berg (1940) except for erection of the family Zaniolepididae. (For reference figures of generalized serranid and scorpaenid skeletons see Starks (1898, 1901).)

OSTEOLOGY

Splanchnocrania of the families Serranidae, Cirrhitidae, Scorpaenidae, Hexagrammidae, Zaniolepididae, and Cottidae are closely similar and appear to have only a few trenchant differences at the family level. Size and arrangement of toothed upper pharyngeals and number of branchiostegals may differentiate some families. There are considerable differences in shape and degree of development of splanchnocranial elements between species and genera within some families (for example, see Matsubara, 1943), and family lines are very difficult to draw for these structures. None of the families show the extreme flattening of the skull exhibited by *Platycephalus*. Preopercular spines are absent in all hexagrammids except *Ophiodon*, which has them feebly developed.

TOOTHED UPPER PHARYNGEALS.

The number of paired upper pharyngeal bones is important to the taxonomy of the mail-cheeked fishes. This was first recognized by Cope (1871), who stresses this character in addition to the presence or absence of a myodome. Gill (1889) discusses Cope's taxonomic use of the upper pharyngeals and concludes that they are probably not of great importance. However, Regan (1913) finds them useful and includes them in his synoptic key and discussion.

The representatives of the Serranidae, Cirrhitidae, Scorpaenidae, Hexagrammidae, Zaniolepididae, and Anoplopomatidae have three separate pairs of toothed upper pharyngeals. Similar number and arrangement are figured for *Roccus saxatilis* by Merriman (1940), for *Sebastolobus alascanus* by Starks (1898), and for Platycephalidae by Matsubara and Ochiai (1955). All species with three pairs have the upper pharyngeals attached to branchial arches 2–4. Cottid representatives (three genera, three species examined) contrast in having only two pairs of upper pharyngeals (or but one pair in some representatives according to Taranets, 1941). The paired pharyngeals of the cottids occupy arches 2–4 and the third and fourth arches lead to the second pharyngeal only instead of the second and third pharyngeals as in the other families. The evidence strongly supports Regan's view that the large second upper pharyngeal of Cottidae actually represents coalescing of primitively separate second and third elements.

Although hexagrammids and zaniolepidids resemble the serranids, cirrhitids, scorpaenids, anoplopomatids, and platycephalids in having three pairs of upper pharyngeals, they differ by having the last pair reduced in size. In all but *Oxylebius pictus,* the third pair is less than one-half the size of the first pair. In *O. pictus* the size is larger, slightly greater than one-half. In *Anoplopoma fimbria* the first and third pairs are of approximately the same size and only slightly smaller than the second; in *Erilepis zonifer* the first pair is considerably smaller than the second.

Upper and lower pharyngeals have simple teeth of approximately the same size as those in the jaws in all hexagrammid genera but *Ophiodon,* which has canine jaw teeth. All Serranidae, Cirrhitidae, and mail-cheeked fishes have one pair of lower pharyngeals.

BRANCHIOSTEGALS.

Six branchiostegals are found in the Hexagrammidae, Zaniolepididae, Anoplopomatidae, and most Cottidae. The uppermost and outermost is attached to the epihyal and the next branchiostegal is attached to or slightly lateral to the epihyal-ceratohyal junction. Two more are attached to the lateral, wide section of the ceratohyal, and the innermost two are on the medial, narrow part. The branchiostegal arrangement of the group is the same as that of *Cirrhitus rivulatus,* which differs, however, in having the innermost ray shortened considerably. According to Jordan and Evermann (1905), cirrhitid branchiostegals number from three to six, and usually six.

Seven branchiostegals characterize the Serranidae, Scorpaenidae, Triglidae, and Platycephalidae examined by boiling or staining. The additional branchiostegal not found in the hexagrammids and cottids appears to be one of three attached to the innermost, narrow portion of the ceratohyal. Jordan and Evermann (1905) characterize the serranids as having "normally 7 (occasionally 6)" branchiostegals and Matsubara (1943) found a similar branchiostegal number and arrangement for all but three of 33 scorpaenoid genera; *Cocotropus, Aploactis,* and *Erisphex* have six rays.

NEUROCRANIUM

SUBORBITAL BONES

The well-developed suborbital stay of the hexagrammids conforms most closely to the scorpaenid type 2 described by Matsubara (1943). Its posterior extremity is truncate and attached to the preopercle. However, the attachment does not appear to be as firm as that in the scorpaenoid fishes.

Five was the maximum number of suborbital elements, excluding the lachrymal, found in the perciform groups. Among the mail-cheeked fishes, the hexagrammids and some marine cottids show the most generalized condition in which the postorbital suborbitals lie separately between the second suborbital and the sphenotic. The fifth, uppermost suborbital of the hexagrammids lies over the sphenotic projection, bearing the same relationship to the sphenotic as in other representatives of the mail-cheeked fishes. It is undoubtedly the same as Allis' (1909) prefrontal and Harrington's (1955) dermosphenotic. *Zaniolepis* has only one free suborbital behind the orbit: the dermosphenotic is firmly attached to the sphenotic and the second and third suborbital elements appear to be fused. In his figures of freshwater cottids and comephorids of Lake Baikal, Taliev (1955) shows from one to all of the last three suborbitals missing. *Anoplopoma* also has a reduced condition in which only one of the last three is evident. In *Cirrhitus* and the serranids and scorpaenids, the fifth suborbital (dermosphenotic) is firmly attached to the sphenotic. Matsubara (1943) found a high degree of variation in the scorpaenids and their allies in regard to presence or absence of the third and fourth suborbitals.

SUPRATEMPORAL CANAL

This sensory canal extends dorsally from the junction of pterotic and main lateral line canals to the skull vertex. In the Serranidae and Cirrhitidae each supratemporal canal transverses three small scale bones that are free from the skull, a relationship very similar to that shown for *Perca* by Cuvier and Valenciennes (1828). In the mail-cheeked fishes, the ossicles carrying this canal appear to be fused to the parietals, and are actually fully enclosed by a posterior parietal ridge in some forms. These findings agree with those of Allis (1909), who discusses and figures these elements for representatives of varied fish groups, including several mail-cheeked forms. They agree also with Harrington (1955), who discusses the canal's homologies in various teleost groups.

Important differences in the arrangement of this canal distinguish some hexagrammids, cottids, and some other mail-cheeked fishes. Frequently the differences are visible in figures from the literature. In the hexagrammids, zaniolepidids, and some cottids, the supratemporal canal is in the form of a raised bony tube on the dorsal surface of the parietal (figure 1). It traverses the middle or anterior sections of the parietal in all hexagrammids except *Ophiodon,* in which it extends along the posterior parietal margin. In the scorpaenids, *Anoplopoma,* and other cottids, in contrast, the supratemporal canal is enclosed by the posterior margin of the parietal and emerges near the midline, never appearing in the form of a raised bony tube.

The first accessory lateral line in the two species of *Hexagrammos* that were examined for this feature *(H. decagrammus* and *H. lagocephalus)* was found to originate on the occiput at the junction of the supratemporal canals, with the lumen of the line and the canals seeming to be continuous. Rutenberg (1955) figures and describes the supratemporal canals in representatives of two hexagrammid genera and uses their weak development in *Pleurogrammus* (figure 1) as an argument for separating this genus as a distinct subfamily.

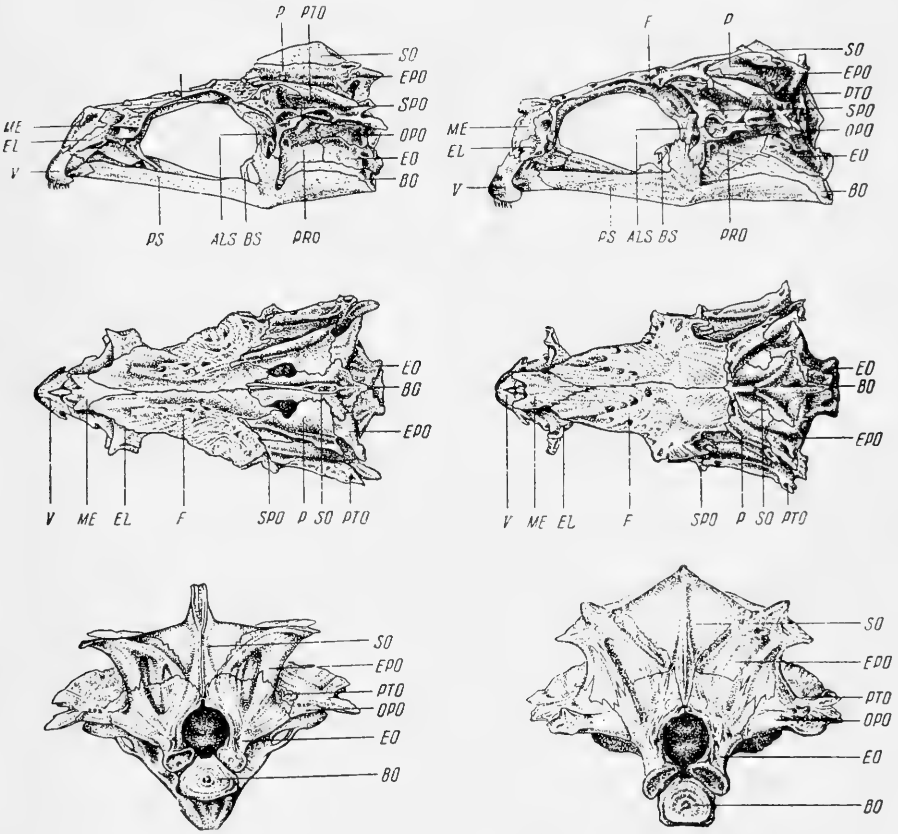

Figure 1. Neurocrania of *Pleurogrammus monopterygius* (left) and *Hexagrammos lagocephalus* (right). Note the large foramina in the cranial roof of *P. monopterygius*, as well as the widely separated anterior openings of the supratemporal canals in this species. ALS — pterosphenoid; BO — basioccipital; BS — basisphenoid; EL — lateral ethmoid; EO — exoccipital; EPO — epiotic; F — frontal; ME — mesethmoid; OPO — opisthotic; P — parietal; PRO — prootic; PS — parasphenoid; PTO — pterotic; SO — supraoccipital; SPO — sphenotic; V — vomer. (From Rutenberg, 1955.)

Opisthotics.

The size and forward contacts of the opisthotics vary considerably among representatives of the mail-cheeked fishes, as shown by Regan (1913). The specimens at hand were surveyed in this regard: in all serranids, the large opisthotic extends forward to a sutural contact with the prootic, a relationship true also for *Cirrhitus*, the scorpaenids, *Prionotus*, all hexagrammids (except *Ophiodon*), *Zaniolepis*, and *Platycephalus*. In *Ophiodon*, *Anoplopoma*, and the Cottidae examined, an area of the pterotic intervenes between the prootic and a small opisthotic. Taliev (1955) shows a small opisthotic in his figures of the Lake Baikal cottids and comephorids.

EXOCCIPITALS.

In the serranid representatives (and five species of *Roccus* figured by Woolcott, 1957) the exoccipitals are in contact below the foramen magnum, as also in *Cirrhitus* and species of *Sebastodes.* In *Scorpaena,* hexagrammids, zaniolepidids, *Anoplopoma,* and cottids, the exoccipitals are not visibly in contact in the region of the foramen magnum. The hexagrammid genus *Oxylebius* shows an intermediate condition in which the exoccipitals are well separated on the floor of the foramen magnum but contact anteriorly.

PARASPHENOID-PTEROSPHENOID JUNCTION.

The Hexagrammidae, Zaniolepididae, Cottidae, *Anoplopoma,* Agonidae, and Cyclopteridae are distinguished from the Scorpaenidae and other mail-cheeked fishes by a junction of the ascending lateral wing of the parasphenoid with the pterosphenoid element on each side of the neurocranium (figure 2). This character was first utilized for the systematics of the mail-cheeked fishes by Gill (1889). In the more generalized condition found in serranids (usually) and scorpaenids, the prootic clearly separates the parasphenoid and pterosphenoid at the orbital surface; this simple relationship is figured for various species of *Sebastodes* by Cramer (1895), and Matsubara (1943) indicates in his figures that the simple arrangement holds for scorpaenid fishes in general. The presumed derived condition where parasphenoid and pterosphenoid are conjoined also occurs in the cottids and comephorids of Lake Baikal, according to the figures of Taliev (1955), and Rendahl (1934) figures this condition for *Hypsagonus quadricornis.*

The serranids do not uniformly show the simple condition. *Dermatolepis punctata* is unique among the serranids investigated in having the parasphenoid and pterosphenoid conjoined, much as the Hexagrammidae and Cottidae (in other respects the neurocrania are dissimilar). The opposite case occurs in the reputed anoplopomatid *Erilepis zonifer,* whose family status should be reviewed. In *E. zonifer* the parasphenoid and pterosphenoid are widely separated, whereas in *Anoplopoma* not only are the two elements in contact but the parasphenoid also conjoins with the frontal element.

One possible mode of origin of the junction is suggested by the arrangement found in *Cirrhitus* and *Scorpaena,* in which the parasphenoid and pterosphenoid are narrowly separated by a notch. But an even more provocative situation was found in the arrangement of ligaments and bones in *Sebastodes* spp. and *Erilepis zonifer.* In these examples the parasphenoid and pterosphenoid do not contact but the space between the two is bridged by a ligament, which if ossified toward its center from the two bones would effect their junction. The parasphenoid-pterosphenoid junction appears

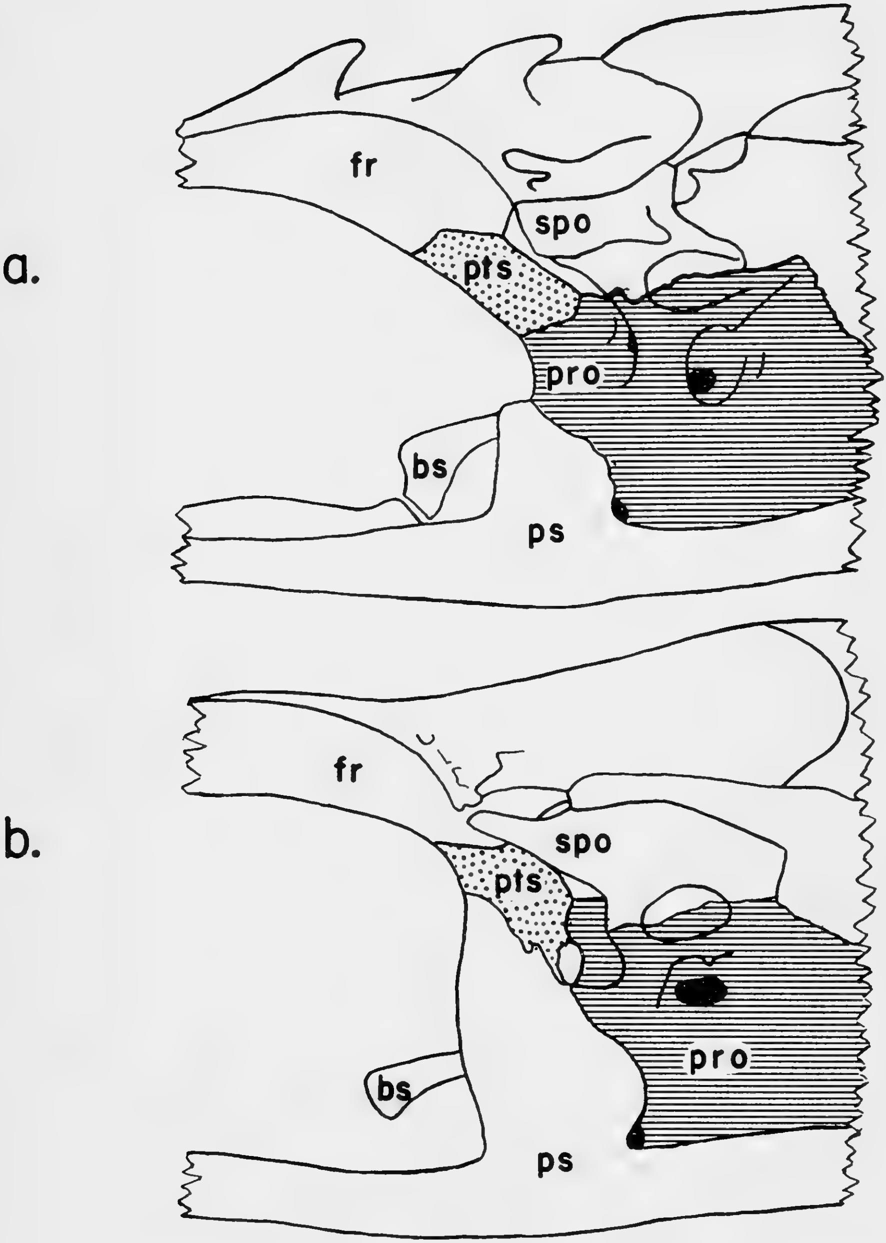

FIGURE 2. Posterior orbital region of the neurocrania of two spiny-rayed fishes. Two relationships between the posterior orbital elements are illustrated: *a*, the parasphenoid and pterosphenoid separated by a broad gap and the prootic bordering the orbit *(Sebastodes serriceps)*; *b*, the parasphenoid and pterosphenoid in contact, forming a new foramen anterior to the prootic *(Oxylebius pictus)*. *bs* — basisphenoid; *fr* — frontal; *pro* — prootic; *ps* — parasphenoid; *pts* — pterosphenoid; *spo* — sphenotic.

to be consistent in the hexagrammid-cottid evolutionary line despite the exceptions found in the other groups; it is a reliable taxonomic character for separation of the scorpaenoid fishes from the hexagrammids, zaniolepidids, and cottids.

BASISPHENOID.

Presence or absence of the basisphenoid is a character of importance in Regan's system and was found to be generally consistent in the families I examined. This median bone originates at or above the parasphenoid in the membranous interorbital septum and bends upward and posteriorly to its T-shaped termination, which contacts inwardly directed processes of the prootics. The inwardly directed prootic processes may also meet behind the basisphenoid to form a "prootic bridge" (Rendahl, 1934b). The bridge thus formed separates the optic nerves and the anterior section of the brain above from the myodome (the canal containing the rectus eye muscles) below. Posterior to the prootic bridge, the pituitary fossa connects the brain cavity with the myodome cavity. The prootic wings meet again behind the pituitary fossa to complete the floor of the cranial cavity and the roof of the myodome.

According to Regan, the presence of a basisphenoid distinguishes the Scorpaenidae and Hexagrammidae from the cottids, comephorids, and agonids. My investigations and the works of Taliev and Rendahl generally support this view. Two minor exceptions have been noted in the literature. Matsubara (1943) found the genus *Setarches* to be exceptional among the scorpaenoid fishes in the lack of a basisphenoid, and Gutberlet (1915), without comment, figures the skull of the primitive cottid *Scorpaenichthys marmoratus* with a basisphenoid. The prootic supports for the basisphenoid are surprisingly well developed in this species and it seems possible that Gutberlet had an aberrant specimen. However, this element was lacking in all specimens I examined and I am inclined to believe that he was in error.

The loss of the basisphenoid in the cottids and agonids seems associated with the general reduction of the cranial floor in these fishes. In the families with a well developed basisphenoid, e.g. Serranidae, Scorpaenidae, and Hexagrammidae, the cranial floor is usually normal.

LATERAL ETHMOIDS.

Considerable variation occurs both between and within the mail-cheeked fish families in regard to the development of the lateral ethmoids and in regard to number and position of the facets for articulation with the lachrymal and palatine bones. These characters are unsatisfactory for the differentiation of either the Hexagrammidae or the Cottidae, although they may be of value in the systematics of lower ranks within the families.

VERTEBRAE AND ASSOCIATED STRUCTURES

VERTEBRAE (INCLUDING UROSTYLE)[2]

In his diagnosis of the Hexagrammidae, Regan gives the vertebral number range as 42–64. Although he includes *Oxylebius* in the family, he fails to include its vertebral count in the family diagnosis. With the inclusion of the *Oxylebius* range, with a minimum of 37, the family Hexagrammidae and the Scorpaeniformes of Regan (Scorpaenoidae of Berg, 1940) are no longer completely distinct.

The families investigated appear to overlap widely in vertebral morphology and no consistent family differences can be drawn. In *Hexagrammos* and *Ophiodon* the parapophyses are more strongly developed and project more laterally than in the serranids and scorpaenids, but *Oxylebius* resembles the serranids and scorpaenids more closely in this respect. The contrasting development of the parapophyses that Gill (1889) implies as a differentiating character between the cottids and hexagrammids is not consistent within the families; the cottid *Scorpaenichthys marmoratus* is very similar to *Hexagrammos*. Width and length measurements on caudal vertebrae (the fourth before the urostyle was chosen as representative) disclose a general tendency in the hexagrammids for the vertebrae to be shorter in respect to their width as species vertebral number increases, as might be expected. However, the ratio is not of taxonomic value because hexagrammid ranges broadly overlap those of other families. A tendency toward reduction of the first neural spine noted for cottids is not apparent in the serranids, cirrhitids, scorpaenids, hexagrammids, zaniolepidids, or anoplopomatids.

The proportion of precaudal vertebrae in the hexagrammids ranges between 34–46 per cent. This is beyond both the upper and lower limits of the serranid, cirrhitid, and scorpaenid representatives, which have an inclusive range of 36–42. Hexagrammid values broadly overlap those of the cottids (39–42 per cent) and exceed those of *Erilepis* and *Anoplopoma* (22–31 per cent). The zaniolepidids (33 per cent) are slightly below the lower limit of the Hexagrammidae, within the range of the Cottidae, and above the upper limit of the Anoplopomatidae.

Percentage of precaudal vertebrae with parapophyses bridged by a haemal arch varies considerably among the families. The highest, 50 per cent, characterizes *Cirrhitus rivulatus*. *Hexagrammos (H. decagrammus* and *H. lagocephalus)* and *Oxylebius* vary from 35–43. In *Ophiodon* the proportion is the lowest, usually with only one precaudal vertebra, or 4 per cent of an average of 23, bridged.

Autogenous haemal arches in the hexagrammids are normally limited to the last two caudal vertebrae before the urostyle (table 2).

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[2] "Urostyle" is here used as synonymous with the longer but more descriptive term "urostylar half-vertebra" of Gosline (1961).

TABLE 2.

Occurrence of terminal caudal vertebrae with autogenous haemal arches, Hexagrammidae.

Species	Number of vertebrae	Per Cent having 2	Number of specimens
Hexagrammos agrammus	2–3	81	16
H. decagrammus	2–3	83	59
H. lagocephalus[1]	2–3	89	44
H. octogrammus	2–3	91	35
H. otakii	2–3	82	11
Ophiodon elongatus	2–3	96	27
Oxylebius pictus	2–3	93	30
Pleurogrammus monopterygius	2–4	71	7

[1] Includes *H. superciliosus.* Thirty-nine specimens are from the eastern Pacific and Aleutian Islands and 5 are from the western Pacific.

RIBS.

In his synopsis of the families and superfamilies of mail-cheeked fishes, Gill (1889) states that the Scorpaenoidae (including the Hexagrammidae) have "ribs, typically, borne on enlarged parapophyses," distinguishing them from the Cottoidae, which have "ribs sessile on the vertebrae." However, in making this distinction between the two groups, he does not note that the mail-cheeked fishes have two types of ribs, pleural and epipleural, and also that the pleural ribs are absent from more precaudal vertebrae in the cottids than in the scorpaenids and hexagrammids. Regan (1913) establishes this second difference between the two groups and his findings are verified by my examinations. The hexagrammids, *Zaniolepis,* and *Anoplopoma* differ from the serranids and scorpaenids in having the epipleural and pleural ribs inserted together on the vertebral parapophyses. In the serranids and scorpaenids, epipleural ribs are inserted on the pleural ribs themselves for at least the first four pleural ribs — a relationship figured for *Roccus saxatilis* by Merriman (1940) and *Sebastolobus alascanus* by Starks (1898). According to Regan, all ribs are absent in the scorpaeniform families Caracanthidae, Aploactidae, and Synancejidae; the unusual situation he describes for the Platycephaliformes, the pleural ribs attached to the epipleurals, was verified by examination of one representative. In all the percoid representatives I list, the series of epipleural ribs begins on the first vertebra with at least the first two sessile on their vertebrae. Pleural ribs, when present, begin on the third to fifth vertebra in all groups except the cottids.

DORSAL PTERYGIOPHORES.

Despite abundant published osteological studies of teleosts and figures of the axial skeleton that show important differences in arrangement of the dorsal pterygiophores, there has been little attempt to classify the various arrangements and use the patterns for taxonomic purposes. Matsubara (1943) discusses various arrangements in the scorpaenoid fishes but makes no comparisons with other mail-cheeked groups, or with the acanthopterygian fishes in general. Dramatic and apparently consistent differences that are probably of taxonomic importance exist between various fish groups.

Pterygiophores are doubled in one or more of the anterior interneural spaces beneath the spinous dorsal fin in a large number of acanthopterygian fishes. Representative arrangements of these bones in single species are illustrated in figures of *Roccus saxatilis* (Starks, 1901; Merriman, 1940), *Archoplites interruptus* (Dineen and Stokely, 1956), and *Sebastes viviparus* (Andriashev, 1954). In addition, I found the condition to be consistent in representatives of the following families: Holocentridae (2 genera, 2 species), Serranidae (4 genera, 6 species), Centrarchidae (1 species), Sciaenidae (1 species), Cichlidae (1 species), Pomacentridae (1 species), Cirrhitidae (2 genera, 3 species), Scorpaenidae (5 genera, 8 species), Triglidae (2 genera, 2 species), Anoplopomatidae (2 genera, 2 species), and Platycephalidae (1 species).

Representatives of the Hexagrammidae (except *Ophiodon*), Zaniolepididae, Cottidae, and Cyclopteridae normally differ from the scorpaenoid fishes (except *Parabrachirus*) in having a single pterygiophore in each interneural space beneath the dorsal fin (*Oxylebius pictus* rarely has a doubled pterygiophore in the second space).

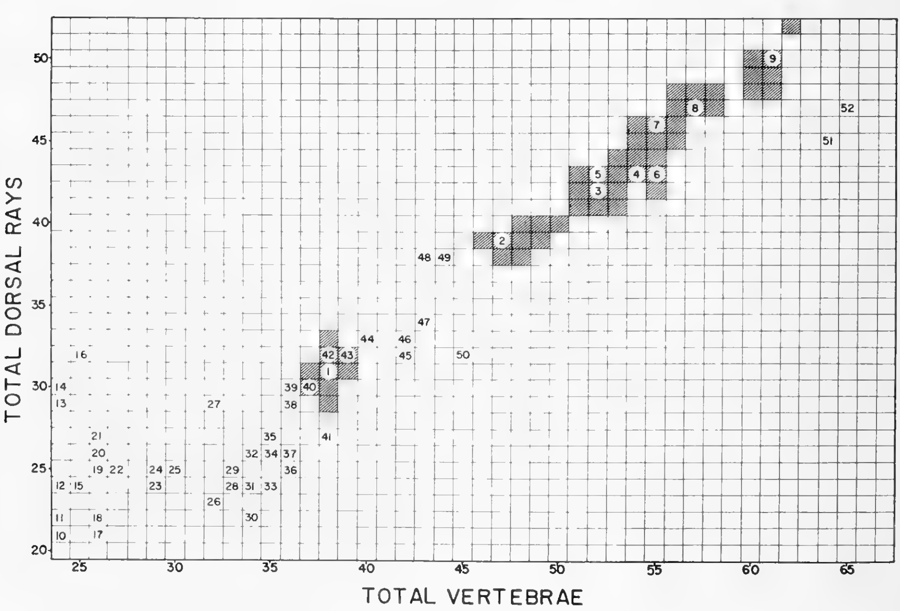
Ophiodon elongatus is exceptional among the hexagrammid fishes, and acanthopterygian representatives for which X-rays or published illustrations are available, in having a combination of doubled dorsal fin spines and a first dorsal pterygiophore of doubled structure at the first interneural space (between the cranium and the first neural spine). Oddly, this arrangement is not a serious violation of the one-to-one arrangement between pterygiophores and vertebrae beneath the spinous dorsal fin that characterizes the hexagrammid fishes, because a compensating gap in the pterygiophore series occurs more posteriorly in *Ophiodon*, discussed below. Because of this compensating arrangement, I regard *O. elongatus* as basically consistent with the general hexagrammid one-to-one pattern. The occurrence of this pattern in the zaniolepidids and cottids is additional evidence for the close affinity between the three families. The one-to-one arrangement is also found in some other, presumably unrelated, percoid groups and is figured for *Perca* by Cuvier and Valenciennes (1828) and for representatives of four families of northern eel-like blennioids by Andriashev (1954). Some degree of doubling of dorsal pterygiophores in their spaces probably characterizes the overwhelming majority of other perciform fishes.

DORSAL RAY TOTALS.

The hexagrammids show a close interspecific correlation between sums for dorsal rays and vertebrae. The dorsal rays and their associated pterygiophores normally occupy approximately 81 per cent of the interneural spaces above the vertebral column. When plotted graphically, proportions for the various hexagrammid species form a nearly straight regression line that differentiates them from the proportions obtained for numerous other perciform representatives (figure 3). Significantly, the Zaniolepididae and Cottidae, which have close affinities with the Hexagrammidae on the basis of other osteological evidence, also show similar proportions (figure 3).

Several anatomical factors are responsible for the distinct relationships between dorsal rays and vertebrae that characterize some fish groups (figure 3). The hexagrammid proportions reflect a high vertebral number, a one-to-one relationship between the pterygiophores (with their associated dorsal fin rays) and the interneural spaces, and a constant extent (percentagewise) of the vertebral column that is occupied by the dorsal fin and its supporting elements.

When first examined, specimens of *Ophiodon elongatus* appeared to be an exception among the hexagrammid fishes because the dorsal spines are doubled over the first interneural space. This arrangement would give a sum for dorsal spines one in excess of that for associated neural spines and vertebrae if the usual hexagrammid arrangement, one element per inter-



neural space, were followed. However, in the 20 *Ophiodon* specimens examined, the total number of dorsal fin spines was equal to the total number of neural spines. In each specimen the dorsal pterygiophore and its dorsal fin spine was absent in an interneural space somewhere between vertebrae 12 and 16. Investigation shows that *Ophiodon elongatus* is not unique in this arrangement—*Erilepis zonifer* and the holocentrid representatives were found to lack a pterygiophore and its spine. The absence of a pterygiophore and spine may also be observed in figures of *Perca* by Cuvier and Valen-

Figure 3. Ratios between sums for dorsal fin rays and vertebrae in hexagrammids and representatives of other spiny-rayed fishes. Numerals represent modal frequencies for ratios of hexagrammid species or individual ratios for non-hexagrammids. Hatched region gives the hexagrammid range of variation. Species key below:

1. *Oxylebius pictus*
2. *Hexagrammos agrammus*
3. *Hexagrammos otakii*
4. *Hexagrammos stelleri*
5. *Hexagrammos octogrammus*
6. *Hexagrammos lagocephalus*
7. *Hexagrammos decagrammus*
8. *Ophiodon elongatus*
9. *Pleurogrammus monopterygius*
10. *Scorpaena guttata, S. mystes*
11. *Pterois antennata,*
Diplectrum macropoma
12. *Paralabrax auroguttatus,*
P. nebulifer
13. *Alphestes galapagensis,*
A. multiguttatus (in part)
Paranthias colonus
14. *Alphestes multiguttatus* (in part)
15. *Sebastiscus marmoratus*
16. *Micropogon altipinnis*
17. *Cirrhitus marmoratus,*
Paracirrhites arcatus,
Prionotus stephanophrys
18. *Prionotus albiostris*
19. *Myripristis clarionensis*
20. *Sebastodes chlorostictus*
21. *Eupomacentrus beebei,*
Sebastodes paucispinis
22. *Holocentrus suborbitalis*
23. *Sebastolobus altivelis* (in part)
24. *Sebastolobus altivelis* (in part)
25. *Sebastolobus alascanus*
26. *Micropterus salmoides*
27. *Cichlasoma dovii*
28. *Artedius notospilotus* (in part)
Clinocottus analis (in part)
29. *Clinocottus analis* (in part)
30. *Icelinus* sp. (in part)
31. *Artedius notospilotus* (in part)
32. *Oligocottus* sp. (in part)
33. *Icelinus* sp. (in part)
34. *Leiocottus hirundo.*
Icelinus sp. (in part)
35. *Oligocottus* sp. (in part)
36. *Leptocottus armatus*
37. *Chitonotus* sp.
38. *Scorpaenichthys marmoratus*
39. *Hemilepidotus hemilepidotus*
(in part)
40. *Hemilepidotus hemilepidotus*
(in part)
41. *Icelinus* sp. (in part)
42. *Radulinus* sp.
43. *Liparis florae* (in part)
44. *Liparis florae* (in part)
45. *Zaniolepis latipinnis*
46. *Zaniolepis frenata* (in part)
47. *Zaniolepis frenata* (in part)
48. *Liparis dennyi* (in part)
49. *Liparis dennyi* (in part)
50. *Erilepis zonifer*
51. *Anoplopoma fimbria* (in part)
52. *Anoplopoma fimbria* (in part)

ciennes (1828) and in a figure of the freshwater centrarchid *Archoplites interruptus* by Dineen and Stokely (1956).

Representatives of the cottid genera *Hemilepidotus* and *Scorpaenichthys* closely approximate the hexagrammid fishes in pterygiophore arrangement as well as in the ratio between pterygiophores and vertebrae. It is interesting, and of possible evolutionary significance, that *Erilepis, Anoplopoma,* and *Zaniolepis* would fall within or closely approximate the hexagrammid region of figure 3 if the rays and/or pterygiophores that are lacking in the anteriormost interneural spaces of these genera were present, as they are in the Hexagrammidae.

Caudal Skeleton.

The apparent basic plan for hypural arrangement in the perciform caudal skeleton is that of three upper and lower hypurals that either articulate with or are fused to the urostyle, or "urostylar half-vertebra," to use the terminology of Gosline (1961). Hypural numbering has been standardized by Gosline to designate the lowest (anteriormost) as the first and the uppermost as the sixth. Also, the first hypural seems always to bear a spinelike lateral process on each side that is associated with a foramen posteriorly. The upper and lower sets of primitively free hypurals can nearly always be readily distinguished by a fairly wide gap that separates them near the midline. The generalized hypural arrangement is figured for *Roccus saxatilis* by Merriman (1940) and *Archoplites interruptus* by Dineen and Stokely (1956), and exists in the representatives of Serranidae, Centrarchidae, Sciaenidae, Cichlidae, and Cirrhitidae that I stained or X-rayed. This condition is also figured by Hollister (1937b) for some iniomous fishes, and is shown in preparations of one beryciform fish (*Myripristis berndti*). Hollister (1936 and following) demonstrates that the number of hypurals may go at least as high as eight in some teleosts (Elopidae) or be reduced to three or two, presumably by fusion (in some Carangidae and Cyprinodontidae).

The scorpaenid, hexagrammid, zaniolepidid, and cottid representatives show a more derived condition; all have fewer than six free hypural elements in the caudal skeleton, presumably because of fusion. The four families illustrate three distinct stages in the fusion of caudal elements. The typical scorpaenid arrangement is that of hypurals 1 and 6 being free, while 2 and 3, and 4 and 5 are fused into lower and upper plates, respectively. This arrangement is illustrated for *Sebastes* and *Helicolenus* by Andriashev (1954). In *Pleurogrammus* and all species of *Hexagrammos* the upper and lower sets of primitively free hypurals are fused into upper and lower plates, each of which is suturally attached to the urostyle. *Oxylebius* and *Ophiodon* have individual variations: hypural 6 is free in

Oxylebius and hypurals 1 and 2 appear weakly joined or sutured in *Ophiodon.*

Representatives of the Zaniolepididae and Cottidae are similar and have much more fusion than the Hexagrammidae. Each of the upper and lower sets of three hypurals is fused into a single plate and the upper plate also seems fused to the urostyle. This condition exists for all cottids (8 genera) examined and also is depicted for the cottids and comephorids of Lake Baikal by Taliev (1955).

The status of *Erilepis zonifer* and *Anoplopoma fimbria* (Anoplopomatidae) is uncertain. In *E. zonifer,* only juvenile specimens (about 1½ feet long) were obtainable. These indicate that hypurals 2 and 3 only are fused. Boiled and X-ray preparations of *A. fimbria* are difficult to decipher because the bones have a spongy texture and sutures are indistinct. However, the available evidence from juvenile and young adult *A. fimbria* suggests that a coossification exists between hypurals 2–3 and also 5–6. If these observations are adequate, both species show a condition primitive to that of the hexagrammids, zaniolepidids, and cottids. Also, the scorpaenid condition is distinct from the anoplopomatid, suggesting that these families are on distinct evolutionary lines within the Cottoidae.

No convincing example was found in the Perciformes of revision to a more primitive hypural arrangement by one member of a group that has, as a whole, a highly derived caudal skeleton. No examples are given in the literature that was examined. In theory this could occur by paedomorphosis (as described by De Beer, 1951). The caudal skeleton of *Pleurogrammus monopterygius* was carefully examined because the species is paedomorphic in numerous respects; however, the caudal skeleton of this species is essentially the same as that of *Hexagrammos* spp.

APPENDICULAR SKELETON

PELVIC GIRDLE.

No important differences in structure or attachment of the pelvic girdle exist between the members of the Serranidae, Cirrhitidae, Scorpaenidae, Hexagrammidae, and Zaniolepididae that were examined. Five soft pelvic rays are present in the Hexagrammidae and Zaniolepididae in contrast to the Cottidae, in which the number is reduced in all but a few primitive genera.

PECTORAL GIRDLE.

Numerous characters of the pectoral girdle have long been utilized in the classification of mail-cheeked fishes. These include the character of the junction between scapula and coracoid, the breadth of these bones, the shape of the radials that support the pectoral rays, and the fusion or freedom of the upper, or first, radial. Gill (1889) uses some of these characters for a few mail-checked representatives and Regan (1913) extends the species coverage. These works are supplemented by the detailed observations of Rendahl (1934a) and the numerous figures of Japanese scorpaenoid representatives by Matsubara (1943).

Nearly all degrees of separation of coracoid and scapula exist among representatives of various percoid groups. At one extreme these elements are well developed and in broad contact; at the other they are reduced and widely separated by cartilage or an open area. Serranids generally have the bones in contact, whereas the elements are separated in the Cottidae examined and evidently in all Comephoridae of Lake Baikal according to the figures of Taliev (1955). Separation of coracoid and scapula is considerable in the Triglidae and reaches an advanced degree in some Cyclopteridae (for examples see Andriashev, 1954).

Representatives of the Cirrhitidae, Scorpaenidae, Platycephalidae, and Zaniolepididae share the serranid condition, in which the scapula and coracoid are broadly in contact. Some variation occurs within the Hexagrammidae and Anoplopomatidae. In *Ophiodon elongatus* the scapula and coracoid are in contact, whereas the two elements are separated by a narrow band of cartilage in *Oxylebius, Hexagrammos,* and *Pleurogrammus,* a condition intermediate between that of the serranids and cottids. In the Anoplopomatidae, *Anoplopoma* has the scapula and coracoid in contact but *Erilepis* appears to have these elements somewhat separated by cartilage (the *Erilepis* specimen, however, was a juvenile approximately one and one-half feet in total length and may not have represented the adult condition).

Cottids also depart markedly from the serranid condition in regard to shape of the radial elements in the pectoral girdle. Serranid representatives have elongate radials interspersed by large foramina, but cottids have square, flat, platelike radials, with the intervening foramina reduced or absent. Again, the hexagrammids are intermediate, as are the zaniolepidids—both have broadened radials and rather large foramina. The anoplopomatid condition is similar to that of the serranids.

A condyle, presumably for articulation of the uppermost pectoral ray, is developed on the upper edge of the scapula adjacent to the first radial in representatives of the Serranidae, Cirrhitidae, Platycephalidae, and in the anoplopomatid *Erilepis.* This condyle is absent in the representatives of the Scorpaenidae, Hexagrammidae, Zaniolepididae, Cottidae, and in *Anoplopoma.*

The first radial element is not ankylosed to the scapula in representatives of the Hexagrammidae, Zaniolepididae, and Anoplopomatidae. In the scorpaenid fishes it may be either suturally attached or fused to the scapula, depending upon the genus. Seven of the twenty-six Japanese genera listed by Matsubara (1943) have the first radial fused to the scapula. The representatives of the Cottidae except *Scorpaenichthys marmoratus* have the first radial free. Taranets (1941) errs seriously in stating that *Scorpaenichthys marmoratus* is exceptional among all mail-cheeked fishes in having the first radial ankylosed to the scapula. The statement would seem accurate if "Cottidae" were substituted for "all mail-cheeked fishes."

Representatives of all perciform fishes examined had the uppermost pectoral ray simple, and Rendahl (1934a) finds this to be true for all mail-cheeked fishes he examined. However, considerable variation occurs between the perciform groups in the number of remaining rays in the pectoral fin that are branched. Rendahl notes that *Hexagrammos octogrammus* and *H. otakii* are exceptional among the cottoid representatives in having all of the remaining rays branched. In general, I find Rendahl's conclusions to be correct: the uppermost one or two are the only simple pectoral rays in adult representatives of *Oxylebius, Ophiodon,* and *Hexagrammos.* The same is true also for both species in the Zaniolepididae and in the Anoplopomatidae. A similar low proportion of simple pectoral rays is also found in some serranids but this condition is rare or absent among the cirrhitids, and the scorpaenids are quite variable in this character (Jordan and Evermann, 1905).

A noteworthy exception to the normal hexagrammid condition of having simple pectoral rays restricted to the one or two uppermost in the fin is found in adults of the hexagrammid genus *Pleurogrammus,* where all pectoral rays are simple. This condition is found only in juveniles of other hexagrammids. Its persistence in adult *Pleurogrammus* is strong evidence for the probable paedomorphic mode of evolution of this genus.

DISCUSSION

Consideration of the osteological characters discussed in the previous sections gives strong evidence that some parts of the classification of mail-cheeked fishes as given by Regan (1913) and Berg (1940) are in need of rearrangement. The past classification, which is primarily the work of Regan, widely separates the superfamily Hexagrammoidae from the Cottoidae (two superfamilies are inserted between). Also, the families Hexagrammidae and Anoplopomatidae are grouped under the same superfamily, the Hexagrammoidae.

The osteological evidence indicates that the hexagrammids and zaniolepidids are early offshoots from the cottid evolutionary line and should be included in the cottoid superfamily. Although representatives of the Icelidae, the family placed first under the Cottoidae by Berg, were not examined, the hexagrammids should probably occupy the first position because their characters seem the most generalized among the living representatives of the cottoid superfamily. Second place should probably be occupied by the Zaniolepididae because the affinities between this family and the cottids are much stronger. The hexagrammid-cottid relationship is anticipated by Jordan and Evermann (1898), and Jordan (1905) notes that some of the more primitive cottids resemble hexagrammids quite closely and that the hexagrammids probably are primitive to both the cottids and *Zaniolepis.*

The Anoplopomatidae, in contrast, have few if any important affinities to the other mail-cheeked fish groups. The suborbital stay appears to be the sole character uniting at least three seemingly distinct evolutionary lines within the suborder—anoplopomatoid, scorpaenoid, and cottoid. It might be speculated that the suborbital stay originated independently in at least two of the groups and that the Cottoidei are a polyphyletic assemblage.

Head skeletons of the Hexagrammidae, Zaniolepididae, and Cottidae are very similar. Nearly all representatives have well-defined supratemporal canals that traverse the parietal elements, and all have a parasphenoid-pterosphenoid junction. These characters are also present in combination in some members of the Platycephalidae and Anoplopomatidae, which are not classed in the superfamily Cottoidae. However, in these forms the supratemporal canals are not well-defined structures but are submerged in the fissures of the posterior parietals; the canals are more difficult to distinguish, and bear a closer resemblance to those of the Scorpaenidae. Presence or absence of the parasphenoid-pterosphenoid junction should be used with caution in judging the affinities of percoid groups; this contact appears to have been independently evolved in some genera of Serranidae, and the elements are nearly in contact in examples of *Cirrhitus rivulatus* and one species of *Scorpaena.*

The head skeletons of hexagrammids and zaniolepidids are intermediate between the generalized condition of the scorpaenids and the more derived condition of the cottids in several additional respects. The presence of a basisphenoid definitely separates the Hexagrammidae and Zaniolepididae from the cottids and its absence in the cottids may be associated with reduced ossification of the myodome roof. The basisphenoid and myodome roof are delicate in the hexagrammids and zaniolepidids but otherwise as in the Scorpaenidae. In these respects the hexagrammids and zaniolepidids probably represent the ancestral condition of the cottids.

A similar relationship exists in regard to fusion and size of the upper pharyngeals. The most primitive condition is shown by representatives of the Scorpaenidae, Anoplopomatidae, and Platycephalidae, in which all three pairs of upper pharyngeals are approximately the same size. The third pair of pharyngeals is small in the hexagrammids and zaniolepidids (usually one-half or less the size of the first pair), and the third pair lies close to the posterolateral edge of the much larger second pair. In contrast, the last two pairs are fused in the cottid representatives, and the resulting combined structure is similar in shape and in relative size to the last two closely associated pharyngeal pairs of the hexagrammids and zaniolepidids. The cottid condition, once again, could easily be derived from that of the hexagrammids and zaniolepidids.

Examples from the hexagrammid-cottid and the scorpaenoid lines are quite distinct in regard to condition and completeness of the suborbital series of bones; they are also quite distinct in regard to the degree of proximity shown by the exoccipital elements on the floor of the foramen magnum. All hexagrammid representatives and many of the cottids have a complete bony ring composed of five suborbital elements. The last element, the dermosphenotic, is loosely attached to the sphenotic. In the zaniolepidids the second and third elements appear fused. Other mail-cheeked fishes usually have several of the posterior suborbital elements missing, and also have the dermosphenotic firmly attached to the sphenotic. The exoccipital elements on the floor of the foramen magnum are widely separated in both hexagrammid and cottid representatives (except *Oxylebius*), which contrasts strongly with the scorpaenid representatives, in which the exoccipitals are in broad contact. *Oxylebius* is intermediate, having these elements in contact anteriorly and broadly separated posteriorly.

Anatomical and numerical relationships between vertebral column, spinous dorsal rays, and pterygiophores below the spinous dorsal fin are similar in the hexagrammids, zaniolepidids, and cottids. These fishes differ significantly from representatives of the superfamilies Scorpaenoidae and Platycephaloidae. In hexagrammids and cottids, the pterygiophores are nearly always single in the spaces between the neural spines beneath the spinous dorsal fin. Representatives of the Scorpaenidae, Triglidae, and Platycephalidae differ from the hexagrammid-cottid group in having pterygiophores doubled in at least one space in this region, a condition also found in the greater part of the spiny-rayed fishes that are not mail-cheeked. Both anoplopomatid species have some doubling of pterygiophores in their spaces, and therefore differ significantly from the hexagrammids, zaniolepidids, and cottids in this respect.

In rib relationships, the hexagrammids, zaniolepidids, and anoplopomatids differ from the other acanthopterygian representatives in having pleural and epipleural ribs inserted together on the parapophyses. The scorpaenids show what appears to be the more generalized condition, where the epipleural ribs are inserted on the pleurals. Cottids lack peural ribs in an extensive anterior section of the vertebral column but possess "epipleural" ribs that are attached to the vertebrae in this region. The cottid condition seems much more easily derivable from that of the hexagrammids, zaniolepidids, and anoplopomatids, in which the two types of ribs originate on vertebrae, than from that of the scorpaenids.

The caudal skeleton was found to be quite distinctive in many of the fish groups. The anoplopomatids show a presumably more primitive condition that do the scorpaenids, which have all but the first and last (1 and 6) hypurals coossified into a single dorsal and a single ventral plate. Hexagrammids have one or both of the bordering hypurals (1 and 6), which are free in the scorpaenids, ankylosed to their neighbors. In the zaniolepidids and cottids the hypural elements are fused into dorsal and ventral plates—and fusion reaches an extreme with fusion of the plates to each other and also to the urostyle.

In regard to the structure of the pectoral girdle, the hexagrammids are nearly intermediate between the scorpaenids and cottids. The coracoid and scapula are in contact in *Ophiodon* as in the zaniolepidid, scorpaenid, and platycephalid representatives. In the other hexagrammids the two elements are separated by cartilage, a condition shown in a much more extreme degree by the cottids. The radials of the hexagrammids and zaniolepidids are intermediate between the "anvil-shape" of most scorpaenids and the flat plates of the cottids. The pectoral girdle of *Anoplopoma* and *Erilepis* is quite similar to that of the scorpaenids. In regard to branched pectoral rays, the hexagrammids (except *Pleurogrammus*), zaniolepidids, and anoplopomatids, seem unique among the mail-cheeked fishes in having all but the uppermost one or two pectoral rays branched. In *Pleurogrammus,* a genus with a number of other larval characteristics, simple rays are retained.

SYNOPSIS

The summary given below of the preceding osteological discussion follows the classification of Berg (1940, 1955), which, for the mail-cheeked fishes, is but a slight modification of Regan's (1913) classification. (In some instances, characteristics are included that are not osteological but do appear to be outstanding morphological or biological features of a group. This follows the precedent of Regan (1913) and Berg (1940).) The characterizations are based upon Regan's key and synopsis, and my additions bear an asterisk. Additions not original with the present research bear an author citation. Recommended taxonomic changes above the family level (see preceding section) are not included because many of the mail-cheeked groups, particularly the anoplopomatids, cottids, and cottid allies, are in need of intensive study.

Superfamily Scorpaenoidae

Characters in common with the Hexagrammidae:

Opisthotic extends forward to prootic (except *Ophiodon*).
Basisphenoid usually present.
Myodome roof osseous.
Hyopalatine bones present and normally developed.

Characters absent in the Hexagrammidae:

No parasphenoid-pterosphenoid contact.

1. **Scorpaenidae**

Characters in common with the Hexagrammidae:

Head: Posttemporal forked.
Three pairs of dentigerous upper pharyngeals.
Gill membranes free from isthmus (except *Ophiodon*).

Axial: Ribs present on all precaudal vertebrae.
Hypurals 2–3 and 4–5 fused.*

Pectoral: Radials anvil-shaped.

Pelvic: Fins usually I, 5 and normally developed.

Characters absent in the Hexagrammidae:

Head: Dermosphenotic fused to sphenotic.*
Third pair of upper pharyngeals as large or nearly as large as second pair.*
Seven branchiostegals.*
Usually no slit behind last gill arch (Jordan and Evermann, 1905).*

Axial: Pterygiophores usually paired in one or more spaces below spinous dorsal fin.*
Usually fewer than 37 vertebrae.
Hypurals 1 and 6 free.*

Pectoral: Coracoid and scapula in contact (except *Ophiodon*).

2. **Triglidae**

Characters in common with the Hexagrammidae:

Head: Posttemporal forked.
Three pairs of dentigerous upper pharyngeals.
Gill membranes free (except *Ophiodon*).

Axial: Ribs present on all precaudal vertebrae.
Hypurals 4 and 5 fused.*

Pectoral: Coracoid and scapula not in contact (except *Ophiodon*).

Pelvic: Fins I, 5 and normally developed.

Superfamily SCORPAENOIDAE — Cont.

2. **Triglidae** — Cont.

Characters absent in the Hexagrammidae:

Head:	Second suborbital attached to lateral ethmoids. Dermosphenotic fused to sphenotic.* Upper limb of posttemporal developed into a triangular plate. Armored.
Axial:	Pterygiophores doubled in some spaces below spinous dorsal fin.* Fewer than 37 vertebrae. Hypurals 2 and 3 free.*
Pectoral:	Radials platelike. Lower rays free, simple, and specialized.

3. **Caracanthidae**

Characters in common with the Hexagrammidae:

Head:	Posttemporal forked. Three pairs of dentigerous upper pharyngeals.
Pectoral:	Radials anvil-shaped.

Characters absent in the Hexagrammidae:

Head:	Gill openings restricted to above pectorals.
Axial:	Pleural ribs absent. Vertebrae fewer than 37.
Pectoral:	Coracoid and scapula in contact (except *Ophiodon*).

4. **Aploactidae**

Characters in common with the Hexagrammidae:

Head:	Posttemporal forked.
Anal fin:	Spines flexible.

Characters absent in the Hexagrammidae:

Head:	Single pair of dentigerous upper pharyngeals.
Axial:	Pleural ribs absent. Vertebrae fewer than 37.
Pelvic:	Fins I, 2.
Other:	Dorsal fin commencing on head. Body scaleless.

5. **Synancejidae**

Characters in common with the Hexagrammidae:

Head:	Posttemporal forked.

Superfamily Scorpaenoidae — Cont.

5. **Synancejidae** — Cont.

Pectoral: Some cartilage between scapula and coracoid.
Anal fin: Spines flexible.

Characters absent in the Hexagrammidae:

Head: Single pair of dentigerous upper pharyngeals.
Gill membranes attached to isthmus (except *Ophiodon*).
Axial: Pleural ribs absent.
Vertebrae fewer than 37.
Pectoral: First radial fused to scapula.
Pelvic: Fins of some species I, 4.
Innermost ray adnate to abdomen.
Other: Dorsal fin commencing on head.
Body scaleless.

6. **Pataecidae**

Characters in common with the Hexagrammidae:

Head: Posttemporal forked.
Gill membranes free from isthmus.

Characters absent in the Hexagrammidae:

Head: Suborbitals thin or sometimes membranous.
Epiotics united by a suture behind the supraoccipital.
Single pair of dentigerous upper pharyngeals.
Axial: Vertebrae fewer than 37.
Pelvic: Fins absent in some species.

Superfamily Hexagrammoidae

1. **Hexagrammidae** *(Oxylebius, Ophiodon, Hexagrammos* (including *Agrammus), Pleurogrammus).*

Distinctive characters:

Head: Opisthotic large, reaching prootic (except *Ophiodon*).
Five suborbitals and lachrymal present.*
Dermosphenotic loosely attached to sphenotic.*
Parasphenoid-pterosphenoid contact.
Myodome with osseous roof.
Basisphenoid present.
Supratemporal canals usually conspicuous.*
Posttemporal forked.
Three pairs of dentigerous upper pharyngeals.

Superfamily HEXAGRAMMOIDAE — Cont.

1. **Hexagrammidae** — Cont.

Third pair of upper pharyngeals small, one-half or less the size of the first pair in most species.*
Six branchiostegals.*
Gill membranes free from isthmus and broadly joined (except *Ophiodon*).
Large slit present behind the last gill arch.*
Adults usually with posterior nostrils reduced.*

Axial: Vertebrae 37–64.*
Dorsal fin spines begin on first pterygiophore or are doubled on the second.*
Pterygiophore series begins in first space behind cranium.*
Pterygiophores usually single in their spaces below spinous dorsal fin.*
Dorsal pterygiophores occupy approximately 81 per cent of the spaces available.*
Epipleural ribs present.
Pleural ribs present.
Pleural and epipleural ribs inserted together on parapophyses.
Hypurals 1, 2, 3 and 4, 5, 6 usually fused into plates (except *Oxylebius* and *Ophiodon*).*
Hypural plates not fused to urostyle.*

Pectoral: Coracoid and scapula not in contact (except *Ophiodon*).
Four anvil-shaped radials.
No pectoral condyle on scapula.*
All pectoral rays but uppermost one or two branched (except *Pleurogrammus*).*

Pelvic: Fins I, 5 and normally developed.

Anal fin: Spines variable in number, 0–III, and flexible.*

2. **Anoplopomatidae** *(Anoplopoma, Erilepis)*

Characters in common with the Hexagrammidae:

Head: Basisphenoid present.*
Posttemporal forked.
Three pairs of dentigerous upper pharyngeals.
Six branchiostegals.*
Large slit behind last gill arch.*

Axial: Pleural ribs present.
Epipleural ribs present.

Superfamily HEXAGRAMMOIDAE — Cont.

2. **Anoplopomatidae** — Cont.

Pleural and epipleural ribs inserted together on parapophyses.

Pectoral: Four anvil-shaped radials.
All pectoral rays but uppermost one branched (except *Pleurogrammus*).*

Pelvic: Fins I, 5 and normally developed.

Characters absent in the Hexagrammidae:

Head: Opisthotic small, not contacting prootic (except *Ophiodon*).
Supratemporal canals inconspicuous.*
Third pair of pharyngeals nearly as large as second pair.*
Gill membranes attached to isthmus (except *Ophiodon*).
Branchiostegal membrane scaled.*

Axial: Doubled pterygiophores in some spaces below spinous dorsal fin.*
No pterygiophores in spaces 1–4.*
Hypurals 1, 2, and 4, 5, free.*

Pectoral: Coracoid and scapula in contact (except *Ophiodon*).

3. **Zaniolepididae*** *(Zaniolepis,* incl. *Xantocles)*

Characters in common with the Hexagrammidae:

Head: Opisthotic large and reaches prootic (except *Ophiodon*).
Posttemporal forked.
Parasphenoid-pterosphenoid contact.
Basisphenoid present.
Myodome with osseous roof.
Supratemporal canals conspicuous.*
Three pairs of dentigerous upper pharyngeals.
Third pair of upper pharyngeals less than one-half the size of the first pair.*
Six branchiostegals.*
A large slit behind the last gill arch.*

Axial: Pterygiophores single in their spaces below spinous dorsal fin.*
Pleural ribs present.
Epipleural ribs present.
Pleural and epipleural ribs inserted together on the parapophyses.

Superfamily Hexagrammoidae — Cont.

3. **Zaniolepididae** — Cont.

Hypurals 1, 2, 3 and 4, 5, 6 fused into two plates (except *Oxylebius* and *Ophiodon*).*

Pectoral: No condyle on scapula.*
Four anvil-shaped radials.
All pectoral rays but uppermost one branched (except *Pleurogrammus*).*

Pelvic: Fins I, 5 and normally developed.

Characters absent in the Hexagrammidae:

Head: Four suborbitals (in addition to the lachrymal).*
Dermosphenotic firmly attached to the sphenotic.*

Axial: Dorsal fin spines begin posterior to first interneural space.*
Dorsal fin spines always single above the second interneural space.*
Dorsal and ventral hypural plates (formed from the fused hypurals) fused to each other and the urostyle.

Pectoral: Coracoid and scapula in contact (except *Ophiodon*).

Other: Scales "comb-shaped."*
Lateral line scales without perforations.*

Superfamily Platycephaloidae

1. **Platycephalidae**

Characters in common with the Hexagrammidae:

Head: Hyopalatine bones normally developed.
Parasphenoid-pterosphenoid contact.
Basisphenoid present.*
Opisthotic large and extending to prootic.
Posttemporal forked.
Three pairs of dentigerous upper pharyngeals.*

Pectoral: Four radials.

Pelvic: Fins I, 5.

Characters absent in the Hexagrammidae:

Head: Parasphenoid-frontal contact.
Third pair of upper dentigerous pharyngeals larger than the first pair.*
Seven branchiostegals.*
Skull flattened.

Superfamily Platycephaloidae — Cont.

1. **Platycephalidae** — Cont.

Axial: Pleural ribs attached to the epipleurals.
Epipleural ribs sessile.
Vertebrae fewer than 37.
First and sixth hypurals free.*

Pectoral: Coracoid and scapula contact (except *Ophiodon*).
Condyle on scapula.*
Radials short square plates.
Simple rays present in addition to uppermost one.*

Pelvic: A large oval space enclosed by the girdles (Matsubara and Ochiai, 1955).*

Anal fin: Spines absent (Matsubara and Ochiai, 1955).*

Superfamily Hoplichthyoidae

1. **Hoplichthyidae**

Characters in common with the Hexagrammidae:

Head: Basisphenoid present.
Opisthotic large and extending to prootic (except *Ophiodon*).
Posttemporal forked.

Axial: Epipleurals inserted on parapophyses.

Pectoral: Four anvil-shaped radials.

Characters absent in the Hexagrammidae:

Head: Myodome roof not osseous.
Palatine and pterygoid form a long slender rod.
No mesopterygoid; metapterygoid reduced.
Interopercle absent (Matsubara and Ochiai, 1955).*

Axial: Pleural ribs absent.
Vertebrae fewer than 37.

Pectoral: Coracoid and scapula contact (except *Ophiodon*).
Interradial foramina closed by an osseous membrane.
Some pectoral rays detached (Matsubara and Ochiai, 1955.)*

Anal fin: Spines absent (Matsubara and Ochiai, 1955).*

Other: Scales restricted to lateral line (Matsubara and Ochiai, 1955).*

Superfamily CONGIOPODOIDAE

1. **Congiopodidae**

Characters in common with the Hexagrammidae:

Head: Opisthotic large, contacting or nearly contacting the prootic.
Three pairs of dentigerous upper pharyngeals.
A single nostril on each side.

Axial: Pleural ribs present.
Vertebrae 39.

Pectoral: Radials anvil-shaped.

Characters absent in the Hexagrammidae:

Head: Posttemporal simple.
Posttemporal forms an integral part of the skull.
Gill openings restricted to a region above the pectorals.

Dorsal fin: Originates on the head.

Pectoral: Coracoid and scapula contact (except *Ophiodon*).

Superfamily COTTOIDAE

Characters in common with Hexagrammidae:

Posttemporal forked.
Epipleural ribs present.
Precaudal vertebrae with epipleurals sessile or on short parapophyses.

Characters absent in the Hexagrammidae:

No basisphenoid.
Dentigerous upper pharyngeals restricted to one or two pairs.
Pleural ribs absent or developed on a few posterior precaudals only.
Pectoral interradial foramina small or absent.

1. **Icelidae*** *(Icelus, Ereunias, Marukawichthys),* Berg (1940)

Characters absent in the Hexagrammidae:

Head: Vomer and mesethmoid unossified.
Opisthotic large, forming the upper margin of the foramen magnum.
Vagus foramen in opisthotic.

2. **Cottidae**

Characters in common with the Hexagrammidae:

Head: Parasphenoid-pterosphenoid contact.

Superfamily Cottoidae — Cont.

2. **Cottidae** — Cont.

Dermosphenotic loosely attached to the sphenotic.*
Six branchiostegals in most species.*
Gill membranes connected (except *Ophiodon*) (Jordan, 1929).*

Axial: Pterygiophores single in their spaces beneath the spinous dorsal fin.*
Pterygiophores begin with the first dorsal space.*

Dorsal fin: Spines begin with the first pterygiophore.*

Characters absent in the Hexagrammidae:

Head: Opisthotic small, not contacting prootic (except *Ophiodon*).

Axial: Hypurals fused into plates that are fused to the urostyle.*

Dorsal fin: Spinous and soft sections usually separate.

Pectoral: Coracoid and scapula widely separated.
Radials platelike.
Interradial foramina absent.
Simple rays in lower half of fin.*

Pelvic: Fins I, 4 or fewer in many species (Jordan, 1905).*
(Fins absent in *Ascelichthys.*)

Anal fin: Spines absent.

3. **Cottocomephoridae*** (regarded as a subfamily of Cottidae by Taliev, 1955).

Characters very similar to those of the Cottidae. Limited in its distribution to Lake Baikal, U.S.S.R.

4. **Comephoridae**

Characters in common with the Hexagrammidae:

Axial: Vertebrae 48–50.

Characters absent in the Hexagrammidae:

Head: Suborbital stay rudimentary.

Axial: Pleural ribs absent.

Pectoral: Postcleithra absent.

Pelvic: Fins absent.*

Other: Viviparous, limited to Lake Baikal, U.S.S.R.*

Superfamily Cottoidae — Cont.

5. **Normanichthyidae.*** For osteology see Clark (1937), Norman (1938), and Tortonese (1939).

Characters in common with the Hexagrammidae:

Head: Unarmed.
Pelvic: Fins I, 5.
Other: Body covered with ctenoid scales.

Characters absent in the Hexagrammidae:

Axial: No pleural ribs.
Hypurals 4, 5, 6 separate (Tortonese, 1939).*

6. **Cottunculidae**

Characters absent in the Hexagrammidae:

Head: Opisthotic small (except *Ophiodon*).
No parasphenoid-pterosphenoid contact.
Pelvic: Incomplete (Jordan, 1905).*
Other: Scales absent (Jordan, 1905).*

7. **Psychrolutidae**

Characters in common with the Hexagrammidae:

Axial: Vertebrae 40.

Characters absent in the Hexagrammidae:

Head: Parasphenoid forms a complete interorbital septum.
Branchiostegals seven (Taranets, 1941).*
Flattened.
Pectoral: Coracoid and scapula widely separated.

8. **Agonidae**

Characters in common with the Hexagrammidae:

Head: Parasphenoid-pterosphenoid contact.

Characters absent in the Hexagrammidae:

Head: Suborbitals completely fill the cheek.
Myodome roof reduced.
Pectoral: Coracoid and scapula widely separated by cartilage.
Other: Body completely or almost completely invested in bony plates.

9. **Cyclopteridae**

Characters in common with the Hexagrammidae:

Axial: Vertebrae 29–44, the range partially overlapping that of the Hexagrammidae.*

Superfamily Cottoidae — Cont.

Characters absent in the Hexagrammidae:

Head:	Olfactory nerve not entering orbit.* Pterosphenoids absent.
Pectoral:	Coracoid and scapula widely separated by cartilage.
Pelvic:	Fins form a sucking disc.
Other:	Spinous dorsal fin separate or absent.

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REESTABLISHMENT OF THE NORTHERN ELEPHANT SEAL *(MIROUNGA ANGUSTIROSTRIS)* OFF CENTRAL CALIFORNIA[1]

by

Keith W. Radford
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, California

Robert T. Orr
California Academy of Sciences and
University of San Francisco
San Francisco, California

and

Carl L. Hubbs
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, California

Abstract: It is believed that the northern elephant seal may have bred as far north along the Pacific coast of North America as central California prior to the reduction of the population almost to the point of extinction by sealing activities during the nineteenth century. Since 1900, however, the species has made a remarkable comeback on Guadalupe Island, Baja California, and on the Channel Islands off southern

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[1] Contributions from the Scripps Institution of Oceanography, University of California, San Diego, and from the California Academy of Sciences and the University of San Francisco.

California. Furthermore, northward migrants, usually identified as males, have been observed as far north as southeastern Alaska. Since 1955 elephant seals have been observed periodically on Año Nuevo Island along the central California coast. In the winter of 1960–61, females gave birth to pups and were observed copulating with one of the four adult bulls present. In May, 1961, the population reached a peak for the year of 86 individuals, all immature. During the following winter (1961–62) 23 pups were born on the island. In 1961 the species was also recorded on the Farallon Islands (about 30 miles west of San Francisco and 55 miles northwest of Año Nuevo Island).

HISTORICAL RETROSPECT

Whether or not the title of this paper is correct is dependent upon one's interpretation of Scammon's (1869) remark that the northern elephant seal *(Mirounga angustirostris)* "was in former years found along the coast from Cape St. Lazarus [Cabo San Lázaro, on the west coast of Baja California, México, Lat. 24° 47′ N.] to Point Reyes [central California, Lat. 38° N.]. . . ." It has generally been assumed from this and other similar statements by Scammon (1874) that elephant seals formerly may have bred as far north as central California, possibly at such locations as Pt. Reyes, the Farallon Islands, and Año Nuevo Island. Intensive sealing operations, however, brought the species close to extinction during the nineteenth century. In fact, Captain Scammon, writing about the species in 1869, stated that ". . . they have become nearly, if not quite, extinct, or have fled to some isolated, unknown points for security. The latter conjecture, however, seems hardly probable, for the Sea-elephant, it is said, has never been found in the north Pacific, except on the coasts of the Californias."

Apparently a small number survived destruction by sealers and during the past few decades the species has made a remarkable comeback. Bartholomew and Hubbs (1952 and 1960) have traced its recovery from an estimated population near the end of the nineteenth century of probably fewer than 100 individuals, confined to Guadalupe Island off the coast of Baja California, to an estimated population of 15,000 ranging from Guadalupe Island north to the Channel Islands of California. The great majority of the elephant seals recorded in 1960 were in the Guadalupe Island area, with about 1600 estimated on the San Benito and Channel islands.

The reestablishment of small rookeries on the Channel Islands of southern California, as early as 1938 on San Miguel, 1948 on Santa Barbara, and 1949 on San Nicolas, has been reported by Bonnot, Clark, and Hatton (1938), Bartholomew (1950), and Bonnot (1951). A small group was discovered on South Coronado Island, just south of the international border, in 1949 (Bartholomew, 1950). From five to as many as 73 individuals have been seen at this island locality on all of the numerous subsequent visits.

Despite some poaching, the breeding colonies on the Channel Islands have maintained themselves and are increasing (Bartholomew and Boolootian, 1960).

Northward migrations from the Baja California and southern California rookeries, chiefly by bulls, appear to have been undertaken even in years when the population was extremely low. An adult male was seen at close range inside of San Diego Bay, California, by Hubbs sometime between 1904 and 1906. Migrant individuals, usually identified as adult males, have been recorded for the coasts of southeastern Alaska (Willet, 1943; Kenyon and Scheffer, 1953), British Columbia (Cowan and Carl, 1945; Cowan and Guiguet, 1960), and Oregon (Freiburg and Dumas, 1954). John D. Isaacs of the Scripps Institution of Oceanography has informed us that when he and others fished the "blue water" far off the coast of Oregon and Washington about 1936, they occasionally saw large pinnipeds that were probably elephant seals.

In December, 1950, an adult male elephant seal was observed and photographed by several local residents at Big Lagoon, Humboldt County, in northern California. It remained in the lagoon until December 26 when the sand spit separating this body of water from the sea was opened. An account of the observations, and two photographs of the animal, were published in the *Arcata Union,* a local newspaper, on December 27, 1950.

The next northern or central California record of which we are aware is of an individual, sex unknown, that was observed among a group of sea lions hauled out at Point Reyes, Marin County. This observation was made by Cecil Tose of the California Academy of Sciences, during the summer of 1954. In February, 1955, Merton E. Hinshaw, then director of the Museum of Natural History at Pacific Grove, observed several male and female elephant seals hauled out on Seal Rock, Monterey County, California. In May of the same year he saw five or six females on the same low rocks (personal communication, 1956).

Other offshore records for the central California coast include an adult male seen by Doyle E. Gates and Clyde Paul, California State Department of Fish and Game, from the R/S *Alaska,* on May 30, 1959, ten miles north of Point Sur and about seven miles offshore. An individual of undetermined sex was seen by Nels F. Giberson about June 1, 1959, six miles west of the central Monterey Bay coast.

All these offshore records of elephant seals considerably north of known rookery areas, even in years when the population of these animals was relatively low, seem to indicate a northward migration during the non-breeding period. This northward movement of the males, to waters rich in food, may be related to their rapid growth to a large size. Similarly, it is the males of the California sea lion *(Zalophus californianus)* that migrate from northern Baja California and from southern California to the cool and rich waters north of Point Conception (Fry, 1939, and personal observations). In contrast, among the northern fur seals *(Callorhinus ursinus)* it is the females that migrate, but they move southward, leaving the bulls in the far north.

RECENT ESTABLISHMENT ON AÑO NUEVO ISLAND

The first indication of the possible recent establishment of a population of elephant seals in central California was obtained when Melvin Johansen of the Snow Museum in Oakland, California, reported finding two subadult males and two females, one mature and the other younger, on Año Nuevo Island in the latter part of July, 1955. A picture, as well as an account of their presence, appeared in the *Oakland Tribune* for July 31 of that year. The following year, on September 19, 1956, Radford, in company with several other observers, noted two immature female elephant seals on the sandy beach on the east side of this island.

Año Nuevo Island, which is slightly less than 12 acres in extent, and lies approximately one-half mile off Point Año Nuevo, San Mateo County, California, at 37° 06.5′ N. Lat., 122° 20.2′ W. Long., has long been known to have the largest breeding population of Steller sea lions *(Eumetopias jubata)* south of Alaska (Orr and Poulter, 1962). It has been visited for over half a century by biologists of the California State Department of Fish and Game in the course of their sea-lion censuses, and by other observers, not one of whom, prior to 1955, is known to have reported the elephant seal from the island. Furthermore, because a lighthouse was situated there, United States Coast Guard personnel were based on the island for many years until the light was abandoned in 1948. If elephant seals had regularly visited the island during this period of occupation, their presence would almost surely have been made known.

Two of the photographs of Año Nuevo Island made on August 13, 1958, by the California Division of Beaches and Parks, which received title to the island in 1955, when examined by Orr on December 8, 1961, revealed a group of nine elephant seals on the southwest sand beach. All were immature, but one was obviously a subadult male with a well marked proboscis. William K. Kirsher subsequently informed us that he saw a small herd of elephant seals on the island in October and in December, 1960.

Beginning in the spring of 1961, regular visits have been made to Año Nuevo to observe these animals. The first of these trips was by a party from Scripps Institution of Oceanography on March 11, 1961. In May of that year a long-range project was begun by Orr, in cooperation with Thomas C. Poulter of Stanford Research Institute, to study the population dynamics and behavior of the four species of pinnipeds regularly occurring on the island, namely the northern elephant seal, the California and Steller sea lions, and the harbor seal *(Phoca vitulina)*. The results of this work, which has continued for several years, will appear elsewhere. However, certain information relative to elephant seals obtained in 1961 is included here, as well as a brief summation of data regarding the breeding of this species on the island in the winter of 1961–62. In addition, William K. Kirsher has provided data on the number of elephant seals seen by him on visits to the island in 1960 and 1961. Data on the number and approximate composition of the elephant-seal population recorded there from 1955 to 1961 (table 1) indicate an increase. The most complete data for 1961 indicate that fewer elephant seals were on the island during the summer than during the spring and autumn of that year.

The part of the island where these animals generally haul out is the sandy beach on the southwest side (fig. 1). Here they tend to be grouped on the higher part of the beach, often at the base of the bluff. As is their custom when in such situations, most of their time is spent in sleeping in various positions ranging from prone to supine. When sleeping belly side

Table 1. *Elephant Seals Observed on Año Nuevo Island, 1955–1961.*

Year	Date	Observer	Sex and Estimated Age	Total
1955	July (later part)	M. Johansen	2 subadult males; 1 adult, 1 subadult female	4
1956	Sept. 19	K. W. Radford and party	2 immature females	2
1958	Aug. 13	Div. Beaches and Parks	1 subadult male; 8 immature	9
1960	Oct. 16	W. K. Kirsher	Sex and age undetermined	35
1960	Dec. 3	W. K. Kirsher	2 subadult males included	35
1961	Mar. 11	K. W. Radford and party	4 adult males; 2 adult females; 16 immature; 2 pups	24
1961	May 7	W. K. Kirsher	All immature	86
1961	May 25	R. T. Orr and T. C. Poulter	Subadult males; females; immature	53
1961	June 27	R. T. Orr and T. C. Poulter	1 large male; mostly subadult males; possibly some females	18
1961	July 2	W. K. Kirsher	Several adult males included	24
1961	July 13	R. T. Orr and T. C. Poulter	Mostly subadult males	1
1961	July 28	R. T. Orr and T. C. Poulter	All males (4 large, 3 medium, 1 small)	8
1961	Aug. 11	R. T. Orr and T. C. Poulter	4 subadult males; 7 immature	11
1961	Sept. 7	R. T. Orr and T. C. Poulter	All immature	6
1961	Sept. 23	R. T. Orr and T. C. Poulter	All immature	50
1961	Nov. 19	T. C. Poulter	Sex and age undetermined	51

Figure 1. Aerial photograph of Año Nuevo Island taken on April 7, 1961, by John Gorman. The sandy beach to the left of the buildings on the right side is here seen to be occupied by both California sea lions and elephant seals. The latter are light in color and are on the higher central part of the beach as well as scattered about on the left end.

down, they frequently rouse themselves sufficiently to toss sand over their bodies with the front flippers.

As has been noted by others who have observed them on the islands off southern California and off northern Baja California, elephant seals show relatively little fear of man. Their reaction to human approach is in marked contrast to that of the California sea lions that mingle with them on the same beach. The sea lions take alarm and with much barking dash into the surf when one comes within 50 yards of them in the open. The elephant seals, on the other hand, remain on the beach, either sleeping, glancing about, or intermittently inching over the sand. Unless an observer comes quite close, they pay little attention to him. It was often possible for us to touch a sleeping individual or to mark it by spraying colored lacquer, without awakening it. Even those that are awake rarely move much until approached within about 30 feet.

The first indication that Año Nuevo Island was being used as a breeding rookery for this species was obtained by Radford and party on March 11, 1961, when 24 elephant seals were observed on the sandy beach to which reference has already been made. This population comprised four adult bulls, two adult cows, two nursing pups, and 16 immature animals.

An emaciated bull stayed at the far end of the beach, apart from the main group. Another bull, exhibiting definite dominance, vocalized and charged when any of the subordinate males approached the mature females. Even when he entered the water, the loud resonant vocalization of this dominant male appeared to deter the other males from approaching the females. He attempted copulation with each of the females on several occasions and was successful once, following the behavioral complex described by Bartholomew (1952). Later, an amber jellylike substance, similar in color to the seminal fluid described by Bartholomew, was observed on the sand in the area.

The presence of breeding animals, as well as two small nursing young in dark juvenal pelage, provided conclusive evidence that a reproducing colony was established on Año Nuevo Island in the winter of 1960–61. Of the 24 elephant seals on the beach on March 11, 1961, 16 were measured as they slept. These measurements (from tip of snout to tip of hind flipper) were as follows: two adult males, 345 and 363 cm.; two adult females, each 259 cm.; two pups in juvenal pelage, 130 and 155 cm. (the larger seen nursing); and ten slick-haired juveniles, measuring 155, 165, 173 (four), 198 (three), and 206 cm.

During the following winter 23 pups were born on the island, indicating not only a marked increase in the breeding population but also the permanence of the colony (figs. 2–6).

FIGURE 2. Immature elephant seals in the foreground with California sea lions beyond. Photographed at Año Nuevo Island, May 15, 1961, by Charles E. Crompton.

FIGURE 3. An adult bull elephant seal, on the left, with a harem of six cows and seven pups whose ages were estimated to range from about one to several weeks. Photographed at Año Nuevo Island, February 24, 1962, by Robert T. Orr.

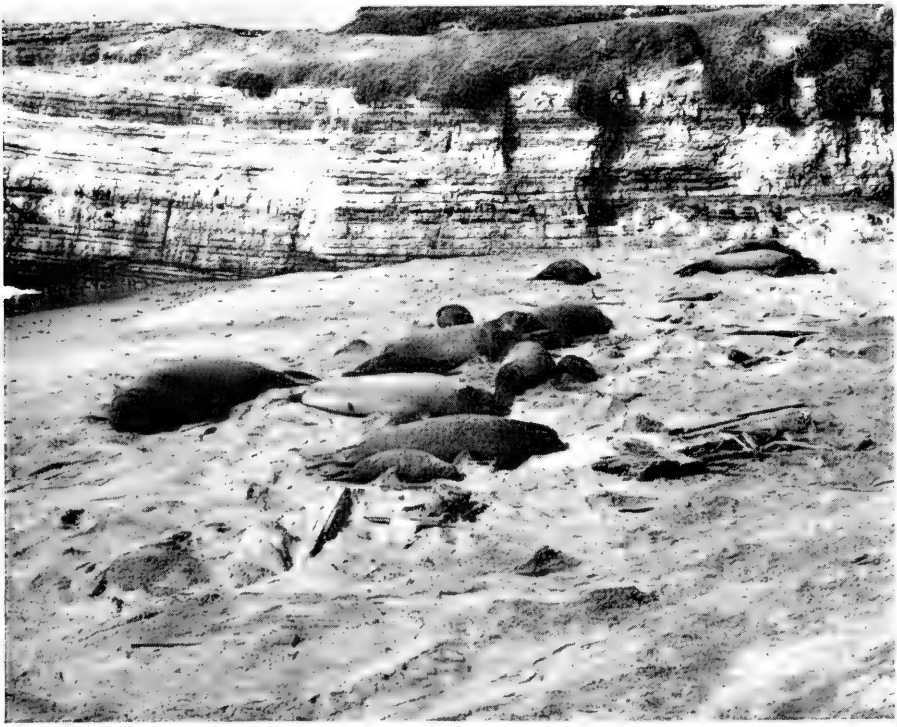

FIGURE 4. Elephant seal cows and pups. Photographed at Año Nuevo Island, February 24, 1962, by Robert T. Orr.

FIGURE 5. An elephant seal pup still in juvenal pelage. Photographed at Año Nuevo Island, February 24, 1962, by Robert T. Orr.

FIGURE 6. A group of elephant seal pups sleeping together. The largest individuals are molting or have already lost the juvenal pelage. Photographed at Año Nuevo Island, February 24, 1962, by Robert T. Orr.

OCCURRENCE ON FARALLON ISLANDS

Evidence was also obtained in 1961 that elephant seals occur presently on the Farallon Islands. David C. Regnery, Associate Professor of Biology at Stanford University, and one of his graduate students, Theodore C. Pinney, while making serological studies on European rabbits, observed two elephant seals on a sandy beach on March 29 and 30, 1961. Later an examination of a motion picture of some of the pinnipeds on the island, filmed on May 20 of that year, revealed the presence of 11 adult female or immature elephant seals. None possessed a well-developd proboscis.

ACKNOWLEDGMENTS

For certain information contained in this report as well as for their cooperation, we wish to thank Don White and Norman Cleaver of the California Division of Beaches and Parks, William E. Ripley and John L. Baxter of the California Department of Fish and Game, Thomas C. Poulter of Stanford Research Institute, William K. Kirsher of Menlo Park, David C. Regnery and Theodore C. Pinney of Stanford University, and John P. Harville of San Jose State College. For the aerial photograph of Año Nuevo Island, we wish to express our thanks to Jack Gorman.

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On *Amphisbaena heathi* Schmidt and *A. carvalhoi*, new species, small forms from the northeast of Brazil (Amphisbaenia: Reptilia)[1]

by

Carl Gans

Department of Biology
State University of New York at Buffalo
Buffalo, New York 14214

Review of the materials of South American amphisbaenids has repeatedly emphasized the scattered nature of our knowledge of these animals. The available samples scarcely permit the beginning of zoogeographical study; not even the ranges of many species can thus far be plotted with any degree of certainty.

Contributing to this is what may be an interesting tendency of certain groups to speciate on even relatively small mountain ranges. Examples are *Amphisbaena muñoai* Klappenbach (1961) restricted to a series of relatively low mountains scattered through the lowlands of eastern Uruguay, and *Amphisbaena vanzolinii* Gans (1963b) thus far known from only a single isolated plateau in southern British Guiana. These two species belong with *Amphisbaena mitchelli* Proctor and *A. slevini* Schmidt (Gans, 1963a) among the smallest South American amphisbaenids. It is thus not surprising to find that the Serra do Acahy in the State of Pernambuco appears to be inhabited by yet a third of these small montane forms. This species

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[1] Notes on amphisbaenids 16.

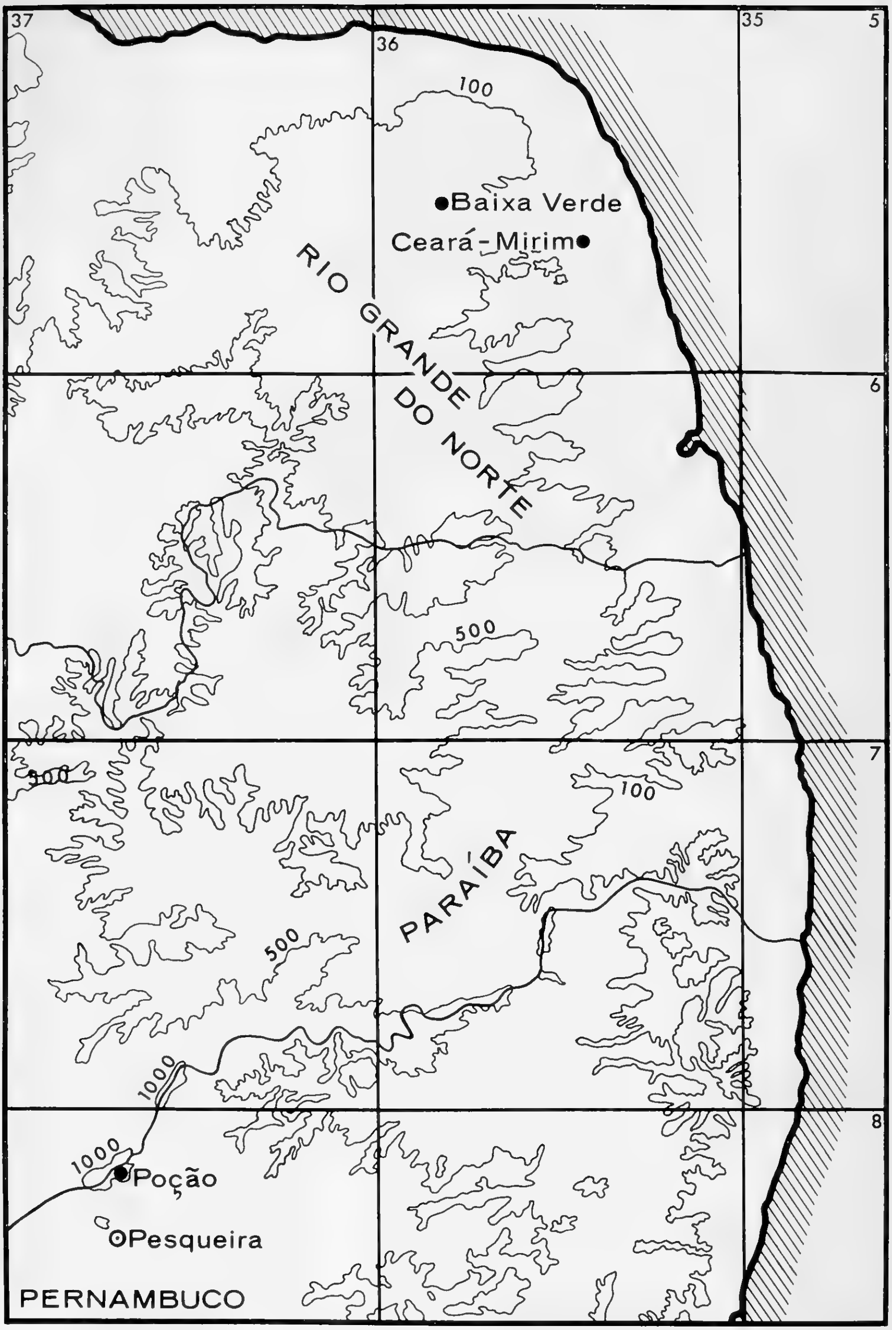

FIGURE 1. *Amphisbaena.* Sketch map of the extreme northeast of Brazil to show the localities mentioned in the text. The 100, 500, and 1000 meter lines have been shown on the map.

is clearly distinct, both from the large forms *A. alba, A. pretrei,* and *A. vermicularis,* all of which occur in the general vicinity, as well as from the peculiar, small, lowland species *A. heathi* described from Rio Grande do Norte by the late K. P. Schmidt on the basis of two specimens.

This paper describes the new species and also furnishes a standardized redescription and illustrations of *Amphisbaenia heathi.* It is a pleasure to name the new form *Amphisbaena carvalhoi* after the collector, Sr. Antenor Leitão de Carvalho, in recognition of his contributions to our knowledge of the herpetofauna of northeastern Brazil and in gratitude for his assistance and hospitality. Dr. Alan E. Leviton of the California Academy of Sciences (C.A.S.), Drs. Antenor L. de Carvalho and Bertha Lutz of the Museu Nacional, Rio de Janeiro (M.N.) and Dr. George S. Myers of the Stanford University Systematic Collections (S.U.) made available specimens in their care. Mrs. Margaret McKinney sketched the animals and Miss Charlyn Rhodes furnished technical assistance. The description follows the standard form used in Gans and Alexander (1962). Figure 1 shows the localities mentioned in the text. The review of the amphisbaenia is supported by NSF G-21819.

Amphisbaena heathi Schmidt.

Amphisbaena heathi Schmidt, 1936, p. 29 (plate 3, fig. 1). Terra typica: "Baixa Verde, Rio Grande do Norte," Brazil. HOLOTYPE: CAS 49374. PARATYPE: CAS 49424 (Ceará Mirim, Rio Grande do Norte, Brazil).

Diagnosis. A small form of *Amphisbaena* with a pointed, elongate, markedly flattened, very wide head, and somewhat prognathous snout, all circumscribed by smooth curves, and covered dorsally by very regular shields up to the nuchal region, with trapezoidal first parietals in point contact with each other; and with three supra- and three infralabials. The form has 183 to 187 body annuli; 7 to 8 caudal annuli up to the autotomy constriction (at which the tail is broken in both specimens); 12 dorsal and 18 to 20 ventral segments to a midbody annulus; and four well expressed, large, round precloacal pores in the male, none in the female. Only the lateral sulci, and these but faintly, are apparent. Neither dorsal nor ventral segments are wider than long. The color of preserved specimens is an even brown dorsally, the pigment covering the entire segmental surface and fading out laterally.

Notes on the types. Both specimens are externally in reasonable condition, with some slight soft spots.

Description. Figure 2 of the present paper shows views of the head, figure 3 the cloaca and (autotomized) tail, figures 4 through 6 inclusive photographs of the coloration and other aspects of specimens. Figure 7

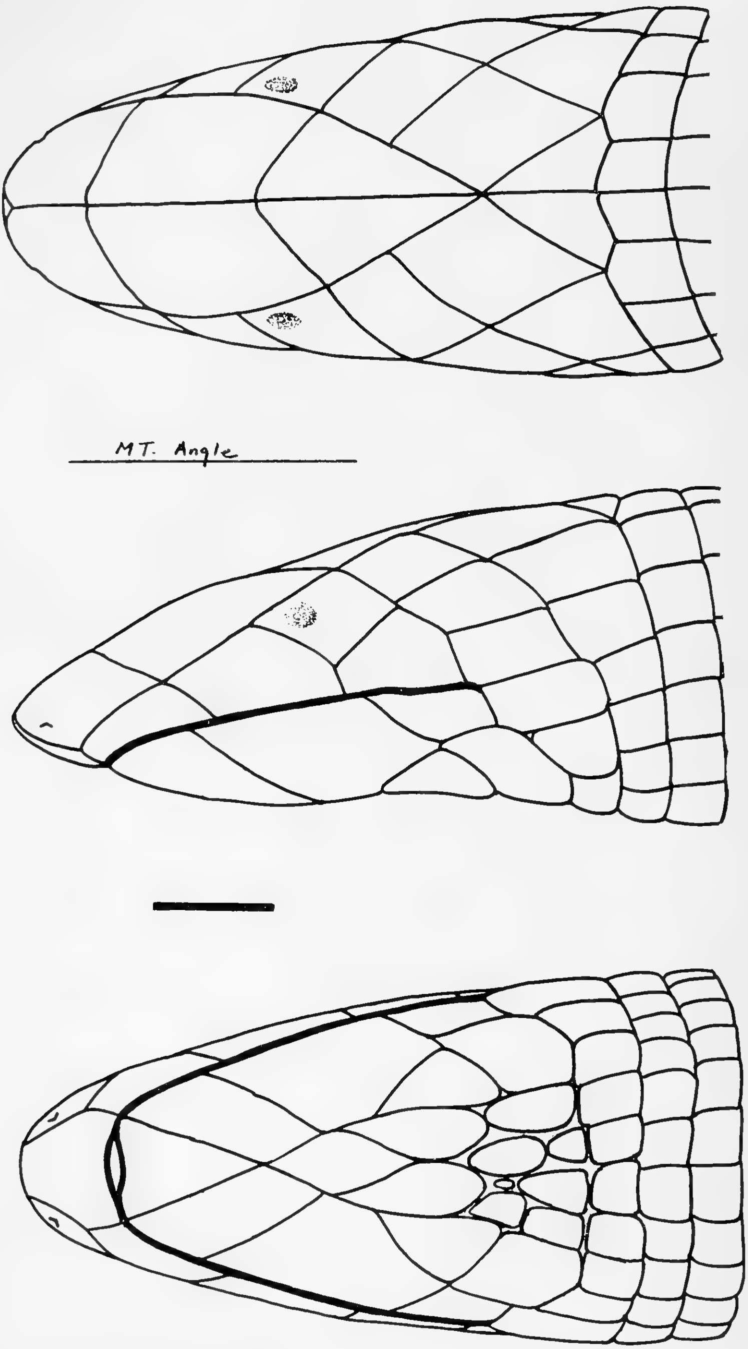

FIGURE 2. *Amphisbaena heathi.* Dorsal, lateral and ventral views of the head of the holotype, CAS 49374, from Baixa Verde, RGN, Brazil. The line equals 1 mm. to scale. (M. McKinney, del.)

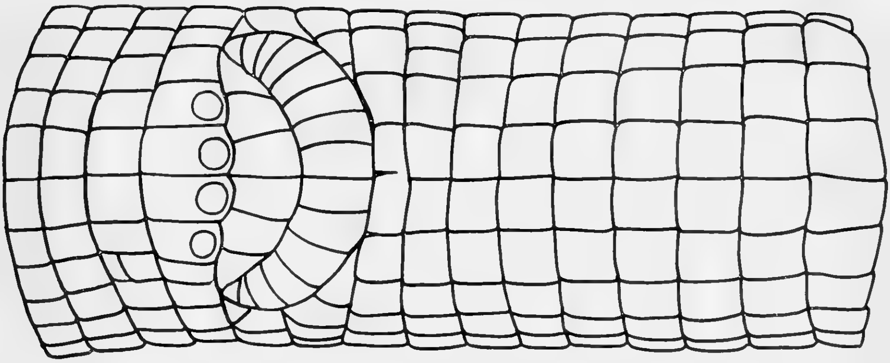

Figure 3. *Amphisbaena heathi*. Ventral view of cloaca and autotomized tail of CAS 49374. (M. McKinney, del.)

compares body proportions with those of *A. carvalhoi*. Meristic data are listed in table 1.

This is a small-sized species of *Amphisbaena* of a brownish dorsal color, without pattern, but with a slight dorsoventral countershading. The lightened color appears to extend anteriorly through the infralabial region. The entire surface of a dorsal segment is evenly pigmented. Countershading occurs by a gradual fading out along the sides with no trace of segmental drop-out in the (faded) specimens.

The head segmentation is characterized by lack of major fusions, by a pair of extremely large prefrontals, and by the fact that the large trapezoidal first parietals are only in point contact on the middorsal line. The head is of generally spatulate appearance, with the snout pointed, elongate, and markedly flattened. The wide head is circumscribed dorsally, laterally, and ventrally by smooth curves that run from the nuchal region to the rostral tip. The smooth transition is not interrupted dorsally by the faintly apparent temporal muscle bulges that provide a faint set off of the head from the trunk, but the chin is ventrally flattened and set off from the body.

The rostal is slightly larger than the third supralabial and only its very tip is visible from above. Pairs of nasals, very large prefrontals, frontals, and first and second parietals form a sequence of large shields along the dorsal surface of the head. The posterior edge of the frontals lies just caudad to the level of the angulus oris. The first parietals are large, trapezoidal and may or may not be in point contact with each other just posterior to the frontals' posterior tips. The second parietals form a pair of right triangles, the hypotenuse of which contacts the posteromedial edge of the first parietals. The lateral sutures of the prefrontals and frontals appear to be prolongated across the midline to form the lateral edge of the second parietals of the opposite

TABLE 1

Table of data for available specimens

Species and number	Sex	ANNULI Body+Lat+(Aut.)Tail	SEGMENTS Dors/Vent	Labials	Chin Segments	Cloacal Segments	Length
Amphisbaena heathi							
CAS 49424	♀	187+4+(7)x	12/18	3/3	2-3-6	0-8-11	115+x
CAS 49374	♂	183+3+(8)x	12/18-20	3/3	2-3-6	4-8-12	124+x
Amphisbaena carvalhoi							
MN 1759	–	234+4+(7)20	13-14/18	3+/3	2-3—	4-6-14	121+15
MN 2093	♂	235+5+(7)20	13-14/18	3+/3	3-3—	4-8-12	82+10
MN 2094	–	245+3+(7)20	12/17-18	3/3	2-0—	4-8-12	89+11
MN 2095	♂	231+4+(7)19	12/16	3+/3	2-3—	4-8-12	129+16
MN 2096	♀	237+3+(7)21	12-13/17-18	3/3	2-3—	4-8-12	121+15
MN 2097	–	236+4+(7)20	14/18	3+/3	2-3—	4-8-14	86+10
MN 2098	–	245+3+(7)20	14/18	3+/3	2-3—	4-8-12	85+11
SU 17289	–	236+4+(8)21	14/18	3/3	2-3—	4-8-13	112+14
SU 17290	–	244+4+(8)22	13-14/18	3/3	2-3—	4-8-13	94+11

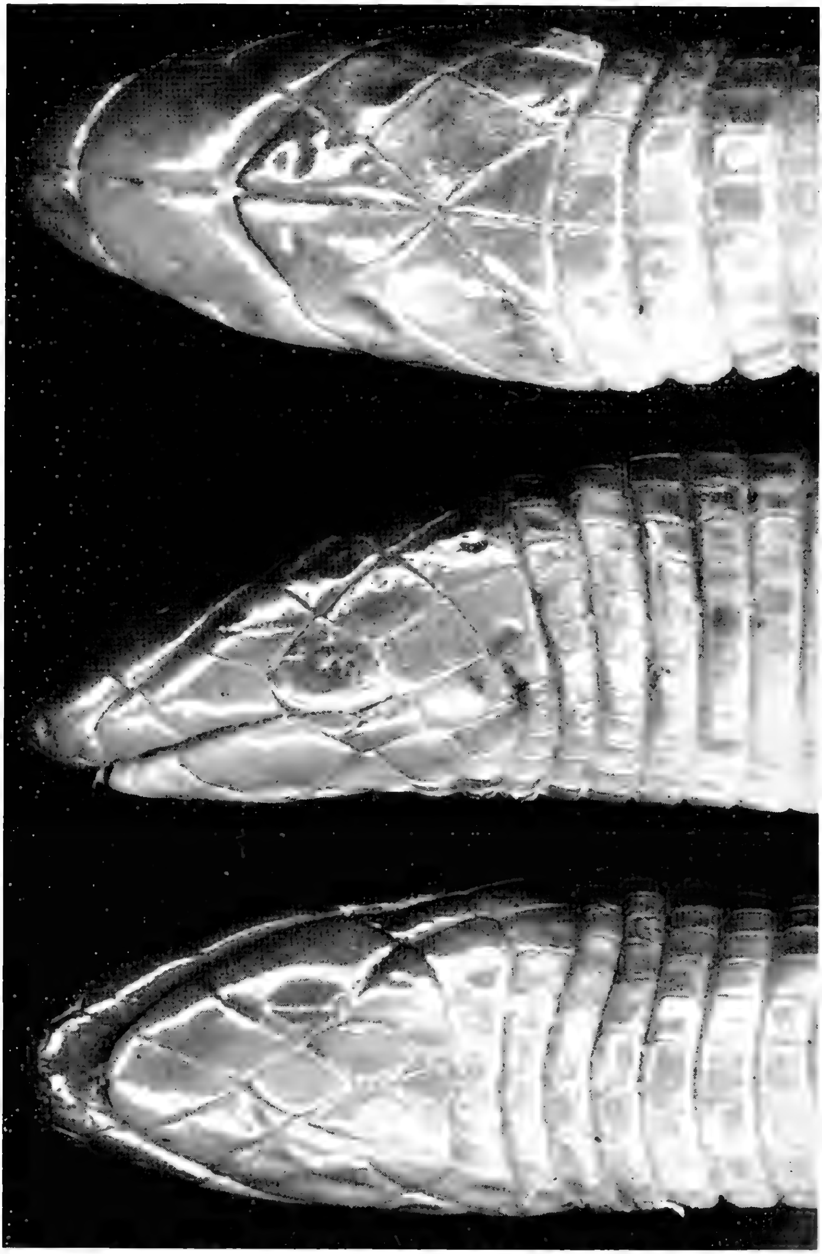

FIGURE 4. *Amphisbaena heathi.* Dorsal, lateral and ventral views of the head of the paratype, CAS 49424, from Ceará Mirim, RGN, Brazil.

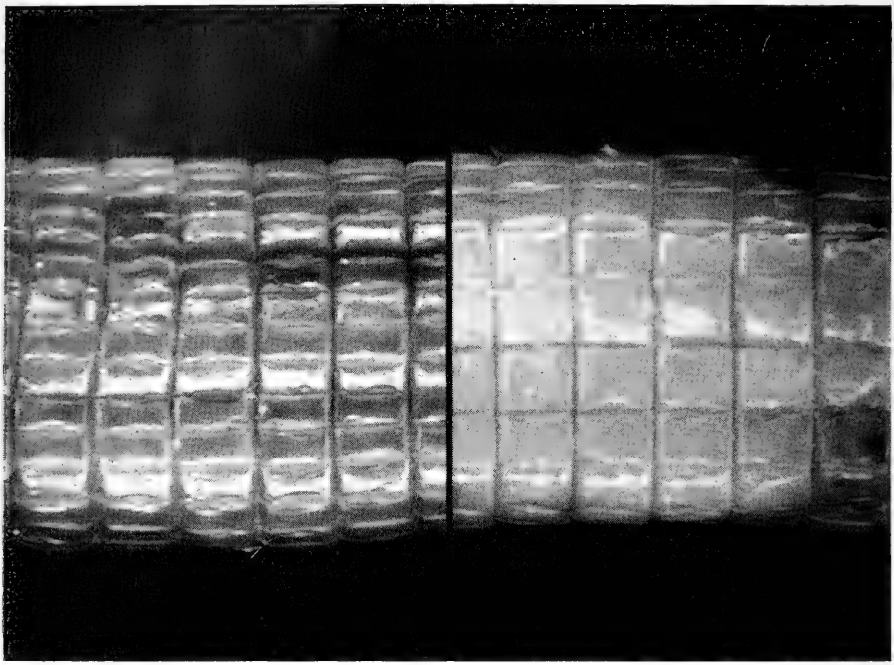

FIGURE 5. *Amphisbaena heathi.* Dorsal and ventral views at midbody of CAS 49424, to show segment proportions.

side. They are paralleled by the sutures between ocular and third infralabial, which continue in an unbroken straight line as the post-ocular-temporal sutures and as those between the first parietals and the segments ventral to them. All of this gives the scale pattern a very characteristic regular geometrical appearance. There are three subequal supralabials, the second the largest, the third occupying the shortest distance along the labial edge. The posterior edge of the third supralabial always lies slightly anterior to that of the third infralabial. The interlabial sutures run anteriorly at angles (to the labial edge) of 30°, 45°, 90°, and 90° respectively. The ocular is quadrilateral, in contact with the dorsal edges of the second and third supralabials, in broad contact with the prefrontals, in point contact with the frontal, and margined posteriorly by the equal-sized postocular.

The mental is elongate and triangular, and in point contact with the small rhomboidal postmental, the sides of which are approximately equal in width to the elongate trapezoidal first infralabials whose medial edges contact it. The second infralabials are huge and in point contact with the postmental. Two first large postgenials lie between the medial edges of the second infralabials, and the posterolateral edges of the postmental. These are followed by the three small second postgenials. The third infralabial is

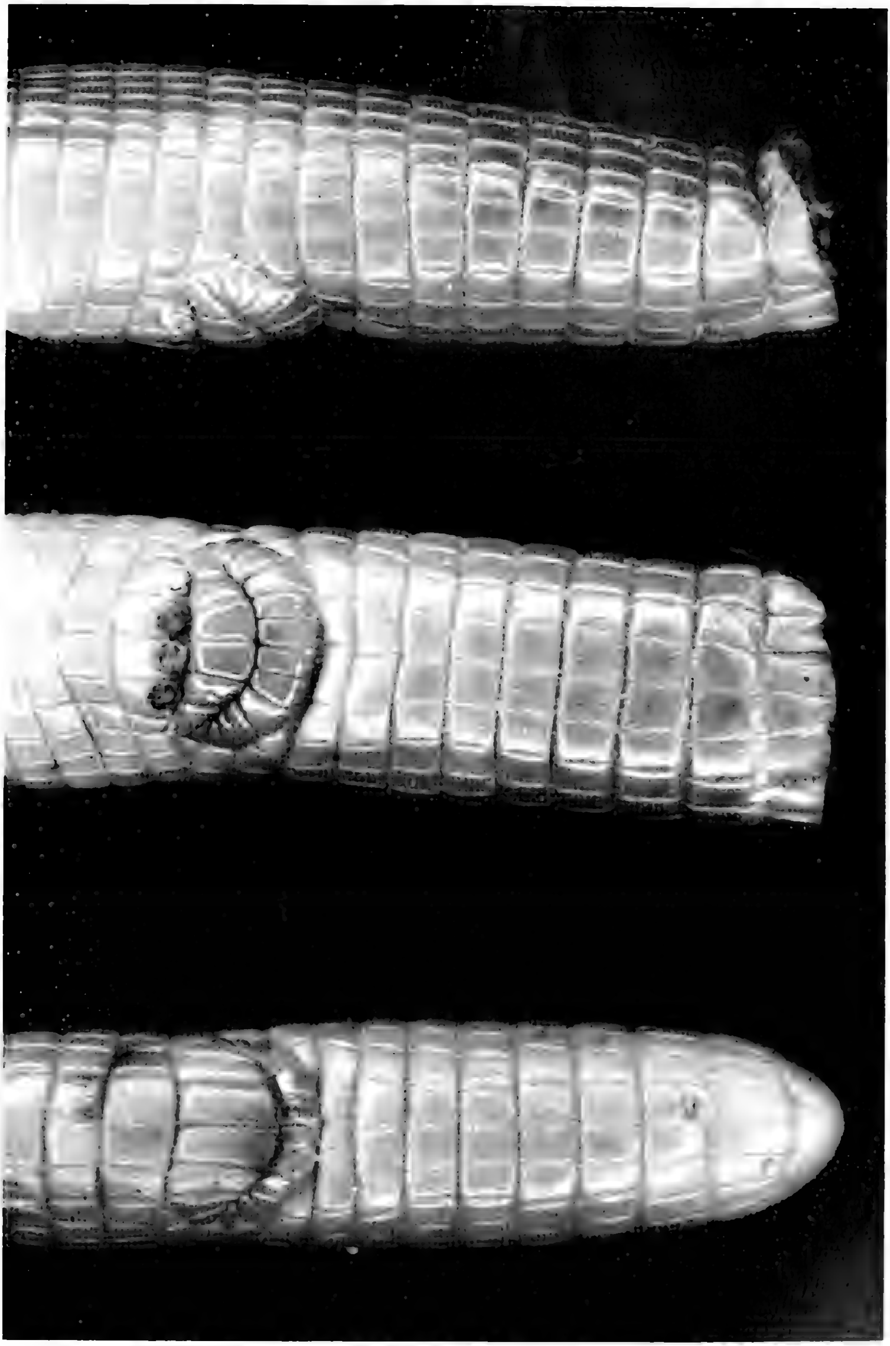

FIGURE 6. *Amphisbaena heathi*. Lateral (top), and ventral (middle) views of the cloaca and tail of the holotype, CAS 49374, and ventral view (bottom) of the tail of the paratype, CAS 49424, to show expression of the precloacal pores, and healing of the autotomized stump.

small. Medial to it lies a pair of large shields on each side, occupying the position normally held by the malars. Neither pair contacts the postmental. The posterior ones are here considered as the enlarged extreme lateral segments of the postmalar row, which then numbers six segments. Enlarged postsupralabials (postinfralabials) larger than the preceding segment(s) in line, lie caudad to the angulus oris.

Dorsally the first body annulus includes two large shields back of the first supralabial and the trapezoidal postocular. The second body annulus also sweeps forward to include two segments plus the enlarged first parietals. The second parietals represent a remnant of an intercalated dorsal half annulus. The anterior edge of the third body annulus sweeps slightly anterior and its middorsal elements are slightly lengthened. The midventral elements of the first through fourth annuli are somewhat narrower but otherwise regular. This narrowing accounts for the anterior curvature of the ventral portions of these and the four succeeding annuli. More posterior annuli show no anterior curvature and lie normal to the long axis of the trunk.

There are 183 to 187 body annuli from the back of the third infralabial, up to and including the precloacal "pore bearing" row. The pectoral region is very short and not complexed. There are neither intercalated dorsal half annuli nor irregularities along the trunk. Only the paratype has an irregularity in the immediate precloacal region. There are 12 dorsal and 18 to 20 ventral segments to a midbody annulus.

The cloacal region of the male is characterized by four large round precloacal pores which are completely lacking in the female. Both specimens are clearly adult and have mature gonads. The female has the oviduct filled with a poorly preserved yolk mass in an early stage of development. There are eight pre- and 11 to 12 postcloacal segments, with the two lateral precloacals very much the smallest, and three to four lateral half annuli. There are seven or eight caudal annuli up to and including the autotomy annulus after which the tail is freshly autotomized in the holotype and autotomized and healed in the paratype (which accounts for Schmidt's remarks).

The lateral sulci are faintly indicated by elaboration of the aligned intersegmental sutures after approximately the thirty-fifth body annulus and until the eighth precloacal annulus. Dorsal and ventral sulci are, if present, expressed only by alignment of intersegmental sutures.

The middorsal segments are approximately 1.5 times as long as wide and the midventral 1.2 to 1 as long as wide, so that there are no segments wider than long. There is relatively little change in segment proportions along the length of the trunk.

Range. Brazil. Rio Grande do Norte, lowland coastal region.

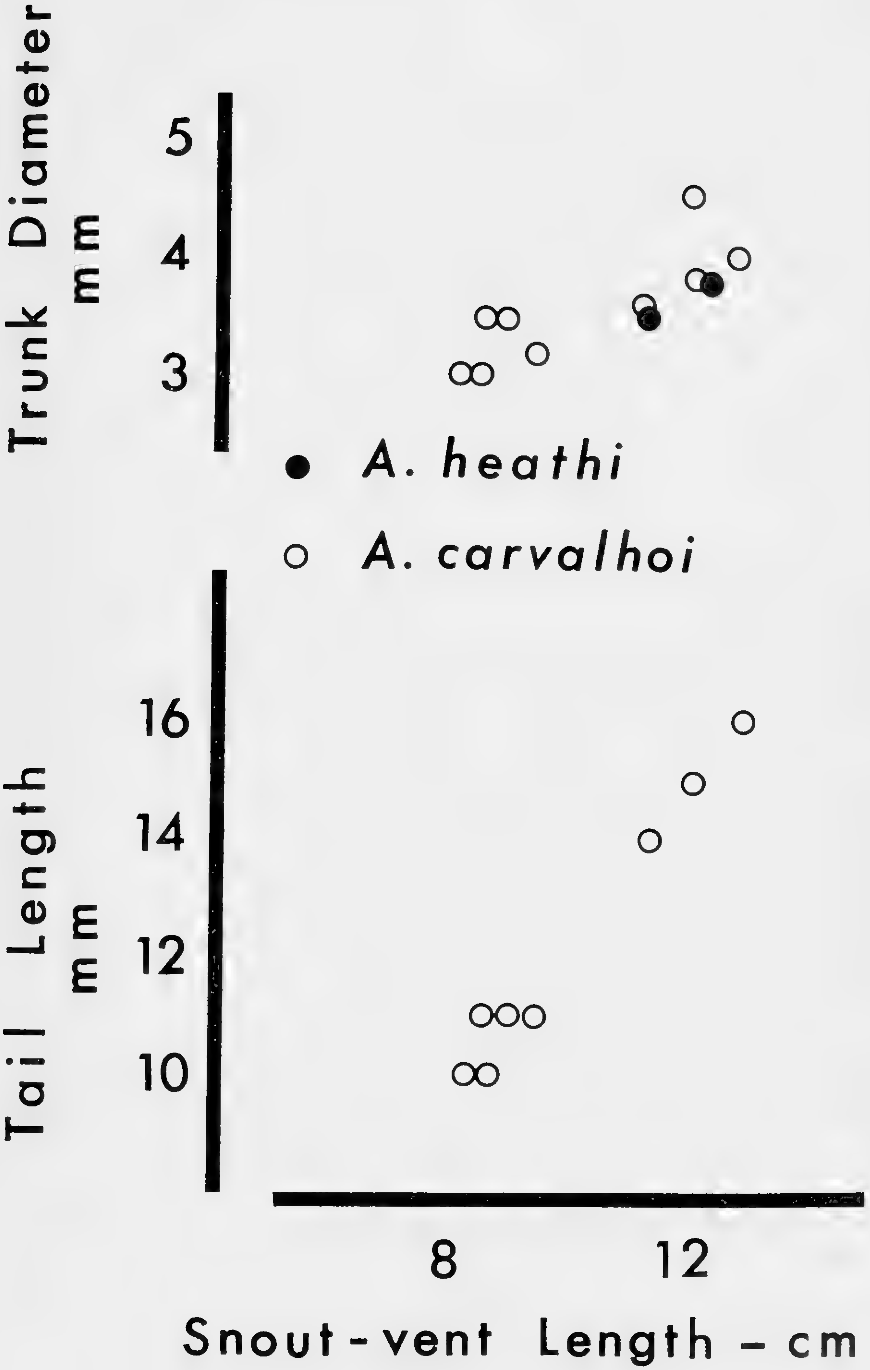

FIGURE 7. *Amphisbaena.* Scatter diagram of body diameter and of tail length, versus snout-vent length of specimens mentioned in the paper.

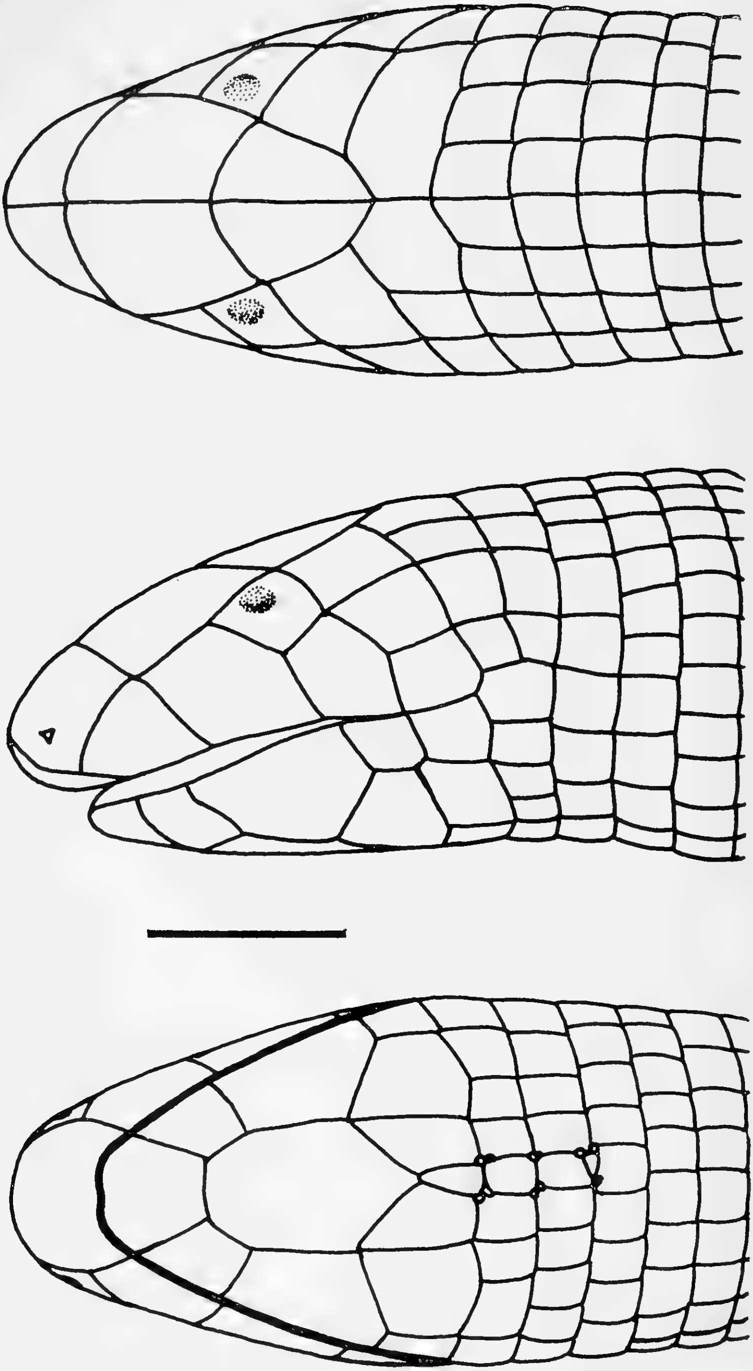

FIGURE 8. *Amphisbaena carvalhoi.* Dorsal, lateral and ventral views of the head of the paratype, MN R–2094, from Poção, Pernambuco, Brazil. The line equals 1 mm. to scale. (Mrs. M. McKinney, del.)

Distribution records. BRAZIL: Rio Grande do Norte: Ceará Mirim, CAS 49424 (paratype). Baixa Verde, CAS 49374 (holotype).

Amphisbaena carvalhoi Gans, new species.

Diagnosis. A very small form of *Amphisbaena* without major fusions of head shields, with slightly enlarged first parietals, with three supra- and three infralabials; and with two postgenial and no postmalar rows. The head is slightly compressed dorsoventrally, noticeably set off from the neck and bears a regular segmentation pattern. The form has 231 to 245 body annuli; 7 to 8 caudal annuli up to the autotomy constriction (all tails are complete); 19 to 22 caudal annuli from the cloaca to the conical caudal spine; 12 to 14 dorsal and 16 to 18, generally 18, ventral segments to a midbody annulus; and four clearly expressed, small, round precloacal pores in both sexes. The color of preserved specimens is brown dorsally, fading out ventrally on the trunk. The nape and parietal aspects of the head and the dorsal surface of the tail are slightly darker. The lightened area extends across the supralabials and the rostral region. Pigmentation consists of a general coloration of the dorsal segments, emphasized on the rectangular segmental centers. Laterally the margins fade, the rectangles decrease in size, and segmental drop out occurs.

Holotype. MN R2095, an adult male, collected by Antenor Leitão de Carvalho at Poção, Municipio de Pesqueira, Pernambuco, Brazil. Poção lies on the Serra de Acahy at 1035 m elevation, and the specimen was collected in broken up granite gravels near the top of the mountain range (cf. Carvalho, 1937).

Paratypes. MN R1759, R2093–R2094, R2096–R2098; SU 17289–17290 (taken with the holotype).

Description. Figure 8 of the present paper shows views of the head, figure 9 shows ventral and lateral views of the tail and figures 10 through

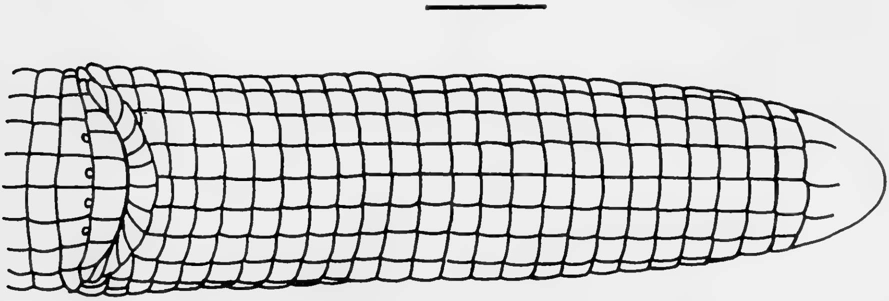

Figure 9. *Amphisbaena carvalhoi.* Ventral view of cloaca and tail of the paratype, MN R–2094, from Poção, Pernambuco, Brazil. The line equals 1 mm. to scale. (Mrs. M. McKinney, del.)

12 are photographs of the coloration and other aspects. Figure 7 compares body proportions with those of *Amphisbaena heathi.* Meristic data are listed in table 1.

This is a small-sized species of *Amphisbaena* with an even brown dorsal color, emphasized on the parietal region and on the dorsal surface of the tail. The ventral surface is light colored from the tip of the tail up to and including the infralabials, first (and second) supralabials and the rostral tip. Some specimens (including the holotype) show a fainter version of the dorsal color on the ventral surface of the tail. Pigmentation is uniform across many of the dorsal segments; others show a rectangular darkened area. The countershading is achieved by a gradual fading of the segmental margins, proceeding more rapidly below the lateral line, by a decrease of the area occupied by the central rectangle, and by marked segmental drop-outs.

Head segmentation is characterized by lack of major fusions, by large prefrontals, by postoculars almost as large as the frontals, and by medium-sized first and no enlarged second parietals. The head is relatively short, more or less pointed and dorso-ventrally compressed. The temporal muscles bulge noticeably and the middorsal sutures are faintly sunk from the level of the frontals to the third body annulus. The nuchal region is slightly constricted. After this the trunk continues at constant diameter along most of its length.

The rostral is approximately of the size of the first supralabial and only its tip is visible in dorsal view. Pairs of sizeable nasals, large prefrontals, small frontals, and medium-sized first parietals form a sequence of large shields along the dorsal surface of the head. The posterior edge of the frontals lies slightly anterior to the level of the angulus oris. There are three supralabials, the second the largest; the third the smallest. The posterior edge of the third supralabial generally lies slightly anterior to that of the third infralabial. The interlabial sutures run anteriorly at angles (to the labial edge) of 30°, 50°, 60°, and 75° respectively. The ocular is quadrilateral, in contact with part of the dorsal edges of the second and third supralabials, in broad contact with the prefrontal, in point contact with the frontal, and margined posteriorly by the postocular and possibly by the segment ventral to it.

The mental is a small, rectangular segment only slightly larger than the small first infralabials, and approximately one-half the size of the septagonal postmental. The second infralabials are very large and are medially in full contact with the postmental. The malars are large, and lie immediately posterior to the large second and medial to the small third infralabials. They never contact the postmental. Two subtriangular first postgenials enclose the posterior tip of the postmental and are followed

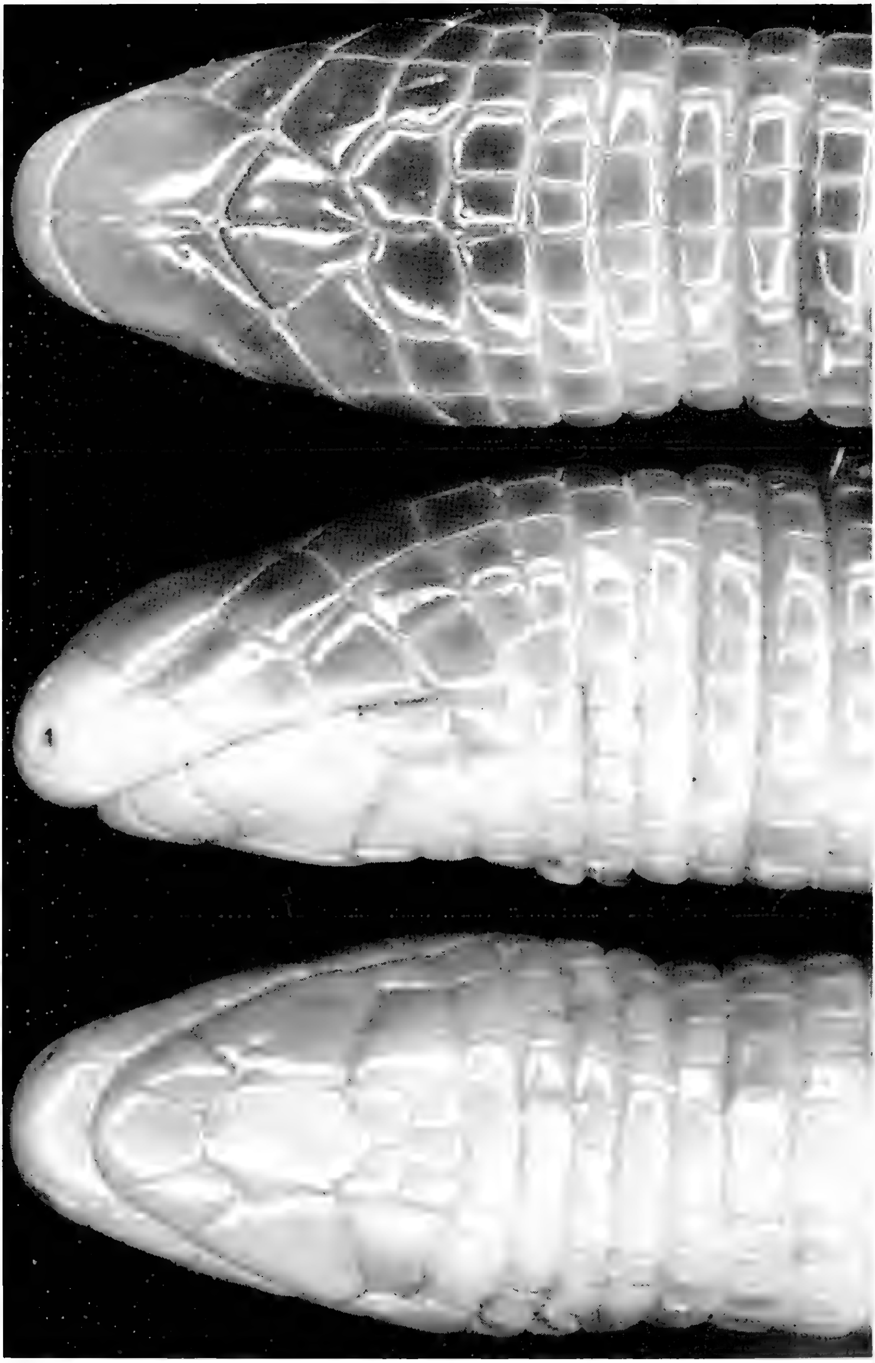

FIGURE 10. *Amphisbaena carvalhoi.* Dorsal, lateral and ventral views of the head of the holotype. MN R–2095.

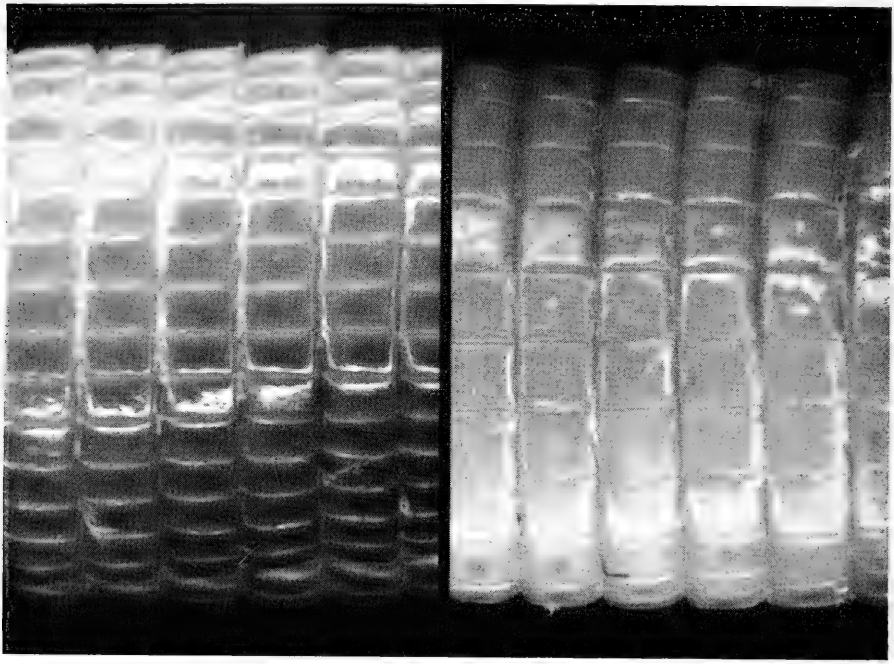

FIGURE 11. *Amphisbaena carvalhoi.* Dorsal and ventral views at midbody, of MN R–2095, to show segment proportions and pigmentation pattern.

by three postgenial segments of the second row. One specimen has a tiny median segment midway between the two large first postgenials. There are no postmalars. The lateralmost postmalar segments of the first body annulus are widened.There is always a pair of enlarged postsupralabials and postinfralabials.

Dorsally the first body annulus includes two large shields back of the third supralabial and the large postocular. The second body annulus generally splits one segment dorsal to the angulus oris, giving rise to two dorsal half annuli. The anterior of these is normally an intercalated one and the posterior one the dorsal continuation of the second body annulus, though irregularities occur and some specimens have two rather than one intercalated half annuli. The anterior dorsal half annulus includes two medium-sized, pentagonal first parietals as well as two to three smaller segments on each side. The posterior dorsal half annulus culminates in the second parietals which are scarcely enlarged. The midventral elements of the second through sixth body annuli are somewhat narrowed. The posterior annuli show no curvature and lie normal to the long axis of the trunk.

There are 231 to 245 body annuli from the back of the third infralabial up to and including the precloacal porebearing row. The pectoral region

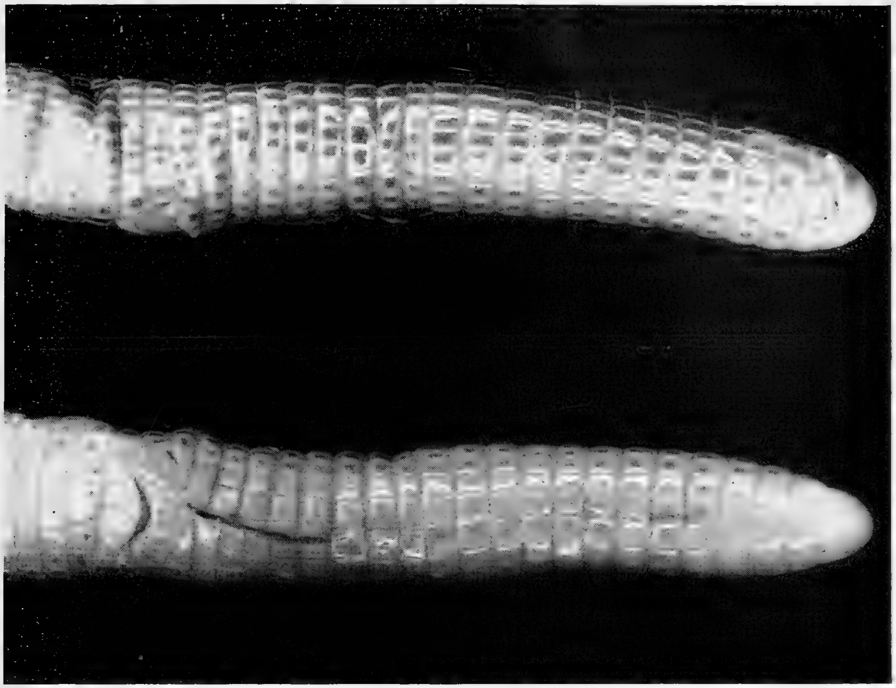

FIGURE 12. *Amphisbaena carvalhoi.* Lateral (top) and ventral (bottom) views of the cloacal region and tail of MN R–2095, to show proportions, segment and pore arrangement, and color pattern.

is not complexed. There are no irregularities or intercalated dorsal half-annuli along the trunk, though there generally is some irregularity in the ten precloacal annuli. There are 12 to 14 dorsal and 16 to 18, generally 18, ventral segments to a midbody annulus.

The cloacal region is characterized by four medium-sized, but clearly expressed, round precloacal pores, present in both sexes and in juveniles. Six larger precloacal segments cover a half-moon-shaped precloacal shield, that is extended laterally by a small straight segment on each side, so that there generally are eight precloacals. Twelve to 14 radially arranged postcloacal segments, with the two midventral ones slightly enlarged, border the posterior lip of the cloaca. Lateral half annuli number three to four. There are 7 to 8 caudal annuli up to and including the clearly narrowed and constricted autotomy annulus, and 19 to 22 from the cloaca up to and including the caudal tip. The tail swells slightly posterior to the autotomy constriction, and then becomes gradually conical, reducing down to the parabolic, vertically oval tip.

The lateral sulci are clearly indicated after the fiftieth body annulus and run up to the level of the cloaca. At midbody they are expressed as grooves half as wide as one of the fringing segments and filled with broken segments. The dorsal sulcus is barely indicated by alignment of intersegmental sutures. It is clearly apparent only at the base of the tail and in the nuchal region. The ventral is indicated only by alignment of intersegmental sutures.

The middorsal segments are approximately 1.3 to 1.5 times as long as wide. The midventral segments vary from 0.9 to 1.2 times as wide as long. There is some minor variation in segmental proportions along the length of the trunk.

Range. Brazil. Pernambuco, Serra do Acahy.

Distribution records. BRAZIL: Pernambuco: Poção, Municipio de Pesqueira, elev. 1035 m., MN 1759, 2093–2094, 2095 (holotype), 2096–2098; SU 17289–17290.

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BEHAVIOR AND NATURAL REACTIONS OF THE NORTHERN ANCHOVY, *ENGRAULIS MORDAX* GIRARD, UNDER THE INFLUENCE OF LIGHT OF DIFFERENT WAVE LENGTHS AND INTENSITIES AND TOTAL DARKNESS

By

Anatole S. Loukashkin and Norman Grant

California Academy of Sciences
San Francisco

I. INTRODUCTION

It has been known from times immemorial that certain fishes respond positively to artificial light and aggregate within illuminated zones. This peculiar behavior of fish has long been extensively exploited by fishermen. Torches and bonfires (still in use in some areas) were the first sources of artificial light for attracting the schools of fishes into nets and fish traps. With advancing technology, these light sources gave way to petrol and acetylene lamps and electricity, especially to the latter because of its applicability for underwater illumination (Verheijen, 1958). With underwater illumination possible, a new trend in commercial fishing has been developing since the end of World War II (Ellson, 1953), particularly in the Soviet Union

(Borisov, 1950; Borisov and Protasov, 1959; Leskutkin, Nikonorov and Patëev, 1955; Nikonorov, 1955, 1956, 1958, 1959a, 1959b; Terentiev, 1957). Instead of using conventional gear such as nets or traps, new, so-called "netless" fishing equipment has been introduced in certain fisheries. It consists of submerged electric lamps and the "fish pump." The fish attracted by the light at night are sucked into the pump funnel and pumped directly into the vessel's hold. In this technique, experiments have been made also to apply an electrical field within the illuminated zone so that the aggregated fish would be forced to swim toward the pump funnel, which is made the positive pole (Nikonorov and Patëev, 1959; Smith, 1955).

More and more species of fishes and other aquatic organisms have been reported in the literature as reacting positively to sources of artificial light under laboratory conditions or in the natural environments. Considerable research has been done on the structure and function of the fish eye (Baburina, 1955, 1958; Brett, 1959; Tamura, 1959; Vilter, 1950), on the ability of the fish to discriminate colors, and on innate preferential selectivity of monochromatic lights (Arora and Sperry, 1958; Breder, 1959; Bull, 1957; Kawamoto, 1959; Loukashkin and Grant, 1959), on the ability of fish to respond differently to different intensities of artificial light (Breder, 1959; Privolnev, 1956, 1958), and on many other specific problems related to fish behavior as it is affected by natural and artificial lights.

Out of the voluminous literature on the subject published in recent years and of special interest to the writers, only a few papers are selected and mentioned below. Borisov (1950) recorded 42 species and subspecies of fishes which responded positively to electric light. His list includes marine, anadromous and freshwater fishes found in the USSR; in 1955, he listed more than 60 forms. In 1954, Radovich and Gibbs reported 44 species of marine fishes from the waters of California and western Mexico which responded positively to electric light under natural conditions.[1] Baranov (1955) listed 17 species for the northwestern Pacific, and Parin (1958) mentioned 54 marine fishes collected at night light stations during oceanic exploration of the Pacific in 1954–55.[2]

Among pelagic fishes of commercial importance, the clupeids, or herring-like fishes, have been found the most responsive to artificial light, and

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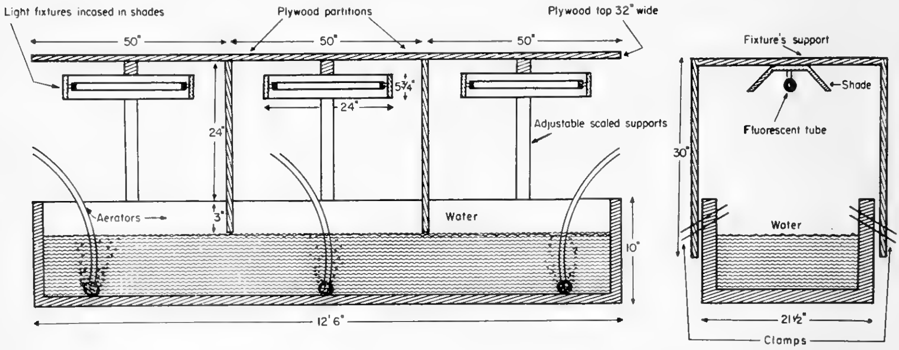
[1] Since the date of Radovich and Gibbs' report (1954), many more species of the fishes from the same area have been found to respond positively to electric light in the open sea (a continuously expanding unpublished list has been maintained by the California State Fisheries Laboratory at Terminal Island). While on research cruises of the California Fish and Game M/V *Alaska* in Mexican territorial waters in 1958 and 1961, the senior author recorded 20 species as supplementary to Radovich and Gibbs' list of 1954. These fishes are as follows: *Astroscopus zephyreus*, *Auxis* sp., *Carcharhinus lamiella*, *Cetengraulis mysticetus*, *Chloroscombrus orqueta*, *Cynoscion parvipinnis*, *Harengula thrissina*, *Menidia starksi*, *Mugil cephalus*, *Mugil* sp., *Nectarges nepenthe*, *Oligoplites* sp., *Polynemus* sp., *Pseudophallus starksii*, *Raja* sp., *Sphyraena* sp., *Sphyrna zygaena*, *Synodus lucioceps*, *Trachurops crumenophthalmus*, and *Upeneus* sp.

[2] A complete list of the fishes collected at night light stations by Parin in the Pacific Ocean during the 1954–1960 oceanological expeditions aboard the research vessel *Vitiaz* will be published by him and is in press.

most of the references herein cited refer to this family. Species displaying a strong positive taxis to artificial light, readily aggregating in masses within illuminated zones, are as follows: sardines—*Sardinops caerulea* (Radovich and Gibbs, 1954; Rasalon, 1959), *Sardinops sagax melanosticta* (Borisov, 1955; Yudovich and Kolegov, 1956), *Sardina pilchardus sardina* (Verheijen, 1957, 1958; Nikonorov, 1959), *Sardinella macrophthalma* (Breder, 1959), *Sardinella aurita* (Verheijen, 1958); herrings—*Clupea pallasii* (Gristchenko, 1951; Radovich and Gibbs, 1954; Baranov, 1955; Borisov, 1955; Nikolaev, 1957), *Clupea harengus harengus* (Craig and Baxter, 1952; Borisov, 1955; Blaxter and Parrish, 1958; Radakov and Soloviev, 1959; Tihonov, 1959; Zaitsev and Azhazha, 1959), *Clupea harengus membras* (Borisov, 1950, 1955); Caspian shads—*Alosa brashnikovi brashnikovi, Alosa brashnikovi agrachanica, Alosa caspia caspia, Alosa kessleri kessleri,* and *Alosa kessleri volgensis* (Borisov, 1955; Chugunova, 1955); Caspian sprats "kil'ka"—*Clupeonella delicatula caspia, Clupeonella engrauliformis,* and *Clupeonella grimmi* (Eremtstov and Nikonova, 1949; Tokarev, 1949; Borisov, 1950, 1955; Bondarenko, 1951; Prihodko, 1951, 1957a, b; Leskutkin and Prihodko, 1951; Safronov, 1952; Evtëev, 1953; Leskutkin, Nikonorov and Patëev, 1955; Lovetskaya, 1955, 1958; Nikonorov, 1955, 1956a, b, 1958, 1959a, b; Chugunova, 1955; Terentiev, 1957; Borisov and Protasov, 1959); sprats—*Sprattus sprattus sprattus* (Blaxter and Parrish, 1958), *Sprattus sprattus balticus,* and *Sprattus sprattus phalericus* (Borisov, 1950, 1955); Pacific round herring—*Etrumeus acuminatus* (Radovich and Gibbs, 1954); Pacific thread herring—*Opisthonema libertate* (Radovich and Gibbs, 1954); Atlantic dwarf herring—*Jenkinsia lamprotaenia* (Breder, 1959); and zunasi herring—*Harengula zunasi* (Sasaki, 1959).

Among other commercially important pelagic fishes which are known to respond strongly to artificial light are the following: anchovies—*Engraulis mordax, Anchoa delicatissima,* and *Anchoa compressa* (Radovich and Gibbs, 1954), *Engraulis japonica* (Borisov, 1950, 1955; Baranov, 1955; Parin, 1958), *Engraulis encrasicholus* (Verheijen, 1958), *Engraulis encrasicholus pontica* and *Engraulis encrasicholus maeotica* (Borisov, 1950, 1955; Safianova, 1952, 1958; Kirillov, 1955; Radakov, 1956); mackerels—*Scomber scombrus* (Blaxter and Parrish, 1958), *Pneumatophorus diego* (Radovich and Gibbs, 1954), and *Pneumatophorus japonicus* (Borisov, 1950, 1955; Baranov, 1955; Parin, 1958) jack-mackerels or horse-mackerels—*Trachurus symmetricus* (Radovich and Gibbs, 1954), *Trachurus japonicus* (Parin, 1958, Sasaki, 1959), and *Trachurus trachurus* (Borisov, 1950, 1955; Safianova, 1952, 1958; Radakov, 1956; Protasov, 1957; Blaxter and Parrish, 1958; Borisov and Protasov, 1959); saury—*Cololabis saira* (Pochekaev, 1949; Radovich and Gibbs, 1954; Baranov, 1955; Borisov, 1955; Yudovich, 1956; Parin, 1956, 1958; Gristchenko, 1957; Pokrovsky, 1957; Fukuhara, 1959); tunas—

Neothunnus macropterus and *Euthynnus yaito* (Hsiao, 1952; Tester, 1959); cod-like fishes—*Gadus morhua morhua* (Borisov, 1950, 1955; Lagunov, 1955), *Gadus morhua macrocephalus* (Baranov, 1955), *Melanogrammus aeglefinus, Odontogadus merlangus euxinus,* and *Boreogadus saida* (Borisov, 1955).[3] The behavioral studies conducted at the California Academy of Sciences have been confined to four species of marine pelagic fishes: Pacific sardine, *Sardinops caerulea* (Girard); northern anchovy, *Engraulis mordax* Girard; Pacific mackerel, *Pneumatophorus diego* (Ayres); and Pacific jack mackerel, *Trachurus symmetricus* (Ayres). The behavior and reactions of the sardine under the influence of white and colored lights and darkness have already been explored (Loukashkin and Grant, 1959). The present paper sums up the results of the study of the behavior and reactions of the northern anchovy stimulated by artificial light of different wave lengths and intensities and by darkness. In essence, it is a continuation of the earlier experimental work on sardines. The equipment, facilities, and methods (fig. 1) used in the laboratory experiments for the larger part of the study were exactly the same as described earlier for the sardine; therefore, to avoid unnecessary repetition the reader is referred to that report. However, changes in technique or equipment are noted and full information is presented in appropriate sections below.



LONGITUDINAL CUT CROSS-SECTIONAL CUT

Figure 1. Sketch drawing of the experimental tank divided into three light zones for testing the anchovy's ability to discriminate colors of the light and intensities of white light. (After Loukashkin and Grant, 1959.)

For measuring light intensities, a Weston Illumination Meter, model 756, was used. This model is visual and cosine corrected, with direct dial read-

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[3] The size of the present report excludes the possibility of listing all the other marine and freshwater fishes whose phototactic responses to artificial light have been tested in recent years. Readers interested in this subject will find more information in the accounts by Baranov (1955), Blaxter and Parrish (1958), Borisov (1950, 1955), Parin (1958), Pochekaev (1949), Privolnev (1958), Protasov (1957, 1958), Radovich and Gibbs (1954), Sasaki (1959), and especially in the Verheijen report (1958) in which a review of the literature on fish responses to light is included.

ings on the scales ranging from 0 to 500 foot-candles. The illumination meter was manufactured by the Weston Electrical Instrument Corporation of Newark, New Jersey.

This account is based on the experiments carried out on two large schools of adult anchovies kept in the display tanks of the Steinhart Aquarium, California Academy of Sciences, at different times (approximately two years apart). The majority of the experiments were devoted to the investigation of the ability of the anchovy to discriminate the same monochromatic lights, white light and darkness, which had been successfully applied in the experiments with the Pacific sardine (fig. 2). The second portion of the study involved the use of ultraviolet and infrared wave lengths and observations on the reactions of the anchovy to different intensities of the white light. As with the stock of the Pacific sardine used in earlier experiments, the northern anchovy schools were kept in a 1,000-gallon display tank illuminated with an ordinary 300-watt incandescent lamp which was suspended two feet above the water surface. Therefore, the fish used in the study can be considered "light-adapted" animals.

The scientific names of most of the fishes mentioned in the text are based on Roedel (1953) for the California and Mexican species, and on Berg (1932–33, 1949), Borisov and Ovsiannikov (1951), and Svetovidov (1952) for the fishes of the USSR.

II. REACTIONS OF NORTHERN ANCHOVY TO LIGHT WAVE LENGTHS AND INTENSITIES

(1) Preferential reactions to monochromatic lights, white light, and darkness.

The ability of the anchovy to react differently to different light wave lengths was tested in a tank which could be divided into two, three, or four

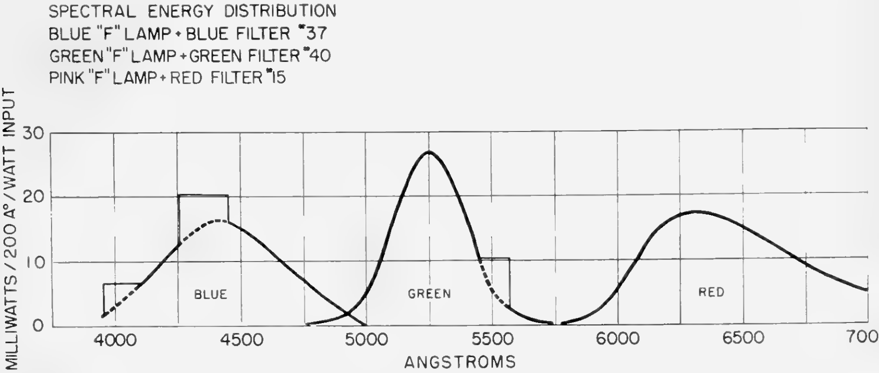

Figure 2. Spectral energy distribution of the monochromatic light sources used in the present study. (After E. A. Lindsay, 1948.)

zones and equipped with electric light sources of contrasting illumination. Results of the experiments of two-zone tests are presented in tables I–XI, those of the three-zone tests in tables XII and XIV, and of the four-zone tests in table XIII. In the two-zone tests different groups of six fish were subjected to the effect of a given pair of lights or of light and darkness. Each combination was used in two experiments consisting of six tests with 100 recorded observations, totalling 7,200 fish. Altogether, 79,200 fish are grouped in eleven tables for comparison of natural preference reactions to one type of illumination, or another. In testing the ability of the anchovy to distinguish green light from other colors, it was found that when this light was paired with white light, 5,424 fish out of 7,200 moved to or remained in the green-light zone, displaying definite preference for this light (74.34 per cent) over the white light (24.66 per cent), as seen from table I. When green and red lights were paired, this preference for green light rose to 97.86 per cent. The highest degree of negative reactions to red light in tests 2, 6, and 12 was manifested by total avoidance of the red light zone, as shown in table II. When green light was presented along with blue light, anchovies were able to differentiate these two lights in contrast to the Pacific sardine, which was unable to do so (Loukashkin and Grant, 1959). As seen from table III, anchovies reacted preferentially to green light; 73.18 per cent of the individuals which were tested selected the "green zone," compared to 26.82 per cent which showed preference for the "blue zone." When paired with a darkened zone, the green-light zone was frequented by 6,918 fish (96.08 per cent), while only 282 (3.92 per cent) made occasional movements of short duration into the darkened zone. In tests 1 and 5, avoidance of the darkened zone was total (table IV).

When testing the blue light paired with white light or red light or darkness, fish responded favorably to the blue light. Table V shows a slight preference for blue (52.15 per cent) over the white light (47.85 per cent), and a marked preference for blue (81.60 per cent) over the red (18.40 per cent) and (97.03 per cent) over darkness with four examples of total avoidance of the darkened zone in tests 1, 6, 7, and 12 (tables VI and VII).

Red light, when paired with white light (table VIII), as in the trials with green and blue lights, elicited negative responses on the part of the fish tested (in tests 1 and 9 only one fish entered the red light zone each time). Preferential reaction for the white light was as high as 88.39 per cent. The red light attracted anchovies only when it was opposed by total darkness (92.97 per cent) as seen from table IX.

When testing white light versus darkness, anchovies responded positively to the former (97.88 per cent) and negatively to the latter (2.12 per cent) with total avoidance of that zone in tests, 4, 5, 6, 8, 10, 11, and 12 (table X). This is in full accord with other experiments in which an illuminated zone was presented with the darkened one (tables IV, VII, and IX).

Diagrammatic interpretation of the relationship in the effects of different lights on the anchovy's discriminating ability tested in pairs is shown in figure 3.

To evaluate the significance of the apparent preference responses of the fish to monochromatic lights, the same groups of anchovies, either before or after experiment, were kept in a two-zone tank under a white light of the same intensity. The results obtained are presented in table XI, and they clearly display a normal distribution of 7,200 fish very close to a 50:50 ratio; however, the relationship varied from test to test. The average distribution of anchovies for 12 tests was found to be 50.06 per cent for one zone, and 49.94 per cent for the other. These tests were considered as controls.

After completing the series of experiments in a two-zone tank, anchovies were subjected to experiments in three-zone and four-zone tanks. In these experiments light intensities were maintained at a uniform level for all lights as in the two-zone experiments, or they were presented in different values. The latter modification was intended to see if the increment in light intensity would elicit a change in response because of brightness of illumination regardless of the color of light. The results of these experiments are presented in tables XII and XIII. The first four experiments in a three-

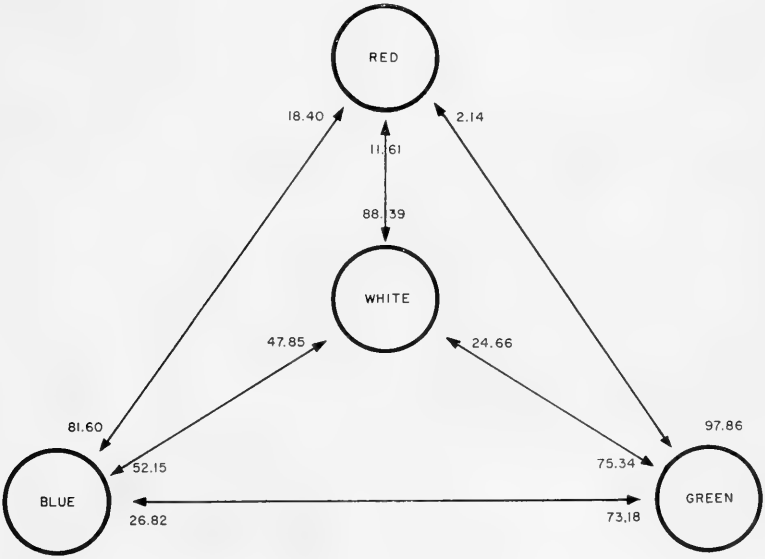

Figure 3. Diagrammatic interpretation of the relationships between the effects of different lights on the anchovy's discriminating ability tested in pairs in the two-zone tank. Positive and negative reactions are expressed in per cent. All sources of light were maintained at 9 foot-candle intensity.

zone tank illuminated with white, green, and red lights, regardless of variation in intensities, demonstrated overwhelming preference of the anchovies for the green light. The positive preference responses in these experiments for the green light averaged as high as 66.33 per cent (14,400 fish), though in separate cases this preference varied from 56.0 per cent to 72.0 per cent. Negative responses to the other two lights were as follow: 19.63 per cent for white light and 14.04 per cent for red light. These results are in full agreement with those obtained for the green light when tested in pairs with the others in a two-zone tank. In experiment WGD (table XII) the intensity of the green light was reduced to 6 foot-candles, while the white-light intensity was increased up to 30 foot-candles. The third zone was darkened. Again, anchovies responded in favor of the green light (69.33 per cent). In another experiment RDW (table XII) red and white lights were presented in intensities of 30 foot-candles with the middle zone darkened. As anticipated, the white-light zone was frequented most of all (50.34 per cent), and red-light zone least of all (19.33 per cent). The reason why more fish were found in the darkened zone than in the red-light zone may have been that the white light penetrated the darkened zone. In other experiments, DBR-1 and DBR-2 (table XIII), the blue and red lights were applied, the third zone having been darkened. In both experiments with uniform intensities of 9 foot-candles and with contrasting intensities (4 foot-candles for the blue light, and 30 foot-candles for the red light) anchovies displayed extremely high preference for the blue light (93.16 per cent and 98.67 per cent respectively).

Table XIII presents the results of experiments in a four-zone tank in which green, blue, and red lights of 9 foot-candle intensity, and darkness were tested. Out of 9,600 fish, 80.19 per cent were found in the green-light zone, 15.34 per cent in the blue, 2.56 per cent in the red, and 1.91 per cent in the darkened zone. This preference of the anchovies for the green light perfectly agrees with all previous results.

The last experiments in the present series were made to duplicate approximately the natural vertical distribution of the sunlight spectrum in water. The tank was divided into three zones as follow: daylight (white light with normal percentage of red light in it)[4] to imitate surface and near-surface illumination; green light for a deeper horizon of water mass; and blue light to represent the deepest horizon of the water medium in which the anchovy is found. In experiment DGB-1 the intensities of lights were maintained at 16, 7.8, and 0.5 foot-candles respectively; for DGB-2 these intensities were reduced to 6.0, 3.0, and 0.25 foot-candles respectively (table XIV). The results of 12 tests with a group of nine anchovies in each of the two experiments show the same preferential tendency of the fish

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[4] General Electric 20-watt "Daylight" fluorescent tube 24 inches long, ordering symbol F20T12/D.

toward the green light as in all other experiments in which various combinations of monochromatic and white lights were applied. This preference for the green light was found to be 48.57 per cent, in the experiment DGB-1, and 44.79 per cent in DGB-2 compared to 30.01 per cent and 30.24 per cent respectively for the daylight and 21.42 per cent and 25.40 per cent for the blue light.

(2) Responses to ultraviolet wave length.

In this series of experiments, low and high intensity sources of ultraviolet radiation were used. In the first set of experiments a "black light" 20-watt fluorescent tube (24 inches long) manufactured by the General Electric Company (trade symbol F20T12/BLB) was used. Its spectrographic characteristics are shown by the curve in figure 4, from which it is seen that this lamp emits a certain amount of visible light, too. This source

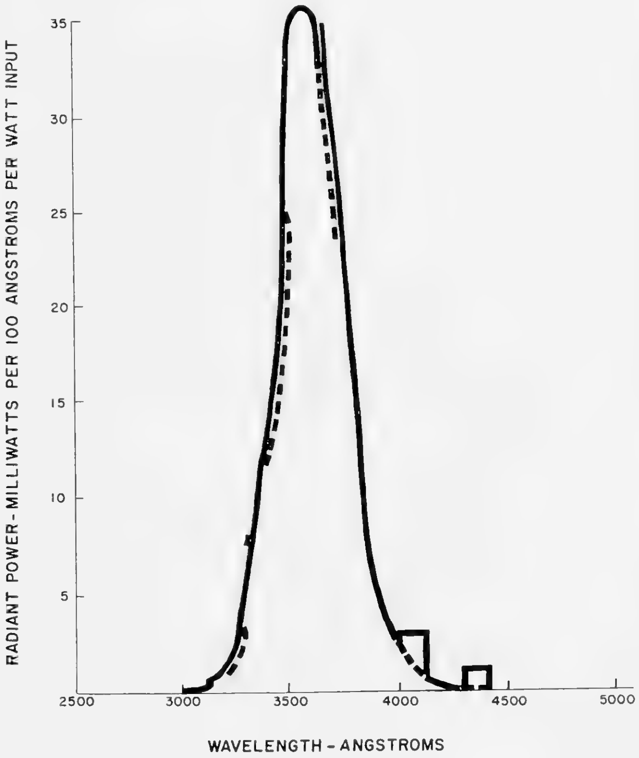

FIGURE 4. Spectral energy distribution of the "Black Light Integral Filter Fluorescent Lamp" manufactured by the General Electric Company. Official drawing on file with the Company based on 40-watt lamp is reproduced here with written permission of the manufacturer. The curve is also typical for the 20-watt lamp (F20T12/BLB) used in the present study.

of ultraviolet radiation was first tested paired with monochromatic lights, using the same colored fluorescent tubes and filters as in the preceding series. Because of the extremely low intensity of the "black light," the other lamps were masked to reduce the intensity of colored lights to the level of the former, which was as low as 0.2 foot-candle. The results of six experiments covering the distribution of 57,600 fish are tabulated in tables XV–XVII.

Paired with blue light, the ultraviolet wave length had no specific effect upon behavior of the anchovies. The average figures show a 50:50 distribution ratio (table XV). The ultraviolet-green combination revealed slight preferential reactions toward the green light (54.79 per cent). This tendency was observed in all of the 24 tests (table XVI), while in ultraviolet-blue combination fish responses varied considerably from test to test, especially in experiment UL-1.

In experiments using ultraviolet light and red light, anchovies at first displayed very slight but constant preference for the ultraviolet zone (52.25 per cent in experiment UL-5.). In the next experiment (UL-6) this preference rose to 91.70 per cent varying between 80.50 per cent to 100.0 per cent from test to test, and averaging 71.79 per cent and 28.03 per cent for ultraviolet and red light respectively (table XVII). However, in this case it can be assumed that it was not the attractive value of the ultraviolet rays that resulted in greater frequenting of the "black light" zone, but rather the repelling effect of the red light as revealed in previous experiments when monochromatic lights were used and the anchovies avoided the red-light zone unless the alternative was darkness. The same avoidance reactions toward the red light were demonstrated earlier on the Pacific sardine (Loukashkin and Grant, 1959).

The next two experiments, with application of higher light intensity, were made in a two-zone tank. It was illuminated with clear light, and a source of ultraviolet radiation alternately added to one of these zones. The white light was produced by the General Electric 15-watt incandescent lamp ("frosted"), one in each zone, and the ultraviolet source was the same 20-watt "black light" described above. A light intensity of 10.5 foot-candles was maintained in both zones. The results of 24 tests involving the distribution of 19,200 fish are shown in table XVIII. The averages for the white-light zone and white-light plus ultraviolet zone are almost identical: 49.84 per cent for the former, and 50.16 per cent for the latter. The fish seemed to be unable to differentiate one zone from the other, and the numbers of fish frequenting one zone or the other varied considerably from test to test, especially in experiment UL-7.

Following this, an ultraviolet source of very high intensity was tested. For this purpose a "New Black-Ray Model B-100 (3660Å)" equipped with 100-watt mercury spotlight bulb, ballast, and ultraviolet-transmitting Kopp

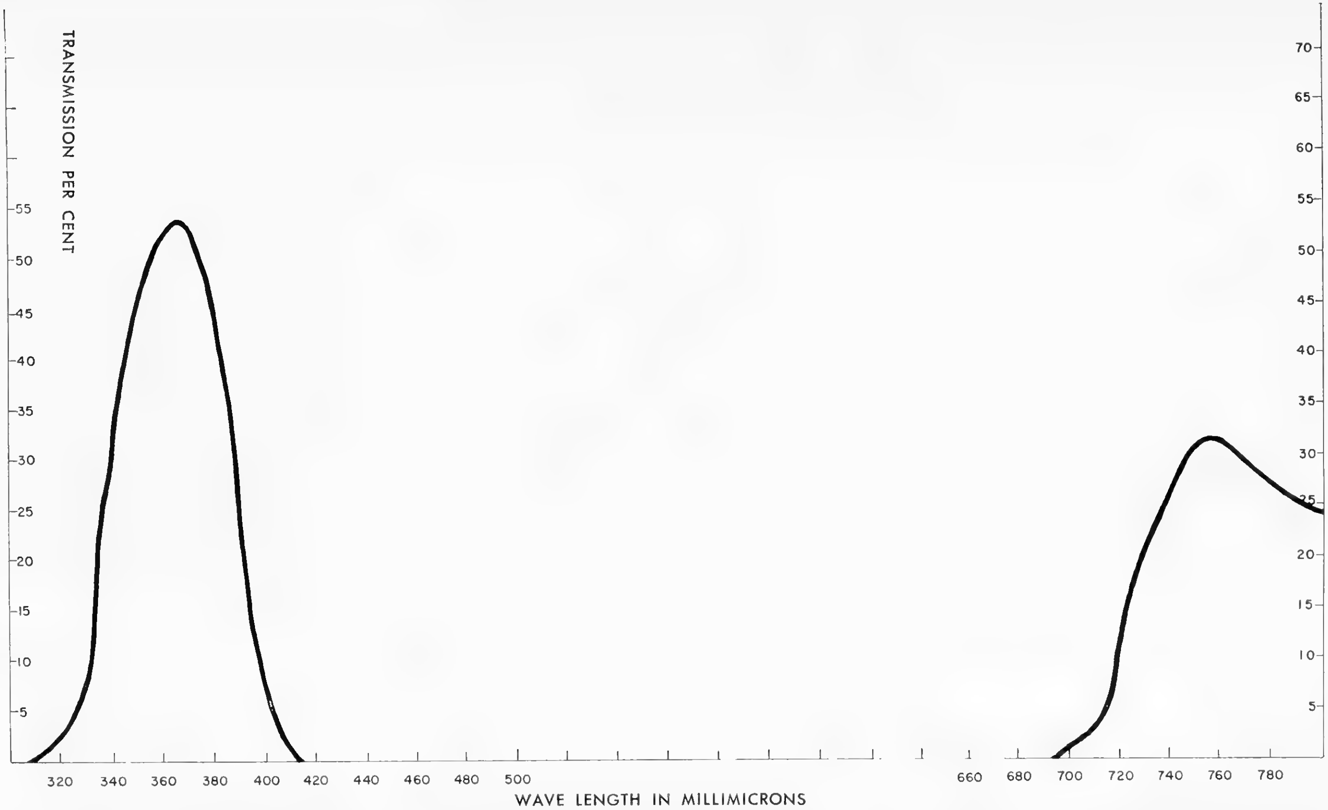

FIGURE 5. Spectral properties of the ultraviolet transmitting filter "Kopp no. 41" as used on the "New Black-Ray Model B-100 (3660Å)" lamp manufactured by the Ultra-Violet Products, Inc., San Gabriel, California. Courtesy of the manufacturer.

41 filter was used. This source of ultraviolet radiation was manufactured by the Ultra-Violet Products, Inc., San Gabriel, California. The spectral-energy distribution of this lamp, with filter attached, is shown in figure 5. In addition, an extra filter (Corning Glass Works, no. 5840) was acquired in order to filter out most of the visible rays. Its properties are shown in figure 6.

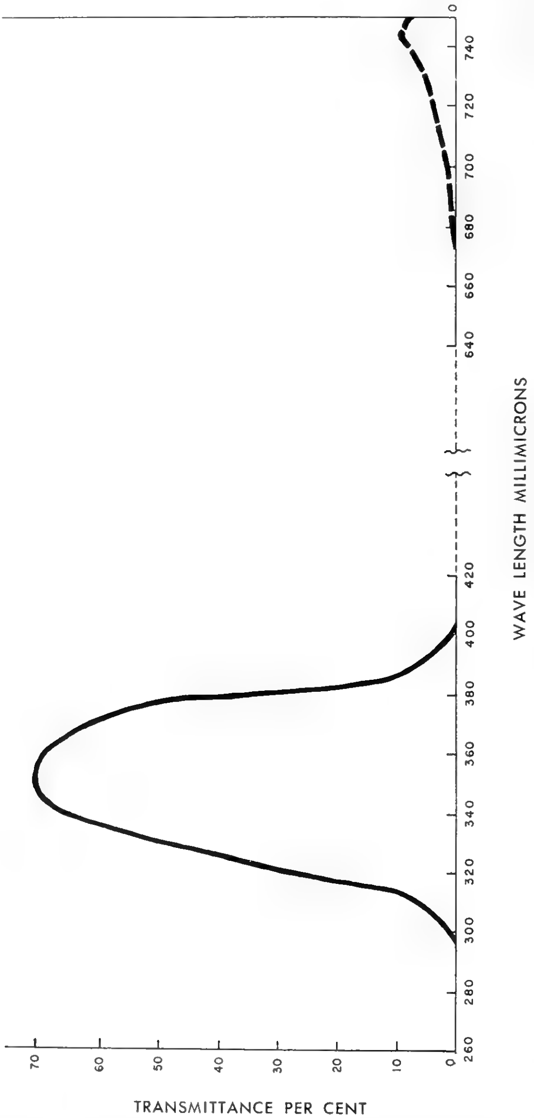

FIGURE 6. Spectral properties of the ultraviolet-transmitting filter no. 5840 (7–60) of the Corning Glass Works. Courtesy of the manufacturer.

At first, attempts were made to test the effect of ultraviolet wave lengths in total darkness by placing this source in one zone and keeping the other zone darkened. These, as all other tests herein reported, were carried out in a specially built dark room in the Steinhart Aquarium. Despite all possible efforts, the investigators had to abandon this experiment because the use of both filters together failed to entirely filter out visible light rays. Though of extremely low intensity and detectable by the human eye only after prolonged stay in the dark room, these rays, fortified by the ultraviolet wave length, created fluorescence in water. Reflections from the bottom and tank sides dimly illuminated the entire tank though a much brighter glowing spot appeared directly under the lamp. Under this meager illumination the fish were able to still orientate and swim in a loose school formation and to continue their typical counter-clockwise movement in the tank. However, the speed of swimming slowed to one-half of normal. The intensity of light was far below 0.01 foot-candle.

In the next trial, the 100-watt mercury spotlight lamp (General Electric H-100-SP4) was suspended over the center of the experimental tank. Its spectrographic characteristics are shown in figure 7. A dividing shield was removed. Light intensity at the surface of water directly under the lamp was 500+ foot-candles with a rapid decrease toward the tank's ends. One-half of the tank was covered with a clear glass plate to filter out ultraviolet rays. The other half remained open to allow ultraviolet radiation to enter. In this experiment (UL-9, table XIX) 64 per cent of 8,000 fish responded positively to the zone covered with the glass plate, while 36 per cent entered the ultraviolet zone. The glass plate was then removed and both halves of the tank were subjected to ultraviolet radiation. In this experiment (UL-10, table XIX) 52.20 per cent of the fish entered one zone, and 47.80 per cent the other, which is close to a 50:50 ratio. After this, in order to evaluate the role of the clear-glass plate as a filter and its effect upon the numbers of fish gathering under it, an ultraviolet source was replaced by the KEN-RAD 300-watt reflector flood lamp emitting clear light of the same intensity as the mercury spotlight lamp. One-half of the tank was again covered with the glass plate. This time (UL-11, table XIX) the fish distributed themselves evenly (50.45 per cent and 49.55 per cent). Thus, it seems reasonable to assume that the 64.0 per cent response of the fish to the ultraviolet-free zone in experiment UL-9 was not incidental, and that the fish displayed a normal "avoidance reaction" toward the ultraviolet zone.

In the last set of experiments with ultraviolet radiation, the light intensity was reduced by half, and the procedure was different. In the experiment UL-12 (table XX) the tank was divided again into two zones by installing a separating shield in the center. In each zone one KEN-RAD 300-watt reflector flood lamp emitting white light of 225 foot-candle intensity

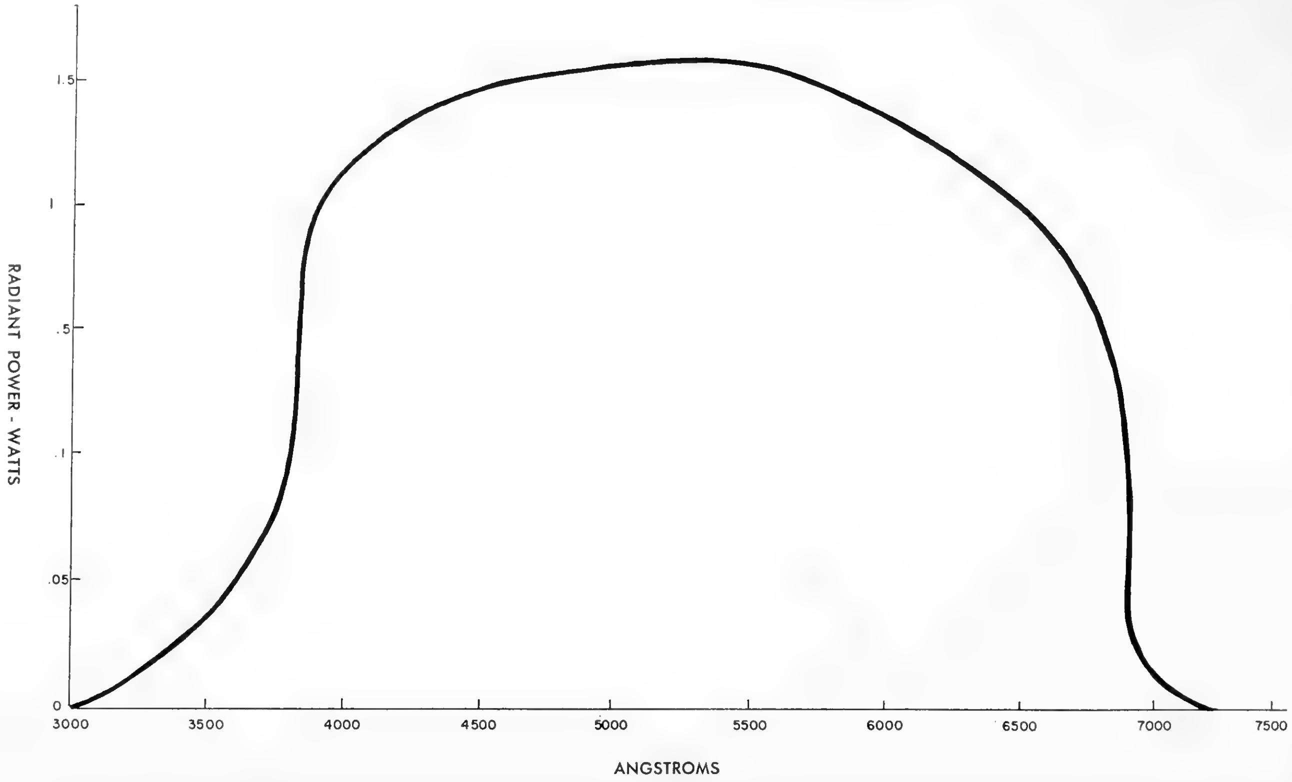

FIGURE 7. Spectral energy distribution of the General Electric 100-watt mercury reflector spotlight lamp (near-ultraviolet region of the spectrum) No. H–100–SP4 (Black Light) based on the data published by the manufacturer. [The pamphlet "Mercury Lamps and Transformers," LS–103, second printing, dated January 1958.] Courtesy of the General Electric Company.

was installed. In ten tests involving 6,000 fish, as anticipated, there resulted a more or less even distribution of fish (48.47 per cent and 51.53 per cent). In experiment UL-13 (table XX), one of the white lights was replaced with 100-watt mercury spotlight lamp (ultraviolet), and the positions of these two sources were alternated during the experiment. The intensity of light in both zones remained the same as in the previous experiment. Throughout all ten tests, the anchovies consistently preferred the white-light zone. Their responses for the white-light zone varied between 60.0 per cent to 100.0 per cent from test to test, averaging 72.1 per cent and displaying negative or avoidance reaction toward the ultraviolet zone (27.9 per cent) once again. Diagrammatic interpretation of the anchovy reactions toward the ultraviolet wave length is shown in figure 8.

(3) Responses to infrared wave length.

In this series of experiments the first tests were made in a two-zone tank; one zone was exposed to infrared radiation, the other remained in total darkness. Instead of being six inches deep, as in all other experiments, the

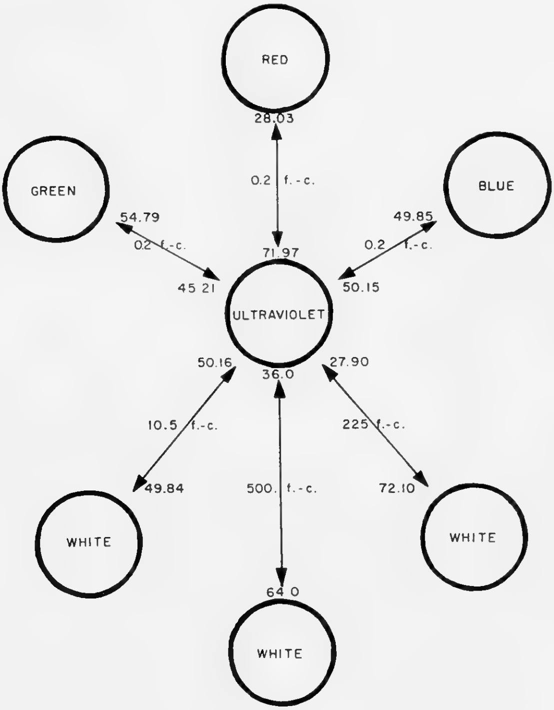

Figure 8. Diagrammatic interpretation of the anchovy's reactions toward the ultraviolet wave length in relation to opposing monochromatic and white lights. Positive and negative reactions are expressed in per cent.

water level was lowered to three inches and the lamp was suspended six inches above its surface. A G.E. 250-watt reflector heat lamp with red coating provided the source of the infrared radiation (its spectrographic features are shown in figure 9). A Corning filter no. 2540 was used to absorb all visible rays, transmitting infrared rays alone. Figure 10 shows the spectrographic properties of this filter.

Eight anchovies were placed in an experimental tank two hours prior to testing and were kept there in total darkness. A recording of fish distribution was made every ten minutes with the aid of dimmed ruby-red flashlight; this operation required not more than two or three seconds and only the fish in one zone were counted at a time. Altogether ten tests each of 30 recorded observations were made covering the distribution of 2,400 fish. The results of experiment INF-1 are shown in table XXI. From the very start, it was clearly evident that the fish did not respond to infrared radiation. In both darkened and infrared zones, they behaved in exactly the same manner as did the Pacific sardine in total darkness (Loukashkin and Grant, 1959). The school was broken up; fish were scattered throughout the tank; swimming speed was slowed almost to a "stand still"; orientation was completely lost, individual fish moving randomly, and all the fish moved so close to the surface of the water that their dorsal fins and backs projected above the water. The average distribution of fish in ten tests was found to be about even: 51.33 per cent of the fish were recorded in the infrared zone, and 48.67 per cent in the darkened zone. To check the results, the infrared lamp was turned off, and the fish were kept in total darkness in both zones. Following the same procedure as in experiment INF-1, the investigators obtained exactly the same results: 48.58 per cent and 51.42 per cent (exp. INF-2, table XXI). After this, an infrared source was turned on again, and to the surprise of the observers, the fish began to concentrate under the lamp, though there was no visible change in the over-all situation. The mirror, placed under the lamp, revealed a tiny crack in the filter, through which just a pin point of red light was reflected by the mirror. Intensity of this light was about 0.001 foot-candle. The human eye, adapted to the darkness of the dark room, was unable to see this light without the use of a mirror, but the anchovies were able to perceive such a meager light value and to respond to it very readily. The averages for ten tests (exp. INF-3, table XXI) show a definite preference by the fish for this zone (74.17 per cent) over the zone of darkness (25.83 per cent).

In the next two experiments (INF-4 and INF-5, table XXII), one of the two zones was illuminated by white light using a KEN-RAD 300-watt reflector floodlight lamp; light intensity at the surface of the water measured 500 foot-candles. The other zone was illuminated with a G.E. 250-watt reflector heat lamp without red coating, which emitted both white light and

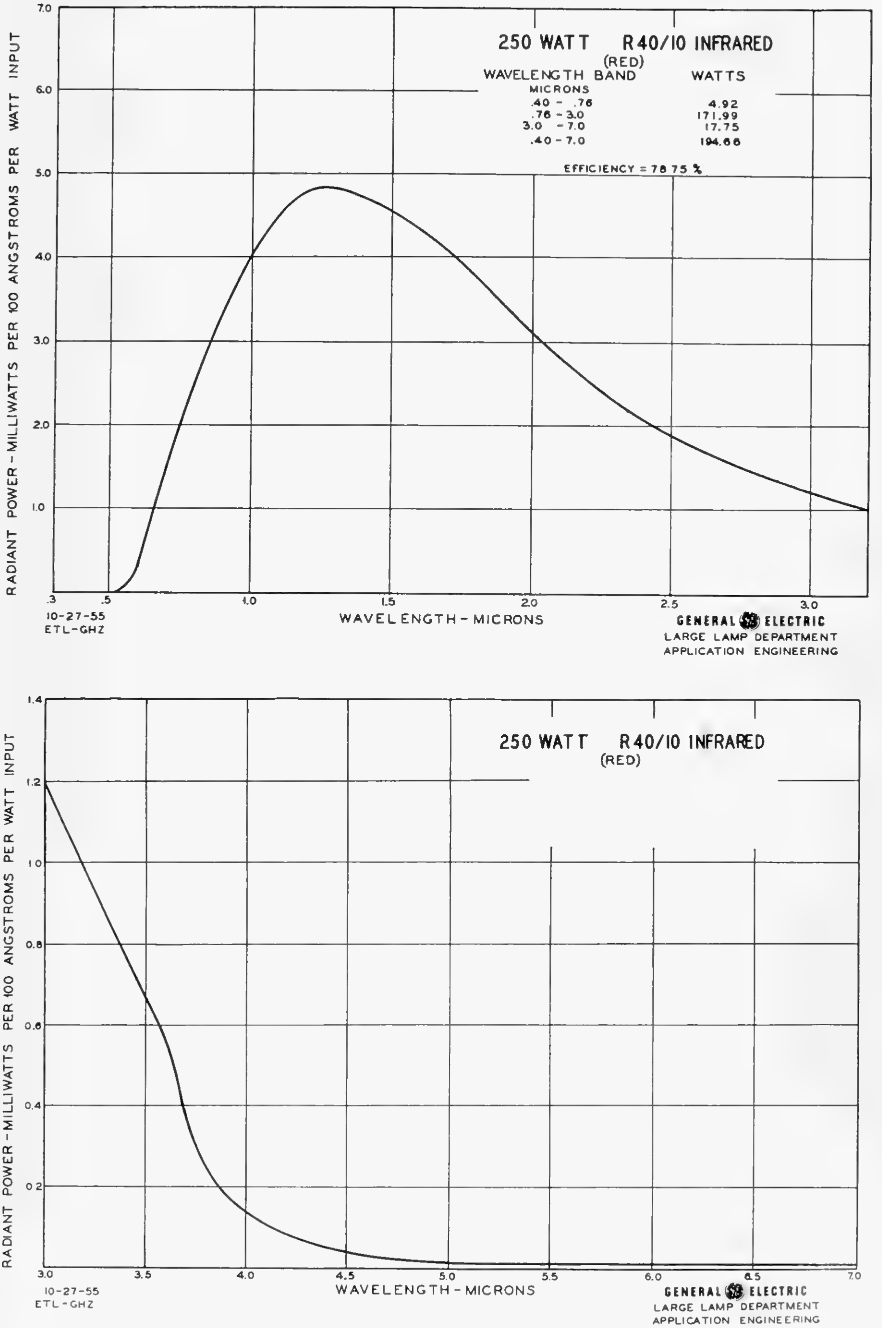

FIGURE 9. Spectral energy distribution of the 250-watt reflector heat lamp with red coating (infrared) manufactured by the General Electric Company. These graphs are official manufacturer's copies reproduced here with the Company's written permission.

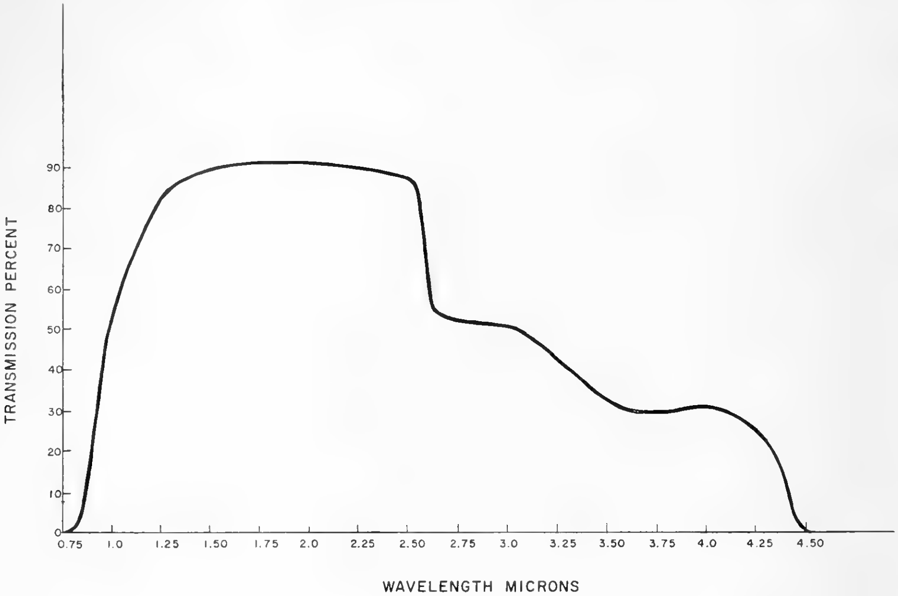

FIGURE 10. Spectrographic properties of the infrared transmitting filter of the Corning Glass Works' manufacture no. 2540 (7–56). Courtesy of the manufacturer.

infrared rays, as shown in figure 11. The light intensity of this lamp was also 500 foot-candles. Observations were made every ten seconds.

In 24 tests the fish behaved normally, maintaining typical school-formation, and circled at normal speed in counter-clockwise direction. They displayed preference for neither zone; of 19,200 fish 49.52 per cent were found in the white light zone, 50.48 per cent in the infrared zone.

Two more experiments concluded the infrared studies (INF-6 and INF-7, table XXIII). In these, one zone was illuminated with white light produced by the G.E. "soft white" fluorescent tube. The other zone was illuminated with a similar source of light to which the G.E. 600-watt electric heater was added as a source of infrared radiation. The intensity of light in both zones was equal to 25 foot-candles at the water's surface. As in the preceding case, the fish behaved normally and maintained typical school-formation and circular path of movement. They showed no marked preference for either of the zones. The average figures for 24 tests in the two experiments involving 19,000 fish are as follows: 51.79 per cent for the white-light zone and 48.21 per cent for the white-light-plus-infrared-wave-length zone. For all practical purposes these figures show an even distribution of the fish, and as in all other experiments with application of infrared radia-

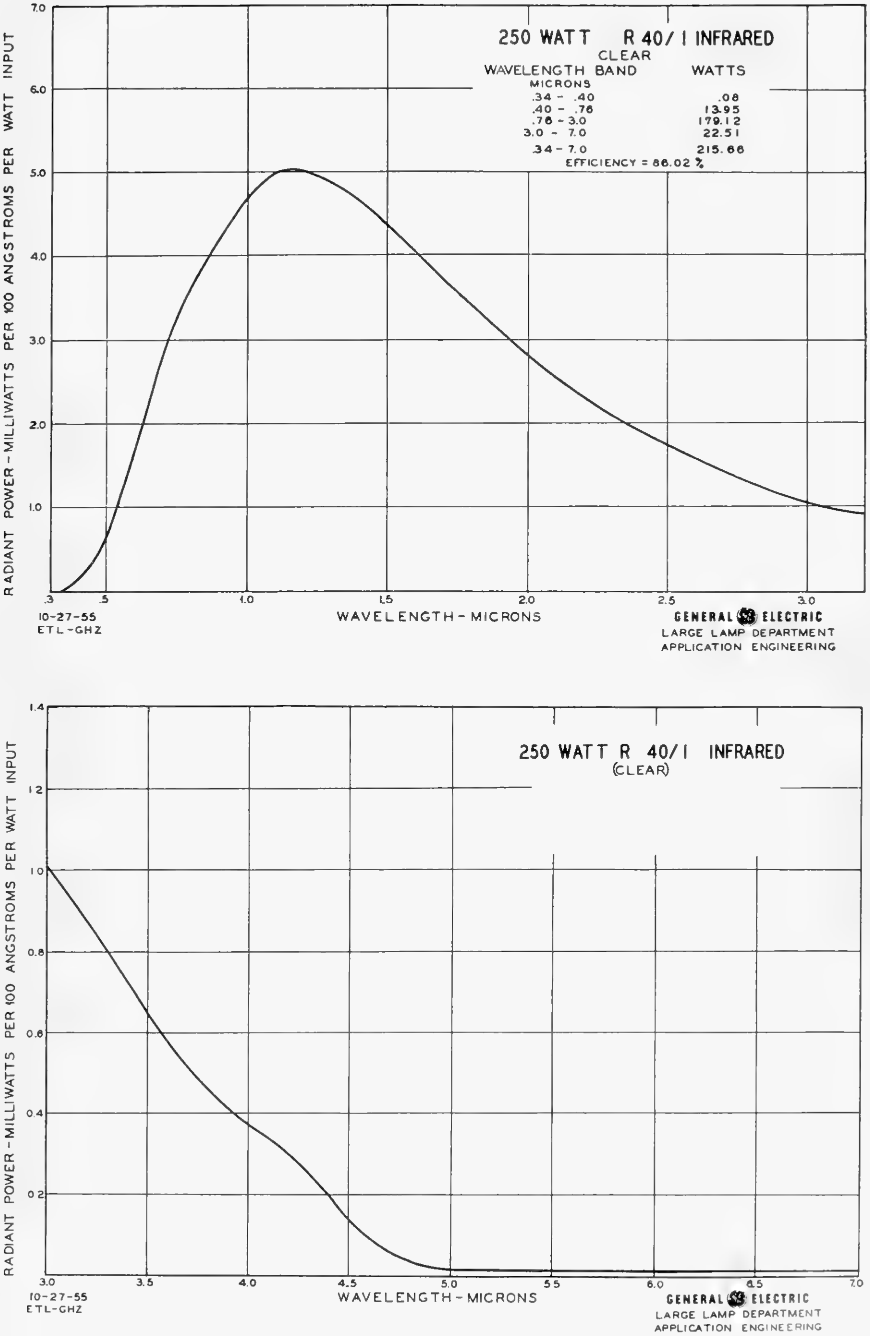

FIGURE 11. Spectral energy distribution of the 250-watt reflector clear heat lamp (infrared) manufactured by the General Electric Company. These graphs are official copies of the manufacturer. Courtesy of the General Electric Company.

tion they manifest very clearly the inability of the anchovy to perceive infrared radiation.

(4) Responses to different values of intensity of white light.

In an attempt to determine the ability of the northern anchovy to respond differently to different values of light intensity, the experimental tank was divided first into five zones, then into four, and finally into two zones. Illumination was provided by G.E. incandescent ("frosted") lamps emitting white light. In the five-zone arrangement, light intensities were as follows: 2, 10, 20, 50, and 100 foot-candles. After five tests in each of two experiments (INT-1 and INT-2, table XXIV), the positions of the light sources were reversed in order to avoid conditioning responses. Average response percentages for the gradient values in both experiments were close to each other, especially for the first three intensity gradients. The 20,000 fish used in 20 tests were distributed with respect to the five different light intensities as follows:

0.53 per cent — 2 foot-candles
6.03 per cent — 10 foot-candles
29.23 per cent — 20 foot-candles
41.94 per cent — 50 foot-candles
22.27 per cent — 100 foot-candles

In the four-zone tank, illumination was provided by incandescent lamps of the same type and manufacture, which emitted white light in 75, 125, 250, and 500 foot-candle intensities. As in the preceding experiment, the positions of light sources were reversed after the first five tests. The average response percentages in experiment INT-3 (table XXV) were:

14.20 per cent — 75 foot-candles
30.21 per cent — 125 foot-candles
37.16 per cent — 250 foot-candles
18.43 per cent — 500 foot-candles

In these two arrangements of five and four intensity values, anchovies seemed to keep within the region of moderate light intensity; they shied away from the extremes. In each instance, most of the fish responded more positively to the lights of moderate intensities in centrally located zones and displayed an avoidance reaction to lights of the highest and lowest intensities. In the first arrangement, 71.17 per cent of 20,000 fish were found to frequent the two adjacent zones of 20 and 50 foot-candles; in the second—67.37 per cent of 10,000 fish frequented adjacent zones of 125 and 250 foot-candle intensities.

The most striking example of avoidance by anchovies of the brighter zone was demonstrated in experiments INT-4, INT-5, INT-6, and INT-7, when intensities of white light were presented in sharply contrasting pairs, in which the higher value remained constant throughout the four experiments. An intensity of 500 foot-candles was opposed by intensities of 20, 10, 5, and 2 foot-candles. Each of the above-mentioned experiments consisted of three tests of 100 recorded observations of the behavior of eight anchovies. The preference responses to the lower values of light intensity over the 500 foot-candle intensity were found to be 65.50 per cent for 20 foot-candles, 64.71 per cent for 10 foot-candles, 60.42 per cent for 5 foot-candles, and 83.71 per cent for 2 foot-candles. Of the 9,600 fish involved in these experiments, the average percentage in favor of all the lower intensities taken together equalled 68.52 per cent; that for the 500-foot-candle intensity, 31.48 per cent.

III. TABLES

Tables I–XI

Records of experiments using the two-zone tests for determining the preference reactions of the northern anchovy (Engraulis mordax *Girard) for monochromatic lights, white light, and darkness when presented in contrasting pairs. Light intensity was maintained at 9 foot-candles for all light sources. Each experiment consisted of six tests with 100 recorded observations made every ten seconds for six anchovies subjected to the effect of the light.*

Fluorescent tubes, manufactured by General Electric, and gelatine filters, made by Rascoe Laboratories, used in the present study were described by Loukashkin and Grant (1959).

Table I

		Green Light		*Soft White Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
GR-1	1	468	78.00	132	22.00	600	100
“	2	404	67.33	196	32.67	600	100
“	3	443	78.83	157	26.17	600	100
‥	4	399	66.50	201	33.50	600	100
‥	5	453	75.50	147	24.50	600	100
“	6	425	70.83	175	29.17	600	100
Total	6	2,592	72.00	1,008	28.00	3,600	100
GR-2	7	551	91.83	49	8.17	600	100
“	8	468	78.00	132	22.00	600	100
“	9	582	97.00	18	3.00	600	100
“	10	523	87.17	77	12.83	600	100
“	11	396	66.00	204	34.00	600	100
‥	12	312	52.00	288	48.00	600	100
Total	6	2,832	78.67	768	21.33	3,600	100
Grand Total	12	5,424	75.34	1,776	24.66	7,200	100

Table II

		Green Light		*Red Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
GR-3	1	597	99.50	3	0.50	600	100
"	2	600	100.00	0	0.00	600	100
"	3	561	93.50	39	6.50	600	100
"	4	593	98.83	7	1.17	600	100
"	5	597	99.50	3	0.50	600	100
"	6	600	100.00	0	0.00	600	100
Total	6	3,548	98.56	52	1.44	3,600	100
GR-4	7	598	99.67	2	0.33	600	100
"	8	599	99.83	1	0.17	600	100
"	9	591	98.50	9	1.50	600	100
"	10	514	85.67	86	14.33	600	100
"	11	596	99.33	4	0.67	600	100
"	12	600	100.00	0	0.00	600	100
Total	6	3,498	97.17	102	2.83	3,600	100
Grand Total	12	7,046	97.86	154	2.14	7,200	100

Table III

		Green Light		*Blue Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
GR-5	1	433	72.17	167	27.83	600	100
"	2	429	71.50	171	28.50	600	100
"	3	383	63.83	217	36.17	600	100
"	4	381	63.50	219	36.50	600	100
"	5	480	80.00	120	20.00	600	100
"	6	465	77.50	135	22.50	600	100
Total	6	2,571	71.42	1,029	28.58	3,600	100
GR-6	7	563	93.82	37	6.17	600	100
"	8	419	68.33	181	31.67	600	100
"	9	280	46.67	320	53.33	600	100
"	10	505	84.17	95	15.83	600	100
"	11	441	73.50	159	26.50	600	100
"	12	490	81.67	110	18.33	600	100
Total	6	2,698	74.94	902	25.06	3,600	100
Grand Total	12	5,269	73.18	1,931	26.82	7,200	100

Table IV

		Green Light		*Darkness*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
GR-7	1	600	100.00	0	0.00	600	100
"	2	454	75.67	146	24.33	600	100
"	3	557	92.83	43	7.17	600	100
"	4	597	99.50	3	0.50	600	100
"	5	600	100.00	0	0.00	600	100
"	6	594	99.00	6	1.00	600	100
Total	6	3,402	94.50	198	5.50	3,600	100
GR-8	7	594	99.00	6	1.00	600	100
"	8	559	93.17	41	6.83	600	100
"	9	592	98.67	8	1.33	600	100
"	10	583	97.17	17	2.83	600	100
"	11	594	99.00	6	1.00	600	100
"	12	594	99.00	6	1.00	600	100
Total	6	3,516	97.67	84	2.33	3,600	100
Grand Total	12	6,918	96.08	282	3.92	7,200	100

Table V

		Blue Light		*Soft White Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
BL-1	1	180	30.00	420	70.00	600	100
"	2	464	77.33	136	22.67	600	100
"	3	373	62.17	227	37.83	600	100
"	4	333	55.50	267	44.50	600	100
"	5	367	61.17	233	38.83	600	100
"	6	318	53.00	282	47.00	600	100
Total	6	2,035	56.53	1,565	43.47	3,600	100
BL-2	7	379	63.17	221	36.83	600	100
"	8	289	48.17	311	51.83	600	100
"	9	237	39.50	363	60.50	600	100
"	10	280	46.67	320	53.33	600	100
"	11	234	39.00	366	61.00	600	100
"	12	303	50.50	297	49.50	600	100
Total	6	1,722	47.83	1,878	52.17	3,600	100
Grand Total	12	3,757	52.15	3,443	47.85	7,200	100

Table VI

		Blue Light		*Red Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
BL-3	1	474	79.00	126	21.00	600	100
"	2	591	98.50	9	1.50	600	100
"	3	353	58.83	247	41.17	600	100
"	4	390	65.00	210	35.00	600	100
"	5	438	73.00	162	27.00	600	100
"	6	523	88.83	77	11.17	600	100
Total	6	2,769	76.95	831	23.05	3,600	100
BL-4	7	597	99.50	3	0.50	600	100
"	8	576	96.00	24	4.00	600	100
"	9	403	67.17	197	32.83	600	100
"	10	526	87.67	74	12.33	600	100
"	11	499	83.17	101	16.87	600	100
"	12	505	84.17	95	15.83	600	100
Total	6	3,106	86.28	494	13.72	3,600	100
Grand Total	12	5,875	81.60	1,325	18.40	7,200	100

Table VII

		Blue Light		*Darkness*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
BL-5	1	600	100.00	0	0.00	600	100
"	2	538	89.67	62	10.33	600	100
"	3	578	96.33	22	3.67	600	100
"	4	565	94.17	35	5.83	600	100
"	5	578	96.33	22	3.67	600	100
"	6	600	100.00	0	0.00	600	100
Total	6	3,459	96.08	141	3.92	600	100
BL-6	7	600	100.00	0	0.00	600	100
"	8	594	99.00	6	1.00	600	100
"	9	592	98.67	8	1.33	600	100
"	10	560	93.33	40	6.67	600	100
"	11	581	96.83	19	3.17	600	100
"	12	600	100.00	0	0.00	600	100
Total	6	3,527	97.97	73	2.03	3,600	100
Grand Total	12	6,986	97.03	214	2.97	7,200	100

Table VIII

		Red Light		*Soft White Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
RD-1	1	1	0.17	599	99.83	600	100
"	2	40	6.67	560	93.33	600	100
"	3	8	1.33	592	98.67	600	100
"	4	48	8.00	552	92.00	600	100
"	5	89	14.83	511	85.17	600	100
"	6	81	13.50	519	86.50	600	100
Total	6	267	7.42	3,333	92.58	3,600	100
RD-2	7	13	2.16	587	97.84	600	100
"	8	104	17.33	496	82.67	600	100
"	9	1	0.17	599	99.83	600	100
"	10	209	34.83	391	65.17	600	100
"	11	233	38.83	367	61.17	600	100
"	12	9	1.50	591	98.50	600	100
Total	6	569	15.80	3,031	84.20	3,600	100
Grand Total	12	836	11.61	6,364	88.39	7,200	100

Table IX

		Red Light		*Darkness*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
RD-3	1	570	95.00	30	5.00	600	100
"	2	594	99.00	6	1.00	600	100
"	3	454	75.67	146	24.33	600	100
"	4	583	97.17	17	2.83	600	100
"	5	600	100.00	0	0.00	600	100
"	6	581	96.83	19	3.17	600	100
Total	6	3,382	93.94	218	6.06	3,600	100
RD-4	7	569	94.83	31	5.17	600	100
"	8	520	86.67	80	13.13	600	100
"	9	593	98.83	7	1.17	600	100
"	10	537	89.50	63	10.50	600	100
"	11	588	98.00	12	2.00	600	100
"	12	505	84.17	95	15.83	600	100
Total	6	3,312	92.00	288	8.00	3,600	100
Grand Total	12	6,694	92.97	506	7.03	7,200	100

Table X

		Soft White Light		*Darkness*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
WH-1	1	594	99.00	6	1.00	600	100
"	2	566	94.33	34	5.67	600	100
"	3	589	98.17	11	1.83	600	100
"	4	600	100.00	0	0.00	600	100
"	5	600	100.00	0	0.00	600	100
"	6	600	100.00	0	0.00	600	100
Total	6	3,549	98.58	51	1.42	3,600	100
WH-2	7	543	90.50	57	9.50	600	100
"	8	600	100.00	0	0.00	600	100
"	9	554	92.33	46	7.67	600	100
"	10	600	100.00	0	0.00	600	100
"	11	600	100.00	0	0.00	600	100
"	12	600	100.00	0	0.00	600	100
Total	6	3,497	97.14	103	2.86	3,600	100
Grand Total	12	7,046	97.88	154	2.12	7,200	100

Table XI

		Soft White Light		*Soft White Light*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
CON-1	1	263	48.83	337	56.17	600	100
"	2	286	47.67	314	52.33	600	100
"	3	349	58.27	251	41.73	600	100
"	4	350	58.33	250	41.67	600	100
"	5	228	38.00	372	62.00	600	100
"	6	371	61.83	229	38.17	600	100
Total	6	1,847	51.31	1,753	48.65	3,600	100
CON-2	7	384	64.00	216	36.00	600	100
"	8	238	39.67	362	60.33	600	100
"	9	302	50.33	298	49.67	600	100
"	10	224	37.33	376	62.67	600	100
"	11	318	53.00	282	47.00	600	100
"	12	291	48.50	309	51.50	600	100
Total	6	1,759	48.86	1,841	51.14	3,600	100
Grand Total	12	3,604	50.06	3,596	49.94	7,200	100

Table XII

Records of experiments using the three-zone tests for determining the preference reactions of the northern anchovy in monochromatic and white lights of equal and different intensities. Each experiment is based on six tests of 100 recorded observations, with six anchovies used in each test.

Exp.	*Soft White Light*		*Green Light*		*Red Light*		*Total*	
	Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
	Light Intensity 9 f.-c.		*Light Intensity 9 f.-c.*		*Light Intensity 9 f.-c.*			
WGR-1	1,158	32.17	2,016	56.00	426	11.83	3,600	100
	Light Intensity 30 f.-c.		*Light Intensity 9 f.-c.*		*Light Intensity 9 f.-c.*			
WGR-2	516	14.33	2,496	69.33	588	16.34	3,600	100
	Light Intensity 30 f.-c.		*Light Intensity 6 f.-c.*		*Light Intensity 30 f.-c.*			
WGR-3	432	12.00	2,448	68.00	720	20.00	3,600	100
	Light Intensity 30 f.-c.		*Light Intensity 30 f.-c.*		*Light Intensity 30 f.-c.*			
WGR-4	720	20.00	2,592	72.00	288	8.00	3,600	100
Total	2,826	19.63	9,552	66.33	2,022	14.04	14,400	100
	Other combinations in three-zone tests							
	Soft White Light Intensity 30 f.-c.		*Green Light Intensity 6 f.-c.*		*Darkness Intensity 0 f.-c.*			
WGD	804	22.33	2,496	69.33	300	8.34	3,600	100
	Red Light Intensity 30 f.-c.		*Darkness Intensity 0 f.-c.*		*Soft White Light Intensity 30 f.-c.*			
RDW	696	19.33	1,092	30.33	1,812	50.34	3,600	100
	Darkness Intensity 0 f.-c.		*Blue Light Intensity 9 f.-c.*		*Red Light Intensity 9 f.-c.*			
DBR-1	186	5.17	3,354	93.16	60	1.67	3,600	100
	Darkness Intensity 0 f.-c.		*Blue Light Intensity 4 f.-c.*		*Red Light Intensity 30 f.-c.*			
DBR-2	48	1.33	3,552	98.67	0	0.00	3,600	100

Table XIII

Records of experiments using the four-zone tests for determining the preference reactions of the northern anchovy for monochromatic lights and darkness. Each of the two experiments is based on six tests of 100 recorded observations, with eight anchovies used in each test.

Exp.	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
	(Darkness — 0 f.-c.; Lights — 9 f.-c. intensity)									
	Darkness		*Red Light*		*Blue Light*		*Green Light*		*Total*	
DRBG-1	123	2.56	204	4.25	849	17.69	3,624	75.50	4,800	100

TABLE XIII — CONT.

Exp.	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
(Darkness: 0 f.-c.; Lights — 9 f.-c. intensity)										
	Darkness		*Green Light*		*Blue Light*		*Red Light*		*Total*	
DRBG-2	60	1.25	4,074	84.88	624	13.00	42	0.87	4,800	100
	Darkness		*Green Light*		*Blue Light*		*Red Light*		*Total*	
Total	183	1.91	7,698	80.19	1,473	15.34	246	2.56	9,600	100

TABLE XIV

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to white and monochromatic lights arranged so as to approximately duplicate vertical distribution of sunlight spectrum in water mass. Nine fish were used in each test.*

		Blue Light		*Green Light*		*Daylight*		*Total*	
		Intensity — 0.5 f.-c.		*Intensity — 7.8 f.-c.*		*Intensity — 16 f.-c.*			
		Frequency of Occurrence							
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
DLGB-1	1	245	27.22	422	46.87	233	25.89	900	100
"	2	216	24.00	448	49.78	236	26.22	900	100
"	3	207	23.00	435	48.73	258	28.67	900	100
"	4	216	24.00	411	45.67	273	30.33	900	100
"	5	175	19.44	432	48.00	293	32.56	900	100
"	6	186	20.67	434	48.22	280	31.11	900	100
"	7	201	22.33	416	46.22	283	31.45	900	100
"	8	188	20.89	407	45.22	305	33.89	900	100
"	9	151	16.78	435	48.33	314	34.89	900	100
"	10	162	18.00	469	52.11	269	29.89	900	100
"	11	156	17.33	472	55.45	272	30.22	900	100
"	12	210	23.33	455	50.56	235	26.11	900	100
Total	12	2,313	21.42	5,246	48.57	3,241	30.01	10,800	100
		Reduced intensities:							
		Blue — 0.25		*Green — 3.00*		*Daylight — 6.00*			
DLGB-2	1	275	30.56	400	44.44	225	25.00	900	100
"	2	281	31.22	402	44.67	217	24.11	900	100
"	3	246	27.33	396	44.00	258	28.67	900	100
"	4	275	30.56	336	37.33	289	32.11	900	100
"	5	231	25.67	379	42.11	290	32.22	900	100
"	6	226	25.11	416	46.22	258	28.67	900	100
"	7	199	22.11	428	47.56	273	30.33	900	100
"	8	203	22.56	406	45.11	291	32.33	900	100
"	9	210	23.33	425	47.22	265	29.45	900	100
"	10	221	24.55	421	46.78	258	28.67	900	100
"	11	157	17.44	386	42.89	357	39.67	900	100
"	12	219	24.33	396	44.00	285	31.67	900	100
Total		2,743	25.40	4,791	44.36	3,266	30.24	10,800	100

TABLES XV–XVII

Records of experiments using the two-zone tests for determining the preference reactions of the northern anchovy (Engraulis mordax *Girard) to monochromatic lights (blue, green, and red) and black light (ultraviolet radiation) presented in contrasting pairs. A light intensity of 0.2 foot-candle was maintained for all light sources applied. Two experiments were run using each contrasting pair of lights; each experiment consisted of twelve tests of 100 recorded observations of distribution of eight anchovies subjected to testing. Fluorescent tubes of General Electric manufacture 24" long and gelatine filters of Rascoe laboratories as sources for the blue, green, and red lights used in the present study were the same as described by Loukashkin and Grant (1959) in their experiments with the Pacific Sardine.*

For ultraviolet radiation a fluorescent "black light" tube of the same length as the monochromatic light tubes was used (General Electric, F20T12/BLB).

Table XV

		Blue Light		*Ultraviolet Radiation*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
UL-1	1	507	63.37	293	36.63	800	100
"	2	554	69.25	246	30.75	800	100
"	3	509	63.63	291	36.37	800	100
"	4	584	73.00	216	27.00	800	100
"	5	507	63.37	293	36.63	800	100
"	6	420	52.50	380	47.50	800	100
"	7	394	49.25	406	50.75	800	100
"	8	285	35.63	515	64.37	800	100
"	9	400	50.00	400	50.00	800	100
"	10	264	33.00	536	67.00	800	100
"	11	321	40.13	479	59.87	800	100
"	12	308	38.50	492	61.50	800	100
Total	12	5,053	52.62	4,547	47.37	9,600	100
UL-2	13	423	52.87	377	47.13	800	100
"	14	415	51.87	385	48.13	800	100
"	15	417	52.12	383	47.88	800	100
"	16	388	48.50	412	51.50	800	100
"	17	397	49.63	403	50.37	800	100
"	18	383	47.88	417	52.12	800	100
"	19	363	45.38	437	54.62	800	100
"	20	389	48.63	411	51.37	800	100
"	21	359	44.88	441	55.12	800	100
"	22	331	41.38	469	58.62	800	100
"	23	322	40.25	478	59.75	800	100
"	24	332	41.50	468	59.50	800	100
Total	12	4,519	47.07	5,081	52.93	9,600	100
Grand Total	24	9,572	49.85	9,628	50.15	19,200	100

Table XVI

		Blue Light		*Ultraviolet Radiation*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
UL-3	1	432	54.00	368	46.00	800	100
“	2	441	55.12	359	44.88	800	100
"	3	422	52.75	378	47.25	800	100
“	4	432	54.00	368	46.00	800	100
“	5	468	58.50	332	41.50	800	100
"	6	427	53.37	373	46.63	800	100
"	7	470	58.75	330	41.25	800	100
“	8	426	53.25	374	46.75	800	100
"	9	419	52.37	381	47.63	800	100
"	10	470	58.75	330	41.25	800	100
"	11	432	54.00	368	46.00	800	100
“	12	426	53.25	374	46.75	800	100
Total	12	5,265	54.84	4,335	45.16	9,600	100
UL-4	13	462	57.75	338	42.25	800	100
“	14	449	56.12	351	43.88	800	100
“	15	467	58.37	333	41.63	800	100
"	16	386	48.50	414	51.50	800	100
"	17	428	53.50	372	46.50	800	100
"	18	436	54.50	364	45.50	800	100
"	19	462	57.75	338	42.25	800	100
"	20	449	56.12	351	43.88	800	100
"	21	467	58.37	333	41.63	800	100
"	22	386	48.50	414	51.50	800	100
"	23	428	53.50	372	46.50	800	100
"	24	436	54.50	364	45.50	800	100
Total	12	5,256	54.75	4,344	45.25	9,600	100
Grand Total	24	10,521	54.79	8,679	45.21	19,200	100

Table XVII

		Red Light		*Ultraviolet Radiation*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
UL-5	1	387	43.38	413	51.62	800	100
"	2	365	45.63	435	54.37	800	100
"	3	327	40.88	473	59.12	800	100
"	4	360	45.00	440	55.00	800	100
"	5	386	48.25	414	51.75	800	100
"	6	337	42.13	463	57.87	800	100
"	7	375	46.88	425	53.12	800	100
"	8	351	43.88	449	56.12	800	100
"	9	358	44.75	442	55.25	800	100
"	10	471	58.87	329	41.13	800	100

Table XVII — Cont.

		Red Light		Ultraviolet Radiation		Total	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
"	11	444	56.50	356	44.50	800	100
"	12	423	52.87	377	47.13	800	100
Total	12	4,584	47.75	5,016	52.25	9,600	100
UL-6	13	89	11.13	711	88.87	800	100
"	14	93	11.62	707	88.38	800	100
"	15	136	17.00	664	83.00	800	100
"	16	117	14.62	683	85.38	800	100
"	17	156	19.50	644	80.50	800	100
"	18	109	13.62	691	86.38	800	100
"	19	35	4.38	765	95.62	800	100
"	20	25	3.12	775	96.88	800	100
"	21	6	0.75	794	99.25	800	100
"	22	10	1.25	790	98.75	800	100
"	23	0	0.00	800	100.00	800	100
"	24	21	2.62	779	97.38	800	100
Total	12	797	8.30	8,803	91.70	9,600	100
Grand Total	24	5,381	28.03	13,819	71.97	19,200	100

Table XVIII

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to white light and ultraviolet rays presented simultaneously in a two-zone tank. Eight fish were used in each test.*

		White light zone		Ultraviolet zone		Total	
		Two G.E. 15-watt incandescent lamps. Intensity 10.5 foot-candles		Two G.E. 15-watt incandescent lamps and 1 fluorescent G.E. "Black light" tube. Intensity 10.5 f.-c.			
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
UL-7	1	282	35.25	518	64.75	800	100
"	2	240	30.00	560	70.00	800	100
"	3	316	39.50	484	60.50	800	100
"	4	325	40.63	475	59.39	800	100
"	5	328	41.00	472	59.00	800	100
"	6	302	37.75	498	62.25	800	100
"	7	482	60.25	318	39.75	800	100
"	8	520	65.00	280	35.00	800	100
"	9	546	68.25	254	31.75	800	100

TABLE XVIII — CONT.

		White light zone		*Ultraviolet zone*			
		Two G.E. 15-watt incandescent lamps. Intensity 10.5 foot-candles		*Two G.E. 15-watt incandescent lamps and 1 fluorescent G.E. "Black light" tube. Intensity 10.5*			
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
"	10	480	60.00	320	40.00	800	100
"	11	484	60.50	316	39.50	800	100
"	12	434	54.25	366	45.75	800	100
Total	12	4,739	49.37	4,861	50.63	9,600	100
UL-8	13	463	57.87	337	42.13	800	100
"	14	427	53.37	373	46.63	800	100
"	15	416	52.00	384	48.00	800	100
"	16	474	59.25	326	40.75	800	100
"	17	459	57.37	341	42.63	800	100
"	18	436	54.50	364	45.50	800	100
"	19	366	45.75	434	54.25	800	100
"	20	373	46.63	427	53.37	800	100
"	21	371	46.38	429	53.62	800	100
"	22	358	44.75	442	55.25	800	100
"	23	331	41.38	469	58.62	800	100
"	24	378	47.25	422	52.75	800	100
Total	12	4,852	50.54	4,748	49.46	9,600	100
Grand Total	24	9,591	49.84	9,609	50.16	19,200	100

TABLE XIX

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to white light and ultraviolet rays presented in pairs in a two-zone tank. Eight fish were used in each test.*

		General Electric 100-watt mercury spotlight lamp suspended over the middle of the tank. Intensity 500+ foot-candles					
		Zone "A" covered with clear glass to filter out ultraviolet rays		*Zone "B" free for ultraviolet radiation*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
UL-9	1	663	82.87	137	17.13	800	100
"	2	704	88.00	96	12.00	800	100
"	3	639	79.85	161	20.15	800	100
"	4	569	71.12	231	28.88	800	100
"	5	347	43.38	453	56.62	800	100

Table XIX — Cont.

		General Electric 100-watt mercury spotlight lamp suspended over the middle of the tank. Intensity 500+ foot-candles					
		Zone "A" covered with clear glass to filter out ultraviolet rays		*Zone "B" free for ultraviolet radiation*		*Total*	
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
"	6	421	52.62	379	47.38	800	100
"	7	418	52.25	382	47.75	800	100
"	8	402	50.25	398	49.75	800	100
"	9	388	48.50	412	51.50	800	100
"	10	569	71.12	231	28.88	800	100
Total	10	5,120	64.00	2,880	36.00	8,000	100
	Clear glass filter removed, both zones under effect of ultraviolet radiation						
UL-10	1	361	45.13	439	54.87	800	100
"	2	375	46.88	425	53.12	800	100
"	3	361	45.13	439	54.87	800	100
"	4	448	56.00	352	44.00	800	100
"	5	428	53.37	372	46.63	800	100
"	6	440	55.00	360	45.00	800	100
"	7	441	55.12	359	44.88	800	100
"	8	450	56.25	350	43.75	800	100
"	9	416	52.00	384	48.00	800	100
"	10	456	57.00	344	43.00	800	100
Total	10	4,176	52.20	3,824	47.80	8,000	100

To check the role of the glass filter in experiment UL-9, it was introduced again, but instead of 100-watt mercury spotlight (ultraviolet) KEN-Rad 300-watt reflector flood light (white) lamps were installed in each zone. Light intensity was 500+ foot-candles. The results are shown below.

		Zone "A" covered with glass		*Zone "B" open free*		*Total*	
UL-11	1	432	54.00	368	46.00	800	100
"	2	431	53.87	369	46.13	800	100
"	3	398	49.75	402	50.25	800	100
"	4	393	49.12	407	50.88	800	100
"	5	408	51.00	392	49.00	800	100
"	6	404	50.50	396	49.50	800	100
"	7	371	46.38	429	53.62	800	100
"	8	420	50.25	380	49.75	800	100
"	9	371	46.38	429	53.62	800	100
"	10	408	51.00	392	49.00	800	100
Total	10	4,036	50.45	3,964	49.55	8,000	100

TABLE XX

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to white light and ultraviolet rays presented in pairs in a two-zone tank. Six fish were used in each test. Experiment UL–12 shows typical distribution of the fish when white light alone was applied, and experiment UL–13 shows change in distribution after replacing the white-light lamp in one of the zones with a lamp producing ultraviolet radiation.*

Exp.	*Test*	*Zone "A"*		*Zone "B"*		*Total*	
		Frequency of Occurrence					
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
		KEN-RAD 300-watt reflector flood light lamp (white) Intensity 225 f.-c.		*KEN-RAD 300-watt reflector flood light lamp (white) Intensity 225 f.-c.*			
UL-12	1	240	40.00	360	60.00	600	100
..	2	263	43.84	337	56.16	600	100
..	3	270	45.00	330	55.00	600	100
..	4	280	46.67	320	53.37	600	100
..	5	300	50.00	300	50.00	600	100
..	6	240	40.00	360	60.00	600	100
..	7	280	46.67	320	53.37	600	100
..	8	340	56.67	260	43.33	600	100
..	9	335	55.83	265	44.17	600	100
..	10	360	60.00	240	40.00	600	100
Total	10	2,908	48.47	3,092	51.53	6,000	100
		KEN-RAD 300-watt reflector flood light lamp (white) Intensity 225 f.-c.		*G.E. 100-watt mercury spotlight lamp (ultraviolet). Intensity 225 f.-c.*			
UL-13	1	600	100.00	0	0.00	600	100
..	2	477	79.50	123	20.50	600	100
..	3	387	64.50	213	35.20	600	100
..	4	404	67.33	196	32.67	600	100
..	5	372	62.00	228	38.00	600	100
..	6	380	63.33	220	36.67	600	100
..	7	400	66.67	200	33.33	600	100
..	8	420	70.00	180	30.00	600	100
..	9	480	80.00	120	20.00	600	100
..	10	406	67.67	194	32.37	600	100
Total	10	4,326	72.10	1,674	27.90	6,000	100

Table XXI

Records of preference responses of the northern anchovy (Engraulis mordax *Girard*) *to infrared radiation and total darkness in a two-zone tank. Eight fish were used in each test.*

Exp.	*Test*	*Infrared Radiation*		*Total Darkness*		*Total*	
		G.E. 250-watt reflector heat lamp with red coating and Corning infrared transmitting filter.		*Absolute Darkness*			
		Frequency of Occurrence					
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
INF-1	1	167	69.58	73	30.42	240	100
"	2	135	56.25	105	43.75	240	100
"	3	135	56.25	105	43.75	240	100
"	4	106	44.17	134	55.85	240	100
"	5	162	67.50	78	32.50	240	100
"	6	96	40.00	144	60.00	240	100
"	7	98	40.83	142	59.17	240	100
"	8	74	30.84	166	69.16	240	100
"	9	153	63.75	87	36.25	240	100
"	10	106	44.17	134	55.83	240	100
Total	10	1,232	51.33	1,168	48.67	2,400	100
		Total Darkness		*Total Darkness*			
INF-2	1	170	70.83	70	29.19	240	100
"	2	124	51.67	116	48.33	240	100
"	3	105	43.75	135	56.25	240	100
"	4	116	48.33	124	51.67	240	100
"	5	120	50.00	120	50.00	240	100
"	6	95	39.58	145	60.42	240	100
"	7	96	40.00	144	60.00	240	100
"	8	86	35.83	154	64.17	240	100
"	9	150	62.50	90	37.50	240	100
"	10	104	43.33	136	56.67	240	100
Total	10	1,166	48.58	1,234	51.42	2,400	100
		Infrared: Visible Red. Corning filter cracked and began to transmit visible red in the intensity about 0.001 f.-c.		*Total Darkness*			
INF-3	1	124	51.67	116	48.33	240	110
"	2	183	76.25	57	24.75	240	110
"	3	170	70.83	70	29.17	240	100
"	4	166	69.17	74	30.83	240	100
"	5	166	69.17	74	30.83	240	100
"	6	192	80.00	48	20.00	240	100
"	7	196	81.67	44	18.33	240	100
"	8	201	83.75	39	16.25	240	100
"	9	192	80.00	48	20.00	240	100
"	10	190	79.17	50	20.83	240	100
Total	10	1,780	74.17	620	25.83	2,400	100

TABLE XXII

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to white light and infrared radiation in a two-zone tank. Eight fish were used in each test.*

Exp.	*Test*	*Clear Light*		*Infrared Radiation*		*Total*	
		KEN-RAD 300-watt reflector flood light lamp. Light intensity - 500 f.-c.		*G.E 250-watt reflector infrared (heat) industrial lamp (white bulb). Light intensity - 500 f.-c.*			
		Frequency of Occurrence					
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
INF-4	1	377	47.13	423	52.87	800	100
“	2	352	44.00	448	56.00	800	100
“	3	370	46.25	430	53.75	800	100
“	4	363	45.38	437	54.62	800	100
“	5	365	45.63	435	54.37	800	100
“	6	352	44.00	448	56.00	800	100
“	7	406	50.75	394	49.25	800	100
“	8	399	49.88	401	50.12	800	100
“	9	393	49.13	407	50.97	800	100
“	10	480	60.00	320	40.00	800	100
“	11	441	55.12	359	44.88	800	100
“	12	413	51.62	387	48.38	800	100
Total	12	4,711	49.07	4,889	50.93	9,600	100
INF-5	13	415	51.87	385	48.13	800	100
“	14	405	50.62	395	49.38	800	100
“	15	413	51.62	387	48.38	800	100
“	16	471	58.87	329	41.13	800	100
“	17	401	50.12	399	49.88	800	100
“	18	442	55.25	358	44.75	800	100
“	19	388	48.50	412	51.50	800	100
“	20	379	47.38	421	52.62	800	100
“	21	344	43.00	456	57.00	800	100
“	22	385	48.13	415	51.87	800	100
“	23	364	45.50	436	54.50	800	100
“	24	389	48.63	411	51.37	800	100
Total	12	4,796	49.96	4,804	50.04	9,600	100
Grand Total	24	9,507	49.52	9,693	50.48	19,200	100

TABLE XXIII

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to white light and infrared radiation plus visible light in a two-zone tank. Eight fish were used in each test.*

Exp.	*Test*	*White Light*		*Infrared Radiation*		*Total*	
		Fluorescent tube "Soft White" light; Intensity 25 f.-c.		*Fluorescent tube "Soft White" light, and G.E. 600-watt electric heater. Intensity 25 f.-c.*			
		Frequency of Occurrence					
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
INF-6	1	374	46.75	426	53.25	800	100
..	2	390	48.75	410	51.25	800	100
..	3	373	46.63	427	53.37	800	100
..	4	406	50.75	394	49.25	800	100
..	5	389	48.63	411	51.37	800	100
..	6	404	50.50	396	49.50	800	100
..	7	438	54.75	362	45.25	800	100
..	8	459	57.37	341	42.63	800	100
..	9	410	51.50	390	48.50	800	100
..	10	434	54.25	366	45.75	800	100
..	11	429	53.62	371	46.38	800	100
..	12	425	53.12	375	46.88	800	100
Total	12	4,931	51.36	4,669	48.64	9,600	100
INF-7	13	419	52.37	381	47.63	800	100
“	14	458	57.25	342	42.75	800	100
..	15	420	52.50	380	47.50	800	100
..	16	387	48.38	413	51.62	800	100
“	17	415	51.87	385	48.13	800	100
..	18	388	48.50	412	51.50	800	100
..	19	394	49.25	406	50.75	800	100
..	20	449	56.12	351	43.88	800	100
..	21	402	50.25	398	49.75	800	100
..	22	435	54.37	365	45.63	800	100
..	23	416	52.00	384	48.00	800	100
..	24	429	53.62	371	46.38	800	100
Total	12	5,012	52.21	4,588	47.79	9,600	100
Grand Total	24	9,943	51.79	9,257	48.21	19,200	100

TABLE XXIV

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to light gradient tests using five-zone tank and white light (G.E. incandescent lamps) ranging in its intensity from 2 to 100 foot-candles. Ten fish were used in each test.*

		Zone "A"		*Zone "B"*		*Zone "C"*		*Zone "D"*		*Zone "E"*			
		2 f.-c.		*10 f.-c.*		*20 f.-c.*		*50 f.-c.*		*100 f.-c.*		*Total*	
		Frequency of Occurrence											
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
INT-1	1	4	0.40	143	14.30	390	39.00	312	31.20	151	15.10	1,000	100
"	2	3	0.30	83	8.30	247	24.70	390	39.00	277	27.70	1,000	100
"	3	1	0.10	95	9.50	261	26.10	337	33.70	306	30.60	1,000	100
"	4	15	1.50	62	6.20	271	27.10	370	37.00	282	28.20	1,000	100
"	5	2	0.20	43	4.30	332	33.20	374	37.40	249	24.90	1,000	100
"	6	2	0.20	54	5.40	250	25.00	385	38.50	309	30.90	1,000	100
"	7	0	0.00	9	0.90	315	31.50	424	42.40	252	25.20	1,000	100
"	8	1	0.10	26	2.60	253	25.30	406	40.60	314	31.40	1,000	100
"	9	19	1.90	52	5.20	242	24.20	394	39.40	293	29.30	1,000	100
"	10	2	0.20	50	5.00	315	31.50	367	36.70	266	26.60	1,000	100
Total	10	49	0.49	617	6.17	2,876	28.76	3,759	37.59	2,699	26.99	10,000	100
INT-2	11	3	0.30	23	2.30	258	25.80	532	53.20	184	18.40	1,000	100
"	12	1	0.10	28	2.80	265	26.50	486	48.60	220	22.00	1,000	100
"	13	7	0.70	75	7.50	264	26.40	511	51.10	143	14.30	1,000	100
"	14	2	0.20	37	3.70	346	34.60	436	43.60	179	17.90	1,000	100
"	15	1	0.10	93	9.30	297	29.70	486	48.60	123	12.30	1,000	100
"	16	26	2.60	78	7.80	339	33.90	447	44.70	110	11.00	1,000	100
"	17	2	0.20	61	6.10	306	30.60	418	41.80	213	21.30	1,000	100
"	18	9	0.90	68	6.80	242	24.20	425	42.50	256	25.60	1,000	100
"	19	3	0.30	65	6.50	359	35.90	418	41.80	155	15.50	1,000	100
"	20	4	0.40	62	6.20	293	29.30	470	47.00	171	17.10	1,000	100
Total	10	58	0.58	590	5.90	2,969	29.69	4,629	46.29	1,754	17.54	10,000	100
Grand Total	20	107	0.53	1,207	6.03	5,845	29.23	8,388	41.94	4,453	22.27	20,000	100

Table XXV

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to light gradient tests using four-zone tank and white light (incandescent lamps) ranging in its intensity from 75 to 500 foot-candles. Ten fish were used in each test.*

		Zone "A"		Zone "B"		Zone "C"		Zone "D"		Total	
		75 f.-c.		125 f.-c.		250 f.-c.		500 f.-c.			
		Frequency of Occurrence									
Exp.	Test	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
INT-3	1	144	14.40	280	28.00	396	39.60	180	18.00	1,000	100
"	2	167	16.70	275	27.50	360	36.00	198	19.80	1,000	100
"	3	175	17.50	218	21.80	362	36.20	245	24.50	1,000	100
"	4	137	13.70	291	29.10	365	36.50	207	20.70	1,000	100
"	5	170	17.00	356	35.60	377	37.70	97	9.70	1,000	100
"	6	178	17.80	289	28.90	377	37.70	156	15.60	1,000	100
"	7	116	11.60	308	30.80	380	38.00	196	19.60	1,000	100
"	8	111	11.10	301	30.10	326	32.60	262	26.20	1,000	100
"	9	133	13.30	356	35.60	363	36.30	148	14.80	1,000	100
"	10	89	8.90	347	34.70	410	41.00	154	15.40	1,000	100
Total	10	1,420	14.20	3,021	30.21	3,716	37.16	1,843	18.43	10,000	100

TABLE XXVI

Records of preference reactions of the northern anchovy (Engraulis mordax *Girard) to different intensities of white light presented in sharply contrasting pairs in a two-zone tank. Eight fish were used in each test.*

		Zone "A"		*Zone "B"*			
		Frequency of Occurrence					
Exp.	*Test*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
		(A)	*500 f.-c.*	*20 f.-c.*			
INT-4	1	256	32.00	544	68.00	800	100
"	2	297	37.11	503	62.89	800	100
"	3	275	34.38	525	65.62	800	100
Total	3	828	34.50	1,572	65.50	2,400	100
		(B)	*500 f.-c.*	*10 f.-c.*			
INT-5	1	319	39.88	481	60.12	800	100
"	2	302	37.75	498	62.25	800	100
"	3	226	28.25	574	71.75	800	100
Total	3	847	35.29	1,553	64.71	2,400	100
		(C)	*500 f.-c.*	*5 f.-c.*			
INT-6	1	335	41.88	465	58.12	800	100
"	2	334	41.75	466	58.25	800	100
"	3	285	35.63	515	64.37	800	100
Total	3	954	39.58	1,446	60.42	2,400	100
		(D)	*500 f.-c.*	*2 f.-c.*			
INT-7	1	210	26.25	590	73.75	800	100
"	2	127	15.88	673	84.12	800	100
"	3	54	6.75	746	93.25	800	100
Total	3	391	16.29	2,009	83.71	2,400	100
Grand Total	12	3,020	31.48	6,580	68.52	9,600	100

IV. DISCUSSION

(1) On responses of the northern anchovy to monochromatic lights in relation to reactions of other species.

As stated in the introduction, the experiments described in the preceding pages were carried out as a part of the general study on color vision in certain species of the marine pelagic fishes of the Pacific Ocean. The first stage of this study was published in 1959 by the present investigators. At that time they studied the Pacific sardine to determine the influence of monochromatic and white lights and darkness as environmental stimuli for elucidation of behavioral changes in schooling patterns and conversely to determine the ability of the sardine to discriminate colored and white lights qualitatively. Those experiments demonstrated clearly that different lights and darkness do affect school behavior and schooling patterns; also shown was the ability of the sardine to discriminate between lights on the basis of wave length. The sardines were attracted most of all by green light; they were repelled by both red light and total darkness (Loukashkin and Grant, 1959).[5]

The results of recent experiments with the northern anchovy, to determine their ability to discriminate among differently colored lights and darkness, are strikingly similar to those obtained in the experiments with the Pacific sardine. The anchovy, however, was able to differentiate green light from the blue, while the sardine failed to do so. In choice experiments in which the blue and white lights were presented responses of the anchovy in favor of the blue light (52.15 per cent) were lower than those of the sardine (73.05 per cent). Comparative data on the responses of these two species are assembled in the table XXVII.

TABLE XXVII

Comparison of preference reactions of the northern anchovy and Pacific sardine to monochromatic and white lights in a two-zone tank.

Description	*Responses in per cent*	
	Light source	*Light Source*
	Green	*White*
Anchovy	75.34	24.66
Sardine	78.63	21.37
	Green	*Red*
Anchovy	97.86	2.14
Sardine	95.25	4.17
	Green	*Blue*
Anchovy	73.18	26.82
Sardine	49.17	50.83
	Blue	*White*
Anchovy	52.15	47.85
Sardine	73.05	26.95
	Blue	*Red*
Anchovy	81.60	18.40
Sardine	97.26	2.74
	Red	*White*
Anchovy	11.61	88.39
Sardine	12.43	87.57

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[5] Verheijen (1956, 1958, 1959), speaking of the mass gathering phenomena of certain clupeids under the light at night at sea, disqualifies the interpretation of these phenomena in terms of "positive phototaxis," "being attracted," "intensity preferendum," or "light optimum." He considers all of them unsatisfactory and he attributes the above phenomena merely to a "mass photic disorientation" of the fish.

In the series of experiments comparing the effects of green, blue, red, and white lights in a two-zone tank (tables I, II, III, V, VI, VIII) only 2,315 fish or 10.72 per cent out of 21,600 fish responded positively to red light, and 19,285 fish or 89.28 per cent responded positively to the other lights. The negative reaction of the sardine toward red light was stronger: of 36,000 fish, 2.300 or 6.67 per cent were found in the red-light zone, and 33,610 fish or 93.33 per cent in the other light zones. Comparative data are shown below to better illustrate the preferential responses of the anchovy and sardine to colored and white lights.

Table XXVIII

	Description	*Responses in per cent*	
		Anchovy	*Sardine*
(A)	Green	82.13	74.35
	Blue, Red, White together	17.87	25.65
(B)	Blue	53.52	73.71
	Green, Red, White together	46.48	26.29
(C)	Red	10.72	6.67
	Green, Blue, White together	89.28	93.33
(D)	White	53.63	45.30
	Green, Blue, Red together	46.37	54.70

In the three- and four-zone tank (tables XII, XIII, and XIV) green light was found to have the same effect as in the two-zone tank. The anchovies consistently responded in favor of the green light regardless of the intensities of the opposing lights. As was true for sardines (Loukashkin and Grant, 1959), anchovies were attracted mostly by the blue-green region of the spectrum. They showed a preference for green light over blue, for green over red, and for green over white. A preference for blue, in the absence of green, over red and white was also evident. Similar results were obtained by Breder (1959) in his experiments using monochromatic lights of low intensities (2 foot-candles) on *Sardinella macrophthalma, Jenkinsia lamprotaenia,* and some other fishes. He observes that, when contrasting colored lights are presented in pairs, "a general tendency is evident for fishes to respond more definitely toward the shorter wave lengths (the blue and greens) and much less toward the longer wave lengths (reds)."

The attractive value of the blue-green region of the spectrum was demonstrated in experimental studies by several Japanese behaviorists on young marine fishes, such as *Oplegnathus fasciatus, Stephanolepis cirrhifer, Scomberomorus niphonius, Fugu niphobles, Fugu rubripes, Mugil cephalus, Girella punctata, Pempheris japonica, Trachurus japonicus,* and the fresh-water *Oryzias latipes* (Kawamoto, 1959; Kawamoto and Konishi, 1952; Kawamoto and Takeda, 1950, 1951; Ozaki, 1951).

Protasov (1957) investigated the responses of several species of the Black Sea fishes to monochromatic and white lights in the seaquaria of the Sebastopol Biological Station. He found that the ombre, *Corvina umbra,* responded positively to violet, blue, light blue, green and white lights, and even to ultraviolet rays. The juvenile sturgeon "sevriuga," *Acipenser stellatus,* was found to be phototatic to all types of lights applied but the responses were rather quantitative in character. The fish reacted positively only to higher intensities of the light, regardless of color. The horsemackerel "stavrida," *Trachurus trachurus,* displayed indifference to the blue-green region of the spectrum, but when the intensity of the light was increased (× 5) the fish reacted negatively. This fish responded less positively to white light than to red, especially when water temperature was lowered.[6]

A year later, Protasov (1958) published the results of his studies on the sensitivity of the fish eye to different wave lengths of light, establishing boundaries of the visible spectrum for certain marine and freshwater fishes, as shown in the following table:

Species	*Limits in millimicrons*		
Trygon pastinaca	≈ 420	—	≈ 620
Acipenser stellatus	≈ 420	—	≈ 700
Mugil auratus	≈ 430	—	≈ 700
Scorpaena porcus	≈ 400	—	≈ 600
Silurus glanis	≈ 500	—	≈ 700
Cyprinus carpio	≈ 480	—	≈ 700
Squalus acanthias	≈ 400	—	≈ 620

He also tested the ability of the fish to discriminate monochromatic lights regardless of their intensities, applying the electrophysiological method suggested by Bongard (1955) and Bongard and Smirnova (1959). This study revealed that *Mugil auratus* could distinguish blue, green, red, and orange lights from one another, but failed to distinguish blue from the violet and "extreme red" from red. *Scorpaena porcus* could discriminate red, yellow, orange, green, blue, and light-blue lights, but was unable to discriminate violet from the blue and "extreme red" from the red. The Black Sea turbot, *Rhombus maeoticus,* could distinguish blue, light blue, green, yellow, orange, and red lights, but could not differentiate violet from the blue.[7]

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[6] The rather unusual reaction of the Black Sea horsemackerel (in view of the Kawamoto experiments with the Japanese horsemackerel) had been reported earlier by Safianova (1952), who demonstrated preferential reactions of this fish to the orange-red illumination.

[7] Protasov's studies would have been more complete had he determined the ability of his fishes to react preferentially to certain wave lengths as well.

As to the responses of marine fishes to monochromatic lights in experiments under natural conditions in the open sea, there are several reports of interest to be mentioned in connection with the present study. Pochekaev (1949), testing the effects of overhead and submerged electric lights in the inshore waters of Sakhalin Island as possible attractants in local fisheries, obtained positive phototactic reactions as follows: (1) of the pond smelt, *Hypomesus olidus;* saury, *Cololabis saira;* and Eastern dace *Leuciscus brandti* (all three in juvenile stage) to white, yellow, and violet lights; (2) adult dace, to white and yellow (violet light was not used); and (3) trout "kundzha," *Salvelinus leucomaenis,* pond smelt and saury (all adult), to white light (the other two sources were not used).[8]

In addition to Pochekaev's data on pond smelt, Baranov (1955) found this fish also responded readily to and aggregated in quantities around submerged electric lamps emitting blue, red, and white light, the latter appearing to be the more effective attractant. As to the saury, Yudovich (1956) and Gristchenko *et al.* (1957) described the effectiveness of the blue and red lights in experimental saury catches in the northwestern Pacific. The blue light was used to attract the fish to the vessel (up to forty 500-watt incandescent lamps were installed along one side of the vessel); the red light (not more than four 500-watt incandescent lamps on the opposite side of the vessel) was used for operational purposes. When an aggregation would form in the blue light zone, the light would be extinguished and the red lamps would be turned on. The fish aggregation then would move from the darkened zone into the new dimly illuminated red zone where conical lift nets or blanket nets were installed. Upon lifting the nets, the red lights would be turned off and the blue lights turned on. This procedure would be repeated several times at one night light station.[9]

Experiments carried out by Japanese fishery biologists in the open sea revealed the effectiveness of other monochromatic lights in attracting saury. Light of 4,000 angstroms (violet) wave length was found to be most effective, and that of 6,000 angstroms (red) the least effective (Takayama, 1956).

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[8] Pochekaev indicated that violet light attracted the squid, *Ommastrepes sloani pacificus,* in great masses. A marked preference for violet light over both yellow and white lights was displayed by an instant phototaxis following switching on of the violet lamp and in a short time by the mass aggregation of the squid schools within the illuminated zone. The other two lights were found to be good attractants too, but to a much lesser degree. Positive phototaxis toward white light was recorded for the California squid, *Loligo opalescens,* by Radovich and Gibbs (1954) and for the Mediterranean squid, *Loligo vulgaris,* by Verheijen (1958).

[9] The use of a two-light arrangement as described by Yudovich (1956) and Gristchenko (1957) was introduced in the saury fisheries industry of Japan in the years following the end of World War II; it has been highly appreciated by the fishermen whose catches have rapidly increased (Parin, 1956; Pokrovsky, 1957). The total annual landings of saury in prewar years (1936-1939) in Japan, before the use of artificial lights, amounted to less than 10,000 metric tons. With introduction of light attractants, the catch in 1947 reached 22,900 metric tons; in 1950, 126,400 metric tons; and in 1954, 292,700 metric tons (Rass, 1956). By 1957 the number of fishing vessels with electric-light equipment employed in saury fisheries exceeded 2,000; the annual catch for the same year reached 375,000 metric tons (Fukuhara, 1959).

In experimental studies of natural visual responses of the yellowfin tuna, *Neothunnus macropterus,* and little tunny, *Euthynnus yaito,* in the Hawaii Marine Laboratory of the University of Hawaii, electric lights of white, blue, green, orange, red, and yellow colors were applied. The fish responded to colored and white lights, but "green light appeared to attract tuna" (Hsiao, 1952; Tester, 1959).

According to Nikonorov (1956a), the Caspian anchovy-like sprat "kilka," *Clupeonella engrauliformis,* in its natural environment "prefers" white light emitted by the submerged electric lamp when this light was presented paired with green or red lights. When green and red lights were presented together, the fish concentrated near the green lamp. In studying another Caspian sprat, *Clupeonella delicatula caspia,* under identical environmental conditions and using monochromatic and white lights, Borisov (1955) found out that the most effective attractant was ordinary white light. The results of his trials, expressed in per cent, are shown below:

Catches made with application of:	white light	57.2
	yellow light	27.6
	orange light	5.9
	blue light	5.0
	green light	3.8
	red light	0.5
	no light	0.0
	Total	100.0

In evaluating the results of his exploration, Borisov observed, "Here, apparently, is reaction to the intensity of light but not to the color of light." From this remark it could be assumed that light intensities of the lamps used by Borisov and his associates were not uniform, and therefore the results he obtained were not conclusive.[10]

During the present investigation, two other species of schooling marine fishes, occasionally available for comparative study, were subjected to the influence of lights. One of them, the topsmelt, *Atherinops affinis* (Ayres), was kept in captivity for quite a long time; the second, the Pacific herring, *Clupeaa pallasii* Valenciennes, had been captured at the end of the spawning season and was used in tests following the fish's initial adaptation to an artificial environment in the 1000-gallon display tanks of the Steinhart Aquarium. The results obtained with these fishes are shown in tables below:

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[10] Borisov never mentioned either light intensity figures or spectrographic values of his monochromatic lights in his report. This is also true for most of the Russian works cited in the present paper.

TABLE XXIX

Records of responses of the topsmelt to monochromatic and white lights and darkness. Each experiment consisted of five tests of 100 recorded observations on a group of eight fish. Light intensity was maintained at the 5 foot-candle level.

Experiment number	*Pair of contrasting light zones*					
	Zone "A"		*Zone "B"*		*Total*	
	Frequency of distribution					
	Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Top-1	*Green light*		*Red light*			
	3,970	99.25	30	0.75	4,000	100
Top-2	*Blue light*		*Red light*			
	3,610	90.25	390	9.75	4,000	100
Top-3	*Blue light*		*White light*			
	3,400	85.25	590	14.75	4,000	100
Top-4	*Red light*		*Darkness*			
	2,536	63.40	1,464	36.60	4,000	100

As seen from this table, the preference responses of the topsmelt were toward the green and blue lights. As in the case of the Pacific sardine and northern anchovy, the red light had no attractive value, except when it was opposed by darkness.

TABLE XXX

Records of responses of the Pacific herring to monochromatic and white lights. Each experiment consisted of five tests of 100 recorded observations on a group of six fish. Light intensity was maintained at the 10 foot-candle level.

Experiment number	*Pair of Contrasting light zones*					
	Zone "A"		*Zone "B"*		*Total*	
	Frequency of distribution					
	Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Hrg-1	*Blue light*		*Red light*			
	2,115	70.50	885	29.50	3,000	100
Hrg-2	*Green light*		*Red light*			
	1,591	53.10	1,409	46.90	3,000	100
Hrg-3	*White light*		*Red light*			
	1,524	50.80	1,476	49.20	3,000	100

Possibly, because of the physical and physiological condition of the herring captured during spawning season (in fact, a few females spawned on the tank's walls soon after delivery of the captured fish), their responses to monochromatic and white lights are quite different from those of the anchovy and topsmelt. Only in one of the three experiments did the herring display strongly negative reactions to red light and preferentially positive reaction to the contrasting light (blue). Gristchenko (1951) and Nikolaev (1957), speaking of the Pacific herring, and Tihonov (1959)—of the Atlantic herring, state that in experiments conducted in the open sea they found seasonal changes in phototactical behavior of this fish to the artificial lights. During the fattening period, both herrings reacted positively to light, and readily aggregated in masses in the illuminated zone. During the spawning season they became phototactically negative.[11] This may well explain the confusing results shown in the table XXX.

In closing this discussion on color vision in fishes, a few words should be said about the results of certain experiments in which "training" techniques have been successfully applied (*e.g.*, feeding responses associated with a stimulus of restricted wave length). In the classical work of Reeves (1919) the sunfish, *Lepomis gibbosus,* and horned dace, *Semotilus atromaculatus,* were trained to discriminate light of longer wave lengths from light of shorter wave lengths and from clear light. *Blennius pholis,* used in experiments reported by Bull (1957) in which he applied differential conditioning, displayed unusual ability to qualitatively discriminate monochromatic lights. One of the most interesting studies on color vision in fishes recently published is that of Arora and Sperry (1958). These investigators applied training techniques too. *Astronotus ocellatus* was used as an experimental animal. They found that this fish was able to distinguish red, blue, yellow, and green lights, and painted objects from each other and from various shades of grey. After training, the optic nerve was sectioned; the fish became blind. Regeneration of the sectioned optic nerve and restoration of vision took from 36 to 40 days; upon recovery of vision the fish displayed an ability to discriminate among the colors without further training. A fish which had not been trained prior to the blinding, by sectioning of the optic nerve, learned color discrimination as fast as normal fish. In the opinion of Arora and Sperry, the fish were able to discriminate between colors qualitatively rather than merely because of variation in intensity. In the much earlier work of Brown (1937), who worked with large-mouth black bass, it was concluded that, "in general, and excepting the violet, the degree of difference of different colors to bass is a function of difference in wave length." Puchkov (1954) states, "the ability of the fish to distinguish colors undoubtedly exists." Discussing the results of von Frisch's (1933) experiments, Puchhov observed, "if the fish were color blind, it would per-

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[11] Similar seasonal peculiarities in the behavior of certain marine fishes were recently reported by several Russian investigators: Parin (1956) in regard to saury; Safianova (1952, 1958) and Radakov (1956) concerning the Black Sea anchovy, *Engraulis encrasicholus pontica,* and horsemackerel, *Trachurus trachurus;* and Lovetskaya (1958) about the Caspian sprat, *Clupeonella delicatula caspia.*

Of the freshwater fishes, adult bream, *Alburnus alburnus,* in experimental studies in the laboratory carried out by Privolnev (1956) displayed phototactical periodicity with a change four times a year.

ceive the red color as grey, and thus it would mistake red cups for the grey ones of corresponding brightness. However the fish always distinguished red cups from the grey ones of different degrees of brightness." Walls (1942) flatly concluded that "no reasonable student of the problem [of the color vision in fishes] any longer doubts that fishes—all duplex teleosts at least—can experience hue as a sensation-quality apart from brightness." Fifteen years later, Brett (1957) recognized Walls' statement as the best formulated conclusion to the problem.

As to the present study of the innate ability of the northern anchovy to react differently to light of different wave lengths, the authors are inclined to consider the anchovy's perception of the applied lights strictly as a function of wave length apart from the intensity of the light, in accordance with their earlier report on color vision in the Pacific sardine (Loukashkin and Grant, 1959).

(2) On responses of the northern anchovy to ultraviolet wave length in relation to reactions of other species.

Illumination of the aquatic media differs from that of the aerial environments both quantitatively and qualitatively. Clark (1954) said that the sunlight upon entering water undergoes many changes. First of all, about 10 per cent or more of the light is lost because of reflection at the surface or beneath it. Traveling downward, the light is further modified not only in its intensity but also in its spectral and other properties.[12]

Baburina (1955) states that infrared rays are absorbed in the first meter layer of water. Ninety per cent of the red rays disappear within a depth of five meters; and ninety per cent of the green region of sunlight spectrum is absorbed before reaching thirteen meters of depth. Only violet and ultraviolet rays reach a depth of five hundred meters. The ultraviolet rays were detected 1,000 and more meters below the ocean surface. In conformity with this she maintains that "the eye of the fish is less sensitive to the red and more sensitive to the yellow, green, blue, and violet rays than the human eye, but in contrast with the human eye it is also sensitive to the ultraviolet region of the spectrum." Craig and Baxter (1952), speaking of the physiological importance of the ultraviolet component of natural light in aquatic environments, observed that "in the sea water there is differential absorption so that the centre of maximum intensity is displaced somewhere towards shorter wave lengths, the precise effect depending upon depth and the nature of the sea water. We should not, therefore, be surprised to find marine creatures sensitive to a range including a portion of ultraviolet spectrum." These theoretical reasonings concerning the ability of the fish

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[12] For instance, Boden *et al.* (1960) found that in the Bay of Biscay sunlight passing through water "becomes steadily bluer with depth until at 400 meters the spectrum peaks sharply between 475 and 480 millimicrons."

eye to perceive ultraviolet wave lengths appear to be well founded and correct as has been demonstrated by recent experiments in both the open sea and in the laboratory.

Protasov (1957), who applied an electrophysiological method in the investigation of vision in a number of marine fishes, obtained definite proof that the Black Sea ombre, *Corvina umbra,* could respond to ultraviolet rays as positively as to the rays of the visible spectrum.[13]

With facilities, sources of radiation, and techniques used in the present study, natural responses of the anchovy to ultraviolet rays seemed to be misleading because the fish responded inconsistently to ultraviolet light in various combinations with opposing wave lengths of light. These responses were found to vary from indifferent and negative to highly positive. Because of this seemingly individualistic and confusing behavior of the anchovy in response to the ultraviolet radiation, further experimentation is necessary, especially in total darkness with the application of better filters totally isolating the wave lengths of the visible region of the spectrum. Breder (1959), who experienced the same difficulties with his experimental fishes, in his very carefully worded conclusion states "there is some evidence to support the view that some fishes show a positive reaction toward ultraviolet wave length, but this requires extended analysis . . ." He found out that males of *Gambusia* sp. were ultraviolet positive, the females negative. In his experiments *Anoptichthys hubbsi* reacted positively, and *Anoptichthys jordani* negatively in one case; both species were slightly negative in another case. *Jenkinsia lamprotaenia* was found to be "ultraviolet positive to a very marked extent," and *Atherina stipes* showed an individualistic behavior toward the ultraviolet, being either attracted, or repelled, or indifferent. *Brachydanio rerio* displayed a strong positive reaction to the ultraviolet radiation.

As to the use of sources of ultraviolet radiation in tests in the open sea, only a few attempts have been made. A Netherlands research vessel carried out experiments along the Belgian coast but without success (de Boer, 1950). Craig and Baxter (1952), however, obtained immediate reactions of several species of marine fishes and other marine organisms to a submerged source of ultraviolet radiation (125-watt "black" ultraviolet lamp). They list the following fishes as influenced by ultraviolet rays: herring, mackerel, horsemackerel, dogfish, and whiting. Blaxter and Parrish (1958) also obtained positive aggregation of fish around the same source of radiation as used by Craig and Baxter, but they assumed that the reactions to the ultraviolet light might have been "due to the fluorescence from microorganisms in the water" rather than to the "black light" itself.

The inconclusive results of the experiments herein discussed prompt

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[13] Of freshwater fishes, the trout and pike have been known to perceive ultraviolet wave lengths of light ("Reflector," 1949).

the authors to consider the data obtained as a preliminary step toward further experimentation using improved sources of radiation and applying perfected techniques in the study of behavioral responses of the marine fishes toward ultraviolet radiation.

(3) On responses of the northern anchovy to infrared radiation with reference to experiments of other behaviorists.

There was no evidence that they were attracted, repelled, or frightened by the radiation, which suggests that they did not perceive the infrared wave length. This conforms with work of Duncan (1956) who found that fingerling silver salmon, *Oncorhynchus kisutch,* failed to respond in any manner to infrared radiation. Breder (1959) has found no indicative evidence that fishes would respond differently to radiant heat (infrared radiation) and ambient temperature.

(4) On responses of the northern anchovy to different values of intensity of white light.

The experiments using white light of varying intensities in two separate arrangements (in one these intensities ranged from 2 to 100 foot-candles, in the other from 75 to 500 foot-candles) revealed a natural ability of the anchovy to respond positively to intensities of moderate values regardless of the order of light arrangement, and to react negatively to both the highest and the lowest intensities in the arrangement. On the other hand, in a series of experiments utilizing sharply contrasting light intensities presented in pairs, the anchovies always responded positively to the lower values and displayed a marked avoidance reaction toward the brighter illumination. The results obtained in the present preliminary study suggest other tests, to be made in near future, might disclose the degree of sensitivity of the fish eye to the changes in the intensity of illumination, as well as the specific adaptation of the eye to certain intensity values as earlier demonstrated by Privolnev (1958) on samples of young carp, *Cyprinus carpio,* and young tench, *Tinca tinca.* He had found both were able to differentiate intensities of white light when these intensities were 75 per cent to 85 per cent greater than those to which the experimental fish were originally adapted.

As with other species found suitable for training, the northern anchovy and Pacific sardine should not present any difficulty in training studies. Usually, the newly delivered wild anchovies and sardines began to take food after 5 to 7 days of acclimation to the artificial environment of the Steinhart Aquarium. Following this, the fish were trained to break up the school, to ascend to the surface, and to swim close to the position occupied by the feeding person. The training consisted of propelling a tablespoon in the water for 10–15 seconds prior to dropping live food (brine shrimp) into water. Both the sardines and anchovies became conditioned to the sound of propelling the spoon, developing a feeding reaction within three to five trials (once a day), and they retained this response permanently. This conditioned response was of great help to the investigators at times when they had to pick up a few live specimens from the 1,000-gallon tank.

V. SUMMARY

1. The present investigation was conducted in order to study experimentally the effects of various types of illumination on the northern anchovy, *Engraulis mordax* Girard, from the point of view of its ability to discriminate between different wave lengths of the light spectrum and different intensity values of the white light.
2. The discriminating ability of the anchovy in regard to different types of visible and non-visible light radiation was explored in the specially constructed dark room and an experimental wooden tank which was divisible into a number of light zones [in accordance with the nature of the experiment to be carried out].
3. In the two-zone experiments the following paired lights were tested: green-blue, green-red, green-white, green-darkness, blue-red, blue-white, blue-darkness, red-white, red-darkness, and white-darkness. Ultraviolet was tested in pairs with green, blue, red, white, and darkness; infrared with darkness or with white light.
4. In the three-zone experiments the following combinations of lights were tested: green-red-white, green-white-darkness, red-white-darkness, blue-red-darkness, and blue-green-white ("daylight").
5. In the four-zone experiments the green-blue-red-darkness combination was tried.
6. In the two-zone experiments with monochromatic and white lights, the intensity was maintained uniformly at the 9 foot-candle level; in experiments with monochromatic lights and ultraviolet rays the intensity was adjusted to the maximum intensity of the "black lamp" which was equivalent to 0.2 foot-candle. In other experiments using ultraviolet or infrared wave lengths and white light or darkness, the intensities varied from almost zero to 500+ foot-candles.
7. In the three- and four-zone experiments, the intensities of monochromatic and white lights tested were either uniform or of different values.
8. In all combinations of monochromatic and white lights, the effect of red light on the anchovy remained invariably negative in contrast to the sharply positive reaction of these fish toward other lights tested.
9. In two-zone choice experiments the positive reaction of the anchovy for green light was found to be 97.86 per cent over the red (2.14 per cent);

75.34 per cent over white (24.66 per cent); 73.18 per cent over blue (26.82 per cent). The preference for other lights, tested in pairs, was as follows: 81.60 per cent for blue light over red (18.40 per cent), and 52.15 per cent over white (47.85 per cent); and 88.39 per cent for white light over red (11.61 per cent).

10. In the three- and four-zone experiments, the anchovies consistently demonstrated positive responses toward the green light as they did in the two-zone experiments. Even a considerable increase in the intensities of the opposing lights could not alter the positive reaction to green light.

11. In the two-zone experiments using ultraviolet light paired alternately with green, blue, or red light, the anchovies displayed three conflicting responses. These responses were "indifference" in ultraviolet versus blue light (50.15 per cent – 49.85 per cent), "slightly negative" (45.21 per cent) when ultraviolet was contrasted with green light (54.79 per cent), and "highly positive" (71.97 per cent) when it was paired with red (28.03 per cent).

12. In the other two-zone experiments, when ultraviolet and white lights of much higher intensities were tested, the results were confusing as described above. With respect to the ultraviolet light, the responses of the anchovies varied from negative or avoidance (36:64), through indifference (50:50), to positive (72:28).

13. In experiments utilizing infrared radiation, the anchovies seemed totally unable to perceive it.

14. In experiments intended to test the ability of anchovies to differentiate among different white light intensity values they seemed able to do so as evidenced in the tests with four and five intensity zones, and even more markedly in the two-zone experiments.

15. In the five-zone test arrangement in which intensities of light ranged from 2 to 100 foot-candles, the fish responded preferentially to the moderate intensities of the central zones (29.23 per cent for the 20 foot-candle zone, and 41.94 per cent for the 50 foot-candle zone, or 71.17 per cent for both).

16. In the four-zone test arrangement of white light used in intensities of 75, 125, 250 and 500 foot-candles, the anchovies reacted toward the moderate intensities of 125 foot-candles (30.21 per cent) and 250 foot-candles (37.16 per cent).

17. In the two-zone test experiments involving sharply contrasting intensities of 500 foot-candles, as a constant value, paired with much lower values ranging from 2 to 20 foot-candles, the reaction of the anchovies was always in favor (60.42 per cent to 83.71 per cent, averaging 68.52 per cent) of the lower intensity values.

18. The experiments herein described and discussed reveal a few important factors in the reactions of the anchovy to light and darkness: (1) the an-

chovy is a phototactic animal; (2) it is capable of discriminating qualitatively between monochromatic (green, blue, red) and white lights; (3) it is able to distinguish green light from blue (the Pacific sardine failed to do so); (4) it shows a preference for green and blue lights over white; (5) it proved to react strongly negatively to red light. However, the fish tolerated this type of illumination when it was tested as an alternative to total darkness, and showed a highly positive response in such a case to the red light; (6) in its reaction toward the ultraviolet wave lengths it displayed a rather individualistic pattern of behavior; (7) it is unable to perceive infrared radiation; (8) it is capable of reacting differently to different intensities of white light ranging from 2 foot-candles to 500 foot-candles.

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ERRATA

Page 13. Line 4 from top: for *davis* read *davisi.*
Page 115. Line 2 from bottom: for *A. thersites* read *S. thersites.*
Page 119. Line 8 from top: for *Siphonaris* read *Siphonaria.*
Page 138. Line 12 from bottom (caption under figure): for *barossi* read *barrosi.*
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Page following 160, after running head, add 161
Page 374. Line 8 from bottom: for *bivattatus* read *bivittatus.*
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Page 440. Line 17 from bottom: for *Peters* (italics) read Peters (roman).
Page 450. At top of page add "450" and running head *California Academy of Sciences* [Proc. 4th Ser.
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Page 549. Between lines 13, 14 from bottom: insert as a heading, Genus **Malacobdella** Blainville, 1827.
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BY

FRANCIS X. WILLIAMS
Research Associate
California Academy of Sciences

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