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1.

Comparative Biology of Salticid Spiders at Rancho Grande, Venezuela. Part I. Systematics and Life Histories in *Corythalia*.¹

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(Plate I; Text-figures 1-15).

[This is one of a series of papers resulting from the 45th and 46th Expeditions of the Department of Tropical Research of the New York Zoological Society, made during 1945 and 1946 under the direction of Dr. William Beebe with headquarters at Rancho Grande in the National Park of Aragua, Venezuela. The expeditions were made possible through the generous cooperation of the National Government of Venezuela and of the Creole Petroleum Corporation.

[The characteristics of the research area are in brief as follows: Rancho Grande is located in north central Venezuela (10° 21' N. Lat., 67° 41' W. Long.), 80 kilometers west of Caracas, at an elevation of 1,100 meters in the undisturbed montane cloud forest which covers this part of the Caribbean range of the Andes. Adjacent ecological zones include seasonal forest, savanna, thorn woodland, cactus scrub, the fresh water Lake Valencia, and various marine littoral zones. The Rancho Grande area is generally subtropical, being uniformly cool and damp throughout the year because of the prevalence of the mountain cloud cap. The dry season extends from January into April. The average humidity during the expeditions, including parts of both wet and dry seasons, was 92.4%; the average temperature during the same period was 18° C; the average annual rainfall over a 5-year period was 174 cm. The flora is marked by an abundance of mosses, ferns and epiphytes of many kinds, as well as a few gigantic trees. For further details, see Beebe & Crane, *Zoologica*, Vol. 32, No. 5, 1947. Unless otherwise stated, the specimens discussed in the present paper were taken in the montane cloud forest zone, within a radius of 1 kilometer of Rancho Grande.]

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INTRODUCTION.

Jumping spiders are among the most interesting of all animals for two distinct reasons. First, the epigamic displays and associated

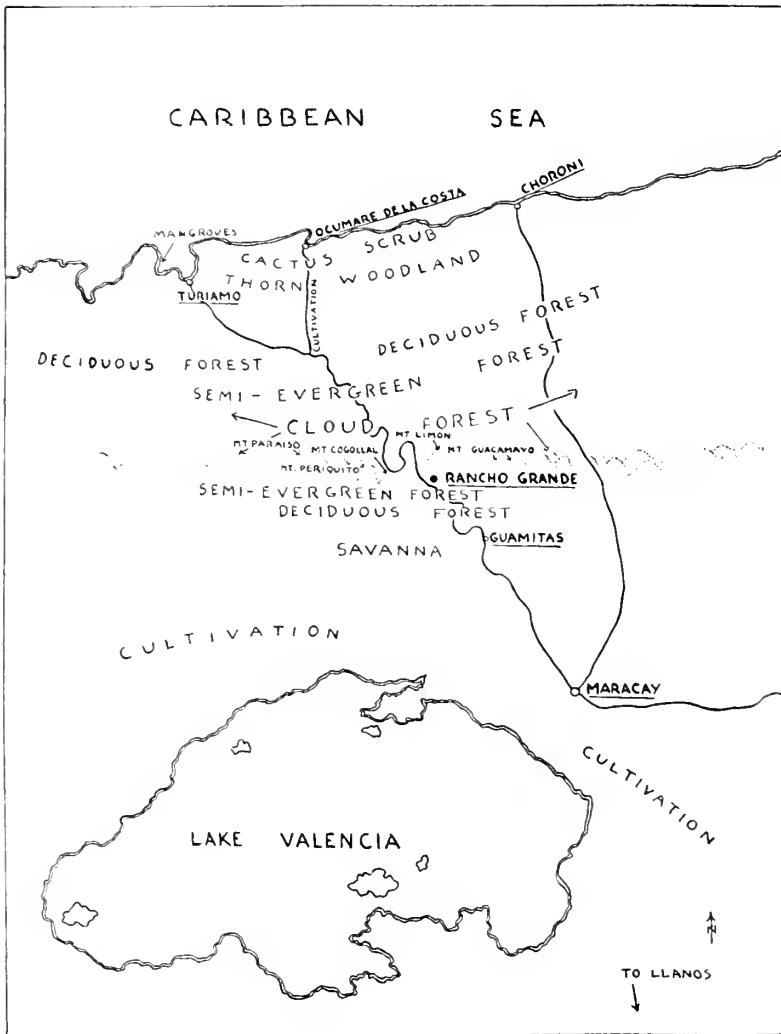
adornments of the males are directly comparable to those of certain fishes, birds and other vertebrates. Second, as all students of spiders have agreed, the family's pattern of evolution is of a challenging complexity. Difficulties in systematics have been increased by the sheer numbers of species, by inadequate series of specimens, by the inability of most workers to study color pattern in living salticids and by the failure of attempts to rear the young and thus gain ontogenetic clues to relationships. Apparently only Bonnet (1933) has reared a salticid through all instars.

The present paper is based on plentiful material representing three new species of the salticid genus *Corythalia*, all studied at Rancho Grande in 1945 and 1946. Each was successfully bred in the laboratory, and all growth stages of both sexes were obtained except for one instar of one species. The report is confined to systematic descriptions of external characteristics of adults and young, accounts of normal display and general life history data. A subsequent paper will present an analysis of display, based both on normal display and on experimental work, and a discussion of evolutionary trends as suggested by development of color and structure, and by behavior. Also to follow is an account of culture and display-study methods.

During the first season at the Rancho Grande station, growth stages and displays of more than forty other species of salticids were also studied in more or less detail. The second year concentrated work was confined to half a dozen of these forms, including *Corythalia*, so that more complete life histories could be obtained and experimental work accomplished.

The three local species of *Corythalia* were among those chosen for special study for the following reasons: first, material of all three species was plentiful and thrived under laboratory conditions; this gave a unique opportunity for comparisons of development, behavior and species barriers in closely related forms. Second, *Corythalia* proved to be highly specialized in many characteristics, particularly in color development and display behavior, and so is an important group for

¹ Contribution No. 783, Department of Tropical Research, New York Zoological Society.



TEXT-FIG. 1. General location of the principal ecological zones near Rancho Grande. The *Corythalia* described in the present paper were taken only in the semi-evergreen and lower cloud forest slopes of the southern watershed. Although only the highest ridge of the coastal range is indicated, the entire region is mountainous except for the Lake Valencia plain.

the study of evolutionary trends, both inside the genus and in comparison with other salticids.

The drawings of *Corythalia* display and the frontal views of females (Text-figs. 12, 13, 14 (part), 15) were made from life by Mr. Kenneth Gosner at Rancho Grande; he also made the preliminary drawings for the growth stage patterns (Text-fig. 2). The final forms of Text-figs. 2 and 14 and the remaining drawings are the work of Miss Pamela Marmont.

The measurement and spine notation systems used are those proposed by Dr. Alexander Petrunkevitch, as outlined in his "Study of Amber Spiders" (1942, pp. 135-139). The standard abbreviations AME, ALE, PME and PLE are used throughout for the various eyes, antero-median, antero-lateral,

postero-median and postero-lateral, respectively. "Instar" and "stadium" are used interchangeably. Unless otherwise stated, averaged measurements are from five specimens of each sex or instar considered; length measurements and spine counts include all specimens.

I wish especially to think Sr. Pedro Infante and Sr. Eduardo Echenagueio, laboratory assistants at Rancho Grande, for their invaluable help in collecting and tending the living salticids.

Deep appreciation goes to Dr. William Beebe and to Dr. Alexander Petrunkevitch for their constructive advice and encouragement.

The types are deposited in the collections of the Department of Tropical Research, New York Zoological Society, New York 60, N. Y.

CHARACTERISTICS OF THE GENUS *CORYTHALIA* WITH SPECIAL REFER- ENCE TO THREE SPECIES.

ADULT FORM AND POST-EMBRYOLOGICAL DE- VELOPMENT OF EXTERNAL CHARACTERISTICS.

More than fifty species have hitherto been referred to the American genus *Corythalia*, originally and in synonymy. Several species occur in the United States, but most have been taken in Central America and the West Indies. The few recorded South American forms, all known only from the original series, are the following: From Colombia, *C. dimidiata* Simon, 1901 (color note only), and *C. electa* (Peckham, 1900); from Trinidad (a biological part of South America, rather than of the West Indies), *C. blanda* and *C. placata* (both Peckham, 1900); from French Guiana *C. heliophanina* (Taczanowski, 1871); and from Brazil, *C. fimbriata* and *C. valida* (both Peckham, 1900). Simon, 1901, p. 655, indicated that he took the genus also in the Andes of Venezuela and Ecuador, but descriptions have apparently never been published. Without question, many more South American species remain to be taken and described; our own collections contain at least three more species, in addition to the three with which the present paper is concerned, from other parts of Venezuela and from British Guiana.

It seems equally certain that when adequate knowledge of the group is attained, some of the species in the genus will be reduced to geographical subspecies, or even merged in geographical clines. On the other hand, since the group is obviously subject to high speciation and a radiative type of evolution, it will always remain difficult to divide systematically. As in the family in general, certain characters are present in widely separated species, and absent in closely related ones, while others vary without sharp boundaries.

As is the case with so many salticid genera, the delimitation and understanding of *Corythalia* are complicated by six factors. First, the limits of the genus are apparently not sharply definable. Second, no general survey of the group has been undertaken, to include the extensive series of species now known from both Panama and the West Indies, as well as earlier material from Central and South America. Third, many of the species now referred to this genus are inadequately known, or have been described from a single sex. Fourth, the color and appearance in life have only rarely been recorded. Fifth, the display has not hitherto been described. Sixth, and finally, the post-embryological development has not been previously studied.

Although the present study makes no attempt to review the genus, the following survey of the three new species proposed in this paper should be of aid in a future review of the group. Comparison of these gen-

eral structural characteristics with those given by recent workers in the group, notably Chickering (1946) and Bryant (1942 ff.) show that they are also typical of many Panamanian and West Indian species of *Corythalia*. Some characteristics, in fact, often mentioned in specific descriptions, are shared by many other salticids; examples are the arrangements of facial bristles and trichobothriae. Nevertheless, the data in this paper are based only on the three species to be described, since the earlier authors do not give sufficient data in comparable form to permit complete comparison.

The present survey is given in order to eliminate repetition in the actual specific descriptions, which begin on p. 14, and to form a foundation for the eventual general survey. A résumé of the post-embryological development of each character is given under each.

Two of the proposed species, *chaleea* and *fulgipedia*, are closely related, while the third, *xanthopa*, apparently belongs to a different branch of the genus *Corythalia*. All are characteristic, not borderline, species. For these reasons, a detailed comparison of the three yields enlightening information in regard both to similarities and to directions of variation in the group.

Included in the preliminary discussion are descriptions of the general developmental, behavioristic and ecological characteristics of the three species. Discussion and comparison are reserved for final sections on an Analysis of Display and on Phylogeny, to be published later.

In brief, the three species fit into Chickering's diagnosis of the "*Phiale group*" (1946, p. 34) and of *Corythalia* as given (*ibid.*, p. 112). The retromargin of the chelicera in all our species has a single small tooth (present or absent in other genus members); definite fringes present on the first three or all four legs (present or absent in other genus members); total eye space occupying about half length of carapace; PME slightly closer to PLE than to ALE; lateral sides of carapace nearly vertical and nearly parallel; anterior coxae further apart than width of base of lip; ventral spines on first tibia 1r-2-2, 0-1r-2 or 0-0-2, not, as is more usual in the previously described species, 2-2-2.

The various characters and their development will now be considered in detail.

Color in Life: Adults. Integument jet black except for light brown third and fourth, or all, tarsi. A few dark bristles on carapace, described below. Carapace with or without submarginal band and thoracic markings of white scales; ocular quadrangle with or without bronze scales; anterior eyes brownish-black, usually with deep green reflections, always rimmed with yellow or rusty scales; clypeus, chelicerae and palps with or without white or yellow scales and hairs. Palps and legs with plentiful black hairs; male leg fringes black, except for yellow fourth dorsal fringes in *xanthopa*; leg iridescence chiefly purple; white or yellowish

leg scales present in varying amounts in both sexes, better developed in female. Abdomen with transverse bars of black and yellow or white scales (represented subdermally by dark and pale integument) and a pair of terminal spots, all more or less overlaid in males with bronze or yellow scales, or, in female *xanthopa*, with two yellow stripes; dark hairs and bristles arising above scales. This general range of coloration is typical of previously described species in the genus, except that red, occasionally found on faces and abdomens, does not occur in these three species. Sexual dimorphism in color ranges from slight to extreme.

Young. Integument: Pigment absent in first instar, which is translucent with a faint greenish or yellow cast; late in this stadium the pale abdominal bands of the second are faintly visible, since the entire spiderling now has a gray tinge from the black cuticle developing subdermally; radiating lines appear on thoracic region. Second instar integument of carapace and abdomen jet black, except for the two pale abdominal bands, one in anterior third, the other behind middle, and a pair of terminal spots; by this stage, too, pigment may or may not be developing in bands on legs; the latter gain full pigment, except for feet, between fourth and sixth stadia, the palps a stage or two later.

Scales: Even in second instar, abdominal bands and spots are completely covered with white or yellow scales and intervening portions with black; these primary markings persist throughout at least preadult instar and along with black integument are the most characteristic features of the young compared with those of other genera. A few black scales appear on sides of carapace about the fourth instar, but are usually absent in adult. The most characteristic carapace markings are two spots of white or yellow scales behind PME and a similar pair, or a complete cross-bar, behind PLE; these markings, varying with the species, appear in second or third instar and are traceable at least until sixth; usually they are degenerating and overlaid with bronze scales by the fifth. A strong submarginal band of white scales, characteristic among these three only of *fulgipedia*, appears in third instar; never strong in the other species, it does not appear there until the sixth. AME first rimmed with orange or yellow in second instar, ALE in third or fourth. White scales of face, mouthparts and legs almost absent in *xanthopa*, the yellow frontal hairs of male appearing in rudimentary fashion in preadults of both sexes; white face and appendage scales of the other two species appear in early instars, and are best developed in adult or preadult females.

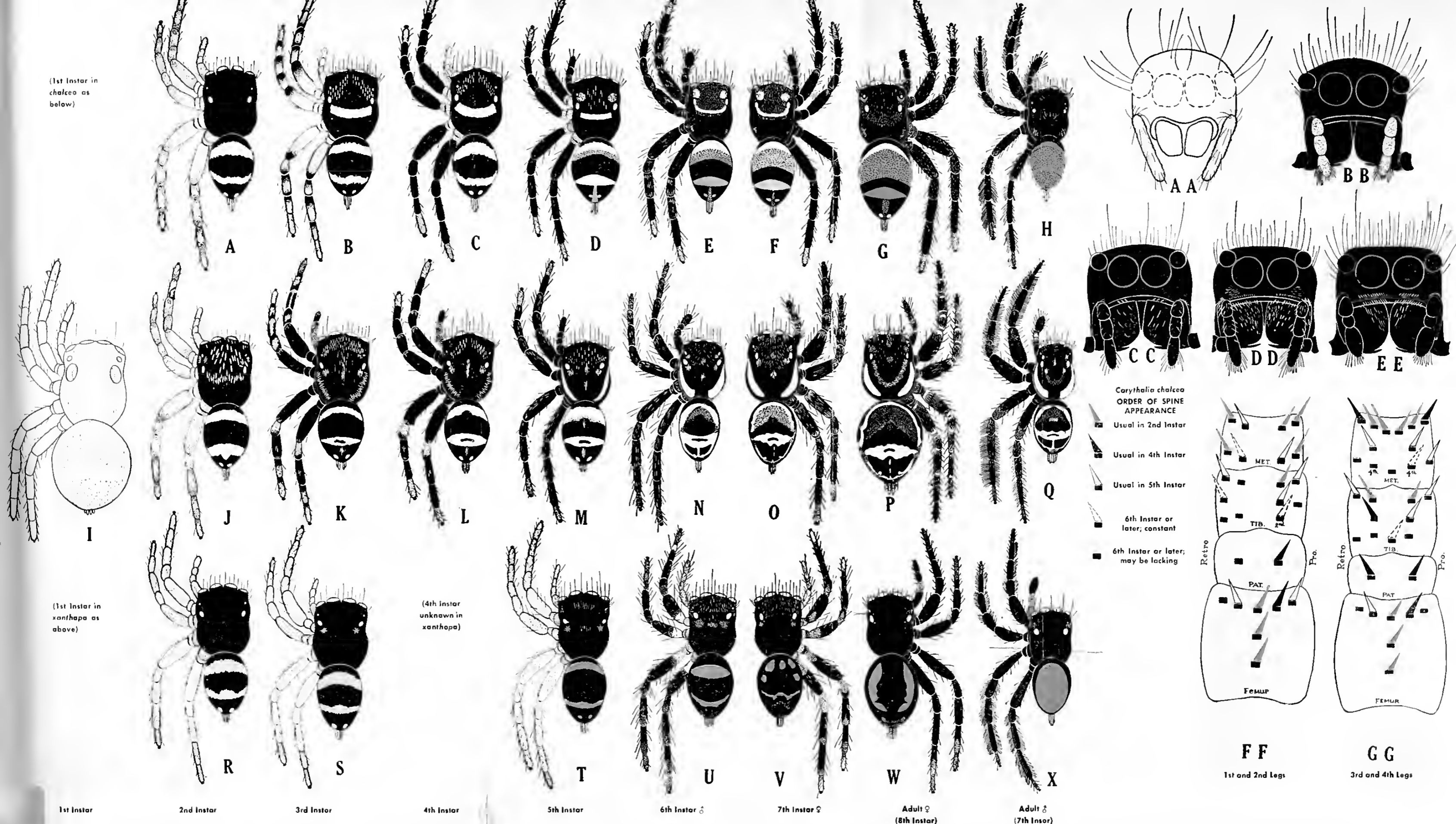
Color in Alcohol: Even after only a few months in 70% alcohol, the distinct color patterns of these spiders are more or less obliterated, and drying the specimens only partially restores them; bronze and gold become dull brown; silvery white scales fade

to gray or creamy; many of the most characteristic scale patches or bars are missing altogether, iridescence cannot be accurately described; finally different individuals fade and lose their scales to very different extents, and this effect of preservation, combined with the normal individual variation in size, structure and pattern, and with sexual dimorphism, would make classification of a few preserved specimens exceedingly difficult; the tendency would be to divide the group into more than the actual number of species. The most constant feature is the light-colored second abdominal band, which, since it is well-marked subdermally, is usually traceable in all three spiders. It cannot be emphasized too strongly that color descriptions should be made from large series of living, displaying specimens, with the details filled in from anaesthetized individuals, and both fresh and worn examples included.

Carapace, General Aspect (Table I): **Adults.** Breadth $7/10$ to $3/4$ of carapace length in both sexes of all three species, the carapace being slightly longer in females than males and therefore relatively narrower; extra relative length of female carapace almost altogether in postocular region. Greatest width either at insertion of second legs (*fulgipedia* always, *chalcea*, sometimes), or at the slight bulge always present before PLE. Height a little greater or less than width, about one-half to three-fifths of length, least in *fulgipedia*, most in *xanthopa*; females slightly lower than males. Profile rises gently from AME to PLE; from here it either extends as a plateau or descends gently to a point midway between PLE and posterior border; posteriorly the descent is abrupt; postocular plateau best developed in *fulgipedia*; thoracic slope most abrupt in *chalcea*. A shallow transverse, median depression between posterior borders of PLE and a short, median, longitudinal thoracic groove beginning at bottom of depression and extending slightly beyond it. Length of ocular quadrangle about three-fifths to two-thirds of its breadth, and about two-fifths length of carapace; breadth of quadrangle relatively widest in *xanthopa*.

Young (Text-figs. 3, 4). Form of carapace changing abruptly from relatively higher and broader than adult in first stadium to much lower and flatter than final form in the second. The final general carapace proportions of the female are almost or quite attained by both sexes in fifth instar, the male keeping female height and breadth proportions until adult (7th) stadium. Text-fig. 3 shows that specific differences in carapace profile are apparent even in second instar, *fulgipedia* being lowest with a longer and flatter postocular plateau. Ocular quadrangle in first stages is wider across its anterior margin than in adult.

Eyes (Table I): **Adults.** Anterior row, viewed from the front, recurved so that a straight line from dorsal borders of AME cuts off one-fourth to one-third of ALE.



(1st instar in chalcea as below)

(1st instar in xanthopa as above)

1st Instar

2nd Instar

3rd Instar

4th Instar

5th Instar

6th Instar ♂

7th Instar ♀

Adult ♀ (8th Instar)

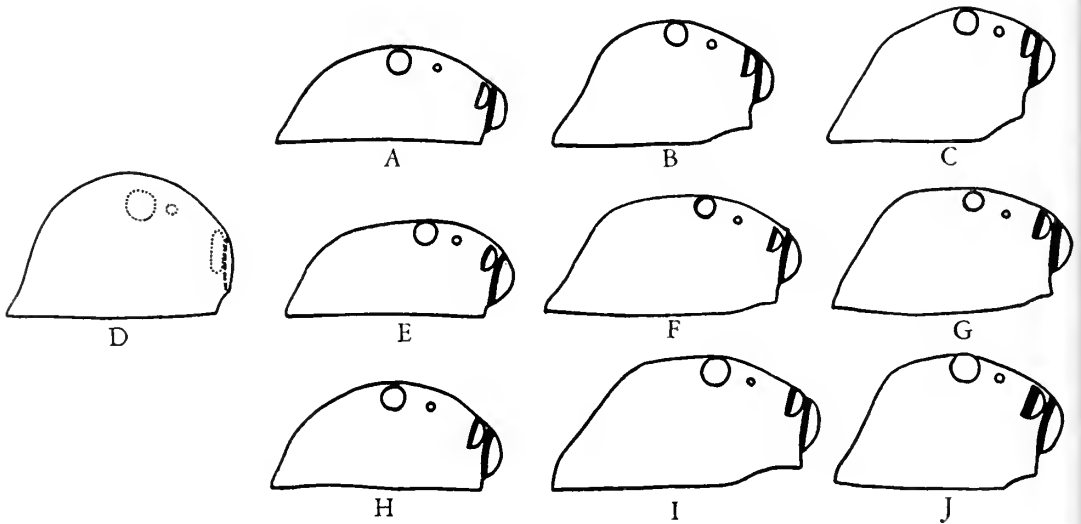
Adult ♂ (7th Instar)

TEXT-FIG. 2. A-X: Growth stages in *Corythalia*, showing comparative development of color pattern and proportions in three species. Color in life is black and white except areas marked in yellow. Clear yellow indicates scales pigmented yellow; yellow stippled with black, or yellow on black, indicates bronze scales. See descriptions for exact colors and variations. Numbers and positions of hairs and bristles not exact; omitted entirely from abdomens. A-H, *Corythalia chalcea*; A, 2nd instar; B, 3rd instar; C, 4th instar;

D, 5th instar; E, 6th instar, ♂; F, 7th instar, ♀; G, 8th instar, adult ♀; H, 7th instar, adult ♂. I-Q, *C. fulgipedia*: I, 1st instar; J, 2nd instar; K, 3rd instar; L, 4th instar; M, 5th instar; N, 6th instar, ♂; O, 7th instar, ♀; P, 8th instar, adult ♀; Q, 7th instar, adult ♂. R-X, *C. xanthopa*: R, 2nd instar; S, 3rd instar; T, 5th instar; U, 6th instar, ♂; V, 7th instar, ♀; W, 8th instar, adult ♀; X, 7th instar, adult ♂. AA-EE, *C. chalcea*. Frontal views, showing development of pigment and scales. The

yellow indicates growth of marginal eye scales; in life the tint varies from pale yellow through orange to rust. AA, 1st instar; BB, 2nd instar; CC, 5th instar; DD, adult ♀; EE, adult ♂. See Text-fig. 6 for total number of primary bristles. FF, GG, *C. chalcea*. Diagrams of typical course of spine development. FF, 1st and 2nd legs; GG, 3rd and 4th legs. Figures under spines indicate their presence on only 2nd or 4th leg. See key at left of diagrams.

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TEXT-FIG. 3. Change in carapace profile in *Corythalia*. **A-C**, *chalcea*: **A**, 2nd instar; **B**, adult ♀; **C**, adult ♂. **D-G**, *fulgipedia*: **D**, 1st instar; **E**, 2nd instar; **F**, adult ♀; **G**, adult ♂. **H-J**, *xanthopa*: **H**, 2nd instar; **I**, adult ♀; **J**, adult ♂. Profile of 1st instar practically identical in all species. Adult females drawn to same scale as adult males, to show difference in relative size.

Slightly longer than width at base; basal excavations reaching about two-fifths of length; general shape nearly triangular from distal end of excavations; tip reaches three-fifths of distance to tip of maxillae. Sternal suture slightly procurved.

Sternum (Text-fig. 5): **Adults**. Broadly scutiform; width in males three-fourths to four-fifths, in females two-thirds to four-fifths of length; almost as wide or slightly wider at anterior border at base of lip; lateral margins with four excavations on each side well or scarcely developed; widest portion opposite posterior side of second legs; posterior end variable, truncated or bluntly rounded, not extending between fourth coxae, which are separated by about one-fifth to one-seventh of their width.

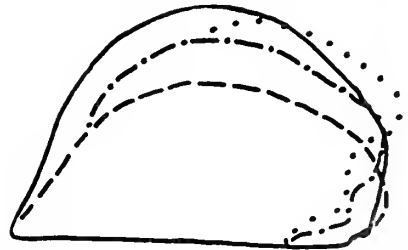
Young. Sternum in first instar almost as broad as long (92%); 77% in second instar; flatter in front and more pointed behind.

Legs. General Proportions (Tables I, VII): **Adults**. In all three species the third and fourth legs are almost equal and are longer than the first and second, which are also of similar length. They are only slightly longer in males than in females, their actual differences being slightly less than appear in Table I, since the male carapace is shorter than that of the female. In both sexes the third and fourth contrast with the first and second in having shorter patellae but longer metatarsi. Tibial index: first leg, males 23 to 27, females 24 to 33; fourth leg, males 17 to 21, females 18 to 27. Legs are relatively shortest and stoutest in *fulgipedia*.

Young (Table VII). Even in the first stadium the legs show these general proportions of the adult, the first two legs being

shorter than the last two; they are much more nearly equal, however, and they measure three-fourths of their adult length in respect to length of carapace. Their tibial index is greater: 27 to 32 (first leg) and 25 to 31 (fourth leg) in the first instar; 24 to 31 (first leg) and 22 to 27 (fourth leg) in the second. The divisions between patella and tibia, and between metatarsus and tarsus, are scarcely discernible in the first stadium, and feebly so in the second in all four legs and the palps. The feet and patellae are noticeably longer in the earliest stages, while the metatarsus elongates chiefly from the fifth instar onward.

Iridescence: In adult male only present prolaterally on patella, tibia and metatarsus in all three species in the same relative strengths, being strongest on tibia and metatarsus; it is present on at least the first three legs, in the following relative strengths: 3, 2, 1; in *xanthopa*, in which the fourth leg is also iridescent, the brilliance is equal to that of the third. A slight flattening of the iridescent surfaces is apparent in



TEXT-FIG. 4. Superimpositions of carapace profiles in *C. chalcea*. Solid line, 1st instar; dash line, 2nd instar; dash-dot line, adult ♀; dotted line, adult ♂.

all three species, though to different extents, the greatest flattening being evident on the species and segments showing the highest iridescence. On the patella this flattening is always on the upper prolateral distal surfaces; on the tibia and metatarsus it occurs on the upper half. On the most highly iridescent surfaces hairs are usually scant or absent. In live specimens iridescence is absent on the femora and on all retrolateral surfaces, although in these areas white scales and hairs are often well developed. In preserved specimens, however, a false, slight iridescence is sometimes apparent on anterior tip of femur and on posterior surfaces, while the true areas of iridescent planes are of much reduced brilliance.

Special Integumentary Structures.

Fringes: In adult males only. At least first three legs conspicuously fringed; *xanthopa* has the fourth legs also strongly fringed. Except in the latter species, in which the fourth fringe is best developed, the fringes occur in the following order of strength on the different legs, from greatest to least: 3-2-1-4. Dorsal and ventral fringes occur on the femur (rudimentary), patella, tibia and metatarsus. Except in the fourth leg fringe of *xanthopa*, in which the dorsal fringe is yellow and longer than the ventral fringe, all fringes are black, and the dorsal fringe is shorter than the ventral. The ventral fringes of femur and patella tend to be each in two distinct rows, prolateral and retrolateral; the remainder, however, are either median, or tend to cover evenly the entire ventral surface. A slight concentration of hairs occurring in preadults of both sexes and in adult females, on lower margins of leg segments, seems to be an adumbration of fringes.

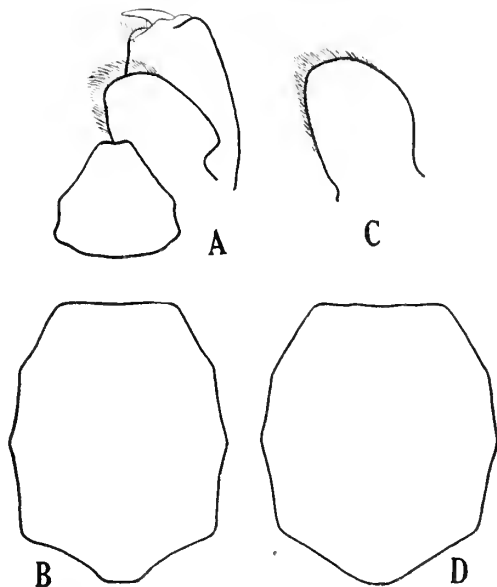
Spines: As will be seen from Table II, the following spines are constant in both sexes of all three species:

All legs: femur, dorsal 0-1-1-1; prolateral, upper distal 1; patella, prolateral 1; tibia, ventral distal 2; metatarsus, prolateral and retrolateral, proximal or near-proximal 1, upper distal 1; ventral proximal at least 1p, almost always 1r in addition; ventral distal 2.

First and second legs; tibia, prolateral proximal or near proximal 1, distal 1.

Third and fourth legs: patella, retrolateral 1; metatarsus, prolateral and retrolateral, lower distal 1.

It will be seen also from the Table that some spines, notably in the third and fourth legs, are constant except for rare females, these specimens sometimes having only a single side in one example of one species deficient. Included in this group are the tibial dorsals and the tibial median and distal pro- and retrolaterals. In spite of their rarity, these variables, like the more common ones, apparently indicate a lack of genetic stability in the spine in question, which always is



TEXT-FIG. 5. A, C. *chalcea*, adult ♂; labium, maxilla and chelicera, ventral view; B, same, sternum drawn to same scale; C, C. *chalcea*, adult ♀; maxilla; D, C. *xanthopa*, adult ♂; sternum, at greater magnification, for comparison with *chalcea*.

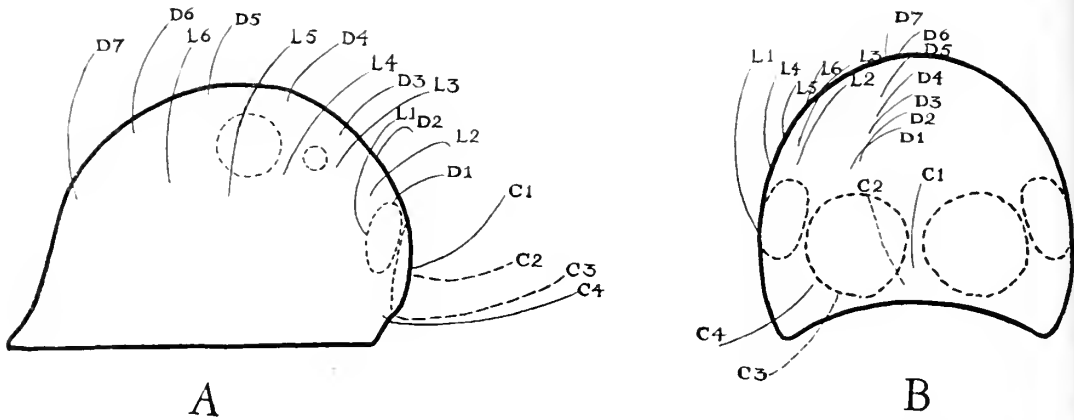
among those appearing late in ontogeny; the constant spines, on the other hand, invariably appear in early instars (see p. 18 and Text-fig. 2, FF, GG).

Constant differences are lacking between adults of both sexes of *chalcea* and *fulgipedia*; *xanthopa* invariably has a few spines fewer than the others.

There are no constant sexual differences within any of the three species, although in each females tend to have fewer spines than males, and their variability is greater.

In regard to exact position of insertion, there is considerable irregularity and variation, especially on the tibia. The dorsal spines on both tibia and metatarsus, and the unpaired tibial ventral proximal, may be inserted either before or behind the midline, although they usually occur behind it. Relative lengths are shown in Text-fig. 7.

Development of Spines. The course of development of the leg spines is similar in all three species, the same spines appearing earliest. On p. 18 and in Text-figs. 2 (FF, GG) and 7, is given a survey of the spine development in *chalcea*. Specific differences, aside from the differences in the adults noted in Table II, are confined to earlier or later appearances of some of the spines occurring first in the third, fourth and fifth instars. Compared with *chalcea*, the spines of *fulgipedia* tend to occur one or two stages earlier, and in *xanthopa* one stage later. The second instar is identical in *fulgipedia* and *chalcea*, while *xanthopa* differs from both only in having neither tibial spines nor first and second metatarsal ventral distals, which all ap-



TEXT-FIG. 6. Arrangement of carapace bristles in 1st instar of *Corythalia*. **A**, lateral view; **B**, anterior view. **C1-C4**: clypeal series (C2 and C3, indicated by broken lines, do not appear until 2nd or 3rd instar). **D1-D7**: dorsal series. **L1-L6**: lateral series.

pear instead in the third instar. In *xanthopa* the lag continues in the tibial and metatarsal ventral spines even into the sixth instar. It is this species which tends also to have fewer spines in the adult.

In all species, no spines appear before the second instar, although the femoral dorsals are represented by long hairs in the first. Often, later appearing spines appear to be represented by hairs in a preceding instar, but are never counted as such when in this rudimentary form; these hairs have no trace of the dark chitinous bases which characterize true spines and which, combined with great stiffness, usually obviate indecision as to whether a structure should be counted as a spine. No spines are ever found in any stage of the young which do not appear in at least one sex of the adult, this sex practically always being the male.

By the fifth instar, at least in *chalcea* and *fulgipedia*, all the constant spines found in both adult sexes may be present. No spine developed in or before this instar in any species is inconstant.

In general, the spines in a given series develop from the distal to the proximal end of a segment. (Exceptions are the highly variable first and second tibial retrolaterals). The fourth and third legs not only have more spines than the other two, but tend to develop their late-appearing variables slightly earlier. Among individuals, the retrolateral side of a third or fourth tibia often develops a late-appearing spine before the corresponding prolateral; however, the general tendency is for development to be from prolateral to retrolateral surfaces.

In general, the latest appearing spines, which are also the most variable, are the lower distal lateral femorals and the proximal spines of tibiae and metatarsi.

Bristles (Text-figs. 6, 7): The long stout bristles present on the clypeus and other parts of the carapace are probably homologous with those of the legs, and will be treated, for convenience, along with them.

These bristles, as a group, are of general occurrence in similar though not identical positions in a great many (if not all), salticids, in both sexes, and occur in early instars. I have been unable to detect specific differences in the three species of *Corythalia* under discussion, except that dorsal carapace bristles are more numerous in *fulgipedia* than in the other two species. Individual variation on the ocular quadrangle and thorax is considerable. The bristles are easily broken at the tip, or altogether lost, but their location can usually be detected from pits in the chitin.

Carapace bristles: Adults. On the clypeus are three long median bristles, arranged in a triangular formation, of which the upper apical one is longest, and may measure up to two and one-half times the diameter of the AME; two pairs are inserted below the AME, one below their middle and the other external to these (Text-fig. 6B). Bristles in moderate numbers occur above all anterior eyes and between and below the dorsal eyes; there are a few on the ocular quadrangle itself and behind the PLE on the antero-dorsal part of the thorax.

Young. Excluding those on clypeus, 13 pairs of carapace bristles are present in first instar and are traceable in some individuals of each stadium including adult. The frequent absence of particular bristles probably always is the result of accident. Later appearing bristles cannot be traced so successfully and are probably variable, as is the case with late-appearing spines; they will be disregarded here. Text-figure 6 shows the positions of the primary bristles. They divide themselves naturally into a dorsal series of seven pairs close to the midline, and a lateral series of six pairs arising near eyes. Three clypeus bristles are always present in first instar, the unpaired median (C1) and the outermost pair (C4); in second instar at least the C3 pair appears, and sometimes the median pair (C2) in addition; the full series of seven is always complete by third

TABLE II.
Comparative Spine Numbers in *Corythalia*.

Key: **Bold face**: constant.

Roman: frequent.

Italics: rare.

Figures in parentheses: alternates.

		First Leg		Second Leg		Third Leg		Fourth Leg	
		♂	♀	♂	♀	♂	♀	♂	♀
FEMUR	Dorsal	<i>chalcea</i>	0-1-1-1	→	→	→	→	→	→
		<i>fulgipedia</i>	0-1-1-1	→	→	→	→	→	→
		<i>xanthopa</i>	0-1-1-1	→	→	→	→	→	→
	Prolateral (distal only)	<i>chalcea</i>	2	→	→	→	→	→	2(1)
		<i>fulgipedia</i>	2	→	→	→	→	→	2(1)
		<i>xanthopa</i>	1	→	→	→	2(1)	→	1
	Retrolateral (distal only)	<i>chalcea</i>	1(2)	1	2(1)	1	2(1)	→	1
		<i>fulgipedia</i>	1(2)	→	2	2(1)	2	2(1)	2
		<i>xanthopa</i>	0	→	0(1)	→	1(0)	→	0(1)
PATELLA	Prolateral	<i>chalcea</i>	1	→	→	→	→	→	→
		<i>fulgipedia</i>	1	→	→	→	→	→	→
		<i>xanthopa</i>	1	→	→	→	→	→	→
	Retrolateral	<i>chalcea</i>	0	→	1(0)	0	1	→	→
		<i>fulgipedia</i>	0	→	→	→	1	→	→
		<i>xanthopa</i>	0	→	→	→	1	→	→
TIBIA	Dorsal (proximal only; pro or retro)	<i>chalcea</i>	0	→	→	→	1	→	→
		<i>fulgipedia</i>	0	→	→	→	1	→	→
		<i>xanthopa</i>	0	→	→	→	1	→	→
	Prolateral	<i>chalcea</i>	1-1	→	1-1-1	→	→	→	1(0)-1-1
		<i>fulgipedia</i>	1-1*	→	1-1-1	→	→	→	1(0)-1-1(0)
		<i>xanthopa</i>	1-1	→	1-1(1-1-1)	→	0(1)-1-1	→	1-1-1
	Retrolateral	<i>chalcea</i>	1(0)-0(1)	0-0	1(0)-1(0)	→	1-1-1	1(0)-1-1	1-1-1
		<i>fulgipedia</i>	1(0)-0(1)	0(1)-0	1(0)-0	0(1)-0	1-1-1	1(0)-1-1	1-1-1
		<i>xanthopa</i>	0-0	→	0-1	0-1(0)	0(1)-1-1	→	→
	Ventral	<i>chalcea</i>	1r-2-2	1r(0)-2-2	1r-2-2	1r-2(1r)-2	1-0-2	→	1(0)-0-2
		<i>fulgipedia</i>	1r-2-2†	1r-2(1r)-2	1r-2-2	1r-1r-2	1-0-2	→	→
		<i>xanthopa</i>	0-0(1r)-2	0-0-2	0-1r-2	→	1-0-2	→	1(0)-0-2
METATARSUS	Dorsal (proximal only; pro or retro)	<i>chalcea</i>	0	→	→	→	1	→	0(1)
		<i>fulgipedia</i>	0	→	→	→	1	→	1(0)
		<i>xanthopa</i>	0	→	→	→	1	→	→
	Prolateral	<i>chalcea</i>	1-1	→	→	→	1-2	→	1-1-2
		<i>fulgipedia</i>	1-1	→	→	→	1-2	→	1-1-2
		<i>xanthopa</i>	1-1	→	→	→	1-2	→	1-1-2
	Retrolateral	<i>chalcea</i>	1-1	→	→	→	1-2	→	1-1-2
		<i>fulgipedia</i>	1-1	→	→	→	1-2	→	1-1-2
		<i>xanthopa</i>	0-1	→	0(1)-1	→	1-2	→	1-1-2
	Ventral	<i>chalcea</i>	2-2	→	→	→	→	→	2(1p)-2
		<i>fulgipedia</i>	2-2	→	→	→	→	→	→
		<i>xanthopa</i>	2-2	→	→	→	→	→	→

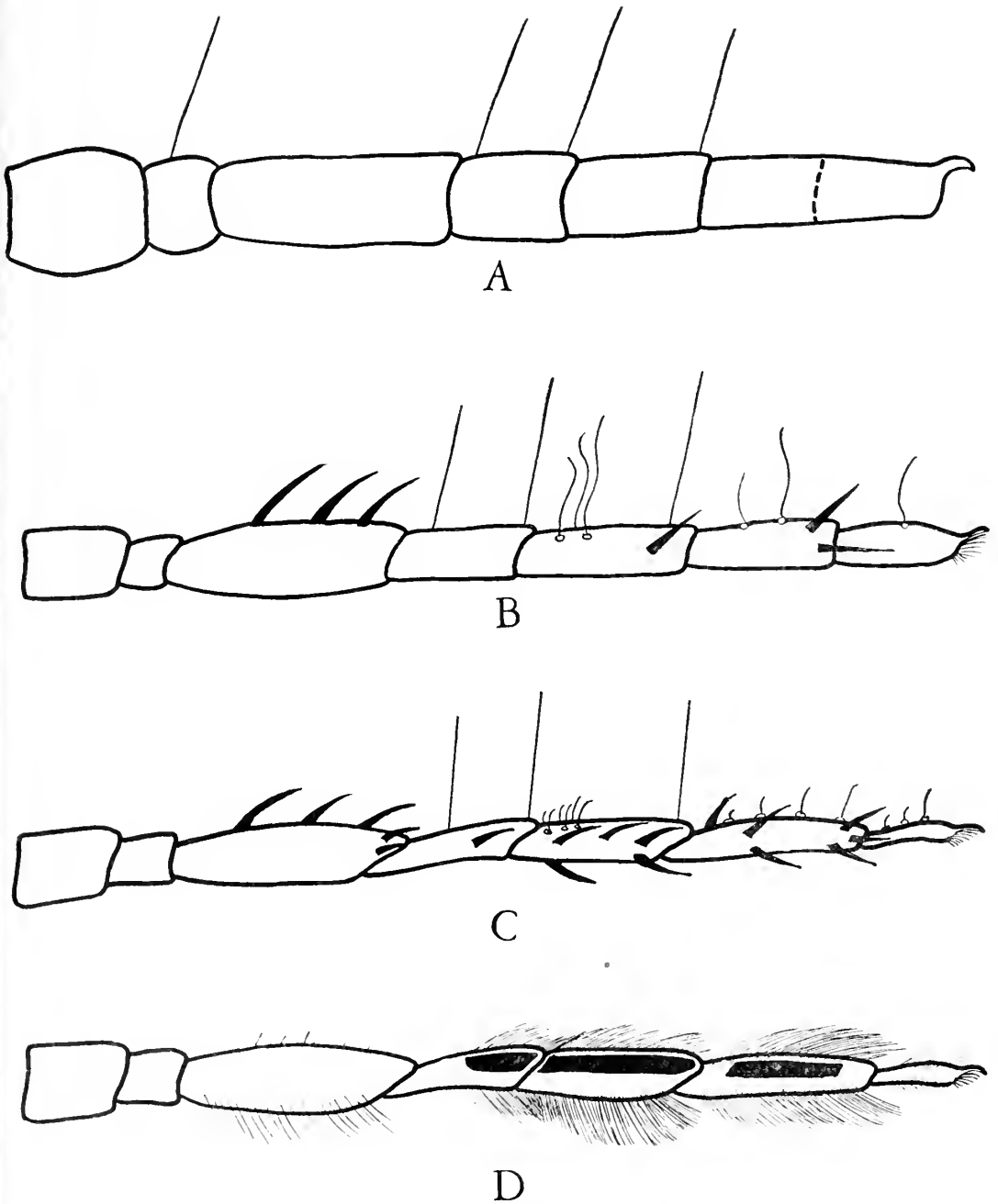
*-1 side of 1 specimen: 1-1-1

†-1 side of 1 specimen: 2-2-2

‡-1 side of 1 specimen: 0-0-0

§-1 side of 1 specimen: 0

||-1 side of 1 specimen: 1-0-1



TEXT-FIG. 7. Third leg in *C. chalcea*, showing segment proportions, development of primary bristles, spines, trichobothria and fringes. **A**, 1st instar; **B**, 2nd instar; **C**, adult ♂; **D**, same, to show fringes and iridescent areas (in black). Bristles represented by long, straight lines, spines by black triangles, trichobothria by curving lines with circular bases. Structures all drawn relative to total length of leg. Secondary bristles, short pale bristles and general hair covering omitted.

instar. In general the carapace bristles do not change much in relative lengths during development; an exception is the C1 median bristle, which is much shorter than C4 in first instar, but thereafter becomes far longer than all others in the series. Short bristles, very rudimentary and pale, appear on superior edges of chelicerae in fourth instar, 5 to

7 are countable in fifth, and more, now stiff and black, are present in adults.

Leg Bristles (Long): Adults and Young (Text-fig. 7). A few of the fairly numerous leg bristles stand out in all instars, beginning with first, and are traceable right through to adults of both sexes. These are located at proximal and distal ends of patella and distal

end of tibia on the palp and all legs. Their frequent absence is obviously due principally to damage; it seems, however, that they may sometimes be naturally lacking, in irregular fashion in various individuals, and varying on the two sides of the same specimen. Of the three bristles, the distal patellal is longest, measuring two or three times width of segment, and the proximal patellal shortest. In addition to these three longest and most constant bristles, a proximal tibial is of frequent and early occurrence on palp, and a more or less paired couple near end of metatarsus on palps and legs; additional tibial bristles also are often conspicuous, but do not appear so early in ontogeny, and are not constant. A trochanter bristle is usually present in first instar only.

Leg Bristles (Short, Pale): Adults and Young. A different type of bristle altogether occurs, apparently constantly, in adults and young on legs only. They are short, always shorter than trichobothria, and stand out in a fashion which makes them at first glance easily confused with short examples of the latter. They are, however, perfectly distinct, lacking altogether the characteristic bases of trichobothria, never bending at the tip, and occurring not only dorsally but also on sides and ventral surfaces of at least tibiae, metatarsi and tarsi. I have not studied these in detail, except to settle the following points: first appearance in second instar; location apparently fixed, occurring quite regularly in single rows. Especially constant and conspicuous are the following: several median dorsals appearing toward distal ends of tibia and tarsus: at least one on patella; prolateral, retrolateral and ventral series on metatarsus and tarsus, consisting of two or three in each series; fewer of latter series on tibia. These bristles occur in very similar fashion on a number of unrelated salticids.

Trichobothria (Text-fig. 7): Adults. Number and arrangement constant throughout the species under discussion, and apparently typical of a great many salticids which I have examined superficially. In *Corythalia* there are two rows of three (rarely four) on the proximal dorsal half of tibia: a single row of four on metatarsus, well distributed along the crest and increasing in length distally; and a single row of three (rarely four) on proximal half of tarsus, also increasing in length distally. On some legs the pro- or retro-dorsal row on tibia is crowded toward proximal end, but I have not been able to find any specific sexual or special leg distinctions in this arrangement. Naturally, some of each series are frequently missing, but apparently practically always because of injury.

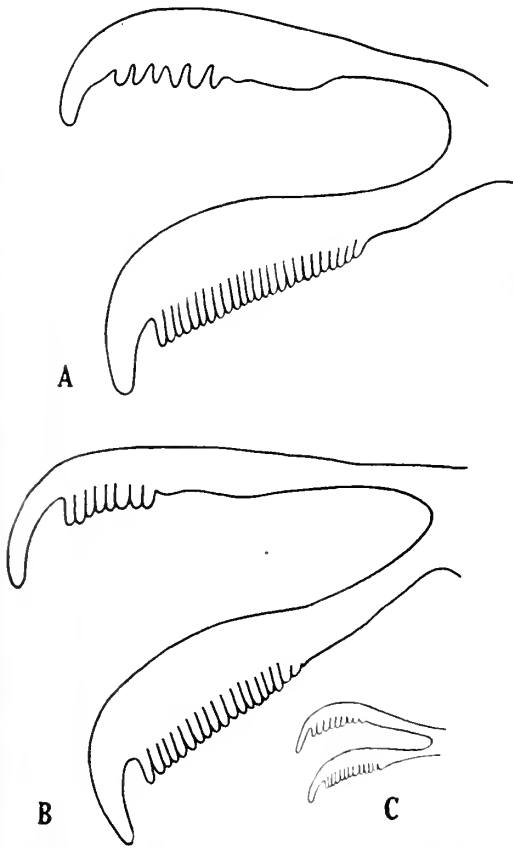
Young. Use of the highest power magnification fails to disclose any trichobothria in first instar. In second stadium, one to three in each series usually present, not in any standard order of precedence, even on corresponding legs of same specimen. The distal

metatarsal trichobothrium appears of very constant development in second instar, and is then relatively very long, measuring more than twice width of segment. Tarsal series usually complete by fifth instar, while metatarsal and tibial series lack only one or two trichobothria. In this stage, also, the absences are not constant for particular trichobothria. As late as seventh female instar (preadult), single trichobothria, especially on metatarsus, may be missing on one or more legs.

Tarsal Claws (Text-fig. 8; Table III): Adults. General type similar on all legs, although first and second differ slightly from third, and particularly from fourth. Proclaw teeth ranging from 13 to 26; very slender, extremely close-set and fine; tips only resolvable (except, sometimes, for one to three distal teeth) except under high power magnification, and then only by transmitted light. Teeth longest and most slender distally; decreasing in size and becoming broader toward proximal end, sometimes abruptly, sometimes in a beautifully graduated series.

Retroclaw teeth 4 to 9, the most proximal one or two being almost always broad, low, often truncate vestiges. All retroteeth shorter, broader and more widely set than pro-teeth, but closer set on fourth leg than on other three, approaching the finely pectinate arrangement of the proclaws, especially in *chalcea* and *xanthopa*. In numbers, proclaw teeth are more numerous on the first and second legs than on third and fourth, while there are one to several more retroclaw teeth on third and fourth legs than on first and second. Individual variation ranging up to about 5 teeth in longest proclaw series, but being only 1 or 2 in a short, retroclaw series. It is not unusual for corresponding claws on different sides of same specimen to vary. Adult males tend to have one or two more teeth on proclaws and one or two fewer on retroclaws, especially on front legs, than adult females. This is not, however, a rigid distinction.

Young. Teeth absent, as usual, on claws of first instar (within the cocoon). I am unable to detect a trace of a third claw at this stage, and unguis tufts are undeveloped. Tufts present in second instar though hairs are sparse, and from here on their increase is gradual. In second instar claw teeth also appear, and are of general adult form, being dissimilar, with proclaw teeth finer and more numerous than those of retroclaw, although they are not quite so closely set for their size as in adult. Also, the two claws of each foot are much more nearly alike than in adult, the number of teeth being intermediate to the final form; there are many fewer pro-teeth and usually one or more extra retro-teeth. (Sometimes, however, the number of retroteeth on posterior legs remains constant). This means that during development pro-teeth increase while retroteeth decrease. Another interesting point is that in the second instar the retroteeth of all four legs,



TEXT-FIG. 8. Tarsal claws in *C. chalcea*. **A**, first leg, adult ♂; **B**, fourth leg, adult ♀; **C**, fourth leg, 2nd instar. In each case, the proseries contains the greater number of teeth.

instead of only the fourth leg, are finer and more closely set than in adults, approaching proteeth type. There is only a small increase in proteeth and no decrease in retroteeth through fifth instar. After that the increases and decreases, respectively, proceed gradually.

In all cases, increase or decrease occurs in the proximal end of a series, the anlagen or vestiges being broad and stumpy. The claw tips are more slender and entire claw more curved in young than in adults, though in *xanthopa* the juvenile shape is maintained and the teeth remain relatively similar, slender and close-set throughout, while the proseries of first and second legs do not attain the high numbers of the other two series.

Unspecialized Hairs; Scales: Hairs, apparently unspecialized, are present on all parts of the body in moderate numbers, especially on legs and abdomen. A few leg and abdomen hairs are present even in the first instar, and as in all integumentary structures, are relatively longer than in later stadia. *C. fulgipedia* is the hairiest of the three species. Scales and scale-hairs, because of their special connection with color pattern, are discussed under the heading of Color.

Palp: *Adult Male* (Text-fig. 9). Compared with its specific importance in other groups, the *Corythalia* palp is a relatively poor taxonomic character. It tends to great similarity among the three species under consideration, which have the following characteristics: tibia about two-thirds as long as patella, viewed dorsally; tarsus about one-third longer than patella; retrolateral tibial apophysis long or of moderate length, slender or stout, pointed or truncate, serrated or plain. A midventral tibial tubercle. Tarsal bulb overlapping tibia moderately at base; one median loop directed internally and two directed externally are distinguishable, the more proximal external loop being usually only partly visible; the exact proportions and amount of distinctness of the loops are decidedly variable in individuals of the same species. Embolus making about one full turn of spiral, this portion occupying distal one-quarter to two-fifths of bulb; distal part of embolus short or moderate, tip forked or simple. The palp of *fulgipedia* is decidedly more robust (as is the entire spider) than those of the other two species.

Young. The male palp is indistinguishable externally from that of the female until the sixth (preadult) instar. In the early stadia the tibia is equal to or longer than the patella, just as in females. In both sexes, unlike the legs, the palp is relatively longer in the first stages; as in the legs, the segments are more nearly equal.

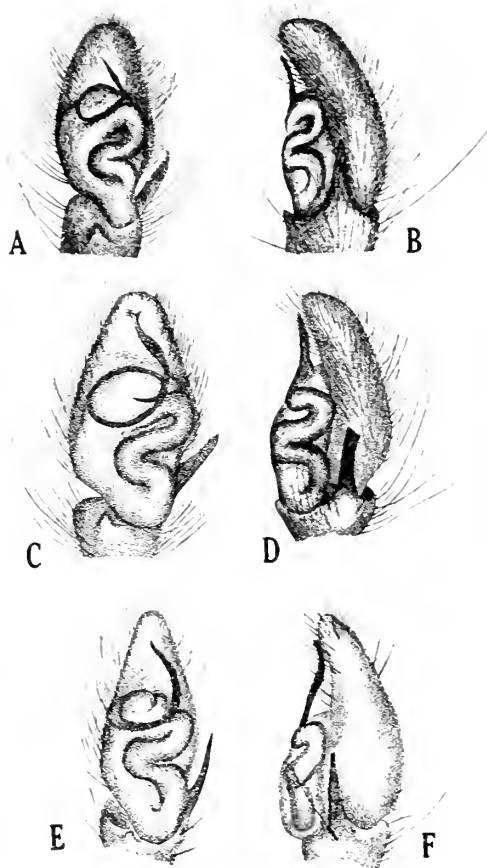
Epigynum (Text-fig. 10). Of similar structure in all three species; specific differences lie chiefly in the size of the organ, since the latter is not proportional to the size of the species, and in the relative size and position of the anterior and posterior pairs of subdermal bodies, light and dark brown, respectively. Dissection shows the anterior bodies to consist of a pair of looped ducts, with the openings external and in advance of the genital slit, near the midline; presumably the spermatozoa are inserted here. A bulge

TABLE III.

Tarsal Claws in *Corythalia**

	First Leg			Fourth Leg		
	2nd Instar	Adult ♀	Adult ♂	2nd Instar	Adult ♀	Adult ♂
<i>chalcea</i>	p. 13; r. 10	p. 21; r. 7	p. 26; r. 6	p. 13; r. 9	p. 18; r. 8	p. 19; r. 7
<i>fulgipedia</i>	p. 14; r. 8	p. 24; r. 5	p. 24; r. 6	p. 10; r. 9	p. 18; r. 7	p. 18; r. 7
<i>xanthopa</i>	p. 11; r. 7	p. 13; r. 4	p. 17; r. 4	p. 8; r. 6	p. 13; r. 6	p. 15; r. 6

* From characteristic specimens.



TEXT-FIG. 9. Left palp of adult δ in *Corythalia*, ventral and ectal views. A, B, *C. chalcea*; C, D, *C. fulgipedia*; E, F, *C. xanthopa*.

in each duct appears to be a small gland opening into it. The ducts curve to the mid-line, whence they proceed, parallel and contiguous, into the pair of posterior spermathecae, which form the second pair of dark bodies visible externally. The passages to the vagina are a pair of small tubules opening from the anterodorsal section of the spermathecae, near the mid-line. A pair of more or less distinct, smooth, bean-shaped, translucent areas cover most of this tubule-spermatheca system.

In actual size, the epigynum of *chalcea*, one of the larger forms, is slightly smaller than that of *xanthopa*, the smallest species.

Young. No trace of the epigynum is visible, at least externally, before the sixth instar (pre-preadult). Then the spermathecae are barely discernible as a pair of minute dark spots just in front of the genital furrow. By the seventh stadium, the spots are clearly distinct.

Abdomen: Adults and Young. Ovoid, widest near middle but of exceedingly variable proportions in individuals of both sexes. Anal tubercle a short flattened cone. Spinnerets all of moderate width; anterior pair stoutest, middle pair longest, posterior pair shortest and slimmest. Colulus indistinguish-

able, apparently represented by a few stiff hairs; tracheal spiracle opening near base of spinnerets. Segmentation discernible posteriorly during first instar.

SIZE AND GROWTH.

The total length range in adults is from 3.46 to 7.2 mm., that of carapace length 2.05 to 3.83. Sexual dimorphism in size is slight, the carapace length of the largest males in each species exceeding that of the smallest females, while even the total length of some recently molted females (before the eggs have enlarged) may be less than that of males. *C. chalcea* and *fulgipedia* are of almost equal size, although *fulgipedia* is bulkier, being more robustly built, particularly in legs and palps, and is hairier. *C. xanthopa* is a smaller species.

All species have one more instar in the female than in the male; at least in *chalcea* and *fulgipedia* the male has seven instars, including the adult, the female eight. Individuals of both sexes of each of these were reared from the egg. In *xanthopa* the fourth instar, if it exists, is unknown, reared specimens having died in the third instar, a younger stadium than that of the youngest captured field specimens. The smaller size of *xanthopa* makes it possible that there are only 6 male and 7 female instars in this species, although the gap is considerable (Text-fig. 11). However, for convenience in comparison of text-figures and descriptions, this stadium is considered to exist.

Table IV gives average carapace lengths at various stadia. As usual (cf. Bonnet, 1930, p. 469) the length increases are slight in the early instars; during the first, total length actually decreases owing to the absorption of yolk. In both sexes of all species there was found to be great individual variation in the amount of carapace length increase in individuals between the last two instars. As a single example, one male *C. xanthopa* reached 90% of his final carapace length in the preadult instar, while another attained 82%. These variations must be kept in mind in a consideration of Text-fig. 11, p. 20.

TABLE IV.

Comparison of Average Carapace Length in *Corythalia* (mm.).

Instar	<i>chalcea</i>	<i>fulgipedia</i>	<i>xanthopa</i>
1st	.93	.91	.83
2nd	1.2	1.1	1.0
3rd	1.4	1.3	1.1
4th	1.6	1.6	—
5th	2.0	2.1	1.5
6th ♀	2.4	2.4	1.9
6th ♂	2.7	2.6	2.1
7th ♀	2.8	3.0	2.1
Adult ♂	3.1	3.2	2.4
Adult ♀	3.4	3.6	2.6

The durations of the instars proved variable, even when members of the same brood were reared under identical conditions. In the Rancho Grande laboratory, at a mean

temperature of about 70° F., individual instars ranged from about 12 days to more than 8 weeks. In general, the earlier instars lasted around two or three weeks, the later ones around four or more. The longest and the most variable were the preadult stadia. A group of *fulgipedia* carried by ship to New York in the egg stage had all the instar lengths greatly prolonged, although they were never exposed to cooler temperatures than those of the Rancho Grande laboratory, and the average and extreme temperatures of the Zoological Park laboratory were higher. The time required for reaching the adult stage is around five or six months, the males requiring several weeks less than the females. One female *fulgipedia*, reared from the egg, lived to an age of 11½ months, and a male to 11 months. No variations in numbers of instars were found in any species, save in one abnormal *C. chalcea* (p. 16).

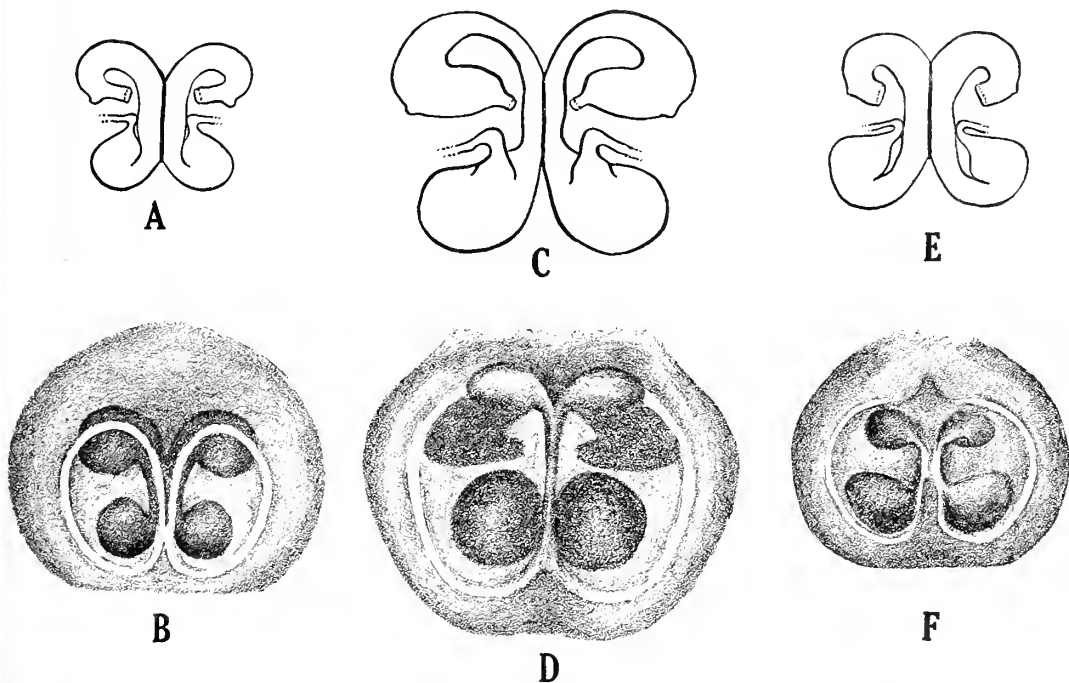
BEHAVIOR.

The general habits of all three species of *Corythalia* are exceedingly similar, both to each other and to the general pattern of salticid behavior. All are diurnal spiders which leap on their prey, eat it at once, pass the night in silk shelters, perform special courtship displays as a necessary preliminary to mating, copulate with the male in the dorsal position and guard the eggs in a cocoon spun between the folded edges of leaves.

The first instar is passed within the co-

coon; the spiderling neither eats nor spins, moves about with difficulty, and is helpless when removed from the nest. From the second instar onwards, however, the young engage in all salticid activities except those connected with breeding. From two days to a week or more is passed in the silk shelter before molting; during this time no food is taken; the spider emerges from one to three days or more after molting. Retirement lasts longest during the molt to the adult. In the laboratory the same shelter is used for successive molts and for passing the night, as long as it is not disturbed; the young spider simply enlarges it as needed, sometimes casting out the exuviae, sometimes incorporating them into the cocoon. Brooding females eat and move about very little. When disturbed they knit up a torn cocoon promptly; one female which escaped and was returned to her jar after three days, readopted the cocoon at once. Three clutches of eggs are usually laid, beginning about 8 or 9 weeks after the molt, the first being the largest and containing between 13 and 28 eggs. After mating, the female loses most or all of her attraction for males within less than 24 hours, and in any case will not accept another male. The latter apparently fill their palps in their shelters (I have never seen a sperm web in this group) and will mate with a series of females from two to three days after molting until at least six weeks after that time. After that their display energy diminishes rapidly.

None of the above activities differs re-



TEXT-FIG. 10. Epigyna in *Corythalia*, all drawn to same scale. Upper row, dorsal (internal) views of dissections; lower row, ventral (external) views. A, B, *C. chalcea*; C, D, *C. fulgipedia*; E, F, *C. xanthopa*. Note that dissected epigynum is smallest in *C. chalcea*, although that species is intermediate in average carapace size, and overlaps size range of *C. fulgipedia*.

markably in the three species considered here. The epigamic displays, however, show great specific distinctions. In all, threat and courtship displays are moderately or strongly differentiated; the fringed and iridescent legs play a conspicuous part at least in threat displays and usually in courtship display as well; in *xanthopa*, however, all fringe and iridescence display is excluded from courtship. True fighting is exceedingly rare in *Corythalia*, and probably never occurs under natural conditions. The subject of display will be discussed in detail, including correlated experimental data, in the sequel to the present paper.

I never saw a hint of cannibalism in *Corythalia*, either between mother and young, or between young of similar size; even several pairs of adults of the same species, quite often of various sizes, sometimes lived peaceably together for weeks, as long as they were well fed and uncrowded.

HABITAT.

The three species of *Corythalia* at Rancho Grande extend from the deciduous seasonal into the cloud forests, from 700 to at least 1,300 meters; their humidity requirements range from moderate to high, the temperatures from upper tropical to lower subtropical. They are never found in either open country or dense forest, and all are predominantly terrestrial, although *C. chalcea* occasionally lives in epiphytic bromeliads. None was ever taken by shaking bushes or saplings.

KEYS TO THE RANCHO GRANDE SPECIES OF *CORYTHALIA* (ADULTS).

The following keys apply equally well to fresh and preserved specimens:

MALES.

- A. 4th leg with well-developed fringes; 1st leg with 1 femoral prolateral spine and with clearly fewer than 20 teeth on tarsal proclaw; tibial apophysis of palp pointed, non-serrate; plentiful long yellow hairs on clypeus and palp; no submarginal carapace band.
C. xanthopa, p. 29.
- AA. 4th leg with fringes rudimentary or absent; 1st leg with 2 femoral prolateral spines and with clearly more than 20 teeth on tarsal proclaw; tibial apophysis of palp serrated distally; clypeus naked or with a few light scales.
- B. Submarginal carapace band rudimentary or absent; tibial apophysis of palp and tip of embolus pointed
C. chalcea, p. 14.
- BB. Submarginal carapace band strongly developed, persistent in alcohol; tibial apophysis of palp truncate; tip of embolus forked
C. fulgipedia, p. 22.

FEMALES.

- A. Abdomen with 2 broad, longitudinal dorsal pale stripes; no submarginal carapace band; 1st leg with 1 femoral prolateral spine and with clearly fewer than 20 teeth on tarsal proclaw
C. xanthopa, p. 29.
- AA. Abdomen without longitudinal stripes, but with a broad, pale band across posterior third; 1st leg with 2 femoral prolateral spines and with clearly more than 20 teeth on tarsal proclaw.
- B. Submarginal carapace band rudimentary or absent; pale clypeal hairs and scales scanty; breadth of epigynal plate less than diameter of one AME
C. chalcea, p. 14.
- BB. Submarginal carapace band strongly developed; pale clypeal hairs and scales abundant; breadth of epigynal plate greater than combined diameters of one AME and one ALE
C. fulgipedia, p. 22.

DESCRIPTIONS OF THE SPECIES.

Corythalia chalcea sp. nov.

DIAGNOSIS.

Adults of both sexes without pale markings on clypeus, chelicerae and palps, or with only a few sparse white scales; submarginal carapace band of white scales present, but sparse, throughout instars. Adult male with abdomen solidly covered with bronze scales above (brownish in alcohol), through which pale basal and median bands and two terminal spots are dimly visible. Adult female abdomen in life with successive bands of silvery-white, bronze, black, golden-yellow and black, the latter marked with a median bronze stripe and a terminal pair of golden-yellow spots; in alcohol these markings are obscured and faded, but at least the second light band is persistent; young with two abdominal bands brilliant silvery white, second through fifth instar. Adults of both sexes with two femoral prolateral spines on first leg, and clearly more than 20 teeth on its tarsal proclaw. Adult male with fringes well developed on first three legs, absent or with mere rudiments on fourth. Tibial apophysis of palp serrated distally, its tip and that of embolus both pointed; breadth of epigynal plate less than diameter of one AME. Second and third legs, but not fourth, elevated during both courtship and aggressive display, although the two are distinct; no rocking in either. Size moderate, total length of adult males around 5.5 mm., of females around 6.5 mm. Terrestrial and arboreal (especially in epiphytes) to a height of at least 8 meters; montane cloud forest only, 1,100 to at least 1,300 meters.

EXTERNAL CHARACTERISTICS IN ADULTS AND YOUNG.

COLOR IN LIFE.

(Text-figs. 2, A-X, AA-EE; 12; 15 A).

ADULT MALE: *Cephalothorax*. Integument of carapace black, ocular quadrangle with a few long black hairs, almost naked or more or less completely covered with golden bronze scales, which may extend in a triangle over the flattened, postocular region bounded posteriorly by the steep thoracic slope, as well as on the side just below level of dorsal eyes, on the margins of which they are strongly concentrated. On each side a scanty submarginal cephalothoracic border of white starts at level of posterior eyes and extends almost to pedicel.

Anterior eyes with deep green reflections, all four surrounded by hairs varying from cadmium yellow to ochraceous orange, except outer upper margin of antero-lateral eyes. Clypeus with a sparse double row of short white scales and hairs, the marginal longer than the submarginal, the hairs of both rows all directed toward the center. Chelicerae with a moderate sprinkling of white hairs, longest on the internal margins; palps completely black except for the usual terminal patch of grayish short hairs. Sternum black.

All legs black except for very pale straw-colored third and fourth tarsi. All fringes jet black (except white scale-hairs on femora described below). White scales on legs as follows: on at least third and fourth coxae, with usually a few on second, and on all three trochanters; to various extents on dorsal and postero-dorsal surfaces of all femora, but on anterior side only on third and fourth, where they form a conspicuous antero-dorsal distal band of scales and a short anteroventral distal fringe of scale-hairs, longest distally; this fringe is better developed on third than on fourth leg. A few scales, yellow rather than white, on dorso-posterior surfaces of all patellae, and tibiae, and, on the fourth leg, of metatarsus and of anterior sides of these segments as well.

Iridescence present on first three legs as follows: these areas are covered with specially flattened, smooth and completely or practically hairless facets. Patellae: first, second and third; upper distal half of anterior face (demarcated sharply by the diagonal) and bent along it. Tibiae: first, second and third; entire anterior side, but the upper (antero-dorsal) aspect of this being naked and slightly flattened, it is the most effective. Metatarsi: first, second and third; antero-upper sides, especially of third, form narrow, shining strips. No trace of iridescence on fourth leg, or on other surfaces of the first three, which have in the bare spots only the ordinary gloss of unspecialized chitin. Without any question, the most brilliant areas are all three patellae, all three tibiae and the third metatarsus.

Abdomen. Integument black, densely cov-

ered except at extreme base with golden bronze scales, through which project relatively few long hairs. Through the scales is more or less dimly visible the typical *Corythalia* band pattern: a sub-basal band of white scales, a post-median band of gold and two terminal gold spots, well separated. Underside of abdomen black, naked save for a variable amount of black pubescence.

Rubbed, old specimens may have the cephalothorax practically or altogether destitute of bronze and white scales, while the bands and spots of the abdomen show plainly. The first scales to be lost are those on the ocular quadrangle and submarginal border of the carapace. Enough of the bronze abdominal coating always remains, however, to make field identification easy. Alcoholic specimens resemble rubbed examples.

ADULT FEMALE: *Cephalothorax*. Dorsal and anterior aspect of carapace as in male, except that there is a more decided concentration of the scales into a spot behind each small eye, and sometimes behind each posterior eye as well. Also, the submarginal carapace band is scantier, and the antero-lateral eye may be rimmed completely instead of only partially with orange, the clypeus bands of white and the white hairs on chelicerae are somewhat better developed, there are a few white hairs below inner margin of anterior lateral eye, and in addition the palps have some white decoration, in a band of close-set scales across tip of femur and with a few scattered scales and hairs on patellae and even fewer on tibia. Sternum black.

All legs black except for very slightly paler coxae and trochanters and first and second tarsi; as in the male, the third and fourth tarsi are very pale. There are white and pale bronze scales to a very variable extent in the following localities: on all coxae, trochanters, femora (especially in a band across tip of latter), patellae and tibiae. On the metatarsi they may be present or absent, sparsely, but are usually found at least on those of the last two legs. Unlike the case of the male, all of these scale groups are developed on the anterior as well as on the dorso-posterior surfaces.

Abdomen. Integument black, with a broad, sub-basal band—the width being variable—of solid bronze scales which leave uncovered, at least laterally, along its anterior edge a trace of a narrow silver-white band. Behind this anterior bronze is a narrow band of black, then a band of gold scales closest to a metallic buff yellow (Ridgway), slightly convex anteriorly, and broadly and shallowly scalloped posteriorly. This is followed by a median bronze stripe down the middle of the succeeding black band, which continues to the dark spinnerets. Just in front of the latter is a pair of oval gold spots of the same shade as the second abdominal band. These various bands extend midway down the sides, and the first, bronze band curves back laterally to join the second, gold band. Below this

point the sides are black covered with yellowish-white scales; venter black with a moderately dense coating of light yellow scales.

Rubbed, old specimens, as in the male, may have the carapace and legs practically destitute of white and bronze scales, the first to disappear being from the apex of the ocular quadrangle. Similarly, the anterior bronze band of the abdomen deteriorates to show clearly the entire width of the anterior narrow band of silvery white, while the posterior gold band and spots become so rubbed that they appear almost white, the integument underlying this particular band and the spots being pale.

Variation. As has been suggested, the normal, individual variation is considerable in the amount of white scalation on carapace and legs, in the width of the bronze abdominal band, and in the shade of gold of the second band and terminal spots, these differences being visible even in newly molted, unrubbed specimens. The following two examples, however, are distinct enough to warrant separate remarks. The first, No. 5, was reared from the third instar, all the subsequent instars being of normal pattern. In spite of her peculiar appearance, six different males displayed promptly to her and attempted to mate without hesitation, before she was permitted to mate with a seventh, and then killed. She differed from the typical most obviously in: (1) anterior bronze abdominal band extended practically to the second (gold) band, and was actually joined to it by a pair of conspicuous, gold, bronze-outlined chevrons on either side of midline. Hence between the two metallic bands were only three small patches of black, of which the median was triangular. (2) The median stripe behind the second band was pale gold rather than bronze, only slightly deeper in tone than the second band and spots, and was formed of small confluent chevrons. The remaining differences were only relative, and included within the bounds of normal variation, a number of other females having them to the same extent; the second band and posterior spots were very pale gilt and the scales of the carapace border, clypeus and legs developed to maximum extent for this species.

The second abnormal female, No. 16, was reared from the egg; her brothers and sisters were completely typical of the species. This example was peculiar not only in coloration, but also in incomplete spinulation and especially in the fact that she underwent 9 molts instead of 8 and even then was not adult. From the second instar her peculiarities were evident; she had the entire posterior half of abdomen brilliant silvery white, instead of broken into a band and terminal spots, and her legs never developed more than the faintest bandings of pigment.

YOUNG. FIRST INSTAR. Typical of *Corythalia*: true pigment lacking, but with the usual two dark abdominal bands clearly visible in latter part of stadium.

SECOND INSTAR. Carapace above black, lacking scales entirely. AME with a few yellowish-orange marginal scales. Clypeus, mouthparts and sternum dark gray to black. Palps, legs and spinnerets translucent buff, with slight or no darkening at the joints. Abdomen: the two bands and small pair of terminal spots are shining silvery white, the anterior band usually wider than the posterior. Venter translucent and colorless.

THIRD INSTAR. All markings shining silver white. Carapace with a variable number of scales on ocular quadrangle, ranging from a simple spot behind each PME to a pair of bars extending obliquely forward between PME and AME. A strong crossbar, of variable width, is always present across anterior part of thorax behind PLE; in some specimens this has a very faint gilt tinge, which may prove to be a sexual difference. AME and ALE both rimmed with scales ranging from yellowish through orange to deep rust-color, though the ALE rimming is still incomplete on upper outer margins; frontal aspects otherwise unchanged from second instar. Legs strongly barred with dark pigment, usually deposited at all joints except between coxae, trochanters and femora; strength of banding highly variable, even in individuals of the same brood on corresponding days after molting. Abdomen above as in second instar. Venter grayish-black to black.

FOURTH INSTAR. Differs from third as follows: a slight yellowish or bronze tinge on some ocular quadrangle scales; clypeus sometimes with a scanty submarginal border of white scale-hairs; femur of palp sometimes darkened basally; its distal end and patella rarely with a few white scales; leg integument darker, usually only coxae, trochanters and tarsi remaining pale; second abdominal band sometimes followed by one or two white scales in the midline.

FIFTH INSTAR. Ocular quadrangle with a frosting of bronze or bronzy-gold scales moderately or well developed, although the primary spots and postocular bar are still sharply defined even when reduced in size. ALE sometimes completely rimmed with rust scales. Clypeus with submarginal band of scale-hairs well developed, sometimes with a second line of scales immediately above it and sometimes with a few more scales below each AME. One example had a very few submarginal thoracic scales, but they usually do not appear until the sixth instar. Palp integument dark or pale; all legs usually dark except tarsi, and all, or only third and fourth, coxae and trochanters; leg tibiae and metatarsi sometimes slightly paler; a few white scales on palps, chelicerae and legs. First abdominal band with a trace of bronze across its posterior border and in midline behind second band; second band, at least in male, may have a faint tinge of silver gilt. Venter dark brown or black, with or without one or several darker median stripes; a scattering of white scales present.

SIXTH INSTAR. Ocular quadrangle with a general frosting of bronze or gold scales well developed, usually extending behind ocular quadrangle on anterior thorax to a greater or less extent, and even slightly below dorsal eyes on sides of carapace; the primary scales—white spots behind PME and the bar behind PLE—are still traceable, however, and sometimes persist strongly under the colored scales. Marginal scales of anterior eyes varying from rust to bright orange. Clypeus with at least a submarginal band of white scale-hairs and usually with a second band of scales just above it, as well as a few below each ALE. Thoracic submarginal scales present or absent, sometimes absent in individuals which had them in the preceding stadium. Integument of palp practically black, and of all legs except brown tarsi. White scale or scale-hairs on appendages variable in number, never profuse, usually present at least on patella of palp, and may be present on every leg segment except tarsi, regardless of sex; they tend to be best developed on anterior surfaces. Abdomen with the bronze posterior portion of first band and in midline behind second much better developed than in preceding stadium, but not so extensive or strongly colored as in adult female. There appears to be a definite sexual difference in the brightness of the gilt tinge to the second band: in females it is definitely paler than in males, where it should now be described as pale gold rather than silver gilt. Terminal abdominal spots now usually joining in a white bar. Venter black, usually with a uniform scattering of white scales.

SEVENTH INSTAR. (Female). Differs from adult female only in the usually slightly greater number of white scales on clypeus, palps, chelicerae and legs, in the lesser extent of the bronze portion of the anterior abdominal band, and in the color of the second band and terminal spots, which are still only silver gilt, not golden yellow. It is thus perfectly intermediate between the sixth stadium and the adult. The white scales are as usual highly variable.

SUMMARY OF COLOR DEVELOPMENT IN *C. chalcea*: Integument. Carapace, mouthparts and sternum black in second instar. Palps may begin to darken in fourth, usually not until fifth, pigment not complete until sixth. Legs scarcely banded in second, strongly in third, color complete except for tarsi in sixth. Abdomen black above (with usual two sub-scale bands and paired terminal spots) in second, venter black in third. *Light-colored scales and hairs*: carapace above lacking scales until third instar, when they appear as a pair of ocular quadrangle spots or oblique bars and a postocular bar of silver white, which form the primary carapace scalation; a general frosting of bronze secondary scales begins in fourth on and close behind ocular quadrangle, reaching maximum development in sixth and seventh instars. White submarginal scales on sides of

thorax may appear in fifth, usually not until sixth, and may thereafter persist or disappear. AME first rimmed with yellowish in second, ALE in third, although rimming of latter eyes is not complete until fifth. White scales usually first appear on clypeus, chelicerae and palps in fifth, rarely in fourth; leg scales never appear before fifth; in males these frontal and leg scales usually reach maximum development in sixth (preadult) instar, sometimes in fifth; in females maximum development usually occurs in seventh (preadult). Abdomen with two sharp bands and a pair of terminal spots formed of brilliant silvery white scales until fifth; in this stadium bronze becomes visible in posterior part of first band and in midline behind second; also it seems likely that the faint gilt tinge sometimes apparent on second band is confined to males; if so, it is the only sexual distinction so far found among the three species before the sixth instar; in the sixth, this color distinction is unquestionable, the second band being pale gold in males, scarcely silver gilt in females; the bronze is also better developed in males; the seventh stadium of the female has the bronze and gold about as well developed as in the sixth male, but less strong than in the adult female. The terminal spots tend to be joined by a less distinct silvery band in the fifth. White scales first appear on the venter in the fourth (rarely) or fifth.

STRUCTURE.

With the characteristics described on p. 3 ff.

In contrast to color development, the course of post-embryological development of structure shows no clear distinctions from the closely related *fulgipedia*, except in the tardiness of the appearance of some of the spines. The general account of postembryological development, under the various structures, is given on pp. 4 ff. The account below, therefore, concerns adults only, unless otherwise noted.

Ranges and averages of proportions of adults are given in Table V, and comparisons with the other species in Table I.

Carapace. Height slightly more than half of length; anterior part of thoracic profile descending moderately gently. Anterior width of ocular quadrangle clearly narrower than width of carapace. Width at level of second-to-third coxa scarcely more than that at bulge before PLE.

Eyes. All eyes larger than in the closely related *fulgipedia*, and about the same, relatively, as in *xanthopa*, except that ALE and PLE are smaller than in the latter. PME about midway between ALE and PLE.

Clypeus. Half or slightly less than half diameter of AME.

Chelicerae. Apparently no teeth on pro-margin.

Maxillae. Outer margin distinctly concave; tubercle well developed.

TABLE V.
Relative Proportions in *C. chalcea*.

	Males		Females	
	Range %	Average %	Range %	Average %
Carapace Length: Breadth	71-74	72.6	70-75	72.2
Carapace Length: Height	48-55	51.2	48-54	51.6
Carapace Length: Oc. Quad. Length	36-42	38.8	37-40	38.2
Carapace Length: Oc. Quad. Breadth	57-65	60.6	56-63	59.9
Carapace Length: AME Diameter	18-21	19.2	18-19	18.6
AME Diameter: ALE Diameter	61-64	63.0	57-65	61.4
AME Diameter: MLE Diameter	16-20	18.0	16-18	17.0
AME Diameter: PLE Diameter	56-62	58.4	54-57	55.6
AME Diameter: Clypeus	42-53	48.0	46-54	50.2
Carapace Length: 1st Tibia	35-40	37.2	29-34	30.8
Carapace Length: 2nd Tibia	35-39	36.0	29-31	29.6
Carapace Length: 3rd Tibia	44-48	45.6	35-40	37.6
Carapace Length: 4th Tibia	43-46	44.0	39-41	39.8
Carapace Length: 1st Metatarsus	30-33	31.8	28-28	28.0
Carapace Length: 2nd Metatarsus	29-33	31.0	26-30	27.4
Carapace Length: 3rd Metatarsus	48-54	51.2	40-44	42.0
Carapace Length: 4th Metatarsus	51-55	53.2	44-49	46.2
Carapace Length: Palp	70-81	74.4	80-84	81.2

Lip. No distinctive specific characteristics.

Sternum. Width three-fourths of length in male, slightly less in female; not quite as wide anteriorly as base of lip; lateral excavations well developed.

Bristles. No distinctive specific characteristics.

Legs. Third leg longer than fourth leg in all males, but in less than half of females; first leg longer than second in practically all males and in most females. In the formula, Table VI, the alternate order is expressed by the figures in parentheses in the upper row; figures of proportions are averages; for range of variation see Table V. Segments slender like *xanthopa* and unlike *fulgipedia*. Tibial index: first leg, males 25 to 27, females 27 to 28; fourth leg, males 19 to 21, females 18 only. Iridescence strong in adult male, but not as strong as in *fulgipedia*, nor are the segments as sharply modified. Fringes as long as in *fulgipedia*, but not so thick, present on first three legs although sparse on first; there is a rudimentary trace on fourth leg. See description of *fulgipedia*, p. 26, for details of occurrence of iridescence and of fringe arrangement, since in that species these adornments reach their highest development. Table VII shows change in segment proportions with growth.

TABLE VI.

	<i>C. chalcea</i> : Leg Formula.			
	3(4)	4(3)	1(2)	2(1)
Males	2.21	2.08	1.74	1.71
Females	1.96	1.97	1.57	1.55

Spines. There are no invariable spine differences separating *chalcea* from *fulgipedia*, nor the sexes from each other. Comparisons of the three species, with variables are given in Table II. The order of spine development in this species follows the general outline given on p. 7. The following paragraphs describe spine development by instars (see also Text-figs. 2 (FF, GG) and 7).

Second Instar. First leg: all three femoral dorsals; tibial distal (usually); metatarsal prolateral distal; metatarsal ventrals, proximals and distals. Second leg: like first except metatarsal proximal proventral lacking. Third leg: like first except for addition of tibial retrolateral distal; metatarsal prolateral and retrolateral distals complete; metatarsal ventral distals rarely present. (Note: these ventral spines may appear on either third or fourth legs, on either side; and in the pro- or retro-series at any time through fifth instar. When present in second instar they are small and weak, scarcely more than bristles). Fourth leg: like third, except that tibial prolaterals and retrolaterals may be lacking.

Third Instar. As in second.

Fourth Instar. The following spines are usually present in fourth instar, in addition to those appearing in second: all legs: femoral distal upper prolateral; patellar prolateral. Second leg: metatarsal proventral proximal (or appears equally frequently in fifth instar). Third and fourth legs: patellar retrolateral. Fourth leg: tibial median retrolateral; metatarsal median retrolateral. Any leg: tibial distal ventral. (The latter spines, however, never appear in all legs in this stadium, and occur rather as a typical fifth instar development).

Fifth Instar. There now appear any of the previous series which did not appear in the fourth instar. In addition, on all legs: femoral distal upper and sometimes lower, retrolaterals; femoral distal lower prolaterals (occasionally; usually not until later, especially on third and fourth legs); tibial distal ventrals and middle prolaterals (latter sometimes absent on third and fourth legs). On first and second legs: metatarsal proximal prolaterals and distal retrolaterals. On third and fourth legs: tibial proximal ventral (rarely in fourth); metatarsal proximal proventrals (or in fourth or sixth); metatarsal

C. chalcea: Change of Leg Proportions with Growth. (Figures are percentages averaged from leg measurements of three typical individuals in each group).

% of entire leg to all legs.	1st Leg			2nd Leg			3rd Leg			4th Leg		
	1st Instar	2nd Instar	Adult	1st Instar	2nd Instar	Adult	1st Instar	2nd Instar	Adult	1st Instar	2nd Instar	Adult
Coxa	14	12	10	14	12	11	14	11	11	14	11	12
Trochanter	8	5	7	8	5	7	7	5	5	7	5	6
Femur	24	27	26	24	28	29	26	25	27	26	25	28
Patella	14	13	14	14	12	15	12	13	12	12	13	11
Tibia	16	15	18	16	15	16	15	16	16	16	16	17
Metatarsus	24	15	15	24	15	14	26	16	19	19	16	18
Tarsus	13	10	10	13	9	9	14	14	10	13	8	8

proximal pro- and retrolaterals (third leg sometimes) and median pro- and retrolaterals (fourth leg). By the fifth instar all constant spines found in both adult sexes may be present, except for third and fourth metatarsal proximal retroventrals.

Sixth Instar, Male. In this stadium the following spines appear: any of the above mentioned spines not previously present plus the following: First and second legs: tibial median retroventral; sometimes tibial median proventral; usually tibial proximal retroventral; always metatarsal proximal retrolateral. Second leg only: tibial proximal pro-lateral; rarely, tibial distal retrolateral. Third and fourth legs: tibial pro-lateral proximal (sometimes absent in fourth leg); tibial retrolateral proximal (sometimes absent on third leg); tibial dorsal usually present; metatarsal dorsal present or absent on either or both legs; metatarsal proximal retroventral present on third, sometimes on fourth; fourth metatarsal proximal pro-lateral present or absent; fourth metatarsal proximal retrolateral present or absent. The only spines of adult always absent in this instar are the first tibial retrolateral(s), the second patellar retrolateral, and the second tibial proximal retrolateral; all these spines may be absent in the adult.

Sixth Instar, Female. The female has never added all of the above to her fifth instar spines; most are usually lacking, except the fourth metatarsal proximal retroventral, which is constant in the six specimens examined. Of the others, only the first and second tibial median retroventrals, the first and second metatarsal retrolaterals, the fourth tibial proximal retrolateral and fourth metatarsal proximal pro-lateral ever occur in this stadium.

Seventh Instar, Female. Like sixth in female, except that fourth metatarsal proximal pro-lateral is always present.

Trichobothria; Long, Dark Bristles; Short, Pale Bristles. (Text-figs. 6, 7). No distinctive specific characteristics.

Tarsal Claws. (Text-fig. 8). First, second and third leg claws strongly differentiated from fourth and from young. Table III gives comparisons with the other species.

Palp. (Text-fig. 9, A, B). Slender. Tibial apophysis of moderate length, stout, tip curved inward or straight, bluntly pointed; uneven, scarcely incised serrations in distal half, sometimes indistinguishable. Tibial ventral tubercle well developed. Whole of embolus occupying only distal fourth of bulb; stylus short, scarcely longer than shorter diameter of whorl; tip tapering to a point.

Epigynum. (Text-fig. 10, A, B). Smallest of the three forms under discussion, although the species is almost as large as *fulgipedia* and much larger than *xanthopa*. Viewed externally the horizontal extent of the anterior pair of dark spots is broader than that of posterior pair (spermathecae); their diameter is almost as large as that of spermathecae, and extend forward beyond

margin of bean-shaped patches. Breadth of entire epigynal plate less than diameter of a single AME.

Abdomen. No distinctive specific characters.

TABLE VIII.

C. chalcea.

Length Ranges and Averages in mm.

Instar	Carapace Length		Total Length	
	Range	Av.	Range	Av.
1st	.91-1.02	.93	1.81-2.11	1.94
2nd	1.09-1.27	1.16	1.81-2.69	2.21
3rd	1.23-1.57	1.39	1.91-2.78	2.41
4th	1.33-1.88	1.63	2.5 -3.9	2.94
5th	1.64-2.15	1.95	2.7 -4.4	3.52
6th ♀	2.26-2.57	2.39	3.8 -5.5	4.3
6th ♂	2.47-3.06	2.69	4.0 -6.0	4.8
7th ♀	2.39-3.12	2.83	4.4 -6.0	5.3
Adult ♂	2.67-3.83	3.08	4.5 -6.53	5.26
Adult ♀	3.11-3.56	3.42	5.86-7.0	6.7

mens of *C. chalcea*. Table IV gives comparisons with the other species. The amount of relative growth in each instar is diagrammed in Text-fig. 11. Measurements in millimeters of the male holotype and female paratype are as follows:

Male holotype. Total length in alcohol 5.1 mm.; carapace length 3.1; carapace breadth 2.3; carapace height 1.5; ocular quadrangle length 1.3; ocular quadrangle breadth 1.9; diameter AME, .58; ALE .36, MLE .10, PLE .36; clypeus height .31; 3rd patella breadth .43.

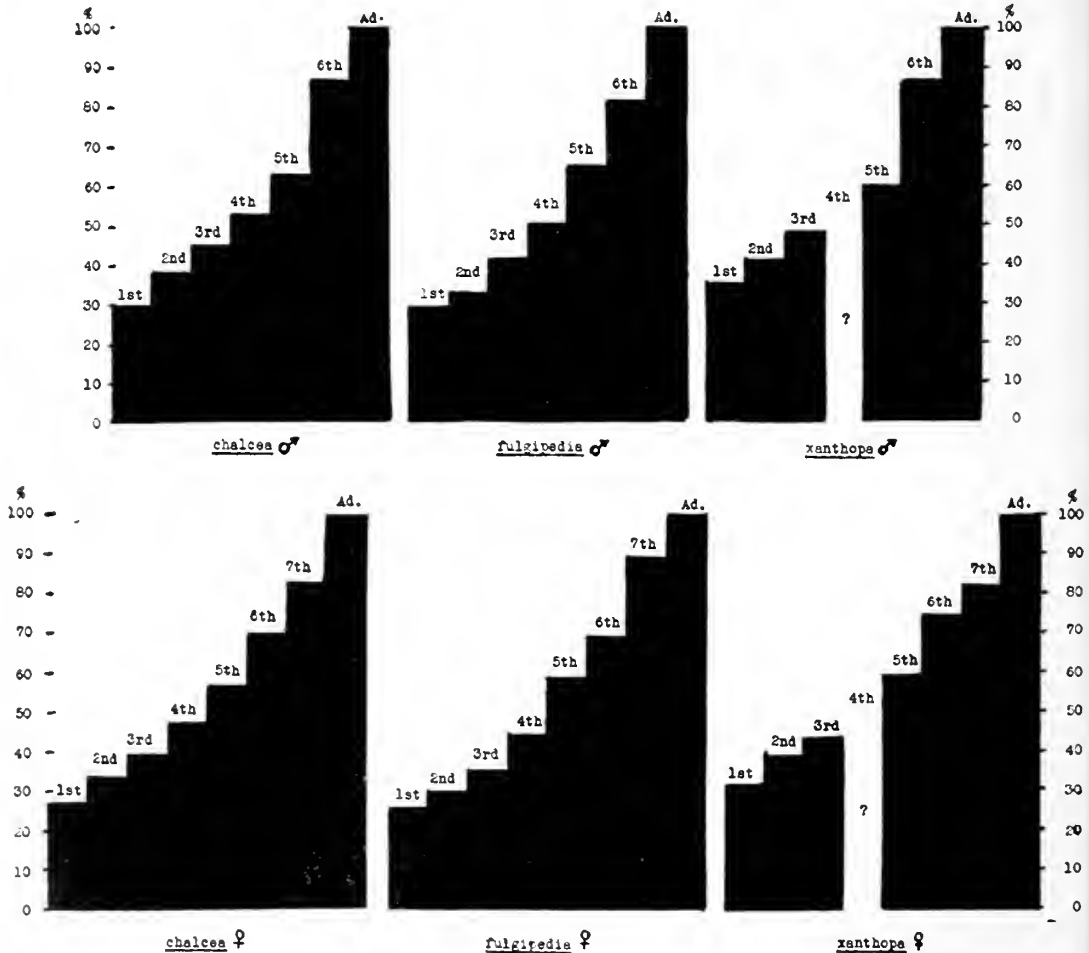
Leg	Femur	Pat.	Tib.	Metat.	Tarsus	Total
1st	1.7	1.0	1.2	.99	.55	5.44
2nd	1.7	1.1	1.1	.99	.51	5.40
3rd	2.4	1.1	1.4	1.6	.62	7.12
4th	2.1	.92	1.3	1.7	.65	6.67
Palp	.89	.41	.31	—	.75	2.36

Female Paratype. Total length in alcohol 5.9; carapace length 3.3; carapace breadth 2.5; carapace height 1.6; ocular quadrangle length 1.3; ocular quadrangle breadth 2.1; diameter AME .64, ALE .38, MLE .11, PLE .36; clypeus height .29; 3rd patella breadth .43.

SIZE AND GROWTH.

MEASUREMENTS.

Table VIII gives the extremes and averages of carapace and total lengths of all speci-



TEXT-FIG. 11. Growth profiles in *Corythalia*. Based on average carapace lengths at each instar.

Leg	Femur	Pat.	Tib.	Metat.	Tarsus	Total
1st	1.7	1.0	1.1	.92	.55	5.37
2nd	1.7	1.1	1.0	.85	.55	5.20
3rd	2.1	1.1	1.3	1.4	.68	6.58
4th	2.1	1.0	1.3	1.5	.65	6.55
Palp	.96	.51	.48	—	.72	2.67

RECORDS OF INSTAR DURATION.

Egg: About 14 to 23 days; *first instar*: about 15 to 27 days; *second instar*: about 25 to 28 days (records of 5 broods); *third instar*: 4 members of 1 brood: 17, 19, 19, 19 days; other records, 18 days (δ); 32 days (δ); 41, 22-plus days (qs); *fourth instar* δ s, 17, 18-plus days; qs , 24-plus days; *fifth instar*: δ s, 16, 19, 20, 24 days, qs , 19, 20, 25 days; *sixth instar*: δ s, 23, 25, 27, 29, 52 days; qs , 20, 23 days; *seventh instar*: qs , 34, 39-plus, 41 days.

BEHAVIOR.

(Text-fig. 12; Pl. I, Figs. 1-3).

COURTSHIP DISPLAY.

DIAGNOSIS: *Stage I.* Body held high. Third legs elevated, extended straight out, and waved up and down in unison above the horizontal, during the rather direct running approach spurts. No posing; no rocking; palps motionless. *Stage II.* First leg held straight out in front, elevated, parallel.

DESCRIPTION: *Stage I.* Carapace elevated moderately high, although lower than distal ends of femora. Abdomen horizontal or slightly depressed. All legs except third remain on ground. Third legs elevated, the femur obliquely up as in other legs, and at peak display, raised from horizontal to oblique vertical, with femur-patella joint as hinge, the distal segments remaining straight. When display is not full, the wave arc is from highest point to ground, the tibial joints bending on the downbeat. The rhythm at optimum display consists of several running steps during which the third legs are raised, in unison, and the body held at its highest, followed by a pause while they are lowered (either partially or completely, as described above). Fourth leg braced farther out than in *fulgipedia*. Progress is fairly direct, with little zigzagging. There is no posing, motion being almost constant, nor rocking, and only rarely any vibration (see under *Variation*). The palps hang motionless and relaxed. *Variation.* In one rare individual, an up and down jitter, including a stamping with first feet, occurred at end of every forward movement.

Stage II. Cephalothorax elevated as in Stage I, abdomen perfectly horizontal, body sustained on three posterior legs while the first pair are held up and forward. To achieve this position, their femora are directed up, parallel and the legs bent straight forward at femur-patella joint, bringing them on a level with top of cephalothorax. *Variation.* If a not entirely receptive female raises her front legs straight up, the male may raise his vertically also, patting her tarsi with his.

If this completes her acceptance, he slides between hers on to the carapace, patting her as he goes. Even at this stage he may break away.

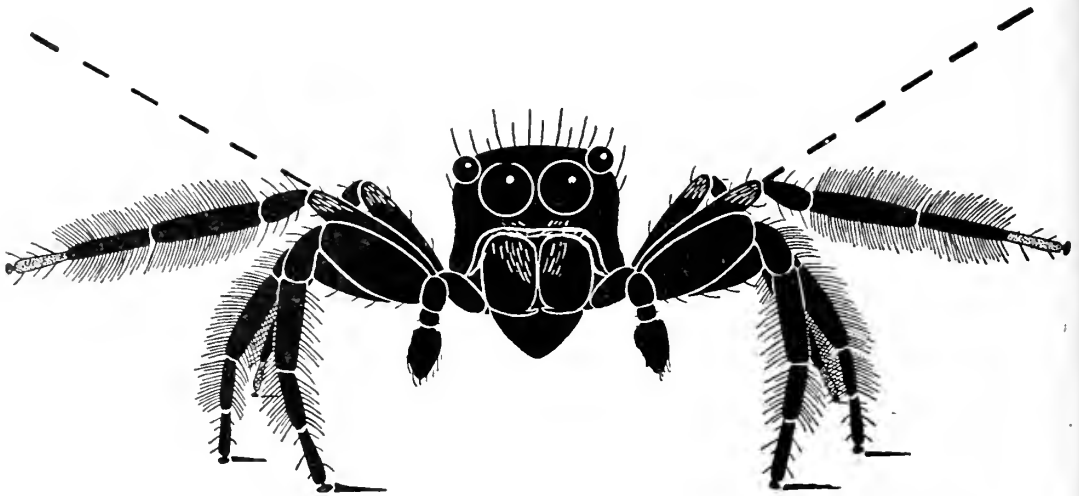
Female Behavior. A completely receptive female makes no display attempt at all, but watches closely, sitting crouched, and may or may not run away a few times before accepting male. No more than two or three minutes of display are required. A non-receptive female constantly runs away and/or attacks, leaping at the male again and again. A partially receptive female raises her first front legs forward as the male enters Stage II, and then sometimes upward (see above paragraph) before accepting or rejecting male. One highly receptive individual female, during a series of experiments on several successive days, performed a peculiar, crouching, rocking display toward the end of the male's Stage I and Stage II. All her legs remained on the ground. About the fourth day, still not having been permitted to mate, she gave up the motion, although she remained responsive as ever to the displays of various males, and was finally mated.

THREAT DISPLAY.

DIAGNOSIS: *Stage I.* Third legs elevated, straight or arched, to horizontal (but not above) and returned in arch to ground, during zigzagging or sidling spurts, which alternate with extended posing. No rocking or vibration. Differs from courtship in that third legs are not brought above horizontal and posing occurs. *Stage II.* First legs held straight overhead, fending off opponent. Differs from courtship in their higher position.

DESCRIPTION: *Stage I.* Carapace held moderately high, as in courtship, although in threat the abdomen hangs down. Also as in courtship, all legs remain on ground except third, which are waved up and down. However, these legs are practically never raised above the horizontal plane and usually do not reach this high, while the low point of every wave is the ground. There is more zigzagging and sidling back and forth than in courtship, where the approach is much more direct, the raised leg on the side of the momentary direction of approach being raised higher. Also there is extensive posing, the spider remaining motionless up to a half-minute, with the third legs either more or less elevated, stretched straight, or simply arched, whether touching or clearing the ground. Although this approaches a fan display, at no time is a perfect fan made by the fringes of adjacent legs, as in *xanthopa*. Fourth leg braced far out to side, as in courtship. Palps held more rigidly than in courtship, bent obliquely outward at patella. *Variation.* Some males have swung on the end of a silk thread to the attack. Usually they start display from not more than three inches away, but one individual leapt from a distance of eight inches.

Stage II. Usually one or the other of the



TEXT-FIG. 12. Peak of threat display in *C. chalcea*. Dotted lines indicate peak position of legs during Stage I of courtship display. Scales white except for russet eye rims; iridescence not indicated.

opponents retreats when within two inches, but occasionally they meet head-on after short leaps, in which case the third legs remain on ground while the first are raised straight in the air and slightly forward, touching the opponent's tarsi. Chelicerae not opened, nor even seem to touch, and no male has ever been seen to be injured. The meeting is always momentary only.

HABITS ASSOCIATED WITH BROODING.

Eggs are laid about seven to nine weeks after the final molt (records inconclusive). The second clutch of individual females is apparently laid about the time the first clutch is ready to molt; the third clutch appears when the second is hatching. The eggs, numbering 20 to 29 (3 perfect first clutches counted) are ivory yellow (Ridgway) and measure 1.06-1.2 mm. in diameter. Eggs of later clutches range from almost normal numbers down to half a dozen. The cocoon is spun in a small dead leaf; a typical example measures 25×18 mm., with the oblong inner cocoon surrounding the eggs 7×9 mm. The later clutches are apparently always laid in the same leaf, but data are scanty in this species.

HABITAT.

C. chalcea was taken only in the extreme upper margin of the semi-evergreen seasonal forest and in the lower part of the montane cloud forest at Rancho Grande, from about 1,000 to 1,300 meters. On its lower edges, the habitat overlaps that of *C. fulgipedia*. It was found principally on the ground, on dead leaves along the roadside, well lighted trails, and on the edges of clearings; however, a number of specimens were taken in bromeliads, and on the trunks of trees near these epiphytes, to a height of about 8 meters.

RELATIONSHIPS.

C. chalcea appears to be most closely related to *C. obsoleta* Banks, 1929, from Panama. It differs in the simpler banding of the female abdomen, in the poorly developed submarginal carapace band, in the lack of grooving in the male embolus and in details of the epigynum.

MATERIAL.

A total of 197 specimens of *C. chalcea* have been preserved, including exuviae. They are distributed as follows among the instars; first instar, 45; second, 28; third, 15; fourth, 10; fifth, 11; sixth, ♂s, 12; ♀s, 10; seventh, ♀s, 7; adult ♂s, 35; adult ♀s, 24. All were taken within a radius of half a kilometer of Rancho Grande. The following have been designated as holotype and paratype:

HOLOTYPE: Male. Cat. No. 461191, Department of Tropical Research, New York Zoological Society; Portachuelo, Rancho Grande, near Maracay, State of Aragua, Venezuela; 1,200 meters; cloud forest; May 10, 1946.

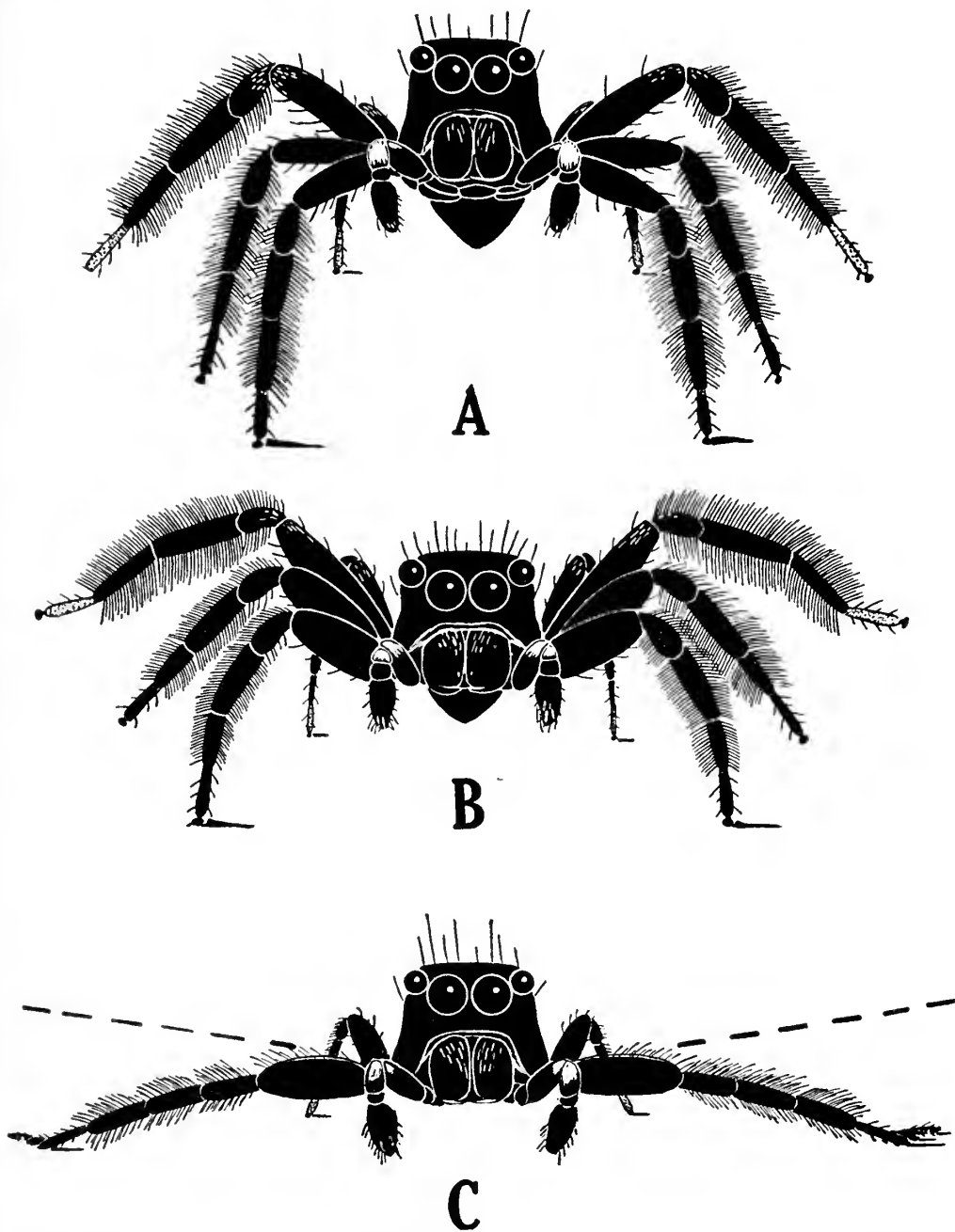
PARATYPE: Female. Cat. No. 461192, Department of Tropical Research, New York Zoological Society; same locality as holotype; May 23, 1946.

The name *chalcea* is proposed in reference to the bronze scales covering the male abdomen.

Corythalia fulgipedia sp. nov.

DIAGNOSIS.

Adults of both sexes with a strong, white, submarginal carapace band; at least traces of 5 white spots on carapace plus a thoracic spot or concave band which may be present or absent; male with face and chelicerae almost naked; female with plentiful yellowish and white hairs and scales in these



TEXT-FIG. 13. Display in *C. fulgipedia*. **A**, peak of threat display; **B**, fan phase of threat and courtship; **C**, courtship, Stage 1; dotted lines indicate elevation limit of third legs. Scales white, except for orange or russet eye rims; iridescence not indicated.

areas; abdomen of both sexes banded successively with white, bronze, black, white, black and white, the white bands all confluent on sides; in alcohol only the second white band is usually persistent. Young with two abdominal bands and a pair of terminal spots pure matte white; dorsal carapace scales present from second instar, a strong submarginal band from third. Adults of both sexes with two femoral prolateral spines on first leg, and clearly more than 20 teeth on

its tarsal proclaw. Adult male with fringes well developed on first three legs and with a rudimentary thickening of hair on fourth. Tibial apophysis of palp serrated distally and truncate; tip of embolus forked; breadth of epigynal plate greater than diameter of one AME plus one ALE. Second and third legs, but not fourth, elevated during both courtship and aggressive display; rocking present in aggressive display only. Size moderate, total length of adult males around 5.5 mm;

of females around 6.5 mm. Terrestrial only on forest roadsides and in open forest clearings in deciduous seasonal and semi-evergreen seasonal forests; occasionally on lower edges of montane cloud forest; about 700-1,100 meters.

EXTERNAL CHARACTERISTICS IN ADULTS AND YOUNG.

COLOR IN LIFE.

(Text-figs. 2, I-Q; 13; 15B).

ADULT MALE: *Cephalothorax*. Integument black. Ocular quadrangle with or without a sparse scattering of yellowish or bronzy scales, usually concentrated around dorsal eyes. There are always 5 white spots in this general region; a pair in front of PME, a pair behind PLE and a median spot between PLE. In addition yellowish or pale tan scales are present or absent on anterior thorax; in the simplest form they make a median spot at beginning of posterior thoracic slope; in greatest extent they form a crescent in this region merging anteriorly with spots behind PLE. A strong pure white carapace band, beginning at level of PME, stopping short of pedicel. AME and ALE unchanging dark brownish-black, rimmed with rust-colored scales. Clypeus completely naked; a few variable white hairs and scales at base of chelicerae; a moderate number on distal part of femur and on patella of palp with scattered long white hairs near tip of tarsus. Legs: Integument black except for slightly paler third and fourth tarsi. First and second legs with a few white scales on dorso-posterior surfaces of patella and basal tibia and metatarsus, rarely on distal femur as well; third and fourth legs with scales much more plentiful, distinctly yellowish, on posterior surfaces of distal part of femur, entire patella, entire tibia, and base of metatarsus; anteriorly on distal femur and patella only.

Abdomen. Anterior band with a variably narrow anterior margin of white, and a broader posterior bronze portion; contiguous to this posteriorly is usually a small median yellowish-white spot; second band white slightly concave forward the anterior edge wavy or plain and the band marked in its center with a short, black bar. Behind second band is a narrow, median, white stripe linking second band to white or yellowish terminal markings, which are usually in form of a wavy narrow band, curving forward or broadly V-shaped. All transverse white bands on abdomen curving to connect with one another high up on the white sides. Venter plentifully clothed in grayish hair.

ADULT FEMALE: Like male except that there are more light scales and hairs on ocular quadrangle, face, palps and legs. Details are as follows: *Cephalothorax*. Ocular quadrangle almost always with a general frosting of dull bronze scales often with a

short median line of white scales behind AME; 5 white spots as in male, behind each ALE, each PME and in midline between PLE; anterior thoracic markings, as in male, ranging from none through a median spot (sometimes represented only by several scales) at beginning of thoracic slope, to a complete crescent, concave forward and merging with PLE spots; these thoracic scales usually have a creamy or tan tinge. A strong, pure white submarginal carapace band exactly as in male. Pale tan short hairs and scales all across clypeus below AME and ALE, and a double row of pure white hairs across edge of clypeus. Thick, pure white hairs also on chelicerae and on palp across distal part of femur and entire patella; palp tibia and tarsus heavily covered with tannish-white, except for black tarsal tips. Legs: integument jet black, except for slightly paler first and second tarsi and definitely paler third and fourth. All segments plentifully covered, both anteriorly and posteriorly, with tannish-white scales except coxae, trochanters at joints, dorsal median parts of patellae and tibiae and entire tarsi. However, coxae beneath are well scaled as is underside of the black sternum. **Abdomen.** Like that of male, except that second white band is convex, not concave, anteriorly while the posterior median stripe is often broken. Venter well covered with grayish hair.

YOUNG; FIRST INSTAR: Typical of *Corythalia*: true pigment lacking, but with the usual two dark abdominal bands clearly visible in latter part of stadium.

SECOND INSTAR: This is the only species in which carapace scales appear before third instar. The black integument and basic pattern of two abdominal bands and a pair of terminal spots are typical of the group. Carapace: large, elongate white scales scattered over entire ocular quadrangle and extending behind it either as a more or less complete band, or as a simple spot behind each PLE. AME bordered with a few rust scales. Clypeus, mouthparts and sternum black. Palps, legs and spinnerets translucent buff with, however, faint dark bands appearing at the leg joints. Abdomen: the bands are dull (not shining) pure white, even, the anterior slightly narrower than the posterior. Venter dark gray.

THIRD INSTAR: All markings dull white, except sometimes for a very faint yellowish tinge on scales on anterior part of ocular quadrangle. These scales are concentrated into obscure oblique lines, thickest behind PME; they are very sparse in posterior part of ocular quadrangle and behind ALE. Between and behind PLE is a short median streak, and a well marked spot behind each PLE. A strongly developed carapace band begins at level of posterior eyes, stopping short of pedicel; this band continues, unchanged, except for further broadening and strengthening, and a slight extension forward, from this instar on. Anterior eyes rimmed with rust except outer margin of

ALE. The clypeus has a double row of white scales and hairs, the upper represented only by a short line below each AME, the lower is the usual submarginal band, the hairs directed inward, with longer ones centrally; a few white scales at inner base of chelicerae and many white scales and hairs at tip of palp femur and all over patella. Palp and legs all black with only faint traces of light bands on patellae, tibiae and metatarsi; tarsi may be dark basally. White scales moderately well developed dorsally at tips of all femora, on patellae, and in distal half of third and fourth tibiae. Abdomen above with the usual two bands of dull white, without jagged edges, the second more convex posteriorly than anteriorly; in midline behind second are a very few white scales; in midline in second band a short, curved black bar is indicated; two terminal spots, oval and well separated. Venter black, without light scales.

FOURTH INSTAR: Carapace as in preceding instar; the scalation on ocular quadrangle is rather variable in extent but is never dense except in the spots near PME and behind PLE, as well as the streak between PLE. ALE now completely rimmed with rust scales. Clypeus, chelicerae and palps as in preceding stadium. Legs all dark except for pale tarsi, and sometimes pale posterior patellae; white scales on legs about as in preceding stadium. Abdomen with two even, simple, white bands with a dark horizontal bar in second, followed by a line of midline scales and a pair of terminal spots, as in preceding stadium; in addition, however, there is a slight median, black invagination in posterior margin of first band.

FIFTH INSTAR: In this stadium the coloration becomes almost identical with that of the adult female because of the following additions and changes since the fourth instar: there is now a general coating on the ocular quadrangle of white, faintly yellowish or bronzy scales, through which the primary white spots are still visible near PME and behind PLE; the median streak between PLE is now divided into two spots, one between PLE and one at beginning of thoracic slope, although either one (but not both) may be lacking. White scales and hairs on clypeus, chelicerae, palps and legs are more numerous than in preceding stage, but still not as widespread and thick as in adult female; palp scales are now present on tibia as well as patella and distal femur; leg scales now occur on all segments except tarsi, especially on dorsal and anterior surfaces; palp integument remains pale except for tarsi; legs black except tarsi. Abdomen with bronze now apparent in posterior part of first band, although it is not nearly as well developed as in succeeding stadia; in this instar also appears the small streak or spot of white or yellowish hairs in midline behind the first band. Second band with median bar well marked, median streak following band well developed; posterior markings persisting

either as the primary spots or joining in a wavy band as in later stadia.

SIXTH INSTAR: Although sex can now be told through the form of the palp, there are no differences in color apparent, both sexes being identical with the adult female except that white scales on face and appendages are not so well developed. The carapace markings vary just as in the adult, both in color (from dull white to yellowish) and in extent of scalation, and this is the first stadium in which a crescentic marking outlining the postocular plateau region of the thorax may be present; it seems that if it is to be present in the adult it appears in this stage; if, on the other hand, the thoracic marking is to be a simple median spot, this spot is retained throughout. Tarsi almost as dark as other segments. Median whitish or yellowish patch in midline following bronze portion of first abdominal band present or absent. Terminal abdominal markings variable, the median marking complete or broken, the primary spots completely joined or practically separate; bands curving on sides toward each other, but rarely merging as completely as in final stages. Sternum and abdomen beneath well covered with white scales.

SEVENTH INSTAR: (Female only). Like adult, including amount of variation, except that there is still not quite the profuseness of white scales in frontal aspects and on legs.

SUMMARY OF COLOR DEVELOPMENT IN *C. fulgipedia*: Integument. Carapace, mouthparts and sternum black in second instar, as usual. Palps begin to darken in third, are not completely dark until fifth. Legs moderately banded in second; color complete in fifth. Abdomen black above (with two usual subscale pale bands and terminal spots) in second; venter black in third. *Light-colored scales and hairs.* Carapace above has white primary scale-hairs in second; by third the most prominent 5 patches correspond in position to the 5 constant spots of adult; a general white, yellowish or bronze frosting (secondary scalation) begins in third; separate thoracic spot or crescent, if present in adult, appears in fifth or sixth. Sub-marginal carapace band appears in third and is strong even in that early instar. AME first rimmed with rust in second, ALE in third. Light scales appear first on clypeus, chelicerae, palps and legs in third, reaching maximum development in preadults of both sexes. Abdomen with two sharp bands and a pair of terminal spots pure, dull white until fifth, when a very faint cast of bronze may appear over posterior part of first band; sometimes the bronze does not appear until sixth. Second band with a dark horizontal median bar in third and subsequent instars. Median whitish spots or short stripes following each band appear in fifth; terminal spots merge into an irregular band, and all bands are confluent on lateral margins from sixth on. White or grayish scales appear on venter in fourth or fifth.

STRUCTURE.

With the characteristics described on pp. 3 ff.

In contrast to color development, the course of post-embryological development of structure shows no clear distinctions from that of the closely related *chalcea*, except in the earlier appearance of some of the spines. The discussion below therefore concerns adults only except where otherwise specified. Ranges and averages of proportions of adults are given in Table IX, and comparisons with the other species in Table I.

Carapace. Height less than half of length; anterior part of thoracic profile a plateau. Anterior width of ocular quadrangle much narrower than width of carapace. Width at level of second-to-third coxa much greater than that at bulge before PLE.

Eyes. All eyes definitely smaller than in either of the other species. PME about midway between ALE and PLE.

Clypeus. Half or slightly more than half diameter of AME.

Chelicerae. Two minute teeth on promargin.

Maxillae. Outer margin distinctly concave; tubercle well developed.

Lip. No distinctive specific characters.

Sternum. As in *chalcea* width three-fourths of length in male, slightly less in female; not quite as wide anteriorly as base of lip; lateral excavations well developed.

Bristles. No distinctive specific characteristics.

Legs. Third leg usually longer than fourth leg in both males and females; second leg longer than first leg in all males and in more than half of females. In the formula, Table X, the alternate order is expressed by the figures in parentheses in upper row; figures of proportions are averages; for range of variation see Table IX. Segments thicker and broader in relation to their length, and length relatively shorter than in either *chal-*

cea or *xanthopa*, particularly in female. Tibial index: first leg, males 25 to 27, females 27 to 33; fourth leg, males 17 to 21, females 21 to 27.

Both iridescence and luxuriance of fringe reach their highest development in the present species, compared with the other two. Iridescence is present on first three legs, but altogether absent on fourth. The correlated flattening of the surfaces is greater than in either of the other species. Fringes also are present only on the first three legs, although on the fourth there is some thickening and a very slight elongation of the profile hairs. In detail, the fringes are as follows: *First leg*: femur: ventral only; short, downy, chiefly on posterior surface. Patella. Dorsal short and scanty, ventral moderate, anterior, slightly less than length of segment. Tibia: like patella. Metatarsus: no true fringe, but plentiful long hairs. *Second leg*: like first leg, but longer and thicker on all segments,

TABLE X.

C. fulgipedia: Leg Formula.

	3 (4)	4 (3)	2 (1)	1 (2)
Males	2.06	2.04	1.70	1.66
Females	1.81	1.86	1.51	1.48

and very well developed on metatarsus. *Third leg*: maximum development. Like second, but longer and thicker, except on femur, where it still does not constitute a true fringe, since it is composed of soft, pale hairs, well separated. Dorsal fringe of the three true, fringe-bearing segments always only about half as long as ventral, and always thinner, the difference being most noticeable on this leg. Dorsal fringe best developed in all three legs on metatarsus. Ventral tibial fringe of graduated length, the longest hairs coming at middle of segment, which is also widest part. This is true also of second tibia. The longest fringe is about as wide as widest part of tibia. *Fourth leg*: the profile hairs of the middle segments, although very short and

TABLE IX.

Relative Proportions in *C. fulgipedia*.

	Males		Females	
	Range %	Average %	Range %	Average %
Carapace Length: Breadth	72-77	74.0	69-75	72.0
Carapace Length: Height	45-51	48.0	47-50	48.4
Carapace Length: Oc. Quad. Length	35-43	37.8	34-38	36.4
Carapace Length: Oc. Quad. Breadth	55-60	57.2	53-58	56.0
Carapace Length: AME Diameter	16-19	17.2	17-18	17.4
AME Diameter: ALE Diameter	59-71	63.2	55-59	57.8
AME Diameter: MLE Diameter	19-23	21.4	18-22	19.4
AME Diameter: PLE Diameter	52-60	56.0	49-53	50.6
AME Diameter: Clypeus	53-56	54.0	53-62	55.6
Carapace Length: 1st Tibia	32-34	32.8	27-30	29.0
Carapace Length: 2nd Tibia	34-35	34.8	28-36	29.8
Carapace Length: 3rd Tibia	34-42	39.2	30-34	32.4
Carapace Length: 4th Tibia	36-42	39.8	36-37	36.8
Carapace Length: 1st Metatarsus	30-33	30.8	23-25	23.8
Carapace Length: 2nd Metatarsus	27-31	29.8	24-27	25.6
Carapace Length: 3rd Metatarsus	44-47	45.8	36-39	37.6
Carapace Length: 4th Metatarsus	46-51	48.4	41-43	42.2
Carapace Length: Palp	77-89	81.0	79-81	79.6

weak, are thickened enough to be termed a fringe, especially on ventral surfaces. There are rudimentary fringes on all tarsi, although the hairs are pale, and longer on dorsal, not ventral surfaces.

Spines. There are no invariable spine differences separating *fulgipedia* from *chalcea*, nor the sexes from each other. Comparisons of the three species, with variables, are given in Table II. The order of spine development in this species follows the general outline given on p. 7; details are given for *chalcea* on p. 18 and in Text-figs. 2, 7. Here it is to be noted that although they appear in the same order, certain spines appear one or more instars earlier in *fulgipedia* than in either of the other two species. The *second instar* spines are identical for both species, except that in *fulgipedia* the second metatarsal ventrals are 2-2, not 1r-2, and, in one example, a third patellar prolateral occurs. In the *third instar* appear the following spines, which do not appear in *chalcea* until the fourth or fifth; femoral distal upper prolaterals; all patellar prolaterals; third and fourth patellar retrolaterals; some tibial distal ventrals. In the *fourth instar* of *fulgipedia* most spines are present which typically appear in the fifth of *chalcea*; the third and fourth tibial median prolaterals and corresponding retrolaterals are exceptions, however, since they do not appear until the fifth. In the *fifth instar* of *fulgipedia* the acceleration of development in comparison with *chalcea* loses its impetus, since about the same spines are present in that stage in both species, and the same is true, including the high variability, of the *sixth* (both sexes) and *seventh* (female) instars.

Trichobothria; Long, Dark Bristles; Short, Pale Bristles. No distinctive specific characteristics.

Tarsal Claws. As in *chalcea*, the first, second and third leg claw-teeth strongly differentiated from those of the fourth and of the young. Table III gives comparisons with the other species.

Palp. (Text-fig. 9, C, D). Robust. Tibial apophysis very broad, compressed along dorso-ventral axis, the end obliquely truncate, with the low corner dorsad; tip irregularly serrated. Whorl of embolus large, occupying almost distal two-fifths of bulb; stylus long, broad, tapering; tip shallowly forked, the tines unequal.

Epigynum. (Text-fig. 10, C, D). By far the largest of the three under discussion. Viewed externally, the horizontal extent of the clearly visible portion of anterior pair of dark spots is a little less broad than that of posterior pair (spermathecae); they extend to anterior edge of bean-shaped patches. Subdermally, the structure is seen to be almost identical with that of *chalcea*, except for size. Breadth of plate greater than diameter of one AME plus one ALE.

Abdomen. No distinctive specific characters.

SIZE AND GROWTH.

MEASUREMENTS.

Table XI gives the extremes and averages of carapace and total lengths of all specimens of *C. fulgipedia*. Table IV gives comparisons with the other species. The amount of relative growth in each instar is diagrammed in Text-fig. 11. Measurements in millimeters of the male holotype and female paratype are as follows:

Male holotype. Total length in alcohol 5.7 mm.; carapace length 3.5; carapace breadth 2.5; carapace height 1.7; ocular quadrangle length 1.2; ocular quadrangle breadth 1.9; diameter AME .59; ALE .34, MLE .09, PLE .28; clypeus height .31; 3rd patella breadth .54.

Leg	Femur	Pat.	Tib.	Metat.	Tarsus	Total
1st	1.9	1.1	1.2	1.0	.54	5.74
2nd	1.9	1.1	1.1	1.0	.54	5.64
3rd	2.3	1.2	1.5	1.6	.70	7.30
4th	2.3	1.0	1.3	1.6	.70	6.90
Palp	1.0	.48	.27	—	.97	2.72

TABLE XI.

C. fulgipedia.

Length Ranges and Averages in mm.

Instar	Carapace Length		Total Length	
	Range	Av.	Range	Av.
1st	.86-.97	.91	1.72-2.15	1.86
2nd	.96-1.13	1.06	1.54-2.02	1.77
3rd	1.27-1.4	1.32	2.3-.30	2.49
4th	1.47-1.81	1.59	2.5-.39	3.22
5th	1.88-2.19	2.07	2.9-.41	3.68
6th ♀	2.33-2.67	2.41	3.55-4.9	4.23
6th ♂	2.12-2.84	2.62	3.4-.528	4.49
7th ♀	2.84-3.15	3.00	4.9-.624	5.53
Adult ♂	2.8-.363	3.19	4.61-6.14	5.43
Adult ♀	3.28-4.0	3.59	5.76-7.2	6.53

Female Paratype. Total length in alcohol 7.7 mm.; carapace length 3.8; carapace breadth 2.7; carapace height 1.8; ocular quadrangle length 1.3; ocular quadrangle breadth 2.1; diameter AME .59; ALE .34, MLE .11, PLE .28, clypeus height .34; 3rd patella breadth .54.

Leg	Femur	Pat.	Tib.	Metat.	Tarsus	Total
1st	1.9	1.1	1.1	.91	.59	5.60
2nd	1.9	1.2	1.0	1.0	.54	5.64
3rd	2.2	1.1	1.3	1.4	.75	6.75
4th	2.2	1.1	1.3	1.6	.75	6.95
Palp	1.1	.48	.54	—	.86	2.98

RECORDS OF INSTAR DURATION.

Egg: About 8 to 16 days: *First instar*: more than 12 to less than 31 days (no exact records); *second instar*: 20, 21, 25, 25 and 31 days; *third instar*: 19, 19 and 20 days (specimens taken to New York laboratory: 30, 34 and 42 days); *fourth instar*: the only complete records are of specimens taken to New York: 33, 35 and 37 days; judging by the delayed molting in New York of the other stadia, the normal time is much less, probably around three weeks; *fifth instar*: 22, 27-plus days (both ♂s); in New York laboratory, 67 days (♂); *sixth instar*: ♀s, 20-plus,

27-plus days; ♂s, 26, 26-plus, 34, 34-plus days; New York laboratory, 41 days (♂); seventh instar (♀s); 35-plus, 37, 46, 50 and 61 days.

BEHAVIOR.

(Text-fig. 13).

COURTSHIP DISPLAY.

DIAGNOSIS. *Stage I.* Body held low, with legs wide spread laterally; third legs intermittently raised and vibrated in unison with body during or between spurts of progress. No posing; no rocking. Palps jerked, in unison, almost constantly.

Stage II. As in *chalcea* but body held lower, and there is vibration.

DESCRIPTION: *Stage I.* Cephalothorax held very low with first three pairs of legs stretched progressively farther out to side, so that the femora are parallel with ground and the tarsi show one behind the other; only the fourth legs are extended behind, not laterally, for balance. Abdomen horizontal. All legs left continually on ground except third which are intermittently moderately elevated and vibrated in the air, up and down, in a small arc in unison with vibration in the body, especially the abdomen. The vibration—of about a second's duration—takes place either between or during spurts of rather direct progress. There is no posing and no rocking. The palps are jerked up and down almost continuously, usually with a roughly circular motion, one going clockwise as the other goes counterclockwise, and vice versa; sometimes it is more of a simple jerking up and down. As the female becomes more receptive the elevation of the third legs almost ceases and the male approaches with the cephalothorax even lower, almost touching ground. *Variation.* Some individuals lower the body regularly more than others.

Stage II. As in *chalcea*, with first legs out in front, parallel, level with top of cephalothorax, but the body is held lower, and the same type and rhythm of body vibration occurs as in Stage I. He may in this stage, practically touching female, pose utterly motionless if she fences with him, but does not actually run.

THREAT DISPLAY.

DIAGNOSIS: *Stage I.* Body held exceptionally high, second and third legs raised intermittently, the second just clearing ground, the third higher, bent at patella only, or arched. No vertical vibration, but occasional side-to-side coarse rocking; a moderate amount of posing with raised third legs. Palps jerked at intervals.

DESCRIPTION: *Stage I.* Position exactly opposed to courtship display, the cephalothorax elevated to maximum extent through the legs, especially first and fourth, being held in close to body and stretched to maximum vertical; at peak display the first femur slants forward and strongly downward. Sec-

ond legs and third legs extending progressively further laterally. Toes of second legs not touching ground at peak display, and third legs raised and bent only at the femoropatella joint which is raised above level of cephalothorax, the more distal joints held straight at an obliquely downward angle. At less than peak display the cephalothorax is lower, and the leg more arched, its fringes never, however, forming a perfect fan with those of first and second. Fourth leg braced far back. There is no trace of the up-and-down vibration typical of courtship, but some intermittent coarse rocking between spurts of zigzag progress, usually about six rocks (three to each side)—occupying about a second or less—in a series. There is more zigzagging and sidling than in courtship, and the raised leg on the side of direction of rocking or progress is raised higher. Posing plays a moderate part in threat display, the third legs being usually in the arched, not maximum obliquely bent, position. Palps jerked as in courtship at beginning of threat, but held motionless at peak, with femur bent out and the other segments hanging down.

Stage II. As in *chalcea*.

Female Behavior. A completely receptive female practically always raises first front legs forward as male enters Stage II, as does the only partially receptive *chalcea* female. A non-receptive female is more combative than a non-receptive *chalcea* female, usually leaping on the male savagely, after hunching her body well down between her close-gathered legs and rocking violently back and forth; if these tactics fail to discourage him—they usually scare him away quite quickly—she will leap, then run away. So far no female has actually hurt a male in this group. A potentially receptive female alternately leaps, sits, and runs away, punctuating these activities with rough versions of the male threat, and as in *chalcea* she raises her first legs first forward and then sometimes upward, although her arched-out second and third legs apparently never actually leave the ground.

HABITS ASSOCIATED WITH BROODING.

Each of several females which molted and mated in the laboratory laid eggs between eight and nine weeks after molting, and between three and nine weeks after mating. The second clutches were apparently laid just about the time the first clutch was hatching. Since the former was laid, in its own inner cocoon, within the same leaf and outer cocoon as the first clutch, it was impossible to obtain exact data on these broods without unduly disturbing the female and young. We have two examples of a third clutch also laid in the same cocoon, just about the time the first brood was leaving the nest.

A single leaf is always used for the cocoon, which is more extensive than that of *C. chalcea*. Bits of earth are mixed with the silk binding the edges together. A typical leaf

measures 70 mm. long, and the outer cocoon silk binds its whole length together; each egg packet is about 7 mm. in diameter. The eggs, numbering 13 to 28 (6 perfect first clutches counted) are ivory yellow (Ridgway) and measure .98 mm. in diameter. Eggs of second and third clutches have from 2 to 5 eggs fewer than those in the preceding clutch.

HABITAT.

C. fulgipedia is typical of relatively open leaf-litter in the deciduous seasonal forest, although individuals occur on up through the semi-evergreen seasonal forest across the lower boundaries of the cloud forest along the well-lighted and intermittently dry roadside. In this upper zone its range overlaps that of *C. chalcea*, but it occurs typically only in the drier localities. The altitude range is between 700 and 1,100 meters. It is completely terrestrial.

RELATIONSHIPS.

C. fulgipedia shares with a large group of species the possession of well-formed fringes on the first three legs and a strong cephalothoracic band; the dorsal cephalothoracic markings in the female check closely with those of *spiralis*, *bicincta* and *opima*, from Central America and Panama (see especially Chickering's keys and descriptions, 1946). The species appears most closely related, however, to *C. blanda* (Peckham, 1900) from Trinidad, and *C. panamana* Petrunkevitch, 1925, from Panama. It differs from *blanda* in the absence of red hairs on the clypeus and in the form of the palpal tibial spine. The abdominal pattern appears identical with that figured by Peckham for *placatus* from Brazil, and the palps are also similar (Peckham, 1901, pls. xxv, fig. 11, xxvi, fig. 2). It differs from *panamana* as follows: the first leg tibial ventral spines are 1r-2-2, not 2-2-2; the tibial spine of the palp is truncate in a lateral view and the embolus is cleft distally; the epigynum is slightly different, although obviously similar to those of both *panamana* and *obsoleta* (cf. Chickering, 1946, fig. 133); and the dorsal carapace markings are apparently better developed. *C. fulgipedia* is smaller than either *blanda* or *panamana*.

MATERIAL.

A total of 142 specimens of *C. fulgipedia* have been preserved, including exuviae. They are distributed as follows among the instars: first instar, 35; second, 36; third, 8; fourth, 8; fifth, 7; sixth, ♀, 4; sixth, ♂, 9; seventh, ♀, 6; adult, ♀, 15; adult, ♂, 14. All were taken within a radius of two kilometers of Rancho Grande. The following have been designated as holotype and paratype:

HOLOTYPE: Male. Cat. No. 461193, Department of Tropical Research, New York Zoological Society; roadside between Guamitas and Rancho Grande, near Maracay, State of Aragua, Venezuela; deciduous seasonal forest; 900 meters; June 30, 1946.

PARATYPE: Female. Cat. No. 461184, Department of Tropical Research, New York Zoological Society; same location as holotype; July 12, 1946.

The name *fulgipedia* is proposed in reference to the brilliant iridescence on the legs of the male.

Corythalia xanthopa sp. nov.

DIAGNOSIS.

All light scales and scale-hairs on carapace and abdomen yellow in life, creamy to brown in alcohol, in both sexes and in young; no submarginal cephalothoracic band in adult of either sex. Adult male with long, thick hairs on palp and clypeus making bright yellow band in life (pale yellow to cream in alcohol); abdomen above entirely bright yellow (brownish in alcohol). Adult female clypeus with pale hairs or scales completely lacking, abdomen black medially, flanked in life by a pair of broad longitudinal yellow stripes, which persist subdermally and in alcohol as pale areas. Both sexes in adult with one femoral prolateral spine on first leg and clearly fewer than 20 teeth on its tarsal proclaw. Adult male with fringes on all legs though they are weak on first; dorsal fringe of fourth leg in life formed principally of yellow hairs. Tibial apophysis of palp non-serrate, pointed; embolus tip pointed. Courtship and aggressive displays sharply distinct, the fourth leg being elevated during aggressive display only. Size small, total length of adult males around 4 mm., of females around 5 mm. Terrestrial on trail and forest edges; semi-evergreen seasonal and lower part of montane cloud forests; 740-1,100 meters.

EXTERNAL CHARACTERISTICS IN ADULTS AND YOUNG.

COLOR IN LIFE.

(Text-figs. 2, R-X, 14, 15 C).

[All yellow mentioned below is straw yellow (Ridgway)].

ADULT MALE. Cephalothorax: Carapace integument black with a faint small patch of yellow hairs on each side between AME and ALE. AME and ALE unchanging black rimmed with yellow hairs. Short and fairly long yellow hairs densely covering black integument of clypeus and inner distal half of chelicerae, which may be spotted with brown proximally; yellow hairs all directed toward the center. Mouth-parts and sternum black. Palp integument black except for pale distal half of femur and entire patella and tibia, which are also covered densely with long yellow hairs. All legs black, except for tarsi, including ventral fringes and all dorsal fringes on fourth leg. Fringes on patella, tibia and metatarsus of latter formed mostly of yellow hairs with a few black. All tarsi pale, yellowish or brown, not black, the first

and second pairs darker than third and fourth. No white or yellow scales on legs. Iridescence in usual locations and, in addition, in same positions on fourth leg. *Abdomen*. Integument black, entirely covered dorsally with yellow scale-hairs which appear brighter than straw yellow because of their shininess; a suggestion of a distal yellow chevron; a scattering of long black and pale hairs projecting through scale-hairs. Venter black with dark brown striations in indistinct stripes.

ADULT FEMALE: Cephalothorax. Carapace integument black with a few yellow hairs irregularly outlining ocular quadrangle. Eyes black rimmed with yellow. Clypeus naked. Chelicerae and mouthparts black. Palps black except for distal part of femur and entire patellae which are pale. Sternum black. Legs black except for distal half of metatarsi and all tarsi, which are brown. No white or yellow scale-hairs.

Abdomen. Above, black, with a pair of long broad stripes of yellow scale-hairs extending two-thirds of distance to posterior tip and beginning at highest point on outer margin of dorsal surface. Behind these a pair of indistinct yellow spots, or, rather, the yellow stripe is interrupted on each side by a black spot joined to its fellow by an indistinct yellow band. Lateral stripes often partly interrupted farther forward by two other, partially isolated spots; a few black and pale hairs as in male. Venter, black except for a pair of ovoid yellowish patches spotted with black.

YOUNG; FIRST INSTAR: Typical of *Corythalia*: true pigment lacking but with the usual two abdominal bands clearly visible in latter part of stadium.

SECOND INSTAR: From this point on, the species is distinct in having all light carapace and abdominal markings yellow, not white and bronze, and in the tardy development of leg pigment. The black integument (dark brownish-gray on abdomen in early second instar) and basic pattern of two abdominal bands are, however, typical of the group. Second instar, carapace: scales and light hairs lacking except for a very few long pale hairs around lower margin of AME. Clypeus, mouthparts and sternum black. Palps, legs and spinnerets translucent buff. *Abdomen:* the bands are very pale yellow, each composed of a single row, in this stadium, of large-diametered scale-hairs of unequal length, giving a characteristic uneven, scraggly appearance to the bands; longer hairs in the anterior band near middle project posteriorly; anterior wider than posterior throughout instars; here it is straight, while the second is slightly wavy with an anterior median peak; neither curves forward or back on sides. Two terminal abdominal spots though present, are inconspicuous. As usual, there is pale integument beneath bands and spots. Venter apricot brown.

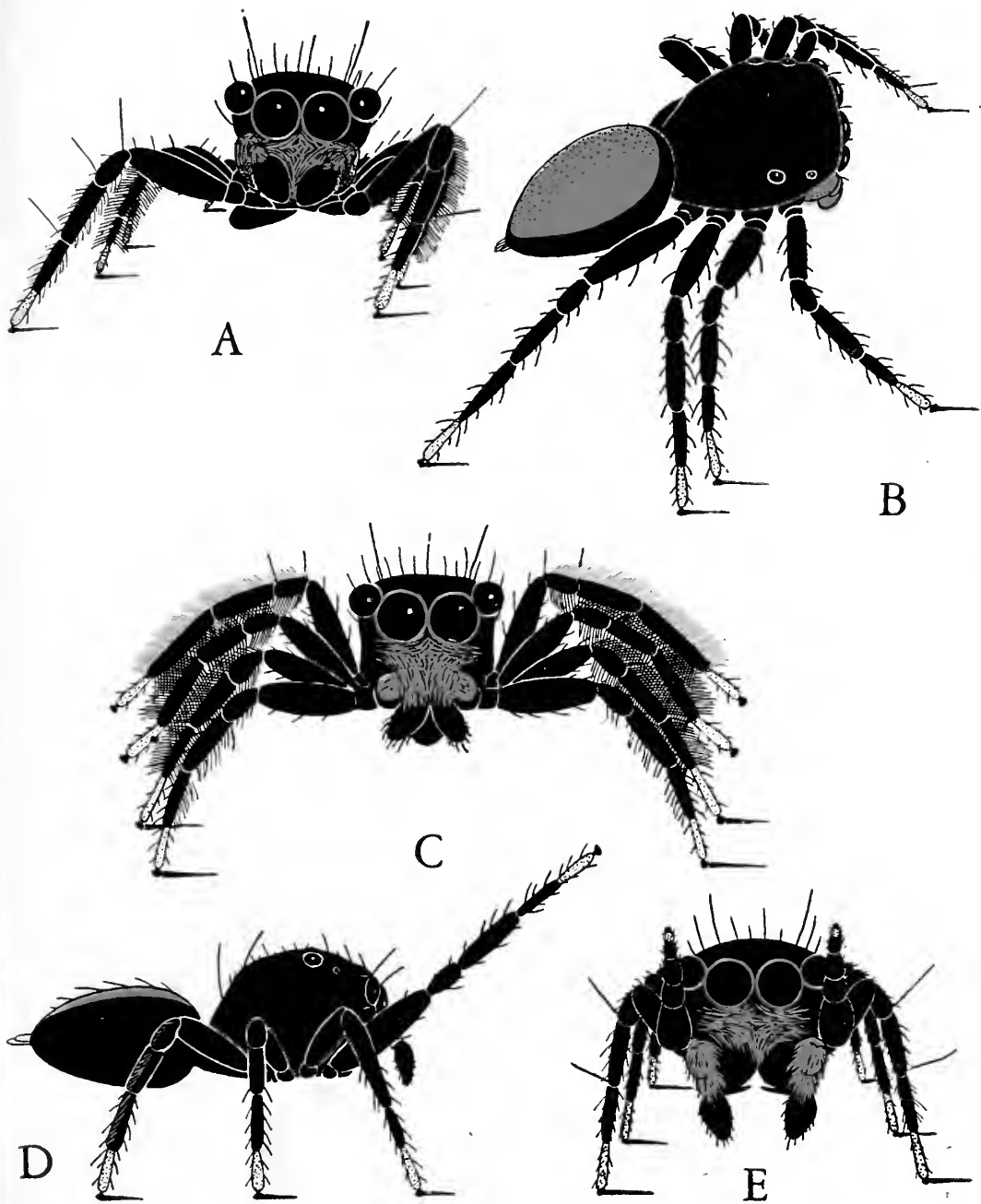
THIRD INSTAR: Carapace with a tiny pale

yellow spot behind each PLE, sometimes absent; appendages and abdomen as in preceding stage.

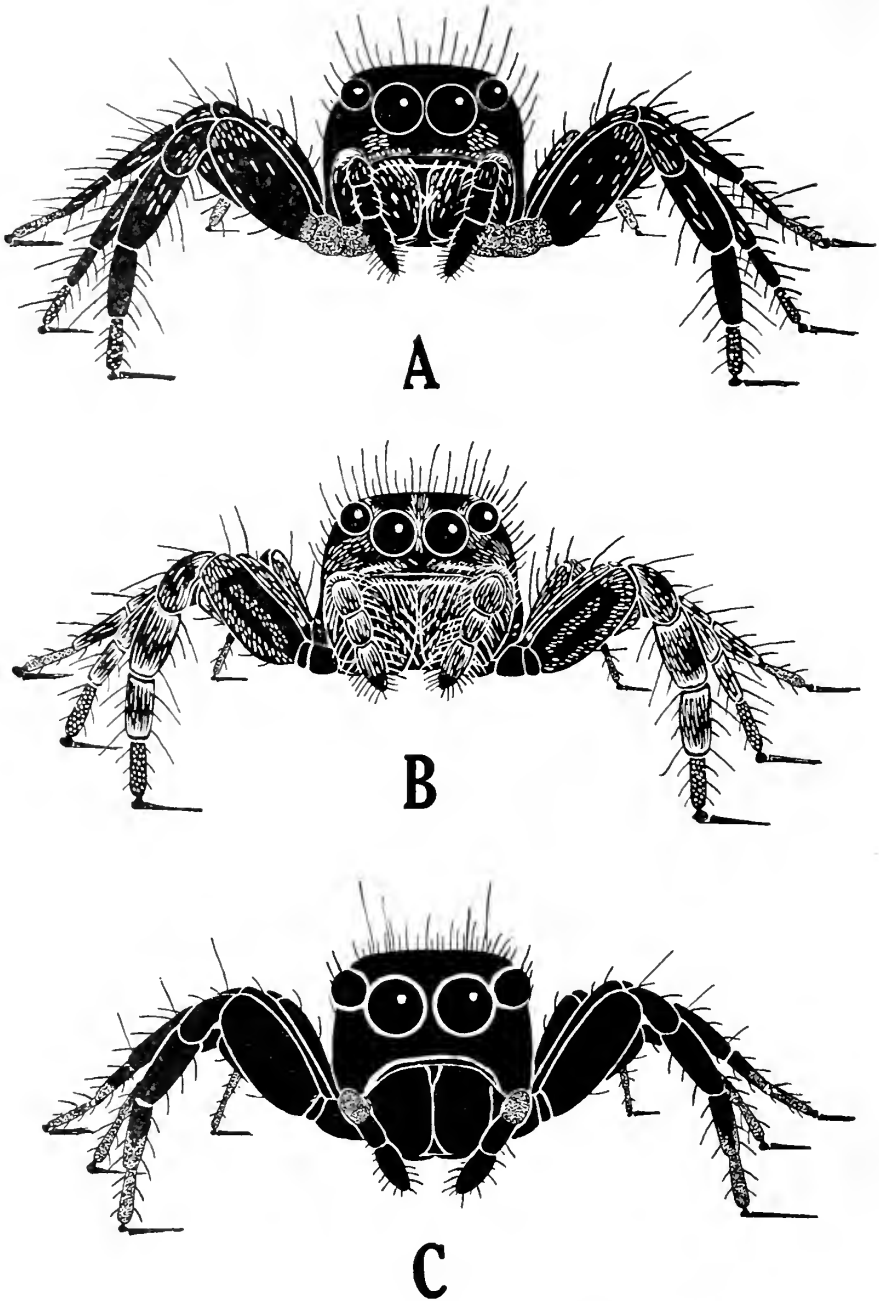
FOURTH INSTAR: Unknown.

FIFTH INSTAR: Carapace with a few yellow hairs on ocular quadrangle, sometimes numerous enough to form a faint band between PME, or there is only a spot around each PME, with another in middle anterior part of ocular quadrangle; behind each PLE a yellow spot as in preceding stadia, or an almost complete bar. AME and ALE rimmed narrowly with yellow; clypeus still naked; palp translucent; legs either still translucent or banded strongly. *Abdomen* as in preceding stadia, but bands are now relatively narrower and tend to approach each other on sides. Venter light brown, spotted and blotched irregularly with dark brown.

SIXTH INSTAR, MALE AND FEMALE: Cephalothorax: Dorsal part of carapace marked very variably with yellow, the variability depending not only on wear, but on individual differences, since fresh-molted specimens may appear quite different, regardless of sex; in general, however, males tend to have more yellow than females. Scale-hairs of this region now brighter, straw yellow as in adult, than in preceding stadia; at maximum it is a general frosting over of entire ocular quadrangle and extending behind it over anterior thorax in a rough inverted triangle; the minimum development is a small spot around or in front of each PME and around PLE, plus a strong spot behind each PLE; these latter spots are often joined by a faint yellow bar in place of the broad triangle. Scales rimming ALE and AME ranging from rust to chrome yellow. Male has a few submarginal yellow hairs on thoracic part of carapace; this is the only stage in which they appear at all in this sex in this species; also for the only time in males there are a few yellow and white scale-hairs on upper anterior parts of femora, patellae, and tibiae of all legs; in females corresponding hairs appear only on patellae. The characteristic yellow scale-hairs and hairs of adult males first appear, although pale and sparse, in this instar on clypeus, chelicerae and palp patellae. Basal two-thirds of palps either dark or translucent in both sexes; remaining palp segments always translucent except for a few black hairs on the brownish male tarsus. Legs black except at least for coxae, trochanters and tarsi, which are all translucent horn in both sexes; in addition, basal parts of femora, patellae and distal parts of tibiae may be pale, especially in female. *Abdomen.* Both bands remain very pale, dull yellow in both sexes. Anterior band still broader than posterior, with a slight, posteriorly directed median apex; posterior continuing to have a median bulge directed forward and the ends curve forward laterally. Terminal paired spots either distinct and laterally placed or very obscure; in addition there is usually a median terminal indistinct blotch or band,



TEXT-FIG. 14. Display in *C. xanthopa*. A, frontal view of rocking preface to threat and courtships displays; B, dorsal view of same; C, threat display; D, courtship, Stage I, lateral view; E, same, frontal view. Yellow scales indicated in color; iridescence of legs not shown.



TEXT-FIG. 15. Frontal views of adult ♀ *Corythalia*. **A**, *C. chalcea*; **B**, *C. fulgipedia*; **C**, *C. xanthopa*.

in place of simple paired spots, this terminal irregularity being typical from this instar onward.

SEVENTH INSTAR, FEMALE: Cephalothorax: Ocular quadrangle and thoracic region as in preceding stadium, the yellow scale-hairs being very variable, although in general there is less yellow than in sixth instar. Always, however, there is at least some yellow across anterior part of quadrangle, with spots traceable in front of or around PME. The thoracic region is the most variable,

the yellow ranging from a simple pair of spots behind PLE to an inverted triangle almost as extensive as in some preadult males. ALE and AME rimmed with chestnut. Clypeus with a very few yellow hairs. Palps usually translucent horn; rarely with darkened femora, tips of tarsi dark. Legs strongly banded as in preceding stage; the same segments and degree of variation are involved, though individuals are always darker in the seventh than in the sixth stage. A few yellow scales on dorsal part of fourth

femur; rest of femora, patellae, tibiae and proximal half of metatarsi with a few sparse whitish and yellowish scales, especially at joints, on all except first legs where they are practically absent; these leg scales reach maximum development for this species in this sex and stadium. Abdomen. The most characteristic feature of this stadium is the breaking down of anterior band into a semicircle of variable, asymmetrical, irregular spots. Usually three decided spots occur anteriorly, and another pair, one on each side, behind and lateral to, the outer spots; sometimes, however, the spots are indistinct and tend to merge. The second band is unbroken but slender, usually strongly W-shaped, with a decided median peak and the lateral edges curving strongly forward toward the more posterior spots. The general effect is of a broken circle occupying anterior two-thirds of abdomen. The terminal markings usually consist of a fairly continuous band, just before the spinnerets, triangular, with the apex directed forward, or it may be an arched band; it is never a simple pair of spots. Venter brown, spotted and speckled with black and with a large black irregular central marking; there are some short grayish-buff hairs, especially laterally.

SUMMARY OF COLOR DEVELOPMENT IN *C. xanthopa*.

(It must be kept in mind that Fourth Instar is unknown).

Integument. Carapace, mouthparts and sternum black in second instar, as usual. Palps remain completely translucent and pale until sixth in male, when basal part of femur may or may not darken; in female basal part of femur may darken to brown in sixth or seventh. Leg pigment develops tardily, two or three instars later than in *chalcea* or *fulgipedia*. There is no trace of

banding before fifth, and then it is present in only two out of three observed specimens. Preadult males and females (sixth and seventh instars, respectively) have the legs still pale at least proximally and distally, and often strongly banded; even the adults have all feet pale, not only the third and fourth. Integument of abdomen does not attain full blackness until third, the second, at least in early part of stage, being dark gray-brown.

Yellow hairs and scale-hairs: Throughout the instars the color yellow almost completely replaces the white and bronze of *chalcea* and *fulgipedia*, the only exception being a few whitish or bronze leg scales in the preadult instar. Carapace, like that of *chalcea*, lacking light scale hairs until third. Unlike *chalcea*, the basic pattern of dorsal carapace is two postocular spots instead of a postocular bar. In later instars, from the fifth through the seventh female, there is a considerable and highly variable amount of yellow on and immediately behind ocular quadrangle, especially concentrated around and near PME; only the latter areas survive in adults. Large eyes rimmed as usual with yellowish, varying from rust to chrome, from fifth on. Clypeus and chelicerae remain naked (except for the usual black bristles) until sixth; then the first pale yellow hairs appear on palps, face and chelicerae of male, reaching their full development a stage later in the adult. In females, a few yellow hairs appear on clypeus in the seventh only, being lost in adult. A few white and yellow leg scales in sixth only of males and in seventh only of females. Abdomen. The yellow scales are in the form of two bands and a terminal pair of spots throughout the sixth instar. The preadult (7th instar) female is unique in having the anterior band broken into spots.

STRUCTURE.

With the characteristics described on

TABLE XII.
Relative Proportions in *C. xanthopa*.

	Males		Females	
	Range %	Average %	Range %	Average %
Carapace Length: Breadth	69-75	71.8	68-74	71.0
Carapace Length: Height	57-65	60.0	55-59	56.2
Carapace Length: Oc. Quad. Length	38-49	43.2	38-44	40.4
Carapace Length: Oc. Quad. Breadth	68-75	71.2	66-68	67.2
Carapace Length: AME Diameter	20-22	21.2	19-21	19.8
AME Diameter: ALE Diameter	66-77	71.2	69-74	71.2
AME Diameter: MLE Diameter	18-20	19.2	19-21	20.4
AME Diameter: PLE Diameter	52-63	60.4	55-67	61.4
AME Diameter: Clypeus	42-50	45.4	43-52	47.3
Carapace Length: 1st Tibia	31-35	33.0	29-31	30.6
Carapace Length: 2nd Tibia	32-35	33.4	30-32	29.6
Carapace Length: 3rd Tibia	42-47	45.0	38-42	40.6
Carapace Length: 4th Tibia	45-48	47.0	42-45	43.2
Carapace Length: 1st Metatarsus	29-32	30.4	30-32	29.8
Carapace Length: 2nd Metatarsus	30-33	31.8	29-31	29.6
Carapace Length: 3rd Metatarsus	47-51	48.8	44-47	45.8
Carapace Length: 4th Metatarsus	52-57	53.6	51-54	52.2
Carapace Length: Palp	74-79	76.8	77-84	81.4

pp. 3 ff. In contrast to color development, the course of post-embryological development of structure shows no clear specific distinctions except in the relative tardiness of the appearance of some of the spines and details of tarsal claw-teeth development. With these exceptions, therefore, the discussion below concerns adults only. Ranges and averages of proportions are given in Table XII; and comparisons with the other species in Table I. In regard to development, see also pp. 4 ff.

Carapace. Height clearly more than half of length; anterior part of thoracic profile descending very gently. Ocular quadrangle broad anteriorly, especially in males. Greatest width at bulge before PLE, or width at that point equal to width at level of second-to-third coxae.

Eyes. Eyes relatively about as in *chalicea*, except that ALE and PLE are a little larger. PME slightly nearer to PLE than to ALE.

Clypeus. Slightly more than half diameter of AME.

Chelicerae. Apparently no teeth on superior margin.

Maxillae. Outer margin scarcely concave; tubercle faintly indicated.

Lip. No distinctive specific characteristics.

Sternum. Broader than in other two species, the width in both sexes being four-fifths of its length, and slightly wider anteriorly at base of lip; lateral excavations feebly developed.

Bristles. No distinctive specific characters.

Legs. Fourth leg usually longer than third in both sexes; first longer than second in both sexes in only about 60% of individuals measured. In the formula, Table XIII, the alternate order is expressed by the figures in parentheses in the upper row; figures of proportions are averages; for range of variation see Table XIII. Segments slender, as in *chalicea*. Tibial index: first leg, males 23 to 25, females 24 to 25; fourth leg, males 17 to 22, females 18 to 20.

Fourth metatarsus longer than third to a greater degree than in other two species. Iridescence feebly developed in this species, though present on same segments as in *chalicea* and *fulgipedia* on first three legs, and on corresponding segments of fourth leg in addition; there is relatively little flattening even of the strongly iridescent third and fourth tibiae and metatarsi. Fringes of first three legs also similar to those found in other two species, the segments of occurrence and relative strength being unchanged (see *ful-*

dorsal and ventral surface. The main specific difference is the presence of a well developed fringe on fourth leg; this is distinguished from that of third in having dorsal fringe composed chiefly of yellow, not black, hairs and in being much longer, not shorter, than ventral; tibial ventral fringe shorter than corresponding width of segment on fourth leg, although it is as thick as on third.

Spines. Adults: fewer than in other two species. The following distinctions are constant; for variables consult Table II. Femur: prolateral 1, not 2, at least on first two legs; retrolaterals lacking, at least on first leg. First and second tibiae: proximal ventrals always lacking. First metatarsus: proximal retrolateral always lacking. No constant sexual differences.

Young: compared with *chalicea* and *fulgipedia*, there is a lag in spine development, the spines of tibia and metatarsus which always occur in the second instar in these species (Text-fig. 2, FF, GG) not appearing in *xanthopa* until the third or later. The first and second metatarsal ventrals are not always complete even in the fifth, nor all the constant pro- and retrolaterals of the same segments in the sixth. Details are as follows:

As in *chalicea* and *fulgipedia*, the femur dorsals are present in *second instar*, as are the metatarsal prolateral distals of first and fourth legs and the metatarsal retrolateral distals of third and fourth. The rest of the earliest appearing constants, however, do not appear in *xanthopa* until the third stadium or even later. These delayed spines are the following: tibial prolateral distals, all legs; tibial retrolateral distals, third and fourth legs; metatarsal prolateral distals, second and third legs; metatarsal ventral proximals and distals, first and second legs; metatarsal ventral distals, fourth leg. Although this group of spines usually appears in the *third instar*, some specimens still lack the second leg's tibial prolateral distal, while the metatarsal distals of all legs are usually weak or incomplete. The *fourth instar* is unknown in *xanthopa*. In the *fifth instar* the constant first and second metatarsal ventrals and pro- and retrolaterals of the same segment are still usually incomplete, unlike the usual condition in *chalicea* and *fulgipedia*. In the *sixth* and *seventh* instars, the spines are as well developed as in corresponding *chalicea* and *fulgipedia*, allowing for specific differences, except that the constant metatarsal pro- and retrolaterals are not always complete even in the sixth instar.

Trichobothria; Long, Dark Bristles; Short, Pale Bristles. No distinctive specific characteristics.

Tarsal Claws. First, second and third leg claws less differentiated from fourth and from young than in other two species. Table III gives comparisons with the other species.

Retroteeth almost as slender, close-set and well graduated as pro-teeth in both first and fourth legs; as usual there are usually one or more broad, truncate rudiments or ves-

TABLE XIII.

C. xanthopa: Leg Formula.

	4(3)	3(4)	1(2)	2(1)
Males	2.21	2.18	1.70	1.64
Females	2.07	2.01	1.56	1.55

gipedia, p. 26, for details). However, the hairs are less dense than in this species, they are scarcely developed in first leg, and there is less difference in hair length of fringes of

tiges at proximal ends of series, and in individuals there may be variations of one or more teeth in either direction. In one adult female fourth leg, there were 8 completely subdermal pro-teeth proximal to the usual, well graduated, extruded series of 13.

Palp. (Text-fig. 9, E, F). Slender. Tibial apophysis slender, simple, non-serrated, tapering to a point which extends almost to tip of distal external loop. Ventral tibial tubercle not conspicuous, poorly chitinized, close to distal edge. Whorl of embolus occupying distal third of bulb; stylus slender, much longer than shorter diameter of whorl, tip not forked.

Epigynum. (Text-fig. 10, E, F). Horizontal extent of anterior pair of dark spots, viewed externally, less than that of posterior pair (spermathecae), and they do not quite extend to anterior edge of bean-shaped patches. In size, the epigynum is a little larger than that of *chalcea*, a much larger species.

Abdomen. No distinctive specific characters.

SIZE AND GROWTH.

MEASUREMENTS.

TABLE XIV.

C. xanthopa.

Length Ranges and Averages in mm.

<i>Instar</i>	<i>Carapace Length</i>		<i>Total Length</i>	
	<i>Range</i>	<i>Av.</i>	<i>Range</i>	<i>Av.</i>
1st	.79-.85	.83	1.44-1.73	1.54
2nd	.99-1.03	1.01	1.34-1.63	1.44
3rd	1.09-1.2	1.14	1.82-2.11	1.96
5th	1.53-1.55	1.54	2.5-3.07	2.78
6th ♀	1.74-1.95	1.86	3.26-3.84	3.56
6th ♂	1.92-2.29	2.09	2.9-3.46	3.13
7th ♀	2.02-2.22	2.14	3.55-4.13	3.91
Adult ♂	2.05-2.73	2.4	3.46-4.99	4.27
Adult ♀	2.33-2.8	2.58	4.32-5.95	5.04

Table XIV gives the extremes and averages of carapace and total lengths of all specimens of *C. xanthopa*. Table IV gives comparisons with the other species. The amount of relative growth with each instar is diagrammed in Text-fig. 11. Measurements in millimeters of the male holotype and female paratype are as follows:

Male holotype. Total length in alcohol 4.8 mm.; carapace length 2.7; carapace breadth 1.9; carapace height 1.5; ocular quadrangle length 1.0; ocular quadrangle breadth 1.9; diameter AME .55, ALE .40, MLE .10, PLE .34; clypeus height .28; 3rd patella breadth .38.

Leg	Femur	Pat.	Tib.	Metat.	Tarsus	Total
1st	1.4	.68	.85	.79	.55	4.27
2nd	1.4	.79	.92	.89	.41	4.41
3rd	1.8	.85	1.2	1.3	.62	5.77
4th	1.9	.62	1.3	1.4	.62	5.84
Palp	.72	.41	.21	—	.68	2.02

Female paratype. Total length in alcohol 4.9 mm.; carapace length 2.7; carapace

breadth 1.9; carapace height 1.5; ocular quadrangle length 1.1; ocular quadrangle breadth 1.8; diameter AME .51, ALE .36, MLE .10, PLE .34; clypeus height .22; 3rd patella breadth .37.

Leg	Femur	Pat.	Tib.	Metat.	Tarsus	Total
1.	1.2	.79	.82	.79	.44	4.04
2.	1.4	.79	.85	.79	.44	4.27
3.	1.7	.79	1.1	1.3	.55	5.44
4.	1.6	.65	1.2	1.5	.58	5.53
Palp	.68	.44	.34	—	.65	2.11

RECORDS OF INSTAR DURATION.

Egg: About 15 to 18 days (records of 2 broods). *First instar*: 12 to about 16 days (records of 3 broods); *second instar*: about 17 days; *third instar*: unknown, but more than 14 days (all examples died or were preserved before molting); *fourth instar*: unknown; *fifth instar*: the single specimen, a female, allowed to molt from this stage did so on the 18th day after capture; *sixth instar*: a reared female, 17 days; three females captured in this stage molted on 21st, 22nd and 28th days; three males on 17th, 17th and 21st after capture; *seventh instar*: total duration, three females, 22, 24 and 28 days; a fourth, already in seventh instar when captured, molted on the 24th day.

BEHAVIOR.

(Text-fig. 14; Pl. I, Fig. 4).

COURTSHIP DISPLAY.

DIAGNOSIS: *Stage 1a.* A short series of rapid, side-to-side rocking jiggles. *Stage 1b.* First legs extended forward, straight, parallel, and raised to 45° angle above the horizontal. Often punctuated with the rocking of *Stage 1a.* *Stage 2.* The usual forward extension of first legs to horizontal to touch female and creep over her. At no point in courtship are the decorated fourth legs used, or even visible.

DESCRIPTION: *Stage 1a.* Carapace moderately elevated, all legs touching ground; abdomen slightly pendent; palps hang down, at outer sides of clypeus. Action is an exceedingly swift rocking motion from side to side. Analyzed from motion picture film, this is seen to consist of (1) alternate shifts of the carapace to right and left and (2) a corresponding, complicated bending and shifting of the legs; those on the side of the tilted body are gathered in a forwardly-directed cluster, the femora bent up and the patellae down at strong angles; those of the opposite side are well extended laterally, the first and fourth legs serving as props fore and aft, while the second and third are variably extended, usually close together, between. A series consists of from a single pair of rocks to about four pairs; they are of such lightning speed that even a 16-mm. camera at 24-frames per second fails to stop the blur of action. The abdomen swings pendulum fashion in the opposite direction from that of the sinking of the carapace.

A series of rocks alternate with approaching zigzags.

Stage 1b. Body elevated moderately on second, third and fourth legs; first two legs directed straight out to front, parallel, and elevated to angle of 45° or more above the horizontal; palps hang down at sides of clypeus, motionless; abdomen extended straight out. This stage is often punctuated with rocking of Stage 1a, sometimes with the first legs remaining in air.

Stage 2. Typical, the first legs being lowered to the horizontal position to touch the female as she allows it and to creep over her into copulating position. There is practically no preliminary patting.

THREAT DISPLAY.

DIAGNOSIS: *Stage 1.* The identical rapid, rocking jiggle used in courtship, Stage 1a (p. 35). *Stage 2.* Body elevated high on first legs; second, third and fourth pairs all off ground, raised successively higher forming perfect fan; posing for several seconds in this position.

DESCRIPTION. *Stage 1.* Rocking. The rocking motion is less important in threat than in courtship, being almost always confined to one or two jiggles before the fan display, rarely occurring between the fan displays; once or twice I have seen it omitted altogether from threat displays.

Stage 2. Carapace supported on tips of first legs, the femora being held at right angles to body, the distal segments arching widely to touch ground far out from carapace; the other three pairs are arched successively higher and more widely, all held free of the ground, suggesting a perfect fan, and held up to several seconds in statuesque immobility. The yellow dorsal fringe of the fourth leg, as well as the pale feet of all are very conspicuous. At the height of display the tip of the abdomen often touches the ground as a prop. The palps are held motionless, their yellow-haired distal-femora, patellae and tibiae touching each other in the midline below the yellow clypeal beard; the black tarsi are often directed outward.

The aggressor advances sidewise from time to time, between fan posing, always facing his opponent, an inch in one direction an inch in the other. For this progress, the second or second and third pairs are lowered, to be raised again into rigid fan position as soon as he stops. The abdomen is never raised to the horizontal in these progressions, but is just cleared of the ground; rocking between fan displays, as has been said, occurs only rarely. Sometimes, at start of the fan phase, the third and fourth legs twitch up and down in the air, before motionless posing; in view of its rare occurrence, it seems likely that only balancing is involved, rather than a peacock-like shimmer of iridescence; on the other hand, since this vibration would seem to increase the play of iridescence, it may be a tendency being en-

couraged in the species by natural selection, which has not reached its full development.

This species was seen actually to fight only once. On this occasion two males were confined much more closely than usual, in a photographic cell only an inch square, under hot lights. Poison injected by his opponent's chelicerae kept one of them incapacitated, upside down, for an hour, but at the end of that time he recovered fully. The second-long fight started and finished so quickly that I missed seeing whether the usual aggressive display preceded it. No such behavior was ever seen in the field, or in the usual roomy observation dishes.

HABITS ASSOCIATED WITH BROODING.

Five females which molted and mated in the laboratory laid eggs on the 27th, 28th, 30th, 33rd and 39th day after molting, respectively. Only those laid on the 30th and 33rd day hatched; the parent females of these young were mated on the 9th and about the 19th day after molting, respectively. A sixth female laid eggs on the 44th day after capture as an adult; those eggs also failed to hatch. The second clutch of individual females, were, as usual, laid a few days before the young of the first clutch left the cocoon, that is, about three weeks after the first clutch was laid (two examples); a third clutch was laid by one female 35 days after the second; most of the second lot, however, failed to hatch, and none of the third, nor of the later clutches of other females.

The cocoon is typical, spun on the underside of a dead leaf, flat, with the central mass of eggs, within the fine inner sac, forming a bulge; the dimensions of the whole are about 7.5×9.6 mm. The eggs, numbering 14 to 21 (four perfect first clutches counted) are straw yellow (Ridgway), and measure .34-.44 mm. Eggs of later clutches range from almost normal numbers to four or five; none of these small clutches ever hatched. The period of incubation is between 15 and 18 days (two examples).

SEASONAL OCCURRENCE.

There was a decided peak of abundance at the beginning of the rainy season in both 1945 and 1946, extending roughly from mid-April to mid-May. However, the species was exceedingly scarce throughout its range in 1946, or perhaps 1945 was a season of abnormal abundance. The chief weather characteristic of early 1946 was an early and chilly wet season. Thanks to a 150-foot stretch of path along the Water Trail near the laboratory, fairly accurate counts could be made throughout each season. Maxima of around 60 were counted on a number of days early in the rainy season during 1945; the following year no more than 6 were ever counted in a single day under apparently identical conditions. Thirty minutes were used to cover exactly the same strip of ground each time, a careful watch being kept

about three feet to each side of the path, that is, to the edge of the cleared space. It was found by sifting experiments (see below) and observation that very few individuals stayed out of sight under the leaves, especially during optimum weather for the species. These conditions included a moderate amount of sun filtering through the canopy following a rainy or densely misty night. Practice made the spiders very easy to see. Curiously, very few young were observed in either year. This observation area was never disturbed by sifting, but about 20 yard-square samples, taken from time to time from adjacent, equally rich pathside leaves yielded practically no early stadia. Before the sifting, it was assumed that very young spiders in particular hunted such prey as collembola in the lower part of the litter. However, more sifting should be done in years of abundance.

HABITAT.

This species seems to be confined to semi-evergreen seasonal forest and the lower borders of montane rain forest, from 740 to 1,100 meters; the individuals at the lower levels were found in semi-evergreen seasonal riverbed intrusions into deciduous forests. They were never taken in typical samples of the latter, nor in the immoderately mist-laden slopes of the pure montane cloud forest above Rancho Grande. They are completely terrestrial, among dead leaves on edges of clearings and trails; they never occur in dense undergrowth on the one hand nor in bright, often dried areas like open roadsides on the other.

RELATIONSHIPS.

C. xanthopa does not appear to be closely related to any species so far described. The strong fourth leg fringes set it apart at once from all described Central American and West Indian *Corythalia*. *Dynamius fimbriatus* Peckham, 1900, from Brazil, has heavy fringes on all legs, but differs in most other respects. The similarity of the male clypeus decorations to those of the otherwise very different *C. canalis* (Chamberlin, 1925) is a good example of the sporadic appearance of male decorations.

MATERIAL.

A total of 116 specimens of *C. xanthopa* have been preserved, including exuviae. They are distributed as follows among the instars: the first instar, 13; second, 11; third, 4; fourth, none; fifth, 3; sixth, ♀, 5; sixth, ♂, 7; seventh, ♀, 15; adult, ♀, 28; adult, ♂, 30. All were taken within a radius of two kilometers of Rancho Grande. The following have been designated as holotype and paratype:

HOLOTYPE: Male. Cat. No. 461195, Department of Tropical Research, New York Zoological Society; Water Trail, Rancho Grande, near Maracay, State of Aragua, Venezuela; 1,100 meters; lower cloud forest; Mar. 14, 1946.

PARATYPE: Female. Cat. No. 461196, Department of Tropical Research, New York Zoological Society; same location as holotype; Sept. 2, 1946.

The name *xanthopa* is proposed in reference to the conspicuous yellow face of the male.

SUMMARY.

Three new species of *Corythalia*—*chalicea*, *fulgipedia* and *xanthopa*—are described after detailed study in the field and laboratory. All were taken on a single mountain range of the coastal Andes of Venezuela, at elevations of 700 to 1,300 meters; the niches of all the species overlapped.

Range of variation in color, measurements, proportions and integumentary structures are emphasized in each species, the course of their post-embryological development is traced and display behavior recorded. In these descriptions lie clues to the evolution of the genus and family, to the maintenance of specific barriers and to the evolution of display. Discussion of these subjects will follow in subsequent sections of this study. Here may be noted the following points of general interest to students of spider development and speciation:

1. *Specific differences:* In adults, the greatest specific distinctions occur in color and in display behavior; the principal minor differences involve size, carapace shape, leg length, form and size of palp and epigynum, presence or absence of certain spines and details of the tarsal claw-teeth. In the young, differences are confined principally to color and pattern, and to appearance time of leg pigment, certain scale groups and secondary spines.

2. *Sexual dimorphism:* Color dimorphism ranges from slight to extreme among the three, closely related species. There is little sexual difference in size, the ranges in each species overlapping. The legs, as usual, are slightly longer in the male. Aside from white or colored scales and hairs, the male secondary sexual decorations consist of flattened iridescent areas and fringes on the legs; these structures are closely correlated with display. The sexes cannot certainly be distinguished before the sixth (preadult male) instar.

3. *Instars.* There are seven instars in the male, eight in the female, each of the juvenile stadia lasting from about 12 days to almost two months; the preadult stadium is usually longest. A male and female each lived almost a year from the time of hatching. The first, second, fifth and adult instars show the greatest changes. In the first instar the carapace is about 30% of its adult length; most of the growth occurs in the late stadia.

4. *Proportions.* In the first stadium the carapace is relatively higher, and in the second lower than in the adult. The sternum is broader in early instars. *Corythalia* is unusual in having the two posterior legs longer than the first, correlated with their use in display; this trait is evident even in the first

instar, although the legs are shorter, thicker and more nearly equal at that time. The metatarsi in late stages elongate at the expense of the tarsi.

5. *Eyes*. The anlagen are unmistakably salticid in arrangement and relative size even in the first instar, and in the second are typical of the *Plexippus* group and of *Corythalia*. They are relatively slightly larger than in adults, less recurved, and project farther laterally.

6. *Integumentary structures, including pigment and scales*:

a. *Appearing in first instar*: Primary bristles of carapace and legs.

b. *Appearing in second instar*: Black integumentary pigment of carapace and abdomen; present on legs, if at all, in bands; two primary scaled bands and terminal spots on abdomen; border scales of AME; primary carapace scales (or in third instar); primary spines (all invariable in adult), including some on each spine-bearing segment, especially distally; a few trichobothria and short, pale bristles, all well distributed; tarsal claw-teeth, those of pro- and retro-series being less differentiated than in adult, and those of first legs less distinct from fourth; facial bristles complete (or in third instar).

c. *Appearing in fourth and fifth instars, or later*: Darkening of legs; highly variable secondary scalation, often including metallic bronze scales, on carapace and abdomen; highly variable scalation of legs; secondary spines, many of them variable in adult, and including certain spines on each segment; remaining trichobothria and short bristles; additional teeth on tarsal proclaws, although retroteeth are reduced, especially on anterior legs; chelicerae teeth in sixth instar or later.

d. *Appearing only in adult males*: In all species, fringes and iridescent areas on legs; in two species, complete yellow or bronze scalation of dorsal side of abdomen; in one species, long yellow facial and palp hairs (anlagen in preadult).

e. *Reduction of structures*: Both primary and secondary carapace and leg scalation of the middle and preadult instars are usually reduced or eliminated in the adult male, and sometimes in the adult female as well. Apparently the only other cuticular structures to be reduced in late instars are some teeth on the retroclaws and the primary trochanter bristle.

7. *Display*: Threat displays between rival males are distinct from courtship behavior in all species. The fringed, iridescent legs are always involved in threat display, but in *C. xanthopa* they are never used in courtship. True fighting, in which poison is injected, apparently does not occur in *Corythalia* except under rare laboratory conditions. Unlike most salticids, in all three species the first legs are less specialized than others, and are elevated only in the final stages of courtship and, sometimes, of threat display. Results of experimental work on the release mechanisms and functions of display will be recorded in a subsequent section.

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EXPLANATION OF THE PLATE.

PLATE I.

- Fig. 1. *Corythalia chalcea*. Preliminary posturing of males before threat display.
- Fig. 2. Same. Threat display, Stage I. Lower male is advancing in zigzag motion. Cf. frontal view of climax, Text-fig. 12.
- Fig. 3. Same. Courtship display, Stage II. Female is on vertical wall of box, facing away from male. The male's position, with first legs elevated and extended straight in front of him, is typical of Stage II courtship in all three species. Cf. Stage I, Text-figs. 12-14.
- Fig. 4. *Corythalia xanthopa*. Threat display, Stage I, dorsal view. Cf. Text-fig. 14C.



FIG. 1.



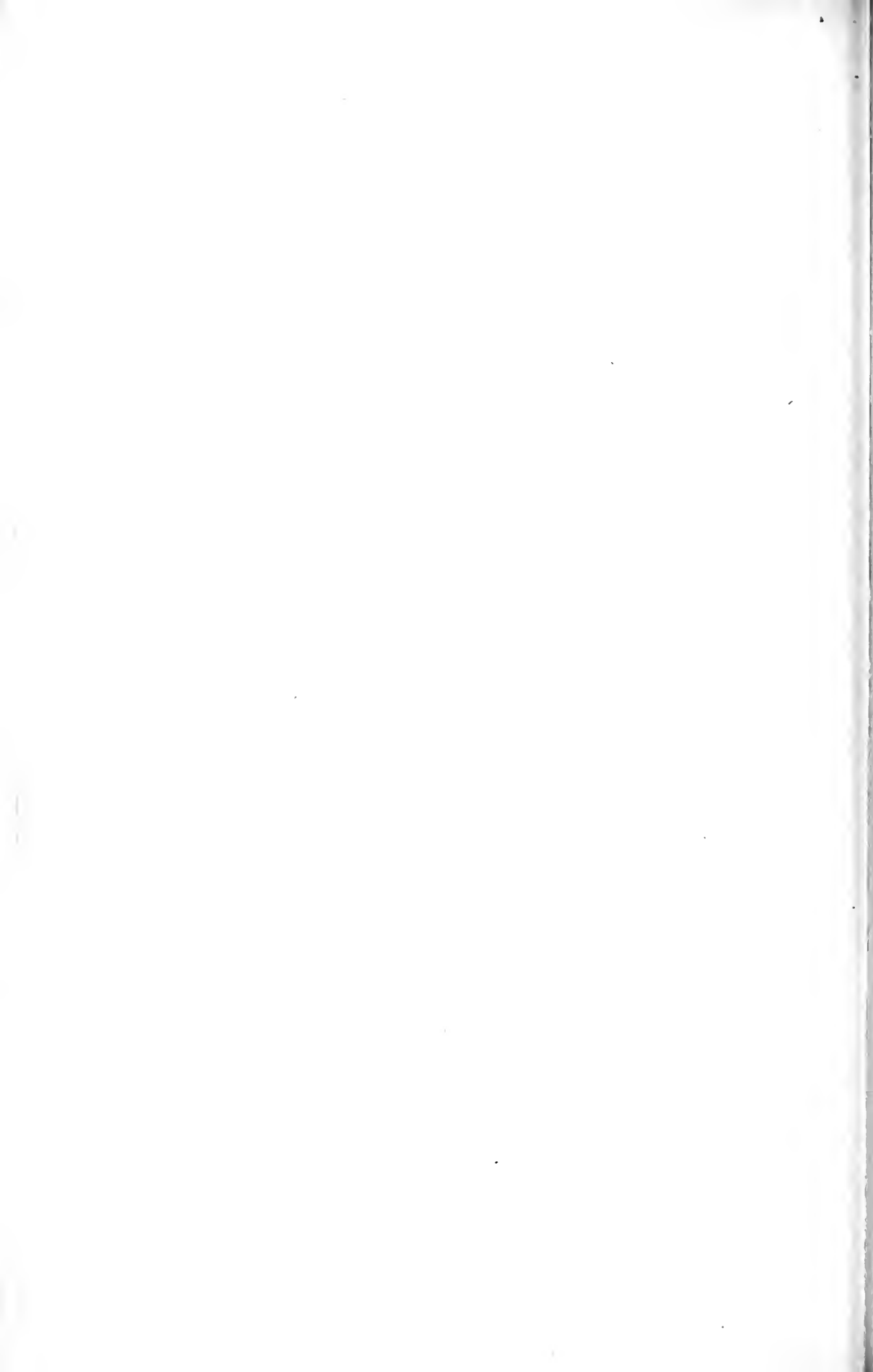
FIG. 2.



FIG. 3.



FIG. 4.



2.

A New Genus and Species of Orneodidae (Moths) from Rancho Grande, North-central Venezuela.¹

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New York Zoological Society.*

(Plate I; Text-figure 1).

[This is one of a series of papers resulting from the 45th and 46th Expeditions of the Department of Tropical Research of the New York Zoological Society, made during 1945 and 1946 under the direction of Dr. William Beebe with headquarters at Rancho Grande in the National Park of Aragua, Venezuela. The expeditions were made possible through the generous cooperation of the National Government of Venezuela and of the Creole Petroleum Corporation.

[The characteristics of the research area are in brief as follows: Rancho Grande is located in north-central Venezuela (10° 21' N. Lat., 67° 41' W. Long.), 80 kilometers west of Caracas, at an elevation of 1,100 meters in the undisturbed montane cloud forest which covers this part of the Caribbean range of the Andes. Adjacent ecological zones include seasonal forest, savanna, thorn woodland, cactus scrub, the fresh water lake of Valencia, and various marine littoral zones. The Rancho Grande area is generally subtropical, being uniformly cool and damp all the year because of the mountain cloud cap. The dry season extends from January until April. The average humidity during the expeditions, including parts of both wet and dry seasons, was 92.4%; the average temperature during the same period was 18° C.: the average annual rainfall over a 5-year period was 174 cm. The flora is marked by an abundance of mosses, ferns and epiphytes of many kinds, as well as a few gigantic trees. For further details see Beebe & Crane, *Zoologica*, Vol. 32, No. 5, 1947. Unless otherwise stated, the specimens discussed in the present paper were taken in the montane cloud forest zone, within a radius of 1 kilometer of Rancho Grande.]

INTRODUCTION.

Four individuals of Orneodidae were collected at Rancho Grande, Venezuela, in 1946. All the specimens belong to a new genus and species. The specimens were captured along the road connecting Rancho Grande with Ocumare de la Costa, between kilometers 24 and 26. This region is approximately 3,400 feet high and is on the ocean side of the pass. The area is usually blanketed in clouds for the greater part of the day with the result that the vegetation rarely fails to be dripping with moisture (see Beebe and Crane, 1947, for maps and ecology).

The specimens were caught at separate times in 1946 but always on foggy days. It was necessary to beat the fog-drenched

bushes to startle the moths into flight, and unfortunately the insects were usually deluged. Three of the specimens were caught at the base of high, moist banks and the remaining specimen less than 15 feet from a similar bank. The pyraustid moth *Lamprosema coeruleonigra* Schaus was very common in the localities where the orneodids were taken and were distinctly partial to the same type of ecological niche. No Orneodidae were taken at lights although we operated lamps in this area in an attempt to collect larger series.

I wish to express my thanks to Miss Pamela Marmont for the venation-figure and to Sam Dunton for the photographs.

Alinguata, new genus.

Text-fig. 1.

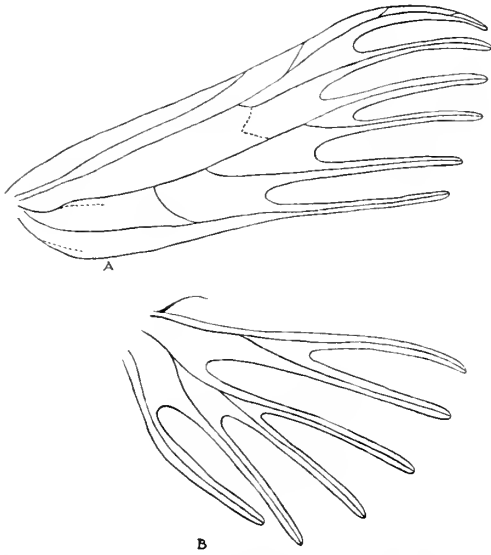
Tongue and maxillary palpi absent. Labial palpi decumbent and as long as width of eye. First joint of labial palpi bulbous; at its distal end broader than second and third joints; pedunculate at its juncture with the head. Second joint with a ventro-lateral tuft of specialized scales extending well along the third joint. Third joint of labial palpi acuminate and as long as second joint. Ocelli conspicuous and very slightly separated from eye. Vertex of head with a prominent anterior bulge, conical in outline looking down on head from above. Angle formed by vertex and front of head acute. The above characters have been determined from a detached head with the scales removed.

Legs slender. Epiphysis covered with long scales extending to first tarsal joint. One pair of spurs on mesothoracic legs and two pairs on metathoracic legs, with the outer spurs slightly shorter than inner spurs.

Forewings not deeply cleft as in Orneodes. Clefts in cell R₃ and in cell M₂ approximately equal in depth and cleft for one-quarter of wing. Cleft in cell M₁ extends for one-third of wing and cleft in cell M₃ but slightly more. Cleft in cell Cu₁ reaches almost to one-half of wing measured along caudal margin of plume Cu₁.

Frenulum in hindwing long and prominent. Clefts of hindwing as follows: Cleft in cell R is one-half of length of wing measured along costal margin, cleft in cell M₁ is five-sixths of length of wing measured

¹Contribution No. 784, Department of Tropical Research, New York Zoological Society.



TEXT-FIG. 1. *Alinguata neblina*. Paratype: (Cat. No. 46132). **A**, venation of forewing. **B**, venation of hindwing.

from tip of plume M_1 to base of wing, cleft in cell M_2 is slightly more than one-half of length of wing measured from tip of plume M_2 to base of wing, cleft in cell M_3 is two-thirds of length of wing measured from tip of plume M_3 to base of wing, and cleft in cell Cu_1 is deepest of all, extending almost to base of wing.

In the forewing only vein R_1 of radials completely absent, but vein R_3 and vein R_4 , which are short and located in first plume, very faint. Vein R_5 a strong tubular vein. Traces of upper discocellular vein present. Vein Cu_2 strongly divergent from cell and fuses with vein $2d$ A well before beginning of plume Cu_2 $2d$ A. See text-figure 1 for venation of fore and hindwing.

Alinguata will run to *Paelia* in Meyrick's key (1910, p. 2), from which it may be distinguished by the absence of a tongue. In addition, the third joint of the labial palpi is as long as the second joint in *Alinguata* while the third joint of the labial palpi in *Paelia* is described in the literature as short. If I am correct in interpreting Meyrick's discal cleft (1910, p. 3) as the cleft in cell M_2 , then an additional difference may be noted; this cleft extends to one-half of the forewing in *Paelia* but in *Alinguata* for only a quarter. Walker (1866, p. 1846) in his original description of the genus *Paelia* states that the labial palpi are decumbent, but Meyrick (1910, p. 3) writes that they ascend; in *Alinguata* they are decumbent.

Genotype, *Alinguata neblina*, new species, described below.

***Alinguata neblina*, new species.**

Plate I.

Length of forewing of male 6 mm., of female 7.5 mm.

Head loosely covered with grayish-brown scales. Dorsum of thorax covered with black-

ish-brown scales while the spatulate scales of the patagia have an additional grayish glitter under the microscope. Ventrum of thorax shining, grayish-white. Coxae and femurs silvery gray with scattered brown scales but tibiae brown with scattered gray scales. Prothoracic legs darker than remaining legs. Epiphyses brown. Spurs brown with tan tips. Tarsal segments brown mixed with a few gray scales. A narrow gray band circles each tarsal segment but least prominent on metathoracic legs. Distal band of each leg faintest.

Dorsum of abdomen dark brown and ventrum gray. Abdomen unbanded.

Upper side of wings brownish-black with bluish-white markings in daylight. Under the microscope the color of the wings is bronzy-chocolate brown similar to the colored figure of *Paelia lunuligera* Walker in Meyrick (1910) and the white markings are shining grayish-white. Latter restricted to plumed part of wings and costal margin of forewings.

Forewings with minute patch of grayish-white scales one-eighth from base of wing on costal margin, and a short streak of grayish-white scales approximately one-half from base. Two half circles or crescents composed of grayish-white scales with their centers on the costal margin of the wing are distad of the streak. The three figures are approximately equidistant from each other with the most distal half circle located in the vicinity of the base of the first plume. A very short, grayish-white streak is present in the caudal region of first plume and a grayish-white line distad of the streak runs diagonally across the plume. Another grayish-white half circle follows which is smaller than the half circles previously mentioned and located on the unplumed section of the costal margin. The last figure along the costal margin of the wing is a subterminal streak.

Three V-shaped figures are present on the second plume equidistant from each other and a small irregular patch of grayish-white scales near the base of the plume. These and subsequent Vs mentioned have their apices pointing toward the base of the wing. They are not perfectly shaped Vs like those on the wings of *Paelia lunuligera* Walker and many species of *Orneodes*, as the arms of the V are widespread, and the apices not sharp or pointed.

The third plume also has three equidistant Vs. There is a small patch of grayish-white scales at the base of the third plume on its cephalic margin and another patch on the caudal margin. The latter patch extends over on the fourth plume.

The fourth plume has three Vs but differs from the other plumes in that the two basal Vs are close together.

The fifth plume resembles plumes two and three.

The sixth or last plume has only two Vs. This plume has a small patch of grayish-white figures approximately one-quarter from the base of the plume on the inner

margin of the wing, and another patch at the base of the cephalic margin of the plume.

Ground color of hindwing brownish-black. A patch of white spatulate scales along the costal margin of basal third of wing. A half-circle near the base of the first plume differs from those on the forewing in lying on the inner margin of the first plume rather than on the costal margin. Its center is likewise on the inner margin. There is a V subterminal figure on the first plume. Each of the remaining plumes has four Vs equally spaced from one another, except the last or sixth plume which has only two Vs.

Under side of wings the same as upper, except that the half circle figures along the costal margin of the forewings incomplete on the under side.

Material: A total of four specimens taken as follows: Rancho Grande, north-central

Venezuela: June 24, ♀ holotype (Cat. No. 461069); July 3, ♂ allotype (Cat. No. 461067); March 18, ♀ paratype (Cat. No. 46132); July 7, ♂ paratype (Cat. No. 461068).

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EXPLANATION OF THE PLATE.**PLATE I.**

- Fig. 1. *Alinguata neblina*. Holotype: (Cat. No. 461069). Upper side of wings and body.
- Fig. 2. Under side.



FIG. 1.

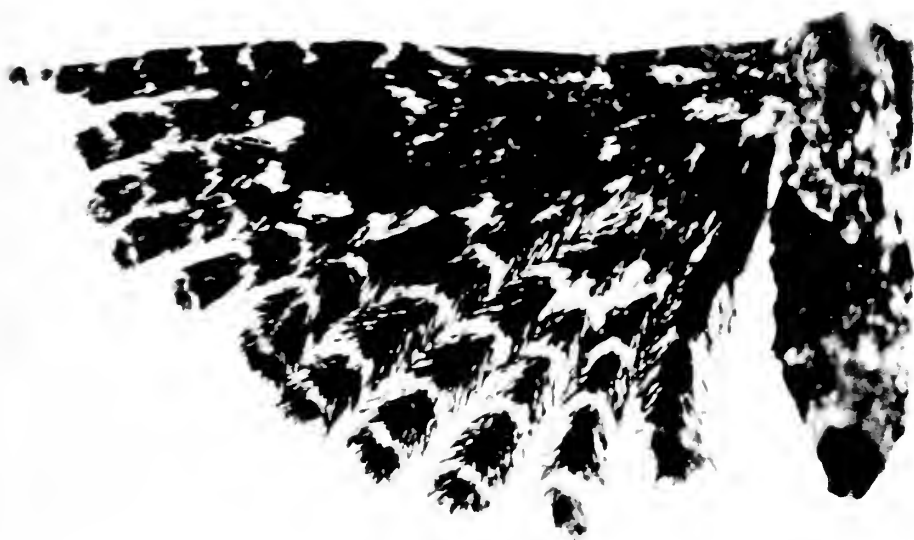


FIG. 2.

A NEW GENUS AND SPECIES OF ORNEODIDAE (MOTHS)
FROM RANCHO GRANDE, NORTH-CENTRAL VENEZUELA.



3.

Prickle Cell Hyperplasia in the Snout of the Redhorse Sucker (*Moxostoma aureolum*) Associated with an Infection by the Myxosporidian *Myxobolus moxostomi* sp. nov.

ROSS F. NIGRELLI.

New York Aquarium, New York Zoological Society.

(Plates I-III).

INTRODUCTION.

The corium is the primary site of infection for many histozoic myxosporidians. Tissue responses to such infection are usually manifest as inflammatory reactions and hyperplasia of connective tissue which often form the cysts enclosing the developing spores (Kudo, 1919, 1929, 1930, 1934; Nigrelli and Smith, 1938). The degree of these responses varies with the host, parasite and site of infection. In certain instances the connective tissue cells become highly modified, transforming into epithelioid-like cells. Such a case was reported by Kudo (1929, 1934, 1946) for the connective tissue cells in the corium of the minnow, *Pimephales* (= *Hyborhynchus*) *natatus*, infected with *Thelohanellus* (*Myxobolus*) *notatus* (Mavor). Occasionally a hyperplasia of the epithelium is also associated with these infections (Nigrelli and Smith, 1940), although in most cases there is a tendency for this structure to become thin and sloughed as a result of pressure induced by the enlarging underlying cysts.

The present contribution deals with a new species of myxosporidian, *Myxobolus moxostomi*, found in the corium of the snout of the northern redhorse sucker, *Moxostoma aureolum* (LeSueur), collected in Illinois. Associated with this growth is an hypertrophy of the overlying epithelium in which prickle cells are the main cellular elements involved.

The writer wishes to thank Dr. G. M. Smith for assistance in preparation of the material.

DESCRIPTION OF THE PARASITE.

The affected fish showed a marked swelling in the midregion of the snout just above the maxilla. No external cysts were visible. The fish was sacrificed and the swollen part excised and fixed in 10% neutral formalin. Paraffin sections were cut at six microns and stained with hematoxylin-eosin, Mallory's, Masson's and Giemsa's methods.

The infection was localized in the corium. The cysts were composed of delicately developed connective tissue, and were more or less confluent (Plate I, figure 1). Those that were discrete measured from 0.5 mm. to

4 mm. The central part of the cysts contained numerous spores, a smaller number of developing disporablastic pansporoblasts and cellular debris.

Like the other members of the genus *Myxobolus*, the parasites are polysporous. The spores (Plate I, figure 2) varied in shape from circular to ovoid in front view and were fusiform, with more or less rounded tips in side view. They measured $6.2-9.4 \times 5.5-9.4 \times 3.1-4.7$ microns (average, $7.6 \times 7.2 \times 3.9$ microns). It can be assumed that the living spores were slightly larger than the measurements indicated since some shrinkage must have occurred during fixation. The shell was of uniform thickness, with several darkly-staining bodies present in many of the (immature?) spores. The sutural ridge and line were not especially conspicuous. The polar capsules were pyriform in shape, often convergent. They measured $2.3-3.9 \times 1.6-3.2$ microns (average, 3.6×2.3). The polar filament, when evident, showed from three to five spiral turns. The sporoplasm was either uninucleate or binucleate. An iodophilous vacuole was evident in many spores.

This parasite was tentatively identified by Nigrelli (1943) as *Myxobolus conspicuus* Kudo. However, a more detailed comparison of the present species with those reported by Kudo (1934) from the same and related fishes is given in Table I. It differs from them in shape and size of spore, details in structure of shell, site of infection and type of tissue responses elicited. The most striking difference is found in measurements of the various parts of the spore. It is for these reasons that it is considered a new species for which the name *Myxobolus moxostomi* is given.

PATHOLOGY.

The actual site of infection with *Myxobolus moxostomi* was in the deeper layers of the corium. Host response in this region was shown by the development of a delicate fibrous growth around the trophozoite and spore masses. There was some invasion and destruction of muscle and periosteal tissues, accompanied by a mild inflammatory reaction. Corial melanophores were at a minimum.

TABLE I.
Comparison of Species of *Myxobolus* from *Moxostoma*.

PARASITE:	<i>M. morostomi</i> sp. nov.	<i>M. congesti-</i> <i>cus</i> Kudo, 1934	<i>M. vastus</i> Kudo, 1934	<i>M. gravidus</i> Kudo, 1934	<i>M. conspicuus</i> Kudo, 1929
HOST:	<i>M. aureolum</i>	<i>M. anisurum</i>	<i>M. aureolum</i>	<i>M. anisurum</i>	<i>M. breviceps</i>
SITE OF INFECTION:	Corium of head Deep	Fins Superficial	Corium, body scales Superficial	Skin, fins Superficial	Skin of head Superficial
TUMOR:	Present	Present	Present	.....	.....
SIZE OF CYSTS:	0.5-3 mm.	0.3-1 mm.	2.5-3.8 mm.	0.5 mm.	0.5-4 mm.
CONNECTIVE TISSUE DEVELOPMENT:	Minimum	Minimum	Hypertrophy	.....	Hypertrophy
EPIDERMIS:	Hypertrophy	Thin, broken	Thin	.....	Thin, unicel- lular glands absent
VASCULARIZATION:	Poor (region around tro- phozoites)	Rich	Rich	.....	.....
SPORE SHAPE FRONT:	Circular to ovoid	Circular to oval	Oblong	Oval to oblong	Oval
SIDE:	Fusiform, rounded ends	Lenticular	Lenticular	Fusiform	Fusiform
SPORE SIZE:	6.2-9.4 × 5.5- 9.4 × 3.12- 4.68 micra	9-10 × 8.5- 9.5 × 6 micra	9.5-10.5 × 7.5- 8 × 4-4.5 micra	12-14 × 9.5- 10 × 7 micra	9-11.5 × 6.5- 8 × 4.5-5.5 micra
SHELL:	Mod. thick	Mod. thick, radiating folds	Mod. thick 7 radiating lines	Mod. thick, 4-6 folds in post. part	Mod. thick No striations
SUTURAL RIDGE:	Not promi- nent	Wide	Thickened at ends	Inconspicu- ous	Wider than thickness of shell
SUTURAL LINE:	Present	Indistinct	Indistinct	.....	Straight
CAPSULE SHAPE:	Pyriform, slightly divergent	Pyriform, convergent	Pyriform	Pyriform, convergent	Pyriform, dissimilar in size
SIZE:	2.3-3.9 × 1.56- 3.2 micra	5-6 × 2.5-3.5 micra	4.5-5.5 × 1.5 -2.5 micra	5-5.5 × 2.5 micra	5-7 × 2-2.5 micra
FILAMENT:	3 to 5 turns	.....	.....	.....	10 turns

The most striking changes, however, were noted in regions immediately above and adjacent to the actual site of infection (Plate II, figure 3). The fibrous growth here was considerably thickened and more vascularized. In some areas of the growth, the connective tissue appeared to give rise to a supporting stroma of the hypertrophied stratified epithelium. The cellular elements of the latter were mainly prickle cells showing prominent intercellular bridges (Plate III, figure 5). In some parts of the growth the cells appeared as normal polygonal-shaped structures with finely granular cytoplasm and nucleoplasm; the latter occasionally contained several deeply stained, peripherally placed granules of various sizes. The majority of nuclei also possessed a single

nucleolus and few cells showed two such bodies. In most cells the staining reaction of the nucleus was not intense with hematoxylin, but isolated groups of prickle cells were encountered in which this structure was definitely hyperchromatic. Although no mitotic figures were found there was some evidence of activity. In certain regions the cells had broken through the basement membrane and invaded the corium (Plate II, figure 4). The invasion, however, was not extensive.

In other regions of the growth there was considerable evidence of degeneration. The prickle cell growth had crowded and destroyed the mucous gland cells of the skin. The outermost layer of prickle cells showed the greatest changes, manifested metachromatically

with Masson's and Giemsa's stains. The nucleoli of these cells were larger and often filled the entire nucleus. These regions also showed considerable infiltration by macrophages.

DISCUSSION.

Kudo (1929) and Nigrelli and Smith (1940) have shown that histozoic myxosporidian parasites may induce a thickening of the epithelium in the regions of the infection. Auerbach (1909) also found that the coelozoic parasite *Myxidium bergense* may cause a thickening of the epithelium of the gall bladder of *Gadus virens*. In these cases the parasites were in more intimate contact with the tissues involved. In the redborse sucker, the epithelial hyperplasia was immediately above but some distance away from the infection. Whether or not there was any direct association between the infection and the hyperplastic growth is difficult to say.

Intercellular and intracellular cnidosporidians elaborate proteolytic enzymes and other chemical substances which may be responsible for considerable cellular degeneration, cell hypertrophy and other tissue responses noted in these infections. It is altogether possible that chemical substances elaborated by the developing parasites may have a stimulating growth factor which may diffuse to more distant areas either directly or through the circulation.

SUMMARY.

A new species of myxosporidian, *Myxobolus moxostomi*, from the corium of the snout of the common redborse sucker, *Moxostoma aureolum* (LeSueur), is described.

Hyperplasia of the connective tissue and stratified epithelium is associated with the infection. In the hyperplastic epithelium, prickle cells are the main cellular elements involved.

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EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. Section through cysts showing numerous spores of *Myxobolus morostomi* together with a few pansporoblasts and other cellular elements. Giemsa. $\times 75$.
- Fig. 2. Mature and immature spores of *Myxobolus morostomi*. Giemsa. $\times 675$.

PLATE II.

- Fig. 3. Section through the overlying growth showing extensive development of corial fibrous tissue and hyperplastic epithelium. Hematoxylin-eosin. $\times 75$.
- Fig. 4. Basal columnar cells of the hyperplastic epithelium showing infiltration into the corium. Hematoxylin-eosin. $\times 675$.

PLATE III.

- Fig. 5. Prickle cells of the hyperplastic epithelium. Hematoxylin-eosin. $\times 675$.

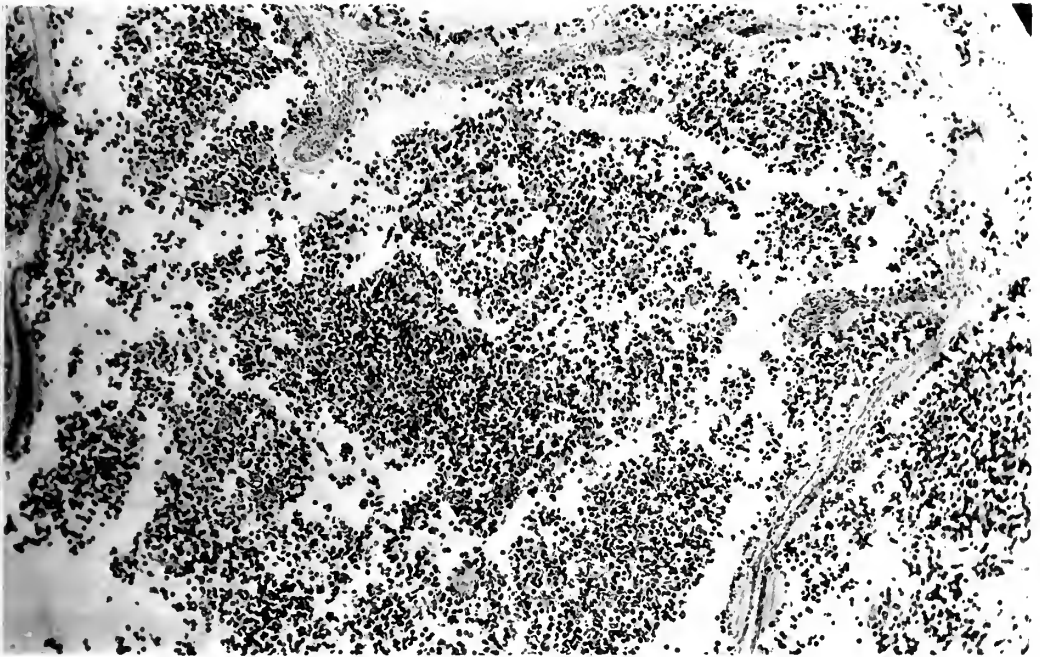


FIG. 1.

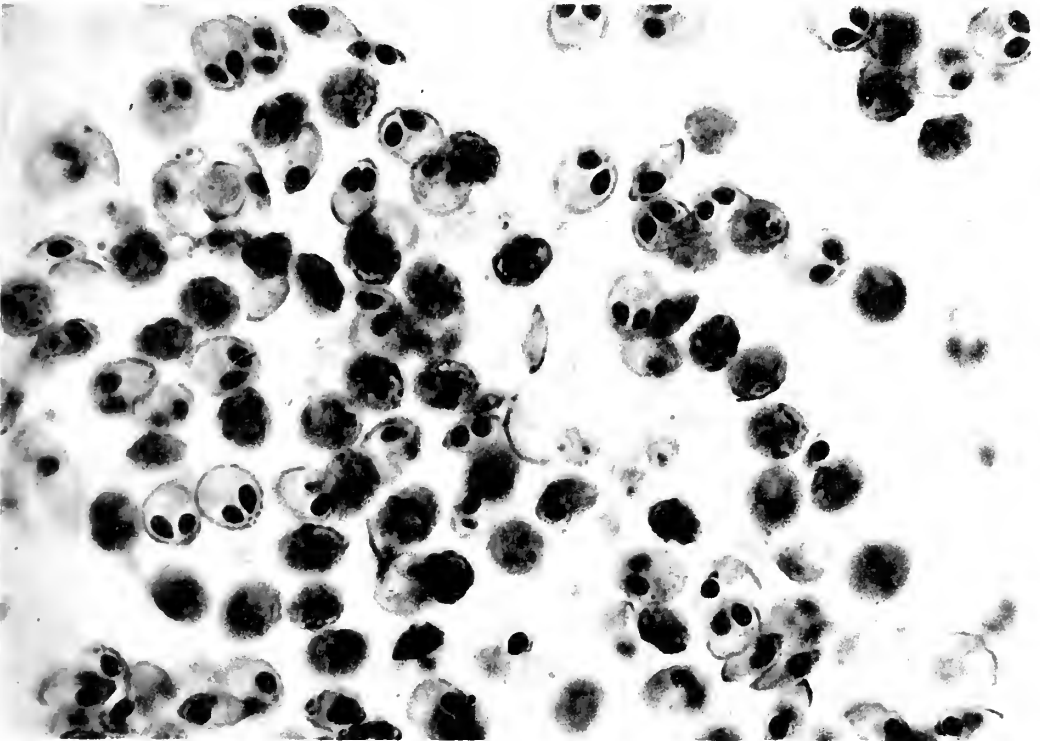
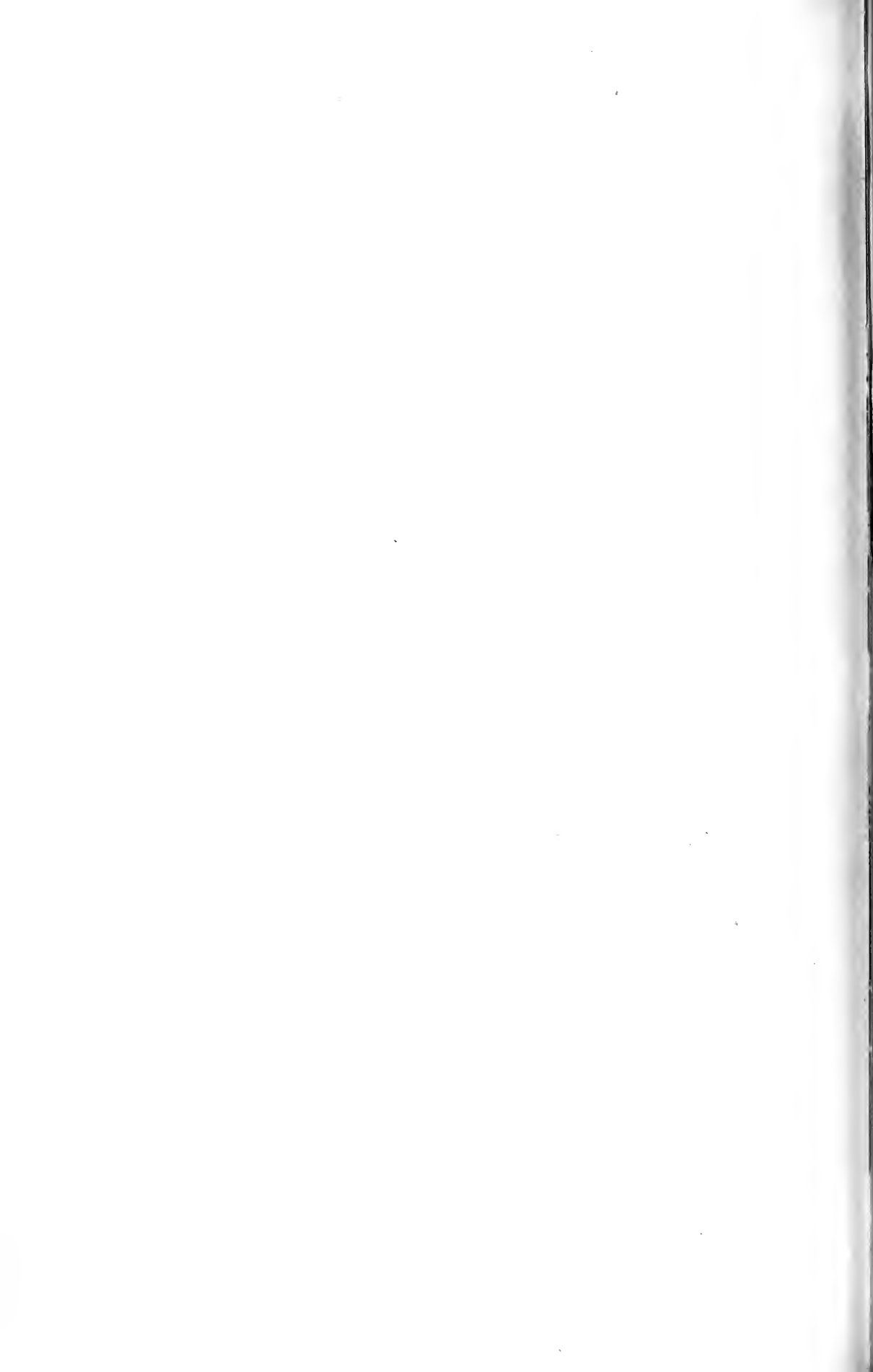


FIG. 2.

PRICKLE CELL HYPERPLASIA IN THE SNOUT OF THE REDHORSE SUCKER
(*MOXOSTOMA AUREOLUM*) ASSOCIATED WITH AN INFECTION
BY THE MYXOSPORIDIAN, *MYXOBOLUS MOXOSTOMI* SP. NOV.



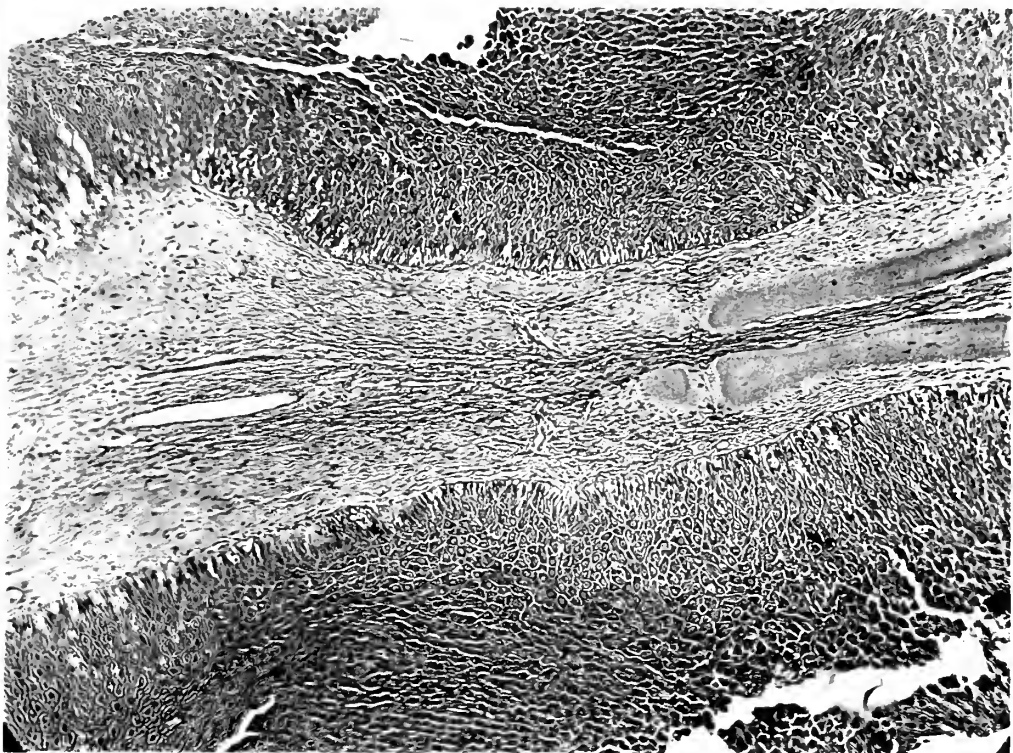


FIG. 3.

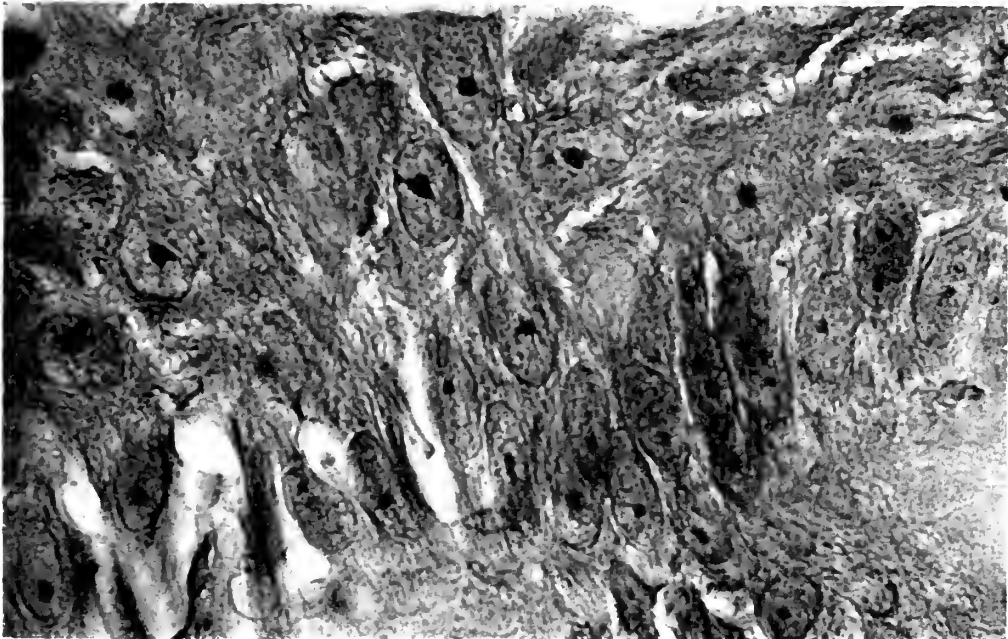
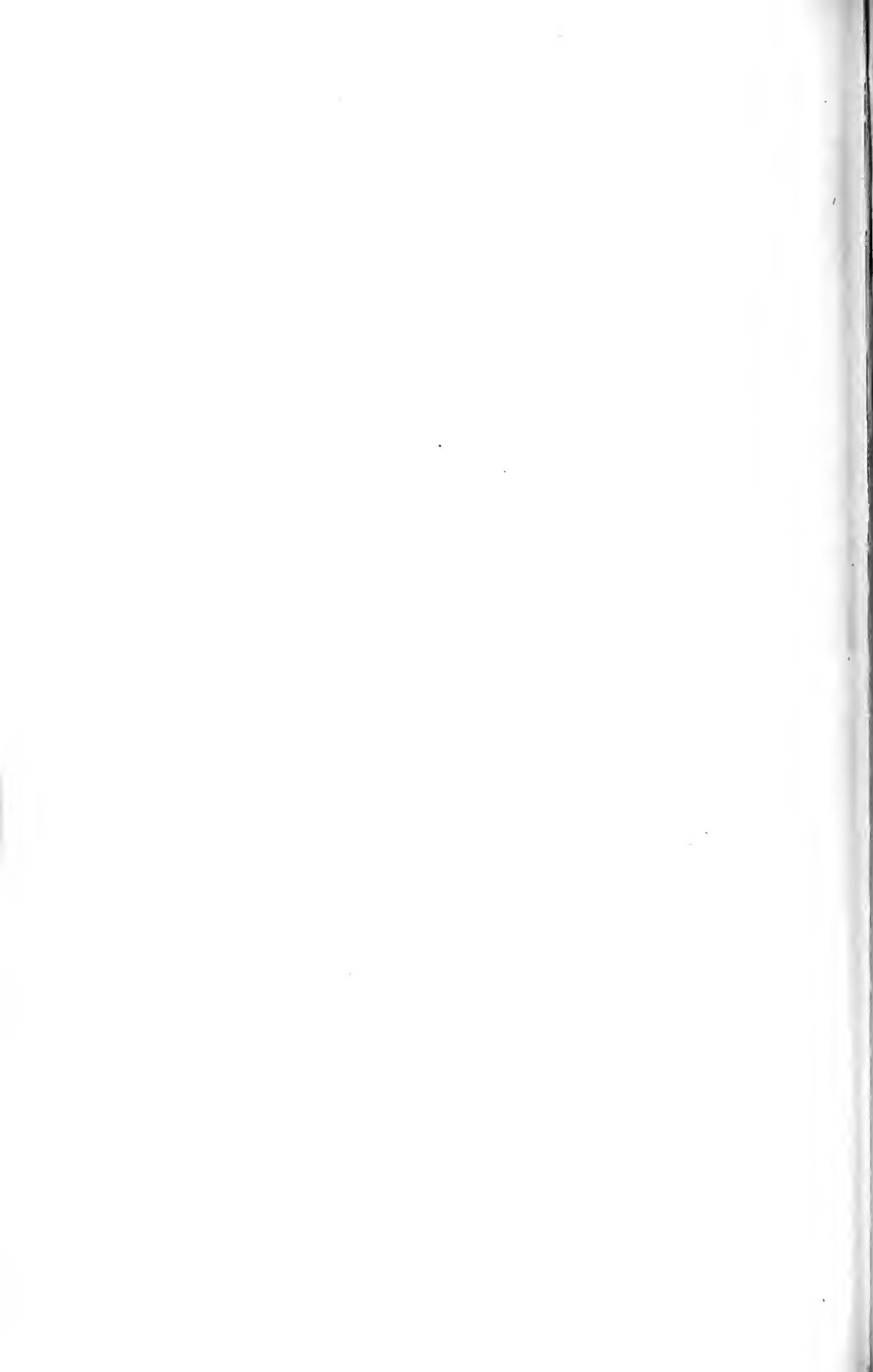


FIG. 4.

PRICKLE CELL HYPERPLASIA IN THE SNOUT OF THE REDHORSE SUCKER
(*MOXOSTOMA AUREOLUM*) ASSOCIATED WITH AN INFECTION
BY THE MYXOSPORIDIAN, *MYXOBOLUS MOXOSTOMI* SP. NOV.



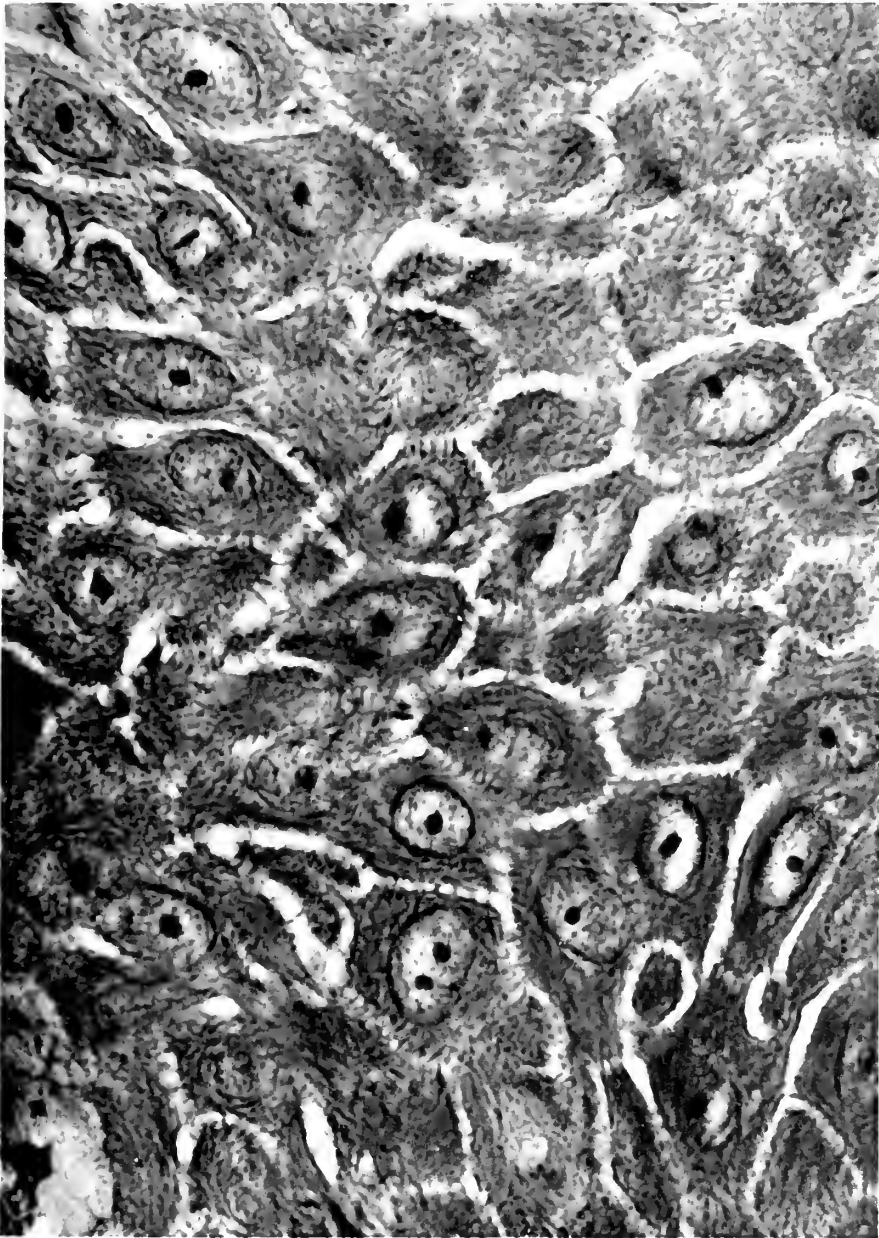


FIG. 5.

PRICKLE CELL HYPERPLASIA IN THE SNOOT OF THE REDHORSE SUCKER
(*MOXOSTOMA AUREOLUM*) ASSOCIATED WITH AN INFECTION
BY THE MYXOSPORIDIAN, *MYXOBOLUS MOXOSTOMI* SP. NOV.



4.

Odonata (Dragonflies) of Kartabo, Bartica District, British Guiana.¹

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(Plates I & II).

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[This contribution is a result of various expeditions of the Department of Tropical Research of the New York Zoological Society, all made under the direction of Dr. William Beebe. The Guiana trips were made during the years 1909, 1916, 1917, 1919, 1920, 1922, 1924 and 1926. The Kartabo collections and observations were carried on in one-quarter of a square mile of jungle. For detailed ecological and meteorological notes see *Zoologica*, Vol. II, No. 7, 1919, pp. 205-227.]

INTRODUCTION.

Dr. William Beebe has asked me to report on the Odonata taken at the New York Zoological Society's Tropical Research Laboratory at Kartabo, British Guiana. The collection contains many interesting forms which, in a number of instances, have prompted some excursions into their ecological relations. With Dr. Beebe's consent, I have included smaller lots, hitherto unreported, collected by Dr. Charles Hodge, IV, at Kartabo in July-August, 1926; by Mr. George B. Fox along the Essequibo River; and by the late Dr. William Schaus in French Guiana. The first two lots are in the Academy of Natural Sciences of Philadelphia, the third was sent to me for study some years ago, by the United States National Museum. The

¹ Contribution No. 797, Department of Tropical Research, New York Zoological Society.

types of the new species of Dr. Beebe's collection are deposited in the Academy of Natural Sciences of Philadelphia, as is also the type of one other species. The Odonate fauna of Guiana not represented in these four collections is not considered in this paper.

The only attempt² at a list of the Odonata of any of the Guianas known to me is that of W. F. Erichson of 1848, as a section of the Insect part of Richard Schomburgk's "Reisen in Britisch Guiana in den Jahren 1840-1844 im Auftrag Sr. Majestät des Königs von Preussen," Band III, pp. 583-586. Twenty-six species of Odonata are listed, without localities for any of them; fourteen of them are described, ten of the fourteen, including three credited to Hoff[manse]gg, as new species. Seventeen species of Erichson's list are represented in the collections from Kartabo.

Taxonomic works before and after Erichson—Rambur, deSelys, Hagen, Kirby, Förster, the Williamsons, Montgomer, Borrer, Campion, Martin, Ris, Needham, Geijskes and the present writer—add many other species from the Guianas.

DISTRIBUTION OF THE KARTABO ODONATA.

The flora at the Kartabo laboratory is described as consisting of the typical rain forest of eastern South America with swampy areas and clearings made by Dutch and Indian planters.³ It is of interest to compare the distribution of the Kartabo Odonata, throughout the entire geographic range of each species, with Messrs. Dillon and Smith's Generalized Phytogeographic Map of Latin America.⁴ That map divides Latin America, from the northern boundary of Mexico to Cape Horn and including the West Indies, into 14 zones characterized by vegetation features. Kartabo and most of the Guianas lie in Zone 1, "tropical and subtropical rain forest," while a narrow band along the coast, in which Georgetown, Paramaribo and Cayenne lie, is part of Zone 7, "savanna regions."

In making the allocations which follow, it is not to be forgotten that the Odonata of large areas of South America are still unknown. The map employed is indeed generalized, in that its scale does not permit showing the microgeographic details so interpenetrating in a continent of such abrupt

changes in altitude (with all that they imply). Forest and clearings are frequented by different species of Odonata, and even the small area of study at the Kartabo laboratory, 2,000 by 4,000 ft. (650 × 1,300 m.), embraces at least these two kinds of habitat. It must be remembered, too, that the powers of flight of many Odonata are such as to enable them to pass easily from one sort of habitat to another; the correlation of the carnivorous Odonata with the flora must be indirect in most cases, through the intermediation of the phytophagous animals which in turn serve as food for the Odonates; and that more direct relations between dragonflies and plants exist where certain plants, such as bromeliads, serve the oviposition needs of certain Odonata (*Mecistogaster*).⁵ The real index to Odonate distribution is not that of the winged adults but of the aquatic larvae and of the latter we are still almost entirely ignorant.

But with all these considerations, the results of allocating the Kartabo Odonata to the zones of Dillon and Smith's map are striking.

Of the 75 identified species here treated, none falls within zone 4 (palm forests), 5 (sub-antarctic heath forest), 9 (coastal desert of Pacific South America), 10 (Patagonian-Fuegian steppes) or 12 (transitional vegetation of central Chile).

In zone 11 (desert scrub) appears only the widespread *Orthemis ferruginea* (in Sonora), which occurs abundantly in zones 1-3, 6, 7 and 14.

In connection with each of the following lists of species (*a-f*), after indicating the plant zones of Messrs. Dillon & Smith (DS.) in which they fall, it is pointed out how far these areas agree with the provinces of South American scorpions proposed by Dr. Mello-Leitão⁶ (ML) and the districts of South American mammals proposed by Drs. Cabrera and Yapes⁷ (CY).

⁵ Another case, although not pertaining to the Guianan fauna, is that seen by E. B. Williamson at the Quebrada Sabaleticus, in Antioquia, Colombia, and thus described: "Here for the first time we saw *Cora* and observed its peculiar habit of ovipositing, which it shares with *Miocora*. The eggs are inserted in comparatively solid but barkless horizontal tree trunks or pieces of logs over water. In some cases the logs were scarcely damp, and the eggs were placed as high as six feet above the water." (*Misc. Publ. Mus. Zool. Univ. Mich.*, 3, 17, 1918.) Whether it is merely the physical condition of the logs which determines oviposition in them, irrespective of their kind, is not stated. Still more remote from the Guianan fauna is the case of the European *Aeshna viridis* which is believed by Wesenberg-Lund (*Internat. Revue Gesam. Hydrobiol. Hydrogr.*, 6:191, 389, 1913) and Münchberg (*Ztschr. Morph. Ökol. Tiere*, 20 (1): 181-183, 1930) to oviposit only in living plants of *Stratiotes aloides*. Münchberg states that *Anax parthenope*, in Grenzmark, eastern Prussia, oviposits in *Phragmites communis*, less often in *Scirpus lacustris*, never in dead plant tissue (SB. Ges. Naturf. Freunde, Berlin, 1932: 71).

⁶ 1945. *Arquivos Mus. Nac. Rio de Janeiro*, 40:9-468, map fig. 185.

⁷ 1940. *Historia Natural Ediar Mamíferos Sud-Americanos*. Compania Argentina de Editores, Buenos Aires, 4to, 370 pp. Map facing p. 14: reproduced as fig. 184 of Mello-Leitão above quoted.

² Whether Carl Peter Thunberg's "Fauna Surinamensis Resp. Collin. 12 Dezbr. 1822. Upsaliae, Acad. Typogr. 4 p. 1-8" and "Fauna Cayenensis, Resp. Kjeller. 4. Juni 1823. Upsaliae, Palmlad. 4. p. 1-11," thus quoted in Horn u. Schlenkling's *Index Litteraturae Entomologicae*, Band IV, p. 1229 (1929), contain anything on Odonata, I do not know, as I have not seen them.

³ Beebe, W., 1925; Beebe, W. & Gleason, H. A., 1925, *The Guianas, in Naturalist's Guide to the Americas*. Baltimore, Williams & Wilkins Co., pp. 654-655.

⁴ Accompanying Smith, A. C. and Johnston, I. M., 1945. *A Phytogeographic sketch of Latin America*. Plants & Plant Science in Latin America, XVI, pp. 11-18. Chronica Botanica Co., Waltham, Mass.

Passing to Odonata of narrower geographic distribution, there are:

(a) Those at present known only from zone 1 (DS) (tropical and sub-tropical rain forest) of the Guianas and including in some cases the island of Trinidad. These are:

*Argia insipida*⁸
*Leptagrion beebeanum*⁹
Leptagrion sp.
Aeolagrion demerarum
Acanthagrion adustum
*Metaleptobasis tetragena*⁹
Neonura joana
Protoneura calverti
*Aphylla alia*⁹
Gomphoides fuliginosa
Macrothemis pumila (occurs also in zone 7, savannas at Georgetown)

It is quite likely that the apparently limited distribution of these species is due to scanty knowledge on our part.

Kartabo lies within the Carib province (ML) or the Amazonian district (CY). The Carib province roughly corresponds to the Savanna (Sabanico) district but its southern boundary is farther south and extends farther to the east.

(b) Species of the Guianas and the Amazon valley in zone 1 (DS) (tropical and sub-tropical rain forest).

Hetaerina moribunda
Microstigma maculatum
Megapodagrion macropus
Zonophora batesi
*Phyllocycla bartica*⁹
Fylgia amazonica
Micrathyria spinifera
Erythrodiplax angustipennis
E. laurentia

These species inhabit the Carib and Amazonian provinces (ML) or the Amazonian district (CY). The two maps of these authors are in agreement as to the southern and western boundaries of the Amazonian area.

(c) Species extending across much of the northern part of South America, but not farther north and not farther south than the Amazon valley.

Hetaerina dominula
Mecistogaster lucretia
Phyllocycla signata
Progomphus dorsopallidus
Archaeogomphus hamatus
Aeschnosoma peruviana
Orthemis aequilibris
Diastatops dimidiata
Zenithoptera fasciata
Oligoclada raineyi

Five of these species are in our present

knowledge limited to zone 1 (DS), but *M. lucretia* and *P. dorsopallidus* occur also in zone 6 (thorn forest), *Z. fasciata* in 1 and 7 (savannas), *O. aequilibris* in 1, 6 and 7.

These species extend westward into the Incan (Incasica, Incasico) province (ML) or district (CY) which borders the Pacific coast of South America from Panama to Latitude 20° S.; such parts of zone 6 (DS) as they inhabit are along the Venezuelan coast of the Carib province (ML) or Savanna district (CY), while their area of zone 7 (DS) narrowly borders the Atlantic coast of the east end of the Carib and Amazonian provinces (ML) or of the Amazonian district (CY).

(d) Species which extend from the northern coast of South America and in some cases Trinidad (but not farther north) southward beyond the Amazon valley and falling in zones 1 and, mostly, in 7 (DS).

Mecistogaster linearis (not in 7)
Staurophlebia reticulata reticulata (also in 6)
Gynacantha tenuis
Diastatops pullata
D. obscura (also in 2, tropical deciduous forest)
Perithemis thais (not in 7)
Oligoclada pachystigma
Uracis ovipositrax
U. infumata
Erythrodiplax castanea (also in 2 and 3, south Brazilian forest and savanna zone)
E. latimaculata (also in 2 and 6)
E. maculosa (perhaps also in 2)
E. melanorubra (also in 2 and 6)
Rhodopygia cardinalis
Macrothemis polyneura
Idiataphe longipes longipes

These species add to their distributional areas the Cariri province (ML) which is nearly equivalent to the Tropical district (CY). Some of them invade the Tupi and Guarani provinces (ML) which together correspond to the Tupi and Sub-tropical district (CY) although their respective boundaries in the two maps are different.

(e) Species which extend to the north of South America on the North American continent, to Central America, or to Mexico, or to the United States, but not into the West Indies. They reach in most cases southward below the Amazon valley; the numbers of the DS zones, in addition to zone 1, in which they occur, are added in parentheses.

- i. Not in zone 14 (montane)
 - Hetaerina caja* (2, 6, 7)
 - Megaloprepus caeruleus* (2)
 - Ceratura capreola* (3, 7)
 - Triacanthagyna ditzleri*
 - Gynacantha auricularis* (2, 7)
 - G. gracilis* (2)
 - G. membranalis* (2, 6)

⁸ *Argia insipida* was recorded by Kirby from St. Vincent and Grenada in the West Indies (*Ann. Mag. Nat. Hist.*, (6) 14: 263, 1894); the identification should be confirmed.

⁹ Species described as new in this paper.

Orthemis biolleyi
Uracis imbuta (2, 7)
U. fastigiata (7)
Micrathyria eximia (2, 3)

Some of these species extend southward into the Cariri, Tupi, Guarani and Pampean provinces (ML) or Tropical, Sub-tropical, Tupi and Pampean districts (CY).

ii. Also in zone 14

Libellula herculea (Cuenca) (2, 3, 7, 9?)
Orthemis cultriformis (Chiriqui) (2, 8)
Erythrodiplax connata fusca (Cuernavaca, Vilcanota; possibly Huanuco and Colonia del Perene, both in Peru, lie within zone 14)

The Montane zone (DS) includes the higher altitudes of the Incan, Pampean and Chilean provinces (ML) or of the Incan, Andine, Sub-andine and Chilean districts (CY).

(f) Species extending into the West Indies other than Trinidad and Tobago; these are mostly widespread in South America, Central America and Mexico, and some reach the United States; they all occur in zones 1 and 7, most of them also in 2, of the DS map. The numbers of the zones in addition to zones 1, 2 and 7 in which they occur, as well as the most southern geographical limit, are added in parentheses.

Ceratura capreola (3) (Rio Grande do Sul)

Triacanthagyna septima (6) (Rio de Janeiro)

Gynacantha nervosa (6) Porto Suarez, Bolivia)

Coryphaeschna virens (6) (Santa Cruz, Bolivia)

Orthemis ferruginea (3, 6, 11, 14) (Montevideo)

Erythrodiplax unimaculata (Paraguay)

E. famula famula (Minas Geraes)

E. umbrata (3, 6, 8, 14) (Buenos Aires)

E. basalis basalis (6) (Santa Cruz, Bolivia)

Erythemis peruviana (6) (Corrientes)

E. attala (3, 6, 8, 14) (Buenos Aires)

Leptemis vesiculosa (3, 6, 14) (Corrientes)

Dythemis multipunctata (3, 6, 8) (Buenos Aires)

Tholymis citrina (6) (Minas Geraes)

Pantala flavescens (3, 6, 11, 14) (Sao Paulo)

Tamea cophysa (6, 8, 14) (Santos, Brazil)

(See also footnote 8 on *Argia insipida*, page 49).

It will be seen that these species reach southward into the Tupi, Guarani, Cariri and Pampean provinces (ML) or Tropical, Sub-tropical, Tupi and Pampean districts (CY).

ODONATA FROM KARTABO.

The species here treated are listed under two sets of relevant subfamily names, the

first that of de Selys and Hagen, dating from their *Revue des Odonates* of 1850 and widely used, the second that of the most recent classification of Tillyard and Fraser (*Australian Zoologist*, 9, 1938-40). Where one of the latter subfamilies is more than a subdivision of one of the former, that fact is indicated by marking it with a roman numeral. All these subfamily names are inserted for the convenience of the reader and do not necessarily imply acceptance of them by the present writer. For each species are given only those bibliographical references pertinent to the present text.

CALOPTERYGINAE S. & H., 1850 (as Caloptérygines). HETAERININAE T. & F., 1939.

Hetaerina dominula Hagen, 1853.

(Plate I, figs. 3-6).

Selys & Hagen, 1854, *Monog. Calopt.*: 107, pl. 11, fig. 1 (Surinam).

Williamson, E. B., 1923, *Occas. Papers Mus. Zool. Univ. Mich.*, 130: 15, 19 (Brit. Guiana).

Geijskes, 1943, *Ann. Ent. Soc. Amer.*, 36 (2): 168, pl. II, figs. A-G (nymphs, Surinam).

Kartabo, 22.X.1920, one male, lacks abdominal segments 4-10; 1922, one female.

French Guiana, 60 m(iles) up Maroni River, 8.04, Wm. Schaus, U. S. Nat. Mus., one male.

The Maroni River male is of the same species as two males from Wismar, February 16, 1912, and two males from Tumatumari, February 11, 1912, all four from British Guiana, by L. A. and E. B. Williamson and B. J. Rainey and referred by Williamson (1923) to *dominula*. All five, however, differ from Selys and Hagen's figure of the superior appendages (1854) in having the proximal of the two divisions of the "dilatation" of the inner margin rounded, not acute, and from their description in the yellow of the sides of the thorax being well marked, including the stripe on the first lateral suture and the "terminale" stripe. The superior appendages, however, possess what their description of 1854 gives as a character distinguishing *dominula* from *caja*, viz.: "le bord interne supérieur offre, immédiatement après la dilatation, une petite dent analogue à celle de la *divina*."¹⁰ The yellow lateral thoracic stripes are, however, narrower than the "bronze noirâtre" which separates them and hence differ in this respect from the description of *caja*.

On the other hand, the Wismar and Tumatumari males have the postoccipital tubercles angular and well marked, whereas

¹⁰ On comparing pages 106, 112, 114 and 118 of the *Monographie des Caloptérygines* it would seem that in the original draft of the work it was the intention of the authors to recognize *divina* as a distinct species, but they did not do so and did not alter their original reference to it.

Williamson says (p. 19) that in *dominula* they are low and rounded. The head of the Maroni River male is distorted and the tubercles can not be seen plainly. This apparent contradiction, as well as the condition of the inner dilatation of the superior appendages, caused me to ask Mrs. Leonora K. Floyd to make comparisons with Williamson's specimens at the University of Michigan. She kindly replied as follows (February 22, 1943): "The situation seems to be this. Apparently Mr. Williamson (1923, p. 19) meant that the postoccipital tubercles of *dominula* appear low and rounded in comparison to those of *mortua*, as seen in the field without the aid of a microscope (*caja* was not taken in the same locality). I also looked up Hagen's figure of the superior appendages of *dominula* (cited above) and oriented one of E. B. Williamson's specimens so labeled until the appendages looked very much like Hagen's figure. The specimens Mr. Williamson sent you are of the same species as those at Ann Arbor, so there is no mistake in the labeling."

The Kartabo male lacks the appendages essential for determination. It has the postoccipital tubercles as in the Wismar and Tumatumari males, the yellow stripe absent from the first lateral thoracic suture, the yellow on the second lateral thoracic suture and on the metepimeron so reduced as to be much narrower than the intervening black, thus as originally described for *dominula*, but the (pale) reddish spot of the front wings does not reach the costa and is pale brown between costa and subcosta. The basal spot of the hind wings is pale brown, slightly tinged with red (hence this individual is probably not fully aged), its area corresponding fairly well with the original description.

An envelope containing two *Hetaerina* males from Bejuma, Carabobo, Venezuela, February 13, 1920, by J. H. and E. B. Williamson and W. H. Ditzler, sent to me by Mr. E. B. Williamson, was labeled *H. caja* but probably not in his handwriting. One of these in coloring, thoracic pattern and appendages is undoubtedly *caja*; the other is *caja* in coloring and thoracic markings, but its appendages are like those of *dominula* and are shown in our figure 3, Plate I.

The female from Kartabo is small (abdomen 33 mm., hind wing 22 mm.) and agrees with the description of that of *dominula* except that it has the genital valvules and the legs pale brownish-ochre instead of black; the postoccipital tubercles are as in the males described above.

Distribution of *dominula*: Guiana, "Brazil."

Hetaerina moribunda Hagen, 1853.

Selys & Hagen, 1854, Monog. Calopt., 134, pl. 12, fig. 4 (Para, Cayenne).

Sjöstedt, 1918, *Arkiv Zool.*, 11(15): 39 (Manaos, Brazil).

Geijskes, 1943, *Ann. Ent. Soc. Amer.*, 36 (2): 171 (supposed nymph, Surinam).

Kartabo, 6. VI. 1921, one male.

This male agrees with the appendages as described and figured for *moribunda* by Selys and Hagen (1854), but the wings differ in numbers of antenodals (33-34 on front wings, 31-37 on hind) and in the extent of the basal spots, as follows: on the front wings red from the costa to the hind margin but brownish in the costal cells to the level of the middle of the quadrilateral and in the subcostal cells to the separation of R and M; red ending six cells beyond the level of the quadrilateral. On the hind wings brownish-red from C to Cu (right) or slightly below Cu (left), extending in the costal cells to the 17th antenodal, in the subcostal cells to the 20th or 21st antenodal, and between M2 and Cu to the distal end of the quadrilateral.

The left hind wing is abnormal in the following respects as compared with the apparently normal right hind wing, whose features are noted in parentheses: total length 24.5 mm. (25.5), nodus farther from base 15 mm. (11) but nearer apex 10 mm. (15), maximum width beyond nodus greater 5.9 mm. (5.72), costal area beyond the nodus wider, many of the postnodals anastomosed, stigma smaller, irregular, M2 beginning three cells distad of nodus (at the subnodus), cell rows between R1 and M3 distad of nodus irregular.

I have before me for comparison a male from Wismar, British Guiana, January 31, 1912, taken by the late Messrs. L. A. and E. B. Williamson and Mr. B. J. Rainey, with typical *moribunda* appendages and numbers of antenodals (28 front wings) and postnodals (45 front wings), with the basal spot on the front wings nearly as in the Kartabo male except that in the subcostal space the brownish-red reaches beyond the point of separation of R and M to the same level as the red behind it, i.e., to the level of six cells distad of the distal end of the quadrilateral, while on the hind wings the red (less brownish than in the Kartabo male) reaches caudad to one row of cells below Cu and even to the hind margin from the wing base to eight cells distad therefrom, in the costal space to the 21st antenodal, in the subcostal space to the 23rd antenodal and between Rs and Cu to one or two cells beyond the quadrilateral. The hind wing is 25 mm. long.

On the other hand, two males respectively from Manaos, June 16, 1922, and Villa Murтинho, Matto Grosso, April 7, 1922, by J. H. Williamson and J. W. Strohm, with *moribunda* appendages, have the basal spots of the wings very nearly (Manaos) or smaller than (Villa Murтинho) as described for

the Hagenian types. Sjöstedt (1918) also has a note on a male from Manaos.

Distribution: Guiana, Amazon valley.

Hetaerina sp.

Kartabo, III. 9. 1926, one female, lacking head and abdominal segments 4-10.

This female has the hind wing 30 mm. long, antenodals on the front wings 24 (right), 23 (left), thoracic pattern similar to that figured by Ris¹¹ for *H. caja* female except that the dark green median thoracic stripe is wider anteriorly and the green upper metepisternal spot is connected with the green spot at the upper end of the second lateral suture; the middle and hind lobes of the prothorax are almost entirely metallic green and the hind margin of the hind lobe has some slight structural differences from that of *caja*.

Distribution of *H. caja*: Acapulco, Mexico, to Guayaquil, Ecuador, eastward to Trinidad, but not recorded from the Amazon valley or the Guianas.

AGRIONINAE S. & H., 1850 (as Agrionines).
i. Pseudostigmatinae T. & F., 1938.

Megaloprepus caerulatus caerulatus (Drury, 1782).

Megaloprepus caerulatus Ris, 1918, *Archiv Naturges.*, 82, A (9); 64. Calvert, 1923, *Ent. News*, 34:129, 168.

Kartabo, Odon. 81, one female, abdomen 77 mm., right hind wing 67 mm., maximum width 17.5 mm., ratio length to width 3.82.

This female agrees better with the characters given by Ris (1918) for *M. c. caerulatus* than for *c. brevistigma*. He remarks: "Die Zahlenreihen ergeben dass eine scharfe Begrenzung von Formen nicht möglich ist. Immerhin ist eine relative Unterscheidung wenigstens der Form *brevistigma* in genügend bestimmter Form zu geben." In a study published five years later (1923) and based on fewer specimens, the present writer said: "An examination of his (Dr. Ris's) data on which these definitions are based clearly shows that one race grades into the other."

Distribution of *Megaloprepus caerulatus* as a whole: Vera Cruz, Mexico, to Demerara and to Yungaz, Bolivia.

Microstigma maculatum Hagen, 1860.

(Plate II, fig. 38).

Hagen in Selys, 1860, *Bull. Acad. Roy. Belg.*, (2) 10 (6): 17.

Selys, 1886, *Mem. Couron. Acad. Roy. Belg.*, 38 (4): 12.

Kartabo, 18. III. 1922; 30. III. 1926; V. 7. 1924; VI. 1. 1924; 28. VII. 1920; 8. VIII. 1920; five females, one male, also one male, "Odon. 130," head, left wings and

apex of right front wing lost. Most of these have lost the terminal abdominal segments.

Two species of this genus were at one time (1860), at least, reported from the Guianas by deSelys; they were stated to differ as follows (1860, but with the greater range of size given by him in 1886; italics as in de Selys, 1860):

	<i>M. anomalum</i> Rambur, 1842	<i>M. maculatum</i> Hagen, 1860
Size	medium, abd. ♂ 69-88 mm., ♀ 58-77; hind wing ♂ 47-72, ♀ 45-60	small, abd. 62-74 mm.; hind wing 48-55; sex not stated
Hind margin of prothorax	similar in the two sexes, rounded	much cleft ♂ (not described for ♀)
Wings	quite broad, ¹² rounded	quite narrow ¹²
♂ Front wings	terminal ninth (to twelfth, 1886) very finely reticulated, forming a dull yellowish, well circumscribed spot, oblique within (adult), yellowish-white (young); stigma slightly reddish (adult), yellowish-white (young), of 3-4 cells	apex very finely reticulated, not opaque or colored
Hind wings	stigma blackish-brown (adult), yellowish-white (young), of 3-4 cells	brown, of one cell only
♀ All wings, apex	narrowly and obliquely white or pale yellow	narrowly and obliquely milky (front) or slightly so (hind)
stigma	blackish-brown, of 3-4 cells, larger on front wings	yellow, of one to several cells (or absent, 1886)

All seven individuals from Kartabo approach the description of *maculatum* more closely than that of any other species. As few specimens of this species have been recorded or discussed in the scanty literature, the presence of these seven from one and the same locality renders it desirable to set down their range of variability in the characters which have been assumed as specific.

In all but one female (V. 7. 1924) the terminal portion of the abdomen is lost; in that female the abdomen measures 78 mm.

Hind margin of the prothorax in both males strongly cleft, in the females with a median, pointed (in profile view), shining,

¹¹ *Archiv Naturgesch.*, 82, A (9): 53, fig. 24, 1918.

¹² Width not stated numerically.

brown or black tubercle, narrowly yellow posteriorly.

♂. Front wings: denser reticulation at apex beginning .49-.82 mm. proximal to the stigma, denser between C and M1a than caudad, its proximal edge nearly straight, at right angles to C, its color faintly brownish-gray, its length 5.72 mm.; stigma .66-.74 mm., 2-celled, brown. Hind wings: 48-51 mm., denser reticulation at apex beginning at 4 cells proximal to, or .82 mm. distal to, the stigma, denser between C and R1 than caudad, its proximal edge nearly straight, at right angles to C, uncolored or faintly brownish, its length 1.88-5.32 mm. (in the male of 8.VIII.1920 asymmetrical in right and left wings); stigma .41-.74 mm. 1-celled or smaller, brown.

♀. Front wings: denser reticulation at apex beginning 2.2-4.25 mm. proximal to stigma, denser between C and M1a, or M2, or one row of cells posterior to M2, than caudad, its proximal edge convex, its color pale milky brown, faintly gray, faintly brownish-gray, faintly pink, or yellowish, its length 5.50-7.77 mm. (in some individuals asymmetrical in right and left wings); stigma .5-.9 mm. (asymmetrical in all individuals), 1-7-celled (frequently asymmetrical), pale gray to dark brown. Hind wings: 54-56 mm.; denser reticulation at apex beginning 1.5-3.93 mm. proximal to stigma (asymmetrical in four individuals), denser between C and M1a, or one row of cells posterior thereto, than caudad, its proximal edge convex (except in the left hind wing of ♀ V.7.1924 where it is slightly concave), its color pale milky brown or faintly gray, its length 5.3-7.0 mm. (asymmetrical in three individuals); stigma .5-.74 mm., slightly asymmetrical (markedly so in one individual), 1-celled (except 1 + in right wing of ♀ V.7.1924 and 2 + in right hind wing of ♀ 28.VII.1920), white to dark brown.

♂♀. All seven individuals have a yellow humeral stripe. A black, median, longitudinal, pectoral stripe is present in male 130, is present but interrupted in the other male and the female of 28.VII.1920, is very slight and linear in the female of 18.III.1922, is represented by a small blackish quadrilateral spot behind and between the third coxae in two females (V.7.1924 and VI.1.1924) and is absent in the remaining female.

On September 1, 1942, Prof. B. Elwood Montgomery kindly compared the Kartabo male of 8.VIII.1920 with Hagen's type of *maculatum* in the Museum of Comparative Zoology, Cambridge, Massachusetts, at my request. Of this type he wrote: "Under the side label *M. maculatum* in box, a male with following pin-labels: Essequibo Schmid, *M. obliquus* coll. Hagen, red type label Type 12123 and *Microstigma maculatum* Hagen. Tips of all wings somewhat frayed; left fore wing torn or shredded to base; speci-

men otherwise in good condition. Right fore wing is probably complete enough to check any details of venation. Pterostigma, front wing 1-celled, approximate size 1/3 mm.; same, hind wing, seems to fill only one-half cell, as in hind wing of Kartabo male, approximate size one-third mm. Venation at tip of wings more dense in the Essequibo (type) male; color of the tip, front wing, pale pink (due to color of veins as determined under microscope); both rear wing tips torn away. In the costal area of both wings there is a slight cloudiness bordering the cross veins giving the appearance of a slight cream color. Shape of the prothorax, especially its hind lobe, identical or very similar. Thorax of type is somewhat crushed, but markings appear to be identical, especially the yellow humeral stripe, except that it *may* not extend quite so far downward. Fore part of thorax is broken and covered with glue; dark mark on posterior (ventral) portion is same in shape (as in Kartabo male), but less dark in Essequibo male. Length of hind wing about 50 mm. estimated (tip broken off). The wings correspond in width to those of Kartabo male."

Prof. Montgomery also made a camera lucida drawing of a portion of tip of right front wing of the Essequibo male which is here reproduced (Fig. 38). The greater density of the reticulation, as compared with that of the Kartabo male is shown by the following figures:

	♂ Essequibo (type)	♂ Kartabo
Rows of cells between veins C and R	3	mostly 2
Rows of cells between veins R and M1	5-4	3-2-3
Rows of cells between veins M1 and M1a	5-3	3-2-3
Rows of cells between veins M1a and M2	2-3?	2-3

The material of *maculatum* cited in 1860 consisted of a male from Cayenne, a female from Santarem, a female (or a male) from Essequibo and a female from Surinam. In 1886, *maculatum* is quoted from Cayenne, Essequibo, Surinam and "un male de grande taille que je lui attribue est d'Obidos sur l'Amazone." The "patrie" of *anomalum* was given in 1860 as "Le Para, Santarem sur l'Amazone, Cayenne" (the last was the habitat given by Rambur for his *proximum* which de Selys placed as a synonym of *anomalum*); in 1886 as "Amazone (Para, Santarem) . . . exemplaires du haut Amazone (Masari, etc.)."

REFRACTIVE BODIES IN CERTAIN WING CELLS OF *Microstigma maculatum*.

In the original description of *Microstigma anomalum* Rambur wrote:¹³ "alis hyalinis,

¹³ Histoire Naturelle des Insectes Neuropteres, Paris, Roret, 1842, p. 289.

apice reticulatissimis nervis rufis, pterostigmate nullo vel subnullo ♂ . . . avec les nervures et nervules rougeâtres, portant çà et là petites globules très-fins (peut-être accidentels); très-finement réticulées à leur sommet antérieurement qui est blanchâtre sale ou un peu roussâtre . . ." No habitat was given for the single individual of this species.

I have not found any later references to these "petites globules très-fins" in the literature, so set forth the following data on their appearance as shown by the present seven specimens of *M. maculatum*.

Males: The cells of the apex of the front wings are smaller and more numerous than those of the hind wings. The faintly brownish-gray at the apex of the front wings is apparently due to almost colorless, finely granular, refractive bodies, = .013 mm. in diameter, without sharp outlines, located in the membrane of the wing of the cells between the costa and vein M1a. There may be as many as 100= of these bodies in a single cell. The cells in which these refractive bodies occur vary in their longest diameters from .2 to .635 mm. The cross veins separating these small cells are wider, e.g., .026 mm., than the cross veins (.017 mm.) which are both farther caudad and proximad. The refractive bodies may occupy the whole or only parts of the cells. Cells at the proximal edge of the gray area do not show a less density of the refractive bodies within them than exists in adjoining cells farther distad in the gray area. The refractive bodies are present in the four larger cells proximal to the first small cells between the costa and vein R1. The hind wings do not show these refractive bodies. The smallest cell observed in the hind wings has a long diameter of .14 mm. and, as in the smallest cell in the front wings mentioned above, is at the wing margin.

Females: Refractive bodies are present in the apical cells of both front and hind wings of all five females. In the front wings they are found in the cells from the costa to vein M2, or to one row, or to two rows, below M2, or to Rs. The smallest apical cell noted was .108 mm. in diameter. In the hind wings these bodies occur in apical cells between the costa and M1a, or M2, or one row of cells below M2. The smallest apical cell noted was .038 mm. in diameter, but the impression was that the cells in the apex of the front wings are on the whole smaller than those in the hind wing.

The following observations were made on the right hind wing of the female of 30.III.1926, under both a binocular Greenough microscope and a compound Leitz microscope. Immersion of the wing apex in 95% alcohol between a slide and cover slip for three hours produced no change in

the refractive bodies. A similar immersion in potassium hydrate (strength unknown) produced a sharply marked polygon, clearer than the refractive body itself, around each body. The wing apex was then transferred to a Syracuse watch glass of the same KOH solution in which it remained bathed for 14½ hours. Examination at the end of that period showed that some cells preserved the polygons as above noted, others were as at first examined in the dry condition, still others had many small air (?) bubbles within them. The wing apex was then washed in water and transferred, still wet, to a slide but without a cover slip; the three sorts of cells as stated for the KOH condition were still visible. The wing apex remained on the slide until it dried, when its appearance in all its cells was the same as that of the apex of a front wing of the same female which had been kept untreated in the dry condition.

At the suggestion of Dr. Rudolf G. Schmieder, the extreme tip of the wing apex which had been treated was cut off through some of the cells containing refractive bodies, mounted dry in a vertical position and the cut edge examined through Leitz objectives 3 and 6 to endeavor to determine whether the refractive bodies could be distinguished, possibly as thickenings of one or other of the two wing membranes. Clusters of granules, of the size seen in the refractive bodies in surface view of the wing apex, were observed here and there, apparently on the outer surface of one or another membrane. These were not found in a similarly mounted fragment of a part of the same wing not containing the refractive bodies. It would appear, therefore, that the outer surfaces of the wing apex, in the refractive body areas, are roughened here and there, and thicker at the site of each refractive body. The thickness of the combined two wing membranes where free from veins and refractive bodies was between .00145 and .00097 mm. in both the fragments examined. At a refractive body the wing section was .0029-.0058 mm. thick; at a cross vein .026-.058 mm. thick.

Mecistogaster Rambur, 1842.

Two species of this genus are represented in the present material from Kartabo. They may be distinguished from each other as follows:

The pale antehumeral and humeral stripes less unequal in length, their levels overlapping, the former 2.38-3.68 mm., the latter 3.68-4.09 mm. Pterostigma of the front wings longer (♂4.91-5.89, ♀4.91-5.32 mm. or not differentiated), of the hind wings shorter (♂4.91-5.73, ♀4.50 or not differentiated). Males with front margin of hind wing not produced forward before the apex; superior appendages in profile view not bent ventrad,

apex truncated obliquely caudad and ventrad. Females with a yellow spot on each side of hind end of abdominal segments 7-10 or some of them. Abdomen ♂100-125, ♀63-98, hind wing ♂49-60, ♀43-75 mm. (Dimensions according to de Selys 1886) . . .

linearis

The pale antehumeral and humeral stripes very unequal in length, the former less than 1 mm., the latter 3.27-4.58 mm., the former not reaching upward as far as the level of the lower (or anterior) end of the latter. Pterostigma of the front wing shorter (♂2.37-4.25 mm., ♀2.37-2.94 mm. or not differentiated), of the hind wing longer in the male (5.97-7.94 mm.) but shorter in the female (3.27-2.94 mm. or not differentiated). Males with front margin of hind wing gradually produced forward in an elliptical curve at the stigma; superior appendages in profile view bent obliquely ventrad beyond mid-length, apex slightly bifid. Females with no yellow spots on abdominal segments 7-10. Abdomen ♂120-130 (117-137), ♀85-110, hind wing ♂58-68, ♀55-70 (♂51-64, ♀49-60) mm. (Dimensions according to de Selys, 1886, but where the Kartabo examples exceed his ranges they are given enclosed in parentheses () *lucretia*

Mecistogaster linearis (Fabricius, 1777).

Agrion linearis Fabricius, 1777,¹⁴ Gen. Insect. :249 (nec Fabr. 1781, Species Insect., 1:528, No. 5; 1793, Ent. Syst., 2:388, No. 5). Campion, 1917, *Ann. & Mag. Nat. Hist.*, (8) 19:447.

Mecistogaster linearis Selys, 1860, *Bull. Acad. Belg.*, (2) 10 (6): 22; 1886, *Mem. Couron. Acad. Belg.*, 38 (4):23. Kirby, 1897, *Ann. & Mag. Nat. Hist.*, (6) 19:615. Ris, 1918, *Arch. Naturges.*, 82 (A9): 73. Sjöstedt, 1918, *Arkiv Zool.*, 11 (15):33. Munz, 1919, *Mem. Amer. Ent. Soc.*, 3:74, pl. 8, fig. 50 (venation, hind wing ♀). Needham, 1933, *Amer. Mus. Novit.*, 664:1. Fraser, 1946, *Trans. R. Ent. Soc. London*, 97 (18):462, figs. 3 c, d (wing tips ♂), 4 b, c (apps. ♂).

Mecistogaster marchali var. *selysia* Navas, 1923, *Mem. Pontif. acc. Rom. Nuovi Lincei*, (2) 6:9 (new synonym).

After considering the discussions by de Selys (1860) and Campion (1917) on the type of this species, it seems permissible to regard the Fabrician specimen in the Banks collection of the British Museum as the lectotype,¹⁵ fixed by de Selys (1860) as the first reviser.

In 1860, de Selys distinguished different ages of imagos of both sexes of this species.

The number of specimens from any one locality, as reported in the literature earlier than Col. Fraser's paper of 1946, is smaller than of those present from Kartabo, five males, three females. The latter are listed, therefore, as follows to show both their age, following de Selys, and their seasonal distribution:

Young, front wings, tip white or pale yellow, including the yellowish stigma; hind wings as stated for front wings. Two males, "Odon. 87," 1917, and 22.XI.1920; two females, V.8.1924, and 19.VII.1920.

Semi-adult, front wings, tip whitish, stigma orange above and below; hind wings as stated for front wings. One female, "Odon. 82," 1921.

Adult, front wings, tip smoky or uncolored, stigma orange or ochreous above, dark brown beneath; hind wings, tip faintly smoky, stigma as stated for front wings; abdomen with some pruinosity on hind segments. Three males 3.IV.1924, 24.VII.1920, and 6.XI.1920.

The males have the pterostigma extending from C to M1, with one row of cells between C and R1 and one row between R1 and M1.

It is to the young imagos of *M. linearis*, or of *M. lucretia*, or of both species, that the following observations, made by Dr. Beebe on the Aremu River, a right tributary of the Cuyuni, some 25 miles from Kartabo, in late March, 1909, probably refer. "At noon we stopped for breakfast in a primeval forest with rather thin underbrush. . . . Spinning through the aisles made by the giant columns of tree-trunks, were curious translucent pin-wheels, and not until we captured one in the butterfly net did we realize we were looking at the same attenuated forest dragon-flies (*Mecistogaster* sp.) which had deceived us so completely five years ago in Mexico.¹⁶ The movement of the long, narrow wings, with the spot of white at the tips was, to the eye, a circular revolving whirl, with the needle-sized body trailing behind. The white spots revolved rapidly, while the rest of the wings became a mere gray haze. These weird creatures, apparently so ethereal and fragile, were hunting for spiders, and their method was regular and methodical. From under leaves or from the heart of widespread webs, good-sized spiders were snatched. A momentary juggling with the strong legs, a single nip and the spider minus its abdomen dropped to the mould, while the dragon-fly alighted and sucked the juices of its victim. If we drew near one of these spiders on its web, it instantly darted away, sliding down a silken cable to the ground or dashing into some crevice, but the approach of the hovering dragon-fly, although rather deliberate, was unheeded,

¹⁴ For 1777, instead of 1776, the usually quoted date of publication, see Hagen, *Biblioth. Ent.*

¹⁵ For definitions of lectotype and references to pertinent literature, see Frizzell, 1933, *Amer. Midl. Nat.*, 14:655; Cresson, 1934, *Ent. News*, 45:124.

¹⁶ Two Bird-lovers in Mexico, pp. 239-241.

the spider remaining quiet until snatched from its place."¹⁷

Geographical distribution of *M. linearis*: The Guianas, Amazon Valley from Para to the Rio Bobonaza in Ecuador, Muzo, etc., in the eastern Cordillera of Colombia; Venezuela; one male from Matto Grosso (Ris, 1918).

THE SEASONAL DISTRIBUTION OF *Mecistogaster linearis* THROUGHOUT ITS RANGE.

It will be noted that of the specimens from Kartabo dated for day and month, both young and adult have been collected in July and November; July in the long wet season, November at the end of the long dry season. The remaining two dated individuals are from April and May, at the end of the short dry and the beginning of the long wet season respectively.¹⁸

Among Schaus's material from French Guiana, in the U. S. National Museum, are two young females from Cayenne, December, 1903, and the Maroni River, June, respectively.

The records of occurrence at Kartabo and in French Guiana indicate that *linearis* imagos are to be met there during much of the year and are not limited to any one season, but the data are not yet full enough to make more precise statements.

Kirby (1897) records *linearis* taken in forest at Santarem, lower Amazons, February 27, 1896, in the wet season. Sjöstedt (1918) has briefly described a semi-adult male, a young male and three young females from the Amazons (Rio Autaz, Sept.-Nov., Rio Purus, Jan., and Manaus, July). In the collection of the Academy of Natural Sciences of Philadelphia is a semi-adult male taken at Manaus X.18.1919. July to November represent the relatively dry season, January the height of the wet season.¹⁹

Ris (1918) has described very adult males and females from Muzo in October, 1910, a very adult male from Llanos de Medina in June, 1910, and an adult male and young and adult females taken at Villavicencio, in January, 1911, all in Colombia. Villavicencio,

at 450 meters elevation, lies at the entrance to the llanos (Ris, p. 3), where January falls in a dry period, June in the wet season.²⁰

Navas (1923) has described females from Muzo of July and October, 1918, under the name *Mecistogaster marchali* var. *selysia*. His account of the membrane of the apex of apparently all the wings as "opalino sive lacte picta" seems to apply better to *M. linearis* than to *marchali* (= *lucretia* Selys, 1890).

Prof. Needham (1933) has recorded a male of *linearis* from Mt. Duida, Venezuela, November 23, 1928. If we may use the precipitation records of Ciudad Bolivar, this would be in the wet season (Reed, 1928, p. 10).

Quite recently (1946) Col. Fraser has published a list of *linearis* taken at localities in Colombia and Peru in the valleys of the Putumayo, Amazons and Huallaga rivers. His largest series of specimens (12♂, 27♀) is that from Mishuyacu, Peru, described as being "near Iquitos" (t. c. (2): 11); the males were taken from Feb. 2 to July 10, the females from Jan. 25 to Dec. 20, except, apparently, Sept. and Oct., all in 1931; one male, Oct. 31, is cited from Yumbatos, Peru, in the Huallaga valley. Brooks says:²¹ "On the Amazon side of the Andes the rainy season last[s] from October to April, and the dry season from May to Sept. but July is the only really dry month." The seasonal range of the *Mishuyacu linearis* extends through a wet season with two maxima, March and December, and a dry with a minimum rainfall of 4.6 inches in August, if we may use the Iquitos data.

In these extra-Guianan records of *linearis*, the wet season is represented by those from Santarem, Rio Purus, Llanos de Medina, Muzo, Mishuyacu and Mt. Duida, the dry from Villavicencio and relatively dry from Manaus, the Rio Autaz, Muzo and Mishuyacu.

Mecistogaster lucretia (Drury, 1773).

Libellula lucretia Drury, 1773, Illustr. Nat. Hist., 2:87, pl. 48, fig. 1, Index p. 2. Sulzer, 1776, Abgekurz. Gesch. Insec. 1: 169, tab. 24, fig. 4.

Lestes lucretia Westwood, Drury, 1837, Illustr. Nat. Hist., 2: tab. 48, fig. 1.

Agrion lucretia Burmeister, 1839, Handb. Ent., 2:818.

Mecistogaster lucretia Rambur, 1842, Ins. Nevrop.: 286. Kirby, 1890, Cat. Odon., 121

²⁰ Kendrew, p. 323. Reed, p. 12, data for Puerto Berrio, nearest station to Muzo. Muzo lies in one of the north to south interandine valleys where in July there is less, in October more, rain. Haurwitz & Austin, p. 235 (Bogota, Medellin). "From the llanos there are no long series of records, but all accounts tell of an almost rainless period from the end of November till the middle of March." (Kendrew, p. 323.)

²¹ Climate, p. 167. Precipitation figures for each month at Iquitos are given by Reed, p. 17; Kendrew, p. 343; Miller, p. 89.

¹⁷ M. B. & C. W. Beebe: Our Search for a Wilderness, New York, Henry Holt & Co., 1910, pp. 270-1. Spiders form at least part of the food of *Megaloprepus caerulatus*, ally of *Mecistogaster*, listed on page 52 antea; Calvert, Ent. News, 34:171-4, 1923.

¹⁸ Climatic data from Beebe, British Guiana in the Naturalist's Guide to the Americas: 649-652 (Baltimore, The Williams & Wilkins Co.), 1926; Reed, Monthly Weather Review, Suppl. 31:8, 1928; Miller, Climatology, London, Methuen, 1931, pp. 75, 88-89. Haurwitz & Austin, Climatology, New York & London, McGraw-Hill, 1944, p. 234. "There is considerable variation in these seasons, and occasionally a short season is almost eclipsed." (Beebe).

¹⁹ See data by Reed (1931) for Taperinha, near Santarem, and for Manaus, in Yearbook U. S. Dept. Agric., 1941, pp. 674, 675. White, O. E., The Amazon Valley in the Naturalist's Guide to the Americas, p. 675, 1926. Kendrew, W. G., Climates of the Continents, 2nd edit. (Oxford, Clarendon Press, 1927), pp. 325-6, 343. Brooks, C. E. P., Climate (New York, Scribners, no date, subsequent to 1928), pp. 142, 144. Miller, A. A., Climatology, p. 89. Haurwitz & Austin, Climatology, 234, 1944.

(in part). Selys, 1890, *Compt-Rend. Soc. Ent. Belg.*, pp. cxix, clxiv. Fraser, 1946, *Trans. R. Ent. Soc. Lond.*, 91(18):452, fig. 3b (tip of hind wing ♂).

Preia lucretia Gistel in Gistel & Bromme, 1850, *Handb. Naturges.*, 452. Cowley, 1934, *Entom.*, 67:202.

Agrion linearis Fabricius, 1781, *Spec. Ins.*, 1:528, No. 5; 1793, *Ent. Syst.*, 2:388. (Nec Fabr., 1777, *Gen. Ins.*, 249).

Libellula linearis Gmelin, 1790, *Syst. Nat.*, 1(5):2625, No. 45. Olivier, 1792, *Encyc. Meth. Ins.*, 4:567, No. 41 (in part).

Libellula longissima Fée, 1832, *Vie de Linné*, 365.

Mecistogaster marchali Rambur, 1842, *Ins. Nevrop.*, 283. Selys, 1860, *Bull. Acad. Roy. Belg.*, (2) 10 (6):25; 1886, *Mem. Couron. Acad. Roy. Belg.*, 38 (4):25. Kirby, 1890, *Cat. Odon.*, 121.

Mecistogaster filum & *pedicillatus* Rambur, 1842, *Ins. Nevrop.*, 284.

The changes made by de Selys in 1890 in the nomenclature of *M. lucretia* and *marchali* were subsequent to the publication of Kirby's Catalogue. The revised synonymy of what he earlier called *lucretia* Drury, later *amalia* Burmeister, is given in *Biologia Centrali-Americana*, Neuroptera, 354, 1907, and to it I now add a new synonym, *Agrion linearis* Blanchard (1840, *Hist. Nat. Ins.*, 3:64, *Nevrop. pl. 2*, fig. 1.). The revised synonymy and references for de Selys' earlier *marchali*, later *lucretia*, have not been detailed and therefore are given above, after an examination of all the passages quoted. Dr. Ris (1913, *Mem. Soc. Ent. Belg.*, 22:59) has retained the Selysian nomenclature of 1860 and 1886 for *lucretia* and apparently cites only the second reference to *lucretia* by de Selys in 1890, i.e., p. clxiv, quoting McLachlan's opinion, and overlooking the first reference, p. cxix, with the original suggestion by Hagen. I see no reason to change my arrangement in the *Biologia* just quoted and which Dr. Ris doubted.

In 1860, page 20, de Selys distinguished young and adult imagos of this species, under the name of *M. marchali*. As in the case of *M. linearis*, the material present from Kartabo is more extensive than that hitherto recorded in the literature from any one locality. It and two males from nearby Rockstone are, therefore, listed here to show the age and the seasonal distribution.

Young, abdomen not pruinose; front wings, tips whitish or pale yellow, including the stigma; hind wings, tips uncolored except the pale brown stigma. Three males, 5.VIII.1920, 17.VIII.1920, and "Odon. 122;" two females, 1.III.1920, 6.XI.1920.

Semi-adult, abdomen not pruinose; front wings, tip slightly smoky, stigma yellow or ochre; hind wings, tip uncolored, stigma

darker brown. One male, 23.VIII.1920; two females, 16.VIII.1920, and no date. Rockstone (Schaus) one male, no date.

Adult, abdomen with some pruinosity on hind segments; front wings, tips slightly smoky, stigma reddish-brown or darker brown; hind wings, tips uncolored, stigma dark brown. Four males, 13.III (no year), 5.VIII.1920, 18.VIII. (no year), 20.XI.1920. Rockstone (Williamson & Rainey) one male, Feb. 12, 1912.

The males here listed have the pterostigma extending from C to M1 (or to a fraction of a cell below M1 on the front wings); on the front wings it consists of two rows of cells between C and R1 and one or two rows between R1 and M1; on the hind wings it consists of only one row of cells between C and R1 and one row between R1 and M1.

Geographical distribution of *M. lucretia*: Northern Venezuela, the Guianas and the lower and middle Amazon valley (Selys, 1886).

THE SEASONAL DISTRIBUTION OF *Mecistogaster lucretia* THROUGHOUT ITS RANGE.

Considering the ages and dates of the British Guiana imagos, the greatest number of individuals (five males, one female) taken in any one month is in August, wherein young, semi-adults and adults are equally represented. Young and adult were collected also in March and in November. *Lucretia*, like *linearis*, is, therefore, apparently to be found as imagos throughout the year. Except for November, however, the months in which the two species have been collected are not the same, although not far apart. The British Guianan seasons in which *lucretia* imagos have been obtained are the short dry (Feb., March), the end of the long wet (July) and the end of the long dry (Nov.). Finally, a very adult female was taken by Dr. Schaus at Cayenne, in December, 1903 (U. S. National Museum), which is in the beginning of the wet season, only two seasons being recognized here as against the four in British Guiana.²²

In the Academy of Natural Sciences of Philadelphia are two adult males from Cariquito, Venezuela, collected by Stewardson Brown on Jan. 22, 1911. In an account of his expedition by Stone,²³ Cariquito is located on the south shore of the peninsula of Paria. Judging from the rainfall records from the nearest localities, Rio Caribe and Ciudad Bolivar, January is at the end of a wet season at Cariquito.²⁴

These discussions of the seasonal distribu-

²² Reed, 1928, pp. 5, 7-8. Miller, 1931, p. 75. Carlson, *Geography of Latin America*, revised edition, p. 352, 1943 (New York, Prentice Hall).

²³ 1913, *Proc. Acad. Nat. Sci. Phila.*, 65:189.

²⁴ Reed, l. c., p. 10; Carlson, l. c., p. 336.

tion of *M. linearis* and of *M. lucretia* are prompted by the results of one year's observations in Costa Rica which seemed to indicate that imagoes of *M. modestus*²⁵ fly in that country only at the beginning of the wet season.

ii. Megapodagriinae T. & F., 1938.

Megapodagrion megalopus (Selys, 1862).

Kangaruma, 15.II.1921, one male, abdominal segments 6-10 lost. Distribution: Amazon valley (Selys, 1862, 1886).

iii. Argiinae T. & F., 1938.

Argia

By Leonora K. Gloyd

(I have asked Mrs. Gloyd, as the one best acquainted with this genus, to examine and report on the material in question. This she has kindly done as follows. P. P. C.)

Argia sp. A, group of *oculata* Hagen.

Kartabo: 12.III.1924, one male; III.9.1926, one female; III.26.1926, one female; 3.IV.1924, one male (abd. segs. 7-10 lost); 8.VI.1921, one male; 20.IX.1920, one male (abd. segs. 6-10 lost); not dated, one female, No. 20357, abdomen lost; also July-August, 1926, by Dr. Charles Hodge IV, one male.

These males are not quite the same as my specimens of Sp. 26²⁶ from Venezuela which were compared with the type of *oculata* at the M. C. Z. in 1935, nor of Sp. 19²⁶ from Colombia (which may prove the same as Sp. 26. Segments 3-5 of this series have much more blue and there are slight differences in the superior appendages which are difficult to describe. Neither are they the same species as either of two belonging to the *oculata* group Dr. Geijskes sent me from Dutch Guiana. This group is going to take a tremendous amount of study and it may be that by the females we shall know them! Dr. Geijskes's males had such slight differences from Sp. 19 they could have easily been identified as the same but the females are quite distinct. So if these three females from Kartabo belong to the five males from the same locality, and I think they do, then here is another member of the near *oculata* group.

These females have a low tubercle with a depression mesad which forms a shallow pit beneath the short overhanging projection of the mesostigmal lamina; *oculata* has neither pit nor tubercle.

Argia sp. B.

Kartabo: 1922, one male (left front wing lost).

Same as my Sp. 16,²⁶ "Near *sordida* and *ulmea* in Calvert's keys. May be undescribed species. P. P. C. & L. K. G. Sept. 10, 1934."

Argia sp. C.

Kartabo: 22.X.1920, one female, not dated; nos. 20340 and 24449, two females; Hadas Clearing 14/6/22, one female. All four females have lost abd. segs. 7-10 or more.

To me these specimens look like my Sp. No. 1²⁶ or No. 14²⁶ of the *indicatrix* group. Species 1 is from Belem, State of Para, Brazil, and is near, or, *indicatrix*; Sp. 14 is from British Guiana and as nearly as I can make out is what Sjöstedt redescribed as *Argia impura* but Rambur's type of *impura* has abdominal segments 7-10 missing and without a more critical study of several other species which are similar in size, coloration and general appearance, I can neither agree nor disagree with his determination.

Argia sp. D.

Kartabo: IV.6.1924, one female (abd. segs. 6-10 and left front wing lost).

My Sp. 8.²⁶ Color pattern, wings (postquad. cells 3-3), shape of pterostigma, mesostigmal lamina, etc., agree very well. Species 8 according to our mutual studies is still an undescribed species. My sample specimen is from Manaos, Amazonas, Brazil.

Argia insipida Hagen, 1865.

Essequibo River below [between?] mouths of Potaro and Rupinuni, IV-V, 1920, George B. Fox, one teneral female in collection of the Academy of Natural Sciences of Philadelphia.

Males of this species are very near *pipila* but differ in extent of blue in color pattern as well as in appendages. Here again it is the females which are most easily distinguished. *A. ierea* Geijskes is a synonym. *A. pipila* females, as stated in the original description, have no mesepisternal tubercles, *A. insipida* does have them.

Distribution of *insipida*: British and Dutch Guiana. See footnote 8, antea, page 49, on the reported occurrence of this species in the West Indies.

iv. Coenagriinae T. & F., 1938.

Leptagrion beebeanum n. sp.

(Plate I, figs. 1, 2).

Kartabo, V.4.1924, one male, holotype, collection of Dr. William Beebe, deposited by him in the Academy of Natural Sciences of Philadelphia, No. 9275.

Wings: Anal vein separating from the hind margin of the wing slightly proximal to the cu-a cross-vein by a distance one-fourth or less of the length of that cross-vein, which is a little nearer to the level of the second than of the first antenodal. Cross-

²⁵ Calvert, 1911, *Ent. News*, 22(9):402-411; Calvert, A. S. & P. P., 1917, *A Year of Costa Rican Natural History*: 230-243. See also Picado, C., 1913, *Bull. Sci. France & Belg.*, (7) 47 (3):346-7.

²⁶ Temporary numbers given by me to species in sorting and making a preliminary study of the huge amount of *Argia* material accessible to me. L. K. G.

vein descending from the subnodus not continued directly to the hind wing-margin, the marginal cell against which it ends pentagonal (hence like *Leptagrion*, Williamson, *Ent. News*, 28:242, 1917) but not high and the adjoining marginal cells not high (hence not like *Leptagrion*, l. c.). M2 arising at the 7th postnodal (front wings) or 6th (hind wings), Rs and M3 widely separated at the proximal cross-vein between them. Pterostigma with both proximal and distal ends oblique, nearly parallel, the proximal slightly more oblique than the distal; brown, surmounting less than one cell, costal edge 1.09 mm. (front wing), 1.18 mm. (hind wing). Postnodals 13 (right), 14 (left), M1a arising at the 10th (front wings); 13 (right), 12 (left), M1a arising at the 9th (hind wings). Upper side of the quadrilateral, front wings, subequal to the inner (proximal) side and .3 as long as the lower side; hind wings, twice as long as the inner side, half as long as the lower side. Three ultra-quadrilateral, antenodal cells on all four wings.

Most of the legs missing, only one tarsal claw (probably of a first leg) preserved, with a distinct tooth much shorter than the tip of the claw beyond the tooth.

General color black, in many places with a metallic blue or violet reflection, as on the nasus, vertex near each eye and abdominal segments 2-6. Labrum shining black. Labium and rear of head near the "pale clay yellow" of Smith's Glossary.²⁷ Labium cleft in its apical .46. No pale postocular spots.

Hind margin of prothorax convex, somewhat flattened; propleura pale, faded (color in life?).

Mesepisternum at its anterior (inferior) end with a pale yellowish or greenish antehumeral vitta about .7 mm. long. Mesepimeron for most of its length with a pale greenish stripe. Most of the metapleuron, of the metinfraepisternum and of the pectus pale greenish, with a brownish-black streak on the upper half of the second lateral (metapleural) suture and a short transverse blackish streak near the hind end of the pectus.

Abdomen: Intersegmental articulations of segments 1-5 narrowly pale cadmium yellow (Smith, l. c.), mid-dorsally interrupted on 4 and 5; sides of 1-6 inferiorly pale yellowish, rising higher at the bases of 3-6. Dorsal surface of 7-10 partly covered by an incrustation of foreign material which conceals their color pattern, but apparently black, unmarked. Tenth segment not elevated at its hind end, which latter, in dorsal view, is widely emarginated for two-sevenths of the segment's length. On view-

ing the hind surface of 10 from above and behind, there is seen, immediately below the hind dorsal margin, a distinct, sharply margined groove which extends from the level of the middle of one superior appendage to the level of the middle of the other superior appendage; each end of this groove is closed.

Superior appendages one half as long (in profile view) as segment 10, in dorsal view directed nearly straight caudad and showing an infero-internal lamella in the proximal two-thirds of their length; this lamella rounded at its apex and ending nearly at right angles to the remaining superior part of the appendage, which latter tapers to a slender apex bent mesad at its tip and ending in a slight hook. In profile view, the appendage is two-branched, upper branch twice as long as the lower; the distal end of the lamella above mentioned terminates as a convex projection at three-fifths the appendage-length, beyond which the upper branch tapers to an acute tip directed slightly dorsad; lower branch half as long as the upper branch and about three-sevenths as high thereof at base, forming a slender tapering process, curved slightly dorsad and ending a little short of the terminus of the lamella of the upper branch.

Inferior appendages, in profile view, hardly shorter than the lower branch of the superior appendages; the height of one appendage equal to one-half of the height of the tenth segment; upper third of the appendage produced as a blunt cone directed nearly straight caudad.

Abdomen 49, hind wing 32 mm.

This species, named in honor of the Director of the Kartabo Station, belongs in de Selys' group of *L. andromache* and *elongatum*, but differs from both of them in the form of the abdominal appendages and by the oblique pterostigma surmounting less than one cell; *andromache*, moreover, has the pterostigma "presque carré."

Leptagrion sp.

Kaieteur, British Guiana, 18.II.1921, one male, abdominal segments 8-10 lost.

Related to *L. elongatum* Selys, but differing therefrom in the (oblique) shorter pterostigma which surmounts only one cell on all four wings, the presence of a black stripe on the humeral suture for its entire length, only half as wide as the middorsal black stripe, and a still narrower brown stripe on the whole length of the second (metapleural) lateral suture. Abdominal segments 1-7 37 mm., hind wing 26 mm. Owing to the absence of the specifically important abdominal appendages, I give this insect no specific name.

Aeolagrion demerarum Williamson, 1917.

Williamson, E. B., 1917, *Ent. News*, 28 (6):244, figs. (male apps.), pl. XVIII, fig.

²⁷ Smith, John B. Explanation of Terms used in Entomology, plate IV, fig. 22. Brooklyn Entom. Soc., 1906. The title here given is that of the two title pages of the writer's copy, but the back of the original buckram binding reads "Glossary of Entomology."

22 (venation). Geijskes, 1941, *Ann. Ent. Soc. Amer.*, 34:722, fig. 2 (nymph).

Kartabo, two males, one dated, 8.VI.1921; both lack heads.

There is a male from Paramaribo, Surinam, by Miss Katherine Mayo, in the collection of the Academy of Natural Sciences of Philadelphia.

All three males have been compared with a paratype from Georgetown, British Guiana, Jan. 25, 1912, by L. A. and E. B. Williamson and R. J. Rainey, received from Mr. E. B. Williamson, with which they agree.

All four males show a structural feature not mentioned in the original description: On each mesepisternum, at its anterior end, near its lateral margin, is an erect triangular process (mesostigmal lamina), about .14 mm. high, when viewed in profile and slightly from below; directed dorsad and laterad, blue anteriorly, its apex black; it is situated directly behind the "round lateral wing" of the same side of the hind prothoracic border.

Since writing the preceding paragraph, I have received three males and two females of *demerarum* from the Botanic Garden at Paramaribo, collected and sent to me by Dr. D. C. Geijskes. They are dated 19.VI.1939, 10 Oct. and 20.Dec.1938. The females also possess a mesostigmal lamina, less prominent (.09 mm. high) than in the male, the apex (which is triangular and directed laterad in the male) rounded off, the black of the apex continued caudad as a minute metallic green spot on the anterior surface of the mesepisternum; this minute spot absent in all seven males.

Distribution: British and Dutch Guiana.

***Acanthagrion adustum* Williamson, 1916.**

Williamson, E. B., 1916, *Ent. News*, 27 (7):320, pl. XVII, figs. 1, 2 (male apps.), 10 (mes. stigma female). Geijskes, 1943, *Ann. Ent. Soc. Amer.*, 36:180, pl. VI (nymph).

Kartabo, Odon. 19, LAMA 17, one specimen, abdomen lost.

Agrees well with the description and with a paratype from Wismar, British Guiana, Feb. 15, 1912, by L. A. and E. B. Williamson and R. J. Rainey, received from Mr. Williamson, with which it has been compared.

Distribution: British Guiana.

***Metaleptobasis tetragena*²⁸ n. sp.**

(Pl. I, figs. 20-22).

Kartabo, July-August, 1926, by Dr. Charles Hodge IV, one female, not fully matured, holotype, to be placed in the collection of the Academy of Natural Sciences of Philadelphia, by the kindness of Dr. Hodge, No. 9274.

²⁸ τέτρα = four, γενή = be born, in allusion to the four thoracic horns.

Wings: M2 arising at the sixth postnodal (front wings), at the fifth (hind wings); A and Cu2 in the same straight line²⁹ (all wings). Pterostigma longer than wide, grayish, surmounting less than one cell on all four wings, costal margin .71 mm. (front wing), .66 mm. (hind wing), proximal end oblique, distal end less so. Twelve postnodals (all wings), M1a arising at the 10th (all wings), Cu2 ending at the level of the 6th postnodal (3 wings) or 7th (left hind wing). Antenodal ultraquadrilateral cells on all wings three.

Legs yellow, with black or brown spines, 6 on the outer row of the third tibia, 8-9 on the inner row; tarsal claws without a tooth.

Labium as noted by Williamson for *M. mauritia* and *M. manicaria*. Labrum obscure ochre; rhinarium and nasus dark brown; frons anteriorly ochreous, superiorly black, a transverse yellowish stripe laterad to each paired ocellus; vertex dark metallic green and violet; occiput and postero-superior margin of vertex yellowish; rear of head ochraceous; antennae: first and second segments pale cream (?), anterior surface of the first and distal end of the second brown.

Prothorax ochraceous; hind margin with two erect processes, each about .07 mm. wide and a little longer, apex almost transversely truncate, processes separated by a subrectangular interval of about .11 mm. width. (Pl. I, figs. 20, 21).

Thorax with a mid-dorsal metallic violet stripe about .57 mm. wide, remainder of thorax pale brown becoming yellowish on the sides; on each lateral margin of the violet stripe, at its anterior end in dorsal view, is a straight, slender, tapering process ("horn") .45 mm. long, diverging widely cephalad from its fellow; in profile view each process is directed upward at its base, but soon directed cephalad and overhanging the prothorax; at their bases these horns are .24 mm. apart. (Pl. I, figs. 20-22).

Abdomen brown dorsally, with a metallic reflection, a transverse, basal, pale green ring at the anterior end of segments 2-6, interrupted mid-dorsally by the brown and confluent with an inferior stripe of the same pale green on the same segments; posterior third of 8, half of 9 and all of 10 dorsally paler, yellowish. Appendages of 10 reaching to the level of the hind end of 11. Genital valves barely projecting caudad beyond the level of 11; serrulations on their ventral margins about six in number, located in the distal third of the valves, each one wider than high, rounded at apex, first to third separated from each other by 2-3 times the width of each, fourth to sixth separated by

²⁹ Cf. Williamson, 1915, *Proc. U. S. Nat. Mus.*, 48 (2089):637, lines 26-28, in which is an easily overlooked statement of this peculiarity as a venational generic character of *Metaleptobasis*.

the width (or less) of each, first to third each bearing a seta, fourth and fifth each two, sixth (which is close to base of palp) none.

Abdomen 35 mm., hind wing 22 mm.

This female differs from the females of other described species of *Metaleptobasis* or *Leptobasis* in having subparallel processes on the hind margin of the prothorax and longer, cylindrical, diverging "horns" at the anterior end of the mesothorax. The nearest species is *quadricornis* Selys of Para, whose thoracic armature is thus described: "Prothorax roussâtre, le bord postérieur presque droit et chacun de ces côtés portant une corne aplatie, redressée et penchée vers le thorax dont le bord antérieur porte aussi deux petites pointes coniques, redressées plus courtes, une de chaque côté, mais assez rapprochées et dirigées vers le prothorax," and again: *quadricornis* "les deux cornes du thorax et celles du prothorax presque égales coniques, assez courtes," (Selys, 1876). The italics are mine to emphasize the differences. *Quadricornis* is described also as having the pterostigma covering one cell, the internal side hardly oblique.

Ceratura capreola (Hagen, 1861).

Geijskes, 1941, *Ann. Ent. Soc. Amer.*, 34 (4):729, fig. 5 (nymph).

Kartabo, VRS, Odon. 6, one male; Odon. 40, one citrous female.

Both male and female have seven postnodals on the front wings, six on the hind wings, thus agreeing with "the individuals from Brazil, of both sexes, (which) have usually one more postcubital (postnodal) on both front (7) and hind (6) wings than the majority of Mexican and Central-American examples possess." (Biol. Centr.-Amer. Neur. 132, 1903). The dorsum of the eighth abdominal segment of this male has the anterior .57 mm. black, the posterior .4 mm. blue.

Distribution: Cuba, Jamaica, Puerto Rico, Martinique and Vera Cruz, Mexico, to Rio Grande do Sul, Brazil, and Jujuy, Argentina.

v. Protoneurinae T. & F., 1938.

Neoneura joana Williamson, 1917.

Williamson, 1917, *Trans. Amer. Ent. Soc.*, 43:213, 215, 242, 7 figs.

Kartabo, VI.4.1924, one male lacking abd. segs. 7-10; 9.VIII.1920, one male lacking abd. segs. 4-10.

Both specimens were compared with a male paratype from Tumatumari, British Guiana, Feb. 9, 1912, at the Academy of Natural Sciences of Philadelphia. The remaining portions of the June male agree well with Williamson's detailed description and figures, except that the black bar running from either side of the median ocellus does not quite reach the antenna of the same side, although the remainder of this bar,

forward and backward from the antenna, agrees. The August male has the longitudinal black bar on either side of abdominal segment 2 reaching both base and apex of that segment, the black markings on the sides of abdominal segment 1 are not symmetrical.

Distribution: British Guiana.

Protoneura calverti Williamson, 1915.

Williamson, 1915, *Proc. U. S. Nat. Mus.*, 48 (2089):620, 619, 632-635, pl. 41, fig. 1 (venation), pl. 43, figs. 11, 12 (thoracic color pattern), pl. 44, figs. 23, 24 (apps.).

Kartabo: July-Aug., 1926, Chas. Hodge IV, one male.

The Kartabo male differs from Williamson's description and figures and from two of his male paratypes from Tumatumari, British Guiana, Feb. 11, 1912, with which it has been compared, by having the orange red spots on the mesepisternum reaching farther dorsad and caudad, attaining a length of 1.65 mm. as compared with 1.18 mm. in the paratypes, by the longer yellow area, 1.65 mm., on the metepisternum, vs. 1.18 mm. in the paratypes, and by the black on the second lateral thoracic suture being narrower (.19 mm. vs. .33 mm.). In the two paratypes the inferior appendages project as far caudad as do the superiors; in Williamson's figures and in the Kartabo male the inferiors extend beyond the level of the superiors; the shape of the appendages appears to be the same in all three males. The Kartabo male has all surfaces of the middle third of the third femora yellow. The three males have 9-10 postnodals on the front wings, 8-9 on the hind.

Distribution: British Guiana, Trinidad.

GOMPHINAE S. & H., 1850 (as Gomphines).

i. Ictinogomphinae T. & F., 1940.

Zonophora batesi Selys, 1869.

Selys, 1869, *Bull. Acad. Belg.*, (2) 28 (8): 198. Needham, 1944, *Trans. Amer. Ent. Soc.*, 69: 219, pl. XVI, fig. 19a (genit. 2d abd. seg. ♂).

Zonophora bodkini Campion, 1920, *Ann. Mag. Nat. Hist.*, (9) 6:136, pl. VII, figs. 10-14 (venation, vulv. lam., mand., max.).

"Essequibo R(iver) below [between?] mouths of the Potaro and Rupinuni, British Guiana, V.1920, George B. Fox," one male, in coll. Acad. Nat. Sci. Phila.

The mouths of the Potaro and Rupinuni (also spelled Rupununi and Raponunni) Rivers, where they empty into the Essequibo, are about 100 miles (150 km.) apart.

This male has abdomen 58 mm., hind wing 48, its maximum width 13, pterostigma of front wing 5.48, width of head 9.5, 1st femur 4.66 long, 2d femur 5.72, 3d femur 7.93 mm.; antenodals, front wings, 23 and 24, 1st and 6th or 8th thicker, hind wings, 16, 1st and 8th thicker; postnodals, front wings, 15 and 16, hind wings, 17 and 18.

Compared with Selys' description of *batesi*, from Fonte Boa, Upper Amazons, Brazil, this male has the abdomen slightly longer (type 55 mm.) the hind wing slightly shorter (type 50 mm.), pterostigma slightly shorter (type 6 mm.), the ante- and postnodals fewer. Pale markings of the thorax not distinct but apparently not different. Abdominal segment 1 with an orange or yellow spot each side in the posterior half; two yellow or orange spots on each side of 2, one anterior, the other posterior; basal yellow or orange spot on each side of 3 from base to transverse median suture, where it rises almost to the mid-dorsal line, behind this suture a narrower stripe to .9 of the segment's length; a narrower basal stripe each side of 4-6, pointed posteriorly, reaching to the transverse suture on 4, not as far on 5 and 6; the basal ring on 7 reaching to the same suture, interrupted by a mid-dorsal black line. No orange or yellow marks on 8-10. Branches of the inferior appendage spread far wider apart (3.44 mm.) than are the superiors (2.70 mm.). The hamules, penis and especially its vesicle agree fairly well with the figures for this species given by Needham (1944), although the cornua of the penis are extended farther.

The single female from Tumatumari, Potaro River, British Guiana, described by Mr. Campion (1920) as *Zonophora bodkini*, is nearly the same size as the present male, but the hind wing is longer (52 mm.), and in most respects, other than those of sex, this male agrees with Mr. Campion's description, including the stout tubercle behind each of the paired ocelli. The hind margin of the occiput of this male, however, is almost straight, barely concave, the ante- and postnodals are slightly fewer, the pterostigma decidedly shorter and there is a brace-vein at its proximal end.

I think the differences above listed between the present male and the description of *batesi* are not specific and that *bodkini* is the corresponding female.*

Distribution: Guianas, Amazon valley.

***Progomphus dorsopallidus* Byers, 1934.**

Byers, 1934, *Occas. Papers Mus. Zool. Univ. Mich.*, 294:1, pls. I, II.

Kartabo: one female, lacking abd. segs. 4-10.

The female of this species has not been described. The present specimen agrees fairly with the description of the male, especially with the thoracic color pattern. The

posterior margin of the occiput has a slight tendency to form a median excision. Wings colorless, hind wing 20 mm. Pterostigma pale clay yellow, smaller than described, 2.83 mm. long on costal margin, surmounting 4-4½ cells. Antenodals, front wings, 15 and 13, hind wings 10 and 11; postnodals, front wings, 10 and 9, hind wings, 10; all the triangles 2-celled.

Dorsopallidus was described from San Estéban, Venezuela.

***Gomphoides fuliginosa* Hagen, 1854.**

Needham, 1944, *Trans. Amer. Ent. Soc.*, 69:195, 197, pl. XV, fig. 8e, pl. XVI, fig. 8f.

Kartabo: one nymphal exuvia, 7.IX.1920.

I have asked Prof. Needham to study this exuvia in the belief that he would be more able than I to identify it in the course of his examination of allied material. His results are contained in his paper cited above.

Distribution: British and Dutch Guiana.

***Phyllocycla* new generic name**

for *Cyclophylla* Selys preoccupied. Type species: *signata* Hagen, as for *Cyclophylla*, fixed by Kirby, 1890, *Cat. Odon.*, p. 74.

Cowley (*Ent. Mo. Mag.*, 70:244, 1934) pointed out that the name *Cyclophylla* Selys, 1854, was preoccupied by Brandt, 1837, in *Coelenterata*³⁰ but demurred to giving a new name for *Cyclophylla* on the ground that it was unnecessary, since the three genera or subgenera, *Gomphoides*, *Cyclophylla* and *Aphylla*, had been combined into one for which he accepted Muttkowski's 1910 name, *Negomphoides*.

Now that Prof. Needham has resurrected these three genera (*Trans. Amer. Ent. Soc.*, 65:365, 388, 389, 1940) on partly new characters, it seems necessary to adopt a new name for *Cyclophylla*, hence the present proposal of *Phyllocycla*. However, the distinctness of the three groups, based on Needham's new characters drawn from the anal field, is still not sharp, as attention is called below to variations in *Phyllocycla signata*, *Ph. bartica* and *Aphylla alia* in the number of cells in the anal loop and in the course of vein A2 which are not in accord with his characters for *Cyclophylla (Phyllocycla)*.

***Phyllocycla signata* (Hagen, 1854), (new combination).**

Cyclophylla signata Needham, 1943, *Bolet. Entom. Venezol.*, 2(4):201.

Kartabo, 13.iii, one male.

Abdomen 37 mm., hind wing 27, pterostigma (right front wing) 3.30, third femur 5.10, width of head 6.5, width of hind wing 7.85 mm.

* Subsequent to the reading of the first proofs of this article, I received from Dr. Erich Schmidt, of Bonn, Germany, proof sheets of a paper by himself entitled "Revision der Gattung *Zonophora* Selys Deut. che Entom. Zeitschrift 1941, Heft I-II (9 Juli 1941) p. 76ff." Dr. Schmidt has not distributed his separata as yet. His paper is included in the Insecta section of the Zoological Record for 1945. In it he has the same conception of *Z. batesi* as set forth above and has likewise concluded that *Z. bodkini* Campion is the female of *Z. batesi*. This note is inserted here to record that he and I—he first—have independently reached the same conclusions.

³⁰ Neave, *Nomenclator Zoologicus*, 1939, I:920, gives the reference for Brandt's name as 1837, *Bull. Sci. Acad. Imp. Sci. St. Petersb.*, 1 (24): 187, which I have examined. The title of Johann Friedrich Brandt's paper in question is "Remarques sur quelques modifications dans l'arrangement de l'ordre des Acalèphes discophores ou umbrellifères," in which the "Subgenus [Carybdea] *Cyclophylla* Nob." is briefly characterized and two species, *Carybdea periphylla* Per. et Les. and *Carybdea bicolor* Quoy et Guim., are referred to it.

This male corresponds closely with de Selys and Hagen's descriptions and figures of 1854 and 1858 of *signata*, based on a male from "Bresil" in the Berlin Museum and a female from Venezuela by Appun in Hagen's collection. Such differences as I have found (in addition to slight ones in size which the above dimensions indicate) are: Occiput dark brown, hind margin nearly straight (shown as slightly bilobed in Hagen's pl. 12, fig. 4d of 1858); markings of the abdomen not very distinct; on moistening the insect with alcohol, the pale basal spots reach apparently to one-tenth of the segment's length on 3, one-fifth on 4, .15 on 5 and 6 and .17 on 7; 10 is dark brown dorsally; discoidal triangle of front wings 3-celled by 3 veinlets, one from each side, which meet in the center; discoidal triangle of hind wings and internal triangle of front wings each 2-celled, internal triangle (sub-triangle) of hind wings free; antenodals on the front wings 20 and 19, on the hind wings 14; postnodals on the front wings 12, on the hind wings 13.

The following particulars may be added: Pale green antehumeral stripe .8 mm. wide at its lower (anterior) end, just above its union with the green mesothoracic "half-collar" and where it is separated from the brown mid-dorsal carina by exactly its own width, the right and left antehumerals converging upward. The much narrower (.25 mm.) pale humeral stripe complete. A pale green stripe (.5 mm. wide) on most of the length of the brown mesepimeron; a subequally wide pale green stripe on most of the length of the brown metepisternum; between it and the green of the metepimeron is a brown band, about 1 mm. wide, on the second lateral suture; by far the larger part of the metepimeron is pale green to the small brown triangle at its postero-inferior angle.

Anal loop of 3 cells (1 in front, 2 behind) not sharply defined posteriorly, A1 and A2 approximating slightly behind it, thence diverging to the hind margin of the wing; distal portion of A2 convergent with A3. A basal subcostal cross-vein on all wings.

Signata has not appeared in the literature since de Selys and Hagen's *Monographie des Gomphines* of 1858 until it was compared with *C. anduzei* by Needham (1943).

Distribution: Venezuela, Guiana, Brazil.

Phyllocycla bartica, new species.

(Plate I, figs. 7-15).

?*Cyclophylla* sp. No. 6, Needham, 1940, *Trans. Amer. Ent. Soc.*, 65:379 (nymph).

Kartabo: III.4.1926, one female; III.9.1926, one male holotype; III.11.1926, one female; 18.5.1919, one male; July-Aug. 1926, one female by Dr. Charles Hodge IV, in the collection of the Academy of Natural Sciences of Philadelphia, paratypes. Holotype ♂ No. 9277 Acad. Nat. Sci. Phila.

Also, I have had the opportunity to include in the following description one pair taken in copula, the female with a cluster of eggs at the vulva, four other males and one other female from Itaituba, on the Rio Tapajos, Brazil, I, III, and V, 1922, by A. H. Fassel, from the collection of the late Dr. F. Ris (Senckenberg Museum, Frankfurt am Main), and one male from Kartabo, British Guiana, taken by Dr. W. T. M. Forbes, between November 1 and 5, 1920, now in the Cornell University collection—all lent to me by the Museum of Zoology, University of Michigan, through the kind interest of Mrs. Leonora K. Gloyd; these likewise are paratypes.

♂. Face (except rhinarium=anteclypeus), labrum, vertex and occiput reddish brown. Rhinarium, frons, above its transverse carina, pale green, but a narrower reddish-brown band on its upper surface immediately in front of the ocelli. Hind margin of occiput almost straight. Rear of head and labium perhaps pale green in life.

Prothorax reddish-brown. Pterothorax dark brown, mesothoracic "half collar" united broadly with an antehumeral stripe on each side to form a green figure "7", the antehumeral stripe widest (.5-.8 mm.) at its lower end just above where it joins the half-collar and where it is once to nearly twice as far from the green-lined mid-dorsal carina as its own width; right and left antehumerals converging toward their upper ends where each is .42-.65 mm. distant from the same carina. Sides of thorax mostly dark brown, the following green: a complete stripe .3-.4 mm. wide, immediately in front of the humeral suture, a mesepimeral stripe .42-.65 mm. wide at mid-height, for almost the whole length of the sclerite, a metepisternal stripe .57-.66 mm. wide, close to the second lateral suture, and most of the metepimeron and pectus.

Abdominal segments 1 and 2 brown, a dorsal basal spot on each side of 1 (or the two united), a mid-longitudinal stripe and the auricles on 2 and the sides inferiorly of both 1 and 2, pale green; 3-10 blackish, a longitudinal reddish-yellow stripe on each side of 3-7, reaching .8 of the length of the segment on 3, .86 on 4, .7 on 5, .3 or more on 6, .33 on 7 (for shorter distances on other males); some reddish on each side of 8 and 9, and a small yellowish spot on each side of 10 near its hind margin.

Lateral margins of 7 widening gradually from base to apex. In profile 8 shows a distinct lamellate expansion of the ventral tergal margin for its entire length, increasing in depth caudad to a maximum of .25-.38 mm. at three-fourths' the segment's length and terminating in a circular quadrant, ventral margin with 12-14 denticles; expansion on 9 having a maximum of .1 mm. at mid-length of the segment.

Superior appendages 1.70-2 mm. long, longer than 10, subequal to 9, blackish or reddish-brown; in dorsal view each directed nearly straight caudad in its proximal .6, then curved mesad; at .4-.55 length there is an acute, pale-tipped tooth on the upper, carinate margin; opposite this tooth is a slight convexity or a straightness on the otherwise concave mesal ventral margin; at seven-eighths' to nine-tenths' length the outer margin is strongly angled mesad and thence extends in a nearly straight line to the apex; the extreme apex is rounded and finger-like and slightly proximal to it the inner margin is excised, but convex proximal to the excision; the inner (mesal) surface of the appendage is grooved for its entire length, the groove passing under (ventral to) the ante-apical convexity just described. In profile view each appendage as a whole is directed slightly dorsad and its height regularly decreases, especially on its ventral margin, from base to apex; the terminal sixth or more is obliquely truncated ventrad and caudad; the upper margin shows two shallow concavities, the first from base to the superior tooth (above described) at .4-.55 length, the second, shallower, from the tooth to the strong superior angulation at seven-eighths' length or more where the truncation of the apex begins; the inferior margin shows a sharp, conical, basal tooth, whence the margin is slightly convex, thence slightly concave, ascending to the beginning of the apical truncation.

Inferior appendage visible in dorsal, but hardly in profile, view; in dorsal view about one-fifth as long as the superiors, a little wider than long, distal margin with a slight median notch, not always present.

Auricles with 7-10 black, marginal denticles. Genitalia of 2 as shown in figs. 8-10, Plate I. Posterior cleft of the "gaine" (Hagen, 1858, pl. 12, fig. 4j.) = "hood of the penial peduncle" (Needham, 1943, p. 202) with a tooth at the bottom, as in Hagen's figure cited. Cornua of the penis finely serrate as figured by Hagen (l. c., pl. 12, fig. 4i).

Legs reddish, distal ends of the femora and the tarsi reddish-brown.

Wings faintly smoky, stigma brown, surmounting $4\frac{1}{2}$ -7 cells, a basal subcostal cross-vein³¹ on all wings, all triangles (except the free internal of the hind wings) 2-celled (or the discoidal triangle of the front wings 3-celled in seven out of sixteen wings), two ultra-triangular rows (preceded by three cells on the hind wings) increasing to three rows beyond the level of separation of the subnodal sector (Rs bridge) and median vein (M1-2), anal loop of two cells, A1 and A2 converging behind it, thence diverging to the hind margin of the wing (see Pl. I, fig. 13), with one (15) or two (7δ) cells

between them immediately posterior to the anal loop. Antenodals on front wings 14-19 (17), on hind wings 11-15 (13). Postnodals on front wings 9-13 (10), on hind wings 10-13 (11), numbers in parentheses the most frequent. First and fifth or sixth antenodals stronger on the front wings, first and fifth on the hind wings. Venation dark brown.

Dimensions of ♂: abdomen 37.5-40.5 mm., hind wing 27-29, pterostigma, front wing 3.59-3.68, third femur 4.87-5.0, width of head 6.25-7.70, width of hind wing 7.00-8.00 mm.

♀. Differs from the male as follows: Pale antehumeral stripe at its upper end .47-.8 mm. distant from mid-dorsal carina, its maximum width at lower end .9 mm. Sides of thorax apparently the same. Reddish-yellow on the sides of abdominal segments reaching to the full length of 3-7. Lateral expansions of 8 to .09-.14 mm., of 9 to .05-.09 mm. Segment 11 .36 as long as 10, conical, yellowish, Appendages 1-1.4 mm. long, subequal to 10, yellowish or ochre, straight, slender, tapering to an acute apex. Vulvar lamina (Pl. I, fig. 14) .38-.5 mm. long, .24-.28 as long as the sternum of 9, 1.0 mm. wide at base, bifid in distal half or two-thirds, lobes triangular, interval between lobes nearly 90°, interval between apices of lobes .47-.57 mm. Discoidal triangle 3-celled in right front (2♀) or both front (2♀) wings. Antenodals on front wings 16-20 (16 and 18 equally frequent), on hind wings 12-14 (13). Postnodals on front wings 11-12 (11), on hind wings 12-15 (13). The female of III.11.1926 has the first and sixth antenodals on the hind wings thicker.

Dimensions: abdomen 34-39 mm., hind wing 29.5-31, pterostigma of front wing 3.40-4.09, third femur 4.91-5.20, width of head 6.5-7.20, width of hind wing 6.5-8.34 mm.

The younger female, taken by Dr. Charles Hodge, also may belong to this species. Its colors are paler. Head pale brown, the following pale green: a curved stripe on each side of the labrum close to the free margin, rhinarium (anteclypeus), a spot on each side of the nasus (postclypeus), frons above the carina but leaving a wider brown stripe in front of the ocelli. Most of the prothorax pale green, hind lobe pale brown. Pterothorax with a mid-dorsal yellow or pale green stripe .33 mm. wide, each green antehumeral stripe .5 mm. wide where it joins the mesothoracic half-collar, its upper end only .33 mm. distant from the mid-dorsal carina. Sides of thorax pale reddish, the pale green stripes present but not so clearly seen, owing to the partial wrinkling of the surface.

Abdomen pale greenish or reddish with blackish-brown markings as follows: an indistinct oblique line on each side of dorsum

³¹ Two on the left front wing of one male.

of 2, a narrow mid-dorsal stripe on 3 and 4 from the transverse antemedian carina to four-fifths of each segment's length, a similar stripe on 5 and 6 for the entire length of each, a pair of oblique streaks diverging caudad on the hindmost fifth of 3-6; 7 largely pale with some blackish near its hind end and some for much of the length of 8-10.

Vulvar lamina more exposed, .42 mm. long, .21 as long as the sternum of 9, bilobed in its distal half, lobes widely triangular, each lobe a little more than 90° at tip and rounded, interval between lobes a little more than 90°, width of lamina 1.09 mm., distance between tips of lobes .42 mm.; the 9th segment has been accidentally flattened and more of the sternite of 9 immediately behind the vulvar lamina has been exposed, showing a transverse ridge, concave caudad in the middle and followed by a transverse low tubercle bearing many hairs; on each side of the middle line, immediately in front of this ridge is a small, shallow, darker brown pit. (Pl. I, fig. 15).

Wings clear, pterostigma pale clay-yellow (Smith's "Explanation"), surmounting 6-8 cells, discoidal triangle of both front wings 3-celled, internal triangle of front wings and discoidal triangle of hind wings 2-celled, also the internal triangle of right hind wing, that of left hind wing free. Three ultra-triangular cells precede the two rows on the left front wing and on both hind wings, the increase to three rows is at the level of separation of Rs bridge and M1+2 on both front wings and on left hind wing. Anal loop of two cells, shaped as in the above described 7♂, 4♀, with only slight differences in the lengths of the sides. Antenodals on front wings 19 and 20, first and seventh thicker on the right, on the hind wings 14, postnodals on hind wings 13 and 14.

Otherwise this female is as in the four females above described.

Dimensions of this ♀: abdomen 37 mm., hind wing 31.5, pterostigma front wing 4.0, third femur 4.58, width of head 7.2, width of hind wing 9.0 mm.

The venation of the present material of *bartica* agrees fairly well with that described by Needham (1940) for a nymph, *Cyclophylla* sp. No. 6, American Museum of Natural History, "Acc. 3928: came in with fishes from British Guiana." However, in these five female imagos, the distal portion of vein A2 is parallel, not convergent, with A3 on the hind wings of both sides, hence departing from one generic character for *Cyclophylla* as given by Needham (1940, p. 365); the eight males, on the contrary, agree with this character. There are five postanal³² cells, three of them posterior to

the anal loop in three females, four postanal cells, two of them posterior to the anal loop in the remaining female and the males. There are two rows of cells between A2 and A3 from A to the wing margin on the right hind wing of the July-Aug. female, while on its left hind wing two rows begin one cell below A; in three females two cells between A2 and A3 begin only at two cells from the wing margin, i.e., two cells below A; in the males and one female there is but a single row of cells between A2 and A3, although the female has two marginal cells. Considerable variation in the cells of the anal area is, therefore, to be expected, although the anal loop is 2-celled in all thirteen imagos.

The specific name *bartica* here proposed is that of the district in which Kartabo lies.

In size and coloring *Ph. bartica* is very similar to *Ph. signata* Hagen. The males of *bartica* differ from that of *signata* in the smaller lateral dilatations of abdominal segments 8 and 9, in the shape of that of 9, in the superior appendages having a superior tooth at .4-.55 length, a more distinct angulation of the outer margin at seven-eighths' length, the ante-apical excision of the inner margin more abrupt and in having the acute, conical, inferior, basal tooth; and in the 2-celled anal loop of the hind wings. As mentioned under *signata* (antea), the Kartabo male of that species has the discoidal triangle of both front wings 3-celled, whereas in the types of *signata* it is 2-celled. Of the males of *bartica* here described, seven out of sixteen wings have this triangle 3-celled, the remaining nine 2-celled. Of the five females here referred to *bartica*, three have this triangle 3-celled symmetrically, the remaining two have it 3-celled and 2-celled asymmetrically. These five females are referred to *bartica* because of their symmetrically 2-celled anal loop, as in the *bartica* males, while in the single male of *signata* the anal loop is symmetrically 3-celled. The anal loop is not mentioned in the previous descriptions of *signata*.

The descriptions of other species referred, or referable, to *Cyclophylla* (*Phyllocycla*) or *Aphylla*, differ from *Ph. bartica* as follows:

In the absence of a superior tooth near the mid-length of the superior appendages: *ambigua* Selys, 1873, *anduzei* Needham, 1943, *brevipes* Selys, 1854, *caraiiba* Selys, 1854, *crustatus* Needham, 1944, *cubana* Navas, 1917,³³ *curvata* Navas, 1933, *dentata* Selys, 1859, *distinguendus* Champion 1920, *edentata* Selys, 1869, *elongata* Selys, 1857, *gladiata* Hagen, 1854, *hesperus* Calvert, 1909, *molossus* Selys, 1869, *ophis* Selys,

³² As marked by Needham, 1944, *Trans. Amer. Ent. Soc.*, 69: pl. XVI, fig. 4e, here including the two cells of the anal loop.

³³ *Cyclophylla cubana* Navas, 1917, *Mem. Pont. Acc. Romana*, 3:3, may be the same as *Aphylla caraiiba* Selys, 1854.

1869, *pachystyla* Needham, 1944, *producta* Selys, 1854, *protracta* Selys, 1859, *signata* Hagen, 1854, *sordida* Selys, 1854, *tenuis* Selys, 1859, *theodorina* Navas, 1933, *volsella* Calvert, 1905, and *williamsoni* Gloyd, 1933. Of these, *ambigua* differs also in the possession of a median notch in the hind dorsal margin of abdominal segment 10, *anduzei* in the form of the lateral margin of segment 7; *brevipes*, *cristatus*, *dentata*, *distinguendus*, *edentata* and *molossus* have the pale antehumeral stripe not united with the mesothoracic collar to form a figure 7; *cubana*, *gladiata*, *ophis*, *signata* and *sordida* have no stout, inferior, basal tooth on the superior appendages; in *gladiata* and *sordida* the pale humeral stripe is incomplete; *hesperus* and *protracta* differ in the lateral margins of abdominal segments 8 and 9; *ophis* has no angulation at seven-eighths the length of the superior appendage; still other differences are indicated in the respective descriptions.

Ris 1904³⁴ says of the superior appendages of *Cyclophylla argentina* Hagen, 1878, "dessen obere Kante nahe der Basis und an der Stelle der stärksten Krümmung gegen das Ende je ein ziemlich stumpfes Zähnnchen trägt. Das Ende stumpf." His 1913³⁵ figure of the appendages shows the tooth "nahe der Basis" at about .36 of the appendage length.

For *Cyclophylla diphyla* Selys, 1854, it is stated of the superior appendages: "Le bord supérieur porte une tubercule à son premier tiers," but no mention is made or shown (in 1858) of an inferior basal tooth, and the lateral margins of 8 and 9 are different from those of *bartica*.

Gomphoides eugeniae Navas, 1927, has the superior appendages with a superior tooth before mid-length; in dorsal view rounded, not angulate, exteriorly where the appendage changes its direction; lateral margins of 8 and 9 differently shaped.

Cyclophylla pegasus Selys, 1869, has the superior appendages "portant en dedans à leur moitié un petit tubercule," the lateral margins of 8 and 9 almost rudimentary.

In *Gomphoides viridipleuris* Calvert, 1909, "at about half length the inner surface (of the superior appendages) bears a small blunt tubercle near the upper edge of the appendage," but in dorsal view the appendages are rounded, not angulate, exteriorly where the change in direction of the appendage occurs.

Phylloocyela bartica female differs from the descriptions of the following species of which the female only has been described: *andromache* Selys, 1869, which has no pale mesothoracic collar and has short pale antehumeral bands;

Aphylla cornutifrons Needham, 1944, which has a pair of frontal horns;

Gomphoides ictinia Selys, 1878, which has the vulvar lamina reaching abdominal segment 10.

The description of *Cyclophylla obscura* Kirby, 1899, is insufficient to enable its specific recognition.

Aphylla alia n. sp.

(Plate I, figs. 16-19).

Kartabo, 19.VII.1920, one male, abdominal segments 5-10 and left hind wing beyond the triangle lost, holotype, No. 9276, Acad. Nat. Sci. Phila.

This male agrees with the first character for *Cyclophylla* listed by Needham, 1940 (*Trans. Amer. Ent. Soc.*, 65:365), viz.:

(a) Anal loop of two cells sharply defined at its rear by convergence of A1 and A2, but not with the second character, as

(b) the distal portion of A2 is not convergent with A3 but diverges somewhat from it and also from A1. (Pl. I, fig. 18.)

It agrees with the following Selys-Hagen (1858, pp. 216-217) characters for *Cyclophylla*:

(c) internal triangle (subtriangle) of the front wings of two cells;

(d) the same of the hind wings free;

(e) discoidal triangle of all wings 2-celled (here 2-celled); but disagrees with the following Selys-Hagen characters:

(f) labium (i.e., the median lobe or ligula) as long as wide (here wider than long);

(g) "pièce supérieure des parties génitales" (=anterior lamina) emarginate at middle (here a quadrangular plate narrowed posteriorly, reaching caudad against the anterior hamules) (Pl. I, fig. 17);

(h) anterior and posterior hamules, in profile view, almost equally prominent, the anterior more slender, curved strongly caudad and dorsad; in oblique view, an acute, posterior, basal tooth is visible near the floor of the genital fossa; posterior hamule, in profile view erect, at least twice as thick as the anterior hamule, with a bunch of long (.85 mm.) hairs, its apex acute and directed mesad (Pl. I, figs. 16, 17);

(j) "gaine du penis" (vesicle or first segment thereof), in profile view, acutely pointed ventrad; in rear view, this acute point corresponds to a transverse lamella whose margin is trifid, the teeth about .047 mm. long (Pl. I, figs. 16, 19);

(k) glans of penis (=4th segment) with two very long cornua (here the cornua are absent and the glans, in ventral view, is subquadrangular, .6 mm. long, .38 mm. wide at base, .57 mm. at apex, membranous, pale, near its mid-length with two very black denticles in an oblique line on each side of its median line) (Pl. I, figs. 16, 17);

(l) "cueillère" (=sheath of penis, Tilliard, 1917) elongate, slightly wider at apex

³⁴ Hamburger Magalhaensische Sammelreise, Odonaten, p. 19.

³⁵ *Mem. Soc. Ent. Belg.*, 22:74.

with the merest suggestion of a median apical notch (Pl. I, fig. 17, sh).

The characters above lettered (b), (f), (g), (h), (j), (k), which differ from those given by Needham and by Selys-Hagen for *Cyclophylla*, approach or are identical with those of *Aphylla* and hence render doubtful the distinctness of these two "genera."

Other features of this male from Kartabo are: vertex, anterior surface of frons, nasus (postclypeus) except for a small yellow spot each side, lower margin of rhinarium (antelypéus), labrum except for a yellow spot each side, rear of head except for a yellow spot each side near middle of eye-margin—dark brown (near Cologne earth or Roman sepia of Smith's Explanation, pl. iv, nos. 37 and 38). Occiput (its hind margin a straight line), superior surface of frons except a dark brown basal band in front of the ocelli, most of the rhinarium, genae, outer surface of mandibles—greenish-yellow. Labium near pale clay yellow (Smith, pl. iv, no. 22).

Prothorax: fore lobe brown pink (Smith, no. 21), middle and hind lobes greenish-yellow. Pterothorax predominantly darker brown than that on head, the following greenish-yellow: mid-dorsal carina, a transverse stripe ("collar") at anterior end of each mesepisternum for its entire width, an antehumeral stripe .8 mm. wide at mid-height, separated by a distance less than its own width from the mid-dorsal carina, diverging therefrom and from its fellow of the opposite side forward and downward, widened laterad at its upper end where it borders the ante-alar sinus, pointed at its lower end which does not touch the transverse mesepisternal stripe (hence *not* forming a figure 7), a stripe .57 mm. wide at mid-height on the mesepimera, a stripe passing through the metastigma around which it is enlarged but above which it is narrowed to .33 mm., a stripe on the metepimeron .98 mm. wide at mid-height, these three stripes wider at their upper ends which attain the upper margins of their respective sclerites. Interlar tergites with a mid-dorsal row of greenish-yellow or (on the scutella) gamboge spots. Pectus brown pink.

Abdominal segments 1-4: ventral surface dull yellow. Dorsal surface of 1 and 2 dark brown, a mid-dorsal stripe on 2, widened just posterior to the level of the yellow-tipped auricles, thereafter narrowed and confluent at its hind end with a transverse band which borders the entire width of the segment, yellow, auricles moderately prominent with 25-30 minute, posterior, black denticles; 3 largely orange but obscured with dull brownish at anterior end, the submedian transverse carina, an obliquely transverse ante-apical band and a longitudinal stripe on each side of the mid-dorsal carina uniting the former two, black; 4 orange each side for the anterior two-

sevenths of the segment's length, black from the submedian transverse carina as far caudad as a narrow, transverse, ante-apical, orange stripe, and with a slender, blackish prolongation forward on each side of the mid-dorsal carina almost to the anterior end of the segment; intersegmental articulations of 2-3, 3-4, 4-5 black; an inferior, longitudinal, brown stripe on each side of 3 and 4 for their entire lengths.

Legs: femora brown, superiorly reddish, tibiae and tarsi darker brown to black.

Wings (in addition to the features given at the beginning of this description): slightly brownish at the extreme bases of the subcostal and submedian spaces, venation dark brown or black except for the pale yellow costa, stigma pale ochre, surmounting 5½-7 cells, 16 (right), 17 (left) antenodals on the front wings, the 1st and 6th thicker, 12 on the hind wings, 1st and 5th thicker, 11 (right), 12 (left) postnodals on the front wings, 13 (right), 14 (left) hind wings; one basal subcostal, one cubito-anal and one supratrangular cross-veins on all four wings, the cubito-anal nearly at the level of the first antenodal; post-triangular cells, front wings, two rows from the triangle out to the level of the point of separation of M1 and M3 (left) or one cell more remote (right), on the hind wings 3, then two rows to the level of the point of separation of M1 and M3 (left) or of M1 and the bridge of Rs (right). Hind wings with 4 paranal cells (Needham, 1944), of which the first two are also the proximal cells of the anal triangle and the fourth is also the first postanal; 5 postanal cells (Needham, 1944); sequence of cells between A1 and A2 behind the 2-celled anal loop: 1, 2, 3 (right), 2, 2, 4 (left), anal triangle 4-celled.

Dimensions: abdominal segments 1-4 13.5 mm., hind wing 28 mm., costal edge of stigma, front wing, 3.6 mm.

At least five species referred, or referable, to *Aphylla*, viz.: *brevipes* Selys, *dentata* Selys, *distinguenda* Campion, *edentata* Selys and *molossus* Bates Mss. Selys, are described as having the pale antehumeral stripe not connected with the pale mesothoracic "half collar;" in this respect the present male resembles them, but is smaller, has a shorter pterostigma and no pale humeral stripe; some other data concerning these five are given antea in the discussion of *Phyllocycla bartica*. The genitalia of the second abdominal segment of none of these five species have been described and owing to the absence of the last six abdominal segments and appendages of this specimen, it is not possible to say whether it is or is not conspecific with any of the five.

ii. Gomphinae T. & F., 1940.

Archaeogomphus hamatus (Willmsn., 1918).

Agriogomphus hamatus Williamson, 1918,

Occas. Papers Mus. Zool. Univ. Mich., 59:4, pls. i, ii.

Archaeogomphus hamatus Williamson, 1919, op. cit., 63:5, pl. I, fig. 2; 1923, op. cit., 134:7.

Kartabo, 3 males, 1 female; two of the males without most of the abdomen, one male labeled 2.8.1919, another 6.III.1924, the remaining male and the female not dated.

In his paper of 1923 Williamson distinguishes *A. hamatus* female from *A. furcatus* female by the latter having the "rear of the occiput armed with two posteriorly directed spines or horns," while *hamatus* has the "rear of the occiput not armed with posteriorly directed horns." The present female has a horn .09 mm. long on each side of the occiput in the position in which rudiments are shown in his figure 10, pl. i of 1918 for *hamatus*. Since at least two of the present males are *hamatus* by the seminal vesicle (first joint of the penis), the principal character relied upon by its describer, I refer this female to the same species.

Distribution of *A. hamatus*: Dept. Magdalena, Colombia; British Guiana.

Of the thirteen features shown for *Archaeogomphus* in Prof. Needham's Verification Table for the neotropical Gomphinae (*Trans. Amer. Ent. Soc.*, 65:389, 1940) the following show deviations in these four individuals:

Postnodals in fore wings 6, without exception;

Antenodals in hind wings 9, without exception;

Postnodals in hind wings 5-7 (6 most frequent, in 5 wings out of 8);

Cross-veins between the sectors of the arculus proximal to the middle fork in fore wings 3-4 (4 more frequent, in 5 wings out of 8);

The same in hind wings 2, without exception;

Length of hind wing ♂ 15.5-17 mm., ♀ 18 mm.

The remaining seven features show no deviations in the present material.

AESHNINAE S. & H., 1850 (as Aeschnines).

i. Gynacanthaginae T. & F., 1940.

Staurophebia reticulata reticulata
(Burmeister, 1839).

E. M. Walker 1915, *Can. Ent.*, 47:390.

Rockstone, Essequibo, 9.04, Wm. Schaus, one female in the U. S. National Museum.

The colors of this female agree with the description of those from British Guiana given by Prof. Walker, t. c., p. 388. The venational features which he tabulated on page 389 show some variations in this female as follows: antecubitals, front wings, 34 (right), 33 (left), hind wings, 22 (r),

23 (l); postcubitals, front wings, 27 (r), 26 (l), hind wings, 28 (r), 30 (l); marginal cells between Rs and M3, front wings, 46 (r), 42 (l), hind wings, 49 (r), 47 (l); cross-veins in triangle, front wings, 6 (r), 7 (l), hind wings, 6 (r), 5 (l); cross-veins in supratriangle, front wing, 9, hind wings 7; cubital cross-veins, front wings, 8 (r), 9 (l), hind wings, 6 (r), 5 (l); cells in anal loop, hind wings, 21 (r), 18 (l); position of fork of Rs (number of first postnodal cells before stigma, front wings, 9, hind wings, 11 (r), 12 (l). Abdomen exclusive of apps.) 70 mm., hind wing about 70 mm. (extreme apices broken).

To aid in determining the geographical distribution of the Guianan form of *Staurophebia*, which Prof. Walker considered to be *S. reticulata reticulata*, I have re-examined the Honduras and Chiriqui males cited in the *Biologia Centrali-Americana*,³⁶ which presumably are duplicates of specimens in the René Martin collection in the Paris Museum. The Honduras male has a very narrow, reddish line representing the stem of the T-spot of the frons, a faint brown line on the fronto-nasal suture, thorax dull greenish with a narrow (linear) faint reddish-brown streak bordering the ante-alar sinus anteriorly and on each side of the mid-dorsal carina; abdomen faded, its anterior segments reddish-brown, inferior appendage one-half as long as the superiors, elongate, triangular, as shown in Prof. Walker's figure 2, page 396.

The Chiriqui male has a distinct, black, linear stem to the T-spot, a narrow dark brown line on the fronto-nasal suture and along the base of the labrum, thorax dull greenish, discolored in front of the ante-alar sinus, a narrow reddish-brown stripe on each side of the mid-dorsal carina, abdomen faded, its anterior segments reddish-brown, inferior appendage as in the Honduras male except that it is two-thirds as long as the superiors.

I have examined also two males of *Staurophebia* from the Florida road in the forest near Guapiles, Costa Rica, one taken by myself June 4, 1909, the other by Messrs. Schaus and Barnes on June 5 or 6, 1909, and one female taken by Prof. F. Tristán and myself in forest north of Santa Cruz, Costa Rica, January 29, 1910. The first male has a reddish-brown linear stem to the T-spot, barely the suggestion of a line on the fronto-nasal suture, thorax green, no darker markings in front of the ante-alar sinus or along the mid-dorsal carina, green of the thorax continued caudad as far as the extreme base of abdominal segment 3, anterior half of 3 otherwise reddish-brown, inferior appendage reaching to .55 of the length of the superiors. The other Guapiles male was

³⁶ *Neur.*, p. 179, 1905.

apparently similarly colored although the stem of the T-spot is still fainter, the thorax and first two abdominal segments more faded, the inferior appendage of the same extent. The Santa Cruz female is the only one of the three for which I have notes of the living colors; they are as follows: Eyes bright green with black pseudopupillae (6 horizontal rows in profile view, as follows from above downward: 2, 5, 6, 6, 5, 4, those of 2nd and 3rd row largest, decreasing in size from 3rd to 6th row). Remainder of head pale greenish-blue a rather faint pale brown T-spot on frons. Thorax and abdomen pale blue, the former a little grayish from pruinosity, abd. segments 1 & 2 and anterior half of 3 green. Thoracic sutures faintly brown. Abdominal intersegmental articulations dark brown, especially 7/8 and 8/9. Abdominal appendages brown, pale at base. Legs pale blue, tarsi and 3rd tibiae inferiorly black.

The Honduran and Costa Rican individuals thus approach Prof. Walker's *St. reticulata guatemalteca* more closely than either of the other two forms which he has differentiated; the Chiriqui male's living colors may have been such as to place it here also, although its present dried condition might seem to refer it to *St. reticulata obscura*.

René Martin³⁷ is the only author who has described and figured the inferior appendage of a *Staurophlebia* as "triangulaire conique du quart environ des supérieurs," although he adds "plus long chez certains sujets." Where this appendage is mentioned elsewhere in the literature, its length is given as half or more than half as long as the superiors, as it is in the four males mentioned above and in a male from Rockstone, British Guiana, which I received from Mr. E. B. Williamson. Prof. Walker has not discussed variations of the inferior appendage in his paper of 1915.

"The inferior appendage has a superior, basal, triangular process which projects upward and backward between the right and left superior appendages at their base; although well developed it is not mentioned in the descriptions; its morphological significance will, doubtless, be interesting."³⁸ It was subsequently described and figured by Prof. Walker (1915, pp. 392, 394, fig. 1), and by Navas for *St. platyura*.³⁹

How it escaped the careful eye of E. Menger, artist of Martin's Aeschnines in the Catalogue of the Selys Collections, it is difficult to understand.⁴⁰

³⁷ Cat. Coll. Zool. Selys-Longchamps, fasc. XX: 210, fig. 216, 1909.

³⁸ Biol. Centr. Amer. Neur. p. 178, 1905.

³⁹ Bol. Soc. Ent. Esp., 3: 91, fig. 1, 'por encima'. Mayo-Junio, 1920.

⁴⁰ A similar process exists on the inferior appendage of *Aeshna (Coryphaeschna) luteipennis* Burm. and has escaped description, although several times figured: Brauer, 1866. Novara Reise Neurop., tab. I fig. 19 (as *Ae. excisa*);

Geographical distribution of *S. reticulata reticulata*: Porto Cabello, Venezuela, the Guianas, Para and perhaps farther south in Brazil and Argentina.

Triacanthagyna AND *Gynacantha*.

The identifications and the geographical distribution of the following species of these two genera are according to E. B. Williamson's paper of 1923 (*Univ. Mich. Mus. Zool. Misc. Publ. No. 9*) and that of Mr. W. D. Hinks of 1934 (*Entom. Record*, 46:77-81).

Triacanthagyna septima (Selys, 1857).

Kartabo: one male, "Odon. 83," abdomen lost; one male, abd. segs. 9-10 lost; one male, July-August, 1926, by Dr. Charles Hodge IV; Penal Settlement, 1917, one female, abd. segs. 6-10 lost. Georgetown, British Guiana, 15.3.1919, one female, appendages in part lost.

Anal loop with two vertical rows of cells in the hind wings of the three males and the left hind wing of the Georgetown female, with three vertical rows in the remaining three hind wings of the females; the second Kartabo male, however, has a central cell in the midst of the two vertical rows. There are three rows of cells between M4 and M5pl of both front and hind wings of all five individuals. The anal triangle is 2-celled in the three males, except in the left hind wing of ♂ 83.

Distribution: Mexico to Bolivia and Rio de Janeiro, Brazil, including previous records from Dutch and French, but not British, Guiana; also Trinidad and Cuba.

Triacanthagyna ditzleri Williamson, 1923.

Georgetown, British Guiana, Broad Street, Head Office, 10.12.28. L. D. Cleare, Jr., one male in alcohol, lacking both left wings and abd. seg. 6, sup. apps. detached and at bottom of vial; sent by Prof. J. G. Needham.

Probable length of abdomen (excl. apps.) 35 mm., sup. apps. 5.56 mm., hind wing 33. costal edge of pterostigma, front wing, 3.35 mm.

Distribution: Guatemala to Mishuyacu, Peru, and Rio Grande do Sul, Brazil, including a record from Bartica, British Guiana (H. S. Parrish). Williamson, however, thought (l. c., p. 9) that the "similar but larger specimens from southern Brazil" which he referred to this species "will probably be found to be specifically distinct." Geijskes has reported *ditzleri* also from Trinidad, West Indies.⁴¹

Calvert, 1895, *Proc. Calif. Acad. Sci.*, (2) IV, pl. XV fig. 27; Martin, 1908, *Cat. Coll. Zool. Selys*, fasc. XVIII, p. 74, fig. 72 (dorsal view); Navas, 1911, *Revista Mus. Paul.*, 8:480, fig. 3a (as *Remartinia barbiellina*). Calvert, 1941, *Ann. Ent. Soc. Amer.*, 34 (2): 393, fig. 1.

⁴¹ Zool. Meded., Mus. Nat. Hist. Leiden, 15 (1-2): 99, 1932.

Gynacantha tenuis Martin, 1909.

Georgetown, British Guiana, one female.

Abdomen 45, hind wing 46, costal edge of pterostigma, front wing, 3.60 mm.

Abdominal segment 10 in dorsal view 1.04 mm. long, 1.80 mm. wide; a shallow transverse groove at .36 of length of segment, interrupted mid-dorsally; anterior to this groove is a pair of low rounded elevations $.24 \times .42$ mm., separated by a median depression .28 mm. wide; posterior to the transverse groove are two shallow smooth depressions each $.28 \times .60$ mm., separated by a low mid-dorsal ridge, .24 wide, bearing short blackish hairs or fine lines; each of these depressions extends laterad to as far as the level of the lateral margin of the respective appendage. In the proximal anterior angle of each of these two depressions is a transversely elongated "crater," $.19 \times .25$ mm., abutting on the mid-dorsal ridge just mentioned. Although these features of segment 10 are bilaterally symmetrical, it is doubtful whether they are specifically constant—some *T. septima* and *G. auricularis* are similar. The supra-anal tubercle (11th tergite) is .66 mm. long.

Anal loop separated from the hind margin of the wing by only one row of cells; the loop of three vertical rows of cells, except that the first transverse row of cells in the right hind wing consists of 4 cells, where there are but 3 cells in the left wing. Between M3 and M4 on all only one row of cells except where M4 makes a slight curve caudad, at which place there are two double cells on the right front wing, $1\frac{1}{2}$ double cells on the right hind wing, one double cell on both left wings.

Distribution: Colombia to French Guiana and Putumayo district, Peru, including a single female from "Essequibo, British Guiana, Schneider," also two females from Chapada, Matto Grosso, Brazil. This species also has been recorded from Trinidad by Dr. Geijskes.⁴²

Gynacantha auricularis Martin, 1909.

Kartabo: IV.4.1926, one male; V.8.1924, one male; V.12.1924, one male; VI.14.1924, one male; one female, not dated. Mt. Everard, Br. Guiana, one male.

The male of IV.4.1926 shows plainly a thin mid-ventral vertical plate between the right and left hamular processes and between the right and left spines of the anterior lamina but not reaching as far cephalad as the anterior end of the anterior lamina. This is the appressed "anterior parts" (Williamson) of the right and left hamular processes, and is well developed in *G. gracilis* and in *G. membranalis* (but not as strongly in *T. septima*), hence used by Williamson in his key (1923, p. 12) as one of the characters

separating *Triacanthagyna* from *Gynacantha*.

The most frequent condition of the anal loop is to have three vertical rows of cells in its anterior half and two vertical rows in its posterior half, but the three rows extend to the hind edge of the loop in the right hind wings of ♂ IV.4 and of the Mt. Everard ♂. In all six individuals the membranule of the hind wings is very narrow, its maximum width being only .14-.19 mm.

Distribution: Costa Rica to Chapada, Matto Grosso, Brazil, including a record from Bartica, British Guiana (H. S. Parrish).

Gynacantha nervosa Rambur, 1842.

Kartabo, V.17.1924, one female.

The anal loop has three vertical rows of cells, but in the left hind wing there is a transverse row of 4 cells at mid-height.

Distribution: California and Florida to Matto Grosso, Brazil (including a record from Rockstone, British Guiana—Williamson), Cuba, Haiti, Jamaica and Trinidad.

Gynacantha gracilis (Burmeister, 1839).

Kartabo: III.6.1926, one male; 2.VI.1921, one male, abd. segs. 4-10 lost; not dated, one male. Sixty m (iles) up Maroni R (iver), French Guiana, J 04, Wm Schaus, one teneral male, U. S. National Museum.

The prevalent tendency in these four males is for the anal loop to have four vertical rows of cells (6 wings out of 8), but ♂ III.6. has both hind wings with three such rows except for one transverse row of four cells at mid-height, ♂ 2.VI. right hind wing, at one cell below the level of point of separation of Cu2 and A1, are three vertical rows, and in the undated male the right hind wing has three, then four, vertical rows.

The articular area between abdominal segments 1 and 2 in the Kartabo males is almost black around the body except at the genital fossa, but in the teneral Moroni River male this area is not black dorsally.

Distribution: Costa Rica to Bolivia and Rio de Janeiro, Brazil (including a record from Kartabo, British Guiana, October, 1920, W. T. M. Forbes).

Gynacantha membranalis Karsch, 1891.

Kartabo: 3.V.1924, one male; VI.9.1924, one female; VI.20.1924, one male; 11.V.1919, one male; undated, one male. Georgetown, British Guiana, one male.

The Kartabo, VI.20, and the Georgetown males are smaller than the dimensions given for this species in Williamson's paper of 1923, the hind wing being 53 mm. long in the former and 52 mm. in the latter. All my measurements of the superior male appendages of this material are lower than Williamson's, ranging from 5.4 to 5.81 mm., and

⁴² 1932, paper above cited, p. 97.

some of those for costal margin of the stigma, front wing, are lower: 4.9 and 5.1 mm.

The anal loop of the hind wings of the five males has three vertical rows of cells throughout, except the left hind wing of ♂ 11.7. which has four vertical rows with three intermixed and the right hind wing three vertical rows in the anterior half, four such rows in the posterior half; both hind wings of the female have three vertical rows in the anterior half, four in the posterior half.

Distribution: Costa Rica to "Prov. del Sara," Bolivia, and Para, Brazil (including records from Bartica, H. S. Parrish, and Rockstone, E. B. Williamson, in British Guiana). Dr. Geijskes has reported this species from Trinidad.⁴³

ii. Aeshninae T. & F., 1940.

Coryphaeschna virens (Rambur, 1842).

Kartabo: "Odon. 22," one female. R. Supenaam⁴⁴ British Guiana, September, 1930, G. Brinsley, one female, sent by Prof. J. G. Needham. Cayenne, French Guiana, Jan. 04, Wm. Schaus, one male, U. S. National Museum.

Distribution: Tamaulipas, Mexico, to Santa Cruz, Bolivia, Chapada, Matto Grosso, and the Amazons, Brazil; Cuba, Haiti and Trinidad.

CORDULINAE Selys & Hagen, 1850 (as Cordulines).

Corduliinae T. & F., 1940.

Aeschnosoma peruviana Cowley, 1934.

(Plate II, figs. 39-41, 43).

Cowley, 1934, *Stylops* 3 (4): 92-94.

Kartabo, 13.iii, one male, lacking abd. segs. 5-10 and the 2nd pair of legs.

Mr. Cowley has presented a description of, and a key to, the species of this genus, according to which the present male is *peruviana*. His description of *peruviana* was based on a single teneral female from "Peru: Rioja, Prov. Moyobamba, Dep. San Martin (Dr. P. Martin). . . . Rioja lies at an altitude of 848 metres between two tributaries of the Rio Mayo, itself a tributary of the Rio Huallaga."

From his description this male differs as follows: Frontal and dorsal parts of head dark metallic blue, not very brilliant. Right antenna 2.93 mm. long, left antenna broken. Thoracic pale markings present but indistinct, those on the meso- and metanotum more distinct, pale green. Coxal pale spots partly faded. Wings slightly smoky throughout, no yellow or other color at the bases,

⁴³ 1932, loc. cit., p. 98.

⁴⁴ The Supenaam River is a left tributary of the Esse- quibo, near its mouth; see map, p. 24, of Beebe, Hartley & Howes, *Tropical Wild Life in British Guiana*, New York, 1917.

membranule brown, reaching by a narrow prolongation to the anal angle, about 1.18 mm. beyond the apex of the 2-celled anal triangle; stigma dark brown, its costal edge on the front wing 2.13 mm.; antenodals on the front wings 15 (right), 14 (left); under the last costal antenodal on each front wing, but not actually in line with it, is a sub-costal antenodal placed slightly distad (right), distinctly proximad (left); arculus on all the wings proximal to the second antenodal by .24-.33 mm.; supratrangular cross-veins 3 on the front wings 1 (right), 2 (left) on the hind. Abd. segs. 1-4 13 mm., the pale spots on the segments are indistinct; hind wing 34 mm.

The small rounded auricles on abd. seg. 2 occupy about the anterior third of the lateral length of the segment; in ventral view each projects about .33 mm. beyond the surface of the segment; the accessory transverse carina of this segment, directed cephalad and ventrad, meets the auricle a little posterior to its antero-dorsal angle.

Genitalia of abd. seg. 2, profile view: anterior lamina hardly visible but bearing a tuft of hairs .7 mm. long; hamule hardly more prominent than genital lobe, its antero-posterior dimension .66 mm., its dorso-ventral dimension (penis not protruded) .42 mm., its most prominent part is the obtuse apex of the anterior (inner) branch; genital lobe wider (antero-posterior dimension .76 mm.) than high (dorso-ventral dimension .42 mm.), shape as shown in Pl. II, figs. 40, 41.

Supplementing the data on tibial carinae of Corduliinae given by Dr. St. Quentin,⁴⁵ the lengths of these carinae on the first and third legs, in mm. and in percentage of tibial length, are respectively (1) .71 mm., 20%, (3) 5.9 mm., 86%.

As Mr. Cowley points out, the presence of two cubito-anal cross-veins in the hind wings of *Ae. peruviana* necessitates an alteration in the statement of generic characters. A similar condition is found in the Malagassy genus *Libellulosoma* Martin, 1906, which that author placed next to *Aeschnosoma*, and in *Platycordulia* Williamson 1908⁴⁶ and *Neurocordulia* Selys⁴⁶ of North America.

The difference in the color of the frons of this male from that of the female type of *peruviana* is paralleled in *Ae. forcipula* Hagen. *Forcipula* is placed next to *peruviana* in Cowley's key; the length of its male hind wing (33-36 mm., Selys, 1871) is nearer to that of the present male than is that of the latter to the length of the hind wing of the type female of *peruviana* (38-39 mm.); however, the hind wing of *forcipula* female is given by de Selys as slightly

⁴⁵ *Zool. Anzeig.*, 121 (9-10): 225-239, 1938.

⁴⁶ *Ent. News*, 19 (9): 431, pl. xviii, 1908.

longer than that of *forcipula* male (35-37 vs. 33-36 mm.).

Forcipula is reported from Para, Ega and Sao Paulo in the Amazon valley, probably also Bahia (Selys, 1871) and Surinam (Martin, 1906, 1914⁴⁷); *Ae. rustica* Selys from Bahia and Dutch Guiana (Martin, 1906, Cowley, 1934). If our identification of the present male be correct, the distribution of *peruviana* is Peru and British Guiana.

LIBELLULINAE Selys & Hagen, 1850 (as Libellulines).

The sequence of genera is according to Ris, Libellulinae, 1909-1919.

i. Libellulinae T. & F., 1940.

Libellula herculea Karsch, 1889.

Kartabo: VI.10, VI.12, 16.VI, all 1924, three females.

In a male from Cayenne, by Wm. Schaus, in the U. S. National Museum, abd. 32 mm., hind wing 40 mm., the pointed frontal tubercles, measured in dorsal view, project .09 mm. from the anterior surface of the frons; the corresponding rounded tubercles of the three females from Kartabo (abd. 31-34, hind wing 47-49) project .02-.05 mm.

Distribution: Vera Cruz, Mexico, to Cuenca, Ecuador, Iquitos, Peru, and Sapucay, Paraguay.

Orthemis ferruginea (Fabricius, 1775).

Kartabo: 30.VI.1924 and 11.7.1919, two males; three males numbered "Odon." 4, 85 and 105, and one female "Odon. 41."

Distribution: Florida, Texas and Arizona to Montevideo, Uruguay, Tucuman, Argentina (and Chile, Hagen, 1861), West Indies.

Orthemis aequilibris Calvert, 1909.

Kartabo: 5.V and 2.VI, both 1924, two females.

The vertex and frons of these two females approach the purple madder (of Smith's Explanation, pl. iv, fig. 7) and have a metallic violet reflection, but the reflection is not very brilliant; that of 2.VI is the brighter of the two. The same parts in the female from British Guiana by A. F. Porter, Jan. 18, 1912 (cited by Ris,⁴⁸ given to me by E. B. Williamson) are Roman sepia (Smith, l. c., fig. 38) with a metallic blue reflection. The female type of *aequilibris* from Paramaribo, undated (Acad. Nat. Sci. Phila. No. 9264), has the frons nearest burnt sienna (Smith, fig. 35), but somewhat duller, less vivid. The dated female paratype from Paramaribo (Dec. 18, 1904), and a third female of the same locality and date, not cited in the original description but marked at that time "faded-identif. doubt-

ful" have the frons a little darker than the pale brown of Smith (fig. 40).

Distribution: Valencia, Venezuela, to the Amazons.

Orthemis bioleyi Calvert, 1906.

Camaria, 27.VII.1920, one female.

The frons approximates the brown pink of Smith (fig. 21), the vertex is a little darker and has a slight metallic violet reflection. In this female and in that from British Guiana by A. F. Porter, Jan. 15, 1912, cited by Ris⁴⁹ and given to me by E. B. Williamson, the distal margin of the vulvar lamina is almost straight in ventral view. In the females of *O. ferruginea* and of *O. aequilibris* this margin is concave caudad in ventral view.

Distribution: Guatemala to Manaos, Brazil, and Iquitos, Peru.

Orthemis cultriformis Calvert, 1899.

Kartabo: 11.VI.1921, one male, abd. segs. 6-10 lacking.

Distribution: Chiriqui, Panama, to Agamo, Ecuador, Mishuyacu, Peru, and San Isidro near Buenos Aires.

ii. Diastatopidinae T. & F., 1940.

Diastatops.

Identifications and geographical distribution according to Prof. B. E. Montgomery, *Lloydia*, 3: 213-280, 1940. "The known distribution of *Diastatops* extends from the lower Magdalena (Sevilla, Colombia) and Orinoco (Cano d'Vagre, Venezuela) basins to the lower Parana basin (Sta. Fe, Argentina)," Montgomery, p. 221.

Diastatops pullata (Burmeister, 1839).

Montgomery, 1940, p. 238.

(Georgetown): one specimen, head and abdomen lost.

The "light area" of the wings is not at all conspicuous and is hardly paler than the distal brown.

Distribution: The Guianas to Matto Grosso, Brazil, and eastern Peru.

Diastatops obscura (Fabricius, 1775).

Montgomery, 1940, p. 249, pl. III, figs. 1-3.

Kartabo: one male "Odon. 23," abd. segs. 5-10 lost; one male "Odon. 51," head, abd. seg. 10 and apps. lost.

Prof. Montgomery says, p. 251, of this species: "Cephalic surface of anterior lamina [of male] smooth." Both these males, under Zeiss binocular, oc. 4, obj. a₀, show minute spinules here, which are still more evident under a Leitz compound microscope, oc. 10×, obj. 3, in this case used with the lower lens of the objective removed; these spinules are about .009 mm. long.

⁴⁷ Cat. Coll. Selys-Longchamps, fasc. xvii, pp. 57, 60, 1906; Gen. Insect., 153, p. 14, 1914.

⁴⁸ Cat. Coll. Zool. Selys, fasc. 16 (2): 1103, 1919.

⁴⁹ For Camaria, on the Cuyuni River, see M. B. & C. W. Beebe, Our Search for a Wilderness, New York, 1910, pp. 248-250.

Distribution: Colombia and Guiana to Paraguay and Bolivia.

Diastops dimidiata (Linnaeus, 1758).

Montgomery, 1940, p. 257.

Kartabo: 3.VI.1924, one male; 8.VI.1924, one male, abd. segs. 7-10 lost; 11.VI.1924, one male, abd. segs. 5-10 lost; not dated, two males, abd. segs. 4-10 and 6-10 lost respectively.

St. Laurent, Maroni River, French Guiana, March, one teneral female, coll. Wm. Schaus, U. S. National Museum.

Tendencies to form more densely reticulated areas are visible in the post-triangular area of both front and hind wings, between Cu1 and Cu2 near their origins and in the anal loop of the hind wings.

Distribution: Venezuela and the Guianas to Para (Brazil).

Zenithoptera fasciata (Linnaeus, 1758).

(Plate II, fig. 42).

1. Kartabo: "Odon. 53," one specimen, abdomen lost. 2. Hoorie:⁵⁰ "Odon. 16," one specimen, abdomen lost.

With these two specimens I have compared the following material:

3. Cayenne, French Guiana, Dec. 03, one male.

4, 5. Hermina Falls, Maroni River, Surinam, Aug., one male, one female.

6. Surinam River, one male. Nos. 3-6, coll. Wm. Schaus, U. S. National Museum.

7-9. Guinipa (error for Guanipa) River,⁵¹ Ven[e]zuela, Feb., 1911, S. Brown, two males, one female (male 7 lacks the head, male 8 abd. segs. 5-10).

10. Para, 21.10.92. ex Selys coll., one male.

11, 12. Brazil, two males, with labels "Palp. americana L" in Hagen's handwriting and printed labels "Mus. Berol.," "From P. R. Uhler's coll." and "Coll. of P. P. Calvert."

13-23. Rumococha, Rio Amazonas, near Iquitos, Aug. 1939, José Schunke, through Mr. Joseph Hocking.

24. Costa Aguaray, Paraguay, one male, ex coll. Foerster.

Nos. 7-24 are in the Academy of Natural Sciences of Philadelphia.

Nos. 1-10, 12-23 have five yellow, lateral, thoracic stripes and are, therefore, the *Zenithoptera americana* of Ris, 1910.⁵² No. 24 has two orange, lateral, thoracic bands, occupying almost all of the mes- and metepimera respectively—hence as in Ris's *viola*—but also a mesepisternal, distinctly antehumeral, orange stripe, .33 mm. wide at mid-

height, parallel to and distant .7 mm. from the mid-dorsal carina, .47 mm. distant at its upper end and .85 mm. distant at mid-height from the humeral suture, not quite attaining the ante-alar sinus above; this stripe is not mentioned by Ris for *viola* and is decidedly more anterior than the first of the five stripes of his *americana*. This male, No. 24, was labeled by Foerster "Z. fasciata? an americana, an subspecies nova?"; it agrees with the description of *Z. lanei* recently published by Dr. N. Dias dos Santos⁵³ except for some neuration details which I do not believe to be significant.

No. 11 is much faded so that the thoracic markings are not visible. No. 12 has a distinct yellow antehumeral stripe in the same position as the red antehumeral of No. 24. Traces of ill-defined antehumeral red are visible on Nos. 2, 7-9, 13-18, 20 and 21.

The range of size of specimens Nos. 1-23 is abdomen ♂ 14-17 mm., ♀ 14, hind wing ♂ 19-24, ♀ 22-23; in the eleven males from Rumococha the range is abd. 14.0-16.0, hind wing 21-23.5 mm. The largest male is that from Surinam River, the Cayenne male is almost as large, the smallest is from Rumococha, but the mutilated Brazil males (Nos. 11 and 12) have the hind wing 19.5 and 19 mm. The Kartabo and Hoorie specimens (Nos. 1 and 2) have the hind wing 23 and 21.5 mm. respectively.

The width of the white postnodal band, as measured on the right front wing, between veins M1 and M2, varies from 1.10 (Para) to 2.17 (Kartabo) mm.; in the Rumococha series from 1.32 to 1.89 mm., but is not correlated with wing-length. In the Hoorie specimen it is 1.74 mm. wide.

The maximum width of the pale apical or ante-apical spot, measured in the long axis of the wing, varies from 0 (one Guanipa River, Para, one Rumococha, No. 22) to 1.87 mm. (Brazil No. 11). In the first six Rumococha males (Nos. 13-18) its width is 1.18-1.46 mm. and it is separated from the apex by brown which is as wide as the pale spot; in four other Rumococha males (exclusive of No. 22) its width is .3-3.71 mm. and it is situated at the wing apex with no marginal brown; the collector of the Rumococha series gave one number to specimens 13-18, another to Nos. 19-23. In the Kartabo and Hoorie specimens the width of the white postnodal band and of the apical pale spot is 1.27 and .60 mm., respectively, with no marginal brown.

The width of the external branch of the genital hamule varies from .34 (No. 12) to .47 (Nos. 4, 6, 17, 20) mm., and hence is not correlated with locality; the ventral margin of this branch varies from nearly straight to strongly convex, but again is not characteristic geographically. On comparing

⁵⁰ For the location of Hoorie, on the Barama River, British Guiana, see "Our Search for a Wilderness" by M. B. & C. W. Beebe, New York, 1910, map, page 110.

⁵¹ See Stone, W., *Proc. Acad. Nat. Sci. Phila.*, lxxv:189, 1913. The altitude is 0-200 m., the mouth in the Golfo de Paria, 10° N., 62° 20' W.

⁵² *Cat. Coll. Selys-Longch.*, fasc. XI:312, 1910.

⁵³ *Revista Brasil. Biol.*, 1 (2):207, figs. 1-12, Rio de Janeiro, Junho, 1941.

the extruded penes of Nos. 3 (Cayenne), 11 ("Brazil") and 24 (Costa Aguaray), I find no difference.

In profile view, the inferior margin of the male superior appendages is armed with a row of denticles, one of which is usually larger than the others and may consequently be described as a tooth; the position of this tooth varies from one-half to two-thirds of the appendage-length and again is not correlated with locality. In the Rumococha series, however, a correlation between the position of this tooth and the wing markings appears: males Nos. 13-18, which have the pale *ante*-apical spot, have this tooth at 64-68% of the appendage-length, while Nos. 19-23 with the pale spot at the apex, or absent, have the tooth at 50-55% of the appendage-length. Nos. 12 and 24 have the tooth at 67%, No. 10 at 57%, Nos. 6 and 7 at 50% of the appendage length.

For his *americana*, Ris (1910) gives as a female character "im Hinterflügel eine longitudinale, oft nicht complete Aufhellung von A3 bis in die Mitte des Discoidalfeldes," with no mention of the male in this respect. For his *viola* (1910) he states of the eight males he examined: "Alle Exemplare mit longitudinale Aufhellung in Hinterflügel wie das ♀ *americana*." At that time the female of *viola* was unknown to him. In 1919, from a larger series of *viola*, he figured both sexes with the "Aufhellung" on the hind wings. It is also to be noted that his 1910 figure, 173 ter, showing the Aufhellung on the hind wing, is labeled "*americana* ♂."

Of the present material, in which at least the base of the abdomen is preserved, Nos. 4, 5, 6, 7, 8, 9, 11 and 12 have the "Aufhellung" well developed, No. 3 has it feebly indicated, in Nos. 10 and 24 it is absent. It would appear, therefore, that the presence or absence of this "Aufhellung" is not a sexual character in *Zenithoptera* and that it is impossible to determine the sex of specimens 1 and 2.

Distribution of *fasciata* L.: Pacific slopes of Colombia from less than 200 meters elevation to Trinidad and the Guianas, the Amazon from Para to Umbria, Colombia, and Balsapuerto, Peru.

Montgomery (*Lloydia*, 3:233, 1940) has reported *Zenithoptera*, without particulars, from Nicaragua.

THE TYPES OF THE LINNAEAN SPECIES OF *Zenithoptera*.

The specific status of the forms of *Zenithoptera* was discussed by Ris (1910, 1919), but he was not able to examine George Edwards' "A Natural History of Birds" (Part IV, 1751) on which the Linnaean names are based. I have studied a copy in the library of the Academy of Natural Sci-

ences of Philadelphia and present my results.

In the *Systema Naturae*, edit. X, p. 545 (1758), Linnaeus named two "species" now in question. His full statements are as follows:

"*fasciata*. 12. L. alis planis fuscis: fascia alba lineari. *Edw. av.* 174, t. 174. *Habitat in India. DeGeer.*"

"*americana*. 16. L. alis purpurascensibus: fascia alba, primoribus apice albis; posticis linea baseos alba. *Edw. av.* 174, t. 174. *Habitat in America. Corpus viride. Alae fusco-purpurascens.*"

Edition XII of the *Systema*, "reformata," 1767, pp. 903 and 904 respectively, has the same statements except that for *fasciata* has "*av.*" for "*av.*" and that for *americana* has "*Edw.*" for "*Edw.*"

It will be noted that Linnaeus refers to the same plate in Edwards' work for these two species. Edwards' plate 174 contains only two figures: one is of a bird, The Lory Parrakeet, the other is of a "Fly," a photograph of which is here reproduced as our figure 42, Plate II. Linnaeus does not refer to any specimens of either *fasciata* or of *americana* which he may have seen. It would appear, therefore, that each of these specific names is based solely upon one and the same figure and that *americana* was from the very start a synonym of *fasciata*. There is no basis for a suggestion that reference to some other plate in Edwards' work was intended by Linnaeus in one or other of his two species, as an examination of all of Edwards' plates fails to show any other than his 174 to which the Linnaean descriptions could refer. Since only one figure by Edwards is concerned, Ris' 1910 (p. 315) suggestion that *fasciata* Linnaeus might be the same as *tullia* Drury has no standing.

How did Linnaeus arrive at the idea of two species? I can only suggest that he may have seen, in 1758 or earlier, the specimen which his compatriot, DeGeer, later described and figured in 1773 (Mem. Hist. Ins., III:559, pl. 26, fig. 7) as *Libellula violacea* and of which DeGeer then wrote "que je crois originaire des Indes," and on that basis added to his description of *fasciata* "Habitat in India. DeGeer." On difference in habitat, Linnaeus may have separated his *americana* from his *fasciata*, but the basis for the two "species" still remains one and the same figure of Edwards. DeGeer placed *fasciata* Linn. as a synonym of his own *violacea* and subsequent writers have followed him except in recognizing the priority of Linnaeus's name. Sjöstedt has this note on DeGeer's type: "DeGeer's *Lib. violacea* (Mem. Ins. III, p. 559, No. 6 t. 26, fig. 7, 1773) deren Typus vorliegt, ist mit *americana* L. (Ris, o. c.), nicht mit *viola* Ris identisch. Auf der Etiquette des erwähn-

ten Typus in DeGeer's hier im Stockholmer Reichsmuseum aufbewahrter Typus-Sammlung seiner Memoiren steht: '6 *L. violacea* D. G.-L. *fasciata* L., p. 559'" (*Arkiv för Zoologi*, 11 (15) : 40. 1918).

Edwards' description of the insect is as follows (p. 174): "The Fly engraved on this Plate has the Head and body of a dull Green; the wings are of a dirty purplish Brown, with some transparent Spots in them. I drew it from Nature, but forgot to note from whence it was brought; but I think it was from the *West-Indies*." On page 26 of his Part I, Edwards says: "I do not pretend to have any Skill in the Description of Insects, not having at all study'd them; nor do I know the Terms by which their Parts are distinguished: But they being no Part of my Design, I have added them only as Decorations to fill up some void spaces in the Plates where the Birds were small, so that if my Descriptions are obscure, I hope the Justness of the Figures will help to clear them." Pages 236-243 of Edwards' Part IV are occupied by "A Catalogue of the Names of all the Birds, Beasts, &c. contained in the four Parts of this *Natural History*, ranged in a *Generical Order*;" insects are on pages 242-243 and among them are "Flies with very long Bodies, and four pretty long Wings, that fly swiftly over watery Places, vulgarly call'd with us *Horse-flies*, or *Horse-stingers*. The green Horse-fly 112 *The purple and brown Horse-fly* 174." [Incidentally, The green Horse-fly 112, in Edwards' Part III, 1750, is *Neurobasis chinensis* (Linn.)].

No information is afforded by Edwards' figure or description as to stripes or bands on the thorax, nor are the abdominal appendages sufficiently distinct to determine the sex; the wings agree better with Ris' photographs of his *viola* than of *americana*.

Hagen has a two-page article, "Die Neuroptera der Linneischen Sammlung" (Stett. Ent. Zeit., 6:155-156, 1845), in which the following statements occur: "Hr. Buchhändler Dr. J. R. Schulz in London hat auf meine Bitte die Güte gehabt, an Ort und Stelle die noch vorhandenen Arten zu notiren. Seiner gefälligen Mittheilung verdanke ich folgende Bemerkungen: In Linne's eigenem Exemplar der ed. XII der Syst. naturae sind folgende Arten mit Tinte von Linne unterstrichen und sämmtlich noch vorhanden. Die Etiquetten sind nach der Anspruch des Herrn Richard Hippist, Sekretair der Linnean Society, ebenfalls sicher von Linne's eigener Hand." [There follows a list, names only of 33 species, 14 of which are *Libellula*, but not including *fasciata* or *americana*.] Hagen's article continues: "Ausserdem sind in selben Buche mit Bleifeder unterstrichen und mit Etiquetten, welche wahrscheinlich vom Käufer der Linne'schen Sammlung, Herrn Smith her-

rühren und den gelegentlich Zusatz: E description Linn. führen, noch folgende 17 Arten vorhanden: *Libellula fasciata* [and 16 species of non-Odonata]. . . . Leider konnte ich über die Insekten selbst keine nähere Auskunft erhalten." This specimen of *fasciata*, marked in Linnaeus' copy of the 12th edition of the *Systema Naturae* (1767), may or may not have been in Linnaeus' hands when the 10th edition was published (1758).

Summing up, like Ris, Erichson, Rambur and Burmeister, I consider Linnaeus' *fasciata* and *americana* to be one and the same species, but unlike Ris—although in agreement with Erichson and Rambur—I use *fasciata* as the specific name by reason of its priority over *americana* on page 545 of the 10th edition of the *Systema Naturae*.

Ris (1910, p. 313) has briefly discussed also the justifiability of the acceptance of the generic name *Zenithoptera* Bates in Selys (1869) in preference to that of *Potamothemis* Kirby (1889), on the ground of insufficiency of de Selys' characterization. As de Selys' two statements are not generally accessible, they are reproduced here.

"Quant aux deux Palpopleura de l'Amérique méridionale à peine distinctes l'une de l'autre: *P. americana* L. et *fasciata* F. [sic] (*violacea* De Geer) elles ont un facies tout différent, leur abdomen est grêle et selon M. Bates elles portent comme les Agrion les ailes relevées dans le repos. Il convient d'adopter pour elles le genre *Zenithoptera* proposé pour elles par le célèbre voyageur dans les notes manuscrites qu'il m'a gracieusement adressées, lorsqu'il m'a cédé sa riche collection d'Odonates de l'Amazonie." (Recherches sur la faune de Madagascar et ses Dépendances, d'après les découvertes de François P. L. Pollen et D. C. Van Dam. 5me partie, 1re livraison, pp. 15-16. Leyde, Steenhoff, 1869).

"*Palpopleura*, Ramb. — Presque exclusivement africain; une seule espèce aberrante (*P. sexmaculata* Fab.) est asiatique. *L'Americana* a formé le G. *Zenithoptera*, Bates." (Assoc. Française Avanc. Science, 10e Session 1881, p. 667. 1882).

After Karsch (Berlin. Ent. Ztschr. 33 (2) p. 355, 1890) had pointed out the identity of Kirby's *Potamothemis* with Bates' *Zenithoptera*, Kirby placed his *Potamothemis* as a synonym of *Zenithoptera* (Cf. Kirby, Cat. Odon., pp. 9 and 178, 1890) and used *Zenithoptera* in his paper in the *Annals and Magazine of Natural History* (6) 19:602, 1897.

Perithemis thais Kirby, 1889.

Kirby, 1889, *Trans. Zool. Soc. Lond.*, 12 (9) :324.

Ris, 1930, *Misc. Publ. Univ. Mich. Mus. Zool.*, 21:38.

Kartabo, one specimen, abdomen lost, 20.X (?) .1920; one male, undated.

The male has the triangle of the right front wing and of both hind wings 2-celled, of the left front wing free, internal triangle of both front wings 3-celled; discoidal (post-triangular) cells on the right front wing 3, then 2 rows to beyond the level of the nodus, then 3 rows increasing to 6 marginal cells; on the left front wing they are 3.2.2.3, then 2 rows to beyond the level of the nodus, followed by 3 rows increasing to 5 marginal cells; there is 1 (right) and 2 (left) single cells reaching from M4 to Cu1 on the hind wings. The black markings of the abdomen and the brown markings on the wings are as in Kirby's original description of 1889, except that there is no brown border at the tip of the hind wings.

The dated specimen has the triangles of both front wings free, of both hind wings and the internal triangle of both front wings 2-celled; the post-triangular cells of the front wings are: (right) 2.2.2.3.3.2, then 3 rows increasing to 7 marginal cells, (left) 3.2.2.3.2.3.3.2, then 3 rows increasing to 6 marginal cells; there is a single cell reaching from M4 to Cu1 on both hind wings. The brown bands on the wings are greatly reduced and paler than in the male, that at the triangle of the hind wings broken into two clouds, one at the triangle, the other behind Cu2-A1, the ultra-nodal bands of all wings very tenuous at M3.

Distribution: Recorded by Ris (1930) from Trinidad to the Amazons and Matto Grosso, and by Snhr. Dias dos Santos (1944) from Ilha Seca, São Paulo.

iii. Brachydiplacinae T. & F., 1940.

Fylgia amazonica Kirby, 1889.

Kalacoon, Bartica District, one specimen, Odon. 111, lacking head and abdomen.

This specimen is probably a female since the only coloring on the wings is a slight smoky trace in the most proximal row of cells along the anal margin of the hind wings. I have compared this specimen, as far as its mutilated condition permits, with a male from Para, Dec. 26, 1892, by Schultz, given to me by Baron E. de Selys-Longchamps, with which it agrees.

Distribution: The Guianas, Para.

Oligoclada pachystigma Karsch, 1890.

Borrer, 1931, *Misc. Publ. Univ. Mich. Mus. Zool.*, 22:24, figs.

Kartabo, one male, 2.VI.1921; one male, VrS, Odon. 56; one male, LAMA 17, Odon. 39, abd. segs. 6-10 lost.

The occiput in male 56 is intermediate between Borrer's figures 48 and 49, the spines very acute; in male 39 and the dated male it is like his figure 51, but wider posteriorly and without spines.

Distribution: Orinoco Venezuela, the

Guianas, Amazon and Madeira valleys from Para to Porto Velho, Rio Sao Lourenço in Matto Grosso (Borrer).

Oligoclada raineyi Ris, 1919.

(Plate II, fig. 37).

Ris, 1919, *Cat. Coll. Zool. Selys-Longch.*, fasc. 16 (2) : 1134.

Borrer, 1931, *Misc. Publ. Univ. Mich. Mus. Zool.*, 22:34.

Kartabo, 20.V.1924, one female.

The female of this species has not been described hitherto. The present individual agrees so well with the described males in all but sexual characters that I do not hesitate to refer it to this species. It falls at once into the nearest rubrics for *raineyi* in the keys of Ris (l. c., p. 1132) and of Borrer (l. c., pp. 16-17).

The only differences detected between the venation of this female and Ris' figure 650 of that of a male from Tumatumari, British Guiana, are: antenodals $9\frac{1}{2}$ ⁵⁴ on both front wings, 9 (right), 8 (left) postnodals* in the hind wings, one row of 6 (right front and hind wings) or 5 (left front and hind wings) cells between Rs and Rspl, 2 rows of post-triangular cells from the triangle out for 4 cells, followed by 3 rows for at least 4 cells in both front wings (beyond this point the wings are torn); the single row between M4 and Cu1 on the hind wings for 2 cells only, thence increasing; cells bordering the proximal side of the bisector of the anal loop (A2 of Ris and of Borrer) 7 (right), 8 (left*) hind wing; the anal margin of both hind wings, proximal to A3, is torn so that an exact count of rows of cells can not be made, but enough remains to show that no great difference here from Ris' figure can have existed.

Following are other features of this female: Vertex brown ochre;⁵⁵ frons anteriorly nearest cadmium yellow,⁵⁵ above darker brown, with a metallic blue reflection; clypeus pale blue-green;⁵⁵ labrum blue-green at base, becoming brown distad and finally black along the free margin; labium near gamboge,⁵⁵ "with a median band of black as wide as ligula proximally and narrowing to" (Borrer) .28 mm. distally. Occiput burnt siena,⁵⁵ darker in the center, triangular in dorsal view with a pair of finger-like projections on the caudal margin, similar to Borrer's figure 50 for *O. pachystigma*, but each directed laterad, not at all caudad.

Hind lobe of prothorax 1.65 mm. wide in dorsal view, slightly wider than any other part of that segment, bilobed, with a row of marginal gray hairs up to .94 mm. long.

Pterothorax bluish-pruinose with some metallic reflection on the sides. Legs black-

⁵⁴ The differences here marked with an asterisk fall within the range of variation for *raineyi* as given by Borrer.

⁵⁵ Of Smith's "Explanation of Terms used in Entomology," 1906, pl. IV.

ish, first femora pale brown inferiorly in the proximal half, third femora 5.4 mm. long, with 15 spines in the outer (anterior) row, increasing in length distad, last spine nearly twice as long as the penult; following the last spine is a shorter hair or slender spine; 13 more slender spines in the inner (posterior) row; between these two rows, but much nearer to the inner row, is a ventral row of 6 (left femur) — 9 (right femur) spines shorter than, but equally stout as, those of the outer row. Only the merest hint of a tooth on the tarsal claws and even that not visible on all claws.

Abdomen narrowing slightly from 2-8, more abruptly on 9-10, a distinct additional transverse carina on the anterior half of 3 and 4; indian red⁵⁵ dorsally, margins of 8 and all of 9 and 10 blackish; ventral surface darker red, lateral margins and a spot at each postero-lateral angle of 5-8 and sternite of 8 blackish.

Vulvar lamina not projecting caudad as far as the level of the hind tergal margin of 8, its free margin bilobed, its anterior margin defined by a low transverse carina which, in ventral view, is convex anteriorly (Pl. II, fig. 37).

Appendages .19 mm. long, straight, a little longer than 10, and than the anal tubercle (tergite of 11) between them.

Abdomen 13.5, hind wing 20 mm.

Distribution: British Guiana, Surinam, Para (Borror).

Uracis imbuta (Burmeister, 1839).

Calvert, 1906, 1907, Biol. Centr.-Amer. Neur.: 218, 402.

Ris, 1911, 1919, Cat. Coll. Zool. Selys-Longch., fasc. XII: 411, 419; fasc. XVI (2): 1139, figs. 657, 658 (venation).

British Guiana: Kartabo, eight males, six females, four specimens lacking abdomen, eight of them dated March 1-11, 1926, June 1, 1921, June 3, 1924, June 8 and 16, 1920, July-Aug., 1926 (Dr. C. Hodge IV); those not dated numbered Odon. 48, 74, 89, 117, 123, VRS Odon. 20 and 30. Kaieteur, Feb. 2, 1921, one male, abd. segs. 5-10 lost. Essequibo River below [between?] mouths of Potaro and Rupinuni Rivers, May, 1920 (Geo. B. Fox), one female (Acad. Nat. Sci. Phila.).

French Guiana: Cayenne, June, one female; 60 m(iles) up Maroni River, 8.04, one male; St. Laurent, Maroni, March, one male, two females (all by Dr. Wm. Schaus, U. S. Nat. Mus.).

The female from the Essequibo River has the proximal side of the triangle of the hind wings distal to the arculus; the anal field of the same wings between A3 and the anal margin has at base 4 rows of cells, but in its distal half only 3 rows, decreasing to 2 rows and then 1 cell.

Of the 20 individuals from British Guiana, 8 (=40%) have the proximal side of the triangle of the hind wings at the arculus, the remainder have it more distal. Of the 5 individuals from French Guiana, the 3 females have this side at the arculus or very slightly distal, the 2 males more distal. Of the 11 males, 7 females tabulated for taxonomic characters for the Biologia Centrali-Americana, 15 of the 36 hind wings (=41.7%)⁵⁶ had the proximal side of the triangle of the hind wings at the arculus, the remainder more distal. The B. C.-A. material of *imbuta* studied was a much less homogeneous group, geographically, than that here recorded from British Guiana, as it extended from the Isthmus of Tehuantepec to Venezuela and included 3 males and 3 females as the largest number of individuals from any one lot (i.e., the indefinite locality "Panama" M. C. Z.). Of other species of *Uracis*, tabulated at the same time as the B. C.-A. *imbuta*, and which appear in the *Annals of the Carnegie Museum*, 6 (1): 227-229: *siemensi* 1 male, *ovata* 1 male, 3 females,⁵⁷ *infumata* 2 males, *fastigiata* 17 males, 7 females (including those of this last species in the B. C.-A.)—all had the proximal side of the same triangle distal to the arculus.

These facts suggest that the fewer individuals of *imbuta* with the proximal side of the triangle of the hind wings at the arculus represent a more primitive state for this genus, while those *imbuta* with the distally placed proximal side of the triangle, and also the other species of this genus, display a more specialized condition. This view is strengthened by the fact that *imbuta* has the triangle of the front wings placed more nearly at 90 degrees with the supratriangle, while the other species have that triangle more obliquely placed, as Ris pointed out (1911, pp. 410-411). This interpretation of the positions of the proximal side of the triangle of the hind wings in *Uracis* as primitive and as specialized is a contradiction to the recession of the triangle as set forth by Prof. Needham⁵⁸ and perhaps not in harmony with Col. Fraser's ideas⁵⁹ as to this triangle. Neither of these authors deals with the obliquity of the triangle of the front wing in this connection and the question involves the relationship of *Uracis* to other genera, briefly touched on by Ris (1911, p. 409). A similar obliquity in a much less densely veined wing occurs in *Brachygonia oculata* of Borneo (Ris, fasc. XI, p. 352, 1910).

I have not found any other features (color, venation, genitalia of the second abdom-

⁵⁶ These data have not been published hitherto.

⁵⁷ *Ovata* is referred to *infumata* by Ris, 1911, p. 414.

⁵⁸ *Proc. U. S. Nat. Mus.*, 26 (1331): 721, 1903.

⁵⁹ *Australian Zoologist*, 9 (4): 393 and 394, 1940, under *Brachydiplacinae* and *Onychotheminae*, respectively.

inal segment or appendages of the male, vulvar lamina) correlated with these differences in the position of the triangle of the hind wings of *Uracis*.

Distribution of *U. imbuta*: Mexico to Buenos Aires, Trinidad.

***Uracis ovipositrrix* Calvert, 1909.**

Kartabo, III.4.1926, one male; one specimen, not dated, abdomen lost, possibly a female because the brown at the apex of the wings has the centres of the cells paler and the hind wings, between A3 and the anal margin, have 4 rows of cells for 4 cells, then 2 rows almost to the apex of the anal loop, while the male, in the same area, has 4 rows, followed by 3 rows almost to the apex of the anal loop.

Distribution: British Guiana, including Mt. Roraima, Surinam, the Amazons from Santarem to Iquitos; Matto Grosso.

***Uracis infumata* Rambur, 1842.**

British Guiana: Waratuk, 19.ii.1921, one female.

Distribution: British Guiana, Cayenne, Para, Fonte Boa, Bahia and Matto Grosso, Brazil; Mishuyacu, Peru.

***Uracis fastigiata* (Burmeister, 1839).**

Kartabo, I.VIII.1920, one male, abd. segs. 5-10 lost; IV.1.192?, one female.

Hind wing, male, 34 mm., female, 29.5 mm. The last antenodal of both front wings of the female is united with the penult antenodal at an oblique angle at the subcosta; it is more slender than the other antenodals.

Distribution: Mexico to Yumbatos, Peru, east to Trinidad, Bahia and Matto Grosso.

***Micrathyria spinifera* Calvert, 1909.**

Kartabo, 22.II.24, one male.

Distribution: Subsequent to its original description from Surinam, this species has been recorded by Ris (1911) from Para, Villanova and Obidos, all in the Amazon valley, where it was first taken by Henry Walter Bates.

***Micrathyria eximia* Kirby, 1897.**

Kirby, 1897, *Ann. Mag. Nat. Hist.*, (6) 19:609, pl. xiii, fig. 4 (not 3) (body and left wings).

Ris, 1911, *Cat. Coll. Zool. Selys-Longch.*, fasc. XII:450, figs. 285, 286 (apps. ♂).

Kartabo, 20.VI.1924, one specimen (female?), abdomen and the posterior part of the right hind wing proximal to the bisector of the anal loop and as far forward as the anal vein, lacking.

The venation differs from that of *Oligoclada* in the presence of two bridge cross-veins on all four wings, in this respect resembling *Fylgia*, *Nephepeltia*, *Edonis* and *Micrathyria* as figured by Ris (*t.c.*, pp. 391,

393, 395, 397, 426, 449). It differs from *Fylgia*, *Nephepeltia* and *Edonis* in showing not the slightest trace of breaking in the costal side of the triangle of the front wings; from *Edonis* also in having a maximum of only 2 rows of cells between A3 of Ris and the anal margin of the left hind wing.

In Ris' key to the species of *Micrathyria* (1911, pp. 426-429), this specimen falls under rubrics E (except that the arculus is very close to the second antenodal in both front and the right hind wings and at that antenodal in the left hind wing instead of "ungefähr in der Mitte zwischen 1. und 2. Anq.") *ee* and *éé*. These exceptions from E are also found in the following *eximia* in the Academy of Natural Sciences of Philadelphia: Chapada, Matto Grosso, two males, one of which lacks the left front wing, and Puerto Barrios, Guatemala, one male, in which the arculus is *near* the second antenodal on the front wings and *at* the second antenodal on the hind wings. Kirby's original figure of *eximia* shows the arculus between antenodals 1 and 2 but nearer to 2 on both front and hind wings. In the David female shown in fig. 30, tab. 9, *Biologia Centrali-Americana*, Neuroptera, the front wing has the arculus slightly proximal to the second antenodal, the hind wing a little distal to the second antenodal.

Distribution: Guatemala to Santa Catarina, Brazil.

iv. Sympetetrinae T. & F., 1940.

***Erythrodiplax* Brauer, 1868.**

The following identifications and statements of geographical distribution are based on the recent excellent Revision⁶⁰ of the genus by Dr. Donald G. Borror. As stated in its preface: "In this revision of the genus the fundamental criteria of species have been the characters of the male genitalia, particularly those of the penis." In preparing penes for examination, Dr. Borror removed them from the insects, treated them with cold potassium hydroxide and after studying and drawing them, placed each in a small vial of glycerine and the vial in an envelope with the insect from which the penis was removed.

⁶⁰ Graduate School Studies, Contributions in Zoology and Entomology, No. 4, The Ohio State University, 1942, xvi + 286 pp., 41 pls. The following changes in Dr. Borror's key to the species seem desirable:

Page 29, couplets 3 and 3': for "Lateral keel" read "Transverse keel" (compare page 13).

P. 30, couplet 8: transpose "truncate, with distal edge nearly or quite straight" to immediately follow "Genital lobe," and thus make this couplet correspond more exactly to couplet 8'.

P. 30, couplet 9 and p. 42, couplet 68: for "anal edge" read "anal angle."

On reaching couplet 23', page 32, penis "with a more or less distinct posterior lobe," it should be noted that triplet 27" p. 34 (to which 23' leads in some cases), states "Penis with posterior lobe poorly developed and in some cases apparently lacking." A similar case is furnished by the series of couplets 38', 40', 41', 42' and 43'.

In making the present identifications of pinned dry specimens, I have not separated the penes from the insects, for only an infinite series of meticulous curators can assure the continued association of an insect and its detached parts and the possibility of later students examining *all* parts of a specimen. I have, therefore, proceeded as follows, following a suggestion for certain other Odonata which I owe to Mrs. Leonora K. Gloyd. A tiny wad of raw cotton wool, soaked in a weak solution of household ammonia, was placed on the ventral surface of the second and third abdominal segments of the inverted, pinned dragonfly and allowed to remain for one, two, or three hours. When convenient, and if the genitalia were still moist, the insect was placed under a binocular dissecting microscope, Greenough model, the penis gently lifted with fine needles, and even fine forceps, so that it was completely protruded but still attached to the abdomen. A small triangle of white paper (white as being conspicuous), $< 1 \times 2-3$ mm., was then inserted, with the same instruments, between the second and fourth segments of the penis and the insect laid aside to dry. The penis thus remains visible and distinct from neighboring parts. This method is more expeditious than Dr. Borrer's.

It is not pretended that penes treated by this method show all the details revealed in Dr. Borrer's figures of penes prepared with potassium hydroxide and *kept moist*. This is especially true for the details of the internal and posterior lobes of the penis. It is believed, however, that sufficient detail is preserved in the penes, as here treated, to permit safe identification, leaving the finer details for comparative anatomical studies and the potassium hydroxide or similar techniques.⁶¹

To what extent the penes, as here prepared, fall short of Dr. Borrer's figures, may be seen by comparing our figures with his for the same species.

Erythrodiplax castanea (Burmeister, 1839).

(Plate II, fig. 23).

Kartabo, V.4.1926, one male, abdomen lost; V.11.1924, one male; 7.VII.1922, one female, No. 56. Abary⁶² [River, near the coast]; 2.V.1924, one male.

The males have the brownish-yellow spot on the base of the front wings larger (reaching to the cubital cross-vein) than in the female (only half-way to that vein). The first and third males listed have two cubital

cross-veins on the hind wings, the other male and the female have only one. The female has 4 cells in the subtriangle of the left front wing.

Distribution: Trinidad and Colombia to S. Paulo, Brazil, Paraguay and central Peru.

Erythrodiplax angustipennis Borrer, 1942.

(Plate II, fig. 24).

Borrer, 1942, Revis. Erythrod.: 68, figs.

French Guiana: 100 (?) mi.(les) up Maroni River (Dr. Wm. Schaus), one male (U. S. Nat. Mus.).

This male belongs to the *longitudinalis* group of Borrer, pp. 64-65. It agrees with *E. anatoidea* Borrer, 1942, in having the frons metallic bluish-dark reddish brown⁶³ anteriorly and dorsally, where it is coarsely punctate-rugose, sides glabrous and almost blackish, except for a small, triangular, yellow spot at each latero-ventral angle; thorax with no yellow lateral stripe; abdominal appendages nearest to brown pink (No. 21) of Smith's glossary.

It agrees better with Borrer's figures of the genital hamule, genital lobe and penis of *angustipennis* than with those for *anatoidea* or *longitudinalis*.

Thorax blackish dorsally, indian red (Smith No. 33) on the sides. Abdomen cologne earth (Smith No. 37) to blackish, an indistinct brown ochre longitudinal streak on each side of dorsum of segments 4-7, no pruinescence. The venation and dimensions fall within the ranges given for *angustipennis*.

Of the three species of this group, Dr. Borrer saw one male (Bejuma, Venezuela) of *longitudinalis* (Ris), one male, one female (Porto Velho, Brazil) of *anatoidea* Borrer and three males, two females (Cachuela Esperanza,⁶⁴ Bolivia, and Villa Murinho, Brazil) of *angustipennis* Borrer, while a male of the last named from "Alcobaza, R. Totantias" (Alcobaza, Rio Tocantins?) is quoted, page 70, from Ris. No other definite localities for these three species have been published; much is still to be learned concerning them.

Distribution of *angustipennis*: French Guiana, tributaries of the Amazon in Brazil and Bolivia as stated above.

Erythrodiplax unimaculata (De Geer, 1773).

(Plate II, figs. 25, 26).

Kartabo, VRS Odon. 2, 29, 62, three males; Odon. 33, one female, front wings lost; LAMA 17, one female; VRS Odon. 18, 113, two males; Georgetown, one male.

French Guiana: Cayenne, Jan. 04 (Wm. Schaus) one mature male (U. S. Nat. Mus.).

⁶¹ Both Dr. Borrer and I will, I fear, fall under the censure of Dr. G. Fankhauser, who writes: "One of the characteristics that should be included in the description of every species of plant or animal is the number of chromosomes that are to be found in its cells." *Quart. Rev. Biol.*, 20 (1):20, March, 1945.

⁶² See M. B. & C. W. Beebe, *Our Search for a Wilderness*, New York, 1910, map, p. 110.

⁶³ Dragon's blood 34, or burnt sienna 35, of Plate IV of Smith's Explanation of Terms used in Entomology, from which other color terms are here taken.

⁶⁴ Probably Cachuela Esperanza of the National Geographic Society's map of South America of 1942.

The first three males above listed are immature, wing spots yellowish-brown, thorax and abdomen marked with yellow; the second three males are mature, thorax, abdomen and basal wing spots dark brown to black. The LAMA 17 female has the vulvar lamina in caudal view a little more widely rounded than that of No. 33 and may be *laurentia* in view of Dr. Borrór's remarks on pages 40 and 85.

The penes of the two males treated with ammonia are not as much expanded as in Dr. Borrór's figure 97, ventral view, but all seven males agree with the other characters of this species. These two penes have more the appearance shown in his figure 116, ventral view, of *latimaculata*, but the lateral view of the terminal joint is not at all like that of *latimaculata*. The lateral view of what I here identify as *unimaculata* differs from Dr. Borrór's figure 97 in having the apical lobe less projecting, much as in his figures of *fervida* and *ochracea*, 95 and 96, but even the teneral male No. 62 has some bluish reflection on frons and vertex. His figures 227 and 237 are referred on his page 252 to *unimaculata* and both are stated to be of the same specimen, "No. 116b, Georgetown, British Guiana, Oct. 10-15, 1920." On page 63, figure 227 is referred to *E. venusta*.

Distribution: Jamaica, Martinique and Trinidad, Guiana to Matto Grosso, Brazil, Paraguay and central Peru.

***Erythrodiplax laurentia* Borrór, 1942.**

(Plate II, fig. 27).

Borrór, 1942, Revis. Erythrodiplax, 83, figs.

Kartabo, 21.V.1924, one male, abd. segs. 6-10 lost, genitalia of 2 obscured by gum; 6.VI.1924, one male; VI.11.1924, two males.

The male of 6.VI. agrees with *laurentia* in Dr. Borrór's key, page 31, wing spot, fig. 22, appendages, fig. 190, hind prothoracic lobe, fig. 371, and profile of frons, fig. 335, but is more like *kimminsi* in penis, fig. 100, lateral view, hamule and genital lobe, fig. 242, and in size, abdomen 21, hind wing 26 mm.; the internal lobes of the terminal segment of the penis are not dilated in this ammonia-treated male. The two males of VI.11 agree with *laurentia* in wing spot, appendages, hind prothoracic lobe as far as visible and in size, abdomen 20, 21 mm., hind wing 23, 24.5 mm.; one of them is like fig. 241 of the hamule and genital lobe of *laurentia*, but is a little more like *kimminsi* in the profile of the frons, fig. 333; its penis is not protruded; the other of these two males has the profile of the frons as shown for *laurentia*, but is more like *kimminsi* in hamule and genital lobe and in the lateral view of the penis, the internal lobes of the terminal segment of the penis not dilated.

Distribution: Guiana to Para, Brazil.

***Erythrodiplax famula famula* (Erichson, 1848).**

(Plate II, figs. 28, 29).

Kartabo, ten males, five females, some dated from III.9.(1926) to VI.1.(1924), and 27 and 29.X.1920, the male with the last date No. 20773, others numbered Odon. 49 (one male), VrS Odon. 50 (one female), Odon. 54 (one male, Kalacoon 1916), Odon. 109 (one male), Odon. 121 (one female).

In all of these males the basal yellow or brown spot fills only part of the triangle on the hind wings.

Distribution: Cuba, Trinidad, Venezuela, the Guianas to Minas Geraes, Brazil.

***Erythrodiplax latimaculata* Ris, 1911.**

(Plate II, figs. 30, 31).

Kartabo, one immature male, with labels Odon. 38, LAMA 17.

This male is apparently *latimaculata* by its characteristic penis (Borrór, fig. 116), genitalia of the second abdominal segment (B., fig. 250) and hind lobe of the prothorax (B., fig. 374), but is very small: abdomen 15 mm., hind wing 18 mm., stigma of the front wing 2.22 mm. Basal spot of wings brownish-yellow, on the front wings to the second antenodal for the entire width of the wing, on the hind wings to the fourth antenodal, apex of triangle and to the hind margin 1-2 cells proximal of the apex of the anal loop. Venational details within the ranges given by Dr. Borrór for this species.

Neither Ris nor Dr. Borrór describe immature males of this species. The differences in coloration are considerable as the following show: Vertex brown with a transverse darker line connecting the lateral ocelli, frons red without blue or purple reflections (frons and vertex of the shape and punctuation as in an adult male from Pirassununga, S. Paulo, Brazil); clypeus, labrum and labium reddish-yellow without dark markings; thorax brown above, pale greenish on the sides; abdomen pale brown, an ill-marked, narrow, darker, mid-dorsal stripe or line on 3-10, appendages pale brown, legs pale brown. Similar teneral males, distorted after removal from alcohol, are in the lot from Pirassununga.

Distribution: Venezuela, Bolivia (Santa Cruz), British Guiana, Brazil (Amazonas, Minas Geraes, S. Paulo).

***Erythrodiplax umbrata* (Linnaeus, 1758).**

Kartabo, twelve males, six females, some dated from III.9.(1926) to August (1920, 1926, Dr. C. Hodge IV), some numbered Odon. 73 (one male), VrS Odon. 125 (one male), Odon. 61 (one female), LAMA 17 (one male), Odon. 3 and 64 (two females), Odon. 31 (one male). Georgetown, one male, one female. Essequibo River below [between?] mouths of Potaro and Rupinuni, V.1920

(Geo. B. Fox), one female (Acad. Nat. Sci. Phila.).

Two males from Kartabo, 11.VI.1924 and July-Aug., 1926, are teneral. All eight females are heterochrome, i.e., lack the broad dark band on the wings between nodus and stigma.

Distribution: Indiana and Ohio (U.S.A.) to Argentina (Santa Fe and Buenos Aires) and central Peru and Bolivia (Santa Cruz), including the West Indies but not Chile.

Erythrodiplax maculosa (Hagen, 1861).

(Plate II, figs. 32-34).

Ris, 1911, Cat. Coll. Zool. Selys-Longch., fasc. XII:526, fig. 316.

Borrer, 1942, Revis. Erythrodiplax, 119 (with bibliography and synonymy).

Dias dos Santos, 1945, *Ann. Ent. Soc. Amer.*, 37 (4):389-392, pl. I.

Borrer, 1945, *Ann. Ent. Soc. Amer.*, 37 (4):393-395, figs.

Kartabo, one male, abd. segs. 6-10 lost, labeled LAMA 17 Odon. 63.

This male agrees in many respects with the recently (1945) published descriptions and figures by Senhr. Dias dos Santos and Dr. Borrer, but also shows the following differences: occiput black above, yellow behind, basal spot on front wings confined to the cubital and anal spaces but not reaching the first anal cross-vein or its level in the cubital space; basal spot on hind wings darkest in the subcostal and cubital areas and triangle (nearest to the brown ochre of Smith's glossary, pl. IV, No. 36, but darker), remainder of the spot paler, fading out at the fifth antenodal and at two cells beyond the triangle, anal area behind A not as markedly paler than the rest of the spot as shown in Dr. Borrer's (1945) figure 3; front wings with 6(*)⁶⁵ antenodals, the last continued to R1, costal side of triangle broken so that the distal piece is slightly longer(*) than (right) or equal(*) to (left) the proximal piece; hind wings with 4(*) postnodals, base of the triangle a little distal of the arculus, only 1 cell between the bases of A2 and Cu2; size smaller(*): hind wing 13 mm. vs. 16-17.5 mm.; fewer cells between Rs and Rspl: 6(*) (front wings), 5(*) (right hind wing), 4(*) (left hind wing), symptomatic of other details in the distal half of the wings and perhaps correlated with their smaller size. The variation in the origin of the nodal sector, M2, in this male is shown in our figure 34; its condition in the left front and right hind wings is to be considered normal, in the other two wings abnormal (compare Dr. Borrer's 1945 figure 3).

It is of interest to note the points of resemblance between this male and the male

type of *Edonis helena* Needham (1905)⁶⁶: the black lips, all triangles and the subtriangle free, the non-development of Mspl, 1 cubital cross-vein, the brown basal, although much smaller, spots on the wings, the 6 antenodals on the front wings, all continued to R1, the venation of the area between A3 and the hind wing margin, and only 1 cell between the bases of A2 and Cu2. There are, of course, many differences, *Edonis* having 2 bridge cross-veins, the costal side of the triangle of the front wings not broken, Rspl more sharply defined, the differently shaped genitalia of the second abdominal segment, without considering all those venational features of *maculosa* for which the latest two authors give variation data.

The single male deters me from attempting a caustic potash-glycerine preparation of its penis, but I have made two drawings of the dried organ for comparison with Snhr. Dias dos Santos' figure 9. The resemblances here, those mentioned above and absence of the appendages from this male, all deter me from regarding it as specifically distinct from *maculosa*.

Distribution of *maculosa*: British Guiana, Minas Geraes and S. Paulo, Brazil, Paraguay; the original locality (Georgia, U.S.A.) reported by Hagen is almost certainly erroneous.

Erythrodiplax basalis basalis (Kirby, 1897).

(Plate II, figs. 35, 36).

Kartabo, one male, abd. segs. 6-10 lost, labeled Kalacoon 1916 Odon. 115, three females, labeled VrS Odon. 21, Odon. 59 and Odon. 90, respectively.

The abdomens of the three females measure 16-16.5 mm., hind wing of the male 17.5, of the females 18.5-19, stigma of the front wings, male 2.13, of the females 2.36-2.64 mm. The front wings have the triangle free in the male and in two females, and once-crossed in female 21; the subtriangle 3-celled except in the right front wing of female 59 where it is 2-celled, two post-triangular rows from the triangle out in the same three, three post-triangular cells, then 2 rows in female 21. The hind wings have Cul separating from the triangle a little distad of its hind angle and only 1 cell between that angle and A2 in all four individuals. The arculus is proximal to the second antenodal in all wings except in the left hind of female 21. The basal spot of the wings of the females is yellow, reaching to the cubital cross-vein or less on the front wings, to the arculus or less and to the anal angle on the hind wings.

Distribution: Jamaica, Trinidad, the Guianas, Colombia to Matto Grosso, Brazil, central Peru and Santa Cruz, Bolivia.

⁶⁵ Differences marked with a (*) are also differences from Ris' 1911 description and figure of Hagen's type of *maculosa* in the Zürich Museum.

⁶⁶ *Proc. Biol. Soc. Washington*, 18:113.

Erythrodiplax connata fusca (Rambur, 1842).

Erythrodiplax connata Burm. *e* (*fusca* Ramb.) ♂, Calvert, 1906, Biol. Centr.-Amer. Neur., pl. IX, fig. 41 (penis, untreated).

Kartabo, seven males, two females, some dated from 3.5 to VI.15.1924, one male is XI.1920, others are labeled VRS Odon. 13 and 128 (two males), Odon. 120 and VrS Odon. 9 (two females). Essequibo River below [between ?] mouths of Potaro and Rupununi, IV-V.1920 (George B. Fox), two males, one has lost abd. segs. 6-10 (Acad. Nat. Sci. Phila.).

French Guiana: 60 mi(les) up Maroni R(iver), 8.04 (Collection Wm. Schaus), one teneral male in bad condition, abd. segs. 5-10 lost (U. S. Nat. Mus.).

A Kartabo male of 6.VI.1924, has the frons reddish but with a purplish tinge which would incline me to refer it to *E. c. connata*. Dr. Borror, however, refers all British Guiana material of *E. connata* to *E. c. fusca*. It is not *melanorubra* (cf. his Revision, page 163) because of the shortness of the terminal joint of the penis: 1.09 mm.

Distribution: Mexico and Trinidad to southern Peru, Bolivia (Santa Cruz), Argentina (Tucuman) and Uruguay.

Erythrodiplax melanorubra Borror, 1942.

French Guiana: St. Laurent, Moroni River (Collection Wm. Schaus), two females, undated. (U. S. Nat. Mus.).

One female has the vulvar lamina apparently normal, its antero-ventral margin in profile view .95 mm. long, almost equal to the lateral tergal margin of abdominal segment 9; abdomen 16 mm., hind wing 21, costal edge of stigma of front wing 2.74 mm. The second female has the dimensions of the vulvar lamina, abdomen, hind wing and stigma as in the preceding individual, but the ninth segment appears to be retracted slightly into the eighth, so that its visible lateral tergal margin is slightly shorter. The nearest localities to French Guiana, recorded by Dr. Borror for *melanorubra*, are in the states of Aragua, Carabobo and Yaracuy of Venezuela, so that this species should appear in British Guiana also.

Distribution: French Guiana, Venezuela to central Peru, Bolivia (Santa Cruz), Paraguay, Brazil (S. Paulo) and Argentina (Entre Rios).

Erythemis peruviana (Rambur, 1842).

Kartabo, one male, 1.V.1921, one female, 7.VI.1924; LAMA 17 Odon. 92, one male; Abay (Abary ?, on the coast) Odon. 32, one male; G(eorge)town, one male, abd. segs. 5-10 lost. Male Odon. 32 and the female bear pin labels "Erythemis peruviana (Rambur) Cur" presumably in Mr. R. P. Currie's handwriting; male 32 lacks head and abdomen.

Distribution: Tamaulipas, Mexico, to Corrientes, Argentina; Jamaica.

Erythemis attala (Selys, 1857).

Kartabo, 6.5.1924, one female, right hind and left front wings lost.

Distribution: Guadalajara, Mexico, to Buenos Aires; Cuba, Haiti, Martinique.

Leptthemis vesiculosa (Fabricius, 1775).

Kartabo, eight males, four females, some dated from III.7 (1921) to 17.VIII (1920), including two males by Dr. C. Hodge IV (1926), one male numbered Odon. 115, one male labeled LAMA 17 Odon. 129, one female VRS Odon. 119 (?). Most of the specimens have lost some segments of the abdomen.

Distribution: Sanibel Island (Westfall, 1941), Florida and southern Texas to Corrientes, Argentina.

Rhodopygia cardinalis (Erichson, 1848).

Kartabo, two males, terminal abdominal segments lost, one labeled Odon. 28, the other Odon. 110.

Distribution: Guiana to Matto Grosso, Brazil, and eastern Peru (?).

v. Trithemiinae T. & F., 1940.

Dythemis multipunctata Kirby, 1894.

Ris, 1919, Cat. Coll. Zool. Selys-Longch., fasc. XVI (2):1202, 1206.

Kartabo, 3.VI.1924, one male.

French Guiana: Cayenne, Dec. 03 (Collection Wm. Schaus), one male (U. S. Nat. Mus.).

These identifications are according to Ris' revision of the species of 1919, without further study on my part. These two males agree with his description (p. 1207) of a series of seven males from Tumatumari, British Guiana, 7.12.II, except that there are no pale spots on abdominal segment 7 of the Kartabo male and none on segment 8 of both males. His description of the Guiana examples is comparable with that of six males from Guatemala wherein is stated: "meist ein schwarzes Bogenstreifen über den Postclypeus;" in the Kartabo male the black arched streak is on the lower margin of the postclypeus (nasus).

Distribution: Guatemala and the Guianas to Peru and Buenos Aires; St. Vincent, Grenada and Trinidad in the West Indies.

Macrothemis polyneura Ris, 1913.

Ris, 1913, Cat. Coll. Zool. Selys-Longch., fasc. XV:888; 1919, XVI (2):1214.

Kartabo, VI.17.1924, one female, abd. segs. 6-10 lost.

Ris (1913) described this variable species from one male each from Poco Grande (Estado S. Paulo), and Parana, Brazil, from one female each from Surinam, Jurimaguas

and Jatahy (Goyaz) and from two females from Espirito Santo; in 1919 he added the description of a male from Kaieteur Ravine, British Guiana (11.IV.1912).

The present female differs from the description of the five females as follows: Lips nearest Van Dyke brown of the colors shown on Plate IV of Smith's Explanation of Terms used in Entomology; frons Van Dyke brown with metallic bluish reflection anteriorly and superiorly. The "gelbliche Längsbinden . . . der Dorsalkante genäherte auf Segment 5-7" of the abdomen appear to be present on segment 4 also. Yellow at base of front wings reaching to 2 cells beyond the triangle, at base of hind wings to antepenult antenodal and 4 cells beyond the triangle, paler where it reaches the hind margin of the wing proximal to the anal loop, remainder of all wings faintly brownish. Two cells in the widest part of the anal loop on the distal side of A2 opposite the external angle, but only 1 row of cells on the proximal side of A2, i.e., between A2 and A3; 4 rows of cells between A3 and the anal margin; post-triangular (discoidal) cells on the right hind wing 2 rows from the triangle distad for 5 cells, thence increasing; on the left hind wing they are 1, 2, 1, 1, 1, 2, 2, 2, 3. . . . Antenodals front wings, 14½, arculus slightly proximal to the 2nd, hind wings, 11 (right), 10 (left), arculus distal to the 2nd. Abdominal segments 1-5 15 mm., hind wing 32 mm., stigma, front wing 2.13 mm., Cologne earth of Smith's glossary, *loc. cit.*

Distribution: The Guianas to Parana, Brazil, Jurimaguas (Yurimaguas?), Peru.

Macrothemis pumila Karsch, 1890.

Karsch, 1890, Berl. Ent. Zeitsch., 33 (2): 364, 368. Ris, 1913, Cat. Coll. Zool. Selys-Longch., fasc. XV:895; 1919, fasc. XVI (2): 1218. Geijskes, 1932, *Zool. Meded.*, 15 (1-2): 125.

Kartabo, two females, both lacking abd. segs. 7-10, one dated 20.X.1920.

Both females agree well with Karsch's original description of this species from Bahia. Ris figured (1913) the appendages and the genitalia of the 2nd abdominal segment of the male and in 1919 described both sexes from British Guiana and Trinidad with figures of their venation. Dr. Geijskes (1932) also has notes on Trinidad examples.

Distribution: Trinidad, British Guiana, Amazon valley from Para to Umbria, Colombia, and Porto Velho on the Rio Madeira, Bahia.

vi. Zygommatinae T. & F., 1940.

Tholymis citrina Hagen, 1867.

Kartabo, July-Aug., 1926 (Dr. Charles Hodge IV), one male (Acad. Nat. Sci. Phila.).

Distribution: Vera Cruz, Mexico, to Mi-

nas Geraes and Matto Grosso, Brazil; Cuba, Jamaica.

Pantala flavescens (Fabricius, 1798).

Bartenef, 1931, Zool. Jahrb. Abt. Syst. Ökol. Geog. Tiere, 60 (5-6):471-488 (geographical distribution with world map).

Kartabo, four males, V.4.1924 to July-Aug. 1926 (including one by Dr. C. Hodge IV in Acad. Nat. Sci. Phila.).

French Guiana: St. Laurent, Maroni River, M[ar]ch (collection Wm. Schaus), one male (U. S. Nat. Mus.).

Distribution: The most wide-spread of all Odonata: circumtropical, extending northward to North Dakota and Maine, Egypt, Transcaucasia, Turkestan, the Himalayas, Amur region of Siberia and Kamtschatka and southward to Sao Paulo, Natal and New South Wales (Bartenef, 1931).

Tramea cophysa Hagen, 1867.

Ris, 1913, Cat. Coll. Zool. Selys-Longch., fasc. XVI (1):988, fig. 570 (genit. male); 1919, fasc. XVI (2):1223.

Referred by implication to *Trapezostigma* Hagen, 1849, by Cowley, 1935, *Entom.*, 68: 283.

Kartabo, 2.V.1921, one male, hind wing 41 mm., abdomen (excl. apps.) 28 mm.

French Guiana: Cayenne, two males 12.03, 2.04, one female Jan. 04 (collection Wm. Schaus, U. S. Nat. Mus.).

The Kartabo male is puzzling, with features agreeing with *cophysa* on the one hand and approaching *onusta* on the other.

Those agreeing with *cophysa* are: Head (if it belongs here, left eye considerably damaged) with vertex and frons metallic violet; thorax with well-marked yellow stripes on mes- and metepimera, reaching more ventrad than the level of the metastigma; (labium discolored); face greenish-yellow along the eyes; thoracic dorsum reddish-brown, no black markings (apices of superior appendages broken off); hamule pressed against the genital lobe so as to be no more prominent than the lobe, its shape like that in Ris' figure 570; wings, other than the basal spots, hyaline, venation somewhat reddish-brown except in the basal spots where it is yellowish; basal spot of front wing yellow half-way to first antenodal; only 1 row of cells between A2 and A3.

Those features approaching *onusta* are: Basal spot of the hind wings brown reaching to: in C and Sc one-half way between 1st and 2nd antenodals, in R and M to arculus, in supratriangle and triangle to level of 2nd antenodal, filling the hindmost cell of the first row of post-triangular cells, the first 2 cells between Cu1 and Cu2, to nearly the same level between Cu2 and A2, behind A3 nearly to the level of the distal angle of the triangle, thence curving slightly

proximal and caudad to the anal angle of the wing; the distal margin of this basal brown spot, therefore, serrate in its anterior half; one row of cells between Cu1 and Cu2; the pale area posterior to the membranule and along the anal margin of the wing occupies a maximum width of 7 cells at right angles to that margin, hence far from A3. This present specimen has the most extensive basal spot on the hind wings for any *cophysa* yet described.

Ris (1913) recognized three forms of *cophysa*: (a) with the basal spot of the hind wing "relativ gross von reichem gold braun, gelb geädert und meist mit breitem gelbem Hof"; (b) with the basal spot "sehr klein" or (c) "klein." This Kartabo male falls in his form (a).

As to the three examples from Cayenne, although the lateral, yellow, thoracic stripes, if present, have faded, I believe them also to be *cophysa* form (a); otherwise they agree fairly closely with Ris' description. The lengths of the superior appendages, of segments 9 + 10, and of segments 8 + 9 + 10 (measured along the mid-dorsal line) of these three specimens are, respectively, 3.19, 2.21, 4.90; 3.52, 2.62, 4.91; 2.69, 2.54, 4.66 mm. The genital hamules do not project quite as far beyond the genital lobe as shown in his figure 570 from a male from Guayaquil. The dark brown basal spot of the hind wings extends to the cubital cross-vein or to the origin of A2 (males), or half-way between the origins of A2 and Cu2 (female).

Distribution of form (a): Tennessee and Texas (Williamson, 1914), and from Ocotlan, Mexico, and Cuba to Guayaquil, Ecuador, and Santos, Brazil.

Idiataphe longipes (Hagen, 1861).

Cowley, 1934, *Ent. Mo. Mag.*, 70: 243 (*Ephidatia* preoccupied).

Ephidatia longipes Calvert, 1906, *Biol. Centr.-Amer. Neur.* 216, tab. ix, figs. 1-5. Ris, 1913, *Cat. Coll. Zool. Selys-Longch.*, fasc. XVI (1): 1013. Klots, 1932, *New York Acad. Sci. Surv. Porto Rico, etc.*, XIV (1), pl. II, fig. 16 (genit. male).

Ephidatia longipes longipes Ris, 1913, op. cit.: 1014 and 1919, fasc. XVI (2): 1227.

Ephidatia longipes cubensis Ris, 1913, 1919, op. cit.: 1013, 1226.

Ephidatia cubensis Needham & Fisher, 1936, *Trans. Amer. Ent. Soc.*, 62: 108 (nymph), figs.

Idiataphe cubensis Garcia-Diaz, 1938, *Journ. Agr. Univ. Puerto Rico*, 22 (1): 60, pl. VII, fig. 3 (venation).

LAMA 17, Odon. 1 and 60, two males.

Both males have lost abdominal segments 5-10, both have the outer branch of the genital hamule "breit, fast quadratisch," one of the characters by which Ris (1913, p.

1012) distinguished *longipes* from *batesi*. This quadrate form is shown by Calvert (1905, fig. 4) and by Mrs. Klots (1932). Ris further gave 7½-8½ antennodals on the front wings for *longipes*, 6½ for *batesi*. Both of these males have 6½ antennodals; they show a faded pale (yellowish?) stripe on the ventral inflexed part and, more narrowly, on the adjacent dorsal part of the tergite of the third abdominal segment only, this stripe reaching from the anterior end to three-fourths' length of the tergite; basal brown spot of the hind wings reaches in Sc half-way to the first antennodal and in Cu to the origin of A2; labium yellowish-brown in distal half, almost black in the proximal half; labrum black, clypeus nearest Van Dyke brown of plate IV, No. 39, of Smith's glossary; vertex almost black, frons very dark metallic violet blue, thorax blackish, no pale markings visible (faded?); hind wing 27, 28 mm.

These two males, therefore, do not agree completely with either of the two subspecies of *longipes*, *longipes longipes* and *longipes cubensis*, recognized by Ris.

Distribution of *longipes longipes*: British Guiana: Para (?), Minas Geraes, Espiritu Santo, S. Joao del Rey (Rei) and Rio de Janeiro, Brazil. (Ris). Kirby adds Colombia (*Trans. Zool. Soc. Lond.*, 12 (9): 331, 1889).

Distribution of *longipes cubensis*: Bahamas, Cuba, Isle of Pines, Puerto Rico, Trinidad, Mexico, Guatemala, Panama, Colombia; Santarem, Brazil (Ris, 1913, 1919; Needham & Fisher, 1936; Garcia-Diaz, 1938).

It is of interest to note that Ris, 1919, p. 1227, records both *E. longipes longipes* and *E. batesi* from Wismar, British Guiana, as taken on the same days, 15, 16.II.1912, by the same collectors, Williamson and Rainey.

ADDENDUM.

Dicterias cothurnata (Foerster) new combination.

Neocharis cothurnata Foerster, 1906, *Jahresber. Mannheim. Ver. Naturk.*, 71-72: 68. Ris, 1918, *Arch. Naturgesch.*, 82A (9): 12. Munz, 1919, *Mem. Amer. Ent. Soc.*, 3: 47, 73, pl. VI, fig. 31 (venation ♂).

Charitopteryx cothurnata Cowley, 1934, *Entom.*, 67: 201.

Subsequent to the proof-reading of this paper, a single female of this species was found among a miscellaneous lot of unstudied Odonata at the Academy of Natural Sciences of Philadelphia, wherefore the following for completeness' sake.

Bartica, British Guiana, 12.17.1913, H. S. Parish, 1♀; allotype, A.N.S.P.

Distribution: Surinam, British Guiana.

Until the specific characters of forms referred to *Dicterias* are better known, *D. cothurnata* is to be added at the top of list a on preceding page 49 of this paper, "Dis-

tribution of the Kartabo Odonata." *Dictierias* is placed in the Calopteryginae by deSelys and Hagen, 1853, in the family Heliocharitidae by Tillyard and Fraser, 1939.

The present female (this sex has not been described hitherto) differs from Foerster's description and Munz's figure of the venation of *cothurnata* male as follows:

Arculus nearest and proximal to the third costal antenodal on the right front wing, midway between the 2nd and 3rd on the left front wing, slightly distal to the 2nd on both hind wings. One double cell between Cu2 and the hind wing margin at less than half distance from the quadrilateral to the distal end of Cu2 on both hind wings; 21 right, 22 left costal antenodals on the front wings, 16 right, 17 left on the hind wings; antenodal length 14 mm., postnodal length 20 mm. on the hind wings, apices of the front wings beyond the stigmata destroyed. Two basal subcostal cross-veins on both front wings and the left hind, one on the right hind. The single cubital cross-vein nearly as far proximal of the arculus as the arculus is long on all the wings, separation of vein A from the hind margin of all the wings as far proximal of the cubital cross-vein as the arculus is long. Nodal sector (M2) separating from M1 $\frac{1}{2}$ -1 $\frac{1}{2}$ cells beyond the nodus, M1a at 6 $\frac{1}{2}$ -8 $\frac{1}{2}$ cells beyond the nodus on the front wings, at 6 $\frac{1}{2}$ -7 cells on the hind wings, and 6 cells beyond the origin of M2 on the front wings and the right hind, 5 cells on the left hind.* Supplementary sectors as in Munz's figure, rather than in Foerster's lines 26-29, page 68. Postnodals, front wings, 22 right, left broken; hind wings 17 right, 18 left.

Abdominal appendages 1.14 mm. long, subequal to abdominal segment 10, straight, simple, tapering to a very acute apex. Distal half of ventral margin of genital valves serrulate. Palps of genital valves .74 mm. long, cylindrical, divergent in dorsal or ventral view, but curved slightly mesad in terminal fourth, extreme apex slightly thickened, reaching to beyond the level of abdominal segment 10 but not as far as that of the apex of the abdominal appendages.

Third femur 11 mm., 3rd tibia 15 mm., 3rd tarsus 2 mm. Abdomen 39, hind wing 34 mm.

Pterostigma of the front wings total

* Lines 21-23, page 68, of Foerster's description should apparently read: "Der Sektor subnodalis entspringt 10 Zellängen nach dem Arculus, der Nodalsektor 1 Zelle und der Ultrannodalis 7 Zellen nach dem Niveau des verdickten Nodus."

length 5.32 mm., costal margin 4.74 mm., brown, a brace vein present on the front wings and the left hind, but not on the right hind, not thicker than adjacent cross-veins and not continued in the same oblique line as the proximal side of the stigma. Apex of the wings hyaline, not brown.

No distinct pale band across the ocelli.

Pterothorax olive with the mid-dorsal carina black and reddish-brown (Van Dyke brown of Smith's Glossary) stripes ca. .57 mm. wide on the mesepisternum, humeral (mesopleural) suture and on the metepimeron and ca. .4 mm. wide on the mesepimeron and the 2nd lateral (metapleural) suture; the two sutures named are each finely lined with yellow.

Abdomen olive green, segments 2-8 (or -10?) with an inferior longitudinal Van Dyke brown stripe for the entire length.

Legs reddish-brown.

This female is of nearly the same size as those of *D. umbra* Ris, 1918,[†] of *D. peruviana* Navas, 1920,[‡] and perhaps of *D. procera* Hagen, 1859,[§] (dimensions not given), but larger than that of *D. atrosanguinea* Selys, 1853.[¶]

Cothurnata differs from all these four species in having two cross-veins in the quadrilateral of all four wings; this is the second of two characters given by Munz as separating *Neocharis* from *Dictierias*; the first is negated by *D. umbra*.

The position of the arculus with respect to the antenodals, the number of basal subcostal cross-veins (i.e., proximal to the first thickened antenodal), the extent to which M1+3 approximate R, the point of separation of M1+2 from M3, the point of separation of M2 from M1, the exact position of cu c-v and of the point of separation of A from the hind margin of the wings are features which vary even in specimens referred to the same species, so that it is impossible, in the present paucity of material of *Dictierias* recorded in the literature, to determine how many of these venational details have specific significance.

[†] *Arch. Naturgesch.*, 82 A (9):12, pl. I, figs. 1, 2 (venation ♂, ♀).

[‡] *An. Soc. Cient. Argent.*, 90:34; Cowley, 1937, *Proc. Roy. Ent. Soc. London*, (A) 12 (8-9): 24, fig. 2 (1st leg).

[§] Hagen in Selys, *Bull. Acad. Belg.*, (2) 7:444; Needham, 1933, *Amer. Mus. Novitat.*, 664:4, fig. 2 (venation).

[¶] *Syn Calopt.*:56; *Monog. Calopt.*:191, pl. 5, fig. 6 (venation), pl. 8, fig. 12 (mouth parts), pl. 14, fig. 6 (abd. apex), 1854; *Bull. Acad. Belg.*, (2) 37:662, 1869. Munz, 1919, *Mem. Amer. Ent. Soc.*, 3, pl. VI, fig. 32, has copied the figure of the venation of the Monog. Calopt.

EXPLANATION OF THE PLATES.

Abbreviations on some of the figures:

al, anterior lamina
gl, genital lobe
gs, glans of penis
h, hamule
hl, first (anterior) hamule
h2, second (posterior) hamule
p1-p4, first (vesicle) to fourth joints of penis
pr, hind lobe of prothorax
sh, sheath of penis
A1, A2, A3, C, M1, M1a, M2, M3, R1, Rs,
veins according to the Comstock-Needham notation.

Most of the drawings have been made with the aid of a Zeiss camera lucida, the majority in connection with a Zeiss-Greenough binocular microscope using paired objectives 2 or 10, paired objectives F55 or a.. Drawings of the penes of *Erythrodiplax* and figures 1, 2, 20, 21 and 22 have been made under a Leitz compound microscope, ocular 10 \times , objective 3 with its lower lens off for the camera lucida, adding this lens to complete the details by free hand.

PLATE I.

- Fig. 1. *Leptagrion beebeanum* n. sp. Dorsal view of abdominal segment 10 and appendages of δ type, Kartabo, British Guiana, 6.24.1924.
- Fig. 2. *Leptagrion beebeanum* n. sp. Right profile view of the same.
- Fig. 3. *Hetaerina dominula* Hagen. Left superior appendage δ Bejuma, Venezuela, February 13, 1920. t indicates the small tooth on the internal superior margin, referred to in the text as being a distinguishing character of *dominula* according to de Selys and Hagen.
- Fig. 4. *Hetaerina dominula* Hagen. The same from Tumatumari, British Guiana, February 11, 1912.
- Fig. 5. *Hetaerina dominula* Hagen. The same from Maroni River, French Guiana, 8.04.
- Fig. 6. *Hetaerina dominula* Hagen. Outline of head δ to show the occipital tubercles. Kartabo, 22.X.1920.
- Fig. 7. *Phyllocycla bartica* n. sp. Left profile view of abdominal segments 8-10 and appendages, δ , holotype, Kartabo, III.9.1926.
- Fig. 8. *Phyllocycla bartica* n. sp. Left profile view of genitalia of second abdominal segment δ holotype. One cornu is directed cephalad for clearness' sake. At a is shown a piece of a cornu of the penis more highly magnified.
- Fig. 9. *Phyllocycla bartica* n. sp. Rear view of vesicle (first joint) of penis, δ holotype.
- Fig. 10. *Phyllocycla bartica* n. sp. Ventral view of hamules and anterior lamina, δ holotype.

- Fig. 11. *Phyllocycla bartica* n. sp. Dorsal view of tenth abdominal segment and appendages, δ holotype.
- Fig. 12. *Phyllocycla bartica* n. sp. Right hind wing base, δ , Kartabo, III.11.1926.
- Fig. 13. *Phyllocycla bartica* n. sp. Right hind wing base, δ holotype.
- Fig. 14. *Phyllocycla bartica* n. sp. Ventral view of vulvar lamina and ninth abdominal segment, δ Kartabo, III.4.1926.
- Fig. 15. *Phyllocycla bartica* ? n. sp. The same, δ Kartabo, July-August, 1926.
- Fig. 16. *Aphylla alia* n. sp. Left profile view of genitalia of second abdominal segment, δ holotype, Kartabo, 19.VII.1920.
- Fig. 17. *Aphylla alia* n. sp. Ventral view of hamules, δ holotype.
- Fig. 18. *Aphylla alia* n. sp. Right hind wing base, δ holotype.
- Fig. 19. *Aphylla alia* n. sp. Rear view of vesicle (first joint) of penis, δ holotype.
- Fig. 20. *Metaleptobasis tetragena* n. sp. Dorsal view of mesothoracic horns and hind lobe of prothorax, δ holotype, Kartabo, July-August, 1926.
- Fig. 21. *Metaleptobasis tetragena* n. sp. Frontal view of same, δ holotype.
- Fig. 22. *Metaleptobasis tetragena* n. sp. Left profile view showing left mesothoracic horn and left tubercle of hind lobe of prothorax, δ holotype.

PLATE II.

- Fig. 23. *Erythrodiplax castanea* (Burmeister). Right profile (lateral) view of last joint of penis, Kartabo, 2.V.1924.
- Fig. 24. *Erythrodiplax angustipennis* Borrer. Right profile view of last joint of penis, Maroni River.
- Fig. 25. *Erythrodiplax unimaculata* (De Geer). Right profile view of last joint of penis, Kartabo, VRS. Odon. 62.
- Fig. 26. *Erythrodiplax unimaculata* (De Geer). Ventral view of apex of last joint of penis, Kartabo, VRS. Odon. 18.
- Fig. 27. *Erythrodiplax laurentia* Borrer. Right profile view of last joint of penis, Kartabo, 6.VI.1924.
- Fig. 28. *Erythrodiplax famula famula* (Erichson). Ventral view of apex of last joint of penis, Kartabo, 20.IV.1920, not fully colored.
- Fig. 29. *Erythrodiplax famula famula* (Erichson). Right profile view of last joint of penis, Kartabo, 1.VI.1924.
- Fig. 30. *Erythrodiplax latimaculata* Ris. Ventral view of apex of last joint of penis, LAMA, Odon. 38.
- Fig. 31. *Erythrodiplax latimaculata* Ris. Right profile view of last joint of penis of same.

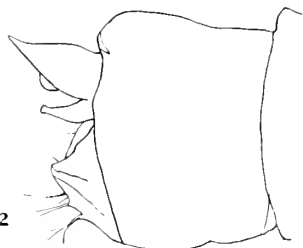
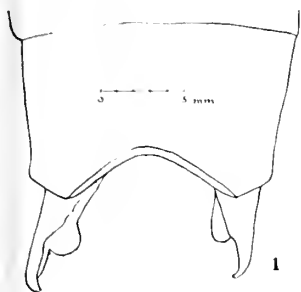
- Fig. 32. *Erythrodiplax maculosa* (Hagen). Ventral view of apex of last joint of penis, LAMA 17, Odon. 63.
- Fig. 33. *Erythrodiplax maculosa* (Hagen). Right profile view of genitalia of second abdominal segment of same.
- Fig. 34. *Erythrodiplax maculosa* (Hagen). Nodal region of the four wings of same.
- Fig. 35. *Erythrodiplax basalis basalis* (Kirby). Ventral view of last joint of penis, Kalacoon, 1916, Odon. 112.
- Fig. 36. *Erythrodiplax basalis basalis* (Kirby). Right profile view of last joint of penis of same.
- Fig. 37. *Oligoclada raineyi* Ris. Ventral view of vulvar lamina and abdominal segment 9, Kartabo, 20.V.1924.
- Fig. 38. *Microstigma maculatum* Hagen. Apex of right front wing, Essequibo ♂, type of Hagen, in the Museum of Comparative Zoology; from camera lucida drawing by Prof. B. Elwood Montgomery.
- Fig. 39. *Aeschnosoma peruviana* Cowley. Rear view of vesicle (first joint) of penis, Kartabo. 13. iii.
- Fig. 40. *Aeschnosoma peruviana* Cowley. Left profile view of genitalia of second abdominal segment of same male.
- Fig. 41. *Aeschnosoma peruviana* Cowley. Ventral view of hamules and genital lobes of same male.
- Fig. 42. *Zenithoptera fasciata* (Linnaeus). Photographic reproduction, by Mr. A. D. Warden, of George Edwards' figure, pl. 174, of his Natural History of Birds, quoted by Linnaeus as the basis for his *Libellula fasciata* and also *Libellula americana*.
- Fig. 43. *Aeschnosoma peruviana* Cowley. Photograph, by Mr. Herman A. Walters, of male from Kartabo, 13.iii.

Corrections to Plates.

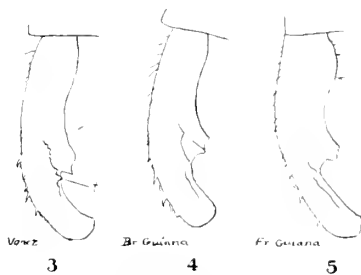
Plate I, Fig. 16. For h2 read h1; for h1 read h2.

Plate II, Fig. 38. Following are the abbreviations marking the wing-veins from above downward: C, R1, M1, M1a, M2, Rs, M3.

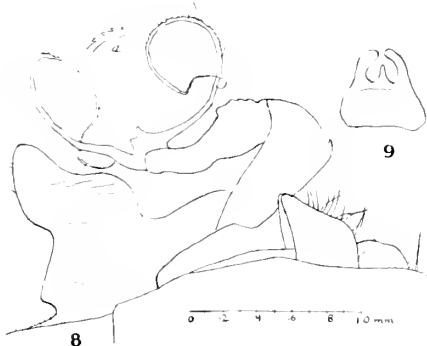
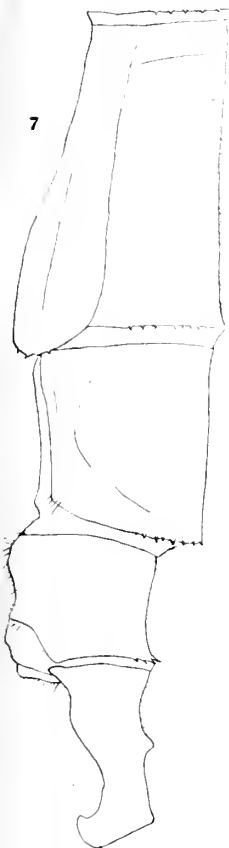




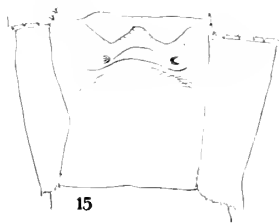
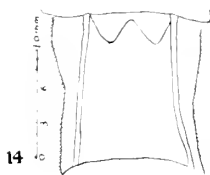
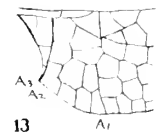
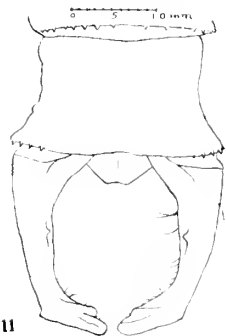
1, 2 *Leptagrion beebeanum* n. sp.



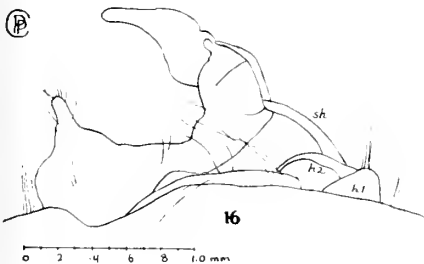
3-6 *Hetaerina dominula* Hagen



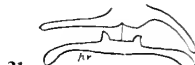
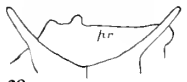
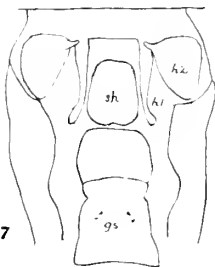
7-15 *Phyllocyca bartica* n. sp.

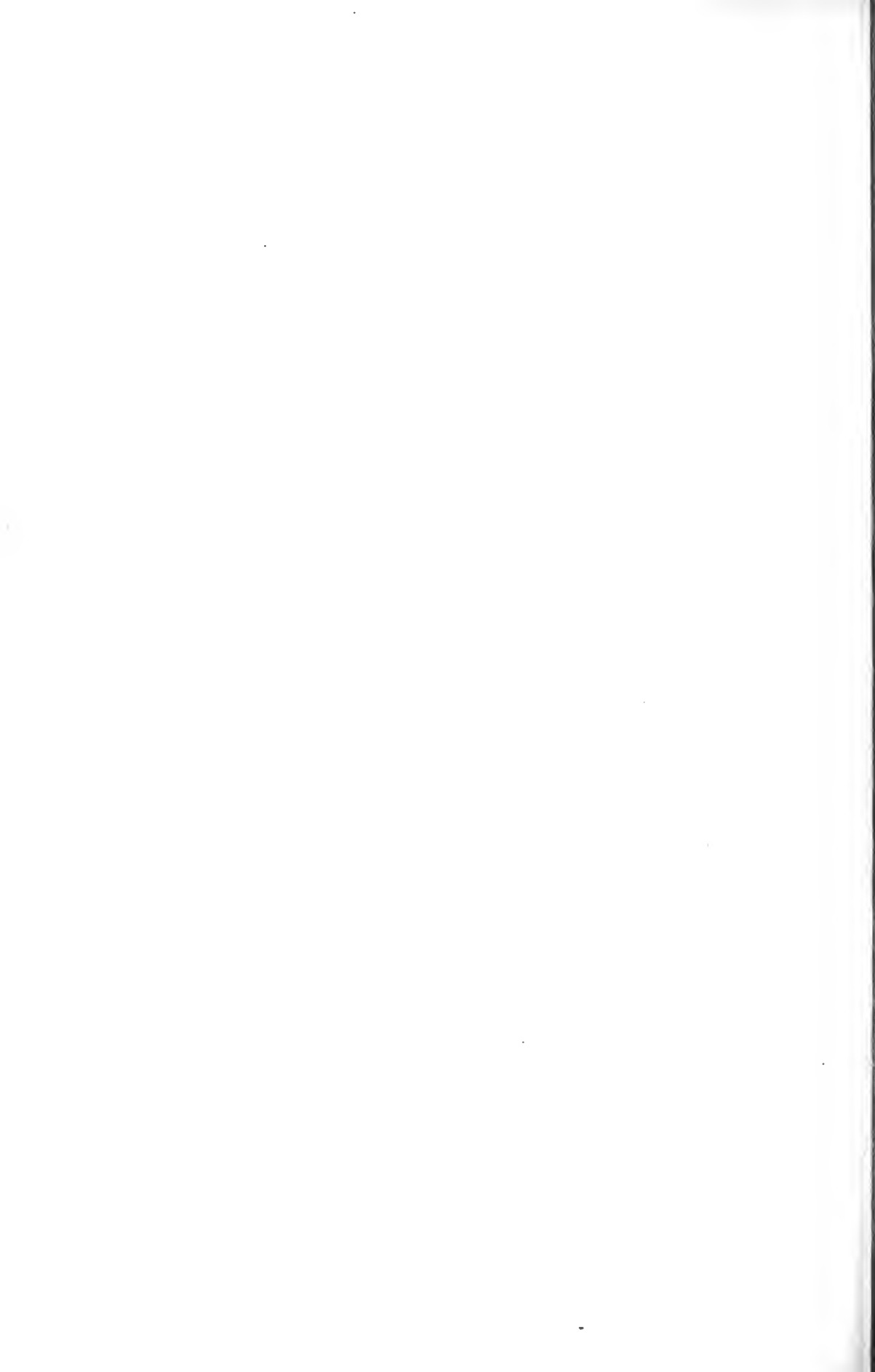


20-22 *Metaleptobasis tetragena* n. sp.



16-19 *Aphylla alia* n. sp.







23 Erythrodiplax castanea (Burm.)



24 E. angustipennis Bor.



25,26 E. unimaculata (DeGreer)



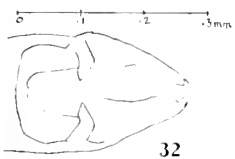
27 E. laurentia Borrer



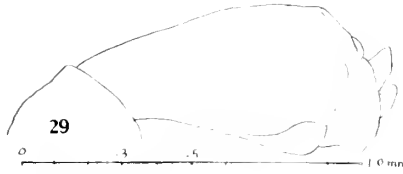
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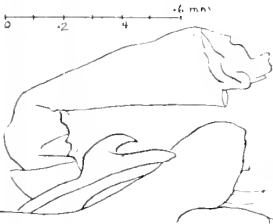
30,31 E. latimaculata Ris



30

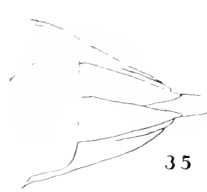


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33

28,29 E. famula famula (Erichson)

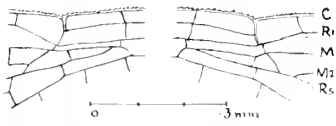


35

35,36 E. basalis basalis (Kirby)

37

Oligoclada raineyi Ris



34



36



32-34 E. maculosa (Hagen)

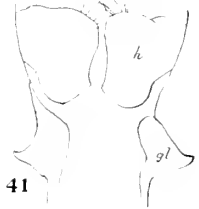


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38 Microstigma maculatum Hagen

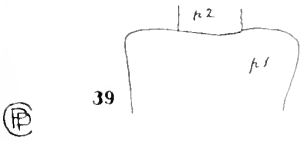


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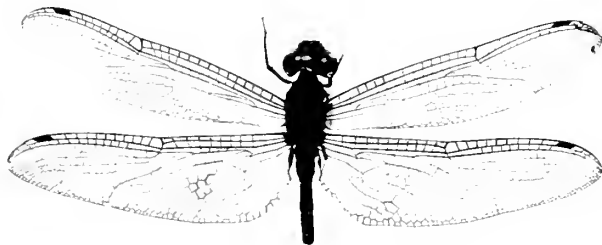
39-41 Aeschnosoma peruviana Cowley



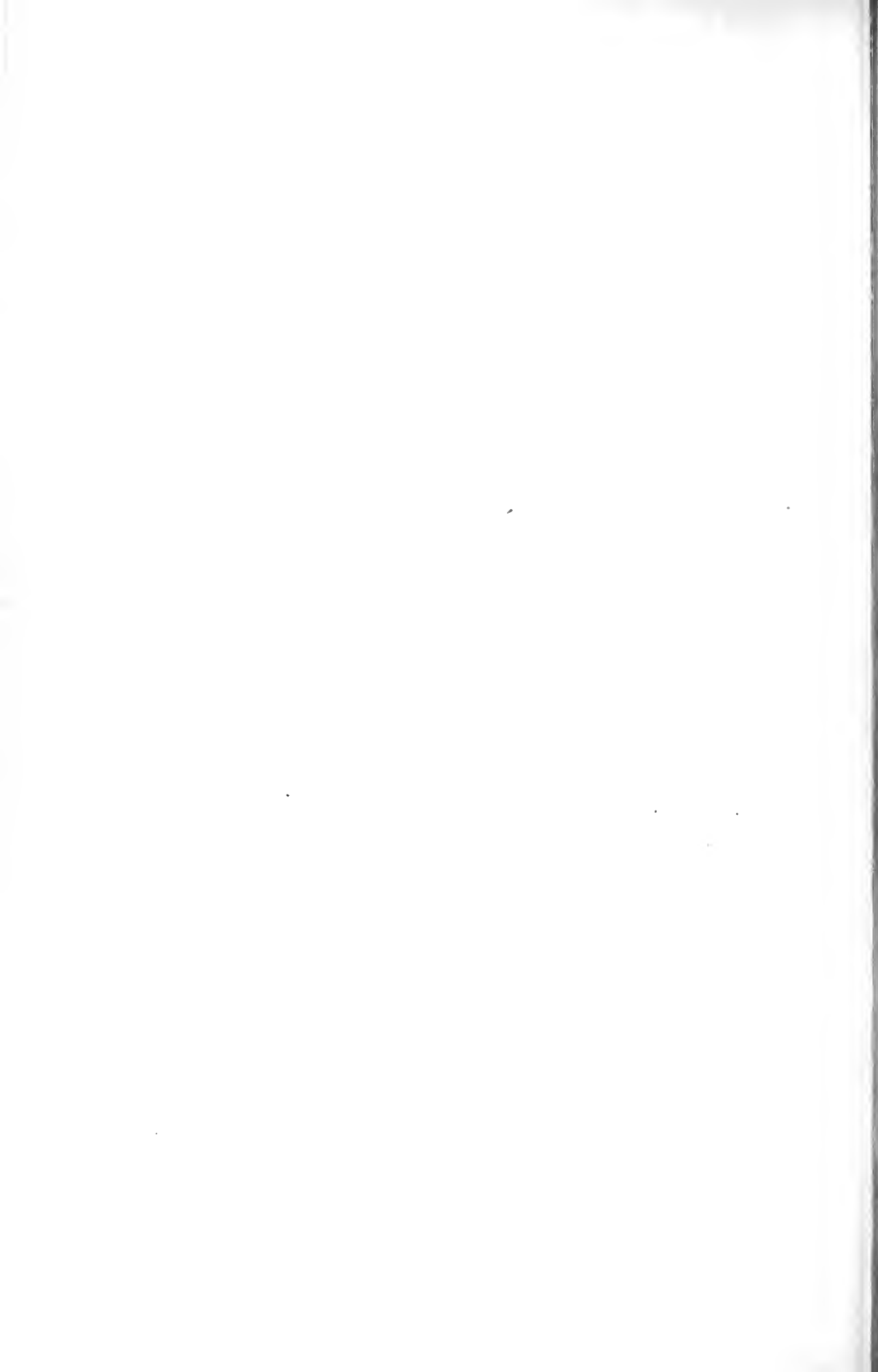
39



42 Zenithoptera fasciata (Linnaeus)



43 Aeschnosoma peruviana Cowley



5.

Army-ant Life and Behavior under Dry-season Conditions
with Special Reference to Reproductive Functions.

II. The Appearance and Fate of the Males.

T. C. SCHNEIRLA.

*The American Museum of Natural History.*¹

(Plate I; Text-figure 1).

INTRODUCTION.

In keeping with the marked deviations of the doryline ants from most other ants in their general behavior pattern, there are extensive differences in their mode of reproduction. The close relationship which exists between general reproductive pattern and colony behavior in the American subgenus *Eciton* (*Eciton*), has been described in previous reports (Schneirla, 1938, 1944). The present paper represents an attempt to throw further light upon *Eciton* reproductive processes by inquiring into dry-season events and particularly the appearance and function of *Eciton* males.

The wasplike winged males of the dorylines, which contrast sharply with the curiously-structured wingless dichthadiigynes or fertile females of these ants, have been described by various authors (Gallardo, 1920; Mukerji, 1926; Wheeler, 1921; Smith, 1942), yet the manner in which these reproductive forms are produced and the nature of their functional relationship to colony activities have remained obscure to the present time.

The elusiveness of this problem is suggested by my failure to find any trace of developing *Eciton* male forms during the rainy season, notwithstanding the fact that an extensive search of the nests was carried out in the rainy months of four different years. The studies (Schneirla, 1933, 1938, 1944) were made in the Caribbean area of Panama, in a region that has well marked and fairly regular annual rainy and dry seasons. It would seem by elimination that young reproductive individuals of both sexes must appear during the latter part of the rainy season or in the course of the annual dry season.

Most of our previous evidence on the fertile forms of *Eciton* has come as we shall see (in the "Discussion" section of the present paper) from the occasional capture of males and females in scattered localities, under seasonal and colony conditions which are generally very incompletely reported.

The desirable procedure to clarify the confusion is a comparison of data from areas with similar annual climatic changes. A beginning was made by the writer in the dry season of 1945, in a sampling of *Eciton* colonies in various rain-forest localities in southern Mexico through the latter two-thirds of the regular dry season (Schneirla, 1947). This general area was selected because its annual rainy-dry seasonal cycle approximates that of the Atlantic rain-forest area of Panama. In that study various well-separated localities were visited successively, a procedure calculated to give a broad view of *Eciton* conditions through the period. A predominance of worker broods was found, with but limited evidence on the reproductive forms. Just one brood of developing males was found, under conditions somewhat resembling the single male brood previously found by Wheeler (1921). It is clear that a cross-sectional survey is not adequate for the study of events as elusive as the production of *Eciton* fertile forms appears to be.

The present survey represents a longitudinal or relatively continuous survey of conditions in the locality of the original Panama studies. As was anticipated, male forms appeared in the *Eciton* broods and an extensive study of their relations to the colonies became possible. Among the questions to which the study was directed were these: Do the males appear in distinctive broods or in mixed broods (e. g., with worker forms)?—How many males may be produced by a given colony, and do all colonies produce them?—Is the production of males synchronized in some manner with the ordinary production of worker broods by *Ecitons*, or does this process occasion interruptions or irregularities in the ordinary reproductive rhythm? Such questions are of interest not only from the standpoint of *Eciton* reproductive functions, but also with regard to the general problem of caste determination in insects.

We are of course interested in learning the relationships of males to colony behavior, both when they are in broods and after they have emerged as alate adults. We have found that worker broods have a regular and important causal function in the occurrence of the periodic nomadic and stately changes in colony behavior which are consistent

¹ This investigation was carried out while the writer was a Fellow of the John Simon Guggenheim Memorial Foundation. Supplementary studies have been supported by a grant to the Department of Animal Behavior from the Committee for Research in Problems of Sex, National Research Council.

features of *Eciton* life under rainy-season conditions (Schneirla, 1938; 1944). Is it possible that the appearance of developmental forms other than workers is reflected in a different set of relationships between brood and colony?

Finally there is a whole set of questions concerning the behavior and function of the males, in particular the conditions of their dispersal as winged individuals and the manner of their eventual meeting with the unique wingless *Eciton* dichthadiigynes. Problems such as the last, concerning the process of mating, will be touched upon only circumstantially here in relation to the dispersion of the males from their colonies of origin.

LOCALITY AND GENERAL CONDITIONS OF THE INVESTIGATION.

This paper is based upon a systematic investigation of *Eciton* behavior and related colony conditions in a given general locality, Barro Colorado Island, C. Z., through the principal part of a given dry season.

The survey extended over roughly the last three-fourths of the dry season of 1946 into the early part of the next rainy season, in all from February 7, 1946 to June 16, 1946. Until near the end of this period rains were exceptional and generally very light, with numerous sequences of rainless days until after mid-April. These circumstances are typical of the locality.

That there is a sharp seasonal difference in rainfall on Barro Colorado Island (as in the Caribbean area generally) is clear from the fact that in a summary of monthly averages and deviations for a period of fifteen years on the Island during which records were kept by the same method, the smallest monthly rainfall probable in the wet months from May through November (6.3 in. for September) clearly exceeds the largest monthly fall probable in the dry months from December through April (5.0 in. for April).² Thus the Island itself may be considered a very satisfactory region in which to investigate the seasonal differences in ecology and behavior of tropical American rain-forest animals. With respect to dry-season conditions in the spring of 1946, it should be added that the preceding wet season had brought an exceptionally large fall of rain before dry weather set in about mid-December; consequently even the rather high ground of Barro Colorado, well-forested as most of it is, may have retained more moisture than is usual during the dry season. Only the terrain in the eastern section of the Island, with its lighter forest cover than other sections, approached in dryness the conditions generally encountered in southern Mexico in the spring of 1945 (Schneirla, 1947, areas 1, 3 and 4).

The study is mainly concerned with two terrestrial species of the subgenus *Eciton*

(*sensu stricto*), which are among the most frequently encountered members of the genus *Eciton* in Central America.

The general method involved surveys of behavior and biological conditions of *Eciton* colonies in the field, with special field and laboratory tests introduced when feasible. The plan was to keep as complete a record as possible of army-ant colonies present in the eastern and southeastern half of the Island (the drier section). Two colonies, one of *Eciton* (*E.*) *burchelli* (colony B-I) and one of *E.* (*E.*) *hamatum* (colony H-B) were kept on record throughout the four months of the study, and numerous other colonies of these two species were studied for shorter intervals of time.

At intervals of about three days through the period of investigation, when accessible the bivouacs of colonies under observation were broken into as carefully as possible for brood samples. Periodically the bivouacs of colonies other than the two principal cases (B-I and H-B) were ransacked for a thorough inspection of their brood and adult population. A large part of the collected brood material was fixed in a modified Bouin's solution before preservation in 70% alcohol.

Live *Eciton* material was kept at the laboratory for special behavior observations and tests arising from the field work. For sampling the population of flying *Eciton* males, occasionally a small light trap was set at various places in the general forest and a larger light trap was placed in the forest near the laboratory clearing. Also, a white illuminated board just outside the main laboratory building was inspected each night for alate males.

RESULTS.

General Results: The Nature and Occurrence of Eciton Male Broods.

It has developed from numerous seasonal investigations on Barro Colorado Island (Schneirla, 1933, 1938) that in the regular season of rains in that locality *Eciton* colonies produce only worker forms in immense broods. No sexual forms were found in a great number of broods examined during the period from May through September. Our present results indicate that the production of males is seasonally conditioned, and evidently limited to the dry season.

The general findings are summarized chronologically in Table I. From the time the study was begun on February 7 until the latter part of February, only broods containing worker forms were found in the bivouacs of *Eciton burchelli* and *E. hamatum*. In agreement with the 1945 results from southern Mexico, such broods resembled those of the rainy season in containing the entire polymorphic series of worker types, and from general inspection seemed to approach them in numbers of individuals (ca. 25,000). The first brood containing male forms was found on February 16 in a colony of *E. burchelli* (No. B-III), chanced upon

² The writer is grateful to Mr. James Zetek, Resident Manager of the Barro Colorado Island laboratory, for having made this data available, and for the many other ways in which he generously facilitated arrangements for these investigations.

late in the evening during the early part of its bivouac-change movement. It was observed that some rather bulky larvae were being carried by workers in the column. Samples of these larvae were taken, and later at the laboratory were found to be all of the characteristic sub-cylindrical male type and all nearly the same size, about 14 mm. in length. On February 20, when the bivouac of this colony was examined carefully, the brood was estimated to contain 3,000 larvae, all of the male type and not very different in size. The last distinct brood of males found in the investigation was a lot of alate males discovered in a colony of *E. hamatum* (H-L) on April 16. As Table I indicates, male broods were discovered in various other colonies of both *E. burchelli* and *hamatum* during the intervening period of about two months.

Representative stages of development in *Eciton* males, from early larval to mature forms, are illustrated in Plate I.

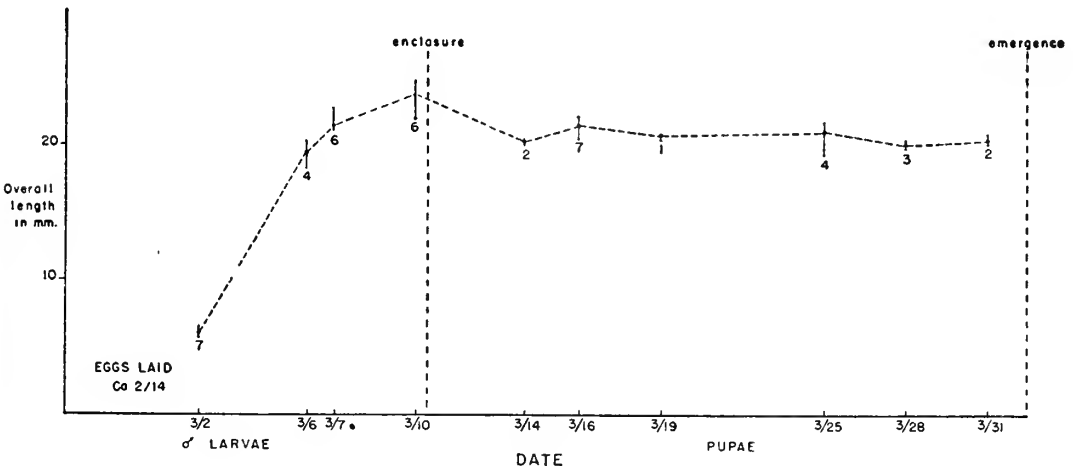
Altogether, male broods were found in 5 of 26 different colonies of *E. hamatum* under observation at different times from mid-February to late April, and in 6 of 21 different colonies of *E. burchelli*. Dealate males in limited numbers were found at intervals in the colonies of both species up to the time when the study ended in mid-June. In these species the production of males seems to be confined to the dry months.

The results summarized in Table I suggest that a species difference exists in the time of male-production. Inspection of the captures shows that male broods of *E. burchelli* were found from shortly after mid-February, when early larval broods were discovered in the bivouacs, to the end of March when only alate forms were found. In contrast, larval male broods of *E. hamatum* were not found until the middle of March, and alate broods of this species were not taken until mid-

April. Notwithstanding the relatively small number of cases, in view of the fact that numerous colonies of these two species were investigated with approximately equal frequency during the period, it is quite possible that we are dealing with a reliable difference in the timing of male production. Especially suggestive is the fact that all of the respective stages of *E. hamatum* males from early larvae to dealate forms were taken later than were the corresponding male types of *E. burchelli*. The *burchelli* colonies on the Island evidently begin their production of males earlier than do *hamatum* colonies, and finish earlier. Judging from the fact that winged males of various species of *Eciton* (*Labidus*) and *E. (Neivamyrmex)* were taken at lights from the early part of February, it is possible that males are produced still earlier in the season in some of these species.

In this study, two colonies of different species of *Eciton* (*Eciton*) were kept on record for approximately four months after early February. All of the principal activities such as raids and nomadic movements were investigated, and whenever possible samples of their broods were taken at 3-day intervals. In one of these colonies, H-B of *E. hamatum*, four all-worker broods were produced during the interval, but this colony produced no males of its own. Within the same time, colony B-1 of *E. burchelli* brought forth three worker broods and in addition one all-male brood of its own. There follows a résumé of the latter case, which as various other results indicate is representative of the circumstances of male-production in species of *Eciton* (*Eciton*).

The record of colony B-1, E. burchelli. The colony was found on February 6, through chancing upon its raiding system. At the time its bivouac cluster was established within a large hollow tree, about 2.5 meters from the ground, one side of it visible



TEXT-FIG. 1. Sketch of representative stages in the development of a male brood of *E. burchelli* (colony B-1), from larva to mature pupa. Size at each stage is represented by the overall length of specimens taken in small samples. The number of individuals in each sample is indicated below the short vertical line representing range and average of lengths in the sample.

through a huge knothole. This was clearly a statory site into which the colony had moved within the preceding few days, for an immense brood of probably more than 25,000 mature worker larvae newly enclosed in cocoons was present. On February 16 unsuccessful attempts were made to discover and sample a new brood of eggs which, in the regular cycle of Eciton events, would be expected at about that time (Schneirla, 1944). On February 28, with the greater part of the now mature worker brood removed as callows from cocoons, the colony set off upon a nomadic period in which raids were larger than before and successive nightly bivouac-change movements occurred.

Larvae of the new brood, which later proved to be an all-male brood, were taken from the temporary bivouac of March 2. These larvae were all nearly the same size, about 6.4 mm. in length. In the following days they grew with surprising rapidity. For example, on March 10 a small sample of six of them approximated 23 mm. in length. At that time these larvae evidently were nearly mature, for the first spinning was observed on March 9. The growth rate of this brood is represented in Text-figure 1.

On March 10, when the colony spent its first day of a new statory period clustered within the basal trunk cavity of a large hollow tree, cocoon-spinning appeared to be widespread among the mature male larvae. The spinning evidently lasted about six days in all. On March 19 approximately 200 of the enclosed larvae were dragged by workers to the outer edge of the tree-opening, where they were discarded. All larvae in the heap of discards were found to be dead at the time. A general examination disclosed no clue as to possible causes of death.

On March 29, when all members of the male brood seemed to be nearly mature pupae in a well-pigmented condition, the colony began to shift away from its statory site in the hollow tree.³ At this time laboratory tests showed that most of the males were capable of antennal, tarsal, and trunk reflexes of sufficient amplitude to be readily observable with the naked eye. Large numbers of newly emerged alate males were seen nightly in the columns after this time, together with many unopened cocoons which were lugged along by workers. On the night of March 31 the "shucking" of mature male pupae from their cocoons was observed in full swing at both old and new bivouacs. At the time it was estimated that more than three-fourths of the males had emerged as callows.

On April 1 the presence of a new brood of very young worker larvae in colony B-I was established. The nightly bivouac-change columns of the colony now were thronged with many hundreds of alate males, passing

along the trails under their own power in single file or in small groups, generally surrounded and closely followed by workers in large groups. Successive nightly movements were observed in which for periods of two hours or more the alate males ran in column with workers from the old to the new bivouac site. The males appeared only during the nightly removals; in the daytime they remained within the bivouac cluster and never were seen among the workers on the raiding trails.

On April 2 the emergence of this brood from cocoons seemed to be complete. Judging by a count of empty cases collected from the statory site and first few nomadic bivouacs, this brood of males numbered close to 3,000 individuals.

Each evening after April 3, within a few hours after dusk in the early beginning of the bivouac-change, as many as a few dozen winged males were to be seen in the vicinity of the bivouac of the day, running circuitously about on the ground and on low vegetation and other objects close to the ground. Generally each male had a few workers hanging to his body or running in close contact with thorax or gaster. No departure flights were observed until after April 5, then on succeeding nights the male take-off flights were observed frequently, from the vicinity of the old bivouac and sometimes from the new site, but never from the moving column. (No movements of the colony occurred on the nights of April 4, 6, and 8.)

On April 14, when colony B-I entered a further statory period (with its larval worker brood now mature and engaged in spinning), alate males were not very numerous, and it was judged that not more than 600 of them remained with the colony. A few nightly departures of males were observed during the statory period, from the large lightning-split tree in which the colony was clustered, until in the first bivouac-change movement of the new nomadic period it was not possible to observe any alate males at all. (At this time the major part of a new brood of mature pupal workers had emerged from cocoons.) Since no alate males were observed in the B-I columns during subsequent nightly removals, it was judged that the last of them had left the colony.

To sum up the life of this male brood in colony B-I in which it was produced, its growth stages (cf. Text-figure 1 and Plate I) may be timed approximately as follows:

- | | |
|--|-------------|
| Probable midpoint date of egg-production: (During the early third of a statory phase). | February 14 |
| Presence ascertained as very young larvae: (In the early days of a new nomadic period). | March 3 |
| Mature male larvae at height of cocoon-spinning: (At beginning of a further statory period). | March 10 |

³ The nightly bivouac-change movements through which this colony shifted from the statory site of March 10-31 were complex and rather exceptional, involving as they did a process of true colony-division which will be discussed in a forthcoming paper.

TABLE I.
Principal records of male Eciton broods in the 1946 dry season at Barro Colorado Island.

Date found	Colony symbol and species	Condition of male brood	Estimated brood population	Other broods present	Colony behavior	Remarks
Feb. 22	B-II-X <i>E. burchelli</i>	Nearly mature larvae	3,000	Large brood of callow workers	Nomadic; four nightly moves observed	No movement on second night after large part of male brood was taken away
Mar. 1	B-III <i>E. burchelli</i>	Mature pupae, largely emerged alates	3,000	Large brood very young worker larvae	Newly nomadic; three successive nightly moves observed	Evidently found on day following the first nomadic move
Mar. 2	B-I <i>E. burchelli</i>	In early larval stage	3,000	Large brood newly emerged callow workers	Nomadic; on move until larvae mature, enclosed	Nomadic activity rose considerably in following days
Mar. 6	B-IV <i>E. burchelli</i>	Adult alates	500	Large brood nearly mature larval workers	Nomadic; four successive moves, then stately	No males remained after stately period of 22 days
Mar. 29	B-V <i>E. burchelli</i>	Adult alates	1,000	Large brood fairly mature larval workers	Nomadic; two successive moves observed	Exodus of males observed from bivouac area
Mar. 31	B-VI <i>E. burchelli</i>	Adult males	500+	Large brood mature larval workers	Nomadic; moved that night into stately bivouac	No alate males remained after stately period of 21 days
April 3	H-J <i>E. hamatum</i>	Very young larvae	3,000	Large brood newly emerged callow workers	Nomadic; large raids, two successive moves seen	Just three days after stately period
April 4	H-K <i>E. hamatum</i>	Larvae more than two-thirds grown	3,000	No other broods observed	Nomadic; two successive moves observed	Raids exceptionally large; movements long
April 9	H-L <i>E. hamatum</i>	Newly emerged callow alates	2,000	Large brood very young worker larvae	Nomadic	Queen contracted; two de-alated males found in bivouac
April 10	H-M <i>E. hamatum</i>	Newly emerged callow alates	2,000	Immense brood very young worker larvae	Nomadic	250 meters from H-L; possibly from same base colony

Mature males emerging from cocoons: (At beginning of a new nomadic phase). March 31
 Alate males probably all gone about April 20

Provided that the eggs of this brood were laid on or about February 14, as there is reason to believe was the case, the total development time of this male brood was close to 46 days, with 22 days of this time for growth from the stage of larval maturation to pupal maturation. The males left the colony in nightly lots, and practically all of them appeared to have flown off within little more than three weeks from the time of their emergence as callow alates. Actually, the major part of this brood got away during the nomadic period of about 12 days which followed directly upon their emergence from cocoons. However, no departure flights were witnessed on the first three nights after emergence from cocoons had begun.

Colony B-I had but one brood of males, preceded by one immense all-worker brood and followed by two others, all broods appearing at regular intervals during the period of study. The total developmental time of the male brood was roughly the same as that of worker broods.

Evidence from briefer studies of male production. In all, 11 male broods were found in 47 colonies of *E. burchelli* and *E. hamatum* studied during the season of investigation. The chief characteristics noted above in the evidence from the production of a male brood by colony B-I were confirmed in briefer investigations of the other cases. The gist of the evidence from the other ten cases is presented in Table I, in chronological order, and further relevant facts from other colonies are given below, roughly in the sequence of developmental stages.

Colony H-J (*E. hamatum*) was found at 11:00 a. m. on April 3, engaged in a large three-system raid from a temporary bivouac 100 meters to the east of the Shannon trail, opposite Station 6.⁴ There was a brood of many thousands of newly emerged callow workers, relatively few of which were to be seen outside the bivouac. Near the rear center of the cylindrical bivouac cluster were found two walnut-sized clumps which contained relatively small sub-cylindrical larvae (later identified as Eciton male larvae) all roughly the same size. The colony was definitely nomadic, since it moved to a new bivouac site late that evening, and staged a new 3-system raid on April 4. Two broods: a large brood of callow workers, and a brood of young male larvae.

Colony H-K (*E. hamatum*) was found at 10:00 a. m. on April 4, about 200 meters to the east of Wheeler trail near station 22. A large 3-system raid was in progress; the bivouac was a very broad irregular cylinder beneath a large log. Well distributed through

the walls and interior of the mass was a brood of male larvae considerably more mature than the brood of colony H-J, and estimated to number between 2,500 and 3,500 individuals. That evening the colony moved to a new bivouac site about 200 meters distant. One brood: a relatively small brood of moderately developed male larvae.

Colony B-II-X (*E. burchelli*) was found on the move into Lutz ravine on the evening of February 20, crossing Barbour trail near station 2. In the column were observed many thousands of newly emerged callow workers, distinguished from older workers by their light pigmentation, and large numbers of rather advanced male larvae lugged along by workers. The bivouac of February 21 could not be investigated; however the move of that evening was traced to the new site, and on February 22 the bivouac contents were examined. The brood of callow workers was relatively immense; that of male larvae was much smaller and was close to maturity. The new bivouac of February 23 was an unusually tall structure. It was a regular cylinder 90-100 cm. in height and about 35 cm. in width at the top (depending to the ground from the undercut upper edge of a broad buttressed root) and tapering inward toward the bottom which touched the ground. The male larvae were evenly distributed throughout the walls of the cluster, held by workers, and heaped in occasional pockets in the interior meshwork of workers. Nightly moves were observed until February 25, when the colony held its position within the base of a small partially open hollow tree, occupied the night of February 24. Late in the day on February 25 signs of larval cocoon-spinning were observed. On the night of February 26, after a very large raid during the day, the colony moved across Donato trail beyond station 3, about 160 meters to the north where a cluster was formed against the upper interior wall of a great hollow tree. Cocoon-spinning by larvae was greatest on February 27, judging by the rate at which wood dust fell to the ground from the elevated cluster of ants, and by the same sign this activity was completed on February 29 (as far as transportation of larvae to spinning places by workers was concerned). On the evening of March 21 the colony moved away, leaving a large heap estimated to contain more than 2,000 male pupa cases on the tree floor. Two broods: one immense brood of callow workers, one relatively small brood of males. Presumably a further brood of eggs was laid early in the 22-day statary period.

Colony B-III (*E. burchelli*) was discovered at 8:30 a. m. on March 1, about 300 meters to the north of the Van Tyne trail near station 8. At the time the last ants were leaving in column from what was evidently the previous bivouac site of the colony beneath the overhung side of a somewhat raised log, for under the log in one spot was found a sizeable heap of empty male pupa cases. (These were later counted at the laboratory, and

⁴ See special map of Barro Colorado Island prepared by 11th Engineers, Office of Department Engineer, Panama Canal Department U. S. Army.

totalled 2,740). The column itself was thronged with alate males, and other alates were huddled in small groups at occasional caches along the route where workers were seen with small numbers of male cocoons, some in the process of being opened. The alate males were strung out at intervals in the column, each running with an entourage of workers. The new bivouac was about 100 meters distant from the log under which the previous site evidently had been, and was a large exposed cylinder depending from low vines to the ground. The alate males remained within this cluster once they entered. The bivouac was found to contain several hundreds of alates, more than 100 unopened or partially opened male cocoons, and an immense brood of very young worker larvae gathered into a few masses in the very center of the bivouac. The described column evidently took the route of a protracted bivouac-change movement which had lasted through the preceding night. This route was not used after the movement was completed at 9:25 a. m. During the day a vigorous raid developed southward, and that night the colony moved to a new site over the principal trail of this raiding system. Further raids and bivouac-change movements were observed on March 2 and 3. The last male cocoons were opened on March 3. Two broods: a newly emerged brood of callow alate males estimated to number about 3,500; and an immense worker brood in the early larval stage at the time of study. With the appearance of the callow males the colony clearly had terminated a statary period at the time it was discovered.

Colony B-V (*E. burchelli*) was found at 11:40 a. m. on March 29 on Ocelot Hill about 350 meters to the southeast of station 8 on the Shannon trail. The colony formed an elongated cluster wrapped around the trunk of a small tree, its bottom clearing the ground by about one meter. The ants were staging a large raid. Distributed through the bivouac walls and interior was a brood of alate males estimated to contain not more than 1,000 individuals, and an immense brood of nearly mature worker larvae. That evening the colony moved about 150 meters to occupy a site in the upper interior of a small hollow tree. On the following day the ants staged a large raid, but their bivouac-change movement that night had to go unobserved and the colony "escaped." Since some spinning had been observed in the essentially mature larval worker brood, it is probable that the colony became statary on March 30 or 31. Two broods: a brood of alate males, evidently reduced to a few hundred by previous departures, and an immense brood of nearly mature larval workers. The colony was nomadic, but evidently about to enter a statary phase.

Colony H-L (*E. hamatum*) was found at 9:40 a. m. on April 9, bivouacked about 50 meters to the south of the cut-off trail between Wheeler 14 and Armour 3. A large 3-system raid was in progress. The bivouac,

a cylindrical cluster formed against a buttressed tree root, contained many hundreds of recently emerged alate males (but no male cocoons), and an immense brood of very young worker larvae massed in a few boluses in the very center of the cluster of ants. (The queen was found in the contracted condition; also, two dealated males were discovered in the cluster.) The colony did not move that night (possibly because of my having thoroughly disrupted the bivouac); however, after a large 3-system raid on April 10, a bivouac-change movement over more than 250 meters occurred in the evening. The colony evidently was in the early stages of a nomadic period. Two broods: a newly emerged brood of callow alate males estimated at 2,000 individuals, and an immense brood of very young worker larvae.

Colony H-M (*E. hamatum*) was discovered at 10:00 a. m. on April 10 about 75 meters to the north of Armour 2. A large 3-system raid was in progress, distinctly separated from the raiding system of colony H-L. In the bivouac, an irregular mass under low vines, there were found hundreds of alate males and a brood of many thousands of very young worker larvae. Despite the separation of raiding trails, this colony and H-L may have been divided from the same colony within the days just preceding, a possibility supported by the similar status of their two broods and by their presence in the same area. Two broods: hundreds of alate males, and a large brood of very young worker larvae.

Colony B-IV (*E. burchelli*) was found on March 6 at 10:15 a. m., bivouacked 150 meters southeast of Barbour 3, and raiding vigorously to the northward. The large irregular bivouac cluster, massed beneath some vines, contained hundreds of alate males and a huge brood of half-matured worker larvae. On each of the following days until March 11 this colony carried out large daily raids and successive nightly movements. On the night of March 8 one dealated male was seen in the bivouac-change column, moving along under his own power closely followed by groups of workers. In each of the nightly movements the column was crowded with alate males, and numerous males were observed in take-off flights from the vicinity of the bivouac. On the night of March 11 a dealated male was seen in the column within a few meters of the old bivouac, running toward the cluster with numerous workers clinging to his gaster. On the night of March 12, when the colony moved into a hollow tree near Wheeler 2, which was to be its statary bivouac for the next 21 days, it was estimated that perhaps 300 alate males remained. (At that time the mature larval worker brood was spinning cocoons.) On March 22, when the colony was etherized and the bivouac ransacked (to check the time of egg-laying in the queen) no winged males were seen. On April 1 the first signs of cocoon-opening were noted, and on the evening of April 3, with the greatest part of

the new worker brood removed from cocoons, the colony moved off. No males were seen in this movement; very probably none remained. Three broods: a callow alate male brood; then a huge worker brood; and a further brood of worker larvae.

Colony B-VI (*E. burchelli*) was found on March 31 at 4:30 p. m., bivouacked under some heaped-up branches in the lower part of Lutz Creek. An extensive raid was in progress at the time. When the bivouac cluster was opened a considerable number of alate males (estimated at more than 500 individuals) was found, together with an immense brood of nearly mature worker larvae. In the latter brood numerous indications of spinning activity were observed. When the bivouac-change movement was well under way at 10:00 p. m., alate males were numerous in the procession. Considerably before the termination of the movement a queen (contracted) was observed in the column. In this movement the colony passed to a clustering site high in a large fig tree between Snyder-Molino 2 and Pearson 2, where it entered a stately phase. Thus there was no opportunity to check the departures of the remaining males. On the night of April 20 when the colony again became nomadic, an immense brood of newly emerged callow workers was seen, but no males were observed in the bivouac-change column. Two broods: the remnant of an alate male brood; and an immense brood of workers.

General summary of male production. This evidence from shorter studies of *burchelli* and *hamatum* colonies corroborates the results of the extensive survey of colony B-I in every important respect. The males appear in distinct lots of that sex alone, and at given points in the regular Eciton brood-production cycle, when worker broods might otherwise appear. Thus the male larvae of a given brood exhibit a limited size range at any given time and pass through the respective phases of their development closely in step with one another so that all eventually emerge from their cocoons as callow individuals within a short period of a few days. In other words, a given male brood appears to have essentially the same time relations with the worker brood which preceded it and the one which follows it as would a worker brood under ordinary conditions (cf. Schneirla, 1938, 1944). We have reported three cases (colonies B-I, B-II and H-J) in which male broods were preceded by worker broods, and it may also be noted that in colonies B-I and B-II the male brood was followed by a brood of workers as was the case in colonies B-III, B-IV, B-V, B-VI, H-L and H-M. The conclusion seems inescapable that the eggs of a given male brood must be laid by a single functional queen in each colony, and that this queen delivers a male brood after having produced one or more worker broods. These facts raise some interesting questions for the student of insect genetics.

There is a striking difference between male broods and worker broods, in that while

our single batches of developing worker forms are all very large with a population of probably more than 20,000 individuals in each, the male broods are all relatively small and number close to 3,000 individuals each. However, rough calculations (based on the relative bulks of preserved material) suggest that we should not be surprised to find the total "tissue bulk" of a male brood at maturity closely approaching or even exceeding that of a worker brood at maturity. The reader should be reminded here that none of the investigated male broods were sampled in the egg or earliest larval condition⁵, so that the number of potential males could be compared with the number of potential workers in respective newly delivered broods.

The chief reason for this hiatus in our evidence is readily understood when the complex but regular relationships between brood-production phases and the stately-nomadic changes in colony behavior (Schneirla, 1944) are recalled. The eggs of a new brood are produced when the colony is roughly one-third through a stately phase, at a time when the bivouacs are located in relatively inaccessible places such as hollow trees or logs, all too easily passed by since the raids then generally are small and in the dry season frequently are absent (Schneirla, 1947). Even when a stately bivouac is located, one must go to the heart of the bivouac to sample the eggs or young brood concentrated there, a procedure which for instance was out of the question when the male brood of our record colony B-I was in the earliest developmental phase. To obtain such material a concentrated collecting procedure will be essential, directed at the sampling of brood populations rather than at the gathering of normative behavior data.

Behavior and Behavioral Relationships of Males.

Activities of the male brood considered as a colony energizing factor. When the male larvae are still very small they are packed into boluses in the very center of the bivouac cluster, much as are worker larvae at comparable early stages. This is certainly true of the stately bivouac in which they begin their life, and also of the earliest part of the ensuing nomadic period, except for the time each night when the brood is scattered about in small packets through the new bivouac after having been transported over the bivouac-change trail.

There is no reason to believe that when very young the male larval brood is an important factor in raising the general colony excitation threshold to the level of large raids which can pass over at nightfall into the bivouac-change process. Thus when colony B-I took to the march on February 28, it was presumably a sharp rise in tactuo-chemical stimulation from the immense brood of cal-

⁵ However, an eventual cytological examination of other preserved brood samples in very early stages may bring further male broods to light.

low workers circulating through the community which set off the new behavior developments, rather than stimulation from the small male larvae then packed into a few centrally-located masses. Hypothetically, we may believe that the stimulative role of the male larvae increases rapidly in keeping with their rapid growth rate in the nomadic period (cf. Text-figure 1), so that they take over the principal excitatory function after that of the callow brood has lapsed somewhat.

In this connection it appears significant that the fourth and fifth raids of colony B-1 (March 3 and 4) were noticeably smaller than the three first raids of the nomadic period which began on February 28, and that the distance of the nightly bivouac-change movements was considerably reduced as compared with the preceding ones. The movement of March 2 carried over only 30 meters, that of March 3 over 19 meters, and on the night of March 4 the colony shifted its bivouac only 8 meters, as compared with movements of 110 and 75 meters on the first two nights respectively. It is probable that the noticeable decline in the vigor of raids and in the extent of nomadic movements at this time was based upon a reduction of effective stimulation from the broods. We have suggested previously (Schneirla, 1944) that the stimulative effect exerted by new callows drops off sharply within the few days after their emergence. At that time a very young larval male brood (relatively small as it is in numbers) may be still rather weak in energizing the colony, although both of these brood factors may act together in keeping the colony above the stately level of activity.

For the remainder of the nomadic period during which the B-1 male larvae were growing rapidly, the daily raids were large and all of the nightly bivouac-change movements were relatively lengthy affairs carrying over more than 100 meters of ground. Then, as we have seen, the colony became stately on the day when most of the mature larvae had become enclosed. It remained stately with small daily raids or no raids on given days, until identifiable reflex activities of the enclosed but nearly mature male pupae occurred. Then the daily raids became increasingly extensive and vigorous, and the colony became nomadic at the time when the major part of the male brood had emerged as callows.

This is the same type of coincidence of brood condition and colony behavior which we have identified when worker broods are present in *Eciton* colonies. It indicates that male broods have much the same trophallactic (i. e., social-stimulative) relationship and colony-energizing function as have worker broods. A consideration of the general behavior evidence concerning males further supports this view.

Responses of workers to the male larvae. When they are very young, the male larvae are gathered together into a few packets generally kept near the center of the bivouac.

These boluses of larvae thereby are somewhat isolated from the workers of the general colony, although they are the scene of much activity on the part of the diminutive workers minor. The minima not only crowd upon the external surface of the massed larvae, but also push into the interior through narrow galleries among the larvae. Presumably, as with young worker broods, the workers minor are more or less consistently occupied with licking the tiny larvae of the young brood and palpating them with antennae. Presumably also, at some time before the colony leaves its stately bivouac (e. g., before February 28 in colony B-1), larval feeding also begins. Although direct evidence upon these early events is very scanty at the present time as far as male broods are concerned, the state of affairs probably is similar to that previously observed with young larval worker broods.

We have some direct observational evidence for the colony relations of male larval broods after the colony takes to the march, when there is a much more rapid increase in body size than with worker larvae and a proportionately rapid increase in the scope and vigor of larval activities. The almost incessant twisting and squirming movements of the larvae, which are increased noticeably as workers touch them antennally or run across them, act in turn to increase the activities of the workers. The result is that, as these stimulative relationships increase to the point of involving workers through the intermediate types, the workers frequently pick up the larvae and hold them individually, or carry them about. As the brood advances in development, it is thereby more widely distributed through the bivouac cluster. This change obviously increases the stimulative scope of the brood, and as with worker broods, that development is related causally to wide increases in the extra-bivouac activities of the colony (cf. Schneirla, 1938).

Thus it seems that a male larval brood enters into trophallactic relations with the adult membership of the colony which serve to increase colony "drive" much as does the stimulative effect of a worker brood. The fact that the population of a male brood in species of *Eciton* (*Eciton*) contains only about one-tenth as many individuals as do worker broods is not contradictory on this score. To resolve the difficulty it is only necessary to consider that, at comparable growth stages, the body size of any male larva in the nearly homogeneous brood is many times that of the median size larvae in a worker brood. Accordingly, we should expect that the stimulative effect of each male larva (both in tactual effects through movements and chemostimulative effects through cuticular secretions) would be much greater than that exerted by worker larvae with their much smaller size, strength, and body area. From our observations, such is undoubtedly the case. For instance, while in the bivouac even the largest worker larva generally is

held by no more than one or two workers, it is not uncommon to see a bulky male larva held in place by a dozen or more workers. Based upon such differences, interesting variations appear in certain extra-bivouac activities when a male brood in a fairly advanced larval stage is present.

Behavior involved in the nomadic transfer of a larval male brood. The transportation of a young larval worker brood by a nomadic colony occasions no particular difficulties, since the tiny larvae are carried in small packets by individual workers, and in the night-time hours following the movements are gathered together into the center of the new bivouac. When the worker larvae are larger and even when they are nearing maturity and are close to maximal size, they are carried readily by individual workers, each larva slung beneath the body of a carrier, the anterior segments of the larva gripped in the mandibles of the carrier. Little difficulty is involved except in starting out from the old bivouac, when a single larva often is gripped by numerous workers pulling against one another. This often happens when a worker has grasped a larva much too large for it to carry in straight-forward progress, and a circuitous tugging results which attracts other workers to the scene. Usually as a result of these tussles one of the larger intermediate workers large enough to deal with the burden finally keeps possession of the larva, and notwithstanding her load moves unobstructedly ahead as a member of the column. Even in the absence of quantitative data it is safe to say that in the Eciton bivouac-change column there exists a direct relationship between bulk of burden and size of the worker carrying it.⁶

Difficulties due to excessively bulky burdens do not occur in the first few nomadic movements of a colony with an early brood of male larvae. In fact, despite a vigilant observation of the first three bivouac-changes of colony B-1 when its male larval brood was small, the brood escaped my notice and was first sampled from the bivouac on the fourth day. The observation of an increasingly striking set of events in the eighth and ninth movements of the period on the nights of March 7 and 8 first brought out some notable differences between the transportation of larval worker and of larval male broods.

In the early stages of the bivouac-change movement lugging of the bulky male larvae from the bivouac begins when each larva becomes the center of much worker activity. A very circuitous, hit and miss process then is involved in getting a larva into carriage on the trail. At first the unwieldy object is pulled around haphazardly in different directions near the bivouac by numerous workers tugging at it, so that it is yanked and

dragged on and off the trail repeatedly. There is much bumping and colliding of bodies moving variously at "cross purposes," in a hectic time-consuming process. In the course of this largely random activity, more and more workers come to mill about with increasing numbers of larvae at the trail-base close to the bivouac. Added to the difficulty of somehow attaining a coordination of worker activities in carrying individual larvae, many special interferences are presented by an irregular terrain complicated by leaves, brush and tangled vines. But gradually, in the course of two or more hours as the bivouac-change movement gets under way, a development arises from the tussle and struggle which in the end helps to resolve the whole difficulty very nicely.

In the yanking and pulling about of larvae by groups of workers, by degrees more and more of the workers drop out of the activity and huddle or stretch out motionless on the spot where a summation of swarming-under or rough treatment occurs. By small steps and very slowly a layer of clustered ants thereby forms over the trail itself and at the sides of the trail near the bivouac. Over this "ant roadway" other workers run and pull larvae about, incidentally smoothing the substratum further by forcing protruding parts of the cluster to shift position. Of course the roadway is not of uniform thickness, since the ants cluster most readily at the edges of leaf obstacles and at terrain depressions and similar points of obstruction where the greatest amount of pellmell struggle and bumping about of bodies is certain to occur.

The early stages of this complicated process must be observed in detail and in sequence, if one is to appreciate just what causes workers to form the "roadway." Watching individual workers in the push, we note that the elements of the roadway are recruited from among those individuals that are repeatedly buffeted and overrun within limited intervals of time. Once they are out of general activity, such workers lie motionless except for a vibration of antennae, stretched in place by catching with their tarsal hooks into objects such as leaf edges or the projecting body parts (generally legs) of other workers. Workers may thus lie in place immobilized for hours as the procession rushes over them. Evidently a repetition of tactual stimulation is essential to keep the workers immobilized in the pavement of bodies. For as the column gets under way and side eddies of traffic cease to pass over ants clustered at places away from the main line or in remote depressions where larvae happened to roll in the early struggle, workers in such isolated clusters presently begin to stir, disengage themselves, and run off.

The roadway of clustered workers is widest close to the bivouac and progressively narrower in trail sections farther out. An even more striking reminder that the roadway arises indirectly out of difficulties in

⁶ Lutz (1929) reported essentially the same conclusion for the carrying of leaf-segments by workers of *Atta cephalotes*. The average load under the conditions of Lutz's survey was roughly five milligrams more than twice the weight of the carrier.

transporting bulky objects over rough ground, is the fact that it is started at the old bivouac site and laid down progressively over the trail toward the new site. In the outermost stretches of trail (e. g., more than 75-100 meters from the old bivouac) the band is thin and narrow or even absent, except where irregularities and obstructions in the route such as upturned leaves have produced serious interferences with the transportation of larvae. When a male larval brood nears maturity and occasions the greatest difficulties in transportation, the roadway is most likely to be clearly formed as a meandering ribbon of clustered workers extending perhaps the entire distance from old to new bivouac sites. The adaptive significance of the roadway, as a relatively even surface over which the huge male larvae can be moved to the new clustering site, does not require much emphasis here.

The indirect manner in which the ant roadway comes about is further revealed by observations upon changes in the carrying of larvae. In some respects the changes are similar to those involved in the transportation of worker larvae as first described above. The building of the roadway is the result of hours of laborious changes during which a directionalized column arises. To indicate how the shift from inefficiency to efficiency occurs in larva-carrying, for the sake of clarity it is best to choose a time after the drift from the old bivouac is fairly well under way. Then each male larva is dragged from the bivouac by several workers of nearly all sizes except majors, clutching and tugging at it on all sides. In the course of much thrashing about with the burden most of these are shuffled off and rolled underfoot, to furnish a source of recruits for the roadway. Finally, as a rule only two of the larger intermediate workers retain their holds and carry the larva in the direction of general movement. Characteristically they run in tandem with the larva slung beneath their bodies, straddling it with their legs, one clutching the burden in her mandibles at the anterior segments while the other catches hold behind the midsection. Relatively immature male larvae may be transported in other ways as well, and in carrying these the smaller workers may participate all of the way; however, with bulky, advanced larvae there is least variation in the size of burden-bearers since smaller workers are largely eliminated during the initial tussle. Although both early and late in the movement difficulties such as those described occur at the start of the journey, once the eventual carriers are under way with their burden on a fairly well-formed "roadway," they make surprisingly good headway and there is a minimum of stoppage. The occurrence of the roadway, typical of bivouac-change movements when advanced male larvae (but generally not worker larvae) are transported, is an expression of the high stimulative effect which the maturing and bulky males, individually and collectively,

exert upon the worker membership of the colony.

Behavior associated with enclosure and pupation of the male brood. Colonies of *E. burchelli* and *E. hamatum* cease nomadic movements when their male larval broods mature and become enclosed, and remain stately until the colony's male brood has completed its pupation. In these respects the results for case B-1 coincide with data from numerous other colonies of both species.

The spinning of cocoons by male larvae resembles in general outline the process as described by Beebe (1919) and by Schneirla (1934) for Eciton worker broods. The difference is that all phases of the process occur in a much more striking way when male larvae are involved. Some of the highlights from the B-1 record will stand as representative.

The last nomadic nest of colony B-1, when its male brood was at maturity, was established in a shallow mammal burrow. Larval spinning must have occurred during this day (3/9/46) since many of the larvae picked out from the bivouac-change column of the same night were provided with thin envelopes. Later that night scattered instances of spinning were observed on the interior floor of the large hollow tree into which the colony passed. However, the bivouac cluster was formed within the cavity of the tree just above the wide opening at its base, and most of the spinning evidently occurred in the upper spaces. Much of the time during the first three stately days (March 10-12) the cavity walls and the ground both within and immediately around the tree were covered with throngs of milling ants. Both day and night, occasional concentrations of workers were observed around larvae which had been lugged to the floor of the cavity where spinning took place on a carpet of wood dust. Evidently the enclosure of only a minor part of the male brood was begun in this way, judging by the number of similar groups observed by flash-light in activity around the bivouac, and by a constant downward drifting of fine wood detritus through the air. This fall continued for about five days, until there had accumulated on the broad floor of the cavity a wide conical heap of finely divided woody material more than 15 cm. deep in one or two places.

Some notes on events in colony B-1 typify the details of behavior. "On the floor of the tree hollow (6:15 p. m., March 12) here and there are groups of a dozen or more workers gathered around one of the large larvae, touching it at intervals with antennae and mouth parts as its anterior end twists about in spinning, and tugging at it intermittently. Each larva is the center of much commotion, particularly when the joint tugging of numerous workers shifts or rolls it about on the gently sloping sides of the wood-dust mound. Other similar groups can be seen stationed at intervals on the nearly vertical back interior wall of the tree, with a variable number of workers holding fast to each larva

engaged in spinning. This number often grows into a sizable mass of squirming bodies around a larva which (through its own movements or because of a flurry among the ants) happens to slip momentarily from the mandibles of workers which have been holding it in place."

None of the larvae thus engaged in spinning outside the bivouac were enclosed by more than thin transparent envelopes, whereas after March 11 the bivouac contained a rapidly growing number of larvae with heavier and translucent brownish cases. The inference is that the early stages of enclosure take place outside the bivouac, whereas once the envelope is started it may be completed while the larva is held within the mass of ants in the bivouac cluster itself. The ants seem to drag out only naked larvae or larvae in the early stages of spinning.

When spinning is completed, colony activity decreases markedly. For example, on March 14 practically all of the B-I brood was enclosed in brown cases, and no spinning was observed outside the bivouac. At 8:30 a. m. a few hundred ants were running about over the floor of the cavity, and there were two or three columns which extended only a meter or two outside the tree. No raiding system was formed on this day; only a limited raiding system formed on March 15, and there was none on March 16. Judged in terms of amount of activity outside the bivouac, particularly the frequency and the size of raids, the general activity of the colony fell to a low point after the larval brood was enclosed. It is significant that although daily raids occurred during the first four days of the starchy period, in which brood-enclosure evidently was completed, no raids developed and colony activity was minimal on the three following days. Activity in B-I remained at a relatively low ebb, with no raids occurring on half of the days, through the central part of the starchy period until March 26. This was the quiescent period of pupation in the male brood.

Thereafter raids occurred daily, increasing in vigor, until on March 30 a recognizable nomadic condition arose. The increase in colony activity appeared coincidentally with certain new brood developments. On March 27 there were reflex movements of antennae and tarsi, as well as general trunk contractions in some of the pupae, readily perceptible to the naked eye. A few empty male pupa cases were found below the bivouac on that day. The number was considerably greater on March 29, when cocoon-opening by workers was found. This process is similar to that previously described for the delivery of a worker brood (Schneirla, 1934, 1938). The difference is that each male cocoon is the center of a far greater commotion as it is held by struggling workers stationed in the bivouac structure.

As is the case with worker broods, the colony begins its nomadic movements when the major part of the mature pupal brood has emerged. Also, as with worker broods,

a critical species difference appears in that in the first movement of *burchelli* colonies a considerable part of the brood (nearing one-third in given instances) may be carried along in column in unopened cases, whereas in *hamatum* colonies the unemerged increment is much smaller or even absent. Hence in the first *burchelli* movements one may observe numbers of bulky male cocoons carried along in a bivouac-change column which is thronged by newly emerged callow males.

Behavior of callow males and colony responses to them. We have set forth the principal facts with respect to the behavior relations of callow males to the colony, in records condensed in an earlier section of this paper. Within the period of about three weeks required for the complete discharge of a male brood from its parent colony, only after dusk do the callow males appear outside the bivouac. In the daytime the males hang in the cluster, among the workers, but in the hours after nightfall they may be seen in small numbers as a rule running about close to the bivouac. Each of them is attended by a small group of workers which follow him closely as he runs about circuitously and erratically, a few of them clinging to his wings and gaster, others riding upon him. From time to time a relatively free male may take short hopping runs, flit his wings nervously and even leave the ground in short flights, frequently after having mounted a stalk or vine. At intervals, as the night advances, the males take off in flight from low vegetation. Although one gets the impression that the worker "hangers-on" impede the flight escape of males, it is possible that males sometimes fly off carrying workers with them. A few such escapes were observed in the present study.

As a rule, not many of the callow males leave the bivouac until the workers have begun their regular exodus in the bivouac-change movement. Then the alates take their exit from the cluster among the workers, each of them followed rather closely in the procession by a group of workers. Clumsy behavior in beginning the movement is typical of males, with frequent stops and returns occurring before they get under way in the column from the bivouac. During traffic interruptions which are occasioned by such behavior, males with their worker retinues may separate from the column and enter the zone around the bivouac where males are skipping and flitting about more or less independently.

Once they are under way in the regular bivouac-change columns, the alate males move along under their own power, at a regular pace and with closed wings. One gets the impression, from watching the movements of a given colony evening after evening, that the trail-running of males undergoes an improvement in the course of time in that after a few nights progress seems to be more regular than at first and there are fewer returns and interruptions. The

males often run in single file with workers; often males run together in file. The clinging and crowding workers generally retard the pace of the alates somewhat, and the path is blocked variously (by the slowness of other males in particular), so that colonies with alate male broods sometimes require the entire night and perhaps the early daylight hours as well to complete their movements.

When the new bivouac cluster is reached, most of the alates stream directly into it with the workers. It is the first males to reach the new site, before the cluster has been well started, that may get away from the main group of workers and run about in the vicinity. Some take-off flights may result.

Events after departure from colony of origin. Our findings show that after a brood of perhaps 3,000 winged males has emerged, these alates leave the parent colony by flying. However, in the colonies for which emergence of callow alates was observed, no escapes were recorded on the first three or four nights after the cases were removed. Then, a given number of males takes off nightly by flying away in the course of excitatory activity in the vicinity of the bivouac, until in the course of about three weeks after emergence most or all of the winged males have left the bivouac of origin.

Direct observations show that *Eciton* males are capable of strong maintained flight once they are under way, so that with the assistance of air currents some of them must get several hundred meters if not greater distances from the parent colony. From early February of 1946 at Barro Colorado the winged males of various *Eciton* (*Labidus*) and *E. (Neivamyrmex)* species were taken nearly every night at the laboratory lights and often on the white reflecting board at the laboratory clearing, as well as in the small light trap set at various places within the forest. The alates of these groups also were taken occasionally by hand when attracted at night to the reflector of the 5-cell headlamp which I used in the forest. However, our study concerns male-production in the species of *Eciton* (*Eciton*) particularly, and for some reason the alates of species in this subgenus were almost never taken at lights in these ways. The exceptions occurred when I worked with a light within the area around a colony from which alates were known to be issuing at the time.

Special field and laboratory tests show that the males are able to follow the chemical trails of their own colony or another colony of their species. Alate males ordinarily do not leave the bivouac of their colony in the daytime. On the other hand dealate males

TABLE II.

Dealate males of *Eciton* (*Eciton*) species found on Barro Colorado I. during the period February—June of 1946.

Date of capture	Colony and species	Time of day	Locality and general circumstances	Alates present in the colony	No. taken
March 3	B-I <i>E. burchelli</i>	8:00 p.m.	Running in bivouac-change column with workers, en route toward new bivouac	None; only males in early larval stage	7
March 4	B-I <i>E. burchelli</i>	9:00 p.m.	Running with workers in bivouac-change column	None; only males in early larval stage	3
March 8	B-IV <i>E. burchelli</i>	7:40 p.m.	Approaching old bivouac in column of workers	Remnants of alate brood present	1
March 11	B-IV <i>E. burchelli</i>	9:00 p.m.	Approaching new bivouac in column of workers during bivouac-change	Remnants of alate brood present	1
March 27	H-B <i>E. hamatum</i>	10:45 a.m.	Moving with workers in column a few cm. from the bivouac	No male brood produced by H-B	1
April 6	B-I <i>E. burchelli</i>	8:40 p.m.	Running toward the old bivouac in column of workers	Own alates present in bivouac	1
April 9	H-L <i>E. hamatum</i>	10:00 a.m.	Captured from central part of colony bivouac cluster	Newly emerged alates present	1
April 12	H-H <i>E. hamatum</i>	10:15 a.m.	Captured from central part of colony bivouac cluster	No male brood produced by H-H	2
May 5	B-I <i>E. burchelli</i>	10:30 p.m.	Taken from bivouac-change column en route toward new bivouac	Few if any alates remain from own male brood	1
May 13	H-B <i>E. hamatum</i>	7:45 p.m.	Standing among workers on log close to bivouac, among larvae (cocoon-spinning)	No male brood produced by H-B	1

have been taken on occasion in the present study and by others (Wheeler, 1912; Reichensperger, 1926), running about on the raiding trails of their species in the daytime. Appropriate tests show that after their flight males are accepted into groups of workers of their own or other colonies of their species. It is probable that the chief means of getting into some colony after the flight is through the following of a chemical trail which is crossed accidentally as the scattered males run about over the forest floor.

Although we have little direct evidence on what happens to alate males once they leave the parent colony on their flights, from certain facts the general nature of events may be suggested. In the first place, laboratory tests indicate that a considerable amount of flying leads to loss of the wings within a few hours, hence our attention turns to occurrences involving dealate males.

Table II shows that dealate males were discovered in association with Eciton colonies on ten different occasions in this study. In five of these instances (B-I, March 3; B-I, March 4; H-B, March 27; H-H, April 12; and H-B, May 13), the dealates clearly must have originated in another colony of the species. For example, a limited number of dealates was found in the bivouac-change columns of colony B-I on two successive evenings at a time considerably before the male brood of this colony had even completed the larval stage, but at a time when a *burcheilli* colony with alate males was known to be located in bivouac relatively close by. On the night of March 3 seven dealate *burcheilli* males were captured while running at intervals of a few meters apart in the B-I column. Obviously these males must have come from some other *burcheilli* colony, since at the time the male brood of colony B-I was in its early larval stage. The most likely source was another *burcheilli* colony with a large brood of escaping alate males which at the time was bivouacked only about 350 meters from the location of colony B-I. On the following night, when the colonies were still no more than 450 meters apart, three additional dealate males were found in the B-I column. Subsequently these colonies moved divergently, and no further dealates were observed in colony B-I until May 5. The capture of dealate males from two different *hamatum* colonies (H-B, on March 27 and May 13; H-H, on April 12) took place when no alates were present and only worker broods had been produced. In four of the cases (B-IV, March 8; B-IV, March 11; B-I, April 6; and H-L, April 9) the dealate individuals were found at times when alate males produced by the same colony were also present, and may have been returned males of the same brood. The case of colony B-I on May 5 is more doubtful. Although a few survivors of the alate male brood may have been present at the time, none had been seen during the preceding week. Our cases divide nearly equally into those in which the dealate males must have come from another colony of the spe-

cies, and those in which they may have originated in the colony in which they were taken. Although, in some instances males evidently return to their own colonies after the flight, the surprising thing is that so few dealates were found in colonies known to contain alates. Evidently post-flight returns into the colony of origin are exceptional.⁷

As Table II shows, dealate males were taken in this study both in bivouac-change columns at night and in raiding columns in the daytime (and under the latter condition also by Wheeler, 1912, and by Reichensperger, 1926). There is no evidence that dealate males leave the bivouac of the host colony in the daytime to run the raiding trails, and it seems more probable that instances of dealates on raiding trails involve newly dealated individuals that have encountered the chemical routes of a colony after alighting but have not yet entered its bivouac. Some of our night-time captures of dealates on bivouac-change trails may similarly involve newly alighted individuals; however, it is also very likely that in others of these instances the males were running in the movement after having spent one or more days in the host colony. The case of the males found in the B-I column on the nights of March 3 and 4, as the circumstances described above suggest, seems the clearest instance of probable night entrance into a column. Other facts suggest that such entrances may occur either by night or by day, when stray males chance upon and follow trails.

As mentioned above, our laboratory and field tests show that males of *E. burcheilli* and *E. hamatum* are capable of following the chemical trails of their own colony or another colony of their species. For instance, on numerous occasions dealate males were placed close to a circular column formed in the laboratory by workers of a strange colony of their species. In virtually all cases the male finally entered the column more or less readily after chancing upon the trail, and soon was running on the endless route among the workers, although typically with a clumsiness that contrasted notably with the typical stereotyped precision of the ordinary workers. For their part the workers generally accept any stray dealates one may present from other colonies, on occasion nipping at the newcomer for a time, but generally indicating in their behavior that he exercises a considerable chemo-receptive attractive effect upon them. When the new male is set down experimentally at a raiding trail in the field, as a rule he is taken into column by the workers. Typically they are soon clustered around him and, when he eventually moves off on the trail, he has an entourage of closely following workers some of whom cling to his body or even ride upon him. The attractive effect of Eciton males upon work-

⁷ The latter type of case very probably appears with misrepresentative frequency in our records, since colonies with male broods were examined more frequently in detail than were others.

ers resembles that of the queen (Schneirla, 1944), with the difference that the latter appears to be definitely more powerful.

SUMMARY AND DISCUSSION.

It is clear that in the area of this study and for the *Eciton* species investigated, the production of males is limited to the dry season. In studies on Barro Colorado Island confined to the rainy season (Schneirla, 1933, 1938, 1944) only worker forms have been found in *Eciton* broods, but in the dry season of 1946 male broods at all stages were discovered in colonies of the same species (*E. hamatum* and *E. burchelli*). Moreover, there appears to be a species difference in susceptibility to whatever conditions account for male-production. In our records for the 1946 dry season male broods appeared roughly one month earlier in colonies of *E. burchelli* than in colonies of *E. hamatum*.⁸ This difference may be added provisionally to other differences previously described in the raiding, bivouacking and general behavior of these two species of subgenus *Eciton* (*Eciton*).

The discovery of immature male *Eciton* broods has been reported in three instances from other localities. The first of these is not strictly comparable to our results, since it concerned a species of the hypogaecic subgenus *Neivamyrmex* (= *Acamatus*). The engineer Hubrich sent to Carlos Bruch (1924) specimens of advanced male pupae of *E. (Neiv.) hetschkoi* taken at the end of July (in "winter") 1924 in the Sierra Alta Gracia of northern Argentina. Numerous enclosed male pupae approximately 13 mm. in length were found in the bivouac cluster, which was beneath a large tree trunk. This finding, together with various discoveries of mature male broods to be noted below, suggests that in *Neivamyrmex* species also the males appear in distinctive broods of their own sex alone.

The first discovery of a developing male brood in any species of *Eciton* (*Eciton*) was reported by Wheeler (1921). The find was made at the Kartabo station in British Guiana on July 17, 1920, at the end of a short semiannual wet period. A colony of *E. burchelli* which Drs. Wheeler and Emerson drove with smoke from its bivouac in a hollow tree was found to have a brood of a few hundred mature male pupae in cocoons. A brood of male pupae somewhat less advanced than in the above instance was found by Schneirla (1947) during early April of 1945 in a colony of *E. hamatum* in the area of the upper Coatzacoalcas R. in southern Mexico. The conditions in this case were similar to those of our 1946 Panama records given in the present paper, in that a brood of more than 1,000 pupae was found during the latter half of a well-marked annual dry season,

in a colony which was definitely "statory" at the time. A further resemblance is found in the fact that in the Kartabo and S. Mexico cases a large brood of very young (evidently worker) larvae was present in addition to the male pupal brood, a relationship of broods which holds uniformly in our 1946 Panama records.

The present study involved the investigation of particular colonies of *E. hamatum* and *E. burchelli* over considerable intervals of time while male broods were undergoing their development. The results from the respective instances, which represent all stages of male development, indicate that a given male brood appears at a predictable time in the colony brood-production process, that is, occurs in a definite temporal relation to preceding and following (worker) broods. Thus the present results for male broods fit the timing of the *Eciton* reproductive process as previously described for the rainy season (Schneirla, 1944). Our results indicate the prevalence of a pattern of events which is adequately represented by the case of *E. burchelli* colony B-I. Numerous other evidence given above supports this fully investigated case in showing that the eggs of a male brood must be laid (in both our test species) in the first part of a statory period when an enclosed brood of worker forms entering pupation is present, and that when this male brood enters its pre-pupal phase during the next statory period of the colony, a huge new brood of (worker) eggs is then laid by the queen.

The expression "*the queen*" is used advisedly here, since from our results it is evident that the eggs of an all-male brood must be laid by the single functional dichthadiigyne responsible for the delivery of the large worker broods which precede and follow the males in a given colony. Our results invariably indicate a high degree of regularity in the time relationships of male and worker broods found in particular colonies, without any evidence that more than one *functional queen* is present in a given case.⁹

There is one report in the literature which suggests that conditions in other *Eciton* subgenera may be similar to those evidently prevalent in species of *Eciton* (*Eciton*). That is the discovery of a large colony of *E. (Lab.) praedator* by Luederwaldt (1918) on October 23, 1916, bivouacked in an old termite nest in a garden at São Paulo, Brazil. This colony possessed a brood of enclosed worker pupae, as well as numerous empty cocoons about 20 mm. in length from which males were thought to have emerged. Furthermore, the queen was physogastric at the time and masses of newly laid eggs were found—a set of circumstances suggesting a regular succession of broods, with one of them evidently a male brood.

⁸ It is well known that seasonal production of males as well as females is common among the other subfamilies of ants. Characteristic differences in the time of year at which fertile forms are produced have been described by Talbot (1945) for four temperate-zone species representing two ant subfamilies.

⁹ In a subsequent paper the conditions under which a second queen was found in colony B-I will be reported. Various reliable circumstances made it clear that she was not the functional queen of this colony but a new super-numerary dichthadiigyne.

Our findings on the male broods in species of *Eciton* (*Eciton*) indicate that such broods contain only male individuals. They also suggest that very possibly no colony has more than one such brood in a given season and that otherwise worker broods are produced.¹⁰ It is also quite probable that some of the colonies produce no males whatever. At any rate we have the record of colony H-B (*E. hamatum*) which produced four large worker broods but no male broods during the 1946 dry season. In this survey more than fifty colonies of *Eciton* (*Eciton*) species were studied for intervals of a few days or for longer intervals, yet indications of male-production were found in but eleven of these cases. Although the possible errors of sampling were much greater when *Ecitons* were searched for in five different localities of southern Mexico in the dry season of 1945 (Schneirla, 1947), it is worth repeating here that only one of more than 20 *Eciton* (*Eciton*) colonies then studied had a male brood at the time. The Panama results suggest that very few if any colonies of this subgenus have more than one male brood per season.

From our evidence the influence of a male brood upon colony behavior is very similar to that which we have described for worker broods (Schneirla, 1944). As with worker broods, the energizing or "drive" function of a male brood is introduced and is removed in an essentially all-or-none fashion, in dependence upon the growth stage reached by the brood. Clearly the basis of this factor is the capacity of the queen to complete laying the eggs of a given male brood within a few days, so that the entire brood passes through the successive stages of development in step. Consequently, at any given time all individuals in the male brood exert similar effects upon the general colony.

We have found that when male broods appear in *Eciton* (*Eciton*) colonies there are no important interruptions or differences in the nomadic-statory cycle of colony behavior, which occurs substantially as when worker broods are present. Colonies with fairly advanced broods of male larvae are found in the nomadic condition, staging large daily raids that terminate each night in a bivouac-change movement of the entire colony. As with worker broods, the colony shifts from nomadic to statory behavior precisely at the time when its male brood has completed larval development and is spinning cocoons. Then later, when the enclosed male brood has completed its pupation, a further nomadic period begins with the emergence of the callow males from their cocoons.

The occurrence of male broods evidently does not disturb the timing of nomadic-statory phases in any important way, since we have found no identifiable differences in the duration of the phases and in the total developmental time of male and of worker broods. We have inferred that the inclusive

developmental period of a male brood requires about 45 days, and have found in the case of three *burchelli* colonies that the males spend close to 21 days of this time enclosed in cocoons, just as do worker broods. From the routine facts alone, as concerns the intensity of daily raids and the occurrence or non-occurrence of night-time movements, it would be difficult to tell which type of brood, male or worker, was present.

As we have suggested above, the basis of the concomitant changes in male brood and colony behavior is found, as with worker broods, in the trophallactic relationships of workers and brood (Wheeler, 1928; Schneirla, 1941). Our field observations and specific laboratory studies show that male larvae stimulate the workers both tactually and chemically, and thereby exert a distinctive energizing effect upon the workers. We have found "nomadic" colonies somewhat sluggish when their male larvae are still small, and have interpreted this condition as an insufficiency of the energizing effect of a male larval brood to maintain colony activity at its peak early in the nomadic period, at the time when the stimulative effect of a callow worker brood (which initiated the period) has waned. The stimulative effect of the male larvae soon increases greatly in keeping with a rapid advance in their size and activities, a change which evidently provides the essential basis for a marked rise in general colony activity. In the daytime the large larvae are spread well throughout the bivouac, each held by a group of workers as the center of a rather extensive zone of stimulation in the cluster. And at night in the colony movement, the bustle and complexity of events in the transportation of the bulky larvae emphasize the great stimulative effect which the brood exerts upon the colony. One outstanding event that is peculiar to the relations of the male brood to worker behavior is the formation of the "ant roadway." We find that although a male brood is roughly only one-tenth as numerous as a typical worker brood, after early development its total stimulative effect appears to equal or even exceed that of a worker brood at corresponding stages.

There is no support in *Eciton* behavior for the assumption of Brauns (1901) and others that doryline colonies must remain in place while breeding the sexual forms because it is impossible to transport the large larvae of these forms. We have ample evidence that *Eciton* colonies are able to carry along the male larvae nightly in bivouac-change movements so long as these larvae are immature and unenclosed, even when the larvae are maximal in size and very unhandy to lug along in column. The eventual stoppage of colony movements when the male larval brood is mature depends upon quite different causes than mere bulkiness of the brood.

The manner in which *Eciton* colonies drop to minimal activity once their male broods are enclosed contrasts strongly with the

¹⁰ The circumstances of queen-production are unknown at the present time.

crescendo which occurs in colony activity as the maturing pupae begin their reflex stirring within cocoons. These activities arouse the workers to a mounting pitch of activity within and outside the bivouac, which eventuates in the shucking of callow males from their cases and the transition of the colony into a new nomadic phase. It is during this period of about two weeks that most of the few thousand males leave the colony. This concurrence of events has a particular adaptive value, as we shall see.

The exodus of winged doryline males from their nests has been reported in numerous instances in the literature. For Old World dorylines, Brauns (1901) reported the notes of G. A. Marshall on a colony of *Dorylus* observed in Rhodesia (Africa). In this case, large numbers of alate males emerged from the extensive subterranean excavations of the colony, with the workers evidently driving out the males or even pulling them from the nest. In India, Wroughton (1892) saw the workers of *Aenictus wroughtoni* on two successive days apparently driving winged males from the nest of the colony beneath a verandah floor. Santschi (1908) discovered beneath a dye-shop oven in Tunis a large *Typhlopone fulvus* nest from which hundreds of males took flight in the late afternoon on six consecutive days.

The previous *Eciton* observations are relatively few, and are limited to the hypogaecic species. A number of winged males was found by Hetschko (Mayr, 1886) in the subterranean galleries of an *E. (Acam.) hetschkoi* nest excavated by him at Paraná, Brazil. Wheeler (1900) reported witnessing the exit of males in numbers from a nest of *E. (Acam.) schmitti* in dry soil, near Austin, Texas. In the Sierra de la Ventana of Argentina on February 16, 1916, Bruch (1916) saw numerous male individuals erupting one evening from a nest of *E. (Acam.) strobeli* under the foundation of a building. In a colony of *E. (Acam.) spgazzinii* found in a comparable situation at Bella Vista, Argentina, by Gallardo (1915) in April, 1914, eight days after a group of about 50 winged males had been dug out from one part of the nest the workers opened a second exit between stones, from which numerous males presently emerged and flew off. Workers of this species were observed in the same locality in February of 1917, 1918 and 1919, but appeared to be without males; however, in December of 1916 an exodus of males was observed from an *E. (Acam.) spgazzinii* nest in another section of Buenos Aires province (Gallardo, 1920).

These observations support the conclusion that males of the hypogaecic subgenus *Acamatus* (= *Neivamyrmex*) develop in specific broods which emerge from their cocoons within limited periods of time, as do those of *Eciton (Eciton)* species. Smith (1927) concluded, that since alate *Neivamyrmex* males were taken by Wheeler in Texas during October of different years, and since he himself received specimens from the mid-

dle South captured in mid-November, "the males do not reach maturity until late in the season." We may suspect that the males of these species characteristically develop seasonally and leave the parent colony in considerable numbers at given times.

Doryline males of certain species are readily taken at lights in the tropics at given times of year. Vosseler (1905) reported the impression that the males of African species swarm to lights in numbers at times when major changes in humidity occur. Wheeler and Long (1901) reported that the males of *E. (Acam.) schmitti* fly to lights during the spring and early summer in Texas; later Wheeler (1913) noted that males of *E. (Lab.) coecum* are common about lights in the Austin area from early March to late in April. Males of *E. (Acam.) carolinense* were taken by W. Davis in Georgia in June, 1908 (Wheeler, 1921). Von Ihering (1912), who kept a colony of *E. (Lab.) coecum* under observation for about four months while it occupied the same site, stated that in Brazil flights of *Eciton* males generally come in midsummer, particularly in the months of December to February. Also, he noted that the annual flights varied; for example, whereas large numbers of males representing at least six species were taken at lights in the year 1910-1911, the results were sparse the following year. As noted by Gallardo (1920), the males of *E. (Acam.) strobeli* are frequently seen in the Argentine around house lights during the spring and summer, where Strobel (Mayr, 1886) took them in numbers during the summer months of December to February. Sumichrast (1868) reported capturing numerous *Eciton* males at lights during the first rains, in the Cordoba area of Vera Cruz in Mexico. At the lights of the Kartabo Laboratory in British Guiana, Wheeler (1921) took a few males of different *Eciton* species each night between July 26 and August 31, 1920. Of 41 alate male specimens, two were identified as *E. burchelli* males, and 39 were attributed to a colony of *Cheliomyrmex nortoni* nesting close behind the laboratory building.

It will be noted that with the exception of Wheeler's capture of two *E. burchelli* males in British Guiana, all of these reports concern *Labidus* and *Acamatus* species. The difference cannot be attributed to chance, for at Barro Colorado Island during the spring months of 1946 males of the hypogaecic species were commonly taken at the lights of the laboratory, a few dozen meters from the forest edge, and at light traps within the forest itself, whereas no males of the *Eciton (Eciton)* species were taken at the laboratory and few were taken at forest light traps. The difference may be due in part to typical habitat differences among the subgenera, perhaps to unknown differences in flight (e. g., range) and responses (e. g., to light) of the males.

The present study has furnished some direct evidence concerning the manner in which alate *Eciton* males are dispersed from

their parent colonies. The alates ordinarily remain within the bivouac during the day, emerging only after nightfall. One important factor as laboratory tests show is their withdrawal from very bright light. The males of *Eciton* (*Eciton*) species have large compound eyes as well as dorsal ocelli, and reactions to light may play more than one rôle in their behavior.

The departure flights of males, once they begin, always occur after nightfall. However, very few flights are to be observed within the first nights after a given brood has emerged. Possibly after emergence there are certain maturational processes which must run their course before the flight can occur, comparable to those reported by Snodgrass (1925) for the drone honeybee. In addition there are certain extrinsic circumstances which appear to operate in favor of a certain detention of *Eciton* males in their colony of origin.

We have seen that, within the first nights after the main part of a male brood has emerged from cocoons, the alates begin to appear outside the bivouac in limited numbers. A few of them at a given time may be seen in action on the surface close to the bivouac, alternately engaged in short spurts of running or (more frequently on further nights) in bursts of wasplike wing-vibration and in clumsy short flights. The way in which each active male is closely followed and actually gripped by workers may serve as a deterrent to premature departure flights. Another factor which would appear to retard the depletion of a brood of alate males is their involvement in the bivouac-change exodus. Most of them, when they leave the bivouac, pass almost at once into a directionalized stream of workers, and once in the column they make their way more or less directly to the new home site. Seldom are they free to run or flit about and to mount low vegetation (that is, to enter the pre-flight condition) except on rare occasions as when a major traffic interruption occurs (e. g., crossing of the route by a night-raiding hypogaecic *Eciton*). The new bivouac is entered directly by most of them, with little opportunity to stray.

The result is that probably not more than a few dozen or at most a few hundreds of the alates leave the colony on a given night, and hence the male brood is not entirely gone until three weeks or perhaps a longer time after its emergence from cocoons. Hence our findings confirm the hypothesis of M. R. Smith (1942) that *Eciton* males do not remain long in the parental bivouacs after emerging as callows. Since they fly off in greater numbers on moonlight nights, it may be that the males are all away sooner when a brood emerges during a period of full moon. The fact that male broods leave the colony in nightly lots inevitably increases the chances that at least a few of the males may get into colonies of their own species. Within a period of three weeks it is reasonably certain that any "loaded" colony will

come within male-flight range of one or more conspecific colonies.

Preliminary ground activity appears to be prerequisite to flight. Much excited running about and intermittent bursts of wing action are regular preliminaries to the take-off flight of *Eciton* males. In the case of any given male such behavior may last as long as thirty minutes before he actually flies away. We have mentioned the possibility that the retinue of workers may function incidentally to prevent premature flights. The existence of an organic build-up process of given duration is suggested by the fact that, up to the moment of actual departure, there appears to be little actual flying other than occasional short hopping flights.

Evidently, the take-off generally involves a clear departure from the vicinity of the home colony. Some of our results indicate that the flights carry over distances of at least a few hundred meters from the parent colony. Thus it may be possible for an *Eciton* colony to distribute males widely through a fairly large area around each bivouac site occupied during the period when nightly flights are being made by males. The process of dispersion must be assisted considerably by the influence of air currents and wind. Furthermore, the area which can be "seeded" with males from a given colony is greatly augmented through the fact that from the time the male alates first emerge their colony is nomadic, i. e., through about 12 days in *E. burchelli* and 17 days in *E. hamatum*. This of course means that each night finds the colony in a new focus of distribution relatively distant from the preceding site. These positive factors operate against numerous hazards of the flight which must tend to reduce greatly the chances that any given male will survive and eventually reach a scene of possible reproductive function. For, as we shall see, flight (or its equivalent) and dealation appear to be prerequisites for sexual response and function in *Eciton* males.

In view of the fact that a male *Eciton* brood probably contains a minimum of two or three thousand individuals as a rule, and that dozens or even hundreds of alates may leave a loaded colony on a given night, we are impressed by the rarity with which dealate males are observed in association with colonies. In contrast to the great frequency with which *Eciton* males (of hypogaecic species) are taken at lights, a survey of the doryline literature shows that dealate males are found only exceptionally.

The first discovery of this kind on record occurred in western Africa near the Gaboon R., in April of 1847, when Savage (1849) observed a few large insects later identified as dealated males of *Dorylus nigricans*, running back and forth in the columns of a colony of this species. These dealates were able to return and were readily accepted by the workers when displaced from the route. The first *Eciton* male dependably referred to its species was a male with only remnants of wings taken by W. Müller (1886) on

March 1, 1885, from a column of *E. burchelli*. The ants evidently were engaged in a bivouac-change movement in which the male was participating, for Müller noted that his find was partially running and partially nudged along by workers. On October 21, 1905, K. Fiebrig took a single dealate male from a column (also evidently migratory) of *E. (Lab.) praedator* in San Bernardino, Paraguay (Forel, 1906). Reichen-sperger (1926) reported a "developed" male and single queen of *E. (E.) mattogrossensis* sent to him in 1924 from Monte Alegre, Pará, after having been captured from the nest of the same colony. The finder, P. Cherubim Mones O. F. M., judged that a migration was in progress at the time. On November 29, 1911, Wheeler (1912) took two winged males of *E. (E.) vagans* near San Jose, Costa Rica, in a column of workers. Since these last males were taken in the daytime and evidently from raiding columns, presumably they were recent post-flight individuals. From a long file of *E. (Acam.) pilosum beebei* at Kartabo, British Guiana, in July of 1920 Beebe took two partially dealated males, and a little later on the same day Wheeler (1921) removed two additional males from the same column in which they "were being conducted along by the workers." Smith (1942) reported that D. E. Read found three dealate males in a nest of *E. (Acam.) carolinense* which was excavated in the vicinity of Spartanburg, S. Car.

My own experiences, based upon a concerted searching of Eciton bivouacs, further suggest that very few Eciton males reach colonies after their flights. In the first place, their seasonal occurrence is indicated by the fact that despite countless chances for discovery, only one dealate male has come to light during four rainy season surveys.¹¹ Further, in more than twenty Eciton colonies which were examined by me in southern Mexico during several months of the regular dry season of 1945, only one dealate male was found in any of the bivouacs. This male was found on May 1, 1945, in the midst of a mainly subterranean *E. hamatum* bivouac in a dry forest in northeastern Oaxaca (Schneirla, 1947). Relatively few dealate males were found in the present study.

It seems very probable that under ordinary conditions most of the few thousand alates in a given Eciton male brood are lost through the flight, and that only a small handful of them succeeds in getting into colonies. The possibility must also be considered that some of those which reach colonies of their species may be killed by work-

ers when first encountered on raiding trails or in other ways may have their span of life cut short after entering the bivouacs. It is probable that the greatest part of the male output is lost after landing from the flight, through the action of hazards such as predators, exposure and desiccation.

It is apparent from our evidence that very few of the males re-enter their own parental colonies, confirming the surmise of Gallardo (1920) that the flight operates against inbreeding and in favor of cross-fertilization.

Evidently the males can get into other colonies only by chance after their flight through happening to cross chemical trails in the course of their running about. Observations and appropriate tests show that Eciton males can follow the chemical trails of other colonies of their species. Hence, among those males that survive for any length of time after the flight, the ones that happen to encounter a chemical trail of their own species while wandering about on the ground may thereby reach a bivouac. (This wandering process is of course inferentially inserted here, since Eciton males have not been captured, either as alates or dealates, on the ground except with columns of workers or in bivouacs.) The process of such trail discovery, if it actually occurs, must be highly fortuitous. For example, the trail would have to be crossed near a bivouac or the male might get lost in its ramifications, must be a recent one or it might be too faint to be followed, and so on. Casualties must be numerous.

It should be noted that the ability of males to follow chemical routes thus encountered may be the outcome of a habituation to their own colony (and species) chemical during their initial stay of some days in the parent bivouacs. Also these chemical stimuli have been followed when the colony bivouac-change routes are travelled by the male callos during nightly bivouac-change movements. Furthermore, the pre-flight stay of males in their parent bivouacs may operate to insure the adequate impregnation of cuticular surfaces with the species chemical, thereby increasing the chances that in possible post-flight arrival at the trails of other colonies they will not be attacked by the foraging workers.

Since the males retain their wings through a rather lengthy stay in their parent colony, and since we find them without wings relatively soon after the flight, it would appear that through the flight itself physiological changes are set up which lead to dealation. The process may resemble the characteristic post-flight dealation of queens which prevails widely among most species in ant subfamilies other than the dorylines. The matter deserves special study.

It may be that the flight is essential for the occurrence of mating behavior and reproductive function in the Eciton male. The Ecitons exhibit the predominant tendency among ants for a full male flight under ordinary natural conditions.¹² However, at

¹¹ On June 13, 1932, in the early weeks of the rainy period, a single dealate male was found running in a column of *E. hamatum* workers. The male was in the last section of a bivouac-change movement which had been delayed by rain and was completed shortly after the find, at 9:00 a.m. He ran under his own power, although occasionally the workers which crowded closely around and after him nipped and tugged at his legs when he paused or started to reverse directions. This was the only dealate male observed in three periods on Barro Colorado Island in the early months of rain, when, presumably, dealate males might still be present in some of the colonies.

present we do not know whether under any conditions the males may go flightless without impeding their eventual fertility. In the present investigation a few tests of preliminary nature were made in which alate *Eciton* males were found not especially responsive to queens. But on the other hand in just two opportunities to test the behavior of dealates placed together with queens, coupling occurred within a period of minutes. Gallardo (1920) considered it unlikely for hypothetical reasons that fertilization may be carried out by *Eciton* males that have not made their flight. He observed that males of *E. (Lab.) praedator* taken at lights by E. Caride had the genital organs completely distended, a condition noted also by the present writer in the case of *E. (Lab.) coecum* males taken around lights at Barro Colorado in May of 1933. It is barely possible that the flight itself may set up physiological changes prerequisite to mating, as Goetsch (1933) has suggested for termites. However, in certain termites Grassé (1942) has obtained dealation and successful mating through isolation without benefit of any flight, and C. P. Haskins (personal communication) has obtained comparable results with the alates of certain ponerine ant species.

By and large, male flight appears to be the rule among the *Ecitons*, presumably insuring a predominance of cross-fertilization of apterous young queens in foreign colonies. However, we must reserve the possibility that on occasion short flights or the activity-equivalent of flight may permit a return into the parental colony, and subsequent inbreeding.

Finally, let us consider whether our findings cast any light on the problem of when, how, and by what individual or individuals the male eggs are produced. The last question would seem to have priority. If the Dzierzon rule holds for *Ecitons* as it holds widely among other social insects (Phillips, 1915; Snodgrass, 1925), then army-ant males arise from unfertilized eggs which might be laid by workers or by a regular queen. Of course workers as possible male-producers cannot be excluded without good reason, since production of males from worker eggs has been demonstrated in numerous species of bees (Plath, 1922; Snodgrass, 1925), is known to be common among ant species particularly when colonies are old and well-fed (Fielde, 1905; Emery, 1918; Wheeler, 1928; Weyer, 1929), and is even believed by Verlaine (1926) to be virtually the rule among social insects. In fact, Haskins and Enzmann (1945) have reported evidence that in certain ponerine species not only males but also females may arise

from impatinate worker eggs. Worker ants of many species are known to possess ovarioles (Bickford, 1895; Holliday, 1904), although in virtually all investigated cases workers have fewer than in the queen. Mukerji (1933) discovered ovaries in two of twelve workers of the Old World species *Dorylus (Alaopone) orientalis* examined by him, with indications that one of these workers might have been capable of producing eggs. At present evidence is lacking that the workers of New World doryline species may be functional. The anatomical evidence is meagre and negative, since Miss Holliday found no evidence of ovarioles in several workers of *E. (Acam.) schmitti* which she studied histologically.

The findings reported in this paper flatly oppose the possibility that in *Eciton (Eciton)* species male broods result from worker eggs. These broods number in the few thousands, and in our experience always appear as distinct all-male broods in which all individuals are approximately of the same age. There are far too many eggs in such broods, far too similar in time of production, to be conceivably the product of workers. A sporadic egg-production in small lots but not in precise broods, would be expected of workers. Moreover, such broods are always found to be exactly synchronized with other (worker) broods just as would be expected were the egg-laying cycle of a single colony queen responsible for all (Schneirla, 1944). In many laboratory observations of *hamatum* and *burchelli* workers in lots varying from a few dozens to a few hundreds, housed in artificial nests and given all possible care as to food and moisture in particular, the writer has found no evidence that eggs were ever laid. Contrary to the state of affairs existing rather widely among other ants, it is exceedingly doubtful that *Eciton* workers play any direct role in species genetics by functioning as reproductives.

We have concluded that *Eciton* male-production is a seasonally-conditioned process, limited (at least in the area and under the conditions of this study) to the dry season. From our previous evidence (Schneirla, 1944; 1947), the *Eciton* colony queen at regular intervals throughout the year produces huge batches of inseminated (i. e., functionally diploid) eggs, resulting in successive large worker broods through the rainy season and most of the dry season. In the present investigation we have found that during the early part of the dry season there arises somehow as a regular delivery episode in the given queen's cycle a much smaller batch (and probably only one) of male-producing eggs.¹³

On the Dzierzon rule these eggs which produce males are presumably unfertilized, functionally haploid eggs. What can account for this seasonally-conditioned and time-limited change in the queen's function? It might be thought that these eggs are laid

¹² Whether or not a flight is indispensable, pre-nuptial flying evidently occurs in the males of all ant subfamilies, except for the minority of species in which the male lacks wings (e.g., certain species of *Ponera* and *Cardiocondyla*—Wheeler, 1913). Thus the males went aloft in all four of the myrmecine and camponotine species investigated by Talbot (1945). In these same species female flight also appeared to precede mating, although it was limited mainly to wing action on the ground in the bulky females of *Prenolepis imparis*.

¹³ How young queens are produced in *Eciton* colonies is unknown at present.

by old queens whose sperm supply is exhausted. Male-production by old queens is known to occur in honeybees, and Goetsch (1939) has reported it for certain ants. However, it is very doubtful that this can be the regular mode of male-production in the Ecitons. We have found several male broods in *E. burchelli* and *hamatum* which were followed (and some of them known to have been preceded) by regularly-spaced worker broods. Although the writer has a little (unpublished) evidence for the possible refertilization of functional colony queens in *E. hamatum*, there is no good reason to believe that such events occur widely as sequels to an annual exhaustion of sperm accounting for male broods. In the absence of direct evidence, it seems wiser to hypothecate a temporary process of blocked insemination of eggs by virtue of seasonal and time-limited causes.

The possibility that at given times the effective fertilization of eggs by sperm is prevented temporarily through a reflex-physiological change in the queen has been made plausible by the recent studies of Flanders (1946) on the honeybee and by earlier work on other insects. Flanders finds significant evidence justifying the idea long known as the "Wagner theory" (cf. Phillips, 1915, p. 188). In the queen honeybee it is probable that under certain conditions of extrinsic stimulation (e. g., small comb cells) the sperm valve may open, permitting the release of sperm from the spermatheca and the fertilization of eggs; whereas under other stimulative conditions (large cells; old comb) the valve remains closed and unfertilized male eggs are laid. In the fertile females of other insects, equivalent stimulative conditions may control fertilization in a corresponding manner (see Flanders, 1939). The seasonal production of males with species differences in the timing is an occurrence widely present among ants (Talbot, 1945), and male-producing eggs are commonly laid in the autumn by honeybee queens (Vandel, 1930). Insects in general are known to be rather delicately affected metabolically by changes in environmental conditions such as prevalent temperature and humidity (Uvarov, 1931; Chapman, 1931; Buxton, 1932; Himmer, 1932; Mellanby, 1935). Their reproductive processes are known to be affected by ecological conditions (Alpatov, 1932; Wigglesworth, 1934). Since, as Ezikow (1926) and others (Wheeler, 1913) have shown, the ovaries of queen ants react in a fairly sensitive manner to the prevailing metabolic condition of the individual, it is conceivable that a delicately adjusted process such as that which must underlie the impressive egg-production rhythm of the Eciton queen might be affected temporarily by an abrupt change in general conditions. A reasonable hypothesis would appear to be that seasonally the Eciton queen is so influenced by the first impact of dry-season conditions that the fertilization process is temporarily blocked. Despite the occurrence of a vertical

shifting of Eciton bivouac sites in dry terrain (Schneirla, 1947) which may act as a partial buffer for the queen against non-optimal atmospheric conditions, it is possible that a time lag may exist in the queen's readjustment to these or related seasonal changes (such as available water in food,—Buxton, 1932) sufficient to account for a temporary inhibition of insemination. While these considerations may seem reasonable, they must be regarded as highly tentative in the absence of direct evidence concerning the ecological relationships of Eciton reproductive processes.

RÉSUMÉ AND CONCLUSIONS.

Males of the two investigated species of *Eciton* (*Eciton*) appear during the first half of the regular dry season, in distinctive broods of about 3,000 individuals each. Male-production in the 1946 season began a few weeks earlier in *E. burchelli* than in *E. hamatum*.

The production of one male brood per colony in a given season appears to be the rule, with some colonies having none. Results indicate that the male brood is the progeny of the regular colony queen, since it appears that the all-male brood of a given colony generally arises as a regularly synchronized episode in the reproductive cycle, spaced between worker broods.

It is suggested that the impact of dry-season conditions operates to inhibit the insemination process of the queen completely so that a batch of male-producing unfertilized eggs is laid before a readjustment to dry-season conditions somehow occurs.

Results show that a male brood has trophalactic stimulative relationships with workers comparable to those ordinarily exerted by a worker brood. Once larval development is well under way, the energizing effect of a male brood is comparable to that exerted by a worker brood roughly ten times its population size. Since male developmental phases are largely the same as those of worker broods, the appearance of male broods occasions no substantial modification of the (nomad-statory) cycle of colony behavior changes.

The complete dissemination of alate males from the parental colony begins a few nights after emergence and ordinarily requires about three weeks for its completion. The alates escape in nightly lots, which perhaps are larger on moonlight nights than at other times. The expenditure of a given brood of alates in flight may be retarded both through the behavior of workers and through participation of males in bivouac-change movements.

The male flight operates largely in favor of cross-breeding of colonies, although inbreeding evidently is not excluded. The "seeding" of males from a given colony is widened greatly in scope by the fact that (in the species studied and probably also in others) colonies are nomadic for a number of days after the alates emerge.

Most of the alate males evidently are lost through the flight, and few reach a situation of possible reproductive function. It is suggested that upon landing after the flight, males generally get into other colonies through chancing upon and following the chemical trails established in the daily colony raids. The pre-flight stay of alates in their parental colonies may operate to prepare them for this process, by habituating them to species chemical as in trail-following, and by insuring the saturation of their cuticle with species chemical. Thus acceptance of males into other colonies of their species may be facilitated through the chemically conditioned responses of workers to them much as to nestmates rather than as to booty.

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EXPLANATION OF THE PLATE

PLATE I.

Representative growth stages in males of
Eciton burchelli.

- Fig. 1. Larvae from the brood of colony B-I, taken at four-day intervals (cf. Text-fig. 1). Left, sample of March 2 (range of lengths, 5.6-6.6 mm.); middle, March 6 (range of lengths, 18.3-20.4 mm.); right, March 10, at larval maturity (range of lengths 22-24.8 mm.).
- Fig. 2. Post-larval male specimens from the brood of colony B-I. Left, pre-pupa of March 14, removed from cocoon; middle, pupa of March 25, removed from cocoon; right, enclosed pupa of March 25.
- Fig. 3. Mature males of *E. burchelli*. Left, alate post-flight males, preserved a few minutes after flight in laboratory cage; right, dealate males, preserved several hours after laboratory flight and loss of wings.

All specimens twice natural size.



FIG. 1.

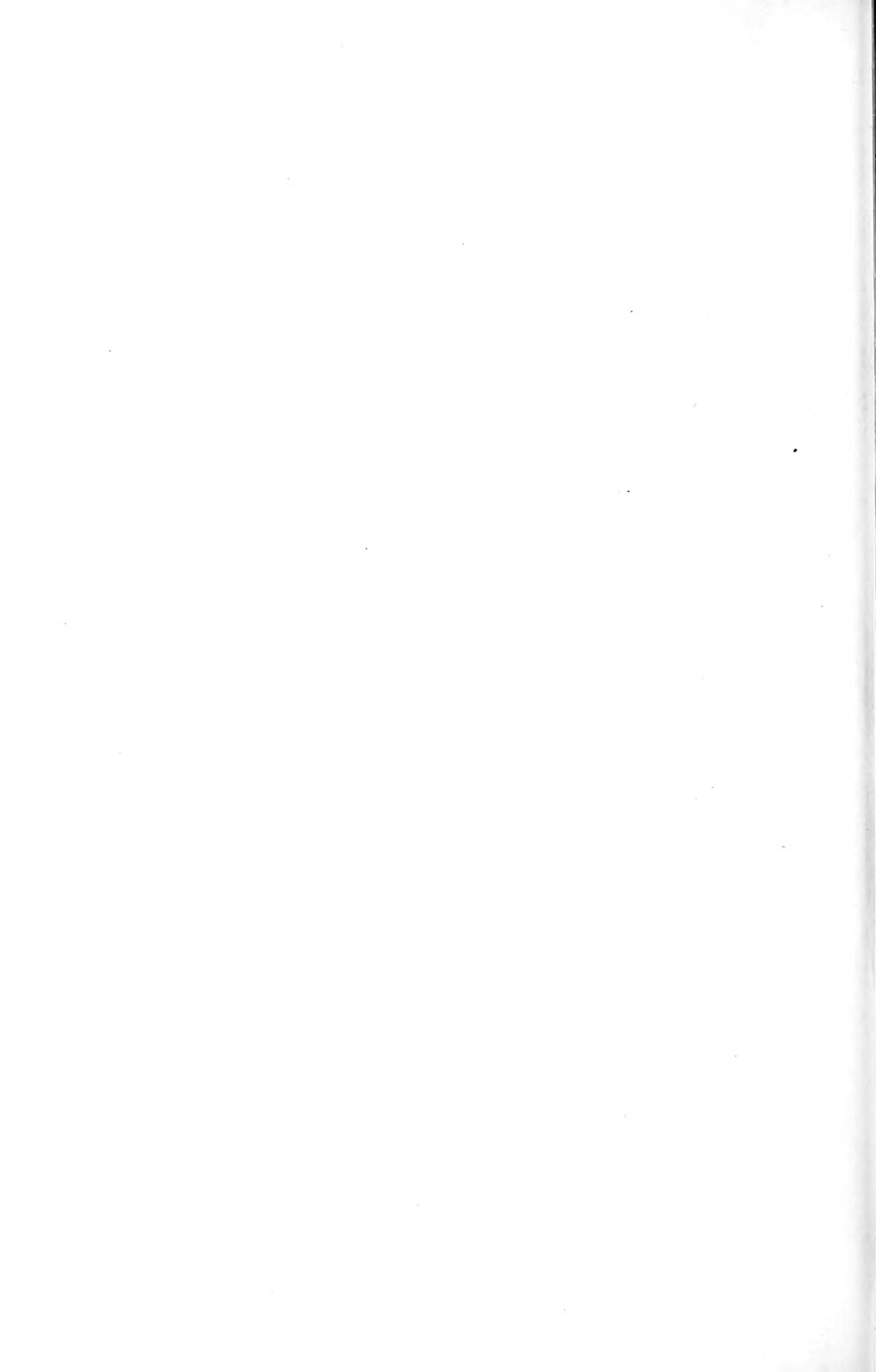


FIG. 2.



FIG. 3.

ARMY-ANT LIFE AND BEHAVIOR UNDER DRY-SEASON CONDITIONS WITH SPECIAL REFERENCE TO REPRODUCTIVE FUNCTIONS. II. THE APPEARANCE AND FATE OF THE MALES.



6.

Notes on the Display of the
Three-wattled Bell-bird (*Procnias tricarunculata*).

LEE S. CRANDALL.

(Plate I).

When Charles Cordier, Staff Collector for the New York Zoological Society, arrived at the Zoological Park from Costa Rica on August 31, 1947, he brought with him three specimens of the Three-wattled Bell-bird (*Procnias tricarunculata*). It is believed that these were the first representatives of the species to be seen alive outside their native habitat, which includes the mountains of Nicaragua, Costa Rica and Panama.

The trio consisted of an adult male with chestnut body and white head and throat, an immature male in mottled green plumage, its back slightly blotched with chestnut, and an adult female. The adult male, unfortunately, escaped soon after arrival but the younger bird remained available for observation. In writing of this particular bird¹, Cordier states that he was calling regularly at the time of his capture in mid-May, 1947. After being placed in a flight cage at the Zoological Park in September, 1947, he quickly resumed his demonstrations. At this time, although calling was frequent, there was no noticeable enlargement of the wattles, the three appendages remaining black and shrunken. The nasal wattle was about $\frac{3}{4}$ " in total length, the basal $\frac{1}{4}$ " being approximately $\frac{1}{8}$ " in diameter, the distal $\frac{1}{2}$ " about $\frac{1}{16}$ " in diameter. When in this condition, the slightly thickened basal $\frac{1}{4}$ " was faintly erectile. The lateral wattles were estimated to be 1" in length and $\frac{1}{16}$ " in diameter, each with two or three sharply angular kinks.

In January, 1948, it was noted that there was some extension of the wattles when the bird was calling. This enlargement increased gradually, reaching a maximum about May 1, when the following notes were made. Certain plumage changes had occurred by this time, the chocolate of the upper parts having increased, the head having become thickly mottled with white and the throat almost entirely white, with a strong wash of yellow.

The bird begins its display by bringing its body into a stiffly horizontal position, held high on the legs, much as in *P. nudicollis*. The mouth is opened widely, until the lower

mandible approximates a right angle to the upper. The wattles remain shrunken. The body is then pumped rapidly up and down for about five seconds. This movement then ceases and with the body, legs and wings rigid, a violent convulsion of the throat and neck is followed by the sharp, metallic "bell" sound. Frequently, but not invariably, this initial effort is followed by a series of five or six lesser ones, in regularly decreasing volume.

Pumping and calling may alternate continuously for periods of an hour or even longer. As calling continues, the wattles gradually enlarge until, after several efforts, the maximum is reached. At this point, the following dimensions were estimated: nasal, length $3\frac{1}{4}$ ", diameter, $\frac{1}{4}$ "; laterals, 3", diameter, $\frac{3}{16}$ ". All wattles are completely sessile at the maximum and move from side to side as though weighted, when the convulsive calls are given.

At this stage, the display is frequently preceded by head shaking and experimental opening of the mouth. This seems to be related to the position of the heavy nasal wattle, which causes the bird obvious annoyance. It may fall at either side and frequently drops within the widely opened mouth, which sometimes closes upon it.

While several efforts are required before the wattles reach their maximum, any sudden disturbance of the bird will cause them to shrink almost instantaneously. If activity is promptly renewed, enlargement takes place visibly, so that the maximum is regained within a few seconds.

During the period under consideration, the female has continued to occupy the same cage. Her general reaction seems to be one of mild alarm, although on several occasions she appeared to be attracted by the dangling wattles. At least once, she was seen to reach out as though to peck at them. This action caused the male to move quickly, with immediate retraction of the wattles.

Often, following several displays, the male darts rapidly at the female, which flies in alarm. No attempt at copulation has been noted.

¹ *Animal Kingdom*, November-December, 1947, pp. 175-6.

EXPLANATION OF THE PLATE.

PLATE I.

Photographs by Sam Dunton, Staff Photographer, New York Zoological Park.

- Fig. 1. *Procnias tricarunculata*, ♂, sub-adult. Showing wattles in normal resting condition.
- Fig. 2. *Procnias tricarunculata*, ♂, sub-adult. Calling position, wattles somewhat less than fully extended.

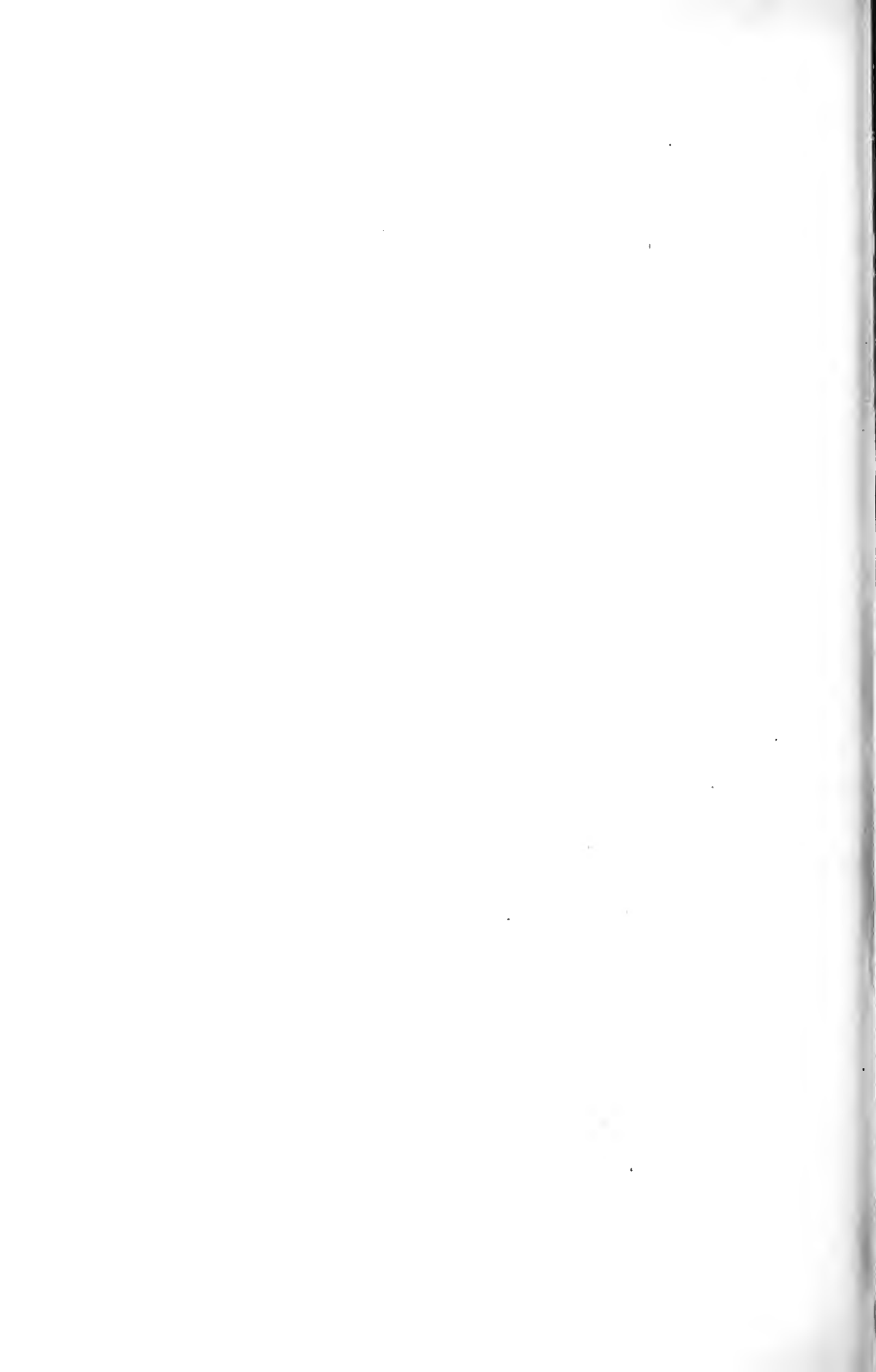


FIG. 1.



FIG. 2.

NOTES ON THE DISPLAY OF THE THREE-WATTLED BELL-BIRD
(*PROCNIAS TRICARUNCULATA*).



7.

The Cephalopoda Decapoda of
the Arcturus Oceanographic Expedition, 1925.¹

BY THE LATE G. C. ROBSON, M.A.

Formerly Deputy Keeper, British Museum (Natural History).
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(Text-figures. 1-18).

[This paper is based on the collections taken on the *Arcturus* Oceanographic Expedition to the eastern Pacific in 1925. This, under the direction of William Beebe, was the seventeenth expedition of the department of Tropical Research of the New York Zoological Society. For detailed data on localities, dates, dredges, etc., refer to *Zoologica*, Vol. XXII, No. 2, pp. 33-46].

PREFACE.

This report was prepared by the late G. C. Robson in 1932 but his last illness prevented the paper from being completed. His successors, Mr. G. I. Crawford and Dr. W. J. Rees, have made a few minor corrections, prepared a list of species and a revised bibliography, but it has been deemed advisable to leave the text as written by the author.

The paper is of considerable interest as it deals with a hitherto little-known cephalopod fauna and also presents the views of an acknowledged authority on the status of many important genera of squids.

An appreciation and a full list of Robson's cephalopod researches by Dr. W. Adam of Brussels has been published in the *Proceeding of the Malacological Society of London*, Vol. 27, pp. 131-136, 1946.

N. B. KINNEAR,
Director,
Brit. Mus. (Nat. Hist.).

INTRODUCTION.

The decapod cephalopods collected by Dr. Beebe during the spring and early summer cruises of the *Arcturus* in 1925 were examined by Mr. J. F. W. Pearson and made the subject of a preliminary report. This was submitted as a thesis for a Degree in the University of Pittsburgh, but was never published. Mr. Pearson was unable to continue his work on the collection and in 1928 Dr. Beebe invited me to complete the study of the material. A copy of Mr. Pearson's thesis was sent to me and I have found it very useful as a preliminary survey. It contained much information concerning the gear used on the *Arcturus*, the stations at which cepha-

lopods were taken, and a general discussion on the research problems involved. Of these sections I have unfortunately not been able to make any use. As regards the systematic work Mr. Pearson evidently considered his identifications very provisional. In spite of the limited time at his disposal, however, and the difficulty he obviously experienced in getting the necessary literature, whenever he ventured on a specific diagnosis his judgment was rarely at fault.

The bulk of the collection consists of juvenile specimens with no associated adult stages, and it has proved quite impossible to determine the generic position of two or three forms. There are also a good number of fragments and badly mangled specimens of which the identification is very dubious.

As regards the juvenile stages of uncertain status, I have given here full particulars in the hope that when such stages are better known in the decapods as a whole, the relationships of these specimens may be understood from my descriptions.

The collection of Decapoda is represented by some 30 species and is therefore an unusually rich one. I have been compelled to describe five new species and a new genus. The majority of the species here described come from the waters near the Galápagos Archipelago and it would have been very interesting to compare this fauna with those of adjacent areas, e.g. the coast of Central America and Colombia and the more remote regions of the Pacific. Unfortunately the lists available for such a study are so meagre in contents that by the time the doubtful identifications have been eliminated, the basis for a reasonable comparison has disappeared. That 16% of the species here mentioned are new, may be a little surprising, but it must be remembered that the cephalopod fauna of the equatorial Pacific is very poorly known. There is another important fact to bear in mind. Many of the species of teuthoid decapods are regarded as cosmopolitan and the chief students of the group (notably Pfeffer), adopting a conservative attitude, have refrained from creating new species out of the obvious variants that turn up from time

¹ Contribution No. 815, Department of Tropical Research, New York Zoological Society.

to time. Perhaps there is some justification for this attitude when the study of a group is in the stage when material is being amassed and before the extent of the variation is fully realized. But at present the assumed genetic homogeneity of cosmopolitan marine species (seen in other groups as well, e.g. in Copepoda, etc.), if it is not a mere product of taxonomic conservatism, is a challenge to our curiosity. It implies not only that the natural "divides" (such as the Agulhas Divide) in the ocean and the regional changes of temperature and salinity, etc., have no modifying effect on the natural population (which in the case of planktonic forms such as *Liocranchia reinhardti* seems very surprising), but also that such mutations as do arise are readily suppressed and have no effect in producing the local modifications that we see in widely-ranging terrestrial animals. One is bound to view this alleged homogeneity with some suspicion. If it is, however, substantiated, it is a matter of considerable importance. As far as the Cephalopoda are concerned, the statistical analysis of natural populations is still very much limited by the smallness of the catches made, and there is great need for the intensive study of variation in the commoner and more widely ranging species.

My best thanks are due to Dr. Beebe for the opportunity of studying this interesting collection.

LIST OF SPECIES OBTAINED

Order Decapoda

Sub-order Teuthoidea

Family Loliginidae

Sepioteuthis occidentalis Robson
(?subsp. nov.)

Family Bathyteuthidae

Bathyteuthis abyssicola Hoyle
Bathyteuthis sp.

Family Enoploteuthidae

Abraliopsis hoylei (Pfeffer)
Abraliopsis ?hoylei (Pfeffer)
Abraliopsis sp.
Pyroteuthis giardi (Fisher)
Genus and species uncertain.

Family Octopodoteuthidae

Genus and species uncertain.
Octopodoteuthis nielsenii n. sp.
?Octopodoteuthis sp.

Family Onychoteuthidae

Onykia sp.
Onykia ?appelofi (Pfeffer)
Onychoteuthis ?banksi (Leach)
Genus and species uncertain (subfam. Lycoteuthinae)

Family Histiototeuthidae

Stigmatoteuthis arcturi n. sp.
Histiothauma oceani n. gen., n. sp.
Genus and species uncertain.

Family Ommatostrephidae

Genus and species uncertain (subfam. Illicinae)
Stenoteuthis pteropus (Steenstrup)
Stenoteuthis bartrami (Lesueur)

?Stenoteuthis spp. (*Rhyncoteuthion* stage)

Hyaloteuthis pelagica (Bosc)

Symplectoteuthis oualaniensis
(Lesson)

Genus and species uncertain.

Family Chiroteuthidae

Chiroteuthis sp. (*Planctoteuthis* stage)

Mastigoteuthis sp.

Mastigoteuthis sp.

Family Cranchiidae

Liocranchia reinhardti Steenstrup

Galiteuthis sp.

Taonidium pacificum n. sp.

Helicocranchia beebei n. sp.

Helicocranchia sp.

DESCRIPTIVE SECTION.

FAMILY LOLIGINIDAE.

Sepioteuthis occidentalis Robson
(? subsp. nov.).

One (♂) from Station 22; 1,000 miles south of Bermuda; (No. 3). Taken in dip-net at night (attracted by electric light). This specimen is rather immature, measuring only 60 mm. in dorsal mantle-length. Its main features resemble my *S. occidentalis* (Robson, 1926), but it tends to draw near to *S. ehrhardti* in the width of the fins (index: *occidentalis* 26, the present specimen 22, *ehrharti* 21). In its mantle-index (38), form of teeth of the tentacular and brachial suckers and shape of the first arms it agrees with *occidentalis* very well and differs from the other western Atlantic species. There is one marked difference, however, viz., the tentacle is like that neither of *occidentalis* nor of *ehrharti*, as it is only slightly longer than the mantle.

I note in this specimen the approximation to double hectocotylization observed in the type of *occidentalis* (Robson, 1926, p. 354, fig. 3). The only difference from the type in the *Arcturus* specimen is that the reduced suckers are continued over rather a wider area in the former.

Since the appearance of my paper on *S. occidentalis*, Boone (1928, p. 16) has revived the ambiguous *S. sloanei* Gray (Leach MS) for specimens obtained in tropical eastern American seas. The type of this West Indian form cannot be found. Boone's well-described form is quite different from my species in fin-proportions, sucker-dentition, etc.

FAMILY BATHYTEUTHIDAE.

Bathyteuthis Hoyle.

I agree with Naef and Grimpe in regarding Hoyle's name (Hoyle, 1885) as having priority over Verrill's *Benthoteuthis* (Verrill, 1885). Hoyle's date of publication was evidently May, 1885. Although the sheet on which Verrill's generic name appears is dated "April, 1885," there seems no escape from the conclusion that the actual publication was in or after the June of that year

(i.e. the date given by the last sheet of the part).

***Bathyteuthis abyssicola* Hoyle.**

1 specimen from Stn. 33; N.E. of Galápagos; PT-1 (No. 86); 600-0 fms.

1 specimen from Stn. 39; Galápagos Is.; PT-1 (No. 109); 500-0 fms.

1 specimen from Stn. 50; S.E. of Galápagos; T-2 (No. 146); 400-0 fms.

1 specimen from Stn. 59; S. of Cocos Id.; T-5 (No. 36); 600-0 fms.

1 specimen from Stn. 59; S. of Cocos Id.; T-5 (No. 35); 600-0 fms.

1 specimen from Stn. 59; S. of Cocos Id.; T-9 (No. 143); 500-0 fms.

1 specimen from Stn. 74; S. of Cocos Id.; T-21 (No. 119); 400-0 fms.

1 specimen from Stn. 74; S. of Cocos Id.; OT-2 (No. 38); 750-0 fms.

1 specimen from Stn. 84; Galápagos Is.; PT-4 (No. 89); 400-0 fms.

1 specimen from Stn. 86; Galápagos Is.; T-9 (No. 37); surface.

Nos. 86, 36, 35, and 119 are well-preserved specimens, 22-7 mm. in mantle-length and of normal structure. Of the remaining specimens all are fragmentary or otherwise in poor condition, but I do not hesitate concerning their identity. One specimen (No. 146), which measures 5 mm. in mantle-length, has remarkably small fins. The width of the head, the eyes and the arm-circlet of this example remind one of the form described below. Pfeffer (1912, p. 327) regards all the described forms of *Bathyteuthis* as conspecific. Between the type specimen of *B. abyssicola* (S. Ocean), the original example of Verrill's *Benthoteuthis megalops* (regarded as synonymous) (N. Atlantic), Chun's specimens (Indian Ocean and 36° and 170° E.) and Hoyle's E. Pacific forms (Cape Mala), there are some important differences which are carefully analyzed by Pfeffer. As the matter stands now I have no option but to adopt the latter's treatment of these forms, though I am not entirely satisfied with it.

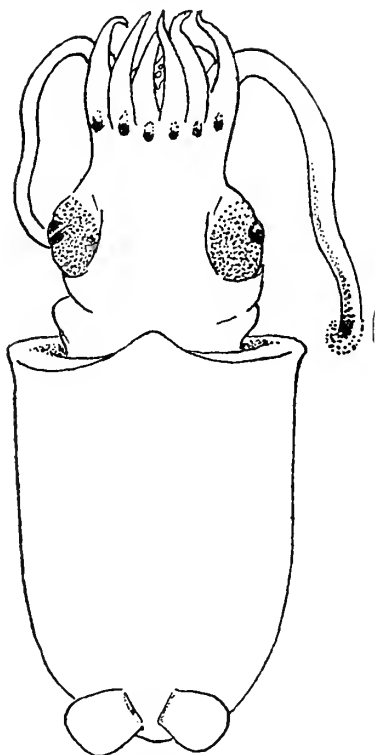
***Bathyteuthis* sp.**

(Text-figure 1).

One specimen (?♀) from Stn. 84, off Narborough Id., Galápagos Is. Young Fish Trawl; (No. 88); 700-0 fms.

This is represented by a small and juvenile specimen about 7 mm. long in mantle-length; it is in fairly good condition, though the body is a little distorted and the eyes somewhat damaged.

The mantle, which measures 7×5 mm., is much broader than in the equivalent stage of *B. abyssicola* ("megalops") (Chun, 1910, pl. XXIV, fig. 4). The head is narrower than at the corresponding stage of that form, in which the interocular width exceeds the mantle-width and the arm-circlet is distinctly



TEXT-FIG. 1. *Bathyteuthis* sp. from Stn. 84, (No. 88); circa×8.

narrower. One of Hoyle's Cape Mala specimens (1904, p. 33) has a broad body, the width of the latter being about two-thirds of the length. It also has a narrow arm-circlet. This specimen was 23 mm. long in mantle-length. Actually Pfeffer (1912, pl. 27, f. 13) shows a figure of a specimen from the Plankton Expedition with a narrow circlet of arms, but the shape of the body, fins and head in this specimen are very different from that seen in our Galápagos example.

The fins are diminutive, but not noticeably smaller than those of some specimens previously figured. The arms and tentacles and their suckers do not seem to differ from those of *abyssicola*. There is a very marked difference in the adhesive-organ, which is very narrow in *abyssicola* (Chun, 1910, pl. XXV, fig. 7) and much wider in this form. It must be noted, however, that Chun's figure is of an adult. The tentacular manus is rather more compact than that figured by Chun.

On the whole the features agree fairly well with those of *abyssicola*. But it is impossible to treat a form so different in head- and body-shape and in general proportions as referable to that species. All the same I am unwilling to describe such a young and immature specimen as the type of new species.

Actually from Pfeffer's figures (1912, pl. 27) and Chun's it seems that there is a very great deal of variation within the forms referred to *abyssicola*. It must be noted that

undoubted *abyssicola* of approximately this size (Chun 1910, pl. XXIV, fig. 4) has the large eyes and arm-circlet of the adult.

***Abraliopsis* Joubin.**

Having had no opportunity of seeing original specimens and revising this genus, I refrain from criticizing Pfeffer's treatment (1912) in detail. It seems to me very unsatisfactory, especially as he does not state what the status of the well-figured and fully-described "*A. morisii*" of Chun (1910) is. I feel very uncertain as to the real relationships between *A. hoylei*, *A. morisii* and Hoyle's eastern Pacific "*hoylei*" (= *affinis* Pfeffer). For the time being I confine myself to describing the *Arcturus* specimens and pointing out their relationship to the various forms previously described.

***Abraliopsis hoylei* Pfeffer.**

1 specimen (?♀) from Stn. 51; S. of Galápagos Is.; T-2, (No. 154); 165-0 fms., young, 0.14 mm. long.

1 specimen (♀) from Stn. 61; W. of Cocos Id.; T-5, (No. 170); 600-0 fms., a head only.

1 specimen (♂) from Stn. 68; N. of Cocos Id.; PT. 1, (No. 24); 600-0 fms.

1 specimen (a fragment) from Stn. 68; N. of Cocos Id.; PT 1, (No. 171); 600-0 fms.

1 specimen (♀) from Stn. 74; S. of Cocos Id.; OT-4 (No. 26); 625-0 fms., discolored and without tentacles but apparently referable to this species.

1 specimen (?♀) from Stn. 74; S. of Cocos Id.; T-7 (No. 118); 450-0 fms., damaged.

2 specimens (♀) from Stn. 74; S. of Cocos Id.; (Nos. 30 & 31); 750-0 fms., a head and arm only, a good deal damaged.

The specimens as originally measured ranged from 42 mm. to 5 mm. The body in head and mantle length, and the fins in shape, tend to resemble in shape those of *hoylei* (Pfeffer, 1912, pl. 17) and differ from Chun's "*morisii*." Hoyle's fig. 3, pl. 1, is doubtless badly drawn. The ocular light-organs exactly resemble those of Chun's "*morisii*," as do the tracts on the head. The latter, but not the ocular organs, are like those figured by Hoyle (1904, pl. 10, fig. 1). The tentacular manus resembles that seen in Pfeffer's fig. 9, pl. 17, in having four neat distal rows of suckers. But it has 3 large and 3 small hooks (unlike all the others) and agrees with Chun's fig. 5. pl. VIII, in having five carpal pads and suckers. There is one sucker between the distal and middle small hooks. The structure of the hectocotylus is more or less intermediate between that seen in Hoyle's figure and that illustrated by Chun. There is no large triangular basal lappet as in Hoyle's specimens. The arrangement of the fringe on the ventral side is otherwise very like that figured by Hoyle. Hoyle figures, probably in error, the large hooks as on the ventral side, whereas in our specimen and in Chun's they are on the dorsal side. Both Hoyle and Chun

figure a number of papillae at the base of the hectocotylus; but here I most certainly found a number of small suckers.

I think this is undoubtedly a member of the polymorphic species indicated by Chun, Pfeffer and Hoyle and as such I prefer to use Pfeffer's name *hoylei* rather than that proposed by him for Hoyle's eastern Pacific specimen.

***Abraliopsis ?hoylei* Pfeffer.**

One specimen (♂) from Stn. 74; S. of Cocos Id.; (No. 23); trawl; 0-844 fms.

This is represented by a specimen 25 mm. in dorsal mantle-length. Each fin is 11.5 mm. wide by 18 mm. long (over all). They are thus well over half the mantle-length. The anterior border is convex.

The mantle is slender with some evidence of the aperture having been flared outwards. It measures 10-11 mm. at the aperture and ca. 6 mm. half way along.

The tentacular manus resembles that of Chun's "*morisii*"; but the distal rows of suckers are more numerous and the extremity is thicker and shorter.

The "Seitenbrücke" of the hectocotylized arm which are enclosed in the web are nearly five times as long as the arm is wide and the unenclosed ones are closer than in Chun's figure. Though it is damaged one would say that the hectocotylus resembles that of *hoylei* figured by Hoyle (1904, pl. 8, fig. 5).

The specimen is not very well preserved and I would not care to dogmatize about its position.

The following specimens are indeterminable:

***Abraliopsis* sp.**

1 specimen (?sex) from Stn. 51; S. of Galápagos Is.; T-3, (No. 96); 274-0 fms. A very small specimen devoid of the tentacles.

1 specimen (?♀) from Stn. 74; S. of Cocos Id.; OT2 (No. 32); 750-0 fms. Shrivelled up; unrecognizable.

***Pyroteuthis giardi* (Fischer).**

1 specimen from Stn. 38; Tower Id. Galápagos; PT. 1 (No. 70); 300-0 fms.

1 specimen from Stn. 51; S. of Galápagos Is.; T-3 (No. 99); 274-0 fms.

1 specimen from Stn. 53; S. of Galápagos Is.; T-2 (No. 100); 800-0 fms.

1 specimen from Stn. 59; S. of Cocos Id.; T-8 (No. 28); 300-0 fms.

1 specimen from Stn. 74; S. of Cocos Id.; T-56 (No. 152); surface.

1 specimen from Stn. 84; Galápagos Is.; PT.-4 (No. 93); 700-0 fms.

2 specimens from Stn. 84; Galápagos Is.; T-8, 9, 10 (No. 157); 500-0 fms.

3 specimens from Stn. 84; Galápagos Is.; T-20 (No. 90); 500-0 fms.

2 specimens from Stn. 84; Galápagos Is.; T-1 (No. 149); 300-0 fms.

3 specimens from Stn. 86; Galápagos Is.; T-1 (No. 57); 400-0 fms.

3 specimens from Stn. 86; Galápagos Is.; T-2 (No. 59); 500-0 fms.

1 specimen from Stn. 86; Galápagos Is.; T-8 (No. 62); 500-0 fms.

1 specimen from Stn. 86; Galápagos Is.; T-11 (No. 69); 1,000-0 fms.

1 specimen from Stn. 86; Galápagos Is.; T-5 (No. 78); 1,000-0 fms.

2 specimens from Stn. 87; W. of Galápagos Is.; T-3 (No. 83); 450-0 fms.

The following young forms are possibly referable to this species:

from Stn. 86, Galápagos Is.; T-11 (No. 77), 1,000-0 fms.

from Stn. 86, Galápagos Is.; T-11 (No. 64), 1,000-0 fms.

from Stn. 49, off Hood Id.; T-2 (No. 107), surface.

The largest of these specimens has a mantle-head length of 30 mm. Several are in a fragmentary condition and their identity is very doubtful.

Many of these are clearly referable to *P. giardi*. There is, however, a frequent difference from the described forms in the possession of long and narrow tentacular manus. The proximal (carpal) suckers are enlarged as in the Galápagos variety (var. *hoylei* Pfeffer, 1912), described by Hoyle (1904); but there are no carpal pads and the manus is much more slender. The arrangement of the arm hooks and suckers and of the "Schutzsaüme" (which are usually damaged) is very much the same, though slight differences occur in the number of hooks. The arrangement of the ocular light organs exactly resembles that figured for *giardi*.

The shape of the body is distinctly more slender than that shown in Hoyle's figure, though the latter is actually of a larger specimen, and is more like that seen in Chun's figures (Pl. XII, figs. 1-2) which are more of a size with ours. The shape of the fins, on the other hand, is very like that seen in Hoyle's figure and unlike that in Chun's.

It is very remarkable that these specimens should show such a definite difference in the form of the manus from Hoyle's examples from the same locality. It is a pity that none of my specimens are males.

Genus and species uncertain.

One specimen from Stn. 51; S. of Hood Id., Galápagos; T-3 (No. 97); 274-0 fms.

The mangled specimen has hooks on the thin upper arm-pairs and the tentacles. There are no light organs on the eyes but there are traces of very small organs on the ventral surface of the head and mantle. The surface has, however, been scraped fairly clean and few of these organs are left. As their distribution is the chief diagnostic feature, the status of this form cannot be discussed.

FAMILY OCTOPODOTEUTHIDAE.

Genus and species uncertain.

One specimen from Stn. 28; E.S.E. of Cocos Id.; T-1 (No. 141); surface.

This specimen is in fairly good condition. It has hooks on the three upper arms and none on the tentacles. The suckers on the latter are of dubious arrangement (?2-3 rows). The absence of hooks on the tentacles and the biserial (?) disposition of the suckers might induce one to place it in the Octopodoteuthidae. The fins are very small, about one-quarter of the mantle-length. The head is enormous. There is a row of light-organs round the top of the eye-ball. I could distinguish none on the body or head.

Octopodoteuthis Rüppel.

Pfeffer (1912, p. 124) subdivided the Octopodoteuthidae into two groups, in a key translated (with some omissions) below.

- A. Arms (?always) with a spindle-like termination and long, small-based, "sich zum Teil deckenden" hooks which are arranged in two straight series mostly with suckers opposed ("zusammenhängenden"). Some normal suckers are found between the tip and the hooks, except in the ventral pair which is devoid of them and has rudiments of "Basalpolster." Fins terminal *Octopodoteuthis*
- B. Arms devoid of spindle-like end. "Die Haken sich nicht Deckend." Apparently no normal suckers.
1. Tentacle stumps persistent *Cuciototeuthis*
 2. Tentacles stumps not persistent *Octopodoteuthopsis*

Octopodoteuthopsis further has its hooks widely alternating and with broad bases. The oral surface shows a median groove or line. The fins are terminal, but not reaching the tip of the mantle.

The character of the two specimens before me make this classification very questionable. To begin with, though clearly conspecific, they vary a good deal *inter se*. One has a well-marked spindle-like termination of the arms; in the other it is almost imperceptible. In one there is a number of microscopic normal suckers between the hooks and the end of the arms. In the other I could not find them. These features do not present such a correlation of characters as would suggest that the two individuals are representatives of *Octopodoteuthis* and *Octopodoteuthopsis* respectively, as the one specimen with the end swelling (as in *Octopodoteuthis*) is devoid of the normal suckers (as in *Octopodoteuthopsis*).

Over and above these anomalies we must note a further incompatibility with Pfeffer's scheme. In one specimen the fins do not reach to the tip of the mantle (*Octopodoteuthopsis*), but the specimen has the end swelling of *Octopodoteuthis*. Similarly both seem to show the latter feature, yet in both the suck-

ers are arranged in a zig-zag and enclose a median groove (*Octopodoteuthopsis*). In short I believe Pfeffer's grouping breaks down and, though distinct groups may be found in this family, they are not revealed by his key. I place these forms provisionally in *Octopodoteuthis*, though there are some marked differences that might justify the creation of a new genus for them.

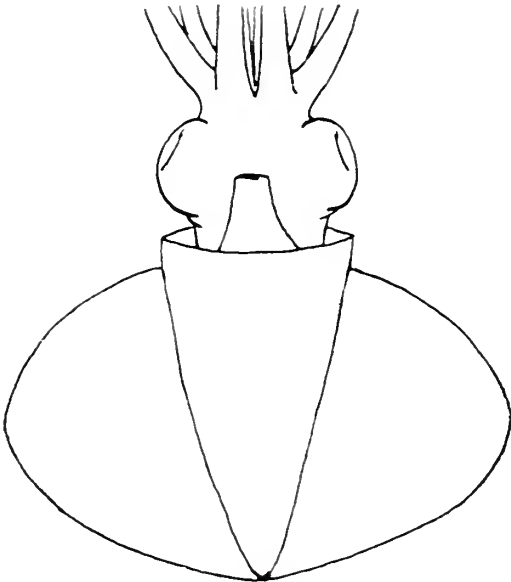
***Octopodoteuthis nielseni*, n. sp.**

(Text-figs. 2-4).

Two specimens from Station 74; Cocos Id.; T-69 and T-70; 400-0 and 500-0 fms. respectively. (Nos. 33 and 34).

Dorsal length of mantle	26 (?+) mm.
Maximum width of mantle	12+mm.
Maximum length of fins	22 mm.
Total width of fins	34 mm.
Length of head (mantle edge to base of dorsal arms)	9 mm.
Width of head	11 mm.
Length of third left arms	36+mm.

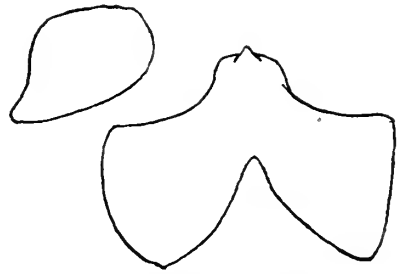
O. sicula has been many times described and figured. I shall at a later date give a full analysis of its variation, but confine myself now to pointing out the chief points of difference of *O. nielseni* from the eastern form.



TEXT-FIG. 2. *Octopodoteuthis nielseni* n. sp.; outline of body.

In *O. nielseni* the suckers and hooks are arranged in a zig-zag about a median furrow. So much damage has been done to the arms that it is not easy to say how many hooks there were. On one arm there are at least 20 pairs.

The hooks are, as in *sicula*, sheathed in fleshy casings and are upright and columnar. The fins are 84% of the body-length and their total span is 130% of the mantle-length



TEXT-FIG. 3. *Octopodoteuthis nielseni* n. sp.; funnel organ.

(both figures are the same as in *sicula*). The cephalic component of the adhesive-organ is not like that of *sicula* as shown in Pfeffer's fig. 9, pl. 19 (1912); there is a far wider and less distinctly channelled groove. Unlike those of *sicula* the arms are rounded and have neither "Schwimmsaume" nor "Schutzsaume." The latter are found in the oceanic form of *sicula* (Pfeffer) and both types occur in Sasaki's form. The funnel organ (Text-fig. 3) is not like that of *sicula* figured by Jatta (1896) though it is a little more like that shown by Sasaki (1929). The radula is quite unlike that of *sicula* (Jatta, 1896, pl. 13, fig. 8) in its tall rhachidian tooth, with an extraordinary small base and square admedian tooth. The radula is very unlike those of such enoploteuthids as I know. The admedian and first lateral are not unlike those of *Alluroteuthis* (Odhner, 1923, pl. I, fig. 18).

Remarks: This form is somewhat of a difficulty. The general shape and the form of the fins are not particularly different from those of *sicula* (e.g. as given by Pfeffer and Sasaki). The adhesive-organ, radula and the entire lack of membranes on the arms (which cannot be due to damage) are, however, features which preclude our ranking it with *sicula*. The adhesive-organ is of uncertain importance. Another point of diagnostic value is the great length of the third arms. The following table sets forth the relationships of the forms in question.



TEXT-FIG. 4. *Octopodoteuthis nielseni* n. sp.; radula.

sicula. Jatta. Longest arms 30 mm., mantle 25 mm.

Pfeffer. Longest arms equal mantle.

Sasaki. Longest arms slightly shorter than mantle.

nielsenii. Longest arms 36 mm., mantle 26 mm.

On the whole it seems best to regard the Galápagos form as a distinct species. At the same time it must be noted that *sicula* is rather variable and the status of the various forms called by this name is by no means clear.

This species is dedicated to my friend, E. Nielsen of Copenhagen.

?*Octopodoteuthis* sp.

A fragment from Stn. 1, PT-3 (No. 104), from the surface was labelled "*Octopodoteuthis*" by Mr. Pearson. It is now unrecognizable.

FAMILY ONYCHOTEUTHIDAE.

***Onykia* (*Teleoteuthis*, Auctt.) sp.**

4 specimens from Stn. 33; N.E. of Galápagos Is.; T-1, T-2 (Nos. 105, 144); surface; 5-6.5 mm.

1 specimen from Stn. 52; S. of Hood Id.; T-1 (No. 136); surface; 4.5 mm.

1 specimen from Stn. 59; S. of Cocos Id.; T-1 (No. 114); surface; 10 mm.

50 specimens from Stn. 74; S. of Cocos Id.; T-31-33, 35-36, 45-7, 50-65, 66 (Nos. 94, 101, 134, 67, 102, 140, 112, 81, 72, 129); surface; up to 13 mm.

13 specimens from Stn. 77; S. of Cocos Id.; T-1, T-2 (Nos. 124, 132); surface; up to 6 mm.

20 specimens from Stn. 78; N.E. of Galápagos Is.; T-1 (No. 126); surface; 4.5 mm.

2 specimens from Stn. 84; Galápagos Is.; T-1, 8, 9, or 10 (Nos. 151, 164); surface; up to 7 mm.

I am unable to assign this large assemblage of young forms, which range in size from just under 3 mm. up to about 13 mm. in mantle-length, to any known species. The Pacific species of this genus are very imperfectly known. If Pfeffer's figures (1912, pl. 1, figs. 12-13) of the tentacle of early stages of *O. caribaea* are at all representative of that species (which may possibly have a cosmopolitan distribution, but see Pfeffer), they differ markedly from the specimens under investigation in which at the stage represented in Pfeffer's figure 12 the tentacular suckers are far more irregularly arranged. At a stage more or less the same as Pfeffer's figure 13, the two marginal rows of suckers are enlarged and are not unlike those of *Thelidioteuthis* (Pfeffer, 1912, pl. 18, fig. 29). Indeed were it not for the absence of light-organs and other features in all the 91 specimens, I would be tempted to imagine that this might be referable to that genus. Unfortunately there are no signs of the dif-

ferentiation of the suckers into hooks except in one specimen 12 mm. long and in this the manus is so badly preserved that its precise arrangement cannot be made out.

***Onykia* ?*appellofi* (Pfeffer).**

A single (♀) specimen from Stn. 61; T-5 (No. 113); 600-0 fms.

The general shape of the head, body, manus and fins of this specimen agree very closely with *Onykia appellofi*. The manus is particularly like that of *appellofi* figured by Pfeffer (1912, pl. 3, fig. 9). The specimen measures 27 mm. in mantle-length.

***Onychoteuthis* ?*banksi* Leach.**

A very immature example 8 mm. long from Stn. 51, S. of Hood Id., T-2 (No. 156), 165-0 fms., may be referable to this species. It is very like the young specimens figured by Pfeffer.

SUBFAMILY LYCOTEUTHINAE.

Genus and species uncertain.

One specimen from Stn. 84, T-8, 9 or 10 (No. 163), in 500, 400-0 fms.

This is a small, well-preserved specimen measuring about 5 mm. in mantle-length. There are no hooks on any of the arms and none on the tentacles. The arm-suckers are in 2 rows, the tentacular ones in four rows, there being very little difference in size between the suckers. The adhesive apparatus is of the simple type found in the Architeuthidae, Enoploteuthidae and Onychoteuthidae. The fins are very small and terminal. Three light-organs occur on the ventral periphery of the eye-ball and on the under surface of the head and mantle. There are none inside the pallial cavity.

This is a very interesting specimen. It was originally labelled by Mr. Pearson as "Enoploteuthidae; genus undetermined." I think, however, that in young enoploteuthids of this size, the arm-suckers, and probably the tentacular suckers as well, are modified as hooks (cf. Pfeffer 1912, pp. 120 and 141). We ought, therefore, to regard it as an onychoteuthid (the Architeuthidae being ruled out by the occurrence of light-organs). In the Onychoteuthidae the hooks of the tentacles (when they occur) seem to be developed late, since in the specimen of *Teleoteuthis caribaea* over 5 mm. long figured by Pfeffer (1912, pl. 1, fig. 12), the hooks are not yet seen. This might be held to be an early stage of any onychoteuthid genus. The only group of this family, however, that have light-organs are the Lycoteuthinae. As (a) the equivalent stage of the other genera show a sign of size-differentiation in one of the marginal rows of tentacular suckers, which is lacking in this specimen, and as (b) the Lycoteuthinae have no hooks at all, I am inclined to regard this specimen as representing a new group of this subfamily differing from the typical forms in having ocular but no tentacular or intrapallial light-organs.

FAMILY HISTIOTEUTHIDAE.

Stigmatoteuthis Pfeffer.

In his key to genera of Histioteuthidae, Pfeffer distinguishes *Stigmatoteuthis* from *Calliteuthis* by its possession of denticular arm and tentacle-suckers and the lack of accessory chitinous structures on the manus. I am not altogether certain that this is a satisfactory distinction, as there are some marked deviations in the form of the manus in the species which by this definition fall into *Stigmatoteuthis*.

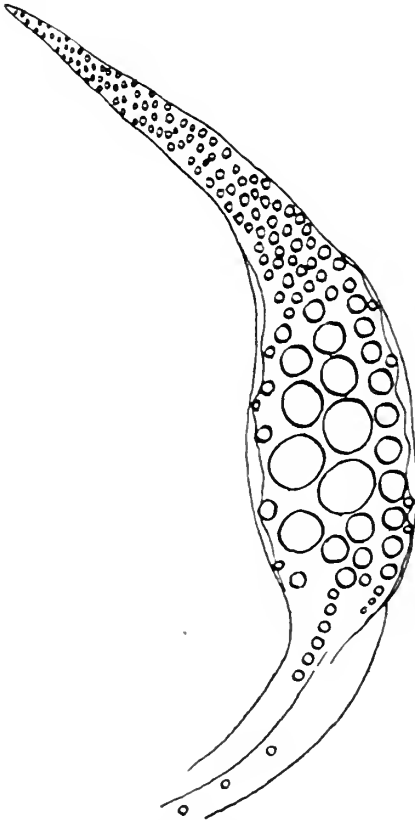
Stigmatoteuthis arcturi n. sp.

(Text-figs. 5-6).

One specimen (♀) from Stn. 7 (No. 18); (26° 54' N; 51° 15' W.); PT-1; 1,640 fms.-surface.

Dorsal Mantle, length:	32± mm.
“ , width:	16± mm.
Fins, length:	11± mm.
“ , width:	11± mm.
1st. arms, length:	ca. 64 mm.
2nd. “ “ :	ca. 64 mm.
3rd. “ “ :	ca. 66 mm.
4th. “ “ :	ca. 62 mm.

The head region has been badly damaged and the epidermis has been removed from all the arms save the ventral. The body is rela-



TEXT-FIG. 5. *Stigmatoteuthis arcturi* n. sp.; tentacular manus.

tively small and broadly conical. It differs in its greater width from *S. verrilli* (= *C. reversa* Verrill). The arms are subequal, but in their present condition it is not easy to specify their exact length.



TEXT-FIG. 6. *Stigmatoteuthis arcturi* n. sp.; cephalic light organ, ×13.

The chitinous rings of the majority of the arm-suckers are equipped with a number of low, broad and closely-set teeth. These are usually better marked on the distal periphery and on some they are virtually absent on the proximal part of the ring.

There is no trace of the excrescence on the proximal circumference noted by Pfeffer in *S. goodrichii*.

The fins are rather torn and their exact shape is uncertain. They seem to be sub-circular. The apical margin projects beyond the end of the body. The surface of the tentacular manus is roughly divisible into two areas, a proximal expanded part bearing the large suckers and a narrow and very much longer distal part bearing very minute suckers (Text-fig. 5). The general shape reminds one of that of *Calliteuthis meneghini* (Pfeffer, 1912, pl. 22, fig. 13), though the resemblance ceases there. There seem to be six rows of suckers in all, but two (the outer marginal of each side) are represented only by 2-3 very minute ones. The first two rhachial pairs are small and are followed by four very large pairs which decrease slowly outwards. After about the seventh rhachial pair the order becomes confused but the distal region seem to consist of 4 or 5 rows. The other margin is occupied by a single row of suckers which are very minute to begin with, and then increase up to the eighth, after which they decrease and become of a size with the distal ones. There is a carpal row of six suckers and knobs. There is no trace of any accessory chitinous pieces. The rim of the sucker-rings is beset, in the majority of the suckers, with a complete series of small distinct and acute teeth. The light-organs (Text-fig. 6) differ from those of *S. goodrichii* as figured by Pfeffer, (1912, pl. 22, fig. 9). The gladius has the lateral areas narrow and not wide as in *S. dofleini*.

This species differs clearly from those previously described, principally in the character of the manus. Differences from *S. goodrichii* and *verrilli* have already been noted. From *S. hoylei*, which it resembles in a gen-

eral way, it differs in the arrangement of the suckers of the manus. Also the teeth of the arm-suckers of that species are said to be sharp. From *S. japonica* it differs very distinctly, particularly in the tentacles. From *S. ocellata* it differs in that the suckers of the latter are "finely spinous" and from *S. dofleini* it differs in the tentacles (Sasaki, 1929, pl. XXII) and in having the lateral area of the gladius narrow and not wide.

Histiothauma n. gen.

Histioteuthid forms without any trace of a web and with very small fins. The peduncles of the suckers are enlarged to form large pyramidal structures. Arm-membranes of both kinds absent. The distribution of light-organs, as far as density is concerned, is midway between *Histioteuthis* and *Meleagroteuthis*. No light-organs on the dorsal surface of the mantle and fins. The tentacular suckers small and undifferentiated in size; no carpal system.

Type of the genus: *H. oceani* (see below).

For some time I was convinced that *Histioteuthis* was a juvenile form of *Meleagroteuthis*. Not only is there a vague general likeness, but in some respects, notably in the disposition of the light-organs on the dorsal arms, the agreement is close. The geographical distribution of the forms also favours this view. On comparing the following list of differences it seems to me, however, that *Histioteuthis* cannot be a young *Meleagroteuthis*. The difference between Pfeffer's specimen (26 mm. mantle-length) and Berry's (up to 59 mm.) are inconsiderable as compared with the differences between these two and the Galápagos specimen. Even if we disregard the condition of the suckers as problematical, so many points of difference still remain of an order not associated with growth-changes, that I have no option but to provide a new genus for the *Arcturus* specimen.

Mantle-length (dorsal): 7.2

Mantle-width: 8

Fins, length: 3.8 (±)

Fins, breadth: 2.6 (±)

Arms 1st: 16.0 (±2)

Arms 2nd: 16.0 (±2)

Arms 3rd: 16.0 (±2)

Arms 4th: 16.0 (±2)

Tentacles: ca. 42

The body is broadly conical and nearly as wide as long. The apex is rounded and blunt. The fins are very small relative to the size of the mantle and do not project beyond the apex and sides as in the other members of the family. They are very much crumpled and their exact shape is not certain but they seem to have been longer than wide.

The arms are subequal. They are devoid of swimming membranes and "Schutzsaüme." The suckers on all the arms are represented by their bases alone which are rather large (usually pyramidal) structures at the apex of which is sometimes seen the vestige of a thread-like stalk (?). On some of the arms a very minute adoral sucker persists. This is quite normal and its chitinous ring seems to be edentulous. Owing to their scarcity I have removed some of these for closer examination.

At first sight one would assume that the suckers had been lost by accident; but if they had been stripped by contact with some foreign body one would expect to find one or two persisting here and there over the arm generally as is often seen. One cannot speak for certain but it seems to me that this is no case of accidental loss. The "cartilaginous" tubercles found by Pfeffer on the dorsum of the three upper arm-pairs are present in this form. But I could find no median pallial row. Berry (1912, p. 308) could find neither and surmises that this may be a juvenile character.

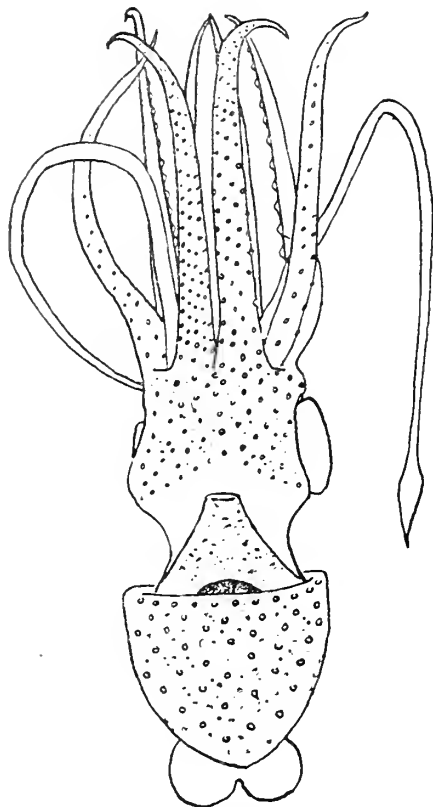
	<i>Meleagroteuthis</i>	<i>Histiothauma</i>
Light organs	Close, numerous. Dorsal and ventral.	Less numerous. Very few dorsal.
Web	Present between upper arms.	Absent.
Arm suckers	Normal.	? Absent.
Manus	Suckers clearly differentiated in size. Carpal suckers present.	Suckers more or less equal. No carpal suckers.
Arm membranes	Both types present.	Absent.
Fins	Over ½ length of mantle. Projecting beyond apex.	Well under that length. Not projecting beyond apex.
Light-organs	Complex.	Simple.

***Histiothauma oceani* n. sp.**

(Text-fig. 7)

One example (?♂) from Stn. 51; S.E. of the Galápagos; T-2, (No. 29); in 165-0 fms.

The tentacle-manus exhibits a number of minute suckers which show even less size-differentiation than *Meleagroteuthis*. They seem to be in six irregular rows. The rims exhibit a number of low knobs or plates which



TEXT-FIG. 7. *Histiotauma oceani* gen. et sp. nov.; ventral aspect, $\times 3$.

in some seem to be raised here and there into what would pass for teeth, though on the whole one would call them edentulous.

There is no trace of a web on any of the arms.

Light-organs: On the first three pairs of arms, there are two disposed irregular (dorsal and ventral) rows of these organs. Occupying the sagittal line on the 1st-3rd arms is a single series of subcutaneous white masses which may also be luminous. On the fourth pair there are five rows of organs, at least to begin with. The organs are rather openly distributed over the ventral surface of the mantle, below a line drawn diagonally from the edge of the mantle, opposite the eye, to a point on the ventral surface, just short of the apex. There are very few on the funnel or fins. The organs are simple and consist (macroscopically) of a simple globular body surmounted by a dark pigment mass.

The left eye, as in examples of other species in this family, is very much larger than the right. This is noted in *Meleagroteuthis hoylei* (Berry, 1912, p. 305; Pfeffer, 1912, p. 295), *Histioteuthis bonelliana* (Robson, 1924, p. 608) and in *Hymenoteuthis macropo* (Berry, 1912, p. 273). This curious phenomenon has never had sufficient attention paid to it. It may be the prelude to a general change of symmetry.

On the two ventral arms the reduction of the suckers is carried to a further extreme. The pedicels are over the greater part of the arm so reduced as to be almost imperceptible. Whether this is to be interpreted as hectocotylization I cannot say. Unfortunately the animal is very immature and it is not possible to determine the sex from the internal organs.

Genus and species uncertain.

One specimen (? sex) from Stn. 74; S. of Cocos Id.; T-2 (No. 68); in 620-0 fms.

This specimen is very much damaged and does not permit of exact study. It measures 11 mm. in mantle-length. It cannot be readily accommodated in any of the known genera. It has light-organs of the scattered type, the suckers are edentulous, the manus is devoid of accessory chitinous pieces and has about 7 rows of smallish suckers. This combination of characters seems to exclude it from the genera hitherto known. As it is so young and may not represent the adult condition I refrain from describing it as a new genus. As a matter of fact, according to the figure of a young *Calliteuthis* given by Chun (1910, pl. 19, figs. 1 & 2, as *Histioteuthis*, determined as *Calliteuthis* by Pfeffer, 1912, p. 268) the manus in that genus of a specimen with mantle-length 10 mm. is undifferentiated. On the other hand the fins of this form are quite unlike those of *Calliteuthis*.

One specimen from Stn. 86; Galápagos Is.; (No. 20); in 600-0 fms.

The remarks made about the preceding form are applicable to this specimen. It has scarcely any web, non-denticulate suckers, the tentacles are devoid of accessory chitinous pieces and the light-organs are small and far more separated than in *Meleagroteuthis*. By the ordinary procedure it is placed in the group of *Calliteuthis* and *Stigmatoteuthis*. But its characters (toothless suckers, no accessory pieces on manus) cut across Pfeffer's classification. It measures 18 mm. in dorsal mantle-length and may be a young form of either of these genera.

FAMILY OMMATOSTREPHIDAE.

Genus and species uncertain.

Two specimens (? sex) from Stn. 74; S. of Cocos Id.; T-7 (Nos. 82 and 73); ? Depth.

These are small specimens measuring 15 mm. in mantle-head length. Their position is rather enigmatic. The foveola is undifferentiated, which immediately ranks them with *Illex* and *Todaropsis* and yet the tentacular manus being clearly undeveloped (it consists of a few small suckers), it is impossible to say if they should go into *Illex* or into *Todaropsis*. Mr. Pearson originally diagnosed them as "*Symplectoteuthis*." Actually I found a very loose strand of tissue connecting the two parts of the adhesive-organ on one side of our specimen but it was really impossible to say if this was adventitious or not. The entirely undifferentiated foveola puts this suggestion out of court at once. In shape,

size of fins, etc., it is not at all unlike the young *Illex* figured by Pfeffer (1912, pl. 29, figs. 3-4). The adhesive-organ also is more like that of *Illex* than it is to *Todaropsis*; but the longitudinal cleft of the cephalic component is not nearly so open as in that genus. The denticulation of the suckers is very obscure.

SUBFAMILY STHENOTEUTHINAE.

Sthenoteuthis pteropus Steenstrup.

Seven specimens (6♀, 1♂) from Stn. 74, D. 1; (No. 803).

These specimens have typical tentacular manus, siphonal foveola and "adhesive-organs." The largest has a dorsal mantle-length of 110 mm., the smallest 49 mm.

Sthenoteuthis bartrami Lesueur.

One specimen (♀) from unknown station, (? CN 2).

A fairly typical form 144 mm. in dorsal mantle-length with 6-7 suckers on the proximal side of the first modified sucker of the manus. The cephalic element of the locking-apparatus is somewhat different in detail from that figured by Pfeffer (1912, pl. 35, figs. 8-9).

(?1) *Sthenoteuthis* sp. (*Rhynchoteuthis* stage). (Text-figs. 8-10).

4 specimens from Stn. 40; off Albemarle Id., Galápagos; T-1 (Nos. 120 and 137); from surface.

1 specimen from Stn. 50; S. of Hood Id.; T-2 (No. 147); 400-0 fms.

1 specimen from Stn. 52; S. of Hood Id.; T-1 (No. 135); surface.

1 specimen from Stn. 53; S. of Hood Id.; T-2 (No. 103); 800-0 fms.

8 specimens from Stn. 62; off Malpelo Id.; T-1 (No. 138); surface.

1 specimen from Stn. 65; N. E. of Cocos Id.; T-3 (No. 121); surface.

1 specimen from Stn. 68; N. of Cocos Id.; T-1 (No. 108); surface.

15 specimens from Stn. 74; S. of Cocos Id.; T-66 (No. 130); surface.

9 specimens from Stn. 74; S. of Cocos Id.; T-45 (No. 139); surface.

5 specimens from Stn. 74; S. of Cocos Id.; T-66 (No. 131); surface.

13 specimens from Stn. 77; S. of Cocos Id.; T-2 (No. 133); surface.

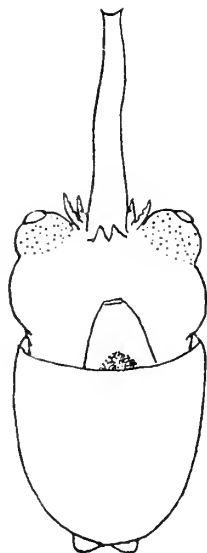
12 specimens from Stn. 77; S. of Cocos Id.; T-1 (No. 123); surface.

7 specimens from Stn. 78; N.E. of Galápagos Is.; T-1 (No. 128); surface.

13 specimens from Stn. 78; N.E. of Galápagos Is.; T-1 (No. 127); surface.

1 specimen from Stn. 84; Galápagos Is.; T-3 (No. 173); surface.

4 specimens from Stn. 84; Galápagos Is.; T-8, 9, or 10 (No. 161); 500-0 fms.

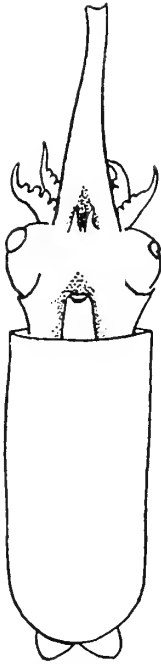


TEXT-FIG. 8. *Sthenoteuthis* (?), *Rhynchoteuthis* stage; larva with a mantle-length of 2.5 mm. from Stn. 53 (No. 103).

This interesting series of 102 individuals varying in size from 10 mm. (mantle-length) down to about 1.9 mm. seems to contain representatives of two species. The whole series was measured and the mantle-width and "spout" width was expressed as a percentage of length from the apex to the center of the eye. On the whole there is manifest a distinct correlation between small size and greater width of the mantle; in other words, younger specimens tend to be wider than older ones. They also tend to have a shorter "spout."



TEXT-FIG. 9. *Sthenoteuthis* sp. (?), *Rhynchoteuthis* stage; larva with a mantle length of 8.4 mm., from Stn. 74 (No. 130).



TEXT-FIG. 10. *Sthenoteuthis* (?), *Rhynchoteuthis* stage; larva with a mantle length of 3.5 mm. from Stn. 74 (No. 131).

Nevertheless the correlation is by no means absolute and two specimens (131/1 and 147/1) are far narrower than the average for their group-size and have a shorter "spout." These seem to me to be representatives of a different species. Chun (1910) noticed a similar dimorphism and Pfeffer (1912, p. 390) considered it evidence of the fact that two distinct species have a *Rhynchoteuthion*-stage. I suspect that the difference between No. 130/3 (width index 50) and No. 139/3 (index 34), of which one is but a millimetre longer than the other, is of systematic importance. Like Degner (1925, p. 42) I could find no clear indication of a differentiation into large- and small-eyed types (Chun, 1910). As far as I can see at present, it is by no means easy to assign any of the various *Rhynchoteuthion* stages to a particular species of the *Sthenoteuthidae*. On the whole specimens obtained by the *Arcturus* do not tend to resemble the early stages figured by Pfeffer (1912, pl. 37, figs. 8-10), though some later stages are like Pfeffer's pl. 37, figs. 2-3.

The most valuable information to be gleaned from these measurements relates to the "spout." Apparently it is developed at an earlier stage than any represented here, as in the smallest it is long and fully developed and the two moieties are nearly completely fused up. Chun (1912, p. 203) found it developed in a specimen 0.8 mm. long. Pfeffer (1912, p. 380) found a specimen of 3.2 mm. mantle-length still covered by an "embryonale Haut." Specimen from Stn. 84 (No. 173),

which measured under 2 mm. in mantle-length, was similarly covered in a membrane and was described by Mr. Pearson as an "egg." The spout is very well developed in this specimen. Its relative length gradually decreases until at about 9.0 mm. length it is not more than 10 or 12% of the body-length. At about this period the two elements which at the earliest stages are completely fused have gradually come apart and are found separated for $\frac{1}{2}$ - $\frac{3}{4}$ of their length. They eventually separate when the animal is 9-10 mm. long. It is quite evident that the fused moieties actually separate. A limited number (13) of these forms of sizes varying from 4.0 to 6.1 mm. in size do not show the spout at all. The tentacles which are very small are completely separated and seem to be mere stumps. It remains to be seen whether these are (1) members of a species distinct from those having the *Rhynchoteuthion* stage; (2) forms which have prematurely lost the funnel; or (3) forms in which it has not yet developed. The development, etc., of this organ suggests several interesting and important questions which are outside the scope of the present paper.

On the whole my results agree with those of Degner, as far as the formation of the spout is concerned. In the early stage it shows a complete fusion of the two moieties and at about 7 mm. long the latter are in contact towards the extremity only. I differ from Degner in finding that at about 7 mm. the area of fusion is in some individuals as much as half the length of the spout. Nor do I find the separation at the apex figured by Degner (1925, fig. 32).

Hyaloteuthis pelagica (Bosc).

One specimen (? ♀) from Station 54, off Hood Island, Galápagos (No. 55), taken at the surface from the ship.

This is a small and very slender specimen 25 mm. long by 5 mm. wide with fins 6 mm. long or nearly a quarter of the mantle-length. The ventral white patches have an arrangement much more like that shown by Férussac and d'Orbigny (1835-48, "Calmars," pl. 18, figs. 1 & 2; and "Ommastrephes," pl. 1, figs. 17, 18) than that illustrated by Pfeffer. The structure of these patches does not agree with the descriptions already given, in two respects. (1) They are not raised above the surface as "petits tubercules blancs, à peine saillants" (Férussac and d'Orbigny, p. 348); (2) nor are they "feache punktfontnigen Gruben, welche im ihrem Grunde je einen . . . Tuberkel tragen" (Pfeffer, 1912, p. 463). They are simply dense white and semi-lustrous patches lying evenly with the surface. A section through one shows no sign of special organization. I assume that, as this specimen is young (Férussac and d'Orbigny's specimen and that in the Hamburg Museum measured 55 mm. in mantle-length according to Pfeffer, 1912, p. 464), the light-organs may not be fully developed.

Symplectoteuthis oualaniensis (Lesson).

One specimen (♀) from stomach of *Germolunga pelamis*, Stn. 74 (No. 5), S. of Cocos Id.

This specimen is very badly damaged and in particular the epidermis has been completely stripped off the ventral surface so that it is not possible to say if the ventral luminous streaks given by Sasaki (1929) as the only diagnostic difference between *S. oualaniensis* and *S. luminosa* are present or absent. Berry has placed the latter in a different genus, *Eucleoteuthis*.

The animal is a small one and measures only 70 mm. from the base of the dorsal arm to the apex of the body. It is remarkably slender as compared with the thicker specimens (e.g. that figured by Pfeffer), but agrees with *oualaniensis* in general shape and not with *luminosa*.

It further differs from *oualaniensis* in (1) the profile of the keel on the 3rd arms, which is lower and not triangular; (2) the shallower "Schutzsaüme" of that arm; and (3) the marked compression of the tentacular manus. I do not know how far all these characters might not be produced by maceration, etc.

Genus and species uncertain.

A very much mangled and fragmentary specimen identified by Mr. Wesley as *S. oualaniensis* does not appear to me to be referable to either of the species of that genus. The fins are well under 1/3 of the mantle-length.

FAMILY CHEIROTEUTHIDAE.**Chiroteuthis** (*Planctoteuthis* stage).

(Text-fig. 11).

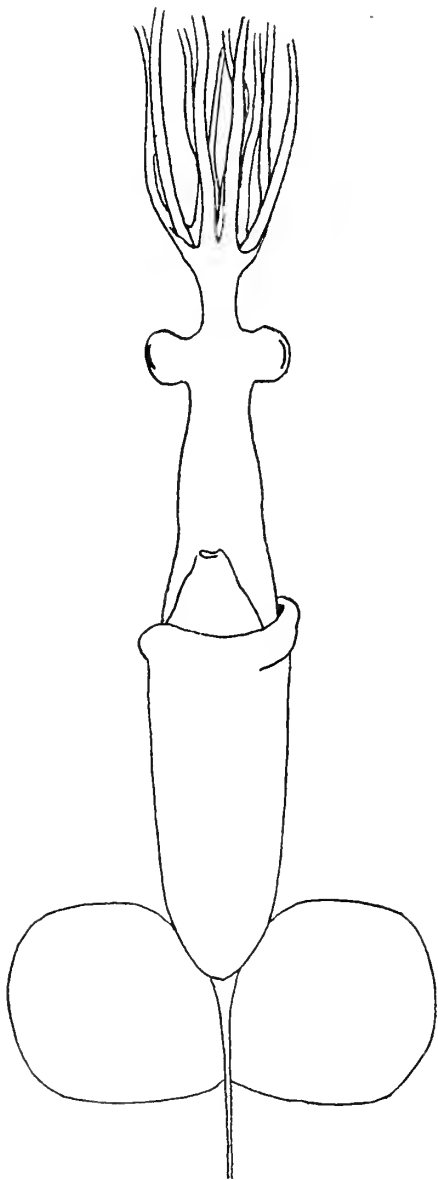
One specimen from Stn. 74; S. of Cocos Id.; T-70 (No. 40); in 500-0 fms.

This specimen, which is very much distorted and mangled, measured ca. 30 mm. from the upper edge of the fins to the eyes. The arms are in the order 4.3.2. (?3=2).1. The manus exhibits four equal rows of suckers which are not differentiated distally as in the "*Doratopsis*" stage. The cephalic component of the adhesive-organ has a basal projection, as in Chun's "*Doratopsis exophthalmica*" (1910, pl. XLVII, fig. 2). Like that species it also has a very slender "Hals" just above the eyes. But its fins are much larger and the body is wider. In the size of the fins it resembles the stage described by me as *Doratopsis* sp. A (1924). The form and length of the terminal spine is uncertain.

This seems to be a new juvenile form.

One specimen from Stn. 45, T-3 (No. 21), from 200-0 fms.

This specimen resembles the above very closely and is better preserved. The head and "neck" (above and below eyes) measure just about the same as the distance from the edge of the mantle to the posterior edge of the fins. This seems to have a complete "spine" 1½ times as long as the fins.



TEXT-FIG. 11. *Chiroteuthis* sp., (*Planctoteuthis* stage), ventral view of specimen from Stn. 74 (No. 40).

One specimen from Stn. 74, PT. 2 (No. 27), from 600-0 fms.

A larger specimen, very much crumpled. It measures 36 mm. in mantle-length. The fins are not quite so large.

Two specimens (fragments) from Stn. 68, PT.-1 (No. 172), from 600-0 fms.

Specimens very much mangled. Fins and mantle only, measuring 26 and 19 mm. in mantle-length.

One fragment from Stn. 74, PT.-1 (No. 201), from 600-0 fms.

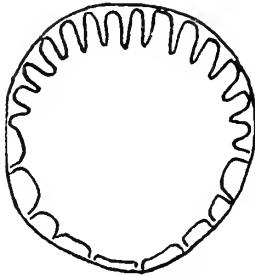
Diagnosed by the characteristic fins. 35 mm. long.

***Mastigoteuthis* sp.**
(Text-figs. 12-13).

One specimen (? or two) (? sex) from Stn. 86; (No. 11); S.W. of Narborough Id., Galápagos Archipelago; (No. 17); surface-1,000 fms.

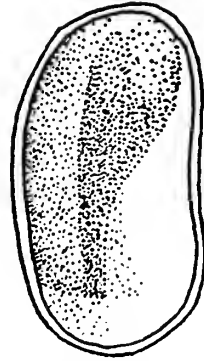
This specimen is in very bad condition. The skin has been entirely stripped off the muscles. It is represented by a head, body and fins all separate, and some fragments of tentacles. I am in fact very uncertain whether the body and fins belong to the same animal. For that reason I refrain from describing it as a new species, which I would most certainly be compelled to do if I were convinced that the fragments were referable to the same animal. The following are such data as I feel qualified to record.

Mantle-length:	65 mm. (?90).
Mantle-width:	24 mm.
Fins, length:	70 mm.
Fins, total width:	62 mm.
Arms R. 1 length:	70 mm.
“ 2 “ :	90 mm.?
“ 3 “ :	90 mm.?
“ 4 “ :	—
Tentacles:	280?+



TEXT-FIG. 12. *Mastigoteuthis* sp., sucker ring from the third arm, $\times 33$.

It is uncertain how long the mantle actually is, as the fins with what looks like the apical part of the gladius have been torn from it. The fins may have been 7/9 of the length of the mantle. They are only slightly longer than wide. The body is rather slender. The arms are probably in the order 4.3.2.1. as usual, but a very unusual feature is the great length of the upper arms which are longer than the mantle. The suckers of the third arm have their distal edge armed with about 14 longish teeth; proximally these become low, broad plates. The cephalic component of the adhesive-organ is moderately wide, its width being 53% of its length. Its rim is very narrow. This form differs from Hoyle's *M. dentata* (1904, p. 34) which was recorded from near the Galápagos in the size of its fins and arms, the dentition of the suckers of the latter and the shape of the adhesive-organ. Nor can I associate it with any other recorded species.



TEXT-FIG. 13. *Mastigoteuthis* sp., cephalic component of adhesive organ, $\times 5\frac{1}{2}$.

***Mastigoteuthis* sp.**

A single tentacle just over 29 cms. long from Station 12; 27° 58'N. 46° 52'W.; (No. 166); "found on sounding-wire" (sounding of 2,840 fms).

This fragment is not like any previously described tentacle of *Mastigoteuthis*. The suckers are excessively minute and very numerous. They seem to be sessile or at least to have very short stalks. I could not distinguish any teeth on the rings.

One specimen (very much damaged) from Stn. 33, PT.-1 (No. 84); from 700-0 fms.

One specimen (very much damaged) from Stn. 50, T-2 (No. 145); from 400-0 fms.

One specimen (very much damaged) from Stn. 33, PT.-1 (No. 85).

Nothing very useful can be said regarding these damaged specimens.

FAMILY CRANCHIIDAE.

***Liocranchia reinhardtii* Steenstrup.**

4 specimens from Stn. 38; off Tower Id., Galápagos; PT.-1 (No. 71); 300-0 fms.

1 specimen from Stn. 38; off Tower Id., Galápagos; Pt.-2 (No. 53); 500-0 fms.

1 specimen from Stn. 33; N. E. of Galápagos; Pt.-1 (No. 8); 700-0 fms.

1 specimen from Stn. 59; S. of Cocos Id.; PT.-1 (No. 52); 600-0 fms.

1 specimen from Stn. 74; S. of Cocos Id.; T-21 (No. 98); 600-0 fms. (shrivelled).

1 specimen from Stn. 74; S. of Cocos Id.; T-76 (No. 51); 500-0 fms.

1 specimen from Stn. 84; Galápagos Id.; PT.-1 (No. 61); 500-0 fms.

1 specimen from Stn. 84; Galápagos Id.; T-1 (No. 150); 300-0 fms.

1 specimen from Stn. 84; Galápagos Id.; T-8, 9 or 10 (No. 158); 500-0 fms.

1 specimen from Stn. 84; Galápagos Id.; T-5 (No. 47); surface.

7 specimens from Stn. 84; Galápagos Id.; PT.-1 (No. 7); 500-0 fms.

7 specimens from Stn. 84; Galápagos Id.; PT.-3, 4 (No. 54); 700-0 fms.

? specimens from Stn. 84; Galápagos Id.; T-14, 20 (No. 54); 500-0 fms.

1 specimen from Stn. 86; Galápagos Id.; T-11 (No. 48); 300-0 fms.

1 specimen from Stn. 86; Galápagos Id.; T-8 (No. 16); 500-0 fms.

1 specimen from Stn. 87; Galápagos Id.; PT.-1 (No. 46).

The following table gives the length \times width ratio and the length of the fins.

Coll. No.	Mantle-length	Mantle width % length	Fins length % mantle-length
16	42	33	23
48	32	27	21
51	26	34	21
71a	26	28	12
71b	25	36	16
46	22	40	13
71c	19	36	13
71d	19	36	14
541	15	40	13
542	14	50	14
543	14	45	12
544	14.3	41	12
47	14	42	14
52	14	46	15
545	13.5	45	14
546	13.2	53	13
61	13	38	11
150	11.5	47	12
547	11	45	19
53	10.5	52	14
158	10+	50	18

From this it seems pretty clear that longer specimens tend to be narrower and to have longer fins. Nearly all the forms in the *Arcturus* collection are relatively narrow and only four attain or exceed an index of 50. The actual form of the body varies from a regularly narrow ovoid to a vase-like form with the greatest width situated anteriorly and slender apical region.

The fins: The apex of the body extends half way or rather less down the fins. I found no specimens like those figured by Pfeffer (1912, pl. 48, fig. 21) in which the apex scarcely overlaps with the fins. The fins are relatively very small and in no case exceed 23% of the mantle-length.

They tend to occur in two phases—one in which each fin has an outline representing the large part of the circumference of a circle and another in which they are rather wider than long.

Arms: In the largest specimen (No. 16) there are 16-17 pairs of regularly biserial suckers on the 3rd arms (cf. the very dif-

ferent arrangement in Sasaki's description). The tentacles differ from those usually encountered in that there is a very marked and abrupt difference in size (manifest at or about the 10th row) in the suckers, there being a small apical region of very small suckers and a larger proximal area having a number of very large ones.

"*Ventral Bands:*" Pfeffer (1912, p. 666) gives as a difference between this species and *globulus* Berry, that there is a double tubercle at the apex of the angle formed by the bands. I have found in these specimens that the tubercle is sometimes double, sometimes single and that sometimes there are two separate tubercles.

Remarks: *L. reinhardti* is manifestly a very variable species and I am not at all sure that all the forms which have been included in it are conspecific. Not only does the bodily shape and that of the fins vary enormously (though an age-factor is undoubtedly influential here), but also the arrangement of the suckers on the arms and tentacles, the relation between the fins and the body-apex, and other characters, etc., differ considerably in the described specimens.

The specimens here recorded seem to be a more or less homogeneous population; but until the variation of this species and of *valdiviae* is more thoroughly understood, the status of the various described forms is determined and the effects of age and sex evaluated, not much can be said.

Galiteuthis sp.

One specimen (??) from Stn. 86; off Narborough Is., Galápagos; T-2; 500-0 fms.

This very interesting form is badly damaged and in poor condition and I am unable, in the absence of several important features, to speak with certainty as to its status.

The form of the fins and the smooth arm-suckers ally it with *Galiteuthis*. Unfortunately the arms have been wholly stripped of their integument and one cannot find any trace of the support-membrane from which to see if the characteristic trabeculae are present. On the other hand the tentacles are absent, which Pfeffer (l.c.) makes a diagnostic feature of *Taonius*. It should be noted that Sasaki gives a description of a *Taonius* with complete tentacles. The outstanding feature of the present specimen, as in Joubin's specimen and one of Sasaki's, is the enormous length and remarkable slenderness of the body. Actually it measures 241 mm. from the centre of the eye to the apex and its width was probably about 22 mm. or under 10% of

	Length	Width nearly	Width: Length %	Fins % Length
<i>phyllura</i> (Berry, 1912)	230	35	nearly 15	49
<i>armata</i> (Chun, 1910)	121	20	16	42
(Sasaki, 1929)				
larger spec.	270	27	10	51
(Joubin, 1898)	350±	—	10	50

the length. The fins measure about 92 mm. from the tip of the gladius to the anterior insertion-point. They are thus nearer a third than a half of the mantle-length (actually 37%). These proportions may be compared with the other species.

The fins, as in Sasaki's figured specimen, but unlike those of Joubin and Chun, are continued right to the apex and there is no protruding "Schwanzfaden" as in the two latter. Differences in this respect as well as in the width of the body make it very likely that all the specimens recorded as *armata* are not actually referable to the same species.

Besides the features above indicated there are no others in a suitable condition for description.

***Taonidium pacificum* n. sp.**

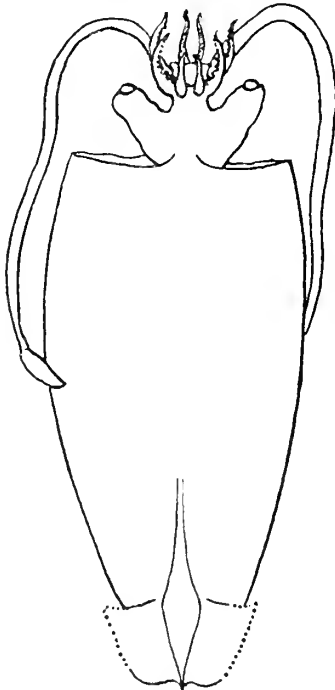
(Text-fig. 14).

One specimen from Stn. 66; N. of Cocos Id.; PT-1 (No. 49); 600-0 fms.

One specimen from Stn. 68; N. E. of Cocos Id.; PT.-1 (No. 81); 600-0 fms.

Measurement (mm). (Larger specimen).

Dorsal mantle-length:	29±
Mantle, width:	14±
Head, length:	3
Fins, length:	4
Arms length, 1st:	2.2
2nd:	3.2
3rd:	4.4
4th:	4.0(?+)
Tentacles, length:	25.0



TEXT-FIG. 14. *Taonidium pacificum* n. sp.; dorsal view, circa $\times 2\frac{1}{2}$.

The body in both specimens is elongate and broadly conical. The fins in the larger specimen are about $\frac{1}{8}$ of the total length and together form a rather broad oval. They are distinctly longer than wide. In the smaller specimen they are much smaller and narrower and though it is likely that this small size may be due to damage, both fins are equal in width and there is no apparent damage.

The tentacles are about as long as the mantle (smaller specimen) or a little shorter than it (in the larger). The manus consists of four series of sub-equal suckers with smooth rings. There are about 10 rows of these. The tentacle stem bears two rows of minute suckers.

In the larger specimen the arms seem to be in the order 3 = 4.2.1. The funnel-organ is more or less crescentic.

Remarks: According to Pfeffer's key this should be *P. chuni* but it differs from that obviously juvenile form (a) in the greater length of the arms and tentacles, (b) in the shape of the body and (c) in the size and shape of the fins.

***Helicocranchia beebei* n. sp.**

(Text-figs. 15-18).

1 specimen from Stn. 74; S. of Cocos Id.; Petersen Fish Trawl No. 1 (No. 144); 600 fms. to surface.

1 specimen from Stn. 86; off Galápagos; T-8 (No. 9); from 500-0 fms.

1 specimen from Stn. 28; S.E. of Cocos Id.; T-1 (No. 142); from surface.

1 specimen from Stn. 74; S. of Cocos Id.; OT-3 (No. 63); from 833-0 fms.

1 specimen from Stn. 74; S. of Cocos Id.; PT-1 (No. 39); from 600-0 fms.

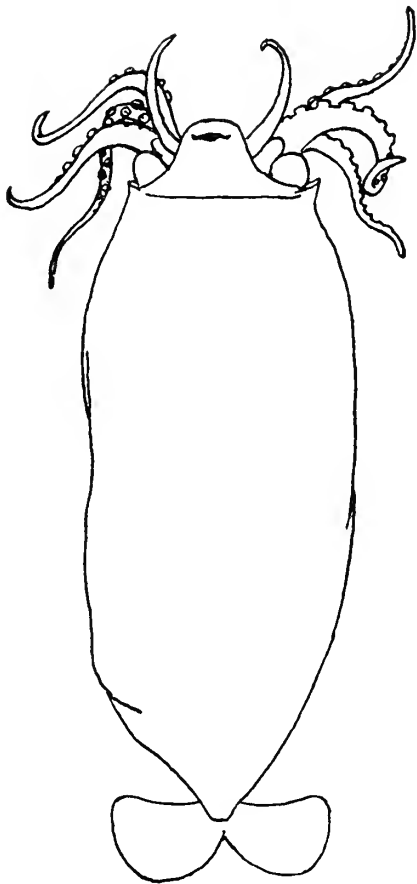
1 specimen from Stn. 74; S. of Cocos Id.; PT-3 (No. 58); from 620-0 fms.

Dimensions.

Dorsal length of mantle:	54 mm.
Width of mantle	
(round the curve):	26 mm.
Length of fins (maximum):	4.9 mm.
Width of fins (total):	13.0 mm.

	R.	L.
Length of 1st arm:	16	16
Length of 2nd arm:	16	17
Length of 3rd arm:	14	14
Length of 4th arm:	11	10

The mantle region is stouter than in *H. pfefferi*. The fins are peculiar and may constitute a ground for excluding this form from Massy's genus. She states in her generic definition (1904, p. 34) that the fins are attached to the end of the dorsal surface and are pedunculate. In our form they are certainly not pedunculate nor are they attached as in *H. pfefferi*. On the other hand there do not seem to be available any detailed drawings of the fin-insertion of *Teuthowenia*. On



TEXT-FIG. 15. *Helicocranchia beebey* n. sp.;
 $\times 1\frac{1}{2}$.

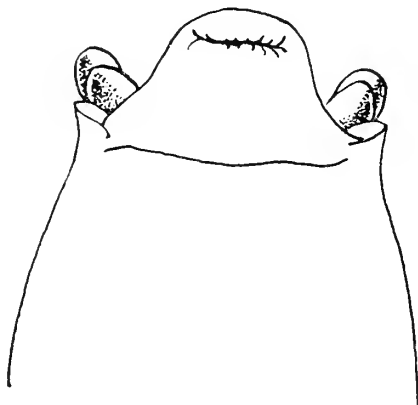
the whole in *H. beebey* the general plan of the insertion of the fins is not unlike that figured by Pfeffer (1908a, p. 105, fig. 120) for *T. megalops*. The shape of the fins and the angle at which they are set to the main axis are very characteristic.

The cephalic region, on the other hand, is very like that of *Helicocranchia*. The arms are in the order 1 = 2.3.4., the longest arms are one-third the length of the body as in *Helicocranchia*, though the order is different. The funnel rises well above the eyes as in Massy's genus, but it is thicker and not so pointed as in the latter. The median part of the funnel-organ is of the same type as in *Helicocranchia*, but its three sections are all more angular and form a less symmetrical trefoil-pattern. The lateral portions are markedly different, as they are L-shaped and very remote from the median part. The suckers have been damaged, so that it is impossible to discuss their number and arrangement. The oral surface has apparently undergone some violent pressure and I find it a little hard to distinguish the real character of the surface.

For example most of the adoral suckers have an ovoid or squareish aperture and I am

unable to determine if this is the result of lesion or if it is natural.

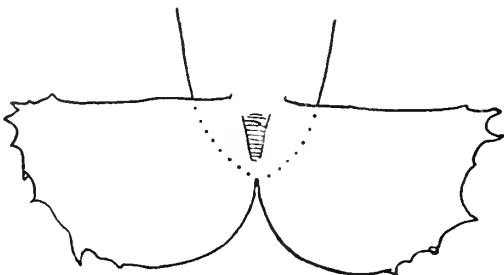
The tentacles are absent. They are represented by two exactly symmetrical stumps on each side. I believe that their absence is not due to accidental destruction, but resembles the similar abortion of the tentacles in *Octopodoteuthis* and *Taonius*. It would be necessary to obtain other specimens of the species before speaking with certainty on this matter.



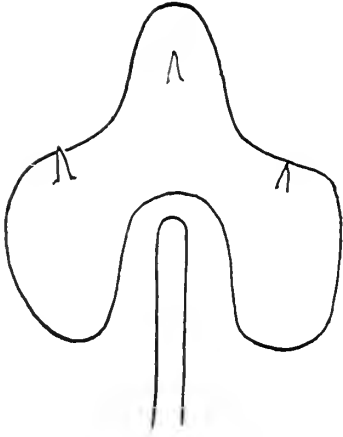
TEXT-FIG. 16. *Helicocranchia beebey* n. sp.;
 funnel, $\times 3$.

The eyes are large and placed on very short stalks, their longest axis being at right angles to that of the stalks. I do not find any obvious structure comparable to the ocular light-organ of *Helicocranchia* and *Teuthowenia*. I have compared the eye of my species with that of the type of *H. pfefferi* and find that the light-organ is very conspicuous and unmistakable in the latter.

This form is distinct from *H. pfefferi* in the fin-shape and attachment, eyes and in certain features of the funnel-organ, and from Berry's *Helicocranchia* sp. (1912) in the shape of its fins and arm-formula. It differs from *Teuthowenia* in the length of its arms and the position of the eyes relatively to the funnel. The apparent absence of ocular light-organs and possibly of tentacles may ultimately necessitate its elevation to sub-generic or even generic rank. The relationship of the genera and subgenera placed in



TEXT-FIG. 17. *Helicocranchia beebey* n. sp.;
 dorsal aspect of fins, $\times 5\frac{1}{2}$.



TEXT-FIG. 18. *Helicocranchia beebei* n. sp.; funnel organ.

the group of *Teuthowenia* by Pfeffer requires further elucidation. I do not know why more stress was not placed by him on the marked divergences in the relationship between the height of the funnel and the level of the eyes.

Helicocranchia sp.

One specimen from Stn. 28; S.E. of Cocos Id.; T-1 (No. 142); from the surface.

Differs from the above in the lower funnel and shallow and more divergent fins. The specimen is very much distorted.

In addition there are two very much damaged and shrivelled specimens labelled "*Teuthowenia*" from Stns. 80 (No. 116) and 61 (No. 117).

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8.

Hyperplastic Epidermal Disease in the Bluegill Sunfish,
Lepomis macrochirus Rafinesque.

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(Plates I-VII).

INTRODUCTION.

Hyperplastic epidermal disease has been reported frequently among European freshwater cyprinids, but only rarely from other species in this and other parts of the world. This disease, variously called carp-pox, Pockenkrankheit des Karpfens, varioles des carps, cutaneous warts and epithelioma papillosum, has been known since the Middle Ages. It is characterized by white or grayish, irregular, raised patches scattered over the skin. Histologically there is a striking hyperplasia of epithelial cells and other epidermal elements, supported by a delicate stroma. According to Hofer (1904), the first accurate description probably was given by Wierzejski in 1887. This atypical growth was restudied and recorded from carp and related fishes by the following: Hofer (1896 a, b; 1901; 1904), Doffein (1898, 1928), Plehn (1906, 1924), Loewenthal (1907), Fiebiger (1909), Thomas (1931) and Schäperclaus (1935).

A somewhat similar hyperplastic disease has been recorded for marine fishes. Johnstone (1925) reported skin lesions in dabs and plaice taken off the coast of England. He referred to these lesions as cutaneous warts or epitheliomata. Smith (1935) described a hyperplastic epidermal disease in winter flounder (*Pseudopleuronectes americanus*) caught in Long Island Sound. This was the first report of such a disease occurring in fishes of American waters.

The present report, insofar as known, is the first description of an epidermal hyperplasia in a freshwater fish of North America. The disease was found in bluegill sunfish, *Lepomis macrochirus* Rafinesque, taken from a lake near New Preston, Connecticut.

The writer is indebted to the late Mr. L. Beeman, former owner of the Warmaug Black Bass Hatchery, at New Preston, for collecting the fish; to George M. Smith, Yale Medical School, for some of the histological preparations, photographs and suggestions incorporated in this paper, and to Mr. James Atz, of the New York Aquarium staff, for criticism in the preparation of this paper.

MATERIAL AND METHODS.

The hyperplastic epidermal growths were

found in bluegill sunfish for four consecutive years from 1938 to 1941. During this period about 200 diseased fish were examined. What percentage of the total population this number represented was not determined. All of the fish studied were sexually mature, measuring from 13 cm. to 24 cm. in standard length. Of this diseased group, 75% were females and 25% were males. Most of the fish were collected during the spring, at which time the epidermal growths were most extensive. Fish caught during this period were kept in aquaria and observed for over a year. They showed no further extension of the growths; instead there was a tendency for the hyperplasia to regress.

The fish were collected and stored in the pools of the Warmaug Black Bass Hatchery. Some were sacrificed, fixed and preserved in 10% neutral formalin. Others were shipped alive and placed in reserve tanks of the New York Aquarium at Battery Park, where the progress of the disease was studied. Skin lesions and various organs of the body were prepared for histological examination from preserved material. They were blocked in paraffin, sectioned at 3 and 6 microns and stained with hematoxylin-eosin and by Masson's, Giemsa's and Willhite's methods. Some scales with the growth were stained and mounted *in toto*.

Attempts at transmission were made, but in all cases negative results were obtained. Diseased fish were kept in tanks with normal-appearing bluegills and other fishes from the same area and with bluegills taken from a pond near Red Bank, New Jersey, for more than a year and a half. The New Jersey fish remained normal throughout the entire period of exposure. Dermal and intraperitoneal transplants of fresh and glycerinated material had no effect. Bits of the epidermal growth were transplanted into the anterior chamber of the eye of both normal and diseased bluegills. The tissue remained intact for several weeks but eventually was absorbed. No regeneration of the growth took place in regions where scales with the overgrowths were removed.

DESCRIPTION OF THE HYPERPLASIA.

The epidermal hyperplasia is quite similar to the disease described from other fishes.

The disease appears as whitish papillomatous-like nodules or mucoid overgrowths on the skin of any part of the body (Figs. 1 and 3), but more frequently on the dorso-lateral surface (Fig. 2). They vary in size from that of a pin-point to 2-3 cm. in length and about 2-4 mm. in thickness (Figs. 3, 7 and 8). Some of the nodules are black or grayish in appearance due to the presence of melanophores (Fig. 5). The latter are not especially increased in amount.

The whole mounts of scales (Fig. 5) also show numerous needle-like crystals usually radially arranged and superficially placed. They measure from 10-25 microns in length, and are not alcohol or xylol soluble, nor do they stain with hematoxylin-eosin. Rod-shaped magnesium phosphate crystals were reported by Johnstone (1925) as impregnating the cutaneous warts of a plaice. The significance of these crystals in the epidermal hyperplasia of the sunfish and those found in the plaice is not known.

Histologically, the growth shows a great hyperplasia of epithelium without keratinization (Figs. 6-10). The hyperplasia appears to arise from the epithelium lining the scale pockets (Fig. 8). Here the cells may vary from the normal three or four layers to many layers as they grow over the scales (Figs. 4 and 7). The proliferating cells seem to follow the paths formed by the scale rings (Fig. 5). The hyperplasia consists of closely packed epithelial cells and epidermal elements around a central core originating from the corium (Figs. 6-8). Melanophores, capillaries, nerve elements and fibrous material are found in this core. In some areas the corium is edematous (Fig. 7) but no inflammatory reaction is evident.

The cells in the normal regions of the epidermis are typically flattened epithelial elements with mucus and sensory cells interspersed. As the cells proliferate along the surface of the scale they take on a more or less spindle shape (Figs. 5 and 9). They are eventually forced up into folds (Figs. 7 and 8), with the corial tissue growing into them (Fig. 8). Along these folds the epithelial cells are columnar with a somewhat thickened basement membrane (Figs. 7, 8 and 10). These cells form the basal elements of the hyperplasia. The outermost cells take on a polyhedral and squamous appearance, and seem to be connected with each other by intercellular bridges, which probably accounts for the rigidity of the growth (Fig. 10). In hematoxylin-eosin and Giemsa's preparations the cells stain homogeneously, each with a typically appearing nucleus. No nuclear or cytoplasmic inclusions are seen in these or in Willhite preparations made for this purpose. Pro-chromosomes are evident in many of the nuclei (Figs. 9 and 10), and typical mitotic figures occur frequently (Fig. 10). Numerous mucus cells are present (Fig. 8). These are more prominent around the

periphery but they may be clustered in any area of the growing tissue. Occasionally they are arranged around a central lumen forming a follicle-like structure (Fig. 11). The secretion within the lumen stains pink or yellowish with Giemsa's and green with Masson's. Sensory cells in the epithelium are not involved in the hyperplasia.

Fishes caught later in the year show many regressive changes. The orderly formation of cell layers, as seen in Figs. 6 and 10, gives way to a disorganized growth. Many of the epithelial cells appear oval in shape with scanty or vacuolated cytoplasm, pyknotic nuclei and with karyorrhexis evident here and there. With Masson's, the tissue gives a metachromatic picture. There is a tendency for the peripheral cells to slough (Fig. 14), and those in the interior of the growth to form epithelial cyst-like bodies (Fig. 12). In some areas there is an abortive attempt to regenerate as evidenced by the presence of cells undergoing mitosis in regions showing considerable degeneration. Eventually, the hyperplastic tissue is invaded by macrophages and degeneration becomes more extensive.

The ecto-parasitic ciliates, *Trichodina* and *Ichthyophthirius*, are found associated with the disease in every preparation studied. The *Ichthyophthirius* is encysted in the growth, while *Trichodina* is found free on the surface (Figs. 13 and 14).

There is no evidence of invasion into the sub-dermal region, nor is there any evidence of metastatic growth. Sections of the various internal organs appear normal. The indications are, then, that the hyperplastic epidermal disease of the bluegill sunfish, as in other freshwater and marine fishes, is a benign regressive disease.

DISCUSSION.

Epidemiologically, the epidermal hyperplastic disease in cyprinids and in the bluegill sunfish gives evidence that an infectious process may be involved. The occurrence of the hyperplasia in the same species of fish, and in the same pond or lake year after year would point in that direction. In the European fish, the disease is usually endemic during the warmer months. In certain years epidemics have been reported throughout the continent, but more often it occurs only sporadically. In one lake, Jasmunder Bodden, in northwest Germany, 20% of the cyprinids (carps, ides, breams, etc.) collected during the summer were found affected (Plehn, 1924). In the bluegill sunfish, the disease was found more commonly during the spring. Fish caught in this period showed more extensive growths than those collected later in the year. In addition, stained sections of material collected in the spring presented more mitotic figures than that prepared from material collected in the summer. The hyper-

plastic growths in the latter group showed considerable degeneration and regression.

The exact cause of the hyperplasia, however, still remains unknown. It is interesting to report that in every instance a parasite has been found associated with the disease. Thus Hofer (1904) and Doffein (1898, 1928) recorded the presence of a histozoic myxosporidian, *Myxobolus cyprini*, and inferred that this organism might have been responsible for the hyperplasia, even though the protozoan infection was localized in the kidney, liver and spleen. Related cnidosporidians (myxosporidians and microsporidians) associated with tissue hyperplasia in other fishes have been demonstrated by several investigators: Kudo (1919, 1924), Nigrelli and Smith (1938, 1940), Nigrelli (1948). As pointed out by the latter, "Intercellular and intracellular cnidosporidians elaborate proteolytic enzymes and other chemical substances which may be responsible for considerable cellular degeneration, cell hypertrophy and other tissue responses noted in these infections. It is altogether possible that chemical substances elaborated by the developing parasites may have a stimulating growth factor which may diffuse to more distant areas either directly or through the circulation."

Other parasites have been associated with the lesions in cyprinids and other fish. Thus, Plehn (1924) reported that the fish louse, the copepod *Argulus*, occurred frequently on the diseased fish, while Smith (1935) showed that winter flounders with hyperplastic epidermal disease were infected with the metacercarial larvae of the digenetic trematode *Cryptocotyle lingua*. In the diseased bluegill sunfish the ciliates *Trichodina* and *Ichthyophthirius* were present in the overgrowths.

Plehn (1924) believed bacteria to be the primary agent responsible for the hyperplasia, as interpreted by her statement, "Durch infektion gesunder Fische mit Karpfenläusen von den kranken konnten solche Wundpocken experimentell hervorgerufen werden. Da der stich des *Argulus* gewöhnlich diese Wirkung nicht hat, liegt die Annahme nahe, dass der Parasit nur als Ueberträger einer anderen Infektion wirkt; vielleicht sind es Bakterien, die die Hautwucherung veranlassen." It is also possible that *Argulus* and other parasites encountered in fishes showing these lesions may be the vector for a virus. A viral agent was indicated by Loewenthal (1907), who found inclusion bodies in the epithelial cells of diseased European cyprinids. The possibility that *Argulus* transmitted a virus was discussed by Thomas (1931), who attributed this suggestion to Plehn. Smith (1940) considers the disease to be caused by a virus on the basis of Loewenthal's findings. That parasites can and do transmit viral disease is known for higher animals, e.g. swine influenza and salmon poisoning in dogs and men. The former is

transmitted by the larvae, which occur in earthworms, of the nematode *Metastrongylus elongatus*; and the latter by the metacercarial larvae, which encyst in the flesh of salmon, of the digenetic fluke *Trogloremma salmonicola*.

It should be pointed out that ectoparasites are found frequently on fishes (Nigrelli, 1943) and in many instances a simple thickening of the skin (corium and/or epithelium) is involved. This is particularly so in the case of infections with *Ichthyophthirius*, a parasite of world-wide distribution. These Protozoa obtain nourishment by feeding on the host tissue cells. Fishes are susceptible to them during periods of varying temperature, which probably accounts for their presence in large numbers, at least in the temperate zone, during the spring. Under these temperature conditions the parasites enter the skin and may be overgrown with epithelium. Whether or not the simple hyperplasia of the epithelium often noted in these infections takes place at the time of active feeding or during the encystment process is not known. It is well known, however, that many parasites are capable of inducing the development of host fibrous tissues, especially during their process of encystment, and it is also probable that a hyperplasia of epithelial tissue may be another manifestation of this response, as in the case of papillomatous diseases associated with parasites (Nigrelli and Smith, 1940).

Schäperclaus (1935) suggested that the hyperplastic epidermal growth occurring in European cyprinids was a manifestation of a nutritional deficiency, but gave no evidence to support this. Nevertheless, this hypothesis finds some support in the work of Wolf (1945) on the "gill disease" of trout. This disease was manifest as a hyperplasia of the epithelium of the gills of trout fingerlings. Wolf considered this hyperplasia a response to chemical irritants, fish waste products, present in hatchery waters. He further pointed out that the susceptibility to the irritants was increased in those fish kept on a pantothenic acid deficient diet. A similar process may be involved in the epidermal hyperplasia of the bluegill sunfish and in other fishes in which this disease has been reported.

One consistent feature of the hyperplastic epidermal disease of fishes is the presence of parasites. Bacterial, protozoan, helminthic or arthropod parasites have been reported in all cases. Only in one instance (Loewenthal, 1907) were inclusion bodies described. Also, with one exception (Plehn, 1924), all attempts to transfer the disease to normal fish gave negative results. The infective agent in this exceptional case was bacterial, but the evidence was not conclusive. It may be concluded, then, that the epidermal hyperplasia found in fishes, is the response of sus-

ceptible hosts to toxic or mechanical irritants produced by parasites.

SUMMARY.

A hyperplastic epidermal disease, similar to "carp-pox," is described in bluegill sunfish, *Lepomis macrochirus*. The disease was endemic in a lake near New Preston, Connecticut, for the four consecutive years from 1938-1941. During this period 200 diseased fish were collected and studied. The lesion is characterized by papillomatous-like nodules or patches and histologically consists of an extensive hyperplasia of epithelial cells and other epidermal elements supported by a delicate stroma. Parasitic infection of the skin with the ciliates *Trichodina* and *Ichthyophthirius* is present, the latter embedded deep in the epithelium. All attempts to induce the disease in normal fish from this and other localities were negative. The disease is a benign regressive hyperplasia, since no invasion of the underlying structures or metastases were found.

The possible role of parasites, chemical irritants and dietary deficiencies in the production of this and similar hyperplastic epidermal growths in fishes is discussed.

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EXPLANATION OF THE PLATES.

PLATE I.

- FIG. 1. Bluegill sunfish, *Lepomis macrochirus*, with epidermal hyperplastic mucoïd-like patches. Such extensive growths are present especially in the spring. Slightly less than natural size.
- FIG. 2. Fish with patches in the dorso-lateral region, the usual position of these abnormal growths. Such fish are caught frequently during the summer months. Slightly less than natural size.

PLATE II.

- FIG. 3. Hyperplastic epidermal growth, showing papillomatous-like arrangement. About 3 X.
- FIG. 4. Isolated scales showing the nature of the overgrowth. Note that each scale's nodule is discrete. About 7 X.

PLATE III.

- FIG. 5. Scale mounted *in toto*. Note the distribution of melanophores, extension of the hyperplastic growth along pathways formed by the scale rings and needle-like crystals interspersed throughout. **n**, needle-like crystals; **e**, extension of growth. Hematoxylin-eosin. 75 X.
- FIG. 6. Hyperplastic epidermis with stroma penetrating from the corium. This is a section of growth taken from a fish caught in the spring. Note the orderly arrangement of the cells and lack of any degenerative changes. **c**, corium; **s**, scale. Hematoxylin-eosin. 75 X.

PLATE IV.

- FIG. 7. Section showing the upfolding of the growth. Note the cellular arrangement and thickened basement membrane of the columnar cells. The corium is slightly edematous. **c**, corium; **s**, scale; **bm**, basement membrane. Hematoxylin-eosin. 80 X.
- FIG. 8. Section of nodule. The light vacuolated bodies are mucus cells. Giemsa. 75 X.

PLATE V.

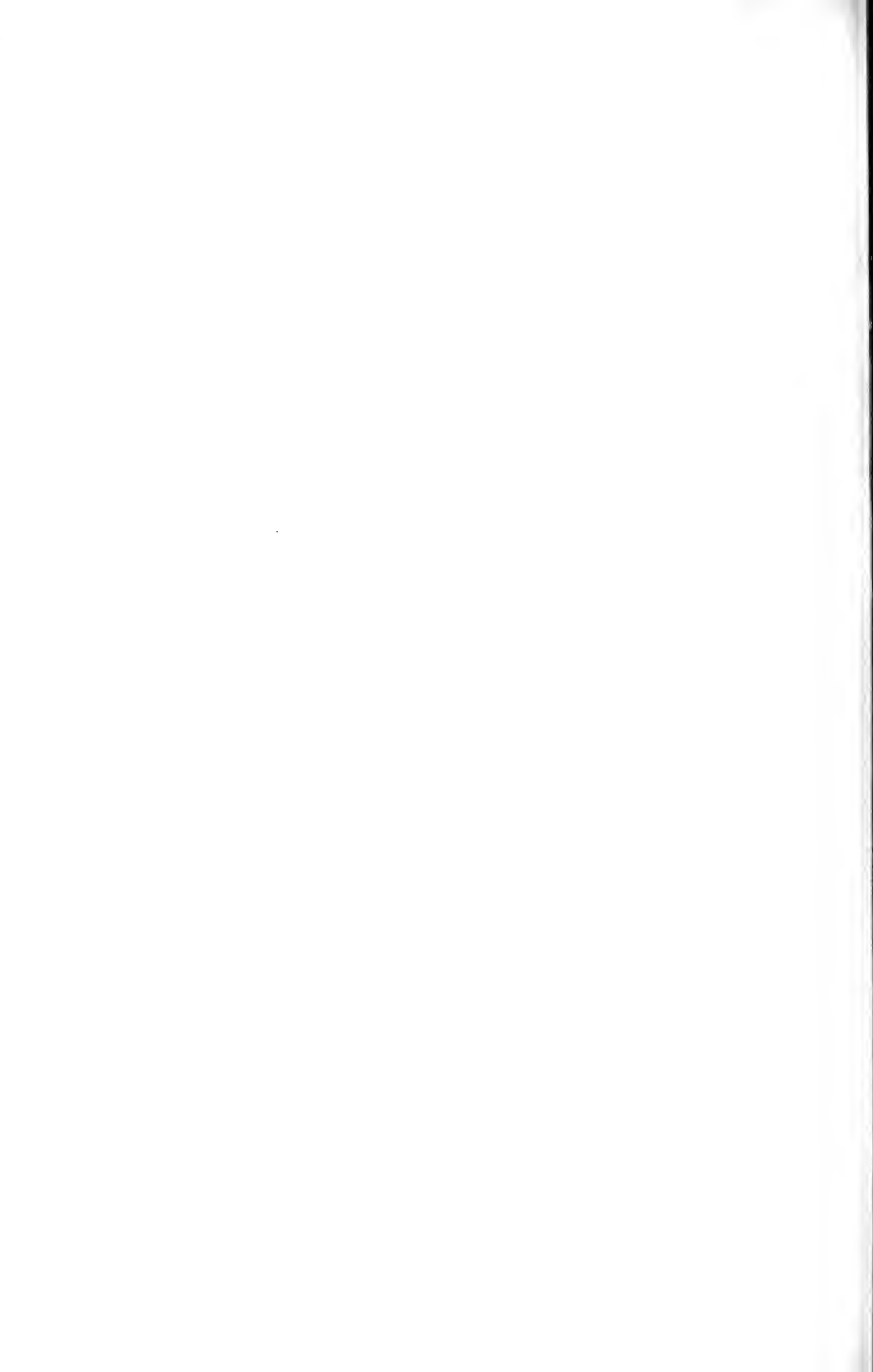
- FIG. 9. Epithelial cells as elongate, fibroblastic-like elements, growing out from the base of the growth. Note the mass of blood elements on the right. Hematoxylin-eosin. 675 X.
- FIG. 10. Details of the growth shown in Fig. 6. From the corium in the lower left, the columnar epithelial cells radiate out and become polyhedral and flattened elements towards the periphery. Most of the nuclei are in the pro-chromosomal stage, but some mitotic figures can be seen. Hematoxylin-eosin. 675 X.

PLATE VI.

- FIG. 11. Follicle-like arrangement of mucus cells. Masson. About 1,000 X.
- FIG. 12. Cyst-like body formed by epithelial cells. Hematoxylin-eosin. 1,000 X.

PLATE VII.

- FIG. 13. A single *Ichthyophthirius* embedded deep within the hyperplastic epithelium. Note the numerous ingested epithelial cells. Masson. 900 X.
- FIG. 14. *Trichodina* on the surface of the growth. Note the degeneration of peripheral cells, pyknotic nuclei and sloughing. Hematoxylin-eosin. 675 X.



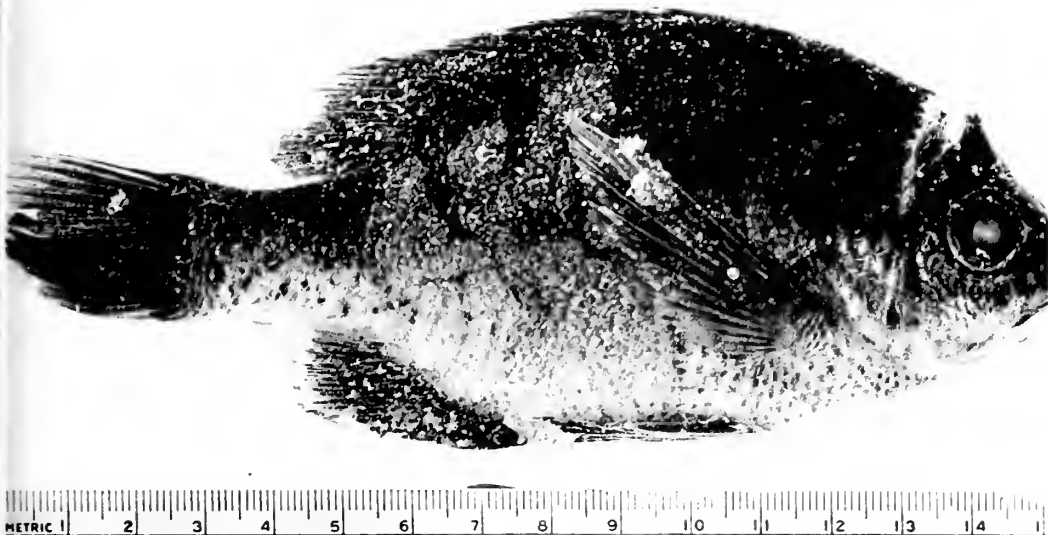


FIG. 1.

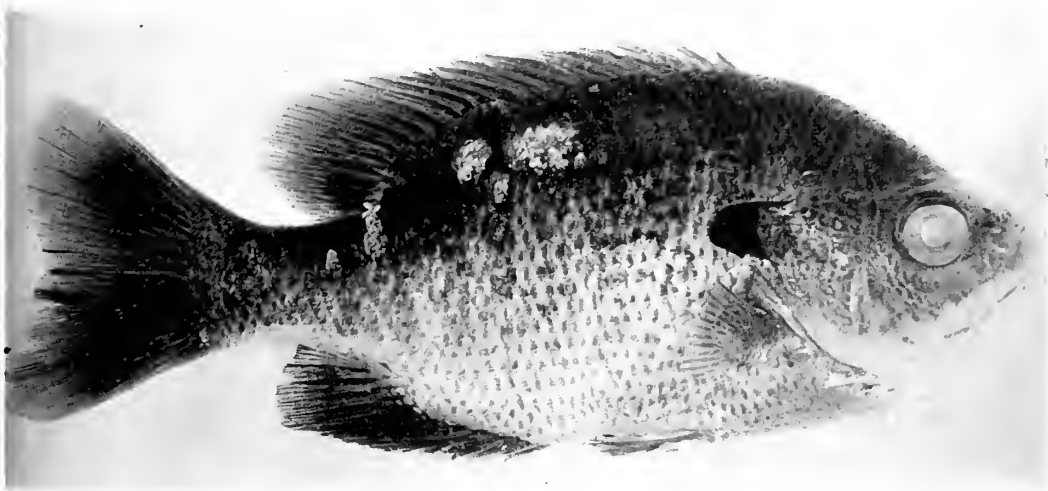
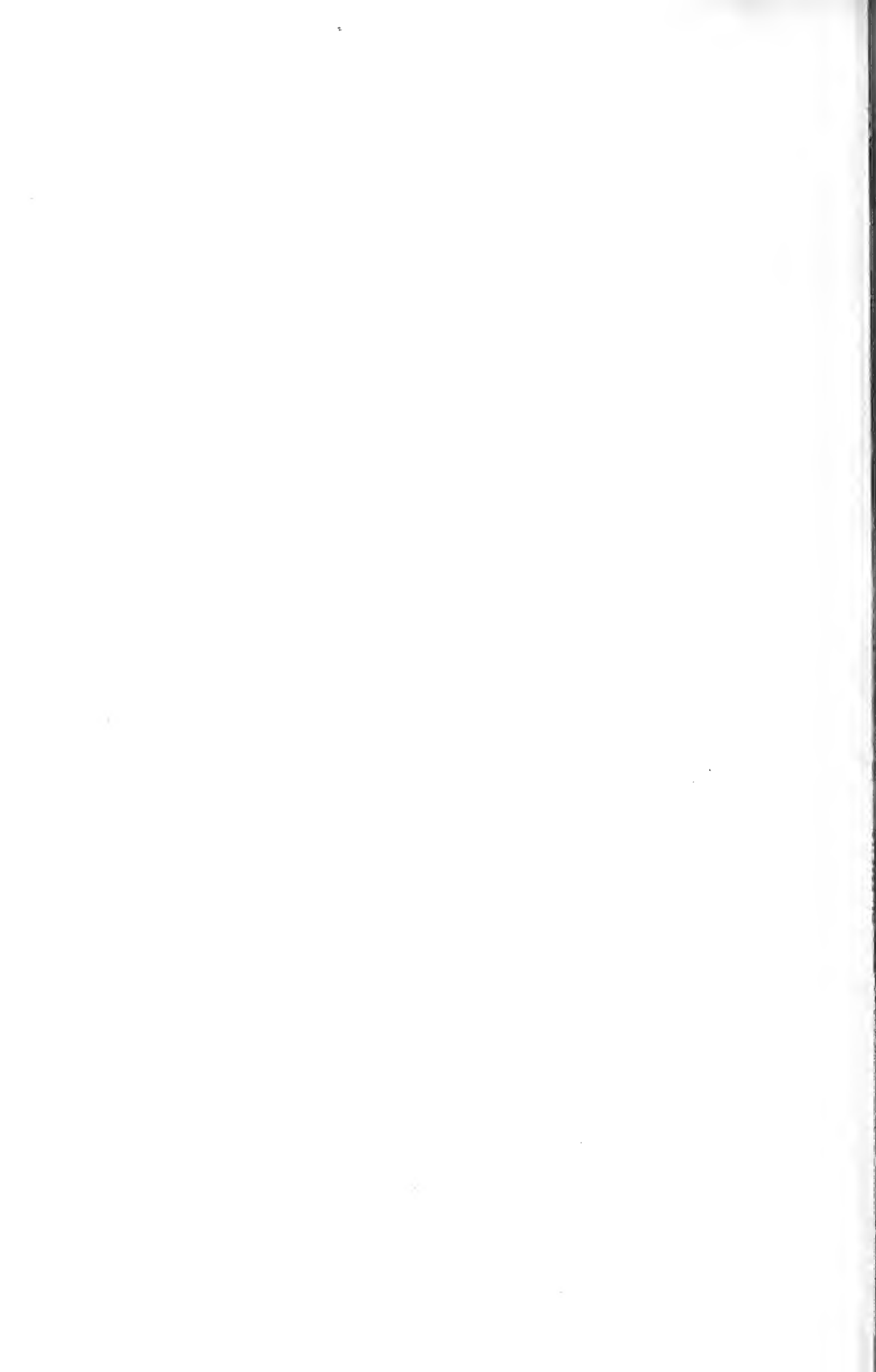


FIG. 2.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS* RAFINESQUE.



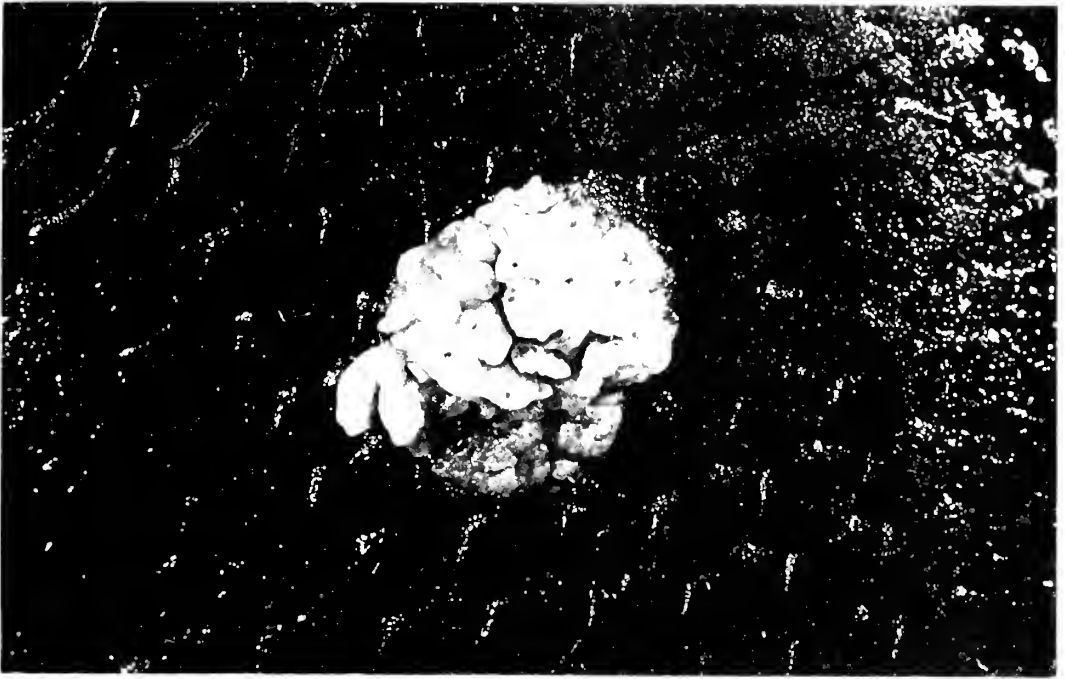


FIG. 3.

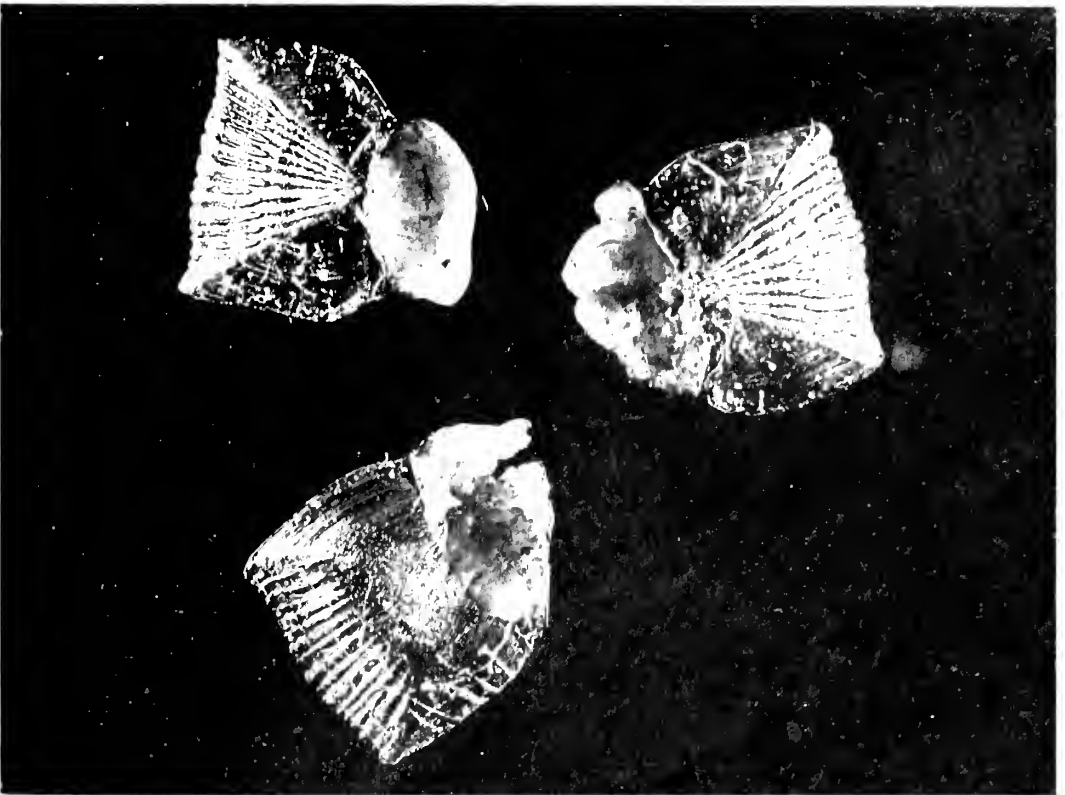


FIG. 4.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS* RAFINESQUE.



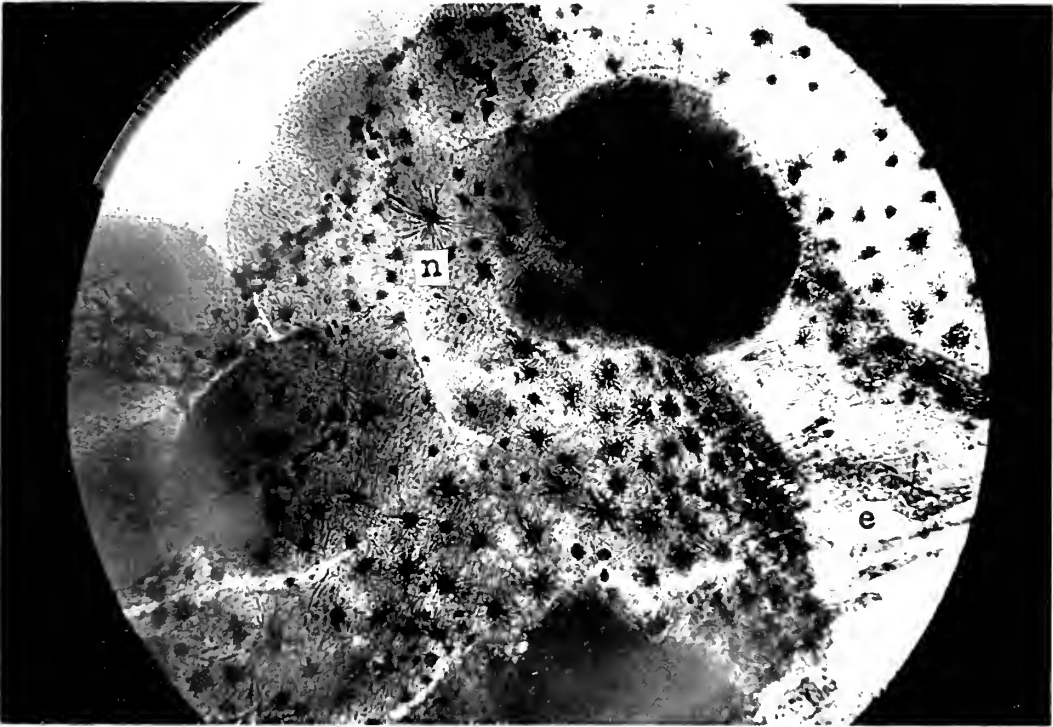


FIG. 5.

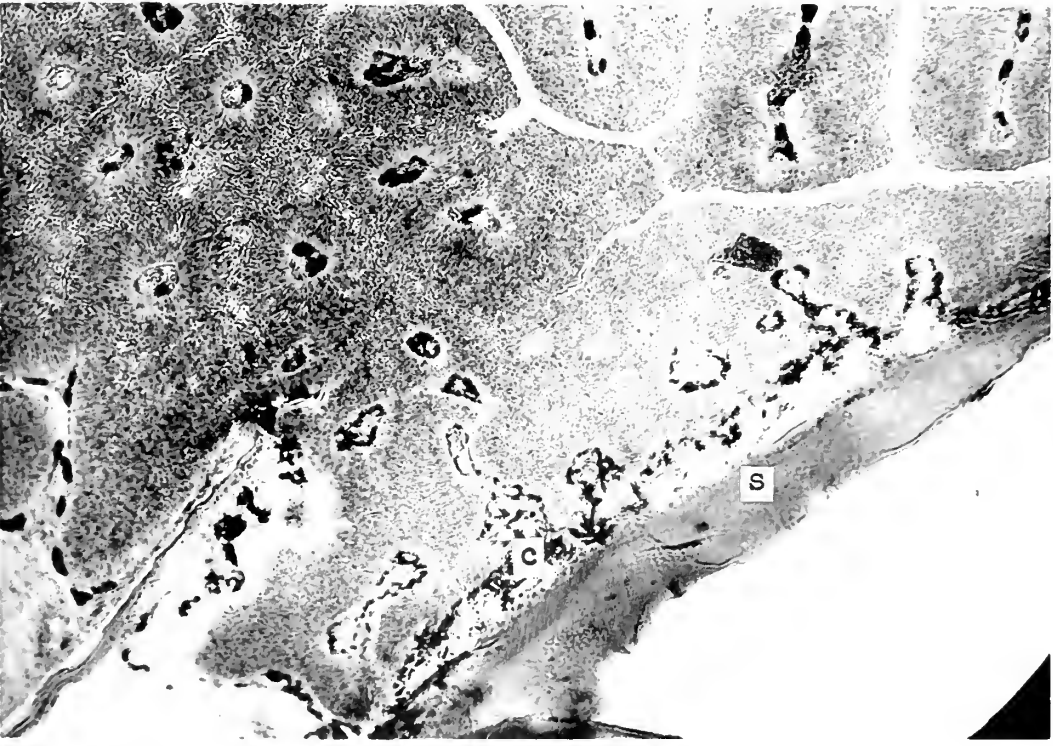


FIG. 6.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS RAFINESQUE*.



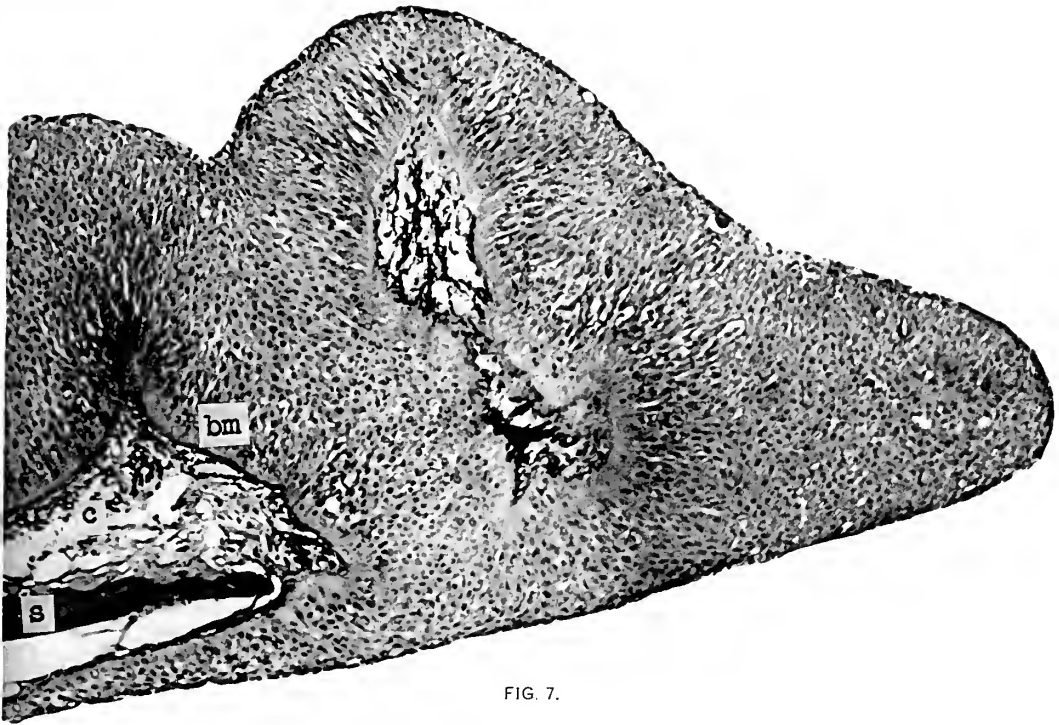
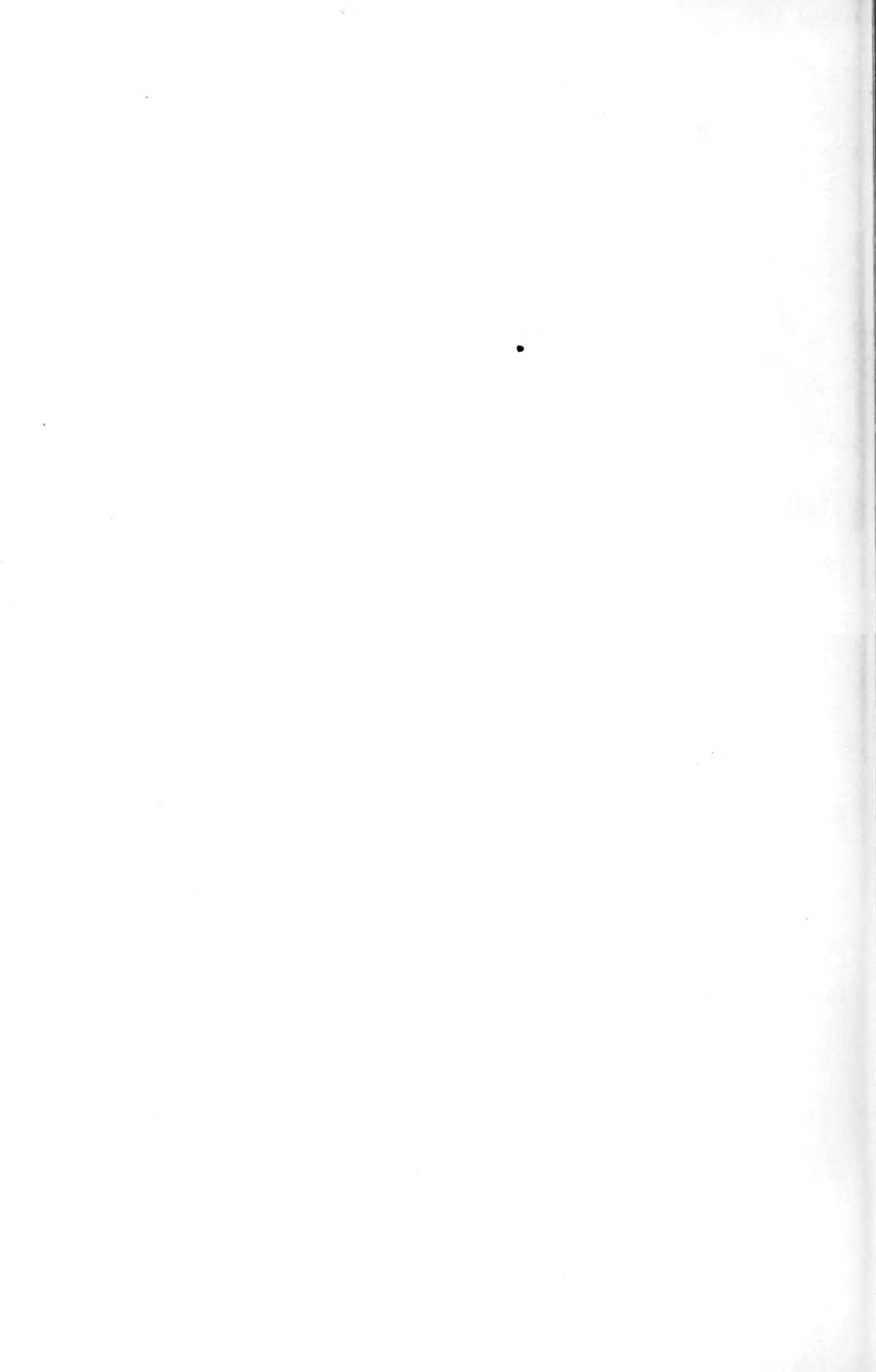


FIG. 7.



FIG. 8.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS* RAFINESQUE.



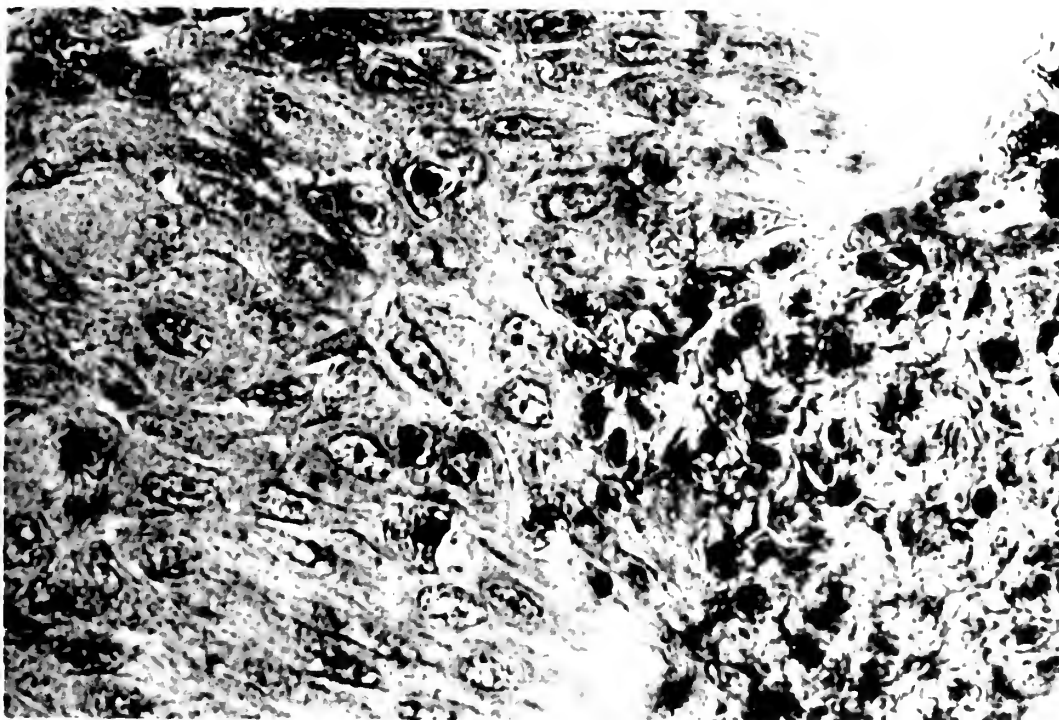


FIG. 9.

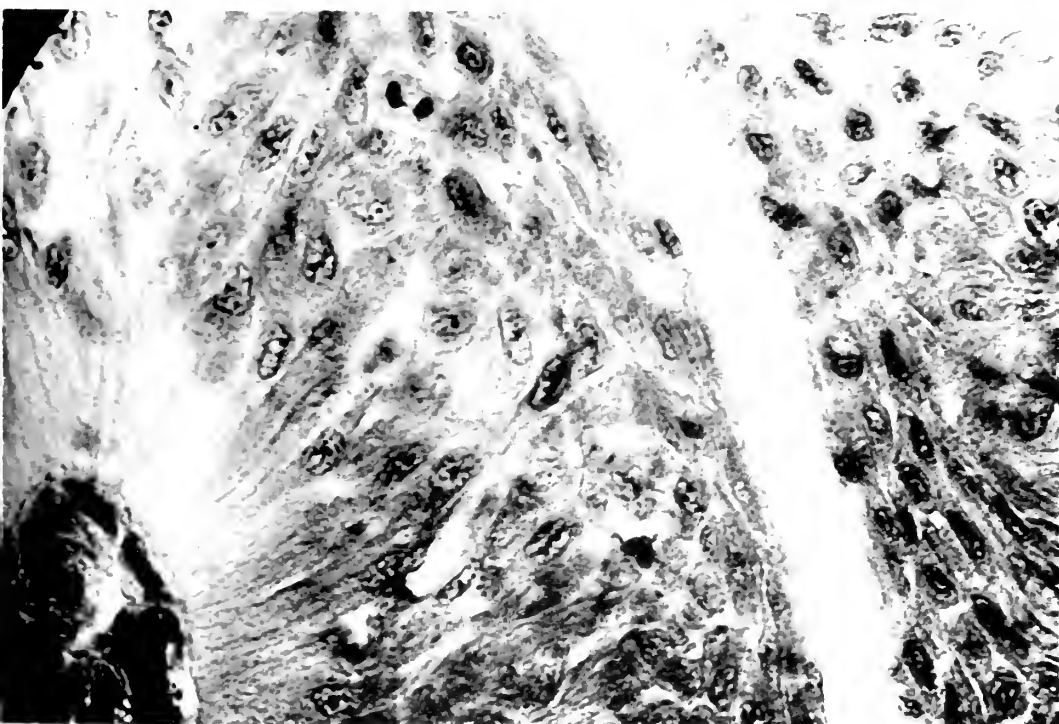


FIG. 10.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS RAFINESQUE*.



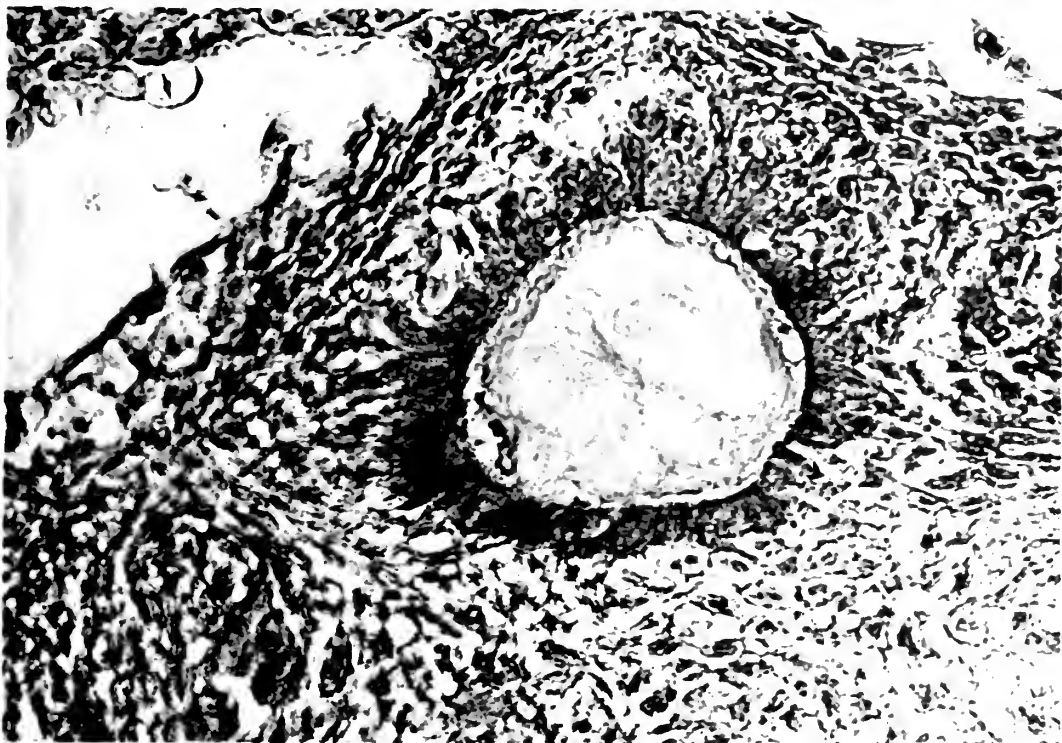


FIG. 11.

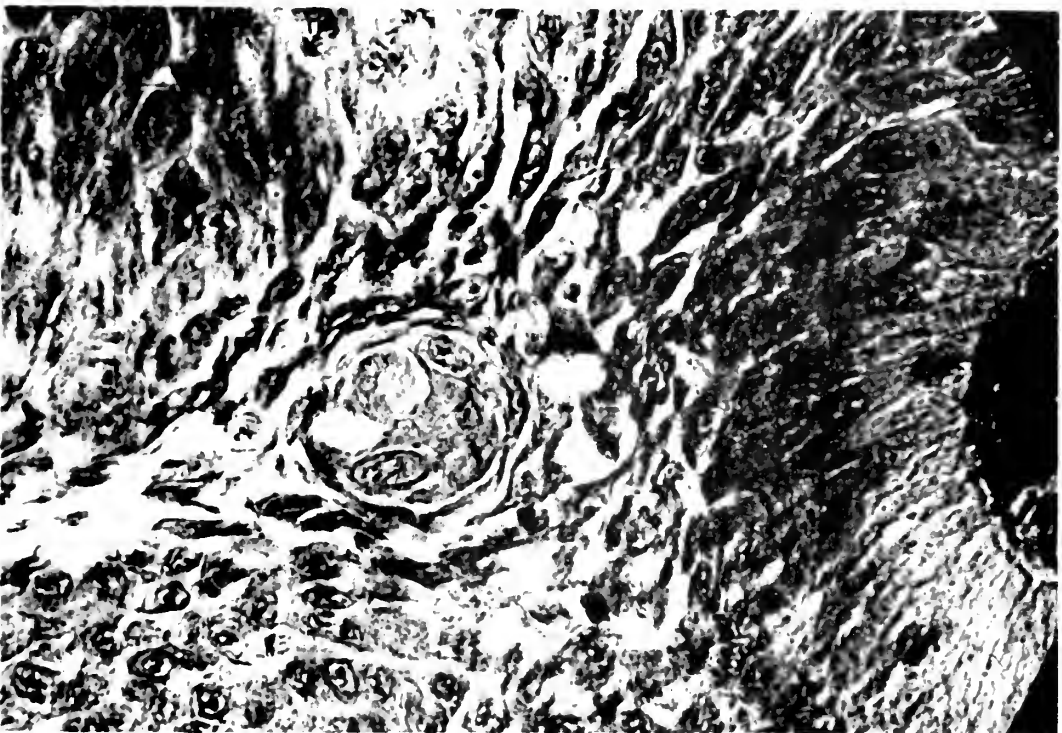


FIG. 12.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS* RAFINESQUE.

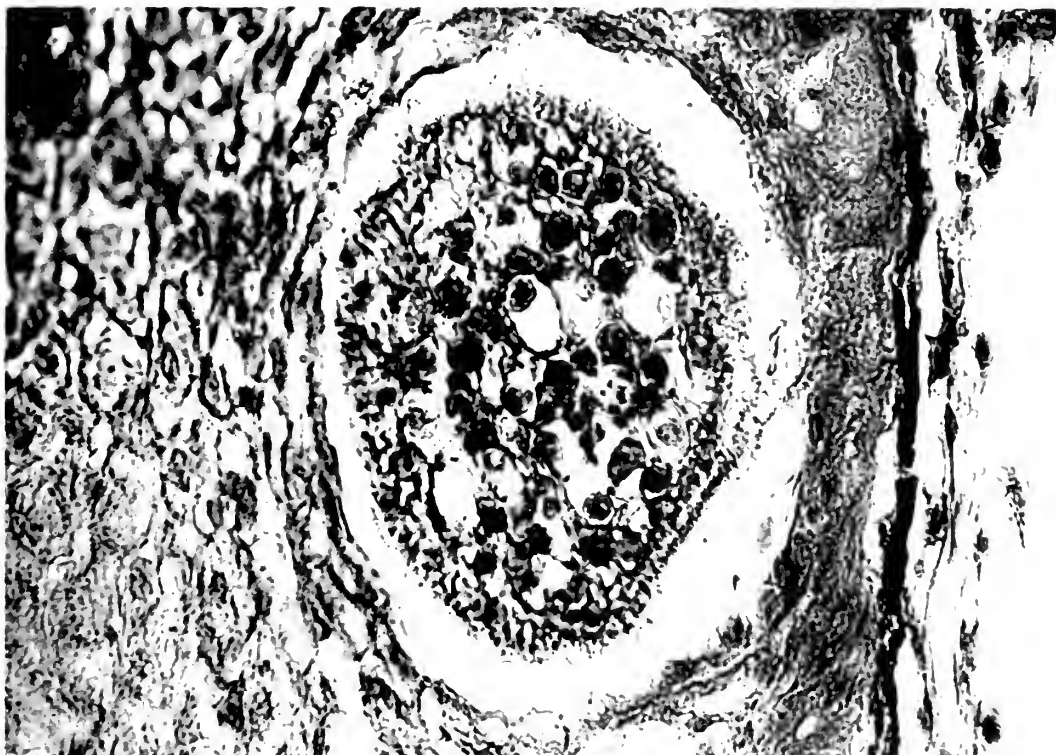


FIG. 13.

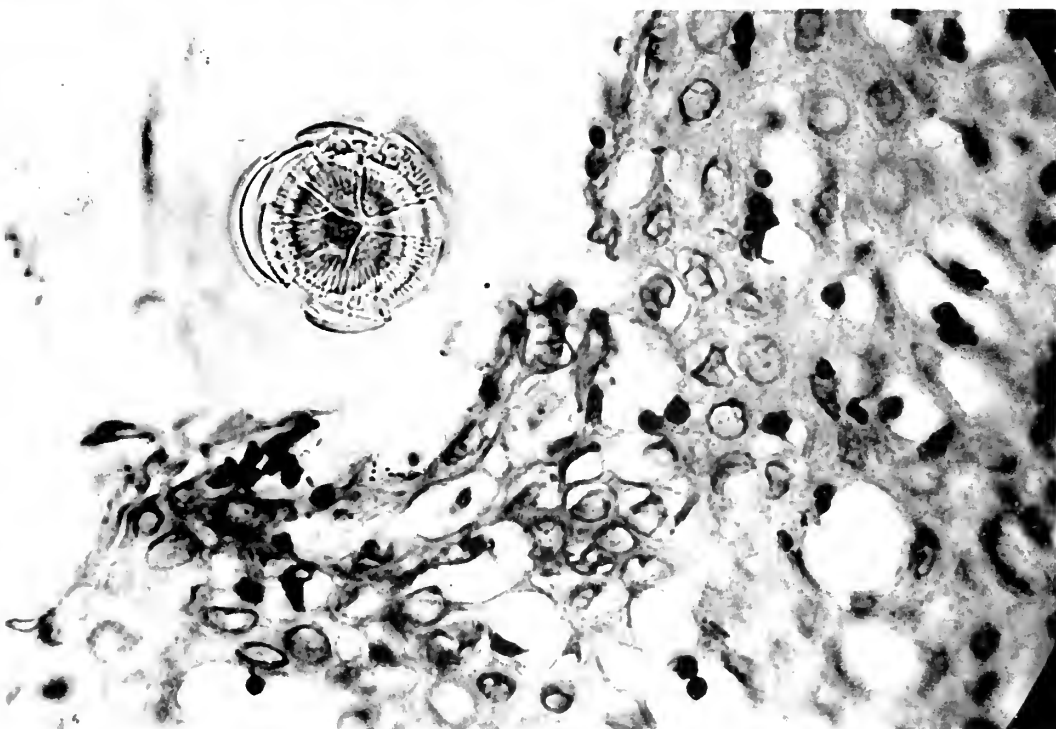


FIG. 14.

HYPERPLASTIC EPIDERMAL DISEASE IN THE BLUEGILL
SUNFISH, *LEPOMIS MACROCHIRUS* RAFINESQUE.



9.

Comparative Biology of Salticid Spiders at Rancho Grande, Venezuela.
Part II. Methods of Collection, Culture, Observation and Experiment.¹

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[This is one of a series of papers resulting from the 45th, 46th and 47th Expeditions of the Department of Tropical Research of the New York Zoological Society, made during 1945, 1946 and 1948 under the direction of Dr. William Beebe, with headquarters at Rancho Grande in the National Park of Aragua, Venezuela. The expeditions were made possible through the generous cooperation of the National Government of Venezuela and of the Creole Petroleum Corporation.]

[The characteristics of the research area are in brief as follows: Rancho Grande is located in north central Venezuela (10° 21' N. Lat., 67° 41' W. Long.), 80 kilometers west of Caracas, at an elevation of 1,100 meters in the undisturbed montane cloud forest which covers this part of the Caribbean range of the Andes. Adjacent ecological zones include seasonal forest, savanna, thorn woodland, cactus scrub, the fresh water Lake Valencia, and various marine littoral zones. The Rancho Grande area is generally subtropical, being uniformly cool and damp throughout the year because of the prevalence of the mountain cloud cap. The dry season extends from January into April. The average humidity during two expeditions, including parts of both wet and dry seasons, was 92.4%; the average temperature during the same period was 18° C.; the average annual rainfall over a 5-year period was 174 cm. The flora is marked by an abundance of mosses, ferns and epiphytes of many kinds, as well as a few gigantic trees. For further details, see Beebe & Crane, *Zoologica*, Vol. 32, No. 5, 1947.]

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I. INTRODUCTION.

The following pages describe the general methods of working with jumping spiders at Rancho Grande, Venezuela. Although some of the field techniques are axiomatic to experienced arachnologists, they are included here for completeness, since they may be helpful to new students of the group, or to those who have not worked in the tropics.

Part I of this series dealt with systematics and life histories in *Corythalia*, excluding

experimental work (Crane, 1948). The applications and results of the techniques outlined in the final section of this paper will be reported in future publications. All of the experimental salticid work at Rancho Grande has been concerned with a comparative study of the innate releasing mechanisms of the epigamic displays in various genera. The ultimate aim is two-fold: first, to work out evolutionary patterns within the family, with particular attention to the relationships between function and structure; second, to compare and correlate the mechanisms in this family with those in unrelated groups, in accordance with the stimulating work of Lorenz, Noble, Lack, Tinbergen and their associates, who have been concerned almost exclusively with vertebrates (e.g., see Tinbergen, 1948, with bibl.).

The study of living salticids is one of the most continuously fascinating and ultimately rewarding of zoological pursuits. Nevertheless, the pioneering Peckhams were quite right when they warned enthusiastic readers, some sixty years ago, against going in for such a study casually. Deep appreciation is due them and all the more recent students of live salticids, including particularly Bristowe, Bonnet and Kaston, who, working patiently in the brief northern summers, have recorded and studied many salticid displays.

The tropics have the great advantage of leisurely seasons combined with large numbers of species. Nevertheless, just as in the north, it is essential to be on familiar terms with the local forms, with their restricted niches, relative abundance and specific idiosyncracies. Also, it is most important to remain in a single locality for as many months of as many years as possible: tropical salticids, although they may be carried north successfully, have their innate rhythms disturbed, becoming irregular in their moults and erratic in activity after the trip.

In some ways tropical salticids are ideal experimental animals. The variety of behavior and correlated structures in closely related forms makes them of peculiar interest in the study of basic evolutionary problems. They are, under proper conditions, exceedingly hardy. Their food supply is usually easily arranged. Individuals have an active

¹ Contribution No. 816, Department of Tropical Research, New York Zoological Society.

adult life of at least one month and usually two or more. The breeding seasons of most species extend over months, and sometimes throughout the year. Most important, these spiders are extremely adaptable to captivity, and adequate comparative observations in both field and laboratory indicate no differences whatever in basic behavior patterns.

Nevertheless, rearing and experimenting with salticids is a finical business. Although the adults are giants compared to *Drosophila*, they are pygmies to a guinea pig, and any trainer of jumping fleas would feel more promptly at home with them than a gifted researcher accustomed to monkey and mice. Rare or experimentally important spiders escape, get squashed or eaten, and inexplicably die at the most inopportune moments. Cloud forest species may be killed in a night if moisture is withheld; xerophytic forest forms can die in three days through too much humidity. An extra whiff of chloroform during some simple operation may ruin forever the future display performance of a valuable male. A rare and delicate female, reared, mated, fed and tended with difficulty through half a year, to secure an evolutionarily significant first instar, ultimately laid nothing but three bad eggs.

Not the least of the exasperations of behavior students in tropical localities is the fact that most salticids turn out to be little known or altogether new, necessitating a great deal of fundamental taxonomic work. Two exceptional neotropical regions are Panama and the West Indies, their spider fauna having been clarified in the excellent recent reports of Chickering (e.g., 1946) and Bryant (e.g., 1943), respectively.

Genetical work is greatly needed in the group and is almost an untouched field. As subjects, however, salticids are only moderately suitable. Few species so far tested breed reliably in captivity. The usual length of a generation averages perhaps six months, and so is too long to be convenient. The broods are small, the total number of eggs laid by a female of average size in many genera never reaching more than thirty, and sometimes numbering less than ten. To rear to maturity even four or five young of a given brood has so far been accomplished only several times at Rancho Grande, and second generation offspring of captive specimens have only been secured twice. However, these mechanical rearing difficulties are directly traceable to the fact that many species were under simultaneous observation, and that no stay in the laboratory was longer than six months; a geneticist who restricted his choice of work species with knowledge and care, and could keep the broods going continuously through, say, two years, would have results of great value.

Finally, any zoological investigator who is fortunate enough to pass sufficient time in a permanent tropical laboratory, will find a field of immense interest in salticid spiders, if he has an inclination for studying complex

behavior and evolutionary problems in a relatively unfamiliar group. Although he will quickly work out his own improved techniques, the following suggestions may save him a number of time-consuming trials and errors.

II. COLLECTING METHODS.

The principal collecting method was the shaking of bushes and branches into a large, inverted umbrella, the specimens being caught in vials as they ran up toward the rim. Because of the steep terrain and tangled, chronically damp vegetation around Rancho Grande, the umbrella method was more efficient and convenient than the equally popular systems of spreading a sheet under the foliage to be shaken, or sweeping the shrubs with a net. *Corythalia* and other primarily terrestrial forms were located by simple visual searching in the right habitats, and were secured in inverted vials, this method proving more effective for the surface-living jumpers than the sifting of leaves. A few salticids were collected on tree trunks and in epiphytic bromeliads. The latter were detached by our tree-climbing Venezuelan assistants, lowered carefully upright to the ground with a light rope, and either dissected over a poncho on the spot or wrapped up and brought intact to the laboratory.

Salticids wanted for study alive should never be risked in the same vial with any other spider, even though their sizes appear so nearly equal that there seems to be small danger of one's eating the other; different species and even individuals differ greatly in aggressiveness and voracity. The most convenient way of carrying a sufficient number of vials up and down mountains is in two light-weight cotton bags—snake-collecting bags are excellent—with drawstring tops; they can be slung over each shoulder, or hung at the belt. With empty vials in one bag and used ones in the other, there is neither delay nor confusion when a single umbrella-shake suddenly yields a half dozen much-desired and extremely agile jumping spiders.

Collecting during or soon after a rain is not rewarding, since salticids then cling their tightest or even go into their night-time shelters, and the water from the shaken leaves is likely to drown whatever spiders there are. Nevertheless, in choosing seasons for tropical collecting, the drier months should be avoided, since salticids are then often impossible to find in deciduous woods, scrub and savanna, and are relatively scarce even in rain and cloud forests.

The richest collecting areas for salticids in northern South America have always proved to be neglected clearings and the edges of forest roads or paths. The forests themselves are uniformly poor, as are open savannas. Unfortunately, no collecting has yet been done high in the forest canopy; that well-lighted niche should prove remarkably rich whenever an adequate system of arboreal locomotion can be devised.

Although many salticids live in the temperate zone, the display season is usually brief and the winter a period of inactivity. In contrast, the great majority of salticids are tropical, so that far more material is available to the student in low latitudes. More important for behavior studies, the tropical breeding season is always prolonged and sometimes, it seems, perennial, so that growth and display may be observed throughout the year in sufficiently humid localities.

III. MAINTENANCE AND CULTURE.

A number of excellent methods have been worked out for keeping various families of spiders alive in the laboratory, among which may be mentioned those of Bonnet (1930), Branch (1942) and Brown (1945). The salticids, however, have always proved difficult. The Peckhams (1889) reared one female salticid through ten molts, but she died before becoming mature. Wagner (1888) also had some success, but does not give details. Moles (1916) reared various families, but could not bring salticids through the early instars. Bonnet's first attempts to rear salticids failed, although he had great success with other groups; finally, however (1933), he reared a brood of *Philaeus regius* to maturity and was able to breed the resultant adults with each other.

The method described below is an adaptation of various techniques of spider and insect culture, and was necessitated both by the sensitivity of the spiders to drought and by the special conditions at Rancho Grande. High humidity was essential to these cloud forest spiders, while the laboratory was relatively dry; yet the spiders could not be kept in stoppered vials with moistened corks, because excessive mold often developed overnight.

The method which eventually proved successful was the following. It involved the care of an average stock of about 75 individuals, exclusive of first and second instar broods. All spiders, except mated pairs, were kept in individual cylindrical specimens jars, measuring $1\frac{1}{2} \times 2"$, $2\frac{1}{4} \times 3"$ or $3 \times 3\frac{1}{2}"$, depending on the size of the spider. The largest size was reserved for large mated pairs or for females with egg cases; individuals did not do better in ample space than in the minimum-sized jars assigned, and to save space and for convenience they were given the smallest size feasible. Strong, fine-mesh, khaki-brown mosquito netting, of regular army grade, was used for covers and secured by rubber bands. The most convenient jar labels proved to be a self-adhesive type put out by the Avery Adhesive Label Corporation of Los Angeles, California; pencilled data in regard to molts, etc., could be erased and changed repeatedly. The jars were kept on a special table near the laboratory windows, in excellent light but away from the direct sun. Jars of experimental adults were kept well

separated, in order to avoid the effects of summation, reinforced stimuli and overstimulation before experiments, since some individuals display on a visual sign-stimulus alone, even through the distortion of two curved glass walls.

Each jar contained a small cylinder of cotton dental wadding 10 or 15 mm. long by about 6 mm. in diameter. This was saturated, although not to the dripping point, every two to four days. The optimum condition seemed to be that it should be practically dry before remoistening. The spiders could all stand prolonged fasting; some survived after several hours in the refrigerator and a few could withstand moderate heat; drought, however, killed all kinds rapidly.

The spiders were fed on *Drosophila* and other small flies several times a week. Since wild *Drosophila* and houseflies were practically absent at Rancho Grande, while small flies of other groups were abundant in the caretakers' cottages, only two or three jars of breeding *Drosophila* were maintained, and were used for emergencies only. Vials full of the other flies were easily captured at night, attracted to a flashlight from the cottage walls and ceilings where they roosted. The quickest feeding methods for our collections proved to be the following: a vial of flies was lightly chloroformed with a moistened cork and decanted onto white cardboard. About three to six flies were then brushed lightly into each jar, after the dental wad had been dipped in water. Where reared *Drosophila* were used, a large group was allowed to escape into a jar inverted over the breeding bottle, and a card with a chloroform-saturated bit of cotton slipped across the aperture; afterwards the stupefied flies were brushed as before into the spider jars. This proved simpler and faster than permitting the requisite number to escape directly into each jar through a small opening in the top of the fly bottle. The spiders became so tame that they were completely undisturbed by the routine. A light tap sent them away from the netting tops. The young, when about to molt, usually spent at least two or three days in their cocoons, never eating at this time; these were disturbed as little as possible, but the wad had to be dampened. Even when the cocoon was spun at the junction of netting and glass, a little care avoided injury. The jars were cleaned about every ten days.

Naturally there were frequent accidents and escapes, especially during transfers to and from observation dishes (see below). One source of trouble was the rubber bands which rotted quickly in the climate and tended to break without warning. Another was an occasional incursion of small ants, who scavenged among the dead flies in the jars, leaving tiny holes in the netting large enough for the escape of small spiders. In a lowland tropical laboratory, ants would be a real nuisance which, however, could easily be prevented by the time-tested custom of

standing table legs in kerosene or wrapping them in poisoned "ant tape." Major and unexplained pests were the mites which often appeared in egg cases. It now seems certain, however, that they attack only bad eggs or dead spiderlings; dead flies in the jars were never touched. Their method of dispersal is a puzzle; infected jars were always carefully cleaned before re-use.

Young spiders were usually removed from their mothers as soon as they emerged from the cocoon, although there was not a single case of cannibalism between mother and young, or between first or second instar spiderlings, in any of the salticids under observation. Two or three second instar spiders could be kept in a single small jar, but were usually segregated before the next molt. A few individuals of placid-tempered species were reared together almost to the adult stage.

No food is taken during the first instar, but is essential during the second. Incidentally, none of the tropical salticids studied spend more than the first instar in the cocoon. During the second, tiny live creatures from the leaf litter were given, collembola and minute worms being the most acceptable to small forms such as *Corythalia xanthopa*. This is the most crucial period of rearing and few individuals were brought through it. As soon as a spider had eaten one meal, it was ready to tackle a wriggling but de-winged *Drosophila*, even though the fly was always considerably larger than the spider. Larger species could seize de-winged *Drosophila* as their first food. Dr. Ernst Mayr and Dr. T. Dobshansky, in conversation, have made the sensible suggestion that a culture of wingless *Drosophila* mutants would be helpful in feeding the youngest specimens on a large scale. Before the second instar was over, the sturdiest individuals could catch normal *Drosophila*, and several *Corythalia chalcea* in one brood caught them as first food. Certain aphids were acceptable to the very young in emergencies, but were not good as a steady diet. I had no success in inducing young salticids to feed on freshly killed and punctured insects, since they never showed any interest in a motionless body (cf. Mole's successful rearing of other families by this method, 1916).

IV. METHODS OF STUDY AND EXPERIMENT.

Color Records. It was essential to record colors from living specimens. The general aspect was described from non-anaesthetized examples in vials under a binocular microscope. Details of scalation were recorded after a specimen was chloroformed. Variations proved to be so great in some species that it was essential to make complete descriptions of a number of examples of each available instar; this was particularly important since, to begin with, nothing was known of the number of instars, their appearance, sexual differences in the young, or even the identity of many examples. The

latter differed so greatly from the adult, or so resembled the young of various species in a single genus, that they had to be reared and only the exuviae preserved. Detailed descriptions and pattern sketches of the young were particularly important since evanescent color patterns are proving exceedingly helpful in working out phylogenetic relationships.

Drawings. Sketches of displays and color pattern were made from the living spider, the exact proportions being worked out from preserved examples. All display drawings were completed in the field, so that final details could be checked from other displaying individuals.

Attention may be called here to an excellent technique recently reported by Dr. Kaston (1948, p. 47), giving credit to Miss Kathryn Sommerman. Palps and other parts may be easily held for hours in any desired position by first placing a bit of vaseline in the bottom of the dry observation dish. The specimen is then partly imbedded before alcohol is flowed in.

Study of Exuviae. The cast skins are best preserved dry, each in a separate vial with a bit of absorbent cotton. They become entangled in the strands just enough to cling when the cotton is removed with forceps. They can be repeatedly taken out for study, comparison and drawing, without damage and with minimum danger of being blown off the stage by an unwary breath. Yet the tangling is so slight that they can be easily manipulated, or legs and other parts detached at will and mounted for high-power study.

Preservation. Except for exuviae, all specimens are preserved directly in 70% alcohol. Early instars needing repeated removal from vials during study are also best tangled in a few strands of cotton.

Display Observation. Fortunately, the displays of a number of the reared species, belonging to widely separated genera, were observed in the field, in various degrees of completeness. In every case, the threat and courtship display behavior was identical with that recorded under laboratory conditions. Some of the experiments were also repeated successfully, using uncaptured spiders in their natural environment; the results of these corresponded closely to those in the laboratory. They will be described in detail in subsequent reports. The important point here is that captivity has no apparent effect on the display behavior patterns of salticids.

The most convenient vessel for display study in the laboratory is a shallow glass dish, measuring at least $4 \times 4 \times 2$ " and covered with a piece of window glass. The aeration system described by the Peckhams (1889, p. 37) is unnecessary in these studies, since the spiders are kept in the dishes for a few hours at most. Transfers from jar to dish are made with a 3×1 " vial, the spider being gently prodded when necessary with a camel's hair brush. Spiders in display condition (see below) never need more than a

few minutes to settle down in their new surroundings. The glass dishes are particularly suitable for experiments, since they can so easily be scalded, wiped with alcohol and aired, in order to remove chemical traces of previous occupants.

A simpler display study technique is applicable to some salticids which, while having especially good eyesight, depend relatively little on chemotactic and/or smell stimuli. Their displays may be studied on an open table, the danger of persistent chemotactic stimuli being eliminated by using a fresh sheet of white or light-colored paper for each test. Various tints of blue, green, yellow and gray made no perceptible difference in the responses. These spiders, of which examples are *Corythalia*, *Eustiromastix*, *Mago* and *Hypaeus*, are all highly developed literal jumpers; even their normal progress is usually a series of hops, and they are invariably less restless—to human eyes less “nervous”—than other groups of the family. Their attention is easily attracted by appropriate visual stimuli and, even in the absence of a stimulus, they do not tend to race off and get lost in a frenzy of multisensory exploration.

The dish-study method will, however, be found to be more practicable for the majority, at least of tropical salticids, which are runners except during the emergencies of hunting and of progress over chasms. These genera include *Semorina* and other ant-like salticids, *Menemerus*, *Ashtabula* and *Sassacus*. This subject of basic behavior variation will be fully discussed in a subsequent paper.

During observation in both field and laboratory, magnifying spectacles were most useful; they consisted of small lenses, about $\times 5$, mounted several inches in front of empty frames.

When unfamiliar males and females were taken, trial-and-error was the only way of determining, while they were still alive, whether they belonged to the same species. Members of the *Phidippus* and *Plexippus* groups are particularly difficult since not only is sexual dimorphism often extreme but also the females are frequently voracious. Extreme vigilance failed to prevent all accidents when I guessed wrong and placed together a male and female of different species. Yet the risk was worthwhile, because sometimes only a single adult pair of a given species in breeding condition was taken during the season. For example, in 1945 the only adult male *Eustiromastix* was kept alive for three months and tried with four different kinds of females before the right one, caught in an early instar, finally molted to the adult form and stimulated the male to display.

In most species, as Bonnet (1933) found with *Philaeus*, there is little danger of cannibalism so long as the spiders are well fed. Our specimens were always given flies not more than 24 nor less than three hours before display experiments.

A vital factor in spider experiments, as in those with other animals, has proved to be the fluctuating physiological condition of both sexes. The only part of this subject which belongs properly in this account of methods is the fact that its influence must always be kept in mind by the investigator. A male taking no interest in a certain female on one day may display and mate promptly with her twenty-four hours later, under conditions as exactly similar as it is possible to make them. Also, the behavior of a male not in top display condition is often not typical of the species; for this reason salticids are best studied when at their physiological peak, that is, when their threshold to display stimuli is low. Under natural conditions it is usually only males in this condition which have sufficient persistence to carry through display to successful mating. Therefore, unlike many vertebrates (cf. Tinbergen, 1948, p. 39), the most easily stimulated spiders give the most typical responses; concomitantly, positive reactions of these individuals to incomplete or abnormal stimulus situations should not be underestimated in determining the relative importance of various releasers.

In discovering the condition of a given male, for use in experiments concerning sign stimuli, one or two stimuli were presented, with known effects on his particular species in different physiological states. For example, a mirror was moved in a certain way for a certain length of time and/or a particular mounted specimen was similarly manipulated. During a series of experiments the condition of the spider must be frequently rechecked by these standards, especially in the case of negative responses. For instance, if a male will not display to a new mount (see below) with a white spot painted on the clypeus, his condition must be rechecked immediately with the standard stimuli, since the spiders tire and/or become overstimulated very suddenly and completely.

This brings up the point of rest periods, the importance of which has been recently reemphasized by Tinbergen in regard to vertebrates (idem, p. 43). It is essential to rotate the members of the test group during each experimental session, in order to avoid the after-effects of stimulation. This principle has been observed in all the experiments with Rancho Grande salticids.

The above remarks have applied equally well to the study of typical display patterns of salticids and to experiments performed to determine their innate releasing mechanisms. The following paragraphs give a survey of general methods used in strictly experimental work. In subsequent papers details of particular experiments will be given where advisable, to substantiate the validity of certain conclusions.

General Position of Experimental Table. In order to minimize possible effects of phototropisms, the observer always sat with back to the window. All experiments concerning releasing mechanisms were con-

ducted in daylight, within a certain range of temperature, brightness and humidity.

Mounted Specimens. L-shaped pieces of cardboard, such as may be cut from library cards, are very useful in experimental work. Individual spiders are chloroformed and at once fastened with glue or paper cement to the short arm, in any desired position. The color of the card is immaterial if it is a fairly light tint, and so contrasts in brightness with the spider. Whether or not it matches the background of the table over which it is manipulated has no apparent effect: a test spider never responds to an L alone. However, to reduce the variables, the procedure was standardized, to use only light green cards on a background of similar hue, brightness and saturation. The tip of the long end is bent up to form a convenient handle. A number is written on the card, and the whole dried (in order to eliminate odor stimuli), protected from pests by paradichlorobenzene crystals; odors from the latter are quickly dissipated before experiments, and in any case have no apparent effect on the subjects. Such a mount becomes a standard and can be used indefinitely. When it is manipulated before a test spider, the latter takes no notice of either the observer's hand, which is usually behind him anyway, because of the length of the L-arm, or of the L itself; his attention, if any, is captured only by the mount. L-cards are also useful in manipulating lightly chloroformed spiders, for example females, where it is desired only to test the effect of her odor as opposed to chemotactic stimuli; the card insulates her from the background, so that she does not leave a "trail" during the manipulations. Finally, painted cardboard models of spiders are likewise glued on L-cards for ease of handling and storing.

Anaesthesia. Ether, refrigeration and chloroform have been tested, and of the three chloroform is the most satisfactory. Recovery from ether is too quick, whether the specimen is anaesthetized for testing reactions to immobility of another individual, or for painting or mutilating; also, ether itself is often highly disagreeable to the observer. Recovery from refrigeration is almost instantaneous or, if it has been prolonged in a tropical spider, normal behavior may never be resumed. A special cold technique, however, is sometimes preferable to chloroform during a long operation: the spider is first chilled to immobility in the refrigerator, then promptly brought to the microscope and the work performed on top of a cheesecloth-wrapped ice cube. Recovery of complete display reactions can never be assured by this means.

Chloroform, when handled carefully, is the most satisfactory anaesthetic. For moderately swift recovery with unimpaired reactions, the spider should be placed in a vial with a chloroform-dipped cork; there it should stay just long enough to make its legs

go rigid *after* its removal from the fumes; that is, it should be taken out before stupor appears complete. In the case of a long operation, several repeated short doses of chloroform are better than a single long one. Different salticid species, even when closely related and of similar size, vary considerably in their reactions to the various methods. The use of carbon dioxide is a possibility still to be tested in this group.

Paint. A number of different kinds of paint were tested for marking and altering patterns in salticids. Uniformly satisfactory for all indoor experimental work except blinding were opaque water colors. In blinding, a base coat of the above water color was given, followed by an overcoat of light-colored Flopaque paint (see below) or even fingernail polish. The base coat is necessary to insulate the spider against harmful effects of the strong chemical varnishes and their removers; the spider may die if paint is allowed to seep around the eye margins; more important, the powerful removers are invariably poisonous. The base coat of water color is stuck with difficulty on the shiny convex surfaces and is easily removed by the spider if not covered with the more adhesive paint; however it is completely harmless, protects the margins from the covering paint, and both layers are sponged off easily and simultaneously with a water-soaked brush. Light colors are used so that complete eye-coverage may be easily checked. Shellac, used by the Peckhams and others, seems to share difficulties with other non-water-colors: although it is not necessarily poisonous in itself and will largely wear off in time, turpentine or other removers are harmful; the importance of this lies in the technique of modern experiments, since a negative reaction, for validity, should be promptly supported by positive reactions to the same stimuli after sight has been restored, to eliminate the factors of post-operative or post-anaesthetic effects.

Water color obviously will not serve for marking spiders to be liberated. For this purpose Flopaque paint (manufactured by Floquill Products, Inc., New York 23, N. Y.), is ideal. It is waterproof, dries almost instantly, and adheres well to either scales or naked chitin. Also, it is thinner than any insect-marking mixture I have tested, so that a variety of identification patterns are easily painted. It is harmless to the spider when applied on top of either carapace or abdomen, but all appendage joints, especially near the body, as well as the eye margins, should be avoided.

Cards were painted with samples of various tints and shades of the opaque water colors, as well as colors straight from jars. These were used to determine their relative brightness with a Weston exposure meter. A similar set of cards with grays of corresponding values, as well as whites, was then made up. Finally the cards were photo-

graphed through a filter (Wratten No. 18A) reflecting substantially all rays except the ultra-violet, in order to determine which of the colors involved an ultra-violet factor; the reds were also tested visually through a blue-green filter for blue and violet content. Obviously these tests can give only approximate results; their value lies in preliminary color vision studies in a field laboratory, in the absence of precision instruments.

In regard to the actual painting technique, nothing need be said except that even the finest paintbrush obviously must be trimmed to paint a successful spot on a half-millimeter clypeus. The spider is best held on the dissecting microscope stage in the bare fingers, but protected by an enfolding wisp of cotton.

Mutilations. A dissecting needle with a tiny distal blade is ideal for quickly removing palps or legs at any desired joint, or for shaving off hairs and scales.

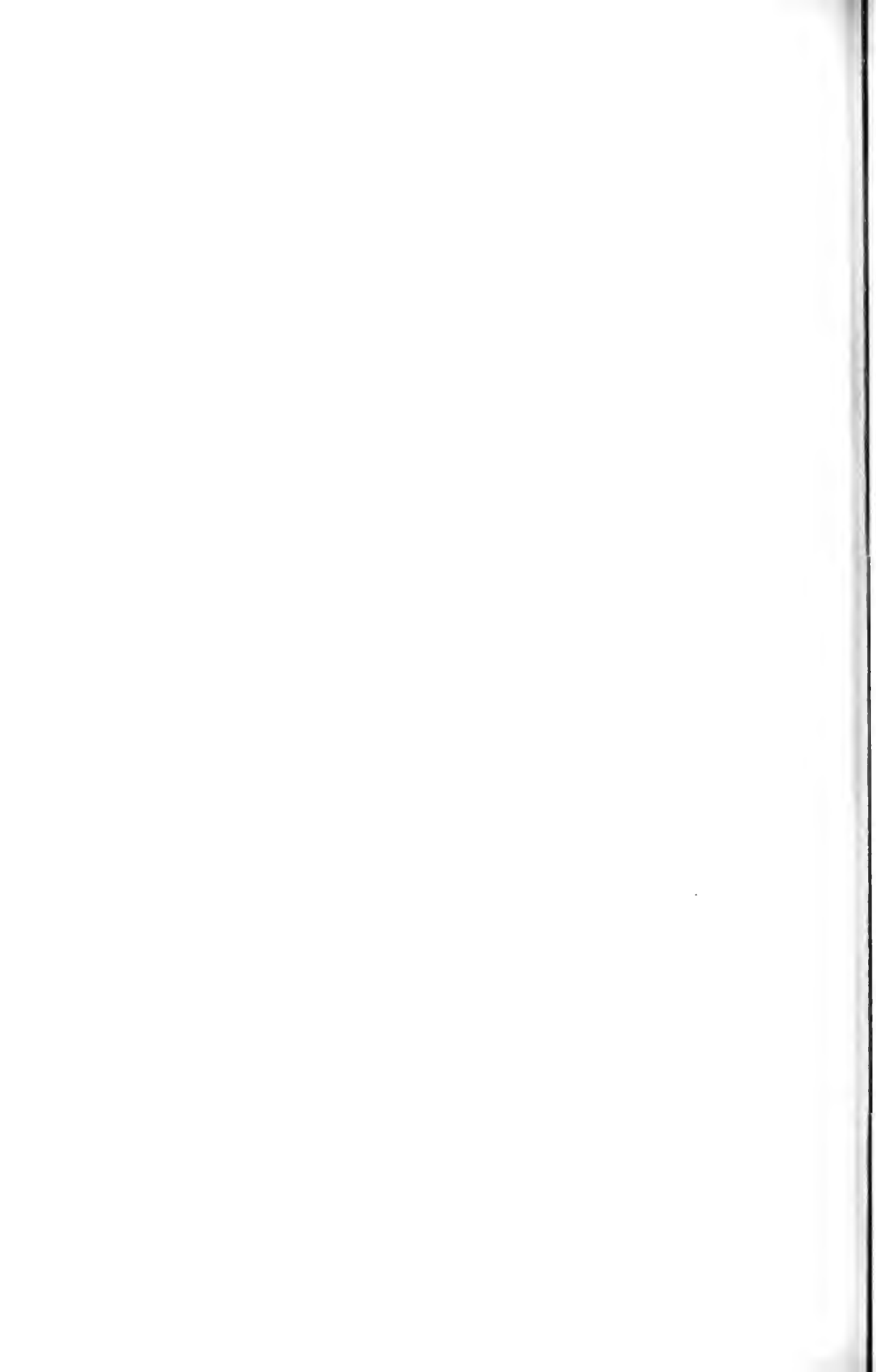
Distance Measurements. Distances at which reactions to a stimulus were initiated were measured conveniently as follows: A piece of green oilcloth was marked with black ink into 12 numbered, concentric circles an inch apart. The whole was varnished with an alcohol-proof preparation, so that chemotactic trails could be removed with alcohol after every use. A sheet of glass might be used, instead of varnish.

V. SUMMARY.

This paper is devoted primarily to methods of studying salticid spiders alive in the tropics. Shaking, visual searching, and examination of airplants are the primary collecting methods. Dry season fauna is scanty, even in rain forests. Specimens are maintained and reared successfully in small jars with mosquito netting tops. Continuous but non-constant moisture is supplied with dampened, cotton, dental wads. Food consists of *Drosophila* and other small flies, reared and wild. Second instar young are fed small leaf litter organisms and de-winged *Drosophila*. Displays are studied in natural habitats, on open tables and in glass-covered dishes. Colors and display positions are recorded from living specimens. Dried or chloroformed examples, for experimental manipulation, are conveniently mounted on the short ends of L-shaped pieces of cardboard. Chloroform, carefully controlled, is a successful anaesthetic. Color and pattern are usually altered with opaque watercolors. Mutilations are performed with a bladed needle. Painted, concentric circles are convenient for measuring distances of responses to stimuli. Precautions against confusion of experimental results are discussed, as well as the general suitability of salticids as subjects for experimental research.

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10.

Fish Fauna of Rancho Grande, Venezuela.¹

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INTRODUCTION.

[This is one of a series of papers resulting from the 45th and 46th Expeditions of the Department of Tropical Research of the New York Zoological Society, made during 1945 and 1946 under the direction of Dr. William Beebe with headquarters at Rancho Grande in the National Park of Aragua, Venezuela. The expeditions were made possible through the generous co-operation of the National Government of Venezuela and of the Creole Petroleum Corporation.

[The characteristics of the research area are in brief as follows: Rancho Grande is located in north central Venezuela (10° 21' N. Lat., 67° 41' W. Long.), 80 kilometers west of Caracas, at an elevation of 1,100 meters in the undisturbed montane cloud forest which covers this part of the Caribbean range of the Andes. Adjacent ecological zones include seasonal forest, savanna, thorn woodland, cactus scrub, the fresh water lake of Valencia, and various marine littoral zones. The Rancho Grande area is generally subtropical, being uniformly cool and damp throughout the year because of the prevalence of the mountain cloud cap. The dry season extends from January into April. The average humidity during the expeditions, including parts of both wet and dry seasons, was 92.4%; the average temperature during the same period was 18° C; the average annual rainfall over a 5-year period was 174 cm. The flora is marked by an abundance of mosses, ferns and epiphytes of many kinds, as well as a few gigantic trees. For further details, see Beebe & Crane, *Zoologica*, Vol. 32, No. 5, 1947. Unless otherwise stated the specimens discussed in the present paper were taken in the montane cloud forest zone, within a radius of 1 kilometer of Rancho Grande.]

INTRODUCTION.

Within the limits of our researches at Rancho Grande living conditions for fish were so poor that only three species were represented. Two of these were characins, which without special adaptations could make their way up low rapids to the limit of permanent pools in the upper middle reaches of the brooks feeding the Rio Limon, south of the Portachuelo Pass watershed.

The smaller and more precipitous streams on the north side of the divide were inhabited by a single species of catfish, *Pygidium*. This, like most members of its family, was adapted for life and progress in

swift currents and restricted pools. The opercles and interopercles were armed with rows of projecting spines, and by alternate movements of these gill covers the fish could cling to steep rocks, and progress against gravity and force of water with remarkable success. The mobile, eel-like body and flattened fins were all of help.

Under laboratory conditions these fish showed pronounced ability to leap, yet I never saw any salmon-like jumps in nature, whereas several times the fish were observed hitching themselves, little by little, up the steep sides of rocks and through water trickling from one small pool to another.

Brown-spotted Pygidium.

Pygidium b. banneau Eigenmann.

Pygidium banneau Eigenmann; *Indiana Univ. Studies*, no. 16, 1912, p. 19; *Mem. Carnegie Mus.*, vol. 7, 1918, no. 5, p. 318.

These catfish belong to the subfamily Pygidiinae, which are mostly of small size, and have unpleasant reputations of being parasitic on the skins of other fish, and actually entering and living within the gill cavities of large catfish. The catfish of Rancho Grande must seek more normal methods of livelihood, for there are no other fish in the upper reaches of these mountain streams. Their habitat is typical, for *Pygidium* as a whole is confined to streams of the higher Andes, living as high as three miles above sea level.

Habitat. Ten minutes away from Rancho Grande brings us to a small brooklet. It crosses the main road by a stone and cement culvert, and from here on down the valley it drops steeply, enters the Rio Ocumare and finally ends, six miles north, in the Caribbean. Near the culvert we found specimens of this fingerlong catfish, the only fish able to ascend this steep succession of falls and small pools, to exist in periods of drought when the stream becomes a drop-by-drop trickle, and to withstand the change to a roaring torrent resulting from cloud-bursts during the height of the rains.

General. The first of this species were taken on April 17, 1946. There were two large ones (60 mm. standard length), and three small (20 mm.).

In seventeen other pools of this same

¹ Contribution No. 817. Department of Tropical Research, New York Zoological Society.

stream, small individual catfish were taken in twelve; large, apparent adults in three more; while two pools were without fish.

When disturbed, the fish wriggled along the bottom, and when alarmed pushed under dead leaves. Fear was a minor sensation with them, perhaps due to the absence of kingfishers and herons. Nevertheless I came suddenly upon a large *Belostoma* water-bug, a three-inch menace to fish and frogs.

On May 22 more small fish were taken from four other small brooks crossing the road along the same stretch as catfish brook number one, all within a half kilometer. None were taken more than thirty meters above the culverts.

On July 4 I collected a number of fish with a few explosive caps. The first pool above the culvert measured two feet by a foot and a half, by a few inches deep, half filled with leaf debris, over a gravelly bottom. The explosion sent a small geyser of water into the air, but for a time there were no visible results. Then several catfish came into view, moving slowly close to the bottom. The only effect was a complete disregard of the hand net. We scooped up twelve in a few minutes. None of them came to the surface as do tide-pool fish, but only swam about slowly, pushing under pebbles and leaves. The largest ones showed subdermal congestion when examined closely, and ultimately died. All of small and medium size recovered. The largest was 73 mm. in standard length.

Color in Life. In a large specimen the upper surface down to the lateral line was cinnamon buff, below fleshy white, immaculate. A line of very faint darker buff marks extended down midline of back, ending at dorsal. On each side a series of unconnected, irregular, dark blotches of all shapes extended to tail. Below this, on the midsides, an almost solid line of dark buff, breaking up posteriorly, reached the tail. On top of head two distinct longitudinal lines were behind the eyes, greenish in life. Two irregular, dark buff blotches on gill covers.

The pattern and colors of the young fish were like those of the larger, except that they were more distinct and linear, less broken into blotches. After three weeks in an aquarium the pigment showed a decided tendency toward breaking into unconnected blotches.

Eye. In the larger fish the eye was 1 mm. in diameter, protuberant, and when at rest directed outward. In extreme movement the eyeball had a vertical rotation of at least 50 degrees, the direction of vision changing from almost lateral to more nearly superior.

Position in Life. The fish rested flat on the bottom of the pool, often beneath a leaf or stone. Pectorals spread wide, flat on bottom, outer elongated ray (ca. 8.6 mm. in length) 45 degrees out from body. Between it and the body the fin fanned out. Lower maxillary

barbel flat, curved obliquely back; upper one slightly raised, obliquely forward, tip curved backward; narial barbel forward, 20 degrees out and back from longitudinal.

Gill Covers in Life. These were divided into two lobes, one above the other, the lower one larger. There were at least thirteen opercular spines projecting through the skin of the lower lobe, arranged in two irregular rows. The distal row, eight in number, penetrated the skin in the shape of slender, curved, sharp, tooth-like spines. Four or five, considerably smaller, projected from the lesser, upper lobe. When the fish was frightened and moved toward the shelter of pool debris, the gill covers could be seen to move independently, and apparently aided the pectorals in forward progression. They must be of decided help in clinging fast to rock crevices and vertical surfaces in swift currents.

Viability. In August we killed the last of the small catfish taken in May. It had increased three mm. in length, and had become somewhat darker in color. For three months it had lived in perfect health, without provided food, in a glass laboratory dish two and a half, by three and a half, by one inch deep, loosely covered, half filled with unchanged water which was thick and opaque with green algal scum.

Terrestrial Locomotion. A fish of medium size (35 mm.) when placed on a dry cement floor instantly flipped a distance of twenty-three inches. It rested four seconds and then cleared twenty-five inches, then fifteen more; ten seconds rest, and two leaps of six and fourteen inches. Two minutes' rest was followed by three flips of two, four and thirteen inches; then a period of wriggling and futile flipping within an area of five inches; a final high effort of eighteen inches and I returned it to its aquarium, very dusty but quite unharmed. For two minutes it hid beneath a leaf and then leaped out upon the floor. A characin under the same conditions merely twisted and wriggled for a minute and then gave up.

Food. In addition to much comminuted vegetable matter, we recorded as additional food an aquatic dragonfly larva, together with two small beetles and a fly which had probably fallen into the pool.

Characins.

Directly in front of Rancho Grande several small streams had their origin, streams which made their way down the steep valley to the south of Portachuelo Pass. Far down at the bottom all of these merged with the Rio Limon, which reached a width of several meters as it flowed over the relatively flat lowlands, and finally emptied into Lake Valencia miles away. The upper reaches of these brooklets were too small for any fish, but before they lost themselves in the larger stream the small pools, connected by less precipitous falls, were inhabited by two spe-

cies of characins. These were *Hemibrycon dentatus metae* and *Creagrutus beni*. Both were found in equal abundance just before the junction of the tributaries and main stream, but higher up, even past the culvert and on up the northern slopes, *Creagrutus* still persisted in rather swift currents.

Dark-tailed Characin.

Hemibrycon dentatus metae Myers.

Hemibrycon dentatus metae Myers, *Proc. Biol. Soc. Washington*, vol. 43, 1930, p. 68; Schultz, *Proc. U. S. Nat. Mus.*, vol. 95, 1944, p. 363.

A single discharge of a small explosive cap on July 22, 1946, in a lower pool, yielded sixteen of these small but colorful characins. They varied from 60 to 105 mm., in standard length, the largest weighing thirteen grams.

Color in Life. Dark silvery blue above, changing to bright silver. Below silvery white. Five specimens had a dark, diffused, shoulder spot, absent in the others. All showed a broad, pale lateral band, and a lateral, jet-black band on the caudal peduncle, extending back to the tips of the mid-caudal rays. Caudal fin either clear or with distinct dusky area above and below, with a strong tinge of lemon yellow or pink on the proximal portion of the fin. In the largest specimens there was a dusky area on the dorsal fin. Anal strongly dusky along the tips of the rays, bright pink on the anterior rays. Upper part of eye bright red.

Food. The largest fish (105 mm.) had just eaten a large (50 mm.) brightly colored sphinx caterpillar, not quite dead. Three other fish had the following in their stomachs: (a) dragonfly larva, cicadellid, membracid, beetle larva, dipteran, vegetable matter and quartz grains; (b) Cassidini, caddisfly larva, dipteran larva, dragonfly larva, a fly and an aphid; (c) small moth and dragonfly nymph.

Pink-tailed Characin.

Creagrutus beni Eigenmann.

Creagrutus beni Eigenmann, *Ann. Carnegie Mus.*, vol. 7, 1911, no. 1, p. 142; Schultz, *Proc. U. S. Nat. Mus.*, vol. 95, 1944, p. 336.

Many of these were collected in the lower and middle reaches of the southward flowing streams. Twenty-nine were taken with a single cap on July 22, 1946, measuring from 21 to 80 mm.

Color in Life. Dark olive above and on sides, except for a broad, very pale silvery blue lateral band. Below, anteriorly whitish with body organs showing through; posteriorly olive. Faint, indistinct peduncular duskiness. Basal half of caudal greenish-yellow, then a large dusky area. Distal portion, especially under lobe, pink, varying to scarlet in some individuals. This tail pattern the same in all sizes, small and large. In small fish and some of medium size the lateral silvery band was dusky on the posterior third. Distal parts of pelvic and anal rays bright lemon. Iris scarlet on upper fourth, silvery and dusky elsewhere.

Food. Two specimens contained the following: (a) firefly larva and unknown insect; (b) small caterpillar, beetle and unknown aquatic larva.

Viability. A 40 mm. *Creagrutus* was kept for five weeks in a quart jar in the laboratory, with unchanged water and no provided food. When killed at the end of this period it was as active as ever, with no diminishing of coloration. The only change was a dense growth of green algae on the rays of the caudal.

Note: I have to thank Dr. Leonard P. Schultz for the identification of the three species. The specimens are divided between the United States National Museum and the collections of the Department of Tropical Research of the New York Zoological Society. The department catalogue numbers are, *Pygidium banneau* *banneau* 30627, 30716, 30831, 30941. *Hemibrycon dentatus metae* 30868, 30892, 30986. *Creagrutus beni* 30869, 30870, 30940.



11.

The Species of *Bathystoma* (Pisces, Haemulonidae).

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The genus *Bathystoma*, first established by Scudder (*Bull. Mus. Comp. Zool.*, 1:12, 1863), differs from *Haemulon* only in normally having 13 dorsal spines, instead of 12. In other characters the two genera essentially agree. As shown in Table III, of 166 specimens of *Bathystoma* examined only 2 variants have 12 spines. In contrast, 62 specimens examined representing 5 species of *Haemulon*, namely, *plumieri*, *sciurus*, *parra*, *macrostomum* and *flavolineatum*, have 12 spines. Therefore, this difference seems sufficiently constant to be used as a generic or subgeneric character.

Jordan and Swain (*Proc. U. S. Nat. Mus.*, 7:308-313, 1884) revised the species of *Bathystoma* which they included in *Haemulon*, used in a broad sense. They recognized three species, as follows, with the geographic distribution as determined by them: *rimator*, North Carolina to Trinidad; *aurolineatum*, Florida Keys to Cuba; *quadrilineatum*, Bermudas to Brazil. Later, Jordan and Fesler (*Rep. U. S. Comm. Fish.*, 17:477-79, 1893) designated the third species *striatum*, instead of *quadrilineatum*; this substitution being a necessary nomenclatorial emendation in their opinion. They also give the distribution of *aurolineatum* as "Florida Keys to Brazil," the latter and San Domingo being the two localities given in the original description. Still later, Jordan and Evermann (*Rep. U. S. Comm. Fish.*, 21:385, 1896) treated *Bathystoma* as an independent genus.

According to the revisers mentioned, therefore, *Bathystoma* comprises three sympatric species. Later authors have followed this conclusion (using the amended nomenclature as noted above), and as occasion required, some of them recorded three species from the same locality, distinguishing *striatum* by the higher scale count and *rimator* from *aurolineatum* by its deeper body, as was done by Jordan and Swain. The data determined in the investigation here recorded prove that this treatment is in error. *Bathystoma* comprises only two known sympatric species, *aurolineatum* and *striatum*, and not more than two occur at any given place. One of these species, *aurolineatum*, differs markedly in body depth with the local populations; but there is no evidence of a bimodal frequency distribution in that character in

any given locality. The local populations are roughly divisible by body depth into three major groups which, for taxonomic purposes, may be treated as three allopatric subspecies. One subspecies, *aurolineatum*, occurs in the West Indies and South and Central America. All specimens examined by me from the coast of the United States belong to only one species, *aurolineatum*, sensu lato. The other species, *striatum*, might possibly occur in the Florida Keys, but this remains to be proved. The composite U. S. population may be designated as a distinct subspecies, *rimator*, which is confined to the coast of the United States. The Bermuda population constitutes a third subspecies, *angustum*, which is formally established below.

I am not satisfied that the nomenclature currently applied to the species (or subspecies) of *Bathystoma* is correct. For instance, the body depth given by Jordan and Swain (above citation), as determined by Sauvage, for the type of *aurolineatum* applies more nearly, judged by my data, to that species which is designated currently by authors, and in this paper, as *striatum*. Also, the locality of *striatum* is given in the original description as North America. If by "America Septentrionali" Linnaeus meant the coast of the United States, the name *striatum* should replace *rimator*. However, the proper use of these names, and the synonymy of the species, could be determined only by a comparative study of the original material. Pending such a study, I continue to use the nomenclature in the sense it is currently applied.

Bathystoma aurolineatum (Cuvier and Valenciennes), sensu lato.

The frequency distribution of body depth is given in Table I, expressed as a percentage of the standard length, segregated into 6 size groups and by population. The depth differs considerably with size and it also differs with the local populations. The size and population differences indicated apparently are only rough approximations, as I was limited by the available material which to a certain extent determined the grouping of the data as given in the table. The minor population differences especially are indicated in a very limited way. Because of the paucity of speci-

mens from most restricted localities, the data to a large extent are grouped by major geographic regions. The local samples comprised in the composite groupings exhibited in the table are shown in the next paragraph. A figure following a locality gives the number of specimens examined, and the next figures in parentheses give the range of their standard length.

United States, Miscellaneous: off Albe-
marle Sound, North Carolina, 3 (88-97);
Cape Lookout, N. C., 1 (161); Browns Inlet,
N. C., 1 (166); off Cape Fear, N. C., 4 (160-
189); Charleston, South Carolina, 12 (124-
242); off Savannah, Georgia, 5 (76-183);
Fernandina, Florida, 1 (196); New Smyrna,
Florida, 1 (134); off Pine Island, Florida, 7
(83-118); Charlotte Harbor, Florida, 2 (136-
149); Gasparilla Light, Florida, 5 (41-89);
off Choctawhatchee Bay, Florida, 2 (53-55);
Pensacola, Florida, 3 (103-108); Galveston,
Texas, 1 (165). *Florida Keys*: Biscayne Bay,
1 (71); Big Pine Key, 1 (74); Bahia Honda,
3 (131-135); Boca Grande, 6 (73-117).
Southern Florida: the Florida Keys as given
above, and Key West, 23 (54-171). *Tortugas*,
5 (78-144). The preceding specimens are
here referred to the subspecies *rimator*; the
following to the subspecies *aurolineatum*.
Hispaniola: Haiti, 8 (67-143); Samana Bay,
Dominican Republic, 5 (141-158). *American
Tropical Atlantic*: Includes Hispaniola as
stated and the following, Bahamas, 6 (124-
172); Cuba, 12 (65-132); Jamaica, 2 (110-
123); Puerto Rico, 2 (94-149); St. Thomas,
Virgin Islands, 1 (124); St. Lucia, Wind-
ward Islands, 3 (86-94); Colon and Porto
Bello, Panama, 2 (78-88); Bahia, Recife and
Rio de Janeiro, Brazil, 6 (105-155).

To display some minor population differ-

ences indicated by the data, groupings are
not the same in all three tables. In Table I
"Key West" and "Cuba" are stated sepa-
rately from "Southern Florida" and "Ameri-
can Tropical Atlantic," respectively, in order
to show some apparent minor differences in
those two populations. In Table II "His-
paniola" and in Table III "Hispaniola" and
"Cuba" are stated separately from the rest
of "American Tropical Atlantic" for the
same purpose.

Table I shows that the combined sample
from the coast of the United States, except-
ing perhaps the smallest size group and also
the Tortugas population, diverges from that
of tropical America to a subspecific degree,
and it seems appropriate to treat the two
major groups of population as two coordinate
subspecies, *rimator* with a relatively deep
body and *aurolineatum* with a more slender
body. The Bermuda population is at the other
extreme and should be treated as an inde-
pendent subspecies.

Within the major groups of populations
there also appear to be some population dif-
ferences of a minor degree. Although the
samples examined are not sufficiently exten-
sive to elaborate the minor differences satis-
factorily, the following seems tentatively
indicated. The southern Florida populations,
as compared with the more northern United
States populations, average the body some-
what deeper in the smaller specimens; but
more slender in the large-size group, over-
lapping the subspecies *aurolineatum* to a
greater extent, especially the Key West popu-
lation. The Cuba population seems to average
a slightly more slender body as compared
with the other American tropical populations.
(The latter comparison is made for the com-

TABLE II.—FREQUENCY DISTRIBUTION OF THE NUMBER OF SCALES SEGREGATED BY MINOR POPULATION, SUBSPECIES AND SPECIES.

Population	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
<i>aurolineatum</i> sensu lato U. S., Miscellaneous				2	3	3	6	1	7	4	4	2	4	1	1							
Southern Florida		2	3	1	5	1	3	6	4	5	1	1	1									
Tortugas			1		1	1				2												
American Tropical Atl.		2	2	5	2	6	4	4	3		1	2		1								
Hispaniola	1	1	1	2	1	4	2		1													
<i>rimator</i>		2	4	3	9	5	9	7	11	11	5	3	4	2	1							
<i>aurolineatum</i>	1	3	3	7	3	10	6	4	4		1	2		1								
<i>angustum</i>					1	2	4	3	2	1												
<i>striatum</i>																	1	1	1			1

bined size group data as the specimens for each separate size group are too few to draw even tentative conclusions.)

The five specimens examined from Tortugas approach the subspecies *aurolineatum* even more closely than the other southern Florida populations. The two larger specimens fall at the mode of the distribution of that subspecies. It is possible that the study of an adequate sample from Tortugas will show that that population is more appropriately grouped with *aurolineatum* rather than *rimator*. If this contingency proves so, such a rather unexpected population difference will find a parallel in *Bathygobius curacao* (see *Jour. Washington Acad. Sci.*, 37: 278, 1947). However, in the absence of satisfactory proof, the 5 Tortugas specimens are tentatively grouped with *rimator*.

Omitting the two extreme size groups, one at each end, the combined data for the other 4 size groups are given under geographical groupings and the subspecies heading in Table I. In the absence of adequate data for each size group separately, this combination gives a roughly approximate measure of the degree of subspecies divergence.

The combined data for the 4 size groups show to some extent a gradual transition in decreasing body depth from the more northern U. S. localities to the Florida Keys to Key West to Tortugas to Cuba. Hence, the pertinence of separating the populations into two distinct subspecies might be questioned. However, this is rather the general rule in subspecies distinctions. That is, subspecies, as a rule, are not homogeneous entities; but the constituent local populations differ in a minor way and in variable degrees. Omitting the Tortugas sample which is discussed above, there is a slightly but perceptibly abrupt transition between the U. S. populations and those from tropical America and this seems to be the proper geographical boundary to draw between the subspecies.

Differences in the scale, gill raker and fin ray counts, shown in Tables II-III, are of minor degrees, less than subspecies magnitude. The subspecies *angustum* averages low soft dorsal and pectoral counts; while *aurolineatum* averages a somewhat high gill raker count on the lower limb. Other differences are indicated for the minor constituent populations within the subspecies as follows: The southern Florida populations, as compared with the more northern United States populations, average lower scale and gill raker (on upper limb) counts, and a slightly higher pectoral count. The Hispaniola population averages somewhat lower scale and soft dorsal ray counts, and the Cuba population averages a high gill raker count on upper limb and a slightly lower pectoral count, within their subspecies.

The color pattern of the subspecies *aurolineatum* and *rimator* is essentially as that described below for *angustum*. The dark

lines disappear with growth, and most of the smaller specimens have two more dark lines than the partly faded specimens of *angustum* examined, one close to the dorsal contour and another on the head, behind the eye.

***Bathystoma aurolineatum angustum*, new subspecies.**

Depth modally 29 (in specimens 74-113 mm.), varying 28-31. Dorsal rays predominantly 14, very often 15. Pectoral rays with the mode decidedly at 17, varying 16-18.

Specimens examined more or less faded and color pattern rather faint or hardly perceptible; a dark blotch at caudal base moderately marked; with rows of small pearly spots along rows of scales, horizontal below lateral line, about 12, oblique above; each spot at anterior part of exposed portion of scales, their periphery darker colored; often shades reversed, the spot darker, the periphery lighter, resulting in rows of darker spots against a lighter background, forming nearly continuous streaks in gross effect; the latter phase more often present on lower part of body and in the larger specimens; a median dark streak from snout to within a variable distance of caudal blotch, interrupted by eye; a second streak above lateral line on dorsal aspect of snout and interorbital space, continued to end of dorsal fin; traces of streaks present in largest specimens examined.

The color pattern, as judged by these faded specimens, is essentially as in the other two subspecies of *aurolineatum*, except that the dark streaks appear to persist to a larger size. The other two subspecies usually have two more streaks, as noted above; but this seeming difference is possibly due to the faded condition of the specimens.

Holotype:—U. S. N. M. 20178 Bermuda; 127 mm. in standard length, about 160 mm. in total length (caudal broken at end).

Other 29 specimens 74-138 mm. in standard length examined from Bermuda.

This is a highly divergent subspecies. It diverges from the other two subspecies of *aurolineatum*, *sensu lato*, to a higher degree than the latter diverge from each other. The divergence in body depth, shown by the determined data, is about of species magnitude. However, *angustum* nearly agrees with the other two subspecies in the scale count, color pattern and other characters, and its treatment as a coordinate subspecies seems the best course to take, judged by available evidence. In two characters, body depth and soft dorsal count, *angustum* bridges the depression in the distribution between *striatum* and the other two subspecies of *aurolineatum*.

***Bathystoma striatum* (Linnaeus).**

This species evidently is not as common as *aurolineatum*. Only 4 specimens were found in the National Museum, 3 from Cuba and 1

from Haiti, and these were the only specimens examined during this study.

Typically with 6 longitudinal dark streaks; the uppermost at a little distance below upper contour, beginning on nape and ending before end of spinous part of dorsal; the second on dorsal aspect of snout and inter-orbital space and continued to end of dorsal; the third short, not continued behind head, converging forward with second on snout; the fourth from upper margin of eye continued backward along lateral line to an area under end of dorsal; fifth median in position, from eye backward, merging with fourth under anterior part of soft dorsal; sixth wider and fainter than others, from pectoral base to within a moderate distance of caudal base; an unpaired streak on midback in front of dorsal; no definite caudal blotch in specimens examined. The streaks are present in the largest specimens examined and possibly do not disappear with growth.

This species, then, has a different color pattern than *aurolineatum*, sensu lato. The streaks occupy somewhat different positions, typically they number 2 more, and they possibly do not disappear with growth. The specimens examined also lack the caudal spot. The structural differences are indicated in the tables. The most divergent character is found in the scale count. The determined data show a slight gap between the two species; but some degree of intergradation may reasonably be expected when more specimens of *striatum* are examined. This species also differs in averaging more gill rakers on the lower limb, fewer anal rays, more pectoral rays, a more slender body and fewer dorsal rays, the degrees of divergence of these overlapping characters perhaps being in the order named. On the whole, it is not difficult to distinguish single specimens of *striatum* from *aurolineatum* sensu lato.

12.

The Morphology of the Pituitary Gland of the South African Clawed Toad, *Xenopus laevis* Daudin.

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(Plate I).

INTRODUCTION.

In recent years much interest has been shown in the South African clawed toad, *Xenopus laevis* Daudin, because of its sensitivity to anterior pituitary hormones. On the basis of this sensitivity, Bellerby ('33) suggested *Xenopus* as a test animal for determining pregnancy. Landgrebe ('39) made such tests and described the technique in detail. The validity of the test was further evaluated by Weisman, Snyder and Coates ('42) and Weisman and Coates ('44). Hogben, Charles and Slome ('31), Bellerby and Hogben ('38) and Berk ('39) described sex factors related to pituitary function in this animal. During a somewhat earlier period a hypophyseal-chromatophore mechanism also received considerable attention (Slome and Hogben, '28).

Thus far while there appears to be agreement on the physiological aspects of the hypophysis of *Xenopus*, the morphological descriptions of the gland to be found in the literature (Rimer, '31; Hogben, Charles and Slome, '31; Levenstein and Charipper, '39; Atwell, '41) seem to be rather incomplete. The purpose of the present report is to describe the normal morphology and histology of the pituitary gland in *Xenopus laevis*, in an effort to augment and clarify the subject.

We wish to acknowledge with sincere appreciation the opportunity to examine the original preparations made by Dr. Irving Levenstein, in collaboration with the senior author during a preliminary survey, also the cooperation of Mr. Christopher W. Coates who through the New York Zoological Society and the New York Biologic Research Foundation generously contributed much of the material used in the current investigation.

MATERIALS AND METHODS.

Sexually mature males and females of *Xenopus laevis* were used in this investigation. The pituitary glands were obtained following decapitation, and, usually, removed from the brain case along with a portion of the midbrain.

The tissues were fixed in Bouin, Zenker,

Formol sublimate, and formalin (10%) for studies of the microscopic anatomy of the gland. To demonstrate the finer cellular details, the tissue was placed in Champy's fluid for twenty-four hours, then in 2% osmic acid at 35° C. for three to six days. The Golgi apparatus was best demonstrated after the longer period of osmication.

Horizontal, longitudinal and cross-sections were then cut serially in paraffin at 3 and 4 micra. These were stained by Masson method with modifications (Foote, '33) and checked with hematoxylin and eosin. The Dawson and Friedgood ('38) method and the Severinghaus ('32) technique were used for further cellular differentiation.

DESCRIPTION.

a. *Gross Morphology.*

In situ, the pituitary gland when observed ventrally is a flattened disc-like structure with lateral elongated projections. The anterior portion of the gland is bounded ventrally by the presphenoid cartilage which extends forward from the basisphenoid bone. When these structures are removed, the gland is seen to be suspended from the *tuber cinerum* by the infundibulum just dorsal to the optic chiasma (Fig. 1).

The *pars anterior* is ventro-caudal to the rest of the gland. In some specimens this portion is ovoid in outline with its longer dimensions antero-posterior while other specimens exhibit a greater diameter in the dextri-ventro axis. Dorsal to this ovoid structure is the flattened, elongated, dumb-bell shaped extensions of the *pars intermedia*, which extend transversely across this anterior lobe. No large blood vessels are observed entering the pituitary body, but a good sized blood vessel is seen embedded in both sides of the brain, lateral to these elongate projections.

b. *Microscopic Anatomy.*

1. General.

A histological study of the *hypophysis cerebri* of *Xenopus laevis* reveals a structure, similar, in general, to that described for most vertebrates. In serial sections, and at the

several planes, this gland shows an anterior portion with a cellularly differentiated area (the anterior process of Atwell '41), a *pars intermedia*, a *pars nervosa* and, lying on either side of the median line, two epithelial plaques embedded in the walls of the infundibulum—the *pars tuberalis*.

The *pars anterior* is ventro-caudal to the rest of the gland (Fig. 2) and is ovoid in shape. It is the largest lobe of the complex and is firmly embedded in a thickened median eminence of the infundibulum. The rostral area of the *pars anterior* is heavily vascularized and distinct from the anterior lobe proper. The area consists chiefly of weak staining basophile cells with few acidophiles.

Dorsal to the anterior lobe is a flattened elongate structure which extends transversely across the anterior lobe (Fig. 3). These projections consist of two clearly demarcated areas, a ventral portion, the *pars intermedia* and a dorsal portion, the *pars nervosa*. The *intermedia* is very closely applied to the *pars nervosa* and only separated by a thin connective tissue septa. The *pars nervosa* is continuous with the infundibulum.

Anterior to and continuous with the infundibulum on either side are thickened extensions of the hypothalamus, the *tuber cinereum*. These structures completely enclose the infundibular cavity which, in some sections, is continuous with the third ventricle of the brain.

In transverse and frontal sections of the *tuber cinereum*, two epithelial plaques (*pars tuberalis* of Atwell '41), one on either side, are found embedded in the ventral surface (Fig. 5). These structures are bounded on the ventral surface by the *pia mater* and on the dorsal side by blood vessels.

2. Pars Anterior.

Of the several structures which make up the pituitary gland, the *pars anterior* is the most complex in its cellular elements. It is seen as nests in transverse sections. These nests are separated by delicate connective tissue partitions (Fig. 4). Very often a capillary can be seen penetrating the center of the nest of cells. In median sagittal sections, the gland is somewhat tubular and consists of cords of cells which are separated by capillary channels containing numerous erythrocytes.

The *pars anterior* fixed in Bouin's, Champy's, or formalin and stained in Masson's stain consists of three general cell types, acidophiles, basophiles and chromophobes. These cells can be distinguished by size, granulation, and staining reaction.

With the Dawson-Friedgood technique ('38), it is possible in some sets of slides to distinguish four cell types on the basis of staining reactions. Two types of acidophiles may be distinguished; an "Azure-carmin" cell and an "Orange G" cell. The "Azure-carmin" cell is larger than the "Orange G," and

contains granules which are coarser and more numerous than those present in the "Orange G" cell. The cytoplasm of the "Orange G" cell is homogenous in appearance, containing very fine acidophilic granules evenly distributed throughout the cell. The nuclei of both of these cells are identical; ovoid with some chromatin material and a very definite acidophilic nucleolus. The third cell type is a deeply staining basophile; the fourth cell type is very much like the "Orange G" cell in size and cytoplasmic granulation, but is distinguishable by lightly staining purple cytoplasm. These cells are sparse.

The distribution and staining intensity of the cells is not uniform throughout. The periphery of the gland appears to contain poorer staining cells. In the rostral portion of the anterior pituitary, below the anterior process, only a very few deeply stained acidophilic cells occur. It was noted, however, that acidophilic cells become more numerous near the center of the gland and diminish toward the periphery. Few well stained basophile cells are encountered in the anterior portion of the gland, but many occur in nests deeper in the anterior pituitary, a condition very much similar to that described for the pituitary gland of *Necturus maculosa* (Charipper, '31).

The acidophile cells are completely filled with coarse spherical granules, and show definite cell outlines (Fig. 10). They contain an ovoid vesicular nucleus within which is a central acidophilic nucleolus. When exposed to osmic acid, the Golgi apparatus appears as a network capping the nucleus.

The basophile cells, though relatively few in the anterior lobe, show a tendency to group and form nests. The granules in the basophile are not as coarse or as numerous as those found in the acidophiles. These cells when exposed to osmic acid demonstrate many clear vacuoles within the cell. The nucleus is not as large as that of the acidophile and is indented or somewhat kidney-shaped. This nucleus is usually clear and contains a definite acidophilic nucleolus. The typical Golgi found here is similar to that described by Severinghaus ('33) for the pituitary of the rat. It occurs in the cytoplasm away from the nucleus. The Golgi network does not appear as a continuous structure but rather as though made up of heavy plates (Fig. 8).

The third type of cell, the chromophobe, in osmicated preparations is light brown in color and takes neither the acidophilic or basophilic stain even after post-chromatization. This cell is more like the acidophile than the basophile in shape, and is found distributed throughout the gland but is the dominant cell in the rostral part of the anterior pituitary. The cytoplasm of these cells is finely granular. The nucleus is vesicular and contains a central nucleolus similar to those found in acidophiles and basophiles. In some

of these cells, Golgi of the acidophilic cell type is found. In others, Golgi characteristic of the basophile cell occurs.

3. Anterior Process.

The terminology adopted here is that suggested by Atwell ('41) although this structure was described by Rimer ('31) and Hogben and Slome ('31) as the *pars tuberalis*.

The anterior process is embedded in the median eminence of the infundibulum. This area, which is continuous with the *pars anterior*, is the point of attachment of the anterior lobe with the infundibulum. The cells of the anterior process are arranged in very definite cords, giving this area a lobular appearance. In transverse sections, these cords appear as nests, each of which is completely within a thin connective tissue septa (Fig. 6). A small lumen may be seen in the center of each nest. Each of these acinar-like structures contains two types of cells. One of these cell types is similar to that found in the *pars tuberalis*. It is chromophobic with a vesicular nucleus and a central acidophilic nucleolus. The cells are ovoid in outline with very little cytoplasm and show poor cell boundaries. The second cell type found within these nests is basophilic, columnar, and contains a nucleus similar to that found in the chromophobe. This basophilic cell is larger than the chromophobe and the nucleus is always basally placed.

The anterior process is heavily invaded by blood vessels from the infundibulum. These vessels penetrate the anterior process and make their way to the anterior lobe proper.

4. Pars Tuberalis.

The center of each plaque forming this part of the gland is pierced by fair sized blood vessels and is well vascularized (Fig. 7). The cells of the *pars tuberalis* in some sections appear to be arranged in cords and separated by thin connective tissue septa (Fig. 9). This cord-like arrangement, however, is not as clear as that found in the anterior processes. The cells of the *pars tuberalis* are quite different from those found elsewhere in the gland. They are comparatively small and the cells are chromophobic with scant cytoplasm. The nucleus which is vesicular occupies the greater portion of the cell. Unlike the cell membrane, the nuclear membrane is well defined. Within the clear nucleoplasm is a large, distinct, usually centrally placed, acidophilic nucleolus.

5. Pars Intermedia.

The *pars intermedia*, as seen in transverse section, is situated between the *pars anterior* and the *pars nervosa*. In frontal section, this portion of the gland is thickest at either lateral end, but only three to four cells in width where the *pars intermedia* forms a concavity into which the oval region of the *pars anterior* fits. The *pars intermedia* is characterized

by its compact irregular cord-like arrangement. These cords are separated from each other by thin connective tissue. This lobe of the pituitary is separated from the *pars anterior* and the *pars nervosa* by well defined connective tissue partitions. No evidence of direct vascularization could be found.

The cells making up the cords of the *pars intermedia* are very tall, columnar, with small basal, ovoid nuclei. When stained with aniline blue after routine fixation, these cells react as basophiles. In cross section the cells are ovoid and have poor cellular outline. The nucleoplasm stains weakly with acid fuchsin but contains a deep staining acidophilic nucleolus. The cells of the *pars intermedia* are very rich in osmophilic material (Fig. 11). Some Golgi configurations such as described for the acidophiles and basophiles of the *pars anterior* are present, but more often the osmophilic material is found either as small rings or thick short filaments, distributed throughout the cell.

6. Pars Nervosa.

This portion of the gland lies dorsal and adjacent to the *pars intermedia* and is separated from the latter only by a connective tissue membrane. The *pars nervosa* is continuous with the infundibulum and consists almost entirely of rather compact basophilic fibrous tissue. These fibres are arranged in cords giving the *pars nervosa* a lobular appearance. Distributed throughout this fibrous mass are several different cellular elements. Especially abundant are the ependymal cells similar to those which line the anterior wall of the infundibulum and the *tuber cinerum*. Mossy neuroglia cells also are present with a scattering of some spindle-shaped cells with a process at each end of their long axis. Many basophilic cells resembling those of the *pars intermedia* can be distinguished here. The *pars nervosa* is well vascularized and contains many blood sinuses and capillaries. The presence of these sinuses give the *pars nervosa* a very sacculated appearance. These blood vessels enter the *pars nervosa* at the region where this portion of the pituitary comes off the infundibulum.

DISCUSSION.

The pituitary gland of *Xenopus laevis* Daudin, in relation to its neurocranium, is similar to that found among the anurans. The entire gland is suspended from the hypothalamus and although when exposed on its ventral surface it is easily movable, the anterior lobe—unlike that of other anurans—is firmly attached to the brain. No major blood vessels penetrate the gland although even macroscopically the anterior lobe is seen to be richly vascular. This concurs with the report of Patterson ('39), who described the vascularization of the brain of *Xenopus* as being similar to that of urodeles and other anurans.

The ramus posterior, a branch of the internal carotid arteries, divides and one of its branches is distributed to the optic lobe while the other vascularizes the pituitary body. Blood is carried to the jugular vein from the pituitary by two very thin-walled veins. These connect with each other by transverse vessels. In the anurans these thin-walled veins are described by Ecker (1889) as small venous plexi on either side of the pituitary body.

The general structure of the pituitary of *Xenopus* is similar to that described by other investigators (Atwell '19, '41; DeBeer, '26; Charipper '31; Rimer '31; and Sato '35). The four characteristic lobes found in all amphibians are present in this animal. As pointed out by Charipper ('37), the pituitary body of amphibians is not compact. This is especially true of *Xenopus* where two elongate lateral extensions are found projecting transversely across and beyond the ovoid anterior pituitary.

The *pars anterior* of *Xenopus laevis*, like that of other amphibians, is ventro-caudal to the rest of the gland. This is transversed on its dorsal side by the *pars intermedia* and *pars nervosa* which are dumb-bell shaped. The *pars tuberalis* in this animal is located in a position similar to that described by Atwell ('19) for *Rana pipiens* and *Rana catesbeiana*. This lobe is described by DeBeer ('26) as consisting of a pair of epithelial plaques "plastered" on the floor of the *tuber cinerum* in front of and separate from the rest of the pituitary body.

The anatomical relationships of these parts, therefore, do not vary from those described in other amphibians. In microscopic preparations, however, *Xenopus laevis* displays an area of cells not occurring in either urodeles or anurans. This particular area is found at the rostral portion of the *pars anterior* and is embedded in a thickened portion of the floor of the infundibulum which Atwell ('41) designates as the median eminence. The cells of this area are of two types, basophilic and chromophobic. The area is well vascularized. This portion of the anterior pituitary, because of its cellular arrangement, cell types and heavy vascularization, is suggestive of the *pars tuberalis* of urodeles described by Atwell ('21) and DeBeer ('26). On the basis of this description Rimer ('31) and Hogben, et al. ('31) have called this area the *pars tuberalis* and concluded that *Xenopus laevis* displayed a "zalamandrine" type of pituitary. As a further confirmation of this, Rimer ('31) reports that despite a careful study of serial sections he was not able to locate the *pars tuberalis* as described for anurans. Atwell ('41), in discussing the anterior margin of the *pars anterior*, is of the opinion that it is not the *pars tuberalis* but rather a differentiated area of the *pars anterior*. He describes the *pars tuberalis* of *Xenopus* as epithelial plaques in the ventral

wall of the infundibulum. Dawson ('40) also reports a similar region in the anterior margin of the *pars anterior* in the pituitary of the African lungfish. This region being single and median in position, does not fit any phylogenetic description of a true *pars tuberalis*.

In this work both the anterior margin of the *pars anterior* as well as the infundibulum were studied serially in transverse, sagittal and frontal planes. The cells were also stained with several techniques to demonstrate cellular detail. As a result, both the anterior process and the paired epithelial plaques as described by Atwell ('41) for *Xenopus laevis* were seen and confirmed. The study of the anterior process is in agreement with that described by Rimer ('31) and Hogben, et al. ('31) for this area. The cell types and arrangement of cells in cords is similar to that described by Atwell ('21) and DeBeer ('26) for the *pars tuberalis* of urodeles. The *pars tuberalis* in *Xenopus laevis* is located in a position similar to that described by Atwell ('19 and '41). However, the present findings differ in that this area showed some tendency to be lobular and definitely vascularized. This is in accord with Sato ('35) and D'Angelo ('41). The latter investigator suggests that the vascularization of the *pars tuberalis* in the frog is appreciable when measured in terms of capillary length.

Atwell ('41) points out that morphogenetic and cytologic studies are necessary to determine whether the anterior process represents the region of earlier attachment of the *pars tuberalis* and whether these two areas are related histologically. In this connection he describes the cells of the anterior process of *Xenopus* to be larger and more definitely chromophilic than those of the *tuberalis*. In this investigation, however, we are able to demonstrate many chromophobic cells within the cords of the anterior process which are identical with the cells of the *pars tuberalis*. However, no valid cytological criteria could be found for further confirmation of the relationship unless negative results be considered. Golgi material could not be demonstrated in the cells of the anterior process or in the cells of the *pars tuberalis*.

The tubular arrangement of the cells in the *pars anterior* of *Xenopus laevis* seems to be peculiar to this form since similar conditions are not described in the literature for other amphibians. Poris and Charipper ('38) report this condition common to all reptilian forms and an outstanding feature of the *Anolis carolinensis* pituitary. In amphibian pituitary, three types of cells are distinguished; acidophiles, basophiles and chromophobes. In their distribution the chromophobe cells are found in all parts of the *pars anterior* and are the dominant cell in its anterior portion. The acidophiles are scant in this area but are more numerous in the center of the gland. There are few true baso-

philes present in the anterior lobe and these are found only in its posterior region. A study of the osmophilic material in these cells reveals bizarre configurations. Many acidophile cells demonstrate Golgi apparatus capping the nucleus, similar to the acidophiles in the rat's pituitary (Severinghaus, '33). This configuration in *Xenopus laevis* is not constant for all acidophiles. Basophiles treated with osmic acid also displayed osmophilic material. The Golgi apparatus is usually away from the nucleus and ring-shaped. This cell, unlike the acidophile, contains many clear vacuoles. Among the chromophobes both types of Golgi configurations are found. This condition is similar to that described by Severinghaus ('33) for the rat and Levenstein ('39) for the pituitary of goldfish.

The *pars intermedia* of *Xenopus*, in general, conforms with that found in other amphibians. As described for most amphibians this lobe of the pituitary contains only one cell type which stains basophilically. Atwell ('19), however, maintains that the cell type of the intermedia is chromophobic and further that that part is well vascularized. The present investigation yields no evidence of direct vascularization in this lobe. This agrees with the work of DeBeer ('26) and D'Angelo ('41) for *Anura*. The cells of the intermedia are very rich in osmophilic material. Seldom, however, do these assume definite configurations but, rather, appear scattered as short rods throughout the cell.

The *pars nervosa* is continuous with the infundibulum and is composed chiefly of coarse basophilic fibres. This portion of the gland contains cords which give it a somewhat lobular appearance. The several cell types present here are chiefly nervous in origin. However, these cells are similar to those present in the *pars intermedia*. The *pars nervosa* is very conspicuously vascularized and contains many large blood sinuses. This is in general agreement with all such previous investigations.

SUMMARY AND CONCLUSIONS.

1. Confirmation is offered for the presence of five anatomical parts of the pituitary gland in *Xenopus laevis* Daudin; *pars anterior*, anterior process, *pars intermedia*, bilateral plaque-like *pars tuberalis* and a *pars nervosa*.

2. The *pars tuberalis* in *Xenopus* is described as definitely vascular.

3. The *pars anterior* contains the usual three cell types: acidophiles, basophiles and chromophobes.

4. Two varieties of chromophobes are described on the basis of their Golgi configuration. One with a compact Golgi capping the nucleus similar to that described in the acidophile; the other with a looser, thinner, band-like arrangement not closely applied to the nucleus and similar to the condition found in

the basophile. This arrangement is very much like the configurations described by Severinghaus ('33) for the rat and Levenstein ('39) for the goldfish.

5. The cell types found in the anterior process, compared to those occurring in the *pars tuberalis*, indicate a possible histogenetic relationship and lend positive weight to Atwell's ('41) question concerning the anterior process as a point of attachment of the *pars tuberalis*.

6. The confirmation of the presence of the *pars tuberalis* as definitely bilateral epithelial plaques further strengthens Atwell's ('41) contention that the pituitary of *Xenopus* is definitely not of the "zalamandrine" type.

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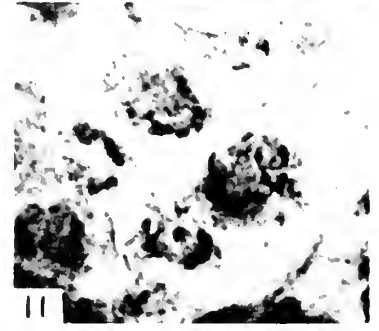
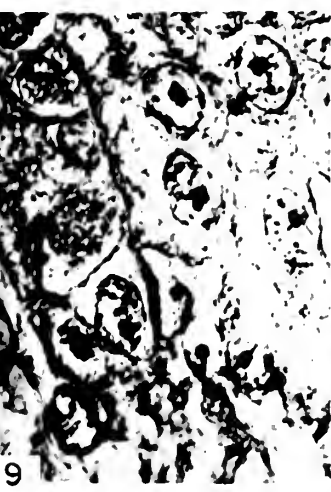
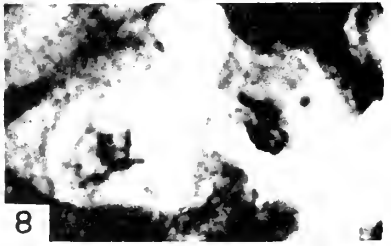
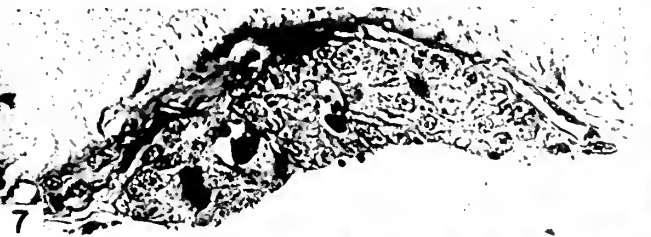
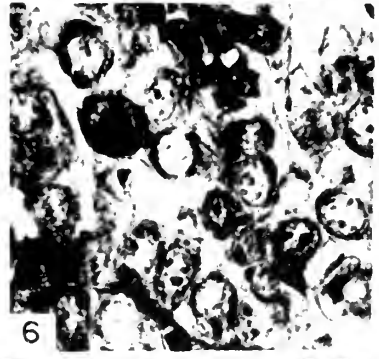
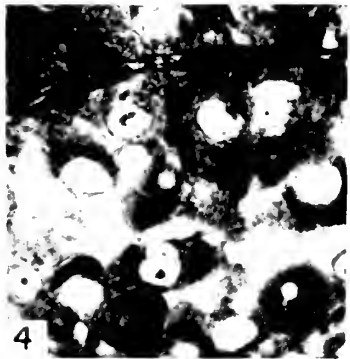
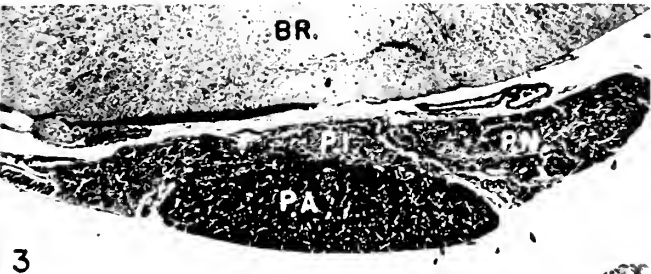
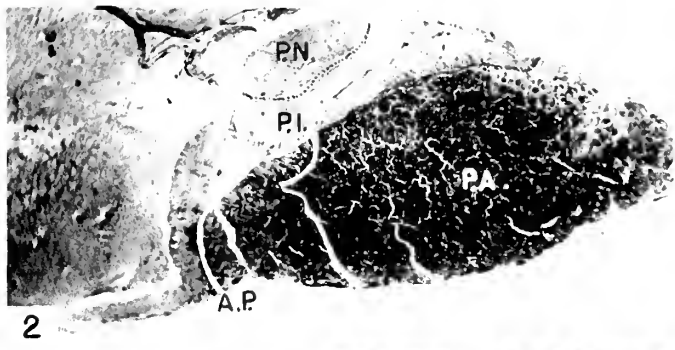
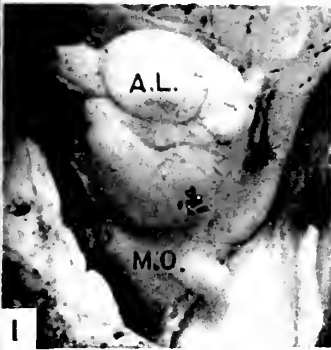
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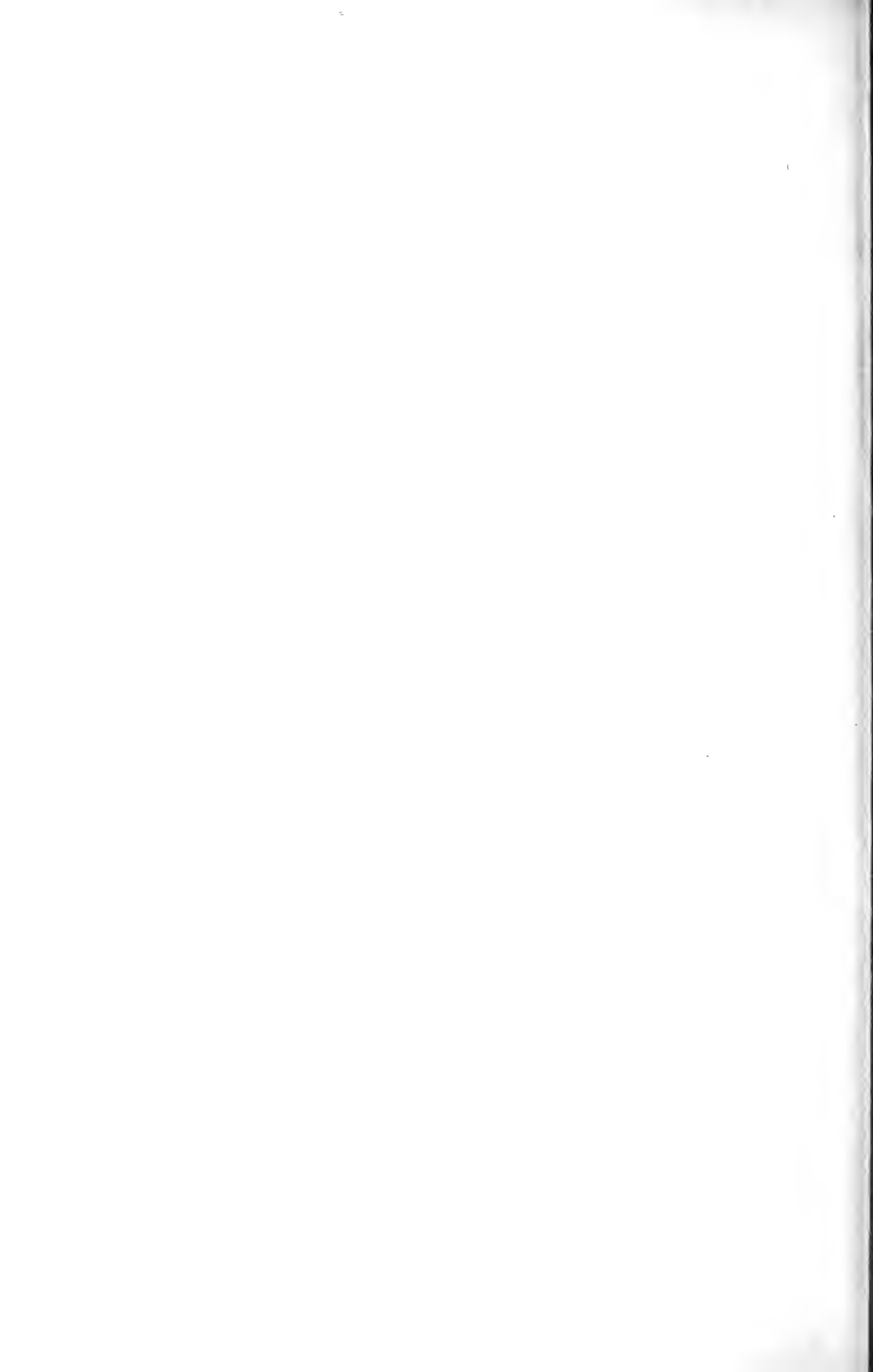
EXPLANATION OF THE PLATE

PLATE I.

- FIG. 1. A ventral view of the pituitary gland of *Xenopus laevis* Daudin, in its relation to the brain. Note the ventrocaudal position of the anterior lobe and the lateral elongated projections dorsal to this structure. **A. L.**, Anterior lobe; **M. O.**, Medulla oblongata.
- FIG. 2. A median sagittal section of the pituitary showing the relationship of the *pars nervosa* (**P. N.**) *pars intermedia*, (**P. I.**) *pars anterior* (**P. A.**), and the anterior process (**A. P.**) in its relationship to the infundibulum. Formalin-sublimate; Dawson-Friedgood, $\times 135$.
- FIG. 3. Transverse section through the pituitary gland. Note the wing-like arrangement of the *pars intermedia* and the *pars nervosa*. Formalin; Mallory modification. $\times 50$.
- FIG. 4. Section through the *pars anterior* showing nesting arrangement, three types of cells and in addition the heavily stained connective tissue system. Bouin; Masson. $\times 1080$.
- FIG. 5. Anterior process (**A. P.**) embedded in this median eminence (**M. E.**). Note the epithelial plaque, the *pars tuberalis*, (**P. T.**) in the broad arm-like tuber cinereum (**T. C.**). Formalin; Mallory modification. $\times 200$.
- FIG. 6. Section showing two cell types present in the anterior process, the darker basophile cells and the lighter chromophobic cells. Mann-Kopsch; Masson. $\times 650$.
- FIG. 7. A higher magnification of the *pars tuberalis* showing its vascularization. Formalin; Mallory modification. $\times 650$.
- FIG. 8. A highly magnified region of the *pars anterior* showing the loose Golgi network of a basophile. Mann-Kopsch; Masson. $\times 1800$.
- FIG. 9. Section through the epithelial plaque forming part of the *pars tuberalis*, showing the chromophobic nature of the cells and their striking similarity to the chromophobes of the anterior process drawn in Fig. 6. Formalin; Mallory modification. $\times 1440$.
- FIG. 10. Section through the *pars anterior* showing the vesicular nature of the nuclei. In addition the different Golgi configurations may be observed. Mann-Kopsch; Masson. $\times 1440$.
- FIG. 11. A section through the *pars intermedia* showing the amount and distribution of the osmophilic substance and to some extent the nature of the Golgi configuration. Osmo-sublimate; Dawson-Friedgood. $\times 1800$.



THE MORPHOLOGY OF THE PITUITARY GLAND OF THE SOUTH AFRICAN CLAWED TOAD, *XENOPUS LAEVIS* DAUDIN.



13.

Eastern Pacific Expeditions of the New York Zoological Society. XXXIX.
Mollusks from the West Coast of Mexico and Central America. Part VI.¹

LEO GEORGE HERTLEIN & A. M. STRONG.

California Academy of Sciences.

(Plates I & II).

[This is the thirty-ninth of a series of papers dealing with the collections of the Eastern Pacific Expeditions of the New York Zoological Society made under the direction of William Beebe. The present paper is concerned with specimens taken on the Templeton Crocker Expedition (1936) and the Eastern Pacific Zaca Expedition (1937-1938). For data on localities, dates, dredges, etc., refer to *Zoologica*, Vol. XXII, No. 2, pp. 33-46, and Vol. XXIII, No. 14, pp. 287-298].

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INTRODUCTION.

This is the sixth of a series of papers dealing with collections of mollusks taken on the Templeton Crocker Expedition (1936) and the Eastern Pacific Zaca Expedition (1937-1938). The general plan of presentation followed in the present contribution is that mentioned in Part II of this series of papers². Formal headings and keys are given for the species collected by the expeditions of 1936 and 1937-1938. Occasionally additional species are included in the keys for convenience but in such cases it is indicated

¹ Contribution No. 820, Department of Tropical Research, New York Zoological Society.

² Hertlein, L. G., and Strong, A. M. Eastern Pacific Expeditions of the New York Zoological Society. XXXII. Mollusks from the West Coast of Mexico and Central America. Part II. *Zoologica*, New York Zool. Soc., Vol. 28, Pt. 3, December 6, 1943, pp. 149-168, pl. 1.

which species do not occur in the present collection.

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Superfamily Veneracea.

FAMILY VENERIDAE.

This large family is represented in the present collection by 51 species and subspecies which are assigned to 15 genera.

Four important papers published by Dall³, Jukes-Browne⁴, Palmer⁵ and Frizzell⁶ are especially useful to anyone studying the west American Veneridae. The paper by Frizzell contains much important information, including references to the supraspecific names applied to the Veneridae and a preliminary reclassification of this large group.

KEY TO THE GENERA OF THE VENERIDAE.

- A. Left valve with an anterior lateral tooth or denticle
- a. Inner margin strongly crenulated
Antigona
- aa. Inner margin not crenulated
- b. Shell orbicular; large, polished
Dosinia
- bb. Shell trigonal or elongated
- c. Shell with reticulate sculpture; pallial sinus slight or lacking
Gouldia
- cc. Shell with concentric sculpture only
- d. Beaks subcentral; shell usually higher than long (sometimes anterior end longer); trigonal *Tivela*⁷
- dd. Beaks usually decidedly anterior; shell longer than high

- e. Ventral margin (interiorly) with oblique grooving; small
Transennella
- ee. Ventral margin without oblique grooving
- f. Pedal retractor impression deeply excavated; shell large, thick and smooth
Megapitaria
- ff. Pedal retractor impression not deeply excavated; shell smaller and thinner
- g. Anterior lateral small and situated near anterior margin of hinge plate
(subgenus)
Agriopoma
- gg. Anterior lateral large and situated close to or nearly midway between anterior cardinal and anterior margin of hinge plate
*Pitar*⁸

B. Left valve without an anterior lateral tooth

- a. Inner margin crenulated
- b. Shell elongate (anterior end often narrow) or subquadrate; small; concentric sculpture very prominent *Irus*⁹
- bb. Shell roundly trigonal or ovately quadrate; usually large
- c. Concentric sculpture of coarse, rugose ridges *Anomalocardia*
- cc. Concentric sculpture of fine or coarse lamellae (sometimes much reduced)
- d. Escutcheon well developed on left valve
- e. Left posterior cardinal elongate; middle cardinal thick; hinge plate triangular; pallial sinus usually short *Chione*
- ee. Left posterior cardinal short; middle cardinal not thickened (strongly bifid) hinge plate narrow and long; pallial sinus usually long
*Protothaca s.s.*¹⁰
- dd. Escutcheon lacking or nearly so on left valve
(subgenus) *Callithaca*

³ Dall, W. H. Synopsis of the Family Veneridae and the North American Recent species. *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, pp. 335-412, pls. 12-16.

⁴ Jukes-Browne, A. J. A Synopsis of the Family Veneridae. *Proc. Malacol. Soc. London*, Vol. 11, Pt. 1, March, 1914, pp. 58-74; Pt. 2, June, 1914, pp. 75-94.

⁵ Palmer, K. Van Winkle. The Veneridae of Eastern America, Cenozoic and Recent. *Palaontogr. Americana*, Vol. 1, No. 5, pp. 209-522 (1-213), March, 1927, pls. 32-76 (1-45), February, 1929.

⁶ Frizzell, D. L. Preliminary Reclassification of Veneracean Pelecypods. *Bull. Mus. Roy. d'Hist. Nat. Belgique*, Tome 12, No. 34, December, 1936, pp. 1-84.

See also Tomlin, J. R. le B. Some synonyms in the Veneridae. *Proc. Malacol. Soc. London*, Vol. 15, Pt. 6, October, 1923, pp. 310-313.

⁷ The subgenus *Eutivela* Dall has crenulated inner margins but is not known to occur in west American waters.

⁸ The subgenus *Tinctora* Jukes-Browne has an irregularly crenulated margin and is represented in west American waters by one species, *Pitar vulnerata*.

⁹ The type species of *Irus* has a smooth inner margin.

¹⁰ Not represented in the present collection.

- aa. Inner margin not crenulated
- e. Shell suborbicular or roundly subquadrate
Cyclinella
- ee. Shell obliquely elliptical or trigonal
- f. Pallial sinus present
- g. Obliquely elliptical; pallial sinus narrow
Compsomya
- gg. Trigonal; pallial sinus wide; small, length not exceeding 8 mm.
Psephidia
- ff. Pallial sinus lacking (in type); anterior and middle cardinal teeth formed by a thin bent lamina, with two pits on ventral side
*Callocardia s.s.*¹⁰

Genus *Dosinia* Scopoli.

Key to the subgenera of *Dosinia*.

- A. Escutcheon present *Dosinia s.s.*¹¹
B. Escutcheon lacking *Dosinidia*

Subgenus *Dosinidia* Dall.

Key to the species of *Dosinidia*.

- A. Orbicular, very large, usually longer than high; expanded posteriorly *ponderosa*
B. Ovately or triangularly orbicular, smaller, usually as high or higher than long; not expanded posteriorly
- a. Pallial sinus pointing toward middle of anterior adductor impression
dunkeri
- aa. Pallial sinus pointing toward ventral margin of anterior adductor impression; ribs subobsolete medially
*annae*¹²

Dosinia (Dosinidia) dunkeri Philippi.

Cytherea dunkeri Philippi, *Abbild. u. Beschreib. Conchyl.*, Bd. 1, Heft 7, October, 1844, *Cytherea*, p. 170 (4), pl. 2, fig. 5. "Patria: Mare Pacificum Mejico alluens."

Artemis simplex Hanley, *Proc. Zool. Soc. London*, April, 1845, p. 11. "Hab. Panama, St. Elena. Mus. Cuming, Hanley."—Hanley, *Cat. Rec. Biv. Shells*, Ap., p. 357, ?1856, pl. 15, fig. 41, 1844, Panama.

Artemis dunkeri Reeve, *Conch. Icon.*, Vol. 6, *Artemis*, 1850, species 34, pl. 6, fig. 34. "Hab. St. Elena and Panama, Central America (from sandy mud at low water); Cuming."—Adams & Reeve, *Zool. Voy. Samarang, Moll.*, 1848, p. 78, pl. 21, fig. 17. Not the record "Hab. Eastern Seas."

Dosinia dunkeri Philippi, Carpenter, *Cat. Mazatlan Shells*, September, 1855, p. 61. *Mazatlan, Mexico*, also earlier records cited.

—Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 354. Earlier records cited. Pliocene and Recent.

Type Locality: West coast of Mexico.

Range: Magdalena Bay, Lower California, to the Gulf of California and south to Zorritos, Peru, and the Galápagos Islands.

Collecting Stations: Mexico: Tenacatita Bay; Manzanillo (184-D-2), 30 fathoms, gravelly sand; 17 miles S.E. of Acapulco (189-D-3), 13 fathoms, mud; Port Guatulco; Nicaragua: Potosi and Monypenny Point, Gulf of Fonseca; Corinto (200-D-11, 19), 8-13 fathoms, sand, mangrove leaves, also beach drift, also Isla Encantada; Costa Rica: Port Parker; Culebra Bay; Isla Cedro, Gulf of Nicoya; 1 mile South of Gofitio Bay; Panama: Isla Parida; Bahia Honda; Colombia: Gorgona Island.

Description: Shell white, somewhat ovately or triangularly orbicular, often slightly higher than long, beaks strongly projecting; lunule ovately oblong, moderately depressed; exterior regularly concentrically grooved, sometimes faint superficial radial striae are present; pallial sinus angular, usually projecting slightly beyond the middle of the shell and pointing toward the middle of the anterior adductor muscle impression.

A specimen from the Gulf of California in the Henry Hemphill collection in the California Academy of Sciences, measures: length, 56 mm.; height, 55 mm.; convexity (both valves), 30.6 mm.

The form described as *Dosinia annae* by Carpenter¹³ is very similar to *D. dunkeri* but the concentric ribs are flatter and more nearly obsolete in the middle portion of the valves and the pallial sinus points more nearly toward the base or ventral portion of the anterior adductor impression.

Compared to *Dosinia ponderosa*, *D. dunkeri* is smaller, higher in proportion to the length, less expanded posteriorly, umbos more ventricose, beaks more projecting, and it is sculptured by finer and more regular concentric grooves.

Dosinia brasiliensis White from the Miocene of Brazil is very similar to *D. dunkeri*, and *D. mathewsonii* Gabb from the Miocene of California also has some features in common.

Distribution: *Dosinia dunkeri* was collected at a number of localities from west Mexico to Colombia on beaches and dredged at depths of 8 to 30 fathoms. It is also known to occur from Pliocene to Recent in the Gulf of California region.

Dosinia (Dosinidia) ponderosa Gray.

Arthemis ponderosa Gray, *Analyst*, Vol. 8, 1838, p. 309. [No locality cited].

Artemis ponderosa Gray, *Conch. Icon.*, Vol. 6, *Artemis*, 1850, species 4, pl. 1, fig. 4. "Hab. Gulf of California (in sandy mud at low water)."

¹³ *Dosinia annae* Carpenter, *Cat. Mazatlan Shells*, September, 1855, p. 61. "Mazatlan; very rare."—Römer, *Mon. Molluskengattung Dosinia, Scopoli*, (Cassel), 1862, p. 18, pl. 4, fig. 1.

¹¹ Not represented in west American waters.

¹² Not represented in the present collection.

Dosinia ponderosa Gray, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 351, pl. 15, figs. 1a, 1b, 1c. Earlier records cited. Pleistocene and Recent.

Type Locality: Gulf of California (here designated as type locality). No locality cited originally.

Range: Scammon Lagoon, Lower California, to the Gulf of California and south to Paita, Peru, and the Galápagos Islands.

Collecting Stations: Mexico: Santa Inez Bay, Gulf of California (144-D-1-4 and 145-D-1-3), 4-20 fathoms, sand, sandy mud, crushed shell, weed, calcareous algae, also on beach; Tenacatita Bay; Santa Cruz (195-D-21), 33 fathoms, mud; Nicaragua: Corinto (200-D-10,11,16), 4-8 fathoms, sand, mangrove leaves; Costa Rica: Port Parker (203-D-1,2,3), 18.2-27 fathoms, sandy mud, crushed shell, shelly mud, algae.

Description: Shell large, orbicular, longer than high, slightly angulated posterior to the ligament, gently convex, thick, cream colored and covered by a shining horn-colored periostracum; lunule cordate, depressed; exterior concentrically grooved but these are usually weaker in the median portion of the valves, faint superficial radial striae are sometimes present; pallial sinus angular and projecting to a point about midway between the anterior and posterior adductor impressions.

A large specimen from the Gulf of California, in the collections of the California Academy of Sciences, measures: length, 145 mm.; height, 139 mm.; convexity (both valves), 75 mm.

Compared to *Dosinia annae* Carpenter, the shell of the present species is larger, the posterior dorsal margin is more expanded, the beaks are less projecting, the posterior portion of the hinge plate is wider and the pallial sinus points toward about the middle rather than toward the base of the anterior adductor impression.

The shell of *D. ponderosa* is larger, thicker, more orbicular in outline, the beaks are less projecting, the dorsal outline is broader, the concentric sculpture is coarser, and the posterior portion of the hinge plate is wider than that of *D. dunkeri*. The Atlantic species *Dosinia concentrica* Born is somewhat similar, and related species occur in the Miocene and Pliocene of California, Peru, and the Caribbean region.

Distribution: Specimens of *Dosinia ponderosa* were collected from the Gulf of California to Costa Rica on beaches and dredged at depths of 4 to 33 fathoms. It also is known to occur in the Pleistocene of southern California, the Gulf of California region, Oaxaca, Mexico, and Ecuador.

Genus *Tivela* Link.

Key to the species of *Tivela*.

- A. A broad, shallow, radial furrow present posteriorly; yellowish-white *argentina*
 B. Radial furrow slight or lacking posteri-

orly; usually brown or brown with cream colored stripes, or purplish coloration

- a. Very convex; high; thick *byronensis*
 aa. Gently convex or compressed; longer than high (slightly produced anteriorly); thinner; dorsal margins meeting at a greater angle
 b. Height usually exceeding 30 mm.; compressed, triangular, thin
 c. Shell gaping posteriorly *hians*¹⁴
 cc. Shell closed posteriorly *planulata*¹⁴
 bb. Height usually not exceeding 30 mm.; more convex, thicker *delessertii*

Tivela argentina Sowerby.

Cytherea argentina Sowerby, *Proc. Zool. Soc. London*, June 1, 1835, p. 46. "Hab. ad Sinum Nicoiyo, Americae Centralis." "Found in sand banks at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 622, pl. 129, fig. 62 (as *Cytheraea argentina*). Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Cytherea*, 1854, species 11, pl. 4, fig. 11. Central America.

Type Locality: Gulf of Nicoya, Costa Rica, in sand banks at low water.

Range: Mazatlan, Mexico, to Panama.

Collecting Stations: Nicaragua: Corinto (200-D-10,11,19), 7-13 fathoms, sand, mangrove leaves, also in beach drift; Costa Rica: 1 mile south of entrance to Golfo Bay.

Description: Shell trigonal, rather thin, moderately convex, yellowish-white, ventral margin arcuate, somewhat attenuated at both ends; a broad, shallow, radial sulcus is present posteriorly; periostracum thin, light brown in color. A large valve from Costa Rica measures approximately: length 61 mm.; height 58 mm.; convexity 16.5 mm.

Distribution: *Tivela argentina* was collected by the expedition at Corinto, Nicaragua, where it occurs fairly commonly, and south of the entrance to Golfo Bay, Costa Rica. This species has been reported as occurring in the Pliocene of Argentina¹⁵ but according to von Ihering¹⁶ that record can be referred to *Tivela fulminata oblonga* Philippi.

Tivela byronensis Gray.

Cytherea radiata Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 23. "Hab. ad oras Columbiae Occidentalis. (Salango and Xipixapi)." "Found in sandy mud at a depth of nine fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 615, pl. 128, figs. 28,29,30,31 (as *Cytheraea radiata*). Original locality cited.

Not *Trigona radiata* Megerle von Mühl-

¹⁴ Not represented in the present collection.

¹⁵ *Tivela argentina* Sowerby, Borchert, *Neues Jahrb. f. Miner. Geol. u. Palaeo.*, Beil. Bd. 14, 1901, p. 204, pl. 8, figs. 9, 10. "Paraná." Argentina, Pliocene.

¹⁶ von Ihering, H., *An. Mus. Nac. de Buenos Aires*, Vol. 14 (Ser. 3, Vol. 7), 1907, p. 384.

feld, 1811. [Referred to *Tivela mactroides* Born, 1778, by Dall, 1902].

Trigona byronensis Gray, *Analyst*, Vol. 8, 1838, p. 304. "Inhabits Pacific Ocean. Capt. Lord Byron."

Venus solangensis d'Orbigny, *Voy. Amér. Mérid.*, Vol. 5, Moll., 1846, p. 564. New name for *Cytheraea radiata* Sowerby, "(non *V. radiata*, Chemn., 1795; Risso, 1826)." Sowerby's locality for *C. radiata* cited.

Tivela radiata Sowerby, Römer, *Monogr. Molluskengattung Venus*, Linné, Bd. 1, 1865, p. 13, pl. 6, figs. 1a-g. Mazatlan, Salango, Xipixapi, Panama, Guayaquil.

Type Locality: Salango, Ecuador (here designated as type locality). "Pacific Ocean" originally cited.

Range: Lagoon Head, Lower California, to the Gulf of California and south to Guayaquil, Ecuador.

Collecting Stations: Mexico: Banderas Bay; Chamela Bay; Tenacatita Bay; Guatemala: 7 miles West of Champerico (197-D-1,2), 14 fathoms, mud; Nicaragua: Corinto (200-D-10, 11, 16, 19), 4-13 fathoms, sand, mangrove leaves, also Isla Cardon; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shell triangularly ovate, solid, gibbous, often somewhat produced posteriorly, lunule large; colored by reddish-brown radial and concentric bands; periorstracum olive brown.

A specimen from Tiburon Island in the Gulf of California, in the collections of the California Academy of Sciences, measures: length, 58 mm.; height, 54.5 mm.; convexity (both valves together), 37 mm. Another from the same locality measures: length, 59.1 mm.; height, 50.4 mm.; convexity (both valves together), 39 mm.

This shell is very variable in shape and color. It may be nearly equilateral or quite inequilateral and ventricose or flattened and somewhat attenuated at each end. The color varies from the white variety, *semifulva* Menke, to all varieties of radially banded brown and white patterns to nearly all brown. Some of the specimens in the present collection could be referred to the striped and latticed color form *hindsii* Hanley¹⁷ but when a large series of specimens is examined so much variation in form and color can be observed that there seems to be but little use to apply names to the various color varieties. Carpenter came to the same conclusion after examining over 600 specimens of this species, as did Römer in his study of this species.

Tivela mactroides Born, in the Caribbean region, is a similar species.

Distribution: *Tivela byronensis* was collected at a few localities along the west coast from Mexico to Panama. It occurs commonly in tropical West American waters. It

also has been recorded as occurring in the Pleistocene of Lower California, and Oaxaca, Mexico, and in the Pliocene of Ecuador.

Tivela delessertii Deshayes in Sowerby.

Plate II, Figure 10.

Cytheraea nitidula Lamarck, Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 616, species No. 14, pl. 128, fig. 25. "Locality uncertain."

Cytheraea delessertii Deshayes in Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 785. "*C. nitidula* (14) is not the true species of Lamarck, but M. Deshayes has named it *C. delessertii*."

Tivela delesserti Deshayes, Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 386. "Scammon's Lagoon (young?); Cape St. Lucas, the Gulf region, and south to Acapulco."

Type Locality: Santa Inez Bay, east coast of Lower California (here designated as type locality). No locality cited originally.

Range: Santa Inez Bay, Gulf of California, to Oaxaca, Mexico.

Collecting Stations: Mexico: Santa Inez Bay, Gulf of California; Cape San Lucas.

Description: Shell broadly trigonal, slightly inequilateral, slightly attenuated anteriorly, moderately convex, a trace of a faint radial sulcus at about the posterior third of the valve present on most specimens; colored light chestnut brown with darker stripes or purplish-brown stripes on a cream colored ground.

A fine specimen from Santa Inez Bay measures: length, 30.9 mm.; height, 23.5 mm.; convexity (one valve), 8.8 mm.

The shell of *Tivela delessertii* is thicker and not as high as that of *T. planulata* Broderip & Sowerby. It is smaller, much more elongated, not as high in proportion to the length and flatter than *T. byronensis*, with striped varieties of which, at times, it has been confused.

Distribution: *Tivela delessertii* was collected by the expedition at Santa Inez Bay in the Gulf of California and at Cape San Lucas. It apparently does not occur nearly so commonly as *T. byronensis*.

Genus *Gouldia* C. B. Adams.

Gouldia C. B. Adams, *Cat. Gen. and Spec. Rec. Shells in Coll. of C. B. Adams* (Middlebury: Justus Cobb, printer), 1847, p. 29. Species cited, *G. cerina* Adams and *G. parva* Adams, both from Jamaica. Footnote states: "Syn. *Thetis*. Ad. This name having been preoccupied by Mr. Sowerby for two fossil species in the Green Sand formation of England, I propose the above in honor of my friend Dr. A. A. Gould."—K. V. W. Palmer. *Palaeontogr. Amer.*, Vol. 1, No. 5, p. 307 (99), 1927. "Genoholotype.—*Gouldia cerina* (Adams)."

Not *Gouldia* Bonaparte, 1849. Aves.

Type: *Gouldia cerina* C. B. Adams. [Designated by Dall, *Jour. Conch.*, Vol. 4, No. 2, April, 1883, p. 61. Referring to the two species originally cited by Adams, Dall stated,

¹⁷ *Cytheraea hindsii* Hanley, *Proc. Zool. Soc. London*, December, 1844, p. 110. "Hab. Guayaquil. Mus. Cuming. Hanley."—Hanley, *Cat. Rec. Bivalve Shells*, Ap., p. 356, 7:1856, pl. 15, fig. 35, 1844. Guayaquil.—Reeve, *Conch. Icon.*, Vol. 14, *Cytheraea*, 1864, species 39, pl. 9, figs. 39a, 39b. Bay of Guayaquil, Ecuador.

... "I have taken the first, largest, and most conspicuous species of the two as a type." On page 62 he mentioned . . . "the typical *Gouldia cerina*." Illustrated by K. V. W. Palmer, text fig. 14, p. 307 (99), 1927, pl. 52 (21), figs. 1, 5, 9, 11, 21, 1929. North Carolina to the Antilles, Bermuda, and south to Cape San Roque, Brazil].

Shell small, beaks minute; lunule long, bounded by an impressed line; no escutcheon; pallial line simple or with a slight sinus; ornamented with fine concentric or reticulate sculpture (Palmer).

Palmer cited the occurrence of three species living in east American waters, six species and subspecies occurring in the Miocene, and two species in the Pliocene of eastern North and Central America.

So far as known this genus is represented by only one species in west American waters. It also is known to occur in the Pleistocene of the Gulf of California region.

***Gouldia californica* Dall.**

Gouldia californica Dall, *Proc. U. S. Nat. Mus.*, Vol. 51, No. 2166, January 15, 1917, p. 579. "Gulf of California near La Paz, in 21 fathoms."

Gafrarium (Gouldia) stephensae E. K. Jordan, *Contrib. Dept. Geol. Stanford Univ.*, Vol. 1, No. 4, November 13, 1936, p. 136, pl. 19, figs. 10, 11. "Magdalena Bay, Lower California." "Pleistocene."

Type Locality: Gulf of California near La Paz, Lower California, Mexico, in 21 fathoms.

Range: La Paz, Lower California, Mexico, to Port Parker, Costa Rica.

Collecting Stations: Mexico: Manzanillo (184-D-2), 30 fathoms, gravelly sand; Costa Rica: Port Parker (203-D-1,3), 12-15 fathoms, sandy mud, crushed shell, shelly mud.

Description: Shell small, thin, white, with touches of brown along the dorsal border, ovate-triangular, the anterior lateral tooth large and prominent, the pallial line hardly sinuated; sculpture reticulate, the concentric sculpture more prominent in the middle of the disk, the radial toward the ends of the valves; the inner valve margins smooth. Length 6 mm.; height, 5.5 mm.; diameter, 3 mm. (Dall).

Distribution: This species was taken off Manzanillo, Mexico, in 30 fathoms and more abundantly at Port Parker, Costa Rica, in 12 to 15 fathoms. It also occurs in the Pleistocene of Magdalena Bay, Lower California.

Genus *Megapitaria* Grant & Gale.

Key to the species of *Megapitaria*.

- A. Margin below beaks broadly rounded; periostracum dull golden brown
aurantiaca
- B. Margin below beaks flattened; periostracum shiny purplish-brown, often mottled
squalida

***Megapitaria aurantiaca* Sowerby.**

Cytherea aurantiaca Sowerby, Gen. Rec.

and Foss. Shells, Vol. 2, Pt. 33, 1831, pl. 196, fig. 8. [No locality cited].

Cythereaea aurantia Hanley, Sowerby, *Thes. Conch.*, Vol. 2, *Cythereaea*, 1851, p. 628, pl. 132, ng. 57 bis. "From Mr. Cuming's collection."

Dione aurantia Deshayes, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863, species 12, pl. 3, ng. 12. "Hab. Acapuico, South America".

Macrocallista aurantiaca Sowerby, E. K. Jordan, *Contrib. Dept. Geol. Stanford Univ.*, Vol. 1, No. 4, 1936, p. 142. Magdalena Bay, Lower California, Pleistocene. Gulf of California to Ecuador, Recent.

Type Locality: Bay of Panama (here designated as type locality). No locality cited originally.

Range: Gulf of California to Salinas, Ecuador.

Collecting Stations: Mexico: Port Guatulco (195-D-4,6), 3-4.5 fathoms, sand, algae, crushed shell, also on shore; Tangola-Tangola Bay (196-D-14,15), 5 fathoms, crushed shell, also on shore; Costa Rica: Port Parker; Culebra Bay; Ballenas Bay; Golfito, Gulf of Dulce; Colombia: Gorgona Island.

Description: Shell large, ovate, convex, thick, smooth, the anterior end the shorter, indistinctly angled posteriorly; sculptured only with concentric lines of growth; periostracum dull orange brown beneath which the shell is orange pink or pinkish-brown; margin smooth.

Large specimens from the Gulf of California in the collections of the California Academy of Sciences measure 115 mm. in length.

The shell of this species is more broadly rounded in outline than that of *Megapitaria squalida*. The dull orange brown periostracum and orange pink shell is different from that of *M. squalida* in which the periostracum is a shiny purplish-brown, often mottled or striped, and the shell is a drab light brown.

Distribution: This species was collected on shore and dredged in 3 to 5 fathoms from west Mexico to Colombia. It also has been recorded as occurring in the Pliocene and Pleistocene of Lower California.

***Megapitaria squalida* Sowerby.**

Cytherea squalida Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 23. "Hab. ad Sanctam Elenam." "Found in sandy mud at a depth of six fathoms."

Cythereaea squalida Sowerby, Sowerby, *Thes. Conch.*, Vol. 2, *Cythereaea*, 1851, p. 629, pl. 131, figs. 87, 88, 89 [Lower] "California." [Not the record cited "from the Philippine Islands"].

Dione squalida Sowerby, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863, species 10, pl. 3, fig. 10. Locality record same as cited by Sowerby, 1851.

Pitar (Megapitaria) squalidus Sowerby, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 347. Earlier records cited. Pliocene to Recent.

Type Locality: Santa Elena, Ecuador, in 6 fathoms, sandy mud.

Range: Scammon Lagoon, Lower California, to the Gulf of California and south to Mancora, Peru.

Collecting Stations: Mexico: East of Cedros Island (126-D-2), 38 fathoms, mud; Arena Bank (136-D-15, 16, 26, 30), 35-45 fathoms, mud, muddy sand, crushed snell, weed, rock; Cape San Lucas; Arena Point area; Cerambo Channel (137-D-3), 46 fathoms, rock; Cerambo Island, shore; Santa Inez Bay (141-D-1-4), 7-20 fathoms, sand, sandy mud, crushed shell, weed, calcareous algae, (143-D-1), 29 fathoms, mud, crushed snell, weed, (144-D-2), 2½ fathoms, sand, weed, rocks, (149-D-1, 5), 4-15 fathoms, sand, also at Santa Inez Point and at Monument Station, shore; Port Guatulco (195-D-1, 2, 21), 2.5-18 fathoms, sand, algae, crushed shell, mud; Tangola-Tangola Bay (196-D-17), 23 fathoms, mud; Costa Rica: Port Parker (203-D-1, 2, 3), 12-15 fathoms, sandy mud, crushed shell, snelly sand and mud, algae, also on beach; Port Culebra (206-D-1-3), 14 fathoms, sandy mud, also on shore; Cedro Island, Gulf of Nicoya; Gofito, Gulf of Dulce; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud; Bahía Honda (222), shore; Colombia: Gorgona Island, shore.

Description: Shell large, attaining a length of 120 mm., smooth, convex, somewhat produced anteriorly and posteriorly and somewhat roundly angulated along the posterior umboanal slope; periostracum shiny purplish-brown often somewhat mottled or striped and beneath this the shell is colored a drab light brown.

The shell of this species differs from that of *Megapitaria aurantiaca* in the coloration and in that it is more produced both anteriorly and posteriorly. Although there appears to be nearly complete intergradation between the two, typical forms are quite distinct.

Macrocallista orcutti Dall, described from the Pleistocene of Magdalena Bay, is a similar species but possesses a much larger and thicker shell. *Macrocallista maculata* Linnaeus, which occurs in the Caribbean region, is another similar species.

Other names which have been applied to *M. squalida* include *Chione biradiata* Gray, 1838, and *Cytherea chionaea* Menke, 1847, which was proposed for a mottled, rounded form.

Distribution: *Megapitaria squadida* is very commonly found in the Gulf of California region and south to Peru. It was collected at many localities from off Cedros Island, Lower California, to Gorgona Island, Colombia, on the beach and dredged at depths of 2.5-46 fathoms. The largest number of specimens found at any one locality was at Port Parker, Costa Rica. It is also known to occur in the Pliocene and Pleistocene of the Gulf of California region and has been recorded¹⁸ as occurring in the Pleistocene of the Newport Bay area in southern California.

Genus *Transennella* Dall.

Key to the species of *Transennella*.

- A. Shell faintly concentrically grooved exteriorly
- a. Length exceeding 10 mm.
 - b. Angle at beaks 90°; thick *pannosa*¹⁹
 - bb. Angle at beaks 120°; more produced anteriorly; moderately thin *puella*
 - aa. Length not exceeding 10 mm.
 - c. Angle at beaks 90°.....*tantilla*¹⁹
 - cc. Angle at beaks 110° *galapagana*¹⁹
- B. Shell strongly concentrically grooved exteriorly; lunule more broadly cordate *sororcula*

Transennella puella Carpenter.

Callista (?*pannosa*, var.) *puella* Carpenter, *Ann. & Mag. Nat. Hist.*, Ser. 3, Vol. 13, April, 1864, p. 313. Described from "Cape St. Lucas." Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 211.

Transennella puella Carpenter, Hertlein & Strong, *Proc. Calif. Acad. Sci.*, Ser. 4, Vol. 23, No. 24, 1939, pp. 377-378 (in text), pl. 32, figs. 14, 15, 16. Cape San Lucas on beach, also dredged.

Type Locality: Cape San Lucas, Lower California.

Range: Guadalupe Island, Lower California, to the Gulf of California and south to Nicaragua and probably to Panama.

Collecting Stations: Mexico: Cape San Lucas; Arena Bank in the Gulf of California (136-D-16), 45 fathoms, muddy sand, weed; Santa Inez Bay (145-D-1-3), 4-13 fathoms, sand; Port Guatulco (195-D-9), 7 fathoms gr. sand, crushed shell; Tangola-Tangola Bay (196-D-13), 10 fathoms, gr. sand, crushed shell.

Description: Shell roundly ovate, small, large specimens attain a length of about 18 mm.; hinge normal for the genus; color pattern consisting of various amounts of brown or brownish zigzag markings on a cream ground or whitish triangular areas surrounded by brown; pallial sinus only slightly ascending, rounded at end, projecting anteriorly to about one-half the length of the shell; interior whitish and purple; interior margin obliquely grooved; apical angle of beaks about 120°.

Transennella puella differs from *T. pannosa* Sowerby, which occurs off western South America, in the thinner shell, which is more produced anteriorly, and in that the apical angle is approximately 120° as compared to about 90° in Sowerby's species.

Macrocallista (*Chionella*) *omissa* Pilsbry & Lowe, 1932, described from San Juan del Sur, Nicaragua, was said to possess a shorter and more triangular shell than that of *Transennella puella* as well as different sculpture and color pattern.

¹⁸ See Bruff, S. C., *Univ. Calif. Publ., Bull. Dept. Geol. Sci.*, Vol. 27, No. 6, 1946, p. 232.

¹⁹ Not represented in the present collection.

Distribution: Specimens of *Transennella puella* were collected at several localities from Santa Inez Bay in the Gulf of California to Tangola-Tangola Bay, Mexico, on the beach and dredged in 4 to 45 fathoms.

***Transennella sororcula* Pilsbry & Lowe.**

Transennella sororcula Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 102, pl. 9, figs. 12-16, text fig. 4. "San Juan del Sur, Nicaragua."

Macrocallista sorocula Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 143, pl. 9, figs. 12-16.

Transennella sorocula Pilsbry & Lowe, Hertlein & Strong, *Proc. Calif. Acad. Sci.*, Ser. 4, Vol. 23, No. 24, 1939, p. 377 (in text), pl. 32, figs. 11, 12. Dredged in 20-220 fathoms due east of San Jose del Cabo, Lower California.

Type Locality: San Juan del Sur, Nicaragua.

Range: Santa Inez Bay, Gulf of California, to San Juan del Sur, Nicaragua.

Collecting Stations: Mexico: San Lucas Bay (135-D-25), 7 fathoms, sand; [?] (135-D-16), 6-20 fathoms, sand; Arena Bank (136-D-27), 50 fathoms, sand, calcareous algae, rock; Santa Inez Bay.

Description: Shell roundly ovate, varying in size from 16 to 35 mm. in length, glossy, rather deeply but unequally concentrically grooved, this character most strongly developed anteriorly and posteriorly; color cinnamon brown, or cream with radial markings or a network of chocolate-colored lines or various combinations of such patterns; interior white tinged with purple; the pallial sinus extends forward nearly one-half the length of the shell; inner margins obliquely grooved.

The more rounded outline, stronger concentric grooves, larger size and more broadly cordate lunule are characters which serve to separate *Transennella sororcula* from other species of the genus in west American waters.

Distribution: This species was taken by the expedition at a few localities from San Lucas Bay to Santa Inez Bay in the Gulf of California, on the beach and at depths of 6 to 50 fathoms.

Genus *Pitar* Römer.

Key to the subgenera of *Pitar*.

- A. Shell with spines or scales along posterior umbonal angulation *Hysteroconcha*
- B. Shell without spines or scales along posterior umbonal angulation
 - a. Shell with fine zigzag sculpture *Hyphantosoma*
 - aa. Shell without zigzag sculpture
 - b. Shell suborbicular; inner margin irregularly crenulated *Tinctora*
 - bb. Shell ovate or subtrigonal; inner margin smooth
 - c. Shell smooth or with fine concentric threads

- d. Left middle cardinal decidedly longer and thicker than anterior cardinal
- e. Left anterior lateral very small and distant from cardinals *Agriopoma*²⁰
- ee. Left anterior lateral larger and close to cardinals *Pitarella*
- dd. Left middle cardinal only slightly longer than anterior cardinal *Pitar* s.s.
- cc. Shell with strong concentric ribs or lamellae *Lamelliconcha*

Subgenus *Pitar* s.s.

Key to the species of *Pitar* s.s.

- A. Shell decidedly elongated; with brown zigzag concentric markings; smooth, very thin *newcombianus*
- B. Shell roundly trigonal or suborbicular
 - a. Anterior lateral tooth of left valve higher than others *consanguineus*
 - aa. Anterior lateral tooth of left valve not higher than others *unicolor*

***Pitar (Pitar) consanguineus* C. B. Adams.**

Cytherea consanguinea C. B. Adams, *Ann. & Lyceum Nat. Hist. New York*, Vol. 5, July, 1852, pp. 496, 545 (separate pp. 272, 321). "Panama."—Römer, *Monogr. Molluskengattung Venus*, Linné, (Cassel), Bd. 1, *Cytherea*, December, 1867, p. 108, pl. 28, figs. 5, 5a, 5b. Panama.

Cytherea consanguinea C. B. Adams, *Sowerby, Thes. Conch.*, Vol. 2, 1853, p. 743, pl. 163, fig. 203. Panama.

Type Locality: Panama.

Range: Port Guatulco, Mexico, to Panama.

Collecting Stations: Mexico: Port Guatulco (195-D-1), 2.5 fathoms, sand, algae; Guatemala: 7 miles west of Champerico (197-D-2), 14 fathoms, mud; El Salvador: La Libertad (198-D-2), 14 fathoms, mud; Nicaragua: Monypenny Point, Gulf of Fonseca; Corinto (200-D-8, 9, 19), 6-24 fathoms, mangrove leaves, also on shore; Costa Rica: Port Parker (203-D-1, 2, 3), 10-15 fathoms, sandy mud, crushed shell, shelly sand, algae, shelly mud; Cedro Island, Gulf of Nicoya; Golfo, Gulf of Dulce.

Description: Shell roundly trigonal, beaks a little anterior to the center, smooth but with fine concentric lines of growth; ornamented with brown radial markings which often do not reach the ventral margin, in some specimens the beaks faintly pinkish colored; hinge with the anterior lateral of the left valve larger and higher than the others; interiorly the umbonal area is usually pink, the remainder of the shell white.

The largest specimen in the collection measures approximately: length 33 mm.; height, 26.4 mm.; convexity (one valve), 9.5 mm.

²⁰ *Agriopoma* has been placed in this key for convenience although it is also cited under *Callocardia*.

The shell of *Pitar consanguineus* is more rounded in outline and possesses a much larger anterior lateral tooth in the left valve in comparison to that of *P. mexicanus*.

The more rounded trigonal form and longer anterior dorsal margin serve to separate this species from *Pitar inconspicuus* Sowerby²¹ and *P. purus* Deshayes²², both described from Peru, and *P. tomeanus* Dall, described from Chile.

Distribution: Specimens referable to *Pitar consanguineus* were taken by the expedition from west Mexico to Costa Rica on the beach and dredged at depths of 2.5 to 24 fathoms. The largest number of specimens collected at any one locality, mostly small, was at Corinto, Nicaragua, in beach drift and dredged in 12-13 fathoms.

***Pitar (Pitar) newcombiana* Gabb.**

C[irce]. L[ioconcha]. newcombiana Gabb, *Proc. Calif. Acad. Nat. Sci.*, Vol. 3, January, 1865, p. 189. "Hab. two valves, Catalina Island, 120 fms. Dr. Cooper."

Pitaria newcombiana Gabb, I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, 1924, p. 151, pl. 57, fig. 2. Monterey, California, to Lower California. Also Pleistocene and Pliocene.

Type Locality: Catalina Island, California, in 120 fathoms.

Range: Monterey, California, to the Gulf of California, and south to Port Guatulco, Mexico, and Clarion Island.

Collecting Stations: Mexico: Cape San Lucas; Port Guatulco (195-D-9), 7 fathoms, gr. sand, crushed shell.

Description: Shell thin, trigonally ventricose, polished, marked by minute concentric striae; beaks large, subcentral; anterior end prominent, narrowly rounded, posterior a little the widest, base convex; lunule not excavated, bounded by an impressed line; color yellowish-white, variously lined with brown angular lines; interior whitish; internal margin smooth; hinge teeth delicate (Gabb).

A specimen from Port Guatulco, Mexico, measures approximately: length, 17.3 mm.; altitude, 14 mm.; convexity (both valves together), 9 mm.

Distribution: One specimen of this species was taken at Cape San Lucas and one was dredged by the expedition at Port Guatulco, Mexico, in 7 fathoms. It also is known to occur in the Pliocene and Pleistocene of southern California and in the Pleistocene of Lower California.

²¹ *Cytherea inconspicua* Sowerby, *Proc. Zool. Soc. London*, June 1, 1835, p. 47. "Hab. ad Paytam, Peruviae." "Found in sandy mud at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 638, pl. 133, figs. 133, 134 (as *Cytherea inconspicua*). Payta, Peru.

²² *Dione pura* Deshayes, *Cat. Conch. Biv. Shells in Brit. Mus.*, Pt. 1, 1853, p. 68. "Hab. Callao (Hinds)."

Cytherea pura Deshayes, Römer, *Monogr. Molluskengattung Venus*, Linné, (Cassel), Bd. 1, *Cytherea*, September, 1867, p. 84, pl. 23, figs. 1, 1a, 1b. Callao, Peru.

Cytherea (Caryatis) pudicissima E. A. Smith, described from the coast of India, was compared to *Dione pura* Deshayes (see *Ann. & Mag. Nat. Hist.*, Ser. 6, Vol. 14, September, 1894, p. 169, pl. 5, figs. 3, 4. "Hab. off Ganjam coast, 24 miles south-east of Gopalpur, in 89-93 fathoms").

***Pitar (Pitar) unicolor* Sowerby.**

Cytherea unicolor Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 23. "Hab. ad Real Llejos Americae Centralis." "Found in coarse sand at a depth of six fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 629, pl. 131, figs. 90, 91 (as *Cytherea unicolor*). "Xippixapi, West Columbia; coarse sand, at 6 fathoms. Cuming."

Chione badia Gray, *Analyst*, Vol. 8, 1838, p. 306. [No locality cited].

Cytherea ligula Anton, *Verzeichniss der Conchyl.*, 1839, p. 7. [*Cytherea* cited as a subgenus of *Venus*.] [No locality cited.]—Philippi, *Abbild. u. Beschreib. Conchyl.*, Bd. 1, Heft 6, *Cytherea*, July, 1844, p. 149 (1), pl. 1, fig. 2. "Patria . . ."

Dione unicolor Sowerby, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863, species 33, pl. 8, figs. 33a, 33b. "Hab. West Columbia."

Type Locality: Real Llejos [near Corinto], Nicaragua, in 6 fathoms, coarse sand.

Range: Humboldt Bay, Lower California (Dall) [Panama]. Acapulco, Mexico, to Jipijapa, Ecuador.

Collecting Stations: Costa Rica: Culebra Bay; Piedra Blanca Bay; Uvita Bay; Golfito; 1 mile south of the entrance to Golfito, Gulf of Dulce.

Description: Shell triangularly elongately rounded, somewhat compressed, thick, concentrically ridged but these are obsolete in the medial portion of the valves, fine radial striations are present on unworn specimens; color white or chestnut brown or some shade between the two. The pallial sinus extends forward more than half the length of the shell, the end is rounded.

The largest specimen collected measured approximately: length 46 mm.; height, 40.5 mm.; convexity (one valve) 10 mm.

Characteristic features of this species are the smooth medial areas externally and the long pallial sinus which extends forward more than half the length of the shell.

Distribution: This species was taken by the expedition only along the coast of Costa Rica.

Subgenus ***Pitarella* Palmer.**

***Pitar (Pitarella) mexicanus* Hertlein & Strong, sp. nov.**

Plate I, Figures 3 and 8.

Pitar lenis Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 100, pl. 16, fig. 6. "Acapulco, 20 fathoms" (type). Also, "Guaymas, 20 fathoms" (paratypes).

Not *Cytherea lenis* Conrad, *Jour. Acad. Nat. Sci. Philadelphia*, Ser. 2, Vol. 1, 1848, p. 130, pl. 14, fig. 19. Marlbourne, Hanover County, Virginia, Eocene. Referred to "*Pitaria (Pitaria) lenis* Conrad by Van Winkle Palmer, *Palaeontogr. Amer.*, Vol. 1, No. 5, p. 218 (10), 1927, pl. 35 (4), fig. 7, 1929.

Type Locality: 4 miles south-southwest of Maldonado Point, Mexico, in 26 fathoms, mud.

Range: Santa Maria Bay, west coast of

Lower California, to Santa Inez Bay in the Gulf of California and south to the Gulf of Chiriqui, Panama.

Collecting Stations: Mexico: Arena Bank (136-D-2), 45 fathoms, mud, *Arca* conglomerate; Santa Inez Bay (143-D-4), 25 fathoms, sand, (146-D-1), 35 fathoms, mud, crushed shell; 19 miles west of Mazatlan (153); Manzanillo (184-D-2), 30 fathoms, gravelly sand; 4 miles ssw. of Maldonado Point (192-D-1), 26 fathoms, mud; Port Guatulco (195-D-1, 20), 2.5-23 fathoms, sand, algae, mud; Guatemala: 7 miles west of Champerico (197-D-1, 2), 14 fathoms, mud; El Salvador: Meanguera Island, Gulf of Fonseca (199-D-1), 16 fathoms, sand, mud, crushed shell; Nicaragua: (exact locality unknown); Costa Rica: Port Parker (203-D-1, 2, 3), 12-15 fathoms, sandy mud, crushed shell, shelly sand, algae, shelly mud; Port Culebra (206-D-1, 2, 3), 14 fathoms, sandy mud; Cedro Island, Gulf of Nicoya (213-D-1, 10), 8-10 fathoms, mud; off Ballenas Bay, Gulf of Nicoya (213-D-11, 17), 35 fathoms, mud.

Description: Shell elongately oval, rather thin, white, exteriorly resembling *Compso-myax subdiaphana* Carpenter; ornamented with close, fine, concentric riblets over the whole valve or subobsolete medially; lunule large, cordate, bordered by an incised line; hinge of left valve with 3 cardinals and an anterior lateral tooth, the anterior and middle cardinals are joined dorsally, the middle one is longer and thicker, a pit occurs at the base, the posterior cardinal is elongate and thin, the lamella forming the middle and anterior cardinals bears slight irregularities or cusps, the anterior lateral with 2; hinge of right valve with a high thin anterior cardinal connected with a bifid posterior cardinal, the middle cardinal is separated from the anterior cardinal by a narrow space but separated from the posterior cardinal by a much wider space, anteriorly there are two low laterals separated by a pit; pallial sinus short, wide, ascending, rounded at the end. Dimensions: length, 42.3 mm.; height, 33.3 mm.; convexity (both valves together), 25 mm.; pallial sinus projects forward approximately 20 mm. from the posterior margin.

Holotype (Calif. Acad. Sci. Paleo. Type Coll.), from Station 192-D-1, Lat. 16° 16' 30" N., Long. 98° 37' W., 4 miles south-southwest of Maldonado Point, Mexico, in 26 fathoms (47 meters), mud.

The species described as *Cytherea lenis* by Conrad was referred to the genus "*Pitaria*" [= *Pitar*] by K. V. W. Palmer. This necessitates a new name for the west American species described under the name of *Pitar lenis* by Pilsbry & Lowe and the name *Pitar mexicanus*, based upon a specimen off Maldonado Point, Mexico, is here proposed.

The shell of this species is somewhat more elongated and less rounded and the left anterior lateral is less elevated than that of *P. consanguineus* C. B. Adams. It is variable in thickness and in the amount of rounding or subangulation of the posterior end.

The ornamentation of some large specimens is similar to that of *Pitar (Pitarella) gatunensis* Dall and *P. (P.) tumbezanus* Olsson, both of which are tropical American Miocene forms. The character of the hinge of the present species, which has the left middle cardinal more elongated and thicker than the anterior cardinal, together with the shape and ornamentation, are so characteristic of *Pitarella* that we have been led to place it in that subgenus.

Distribution: Specimens of this species were taken from Santa Inez Bay in the Gulf of California to the Gulf of Chiriqui, Panama. Usually only one or two specimens were found at each locality but about 75, many of them small, were dredged in 12 fathoms at Port Parker, Costa Rica. This species also has been recorded as occurring in the Pleistocene of Panama.

Subgenus *Hyphantosoma* Dall.

Key to the species of *Hyphantosoma*.

- A. Lunule broadly cordate; pallial sinus projecting forward considerably less than half the length of the shell; white *alates*
- B. Lunule elongately cordate; pallial sinus projecting forward nearly half the length of the shell; brown markings *pollicaris*

Pitar (Hyphantosoma) alates Hertlein & Strong, sp. nov.

Plate I, Figures 9, 11, 12 and 13.

Shell solid, roundly trigonal, plump, uniformly white; beaks prominent, anteriorly directed over a large cordate lunule defined by a fine impressed line; anterior dorsal margin short, straight, posterior dorsal margin sloping, arched, with a shallow depression on each side of the hinge line and extending to the posterior end; ends and ventral margin rounded; exterior surface ornamented by fine lines of growth, strongest near the margins, very faint near the beaks, crossed by numerous, almost microscopic, radial grooves which divaricate along radial lines extending from the beaks to the posterior and anterior ends of the basal margin, obsolete near the beaks; hinge and ligament strong, normal for the genus and subgenus; pallial sinus short, fairly wide, rounded at the end, ascending, projecting forward to about one-third the length of the shell; interior white; margin smooth. The type measures: length, 53.8 mm.; height, 46 mm.; convexity (both valves together), 34.2 mm.; pallial sinus projects forward 21 mm. from the posterior margin.

Holotype (Calif. Acad. Sci. Paleo. Type Coll.), dredged at station 136-D-13, Lat. 23° 29' N., Long. 109° 24' W., Arena Bank, Gulf of California, in 45 fathoms (82 meters), mud, *Arca* conglomerate. Another single valve without information as to locality probably came from the same general region. A small right valve was dredged at Station 214-D-1-4, Lat. 9° 19' 32"—9° 17' 40" N., Long. 84° 29' 30"—84° 27' 30" W., 14 miles S. × E. of Judas Point, Costa Rica, in 42-61 fathoms, mud, shell, rocks.

A single left valve without information as to locality measures approximately: length, 46 mm.; height, 41 mm.; convexity (one valve), 16 mm. The specimen is slightly eroded but except for the absence of zigzag sculpture it is identical with *Pitar aletes*. Zigzag sculpture is lacking on small specimens and it seems likely that this type of sculpture may disappear with slight erosion of the larger shells or it may be missing on some specimens.

In general features the new species is somewhat similar to *Pitar pollicaris* but is higher in proportion to the length, more convex and trigonal in outline.

Pitar (Hyphantosoma) aletes bears a close resemblance to *Pitar (Hyphantosoma) carbaseus* Guppy,²³ described from the Miocene of Jamaica, but appears to be less broadly rounded posteriorly.

The species described by Dautzenberg as *Meretrix (Pitar) intricata*,²⁴ believed to occur in the East Indian region, resembles in general features the west American species here described. Dautzenberg's species differs in color and in other details. *Pitar (Hyphantosoma) sculpturatus* Marshall²⁵ from the Miocene of New Zealand is another member of this group.

***Pitar (Hyphantosoma) pollicaris* Carpenter.**

Dione prora Conrad, Reeve, Conch. Icon., Vol. 14, *Dione*, October, 1863 species 45, pl. 10, fig. 45. "Cape St. Lucas, Xantus, California." [Specimen received by Reeve from Carpenter].

Callista pollicaris Carpenter, *Ann. & Mag. Nat. Hist.*, Ser. 3, Vol. 13, April, 1864, p. 312. "Figured by Mr. Reeve (Conch. f. 45) as '*Dione prora*, var'." Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 210.—Verrill, *Amer. Jour. Sci.*, Vol. 49, 1870, p. 219. Near La Paz, Lower California.

Pitaria pollicaris Carpenter, Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 387. Gulf of California, Cape St. Lucas, and south to Callao, Peru.

Type Locality: Cape San Lucas, Lower California.

Range: Gulf of California to Callao, Peru.

Collecting Stations: Mexico: Port Guatulco (195-D-9), 7 fathoms, gr. sand, crushed shell; Colombia: Gorgona Island.

Description: Shell large, elongately oval, moderately inflated; anterior end somewhat projecting and roundly pointed, ventral margin rounded, posterior end somewhat roundly truncated; a shallow groove is present just

ventral and roughly parallel to the posterior dorsal margin; lunule elongate and bounded by an impressed line, escutcheon narrow; perfect specimens are sculptured by fine zigzag grooves, young shells usually are sculptured in this manner especially on the anterior portions of the valves; the whole colored drab white but in young specimens often with brown zigzag markings which may be somewhat strengthened in radial bands; hinge normal, with a strongly developed anterior lateral tooth in the left valve; pallial sinus extends forward nearly to the middle of the shell, the end is broadly angulated; interior white; margin smooth.

A large specimen in the collections of the California Academy of Sciences from Carmen Island, Gulf of California, measures approximately: length 80 mm.; height, 60 mm.; convexity (both valves together), 39 mm.

The exterior of the shell of this species is often partially covered by a white powdery substance, apparently some form of algae.

This species bears a resemblance to *Pitar proror* Conrad²⁶ from the western Pacific, but the anterior end is less acutely pointed, the posterior dorsal area bears a much stronger radial groove and the posterior margin is more truncated. No fine divaricate grooving is present on specimens of *Pitar proror* collected by Ted Dranga at Vambia, Island of Ono, Fiji, which we have examined. Römer²⁷ discussed the relations of the west American and related species of this group in the Indo-Pacific region.

Distribution: Only a few specimens of *Pitar pollicaris* were collected by the expedition at Port Guatulco, Mexico, and at Gorgona Island, Colombia.

Subgenus *Hysteroconcha* Fischer.

Key to the species of *Hysteroconcha*.

- A. Posterior umbonal angulation bearing spines
 - a. Shell large; spines well spaced
lupanarius
 - aa. Shell small; spines more numerous and crowded; concentric ridges thinly lamellate
*multispinosus*²⁸
- B. Posterior umbonal angulation bearing scales
roseus

***Pitar (Hysteroconcha) lupanarius* Lesson.**

Cytherea lupanaria Lesson, *Centurie Zool.*, 1830, p. 196, pl. 64 [four figs.]. "Cette belle espèce est très-commune sur les grèves entre Colan et Payta sur la côte du Pérou."—Lesson, *Voy. Coquille, Zool.*, Vol. 2, Pt. 1, 1830, p. 430. Original locality cited.

Dione semilamellosa Gaudichaud, Reeve, *Conch. Icon.*, Vol. 14, August, 1863, species 20, pl. 6, figs. 20a, 20b, 20c. "Hab. Central America."

²³ See *Pitar (Hyphantosoma) carbaseus* Guppy, *Woodring, Carnegie Inst. Washington, Publ. No. 366*, May 20, 1925, p. 153, pl. 20, figs. 15-19. Bowden, Jamaica, upper Miocene.

²⁴ *Meretrix (Pitar) intricata* Dautzenberg, *Journ. de Conchyl.*, Vol. 55, No. 4, March 30, 1908, p. 333, pl. 6, fig. 1. Exact locality unknown but believed to have come from the region of the Celebes.

²⁵ *Macrocallista sculpturata* Marshall, *Trans. & Proc. New Zealand Inst.*, Vol. 50, July 15, 1918, p. 272, pl. 20, figs. 6, 6a. Pakaurangi Point, New Zealand. Mid-tertiary. See also *Pitar (Hyphantosoma) sculpturatus* Marshall, *Laws, Trans. & Proc. Roy. Soc. New Zealand*, Vol. 71, Pt. 2, September, 1941, p. 135.

²⁶ *Cytherea prora* Conrad, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 7, 1837, p. 253, pl. 19, fig. 18. "Inhabits the Pacific, probably towards the coast of New Holland."

²⁷ Römer, E., *Monogr. Molluskengattung Venus*, Linné, (Cassel), Bd. 1, *Cytherea*, 1867, p. 108.

²⁸ Not represented in the present collection.

Pitaria (*Hysteroconcha*) *lupanaria* Lesson, Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 388. Ballenas Bay, Lower California, to the Gulf of California and south to Payta, Peru.

Pitar (*Hysteroconcha*) *lupanaria* Lesson, R. H. Palmer & Hertlein. *Bull. South. Calif. Acad. Sci.*, Vol. 35, Pt. 2, May-August (issued September 10), 1936. p. 73. Oaxaca, Mexico, Pleistocene.

Type Locality: Between Colan and Paita, Peru, on the strand.

Range: Ballenas Bay, west coast of Lower California, to the Gulf of California and south to Negritos, Peru.

Collecting Stations: Mexico: Chamela Bay; Tenacatita Bay; Sihuatanejo Bay; Tangola-Tangola Bay; Nicaragua: Potosi and Monypenny Point; Corinto (200-D-16, 19), 4-13 fathoms, mangrove leaves, also at Isla Cardon; Costa Rica: Golfito, Gulf of Dulce.

Description: Shell triangularly ovate, rather ventricose, concentrically ridged, these are somewhat laminated anteriorly and often somewhat obsolete posteriorly; one or two rows of long spines occur along the posterior dorsal umbonal angulation; color whitish and purple-violet, with violet spots at the base of the spines.

This species is very similar to *Pitar dione* Linnaeus which occurs in the Caribbean region. The shell of *Pitar lupanarius* is larger than that of the Antillean species and the ornamentation differs in that violet spots occur at the base of the spines. *Dione expinata* Reeve, described from Central America, is a form of *P. lupanarius* in which the spines are greatly reduced in size.

A form bearing more numerous, more slender, crowded spines and thinner, more lamellate concentric ridges than typical *P. lupanarius*, was named "*Cytherea multi-spinosa*" by Sowerby. The shell described as *Callista* (*Dione*) *longispina* Mörch²⁹ appears to be somewhat similar to the form described by Sowerby.

Distribution: Specimens of this species were taken from Chamela Bay, Mexico, to the Gulf of Dulce, Costa Rica. It also has been recorded as occurring in the Pleistocene of Oaxaca, Mexico.

***Pitar* (*Hysteroconcha*) *roseus* Broderip & Sowerby.**

Cytherea rosea Broderip & Sowerby, *Zool. Journ.*, Vol. 4, No. 15, January, 1829, p. 364. "Hab. ad Littora Oceani Pacifici." "From St. Blas."—Sowerby, *Zool. Beechey's Voy.*, 1839, p. 151, pl. 43, fig. 7. "Found abundantly at St. Blas."

Dione rosea Broderip & Sowerby, Reeve, *Conch. Icon.*, Vol. 14, 1863, *Dione*, species 29, pl. 7, fig. 29. "Hab. Panama."

Pitaria (*Hysteroconcha*) *rosea* Broderip & Sowerby, Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 389. Gulf of California to Panama.

Type Locality: San Blas, Mexico.

Range: Gulf of California to Panama.

Collecting Stations: Costa Rica: 1 mile south of the entrance to the Gulf of Dulce; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shell obliquely heart-shaped, compressed, rose-purple, obscurely banded, concentrically closely ridged, ridges here and there lamellated on the anterior side, on the posterior prickly lamellated along the margin, scarcely spined (Reeve).

Short scaly spines occur on the shell of this species in a white radial streak along the posterior umbonal angulation. A right valve collected in the Gulf of Dulce, Costa Rica, measures: length, 44 mm.; height, 34.4 mm.; convexity (one valve), 10 mm.

A subspecies, *Pitar roseus wiedenmayeri* H. K. Hodson, 1931, has been described from the Miocene of Venezuela. *Pitar vanwinkleae* Olsson, 1922, described from the Miocene of Costa Rica, is also said to be similar to *P. roseus*.

Distribution: One right valve of this species was collected by the expedition on the beach one mile south of the entrance to the Gulf of Dulce, Costa Rica, and one specimen was dredged in the Gulf of Chiriqui, Panama, in 35-40 fathoms. It also has been recorded as occurring in the Pliocene of Ecuador.

Subgenus *Lamelliconcha* Dall.

Key to the species of *Lamelliconcha*.

- A. Shell somewhat rostrate and pointed posteriorly *concinus*
- B. Shell broadly rounded or subtruncated posteriorly
 - a. Concentric lamellae uniform in height *frizzelli*
 - aa. Concentric lamellae not uniform in height
 - b. Lamellae evenly spaced and alternating in height *alternatus*
 - bb. Primary lamellae separated by 1 to 3 lower lamellae *callicomatus*

***Pitar* (*Lamelliconcha*) *circinatus alternatus* Broderip.**

Cytherea alternata Broderip, *Proc. Zool. Soc. London*, June 1, 1835, p. 45. "Hab. ad Columbianam Occidentalem. (Monte Christi)." "Dredged up in sandy mud at a depth of seven fathoms."

Dione alternata Broderip, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863, species 28, pl. 7, figs. 28a, 28b. Broderip's types illustrated.

Cytherea circinata Born, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, August, 1863, species 25, pl. 7, figs. 25a, 25b. "Hab. Mazatlan."

Not *Venus circinata* Born, *Test. Mus. Caes. Vindob.*, 1780, p. 61, pl. 4, fig. 8. "Patria ignota."

Type Locality: Monte Christi, Ecuador, in 7 fathoms, sandy mud.

Range: Gulf of California to Paita, Peru.

Collecting Stations: Mexico: Chamela Bay; Tenacatita Bay (183-D-2), 30 fathoms,

²⁹ *Callista* (*Dione*) *longispina* Mörch, *Malakozool. Blätter*, Bd. 7, January, 1861, p. 196. "Realejo specim. plura."

muddy sand; Tangola-Tangola Bay; Nicaragua: Corinto (200-D-11, 17, 19), 7-13 fathoms, sand, mangrove leaves; Costa Rica: Uvita Bay; 1 mile south of Golfoito Bay.

Description: The shell of this species is ornamented by sharp raised concentric ribs which, in perfect specimens, alternate in height. The color is white with radial chestnut rays and the lunule and escutcheon violet chestnut or in some specimens the entire shell may be entirely violet chestnut or white. The interior is white with violet chestnut on the dorsal portion.

A specimen collected by the senior author at Corinto, Nicaragua, measures: length, 37.5 mm.; height, 31 mm.; convexity (one valve), 11.6 mm.

Young specimens of this subspecies are remarkably similar to the east American *Pitar circinatus* Born. Large specimens are said to attain a greater size, greater convexity, and with the ribs somewhat more widely spaced than those on the east American form.

The shell of *Pitar circinatus alternatus* is more rounded in outline and lacks the decided posterior rostration of *P. concinnus* Sowerby.

Pitar (Lamelliconcha) petersoni Olsson, 1932, described from the Miocene of Peru, is a similar form.

Distribution: This subspecies was taken by the expedition on beaches and in shallow water from west Mexico to Costa Rica. It was found fairly abundantly at Corinto, Nicaragua.

***Pitar (Lamelliconcha) callicomatus* Dall.**

Pitaria (Lamelliconcha) callicomata Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, pp. 389, 402, pl. 16, fig. 8. "Bay of Panama, in 14 fathoms, mud." Also in 7-30 fathoms.

Pitar callicomata Dall, Strong, Hanna & Hertlein, *Proc. Calif. Acad. Sci.*, Ser. 4, Vol. 21, No. 10, 1933, p. 118. Acapulco, Mexico.

Type Locality: Bay of Panama, in 14 fathoms, mud.

Range: Acapulco, Mexico, to Panama.

Collecting Stations: Mexico: Port Guatulco (195-D-20), 23 fathoms, mud; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shape similar to but more oval than that of *Pitar circinatus alternatus*. It is ornamented by prominent concentric lamellae between which occur from one to three low secondary lamellae. The shell is of a dull white color.

The dimensions of the type specimen of this species, were given as: length, 47 mm.; height, 36 mm.; convexity, 22 mm.

Distribution: Only single valves of this species were taken at Port Guatulco, Mexico, in 23 fathoms, and in the Gulf of Chiriqui, Panama, in 35-40 fathoms.

***Pitar (Lamelliconcha) concinnus* Sowerby.**

Cytherea concinna Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 23. "Hab. ad

Panamam." "Found at a depth of ten fathoms in fine sand."

Cytherea concinna Sowerby, Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 630, pl. 132, figs. 99, 100. Original locality cited.

Dione concinna Sowerby, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863 species 31, pl. 8, figs. 31a, 31b. "Hab. Panama, Mazatlan."

Cytherea affinis Broderip, *Proc. Zool. Soc. London*, June 1, 1835, p. 45. "Hab. ad Colombiam Occidentalem. (Xipixapi)." "Dredged up from sandy mud at a depth of ten fathoms."

Dione affinis Broderip, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863, species 30, pl. 8, fig. 30. Original locality cited.

Cytherea tortuosa Broderip, *Proc. Zool. Soc. London*, June 1, 1835, p. 45. "Hab. ad Panamam, et ad Xipixapi." "Dredged up from sandy mud at a depth of six fathoms."

Dione tortuosa Broderip, Reeve, *Conch. Icon.*, Vol. 14, *Dione*, 1863, species 61, pl. 12, fig. 61. Original locality cited.

Venus paytensis d'Orbigny, Voy. Amér. Mérid., Vol. 5, 1846, p. 565. "*Cytherea affinis*, Broder., 1835, *Proceed. Zool. Soc.*, p. 45 (non *affinis*, Gmel., 1789, non *affinis*, Mathéron, 1842)."

Pitaria (Lamelliconcha) acuticostata Gabb, Li, *Bull. Geol. Soc. China*, Vol. 9, No. 3, October, 1930, p. 261, pl. 4, fig. 28. Dredged in Panama Bay. Referred to the Miocene. Li's record was referred to *Pitar (Lamelliconcha) concinna* Sowerby by Pilsbry (*Proc. Acad. Nat. Sci. Philadelphia*, Vol. 83, 1931, p. 430).

Not *Callista acuticostata* Gabb, 1873. [Now considered to be referable to the genus *Pitar*].

Pitaria (Lamelliconcha) labreana Maury, Li, *Bull. Geol. Soc. China*, Vol. 9, No. 3, 1930, p. 261, pl. 4, fig. 29. Dredged in Panama Bay. Referred to the Miocene. Li's record was referred to *Pitar (Lamelliconcha) concinnus* Sowerby by Pilsbry (*Proc. Acad. Nat. Sci. Philadelphia*, Vol. 83, 1931, p. 430).

Not *Pitaria (Lamelliconcha) labreana* Maury, 1912.

Type Locality: Panama, in 10 fathoms, fine sand.

Range: Magdalena Bay, Lower California, to the Gulf of California and south to Paita, Peru.

Collecting Stations: Mexico: Chamela Bay (182-D-1), 8 fathoms, sand, algae; Guatemala: 7 miles west of Champerico (197-D-1-2), 14 fathoms, mud; El Salvador: La Libertad (198-D-1.2), 13-14 fathoms, mud; Meanguera Island, Gulf of Fonseca (199-D-1), 16 fathoms, sand, mud, crushed shell; Nicaragua: Potosi and Monvenny Point; Corinto (200-D-11,17,19), 7-13 fathoms, sand, mangrove leaves, also on shore and at Isla Cardon; Costa Rica: Golfoito; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shell oblong, heart-shaped, rather compressed, chestnut-red or white, rayed with purple rows, concentrically

ridged, ridges slightly reflected, here and there wrinkled, posterior side a little flexuous (Reeve).

The shell of *Pitar concinnus* is somewhat rostrate posteriorly and by this character is readily separable from *P. circumatus alternatus*. It attains a length of at least 51.5 mm. On some specimens there is a shallow, radial depression just anterior to the posterior umbonal angulation.

Pilsbry & Lowe stated that "*Cytherea tortuosa*" Broderip is quite distinct from *P. concinnus*. The series of specimens of *P. concinnus* available to us leads us to agree with Dall's (1902) conclusion that *tortuosa* "is a white specimen with the ribs more irregular than usual."

Pitar (Lamelliconcha) salangus Pilsbry & Olsson, 1941, described from the Pliocene of Ecuador, is a very similar species. It is said to be constantly higher in proportion to the length and less produced posteriorly. *Pitar (Lamelliconcha) labreanus* Maury from the Pliocene of Trinidad is another similar species.

Distribution: This species was taken from west Mexico to Panama, on the shore and dredged at depths of 7 to 40 fathoms. It was dredged abundantly in the Gulf of Fonseca in 16 fathoms. It also has been cited as occurring in the Pleistocene of Maria Madre Island, Mexico, by Hertlein, in the Pliocene of Costa Rica by Olsson, and in the Pliocene of Ecuador as *Pitar (Lamelliconcha) affinis* by Pilsbry & Olsson.

***Pitar (Lamelliconcha) frizzelli* Hertlein & Strong, sp. nov.**

Plate I, Figures 1, 5 and 7; Plate II, Figure 11.

Shell oblong, somewhat compressed, beaks low; surface sculptured by close, concentric ridges, the whole exterior colored by light brown with darker brown blotches and tent-shaped lines; anterior dorsal margin concave with an impressed, elongately cordate lunule; posterior dorsal margin sloping and slightly arched, ends and basal margin rounded; a faint shallow radial depression occurs just anterior to the posterior umbonal curve; hinge and ligament normal for the genus, hinge teeth rather delicate; pallial sinus fairly wide, ascending, rounded at the end, and projecting forward to nearly the center of the shell; interior yellow in the center shading to purple under the beaks and over the muscle scars, white toward the basal margin; margins smooth. The type measures: length, 46 mm.; height, 33.5 mm.; convexity (both valves together), 24 mm.; pallial sinus projects anteriorly 23.5 mm. from the posterior margin.

Holotype dredged at Station 136-D-22, Lat. 23° 28' 30" N., Long. 109° 25' W., Arena Bank, Gulf of California, in 45 fathoms (82 meters), mud. Five valves were dredged in the same general vicinity at Station 136-D-26, Lat. 23° 27' N., Long. 109° 24' W., in 45 fathoms, sand, crushed shell. Two valves

were dredged at Station 150-D-6, Lat. 23° 02' N., Long. 109° 31' W., Gorda Banks, in 60 fathoms, muddy sand, rocks, and two valves were dredged in the same general vicinity at Station 150-D-10, Lat. 23° 06' N., Long. 109° 25' W., in 50 fathoms, rock, crushed shell.

The concentric sculpture on this species is similar to that on *Pitar concinnus* Sowerby but the posterior end is much less pointed and the coloration is of an entirely different pattern.

This species is named for Dr. Don L. Frizzell in recognition of his contribution to the classification of the Veneridae.

Distribution: Specimens of this species were dredged only in the south end of the Gulf of California at depths of 40-60 fathoms.

Subgenus *Tinctora* Jukes-Browne.

Callizona Jukes-Browne, *Proc. Malacol. Soc. London*, Vol. 10, Pt. 6, September, 1913, p. 346. "Type, *Callista vulnerata*, Brod."

Not *Callizona* Doubleday, 1848. *Lepid. Not Callizona* Greef, 1875. *Verm. (Polych.)*.

Tinctora Jukes-Browne, *Proc. Malacol. Soc. London*, Vol. 11, Pt. 1, March, 1914, p. 62. "Type, *Cytherea vulnerata*, Brod." New name for *Callizona* Jukes-Browne, 1913, not *Callizona* Doubleday, 1848.

Callizonata Strand, *Arch. f. Naturgesch.*, Jahrg. 92, 1926, Abt. A, Heft 8, p. 40. New name for *Callizona* Jukes-Browne not *Callizona* Doubleday.

Type (by original designation): *Cytherea vulnerata* Broderip.

Shell thick, sub-orbicular, glossy; valve-margins crenulated; left posterior cardinal long and partly free from nymph; median very thick; pallial sinus short and rounded. Pedal scar as in *Callista* (Jukes-Browne, 1914).

Only one species of *Tinctora* is known.

Nanopitar Rehder³⁰ is said to be somewhat similar to *Tinctora* but lacks the irregular crenulations on the inner margin.

***Pitar (Tinctora) vulneratus* Broderip.**

Cytherea vulnerata Broderip, *Proc. Zool. Soc. London*, June 1, 1835, p. 46. "Hab. in Americâ Centrali. (Real Llejos)." "It was dredged up from sandy mud at a depth of six fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1851, p. 632, pl. 131, figs. 95, 96 (as *Cytherea vulnerata*). Original locality cited.

Dione vulnerata Broderip, *Reeve, Conch. Icon.*, Vol. 14, *Dione*, 1863, species 16, pl. 5, figs. 16a, 16b. Original locality cited.

Pitaria vulnerata Broderip, *Dall, Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 388. Magdalena Bay, Lower California, to the Gulf of California and south to the Bay of Panama.

Type Locality: Real Llejos [near Corinto], Nicaragua, in 6 fathoms, sandy mud.

Range: Magdalena Bay, west coast of

³⁰*Nanopitar* Rehder, *Proc. U. S. Nat. Mus.*, Vol. 93, No. 3161, January 20, 1943, p. 188. "Genotype: *Pitar (Nanopitar) pilula*, new species," p. 188, pl. 19, figs. 5-10. Collected "in Lake Worth, Fla."

Lower California, to the Gulf of California and south to the Bay of Panama.

Collecting Stations: Mexico: Santa Inez Point, east coast of Lower California; Arena Point area, Lower California; Cerralbo Island, Gulf of California; Chamela Bay (182-D-1), 8 fathoms, sand, algae, also on beach; Tenacatita Bay.

Description: Shell suborbicular, moderately convex, finely concentrically ridged; cream color, the umbonal region often finely rayed or mottled with brown, irregularly spaced violet rings or zones of color usually occur more strongly developed toward the ventral margin; pallial sinus rather wide and projecting slightly upward and forward nearly half the length of the shell; inner margins irregularly crenulated. A fairly large specimen measures approximately: length, 45 mm.; height, 40 mm.; convexity (both valves), 27.5 mm.

Distribution: A few specimens of this species were taken by the expedition in the Gulf of California region. It has also been recorded as occurring in the Pleistocene of Oaxaca, Mexico.

Genus *Callocardia* A. Adams.

Key to the subgenera of *Callocardia*.

- A. Left anterior lateral very small and distant from cardinals (in type species); pallial sinus well developed *Agriopoma*
 B. Left anterior lateral and pallial sinus lacking (in type) *Callocardia* s.s.³¹

Subgenus *Agriopoma* Dall.

Callocardia (Agriopoma) catharia Dall.

Plate II, Figures 14 and 15.

Callocardia (Agriopoma) catharia Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, pp. 387, 402, pl. 14, fig. 3 (as *Callocardia catharia* on p. 402). "Bay of Panama in 30 fathoms, mud."

Type Locality: Panama Bay, in 30 fathoms, mud.

Range: Ballenas Bay, west coast of Lower California, to the Gulf of California and south to Panama, in 7 to 66 fathoms (Dall).

Collecting Station: Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shell trigonally ovate, broadly rounded posteriorly, dull white, earthy, ornamented by fine concentric threads; lunule cordate, defined by an impressed line; pallial sinus wide, shallow, ascending.

One left valve 22.8 mm. long and 20.5 mm. high appears to be referable to the species described by Dall as *Callocardia catharia*. The hinge has a well developed anterior lateral tooth which is well separated from the anterior cardinal. The anterior and middle cardinal teeth are formed by a thin folded lamina (the middle tooth the longer) which at the apex of the fold bears two or three minute cusps; on the ventral side there are two triangular pits formed by shelly folds,

the anterior one deeper and lower and forming a depression in the hinge plate; the posterior cardinal is thin and separated from the middle cardinal by a flat-bottomed interspace, the posterior part of the hinge plate is roundly truncated; the pallial sinus is broad and shallow.

K. V. W. Palmer³² gave a discussion of the genus *Callocardia* and published illustrations of *C. guttata* A. Adams, the type of the genus, of which only a left valve is known. The anterior and middle cardinal teeth are formed of a folded lamina with 4 cusps and with a triangular pit on each side. Adams stated that it lacked a left anterior lateral and that the pallial line is simple. Later authors state that the pallial line on the type cannot be discerned clearly and that the degree of sinuosity cannot be definitely stated. Palmer concluded from the curvature of the hinge of the type that a slight elevated area might occur in the region anterior to the cardinals. The general characters described for the shell are similar to those of the present species except that *C. catharia* has a well developed left anterior lateral and a short but well developed pallial sinus.

Dall placed *Callocardia catharia* in the subgenus *Agriopoma* Dall, the type of which is *Callocardia (Agriopoma) texasiana* Dall. As pointed out by Palmer, the characters of the hinge of that species are intermediate between *Callocardia* and *Pitar*. It has a very small left anterior lateral which is situated near the extreme anterior end of the hinge plate and there is a well developed pallial sinus. She considered both *Callocardia* and *Agriopoma* to be subgenera of *Pitar*. She also stated that several east American species originally assigned to *Callocardia* are now referable to other genera or subgenera.

No illustration of the hinge of the type specimen of *Callocardia catharia* has been published but Dall stated: "hinge well developed, normal." The present specimen shows many features said to characterize *Callocardia* as well as *Agriopoma* although it is not typical of the latter. We have therefore retained Dall's nomenclature for the present shell, at least until the characters of the type of *Callocardia* as well as those of the present species are better known.

Distribution: The specimen assigned to this species was taken by the expedition in the Gulf of Chiriqui, Panama, in 35-40 fathoms. According to Dall it occurs commonly as far north as Ballenas Bay, Lower California. A species with a somewhat similar shell which we have found occurring commonly in this same region is *Pitar (Pitar-ella) mexicanus* [= *P. lenis* Pilsbry & Lowe].

Genus *Antigona* Schumacher.

Key to the subgenera of *Antigona*.

- A. Pallial sinus moderately long, wide, and rounded at the end; escutcheon with a longitudinal furrow *Periglypta*

³² See discussion of *Callocardia* by Palmer, *Palaeontogr. Amer.*, Vol. 1, No. 5, pp. 246-248 (38-40), 1927, pl. 38 (7), figs. 1, 4, 11, 1929, and *Agriopoma*, pp. 241-242 (33-34), text fig. 3, 1927, pl. 38 (7), figs. 5, 12, 13, 14, 1929.

³¹ Not represented in the present collection.

- B. Pallial sinus short and acutely angular; escutcheon without a longitudinal furrow
- a. Interspaces between major lamellae bearing concentric threads or lamellae
Ventricola
- aa. Interspaces between major lamellae lacking concentric sculpture
*Antigona s.s.*³³

Subgenus *Periglypta* Jukes-Browne.

Periglypta Jukes-Browne, *Proc. Malacol. Soc. London*, Vol. 11, Pt. 1, March, 1914, p. 72. "Type, *Venus puerpera*, Linn."

Type (by original designation): *Venus puerpera* Linnaeus.

Shell cancellated by strong concentric ridges crossed by radial riblets which crenulate the ridges. Escutcheon narrow, and the right half overlapping the left. Ligament deeply sunk. Nymphs usually having a fine rugose area. Anterior lateral very small and close to the anterior cardinal. Pallial sinus usually wide and rounded (Jukes-Browne).

The right posterior and middle cardinal teeth of each valve are cleft. A narrow longitudinal furrow occurs on the escutcheon.

Periglypta is known to occur from Miocene to Recent. It is represented in the lower Miocene of California by *Antigona vaquerosensis* Loel & Corey, 1932.

Ameghinomya von Ihering,³⁴ founded on a fossil form from Argentina, appears to differ from *Periglypta* chiefly in lacking a longitudinal furrow along the escutcheon.

Antigona (Periglypta) multicostata Sowerby.

Venus multicostata Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 22. "Hab. in Sinu Panamae." "Found in coarse sand at low water."—Sowerby, *Thes. Conch.*, Vol. 2, *Venus*, 1853, p. 706, pl. 152, fig. 10. Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 9, pl. 3, fig. 9. Original locality cited.

Antigona multicostata Sowerby, Van Winkle Palmer, *Palaeontogr. Amer.*, Vol. 1, No. 5, p. 336 (128) (in text), 1927, pl. 61 (30), fig. 11, 1929. West coast of Panama.

Type Locality: Bay of Panama, at low water, sand.

Range: Gulf of California to Punta Verde, Peru, and the Galápagos Islands.

Collecting Stations: Mexico: Banderas Bay; Costa Rica: Port Parker; Culebra Bay; Colombia: Gorgona Island.

Description: Shell large, roundly quadrate, moderately inflated, very thick, anterior end rounded, posterior end roundly truncated; ornamented by thick concentric ribs reflected at the anterior end, undulated, in the middle crenulated, posteriorly irregular, alternately interrupted and slightly crenulated; evenly spaced low radial ribs cross both ribs and interspaces; lunule elongately cordate, pro-

jecting medially; a longitudinal furrow occurs on the escutcheon; hinge with three stout cardinal teeth in each valve and a small denticle near the base of the anterior cardinal of the left valve, the middle cardinal of both valves and the posterior cardinal of the right valve cleft; pallial sinus short, rounded, slightly ascending, projecting anteriorly not quite a third of the distance between the two muscle impressions; inner margin very finely crenulated; interior white, often pinkish or violet under the hinge and umbonal region.

A large specimen collected at Port Parker, Costa Rica, measures approximately: length, 118 mm.; height, 115 mm.; convexity (both valves), 78 mm.; pallial sinus extends anteriorly 54 mm. from the posterior margin.

The shell of this species is quite similar to that of *Antigona listeri* Gray, an east American species. The west American shell is ornamented by coarser concentric lamellae and by more widely spaced radial sculpture.

Antigona dominica Palmer [= *Antigona caribbeana* Anderson], described from the Miocene of Santo Domingo, is a similar species.

Distribution: A few specimens of this species were collected by the expedition off west Mexico, Costa Rica, and Gorgona Island, Colombia. It also occurs in the Pliocene and Pleistocene of the Gulf of California region, and in the Pleistocene of Ecuador and the Galápagos Islands. Trechmann, 1933, cited a species under the name of "*Chione*" *multicostata* as occurring fossil on Barbados Island. We have not seen specimens from that region.

Subgenus *Ventricola* Römer.

Key to the species of *Ventricola*.

- A. Shell suborbicular; large *isocardia*
B. Shell more elongated; smaller; primary concentric lamellae finer and more closely spaced *magdalenae*

Antigona (Ventricola) isocardia Verrill.

Plate II, Figures 2 and 3.

Venus isocardia Verrill, *Amer. Jour. Sci.*, Vol. 49, No. 146, March, 1870, p. 221. "Near La Paz,—Capt. J. Pedersen."

Cytherea (Ventricola) rigida Dillwyn, Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 390. Near La Paz, Lower California, in 9½ fathoms.

Not *Venus rigida* Dillwyn, *Descript. Cat.*, Vol. 1, 1817, p. 164. "Inhabits the coast of Jamaica. Lister. Brazils. Solander. West Indies. *Humphreys*."

Type Locality: Near La Paz, Lower California.

Range: Gulf of California, to Gorgona Island, Colombia.

Collecting Stations: Mexico: Arena Bank in the Gulf of California (136-D-2, 16, 26, 30), 35-40 fathoms, mud, *Arca* conglomerate, muddy sand, sand, weed, crushed shell; 3 miles off Pyramid Rock, Clarion Island (163-D-2), 55 fathoms, rock, coral; Costa Rica: Culebra Bay; 14 miles S. × E. of Judas Point

³³ Not represented in the present collection.

³⁴ *Ameghinomya* von Ihering, *An. Mus. Nac. de Buenos Aires*, Vol. 14, (Ser. 3, Vol. 7), 1907, p. 71. "Je propose le nouveau sous-genre *Ameghinomya* pour ces espèces éteintes de *Chione* avec *Ch. argentina* Ih. comme type." Illustrated by von Ihering, *Rev. Mus. Paulista*, Vol. 2, 1897, p. 252, pl. 7, fig. 45. Upper Patagonian formation.

(214-D-1-4), 42-61 fathoms, mud, shell, rocks; Panama: Hannibal Bank (224), 35-40 fathoms, rock, mud, dead coral, sand, shells, algae; Colombia: Gorgona Island.

Description: Shell large, suborbicular, very convex, ornamented by strong concentric, slightly recurved lamellae which are crowded anteriorly and posteriorly, between these are several (about 6) crowded, slightly elevated lamellae, all lamellae faintly radially striated; lunule broad, cordate, impressed; a narrow smooth area present above and extending beyond the ligament on the left valve but not present on the right valve; right valve with 3 strong cardinal teeth, the middle one somewhat bifid, left valve with 3 cardinals and one short anterior lateral; pallial sinus short, pointed, extending toward the anterior adductor muscle impression a few millimeters beyond the anterior margin of the posterior impression; inner margin crenulated; colored exteriorly with brownish blotches arranged radially, interior white, pinkish or orange under the umbos. The largest specimen in the collection, from Costa Rica, measures approximately; length, 87 mm.; height, 81 mm.; convexity (one valve), 32 mm.; pallial sinus projects anteriorly about 30.5 mm. from the posterior margin.

The shell of this species is very similar to that of the Atlantic *Antigona rigida* Dillwyn and has at times been recorded from west American waters under that name. The posterior teeth of the west American shell are generally larger and longer and in the left valve the posterior tooth is separated from the ligament plate by a shallower groove than on the Atlantic shell. The hinge plate of *A. isocardia* is less flaring in front of the beak than that on the east coast species. *Antigona orientalis* Cox, described from the Pliocene of Mombasa, Africa, is said to be very similar to *A. rigida*.

Description: This interesting large bivalve was collected on beaches and was dredged at depths of 35-61 fathoms, in the southern end of the Gulf of California, off Clarion Island, off Costa Rica, and Gorgona Island, Colombia. It has been recorded as occurring in the Pleistocene of the Galápagos Islands.

***Antigona (Ventricola) isocardia magdalenae*
Dall.**

Cytherea (Ventricola) magdalenae Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, pp. 390, 403, pl. 15, fig. 6. Dredged "off Magdalena Bay on the west shore of Lower California, at station 2989, in 36 fathoms."

Type Locality: Off Magdalena Bay, Lower California, Mexico, in 36 fathoms.

Range: Magdalena Bay, Lower California, to Arena Bank, Gulf of California.

Collecting Station: Mexico: Arena Bank (136-D-2), 45 fathoms, mud, *Arca* conglomerate.

Description: Four single valves, about 35-40 mm. in length, in the collection dredged on Arena Bank in the Gulf of California, are

here referred to *Antigona isocardia magdalenae*. These shells agree well with Dall's description and illustration of that form. The specimens appear to differ from young shells of *A. isocardia* Verrill in possessing a more elongated form and finer and more closely spaced concentric sculpture. The similarity to *A. isocardia* is so great that we consider *magdalenae* to be a subspecies of Verrill's species. Dall stated that this form is similar to the east American *A. strigillina* Dall.

Distribution: The specimens here referred to *Antigona isocardia magdalenae* were dredged on Arena Bank in the Gulf of California in 45 fathoms. Previously it has been recorded only from the type locality, off Magdalena Bay, Lower California.

Genus *Cyclinella* Dall.

Key to the species of *Cyclinella*.

- A. Shell inflated, lunule broadly cordate; sinus sharply angular at end and projecting nearly to center of shell *singleyi*³⁵
- B. Shell less inflated, lunule lanceolate
 - a. Shell subquadrate and elongated ventrally; compressed and rather thin; sinus often pointed at end *subquadrate*
 - aa. Shell orbicular, dosinoid; moderately inflated and thick; sinus short, rounded at end and more anteriorly directed
 - b. Shell not exceeding 30 mm. in height *kröyeri*³⁵
 - bb. Shell exceeding 30 mm. in height *ulloana*

***Cyclinella kröyeri ulloana* Hertlein & Strong,
subsp. nov.**

Plate II, Figures 5, 6 and 7.

Shell orbicular, dosinoid, white, moderately inflated, moderately thick; sculptured by fine but well developed concentric lines of growth; pallial sinus fairly broad, short, rounded at the end, projecting about 33 mm. from posterior margin toward the anterior muscle impression; margin smooth. Dimensions: length, 75.5 mm.; height, 76.5 mm., convexity (one valve), 19 mm.

Holotype, left valve, from Station 143-D-4, Santa Inez Bay, Gulf of California, Lat. 26° 55' N., Long. 111° 54' W., dredged in 25 fathoms (46 meters), sand. Another large and two small valves were also found at this same locality. A few other valves, apparently referable to this subspecies, were taken at Station 136-D-2, Arena Bank, at the south end of the Gulf of California, in 45 fathoms, mud, *Arca* conglomerates.

Cyclinella kröyeri Philippi³⁶ was originally described from South America, and two localities, "Patria: Chile, Peru," were cited. The dimensions were given as "Long. 2"; alt. 11 $\frac{1}{3}$ "; crass. 6'". These measurements

³⁵ Not represented in the present collection.

³⁶ *Venus (Artemis) kröyeri* Philippi, Zeit. f. Malakozool., Jahrg. 4, June, 1847, p. 87. "Patria: Chile, Peru; legit cl. Kröyer."—Philippi, Abbid. u. Beschreib. Conchyl., Bd. 3, Heft 3, *Venus*, 1848, p. 78 (26), Taf. 7, fig. 9. Original locality cited.

in lines³⁷ would be equivalent, in the metric system, to length, 26.16 mm., height, 20.39 mm., convexity, 13.08 mm. The figures of the species given by Philippi in 1848 appear to represent nearly the natural size of the shell. Römer³⁸, 1862, stated regarding Philippi's species . . . "ist eine ächte *Cyclina*."

Dall³⁹, 1902, stated regarding this species: "It is smaller, more orbicular, and proportionately flatter than *C. subquadrata*." He also stated that *Artemis macilenta* Reeve⁴⁰ might be referable to Philippi's species. Reeve's illustration does not agree with the original illustration of *Cyclinella kröyeri* nor with our specimens but appears to resemble more nearly some forms of *C. subquadrata*. Sowerby⁴¹ suggested that it might be the young of *C. subquadrata*. In a later paper Dall⁴² gave the range of *C. kröyeri* as the Gulf of California to Valparaiso, Chile.

Specimens in the present collection vary in size from a small valve 23 mm. in length to a huge left valve 75.4 mm. in length. The huge size of these larger specimens, so far as we know, is much greater than that of any specimens which have been referred to *Cyclinella kröyeri*. The shells in the present collection were dredged only in the southern portion of the Gulf of California. We therefore have proposed the subspecific name *ulloana* for these large shells. This subspecies is named for Francisco de Ulloa, Spanish explorer, who in 1540 discovered that the Gulf of California was land-locked at the north end, thus revealing that Lower California was a peninsula, not an island as formerly believed.

The larger, more orbicular dosinoid form, more polished shell, broader, shorter, usually less pointed and more anteriorly directed pallial sinus, as well as the lack of elongation ventrally, are characters which serve to separate the present subspecies from *Cyclinella subquadrata* Hanley.

Cyclinella beteyensis Olsson⁴³, described from the Miocene of Costa Rica, was compared by its author to *C. kröyeri*.

***Cyclinella subquadrata* Hanley.**

Artemis subquadrata Hanley, *Proc. Zool. Soc. London*, April, 1845, p. 11. "Hab. St. Elena, West Columbia. Mus. Cuming, Hanley." Ref. to "Ind. Test., sup. t. 15, f. 39."—Hanley, *Cat. Rec. Bivalve Shells*, p. 357, 1856?, pl. 15, fig. 39, 1844. "W. Columbia."—Reeve, *Conch. Icon.*, Vol. 6, *Artemis*, Febru-

ary, 1850, species 15, pl. 3, fig. 15. "Hab. St. Elena, West Columbia (in sandy mud at low water), and Lobos Island, Peru (in sandy mud at a depth of from six to seventeen fathoms); Cuming."

Arthemis saccata Gould, *Proc. Boston Soc. Nat. Hist.*, Vol. 4, November, 1851, p. 91. "Inhabits Mazatlan?"—Gould, *Boston Jour. Nat. Hist.*, Vol. 6, October, 1853, p. 396, pl. 15, fig. 2. "Inhabits Mazatlan."

Type Locality: Santa Elena, Ecuador.

Range: Guaymas, Mexico, in the Gulf of California, to Paita, Peru, in 4 to 40 fathoms.

Collecting Stations: Mexico: Port Guatulco (195-D-19), 17 fathoms, gr. mud, crushed shell; Guatemala: 7 miles west of Champerico (197-D-2), 14 fathoms, mud; El Salvador: La Libertad (198-D-2), 14 fathoms, mud; Meanguera Island, Gulf of Fonseca (199-D-1), 16 fathoms, sand, mud, crushed shell; Costa Rica: Port Parker (203-D-1,2,3), 10-15 fathoms, sandy mud, crushed shell, shelly mud, algae; Port Culebra (206-D-1,2,3), 14 fathoms, mud; Cedro Island, Gulf of Nicoya (213-D-1-10), 4-10 fathoms, mud, sand, crushed shell; Gulf of Dulce; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud; Bahia Honda (222).

Description: Suborbicular-subquadrate, broader than long, compressed, a little pellucid, very inequilateral, whitish both within and without, concentrically substriated; ventral edge arcuated in front; convex and rising behind; dorsal edge straightish and decidedly sloping in front, convex and not sloping behind; anterior end very broad, posterior end narrow; lunule large, nearly obsolete (Hanley, *Cat. Rec. Biv. Shells*, p. 357). The measurement was given as 1 $\frac{3}{4}$ [inches]. The pallial sinus is rather narrow, pointed, and directed toward the umbos, margin smooth.

The compressed, suborbicular-subquadrate and somewhat ventrally attenuated form of this species are characters which separate it from other west American species of the genus. *Cyclinella singleyi* Dall, 1902, which ranges from Scammon Lagoon, Lower California, to the Gulf of California and south to Panama, possesses a more tumid shell. *Cyclinella galera* Pilsbry and Olsson, 1941, described from the Pliocene of Ecuador, is similar to *C. singleyi* but the pallial sinus is said to differ in shape and direction. *Cyclinella kröyeri* Philippi is more orbicular and dosinoid in outline. We have not observed any specimens which could be referred to the species described as *Cyclina producta*⁴⁴ by Carpenter, which species was referred to the genus *Cyclinella* by Dall.

A subspecies, *Cyclinella subquadrata quitana* Olsson⁴⁵, has been described from the Miocene of Costa Rica and Trechmann⁴⁶ has

³⁷ For the metric equivalents of European "lines" see H. A. Rehder, *Mollusca* (Tavares, Florida), Vol. 1, No. 6, August 10, 1945, p. 73.

³⁸ Römer, E., *Monogr. Molluskengattung Dosinia*, Scopoli, (Cassel), 1862, p. 84.

³⁹ Dall, W. H., *Proc. U. S. Nat. Mus.*, Vol. 26, 1902, p. 391.

⁴⁰ *Artemis macilenta* Reeve, *Conch. Icon.*, Vol. 6, *Artemis*, March, 1850, species 51, pl. 9, fig. 51. "Hab. Salango, West Columbia (in sandy mud at a depth of nine fathoms); Cuming."

⁴¹ Sowerby, G. B., *Thes. Conch.*, Vol. 2, 1846, p. 662.

⁴² Dall, W. H., *Proc. U. S. Nat. Mus.*, Vol. 37, 1909, p. 267.

⁴³ *Cyclinella beteyensis* Olsson, *Bull. Amer. Paleo.*, Vol. 9, No. 39, January 21, 1922, p. 414 (242), pl. 34 (31), fig. 2. "Gatun Stage: Rio Betey." Costa Rica, Miocene.

⁴⁴ *Cyclina producta* Carpenter, *Proc. Zool. Soc. London*, November 11, 1856, p. 161. "Hab. In Sinu Panamensi; legit T. Bridges."

⁴⁵ *Cyclinella subquadrata quitana* Olsson, *Bull. Amer. Paleo.*, Vol. 9, No. 39, June 21, 1922, p. 415 (243), pl. 34 (31), fig. 8. "Gatun Stage; Quitana Creek." Costa Rica.

⁴⁶ Trechmann, C. T., *Geol. Mag.*, Vol. 70 (No. 823), 1933, p. 36, pl. 4, fig. 4.

cited a species as "*Cyclinella* near *C. subquadrata* Hanley" which occurs as a fossil on Barbados Island.

Distribution: Specimens of *Cyclinella subquadrata* were taken by the expedition from Port Guatulco, Mexico, to Bahia Honda, Panama, in 4 to 40 fathoms. This species has also been reported as occurring in the Pliocene of Ecuador and in the Quaternary of Peru.

Genus *Chione* Megerle von Mühlfeld.

Key to the subgenera of *Chione*.

- A. Concentric sculpture predominant
 - a. Concentric lamellae of broad thickened rolls sometimes coalescent medially
Liriphora
 - aa. Concentric lamellae thin, sharp, serrated
 - b. Pallial sinus well developed; one or more cardinal teeth in each valve bifid or strongly grooved
Chionopsis
 - bb. Pallial sinus very small; one or more teeth in each valve faintly grooved or all smooth . . . *chione* s.s.
- B. Radial sculpture predominant (often coarse) anteriorly or over entire shell
 - a. Escutcheon present on left valve
 - b. Left anterior cardinal tooth elongated anteriorly and rather thin and high; radial ribs coarse anteriorly *Nioche*
 - bb. Left anterior cardinal tooth short and thick; radial ribs coarse, flattened, over entire shell
Notochione
 - aa. Escutcheon lacking *Timoclea*⁴⁷

Subgenus *Chione* s.s.

Key to the species of *Chione* s.s.

- A. Concentric lamellae few and widely spaced; pallial line distant from margin
compta
- B. Concentric lamellae numerous, closer, often recurved
 - a. Shell rostrate or subrostrate posteriorly
 - b. Concentric lamellae strongly expanded posteriorly; interior rose and white *guatulcoensis*
 - bb. Concentric lamellae very low over entire shell; a radial shallow depressed area usually present anterior to dorsal margin
*crenifera*⁴⁸
 - aa. Shell usually rounded or subtruncated posteriorly; larger
 - c. Concentric lamellae on lower half of shell flattened forming a smooth surface
californiensis
 - cc. Concentric lamellae not flattened on lower half of shell, and

finer and more closely spaced
undatella

***Chione (Chione) californiensis* Broderip.**

Venus succincta Valenciennes in Humboldt & Bonpland, Rec. d'Obser. sur Zool., 1827, p. 219, pl. 48, figs. 1a, 1b, 1c. "Habitat ad litus Oceani Pacifici, prope Acapulco Mexicanorum."

Not *Venus succincta* Linnaeus, Syst. Nat., ed. 12, Mantissa, 1771, p. 546. "Habitat . . ." *Venus californiensis* Broderip, Proc. Zool. Soc. London, June 1, 1835, p. 43. "Hab. in sinu Californiae. (Guaymas.)" "Found in sandy mud at low water."—Reeve, Conch. Icon., Vol. 14, *Venus*, 1863, species 35, pl. 11, fig. 35. Original locality cited.

Chione succincta Valenciennes, Weymouth, State of Calif. Fish and Game Comm., *Fish Bull.* 4, 1920, p. 37, pl. 9, figs. 3, 4. Anaheim Slough, California. Also San Pedro, California, to Mexico.

Type Locality: Guaymas, Mexico, in the Gulf of California, at low water, sandy mud.

Range: Point Mugu, California, to Panama.

Collecting Stations: Mexico: East of Cedros Island (126-D-2), 38 fathoms, mud; Cape San Lucas; Monument Station, Santa Inez Bay, east coast of Lower California.

Description: Shell subcordiform, thick; ornamented by rather widely spaced (3 to 5 mm.), nearly equidistant, slightly reflexed concentric lamellae which at about the middle of the valve, and increasingly so toward the base, become crowded, flattened, thickened and nearly cover the interspaces; rounded radial ribs are present and increase by intercalation; lunule ornamented by incremental laminae and radiating riblets; 3 cardinal teeth in each valve, the right anterior and left posterior ones weaker than the others; pallial sinus very short and angular; margin crenulated.

Large specimens from the Gulf of California attain a length of approximately 68 mm., height, 65 mm., convexity (both valves), 38 mm.

As pointed out by Dall, this species can be separated from *C. undatella* Sowerby by the coarser and more widely spaced concentric sculpture, and by the fact that in adult forms the concentric lamellae on the ventral half of the disk are generally flattened and thickened, showing a smooth polished surface which nearly covers the interspaces.

A specimen 48 mm. in height may possess from 18 to 23 concentric lamellae while a large specimen 60 mm. in height may possess 30 to 40 such lamellae.

This species has also been recorded in the earlier literature under the names of *Venus leucodon* Sowerby, *Venus californiana* Conrad, and *Venus crassa* Sloat MS. in Carpenter.

Chione cancellata christopheri Trechmann, described from the Pliocene of St. Kitts Island in the Caribbean, is said to be a similar form.

⁴⁷ Not represented in the present collection.

⁴⁸ Not represented in the present collection.

Distribution: Specimens of this species were taken by the expedition at a few localities along western Mexico. It is often taken with *Chione undatella* Sowerby in bays and inlets just under the surface in firm sand or sandy mud. It also occurs in the Pleistocene of southern California and in the Pliocene and Pleistocene of the Gulf of California region.

***Chione (Chione) compta* Broderip.**

Venus compta Broderip, *Proc. Zool. Soc. London*, June 1, 1835, p. 43. "Hab. ad Peruviam. (Bay of Sechura)." "It was dredged up in coarse sand and mud at a depth of seven fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 710, pl. 154, figs. 32, 33, 34. Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 48, pl. 13, fig. 48. Original locality cited.

Chione meridionalis I. S. Oldroyd, *Nautilus*, Vol. 34, No. 3, January, 1921, p. 93, pl. 4, figs. 3 and 4. "Type locality, Peru."

Not *Venus meridionalis* Sowerby, 1846. [Referred to the genus *Chione* by von Ihering, 1907].

Type Locality: Bay of Sechura, Peru, in 7 fathoms, sand and mud.

Range: Gulf of California to Bayovar, Peru.

Collecting Station: Costa Rica: Port Parker (203-D-1,2,3), 12-15 fathoms, sandy mud, crushed shell, shelly mud.

Description: Shell triangularly rounded, compressed, ornamented by widely spaced concentric ribs which posteriorly develop into broad, raised, gently reflexed lamellae; radial sculpture consists of well developed ribs and, in each interspace, a tiny riblet, anteriorly and posteriorly the ribs become fine and divaricate; pallial line unusually distant from the ventral margin; pallial sinus only slightly indented; margin crenulated.

The specimens of this species in the present collection are all small; the largest, a right valve, measures approximately: length, 33 mm.; height, 31 mm.; convexity (one valve), 10 mm.

The illustrations of *Chione compta* given by Sowerby do not reveal the most characteristic features shown on our specimens. However, the descriptions given by Broderip, Sowerby, and Dall, all exactly apply to our specimens. The species described by I. S. Oldroyd as *Chione meridionalis* appears to be identical with *C. compta*. Both were described from Peru and the characters described for the two are the same. The few, flattened and slightly up-turned concentric lamellae, flattened shell, fine divaricating ribs anteriorly and posteriorly, and pallial line distant from the margin, are all characteristic features of this species.

Distribution: Specimens of this species were dredged at Port Parker, Costa Rica, in 12-15 fathoms. It ranges south to Peru where it has also been recorded as occurring in the Pleistocene. It ranges north to the Gulf of California.

***Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov.**

Plate I, Figures 2, 4, 6 and 10;

Plate II, Figures 1, 8, 12 and 13.

Shell small, subrostrate, only moderately inflated; with low distant concentric lamellae which become expanded posteriorly; radial sculpture of low rather flattened ribs which are separated by subequal, smooth, narrower, interspaces, in the anterior medial area the ribs become obsolete toward the base especially on large specimens and anterior to this the ribs become faintly divaricate toward the base and a few interstitial threads appear; lunule elongated, ornamented by concentric and radial striations; escutcheon well developed, forming nearly a right angle with the dorsal margin, ornamented by fine concentric imbricating lamellae, the right valve slightly overlapping the left posteriorly; exterior white with brown or rose colored radial bands, or brown blotches and fine V-shaped brown lines and dots; interior white and rose, the latter predominant on large specimens; the right posterior and sometimes the left middle cardinal slightly grooved; pallial sinus shallow, broad, rather blunt, nearly vertical; inner margins crenulated except posteriorly. Dimensions (type): length, 11.2 mm.; height, 9.4 mm.; convexity (both valves together), 6 mm. The largest specimen, a paratype, measures 14 mm. in length.

Holotype and paratypes (Calif. Acad. Sci. Paleo. Type Coll.), dredged at Station 195-D-9, in Latitude 15° 44' 28" N., Longitude 96° 07' 51" W., off Port Guatulco, Mexico, in 7 fathoms (12.6 meters), in gr. sand and crushed shell.

This species is similar to *Chione mazyckii* Dall⁴⁹ described from North Carolina. It differs from the east American species in the narrower interspaces, the obsolete radial sculpture in the medial anterior ventral area and anterior to this the presence of only a few faintly divaricate ribs and interstitial threads. In *C. mazyckii* the anterior half of the ribs appear to divaricate and many interstitial threads make their appearance.

Chione crenifera Sowerby⁵⁰, described from Ecuador and Peru, has very low concentric lamellae over the entire shell and a radial, shallow, depressed area is present just anterior to the posterior dorsal margin.

***Chione (Chione) undatella* Sowerby.**

Venus undatella Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 22. "Hab. in Sinu Californiensi (Island of Tres Marias)."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 711, pl. 153, fig. 22. Original locality cited.

Venus neglecta Sowerby, *Zool. Beechey's*

⁴⁹ *Chione mazyckii* Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, pp. 373, 382, pl. 13, fig. 2. Dredged "off Cape Fear, North Carolina, in 17 fathoms, sand."

⁵⁰ *Venus crenifera* Sowerby, *Proc. Zool. Soc. London*, June 1, 1835, p. 43. "Hab. ad Sanctam Elenam." Variety, "Hab. ad Paytam, Peruviae." "Found in the sand at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 715, pl. 156, figs. 73, 74. "... found in sand at low water at Payti, Peru."

Voy., 1839, p. 151, pl. 41, fig. 8. "Inhabits sandy mud on the coast of Central America."

Venus simillima Sowerby, Thes. Conch., Vol. 2, 1853, p. 708, pl. 153, figs. 17, 18. "California."—Reeve, Conch. Icon., Vol. 14, *Venus*, 1863, species 44, pl. 13, fig. 44. "Hab. San Diego, California."

Chione undatella Sowerby, Weymouth, State of Calif. Fish and Game Comm., *Fish Bull.* No. 4, 1920, p. 37, pl. 9, fig. 2. Anaheim Slough, California. Also San Pedro, California, to Mexico.

Type Locality: Tres Marias Islands, Mexico.

Range: Mugu Point, California, to Paita, Peru.

Collecting Stations: Mexico: Arena Bank (136-D-27), 50 fathoms, sand, calcareous algae, rock; Port Angeles, beach; Port Guatulco (195-D-1,2,5,10), 2-4 fathoms, sand, algae, crushed shell, also on beach; Tangola-Tangola Bay.

Description: Shell similar to that of *Chione californiensis* Broderip but slightly more inflated and ornamented with more numerous and more closely spaced thinner and sharper concentric lamellae. Often, but not always, the anterior cardinal tooth is more nearly parallel to the margin than that of *C. californiensis*. A specimen about 46 mm. in altitude may possess from 33 to 40 concentric lamellae.

This species has received many names in the literature, including *Venus bilineata* Reeve, *V. excavata* Carpenter, *V. entobapta* Jonas, *V. neglecta* Sowerby, *V. nuttalli* Conrad, *V. perdis* Valenciennes, *V. simillima* Sowerby and *V. sugillata* Reeve. Coarsely lamellose shells marked with brown and white are referable to the form named *Venus neglecta* Sowerby but there is so much variation in a series of specimens that we have followed Dall in referring them all to *C. undatella*.

Distribution: This species occurs commonly from southern California to Peru. It was taken by the expedition at a few localities off west Mexico. It also is known to occur in the Pleistocene of southern California, Lower California and the Galápagos Islands and in the Pliocene of the Gulf of California region.

Subgenus *Chionopsis* Olsson.

Chionopsis Olsson, *Bull. Amer. Paleol.*, Vol. 19, No. 68, June 30, 1932, p. 111. "Type.—*Chione amathusia* Philippi."

Type (by original designation): *Chione amathusia* Philippi.

Shell of moderate size to large; right posterior and middle left cardinal teeth bifid or grooved, sometimes the others; resiliium very narrow with the ligament not deeply inserted and separated by a narrow, linear nymph; shell usually thinner than amongst the true *Chiones*; pallial sinus well developed; lunule equal or discrepant in size, its margin strongly crenate (Olsson).

Key to the species of *Chionopsis*.

- A. Coarsely serrated concentric lamellae
 - a. Concentric lamellae high; lunule elongately cordate. *gnidia*
 - aa. Concentric lamellae lower; lunule broadly cordate; finer radial ribbing; adductor impressions larger *amathusia*
- B. Concentric lamellae thin and very finely serrated
 - a. Posterior end obliquely truncated or rounded *purpurissata*
 - aa. Posterior end forming nearly a right angle or substrate *pulicaria*

Chione (Chionopsis) amathusia Philippi.

Venus amathusia Philippi, Abbild. u. Beschreib. Conchyl., Bd. 1, Heft 5, *Venus*, April, 1844, p. 129 (7), pl. 2, fig. 4. "Patria? . . ."

Type Locality: Panama Bay (here designated as type locality). No locality cited originally.

Range: Gulf of California to Mancora, Peru.

Collecting Stations: Mexico: 17 mi. SE. × E. of Acapulco (189-D-1,2,3), 13-20 fathoms, sandy mud, mud, algae; Guatemala: 7 miles west of Champerico (197-D-1,2), 14 fathoms, mud; El Salvador: La Libertad (198-D-1,2), 13-14 fathoms, mud; Costa Rica: 14 miles S. × E. of Judas Point (214-D-1-4), 42-61 fathoms, mud, shell, rocks; Gulf of Dulce; Goitino, Gulf of Dulce; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shell triangularly ovate, rather inflated, posteriorly somewhat attenuated; ornamented by pairs of fine, radial ribs between which there is an interrib, and by concentric lamellae which are crenulated and give rise to prickly scales, the lamellae are radially marked on the ventral side; hinge with three cardinal teeth in each valve, the right posterior tooth and the left middle one cleft; pallial sinus well developed, short, rounded; margin crenulated.

The shell of this species is smaller than that of *Chione gnidia* Broderip & Sowerby. It often attains a length of about 40 mm. although it may reach a greater length. Compared to *Chione gnidia* the umbos of the present species are more highly rounded, giving a more cordate cross-section and more rounded lunule, the form is less elongate, the radial sculpture is finer and the concentric lamellae are lower. The adductor impressions of *C. amathusia* are a little larger than those on shells of *C. gnidia* of the same size.

Chione rowleei Olsson, described from the Miocene of Costa Rica, is a similar species. Sowerby's figures of *Venus amathusia* (1853, pl. 154, figs. 26, 27) were referred by Römer to *Venus darwinii* Dunker⁵¹. Lamy⁵²

⁵¹ *Venus darwinii* Dunker in Römer, Krit. Untersuch. Moll. Venus (Cassel), 1857, p. 25 [No locality cited].—Pömer, Malakozool. Blätter, Bd. 14, February, 1867, p. 51 (as *Chione darwinii*). "Panama, Mazatlan."—Pfeiffer, Conchyl.-Cab. von Martini-Chemnitz, Bd. 11, Abt. 1, Veneracea, 1869, p. 204, Taf. 33, figs. 3 and 4.

⁵² Lamy, E., *Journ. de Conchyl.*, Vol. 57, No. 3, 1909, pp. 243-244.

likewise referred Sowerby's figures as well as those of Reeve (1863, pl. XI, figs. 36a, 36b) to Dunker's species. Deshayes, 1853, considered Dunker's species to be a variety of *Chione amathusia* but Carpenter, 1857, regarded it as a variety of *C. gnidia*. Dall, 1902, regarded it "as a doubtfully distinct form and perhaps a variety of *C. subrostrata*." We have not seen specimens which we could refer with certainty to *Chione darwini*.

Distribution: Specimens of this species were collected by the expedition from west Mexico to Costa Rica but nowhere abundantly. The largest number from any one locality was dredged in 14 fathoms west of Champerico, Guatemala. This species has been cited as occurring in the Quaternary of Manta, Ecuador, the Pliocene of Panama, and a similar or identical form in the Pliocene of Costa Rica.

***Chione (Chionopsis) gnidia* Broderip & Sowerby.**

Venus gnidia Broderip & Sowerby, *Zool. Jour.*, Vol. 4, No. 15, January, 1829, p. 364. "Hab. ad littora Oceani Pacifici." Dredged "near St. Blas."—Sowerby *Genera Rec. and Foss. Shells*, No. 41, 1834, pl. 251, fig. 7. [No locality cited].—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 709, pl. 154, fig. 25. Pacific Ocean.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 37, plate 11, fig. 37. San Blas, Mexico.

Venus (Chione) gnidia Sowerby, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 318, pl. 16, figs. 5a, 5b. Earlier records cited. Pleistocene and Recent.

Type Locality: San Blas, Mexico, dredged. *Range*: Cedros Island, Lower California, to Paita, Peru.

Collecting Station: Mexico: Santa Inez Bay, east coast of Lower California.

Description: Shell roundly trigonal, convex, ornamented by prominent concentric lamellae which are rather coarsely scalloped and develop erect prickly scales, the under surface of the lamellae are radially sculptured; interspaces ornamented by well developed, nearly evenly spaced, obscurely paired ribs which are separated from the next pair by a smaller rib; hinge normal for the subgenus; pallial sinus well developed, short, the end rather rounded; exterior colored light drab brown or white, interior white; margin crenulated.

The shell of this species attains a large size. A large specimen collected at San Ignacio Lagoon, Lower California, by Henry Hemphill measures approximately: length, 101 mm.; height, 94.5 mm.; convexity (both valves), 68 mm.

This species attains a larger size, possesses a more elongated form, more prominent lamellation, more elongated lunule and coarser ribs than *C. amathusia*.

Venus ornatissima Broderip, 1835, is now considered referable to *C. gnidia*. *Chione jamaniana*, *C. manabia* and *C. traftoni*, described by Pilsbry & Olsson, 1941, from the Pliocene of Ecuador, are all quite similar to

C. gnidia. *Chione temblorensis* Anderson & Martin from the Miocene of California and *C. richthofeni* Hertlein & Jordan from the Miocene of Lower California are other species belonging to the *Chione gnidia* group.

Distribution: A couple of specimens of this species were collected by the expedition in Santa Inez Bay in the Gulf of California. It often occurs in the quiet waters of bays along the tropical west American coast. It also is known to occur in the Pleistocene of southern California, in the Gulf of California region, and has been cited as occurring in the Quaternary of Ecuador.

***Chione (Chionopsis) pulicaria* Broderip.**

Venus pulicaria Broderip, *Proc. Zool. Soc. London*, June 1, 1835, p. 44. "Hab. ad Columbian Occidentalem. (Chiriqui and Tumaco)." "Dredged up from sandy mud at a depth of three fathoms."

Venus cingulata Lamarck, Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 729, pl. 161, fig. 191. "West Columbia. Cuming."

Not *Venus cingulata* Lamarck, 1818.

Chione montezuma Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 101, pl. 15, figs. 12, 13, 14. "Costa Rica: Puntarenas."

Chione pulicaria Broderip, E. K. Jordan, *Contrib. Dept. Geol. Stanford Univ.*, Vol. 1, No. 4, 1936, p. 139. Magdalena Bay, Lower California, Pleistocene. Gulf of California to Colombia, Recent.

Type Locality: Chiriqui, Panama, in 3 fathoms, sandy mud (here designated as type locality). Tumaco, Colombia, also cited originally.

Range: Gulf of California, to Tumaco, Colombia.

Collecting Station: Nicaragua: Corinto (200-D-11-13,17,19), 3-10 fathoms, sand, mangrove leaves.

Description: Shell roundly triangular, in the adult somewhat acuminate at anterior and posterior ends, moderately convex, a broad shallow radial depression occurs parallel and anterior to the posterior dorsal margin; lunule cordate, brown, sculptured only by incremental lines of growth; escutcheon fairly large and elongate; concentric sculpture of numerous, rather fine, generally equally spaced, low, concentric lamellae, stronger and closer anteriorly and posteriorly and finely serrated by the radial sculpture which occurs on the ventral sides and in the interspaces; on large specimens the concentric sculpture is coalescent and subobsolete medially toward the ventral margin; colored exteriorly by white or cream ground mass with brown dots often arranged in a ^-shaped pattern; middle left and right posterior teeth bifid; pallial sinus well developed, ascending, rounded at end, directed toward the anterior adductor impression and attaining a height of about one half the height of the posterior adductor impression; color of interior white or cream and with purple often just below but sometimes also above the pallial line; margin crenulated.

Specimens of this species in the present collection are small, not over 22 mm. in length, but a large specimen from Kino Bay, Sonora, Mexico, collected by H. N. Lowe, measures: length, 47.3 mm.; height, 39 mm.; convexity (both valves), 30.5 mm.

Specimens of this species from various localities agree exactly with the description of the species given by Broderip, Sowerby, and Hanley, and with the illustration given by Sowerby. The illustration given by Reeve (*Venus*, pl. 8, fig. 26) does not show the acuminate form which develops with large shells, especially posteriorly.

We have been unable to detect any constant difference between this species and the shell described as *Chione montezuma* by Pilsbry & Lowe. There is variation in the amount of rostration and in the development of stronger and more obtuse lamellae posteriorly. After a consideration of these facts we have concluded that the species described by Pilsbry & Lowe belongs in the synonymy of *C. pulicaria*.

The ornamentation of *Chione oulotricha* Gardner, 1936, described from the Alum Bluff Miocene of Florida, appears to be similar to that of *C. pulicaria* but the posterior end of the Floridan fossil is obliquely truncated similar to that of *C. purpurissata*.

Distribution: Specimens of this species were taken only at Corinto, Nicaragua, in 3 to 10 fathoms. It occurs as far south as Colombia and is also known to occur in the Pleistocene of Magdalena Bay, Lower California.

Chione (Chionopsis) purpurissata Dall.

Venus crenulata var., Reeve, *Conch. Icon.*, Vol. 14, *Venus*, June, 1863, species 46, pl. 13, fig. 46. "From the Gulf of California."

[*Venus crenulata*] "?var. *lilacina*" Carpenter, *Rept. Brit. Assoc. Adv. Sci.* for 1863 (issued August, 1864), p. 570. Ref. to fig. 46 of Reeve. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 56. "Cape St. Lucas, Xantus."

Not *Chione lilacina* Gray, 1838.

Chione (Chione) purpurissata Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, p. 393. "Cape St. Lucas and the Gulf of California."

Type Locality: Cape San Lucas, Lower California, Mexico.

Range: Gulf of California to Guatemala.

Collecting Stations: Mexico: Santa Inez Point, east coast of Lower California; Chamela Bay (183-D-4), 16 fathoms, sand, algae, crushed shell.

Description: Shell roundly trigonal, rather tumid, posterior end rounded; ornamented by rather fine radial and concentric sculpture; lunule large, ornamented only by lines of growth; a shallow and rather narrow radial depression occurs posteriorly just above the escutcheon which is large and smooth; a strong raised ridge just above the ligament occurs on the left valve; mottled with brown externally, lunule brown; hinge normal for

the subgenus; pallial sinus ascending and projecting to a point about level with the middle of the posterior adductor impression; margin crenulated except posteriorly; interior colored rose purple.

A large specimen in the collection of the California Academy of Sciences, collected by Fred Baker at Carmen Island in the Gulf of California, measures approximately: length, 64.5 mm.; 57 mm.; convexity (both valves), 42.6 mm.

This shell is much like *Chione pubera* Valenciennes, an east American species, but is rounder in outline and it has less prominent lamellation.

Distribution: Only a couple of specimens of this species were collected by the expedition, one in the Gulf of California and one in Chamela Bay, Mexico. De Long⁵³ has cited this species as occurring in the Palos Verdes Sands, Pleistocene of Signal Hill, Long Beach, California, but we have not seen fossil specimens.

Subgenus *Lirophora* Conrad.

Key to the species of *Lirophora*.

- A. Concentric ribs of uniform strength across entire shell *mariae*
- B. Concentric ribs flattened and nearly coalescent medially
 - a. Ribs bifid on posterior dorsal slope; posterior end rather rostrate and pointed *obliterata*⁵⁴
 - aa. Ribs not bifid on posterior dorsal slope; ribs develop prominent lamellae along anterior and posterior ends; posterior end more broadly rounded *kellettii*

Chione (Lirophora) kellettii Hinds.

Venus kellettii Hinds, *Zool. Voy. Sulphur*, Vol. 2, *Moll.*, Pt. 3, 1844 [January, 1845, on cover of Pt. 3], p. 65, pl. 19, fig. 5. "Inhab. Island of Quibo, West coast of Veragua. In adhesive mud of a low temperature, in between thirty and thirty-four fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 721, pl. 155, fig. 64. Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 82, pl. 18, fig. 82. "West coast of Veragua, Central America."

Chione (Lirophora) kelletti Hinds, Pilsbry & Olsson, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 93, 1941, p. 64, pl. 16, fig. 2. Canoa formation, Punta Blanca, Ecuador, Pliocene.

Type Locality: Island of Quibo [= Coiba], west coast of Veragua, Panama, in 30-34 fathoms, mud.

Range: Gulf of California to the Bay of Panama.

Collecting Stations: Mexico: Santa Inez Bay, east coast of Lower California (143-D-2,3,4), 25-30 fathoms, mud, crushed shell, sand; Tangola-Tangola Bay (196-D-19), 30 fathoms, mud; Costa Rica: 14 miles S. × E. of Judas Point (214-D-1-4), 42-61 fathoms,

⁵³ De Long, Jr., J. H., *Trans. San Diego Soc. Nat. Hist.*, Vol. 9, No. 25, April 30, 1941, p. 243, and table opp. p. 244.

⁵⁴ Not represented in the present collection.

mud, rocks; Panama: Gulf of Chiriqui (221-D-1-5), 35-40 fathoms, sandy mud.

Description: Shell elongately oval, slightly produced at the ends; ornamented by yellowish-brown concentric ribs which are smooth and coalescent over most of the shell but develop into prominent white lamellae along the anterior and posterior ends; radially striated strongest on the upper portions of the umbos; pallial line very short, angular; margin finely crenulated.

A valve from Santa Inez Bay measures approximately: length, 65 mm.; height, 52.5 mm.; convexity (one valve), 18 mm.

Occasionally, small, thick shells of this species bear a slight resemblance to *Chione* (*Lirophora*) *obliterata* Dall⁵⁵ which was described from the Gulf of Panama. Dall's species, however, is narrower, more rostrate and more acutely pointed posteriorly, the lunule is shorter and the exterior of the shell is said to be "sculptured with heavy, tumid, concentric waves which in the adult become somewhat irregular and sometimes coalescent on the disk, more or less angular and bifid on the posterior dorsal slope." It is similar to *C. latilirata* Conrad which occurs in the Caribbean region.

Chione (*Lirophora*) *trimeris* Gardner, from the Miocene of Florida, is somewhat similar to *C. kellestii*.

Distribution: Specimens of this species were taken from Santa Inez Bay in the Gulf of California to the Gulf of Chiriqui, Panama, at depths of 25-61 fathoms. It has been cited as occurring in the Pliocene and Pleistocene of Costa Rica and in the Pliocene of Panama.

E. K. Jordan⁵⁶ has cited *Chione kellestii* as occurring north to Todos Santos Bay, Lower California, but we have not seen specimens from the west side of the Peninsula.

Chione (*Lirophora*) *mariae* d'Orbigny.

Venus cypria Sowerby, *Proc. Zool. Soc. London*, June 1, 1835, p. 43. "Hab. ad Insulam Platae, Columbiae Occidentalis." "Found among coral sand in seventeen fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 722, pl. 157, fig. 113. Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 116, pl. 23, figs. 116a, 116b. Original locality cited.

Not *Venus cypria* Brocchi, 1814; not *Venus cypria* Risso, 1826.

Venus mariae d'Orbigny, *Voy. Amér. Mérid.*, Vol. 5, 1846, p. 563. "M. Cuming l'a pêchée à l'île de la Plata, sur les côtes de la république de l'Equateur." New name for *Venus cypria* Sowerby, not *V. cypria* Brocchi, 1814, not *V. cypria* Risso, 1826.

Type Locality: Island of Plata, Ecuador, in 17 fathoms, coral sand.

Range: Cedros Island, Lower California,

to the Gulf of California and south to Guayaquil, Ecuador.

Collecting Stations: Mexico: East of Cedros Island (126-D-12), 45 fathoms, crushed shell, mud; Arena Bank (136-D-13, 14, 15, 18), 40-45 fathoms, mud, *Arca* conglomerates, crushed shell; Santa Inez Bay (142-D-3, 4; 143-D-3; 145-D-1, 3; 146-D-1; 147-D-2), 4-60 fathoms, sand, weed, mud, crushed shell; Costa Rica: Port Parker (203-D-1, 3), 12-15 fathoms, sandy mud, crushed shell, shelly mud.

Description: Shell roundly triangular, somewhat attenuated posteriorly, dorsal margins nearly straight, only slightly arched posteriorly, slightly concave anteriorly; lunule rather narrow; escutcheon narrow, long, flat, at right angles to the posterior umbonal area and ornamented by concentric lines of growth; sculptured with strong, high, recurved, concentric ribs which cross the shell and are radially striated on the ventral side and slightly flattened posteriorly, interspaces ornamented only with lines of growth; exteriorly light brownish or yellow with a few broad and many fine radial chestnut brown stripes; pallial sinus very short, narrow, subangulate; lunular and ventral margins finely crenulated.

A large valve collected in Santa Inez Bay, in the Gulf of California, measures approximately: length, 34 mm.; height, 26.3 mm.; convexity (one valve), 9 mm.

The shell of this species may be easily separated from that of *Chione kellestii* in that strong raised concentric lamellae cross the shell without any trace of coalescence or obsolescence medially.

Chione (*Lirophora*) *gorgona* Pilsbry & Olsson,⁵⁷ described from the Pliocene of Ecuador, is very similar to large specimens of *C. mariae* and there are related forms in the Caribbean region.

Distribution: Specimens of *Chione mariae* were collected from the Gulf of California to Costa Rica. A few small specimens dredged off Cedros Island furnish an extension north of the known range of the species. It also is known to occur in the Pleistocene of the Gulf of California region and Panama, and in the Pliocene of Costa Rica and Ecuador.

Subgenus *Nioche* Hertlein & Strong, subgen. nov.

Type: *Venus asperrima* Sowerby. Illustrated by Sowerby in *Thes. Conch.*, Vol. 2, 1853, p. 714, pl. 155, figs. 57, 58.

Description: Shell with well developed radial ribs but with reduced concentric sculpture, possessing a radially sculptured lunule which is delimited by an incised line and with a beveled escutcheon on the left valve; hinge similar to that of *Chione* s.s. but with the left anterior cardinal somewhat elongated, approaching parallelism with the dorsal margin and, in the type species, thin and very high, the right posterior and left central (and

⁵⁵ *Chione* (*Lirophora*) *obliterata* Dall, *Proc. U. S. Nat. Mus.*, Vol. 26, No. 1312, December, 1902, pp. 394, 405, pl. 16, fig. 2. "Humboldt Bay, Gulf of Panama."

⁵⁶ Jordan, E. K., *Bull. South. Calif. Acad. Sci.*, Vol. 23, Pt. 5, September-October (issued October 25), 1924, p. 153.

⁵⁷ *Chione* (*Lirophora*) *gorgona* Pilsbry & Olsson, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 93, September 9, 1941, p. 65, pl. 19, fig. 2. "Jama formation, Puerto Jama." Ecuador, Pliocene.

sometimes right central) cardinals bifid; inner margin crenulated; pallial sinus well developed.

This subgenus possesses characters apparently intermediate between *Chione* and *Protothaca*. It differs from the subgenus *Tinoclea* in possessing an escutcheon on the left valve and in that the left anterior cardinal is elongated and high. The well developed escutcheon on the left valve, finer radial sculpture, broader hinge plate and the position of the elongate thin high left anterior cardinal which is more nearly parallel to the dorsal margin are features which serve to separate *Nioche*⁵⁸ from *Protothaca*.

Key to the species of *Nioche*.

- A. Shell exceeding 10 mm. in length
 a. Radial sculpture predominant (and rasp-like) over entire shell; rather compressed *asperima*
 aa. Radial sculpture predominant anteriorly and posteriorly; rather inflated *metodon*
 B. Shell not exceeding 10 mm. in length; ovately oblong *picta*

Chione (Nioche) asperima Sowerby.

Venus asperima Sowerby, *Proc. Zool. Soc. London*, June 1, 1835, p. 42. "Hab. ad Insulam Lobos dictam." "Found in fine sand at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 714, pl. 155, figs. 57, 58. Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 19, pl. 6, figs. 19a, 19b. "Hab. Guacamayo, Central America (in sandy mud, at a depth of thirteen fathoms); Cuming."

Type Locality: Island of Lobos, Peru, at low water, in fine sand.

Range: Magdalena Bay, Lower California, to the Gulf of California and south to Paita, Peru.

Collecting Station: Costa Rica: Port Parker.

Description: Shell ovately oblong, rather compressed, sculptured with alternating large and small radial ribs which are crossed by fine close-set imbricating lamellae which give a rasp-like surface to the ribs; escutcheon on left valve smooth, beveled; the ribbing continues over the lunule which is elongated and delimited only by an incised line; exteriorly sometimes colored by radial violet-brown blotches; right middle and posterior teeth and left middle tooth often grooved, left anterior cardinal high; pallial sinus projecting toward middle of anterior adductor impression and reaching a point nearly midway between the two impressions, the end pointed; margin except posteriorly, crenulated.

A large valve collected at Port Parker, Costa Rica, measures approximately: length, 48.3 mm.; height, 39.8 mm.; convexity (one valve), 12.5 mm.

The rasp-like ornamentation of the ribs, larger lunule, well beveled escutcheon, broader hinge plate and high anterior cardinal on

the left valve are features which serve to separate shells of this species from those of *Protothaca grata* Say.

The species described as *Venus pectorina* by Lamarck, 1818, which occurs in the Caribbean region, is similar to *C. asperima*.

Distribution: Three valves of this species, somewhat worn, were collected by the expedition on the beach at Port Parker, Costa Rica.

Chione (Nioche) metodon Pilsbry & Lowe.

Chione metodon Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 100, pl. 15, figs. 7, 8, 9, 10, 11. "Montijo Bay, Rep. Panama (Lowe)."

Type Locality: Montijo Bay, Panama.

Range: Banderas Bay, Mexico, to Montijo Bay, Panama.

Collecting Station: Mexico: Banderas Bay.

Description: Shell rotundly triangular, inflated, rather thin, colored buff with radially arranged violet-brown markings; lunule delimited by an incised line; sculpture of many low, rather evenly spaced concentric threads which are stronger and slightly lamellose anteriorly and posteriorly; radial sculpture of many fine, low riblets which also occur on the lunule but not on the escutcheon and several coarser radial ribs occur anteriorly; the left anterior cardinal tooth is thin and high; pallial sinus short, but well developed, rounded or subangulate; interior margin finely crenulated; interior white with purple posteriorly.

The largest specimen collected, a right valve, measures approximately: length, 34 mm.; height, 31 mm.; convexity (one valve), 11 mm.; pallial sinus extends forward 14 mm. from the posterior margin.

This species bears some resemblance to specimens of *Chione purpurissata* Dall but is easily separated by the presence of 6 to 8 coarse grooves anteriorly, the radially sculptured lunule and the high left anterior cardinal.

Distribution: A few specimens of this species were collected by the expedition in Banderas Bay, Mexico. The record of the occurrence at this locality is an extension northward of the known range of the species.

Chione (Nioche) picta Dall in Willett.

Chione picta Dall in Willett, *Bull. South. Calif. Acad. Sci.*, Vol. 43, Pt. 1, January-April (issued May 31), 1944, p. 21, pl. 8, figs. A, B. Type "collected by C. R. Orcutt in Magdalena Bay, Lower California, Mexico." Also cited from various localities in the Gulf of California region and in the Pleistocene in Los Angeles County, California.—Woodring, *U. S. Geol. Surv., Prof. Paper* 207, 1946, pp. 84, 88, pl. 37, figs. 3 and 4. San Pedro region, southern California, Pleistocene, Magdalena Bay, Lower California, to Panama, Recent.

Type Locality: Magdalena Bay, Lower California.

Range: Magdalena Bay, Lower California, to the head of the Gulf of California and south to Panama.

⁵⁸ *Nioche*, an anagram of *Chione*.

Collecting Stations: Mexico: Port Guatulco (195-D-8, 9), 6-7 fathoms, sand, gr. sand, algae, crushed shell.

Description: Shell small (not exceeding 10 mm. in length), ovately oblong, posterior dorsal margin long and nearly straight, an escutcheon present on left valve, the right valve overlaps the left along the posterior dorsal margin; sculptured with flattish radial ribs and concentric lamellae which become stronger and laminate on the posterior area; hinge with 3 teeth in each valve, the anterior cardinals slanting strongly forward, the right posterior and left middle cardinals grooved; pallial sinus short but well developed, blunt; inner margin of shell crenulated; exterior white with purple spots, occasionally purple spots over entire shell, interior white with purple beneath hinge and the posterior area.

A valve from Port Guatulco, Mexico, measures: length, 7.2 mm.; height, 5 mm.; convexity (one valve), 2 mm. The largest specimen in the collection measures 8.5 mm. in length.

Chione springvalensis Vokes⁵⁹ described from the upper Miocene of Trinidad, appears to be quite similar to *C. picta*.

Distribution: About 75 specimens of this species were dredged at Port Guatulco, Mexico, in 6-7 fathoms. It has been recorded as occurring north to the head of the Gulf of California and to Magdalena Bay on the west coast of Lower California. It has also been recorded as occurring in the Pleistocene of Los Angeles County, California, and it is known to occur in the Pleistocene at Magdalena Bay, Lower California.

***Notochione* Hertlein & Strong, subgen. nov.**

Type: *Venus columbiensis* Sowerby. Illustrated by Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 61, pl. 15, figs. 61a, 61b.

Shell ovately oblong, thick, moderately inflated, ornamented by fairly broad, heavy, flat-topped ribs which are separated by narrower grooves and crossed by rather fine closely spaced concentric lamellae, subobsolete on medial portions of valves; lunule cordate, delimited by an incised line and ornamented by concentric lines of growth and weak radial riblets; escutcheon beveled, smooth, and well developed on left valve, on the right valve the corresponding area is rounded; three cardinal teeth in each valve, the posterior teeth and the left middle (and sometimes the right middle) tooth grooved; adductor impressions large; pallial sinus well developed, narrow, slightly ascending; ventral margin crenulated, lunular margin only faintly so, posterior margin smooth.

Venus columbiensis Sowerby possesses characters some of which seem referable to *Chione* and others to *Protothaca*. The well developed, beveled escutcheon on the left valve is similar to *Chione* s.s. and the well developed pallial sinus is similar to that of

Chionopsis. The moderate inflation, ovate, elongate shape and strong predominant radial ribbing is suggestive of *Protothaca*. It hardly seems referable to any supraspecific group with which we are familiar and we therefore propose a new subgenus *Notochione* with *Venus columbiensis* Sowerby as type.

***Chione (Notochione) columbiensis* Sowerby.**

Venus columbiensis Sowerby, *Proc. Zool. Soc. London*, April 16, 1835, p. 21. "Hab. ad Sanctam Elenam Columbiae Occidentalis." "Found in coarse sand at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 713, pl. 155, figs. 53, 54. Original locality cited.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 61, pl. 15, figs. 61a, 61b. Original locality cited.

Type Locality: Santa Elena, Ecuador, at low water, in coarse sand.

Range: Mazatlan, Mexico, to Pacasmayo, Peru.

Collecting Stations: Mexico: Banderas Bay; Nicaragua: Potosi and Monypenny Point, Gulf of Fonseca; Fumarole, Gulf of Fonseca.

Description: Shell ovately oblong, thick; sculptured with rather broad, heavy, flat-topped radial ribs which are separated by narrower interspaces; ribs and interspaces crossed by fine, rather closely spaced concentric lamellae which are almost or wholly obsolete on the medial portions of the valves but are crowded anteriorly, giving a nodose appearance to the ribs; lunule cordate, rather small for the size of the shell, ornamented by concentric lines of growth and weak radial riblets; escutcheon beveled, smooth, well developed on the left valve, the corresponding portion of the right valve is rounded and posteriorly overlaps the left; colored by yellowish-gray and brown in general radial arrangement and mottled with larger blotches of ash-brown; hinge typical for the subgenus; pallial sinus well developed, narrow, slightly ascending, rounded or bluntly subangulate, projecting about a third the distance between the adductor impressions; margin crenulated, except posteriorly; interior white tinged with a streak of purple.

The largest specimen in the collection, from Potosi and Monypenny Point, Nicaragua, measures approximately: length, 52 mm.; height, 48 mm.; convexity (both valves), 31.5 mm.

The shell from Japan described as *Venus hirasei* by Pilsbry⁶⁰ was compared to *Chione columbiensis* and appears to be another member of the same group.

Distribution: A few specimens of this species were taken in Banderas Bay, Mexico, and off Nicaragua, in the Gulf of Fonseca. It has been cited occurring as a fossil in Peru.

⁶⁰ *Venus hirasei* Pilsbry, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 53, May 2, 1901, p. 205. "Hirado, Hizen." Japan. Also p. 400, pl. 19, fig. 1, pl. 20, fig. 20, August 16, 1901.

Protothaca jeloensis hirasei Pilsbry, *Hirase, Coll. Jap. Shells*, (Matsumura Sanshodo: Tokyo, Japan), 1934, p. 22, pl. 41, fig. 3.

⁵⁹ *Chione (Chione) springvalensis* Vokes, *Amer. Mus. Novitat.*, No. 988, May 16, 1938, p. 14, fig. 6 (on p. 13). Springvale, Trinidad, Upper Miocene.

Genus *Anomalocardia* Schumacher.

Anomalocardia Schumacher, Essai nouv. Syst. Vers Test., 1817, pp. 44, 134, pl. 20, fig. 4. Sole species, "*Venus flexuosa* Lin. Chemn. 6. pag. 332. Tab. 31. fig. 335."—Prashad, Siboga Exped., Monogr. 53c, 1932, Lamell., p. 260. Genotype: *Anomalocardia fluctuosa* Linnaeus.

Type (by virtual monotypy): *Venus flexuosa* Linnaeus. Illustrated by Chemnitz, Neues Syst. Conchyl.-Cab., Bd. 6, 1782, p. 332, pl. 31, fig. 335. "Es wohnet diese seltene Muschel in den ostindischen Meeren."

Anomalocardia appears to be closely related to *Chione*. The teeth are not bifid and diverge widely from a common center. The shells are usually rather thick and somewhat rostrate posteriorly. The sculpture consists of concentric ridges and subdued radial ribs. The lunule and escutcheon are impressed. The inner margins are crenulated and the pallial sinus is small, often angular and sometimes almost obsolete.

The three west American species in the present collection assigned to *Anomalocardia* differ somewhat in details of shape and sculpture as compared to the type of the genus, *A. flexuosa* Linnaeus. However, there are also similarities and we have therefore followed Dall and Jukes-Browne⁶¹ in placing these species under *Anomalocardia*.

This genus occurs from Pliocene to Recent in Lower California and from Miocene to Recent in Peru and in the Caribbean region. It also occurs both fossil and Recent in the East Indies.

Key to the species of *Anomalocardia*.

- A. Shell with radial furrow anterior to posterior dorsal fold
 - a. Concentric sculpture usually strong over entire shell; posterior dorsal fold strong from beak to base . . . *subrugosa*
 - aa. Concentric sculpture well developed near the beak and anterior submargins only; posterior dorsal fold well developed near beak only *broggi*⁶²
- B. Shell without radial furrow anterior to posterior margin; with bifurcate radial ribs
 - a. Shell with 20-25 concentric ridges *subimbricata*
 - aa. Shell with 6-8 concentric step-like ridges; tumid *tumens*

Anomalocardia subimbricata Sowerby.

Venus subimbricata Sowerby, Proc. Zool. Soc. London, April 16, 1835, p. 21. "Hab. ad Portam Portreram Americae Centralis." "Found in fine sand in thirteen fathoms." Variety from "Acapulco."—Sowerby, Thes. Conch., Vol. 2, 1853, p. 711, pl. 154, figs. 35-38. Puerto Portrero, Central America. Fig. 38 from [Lower] "California."—Reeve, Conch. Icon., Vol. 14, *Venus*, 1863, species 85,

pl. 19, figs. 85a, 85b, 85c. Original locality cited.

Type Locality: Puerto Portrero, Costa Rica, in 13 fathoms, sand.

Range: La Paz, Lower California, to Paita, Peru.

Collecting Stations: Mexico: Banderas Bay; Chamela Bay; Passavera Island; Chamela Bay; Tenacatita Bay; Port Guatulco (195-D-2, 6, 7, 11, 14, 15), 1.5-5 fathoms, sand, algae, crushed shell, gr. sand, coral; Santa Cruz Bay; Tangola-Tangola Bay; Costa Rica: Port Parker; Port Culebra; Culebra Bay; Panama: Isla Parida, Gulf of Chiriqui, Panama.

Description: Shell subtrigonal, ornamented by strong concentric ridges which in large specimens may number about 20-25; radial ribs are present, these are single in the early stages of growth but soon bifurcate due to deepening of a shallow medial incised line, a low radial riblet occurs in the major interspaces; lunule cordate, bordered by an incised line, lunule and escutcheon ornamented only by lines of growth; exteriorly colored by brown radial bands and sometimes by small irregular, V-shaped or zigzag markings on a whitish background; hinge with three teeth, the anterior one narrow and close against the margin; pallial sinus very small or almost obsolete; margin crenulated but often smooth posteriorly; interior white.

A large specimen from Culebra Bay, Costa Rica, measures approximately 50 mm. in length and 45.5 mm. in height.

The shell of this species is less tumid and has many more concentric ridges than that of *Anomalocardia subimbricata tumens* Verrill. Both *Anomalocardia subimbricata* and the subspecies *tumens* differ from *A. subrugosa* Wood in lacking a decided posterior rostration and posterior dorsal groove and in possessing bifurcated radial ribs and a low radial riblet in the major interspaces.

Anomalocardia subrugosa Manger,⁶³ de-
"Type Locality: San Quintin Bay, Lower California." scribed from the Pleistocene of San Quintin Bay, Lower California, was said to differ from *A. subimbricata* in the possession of concentric lamellae between the major ridges. *Venus subrugosa* Wood, 1828, is now placed in the genus *Anomalocardia*; therefore the species described by Manger, 1934, as *Anomalocardia subrugosa* requires a new name. The name *Anomalocardia mangeri* is here proposed for Manger's species.

Pilsbry & Olsson have referred the species here cited as *Anomalocardia subimbricata* to the genus *Chione*. It is not a typical form of *Anomalocardia* but on the other hand it seems as well placed here as in *Chione*.

Distribution: Specimens of *Anomalocardia subimbricata* were collected on beaches and dredged at depths of 1.5 to 5 fathoms, from Banderas Bay, Mexico, to the Gulf of Chiriqui, Panama. This species has a generally more southern distribution than that of the subspecies *A. subimbricata tumens*

⁶¹ Jukes-Browne, A. J., Proc. Malacol. Soc. London, Vol. 11, Pt. 2, June, 1914, p. 80.

⁶² Not represented in the present collection.

⁶³ *Anomalocardia subrugosa* Manger, Johns Hopkins Studies in Geol., No. 11, 1934, p. 299, pl. 21, figs. 3 and 4.

and occurs chiefly south of the Gulf of California. It also has been recorded as occurring from Pliocene to Recent in the Gulf of California region, in the Quaternary of Ecuador and in the Pleistocene of Peru.

Specimens from the West Falkland Islands in the south Atlantic Ocean were identified as "*Cryptogramma subimbricata*" by Melvill & Standen⁶⁴ who stated that the occurrence was adventitious. If correctly identified that no doubt would be the right interpretation because that locality is far beyond the range of the present species, which inhabits warm water.

***Anomalocardia subimbricata tumens* Verrill.**

Chione tumens Verrill, *Amer. Jour. Sci.*, Vol. 49, No. 146, March, 1870, p. 222. "La Paz,—Capt. J. Pedersen."

Type Locality: La Paz, Lower California, Mexico.

Range: Magdalena Bay, Lower California, to the Gulf of California.

Collecting Stations: Mexico: Cerralbo Island, Gulf of California; Cape San Lucas, Lower California.

Description: Shell rather tumid; ornamentation similar to that of *Anomalocardia subimbricata* except that there are only about 6-8 heavy, concentric, step-like ridges.

Judging from the illustration and the description there appear to be but slight differences between *Chione (Chione) vaca* Olsson,⁶⁵ described from the Pliocene of Panama, and *Anomalocardia subimbricata tumens*.

Distribution: *Anomalocardia subimbricata tumens* appears to be confined to the Gulf of California and the southern part of the west coast of Lower California. There is overlapping in the ranges of this subspecies and *A. subimbricata* but the two forms, for the most part, appear to be readily separable.

***Anomalocardia subrugosa* Wood.**

Venus subrugosa W. Wood, *Index, Test.*, Suppl., *Venus*, 1828, p. 5, pl. 2, fig. 6. "Panama."—Sowerby, *Gen. Rec. and Foss. Shells*, No. 41, 1834, pl. 250, fig. 2, pl. 251, fig. 5.—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 86, pl. 19, fig. 86. West Colombia (Cuming).

Not *Venus subrugosa* Bronn, *Ergeb. Nat. Reisen*, Vol. 2, 1831, p. 607.

Anomalocardia subrugosa Sowerby, *Dall, Proc. U. S. Nat. Mus.*, Vol. 37, 1909, pp. 158, 269, pl. 26, fig. 3. Gulf of California to Valparaiso, Chile.—Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, 1932, p. 134. Localities cited from Guaymas, Mexico, to Santa Elena Bay, Costa Rica.

Not *Anomalocardia subrugosa* Manger, 1934. [= *Anomalocardia mangeri* nom. nov.].

Type Locality: Magdalena Bay to the Gulf

of California and south to Boca Pan near Zorritos, Peru. To Valparaiso, Chile (Dall).

Collecting Stations: Mexico: Cape San Lucas, Lower California; Chamela Bay; Tenacatita Bay; Nicaragua: Potosi and Monypenny Point; Corinto (200-D-19), 3 fathoms, mud, mangrove leaves, also beach, Castanones peninsular lagoon and Isla Encantada; Costa Rica: Port Parker; Culebra Bay; Port Culebra; Jasper Island; Panama: Bahia Honda; Colombia: Gorgona Island.

Description: Shell triangularly ovate, somewhat rostrate posteriorly; ornamented by numerous concentric ridges which are crossed by fine incised radial lines; a shallow radial groove from the beak to the ventral margin is present just anterior to the posterior margin; the lunule which is cordate and bounded by a fine incised line and the escutcheon which is elongate are both ornamented only by lines of growth; exteriorly a white or cream colored background is nearly always crossed by 3 (occasionally 4) dark radial rays; hinge with three cardinal teeth in each valve; pallial sinus very short; margin finely crenulated; interior dorsal area purplish-black, the remainder white or with purple areas.

A large specimen from Port Parker, Costa Rica, measures approximately 46 mm. in length.

The presence of a well developed posterior dorsal radial groove easily serves to separate this species from *Anomalocardia subimbricata*. Some of the large nearly smooth specimens collected at Port Parker, Costa Rica, are very similar to *A. broggi* Pilsbry & Olsson⁶⁶ which was described from Peru. A well developed posterior dorsal fold and groove is present from beak to base on the present specimens. According to Pilsbry & Olsson a corresponding fold is well developed only near the beaks on *A. broggi* but is otherwise absent or feebly developed. Their species was described as possessing well developed concentric sculpture only near the beaks and on the anterior submargins.

Anomalocardia paziana Fischer⁶⁷ was described from Panama but it was not stated whether from the east or west coast of that country. The other species described in the same article are from east American waters. The illustration is that of a small elongated posteriorly rostrate form with concentric ridges and a posterior radial depression. We have not seen any west American specimens that could be referred to it but it bears some resemblance to *A. cuneiformis* Conrad, an east American species. Two species occurring fossil in western South America have been described, *Anomalocardia anomiana* Olsson from the Miocene of Peru, and *A. callistoides* Pilsbry & Olsson from the Pliocene of Ecuador.

⁶⁴ Melvill, J. C., and Standen, R., *Ann. & Mag. Nat. Hist.*, Ser. 8, Vol. 13, 1914, p. 133.

⁶⁵ *Chione (Chione) vaca* Olsson, *Bull. Amer. Paleol.*, Vol. 27, Bull. No. 106, December 25, 1942, p. 192 (40), pl. 18 (5), fig. 7. "Rio La Vaca. Quebrada Melissa." Panama. Pliocene.

⁶⁶ *Anomalocardia broggi* Pilsbry & Olsson, *Nautilus*, Vol. 56, No. 3, January, 1943, p. 78, pl. 8, fig. 7. Type "from Bayovar, Sechura, north Peru." Also, Zaramilla, Peru.

⁶⁷ *Anomalocardia paziana* Fischer, *Journ. de Conchyl.*, Vol. 7, 1858, p. 186, pl. 7, figs. 9, 10. "Hab. Panama (Paz). Coll. du Journal."

Distribution: *Anomalocardia subrugosa* was collected on beaches and in shallow water from Cape San Lucas to Colombia. It has been recorded as occurring in the Pleistocene of Lower California and in the Quaternary of Peru.

Genus *Compsomyax* Stewart.

Compsomyax subdiaphana Carpenter.

Clementia subdiaphana Carpenter, *Rept. Brit. Assoc. Adv. Sci.* for 1863 (issued August, 1864), pp. 602, 607, 640. "Vanc[ouver] Is." Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, pp. 88, 93, 126.—Dall, *Proc. U. S. Nat. Mus.*, Vol. 14, 1891, p. 185, pl. 7, figs. 5 and 6. Cited from Port Etches, Alaska, in 14-60 fathoms, to off Drake's Bay, California, in 24 fathoms.

Marcia subdiaphana Carpenter, I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, 1924, p. 155, pl. 33, fig. 3; pl. 38, fig. 1. Range, Sannakh Islands, Alaska, to Santa Barbara Islands and San Pedro, California.

Clementia (Compsomyax) subdiaphana Carpenter, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 334, pl. 17, figs. 10a, 10b, ?15. Earlier records cited. Miocene to Recent.

Type Locality: Vancouver Island, British Columbia.

Range: Sannakh Islands, Alaska, to Cedros Island, Lower California.

Collecting Station: Mexico: East of Cedros Island (126-D-3, 4), 40 fathoms, mud.

Description: Shell elongately ovate, varying in outline and ventricosity, beaks anterior and pointing forward; sculpture consisting of fine concentric lines of growth; lunule broad, faintly defined; hinge with three cardinal teeth in each valve, the right posterior cardinal deeply bifid; pallial sinus ascending and extending forward less than one-half the length of the shell; interior margins smooth.

A very large specimen from Port Ludlow, Washington, in Puget Sound, in the Hemphill collection of the California Academy of Sciences, measures, 68.8 mm. in length, 58 mm. in height, and 40.3 mm. in convexity (both valves).

Distribution: Four specimens of this species were dredged by the expedition east of Cedros Island in 40 fathoms. The occurrence of the species at this locality is an extension south of the known range. It is known to occur from Pliocene to Recent in western America and perhaps also in the Miocene.

Genus *Protothaca* Dall.

Key to the subgenera of *Protothaca*.

- A. Escutcheon well developed on left valve
*Protothaca s.s.*⁶⁸
 B. Escutcheon lacking or nearly so on left valve
Callithaca

Subgenus *Callithaca* Dall.

Key to the species of *Callithaca*.

- A. Pallial sinus extends forward more than $\frac{1}{2}$ the length of the shell . . . *staminea*
 B. Pallial sinus extends forward less than $\frac{1}{2}$ the length of the shell . . . *grata*

Protothaca (Callithaca) grata Say.

Venus grata Say, *Amer. Conch.*, No. 3, September, 1830, [pages of text not numbered] pl. 26, [three figures] . . . "West coast of Mexico."—Reeve, *Conch. Icon.*, Vol. 14, *Venus*, 1863, species 8, pl. 3, figs. 8a, 8b. [Not the locality "Gulf of Mexico"].

Venus histrionica Sowerby, *Proc. Zool. Soc. London*, June 1, 1835, p. 41. "Hab. apud Real Llejos, Americae Centralis, et ad Sanctam Elenam." "Found in muddy sand at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1853, p. 714, pl. 155, fig. 52. "Found in sandy mud at a depth of thirteen fathoms, Guacomo, Central America. Cuming."

Venerupis (Protothaca) grata Say, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 328. Earlier references cited. Pleistocene and Recent.

Type Locality: West coast of Mexico.

Range: Cape Colnett, west coast of Lower California (Lowe), to the Gulf of California and south to Antofogasta, Chile.

Collecting Stations: Mexico: Banderas Bay; Tangola-Tangola Bay; Nicaragua: Potosi and Monypenny Point; Isla Encantada and Isla Cardon, Corinto; San Juan del Sur; Costa Rica: Port Parker; Culebra Bay; Ballenas Bay; Golfito Bay; Panama: Isla Parida; Colombia: Gorgona Island.

Description: Shell elongately ovate, often 30-50 mm. in length, moderately inflated, ornamented by many flattish radial ribs which are coarser anteriorly, separated by narrow interspaces and both crossed by usually weaker concentric imbrications and irregularities due to growth; lunule cordate or elongated, ornamented by fine, radial ribs; escutcheon absent or only slightly developed, ligament deeply sunken; the color pattern varies greatly from blackish-brown to striped or checked brown and white to almost wholly white; the middle cardinals and usually the right posterior cardinal grooved; pallial sinus ascending, end rounded or roundly pointed, directed toward center of anterior adductor impression, projecting about one-third the distance between the two impressions; margin crenulated; color of interior white and purple or often wholly purple.

Specimens of this species are usually about 40 mm. in length but a large specimen in the collection of the California Academy of Sciences is 50 mm. in length. In this specimen the pallial sinus projects anteriorly 21 mm. from the posterior margin.

The shell of *Protothaca grata* differs from that of *P. staminea* Conrad in the shorter pallial sinus, brighter color patterns and in the generally smaller size. This species has received many different names in the literature due in great part to the variable color

⁶⁸ Not represented in the present collection.

pattern. Grant & Gale (1931) have cited many of the names now placed in the synonymy of this species.

The almost complete absence of an escutcheon, smaller lunule, less rasp-like sculpture of the ribs, usually more inflated shell and narrower hinge plate are features which serve to separate *Protothaca grata* from *Chione asperrima* Sowerby.

Some specimens of this species bearing a small escutcheon on the left valve are strongly suggestive of the subgenus *Nioche* but on most of these shells the left anterior cardinal is less elongate and the hinge plate is narrower than it is in typical species of that subgenus.

Distribution: This species was collected at many localities, usually between tides, from west Mexico to Colombia. It has been reported as occurring in the Pleistocene of Magdalena Bay, Lower California, and in the Pliocene of the Galápagos Islands.

***Protothaca (Callithaca) staminea* Conrad.**

Venus staminea Conrad, *Jour. Acad. Nat. Sci. Philadelphia*, Vol. 7, 1837, p. 250, pl. 19, fig. 15. "Inhabits the coast of California, with the above" [that is, *Venus nuttalli* from "Sta. Barbara, and Sta. Diego"].

Paphia staminea Conrad, I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, 1924, p. 156, pl. 35, figs. 1a, 1b. Range, Commander and Aleutian Islands to Puget Sound and Socorro Island, Japan. Also Miocene to Recent.

Venerupis (Protothaca) staminea Conrad, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 329, pl. 18, figs. 1a, 1b, 2a, 2b. Earlier records cited. Miocene to Recent.

Type Locality: San Diego, California (here designated as type locality). Santa Barbara and San Diego, California, indicated at the time of original description.

Range: Aleutian Islands to Cape San Lucas, Lower California. Socorro Island (Dall).

Collecting Station: Mexico: Cape San Lucas, Lower California.

Description: Shell elongately ovate, often 40 to 65 mm. in length, moderately inflated, ornamented by radial and concentric sculpture, the radial usually the stronger; lunule lanceolately cordate, sometimes only faintly defined; color yellowish-gray with varying amounts of wavy brown concentric lines or spots; ligament sunken, escutcheon absent or only faintly indicated; right posterior and middle teeth of both valves grooved; pallial sinus long, rather narrow, rounded at the end or blunt, projecting anteriorly more than one-half the distance between the two adductor impressions; margin crenulated; color of interior usually white but some southern specimens are partly purple and white.

A large specimen of this species in the collection of the California Academy of Sciences collected by Henry Hemphill at Turtle

Bay, Lower California, measures: length, 75.5 mm.; height, 64 mm.; convexity (both valves) 44.5 mm.; pallial sinus projects anteriorly 44 mm. from the posterior margin.

The longer pallial sinus, less brilliant and less variable color pattern and the generally larger size all serve to separate *Protothaca staminea* from *P. grata* Say.

Smith⁶⁹ has discussed the ecology and growth of *Protothaca staminea*.

Distribution: A single specimen of this species was collected on the beach at Cape San Lucas, Lower California. In California the species has been recorded from upper Miocene to Recent. It has been pointed out by Keen⁷⁰ that the species recorded from Japan under the name of *P. staminea* can be referred to *P. euglypta* Sowerby. Bales⁷¹ cited *P. staminea* from Acapulco but we have not seen specimens from south of Cape San Lucas. Eyerdam⁷² cited it from Arica, Peru, but it seems probable that the South American record can be referred to *P. thaca* Molina or some other species.

Genus *Irus* Oken.

Key to the subgenera of *Irus*.

- A. Lunule bounded by an incised line; margin crenulated *Paphnotia*
- B. Lunule not bounded by an incised line; margin smooth *Irus s.s.*⁷³

Subgenus ***Paphnotia* Hertlein & Strong,** subgen. nov.

Type: *Petricola elliptica* Sowerby, 1834.

Shell variable in shape but usually elliptically oblong, beaks anteriorly situated, rather compressed; sculptured with rather distantly spaced concentric lamellae and fine radial riblets which are usually reduced or lacking on the posterior area; lunule defined by an incised line; escutcheon usually well defined on the left valve; teeth small, hinge of left valve with a posterior cardinal moderately strong and fused to the margin, middle cardinal shorter and strongly grooved, anterior cardinal longer than middle tooth and slanting strongly forward; hinge of right valve with posterior and median cardinals about the same length, the median one grooved, and an anterior cardinal almost parallel to the lunular margin; pallial sinus ascending, angular, usually not extending quite to the middle of the shell; exterior usually whitish, interior white, posteriorly brown and often the anterior adductor impression and hinge brown, and sometimes the interior of the shell is wholly brown.

Compared to *Irus s.s.*, which has as type *Donax irus* Linnaeus, the shell of *Paphnotia* has the lunule delimited by a well marked in-

⁶⁹ Smith, G. M., *Trans. Roy. Soc. Canada*, Sect. 5, Vol. 27, 1933, pp. 229-245.

⁷⁰ Keen, A. M., *Sixth Pac. Sci. Congress*, Vol. 3, 1941, p. 480.

⁷¹ Bales, B. R., *Nautilus*, Vol. 52, No. 2, 1938, p. 45.

⁷² Eyerdam, W. J., *Nautilus*, Vol. 53, No. 3, 1940, p. 108.

⁷³ Not represented in the present collection.

cised line, the teeth are more diverging, the inner margin is crenulated and the pallial sinus is angular. Grant & Gale, 1931, pointed out that some west American shells referred to the genus *Venerupis* Lamarck, which has as type *Venus perforans* Montagu, bear considerable resemblance to some species referred to *Irus*.

The species described as *Petricola elliptica* by Sowerby has been referred by some writers to *Petricola* and by others to *Venerupis*. It does not seem to be exactly referable to either of those genera. Some of the specimens in the present collection possess features in common with *Venerupis elegans* Deshayes, the type of *Notopaphia* Oliver⁷⁴ as illustrated by Marwick. The west American species possesses different sculpture and appears to differ in some other details and therefore we have thought it desirable to propose a new subgeneric name *Paphonotia*⁷⁵ with *Petricola elliptica* Sowerby as type.

The similarity of *Paphonotia* to *Notopaphia* of New Zealand is not surprising when it is recalled that *Protothaca* is present in New Zealand (Marwick, 1927, p. 623). Furthermore it appears that the west American species *Chione fluctifraga* Sowerby is very similar to the New Zealand species, *Venus stutchburyi* Gray, and may perhaps be referable to the same subgenus, *Austrovenus* Marwick⁷⁶.

Irus (Paphonotia) ellipticus Sowerby.

Petricola elliptica Sowerby, *Proc. Zool. Soc. London*, September 26, 1834, p. 46. "Hab. ad Paytam." "Found in hard mud at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 774, pl. 164, fig. 3; pl. 166, fig. 10. Original locality cited.—Sowerby, *Conch. Icon.*, Vol. 19, *Petricola*, 1874, species 12, pl. 2, fig. 10. Original locality cited.

Venerupis elliptica Sowerby, Lamy, *Journ. de Conchyl.*, Vol. 67, No. 4, 1923, p. 306, two figs. p. 307. Peru.

Petricola solida Sowerby, *Proc. Zool. Soc. London*, September 26, 1834, p. 46. "Hab ad oras Peruviae. (Lambeyeque)." "Found in hard clay and stones at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 774, pl. 166, fig. 9. Original locality cited.—Sowerby, *Conch. Icon.*, Vol. 19, *Petricola*, 1874, species 15, pl. 2, fig. 15. Original locality cited.

Petricola solidula Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 770, pl. 164, fig. 17.

Type Locality: Paita, Peru, at low water, in hard mud.

Range: Tangola-Tangola Bay, Mexico, to Arica, Chile.

⁷⁴ *Notopaphia* Oliver, *Proc. Malacol. Soc. London*, Vol. 15, Pt. 4, March, 1923, p. 185. Type: *Venerupis elegans* Deshayes, fig. p. 185. [Originally described in *Proc. Zool. Soc. London* for 1853 (issued June 27, 1854), p. 5, pl. 18, figs. 2a, 2b, 2c. "Hab. New Zealand. Coll. Cumings].—Marwick, *Trans. New Zealand Inst.*, Vol. 57, February 12, 1927, p. 662. Type: *Venerupis elegans* Deshayes. Illustrated on pl. 49, figs. 174, 176, 177. New Zealand.

⁷⁵ *Paphonotia*, an anagram of *Notopaphia*.

⁷⁶ *Austrovenus* Marwick, *Trans. New Zealand Inst.*, Vol. 57, February 12, 1927, p. 620. "Type: *Venus stutchburyi* Grav." Illustrated on pl. 47, figs. 158, 159, 160. Recent, also fossil in New Zealand.

Collecting Station: Nicaragua: Corinto (200-D-19), 12-13 fathoms, mangrove leaves.

Description: Shell elliptically oblong, beaks in front of the middle, rather compressed; ornamented by rather distantly spaced concentric lamellae and by moderately fine, closely spaced radial ribs which however, are usually much reduced or lacking on the posterior area; lunule defined by an impressed line; right posterior and middle tooth and left middle tooth are medially grooved; pallial sinus angular, ascending, not reaching quite the middle of the shell; interior brown and white or almost wholly brown; margin crenulated.

The specimens of this species in the present collection are small, not over 10 mm. in length, but large specimens attain a length of 26 mm. or more.

The shell of this species is variable in shape due to the fact that it lives in holes in rocks. Some young specimens that are elliptical in shape later develop into forms vertically truncated posteriorly. The strongly frilled and squarely truncated form was named *Venerupis foliacea* by Deshayes⁷⁷. It appears to be of not more than subspecific value. Dall, 1902, stated that synonyms of this form include *Tapes squamosa* Carpenter, 1857, *Venus troglodytes* Mörch, 1861, and perhaps *Venerupis paupercula* Deshayes, 1853.

The species described as *Venerupis oblonga* Sowerby⁷⁸ appears to be a very similar form but may differ in possessing stronger radial ornamentation on the posterior portion of the valves.

Distribution: Specimens of this species were dredged by the expedition at Corinto, Nicaragua, in 12-13 fathoms. It has been reported as ranging south to Chile. The subspecies *foliaceus* has been recorded as occurring north to Mazatlan, Mexico.

Genus *Psephidia* Dall.

Psephidia cymata Dall.

Psephidia cymata Dall, *Proc. U. S. Nat. Mus.*, Vol. 45, No. 2002, June 11, 1913, p. 593. "Near Cerros Island, Lower California, in shallow water."—Dall, *U. S. Nat. Mus.*, *Bull.* 112, 1921, p. 44, pl. 3, fig. 2. Santa Barbara Islands, California, to the Gulf of California.

Type Locality: Near Cedros Island, Lower California, in shallow water.

Range: Santa Barbara Islands, California, to the Gulf of California.

⁷⁷ *Venerupis foliacea* Deshayes, *Proc. Zool. Soc. London* for 1853 (issued June 27, 1854), pl. 18, figs. 5a, 5b. [Without description].—Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 764, pl. 164, figs. 8, 9. "Mazatlan." Not *Venus foliacea* Philippi, 1846.

⁷⁸ *Petricola oblonga* Sowerby, *Proc. Zool. Soc. London*, September 26, 1834, p. 46. "Hab ad oras Peruviae. (Pacos-mayo)." "Found in hard mud at low water."—Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 765, pl. 165, fig. 21 (as *Venerupis oblonga*). Original locality cited.

Venerupis fernandesiana Stenmoell (*Zool. Jahrb.*, Suppl. Bd. 5, Fauna Chilensis, Bd. 2, Heft 1, December 20, 1898, p. 237, pl. 12, figs. 22, 23. "Fundort: Zahlreiche Exemplare aus Juan Fernandez (Bahia Cumberland)"), was questionably referred to *V. oblonga* by Dall.

Collecting Station: Mexico: East of Cedros Island (126-D-12), 45 fathoms, crushed shell, mud.

Description: Shell small, about 6 mm. in length and 5.5 mm. in height; white, rounded triangular, somewhat anterior beaks; lunule and escutcheon feebly indicated; ornamented by fine concentric low thread-like sculpture; interior polished; three cardinals in each valve; pallial sinus small, ascending, inner extreme bluntly rounded; inner margin smooth; periostracum yellowish, rather coarse (adapted from Dall).

Distribution: A few somewhat worn specimens dredged east of Cedros Island in 45 fathoms appear to be referable to this species. It also has been recorded as occurring in the Pleistocene of Lower California.

FAMILY PETRICOLIDAE.

Genus *Petricola* Lamarck.

Key to the subgenera of *Petricola*.

- A. Radial sculpture nearly uniform over shell *Petricola* s.s.
 B. Radial sculpture much coarser anteriorly; subcylindrical *Petricolaria*

Subgenus *Petricola* s.s.

Key to the species of *Petricola* s.s.

- A. Shell usually attenuated posteriorly; radial sculpture strong *robusta*
 B. Shell usually subquadrate or subrounded; radial sculpture fine
 a. Length usually not exceeding 12 mm. *tellimyalis*⁷⁹
 aa. Length exceeding 12 mm.
 b. Interior white *carditoides*⁷⁹
 bb. Interior blackish-brown *lucasana*

Petricola (Petricola) lucasana Hertlein & Strong, sp. nov.

Plate II, Figures 4 and 9.

Shell oblong, subquadrate or subrounded, thick; ornamented by fine radial riblets; exterior white with bluish tinged concentric areas and reddish or brown near the beaks; interior blackish-brown, sometimes whitish under the umbos; pallial sinus short, broad, rounded; margin smooth; hinged normal for the genus. Dimensions: length, 24.6 mm.; height, 25 mm.; convexity (both valves), 16.6 mm.

Holotype, (Calif. Acad. Sci. Paleo. Type Coll.), from Cape San Lucas, Lower California, Mexico.

This species, in some cases, has been referred to *Petricola robusta* Sowerby but it differs from that species in the oblong or subquadrate shape of the shell which does not taper posteriorly and is less inflated anteriorly, the thicker shell, and in the much finer and nearly uniform radial sculpture. Specimens of *Petricola robusta* dredged by G. D. Hanna and E. K. Jordan in 10 fathoms at Maria Madre Island, Tres Marias group, agree exactly with Sowerby's illustrations

of that species and show it to be quite different from the present species.

This new species resembles *Petricola carditoides* Conrad⁸⁰ which has been reported as ranging from Vancouver Island, British Columbia, to Magdalena Bay, Lower California, but differs in the slightly coarser sculpture, blackish-brown interior and whitish and dark orange brown exterior.

This species occurs in the Gulf of California, at least as far north as Punta Penasco, Sonora, Mexico, where it was collected by H. N. Lowe.

Petricola (Petricola) robusta Sowerby.

Petricola robusta Sowerby, *Proc. Zool. Soc. London*, September 26, 1834, p. 47. "Hab. ad Panamam et ad Insulam Muerte dictam." "Found in rocks at the depth of from six to eleven fathoms."—Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 775, pl. 166, figs. 16, 17. "In rocks, six to eleven fathoms, at Panama. Cuming."—Sowerby, *Conch. Icon.*, Vol. 19, *Petricola*, 1874, species 20, pl. 3, figs. 20a, 20b. Panama.—Lamy, *Journ. de Conchyl.*, Vol. 67, No. 4, 1923, p. 330. Gulf of California and Panama.

Type Locality: Panama (here designated as type locality). Island of Muerte also cited originally.

Range: Gulf of California to Guayaquil, Ecuador.

Collecting Stations: Mexico: Tangola-Tangola Bay; Nicaragua: Corinto (200-D-19), 12-13 fathoms, mangrove leaves.

Description: Of a dull orange tint, with purple at the apices and blackish inside, rather thick, very globose in front, tapering behind, where the valves are unequal, the right valve slightly overwrapping. The radiating striae are distant, numerous, and close in front, but towards the back become separated, strong, acute; the hinder ones of all are a little smaller, serrated, and their ends form a denticulated edge (Sowerby, *Thes. Conch.*).

The pallial sinus is short, broad, rounded at the end; hinge normal for the genus.

Petricola sinuosa Conrad, 1849. *P. bulbosa* Gould, 1851. and *P. venusta* De Folin, 1867, are names now relegated to the synonymy of *P. robusta*.

Petricola typica Jonas, a Caribbean species, has a similar shell but the interior is white. *Petricola riocanensis* Maury, 1917, described from the Miocene of Santo Domingo, is also a similar species.

Distribution: A few specimens, mostly young, referred to this species, were taken off west Mexico and Nicaragua. This species has been recorded from South Africa but as pointed out by Bartsch⁸¹ it does not occur in that region.

⁸⁰ *Saxicava carditoides* Conrad, *Jour. Acad. Nat. Sci. Philadelph.*, Vol. 7, 1837, p. 255, pl. 20, fig. 8. "Inhabits California near Sta. Barbara, where a single valve was collected."

Petricola carditoides Conrad, I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, 1924, p. 163, pl. 34, figs. 6a, 6b. Range, Vancouver Island to Lower California.

⁸¹ Bartsch, P., *U. S. Nat. Mus., Bull.* 91, 1915, p. 247.

⁷⁹ Not represented in the present collection.

Subgenus *Petricolaria* Stoliczka.Key⁸² to the species of *Petricolaria*.

- A. A flattened lunule-like area present
- a. Height nearly one-half the length
 - b. Teeth in right valve massive; shell fairly thick *cognata*⁸³
 - bb. Teeth in right valve moderately fine; lunule-like area and nymphs narrower *pholadiformis*⁸³
 - aa. Height about one-third the length or less *parallela*
- B. Lunule-like area lacking
- a. Anterior end evenly rounded; pallial sinus rounded at end; shell thin *californiensis*⁸³
 - aa. Anterior end tapering to a narrow point; pallial sinus angular, tapering to a point; shell fairly thick, partly purplish-brown *denticulata*⁸³

Petricola (Petricolaria) parallela

Pilsbry & Lowe.

Petricola gracilis parallela Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 99, pl. 13, figs. 4, 5, 5a, 6. "Nicaragua: Corinto (Lowe)." Type.

Type Locality: Corinto, Nicaragua.

Range: Scammon Lagoon, Lower California, to the Gulf of California and south to Corinto, Nicaragua.

Collecting Station: Nicaragua: Corinto (200-D-11), 8 fathoms, sand.

Description: Shell very elongated, dorsal and ventral margins nearly parallel; sculptured with 11-13 coarse, nodulous ribs on the anterior half, posteriorly the ribs diminish to radial striae; lunular region somewhat excavated and ornamented by fine growth lamellae; pallial sinus long, of equal width throughout, rounded at end.

The specimen in the present collection is only about 24 mm. long but agrees exactly with larger shells of this species.

Petricola parallela is very similar to *Petricola gracilis* Deshayes⁸⁴, a species originally described without information as to the locality from which it came. As pointed out by Pilsbry & Lowe there are differences in the shape, ribbing and apparently in the pallial sinus of the two forms.

Compared to *Petricola pholadiformis* Lamarck, an east American species, the shell of the present species is more elongated and the dorsal and ventral margins are more nearly parallel.

Some of the records of *Petricola cognata*

C. B. Adams cited⁸⁵ from the Gulf of California region undoubtedly can be referred to *P. parallela*. *Petricola cognata* C. B. Adams⁸⁶ was described from Panama. Pilsbry & Lowe illustrated the type and stated that it resembles *P. pholadiformis* Lamarck but differs in possessing more massive teeth in the right valve, broader nymphs and in the wider lunule-like area free of radiating sculpture.

Distribution: A single small specimen of this species was dredged in 8 fathoms at Corinto, Nicaragua. It also has been cited⁸⁷ as occurring in the Pleistocene of the Newport Bay region in southern California.

FAMILY COOPERELLIDAE.

Genus *Cooperella* Carpenter.

Oedalia Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863, issued August, 1864, pp. 611, 639. "*Oedalia (Cooperella) scintillaeformis*, n. subgen., n.s." (p. 611) [No description]; "*Oedalia subdiaphana*, n. g., n.s." (p. 639) [Description]. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, pp. 97, 125.—Carpenter, *Journ. de Conchyl.*, Vol. 12 (Ser. 3, Vol. 5), April, 1865, p. 134. "*Oedalia*, n.g." [*Oedalia subdiaphana* described]. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 134.

Not *Oedalia* Meigen, 1820. Dipt.

Cooperella Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863 issued August, 1864, pp. 611, 639. "*Oedalia (Cooperella) scintillaeformis*, n. subg., n. s." (p. 611) [no description]; "*Cooperella scintillaeformis*, n. s. New subgenus of *Oedalia*" (p. 639) [no description]. Reprint in *Smithson. Miscell. Coll. No. 252, 1872, pp. 97, 125.*—Dall, *Trans. Wagner Free Inst. Sci.*, Vol. 3, Pt. 5, December, 1900, p. 1061. "The type *Cooperella subdiaphana* (+ *scintillaeformis*) Cpr."

Not *Cooperella* Gunnell, *Jour. Paleo.*, Vol. 7, No. 3, 1933, p. 291. Pisces.

Oedalina Carpenter, *Proc. Calif. Acad. Nat. Sci.*, Vol. 3, February, 1865, p. 208. New name for *Oedalia* Carpenter, preoccupied.—Lamy, *Journ. de Conchyl.*, Vol. 61, No. 3, 1914, p. 301.

Type (by monotypy): *Cooperella scintillaeformis* Carpenter.

Shell small, very thin, white, ovately rectangular, moderately inflated, beaks a little anterior, smooth or concentrically striated; resilium narrow, depressed, behind and separated from the teeth by a thin plate; hinge of right valve with 2 cardinals, left valve with 3 cardinal teeth, the left middle and frequently the right posterior, and frequently the other teeth, bifid; pallial sinus deep, wide, broadly rounded at the end; margins smooth.

⁸⁵ *Petricola cognata* C. B. Adams, E. K. Jordan, *Bull. South. Calif. Acad. Sci.*, Vol. 23, Pt. 5, September-October (issued October 25), 1924, p. 153. The record "Scammon's Lagoon," Lower California, can be referred to *P. parallela*.

⁸⁶ *Petricola cognata* C. B. Adams, *Ann. Lyceum Nat. Hist. New York.*, Vol. 5, July, 1852, pp. 510, 546 (separate pp. 286, 322). "Habitat.—Panama."—Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, 1932, p. 99, pl. 13, figs. 10, 11. Figure of type. Panama.

⁸⁷ See Bruff, S. C., *Univ. Calif. Publ., Bull. Dept. Geol. Sci.*, Vol. 27, No. 6, 1946, p. 232.

⁸² Adapted from Pilsbry & Lowe.

⁸³ Not represented in the present collection.

⁸⁴ *Petricola gracilis* Deshayes, *Cat. Conchif. or Bivalve Shells in Coll. Brit. Mus.*, Pt. 1, 1853, p. 214. "Hab. —? Coll. Cuming."—Deshayes, *Proc. Zool. Soc. London* for 1853 (issued June 27, 1854), pl. 18, figs. 9, 9a. [No description].—Sowerby, *Thes. Conch.*, Vol. 2, 1854, p. 772, pl. 166, fig. 12. "Hab. —? Cuming's collection."—Lamy, *Journ. de Conchyl.*, Vol. 67, No. 4, 1923, p. 344.

This genus has been recorded as occurring from Miocene to Recent in the Caribbean region and Pleistocene and Recent in the eastern Pacific. One species, "*?Oedalina asiatica*" Melvill, 1899, doubtfully referred to the genus, was described from the Arabian Sea.

A subgenus, *Cooperellopsis* Woodring⁸⁸, 1925, described from the Miocene of Bowden, Jamaica, possesses a subequilateral, strongly inflated shell in which the left middle cardinal is only obscurely bifid rather than strongly so as in *Cooperella* s.s.

***Cooperella subdiaphana* Carpenter.**

Oedalia subdiaphana Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863 (issued August, 1864), p. 639. Region between San Diego and San Pedro, California. Also Santa Barbara Islands, California. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 125.—Carpenter, *Journ. de Conchyl.*, Vol. 12 (Ser. 3, Vol. 5), April, 1865, p. 134. "Hab. San Diego, Cassidy."

Oedalia (Cooperella) scintillaeformis Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863 (issued August, 1864), p. 611. [No description]. San Diego. Santa Barbara Islands. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 97.

Cooperella scintillaeformis Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863 (issued August, 1864), p. 639. Region between San Pedro and San Diego, California. Also Santa Barbara Islands. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 125.—Carpenter, *Proc. Calif. Acad. Nat. Sci.*, Vol. 3, February, 1865, p. 208. "Hab. San Diego; San Pedro, 2 dredged in 8-20 fms. Cooper."

Cooperella subdiaphana Carpenter, Arnold, *Mem. Calif. Acad. Sci.*, Vol. 3, 1903, p. 153, pl. 13, fig. 1. Vancouver Island to Todos Santos Bay (Dall). Also San Pedro and San Diego, California, Pleistocene.—Lamy, *Journ. de Conchyl.*, Vol. 67, No. 4, 1923, pp. 313, 314, (two figs. of hinge, p. 314).

Oedalina subdiaphana Carpenter, Lamy, *Journ. de Conchyl.*, Vol. 61, No. 3, 1914, p. 303, (two figs. of hinge, p. 302). California.

Type Locality: San Diego, California

⁸⁸ *Cooperellopsis* Woodring, *Carnegie Institution of Washington, Publ.* 366, May 25, 1925, p. 165. "Type.—*Cooperella (Cooperellopsis) thaumastra*, new species." P. 165, pl. 22, figs. 13, 14, 15. Bowden, Jamaica, Miocene.

(cited by Carpenter, 1865, and here designated as type locality). Region between San Diego and San Pedro, California, also Santa Barbara Islands, cited originally.

Range: Queen Charlotte Islands, British Columbia, to San Felipe, east coast of Lower California in the Gulf of California.

Collecting Station: Mexico: Santa Inez Bay, Gulf of California (145-D-1-3), 4-13 fathoms, sand.

Description: Shell small and fragile, nearly equilateral, moderately inflated, smooth or concentrically striated; hinge typical for the genus; margins smooth; pallial sinus deep and rounded at the end.

Specimens in the present collection are about 4-6 mm. in length. A large specimen from San Diego, California, in the collections of the California Academy of Sciences, measures: length, 14.6 mm.; height, 11.6 mm.; convexity (both valves), 7.3 mm.

Dall⁸⁹, 1903, gave a careful description of this species. He stated that the types of Carpenter's species "*Oedalia subdiaphana*" and *Cooperella scintillaeformis* are in the United States National Museum. He considered them to represent the same species⁹⁰.

Haas⁹¹ described the "nest" which this species sometimes builds.

Cooperella atlantica Rehder⁹², recently described from Florida, is said to be smaller, more translucent and more equilateral than *C. subdiaphana*. *Cooperella carpenteri* Dall, 1903, described from the Miocene of Florida, is another similar species.

Distribution: Three small somewhat worn single valves of this species were dredged by the expedition in Santa Inez Bay in the Gulf of California, in 4-13 fathoms. It also has been recorded as occurring in the Pleistocene of San Pedro, Playa del Rey and San Diego, southern California, and at San Quintin, Lower California.

⁸⁹ Dall, W. H., *Trans. Wagner Free Inst. Sci.*, Vol. 3, Pt. 5, December, 1900, p. 1062.

⁹⁰ Orcutt, 1919, credited Dall for the identification, and cited *Cooperella scintillaeformis* as occurring at Magdalena Bay, Lower California (*West Amer. Sci.*, Vol. 21, No. 5 (169), 1919, p. 39).

⁹¹ Haas, F., *Nautilus*, Vol. 55, No. 4, 1942, p. 113.—Haas, *Field Mus. Nat. Hist., Zool. Ser.*, Vol. 29, No. 1, 1943, p. 12 fig. 7 (a, b). Alamitos Bay, San Pedro, California.

⁹² *Cooperella atlantica* Rehder, *Proc. U. S. Nat. Mus.*, Vol. 93, No. 3161, January 20, 1943, p. 187, pl. 19, figs. 3, 4. "dredged off Peanut Island, northern Lake Worth, Fla."

EXPLANATION OF THE PLATES.

PLATE I.

- FIG. 1. *Pitar (Lamelliconcha) frizzelli* Hertlein & Strong, sp. nov. Holotype, right valve, from Station 136-D-22, Lat. 23° 28' 30" N., Long. 109° 25' W., Arena Bank, Gulf of California, dredged in 45 fathoms (82 meters). Length, 46 mm., height, 33.5 mm. P. 176. 1
- FIG. 2. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Holotype, left valve, from Station 195-D-9, Lat. 15° 44' 28" N., Long. 96° 07' 51" W., off Port Guatulco, Mexico, dredged in 7 fathoms (12.6 meters). Length, 11.2 mm., height, 9.4 mm. P. 182.
- FIG. 3. *Pitar (Pitarella) mexicanus* Hertlein & Strong, sp. nov. Holotype, left valve, from Station 192-D-1, Lat. 16° 16' 30" N., Long. 98° 37' W., 4 miles south-southwest of Maldonado Point, Mexico, dredged in 26 fathoms (47 meters). Length, 42.3 mm., height, 33.3 mm. View of the interior. P. 171.
- FIG. 4. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Holotype. View of the interior of the right valve of the specimen shown in Fig. 2.
- FIG. 5. *Pitar (Lamelliconcha) frizzelli* Hertlein & Strong, sp. nov. Holotype. View of the exterior of the left valve of the specimen shown in Fig. 1.
- FIG. 6. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Holotype. View of the exterior of the specimen shown in Fig. 2.
- FIG. 7. *Pitar (Lamelliconcha) frizzelli* Hertlein & Strong, sp. nov. Holotype. View of the interior of the specimen shown in Fig. 5.
- FIG. 8. *Pitar (Pitarella) mexicanus* Hertlein & Strong, sp. nov. Holotype. View of the exterior of the right valve of the specimen shown in Fig. 3.
- FIG. 9. *Pitar (Hyphantosoma) aletes* Hertlein & Strong, sp. nov. Holotype, right valve, from Station 136-D-13, Lat. 23° 29' N., Long. 109° 24' W., Arena Bank, Gulf of California, in 45 fathoms (82 meters). Length, 53.8 mm., height, 46 mm. View of the interior. P. 172.
- FIG. 10. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Holotype. View of the exterior of the specimen shown in Fig. 4.
- FIG. 11. *Pitar (Hyphantosoma) aletes* Hertlein & Strong, sp. nov. Holotype. View of the interior of the left valve of the specimen shown in Fig. 9.

FIG. 12. *Pitar (Hyphantosoma) aletes* Hertlein & Strong, sp. nov. Holotype. View of the exterior of the specimen shown in Fig. 9.

FIG. 13. *Pitar (Hyphantosoma) aletes* Hertlein & Strong, sp. nov. Holotype. View of the exterior of the specimen shown in Fig. 11.

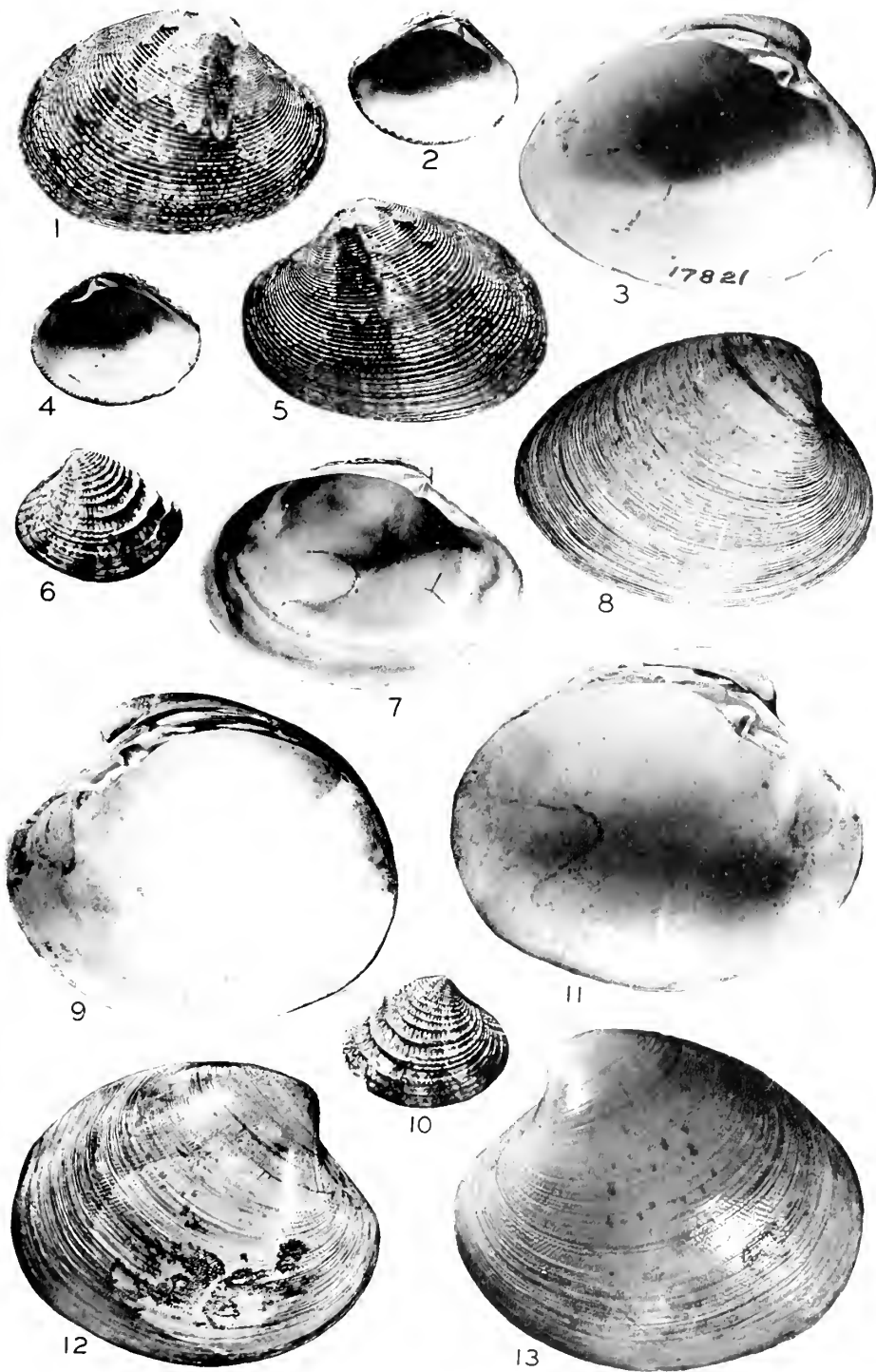
All the specimens illustrated on this plate are in the type collection of the Department of Paleontology of the California Academy of Sciences.

PLATE II.

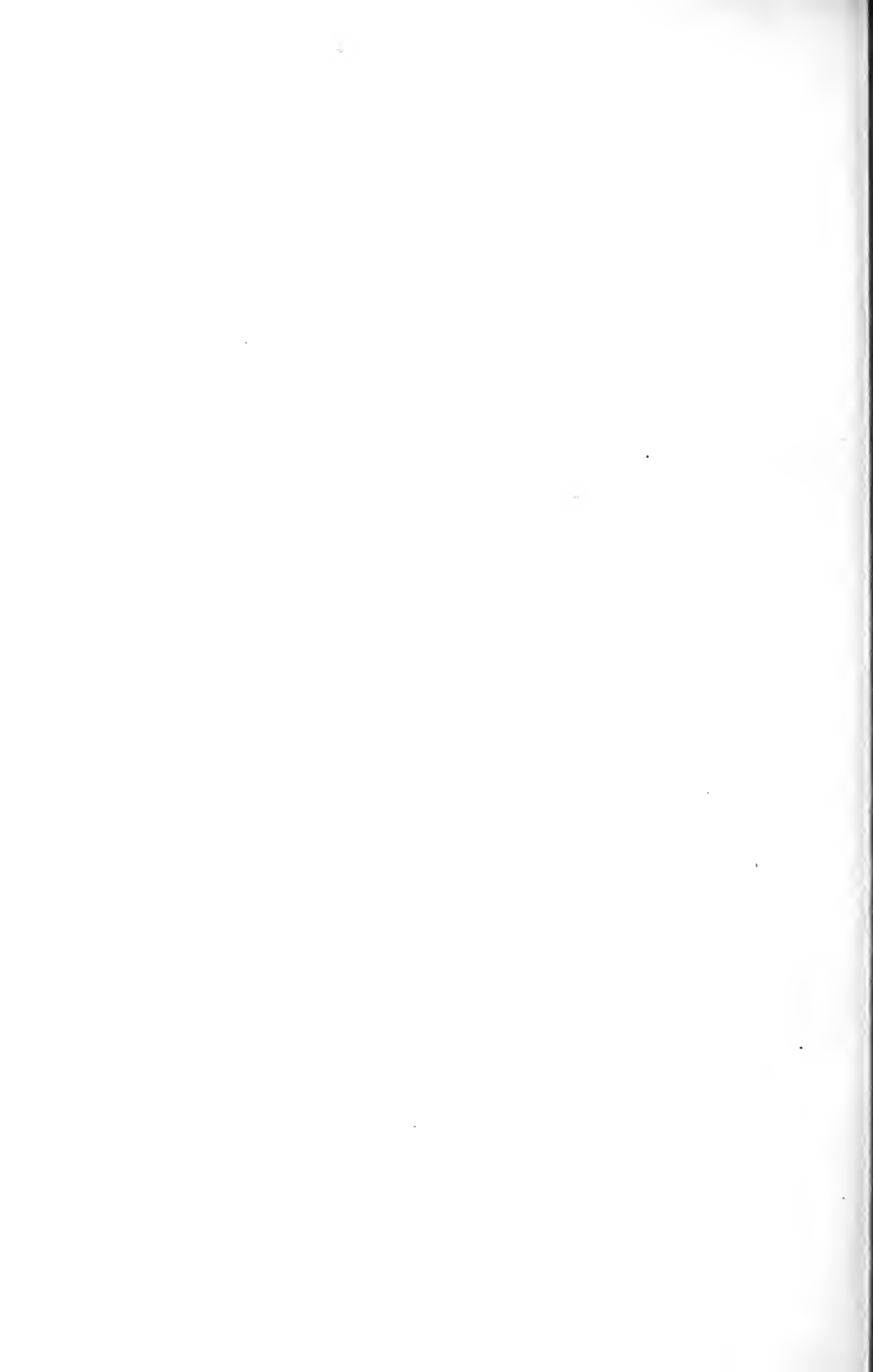
- FIG. 1. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Paratype, left valve, from Station 195-D-9, dredged in Lat. 15° 44' 28" N., Long. 96° 07' 51" W., Port Guatulco, Mexico, dredged in 7 fathoms (12.6 meters). Length, 14.6 mm., height, 11.1 mm. P. 182.
- FIG. 2. *Antigona (Ventricola) isocardia* Verrill. Hypotype, left valve, from Gorgona Island, Colombia. Length, 63.5 mm., height, 57.3 mm. P. 178.
- FIG. 3. *Antigona (Ventricola) isocardia* Verrill. Hypotype, left valve, from Station 136-D-26, dredged in Lat. 23° 27' N., Long. 109° 24' W., Arena Bank, Gulf of California, in 45 fathoms (82 meters). Length, 48.2 mm., height, 44.5 mm.
- FIG. 4. *Petricola (Petricola) lucasana* Hertlein & Strong, sp. nov. Holotype, left valve, from Cape San Lucas, Lower California, Mexico. Length, 24.6 mm., height, 25 mm. P. 194.
- FIG. 5. *Cyclinella kröyeri ulloana* Hertlein & Strong, subsp. nov. Holotype, left valve, from Station 143-D-4, Lat. 26° 55' N., Long. 111° 54' W., Santa Inez Bay, Lower California, in the Gulf of California, dredged in 25 fathoms (46 meters). Length, 75.5 mm., height, 76.5 mm. P. 179.
- FIG. 6. *Cyclinella kröyeri ulloana* Hertlein & Strong, subsp. nov. Holotype. View of the interior of the specimen shown in Fig. 5.
- FIG. 7. *Cyclinella kröyeri ulloana* Hertlein & Strong, subsp. nov. Paratype, left valve, from the same locality as the holotype shown in Fig. 5. Length, 65.3 mm., height, 63 mm.
- FIG. 8. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Paratype. View of the interior of the right valve of the specimen shown in Fig. 1.

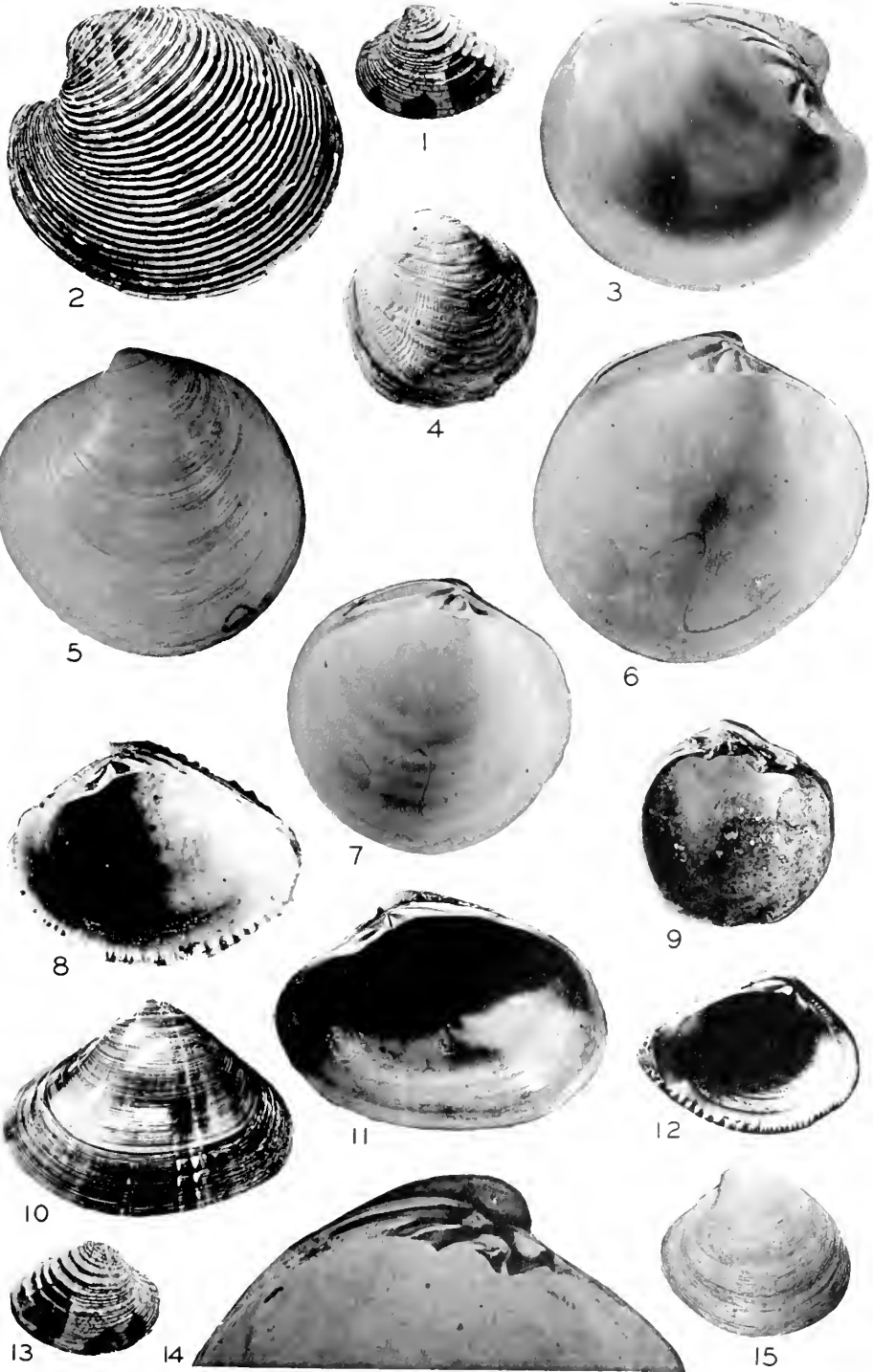
- FIG. 9. *Petricola (Petricola) lucasana* Hertlein & Strong, sp. nov. Holotype. View of the interior of the right valve of the specimen shown in Fig. 4.
- FIG. 10. *Tivela delessertii* Deshayes in Sowerby. Hypotype, left valve, from Santa Inez Bay, Lower California, in the Gulf of California, on beach. Length, 30.9 mm., height, 23.5 mm.
- FIG. 11. *Pitar (Lamelliconcha) frizzelli* Hertlein & Strong, sp. nov. Holotype, right valve from Station 136-D-22, Lat. 23° 28' 30" N., Long. 109° 25' W., Arena Bank, Gulf of California, dredged in 45 fathoms (82 meters). Length, 46 mm., height, 33.5 mm. P. 176.
- FIG. 12. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Paratype. View of the exterior of the specimen shown in Fig. 1.
- FIG. 13. *Chione (Chione) guatulcoensis* Hertlein & Strong, sp. nov. Paratype. View of the interior of the specimen shown in Fig. 8.
- FIG. 14. *Callocardia (Agriopoma) catharia* Dall. Hypotype, left valve, from Station 221-D-1-5, Lat. 7° 54' 45" to 7° 52' 30" N., Long. 82° 04' 32" to 82° 01' W., Gulf of Chiriqui, Panama, in 35-40 fathoms (64-73 meters). Length, 22.8 mm., height, 20.5 mm. View showing the hinge. P. 177.
- FIG. 15. *Callocardia (Agriopoma) catharia* Dall. View of the exterior of the specimen shown in Fig. 14.

All the specimens illustrated on this plate are in the type collection of the Department of Paleontology of the California Academy of Sciences.



MOLLUSKS FROM THE WEST COAST OF MEXICO AND CENTRAL AMERICA.





MOLLUSKS FROM THE WEST COAST OF MEXICO AND CENTRAL AMERICA.



14.

Notes on Indian Birds. II.
The Species *Glaucidium cuculoides*.

S. DILLON RIPLEY.

Peabody Museum of Natural History.

The collection of a number of specimens of barred owlets in India recently and discussions with my friend H. G. Deignan, have prompted me to review this species and to attempt to clear up some of the anomalous specimens and the ranges of the races.

HISTORY OF THE SUPER-SPECIES.

1. *radiatum*.

Glaucidium cuculoides and *G. radiatum* apparently form a super-species, for such evidence as exists of their distribution indicates that they are allopatric. The species *radiatum* is found at low altitudes in the Himalayas, lower than *cuculoides*, and apparently replaces it. From the Himalayan foothills, *radiatum* spreads south throughout the Indian Peninsula as far as Khandesh, the eastern drier part of the Nilghiri plateau and south through Madras Presidency. In the wetter area of the west side of the lower peninsula, Coorg, Cochin and Travancore, *radiatum* is replaced by the darker subspecies, *r. malabaricum*.

In relatively recent times, *r. radiatum* has apparently invaded Ceylon, where it occurs in the drier zones of the Island, east, south and eastern part of the central "massif," only to be replaced in the wet zones of the central Hills, on their western side, and in the low country of the southwest by the strongly differentiated race, *castanonotum*. This race, characterized by having the feathers of the back, wing coverts, scapulars and rump suffused with light chestnut with greatly reduced barring, has been termed a race of *cuculoides* by Peters (Check List Birds World, 1940, IV, p. 133.), and so followed by me (*Spolia Zeylanica*, 1945, 24, pt. 3, p. 209.). In fact *castanonotum* is a small bird (wing 126-138.5 mm.), with fine close barring and obviously belongs with *radiatum*. However, in its high degree of differentiation as compared to the Peninsula race, *malabaricum*, I believe it represents an early wave of invasion which has become localized in the heavy rainfall area in the face of the advance of the later typical *radiatum* stock. The occurrence of typical *radiatum* in Ceylon and in southern India where it impinges closely on the present ranges of its two related races implies a secondary degree of adaptation by the typical race which has allowed it to spread south through drier, more lightly wooded

areas, from its potential land of origin along the base of the Himalayas. Presumably this spread is correlated with geologically recent postpluvial conditions.

2. *cuculoides*.

This species is found along the Himalayan chain from Murree in the west to Assam, the Indo-chinese, Malayan and Chinese subregions. It occurs at higher altitudes in the Himalayas than *radiatum* until the range of that species ceases in Bengal and Arakan. In Bengal *cuculoides* is found at lower altitudes and becomes a lowland and submontane as well as montane bird throughout the rest of its range. Thus it replaces *radiatum* ecologically east of the latter's range. An interesting correlation with the range of *cuculoides* is that it seems to be confined to areas with an annual rainfall of more than 60 inches. In addition the darkest race of the species, most saturated in tone of plumage, occurs in the area where the annual rainfall is more than 120 inches.

One anomaly in the range of *cuculoides* is that there is a discontinuous distribution of the species in the Malayan subregion. A race of *cuculoides* occurs in Tenasserim and Peninsular Siam, and then the species is absent from Malaya, Sumatra and Borneo, but occurs as a very well-marked race, *castanonotum*, in Java and Bali. Like *G. r. castanonotum* of Ceylon, this subspecies is marked by a rufous suffusion on the back, wing coverts, scapulars and rump, but in this case the larger size (wing 142-148.5 mm.) and the wider, coarser barring identify it closely with *cuculoides*. The similar plumage pattern in Ceylon and Java, however, is an interesting case of parallelism in response by the two species.

No valid explanation for this case of discontinuous distribution seems to exist. The original invasion of the Greater Sunda Islands by *cuculoides* stock was presumably pre-pluvial, but no outstanding environmental conditions occur to explain the absence of the species from Malaya or the other Greater Sundas. The only potential competitor would appear to be the smaller species, *Glaucidium brodei*, which, however, occurs not only in the gap area, but throughout a large part of the range of *cuculoides* from the western Himalayas to the Indo-chinese subregion.

SPECIATION TRENDS.

There are two main trends of differentiation in *Glaucidium cuculoides* which act independently. One is size, which follows the degrees of latitude or montane altitude in the traditional way expressed by Bergmann's hypothesis. The second is color which varies from brown to rufous in a random way without obvious correlation except in one case. There is apparently no selective advantage in shades of dark color in these semi-diurnal owls. Dimorphism is not marked as it is in *G. brodei*. In the case of *Glaucidium radiatum* there is some dimorphism, i.e., a more gray plumage, vide Whistler and Kinnear (*Journ. Bomb. Nat. Hist. Soc.*, 1935, 38, p. 238). In *cuculoides* some specimens seem more brownish or more rufescent than others, but I have not seen any specimens in which this is so marked as to prevent their identification.

RACES.

Peters (tom. cit., p. 133.), lists seven races of the species, but as Mayr notes (*Ibis*, 1938, p. 314.), there are several populations of varying color included in one or more of the existing forms, particularly *rufescens*. I would list, therefore, the following:

1. *Glaucidium cuculoides cuculoides* (Vigors).

This is a race lacking in rufescence; blackish-brown above and closely barred with fulvous, the bars on the upper back and nape rather broad and whitish. The wings are rufous-brown with rufous-fulvous bars, the scapulars and outer median wing coverts with white outer edges to the feathers, giving the appearance of spots (not shown in Gould's Plate 4, Century Birds, 1832.). The lower parts are whitish with dark brown and fulvous bars on the breast. The abdomen and vent areas tend to be streaked, more than barred, with light rufous brown.

Measurements:

N. Punjab and Nepal 11 ♂♂ and ♀♀

Wing	Tail	Culmen (from cere)
141-157 (149.5)	75-90 (83.5)	14-16 (15.4)

Range: western Himalayas from Murree and Musoorie through Nepal. Foothills to 6,000 ft.

2. *Glaucidium cuculoides austerum* subsp. nov.

Type: ♂ ad. (U.S.N.M. No. 390166.), collected Jan. 11, 1947, at Tezu, Mishmi Hills, N.E. Assam, by S. Dillon Ripley.

Description: above this race is dark rufous brown with rufous-buff bars. The tone of the wings is darker, richer rufous than in the other races of the species. The tail is blackish, the barring fulvous. Below the amount of basal white on the underparts is much reduced as the barring is heavy and complete on the breast and the bars are rufous buff rather than whitish or fulvous. The abdomen and vent areas are heavily streaked or barred or streaky-barred with dark rufous brown, darker than in any other race of the species.

There is an average size increase over *cuculoides*.

Measurements:

Sikkim to N. Assam, 16 ♂♂ and ♀♀

Wing	Tail	Culmen
148-156.5 (153.1)	81-94 (87.6)	15-16.5 (15.7)

Range: Sikkim, Bengal Duars, Bhutan, Assam north of the Brahmaputra, Mishmi Hills, and south in north Lakhimpur Division, Dibrugarh to Margherita, and into the upper Hukawng Valley of northwest Burma.

Remarks: birds from the Mishmi Hills are the most blackish in tone, but not sufficiently so as to distinguish them from the population of the rest of the range outlined above.

3. *Glaucidium cuculoides rufescens*

Stuart Baker.

This race is more pure brown, far less rufous than *austerum*, and with pure fulvous, less rufous fulvous, bars on the upper and lower parts. The population is, however, distinctly more rufous in tone than typical *cuculoides*. Below *rufescens* is barred and streaked with cinnamon brown, paler than *austerum*, but darker and with far less white showing than *cuculoides*.

Measurements:

Cachar, Burma, 8 ♂♂ and ♀♀

Wing	Tail	Culmen
148-156.5 (153)	85-91 (87.6)	15-16 (15.6)

Range: southeast Bengal, Assam in Cachar, Manipur north to the Patkoi, Burma in the Hukawng Valley (where it may intergrade with *austerum*, the Chin Hills, Myitkina, and south to Pegu and the Shan States.

4. *Glaucidium cuculoides brügeli* (Parrot).

In color there is no real character to separate this race from the preceding one. It is supposed to be less dark above and less rufous below, but I can find no real consistency in this claim. In series it might be asserted that *brügeli* is a trace more rufous on the under parts. There is however, a distinction in size. This race is smaller than *rufescens*.

Measurements:

Siam, 10 ♂♂ and ♀♀

Wing	Tail	Culmen
138-148.5 (144)	76.5-81 (78.7)	14.5-16.5 (15.6)

Range: Burma in Tenasserim; Siam except the southeast; and possibly (?) northern Cambodia, Indo-china.

Remarks: the type of *brügeli* is in Munich. Apparently it came from near Bangkok. However, the type locality has been fixed by Deignan (*Bull. 186 U. S. Nat. Mus.*, 1945, p. 179.), at the Sam Khok district, half-way between Bangkok and Ayutthaya. In this area birds represent the type described above.

5. *Glaucidium cuculoides delgnani* subsp. nov.

Type: ♀ ad. (U.S.N.M. No. 308542.), col-

lected Feb. 12, 1927, at Nongkhor, Southeast Siam, by Hugh M. Smith.

Description: This race is more rufescent on the upper parts than *brügeli* or *rufescens*, but it is a paler type of rufescence. The wing feathers and wing coverts are ferruginous-cinnamon. On the under parts the barring and streaking tends to be more extensive than in *brügeli* and *rufescens* and much more rufescent, but of a ferruginous-cinnamon type, less saturated with fulvous. There is no difference in size between this race and *brügeli*.

In color and in smaller size this race differs greatly from *cuculoides*, being ferruginous-cinnamon in tone and more barred and streaked below. From *austerum* it differs in size and in the cinnamon rather than dark fulvous-rufous coloration of the plumage.

Measurements:

S.E. Siam, S.W. Indo-china 8 ♂♂ and ♀♀

Wing	Tail	Culmen
145-151(148.1)	74-80.5(78.3)	14-16(14.7)

Range: southeast Siam, Nongkhor, Hoopon, Ban Sadet, Sriracha; southwest Indo-china, Da Ban, Dalat, Trang Bom, south Annam, and Bienhoa in Cochinchina.

Remarks: a single bird from the forests of Banteai Srei in northern Cambodia, taken in January, belongs to *brügeli*, although it is rather dark in tone. It may well be a winter wanderer from east Siam.

This race is named for my friend, Herbert G. Deignan.

6. *Glaucidium cuculoides delacouri* subsp. nov.

Type: ♀ ad. (U.S.N.M. No. 304182.), collected May 5, 1924, at Baetan Tray, 36 km. N.N.E. of Lai Chau, Tonkin, Indo-china, by F. R. Wulsin.

Description: this race is the most pure rufescent of all races of the species, darker and more rufous on the upper parts than any other except *austerum*, which is more saturated with dark fulvous, more blackish in tone. Below this race is heavily barred and streaked, more so than any race except *austerum*, in which the barring descends farther onto the abdomen. The general effect is of a suffusion of dark rufescence, richer rufous than in any other race. The rufous tone appears richer than in *austerum* because it is less infused with melanin, more truly "reddish." The bill is longer in *delacouri* than in the preceding races.

Measurements:

N. Indo-china 4 ♂♂ and ♀♀

Wing	Tail	Culmen
150-157.5(154)	86.5-92.5(89.4)	16-16(16.4)

Range: Indo-china in Tonkin, except the northern valley of the Red River (Chapa area), and the extreme east (Tunghing); northern Laos at Xiengkhouang; north Annam at Hoi-Xuan.

This race is named for my friend, Jean Delacour.

7. *Glaucidium cuculoides whitelyi* (Blyth).

This is the largest race of the species and lives in the northernmost part of the range. It is composed of more than one phenotypic population, but I have been unable to separate them on any satisfactory basis. Birds from the western and southern part of the range are darker, more rufous fulvous than birds from the northern and eastern segments of the range. In these latter the barring on the plumage seems paler fulvous in tone. However, lighter birds appear in the west in a declining ratio moving from east to west, just as dark individuals appear in the east.

Beneath, the underparts of this race show more white basally with less of an overlay of brown than any other race except typical *cuculoides*. The general tone of the barring and streaking on the underparts is dark brown.

Measurements:

China, N. Burma, N. Tonkin, 9 ♂♂ and ♀♀

Wing	Tail	Culmen
155-170(162.1)	87-107(96.3)	15-17.2(15.9)

Range: extreme northeast Burma on the Yunnan border (Nan Ling R.); China in Yunnan, southern Szechuan and east, south of the Yangtse River, to Kiangsu; Indo-China in northern Tonkin (upper Red River Valley), and the extreme east, Tunghing.

Remarks: the difference in color between individuals of *whitelyi* had been noted by Sharpe in 1875 (Cat. Birds, II, p. 222), who wrote that Fukien birds in the British Museum collection were more rufous than typical *whitelyi*. As the other specimens listed are from Ningpo, I think it advisable to restrict the type locality of *whitelyi* to Chekiang Prov., eastern China. There is, of course, a possibility that dimorphism in color is developing in this subspecies as it has not apparently developed in other members of the species. However, the general appearance of the series from any one locality, their basic uniformity, tends to discount this possibility.

Many of the previous authors have relied on the number of tail bars in this species as a racial character. There does seem to be a tendency for birds from China to have one less bar on the tail than birds from India (6-7 versus 7-8). This is an uncertain character, however, for birds from intermediate areas like Burma and Assam vary from 6 to 9!

8. *Glaucidium cuculoides persimile* Hartert.

In color this race is more brownish, less rufous above and below than *delacouri*, and smaller and more rufous than *whitelyi*. In general appearance it is very similar but very slightly more rufous than *rufescens*. The culmen, however, is somewhat longer.

Measurements:

Hainan 9 ♂♂ and ♀♀

Wing	Tail	Culmen
148-156(153.3)	85-90(88.1)	16.5-18

Range: Hainan Island.

9. *Glaucidium cuculoides castanopterum*
(Horsfield).

A dark brownish-rufous form with a strong rich rufous suffusion on the back, upper wing coverts, scapulars and rump. In these areas the barring has become obsolete. A distinctive isolated race.

Measurements:

Bali, 2 ♂♂

Wing	Tail	Culmen
142,148.5	70,77	14.5

Range: Islands of Java and Bali.

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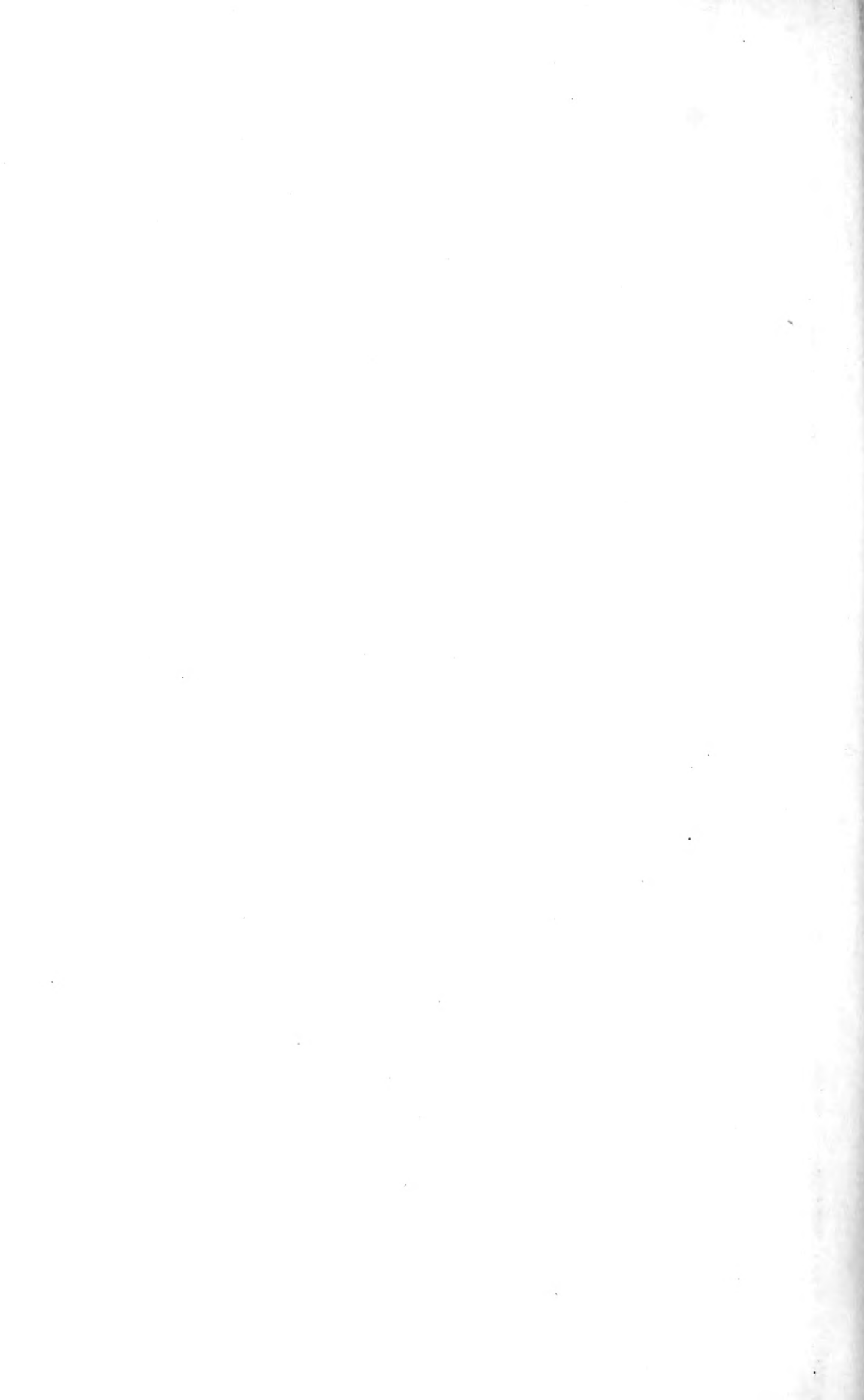
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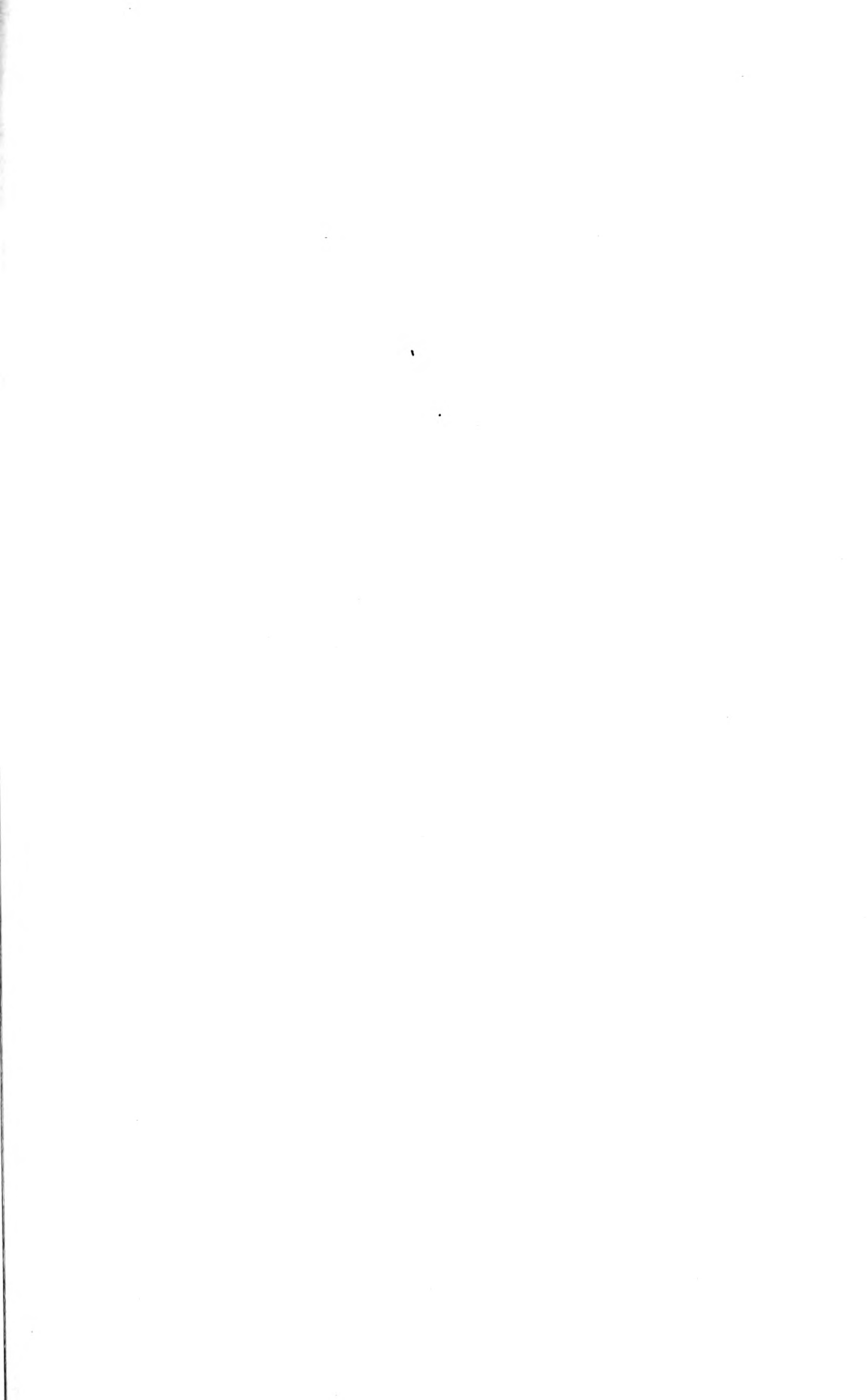
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