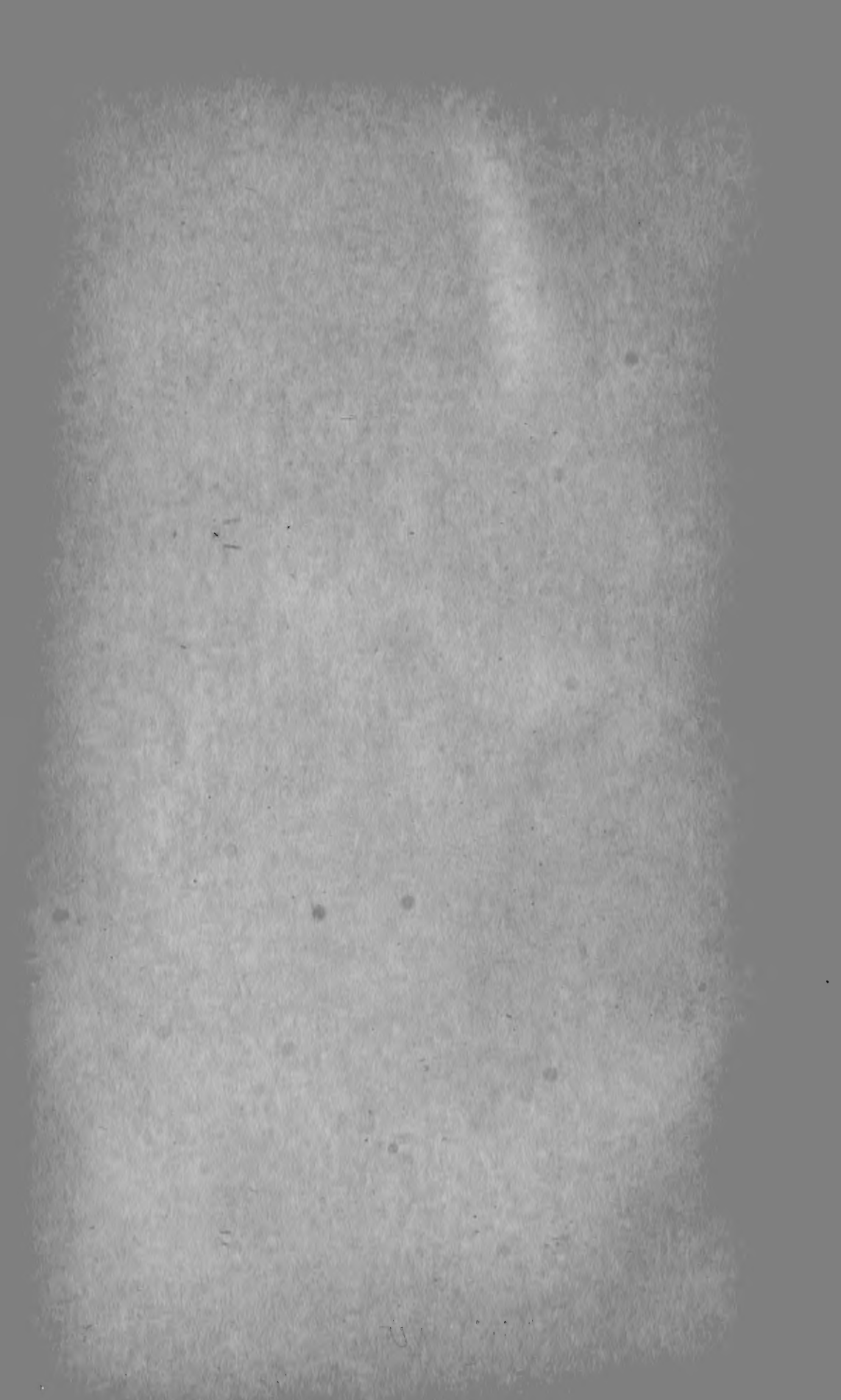


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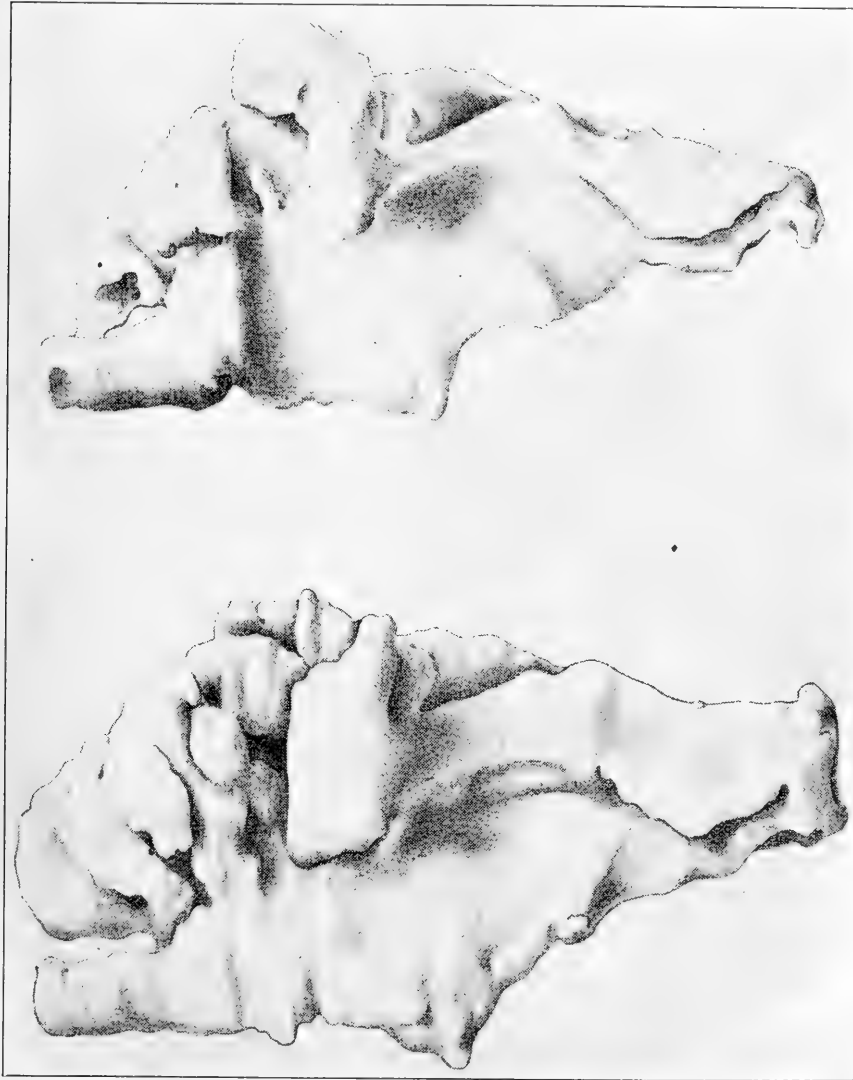
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A Model of the Nasal Chamber of a White Mouse at Birth

Ida Merrill and Eugenia Schoonover

Two models were made by the blotting paper method. In one of these the outer portion of the epithelium was taken as the outer limit and the lining of the cavity as the other. The other model was built from the plates which were cut from the interior of the



Upper figure model of the cavity, from outside.

Lower figure model of epithelium from outside. Both figures X40.

model. The larger model gives a picture of the mucous membrane and the nasal chambers, the smaller shows the shape of the nasal chamber. The knob on the inner side of the larger model is Jacobson's organ. The drawings are by Elizabeth Keyes.

(Contribution from Zoological Laboratory of Pomona College.)



Upper figure section of the model of epithelium.

Lower figure model of epithelium from the outside. Jacobson's organ, the little elevation in the lower center. X40.

The North American Species of *Mimetus*

By Ralph V. Chamberlin

In his "Araneides of the United States," Hentz describes three species under the genus *Mimetus*; namely, *interfector*, *tuberosus* and *sylllepsicus*. Of these three *sylllepsicus* has not since been definitely identified, while *tuberosus* is generally regarded as a synonym of *interfector*, a disposition with which no fault can be found. In 1882 Emerton described a male from Connecticut under the name *M. epeiroides*; but the practice in recent years has been to refer all individuals of the genus found in the United States to one species, *interfector*, and, accordingly, in current catalogues *epeiroides* has been placed in synonymy with that species.

However, a careful study of ample material of *Mimetus* from various parts of the country reveals that there are at least five clearly distinct species that have been confused under the name *interfector*. One species occurs on the Pacific Coast apparently from Washington to southern California and eastward to Texas. Two species occur in the Northeastern States, the commoner of these ranging southward as far as northern Georgia. The other two species are common in the Southern States; and one of them is found as far northward as Long Island, N. Y. It seems reasonably certain that it was one of these two southern forms that was described by Hentz as *interfector*, the particular one being fixed, it is believed, by the figure of the palpus as indicated later in the notes on the species. *Tuberosus* is left as a synonym of *interfector*; but *sylllepsicus* cannot be placed at present and is apparently different from any of the five species here listed.

The males of these five species are easily recognized by the characters presented in the palpus, the armature of the ectal margin of the cymbium providing a convenient index. Another readily observed character of diagnostic importance occurs in the terminal portion of the bulb which in the retracted organ lies adjacent to the base of the embolus and presents typically two flat or lamellar lobes projecting proximad. In one species (*notius*) one of these lamellar lobes is aborted and in another (*puritanus*) the second lobe is itself partly divided or bilobed.

The four species of which females are known may be separated in that sex by the characters of the epigynum, which is in the form of a strongly chitinized, transversely furrowed, caudally projecting lobe. At the caudal end of the epigynum, or near it on its dorsal side, is an opening or pit and cephalad or proximad of this on the dorsal side is a separately chitinized median longitudinal piece or strip. The position and form of this epigynal opening or pit, the size and position of caudal end of the median dorsal strip,

and the form and position of the spermathecae as revealed in cleared specimens furnish good diagnostic characters.

Adults of the species here listed may be identified by means of the following keys in conjunction with the accompanying figures of palpi and epigyna.

Key to Males

- a. Ectal margin of cymbium of palpus with no chitinous, spiniform process proximad of the curved or bent apical one.
- b. Ectal border of cymbium with an elevated and sharply limited lobe at caudal end of scabrous portion of margin, the surface of the lobe covered with minute prickles; bulb with two apical lamellar lobes (Fig. 5) *M. intersector* Hentz
- b.' Scabrous portion of ectal margin of cymbium not ending caudally in any such sharply defined lobe; apical portion of bulb bearing only one developed lamellar lobe, the ectal one being aborted and at most represented by a minute tooth (Fig. 4) *M. notius* sp. nov.
- a.' Ectal margin of cymbium with one or two chitinous processes or spines proximad of the apical one.
- b. With only one spine on margin of cymbium proximad of the apical one, this toward the base; border scabrous from apical to basal spine (Fig. 3) *M. epeiroides* Emerton
- b.' With two spines on ectal border of cymbium proximad of the apical one of which the more distal one is sometimes weak; margin scabrous only from apical spine to the more distal marginal one.
- c. Proximal marginal spine contiguous, or nearly so, with basal lobe or auricle of cymbium; apical portion of bulb with neither lamellar lobe at all subdivided or presenting processes (Fig. 2) *M. hesperus* sp. nov.
- c.' Proximal marginal spine well removed from basal lobe of cymbium; apical portion of bulb with the larger, more mesal, lamellar lobe partly subdivided, being extended at its mesodistal corner (Fig. 1)
..... *M. puritanus* sp. nov.

Key to Females.

- a. The opening or pit located at extreme caudal end of epigynum and visible in ventral view, the end in this view appearing notched at the middle; median dorsal strip extending nearly to caudal end of epigynum *M. puritanus* sp. nov.
- a.' The pit is on the dorsal surface just proximad of caudal end of

epigynum and thus not visible from below, the end not appearing notched at middle; dorsal strip ending considerably proximad of end of epigynum.

b. Opening with no tooth or process from each lateral margin, not thus partially subdivided; spermathecae essentially longitudinal; dorsal strip broader (Fig. 10)
.....*M. notius* sp. nov.

b.' Opening partly divided into a distal and proximal portion by lateral processes; caudal portion of spermathecae bent at right angles, a distinct enlarged anterior and posterior portion being connected by a narrower isthmus; dorsal strip narrower.

c. Lateral margins of epigynum not indented; isthmus of of spermathecae narrower, curved, concave ectally.
.....*M. interfector* Hentz

c.' Lateral margins of epigynum indented near level of caudal ends of spermathecae; isthmus of spermathecae thick, straight (Figs 7 and 8)*M. hesperus* sp. nov.

Mimetus hesperus sp. nov.

In the male of this species the ectal margin of the cymbium of the palpus bears two conspicuous black spines proximad of the apical curved one as in *puritanus*; but in the present species the more proximal of these spines is in the re-entrant angle above basal lobe or auricle, whereas it is distinctly distad of this position in *puritanus*. A readily noted difference in the bulb is that the larger lobe at apex of bulb is entire in *hesperus*, with no separate process from inner distal corner as in the eastern form; and between this lobe and the conductor there are two folds of conical outline not present in the latter species (Cf. fig 2). The female differs conspicuously in not having the epigynal opening terminal and thus producing a median notch when viewed from below. The epigynum in its structure most resembles that of *interfector*, but differs in outline and in the form of the spermathecae (Cf. figs. 7 and 8).

Type Locality.—California: Claremont. Type, a male, M. C. Z. No. 530.

Other Localities.—California: Stanford; Washington: Camp Umatilla; Utah; Texas: San Antonio, Austin.

Mimetus puritanus sp. nov.

Mimetus interfector Emerton (nec. Hentz), Trans. Conn. Acad. Sci., 1882, 6, p. 16, pl. 3, fig. 3.

Mimetus interfector Keyserling (in part, including those figured), *Spinnen Amerikas*, Theridiidae 2, 1886, p. 6, pl. 11, fig. 137.

This species is in the female sex at once distinguishable from all the others in having the epigynal pit at the caudal apex and visible as a median notch from below (Fig. 6). The male may be separated from the other species occurring in the eastern and southern States by the presence of two subapical spines on the ectal margin of the cymbium; and from the western *hesperus*, as indicated above, by the position of the more proximal of these spines and the form of the larger lamellar lobe of the bulb, which is unlike that of any other species (Fig. 1).

Type Locality.—New York: Ithaca. Type, M. C. Z. No. 535, a male.

Other Localities.—New York: Long Island, Sea Cliff; Maine: Ogunquit; Mass.: Ipswich, Plymouth; Conn.: New Haven; Virginia: Great Falls, Falls Church; Georgia: Thompson's Mills.

Mimetus epeiroides Emerton

Trans. Conn. Acad. Sci., 1882, 6, p. 17, pl. 3, fig. 4.

Known only from the male which is clearly distinct from the other species in characters of the palpus. In this the ectal margin of the cymbium possesses a single spine toward the basal lobe, in distinction from the two preceding species in which there are two spines on the margin, and from the two following ones in which there is no marginal spine proximad of the distal one. The ectal border is scabrous over its entire length from apex to basal spine. The terminal portion of bulb bears two lamellar lobes, both of which are simple.

Type Locality.—Mass.: Essex.

Immature specimens referred to this species have also been taken by Mr. Emerton at other places in eastern Massachusetts and at Providence, Rhode Island.

Mimetus interfector Hentz

Journ. Boston Soc. Nat. Hist., 1850, y, p. 3, pl. 4, fig. 12, 13.

Mimetus tuberosus Hentz, *ibid.*, p. 3, pl. 4, fig. 14.

Of each of the two species of *Mimetus* occurring commonly in the southern States, individuals may be found which match the figures of *interfector* given by Hentz reasonably well. I believe the species to be fixed, however, by the figure of the palpus of the male which, in spite of its general inadequacy, shows two prominent lobes projecting proximad from the bulb that are apparently the two lamellar lobes present in the one species, whereas in the other species, listed below as *M. notius*, sp. nov., there is but a single

lamellar lobe. In the species thus considered to be fixed as the true *interfector* of Hentz the ectal margin of the cymbium lacks spines; the scabrous border ends proximally abruptly in a lobe elevated above the general surface and on which the area of prickles is broader, a very characteristic feature enabling one to detect the species at a glance (Fig. 5). The form of the opening of the epigynal pit is similar to that of *hesperus*, being partly subdivided by a projection from each lateral margin and thus differing from that of *notius*. The spermathecae also present a caudal and an anterior larger lobe connected by a narrower, weakly curved, isthmus.

Type Locality.—Alabama.

Other Localities.—Alabama: Morgan, Birmingham; Georgia: Atlanta; Louisiana: Shreveport, Covington, Shrewsbury; North Carolina; New York: Sea Cliff.

Mimetus notius, sp. nov.

In this species the opening of the epigynum lacks projections from its lateral margins, and the median dorsal strip is broader and more conspicuous than, e. g., in *M. interfector* or *M. hesperus*; the spermathecae are essentially longitudinal as shown in fig. 10. The male differs from all the others here considered in having on the distal portion of bulb of palpus only a single lamellar lobe, the ectal one being absent or represented only by a slight tooth at base of the developed lobe. The ectal margin of the cymbium lacks spines proximad of the apex and its scabrous border runs out gradually, not ending in any such abruptly elevated lobe as occurs in *interfector*.

Type Locality.—Runnymede. Type, a male, M. C. Z. No. 551.

Other Localities.—Florida: Altoona, Daytona; Louisiana: Shreveport, Mansura; North Carolina: Raleigh.

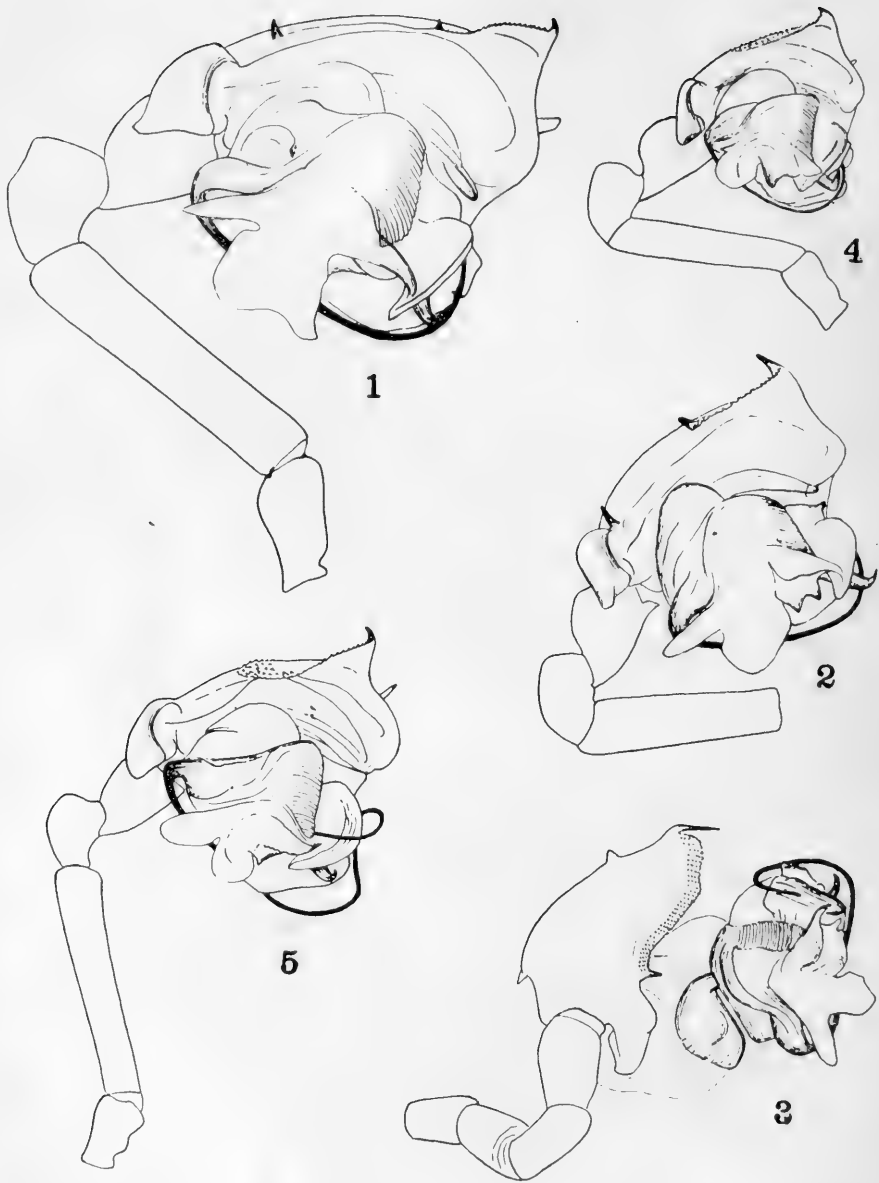


Fig. 1. *Mimetus puritanus* sp. nov. Right palpus of male, subectal view. 2. *M. hesperus* sp. nov. Right palpus of male, similar view. 3. *M. epeiroides* Emerton. Right palpus of male (type) from a more dorsal aspect, the hematodocha distended. 4. *M. notius* sp. nov. Right palpus of male, subectal aspect. 5. *M. interfector* Hentz. Right palpus of male, subectal aspect.

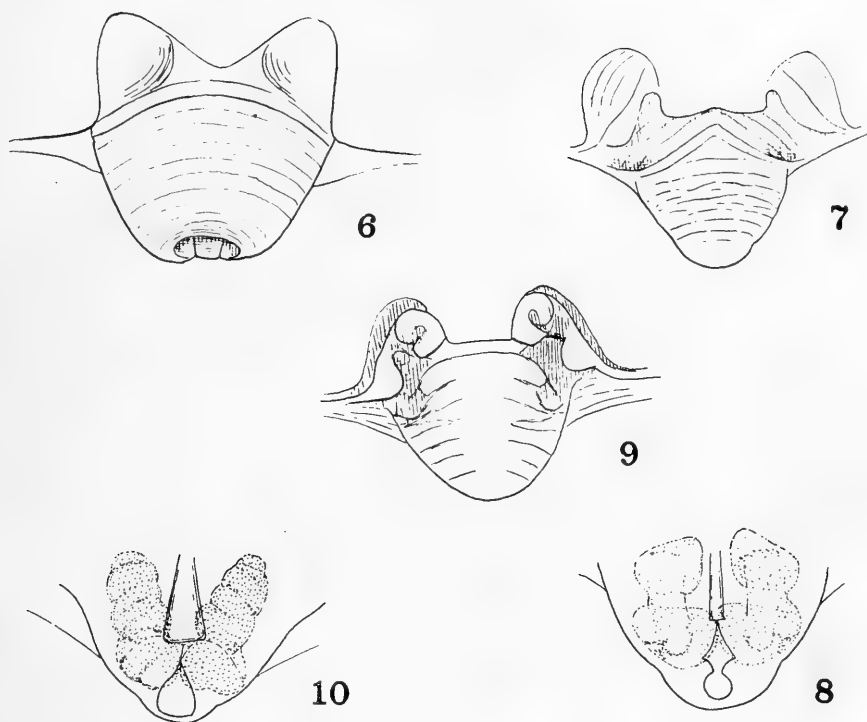


Fig. 6. *Mimetus puritanus* sp. nov. Epigynum, ventral view. 7. *M. hesperus* sp. nov. Epigynum, ventral view. 8. *M. hesperus* sp. nov. Epigynum viewed from above by transmitted light, showing opening, dorsal strip, and the spermathecae in silhouette. 9. *M. interfector* Hentz. Epigynum in ventral view. 10. *M. notius* sp. nov. Epigynum viewed from above by transmitted light to show form of opening and of dorsal strip and the spermathecae in silhouette.

XII. Enteropneusta

For our general knowledge of the central nervous system of this group we have the papers of Spengel, 1884-1894, Bateson, 1886.

Of the development of the nervous system and the larvae the work began in 1870 with the study of the so-called Tornaria larvae. Bateson, 1884-5, worked out the life history of a *Balanoglossus* form and later Spengel, '94 and Morgan, '91 and '94 gave an extended account of the Tornarian forms, including a good account of the nervous system. Ritter, '94 and Davis, '08, gave stages in the development of Tornaria and *Dolichoglossus*, and Herder, 1909, also gave an account of development in which the nervous system was included.

In various accounts of the position and structure of the nervous system especially as summarized in text books and other places, there seems at times to be some difference in the descriptions but I think for the most part the differences are in the way of expressing much the same idea so that no real difference is introduced.

In all cases the nervous system is as a whole epidermal much as in *Phoronis* and in starfish. The epithelium everywhere is more or less made up of columnar cells at the surface with a deeper nervous layer of fibers, in part branches from the surface cells, and a few deeper cells. In places the epidermic nervous system is more marked. The whole body then might be described as covered with a plexus of nerve cells and fibers; the thicker parts of the plexus in places form the so-called nerves. The chief nerves of this sort are a dorsal and ventral tract in the body region below the collar with a circular band connecting these at the lower edge of the collar, and a concentration of fibres about the base of the proboscis, but the greater concentrations are in the collar itself. In the dorsal and ventral surfaces of the collar just under the epidermis is a concentration of nerve cells and fibers but the chief and central concentration of nervous tissues is in the form of a thicker cord running through the cavity of the collar on the dorsal side, although connected with the epidermis at each end. This central nervous system is continuous with the proboscis thickening in front and as just described, with the dorsal and circular nerve tracts behind.

To summarize, the nervous system may be described as follows:

1. General epidermal plexus continuous with other parts.
2. Basal proboscis ring continued into the proboscis by a more diffuse band.
3. Ventral body nerve continued into ventral collar as a thin layer.

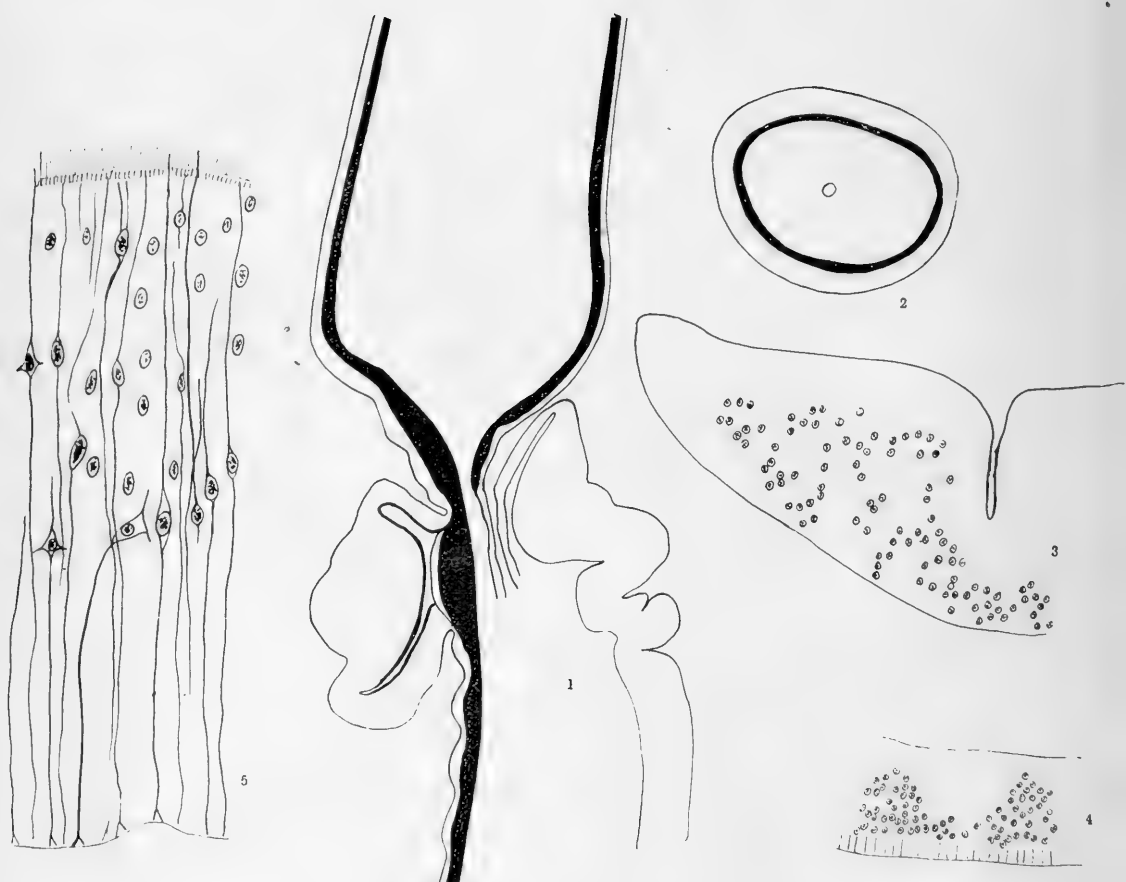


Fig. 25. Diagrams to show the position of the nervous system in *Dolichoglossus*. Nervous system shown by heavy lines below the surface.
 1. Longitudinal section. 2. Cross section through the proboscis.
 3. Central portion much enlarged. 4. Another part of the surface.
 5. Neural epithelium much enlarged.

4. Dorsal collar nerve somewhat cut off from the two following.

5. Dorsal proboscis nerve continued above.

6. Central nervous system running through the central region of the collar on the dorsal side and continuous above with the proboscis nerves and below the collar with the dorsal body nerve.

The dorsal nerve of the collar and the thick central nervous system of the collar are more or less joined by the strands and they together make a sort of nerve tube thin on the dorsal side but thick below.

The histological structure of the nervous system reveals besides the usual epithelial cells of the surface, bipolar supportive

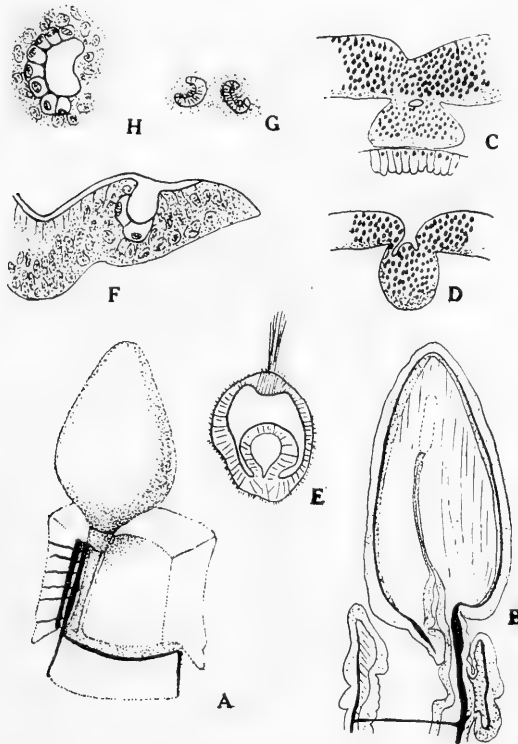


Fig. 24. Nervous System and Sense Organs of Enteropneusta. A. Diagram of *Balanoglossus* showing position of the nervous system. B. Another diagram of *Balanoglossus* in sectional view. Spengel. C, D. Sections of developing nervous system. Morgan. E. Larva after Herder. F. Apical eye of tornaria larva. Spengel. G. Eyes of *Tornaria* after Morgan. H. Eye of *Tornaria* after Spengel.

cells reaching from the surface to the depths of the nervous system and also probably bipolar sense cells as well as more or less deeply placed multipolar nerve cells giving off fibers to the nerve areas.

The epidermis is a general organ of sense, the exact nature of which has not been very clearly determined. Spengel considers that about the proboscis in its ventral face there are points especially sensitive. In fact at this place he describes a deep depression which he regarded as a special sense organ.

In the larval stage the first suggestion of a nervous system we find in the development of the apical plate which in later stages develops eye spots as simple caps of ectodermal cells surrounded by pigment. The eye spots become anterior in position with a pocket of the clear cells each ending in a point. Between the two eye-cups a mass of pigment develops. At the base of the apical plate nerve fibers begin to be seen.

At metamorphosis in a region where the collar will develop a transverse groove forms near the mid-dorsal line. In the mid-dorsal region a strip of ectoderm not crossed by grooves makes the beginning of the neural plate. It sinks beneath the surface and folds of the adjacent ectoderm or neural folds meet over it, and in this way the neural tube is formed.

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XIII. Cephalodiscus and Rhabdopleura

CEPHALODISCUS. The first report on this animal including a sketch of its anatomy was by McIntosh, 1887, and later by Lang, 1890, and Harmer. Delage and Herouard, 1897, summarize the knowledge of the nervous system about as follows:

The nervous system is a thickening of the epidermis on the dorsal surfaces of the tentacles. The histological nature of the nervous system was a little studied, but cells and fibers under the epithelium as in echinoderms were described.

Mastermann, 1903, describes the central ganglion over the sub-neural blood sinus; its position is as in *Actinotrocha*. This gives off below a pair of large nerves each of which divides into six branches for the six pairs of tentacle arms. Above it is prolonged

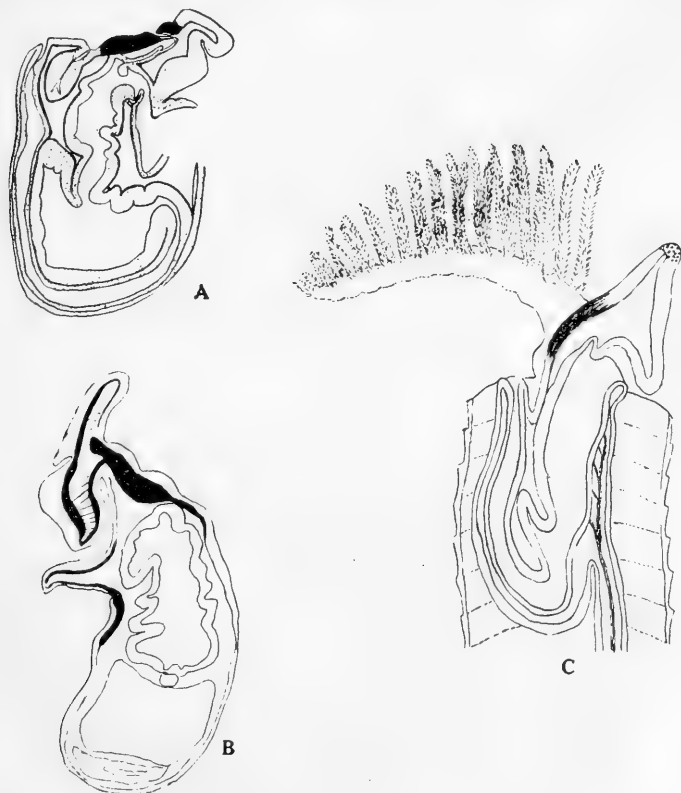


Fig. 26. A. *Cephalodiscus* showing location of the nervous system after Hammer. B. *Cephalodiscus* after Masterman. C. *Rhabdopleura* showing position of nervous system after Delage and Herouard.

into two large branches which follow the dorsal line of the epistome. Laterally from the ganglion two other nerve branches go to the epistomal disc. On the ventral surface of the trunk is a medial longitudinal band which is continued into the peduncle. According to Mastermann the mid-dorsal and two lateral epistomal branches have homologues in *Balanglossus* and *Actinotrocha*.

RHABDOPLEURA. The account of the structure of *Rhabdopleura* which is usually given is that of Fowler, 1892. Other accounts which however give little of the nervous system are those of Allman, 1869, and Lankester, 1874.

The central nervous system is represented by a thickening of the ectoderm in the median region of the neck below the nuchal pore between the branches of the tentacles. There is a differentiation of nervous tissue much as in *Rhabdopleura* or *Balanoglossus*. A black pigment spot is located at the tip of the preoral lobe and may be an eye-spot.

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Notes on the Early Stages of the Syrphid Genus *Microdon* (Diptera)

By Frank R. Cole, Stanford University

The peculiar larvae of the Syrphid flies of the genus *Microdon* have been described by several entomologists, but they are known in only a few species. Enthusiasts in past years placed these bizarre forms among the molluscs in two or three instances, and one entomologist stated that they were the early stages of a Coccid on oaks. Wheeler has given a very interesting account of some of these early stages and the habits of the flies. In America the larvae are recorded only from ants nests, but Wasmann states that they may be found in the nests of certain wasps and termites. They live in nests in the soil, under rocks or under the bark of old logs.

The larvae creep very slowly, with a wave-like motion of the flat ventral sole, which is fringed and applied closely to the surface over which they are travelling. Their food is probably, as Wheeler believes, the minute pellets of food ejected from the hypopharyngeal pockets of worker ants after the moisture has been extracted. There is evidently one brood in a year, the flies emerging in May and June.

In May, 1917, the writer found a number of pupae of *Microdon cothurnatus* Bigot, while collecting in the Hood River Valley of Oregon. The type of this species came from "Mt. Hood," probably somewhere in the valley north of the mountain. While pulling off the bark from an old pine log an ant's nest was uncovered, and among the frenzied inhabitants of the nest a number of *Microdon* pupae were noticed. The ant was later determined as a subspecies of *Camponotus maculatus*. At this date, May 19, there were no larvae of the fly present and the pupae were all fully developed. Eighteen pupae were taken, most of them rather closely crowded near the entrance to the nest; all around them were empty puparia, bearing evidence that the nest had been used for several seasons by the flies. There were several adult flies around the log, some of them freshly emerged, but the ants were so aroused at the disturbing of their domestic tranquility that they quickly drove out any strange insect that came near. The puparia taken were allowed to become too dry and only two adults emerged out of the lot.

In April, 1921, some observations were made on another species of *Microdon*. A student at Stanford University, Mr. Herbert Mason, found a single larva in a nest of *Camponotus maculatus vicinus* Mayr. This specimen was reared by Mr. Carl Duncan and the specimen and notes regarding it kindly turned over to the writer. The species proved to be *Microdon piperi* Knab, a beautiful dark blue species which ranges north along the Pacific coast region.

The larva was not closely examined by the writer, but in the notes made on the specimen the color was given as largely pale

bluish green, with median ridge and the margins of the body brown. The median ridge was quite prominent in the larva. The coarse reticulum on the body has a pattern somewhat like that figured for *M. tristis*, as can be seen from the figure. The length was 11 mm.

The puparium shortens to about 9 mm. The reticulum is much more distinct than in the larva and two prothoracic tubercles push out (in the specimen described one of the tubercles did not push through the body wall). The reticulation is arranged in a more or less symmetrical design and when examined under a high magnification is seen to be made up of two types of processes; those on the dorsal ridge and along the sides just above the fringe are of a shape which might be likened to an inverted wine glass and the other processes are quite short and composed almost entirely of the white stalked portion (see figs. 6 and 7). The base in both cases is dark brown and the apical portion white. From above the body appears to be covered with white discs arranged in a reticulated pattern, the center of each disc with a depression and a minute cavity which appears to penetrate almost or quite through the body wall. These minute structures may function as pores. The anterior margin of the ventral fringe of the body is deeply notched in the middle as shown in figure 4. The structure of the marginal fringe is shown enlarged in figure 8. The fly emerges from the puparium by breaking off the cover in three rather symmetrical pieces, illustrated in figure 2.

The specimen described was taken the last of March and soon commenced to pupate, the puparium being fully colored by April 8. The adult emerged just a month later.

Wheeler notes that the most typical and frequent hosts of the *Microdon* larvae are ants of the genus *Formica* but Wasmann has recorded a species of *Camponotus* in Madagascar as a host.

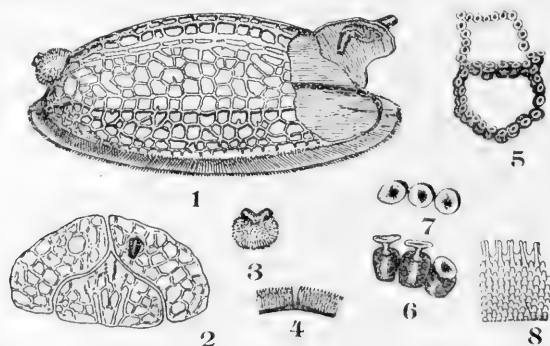


Fig. 1. Puparium of *Microdon piperi* Knab; 2, anterior portion of puparium, showing symmetrical breaking; 3, posterior respiratory tubercle; 4, marginal fringe of puparium, showing split in anterior region; 5, reticulations of two kinds, those with a short, and those with a high base; 6, and 7, portions of the reticulations more highly magnified; 8, marginal fringe, greatly magnified.

Notes on California Bombyliidae with Descriptions of New Species

Frank R. Cole, Stanford University, Cal.

The sun-loving Bombyliidae have always been a favorite group with the writer, as the rather abraded specimens in his earliest collections will bear evidence. California is rich in species of these flies and notes on a few of the interesting forms are given below.

During the past two summers the writer has spent some time in Mill Creek Canyon in San Bernardino County. *Paracosmus morrisoni* O. S. is a very common form in this locality and is usually taken along roads and paths in the bright sunlight. *Aphobantus vittatus* Coq., a trim, beautifully marked little species, occurs along with the above, but is not so common and is often harder to catch. *Villa squamigera* Coq. and *Villa mira* Coq. are not uncommon in the Mill Creek region, the latter species more abundant in August, when it is found out in the sandy river washes. *Villa miscella* Coq. is seldom seen and is quite wary, flying up and down sandy roads for long distances when disturbed. In Glen Martin, in this same general region but at a higher altitude, one occasionally finds *Rhabdoselaphus setosa* Cresson, a little species with a very long proboscis; it is usually taken on the wing in the middle of the day, hovering near the ground. With the first days of autumn specimens of *Villa autumnalis* Cole begin to appear, frequenting the yellow flowers of *Ericameria* and *Chrysothamnus*, and now and then a specimen of the beautiful golden *Lordotus diversus* Coq.

Villa chromolepida new species.

Female. Length 7 mm. Black, clothed with bright iridescent scales; front tibiae without bristles; wings hyaline.

Head rather large in proportion to the body; proboscis pointed and scarcely projecting beyond the oral margin; palpi small, black, cylindrical and black pilose. Antennae black, first joint about twice as long as second and with black pile; third joint twice as long as first two combined and gradually tapering toward apex (see fig. 9), the apical bristle minute. Frons shining black, with erect black pile and sparse golden scales which are purple in certain lights. Face projecting (see fig. 10), shining black, with scales like frons but denser, pile short, black, reclinate. Cheeks shining black, bare of pile or scales. Occiput black, densely clothed with scales like those on face and frons; next the hollowed out back of the head a line of short, fine, yellowish pile.

Mesonotum and scutellum shining black, with golden green scales, purple by reflection; the median portion of dorsum with

erect blackish pile, the front and margins with white pile, stiff and erect just back of the head. Pile of scutellum sparse and white. Pleura shining black, with rather long, dense white pile on the upper mesopleura, the lower part of mesopleura and other pleural plates with sparse black pile, not obscuring the ground color; stiff, blackish bristle-like pile above front coxae. The coxae and pleura with a few scattered iridescent scales. Stem of halteres yellow, the knob white, with a black mark on anterior margin; tuft of pile before halteres largely yellow.

Abdomen black, with erect white pile on sides of first and on anterior corners of second segment; beyond this the pile is very sparse, black, reclinate and scarcely noticeable. On each side of posterior margin of first visible tergite some scales like those on thorax; on the other abdominal tergites and sternites there is a dense covering of tomentum or scales, largely colored like those of thorax and in a definite design on dorsum; in the center of each tergite beyond the first visible one a round spot with sparse black scales, on each side a larger oval spot covered with black scales which have a purplish color in some lights; these lateral spots missing on seventh segment, which is almost wholly covered with iridescent scales. The venter black, with a wide median portion clothed with black tomentum, the sides with iridescent scales as on the more or less telescoped, the last two segments scarcely visible; color of pollen and pile as in male. Apices of femora an ochre dorsum. Femora and bases of tibiae brownish yellow, the rest of legs black; all the spines and pile of legs black, front tibiae without bristles, the anterior tarsi with claws almost as large as on the other tarsi; femora with a few yellowish, iridescent scales and some black ones; tibiae and tarsi with black scales. Wings hyaline, iridescent; the costa and veins at base yellowish, toward posterior margin black; fork of radius rather angular at base. The epaulets with purplish iridescent scales.

Holotype, a female, collected in Mill Creek Canyon, Cal., July 20, 1920 (F. R. Cole), in the collection of the California Academy of Sciences.

The type female is the only specimen known and is not closely related to any species seen by the writer. In Coquillett's table of species it would run to *mercedis*. It is distinct from any described Mexican species.

Amphicozmus vanduzeei new species.

Female. Length 6 mm. A slender species, the body largely shining black, the legs yellow.

Upper two-thirds of frons black, including the large ocellar tubercle, the lower third yellow; pile sparse, fine, white, the narrow orbits silvery pollinose. Face short, projecting, the central portion shining black, sides yellow and with silvery pollen; antennal foveae

deep and connected; first antennal joint slightly longer than second, yellow; second and third joints black, the third joint about as long as the first two combined, narrower (see fig. 6), with a short sub-apical style. Vertex and upper occiput rather full (see fig. 7), black, the lower occiput and cheeks yellow, occiput largely silvery pollinose, the pile minute and whitish.

Mesonotum and scutellum shining black, the pile on median portion of mesonotum and on scutellum short, blackish, on margins of mesonotum white. Humeral callosities yellow, silvery pollinose; a silvery pollinose, white pilose spot just back of humeri. Prescutellar callosities partly yellow. Pleura shining black, the upper mesopleura, the metapleura and hypopleura silvery pollinose and white pilose. Halteres white.

Abdomen largely shining black, rather broad posterior margins of all segments yellowish; apical half of seventh visible segment lemon yellow; yellow on first segment reaches lateral margins, on the second to sixth segments it does not do so. Pile of abdomen very fine, sparse, white, longer on sides of first and second. Venter largely brownish yellow, blackish at base, lemon yellow on genitalia. Femora, tibiae, first tarsal joint, apex of fifth and base of claws honey yellow; third and fourth tarsal joints, apex of second and base of fifth blackish. Coxae and trochanters colored like femora, a black spot below on base of trochanters. Wings hyaline, all veins yellow at base, toward apex and posterior margin blackish. All cells on posterior margin of wing wide open (see fig. 8).

Holotype, a female, collected at Palm Springs, Cal., May 20, 1917 (E. P. Van Duzee), in collection of California Academy of Sciences. The type a unique.

This species differs from *elegans* Coquillett in having the first antennal joint yellow and in the greater extent of black on the abdomen. Coquillett gives no structural characters to distinguish his species. The above described species differs from *cincturus* Williston, from Mexico, in the smaller size and in the color of the antennae and legs, *cincturus* having entirely black legs.

Metacosmus nitidus new species.

Female. Length 5.5 mm. Head black, a small amount of yellow on sides of oral margin. Ocellar tubercle slightly above middle of frons but the lower ocellus nearly in the center; upper half of frons with white pile, the lower part with black; frons shining black, the narrow orbits silvery pollinose. Antennae black, rather short and thick, the second joint larger than first (see fig. 4). Upper face and lower frons near base of antennae silvery pollinose; face short, shining black, distinctly projecting. Occiput thinly gray pollinose, short, sparse white pilose; on the under side, back from mouth opening, an oval yellow spot on each side of middle. Proboscis not projecting beyond oral margin.

Thorax shining black, the dorsum with short, sparse white pile; scutellum shining black, with short white pile. Humeral callosities and lower half of pleura gray pollinose. Stem and under part of knob of halteres blackish, the most of knob white.

Abdomen shining black, finely punctate and with short, sparse whitish pile; hind margins of visible segments one to four narrowly yellowish white, broader on the first. Abdominal pile appears white in certain lights but is largely dark colored. Sternite of seventh segment projects downward in a noticeable triangle as seen in profile. Pile around genitalia rather dense and whitish. Venter black, the hind margins of first five segments yellowish white. Legs wholly black, the pile fine and short. Wings hyaline, rather broad and rounded, the veins black and strong; R2+3 curved slightly forward at tip (see fig. 3).

Holotype, a female, collected at Huntington Lake, Fresno County, California, 7000 feet, July 15, 1919 (E. P. Van Duzee), in the collection of the California Academy of Sciences.

Paratypes.—Two females, taken in the type locality, July 8, 1919, by Mr. E. P. Van Duzee.

This species is evidently near *M. exilis* Coquillett, but differs in the color of the legs and in the wing venation. The only other species in the genus is *mancipennis* Coquillett an eastern form, which has the face and the stems of the halteres white.

Acreotrichus maculipennis new species.

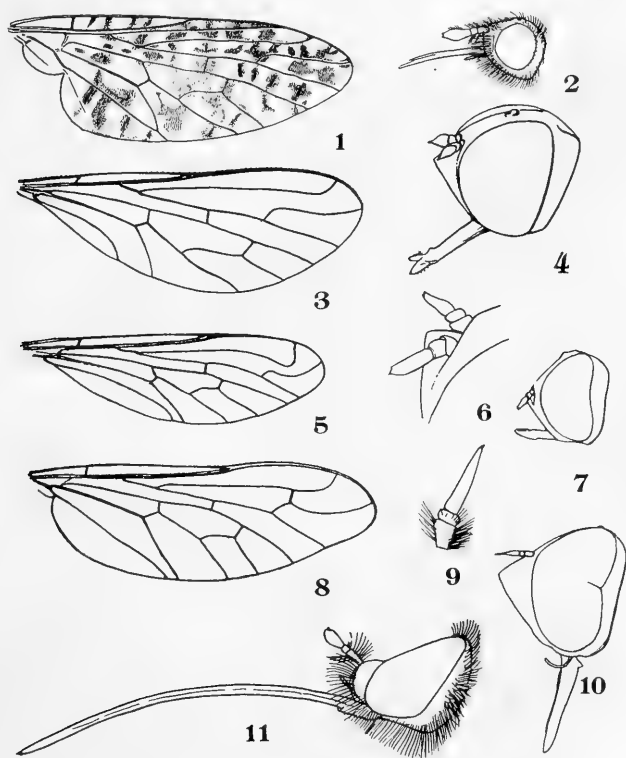
A velvety brown species with thickly spotted wings; the proboscis slightly longer than the head.

Male. Length 4.25 mm. Head black, brownish pollinose, the face and vertex with rather long and erect black pile. Occiput rather flat; occiput and cheeks with black pile. Oral opening large, the antennae placed on the upper edge (see fig. 2); first and second antennal joints rather slender, the first slightly longer than the second, the third slightly longer than the first two combined and considerably widened near the middle, the style short and subapical (see fig. 2); pile on upper side of all antennal joints black. Proboscis black, projecting twice the length of the antennae beyond the oral margin. Palpi black, very slender, with black pile, projecting beyond oral margin about one-third as far as proboscis.

Thorax black; mesonotum velvety black, shading to a sepia brown on the margins; the pile of dorsum erect and yellowish, appearing brown in certain lights. Scutellum velvety black, with comparatively long, coarse yellowish pile. There are indications of two median black vittae on the anterior part of the mesonotum, separated by a fine brown line. Pleura brown pollinose, the sparse

pile on mesa- and sterno-pleura brown. Stem of halteres yellowish, the knob yellow above and blackish brown below.

Abdomen black, sepia brown pollinose, with rather long, erect yellowish pile, nowhere dense enough to obscure the ground color. Venter like the dorsum, the pile shorter and more reclinate. Seventh visible segment projecting over the small eighth, the genitalia quite small, colored like the abdomen, the upper and lower forceps about equal in size and closing over the internal organs. Knees reddish, the rest of legs black; coxae and femora with long black pile. Wings whitish hyaline, densely maculated with dark gray and with remarkable thickenings of the membrane, some of which appear to form supernumerary cross-veins (see fig. 1). The veins near the posterior margin of the wing are wavy.



EXPLANATION OF PLATE

Fig. 1. Wing of *Acreotrichus maculipennis* n. sp.; fig. 2, head of *A. maculipennis*; fig. 3, wing of *Metacosmus nitidus* n. sp.; fig. 4, head of *M. nitidus*; fig. 5, wing of *Paracosmus morrisoni* O. S.; fig. 6, antennae and front of head of *Amphicosmus vanduzeei* n. sp.; fig. 7, head of *A. vanduzeei*; fig. 8, wing of *A. vanduzeei*; 9, antenna of *Villa chromolepida* n. sp.; fig. 10, head of *V. chromolepida*; fig. 11, head of *Rhabdoselaphus setosus* Cresson.

Female. In general very much like the male but lighter in coloration. Pile of cheeks and lower occiput yellowish, on the rest of the head and on the antennae reddish brown. Eyes widely separated, the pollen of frons more buff colored than in male, the pile shorter. Pollen of mesonotum much lighter in color than in male, the pile shorter and paler. Ground color of coxae and pleura yellowish brown in some specimens, the pile yellow. Knob of halteres scarcely darkened below. Abdomen in dried specimens yellow, also the tibiae except apices and bases of the four front tarsi. Pile and fine setulae of femora and tibiae yellowish.

Holotype, a male, and *allotype*, a female, collected on the sand dunes near Golden Gate Park, San Francisco, Cal., September 10, 1920 (F. R. Cole), in the collection of the California Academy of Sciences.

Paratypes.—Two specimens in the Cal. Acad. of Sci., taken in the type locality, and five specimens in the writer's collection, taken with the types.

In 1895 Coquillett described *Acreotrichus americanus* from a single male specimen taken in the state of Washington. This little species has hyaline wings, the antennae are quite different and the proboscis comparatively longer. In May, 1917, the writer took a single male specimen of *A. americanus* near Hood River, Oregon; it appears to be a rare species. *A. atratus* Coquillett, from Mexico, has a slender third antennal joint, three times as long as the first two combined and of nearly an equal width; the wings are grayish hyaline. The three other known species in the genus are described from Australia.

Notes on the Color Changes of Frogs

Sarah Marimon

In all these experiments I chose two identical frogs, and kept one in normal conditions while the other was being subjected to change.

Tree frogs, *Hyla regilla*.

I. June 16. Hot water (about 30° to 35° C.). Left the frogs for one hour.

The spots of the frog faded out, giving a lighter appearance. However the background seemed much the same as the control.

Control. Tap water (about 15°-17° C.). Spots distinct. Grayish green frog.

II. June 17. Hot water. The frogs for this experiment had peculiar red and green markings.

The whole tone was lighter at the end of an hour and one-half. Spots somewhat more indistinct than at first.

Control. Color unchanged.

III. June 16. Cold water. (Cooled with ice—2° C.) The frog was somewhat darker in color; the spots stood out more distinctly than previously.

Control. Tap water (15-17° C.) Color unchanged, spots showing distinctly—not so distinctly as those of the frog in cold water.

IV. June 17. Cold water. a. The frogs were rather light in color. Darker spots more distinct.

b. Two frogs grayish green in color. The color became darker, spots more distinct.

V. June 17. 5:00 P. M. Two frogs with red streaks down the backs.

One jar covered with green tissue paper, the other left as a control.

June 18. 10 A. M. Lighter in tone than the control. The red streak changed to light sandy color. Spots lighter,—greenish along the sides.

Control. Same as the day before, apparently. Spots dark grey, grey sides, broad reddish streak down the back.

11 A. M. The frogs reversed.

June 19. Red streak narrower, sandy colored. The whole cast of the frog was lighter and more greenish.

Streak dark reddish. Frog much darker than the one in green jar.

VI. June 21. Green and cold. To see which has the greater effect, the background or the temperature.

a. Two frogs rather light in color.

The spots are more distinct but the whole color is lighter than the control.

b. Two frogs rather dark in color.

Slightly lighter. The dark colored frogs do not seem to change as readily as the lighter ones.

These experiments would seem to indicate the greater effects of the background. However there was some chance for error here, because (1) the experiment was only over a period of two hours, and (2) because the frogs objected to the cold water, and when they were not watched, they would climb up out of the water and cling to the side of the jar.

VII. June 17. I put two frogs in a jar lined with leaves. One frog very reddish, the other grayish green.

June 21. The grayish green frog much greener, lighter in tone.

The reddish frog much lighter in tone but still decidedly reddish in color.

June 23. The red frog still reddish.

The green background lightened it but did not change its color.

VIII. June 17. 5 P. M. Red cover to the bottle. Placed the frogs in the jars.

June 18. 10 A. M. Slightly darker. Control. Color unchanged.

June 20. a. About the same shade as the other frog (i. e. the control) only with a more reddish tinge. b. Distinctly lighter, and more reddish in color.

June 21. Frogs had each a sandy streak down the back.

The streak brighter reddish. The whole tone of the frog slightly darker than the control. The frogs reversed. Streak sandy colored.

June 22. Streak brightly reddish. Whole tone of frog much lighter. Streak sandy colored. Darker than the one in red.

VIII. (a) June 17. 5 P. M. Took two greyish frogs with no particular color showing. Placed one in a jar covered with yellow tissue paper. The other frog used for a control.

June 18. Much lighter than the control. Seemed to have a yellowish tinge. Spots faded somewhat.

Reversed the frogs.

June 19. Lighter, the spots more faded than when in the control. The difference between the two not so marked as on June 18.

June 20. Slightly lighter, more yellowish in tone. Results not so distinct.

VIII. b. June 21. Two frogs with reddish streak (June 20). The streak more yellowish, now has a distinctly yellowish tone. Spots lighter. Whole tone more yellow than control.

Reversed the frogs.

June 22. Yellowish in tone. Red streak now very yellowish. Spots lighter.

IX. June 17. 5 P. M. Two frogs, dark in color, with red streaks down the back. One in blue covered jar, one control.

June 18. 10 A. M. Frog much lighter than the control.

The red streak along the back now sandy colored, however, still with the reddish tint. Control color unchanged. Noticeably darker than the one in blue.

The frogs reversed.

June 19. Lighter, the red streak sandy colored, same width as before. Sides light grayish green. Whole tone lighter than the one in the control.

The frogs reversed.

June 20. Lighter in tone, more greenish tinge. The red streak now sandy, slightly greenish also.

I observed some pigment cells under the microscopes. The melanophores (black) were the most noticeable, although on close observation yellow and bluish grey pigment cells could be seen.

I stimulated the piece of skin with ice; in some cases the black cells seemed to expand and in others this could not be seen. Some such action, however, would be necessary to cause the darkening in color brought about by cold.

The stimulations with heat were somewhat less definite than with cold; however twice the contraction of the melanophores, due to a heat stimulus, was observed.

Left the two dead frogs for six hours. When I observed them again they were both remarkably lighter than they had been when they were killed.

I took a bit of their skin and observed it again. One portion was much lighter and had several isolated melanophores. I cooled this piece of skin with ice, then stimulated it with hot water. The pigment cells seemed to expand.

Conclusions:

1. The tree frog changes its color in response to heat, cold and changes in the color of its environment.

2. The frog does not actually change color so much as it gets lighter or darker in response to stimuli. There seems to be, however, some actual change in color.

3. The colors, blue, green and yellow cause the frog to get lighter in color. The results with red were so irregular as to suggest that the change might be due to some other agent than the color environment.

4. When there is a reddish color present, i. e., red streak, the red environment intensifies this coloration. When, however, there is no red color present the red environment does not develop it.

5. This same phenomena is true of green coloration. Thus a red frog does not seem to be able to change into a green one, nor a green frog into a red one.

6. The changes in coloration or intensity seem to be due to the expansion of the pigment cells.

Experiments with Rana sp.

I. May 26. Light. I left the frog in the light (sunlight, although not direct) for one hour. At the end of this time it was remarkably lighter than the one in the dark room.

II. May 26. Dark. Frog like the one in light. I left it in the dark room for one hour. At the end of this time it was much darker than the one in the light.

Reversed frogs.

Left two hours. At the end of this time the two frogs were the same color again.

May 28. Repeated the first step of the light and dark experiment with the same results.

May 29. Placed one frog on a white reflecting surface but not in the sunlight. In one hour very little change.

At the end of the hour, placed the frog in the sunlight, still on a white, reflecting surface. Remained there for one hour. At the end of this time it was very much lighter than the one in the semi-darkness.

Sunlight then has more effect than diffused light, or perhaps the difference is caused by the difference in temperature.

III. May 29. Placed one frog in a rather dark but not absolutely dark place, used rather as a control than as an experiment. Apparently it did not change color.

Left it for another hour. The supposition was that it did not change color in the second hour, since the first hour had no effect.

However at the end of the hour it was much darker than the one in the sunlight.

IV. May 27. Heat and cold. Placed a frog in water of 30° C., left it for an hour and one-half.

At the end of this time it was decidedly lighter.

Placed a frog in water of 3° C., left it for an hour and one-half. At the end of this time it was decidedly darker.

There was a great deal of difference in the color of the two frogs at the end of the experiment.

V. May 28. Frog in water 30° C. Left one hour. Much lighter than one in cold.

Frog in water 3° C. Left one hour. Much darker.

Reversed the frogs at 2:24 o'clock.

At 2:45, the two frogs had reached the same color.

VI. June 1. Frog in water of 30° C., left one hour. Much lighter.

Frog in water 3° C., left one hour. Much darker.

VII. May 26. Acid. Placed one frog in a weak acid (HCL) solution. Left for several hours. There seemed to be no change in color—possibly a little lighter than the control.

Control. Placed one frog in water, otherwise its environment was the same as the one in acid.

No change in color.

VIII. Alkali. Placed one frog in a weak alkali (NaOH). Left it for several hours. There seemed to be no change in color—possibly slightly darker than the control.

EXPERIMENTS WITH A LOCAL FROG

IX. *Rana draytonii*

May 27.

X. Cold 3° C. Found a frog among the others identical in color.

Left in cold for one hour. Darker at the end of this time in comparison with the control.

XI. May 29. Light. Placed *Rana draytonii* in sunlight for an hour and one-half. At the end of this time it was very much lighter.

Control. Kept the control in semi-darkness. Did not change color.

Conclusions:

1. These frogs change color under certain conditions of heat, cold, light, dark, or excitement. Acids and alkalis have little if any effect.

2. a. Heat and light cause the frog to lighten in color. There is evidence that heat is the true agent, and light only as it is associated with heat.

b. Cold and dark cause the frog to darken in color.

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Notes on the Lepidoptera of Southern California. No. 1

DONALD C. MEADOWS

Two days during the second week of April 1922 were spent collecting Lepidoptera at Corn Spring, Chuckawalla mountains, Riverside county, California. The Chuckawallas are typical Colorado desert mountains, being low and rough, and having the vegetation for the most part confined to sandy washes. Corn Spring lies on the north side of the range in a canyon of the same name. It is a small palm covered oasis having many introduced plants as it is the home of an old prospector, who has a house and garden at the spring. The elevation is approximately 1500 feet.

Fourteen species of butterflies were collected and three observed. The nomenclature used is that of Barnes and McDunnough's Check List.

1. *Pieris protodice*, form *vernalis*—Edw. Three males and two females taken. Fairly common around spring.

2. *Nathalis iole*—Bdv. Five males collected. Found sparingly flying over bare, windswept desert mosaic. One specimen taken near mouth of Corn Spring canyon far from any vegetation.

3. *Eurymus eurytheme*, form *keewaydin*—Edw. Two males and two females taken. Common near spring.

4. *Danaïs archippus*—Fabr. One specimen seen at spring.

5. *Danaïs berenice*—var. *strigosa*—Bates. One specimen seen with the above flying among the palms at Corn Spring.

6. *Melitaea Neumoegeni*—Skin—Wright. Fourteen males and five females of this interesting species were taken. Probably the most common butterfly of that locality.

7. *Chlosyne californica*—Wright. Nine males and five females taken in a small canyon about two miles above the spring. These butterflies seemed to be very local in their distribution, one small canyon being the only place that they were found. Types figured by Wright from specimens taken in Colorado Desert, South-eastern California. The Chuckawallas are at the northern edge of the type locality.

8. *Vanessa cardui*—Linn. A few specimens seen flying in Corn Spring canyon.

9. *Apodemia mormo*—Feld. One female taken.

10. *Apodemia virgulti*—Behr. One male taken flying with the above. Contrary to expectations these two species were not as common as in other parts of the desert.

11. *Calephilis nemisis*—Edw. One male and two females taken in canyon about two miles above spring.

12. *Atlides halesus*—Cramer. One female taken. Only one other seen flying around a species of mistletoe.

13. *Brephidium exilis*—Bdv. Few Lycaenidae were found, Two *B. exilis* were taken flying over grass growing near spring.

14. *Hemiargus hanno*—Stoll. Two males taken near spring. This is a Mexican butterfly and only occasionally reported from California.

15. *Hemiargus isola*—Reak. A male taken in canyon above spring.

16. *Pyrgus tessellata*—Scud. A common butterfly throughout desert. Very common around Corn Spring.

17. *Thanaos clitus*—Edw. Another common species in vicinity of spring. A very fast flyer and difficult to catch. Six specimens taken.

In all sixty seven specimens were taken near the spring.

A List of Coleoptera Collected on the Beach During the Summer of 1921 at Laguna Beach, California

CLIFFORD T. DODDS

Determined by Dr. E. C. Van Dyke of the University of California.

CICINDELIDAE

Cicindela trifasciata Fab. var. *sigmoidea* Lec.

CARABIDAE

Dyschirius marinus (Lec.)

Bembidion ephippigerum (Lec.)

Bembidion indistinctum Dej.

**Bembidion cautum* (Lec.)

Platynus californicus (Dej.)

HYDROPHILIDAE

Ochthebius interruptus Lec.

‡*Cercyon fimbriatus* Mann.

STAPHYLINIDAE

Bledius fenyesi Bnhr.

Cafius canescens Makl.

‡*Cafius lithocharinus* Lec.

‡*Cafius luteipennis* Horn.

Thinopinus pictus Lec.

‡*Hadrates crassus* (Mann.)

Baryodma sulcicollis Mann.

HISTERIDAE

‡*Acritus maritimus* Lec.

Saprinus scissus Lec.

Saprinus bigemmeus Lec.

‡*Saprinus sulcifrons* Mann.

*This species is not recorded as being as far south as California in Leng's Catalogue of The Coleoptera.

MELYRIDAE

Endeodes basalis (Lec.)

ANTHICIDAE

Anthicus californicus Laf.

Anthicus maritimus Lec.

DERMESTIDAE

‡*Dermestes marmoratus* Say.

TENEBRIONIDAE

Eulabis obscura (Lec.)

Phaleria limbata (Horn)

CHRYSOMELIDAE

Diachus auratus (Fab.)

CURCULIONIDAE

Phycocoetes testaceus Lec.

‡The names thus checked are recorded by Lea Myers, Coleoptera From The Claremont-Laguna Region. Jour. Ent. and Zool. 1918. Vol. X. No. 3. pp. 43-53.

Some Common Chinese Mollusca

ARTHUR S. CAMPBELL

During the last year I had the opportunity to collect and examine a number of the commoner littoral and freshwater shell-bearing Mollusca occurring near Canton and at Chung Chow, Hongkong territory. The shells enumerated include only a fair sample of what might be obtained after longer search under more favorable conditions.

It is interesting to note the alliance of this fauna with that of the islands of the Pacific and with that of the California coast. A number of species occur here that are found on the opposite shore but there is a very complex admixture of the more definitely warm-water forms and with some species of endemic origin. The observations of Ralph Arnold (Palae. San Pedro, Calif., Acad. Sc. 03) concerning the tertiary shells of San Pedro and Japan shows us the affinities at once of the living shell-bearing mollusca of these two regions and likewise adds to our observations concerning the relationship between the whole Pacific molluscan complex. The molluscan fauna of South China appears to be paleotropical considered in its broadest aspect.

All shells were determined by Dr. H. A. Pilsbury of the Philadelphia Academy. In all there are one hundred and thirty-seven species represented in this collection.

(Contribution from the Zoological laboratory and Museum of the Biological Survey of South China, of Canton Christian College).

GASTROPODA

Bullidae

Bulla ampulla L.

Acmaeidae

Helcioniscus eucosmia Pils.

H. toreuma Rve.

Haliotidae

Haliotus diversicolor Rve.

Turbinidae

Turbo coronatus var. *granulatus* Gmel.

T. intercostalis Pils.

T. japonicus Rve.

Neritidae

Nerita lineata Gmel.

N. undata L.

N. crepidularia Lam.

N. albicilla L.

Solariidae

Architectonica perspectiva L.

Littorinidae

Littorina irrorata Say.

L. palliata Say.

Viviparidae

Viviparus rossgeri V. Mlldff.

V. ciliata Rve.

V. orientalis Lea.

V. chinensis Gray.

V. aeruginosus Rve.

Cerithiidae

Cerithium morus Brug.

Clava sinensis Gmel.

Melaniidae

Melania ebenina Brot.

Stombidae

Strombus pugilis var. *alatus* Gmel.

S. canarium L.

S. succinctus L.

S. bittatus L.

Turritidae

Turris desbayesii Doumet.

Cassididae

Cassis japonica Rve.

C. inflata Shaw.

C. strigata Gmel.

Doliidae

Tonnia allium (Soub.) Dillon.

Pyrula dussumieri Val.

P. ficus L.

Cypraeidae

Cypraea arabica L.

C. carneola L.

C. erronea L.

C. moneta L.

C. erosa L.

C. helvola L.

Muricidae

Murex torrefactus Sowb.

M. adustus Lam.

M. fulvescens Sby.

M. tribulus L.

Rapana bulbosa Sol.

Cymatium (*Turrotriton*) *pfeifferiana* Rve.

Gyrineum tuberculata Br.

Thaisidae

- Thais luteostoma Dillon.
- T. lapillus L.

Nyctilochidae

- Bursa rana L.
- Distortrix reticulata Link.

Columbellidae

- Columbella versicolor Sby.

Buccinidae

- Buccinum undatum L.
- Eburna lutosa Lamb.
- E. areolata Lamb.
- Alectrion obsoleta Soby.
- Buscyon perversa L.
- B. (Sycotypus) canaliculata Say.

Trochidae

- Monodonta labrio L.
- Tegula rusticum Gmel.
- T. nigerrima Gmel.
- T. argyrostoma Gmel.
- Astraea undosa Wood.

Volutidae

- Mitra aurnita Desh.

Olividae

- Olivella sayana Rav.
- O. (Callianax) biplicata Sby.
- O. scripta Lam.

Conidae

- Conus suturatus Rve.
- Conus carinalis Hw.
- Conus sulcatus Hw.

Turritellidae

- Turritella bacillum Kiener

Helicidae

- Eulota similaris Fer.
- Polygyra albolabris Say.
- Camaena cicatricosa Mull.

Cyclophoridae

- Cyclphorus elegans Mldff.

Pyramidellidae

- Pyramidula alternata Say.

Naticidae

- Natica (Polinices) mamilla L.
- N. P. melanostoma Gmel.
- N. P. didyma Bolton.
- Sinum neritoideus L.

Auriculidae

Melanpus luteus Guoy.

Scalidae

Epitonium lamellosa Lam.

Siphonaridae

Siphonaria japonica Don.

S. cornuta Gld.

S. sirius Pils.

PELECYPODA

Arcidae

Arca (Scapharca) campechiensis Gmel.

A. decussata Sby.

A. obtusa Rve.

A. granosa L.

A. (Brabatia) fusca Brug.

Parallelepipedum torta St. March.

Mytilidae

Mytilus smaragdinus Ch.

M. californicus Conrad.

M. edulis L.

Modiolus fortunei Dkr.

Septifer virgatus Wiegen.

Pinnidae

Pinna incurva Gmel.

Atrina tuberculosa Sby.

Pernidae

Malleus albus Lam.

Ostreidae

Ostrea lakerousi Lamb.

O. cristata Born.

Pectinidae

Pecten pyxidalus Boru.

P. circularis Sby.

P. circularis var. *aequisulcatus* Cpr.

P. gibbus var. *irradians* Lam.

Amusium pleuronectes L.

Spondylidae

Spondylus cruentata Lisch.

S. imperialis Chemi.

S. sinensis Sby.

Unionidae

Anodonta woodiana Lea.

Veneridae

- Tapes variegata* Handley.
- T. tristis* Lam.
- T. philippinarum* A and R.
- T. phenax* Pils.
- Tivela stultorum* Maue.
- Gafarium divaricatum* Gmel.
- Venus (Chione) cancellata* L.
- V. C. thiara* Dillw.

Macridae

- Macra (Spirula) solidissima* Dillw

Cardiidae

- Cardium robustum* Sol.
- C. rugosum* Sby.
- C. sinensis* Sby.

Chamidae

- Chama rubea* Rve.

Myidae

- Corbula erythron* Lamb.

Solenidae

- Solen grandis* Dkr.

Tellinidae

- Tellina alternata* Say.
- Metis balaustina* L.
- Paphia striata* Lam.
- Caecella cumingi* Desh.

Cyrenidae

- Corbicula fuscata* Lam.
- C. fluminea* Mull.

Ptericolidae

- Ptericola pholadiformis* Lamb.

Anomiidae

- Anomia simplex* D'Orb.



XIV. Echinodermata

ASTEROIDEA

The nervous system of the starfish is about the same in all forms which have been studied. Only minor unimportant differences can be recognized and some of these may be due to the different conditions under which the observations were made or the different methods employed.

Along the radial and circumoral ambulacral vessels on the oral side is a median thickening of the surface epithelium. This is the chief part of the nervous system, that is the superficial radial and circumoral system. Separated from these portions by connective substance there are in each arm on each side of the middle line the deep radial bands while within the nerve ring about the mouth there are two deep circumoral bands continuous with the two in each arm.

From the superficial nervous system fibers may be traced directly to the surface layers of the tube-feet. From the inside nerve rings, fibers follow the ambulacral system. The superficial system is merely a thickening of the epidermis in certain regions while the deep system is a thickening of the surface of the ambulacral system. Nerve strands from the circumoral rings, probably from the deep rings, run to the stomach and other viscera.

In addition to the parts of the nervous system just described there is a rather diffuse network of fibers and probably cells, found in the body-wall outside of the muscles. This last has been called the coelomic.

Sense cells and perhaps something of a nerve plexus seem to be present below the epidermis all over the aboral and lateral parts of the starfish. Just what relationship all these parts of the nervous system bear to each other or how they may be distinguished from each other, has never been made entirely clear.

Almost any portion of the body seems to be sensitive to touch and there may be other sensations without special organs for their perception. At the tip of each arm a little tentacle or papilla marks the end of the radial canal and the superficial nerve cord. This little organ has a special epithelium and may be a special organ of touch but Eimer, 1880, considers it as an organ of taste.

The eye-spot is the most marked sense organ of the starfish. Each arm has, very near the termination of the radial nerve at the tip of the arm, a bright red spot of pigment. A little closer examination of one of these spots shows it to be composed of a number of distinct regions of color. In section these little areas are seen to be little follicles lined with epithelial cells. The cells which line the follicles are spoken of as the visual cells. These are clear at their inner margins but pigmented farther down. Their inner processes come into relation with the nerve strands at the bases of

the eye-spots. Between and surrounding the visual cells are numerous bipolar, elongate supportive cells which stain strongly with connective tissue stains. In some cases the eye areas are not in the form of follicles as Pfeffer, 1901, has shown in a species of *Astropecten*. In those eye areas which appear as follicles a lens has been described and figured by Pfeffer and others but I am inclined to the interpretation of Cuenot, 1887, who believed that no lens is present. In fact, in some sections which I have seen there was no sign of even a membrane over the mouth of the follicles.

In the superficial system many long supportive cells help to make up the bulk of the nerve cord. These stain deeply with usual stains and at their inner ends are more or less intertwined.

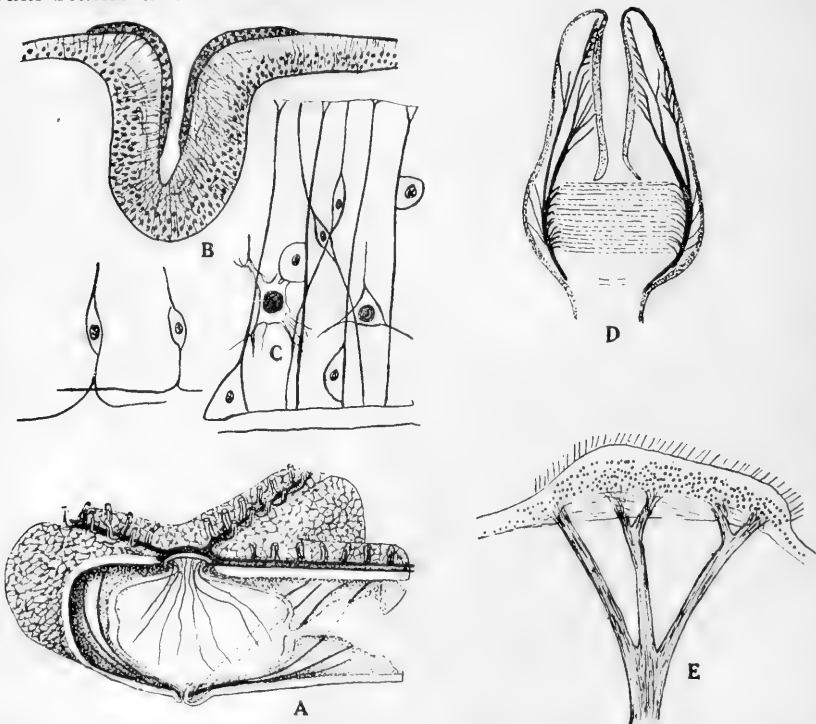


Fig. 27. A. Diagram of a Starfish cut so as to expose internal as well as external parts of the nervous system. In the center the deep nerve ring is shown by a dark curved line, the surface nerve ring by a thicker line. These parts are continued into the arm cut longitudinally on the right. Nerves to the tube-feet are shown. The superficial nerve plexus and internal nerves are indicated. B. Cross section of the radial nerve of starfish, superficial and deep parts shown. C. Nerve cells and supportive cells from the central nervous system. D. Section through one of the pedicellariae of sea-urchin showing distribution of nerves, after Hamann. E. Section through "taste knob" of sea-urchin. Hamann.

In the past I have been inclined to consider these as in part at least with conductive function, but I am sure the true nerve cells are sometimes bipolar, possibly in some cases multipolar with fibers running longitudinally and laterally in the nerve strands. The true nervous elements are more delicate, their fibers or fibrils cross each other at various angles but bear no other obvious relations to each other.

Among the earliest works on the nervous system and sense organs of starfish is that of Haeckel in 1859. In 1860, Wilson has a remarkably clear and accurate paper on the nervous system of the starfish. Another early paper was by Owsiannikow in 1871. Teuscher in 1856, figures the nervous system but not in much detail. Ludwig, 1878, has his figure of the nervous system in section often copied. Hamann, 1883-5, shows more of the structure of the nervous system and gives a good idea of the structure of the eye. Cuenot, 1887, gives a clearer idea of eye structure but not much more about the detail of the nervous system. Jickeli, 1888, recognizes four chief parts of the nervous system of starfish: (1) The ambulacral, (2) the sub-epidermal body plexus, (3) the deep nerves, (4) the intestinal nervous system. Pfeffer, 1901, studies the eyes particularly and distinguishes clearly between supporting cells and nerve cells. More recent papers of Pietschmann, 1906, and especially of Meyer, 1906, show details in the nervous system. The last author distinguishes clearly between supportive cells and nerve cells in the nervous system. He finds the supportive cells uni- or bipolar and usually running from the ventral to the dorsal side of the nerve bands. The nerve cells are bipolar or multipolar with fine branches.

Romanes, 1885, found besides strong negative reactions against injurious stimuli, positive reactions of a chemical nature which he considered due to the sense of smell. This sense depended somewhat on the physiological condition of the animal, chiefly upon its degree of hunger. A starfish, kept several days without food, immediately crawled near some presented. If a small bit of food be withdrawn as the animal approaches, the starfish could be led about in any direction. By severing various parts of the rays, Romanes found that this so-called olfactory sense was equally distributed throughout the length of the body and by varnishing the upper surface he found that the reactions were unaffected. Also by placing a bit of food on the aboral surface no reaction occurred. Preyer, 1886, found great differences in individuals when stimulated with food.

Starfish are positively phototropic but largely lose this tendency if the eye-spots are removed. Romanes found the sensitiveness so great that starfish discriminated between ordinary pine boards covering the tank and the same boards painted black. Romanes Preyer, Jennings and others have studied the righting

reactions of starfish in considerable detail. In general the starfish rights itself by twisting about two or three of its rays until the suckers on the ventral side have a firm hold of the supporting surface and by controlling the twisting movement the body is turned over. In this it is necessary that all five arms do not make the attempt at once to bring the animal into a ventral position. If five or four arms should work at once the animal could not turn over. There must be some coördination between the arms as is seen when the circum-oral nerve is cut. In this case the coöperation of the arms ceases. A single arm removed from the rest can right itself. These experiments seem to show that the central nerve ring acts merely as a conductor of impulses. The ventral side of the starfish seems to be positively stereotropic.

If one arm of a starfish is stimulated the animal moves away in a direction opposite to the stimulated arm. This looks like intelligence, but when one arm is stimulated the tube-feet on this arm draw in and according to the parallelogram of forces, a movement away from the point of stimulation will take place. When the starfish is stimulated as a whole the spines and pedicellariae wave about and the jaws snap time and again. A separate external stimulus is not necessary for each opening or closing of a pedicellaria. Mechanical stimuli that are strong enough always cause them to attack. Very light mechanical shock often produces no effect even if repeated. There are some responses to food rather than defensive movements, a nutrient juice causes the pedicellariae to advance and open. Pedicellariae are often opened for attack. If another starfish brushes against it, even when one of the individual's own rays cross, the pedicellariae may be advanced.

If closed pedicellariae are stimulated they must first be stimulated to open before they will attack. Any stimulus which causes the pedicellariae to rise will when repeated cause them to open. Most stimuli which cause the pedicellariae to withdraw also cause them to close. The larger pedicellariae are usually less inclined to hold objects for a long time. Starfish seem to hold objects for a longer time than sea urchins.

In starfish the pedicellariae seize and hold each other as well as other objects. If a small bit of the body of a starfish, bearing a single spine be cut from the rest, the pedicellariae seize any small object which touches them. If the ventral nerve is cut or the whole ventral side of the ray cut the pedicellariae continue to act, but the cutting of the nerve acts as a stimulus. The transmission of impulses seems to be by the nerve-nets over the body-wall.

Jennings has shown that the elevation of the groups of pedicellariae or the rosettes to attack, is dependent upon the following: 1. Previous mechanical stimuli; 2. Preliminary chemical stimuli; 3. Foregoing chemical stimuli; 4. Cutting the radial nerve leaves the rosettes in such a state that they attack more readily than usual. 5. The rising of the rosettes in a central region leaves them

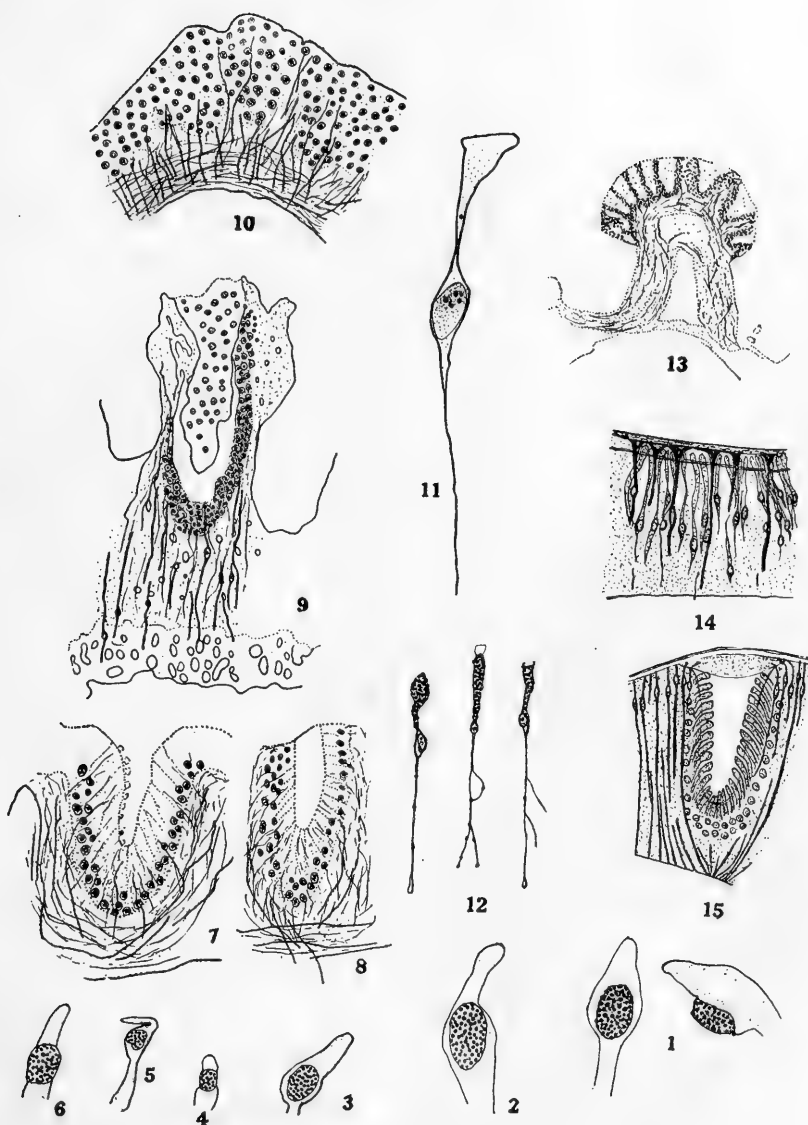


Fig. 28. SENSE ORGANS OF STARFISH. From Campbell.

1. Ventral and lateral views of eye-pad *Pisaster capitatus*, showing general relationship to terminal tentacle. X9.
2. Ventral view of eye-pad of *Orthaster gonolena*. X9.
3. Ventral view of eye pad of *Pisaster ochraceus*. X9.
4. Ventral view of eye-pad of *Asterina miniata*. X9.
5. Ventral view of eye-pad of *Linckia colombiae*. X9.
6. Ventral view of eye-pad of *Asteropectin erinaceus*. X9.
7. Ocellus from *Orthaster gonolena* to show general form. X350.

Drawn by camera lucida.

8. Ocellus from *Linckia colombiae* to show general features. X350. Camera lucida.
9. Ocellus from *Asterina miniata*. X350. Camera lucida. General view, note the clear central margin of pit.
10. Tactile organ from terminal tentacle of *Linckia colombiae*. General view showing papillae and details. Camera lucida. X350.
11. Single sensory cell from *Linckia colombiae*. Very greatly magnified.
12. Sensory cells from *Asterias rubens* showing pigment. Reproduced from Cuenot. Osmic acid. Greatly magnified.
13. General view of eye-pad of *Asteropectin erinaceus*. X350. Camera lucida.
14. Simple ocellus in an *Asterias*. Supportive cells dark. Sensory cells lighter. Reproduced from Pfeffer. Diagramatic.
15. A more complex ocellus from *Asteropectin mulleri*. Note the lens, other features as above. From Pfeffer. Diagramatic.

after subsidence in such a state that they react more readily to stimuli in a distant part of the body than the rosettes near the new stimulus; 6. There are differences in the characteristics of individuals.

The opening of the pedicellariae depends upon:

1. Homogeneous preparatory stimuli
 - (a) Sometimes there is no response to the first stimulus.
 - (b) Sometimes the first stimulus causes retraction and closing while later ones cause extension and opening.
 - (c) Sometimes with large pedicellariae the first stimulus causes momentary opening, the next two or three have no visible effect, the next pronounced opening.
2. Chemical stimuli of a certain character cause the pedicellariae to open later and more readily under mechanical stimuli.
3. Chemical stimuli of a certain character cause later refusal to open under usual mechanical stimulation.
4. Holding some object causes the pedicellariae after release to refuse to open under other stimuli.
5. After closing the pedicellariae often open and close again spontaneously, "snapping." The foregoing action furnishes the condition for the succeeding one.

In many cases the tube-feet are compelled to do much feeling about before they find the object seized by the pedicellariae. In exploring movements two or three rays are raised from the others and swung about in the water; the other rays creep about. The tip of the arm as well as the other parts of the arm are employed in these feeling motions.

The relative intensity of illumination on different parts of the body of the starfish may and at times does determine the direction of movement without regard to the direction of the rays of light. The ventral portion of the surface of the starfish is protected by

movements more than the tips of the arms. After it has been at rest for a time however the eye-spots are usually so placed as to be protected from the light. The starfish in each case (Jennings) moves towards that part of the body that is least illuminated.

There are a number of ways in which starfish right themselves according to Jennings:

1. The simplest method. Two adjacent arms twist their tips with ventral faces inwards.

2. Two arms, the ventral faces not inwards but facing in the same direction.

3. Three adjacent rays attack and usually turn by twisting the outward rays.

4. Four rays take hold, two to right, two to left. Fifth ray helped up, and swings over.

5. All rays attack release later of certain rays.

6. One ray twists and rights the whole.

7. Righting without attaching tube feet of any of the rays. Raises disc strands on tips of arms then topples over.

If a starfish begins a reaction in a certain way it usually continues in the same way even in spite of opposing conditions. When the starfish gets started it continues in the same way. The variability of form in starfish that are righting themselves is very great. No species rights itself in one way alone. When certain tube-feet are prevented from acting in righting movements the others carry on the movements. In righting if one method does not help another is used.

HABIT FORMATION

Preyer, 1886, Jennings, 1907, have brought further information as the results of experiments to test habit formations in starfish. By perverting certain rays to act in the righting reactions in starfish Jennings showed that he could establish temporary habits and the slower formation of more lasting habits. The many factors which determine the righting reactions have not a constant tendency to make starfish turn on one given pair of rays. On the contrary, they must sometimes act in one way, sometimes in another. Therefore no very fixed habits are formed under normal conditions.

In the righting reactions the impulse tends towards the accomplishment of the general turning of the starfish as a whole and given parts sacrifice their own direction or even prevent it in the general result.

We cannot assume single specific external stimuli as the determining factors for each separate movement, yet in some way the relation of the organism to its environment has set in operation a uniform action of which separate movements are parts.

ECHINOIDEA

The nervous system of sea-urchins may be compared with that of starfish more easily than with that of other forms.

The nerves corresponding to the superficial radial and circum-oral nerves are more deeply placed than in starfish and as in starfish are the most obvious parts of the nervous system. An epineural space or tube on the outer side of the nervous band forms the so-called "epineural cavity" or nerve tube, as interpreted by Phouho, '87, and others. The radial and circum-oral sinus follows the nervous system on the inside.

The superficial radial system follows down the inside of the shell in the center of the ambulacral area and these five strands join with the circum-oral ring about the mouth opening.

From the nerve ring between the junctions of the five radial nerves are branches to the intestine which go to make up the intestinal plexus. Nerves run out laterally from the radial nerves to the tube-feet and also to the surface, to the bases of the spines and to the ganglia at the bases of the spines. The radial nerves end in the terminal tentacles through holes in the shell about the anal region. It is by way of these openings, according to Phouho, that the radial nerves contribute to the superficial nerve plexus just outside the test of the sea-urchin. The deep radial nervous system is but poorly represented, so little of it is present closely applied to the superficial radial and circum-oral that it can hardly be recognized apart from it.

According to some, a pentagonal area of aboral nerves surrounds the anus and communicates with the genital organs and with the external superficial system by means of fine fibers from the radial nerves near their termination in the terminal tentacle. It is quite probable that the superficial system communicates with that of the shell at the aboral end not only through the so-called ocular openings but also through the genital openings in the shell.

The surface of the body, the spines and the tube-feet, are all organs of the tactile sense at least.

The so-called eye-spots at the terminal tentacle in the five ocular plates contains pigment and may have some sensitiveness to light, but it is not like the eye-spots of starfish and may indeed not be in any sense an eye-spot.

The chief parts of the system such as the radial and circum-oral nerve bands are composed of about the same parts as in the starfish. In smaller and perhaps younger specimens the outer nuclear layer is thicker in proportion. Nerve cells are bi- and multipolar. In some cases at least multipolar cells are found well within the fibrous area of the strand. Many of the outer cells are probably as in other echinoideans supportive in function. The radial bands are thicker at the oral region and become somewhat

smaller at the region of the terminal tentacle in the ocular plate. This might suggest something as to the nerve tracts or bundles of fibers and gives an indication at least that fibers may convey impulses at different distances such as in the central nervous system of vertebrates.

The deep radial and circum-oral strands of sea-urchins are poorly shown in section. Only a few cells scattered along the inner margin of the fibrous region give an indication of this poorly developed system.

In the sand-dollar, *Dendraster excentricus* some variation in form is suggestive of value in comparison with other forms.

The righting reactions in sea-urchins are carried out with greater difficulty than in starfish and only the fresher or more vigorous individuals are capable of the reaction.

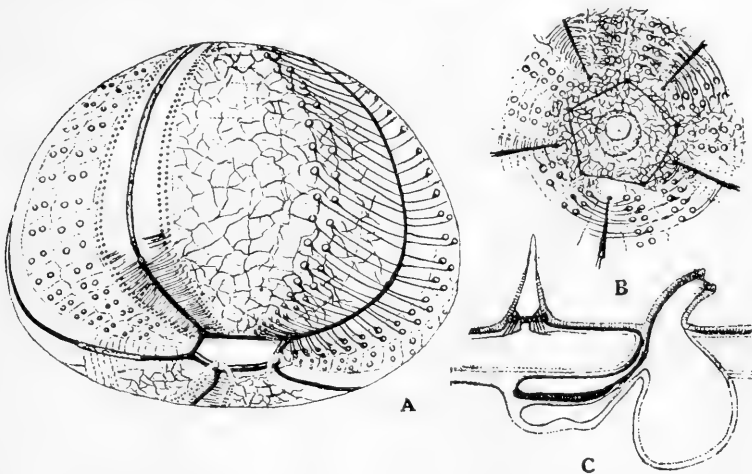


Fig. 29. NERVOUS SYSTEM OF SEA-URCHIN. A. Diagram of nervous system of sea-urchin showing in various ways the superficial and deep nervous system by having the superficial system cut away on part of the two radial nerves at the left. Branches to the tube-feet shown in the central of the three ambulacral areas. Nerves to the bases of the spines show on the right. Superficial nerve plexus show in the center. B. Diagram of the nervous system from the aboral pole, showing the nerve connections at the genital openings and the ends of the radial nerves at the five ocular plates. C. Diagram of cross section of nervous system having branches to a spine and a tube-foot after Delage and Herouard.

Although the eye-spots of sea-urchins are not well developed they seem to avoid light and seek darker corners and sheltered places. One form which has no eye-spots seems to avoid the light. A sudden shadow falling on it causes it to direct its spine to the

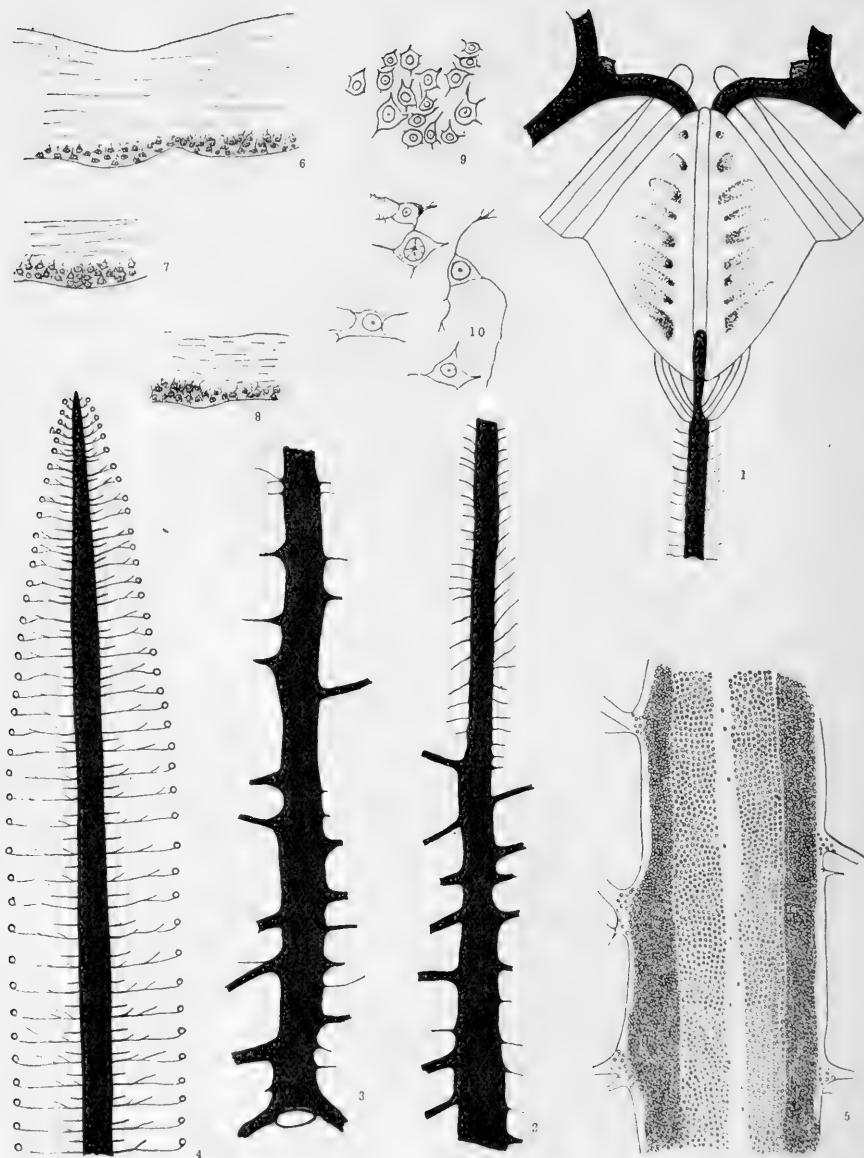


Fig. 30. EXPLANATION OF FIGURES OF SAND-DOLLAR.

1. Diagram of one fifth of Aristotle's lantern of *Dendraster* showing three loops of the circumoral nerve ring, and parts of three radial nerves, the central one partly hidden at its origin by the lantern. The nerves are in black. X9.
2. Drawing of part of the first part of an oral radial nerve. X9.
3. Drawing of the lower end of an oral radial nerve. X9.

4. Drawing of the upper part of an aboral radial nerve. The eye-spot region is up in the figure. X9.
5. Camera lucida drawing of a part of an aboral nerve showing position of cell areas. X70.
6. Drawing of a section of an oral radial nerve. X300.
7. Drawing of a section of circumoral nerve. X300.
8. Drawing of a section of aboral nerve. X300.
9. Nerve cells from central regions of a radial nerve. The arrangement is as shown in the drawing, cells of various levels shown as one layer. Some of the processes possibly relate nearby cells, but most fibers run into the general fibrous mass. All fibres or fibrils are small. There is some indication of tigroid substance in some of the cells. X450.
10. Nerve cells from near a lateral branch from the radial band. X450.

shaded area. Uexkull, 1897, was of the opinion that the sea-urchin possessed a special set of nerve fibers concerned with photic responses.

If a bit of the test with one or more spines be separated from the rest of the animal, the spine or spines may be stimulated to react much as before. In the sea-urchins there are several kinds of motile organs. There are the jaw-like organs or pedicellariae, borne on movable stalks; there are the tube-feet and the long movable spines. All these sets of organs are controlled by nerves, and a nerve network connects all these motile organs. One general network of nerves is within the shell and one without, and these are connected with the five radial nerves and the circumoral nerve ring. Each of these motile organs has a definite number of reaction or responses and in these each group may act independently and each organ may react as an independent individual. Each sea-urchin then seems according to Uexkull to be made up of a colony of almost independent structures yet all these are connected by the nerve network and when one carries out a reaction others may receive a stimulus to carry out its special activity.

The independence of these systems of spines, pedicellariae and tube-feet, and the definite character of their reflexes has been clearly expressed by Von Uexkull. He considers the sea-urchins as made up of a "republic of reflexes." Each reflex is of the same value and is independent of the others except for the nerve-net connections between the systems. This group of chiefly independent systems has nothing like a central unity controlling them as a whole and it is only by the synchronous course of different reflexes that a unified action is simulated. The action is not unified but the movements are ordered. Separate reflexes are so constituted and so combined that the simultaneous but independent course of reflexes in response to outer stimulus produces a definite general action similar to the condition in animals with a common center.

The pedicellariae of sea-urchins refuse to seize or hold each other or parts of the bodies or others of the same species. Von Uexkull believes this is due to a presence of a substance "auto-dermin" which is in the skin. In sea-urchin pericellariae have the power of independent reactions. Each when isolated on a piece of shell may behave as when on the body of the animal. The stimulus from the pedicellariae need not pass through the radial nerves for if the nerve is cut the reactions are as before.

OPHIUROIDEA

The nervous system of serpent-stars is more complicated than that of starfish. The radial and circum-oral nerves are shut off from the surface of the body and inclosed in a small cavity. The more superficial radial and circum-oral nerves are well developed and from the radial nerves fibers run out to the spines of the legs and the tube-feet. These last are provided with ganglia at their bases and with nerve strands running their length. The nerves which run to the spines also have ganglionic thickenings upon them at the bases of the spines. From the ganglia at the bases of the tube-feet delicate strands run out to one epineural ganglion for each tube-foot. On the ventral side of the disc on each side of radial nerves lateral nerves run out to near the margin of the disc communicating with the radial nerves and also connected with the superficial nerve plexus on the lower side of the disc. There are then in this way two lateral nerves from each arm base, and each one of these sends out an inter-radial nerve. Nerves from the circum-oral ring run to the teeth, five pairs in all.

The deeper radial and circum-oral nerves are closely applied to the more superficial nerves and appear much like parts of them, being represented by groups of dorsally placed cells. These deeper nerves are two for each arm. The circum-oral ring about the mouth sends out pairs of nerves to the muscles of the arm.

A system of so-called genital nerves is found quite distinct and independent from the other systems. More or less isolated loops of fibers are found in each area of the disc between the arms.

Hamann, 1888, gives one of the best accounts of the nervous system. Delage and Herouard also figure and describe the nervous system in this group. The first author describes and figures nerves coming out laterally from the chief radial nerve to be applied to the skin. These may be the cutaneous nerves of Delage and Herouard.

Hamann also shows strands from these to the tube-feet where ganglia are located and from these ganglia are nerves with ganglia running in to the center of the arm, and also nerves arching up dorsally to end in small ganglia. These are very much in the position as shown in the diagrams and figures.

The chief radial nerves, as is well known, are concentrated into ganglion-like swellings at the intervals between the vertebrae and here from the dorsal nerve cord strands are sent into the muscles of the arms.

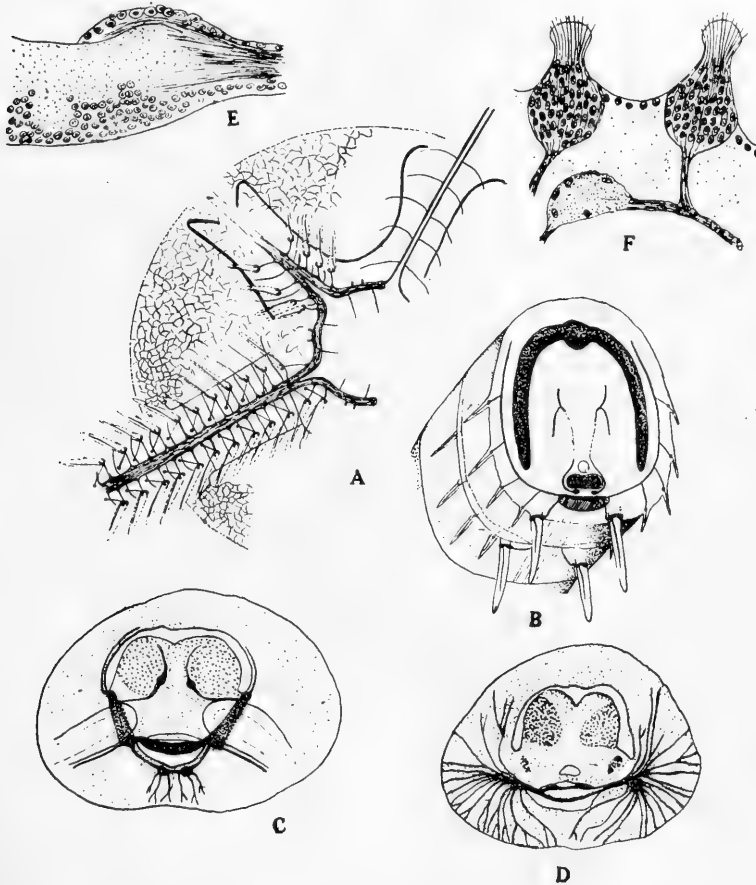


Fig. 31. NERVOUS SYSTEM OF SERPENT-STARS. A. Diagram of the nervous system of a serpent-star, a part of the disc and the bases of three rays shown. In the upper right end ray the superficial nerve ring and radial nerve are removed to show the deeper nerves. In the others and on the disc other nerves are shown. On the disc the superficial nerve-net is given. Out from the radial and circum-oral nerve the chief branches to the tube feet, etc., are shown. B. Diagram of the nervous system of one of the arms cut across showing large cavity of an arm in deep shading and the lowest cavity within radial nerve, with branches to spines and tube-feet. C. Diagram of section of an arm after Hamann. D. Through the arm at another level. E. Section through radial nerve. Hamann. F. Section through sense papilla. Hamann.

The parts of the nervous system are:

1. The superficial radial nerves. The chief branches: (a) muscular nerves, (b) cutaneous nerves to tube-feet and to skin and to spines. On each nerve to the tube-feet a ganglion is formed at base of each tube-foot and strands run dorsally and centrally to the intervertebral ganglia and ventrally to the two ventral ganglia or epineural ganglia. (c) branches communicating with the lateral nerves of the disc on each side of each radial nerve which in turn have altogether 10 interrarial nerves near the center of the disc and branches to the superficial nerve plexus.

2. The superficial oral nerve is pentagonal in shape and gives off: (a) nerves to the stomach, (b) a pair of dental nerves.

3. The deep radial nerves give off nerves to the muscles of the arms.

4. The deep oral ring gives off: (a) interrarial superior nerves, (b) interrarial internal nerves.

5. The genital nerves, independent of the others. Five different nerves between each radial area in the disc.

There are no eyes. The skin has no cuticle except at certain points and these are the only ones where sense cells are located. The tube-feet and spines are sensitive to touch. The palps are sensitive to touch as well as parts of the general surface. The extremity of the palps have sensory functions. The terminal tentacle, it is thought, may be olfactory in function. The oral palps have sensitive papillae well supplied with nerve cells.

The structure of the nervous system is somewhat like starfish but the central cords are parallel with more evident nerve cells and the strands seem to have a more complicated structure.

Hamann's work is perhaps the most valuable in this group. Delage and Herouard make chief use of this in their work. Teuscher 1876, Land, '76, Smith, '79, and Ludwig, '80, are the other chief contributors who have considered the nervous system.

A New Salt Marsh Mealy Bug

(*Eriococcus palustris* n.sp.)

CLIFFORD T. DODDS, University of California

Introduction.—While making a study of the insects of the salt marshes and brackish waters of the San Francisco Bay region, I chanced to find in considerable numbers, a mealy-bug on the salt-marsh cord-grass (*Spartina foliosa* Trin.). It occurred on the upper surface of the leaves and generally out of reach of the ordinary high tides. The probable reason why this mealy-bug, as well as the scale, *Chinaspis spartinae* Comst., occurs almost entirely on the upper surface of the leaves is because of the fact that during transpiration, water is given off from the lower surface of the leaf, leaving after evaporation a considerable deposit of salt.

Type host and locality.—From *Spartina foliosa* Trin., at Almonte, Marin Co., California, November, 1921. Found wherever the host is located about the shore of Richardson's Bay, an arm of San Francisco Bay.

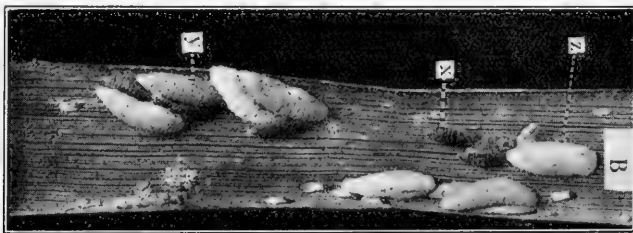


Fig. B. Leaf of host plant *Spartina foliosa* Trin.; w, *Chionaspis spartinae* Comst., adult female; x, *E. palustris*, female before secreting sac; y, sac that has been wet by the tide; z, normal sac.

Sac.—The natural sac is composed of fluffy white waxy filaments (Fig. B, z), which after they have become wet by the tide, and this is usually the case in nature, become a light ashy gray (1), and have a more or less feltlike texture (Fig. B, y), thus offering great protection, especially for the overwintering young. At the posterior end of the sac there is an obscure opening, plugged with wax filaments, where the young escape. The average length of the sac is 4 mm. for the adult females and somewhat less for the males.

Adult female.—type—(Fig. A) Body smooth; six cephalothoracic spines on the dorsum, the two median anterior ones being larger than the other four, all straight, slightly expanded at the base, tapering to a rather blunt apex; eight pairs of very small, blunt, conical, dorso-lateral marginal spines on each side; the

posterior spine of the last pair of each marginal series slightly larger than the others. On the ventral surface there are sparsely scattered hairs, arranged segmentally; four spiracles located posterior to the coxae of the front and middle legs. Anal lobes not chitinized, each with three small ventral and one large terminal setae (Figs. C, D) and two dorso-lateral spines on the inner surface. These spines are slightly larger than the cephalothoracic spines mentioned above, not expanded at the base and very blunt. The last pair of the marginal spines are located dorso-laterally near the basal end of the anal lobe (Fig. E). The terminal setae of the anal lobes are about two and one half times as long as the anal lobes themselves (Fig. C), while the eight setae of the anal ring are less than the length of the anal lobes. Antennae medium stout, six to eight segmented (Figs. G, H, I, J), the normal long

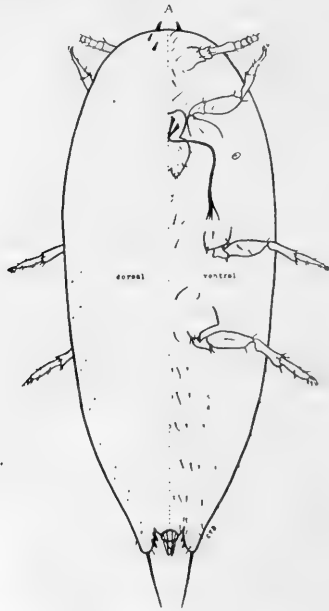


Fig. A. *Eriococcus palustris* n. sp., adult female cleared in caustic potash.

third divided into the third and fourth, and the normal ultimate segment divided into the seventh and eighth. Apparently this division is not closely related to the moults. Legs rather slender (Fig. F), claws not toothed, digitules with flat apical enlargements.

Male.—Body 1 mm. long; folded wings projecting $\frac{3}{4}$ mm. beyond end of abdomen.

Eggs.—Average 60 to 70 eggs per female, 92 highest number noted. Ellipsoidal, pale cadmium yellow (1) ; .5 mm. long, .25 mm. wide.

Type and paratypes deposited in the California Academy of Sciences, paratypes also deposited as follows: United States National Museum, Washington, D. C.; G. F. Ferris, Stanford University, Palo Alto, California; E. O. Essig, University of California, Berkeley, California, and in my own collection.

Comparison.—This is a very distinctive species, the small number of spines, their form, size and distribution separating it quite widely from the known species of this state. The only species that I have seen which at all resembles it is *Eriococcus inermis* Gr., which is found on grass at Camberley, Surrey, England.

Life history.—As a rule the females come to rest with the cephalic end of the body uppermost on the erect leaves, where they

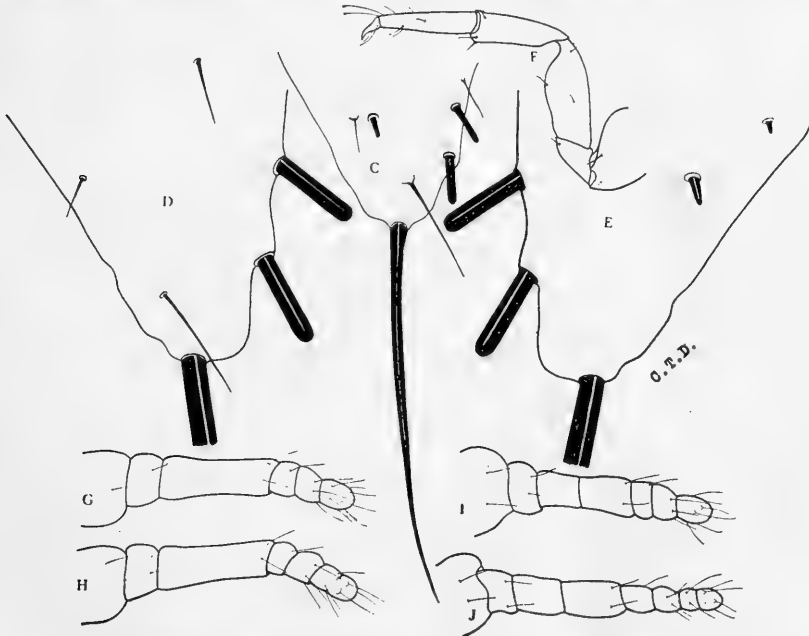


Fig. C. Anal lobe showing relative positions of dorsa-lateral spines to ventral setae.

Fig. D. Ventral aspect of anal lobe.

Fig. E. Dorsal aspect of anal lobe.

Fig. F. Leg.

Figs. G, H, I, J, showing variation of antennae.

Note: (1) Nomenclature of Windsor and Newton's water colors as given in the "Glossary of Entomology", Smith. Brooklyn Ent. Soc., Brooklyn, N. Y., 1906.

secrete the sac about themselves. The eggs are layed in the bottom of the sac, being quite closely packed with wax filaments. As the female deposits the eggs her body is crowded forward, the dead remains being found in the upper end of the sac. In some instances in the laboratory, it was noted that undersized females would secrete a sac, deposit a small number of eggs and die. Upon dissection, it was found that there were often mature eggs in the oviducts or partly developed eggs in the ovaries. The first laid eggs in the bottom of the sac hatched several days in advance of the others and thus the nymphs escaped before the later eggs hatched.

Under laboratory conditions the first moult took place 17 days after hatching and the second moult a week later. After the second moult the individuals had lost the pale cadium yellow color and became the violet gray of the adult. The day following the second moult they secreted sacs, although they were very much smaller than those which first made sacs under natural conditions. Normally they probably have five moults. The overwintering individuals found in nature were first instar nymphs which had not left the sac.

Parasites.—One Hymenopterous insect was found, *Pseudococcobius clauseni* Timberlake (2) which parasitized a large percentage of the mealy-bugs. As many as six of these parasites were found in an adult female. They usually kill the female after she has made the sac and before oviposition. They overwinter in the sac as adults, emerging in the spring through circular holes which they make.

Resistance to drowning.—Several experiments were made to see if this insect was specially protected from the water. It was found that submergence for three or four days had no ill effect on an adult and that they could float on the surface of fresh water for three weeks without dying. These results are of little significance, however, as Mr. Floyd Wymore, in his B. S. thesis work at the University of California, 1922, found that *Pseudococcus gahani* Green, a terrestrial mealy-bug, not only could live under water but laid eggs and otherwise lead quite a normal life.

Acknowledgements.—I am deeply indebted to Prof. G. F. Ferris of Stanford University for numerous courtesies, especially for determining this mealy-bug as a new species and for the permission to examine his collection of Coccidae. I am also indebted to Mr. W. C. Matthews for photographing figure B, and to Prof. E. O. Essig for suggestions and aid.

Note: (2) Mr. A. B. Gahan, Entomological Assistant of the United States National Museum, writes as follows: "The parasite appears to be *Pseudococcobius clauseni* Timberlake. This species was described from a single male specimen bred from *Erium* sp. [*Lichtensioides* Ckle.] * * * at Riverside, Calif. Your males differ very slightly in the extent of yellowish color on the face but I believe there is very little reason to doubt that they represent this species with the type of which they have been compared."

Notes on the Life History of *Dinapate wrightii* Horn. (Col.)*

By ROY E. CAMPBELL, U. S. Bureau of Entomology, Alhambra, Cal.

In May, 1916, Mr. J. O. Martin, of Pasadena, after considerable tedious scouting, discovered a log of the Washington Palm (*Washingtonia filifera*) in Palm Canyon, on the Northwestern border of the Colorado Desert, which contained partially-grown larvae of *Dinapate wrightii*. Mr. Martin could hear more larvae at work in the log, and decided to mark it and wait until the following spring for further action. In 1917 he returned to Palm Canyon and sawed out several pieces from the fallen log, carried them down the canyon to his automobile (a feat which was discovered a little later by the writer to be quite laborious) and transported them to Pasadena.¹

At the suggestion of Dr. F. H. Chittenden, the writer got into communication with Mr. Martin and received directions to locate the remaining 10 feet of the infested log. On May 19, 1917, the writer went to Palm Springs and duplicated Mr. Martin's actions, except that the scouting was unnecessary. The logs were placed in a wire cage, in Alhambra, and closely watched. Mr. Martin's efforts were rewarded by the appearance of the first beetle on August 3, and emergences continued until thirty-one had appeared by September 17. In the writer's cage 3 adults appeared in the latter part of July, and 2 in August.

When the sections were sawed from the log, a few larvae were disclosed, some practically full-grown, while others were quite apparently immature, indicating the possibility of two broods. Also after the emergence of the beetles in 1917, larvae could still be heard at work within the log.

On April 15, 1918, one piece of the log which had been transported to Alhambra, was cut up and examined. Nine larvae were found, four of which were full-grown, and the rest not over half-grown. These larvae were sent to Dr. Chittenden. Also one dead adult female, which had failed to make its way out of the log, was uncovered. The emergences of adults for that year from the remaining piece of log were as follows:

¹ Bull. Brooklyn Ent. Soc. Vol. XII No. 5, pp. 107-110, December, 1917.

*Since this paper was presented for publication, an article by Dr. J. A. Comstock on "A Giant Palm-Boring Beetle" appeared in the March, 1922, Bulletin of the Southern California Academia of Sciences (Vol. XXI, Part I). Besides giving many of his observations, it reviews the literature on this interesting beetle.

August 1, 1918—1 male.

August 2, 1918—1 male.

August 2, 1918—1 male.

August 8, 1918—1 male.

Sept. 2, 1918—1 female, elytra deformed.

Since there evidently was still another brood, or some larvae were slower in developing, the remainder of the log was kept, and three beetles emerged in 1919 as follows:

July 24, 1919—1 male, large fine specimen.

July 25, 1919—1 male, small specimen.

Aug. 25, 1919—1 female, average specimen.

No further attention was paid to the log until April 1, 1920, when out of mere curiosity, it was cut up. To the writer's great surprise one live larva was found.

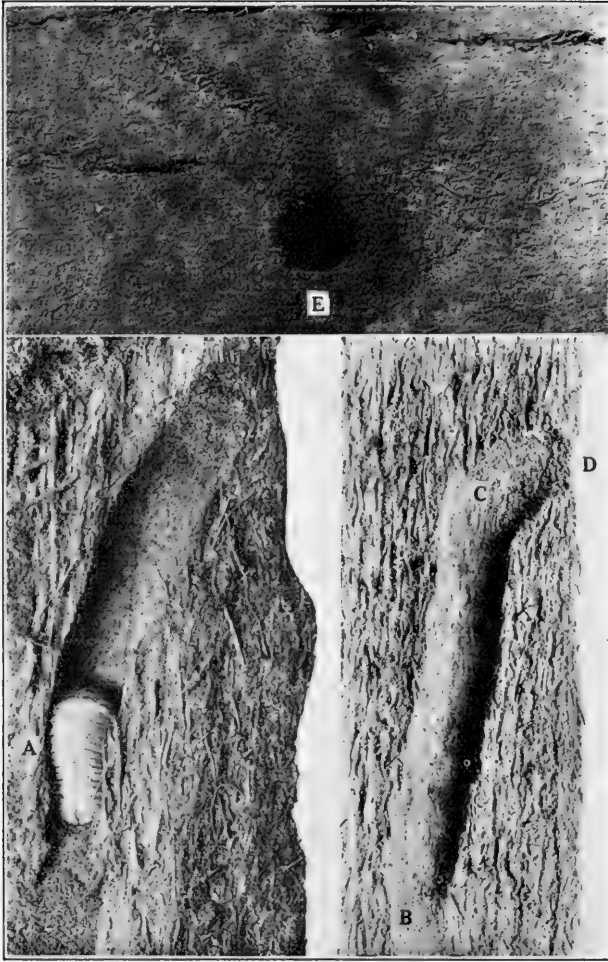
It did not appear to be quite full-grown, or at least was a little undersized, and was soft and flabby. Although it was not expected that it could mature, a hole was bored in the end of a piece of the log, near and parallel to the surface, the larva put in, the hole corked up and the piece of wood placed upside down. The larva soon began to bore into the wood.

On May 24 it was examined again. The larva had continued boring into the wood, parallel with the bark, filling up the hole behind it, and had turned around in the hole and was headed upward. It finally worked a little to one side, and started upward parallel with the other gallery. It was then transferred to another piece of log, and put in a hole bored about 2 inches deep. During the transfer, the photograph of the larva in the gallery shown in Plate I, A, was taken.

The cork plug was removed frequently and the progress noted. Not much eating was done after the above date, and on July 12 the writer was delighted to find that the pupa had formed. It was creamy white, with dark eyes. By August 4 the legs, mouth-parts and head were turning brown, and on August 8 the adult formed. It was put back in the hole and the latter plugged up. The beetle proceeded to the top of the gallery and ate its way upward and outward. It emerged from the log on August 23, a medium-sized female. The gallery eaten by the larva between the time it was put in on May 24, and pupation on July 12, in which pupation took place, is shown in Plate I, B—C, and the exit hole eaten by the beetle at C—D. The walls of the gallery made by the larva are much smoother than those made by the beetle as the latter ate its way out. An exterior view of the exit hole is shown in Plate I, F.

A resume of the above indicates the following:

May, 1916, Palm log with immature larvae discovered in Palm Canyon by Mr. Martin.



EXPLANATION OF PLATE I

A. Mature larva of *Dinapate wrightii* in gallery just preparatory to pupation. B—C. Parallel section of gallery eaten by larva between May 24 and July 12, in which pupation took place. C—D. Hole eaten by adult in order to escape from log. E. External view of exit hole.

May, 1917, Log removed to Alhambra, California.

July and August, 1917, 5 adults emerged from log.

April, 1918, 4 full-grown and 5 partly-grown larvae observed in one piece of log.

August and September, 1918, 4 adults emerged from remainder of log.

July and August, 1919, 3 adults emerged.

April 1, 1920, one nearly full-grown larva found in log.

July 12, 1920, larva pupated.

August 8, 1920, adult formed.

August 23, 1920, adult emerged from log.

The partly-grown larvae observed by Mr. Martin in 1916 must have been the ones to emerge in 1917 and 1918, indicating the life cycle to be at least 2 or 3 years. However, they may have been more than one year old in 1916. Mr. Martin believes that the small larvae observed in 1917 were from a brood deposited after the log was discovered in May, 1916. However, it is apparent that there was no deposition after the logs were taken in May, 1917, and it seems probable that the latest deposition possible was from beetles which emerged in the summer of 1916. If this is true, then the life cycle of the beetle emerging in 1920 was practically 4 years. It is possible that deposition occurred prior to 1916, which would make the life cycle 5 years or more. Beetles emerging in the other years must have been from 1 to 3 years old at the time the log was discovered. If this is so, it would make 4 separate broods, which seems improbable. It is the writer's opinion that there probably were two broods, and that the life cycle of *Dinapate wrightii* may vary from 3 to 5 years. It is certain that the period can be four years. The quantity and quality of food accessible to each individual larva no doubt had much to do with the rate of development, but probably other factors enter in also. If the log contained only one brood, then the variation in the length of life would be still greater.

It is interesting to note that when Mr. H. G. Hubbard visited Palm Canyon in February, 1897, he observed that "all larvae were thoroughly dormant and very flaccid. There are no young, and evidently all are of the same age and nearly or quite adult. I feel sure that they are more than one year old, and probably more than 2 years old, but no doubt they would have issued in July or August of this year."²

Specimens sent to Washington by Mr. Hubbard did emerge in August. His belief that the life cycle would be at least 3 years is demonstrated by the writer's experience.

² Ent. News, Vol. X, No. 4, pp. 228-230, 1899.

Mr. Richard T. Garnett visited Palm Canyon on May 21 and 22, 1917, and after extended search, found an infested log, from which he took 133 adults, 28 pupae and 17 larvae. One fresh exit hole was observed. This and other observations indicate that the period of emergence of the beetles extends from the latter part of May to the early part of September, and it is probable that oviposition also takes place during this period, perhaps continuing a little later. Mr. Garnett observed two sizes of larvae in the log.³

Only one pupal record was obtained, but judging from this, and the condition of the insects on the various dates the log was cut into or examined, it seems that the pupal period is about one month, and the adult may remain in the log two weeks from the time it forms until it eats its way out. Plate I, C—D, shows that the beetle had to bore nearly an inch from the end of the gallery in which pupation took place to the outside of the log.

In view of the relatively large numbers of such a rare beetle collected by Mr. Garnett, Mr. Martin and the writer, Hubbard's fears that the insect was about to become extinct are quite unfounded. The two infested logs were found in the same canyon but more than a mile apart.

³ Ent. News, Vol. XXIX, pp. 41-44, Feb. 1918.

HOLOTHUROIDEA

In sea-cucumbers the chief parts of the nervous system are much as in other groups but the superficial and deep radial and circum-oral systems are quite distinct from each other.

The more superficial system is composed of five strands in an epineural cavity under the longitudinal radial muscles but well in from the surface of the body. The oral ring circles the peristome; at the base of the tentacles between its radial branches there are strands, one for each tentacle; other branches go to the pharynx and intestinal tract. The epineural cavity seems not present in some forms, possibly due to contraction of the animal. The radial nerves end at the anal end of the body but there is no special terminal tentacle. The radial nerves give off branches to the tube-feet and also to the skin; two nerve plexuses have been recognized, a superficial just under the epithelium and a deeper one in the body-wall. Both of these networks receive some branches from the radial nerve.

The deeper nerve ring or hyponeural divides into two strands on the inside of each superficial radial nerve according to Herouard, '87. This deeper system is chiefly motor while the superficial system is sensory, a generalization which he extends to other echinoderms. Branches from the deep system are said to supply muscles of the body-wall and lantern region.

Among the earlier works dealing with the nervous system of holothurians was that of Krohn, 1841, where the radial nerves were noticed but little detail given. Semon, 1883, and especially Hamann, show the general form and histological structure of the nervous system. Herouard, '87-'89, brings out some points, especially emphasizing the motor and sensory divisions of the nervous system, as already noted.

Gerould, '96, shows the nervous system in *Caudina* but little is said about it. Clark in *Synapta*, 1898, shows the nervous system in section. Red spots at the bases of the tentacles, the so-called eyes, are figured.

Five radial nerves are recognized and smaller branches to the tentacles. Each radial nerve is divided longitudinally into an outer and inner band as in other forms, but unlike others has no vessel of any kind accompanying the nerves and no spaces or lacunae. Each tentacle nerve sends off branches to the digits so that almost the whole surface of the tentacle becomes sensory. On the bases of the tentacles and in the ectoderm over the body are sense buds or tactile papillae such as described by Hamann, '83. Under each of these is a small ganglion. From the lower side of the circum-oral ring, between every two tentacles, a broad nerve

runs to the ectoderm of the oral disc and to the muscles of the oesophagus.

Ackerman, 1902, gives figures of the nervous system in *Cucumaria*. Retzius, 1906, by means of the silver method gives a mosaic picture of the epidermal cells. Between these cells are small oval fields, the sense cells between the polygonal areas or supportive cells. These are partly between two cells, partly between several supporting cells; they are not regularly arranged. Reimers, 1912, discusses the development of *Synapta* and gives something of the nervous system. Haanen, 1914, in *Mesothuria*, is not inclined to accept Herouard's (1890) suggestion that the inner nerve band is chiefly a motor nerve. Very fine intestinal nerves from the circum-oral nerve ring are found in this form as well as the thicker nerves found by other observers. Every tentacle and every foot has its own nerve, the first from the circum-oral nerve ring, the second from the radial nerves. The foot nerves are .029 inches broad and smaller and more circular in outline than the tentacle nerves. There seem to be at least some

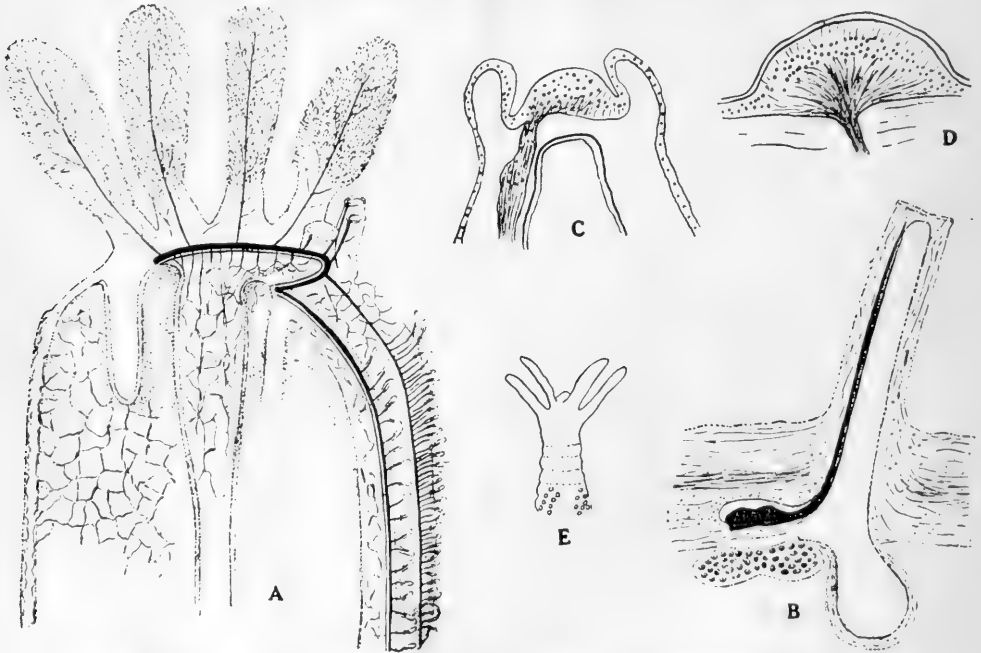


Fig. 32. NERVOUS SYSTEM OF HOLOTHUROIDEA. A. Diagram of a sea-cucumber showing superficial and deep central systems, branches to tentacles and tube-feet and the inner and outer nerve plexus. B. Section through body-wall of Holothuria showing central band in dark with nerve to a tube-foot. C. Nerve supply to tube-foot, Hamann. D. Sense papilla of *Synapta* supplied by a nerve. Hamann. E. Oral end of *Synapta* showing location of sense pores.

motor and probably some sensory fibers in these. Sense cells and an epithelial plexus were not clearly seen in this form. Retzius found sense cells in the skin chiefly about the mouth opening, in the tentacles and the tube feet. In this form the peripheral nerve fibers were not found. Crozier, 1915, discusses the sensory reactions of *Holothuria surinamensis* Ludwig.

The nervous system does not have to be intact for the act of autotomy but it is more successfully carried out when it is uninjured.

The animals are reactive to tactile, vibratile, photic, and chemical stimuli, and practically indifferent to heat in the way of a sensation.

The parts of the body are sensitive in the following order, beginning with the most sensitive: (1) tentacles, (2) anterior end, (3) posterior end, (4) papillae, (5) pedicels (Podia), (6) mid-body surface.

The tube-feet discs are positively stereotropic. This shows in the righting reaction. The arms are photokinetic, negatively phototropic; they do not respond to increase in light intensity, but respond negatively to decrease in light intensity. The whole surface is sensitive in this way. The fluorescent-skin pigment is possibly concerned.

Dissolved substances representing those homologous to human taste qualities for sour, bitter sweet, salt and alkaline, are effective as stimuli.

CRINOIDEA

There are three distinct parts of the nervous system:

1. The superficial epidermal.
2. The deep oral system, according to the suggestions of Delage and Herouard.
3. The deep aboral system.

The superficial oral system is much like the radial and circum-oral system of starfish, with the nerve ring and radial nerves running down the surfaces of the ambulacral grooves in each arm with branches to the surface and to the little elevations covered with sense hairs.

The deep oral system according to Delage and Herouard's interpretation is in the connective tissue under the epidermis and consists of a central nerve ring and strands down each arm with branches to the pinnacles.

The deep aboral system develops later than the oral in the young form. It is in the center of the so-called chambered organ. There is a central mass of nervous matter in the chamber; strands run out from this towards the arms and fork but are united again,

to form a ring or pentagon of nervous tissue. From this ring strands run out to each arm and branch and are distributed to the arms, running embedded in the ossicles of the arms.

Carpenter, '66, and Marshall, '84, found that the aboral nervous system controls the movements of the animals. If the chambered organ is destroyed the animal is paralyzed, but it will swim readily or make the necessary movements just as well when the whole ambulacral nerve ring and alimentary canal are removed.

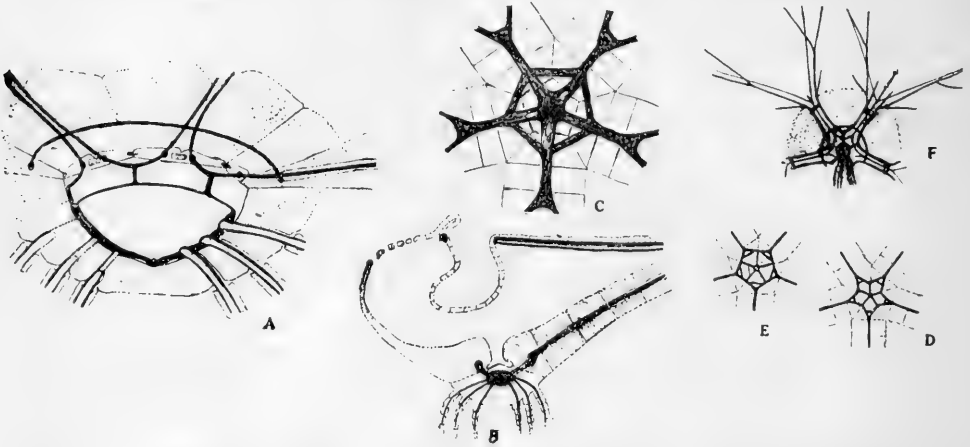


Fig. 33. NERVOUS SYSTEM OF CRINOIDS. A. Diagram of a section through the body of a crinoid showing nervous system by heavier lines. B. Diagram of a section of the nervous system of a crinoid, nerves in black, after Marshall. C, D, and E. Diagrams of the central nervous system of Crinoids, after Marshall and Carpenter. F. Diagram of the plan of the nervous system of a crinoid.

The commissural connectives between the aboral nerves coordinate movements and if these are cut the arms move independently.

The position of the radial cords within the bony plates comes about gradually from larval conditions when they are open, trough-like grooves. These grooves gradually close in.

The cirri each have nerves from the central aboral nerve mass. The arms, the cirri and the palps are tactile organs.

Hamann has shown nerve endings in the surface epithelium as well as by means of little projections with fine hairs at their ends.

Among the important contributions to the nervous system of this group are those of Carpenter, 1865-84, Teuscher, '76, Ludwig, '77, Hamann, '87, Cuenot, '91. The papers of Hamann, Carpenter, Marshall and Haanen are among the most valuable contributions to our knowledge of the nervous system.

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