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New Piscicolidae (Leeches) from the Pacific and their Anatomy

By J. PERCY MOORE
UNIVERSITY OF PENNSYLVANIA

Except in Japan and Europe—notably in Scandinavian seas and the Mediterranean—marine leeches are still very imperfectly known. However, as they abound in numbers and often in moderate variety, well-preserved collections commonly yield novelties. If their internal anatomy be well-explored, peculiarities unknown in any other leech may be found, thereby puzzling the student in his attempt to reach a satisfactory generic reference. Thus often results a tentative assignment, such as the use of *Ichthyobdella* or *Piscicola* as a carry-all, or the establishment of a new generic concept. The material upon which this paper is based has proved to be no exception. Without entering into a discussion of why the systematics of the marine Piscicolidae remains so laggard, the fact is that descriptions of such changeable and reactive organisms must be much more detailed and comprehensive than in groups in which characters are stable and categories well-defined.

Most of the material discussed in the following pages is from the late Mr. E. F. Ricketts of the Pacific Biological Laboratory at Pacific Grove and has been in my possession, though incompletely studied, for several years. It includes all specimens of *Pontobdella loricata* and *Marsipobdella sacculata* and most of the *Branchellion lobata* (fig. 1). Additional examples of *B. lobata,* including whole mounts and transverse sections, were collected in San Francisco Bay and southern California and were generously loaned by Dr. Marvin C. Meyer. All of the *Johanssonia abditovesiculata* were taken from a puffer fish in the Honolulu Aquarium by Mr. Spencer Tinker and sent to me by

Dr. C. H. Edmondson of Bishop Museum. To all of these helpful providers of material go my grateful acknowledgments. On many of the text figures, enlargement is shown in millimeters and drawn to scale; but nerve ganglia, often not drawn to scale, are used only as indicators of metamerism.

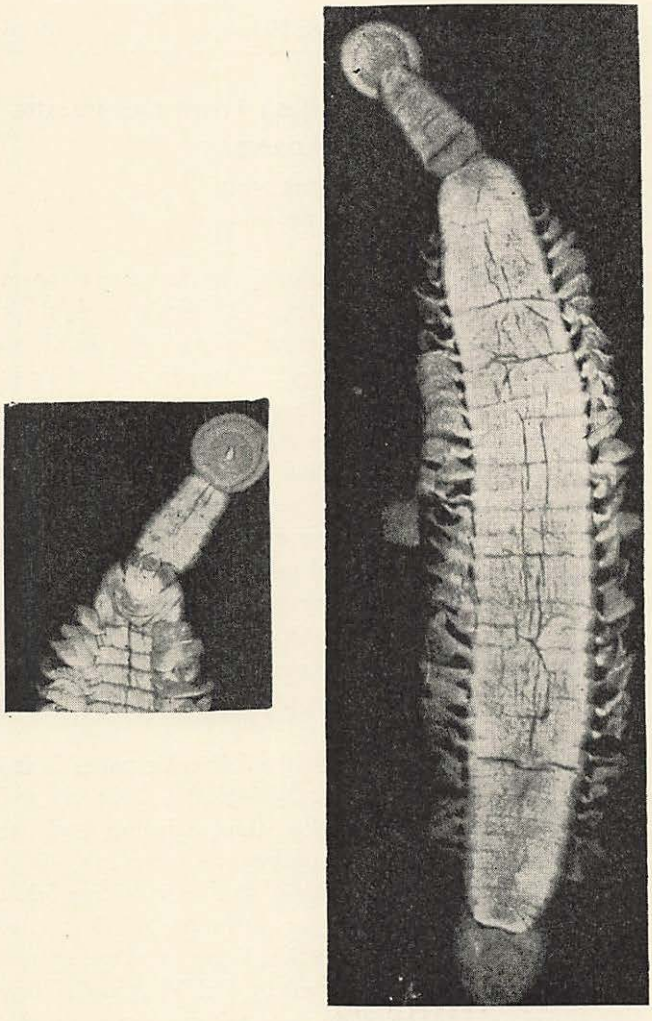

FIGURE 1.—*Branchellion lobata,* holotype, complete dorsal and anterior end of ventral aspect, × 3½.

Pontobdella loricata Harding, in Harding and Moore, Fauna of British India, Hirudinea, 39-41, text fig. 11; pl. 2, fig. 3, 1927. (See figure 2, *a*.)

The external characters of the better preserved of two specimens are well shown in figure 2, *a*. This measures in millimeters: length 69.0, preclitellar trachelosome 9.5, clitellum 4.2; widths: cephalic sucker 3.5, at male pore 2.4, maximum (XIX, XX) 6.0, anus 3.5, caudal sucker (contracted) 4.0. As the leech is perfectly terete throughout, the depths at each point are the same. The other specimen is somewhat smaller and is very hard and shrunken but shows the annulation and tuberculation somewhat better than the first, with which it agrees in their number and arrangement, the tubercles being much more prominent and sharply pointed.

While agreeing with Harding's excellent description in nearly all respects, there are certain minor differences, most of which probably are due to differences in preservation and the degree of distension of the stomach and postcaecum with blood. It is an excess of distension that has smoothed out the furrows and flattened the tubercles of the larger specimen. The arrangement of the tubercles is very constant and regular throughout. Annulus *a2* invariably bears two pairs of large tubercles above and two below, those of the outer dorsal pair larger; *a1* and *a3* agree in having three pairs of smaller tubercles on each face and a pair of much smaller ones at the margins. No variation was found on *a2;* but occasionally on *a1* and *a3* any tubercle may be reduced or, rarely, even absent. A few cases of fusion were noticed. On the shortened clitellum all tubercles are much reduced in size, which exaggerates the recessed appearance of that region. All fully developed tubercles are roughened at the apex and on the sides by minute sensory papillae of which others are scattered over the surface of the annuli between and around them. When the tubercles are retracted, some of their lower papillae are added to the latter group. Harding (3)[1] describes on the cephalic sucker three pairs of "submarginal papillae" on the annulus immediately back of the marginal one. These are relatively elongated, cylindrical, and smooth, quite different from the tubercles of the body segments. The two lateral pairs are conspicuous on both of my specimens, but the dorsal paramedian pair was found on neither. It is possible that they are retracted completely.

Annulation: The crenulated sucker rim, bearing a row of minute tubercles and sensory papillae, probably represents somite I and the prostomium. Behind this are eight fairly distinct but very short (narrow) annuli, all bearing similar little papillae. The first bears the "submarginal papillae" and is considered to be the uniannulate somite II. III is 2-annulate, (*a1, a2*) > *a3;* IV is similar; V is 3-annulate, composed of the last two sucker annuli (V *a1, a2*) and the first free peduncular annulus. VI is 2-annulate, (*a1, a2*) + *a3;* VII to X inclusive are all 3-annulate (*a1, a2, a3*). The preclitellar annuli, with the exception of the two very small pedunculars, bear tubercles having the typical arrangement. The clitellum includes the small annuli between X *a2/a3* and XIII *a1/a2,* which normally should be eight primaries; but we find only six annuli bearing very small tubercles and a very small one without tubercles split off of the anterior margin of XI *a2* and therefore XI *a1;* but there is no similar small annulus on XII, which is therefore 2-annulate, (*a1, a2*) + *a3.* This differs slightly from Harding's description. The male gonopore is at XI *a2/a3* and the smaller

[1]Numbers in parentheses refer to Literature Cited, page 44.

female pore a full somite behind at XII *a2/a3*. Throughout most of the urosome, the 3-annulate, complete somites, XIII to XXIII inclusive, are very uniform both in distribution of tubercles and relative size of the annuli ($a1 < a3 < a2$), except in the region of maximum diameter about XVIII to XX where it is $a1 < a2 < a3$. Not infrequently, a minute crescentic wedge is cut off of the

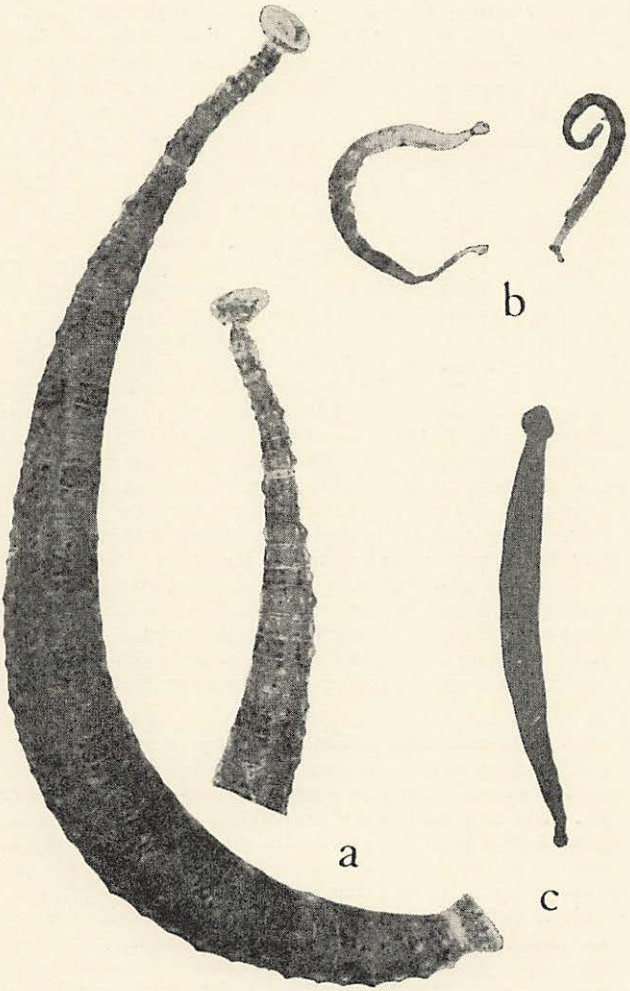

FIGURE 2.—**a,** *Pontobdella loricata,* complete view of right and anterior half of left side, × 2½. The former shows the proboscis pore and the latter the "submarginal papillae." **b,** *Marsipobdella sacculata,* holotype and a contracted cotype, × 2⅔. **c,** *Johanssonia abditovesiculata,* holotype, shows general form and proportions; head at bottom; × 4.

anterior ventral margin of *a2*. Whether XXIV is 2- or 3-annulate is somewhat doubtful; *a1* and *a2* are normal, and the following small annulus bears six dorsal tubercles in one specimen and five in the other, the paramedian pair being united. As it is pigmented more like *a3* of preceding somites, it is probable that it belongs to a 3-annulate XXIV. This is supported by the observation that the large annulus which represents XXV bears both before and behind the large tubercles characteristic of *a2*, a few very small tubercles in an irregular row indicating the inclusion of *a1* and *a3*. XXVI, similarly, is a large annulus with an *a3* but no *a1* element indicated by very small tubercles. The anus is at XXVI/XXVII (Harding states XXVI *a2/a3*), which is followed by two small and obscure annuli.

Color: In life "muddy green brown" (Ricketts). All green has disappeared from the preserved specimens, and the best-preserved one has a complexly mottled distribution of brown of varying tones and whitish, with the latter most distinct on the larger tubercles and the browns deepest on annuli *a1* throughout, resulting in a rather diffuse banded pattern which shows well in the photograph. As neither of the two specimens is suitable for dissection, nothing can be added here.

The present description is based on two specimens collected by E. F. Ricketts at Pacific Grove, Monterey Bay, California. Both were taken from "sharks and rays captured at depths of from 15 to 60 fathoms."

The type and only specimen available to Harding (3) was taken in the Andaman Sea. Dr. G. L. Hora, Director of the Zoological Survey of India, kindly informs me that it was taken in a trawl at Marine Station 233 in 185 fathoms, sandy bottom.

As with other species of *Pontobdella* ectoparasitic on roving pelagic sharks, a wide distribution of *P. loricata* is not surprising.

Genus **Marsipobdella**[2] new genus

Small leeches of the family Piscicolidae, resembling *Carcinobdella* Oka (9, 10) in general external form and annulation but differing greatly in internal anatomy. No sharp division into two regions but trachelosome attenuated; no urosomal collar or shoulders; no pulsatile vesicles or other lateral outgrowths. Cephalic suckers large, excentric; discoid in full expansion; proboscis pore ("mouth") slightly in advance of center. Complete somites 12- (14-) annulate. Proboscis very small; stomach simply camerated; postcaeca united for full length. Testisacs, five pairs, when mature aligned with gastric chambers but alternating with nerve ganglia; unique as known in the family is an unpaired seminal receptacle (spermatheca) in somite XIII.

Genotype, *Marsipobdella sacculata,* new species.

[2] Not to be confused with *Marsipobdella* Goddard and Malan.

Marsipobdella sacculata, new species (figs. 2, *b*; 3-5).

Diagnosis (characters of genus): Length (extended) up to 29 mm., ratio of diameter to length 1:16, contracted 1:9. Cephalic sucker discoid or spoon-shaped, strongly excentric and expanded conspicuously on a very narrow peduncle and slender trachelosome; caudal sucker, when expanded, discoid and larger than cephalic, when contracted cupulate; no eyes, no ocelli. Gonopores separated by two (one again divided) or three annuli. Color (preserved) blotched irregularly and variously in black, dusky, yellowish, and whitish due to a background of opaque blood in the gut and the pale or colored cocoon and mucous glands seen through the unpigmented body walls. Pharynx ending in somite IX. Preatrial loop of sperm duct (ejaculatory bulb) reaching to or beyond ganglion X. Musculature very weak.

Description of holotype (fig. 2, *b*): *Form* elongated clavate, terete or slightly depressed, extended and slender, especially in the trachelosome; greatest diameter at about beginning of caudal third (XVIII/XIX), tapering somewhat irregularly to the very narrow anterior sucker peduncle but very little to the thick caudal peduncle. Ratio of maximum diameter to length 1:16. No sharp division between trachelosome and urosome; no urosomal collar, no pulsatile vesicles, branchiae, lateral flanges or tubercles; sensillae and nephropores not seen. Measurements in millimeters: length 29.0, to male pore (including sucker) about 6.0, trachelosome (without sucker) 5.2; widths, cephalic sucker 1.6 maximum (*ca* XIX) 1.8, caudal sucker 2.1. *Cephalic sucker* discoid, circular, very thin toward margins, very excentric, anterior median radius three times posterior (ventral), attached to peduncle by a low, rounded ridge; dorsum faintly annulated and margins crenulate; ventral concavity very shallow with small proboscis pore slightly before center; no pigmented eyes or ocelli. *Trachelosome* very slender and elongated, the peduncular constriction abruptly very narrow, for the following three annuli increasing in diameter rapidly, then very gradually, especially in depth, to the clitellum. *Clitellum* defined by somewhat deeper furrows, relatively long for a piscicolid, slightly wider in middle due to the crowded ends of cocoon gland ducts, somewhat depressed; ventral face slightly concave with deep irregular furrows in gonopore area; male pore a conspicuous transverse slit at XI *b5/b6*; female pore obscure, deep in furrow XII *a2/b5*, two and a half primary annuli (XI *b6*, XII *a1*, *a2*) caudad of male. Both preclitellum and clitellum conspicuously divided into larger (secondary) annuli, and many of these into more or less well-defined smaller tertiary annuli. *Urosome* comprises about 4/5 of total length and much the thickest part, due to the blood-filled gastric chambers and postcaecum which, with the five pairs of testisacs make it slightly moniliform; otherwise it continues outline of trachelosome. The slightly paler colored swellings due to the ovisacs and five pairs of testisacs give somewhat of a false appearance of marginal vesicles. Skin is smooth and entirely without tubercles but with numerous minute sensory papillae, although no metameric sensillae were seen. *Caudal sucker* more contracted and only about ⅓ larger than cephalic, little exceeding greatest diameter of body, cavity much deeper and walls thicker than cephalic sucker; no ocelli seen. *Color* (preserved): variously blotched due to irregular distribution of pale yellow, pink, or dusky cocoon and paler mucous glands seen through the translucent and unpigmented body walls against the opaque and nearly black background of blood-filled stomach and postcaecum.

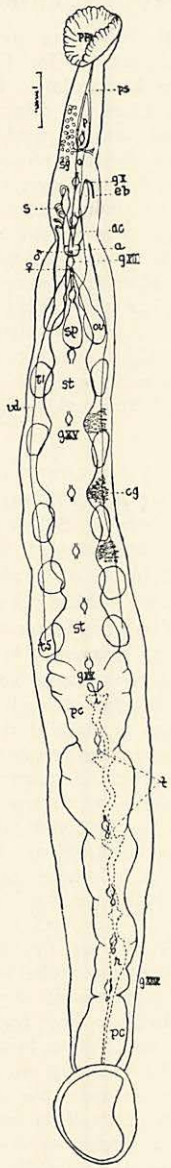

FIGURE 3.—*Marsipobdella sacculata*, general anatomy from venter, × 7: a, atrium; ac, atrial cornu; cg, cocoon glands; eb, ejaculatory bulb; f, fenestrae; g, nerve ganglia; i, intestine; o, oesophagus; ov, ovisacs; p, proboscis; pc, post-caecum; pp, proboscis pore (mouth); ps, proboscis sac; r, rectum; s, sperm duct and vesicle; sg, salivary glands and ducts; sp, spermatheca; st, stomach; t1-5, testisacs; vd, vas deferens; ♂ ♀, male and female gonopores.

Annulation (figs. 2, *b*; 4, *a*): Furrows are generally deep and the annuli conspicuous, except where smoothed out by distension of blood-filled gastric chambers. Complete somites are 12-annulate with all tertiaries developed and usually with two of these in the *a3* region enlarged and subdivided to make 14. On preclitellum of trachelosome, annuli tend to increase in size caudally. First five or six appear to be primaries and remaining 25 or 24 to the preclitellar furrow, secondaries or tertiaries; but wherever strong compression occurs, as at interior bends, some of these are again faintly furrowed. On clitellum, 12 of larger (mostly secondary) annuli are divided into about 21, mostly tertiaries. As the position of ganglia on the intact type specimen could not be determined exactly, no attempt is made to define the somite limits; but the total number of preclitellar (30 or 31) and clitellar (21 or 22) annuli agrees closely with the numbers (29 to 33 and 21 to 23 respectively) counted on cotypes, as does annular position of gonopores. Taking into account the larger divisions only of clitellar annuli, seven precede the male pore, two and a half lie between the male and female, and four follow the latter, making 13 in all. (For internal anatomy see cotypes.)

Additional notes from cotypes on external characters: While all of the 25 specimens agree with the holotype in essentials, some differ in details. All are more or less bent, twisted, and distorted. Shape and proportions are due in part to the degree of distension of the stomach with blood. Some are quite empty and these are mostly contracted, with depth of furrows and annuli exaggerated and cocoon glands usually pale and clear, making color a more uniform pale yellowish. Smallest in same state of extension as type measures 22.0 × 1.6 mm., a ratio of 14:1. Smallest contracted specimen measures 14.0 × 1.6 mm. with a ratio of 9:1. There is considerable variation in the suckers, although the relative size remains nearly constant. Cephalic is constantly strongly excentric and most often expanded, with sides curved ventrad to make it reversed scoop- or spoon-shaped. On contracted specimens it becomes more deeply cupped or even campanulate and somewhat drooping, thick and with marginal crenulation deeper. In all of them, the transverse dorsal furrows remain and narrow peduncle permits great freedom of movement; eyes absent. Caudal sucker rarely departs noticeably from the type, but its margin may be contracted to make cavity deeper and opening narrower. Greater variability is shown by trachelosome and, especially, by clitellum, which is probably correlated with the better developed musculature of the body walls than in urosome. Although shape of preclitellum varies little, its length relative to that of urosome varies considerably and this affects appearance of annulation. Rather striking changes in clitellum are probably to be related to the functional states of reproductive organs. Its boundaries appear to be as usual, X *a2/a3* to XIII *a1/a2*, but in only a few cases are these furrows conspicuously deeper than neighboring ones, the complete composition being X *b5, b6*+XI *b1-b5/*♂ *b6*+XII *a1, a2/*♀ *b5, b6*+XIII *b1, b2*. In only one case does the clitellum have a different color. Several specimens resemble the type in having clitellum slightly bulging; but on others it is narrower, and on two very strongly constricted and flattened or concave on venter at region of gonopores, which are drawn into close proximity. These individuals also have clitellum much elongated and boundaries obscure. Whatever the appearance of clitellum and its annuli, position of gonopores is immediately before and behind ganglion XII.

Internal anatomy (fig. 3): This account is based upon entire specimens stained and mounted or simply cleared, dissections and serial sections, which

latter, owing to distortions, could not be made in precise planes. Digestive and reproductive organs could not be studied fully on the type, but by clearing in glycerine, enough was seen to determine that they agreed in general with the following. *Alimentary canal:* Proboscis sac is a straight, very narrow, thin-walled tube running from proboscis pore through nerve ring to ganglion IX. *Proboscis* (p) small, at rest extending from caudal end of suboesophageal ganglion mass (VII) through only two somites to ganglion IX. Sections show it to be loosely constructed at the very small anterior end, but of normal structure at larger posterior end where it unites with sac and receives ducts of salivary glands which are diffuse, the cells 0.102 × 0.085 mm. in diameter (average of 10) and scattered through somites VII, VIII, and IX. *Oesophagus* (o) long and narrow,

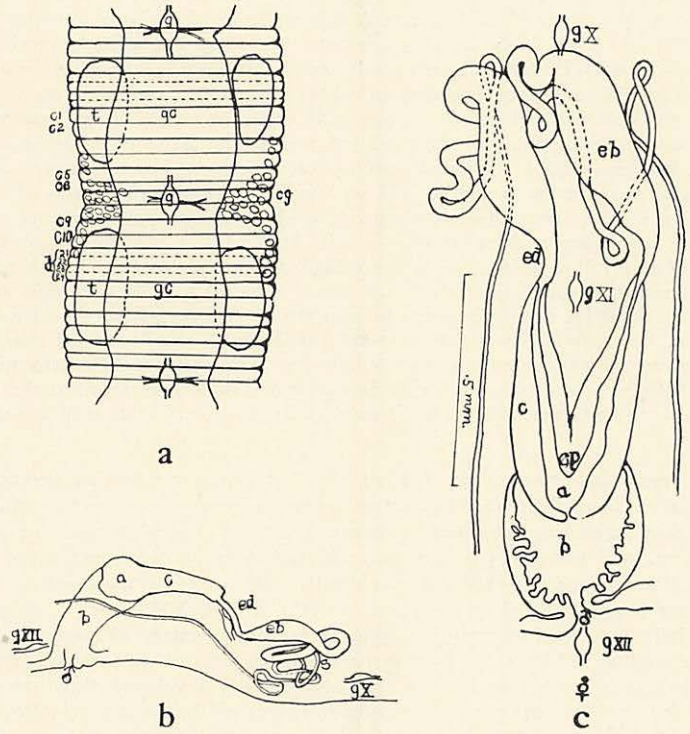

FIGURE 4.—*Marsipobdella sacculata:* a, diagram showing alignment of gastric chambers (gc), testisacs (t), and nerve ganglia (g); cg, aggregations of cocoon glands, × about 25 (designation of annuli by exact neuromeric numbers is tentative). b, freehand drawing of side view of a dissection of male organs, × about 25; c, male organs, except testisacs in dorsal view, reconstructed from sections and dissections, cornua pulled forward to expose bursa, × 56. Symbols: a, atrium; b, bursa; c, cornu; cg, cocoon glands; cp, cornual projection; eb, ejaculatory bulb; ed, ejaculatory duct; g, nerve ganglia; s, sperm duct and vesicle; ♂ ♀, male and female gonopores.

slightly enlarged at union with pharynx in IX; passes between the atrial cornu to join first small chamber of stomach at XIII/XIV. In none examined is there evidence of diverticula. *Stomach* (st), like oesophagus, thin-walled moniliform, consisting of a series of six globoid chambers in somites XIV to XIX/XX separated by constrictions without sphincters or definite muscular septa, but surrounding spaces filled with aggregations of cocoon glands. When empty, stomach nearly tubular, and in some specimens even when filled with blood, constrictions are relaxed and chambered character largely disappears. In somite XX, stomach passes almost without interruption into the massive postcaecum (pc). When filled with blood, paired openings are so large and the one into intestine so small that original relation is obscured. Postcaecum is divided into five large squarish or irregular blocks occupying somites XX to XXIV and a tapered lobulated sixth segment in XXV and XXVI, the last with no trace of division into its component halves. Five fenestrae (f) penetrate the others immediately caudad of ganglia XX to XXIV and, although small, are very distinct in favorable specimens but almost obliterated by pressure in others. In sagittal sections, they show clearly and regularly. *Intestine* (i) is usually empty or nearly so and stands out conspicuously on dorsum of dark-colored postcaecum as a meandering white streak. It begins with a very small opening into dorsum of end of stomach above orifices of postcaecum in somite XX, and to XXIII bears four pairs of small lateral pockets or caeca which are scarcely evident in some specimens but probably are much longer when intestine is full. At XXIII/XXIV is a constriction and sphincter followed by a very thin-walled bulbous rectum (r) which tapers to a narrow tube, opening at the small dorsal anus on XXVII. In some specimens, the digestive system presents an appearance differing from the above description. Stomach is very irregularly filled with blood, has ill-defined chambers and relaxed constrictions and their alignment with ganglia is indeterminate. As in such cases the body wall may be easily detached, it is assumed that this condition is due to maceration, but it may lead to misinterpretation of the metamerism.

Reproductive organs (figs. 4, *b, c*; 5, *a, b*): Data for following description were derived from what could be seen on the type specimen after clearing in clove oil, on four stained and mounted in balsam, 10 others cleared in glycerine, three dissections, and two series of sections. Although some yielded much more than others (the sections of course the finer details), all agreed on the essential facts. *Testisacs* (figs. 3; 4, *a*): Five pairs in XIV/XV to XVIII/XIX inclusive; when fully developed elongated ellipsoidal in form, exactly aligned with and often extending full length of gastric chambers, but alternating with both gastric constrictions and nerve ganglia. When only partially developed, they are more tetrahedral and lie opposite to the cephalic halves of the gastric chambers and in contact with or even slightly penetrating preceding membraneous septum. In this condition, relative positions of gastric chambers, testisacs, and nerve ganglia present a striking resemblance to *Notostomabdella* (8, p. 17). Fifth pair lies in a more ventral position beneath stomach, and may be smaller and occasionally absent. *Sperm duct* presents usual parts. Vas deferens (vd), which is capillary in testicular region, becomes somewhat increased in diameter in XIV and XIII, where several bends and folds form a loose epididymis (s) by side of ovisacs and then continues forward in a straight course laterad of atrium and cornu, anterior to which a second more complex group of enlarged coils forms the anterior seminal vesicle. Diameter of duct becomes still greater in a fusiform ejaculatory bulb (eb) with thick muscular and glandular walls which joins the anterior apex

of atrial cornu by a short ejaculatory duct. The pair of bulbs forms by far the most conspicuous part of sperm ducts, and they are remarkable in that they extend far in front of cornua to ganglion X or beyond; but their exact position and form differ in different specimens. All parts of sperm duct are filled with spermatozoa. Male terminal organ consists of an eversible bursa (b) invaginated from

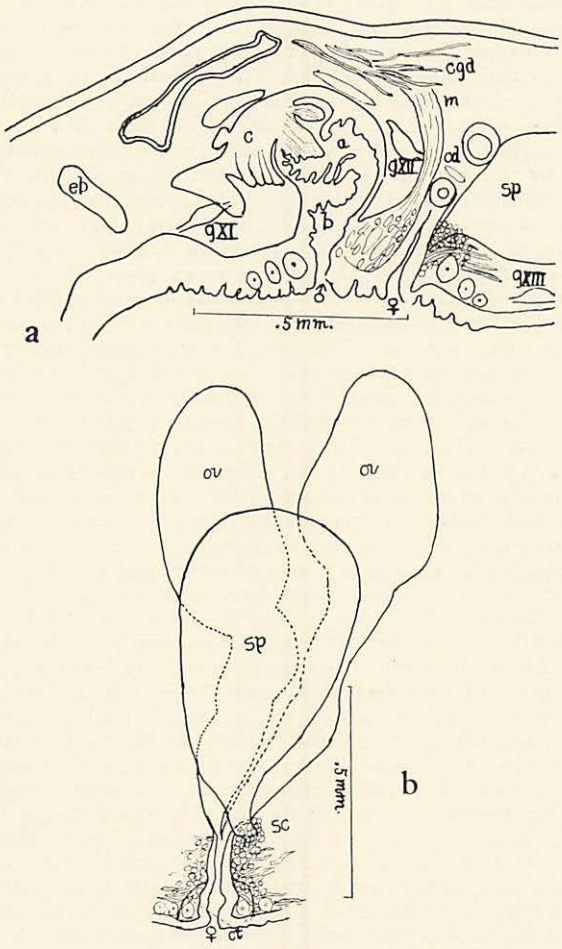

FIGURE 5.—*Marsipobdella sacculata:* a, near median plane, camera lucida drawing of sagittal sections to show relation of gonopores and spermathecal duct, × 56: a, atrium; b, bursa; c, cornu; cgd, cocoon gland ducts; eb, ejaculatory bulb; g, nerve ganglia; m, muscle; od, common duct or vagina; sp, spermatheca; ♂ ♀, male and female. b, female organs from a dissection and mounts with details of ducts from sections, × 56: ct, conducting tissue; ov, ovisacs; sc, spermatheca cells; sp, spermatheca.

ventral body wall and spermatophore-forming organ or atrium (a), which arises by the union of the two sperm ducts. Bursa is a rather long cylindrical sac rising vertically from male pore and having walls composed of a much-folded epithelium and a muscular layer. At its summit, it is somewhat expanded to receive and partly envelope median atrium. Atrium is a small compact globular organ with moderately thick glandular and muscular walls projecting into and opening in dorsal end of bursa. The two limbs or cornu (c) are large, straight conical organs which diverge slightly and taper as they project forward to receive ejaculatory ducts at their apices at ganglion XI. At their enlarged bases they open separately into cephalo-dorsal face of median atrium, with a flattened conical median projection between the two openings. They have thick walls similar in structure to median atrium and relatively small lumena. Arrangement of its musculature shows that bursa is eversible to project atrium with the external pore during spermatophore exchange, but none was seen in normal eversion. In one abnormal case bursa probably has been ruptured, as whole atrium with its cornua and even part of one ejaculatory bulb lie outside of body. Appearance is much like Johansson's figure of *Callobdella* (4). Ovisacs (figs. 3; 5, *a, b,* ov) are the usual one pair and occupy most of lateral parts of somites XIII and XIV in which stomach is small. Each consists of two parts (ov), a posterior globoid or ellipsoid, very thin-walled sac filled with ova in developmental stages and an anterior tubular portion containing mostly mature or nearly mature ova. Latter is usually more ventral in position than larger bulbous portion and continues forward without change to ganglion of XIII, where the pair contract to narrower ducts with thicker walls, pass beneath oesophagus and nerve cord and unite into a muscular common duct or vagina (od), which runs vertically to female pore. In the sections, no spermatozoa were seen within ovisacs, as is usual in other fish leeches. *Seminal receptacle* (spermatheca) (figs. 3; 5, *a, b*): Most remarkable and distinctive feature of this species is presence of a definite unpaired spermatheca in somite XIII. When fully developed and packed full of globular masses of spermatozoa, this is a relatively large pyriform or ovate sac equal in length to width of clitellum and in diameter to bulb of ovisacs. It mostly lies between and somewhat dorsal to ovisacs and partly beneath and partly beside oesophagus, but its relative position varies with its size and size and position of ovisacs and oesophagus. It tapers to a short duct which passes to one side of nerve cord in company with one of the paired oviducts and becomes lost behind common oviduct or vagina. In addition to thin endothelial and muscular layers, wall of spermatheca consists of peculiar small globular cells (sc) with a small central nucleus. In enlarged portion of sac, they are arranged in a single layer as a loose epithelium; but toward narrow end, they increase in number, and in the part mentioned above as the duct, they form a loose mass which obliterates lumen and spreads into general copulatory area about gonopores. Some of these cells appear to become detached and to undergo histolysis in spermathecal cavity, possibly furnishing a nutrient fluid for spermatozoa. In region about common oviduct where lumen of spermatheca disappears there are, besides the small round cells and a few large clear, almost unstained cells, many muscle fibers and connective tissue strands and among them narrow chinks or spaces. But most striking features are several slender, deep-stained cords of cells (fig. 5, *b,* ct) which arch out like the legs of a spider, penetrate between large clear cells, and reach ventral epithelium around female gonopore. One pair of these is symmetrical. While they are mostly solid, under high magnification there are places where a fine lumen is suggested. The whole picture suggests a modification of the conducting tissue (tissu de conduction of Brumpt, 2).

Johansson (4), in *Callobdella nodulifera* Malm, and Leigh-Sharpe (5), in *C. lophii* van Beneden and Hesse, have described and figured somewhat similar but paired organs which both have designated as *vesiculae seminales.* They are definitely paired and tubular and open into male bursa at their anterior ends, then unite and encircle female duct, but again separate and accompany the ovisacs. A restudy of my sections shows definitely that spermatheca of this leech has no connection with male bursa but is separated from it by a wide lacunar space. It is possible, however, that it may be filled and emptied of spermatozoa at coitus through cell cords described above. It appears definitely to belong to the female system and consequently is a true spermatheca. Usually it is fully distended and has the pale-yellow color of parts of sperm ducts filled with sperm. But one dissection shows the organ empty and contracted to a hard ovate form on a short stem rising erect immediately caudad of atrium. Strands directly connecting ovisacs with bursa or with an area surrounding its orifice have been described in several other genera of Piscicolidae.

Cocoon glands (fig. 4, *a*): As mentioned before, cocoon or clitellar glands are large, the mean size of 10 being 0.152 × 0.106 mm. Usually they are disposed rather irregularly, spaced in a single layer beneath body wall throughout urosome to anus, with a few in caudal somites of preclitellum, and they pile up in loose masses in the spaces at gastric constrictions where dorso-ventral muscles are almost obsolete. Ducts remain separate until well forward and then gather into a pair of very large ventro-lateral bundles with a few separate dorsal strands. In some individuals, usually those with little blood in the gut, they are all pale yellow and clear readily; but usually they are varicolored and resist clearing.

Musculature: Except in suckers, preclitellum, and terminal reproductive organs, musculature is exceedingly poorly developed. Layers in body walls are very thin, and in urosome, dorsoventral intermetameric muscular sheets are practically absent. This would seem to indicate that this leech is a permanent parasite and incapable of strong swimming.

Holotype in author's collection. Type locality, Pacific Grove, California; ectoparasitic on marine fishes.

Johanssonia abditovesiculata, new species (figs. 2, *c*; 6 *a-c*; 7, *a*).

Diagnosis: Size small, not known to exceed 15 mm.; suckers moderately expansive, the cephalic strongly excentric, no formed eyes, only imperfect ocelli; lateral vesicles very small, repressed (and doubtful), but some of them indicated in sections by extensions of the lacunar system; complete somites 14-annulate, grouped also as 12 and 6; gonopores separated by two and a half to three primary annuli; color banded on dorsum, striped on margins. Testisacs, five pairs; sperm ducts short, little folded, with no anterior spermatic vesicles but very long tubular ejaculatory bulbs; postcaecum completely unified, at least two fenestrae.

Description of holotype: Form flattened cylindroid, slightly enlarged near middle and tapered both ways; body obscurely divided into two regions by post-clitellar furrow but no collar or widened shoulders. Measurements in mm.: length 14.0, cephalic sucker 0.8, total trachelosome 2.6; widths: cephalic sucker 0.8, at male pore 0.7, maximum (XVIII) 1.2, at anus 0.8; depths: male 0.6,

XVIII 1.0, diameter caudal sucker 1.5. Ratio of width to length 1 : 12. *Cephalic sucker* diameter slightly exceeds width at clitellum, the thickened rim indicating contraction, circular, attached excentrically, the anterior or dorsal radius about two and a half times posterior or ventral. Dorsum convex and faintly furrowed, no eyes and no ocelli apparent on entire worm, although some of latter may be concealed in the heavily pigmented area; venter shallowly cupped, the cavity being limited by the thickened rim, small proboscis pore on a slight elevation in somite III. *Trachelosome* differs little in general appearance from urosome; the peduncular or nuchal constriction only moderate and no especially deep post-cephalic furrow at VI/VII; preclitellar part increases gradually in width with slight flattening to preclitellar furrow X *a2/a3* and is composed of 13 primary annuli which increase in length and subdivision caudally. (See annulation, p. 33.) *Clitellum* (fig. 6, *c*) clearly defined by deeper furrows X *a2/a3* and XIII *a1/a2*, by being slightly recessed and by its nearly solid dark color; composed of eight primary annuli X *a3* to XIII *a1* inclusive; gonopores at XI *a1* and probably XI/XII, separated by two and a half (or three) primary annuli, both small and inconspicuous, the male in center of a pale circular area corresponding to end of retracted bursa; female much smaller in a smaller circular area. *Urosome:* Owing to recession of clitellum, first annulus (XIII *a2*) of urosome seems somewhat abruptly enlarged, but it is in line with last pre-clitellar annulus (X *a1*) and there are no shoulders and no trace of a collar and only slight increase in diameter to the maximum at XVIII, XIX. Along margins are 10 pairs of minute clear spots in center of larger white spots arranged metamerically nearly opposite ventral nerve ganglia in somites XIII to XXII inclusive. As these are in position of lateral pulsatile vesicles of many piscicolids and as sections show some lateral branches (fig. 7, *a*) of lacunar system ending beneath skin at these points, they are regarded as these vesicles, although none was seen rising above surface in blister form as though in diastole. Annulation in this region is rather obscure, but the six secondaries are clearly defined by deeper furrows and each is divided into two tertiaries. In caudal third of somite, one or two of the latter are further, and usually less clearly, divided into two quaternaries. Complete somites may, therefore, be described as 6-, 12-, or 14-annulate with 12 as the most obvious and convincing. Whenever ventral nerve ganglia can be seen through body walls they are aligned with marginal white spots and supposed vesicles on middle third of somites (*a2*). Caudal of XXIII, last of clearly complete somites, to small anus are 27 small annuli, mostly tertiary but some reduced or undivided secondaries at caudal end, followed by two or three half-annuli, post-anal in the thick caudal peduncle. *Caudal sucker* well-expanded, about twice diameter of contracted cephalic sucker, saucer-shaped, no ocelli but dorsal face darkened by a dense chromatophore reticulum, divided by 14 paler rays; ventral face smooth and pale, the margin without sealing membrane, crenations, or papillae. *Color* (as preserved): Dorsum generally olive brown, concentrated in wide intermetameric zones, each composed of a pair of lateral spots and a paramedian paired streak; alternating with narrower, paler bands on middle (*a2*) region of each somite, both being irregular and somewhat mottled by subdermal gland cells. Along entire length of each margin is a narrow continuous brown line sharply defined both dorsally and ventrally by white stripes. The dorsal one is irregular, but continuous and very white, and expands metamerically into conspicuous spots which include the supposed vesicles; it is due chiefly to the white light reflecting reserve cells which lie close to surface. Ventral stripe is narrower and more uniform but somewhat

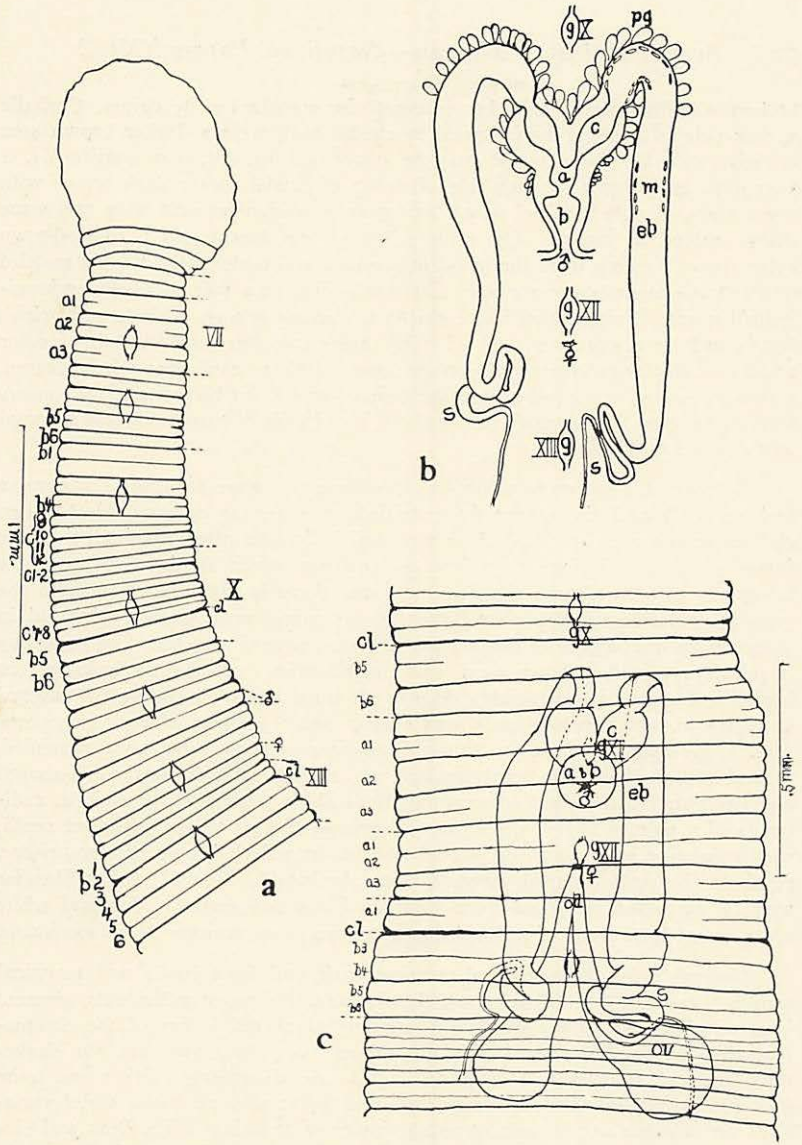

FIGURE 6.—*Johanssonia abditovesiculata:* **a,** dorsal view, slightly rotated, of somites I to XIII of a cotype, showing annulation designated by neuromeric notation, × 31; **b,** reconstructed caudo-dorsal view of terminal male organs from sagittal sections, × about 56: pg, "prostate" glands; m, muscle; **c,** annulation of the venter of the clitellum, with camera lucida outline of reproductive organs from a whole mount, × 56 (bursa and median atrium appear superimposed as one). Symbols: a, atrium; b, bursa; c, cornu; eb, ejaculatory bulb; g, ganglia; od, common duct or vagina; ov, ovisac; s, sperm duct and vesicle.

broken. Clitellum nearly solid brown except for marginal white stripes. Cephalic sucker pale in anterior half, brown in caudal half, with a darker brown spot on each side in which ocelli may be concealed (p. 33). On somite VI, a very dark brown spot on each side. Dorsum of caudal sucker dark brown with seven pairs of pale rays, of which first pair is hidden beneath body and some others extend to margin. On venter, skin is translucent and a coffee-brown color shows through from the blood in stomach and postcaecum, thickly mottled by the vari-colored cocoon glands disposed mainly in a pair of irregular longitudinal tracts. Pigmentation is due chiefly to chromatophores with dense blackish bodies and an elaborate system of finely branching processes. Depth of color results mainly from degree of concentration of these elements; when cleared, reticulum is seen to extend in varying degree throughout body including suckers and with a very fine network in dermis. (For details of annulation and internal anatomy, see cotypes.)

Cotypes: Of the seven additional specimens two were sectioned (transverse and sagittal) and the others first studied in water as opaque objects, then cleared in glycerine or turpinol or mounted in balsam after staining. Sections furnished most information on internal anatomy which is obscured on whole mounts by cocoon glands. In size and form, there is little variation from the type, the relative roundness or flattening depending upon amount of blood in stomach and the degree of contraction of dorso-ventral muscles. *Clitellum* may be either recessed, exactly even with body outline, or slightly bulging, but bounding furrows are invariably deep in all three cases (including the sagittal sections) in which female pore was clearly seen; position of both gonopores (fig. 6, *a-c*) agrees with the type. *Cephalic sucker* may be more expanded, thinner and shallower, or deeply cupped, and thicker, or even nearly bell-shaped and pendent, but the ratio of excentricity is about constant. In sections, rudiments of a pair of "eyes" occur as two groups of four to six imperfect ocelli, each consisting of a glass cell partly enclosed in a dark brown chromatophore, some of the cups directed forward, some backward. *Caudal sucker* likewise may be expanded and discoid or contracted and cup-shaped. Marginal white spots and at least some of pellucid dots are obvious on urosome of all specimens.

General color pattern of alternating dark and light bands and marginal stripes is constant but intensity and details vary. On palest individuals, pigment is confined mostly to the small and intensely black cell bodies of the chromatophores, but dendrites are highly arborescent, very long and fine. On darker ones, pigment is chiefly in dendrites, which are irregularly thicker and unite in a fine reticulum which becomes close and dense at dark spots. Chief variations on urosome are in width and continuity of marginal white lines and size of spots. Frequently there is a very dark brown spot at dorso-cephalic margin of white spots, and occasionally a pair of very dark longitudinal streaks on XIII. There may be a general varied mottling determined by distribution of chromatophores and paler gland cells. While clitellum is always more uniformly colored, it may be paler or darker. On cephalic sucker, pigment reticulum takes form of an irregular and ill-defined Greek cross, the transverse bar of which is darker and includes a pair of widely separated very dark spots (so-called "eyes"). On venter, several specimens have a clear median field permitting nerve cord to show through to serve as a valuable guide to metamerism.

Annulation (fig. 6, *a, c*) : On a small leech such as this, furrows and annuli of the higher orders are often so feebly developed that they are sometimes disregarded in descriptions, making the somite appear more simple than it really is and obscuring possible relationship to larger leeches with conspicuously divided annuli. All specimens agree closely in annulation, but it was worked out in detail on examples that could be treated more freely than the holotype.

Somites I-V *a2* constitute the cephalic sucker, but only the last is clearly defined on the peduncle. VI is 2-annulate, (*a1a2*) + *a3*, followed by a deeper furrow, VI/VII; VII 3-annulate (*a1* = *a2* = *a3*) ; VIII 6-annulate (*b1-6*, *b5-6* mostly slightly larger) ; IX 7- or 8-annulate, like VIII, except that *b6* is larger and divided into *c11* and *c12;* X 8- to 10-annulate (*c1* to *c4* + *b3* to *b6*), or *b3* and *b4* also may be divided. The deeper preclitellar furrow being at X *b4/b5*, placing six or eight annuli in the preclitellum and only the last two in the clitellum, making 13 primary and a total of 25 to 30 annuli of all denominations in the preclitellum. The whole somite X may be contracted and shorter than IX. As is usual in the family, clitellar somites are simplified. The nine annuli counted are all regarded as primaries, except the first two (X *b5 b6*), and any additional *b* furrows are very faint. XI is 3-annulate (*a1* to *a3*), XII 2- or 3-annulate, probably most often (*a1 a2*), *a3* and XIII *a1* with the deep post-clitellar furrow at XIII *a1/a2*. Figure 6, *a, c* shows some of the variation. *Urosome* begins with the larger XIII *a2* and *a3,* both divided into *b3* to *b6* with traces of tertiary furrows and a possible lateral vesicle on *b4*. Somites XIV to XXII or XXIII, including entire testicular and part of post-caecal regions, are complete with 12 or 14 annuli. The 12 tertiary annuli *c1-12* are always clearly defined and grouped in couples separated by deeper secondary furrows emphasizing the six larger secondary annuli. On most of these somites, unless altered by contraction or bending, *a3* region is longer and at least some of its tertiaries, usually *c10* and *c11,* are divided into quarternaries *d19* to *d22*. The complete formula, therefore, is (*c1-2*)+(*c3-4*)+(*c5-6*)+(*c7-8*)+(*c9*+*d19-20*)+(*d21-22*+*c12*) for a 6- to 14-annulate somite. Fixing the external limits of the somite was often possible by the visibility of the nerve ganglia and gastric chambers through the transparent skin. As usual, variations occur, including spiral annulation, annuli split on one side only, extra and occluded furrows. Somites XXIV to XXVI include the 33 or 34 annuli through the anal region to the sucker. Of these, the first 22 are considered to be tertiaries, as they are grouped in twos; the next 11 or 12 are more doubtfully secondary, as they are single. Based on this interpretation the following tentative assignments are offered: XXIV 12-annulate (*c1-12*) ; XXV 11-annulate, (*c1-10*), *b6*; XXVI 6-annulate (*b1-6*) ; XXVII 5-annulate (*b1*+*b2*+*a2*+*b5*+*b6*), the last two postanal.

Internal anatomy: The general features of the internal anatomy were determined on cleared and mounted entire specimens, so far as could be seen through the screen of cocoon glands, and verified with the addition of details by the study of two series of rather poor sections, one transverse and one sagittal. No dissections were made. *Alimentary canal:* From proboscis pore at middle of sucker, proboscis sac runs as a perfectly straight capillary tube to nerve ring, after passing through which it widens to enclose proboscis and continues to behind ganglion VIII. *Proboscis* small, but it has the usual form and structure; at rest, extends from ganglion VI to caudal end of sac, where at its greatest diameter it is about 1/5 of body width. *Proboscis or salivary glands* few and relatively small (0.071 × 0.50 mm., average of 10) scattered beside proboscis from VII

to IX inclusive, ducts enter the base of the proboscis. *Oesophagus* a narrow, thin-walled tube which continues into stomach in XIII without change of structure. *Stomach* a simple moniliform tube with six segmental chambers separated by constrictions and weak or no sphincters in the intersegmental muscular septa; first in XIV has smallest diameter and last, in XIX, is shortest. *Postcaecum* arises from end of stomach along with intestine at XIX/XX by a pair of large openings, and the component pair is completely united and unified, except for two rather large fenestrae immediately caudad of ganglia XX and XXI (possibly others not seen) and a short distance at the caudal end in XXVI. When empty, thin walls are much folded. Like stomach, it is somewhat camerated by constrictions at muscular septa. *Intestine* arises from dorsum of XIX/XX by a small orifice guarded by a sphincter, expands into a small, slightly bilobed chamber and continues on dorsum of postcaecum in a somewhat irregular winding course. The four pairs of caeca may be contracted to small pockets or be much larger with folded walls. Following a constriction and sphincter, it expands in XXIV into the bulbous rectum, the walls of which in the specimens sectioned are contracted and folded, with a small diverticulum into the two postanal annuli, above which it opens at the anus by a short muscular tube and sphincter.

Reproductive organs (fig. 6, *b, c*) : Described chiefly from sections with the grosser characters confirmed on whole mounts. *Testisacs:* five pairs, alternating with gastric chambers in constrictions at XIV/XV to XVIII/XIX inclusive, spheroid, mostly smaller than ½ diameter of gastric chambers, filled with stages of spermatozoan development. In XIII opposite ovisacs, the previously capillary sperm duct (vas deferens) becomes enlarged several diameters and in a few open folds forms a simple epididymis or spermatic vesicle (s). Increasing further in diameter three or four times, it becomes a long cylindrical ejaculatory bulb (eb) extending the entire length of the clitellum which may be straight as in figure 6, *b* or more or less bent but which, in all observed, is remarkably long, with the cephalic end abruptly hooked into a short ejaculatory duct joining the apex of the atrial cornu of the same side. The circular muscles are peculiar in that the layer is not continuous; each fiber appears to be a complete ring (m), flattened and distinctly separated from the others, much like the hoops of a barrel but closer together. There is no anterior sperm vesicle or knot of folds anterior to atrium, nor any preatrial loop as in many species. Atrial cornua (c) are unusually short and wide, broad ovate in form, and united into a septum which projects into cavity of median atrium between pair of cornual openings. Median atrial chamber (a) also is short and globoid with thick glandular and muscular walls and opens into cephalo-dorsal end of bursa. Bursa (b) is about twice as long and of same diameter as median atrium, but with much thinner epithelial and muscular walls. It rises vertically from external male pore and then bends sharply forward to receive opening of atrium. Its musculature indicates that it is fully evertable. Cornua, ejaculatory ducts, and hooked ends of bulbs are covered with a layer of large prostate gland cells (fig. 6, *b*, pg) and median atrium with smaller cells. *Ovisacs* (ov) are simple, thin-walled, elongate oval sacs, the large ends of which lie in somite XIV and taper forward to narrow ducts in XIII, becoming united beneath nerve cord to form a short common duct opening close to the caudal end of the clitellum, apparently at XII *a2/a3*. Nothing is known of spermatophores or egg capsules. Cocoon glands form a single layer within muscle sac throughout urosome and measure 0.104 × 0.077 mm. (average

of 10), being rather compressed in the sections to make length greatly exceed the width. They are widely distributed throughout length of urosome and preclitellar trachelosome. In the latter, except for a more compact, small, median dorsal bundle, the fine ducts remain independent and in somite X, form a pair of loose aggregations occupying most of the lateral quadrants of body. In caudal half of urosome, the ducts similarly remain independent, but farther forward gradually become collected into a pair of much larger ventro-lateral and a pair of smaller dorso-lateral bundles, both of which are much less compact than in many piscicolids, such as *Branchellion.* In addition, there are three small and more compact dorsal bundles, a median, and a pair of paramedians. Ducts from both ends open all around clitellum, except near gonopores.

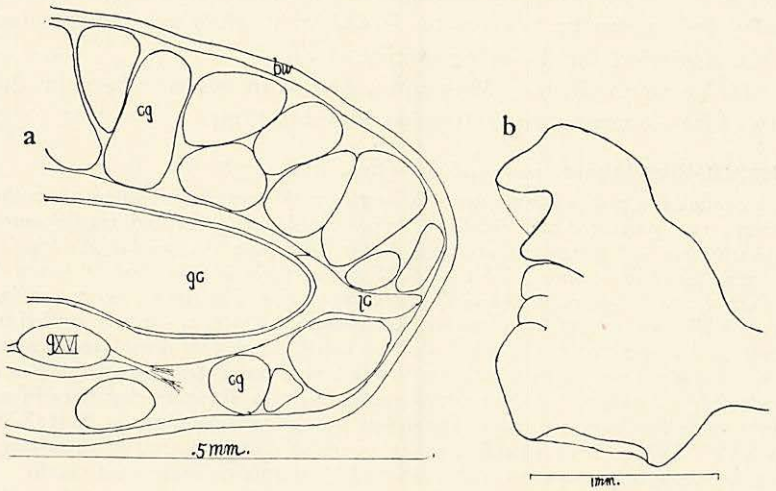

FIGURE 7.—**a,** *Johanssonia abditovesiculata,* camera lucida outlines of a half-section at ganglion XVI, × about 112: bw, epithelial and muscular body wall; cg, cocoon glands; gc, gastric chamber; g, ganglion; lc, marginal lacunar process. **b,** *Branchellion lobata,* camera lucida outline of 15th gill of left side of type, × 25.

The generic reference of this species is tentative. It depends chiefly upon the definite determination of the clear marginal spots (p. 30) as pulsatile vesicles (fig. 7, *a,* lc). They have not been seen in action in living leeches; and until this has been done or until especially prepared material is available for study, there will remain some doubt regarding their nature. Selensky (11) describes *J. kolaensis,* his genotype, as having 11 pairs of very small, flat and externally inconspicuous lateral vesicles with the last pair further deficient and lateral branches of the lacunar system at corresponding points. This agrees fairly well with what appear to be the conditions in the

present species. But he also includes (12) in the genus a second species (*J. pantopodum*) in which he found no vesicles. The external form and annulation of *J. abditovesiculata* agree with *J. kolaensis*. There is also much resemblance in the digestive and reproductive organs so far as they are known, but also some differences. Whereas the former has only five pairs of testisacs, *J. kolaensis* has six, a difference considered by some specialists as generic; the projection of the united contiguous walls of the cornua into the atrium is smaller and less trough-like than in the other species, and the ejaculatory bulbs and spermatic vesicles of *J. abditovesiculata* are peculiar but are undescribed for the other species.

Holotype in Bishop Museum, taken with seven others in the Honolulu Aquarium on *Tetraodon hispidus* Linn.

Branchellion lobata, new species (figs. 1; 7, *b;* 8; 9).

Diagnosis: Size medium, up to a length of 40 mm. Form as usual in the genus, with much-reduced clitellum, conspicuously differentiated trachelosome and urosome and prominent urosomal collar. Pulsatile vesicles large, 11 pairs on annulus *a2* of somites XIII to XXIII inclusive, all but the first on bases of branchiae; first pair reduced and flattened. Branchiae, 31 pairs on every annulus from XIII *a3* to XXIII *a3* inclusive, foliacious, with margin scarcely ruffled or fimbriated and entire except for a shallow notch, suggesting dorsal and ventral lobes. Cupules on caudal sucker about 1,300, larger and disposed irregularly in a central area, smaller and diminishing peripherally in dichotomizing rays in an outer zone. Testisacs five pairs, alternating with gastric chambers at XIII/XIV to XVII/XVIII. No preatrial complex of sperm duct, and arch of ejaculatory bulb reaching only to ganglion X. Coast of California on skates and sharks.

Description of holotype (fig. 1): Form moderately broad and flat; body strongly divided into trachelosome and urosome, the latter with paired branchiae throughout to anal region; measurements in mm.: total length 39.0, tip of sucker to male pore 7.0; widths: head sucker 3.8, male pore 2.5, maximum (XVII) body only 5.0, including gills 9.2, caudal sucker (not fully open) 6.5; depth at middle of urosome 2.3; ratio of width to length, without gills 1:8, with gills 1:4½. *Cephalic sucker* expanded, nearly flat, discoid, perfectly circular, but attachment by a slender excentric penduncle, about ⅓ of diameter from caudal (ventral) margin. Dorsal surface generally smooth with faint annulation in caudal half and a slightly elevated and thickened circular area which occupies a little more than ½ of the diameter, leaving a wide flat margin. A curved, pigmented band crosses middle of sucker which, while it bears no integrated eyes, includes a pair of irregular groups of ocellar elements. Ventrally, wide rim is flat and smooth, like a well-fitted gasket, and central circular area is slightly concave, with the small proboscis pore, from which pointed tip of proboscis projects for about 0.5 mm., situated a little caudad of its center. *Trachelosome* very distinct and sharply divided into pre-clitellum and clitellum by a very deep X *a2*/XI furrow with X *a3* apparently obsolete. *Preclitellum* begins as a very narrow, constricted, peduncle less than 1/5 diameter of sucker and formed of two very short annuli (V *a3*, VI *a1*); it becomes broader and flatter rapidly for

four primary annuli, then more slowly for six where somite X *a1 a2* contracts to the deep preclitellar furrow. *Clitellum* consists of XI to XIII *a1* inclusive, with a contribution by somite X problematical. It is very short, slightly narrower than X but bulges a little in middle, where massed ducts of cocoon glands open in a pair of thickened opaque areas. On dorsum, very little of clitellum is exposed beyond collar and no annuli can be distinguished on the smooth surface; on venter, collar is retracted and median field is exposed about three times as much as on dorsum and six obscure annuli are distinguishable, three of which lie before male pore, one between male and female and two short ones behind female pore. Genital region is a low, domed swelling, just behind the top of

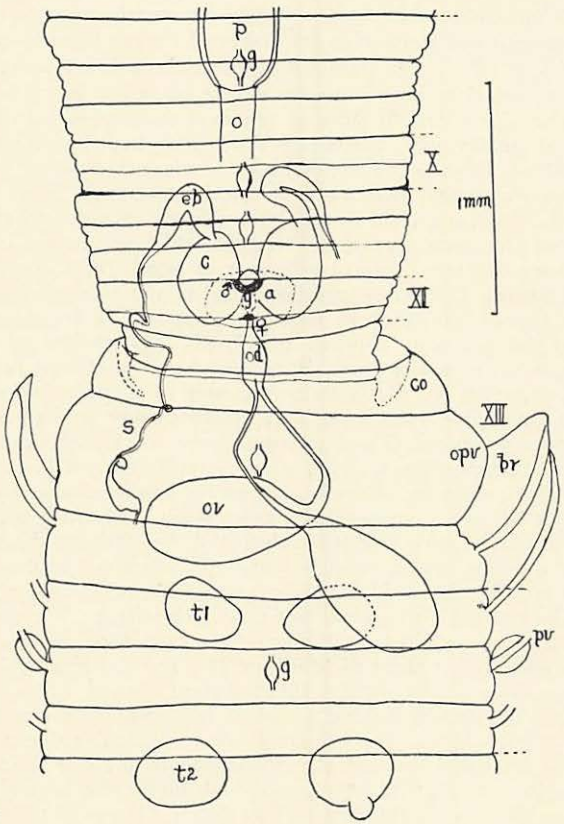

FIGURE 8.—*Branchellion lobata:* general ventral view of somites IX to XIV showing external and internal features based on camera lucida drawings of whole mounts, with additions from sections, × 31: a, atrium; br, gill; c, cornu; co, collar; eb, ejaculatory bulb; g, nerve ganglia; o, oesophagus; od, common oviduct or vagina; opv, obscure pulsatile vesicle; ov, ovisacs; p, proboscis; pv, pulsatile vesicle (reduced in size); s, sperm duct and vesicle; t1-t5, testisacs; ♂ ♀, male and female gonopores.

which is the conspicuous crescentic male pore with the horns pointing forward and close behind it at base of swelling a much smaller transverse slit, the female pore. *Collar* is a smooth unannulated tubular fold extending from somite XIII forward to enclose clitellum nearly completely on dorsum, but on venter not reaching gonopores. Dorsal length or height 2.5 mm.; width at attached base 4.1 mm., at free anterior margin 2.6 mm. *Urosome* caudad of collar moderately depressed and of nearly uniform width to narrowed caudal end; it comprises the collar-bearing annulus XIII *a2,* 31 branchiate annuli, and three large post-branchials, the last two each divided into two, making 37 in all. Throughout branchial region, all annuli are large and very distinct with no trace of subdivision, and on venter, each bears a prominent membraneous fold or flange projecting forward and connecting the stalks of its two branchiae. Beginning with third (XIV, *a2*), every third gill bears at its base a prominent globular vesicle. These vesiculate annuli are the middle or neural annuli of the triannulate somites. There are 10 pairs of spherical vesicles on branchiate annuli and a pair of smaller, flat, blister-like vesicles on the abranchiate XIII *a2.* Annulus XIII *a2,* which begins the urosome, is enlarged, resulting in the shoulder-like prominences that stand out on each side beyond narrow clitellum. *Branchiae* (fig. 7, *b*) of middle somites have margins only slightly ruffled and a small marginal nick suggestive of two lobes, of which the ventral is larger and the dorsal truncate above. Toward both ends of series, they become somewhat smaller and flatter. Following branchiate region, the four somites XXIV to XXVII are greatly simplified in annulation, reduced in length and narrow rapidly to caudal peduncle. Anus at XXVI/XXVII, followed by two annuli, the first bearing a post-anal nodule. *Caudal sucker* partly infolded, hemispherical, and cupped, but even so, nearly twice diameter of cephalic sucker. Dorsum smooth, margin shallowly crenulate and venter thickly studded with minute sucker tubercles or cupuli. Those in central area twice, or more, as large as outer ones and arranged irregularly, whereas the latter are in definite radial lines which dichotomize peripherally as cupules become successively smaller. Owing to infolding of sucker margins, cupules could not be fully counted on the type, and one of the same size was substituted. By dividing the surface into quarters and counting them separately fairly approximate estimates were made. Central area includes about 350. At their central ends, rays number 30, of which a few continue undivided to margin, but most bifurcate at about fourth cupule, making a total of about 120 for this ring. Second divisions occur after four or five more cupules, giving about 54 × 4.5, or 243. In third ring, which for most rays continues to the visible margin, 114 rays were counted, with an average of at least six cupules or 684, making a total of 1,397, which, of course, is not an accurate count but which is likely to err on the conservative side, as tubercules become almost too small to count at extreme margin and lose their cups gradually. *Color* (preserved): A uniform yellowish dusky, the branchiae colorless and translucent; in life light gray. (For details of annulation and internal anatomy, see cotypes.)

Cotypes (fig. 8, p. 37): In addition to holotype, 11 specimens from Pacific Grove and several from other California localities were studied. With the exception of two much smaller ones, none differs greatly from the type in either size or form, variations being due to degree of contraction. Of the small two, one much extended measures 17.5 × 1.5 mm. with a ratio of 12:1; the other, which is widest at XXIII and tapers regularly to the clitellum, measures 12.2 × 1.3

or 9½:1. Both of these have normal number of gills, but they are only 1/6 or 1/7 of the body width and scarcely expanded.

Except for changes due to contraction, folding, and inrolling of margin, the circular, discoid cephalic sucker of the type is quite typical, as is position of proboscis pore behind center, unusual in the family. On some specimens, the ventral surface has a soft, somewhat plushy appearance due to a very fine pile or papillation of epithelial cells. When cleared, pigmented band is seen to result from a loose aggregation of scrawly black chromatophores, the finer branches of which are united in an open reticulum, whereas the larger, denser central bodies occasionally are crescent- or cup-shaped and some of them almost certainly inclose light refracting cells. At two points, the pigment network is more condensed, forming a roughly symmetrical pair (so-called eyes) including three or four irregular pigment cups, each with a visual cell of the spherical form described by Apáthy (1). The exact number and arrangement of these ocelli differ individually, there being only one on each side of smallest specimen and three to five on larger ones.

Both the form and annulation of the preclitellum are very constant, the number being always 14, including the two small pedunculars. There is only one exception in which each of the 12 large primaries is bisected by a shallow furrow, a condition extending through urosome also. Except for the degree of prominence of gonopores, there is little variation in clitellum (fig. 8). Annulation is reduced and obscure, with only one large undivided annulus between male and female pores. However, there is much difference in the degree to which clitellum is exposed by contraction of collar, which may be adjusted to conditions of copulation and egg-laying. The usual condition is for collar to surround clitellum evenly all around to a point a little in advance of male pore, the retraction seen in the type (fig. 8) being unusual. Collar (co) has same relation to anterior margin of annulus XIII *a2,* from which it arises as have the ventral interbranchial flanges, but it completely encircles annulus and is higher or wider. With the exception of the one example mentioned above, urosomes all agree with the type in having 11 triannulate somites (XIII to XXIII inclusive), each bearing a pair of pulsatile vesicles on its neural annulus and together 31 pairs of branchiae on all annuli from XIII *a3* to XXIII *a3* inclusive. With the exception of XIII *a3,* all branchiate annuli bear the ventral interbranchiate fold more or less developed; and on XIII *a2,* the collar. Vesicles of XIII *a2* also peculiar in being free of branchial attachment, blister-shaped instead of spherical, and with the enlarged annulus they contribute to prominence of urosomal shoulders. Since this was written I have received Richardson's paper (13) on *B. parkeri* on which observations of living examples demonstrated that no pulsating vesicles exist on somite XIII. This may be true of *B. lobata* also, or the swelling on XIII *a2* may be non-functional. Following XXIII, postbranchial somites of the anal region (XXIV to XXVII) are greatly reduced, being represented by five annuli, of which first is about size of preceding annuli and divided by a shallow furrow into two, the others each about half the size and undivided and tapering rapidly, the last two post-anal and peduncular. Anus XXVI/XXVII.

Caudal sucker: Typical form is circular, discoid and very little concave, but contraction of margin results in changes of shape and deeper cupping. The small cupulate tubercles are a unique character of the genus, and their number and arrangement may distinguish species, but they have been little described or used.

Two intergrading groups are distinguished: a central area in which they are larger and disposed irregularly and a wide outer zone in which they are arranged in straight dichotomizing lines. Relative size of the two areas varies with age. In smallest specimens, radial lines run nearly or quite to the center and central area arises and grows by their dispersal at the same time as rays extend by marginal growth. Using the same method as for the type, a specimen 12 mm. long was estimated to have about 1,160 cupules and four full-sized specimens 1,268, 1,340, 1,352, and 1,372, respectively, including the small peripheral papillae.

Branchiae are, without exception, 31 pairs on annuli XIII *a3* to XXIII *a3*. On the San Francisco specimens they are flatter and even less ruffled than on the type and usually have the marginal notch. On two small leeches they are scoop-shaped and project obliquely forward about 1/6 or 1/7 of body width, the margin being entire except, usually, for the small emargination. Compared with *B. ravenelii* (Girard) (Meyer, 7), the branchiae are slightly more fluted and have the emargination and they lack almost entirely the bushy aspect of *B. torpedensis,* the genotype, due to the strongly ruffled and fimbriated gills of the latter.

Annulation: Most specimens have only two rather faint annuli on posterior region of head sucker, and immediately anterior to them, a transverse pigment band. Assuming that the latter is in somite IV, which contains the first pair of so-called eyes of many piscicolids, the two annuli following should be V *a1* and V *a2*. On only one example were annuli clearly detectable in front of these. In this case, there are, in all, six sucker annuli grouped in three doublets, of which middle doublet is pigmented. The three are therefore regarded as somites III, IV, and V *a1, a2*. Following the sucker are the two small peduncular annuli in nuchal constriction. The first of these is V *a3;* the second and a somewhat larger annulus following are assigned to somite VI. Somites VII, VIII, and IX are all triannulate with *a3* slightly largest and all increasing in length gradually caudad. X is somewhat contracted in width, but preclitellar portion *a1, a2* is normal. Sections show that its ganglion very nearly touches ganglion XI, the connective being very short and the ganglion itself in contact with the muscular septum at the deep preclitellar furrow. This is regarded as indicating that X *a3* has been reduced to obsolescence and explains the difficulty in interpreting from external examination only the annulation of the type at this point. Probably XI *a1* is also much reduced, as is the whole shortened clitellum in which only six annuli can be detected. These represent XI, XII, and probably XIII *a1;* three are anterior to male pore, one large one between the two gonopores and two behind female pore, but they cannot be determined more specifically. All complete urosomal somites, XIV to XXIII inclusive, are uniformly and distinctly 3-annulate with the three primary annuli approximately equal or *a2* slightly larger. On only one specimen are secondary furrows present, and these are probably to be attributed to its shrunken condition. Somites XXIV to XXVII are greatly reduced; XXIV is a single large annulus divided equally into two by a shallow furrow; XXV and XXVI each consists of an annulus about one-half the size of XXIV and the two somewhat drawn together. Two very small postanals are supposed to represent XXVII and XXVIII.

Color: In life "light gray to milk color"; this also serves fairly for the preserved specimens which lack pigmentation almost completely and are translucent and without a definite color pattern. Blood in stomach and postcaecum may result in a reddish or brown and opaque central region.

Internal anatomy studied on whole mounts, dissections and sections. *Alimentary canal:* Proboscis pore distinctly behind center of sucker, as much as 1/6 of sucker diameter. Proboscis sac a very narrow straight tube from pore through nerve ring, behind which it is enlarged to accommodate proboscis, which extends from caudal end of suboesophageal ganglion mass to ganglion IX or slightly beyond. Its basal half has a nearly uniform diameter of about 1/5 of body width at that point, and apical end tapers to a conical point. Salivary or proboscis glands are numerous and form large masses at side of proboscis from somites VI to X, increasing in number to the latter; individual cells are very large up to 0.35 mm., or nearly equal to basal diameter of proboscis. *Oesophagus* a simple narrow tube without diverticula, extending from base of proboscis to XIII, where it is slightly enlarged, separated from stomach by a constriction with no obvious sphincter at XIII/XIV. *Stomach* divided into a chain of six chambers in XIV to XIX inclusive, the last shortened. All aligned with ganglia and lateral vesicles of their segments and alternating with testisacs. On the specimen best preserved for the purpose the first and last chambers, while somewhat lobed, have no definite lateral caeca, the second and third have one pair, reaching to side walls of body, and the fourth and fifth two pairs, of which second are shorter. It seems probable that this is not typical, but cocoon glands and their ducts obscure a clear picture on most specimens. *Intestine* is nearly straight with four pairs of short caeca in somites XX to XXIII, expanding in XXIV to a thin-walled, irregular chamber (rectum) bearing a pair of large much folded organs and tapering to anus. Postcaecum could be made out only in sections in which it appeared as a simple, straight, rather small tube reaching to somite XXVI.

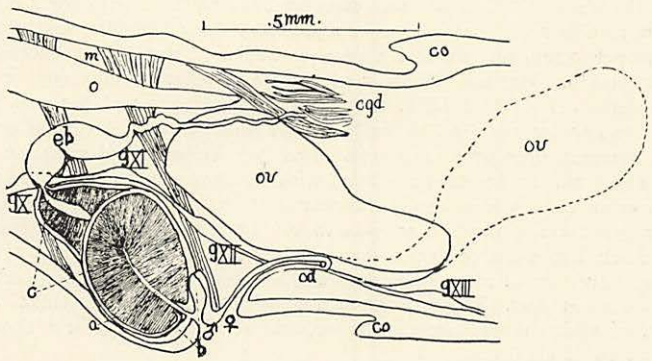

FIGURE 9.—*Branchellion lobata:* composite median plane reconstruction from camera lucida drawings of sagittal sections. In this specimen the ovisac had been displaced forward against the muscular septum XI/XII (its normal position is shown by dotted lines). The left cornu is foreshortened by oblique section, and its base is merged with the median atrium, × 56. Symbols: a, atrium; b, bursa; c, cornu; cgd, cocoon gland ducts; co, collar; eb, ejaculatory bulb; g, ganglia; m, muscle; o, oesophagus; od, common duct or vagina; ov, ovisac.

Reproductive organs (figs. 8, 9): *Testisacs,* except for one possible case of six, always five pairs at XIII/XIV to XVII/XVIII inclusive, with first pair

sometimes pushed entirely into XIV by the enlarged ovisacs. When fully mature, they are large and spherical and occupy the constrictions between gastric chambers. Exclusive of atrium or spermatophore organ, sperm duct is relatively simple. In none of these specimens is there a greatly enlarged and complexly folded seminal vesicle or epididymis, but in somite XIII the capillary vas deferens increases moderately in diameter (about three or even four times) and forms a slightly folded and twisted, but relatively straight and narrow, seminal vesicle (s) lying in somites XII and XI dorsolaterad of the atrial cornu, near apex of which it abruptly becomes enlarged greatly into a U-shaped ejaculatory bulb (eb) which arches forward into somite X but in no case beyond it. Medial limb of bulb contracts into a very short, narrow ejaculatory duct which opens into tip of corresponding cornu. Other than this bulb, no preatrial development of sperm duct. Except that both muscular and epithelial layers are much thinner, structure of walls of bulb is similar to the cornu. Terminal male organ or atrial complex which serves to form and deposit spermatophores during copulation consists of three parts: bursa, median atrium, and paired cornua. *Bursa* (b) is a very small, thin-walled, basin-shaped invagination of external skin and muscular layers at male pore and may be everted to bring median atrium and its orifice to the surface. *Median atrium* (a) also is a relatively small, somewhat flattened ellipsoidal sac placed transversely dorsal to bursa and opening into it by a median pore. Paired cornua (c) are much the larger part, being stout, slightly curved cones which rise separately from dorsum of median atrium and project forward divergently, side by side, to receive the respective ejaculatory ducts at their tips, leaving between a space occupied by nerve cord, oesophagus, and blood vessels. Atrium is a unit structure, the walls of both parts consisting chiefly of a thick outer muscular layer and a very thick glandular epithelial layer which merge completely around a narrow lumen. There are no accessory or covering prostate glands. The pair of clavate, tubular *ovisacs* (ov) normally occupy somites XIV and XIII, the caudal end bulbous and the rest tubular, tapering to narrow ducts, which in XII, pass beneath nerve cord and unite into a short common duct or vagina which runs vertically behind ganglion XII to female gonopore. Entire sacs are filled with developing ova and have very thin membraneous walls which become thicker with definite muscular and epithelial coats in the common duct. *Cocoon glands* very numerous and distributed in a rather thick but variable layer throughout urosome into XXIII. They are much smaller than in most piscicolids and are gathered into groups of several with a common duct. These ducts then unite into dorsal and ventral pairs of bundles, of which dorsal are the larger, and all finally open in a dense mass on each side of clitellum.

Type in my collection.

The holotype and seven other specimens were taken from skates (probably *R. binaculata*) and *Triakis henlei* collected on a muddy bottom in 40 to 60 fathoms in Monterey Bay and four from the claspers of *Squalus sucklii* (Girard) at the same place and depth by E. F. Ricketts. M. C. Meyer also permitted me to study a specimen taken from the gills of *Squalus sucklii* (Girard) taken off San Francisco, 10 collected by E. C. Dougherty from the exterior of *Squatina*

californica (Ayers) at Dillon Beach, seven of which were attached in a cluster to a piece of skin, one from Southern California on *Squalus sucklii,* and from *Raja bimaculata* with no locality stated.

This species differs most strikingly from the 31-gilled *B. ravenelii* (Girard) (Meyer, 7) of the Atlantic Coast in having much shorter preatrial sperm duct loops which reach only to ganglion X instead of VIII. From another 31-gilled species, *B. australis* Leigh-Sharpe (6), it differs in the total absence of tubercles, which are conspicuously developed in *B. australis.* From *B. parkeri* Richardson (13), it departs in annulation and the much larger number of sucker cupules but agrees in the short preatrial loops of the sperm ducts.

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