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Leeches (Hirudinea) from the Hawaiian Islands, and
two new species from the Pacific Region
in the Bishop Museum Collection

By J. PERCY MOORE
UNIVERSITY OF PENNSYLVANIA

INTRODUCTION

No leeches from the Hawaiian Islands are known to have been identified previously, and to my knowledge the only published record of their occurrence is the following brief comment by W. A. Bryan (8, p. 440)¹: "The leeches have not been studied. Two species are quite common in the streams of Oahu, and there are doubtless other species on the different islands." In 1939, E. H. Bryan, Jr. kindly sent to me all leeches available at Bishop Museum. These included what was evidently representative of the material on which the statement quoted above was based: a few examples of two species of small leeches originally described by R. Blanchard from the collections made by Max Weber in the Dutch East Indies and now known to be widely distributed and commonly associated in the Indo-Malayan and Oriental regions. In addition, a single specimen of a previously unknown type of terrestrial leech, collected by F. X. Williams in the mountains of Guatemala, proved so remarkable that I was reluctant to publish the incomplete description that a single specimen would necessitate. Much inquiry and correspondence, however, have failed to produce additional examples, and in the meantime, E. Caballero (9) has described, under the name of *Hygrobdella*, a closely related leech found under similar conditions in Mexico.

Later, a single specimen of a true blood-sucking land leech (*Haemadipsinae*) was submitted by Libbie Hyman, who found it in a collection of land planarians made by E. C. Zimmerman in the Fiji

¹ Numbers in parentheses refer to Literature Cited, p. 191.

Islands and sent to her from Bishop Museum. Finally, there are two examples of an undescribed species of the predacious terrestrial leech *Gastrostomobdella* from Hawaii in the collections of the United States National Museum, which Waldo Schmitt kindly sent with permission to describe it in this paper. Descriptions or discussions of these five species follow under the two headings of Hawaiian species and other Pacific species.

SPECIES FROM THE HAWAIIAN ISLANDS

FAMILY GLOSSIPHONIIDAE

Glossiphonia weberi Blanchard subspecies **lata** Oka.

Glossosiphonia Weberi Blanchard, Zool. Ergeb. Reise Niederländisch Ost-Indien 4: 332-334, fig. 1, 1897.

Glossiphonia weberi et *lata*, Moore, Proc. Acad. Nat. Sci. Philadelphia 76: 351, 352, 1924.

Glossiphonia weberi subspecies *lata*, Autrum, Bronn's Klassen und Ordnungen des Tierreichs, Hirudineen 4 (1): 14, 1936 (full synonymy).

Glossiphonia lata Oka, Annot. Zool. Japon. 7: 168, 1910.

This species, which belongs to the *G. heteroclita* group, was originally described from specimens taken in Lake Manindjau, Sumatra, and, with its subspecies, has since been found to be widely distributed throughout the Indo-Malayan and Oriental regions, commonly in association with *Barbronia weberi*. Reference of specimens from Abyssinia to this species is now known to be an error, and they have been described as *G. disjuncta* (19, p. 299).

Although the Hawaiian material is inadequate for a complete description, I have referred it to *G. lata*, which is the form described by Oka as occurring in Japan and by Moore (15, p. 352; 17, p. 39) in China. Autrum is followed here in regarding *lata* as a subspecies of *G. weberi*, but there is much discrepancy in the several accounts of both forms, especially in the exact number of annuli, the position of the eyes, and the position of the genital pores. This results in part from actual variation, in part from the accidents of preservation which obscure or modify the positional relation of parts, and in part from the differing values which observers assign to certain shallow furrows, thus altering the number of annuli counted at the ends of the body.

The subspecies *lata* is distinguished from *G. weberi* chiefly by the tendency of certain furrows near the ends of the body to become

deeper, thereby increasing the number of recognizable annuli. This is notably the case on somites IV and XXIV, both of which are distinctly triannulate in *lata* and usually biannulate in *G. weberi*. The eyes are usually farther forward and more crowded and the papillae larger and more numerous in *lata*.

The four Hawaiian specimens in this collection agree fully with Japanese and Chinese examples. They show the same variability in the position of the gonopores that previous observers have noted. On three specimens there is a common male-female pore at XI/XII. On the fourth, the male atrium is everted as a conical papilla at XI/XII and the female pore is in the furrow XII *a1/a2*, one annulus caudad, but both are inclosed in a common sunken area. A sectioned specimen shows that the paired ovisacs are united into a short common oviduct which runs forward to open with the male pore. There are six pairs of testes and the ovisacs reach to somite XVII.

The melanin pigment pattern is fairly well preserved. The ground is pale yellowish with a median and four pairs of double longitudinal brown lines, darker brown spots on the median and intermediate papillae of *a2* of all somites from IV to XXVI, and yellowish marginal spots on *a2* of segments of the caudal half at least.

There are three lots labeled as follows: freshwater leeches, stone and cement ditch, Waialae, Oahu, Aug. 2, 1936, F. X. W. [Williams], two specimens mounted in balsam; Punahou Park, Honolulu, 1938, one; freshwater, Oahu, May, 1935, Fosberg's aquarium, one.

FAMILY ERPOBDELLIDAE

Barbronia weberi (Blanchard) subspecies **formosana** (Oka) (fig. 1, *i*).

Dina Weberi Blanchard, Zool. Ergeb. Reise Niederländisch Ost-Indien 4: 353-355, fig. 1, 1897.

Dina weberi, Moore, Proc. Acad. Nat. Sci. Philadelphia 76: 368, fig. 26, 1924.

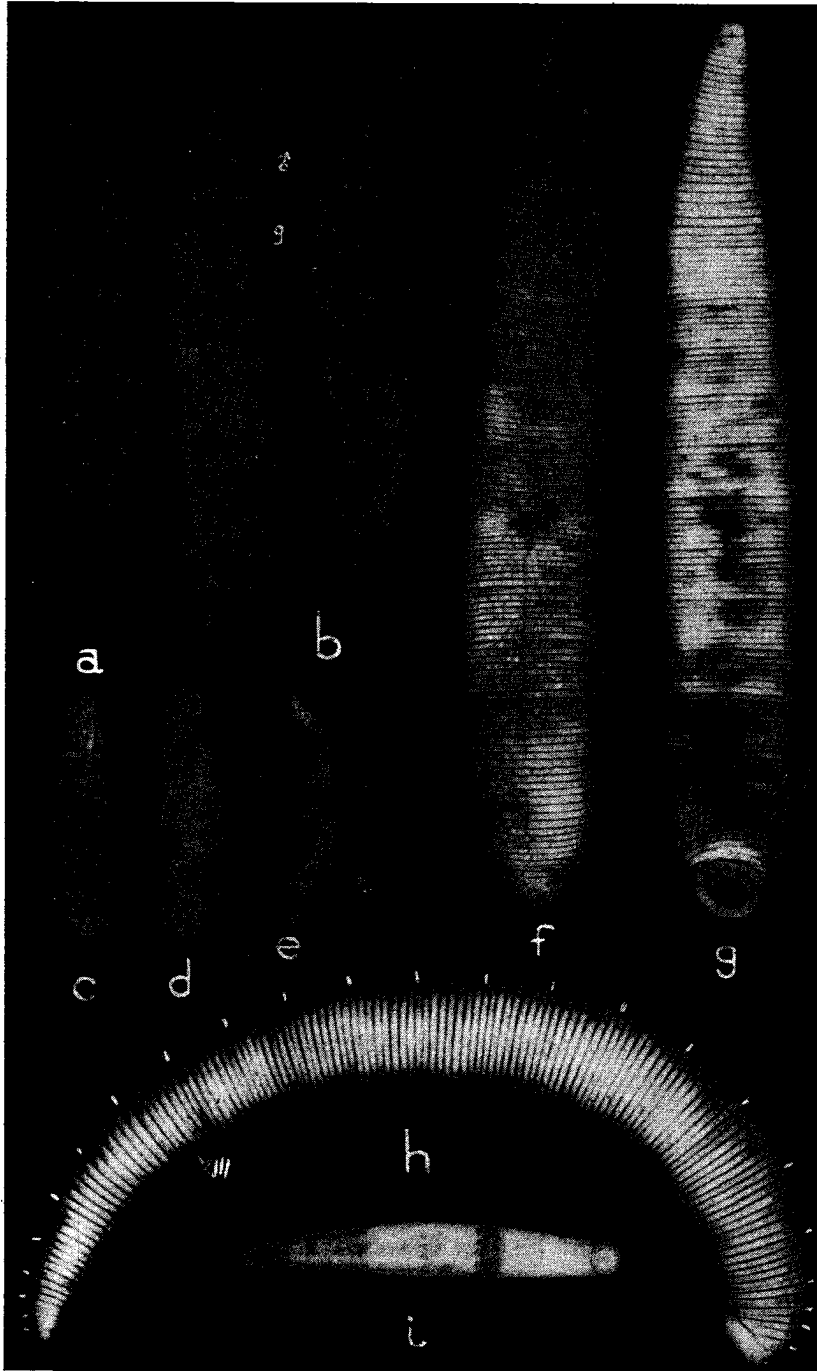
Barbronia weberi, Moore, Fauna Brit. India, Hirudinea, 135-140, figs. 39-42, 1927; Moore, Proc. Acad. Nat. Sci. Philadelphia 82: 183, 1930; Moore, Bull. Dept. Biol. Yenching Univ. 1: 43, 1930; Augener, Mem. Mus. Roy. Hist. Nat. Belgique 2: 12, 1931.

? *Herpobdella hexoculata* Kaburaki, Mem. Indian Mus. 5: 703, fig. 3, 1921.

Herpobdella formosana Oka, Proc. Imp. Acad. Tokyo 5: 277, 1929; 6: 279-281, figs. A-D, 1930.

While Blanchard fails to designate definitely the type locality of this species, the first listed is Buitenzorg, Java. Other specimens were taken by Weber's expedition at Lake Manindjau, Sumatra, and Loka River, Celebes. The genus *Barbronia* was established by Johansson in 1918 for *B. rouxi* as genotype. Four species have been referred to the genus, of which *B. delicata* Moore (19, p. 355) is African and very distinct and need not be considered. The remaining three, so far as can be judged by published descriptions, are very closely related and, when the type lots are compared, may prove to be identical. The type species, which has been reported from New Caledonia only, differs from *B. weberi* chiefly in that the male genital ducts (ducti ejaculatorii) of the former unite into a common duct before opening into the atrium, whereas in all examples of *B. weberi* dissected by me they open separately, much as in North American species of *Dina*. Johansson finds in *B. rouxi* 11 or 12 pairs of testicular sacs distributed from ganglion XIV to the caudal end of somite XVI, whereas I find in *B. weberi* only five to eight on a side, usually distributed asymmetrically in the same region but not extending caudad of ganglion XVI. The ovisacs are tubular as in *B. rouxi* but may be crumpled into a globular mass confined to somite XIII or extend to the caudal end of XIV. Unfortunately, two serious errors occur in my description of *B. weberi* (Fauna Brit. India, Hirudinea, 135-140, 1927), as determined by a reexamination of the selected material. The specimen from which the figure of the external morphology was drawn is abnormal and typically the region designated as somites V and VI is constituted of only five instead of six annuli as shown. My statement (Fauna Brit. India, Hirudinea, p. 138, 1927) that the testes-sacs extend to somite XXIV, which is the usual condition in the family Erpobdellidae, was based on dissections only. When sections were studied, it was found that botryoidal vesicles had been mistaken for testes and that the latter are limited as indicated above to somites XIV and XV, with an occasional one in the cephalic end of XVI.

FIGURE 1.—*Gastrostomobdella quinqueannulata*: a, b, dorsal and ventral views of type, \times about 4. *Haemadipsa bilobaia*: c-e, dorsal, ventral, and lateral aspects, \times 3 (examine with lens). *Diastecostoma octannulata*: f-h, dorsal, ventral, and lateral aspects, \times about 3, white lines indicate somite limits. *Barbronia weberi formosana*: i, ventral view, \times 3, from Oloa, Hawaii.



The third species was described briefly by Oka as *Herpobdella formosana*. Little is known of it and it has been recorded definitely only from the type locality on Formosa. Certain specimens of *Barbronia* from Amoy, China, and Manchuria were found to differ somewhat from numerous examples of *B. weberi* from many localities in India, the Philippine Islands, and Borneo, and are recorded in my notes as a distinct subspecies, probably *H. formosana* Oka. They differ from typical *B. weberi* in that complete somites of mature worms usually have all annuli subdivided by tertiary furrows and not only *b6* and *a2* (secondary furrow), the dermal papillae are much larger and usually there are three clearly differentiated postanal annuli instead of two as usual in *B. weberi*. On all mature specimens of all three forms, the copulatory gland pores are invariably in the furrows X/XI and XIII/XIV, but in younger ones one or both may be absent. In all, the position of the gonopores varies slightly, the male being usually within the caudal half of XI *b1* or less often in the furrow XI *b1/b2* and the female at XIII *b1* or XII/XIII. Comparison of the several descriptions listed under synonymy shows some discrepancy in the annulation of the somites I to VII and in the exact position of the eyes. This is due chiefly to the varying interpretations put upon the shallower intrametameric furrows. When these are all reduced to a common system, there is substantial agreement, taking into account that supplementary eyes may be present and that differing degrees of contraction may alter somewhat the apparent position of the ocular pigment cups.

Taking into consideration all of these facts, the 13 small barbroniae from the Hawaiian Islands are found to have their closest affinities with the coastal and northern form which is believed to be Oka's *Herpobdella formosana*. Three of these specimens, respectively 16, 24, and 27 mm. in length, were sufficiently mature for critical study, and the largest one was dissected. The remaining 10, measuring 5.2 mm. to 15 mm. are in various states of immaturity but prove confirmatory in all determinable characters. All show clearly that we are dealing with a group which resembles *Barbronia weberi* in the essential characters of structure of pharynx and reproductive organs, general metamerism and annulation, position of gonopores and copulatory pits, and number and position of eyes. They differ from the typical subspecies and agree with the coastal and more northern Asiatic subspecies *formosana* in the tendency of the annuli to divide, the larger

size and smaller number of cutaneous papillae, and the increased number of postanal annuli. A specimen from the Simla Hills, India, approaches these in several respects.

The Hawaiian examples are labeled as follows: Oahu, F. X. W. [Williams] (three approaching maturity, one sectioned); freshwater leeches, Oahu, 1936, F. X. W. (three young mounted in balsam with remains of chironomid larvae in gut); freshwater leeches, stone and cement ditch, Waialae, Oahu, Aug. 2, 1936, F. X. W. (one measuring 5.2 mm. with chironomids in gut, mounted in balsam); Lulumahu Stream, Oahu, F. X. W., June 1938 (two small and quite immature); Oloa, Hawaii, Aug. 1939, F. A. Bianchi, from very dirty water of water cooler tank (four of the largest and most mature specimens, the largest of which was dissected). These last retain some of the original color, which in life is probably more reddish owing to the blood showing through. They vary from reddish brown to purplish plum color, paler below, and nearly uniform, except for a fine speckling due to the pale yellowish color of the papillae.

It is interesting to note that each of these three nominal species of *Barbronia* occurs in association with a quite unrelated leech of the *Glossiphonia heteroclita* group. *B. rouxi* has been reported from the type locality of New Caledonia only, where also occurs *Glossiphonia novae-caledoniae* Johansson. It is possible that the form recorded by Augener in 1931 from New Guinea as *B. weberi* may prove to be *B. rouxi*. *B. weberi*, widely distributed through the East Indies, the Philippines and India, is very common and generally associated with *Glossiphonia weberi* and *annandalei*, whereas *B. formosana* occurs with *G. lata*. No *Barbronia* has been reported from Japan, but this is the type locality of *Glossiphonia lata* and *B. formosana* may be expected to occur. Both *Glossiphonia lata* and *Barbronia formosana* live under conditions favorable to their transportation on the roots of plants, to which means Beddard (2) and Michaelsen (14, p. 211) attribute the entire earthworm fauna of the Hawaiian Islands.

***Gastrostomobdella quinqueannulata*,² new species (figs. 1, a, b; 2, a-d).**

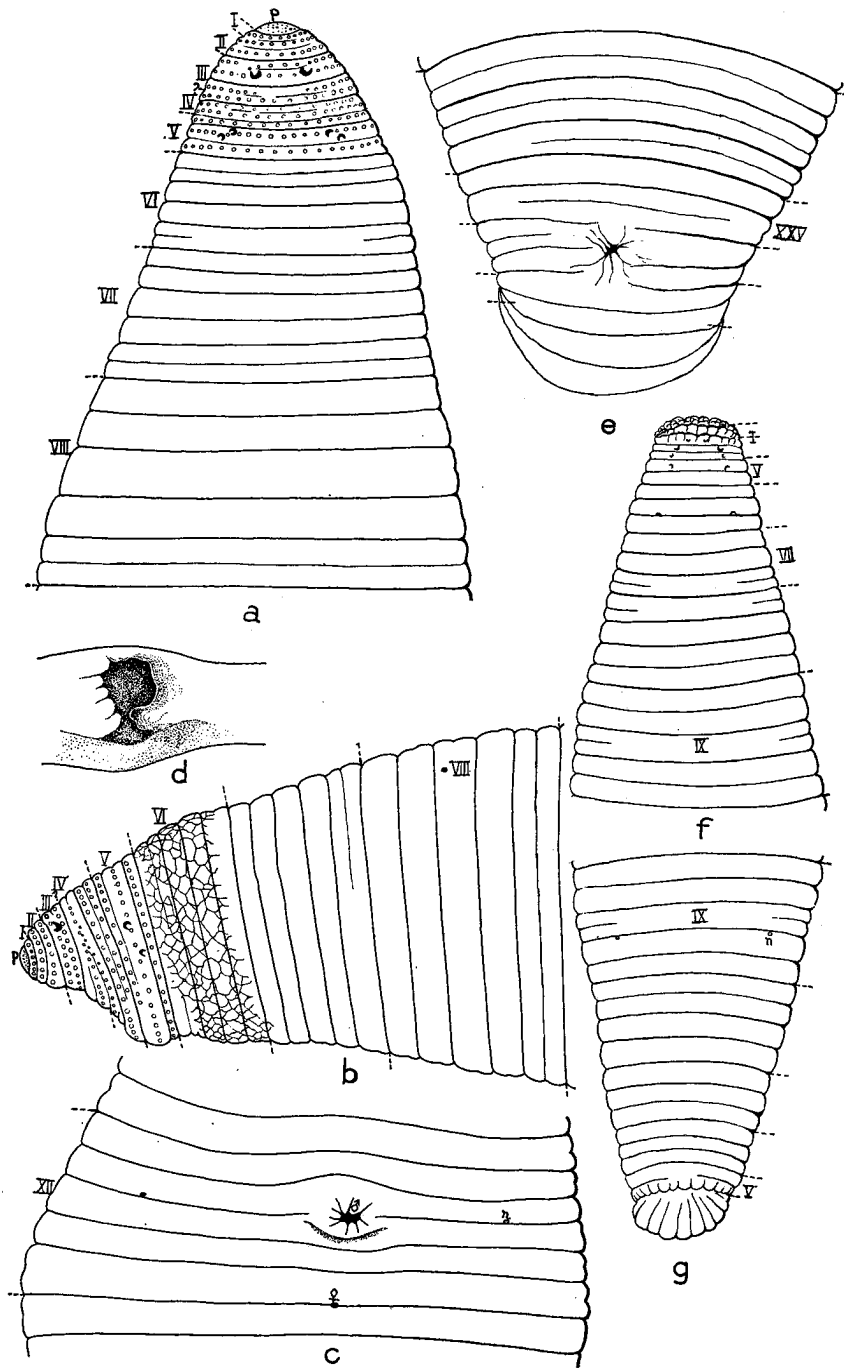
Diagnosis: size rather small (length about 1 inch), complete somites 5-annulate, *b6* only faintly subdivided; eyes 3 pairs, 1 labial, 2 buccal; gonopores separated by 3 annuli, male XII *b2/a2*, female XII/XIII; gastropore on XIV *b6*.

Description of type: general form (fig. 1, a, b) similar to that usual in small erpobdellids, flatter than in genotype. Measurements in moderate contrac-

² Published here by permission of the Secretary of the Smithsonian Institution.

tion, in mm.: length 31, to male pore 5.4; widths, buccal 0.6, at male pore 3.8, maximum (about XIX) 4.3, anus 2.9; depths at same points 0.6, 1.5, 2.6, 1.4; caudal sucker 2.7. Cephalic end slender and tapering from the clitellum to the small head, terete anteriorly, becoming progressively wider and flatter to clitellum, the caudal end of which about equals the maximum postclitellar width, followed by a short, somewhat narrower region beyond which it again becomes wider and remains nearly uniform until near the anus where the margins become thin and flangelike and curve abruptly mediad to the sucker peduncle. Head small, as in species of *Dina*, with small, rounded, faintly furrowed lip composed of a short prostomial lobe studded with 3 or 4 ill-defined transverse rows and some scattered labial sense organs, followed by 8 annuli each defined by 1 or 2 transverse rows of sensory papillae (somites I-V). Eyes 3 pairs (fig. 2, *a, b*), the first or labial far back on the 5th annulus (III(*ala2*)) counting the prostomium as 1, separated medially by about three times their diameter and apparently directed forward; buccal eyes 2 pairs (marginal and supramarginal) situated on the sides of the buccal ring (V(*ala2*)), smaller than the labials and separated on each side by about twice their diameter as viewed from above. Clitellum moderately well developed, projecting slightly beyond the general surface level, extending over 15 annuli, X *b5* to XIII *a2* inclusive. Gonopores (fig. 2, *c*) separated by 3 annuli; the male at XII *b2/a2*, a large pore in the furrow surrounded by a broadly elliptical, radially furrowed disk extending about half way over the bounding annuli, both of which are enlarged in the median field and displace the 1 or 2 contiguous annuli forward or backward; female pore a much smaller, simple orifice in the furrow XII/XIII. Gastropore (figs. 1, *b; 2, d*) on XIV *b6*, $9\frac{1}{2}$ annuli behind the female gonopore, a conspicuous opening on the ventral surface extending over nearly one half of the length of the annulus, which is enlarged medially to accommodate it and bears a low smooth rim surrounding the pore and a soft, low, preceding papilla which forms a sort of anterior lip. A slight incision across the opening shows that the median canal bifurcates at the ventral face of the nerve cord, to the right and left of which the two branches pass. The right limb can be seen distinctly to make definite connection with the gut wall, although the dissection was not carried far enough to demonstrate the actual ental opening; the left limb was traced nearly as far before it passed out of the plane of the section. Anus very large, open, with raised, lobulated margins between a large double annulus (XXVI) and a smaller, faintly divided one, and cutting into both; well in advance of sucker and followed by 3 well-defined and 1 or 2 obscure annuli. Lateral flanges well developed in anal region. Sucker (fig. 1, *b*) circular, directed ventrad, with wide peduncle, rather weak, diameter about three fourths maximum width. Nephropores in the usual position in the intermediate line and caudal margin of annulus *b2* of complete somites but only a few could be detected. Color faded, probably reddish in life; in the preserved specimens dorsally uniform yellowish gray with a faint

FIGURE 2.—*Gastrostomobdella quinqueannulata*: *a*, annulation of the first 8 somites from the dorsum, showing also the eyes and sensory papillae to the end of V, $\times 37$; *b*, left lateral view of the same region with the addition of a small portion of the cutaneous vacular plexus (somite VI), $\times 37$; *c*, ventral view of somite XII showing the sex pores and nephropores, $\times 24$ (a slight distortion of the clitellar region pushes the median line toward the left); *d*, gastropore on XIV *b6*, $\times 37$. *Diestecostoma octannulata*: *e*, dorsal view of caudal end, $\times 12$; *f*, dorsal view of cephalic end through somite IX *b2*, $\times 12$; *g*, ventral view of same region, reversed (*n*, nephropores on IX *b2*), $\times 12$.



indication of a narrow median line which may not be due to pigment; venter gray without yellowish tint; no indication of spotting.

Annulation (fig. 2, *a-c*): except on the head, the furrows are deep and annuli well defined but owing to strong contraction tertiary furrows are accentuated and the length of the annuli becomes irregular. Prostomium a small rounded lobe furrowed ventrally and bearing dorsally numerous minute sensory papillae obscurely in three rows. Somite I uniannulate, a small annulus not clearly separated by a furrow from the prostomium or from II, but with a definite transverse row of sensory papillae. II biannulate or one large annulus bearing 2 rows of papillae separated by a shallow furrow. III 2- or 3-annulate ($(a1+a2) > a3$), each defined by a transverse row of papillae; labial eye pigment cups in the larger anterior annulus; $a3$ enters slightly into sides of buccal ring. IV 2-annulate ($(a1a2) > a3$)³ united with *Va1* ventrally to form buccal ring. V 3-annulate ($a1=a2 < a3$), on venter forming with IV buccal and postbuccal rings, which are not sharply differentiated; $a2$ bears the buccal eyes. VI 4-annulate, the 1st and 4th larger and faintly subdivided, $b5=a2 < a1 (b1 b2) < b6 (c11 c12)$. VII 5-annulate, $b1=b2 < b5$ slightly $< a2 < b6 (c11+c12)$. VIII-XXIV 5-annulate, normally $a2$ slightly and $b6$ considerably longer than the remaining annuli and each again subdivided by a shallow furrow. There is much irregularity in the degree of contraction of different somites, with resulting variation in the length of annuli and the depth of the furrows. On some somites, tertiary furrows are fairly conspicuous both dorsally and ventrally on all annuli. On others they are limited to the enlarged 3d ($a2$) and 5th ($b6$) annuli. Usually $b6$ is distinctly larger and more distinctly divided than $a2$ but on some somites these differences are scarcely or not discernible. Occasionally $b6$ may be divided into 3 subannuli. XXV and XXVI composed of 4 immediately preanal annuli of which the first 3 are smaller and simple and interpreted as XXV, and the last larger and double and regarded as XXVI. Postanal annuli a large double one (probably XXVII) and 2 or 3 undivided ones.

A smaller specimen (cotype) measures $18 \times 3.2 \times 1.8$ mm., the caudal sucker 1.8 mm. in diameter, and is immature with no evident thickening of the clitellum. Except that the lip is more prolonged and the labial furrows smoothed out, the cephalic characters, including number and position of the eyes, agree with the type. The gonopores are smaller but otherwise as in the type but there is no trace of the gastropore. The annulation also is in agreement with the type except that XXVI is divided by a furrow at the margins only and the anus cuts deeply into its caudal half. On complete somites, $b6$ is constantly enlarged and subdivided into 2 or even 3 subannuli, $a2$ is usually slightly larger than $b1$, $b2$, or $b5$, and like them is divided by a shallow furrow confined to the dorsum.

"Punaluu, Hawaii, T. H., Mar. 3, 1930, Otto Degener and Yasuma Iwasaki." Type and cotype in collection of United States National Museum (no. 110/400).

The genus *Gastrostomobdella* has been known previously only from the Indo-Malayan region, the genotype *G. monticola* Moore (16) from Sarawak, Borneo, and *G. vagabunda* Moore (18) from Perak, Federated Malay States. Both of these species are mountain dwellers, and are rather large, robust leeches. In both species, annulus

³ Owing to the obscurity of the annulation, there is some uncertainty about the delimitation of III and IV.

b6 is completely divided into two, making the complete somites definitively 6-annulate. *G. monticola* has the gonopores separated by 6 to 7 annuli and *G. vagabunda* by 9 annuli. The gastropore is present in mature individuals only, in the genotype at XIV/XV, in *G. vagabunda* on XIV a2. Whether *G. monticola* habitually enters water is not known, but its association with Haemadipsinae and the presence of earthworms in the gut show that it is at least facultatively terrestrial. *G. vagabunda*, on the other hand, has been stated by M. W. F. Tweedie, the collector, to live in small streams with *Myxobdella*.

With only two small and indifferently preserved specimens for study, no complete dissection was attempted and consequently it is not known that this species possesses all of the internal characters of the genotype, but the ventral pore and the bifurcated canal leading to the gut is characteristic. It differs strikingly from the Oriental species in the position of the gonopores and gastropore, three instead of four pairs of eyes, and in having complete somites with five instead of six fully developed annuli. It is possible that larger specimens may be found to have the annulus *b6* more completely subdivided, but specimens of similar size of the other species have fully 6-annulate somites. Whether this species is endemic in the Hawaiian Islands is, of course, unknown. It is more probable that, like *Glossiphonia weberi lata* and *Barbronia weberi formosana*, it has been introduced through human agency or possibly by aquatic birds. The leeches of the Indo-Malayan and Oriental countries are too imperfectly known to say that it may not occur there.

NEW SPECIES FROM FIJI AND GUATEMALA

FAMILY HIRUDIDAE

Haemadipsa bilobata, new species (figs. 1, *c-e*; 3).

Diagnosis: based upon the single type specimen. No partial annulus between 3d and 4th pairs of eyes; gonopores separated by seven annuli; auricles bilobate, the median lobe vestigial or wanting; caudal sucker with about 65 rays. Dorsal color pattern chiefly dusky, with several irregular yellowish spots on each side which, like the margins of the dusky fields, have narrow black borders, a median yellow stripe expanded at wide intervals into spots which join those in the lateral fields.

Description: measurements of the contracted, unfed type, in mm.: length 10.2, to male pore 3.4; widths, buccal 1.3, male pore 1.9, maximum (XIX) 2.8, anus?, depths at same points 0.8, 1.2, 1.5, ?; caudal sucker 2×2.4 . Form short, broad and strongly depressed, except in the pharyngeal region which is subterete and firm, whereas the remainder is soft, indicating that the stomach crop

is empty. Greatest width at XIX-XX, gently tapered to buccal region which is slightly widened, and into the broad, bluntly triangular lip. Dorsal surface of lip strongly areolated, each transverse row representing an annulus, the preocular annulus having in addition a marginal row of smaller, rounded granulations indicating the prostomium; ventral surface finely granulated, nearly smooth, with no furrows. Eyes five pairs, large and conspicuous, on annuli 2, 3, 4, 5, and 8, no extra areas indicating a partial annulus between eyes 3 and 4. Buccal ring furrowed as usual but with no evident lateral lobes. No clearly marked furrow pits and no external indications of the limits of the clitellum. Gonopores separated by 7 annuli, the male XI *b5/b6*, female XIII *b1/b2*; male pore conspicuous, female pore minute, obscurely placed deep in the furrow. Nephropores not seen. Auricles formed by the margins of XXIV, XXV, XXVI, small, bilobate, with wide sinus, larger because of the almost total absence of the median lobe which is represented by the merest point. Anus very small, on the caudal border of XXVII. Caudal sucker appears large relatively to the contracted state of the specimen, ovate, longer than wide, with a prominent prehensile papilla and about 65 rays; dorsal surface with four circular rows of areas bearing minute sensory papillae, besides the marginal crenulations.

Color: generally dull yellow, venter and margins without definite markings but only some obscure dusky spots. Dorsum with the entire paramedian-intermediate fields dusky yellow with a few irregular clear yellow spots which, like the margins of the fields, have narrow black borders; median and supra-marginal stripes, head, and caudal sucker yellow, the median stripe expanded at long intervals into five large spots which join the spots in the dusky fields and are similarly black-bordered.

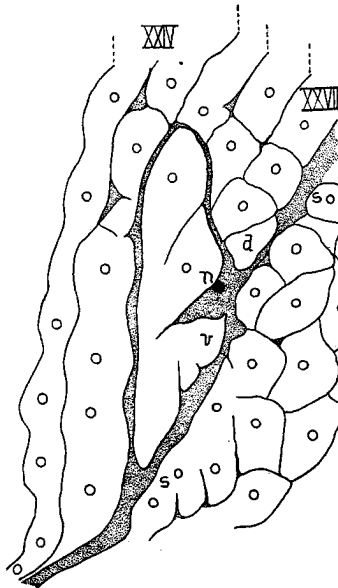


FIGURE 3.—*Haemadipsa bilobata*, left auricle and adjacent areolae of XXIV to XXVII and sucker (*d*, dorsal and *v*, ventral lobes, *n*, 17th nephropore). Enlarged.

Annulation: I, a preocular annulus consisting of a transverse row of 4 areas in front of the first pair of eyes and preceded by the prostomial margin with smaller granulations. II, 1-annulate, 2 large areas in contact bearing first pair of eyes. III, 1-annulate, 1 median, 2 large paramedians behind the oculars of II, 2 intermediate oculars bearing the second pair of eyes, and 2 small marginals on each side. IV, 1-annulate, a pair of intermediate oculars bearing the third pair of eyes, 2 small marginals on each side and 5 interoculars consisting of a large median, a pair of large outer paramedians and a pair of small inner paramedians, the last being so small on the right side that the large paramedians of III and V are almost in contact. V, 2-annulate, the first (*a1a2*) consisting of 6 interoculars, all large except the left paramedian, a pair of intermediate oculars bearing the 4th pair of eyes and several marginal buccals which unite with the second annulus (*a3*) to form the buccal ring; *a3* an irregular complete annulus distinct from *a1a2* dorsally and laterally but united ventrally with the former and with VI *a1a2* to form the buccal ring. VI, 3-annulate, all distinct dorsally and *a3* ventrally, *a1* and *a2* united ventrally, 5th pair of eyes on *a2*. VII, 3-annulate, *a1 = a2 = a3*. VIII, 4-annulate, *a1 = a2 > b5 = b6*. IX, 5-annulate, *a2 > b5 = b6 > b1 = b2*. X to XXII each 5-annulate, all annuli approximately equal; male pore at XI *b5/b6*, female XIII *b1/b2*. Annuli of this region very regular, each with about 15 nearly equal, squarish areas on the dorsal side and each bearing a cluster of non-metameric, minute sensory papillae; intermediate metameric sensillae usually conspicuous as pale spots in dark areas but the other sensillae rarely distinguishable from the non-metameric sensory papillae. On the venter, *b6* is generally recessed between *b5* and *b1*, making deep constriction furrows. XXIII, 4-annulate, *a1 = a2 > b5 > b6*, the last small and incomplete. XXIV, 2-annulate, (*a1a2*) $>$ *a3*, the latter very small. Annuli of XXIII and XXIV and their areolae very irregular and much jumbled but the above interpretation is based upon a careful study of their arrangement together with the sensillae and papillae. XXV, XXVI, and XXVII each 1-annulate and the first two together with XXIV *a2* bearing the marginal auricles. In the caudal one third of the body the areolae become more variable in size and more irregularly polygonal in form and the sensory papillae more prominent and pointed.

Anatomy: as there was available only a single specimen and this was not suitable for successful dissection, nothing is known of the internal anatomy except that on opening the buccal chamber it was determined that there are three jaws, which was necessary to verify the generic reference. While the presence of a median dorsal as well as the paired ventral jaws was clearly ascertained, the dissection was not carried far enough to determine the number of teeth.

Ovalau, near Vuma, Fiji, between 800 and 1,000 ft., July 14, 1938, E. C. Zimmerman. The single type specimen belongs to Bishop Museum.

I have ventured to base a new species on a single specimen in the hope that the rather unusual combination of characters presented by the type will be found to be characteristic of a general population. This species possesses the essential distinguishing characters of the type genus in the subfamily Haemadipsinae of 5-annulate complete somites and three jaws. It departs from most of the species of the

genus, in which the auricles are trilobate and the gonopores separated by 5 annuli, in possessing bilobate auricles and gonopores separated by 7 annuli. It is interesting to note that geographically this species comes within the range of dominance of the Duognathoferae or two-jawed division of the subfamily in which bilobed auricles and aberrant positions of the gonopores are common. Collections of land leeches from the islands of Oceania are greatly to be desired.

***Diestecostoma octannulata*, new species (figs. 1, *f-h*; 2, *e-g*; 4).**

Diagnosis: form as in terrestrial erpobdellids; head and mouth small, eyes 5 pairs, first four on contiguous annuli, 5th separated from 4th by 2 annuli; gonopores separated by 16 annuli, male XI *a2/b5*, female XIII *c11/c12*; complete somites 8-annulate, two at each end (tertiary annuli) smaller than the 4 middle (secondary) annuli, nephropores 2-16 in ventral intermediate line on IX *b2* to XXIII *b2*, 17th pair united in a common median pore beneath ventral rim of sucker, first pair not seen; jaws 3, in VIII and IX; ovisacs in XVI.

Description of type: both ends of the body terete, the middle portion moderately depressed, rounded and of nearly uniform width (fig. 1, *f-h*). Measurements in mm.; length 37.5, to male pore 7.2; widths, buccal 1.2, male pore 4.1, maximum (XIX) 5.6; anus 2.3; depths at same points 1, 3, 3.8, 1.5; caudal sucker 2.3. Preocular lobe short, somewhat tumid, slightly widened anteriorly, conspicuously so when pressed from above, contracted and decurved into mouth, on dorsum divided into two slightly separated annuli, each formed of a transverse row of areolae, of which those of the first or prostomial lobe are smaller. Remainder of head divided on dorsum into four annuli, crowded but well differentiated by furrows, except that the furrow separating annulus 3 from the preocular annulus is incomplete; annuli 3, 5, and 6 are equal, 4 somewhat larger and faintly subdivided into 2; 3 and 4 merge at the sides of the head and taper into the buccal ring formed by annuli 5 and 6 which are very distinct above but only obscurely so below. Venter of lip divided into 9 ridges separated by deep furrows and converging into mouth. Eyes (fig. 2, *f*) 5 pairs, owing to contraction of the head, crowded, with their pigment cups often lying beneath the furrows instead of in the annuli to which they belong; 1st pair on annulus 3 (somite II), paramedian, separated by twice their diameter and directed forward; 2d to 5th of the intermediate series; 2d on anterior half of annulus 4 (III), largest of all and facing cephalo-laterad; 3d on caudal half of annulus 4 (IV?) partly beneath the following furrow, much smaller than, deeper, ventral to, and partly concealed from above by 2d pair, from which they were at first not distinguished, directed latero-caudad; 4th pair on anterior annulus of somite V partly beneath the furrow, very small and at the deep level of the 3d pair, direction not determined; 5th pair similar to 4th and with the pigment cup on the caudal margin of VI *a2*. Inequality of the annuli begins with somite VI as described under annulation. From the small head and narrow, terete buccal region, the width increases rather rapidly and the body becomes slightly more flattened to the clitellar region and then remains nearly uniform until it rapidly tapers to the sucker at the anal region. Clitellum indistinct externally but probably extends from X *b5* to XIII *b4* inclusive or over 19 annuli. Gonopores widely separated by 16 annuli, male a small transverse slit including a round pore in the furrow XI *a2/b5*; female a very minute pore in a small glandular area close to the caudal border of next to the last annulus (*c11*) of XIII. That this is really

the female pore was determined by exposing a small part of the vaginal duct showing its attachment at the median pore. Nephropores of 15 pairs (2 to 16) conspicuous, in the intermediate line on the caudal border of the venter of *b2* beginning at IX and continuing to XXIII, the first 3 pairs each separated by 5

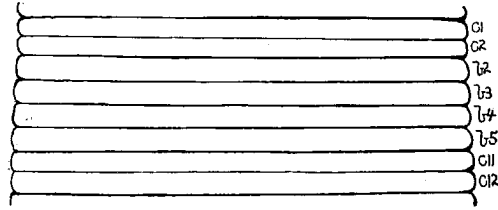


FIGURE 4.—*Diestecostoma octannulata*, somite XV, showing relative size of four secondary (*b*), and four tertiary (*c*) annuli, $\times 12$. Semidiagrammatic.

annuli, succeeding ones by 8 annuli; the 17th pair, belonging to XXIV, united in a large median pore behind annulus 139 and concealed beneath the ventral margin of the caudal sucker; first pair detected neither on VIII nor on buccal ring. No sensillae, papillae, or other similar metameric characters apparent. Anus a large opening well forward of the sucker, dividing in the middle the two annuli of XXVI and followed by 3 partial annuli which merge gradually into the caudal sucker without forming a definite peduncle. Caudal sucker small, one half body width, well formed, thick, deeply cupped, directed ventrad so that it is scarcely visible from above, broadly attached; dorsal face with a half-annular furrow, ventral face finely tessellated, but without radiating ridges, margin strongly crenulate-furrowed. Color all faded, only a faint yellowish tint remaining.

Annulation (fig. 2, *e-g*): Prostomium and I, the preocular lobe, consisting of two rows of areolae united at the margins. II, 1-annulate, areolated and ending at the margins of the lip. III and IV appear to be united in the double annulus which bears the 2d and 3d pairs of eyes and which extends ventrad at the sides of the head to join V in the buccal ring. V, 2-annulate, ($a1a2$) $> a3$, bearing the 4th pair of eyes and forming the buccal ring, $a3$ very distinct dorsally and fairly so ventrally except in the mid-ventral field. VI, 3-annulate, $a1 > a2 > a3$, 5th eyes on $a2$, the pigment cups deep and under the furrow $a2/a3$. VII, 3-annulate, similar to VI but eyeless and larger and $a3$ faintly biannulate on the dorsum. VIII, 4-annulate, $a1 > a2 > b5 = b6$. IX, 5-annulate, $a2 = b2 > b1 = b5 = b6$, first detected nephropores on caudal margin of $b2$. X, 5-annulate, similar to IX, $a2 > b2 > b1 > b6$ very slightly $> b5$. XI, 5-annulate like X but with male pore at $a2/b5$, that is, between the 3d and 4th annuli. XII, 7-annulate, $b2 > b1 > b5 > b3 = b4 > c11 = c12$, the primary annulus $a2$ divided into the two secondaries $b3$ and $b4$ and the last secondary $b6$ into the tertiaries $c11$ and $c12$. XIII to XXII, each 8-annulate, $b2 > b3 = b4 = b5 > c1 = c2 = c11 = c12$; XIII bears the female pore at $c11/c12$ or slightly within $c11$; beginning with XIII $b3$ all annuli become abruptly shorter; the smaller first 2 and last 2 of each somite (tertiary or *c* annuli) a little more than one half the preceding annuli, and the middle 4 (secondary or *b* annuli) somewhat larger, nephropores on caudal margin of $b2$. XXIII, 7-annulate, $b2 > b5 > b4 = b3 > b6 = c1 = c2$, last paired nephropores on $b2$. XXIV, 6-annulate, $b1 = b2 > b3 = b4 > b5 = b6$, grouped in twos represent-

ing the three primary annuli, furrow *b5/b6* incomplete on left side, nephropores transferred to a common opening at base of sucker. XXV, 3-annulate, *a2* and *a3* not differentiated at sides. Then come two irregular annuli cut by the anus and probably constituting XXVI, followed by two more representing XXVII and a half annulus on the dorsum of the sucker.

Anatomy: a few points of internal anatomy essential to fixing its systematic position that could be determined without damaging the unique type show that in these respects it is in substantial agreement with Caballero's description (9) of his *Hygrobdeella pelaezi*. Jaws three (dorso-median and paired ventro-lateral), far caudad in somites VIII-IX, terminating the pharynx, and not separated from it by a cleft but projecting from it like a trifid papilla into the circumpharyngeal chamber and not retractile into sinuses in the wall of the latter; form essentially as in other jawed leeches, but no teeth detected. Circumpharyngeal chamber unusually extended for a jawed leech, the thin outer membranous sheath connected with the pharyngeal wall at IX/X but reflected somewhat farther caudad. Velum, which forms the cephalic boundary of the pharyngeal chamber, also far caudad in VII, a thin, rather high, continuous fold with somewhat ruffled margin but apparently of equal height all around and undivided into the usual three lobes except that there is a fold forming a median dorsal cleft in which is a minute pointed lobe. No lateral buccal lobes. Pharynx short, bulbous with six longitudinal folds internally, three continuing the position of the jaws and three alternating, all prolonged into the short oesophagus. Vagina beginning as a narrow stalk at the female pore, becoming clavate and somewhat wavy and reaching caudad between the nerve cord and the gut, without the usual sharp flexure, for 23 annuli or to the caudal end of somite XVI, including the pair of ovisacs which, with the oviducts, lie on its ental end at XVI/XVII instead of in the usual position for the family on each side of the nerve cord at XII/XIII. Ganglia XIII and XIV were exposed, and were determined to lie in the second and third of the larger annuli of their somites, thus establishing that these are *b3* and *b4* and confirming that the nephropores are in the normal position on *b2*.

"Volcano Tajumulco, Guatemala, Oct. 1934. F. X. Williams. Under stone at 12,500-13,000 ft." Holotype in The Academy of Natural Sciences of Philadelphia.

In 1940, Caballero described, under the name of *Hygrobdeella pelaezi*, a type of leech believed new to America. As long ago as 1869, Baird gave the name of *Heterobdeella mexicana* to a leech which was briefly but accurately described as having 160 annuli (counting the buccal ring as one), gonopores separated by 19 annuli, five pairs of eyes, tessellated annuli and other external characters which agree with Caballero's description. For 70 years, until Caballero's rediscovery, nothing had been added to our knowledge of Baird's very peculiar leech. But the generic name *Heterobdeella* had already been applied by v. Beneden and Hesse (3) to a trematode, so that Vaillant (21) substituted *Diestecostoma* for *Heterobdeella* Baird. The correct name for Caballero's leech is, therefore, *Diestecostoma mexicana* (Baird).

So far as determined, *D. octannulata* agrees with the description of Baird and Caballero in every important respect except the number of annuli in complete somites and number of annuli separating the gonopores. It is customary among modern students of leeches to regard definite differences in the first respect as of generic value. But especially in terrestrial leeches of the family Erpobdellidae, which have elongated bodies, this practice has been occasionally ignored. In a few genera such as the Eurasian *Trocheta* and the Japanese *Orob-della* the species show considerable variation in this respect, and another example is given in this paper, *Gastrostomobdella quinque-annulata* (p. 177). It is also certain that Blanchard's system of genera of the Haemadipsinae, which is based solely on the number of annuli per somite and which already has received some criticism from Johansson (13) will have to be modified. Following this line of thought, *D. octannulata* is considered to be congeneric with *D. mexicana*, unless divergences in its anatomy are found later.

D. octannulata is a very interesting leech and it is unfortunate that it has proved impossible to procure additional material to permit a full anatomical study. However, the few points determined are in agreement with Caballero's account.

It has long been known that terrestrial and burrowing leeches in some variety are common in tropical America, with at least one species widely distributed in the United States. These are dominantly predacious leeches, feeding chiefly on earthworms and insect larvae, and for the most part belong to the Erpobdellidae, the others being mostly atypical Hirudidae. With the exception of one peculiar species, *Mesobdella gemmata* (E. Blanchard), confined to a limited area in humid southern Chile, the true Indo-Malayan sanguivorous land leeches (Haemadipsinae) have been supposed to be absent from the continental Western Hemisphere.

Of exceptional interest, therefore is Caballero's reference of his *Hygrob-della pelaezi* unequivocally to the Haemadipsinae. As he gives an excellent anatomical description with figures of most organs it is possible to check this conclusion. Also it is evident that *D. octannulata* and *D. mexicana* resemble each other in nearly every ascertained respect. Together the two resemble typical haemadipsines in the following: five pairs of eyes, the first four on consecutive annuli, the 4th and 5th separated by two annuli, indicating great reduction of the cephalic somites; rather strongly tessellated annuli, especially dorsally

at the ends of the body; probable opening of the first pair of nephridia on the buccal annulus, and translocation of the last pair to the base of the caudal sucker; three jaws, toothed in *D. mexicana* and probably in *D. octannulata*. While the combination of these characters is suggestive of the haemadipsines no one is strictly limited to them.

On the other hand, they present the following differences: body elongated and of even width instead of rather short with the maximum width far back; head small and buccal region narrow instead of wide; lip elongate and spoon-shaped instead of short and triangular; annuli of complete somites of unequal length instead of approximately equal, as in most haemadipsines, and somites XXV, XXVI, and XXVII not uniannulate; no auricles at the sides of the caudal sucker, which lacks both a prehensile papilla and friction rays; paired nephropores ventral instead of dorso-lateral; segmental sensillae obscure or absent instead of prominent; jaws far back in somites VIII and IX instead of in VI and other differences in the bucco-pharyngeal region; gastric caeca as stated by Caballero seven pairs, while in the Haemadipsinae there are 10 or 11 pairs; no Lambert's organ terminating the last pair of caeca as in many haemadipsines; both the male and female copulatory organs are straight and lack the forward bend on themselves nearly universal in the entire family Hirudidae; and most remarkable of all, the paired ovisacs lie at the end of the vaginal sac in XVI instead of in the usual position on each side of the nerve cord at XIII/XIV.

It will be seen, therefore, that *Diestecostoma* diverges from the Haemadipsinae in many more respects than it resembles them and that in certain respects, such as the position of the jaws and the ovisacs, it departs widely from the entire family of Hirudidae, the so-called 10-eyed leeches. In superficial external appearance, such as the form of the body, head and caudal sucker, the multiplication and inequality of annuli, the wide separation of the gonopores, and the color, both species resemble the terrestrial and predacious Erpobdellidae. However, the arrangement of the eyes and the entire general facies of internal anatomy departs from this family and resembles the Hirudidae, although the caudal position of the ovisacs recalls conditions in the former family.

In 1868, Frauenfeld (10) described under the name *Xerobdella Lecomtei* a remarkable land leech from the mountains of Austria. To this were attributed a peculiarly contracted head bearing four pairs of

eyes arranged like the last four pairs of most true land leeches, 90 tessellated annuli between the mouth and caudal sucker, the gonopores separated by only $2\frac{1}{2}$ to $3\frac{1}{2}$ annuli, a large pore beneath the caudal sucker, three jaws each bearing about 18 coarse teeth, and other characters. Frauenfeld particularly referred to the resemblance of his leech to *Trocheta*, a terrestrial erpobdellid. Later authors continued to associate *Xerobdella* with this family then known as Nephelidae, until 1892, when Blanchard (5), on the basis of a restudy of the type and seven other specimens, including one living one, gave a detailed description of the external characters. Besides confirming Frauenfeld's account he added the following: a curious pair of prominent, almost winglike lappets ("palps") attached to the sides of the buccal ring which appear to be homologous with the much smaller organs which I have designated as lateral buccal lobes in various haemadipsines; complete somites 5-annulate and those from X to XXIII inclusive bearing paired nephropores on the venter in the position common to most leeches; number of teeth about 33. One specimen is figured with the entire pharyngeal region everted as an irregular body borne on a slender stalk with the three jaws at the end. Blanchard also points to variations in the position of the gonopores and on some specimens to the presence of a second small median pore behind the female pore in or near the furrow XIII *b1/b2* which he compares to the copulatory gland pores of *Macrobdella* and to the gastropore described by Horst (11) in a Sumatran erpobdellid. However, he appears to have made no dissection to determine its actual nature. His conclusion is that *Xerobdella* is a member of the Hirudidae related to *Haemadipsa* for essentially the same reasons that led Caballero to place his *Hygrob-della* in the Haemadipsinae.

While we are still ignorant of much of the internal anatomy of *Xerobdella*, some important facts have been added. The first pair of nephropores open at the sides of the buccal ring (20) as in most haemadipsines and the last pair have a common opening (7) in the pore originally described by Frauenfeld. Of even greater interest is the position of the retracted jaws in somites VIII and IX as shown in an outline sketch of Schuster's depicting the first two pairs of nephridia. They terminate the pharynx and project into the circum-pharyngeal chamber exactly as in *Diestecostoma*. It becomes clear that these two genera are closely related and that while properly included in the family Hirudidae, they are not of the Haemadipsinae.

The resemblance of these leeches to the Erpobdellidae on the one hand and the Haemadipsinae on the other would appear to be superficial and adaptive to similar modes of life. They live under stones and logs in wet forests or on humid mountains and feed largely on earthworms, insect larvae, and other small animals. *Xerobdella* is associated with the terrestrial salamander (*Salamandra ater*) which it is said to attack. *D. mexicana* is reported by Caballero to suck the blood of salamanders of the genera *Oedipus* and *Ryacosiredon*.

The only other continental American leech that has been referred to the Haemadipsinae is *Mesobdella gemmata* (E. Blanchard). This is unique in having triannulate somites. Little is known of its internal anatomy except that it has three toothed jaws and "gastric caeca like the Glossiphoniidae," (4) which presumably means not more than seven pairs. It is of interest that it resembles *Xerobdella* and *Diestecostoma* in the position of the nephropores, the first pair buccal, the last median beneath the sucker, and the remaining pairs ventral, in the absence of auricles, the structure of the caudal sucker, and other external features.

As the last two of these genera and possibly the first⁴ stand apart from the established subfamilies of the Hirudidae, it may become necessary to erect a subfamily *Xerobdellinae* for them, but it is my opinion that until more is known of the anatomy of these and some other South American leeches, this would be premature. For the present, they may remain as aberrant members of the Hirudinae.

⁴ After this paper was completed, I received from Raul Ringuet a description of *M. gemmata* (Physis 19: 369, 370, Buenos Aires, 1943) which shows that the reproductive organs are typically haemadipsine, as are also some other features of the anatomy. The suggested close relationship of *Mesobdella* to *Xerobdella* and *Diestecostoma* is therefore withdrawn.

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