Bull. Natn. Sci. Mus., Ser. A (Zool.), 1 (1), March 22, 1975

A New Species of Terricolous Leeches in Japan
(Gastrostomobdellidae, *Orobdella*)[1)]

By

Laurence R. RICHARDSON

4 Bacon St., Grafton, N.S.W., Australia

(Communicated by Yoshinori IMAIZUMI)

OKA (1895) described three species of terricolous leeches in Japan, the 4-annulate *whitmani,* 6-annulate *ijimai,* and 8-annulate *octonaria,* all having the same kind of pharynx which he termed euthylaematous, *i.e.* with the internal muscular ridges arranged as a dorsomedian and a pair of ventrolaterals along the length of the pharynx. On this and other features, he provided the genus *Orobdella* to contain the three species, and (SOOS, 1966) as *whitmani* has page priority this species has the status of type-species for the genus.

There was (SOOS, 1966) no further knowledge of these species until GILYAROV, LUKIN and PEREL (1969) who record a terricolous 4-annulate from the Maritime Territory (Manchurian province) and refer this to *O. whitmani*—the description is not adequate for consideration here; and my own account (1971) of *octonaria* which I found to be gastroporous, provided the genus *Kumabdella* for it, and associated *Kumabdella* with *Gastrostomobdella* MOORE, 1929 in a family Gastrostomobdellidae.

The account of *O. whitmani* as given by OKA is not fully complete; but from the experience of *K. octonaria,* it seemed most probable that *O. whitmani* was gastroporous, since OKA (pl. xxx, fig. 3) shows in a longitudinal section of this species, a saccular organ opening on the midventral line in annulus 32 (=xiii a_1). The gastroporous nature of the new species confirms my earlier conclusion.

The new species exhibits adaptation to the terricolous habit.

The eyes are deep-seated and partially degenerate. Superficial dissection showed a pigmented pair at the level of ii/iii in both specimens; a pigmented pair in iv in the Type, and in v in the Paratype. These are all fully dorsal, corresponding to somital sense organs of the dorsal paramedian and intermediate lines, none 'buccal', agreeing more with an ocular pattern in the form of a broadly open posteriorly directed arch as is typical of euthylaematous leeches. This is supported by OKA's account of the eyes in *Orobdella,* possibly referring to *whitmani* since he illustrates pigmented eyes as seen in a section of this species (pl. xxx, fig. 1), as 5 pairs, all deep seated, the 1st, 3rd, and 4th pairs unpigmented, the 2nd and 5th pairs (*i.e.* somites iii and vi) pigmented.

The absence of well-developed somital sense organs is possibly also an adaptation

1) A study collateral to researches on Australian leeches assisted by an award from the Australian Research Grants Committee.

to the terricolous habit which is fully evident in the irregularity and incompleteness of the annulation of the posterior somites and in the poorly formed posterior sucker which appears incapable of muscular adhesion so that it is improbable that this species moves by dicotylal locomotion in the manner typical of leeches.

The central nervous system is unusual, possibly also reflecting adaptation to the terricolous habit.

In dissections at magnifications of $\times 20$ to $\times 40$ of other aquatic, amphibious, macrophagous and sanguivorous leeches, and also terrestrial sanguivorous leeches, of the size and even much smaller than the new species, the ventral nerve cord, the roots of the somital nerves, are obvious and strong enough to permit manipulation; the ganglionic capsules of the anterior and posterior ganglionic masses and of the somital ganglia, are obvious, and the capsules can be counted.

In the new species, the ventral nerve cord and the roots of the somital nerves are delicate, and readily destroyed even with careful manipulation. The somital ganglia and the posterior ganglionic mass, are small, the latter abbreviated and contained within xxvi. Ganglionic capsules are recognizable along the dorsolateral margin of the anterior ganglionic mass, with none detectable on the lateral and ventral aspects as is usual, or in the somital ganglia and the posterior ganglionic mass.

So far as I have seen in the literature, the locus and nature of digestive enzyme activity have not yet been determined in macrophagous leeches.

ZIA (1927) describes the crop in the macrophagous *Whitmania laevis* (BAIRD, 1869) as opening into a small "spherical stomach," but shows (pl. 1, fig. 5) the crop as joining only to a sacculated intestine. MOORE (1929, fig. 1) shows the crop joining to a spherical chamber in *Gastrostomobdella monticola,* and (1930) describes an anterior chamber of the intestine as "digestive stomach" in *Haemopis* (=*Whitmania*) *gracilis*. Neither ZIA nor MOORE give a reason for the use of these names, nor have I seen a reason given elsewhere.

The crop in the Paratype of the new species contained a small insect; and an oligochaete worm divided into three portions, two small portions entirely in the crop, and the third, a long portion in the crop continuing through the terminal sphincter into the intestine. The insect and the portions of the worm in the crop were intact without any indications of digestion.

The portion of the worm in the intestine was completely digested, there remaining only the chitinous layer of the epidermis as a thin walled tube some 6.0 mm long continuing posteriorly from the sphincter.

There is evidence here of digestive enzyme activity in the intestine of the new species.

The function of the gastroporal duct is unknown.

MOORE (1929) suggested that the duct and pore might serve for the excretion from the crop of earth from the intestine of digested oligochaetes. The evidence in the Paratype does not support this proposal.

Alternatively, MOORE suggested at the same time, the possibility that the duct and

pore might be associated with the transfer of sperm received during copulation. MOORE based this on:

1) The late development of the gastroporal aperture as seen in *G. monticola.* He found several small dermal pits at the site of the gastropore in smaller specimens. In larger specimens, these coalesce into a single depression which deepens to become continuous with the duct.

2) In larger specimens, the development in the body cavity in the vicinity of the gastropore, of a thick layer of homogenous tissue. MOORE suggested that this tissue might be conductive in function.

Conductive tissue is known in some Rhynchobdellae. It is associated with the hypodermal injection of sperm from spermatophores which are formed in the male atrium and/or its associated structures such as the atrial cornua.

The male reproductive system in *Gastrostomobdella* terminates in an atrium with cornua, such as might be suitable for the formation of a spermatophore; but not in *Kumabdella* or the new species. In these, there is no formed functional male median region, and no structure suitable for the formation of a spermatophore. I have not seen any indication of a layer of homogenous connective tissue in the vicinity of the gastropore in *Kumabdella,* or in the new species, the latter including one specimen definitely close to female maturity.

It was not possible to demonstrate in the Paratype or the two additional specimens of the new species, an opening in the floor of the crop leading into the gastroporal connection, nor with confidence a tubular nature for this connection.

The absence of an opening leading through the body wall into the duct in all four specimens, gives the general impression that the gastroporal duct may be more or less vestigial in the new species, a consequence from some measure of failure in development.

It was clear in *K. octonaria* that the wall of the gastroporal duct is of the same nature as the wall of the crop (RICHARDSON, 1971, fig. 3). From this it can be proposed that the duct develops as a median ventral caecum at the anterior end of the crop. The caecum extends ventrally to and has the capacity to evocate in the ventral body wall a pouch to which it connects and fuses, leading then to the formation of the gastropore.

The condition in the new species suggests that failure occurs in the final stage of this development.

The unusual feature is, as described by MOORE and seen in the new species, the postponement into the maturing adult of the completion of a process which is developmental in nature, a process which would be expected to reach completion during those phases in development when tissues still possess some measure of plasticity.

It can be taken with confidence from OKA (1895, pl. xxx, fig. 3) that the gastroporal duct opens through a gastropore in *O. whitmani.* At this time, there is the possibility that the system may be incomplete in the new species, a difference which might have systematic value.

Since the Gastrostomobdellidae are macrophagous, the pharynx longer than in other macrophages and terminating in a powerful muscular sphincter such as I have seen only in gastrostomobdellids, there is the possibility that the completed duct serves for the elimination of fluids in the crop during ingestion.

Genus ***Orobdella*** OKA, 1895

Gastrostomobdellidae; viii to xxii complete 4-annulate (total 15); pharynx terminates in xiv; (crop acaecate); genital pores, xi b_6, xiii a_1/a_2; gastropore, median ventral in xiii a_1; gastroporal duct, a single duct opening from the ventral aspect of the anterior end of the crop; nephropores, 17 pairs, viii to xxiv; testes multiple; anterior region of male paired duct, linear, simple, no sperm vesicles; no formed functional male median region; ovaries compact, saccular, in xiii; oviducts short, joining independently to the genital pore; no formed functional female median region.

Size, medium. Lacking a topographically defined pattern.

Terricolous; macrophagous. Oriental Region, Japan.

Type-species: *Orobdella whitmani* OKA, 1895. Honshu, Kyushu.

The above is derived mainly from OKA (1895) with such additions as seem reasonable from the experience of the new species which has enabled a close analysis of OKA's account of *whitmani*.

Additional species: *Orobdella kawakatsuorum* n. sp., as follows.

Orobdella kawakatsuorum sp. nov.

The specific name is given as a small appreciation of the generous cooperation of Professor Masaharu KAWAKATSU which has provided me with the privilege of studying some of the zoologically significant leeches of Japan.

Type-specimen: 58.0 mm long. Collected, the home garden of Professor M. KAWAKATSU, northeastern part of Sapporo, near Fuji Women's College, Hokkaido; a shaded moist location very near the river; June 1, 1974. Collectors: Tetsuya KAWAKATSU, Miyuki KAWAKATSU. Dissected. Deposited, the National Science Museum of Tokyo, NSMT–An 53.

Paratype: One specimen, 87.0 mm long. Collected, Mt. Sankaku, Sapporo City, Hokkaido, July 10, 1972. Collector, M. KAWAKATSU. Dissected. Deposited, the Australian Museum, Sydney, Coll. No. W 5426.

The collection site for the Paratype is described by Professor KAWAKATSU as a narrow mountain road, near a highway to the Okura Schanze; the ground rather dry; remote from water. The leech was firm-bodied in the hand, and not active.

TYPE

The following description is taken from the Type.

General form (Fig. 1, A). Preserved in alcohol, slightly contracted, very firm to the touch as though strongly muscular.

Lacking obvious eyes; moderately depressed, very low convex across the dorsum, the margins obtusely convex, the venter very low convex anteriorly, then along the greater length of the body, the venter with a low rounded ridge slightly wider than the flattened lateral portions, the ridge outlining the posterior portion of the pharynx, the crop and the intestine.

In dorsal view, the body divided into regions: a short obtusely convex terminal lobe at the anterior end; a preclitellar region widening gradually, confluent with the clitellar region, weakly separated from the postclitellar region which is uniform in width along its length until reducing abruptly to the small sucker. The margins of the sucker are obtusely rounded.

In lateral view, the postclitellar region is divided into a more depressed anterior region almost equal in length to the following deeper portion which terminates with a much depressed shorter portion with the dorsal contour continuous with the dorsum of the posterior sucker.

Total length, 58.0 mm; 2.0 mm wide at 1.0 mm from the anterior end, the width increasing to 4.0 mm at 5.0 mm, with the depth generally 3.0 mm, and of these dimensions to 7.0 mm; widening then to 6.0 mm, the depth 4.0 mm, at 15.0 mm, and of this width back to 53.0 mm, with the depth less than 4.0 mm back to 35.0 mm, increasing then to 4.0 mm back to 47.0 mm, and reduced to 3.5 mm in the terminal body somites. The ventral face of the posterior sucker, 3.5 mm long and 4.0 mm wide.

Colour and pattern. The dorsum uniformly bluish grey; the margins and venter, white. There is no indication of a topographically defined pattern.

Body wall and musculature. The body is very firm to the touch, as though strongly muscular, but the external and internal layers of oblique muscles in the body wall are not obvious in dissection. The longitudinal layer is formed of flat muscle strands, each about 0.1 mm wide, the strands in close contact, edge to edge along the venter, well spaced along the dorsum, and individual strands are identifiable through many somites.

The paramedian palisade of dorsoventral muscles is represented along the greater length of the pharynx, by spaced strands passing between obvious strands of extrinsic radial muscles. In somite x and posteriorly, the palisade is almost a continuous sheet of closely packed strands on each side of the crop. In the intestinal region, the palisade is continuous dorsally, interrupted as spaced columns ventrally.

The intermediate palisade is present as spaced small clusters of dorsoventral strands.

The botryoidal tissue is a thick compact layer dorsal and lateral to the crop and intestine. It is lacking in the ventral portion of the median splanchnic chamber.

Central nervous system (Fig. 1, C; 2, A; Paratype, 2, E). The elements of this system are relatively small; the somital ganglia, minute, without recognizable ganglionic capsules; the somital nerve roots, not always recognizable in dissection and the nerve cord between the ganglia, unusually narrow and delicate.

The ventral component of the anterior ganglionic mass is about 0.5 mm in length

and 0.3 mm in maximum width, with very narrow lateral commissures. The mass is situated in vi a_2; ganglion vii, in vii a_1, briefly separated from the anterior mass; viii, anterior in viii a_2, extending briefly into viii a_1; ix, anterior in ix a_2, extending briefly into a_1.

Ganglia vii, viii, ix, are of similar size, each about 0.3 mm long and wide.

Ganglion x and the following ganglia are smaller, each about 1/2 the length of a_2, some smaller than this, and centered on a_2/b_5.

Ganglion xxiv is posterior in xxiv a_2, widely separated from ganglion xxv which is briefly separated from an elongate ganglionic mass.

This is apparently the posterior ganglionic mass. It is situated in the anterior annuli of xxvi, about 0.8 mm long, and, in dissection, the usual nerve roots and ganglionic capsules could not be detected. Two terminal nerves are present with no indication of the ventral nerve cord posterior to the mass.

While not a fully reliable index, the length of this posterior mass suggests that it contains at least two somital components, xxvi, xxvii. There are no indications of others, which because of the reduction in muscularity of the sucker, and so of its function, might not be represented in the usual manner.

Annulation (Fig. 1, B, C, D; 2, A, C). Moderately extended, the annuli slightly contracted to be low convex on the dorsum, almost flat on the venter; the surface, everywhere smooth, no indication of areolae, papillae, etc.; intersomital and interannular grooves, essentially equivalent; no obvious triplets or couplets of annuli; somital limits, not directly recognizable; eyes, obscure or hidden, black pigmented eyes detectable by superficial dissection; somital sense organs, not detectable; sensillae, minute, a single row with the sensillae narrowly spaced, rarely detectable.

Nephropores, minute, some as circular apertures, the majority obscure, demonstrable only with the tip of the needle; generally symmetrical in a_1, close to a_1/a_2, but asymmetrical in some somites, *e.g.* xvi, xxiv, the left posterior in a_1, the right anterior in a_2.

The annulation given below for the prenephric and postnephric somites is based on the general principles of somital annulation, confirmed where possible by reference to the somital ganglia.

The dorsum of the anterior sucker, elongate, acute, the margins divided by shallow furrows into low short ridges; somite i, uniannulate, very short; the furrows i/ii, ii/iii, weak, incomplete, not reaching to the margins; ii, uniannulate, longer than i; the 1st pigmented eyes, a single pair, wide-spaced, deep beneath ii/iii; iii/iv, well-marked across the dorsum; iii and iv, both 2-annulate, a_1a_2 distinctly$>a_3$; a 2nd pair of pigmented eyes, deep beneath iv a_1a_2/a_3, and dorsal; v, incomplete 3-annulate, $a_1=a_2<a_3$ on the dorsum, a_1 not extending to the midventral line, forms the ventrolateral margins of the sucker (but see Additional Material); vi, complete 3-annulate, $a_1>a_2<a_3$; vii, 3-annulate, $a_1=a_2>a_3$.

Somites, viii to xxii, complete 4-annulate (total, 15), xxiii incomplete 4-annulate. In this series, the differences in the lengths of the annuli are generally small, and longer

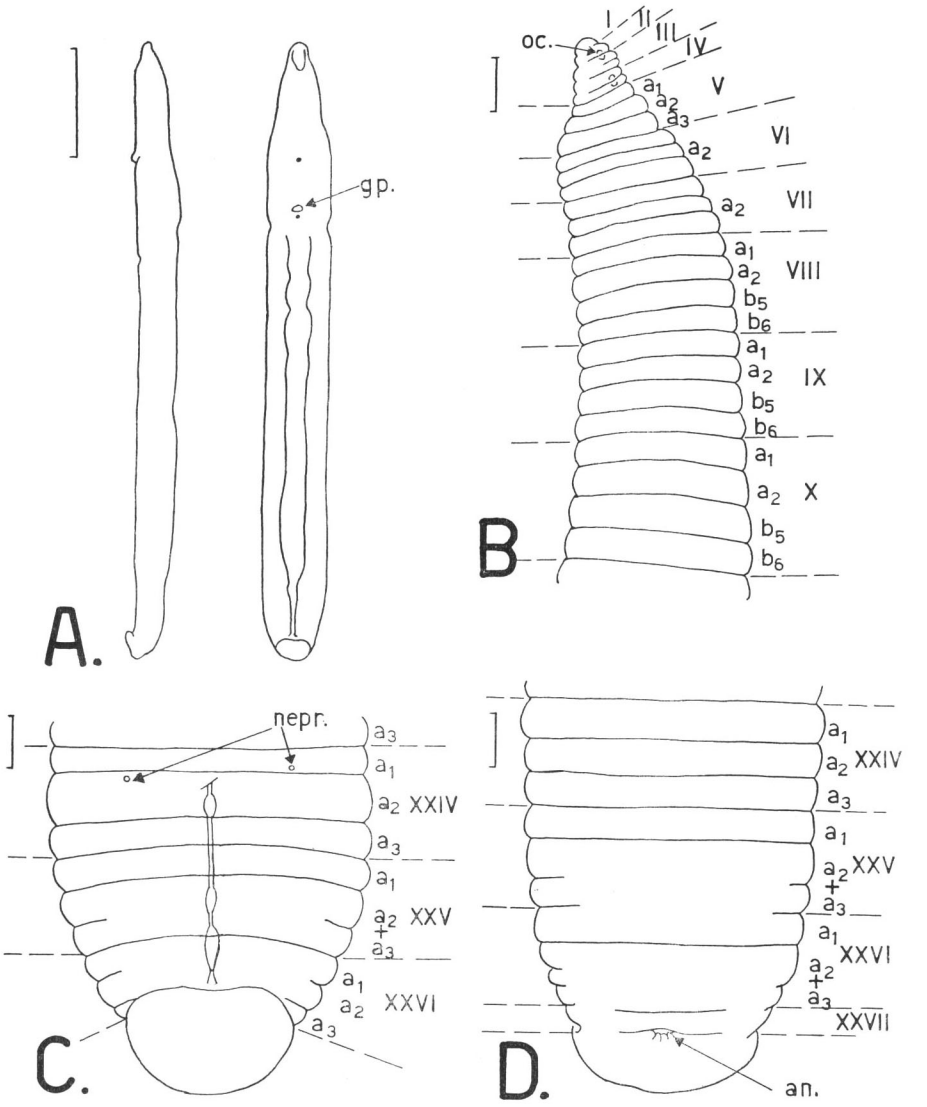

Fig. 1. *Orobdella kawakatsuorum* sp. nov. —— A. Left lateral, and ventral views of the entire animal. B. Annulation, somite i to x, left lateral view. C. Ventral, and D. dorsal views showing annulation of somites xxiv to xxvii, and sucker, C. including ganglia and posterior ganglionic mass. A to D, from Type.
Somites and somital ganglia indicated by roman numerals; annuli 'a_2', etc., somital limits, broken lines; somital ganglia shown at relative size. Scales, 1.0 mm.
Abbreviations: a.g.m., ventral component of anterior ganglionic mass; an., anus; an.g., annular groove; cr., crop; dl.r., dorsolateral, and dm.r. dorsomedian, muscular ridges; f.p., female pore; g.p., gastroporal depression; gp.d., gastroporal duct; int., intestine; m.p., male pore; nepr., nephropore; oc., location of eye; ov., ovary; ph., pharynx; pm.mm., dorsoventral muscles of the paramedian palisade; v.d., vas deferens; vl.r., ventrolateral, and vm.r., ventromedian, muscular ridges.

annuli are not directly recognizable by length alone; viii, $a_1=a_2<b_5>b_6$, the 1st nephropores posterior in a_1; ix, $a_1<a_2>b_5<b_6$; x, $a_1<a_2=b_5=b_6$, b_5 the 1st annulus of the clitellum; xi, as x, the male pore slightly everted in b_6 close to b_5/b_6; xii, $a_1=a_2<b_5=b_6$; xiii, $a_1>a_2>b_5=b_6$, a_2 the last annulus of the clitellum—in the middle of a_1 on the venter, a shallow transversely oval depression 0.5 mm wide, the gastroporal pit; the female pore a small circular aperture in xiii a_1/a_2; in xiv to xxii, the combination of b_6 and a_1 recognizably longer than the combination of a_2 and b_5, with generally a_1 slightly $>a_2=b_5<b_6$; nephropores asymmetrical in xvi; xxiii, incomplete 4-annulate, $a_1>a_2=b_5=b_6$ above, and a_3 below; xxiv, complete 3-annulate, $a_1>a_2<a_3$, the 17th pair of nephropores, asymmetrical; xxv, incomplete 3-annulate, $a_1<(a_2+a_3)$, a_2/a_3 lacking across the dorsum, defined on the margin, and an open shallow groove across the venter; xxv/xxvi lacking across the dorsum, defined on the margins and the venter; xxvi, with a_1/a_2 across the dorsum and margins, lacking on the venter, a_2/a_3 defined only on the margins, indicating a basic 3-annulate condition, with a_3 as the last annulus across the venter; xxvi/xxvii, a shallow incomplete groove across the dorsum, not reaching to short incisions at the margin, so that xxvi and xxvii are incompletely separated, and xxvii essentially uniannulate; the anus at the posterior border of xxvii.

The dorsal surface of the posterior sucker smooth, confluent with and incompletely separated from xxvii, so that there is no distinct basis for this sucker; the margin of the sucker, obtusely rounded, distinct laterally, and continuous across the venter as a low elevated rounded ridge; the ventral surface, smooth, and not significantly excavate.

Alimentary tract (Fig. 2, A, B, C, D). There is a narrow smooth rim on the ventral surface of the anterior sucker. Internal to the rim, the dorsal, lateral, and ventral surfaces of the chamber of the sucker, are papillate, the papillae, large, flat on the dorsal surface, elevated elsewhere, relatively regular in size. There are no indications of furrows or other subdivisions on or between these surfaces.

The posterior edge of the papillate area forms the anterior border of a narrow, shallow, smooth surfaced annular groove which is at the level of v/vi. The anterior end of the pharynx forms the posterior wall of this groove.

The entrance to the pharynx is wide, the inner surface of the pharynx, smooth, flat, divided into wide primary dorsomedian and ventrolateral internal muscular ridges, by shallow narrow grooves in the dorsolateral and ventromedian positions, each groove containing a secondary internal muscular ridge, narrow anteriorly, and slightly wider along the length of the pharynx.

Excepting midventrally, the pharynx is intimately attached along its length to the body wall.

The wall of the pharynx is moderately muscular. The pharynx terminates with a short muscular sphincter extending from about the middle of xiii to join the crop in xiv a_2. The sphincter protrudes briefly into the lumen of the crop. The internal surface of the sphincter is longitudinally rugose.

'Salivary' glands are not detectable.

The crop is thin-walled, rather oblong in section, slightly higher than wide; lacking compartments; acaecate; and the internal surface is transversely rugose anteriorly, longitudinally rugose, posteriorly.

A minute circular aperture in the floor of the anterior end of the crop, is ventral to and concealed by the protrudent end of the sphincter, and slightly to the right of the midline. The aperture leads into a soft-walled gastroporal duct, about 5.0 mm long, widest (0.3 mm) near its origin on the crop, extending anteriorly beneath the pharynx, tapering gradually to its attachment to the internal surface of the body wall in the midline on xiii a_1, immediately anterior to the ends of the oviducts, which it crosses, and above the gastroporal depression.

The crop continues without change in form to end in xx where it joins terminally to the intestine. There is a very narrow ridge-like sphincter at this junction.

There are no indications, externally or internally, of postcaeca opening from the crop in xix or xx.

The intestine is tubular, tapering, without compartmentation, and with some 7 pairs of lateral elongate pockets in xx and xxi, and indications of others in xxii. The pockets diminish in size posteriorly, all opening widely and without restriction into the intestine, and none with the nature of well-formed caeca.

The paramedian palisades of dorsoventral muscles in the intestinal region, are continuous dorsally, interrupted ventrally as spaced columns, and the intestinal pockets protrude between the columns of the muscles.

The intestine joins terminally at xxiii/xxiv to the rectum which is tubular, tapering, longitudinally rugose internally, and terminates at the anus.

Reproductive systems (Fig. 2, C). Assessed as maturing female, the ovaries packed with and distended by thick cords of ovarian tissue; clitellum defined.

Lacking formed functional median regions; testes multiple; no formed sperm vesicles; genital pores, xi b_6, xiii a_1/a_2.

Testes, small thin-walled spherical bodies 0.5 to nearly 1.0 mm in diameter, buried in botryoidal tissue along with the vas deferens in the paramedian splanchnic chamber at the foot of the muscles of the paramedian palisade. Three were detected on one side in xix, 5 on the other, and some were detected in xxii; but the limits of the testicular region could not be determined.

In xxii and anteriorly through xix, the vas deferens is a very thin-walled and delicate duct. In xvii, the duct increases in width to about 0.2 to 0.3 mm, the wall is thickened, fibrous in appearance, opaque, and in xvii anteriorly to xiii/xiv, the vas deferens is of this nature and thrown into many close compact vertical folds.

This change in the nature of the duct can be taken as an indication that the testicular region does not extend anterior to xvii.

At xiii/xiv, the vas deferens narrows. The wall becomes thinner, semitransparent, and the vas deferens continues anteriorly into xi where at the level of b_5/b_6, it turns medially, as a very narrow duct which passes through the paramedian palisade into the median splanchnic chamber and expands into a short poorly defined thin-walled

small vesicle entirely ventral to the nerve cord.

The two vesicles enter the body wall to terminate independently at the male pore. There is nothing recognizable in dissection as either atrium or bursa.

There are no indications of elaboration of the anterior region of the male paired ducts as epididymi, sperm vesicles, or muscular ejaculatory bulbs or ducts..

The ovaries are large, thin-walled, subspherical sacs, each about 1.0 mm in diameter, and located in the paramedian splanchnic chamber in the posterior half of xiii. Each continues through the palisade as a wide thin-walled oviduct which crosses the floor of the median splanchnic chamber. The two oviducts enter the midline of the body wall at xiii a_1/a_2, and join to the female pore without any indication of a formed atrium or bursa.

There is nothing recognizable in dissection as aggregated prostate or albumin glands.

PARATYPE

General form. Preserved in alcohol, generally similar to the Type; the anterior sucker slightly more elongate; the postclitellar region more uniformly continuous, not as obviously divided into subregions; a ventral ridge outlining the crop and intestine.

Colour. Preserved. Dorsum, light brownish along the clitellar region; otherwise, the dorsum of the body and of the posterior sucker, black, mottled coarsely with pale grey, and some few brownish patches; the rim of the anterior sucker, white; the anus enclosed in a small cream circle; the venter, dusky pale light brown; ventral aspect of the posterior sucker, black.

There is no indication of a topographically defined pattern.

Annulation. Preserved, extended; the annuli generally flat; interannular furrows wide, shallow; many annuli crossed by a weak furrow, variable, either anterior or posterior in the annulus, and not given morphological value here; somital limits, not directly recognizable; no detectable somital sense organs; the majority of the annuli with a single transverse row of many, narrowly spaced minute white sensillae, the row commonly posterior in the annulus.

Nephropores, fully ventral, minute; some indicated by white patches; many detectable with difficulty; most, posterior on a_1, symmetrical; some erratic, asymmetrical, *e.g.* xxi, the right posterior in a_1, the left posterior in a_2.

Somites i to vii, as in Type, excepting the posterior pair of deep-seated pigmented eyes, wide spaced, fully dorsal, buried deeply in v a_1; viii to xxii, complete 4-annulate; xxiii, incomplete 4-annulate, a_3 below; the 1st nephropores on viii a_1, the 17th pair on xxiv a_1; xiv to xxii, the combination of b_6 and a_1 usually recognizably longer than the combination of a_2 and b_5, but with more minor variation in the lengths of the annuli in these somites, than in the Type; xxiii, $a_1 > a_2 = b_5 = b_6$ on the dorsum; xxiv to xxvii, some interannular furrows wide, shallow, weak on the dorsum, indicated more strongly at the margins; xxiv, incomplete 3-annulate, $a_1 = a_2$ much $< a_3$ above, and $a_1 = (a_2 + a_3)$ below; xxv, incomplete 2-annulate, $a_1 a_2 > a_3$ above, uniannulate below; xxvi and xxvii,

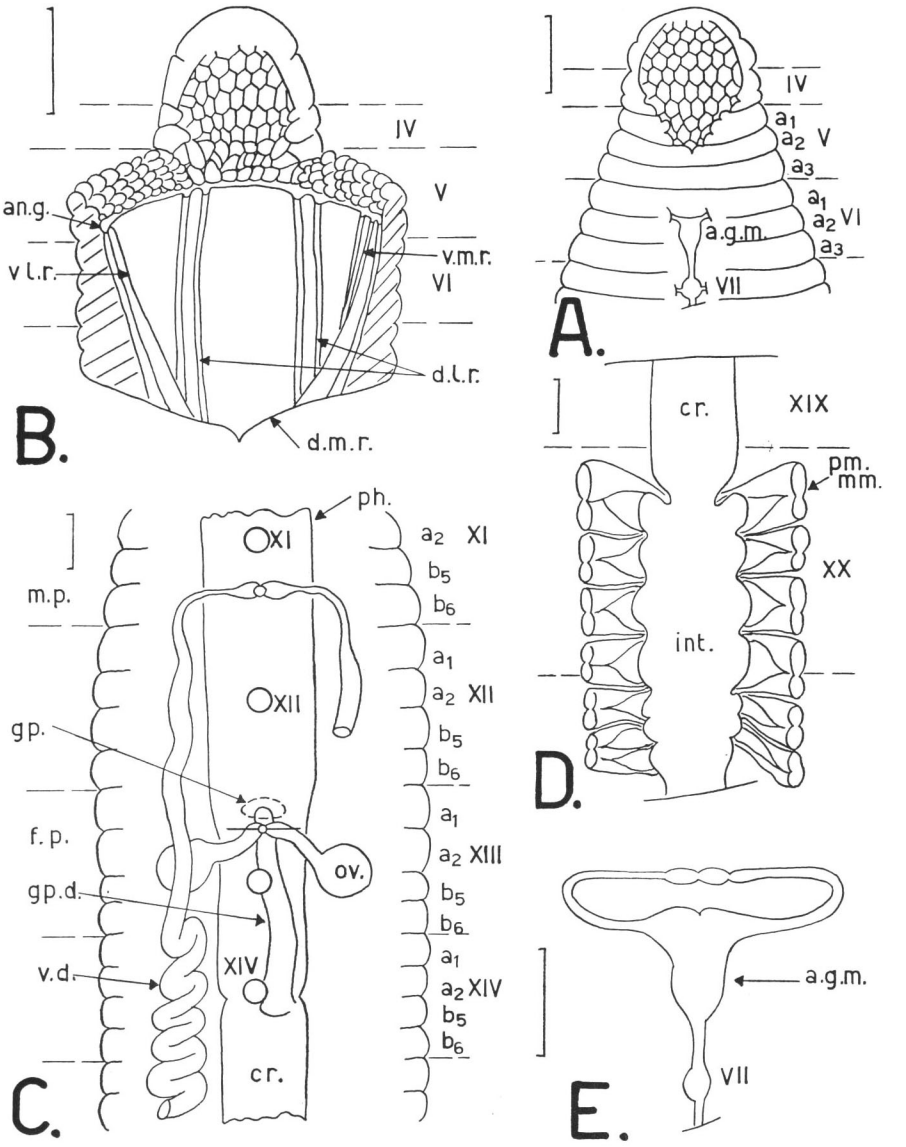

Fig. 2. *Orobdella kawakatsuorum* sp. nov. —— A. Ventral view of anterior sucker, somites iv to vi, showing papillate dorsal surface of the chamber of the sucker, annulation of v and vi, and location of anterior ganglionic mass and ganglion vii. B., as A, opened along the mid-ventral line to show papillate margins of the sucker, annular groove, the wide entrance to the pharynx, and the primary and secondary internal muscular ridges in the pharynx. C. Somites xi to xiv, showing pharynx, reducing in xiii as the sphincter, joining the crop in xiv; gastroporal duct; anterior region of male reproductive system, and female reproductive system. D. Crop and intestine in xix and xx. E. Anterior ganglionic masses and commissures A. to D. from the Type; E., from the Paratype.
For abbreviations, etc., see Fig. 1.

recognizable in the Paratype only as uniannulate, with xxvi the last annulus complete across the venter; xxvii, fusing into the dorsal and dorsolateral aspects of the sucker; posterior sucker, as in the Type.

The male pore, a small circular aperture anterior in xi b_6; gastropore, a deep transverse slit, contracted, the edges adpressed, corrugate, anterior in xiii a_1, the slit leading into a closed pocket much deeper than in the Type; female pore, minute, in xiii a_1/a_2.

Body wall and musculature, central nervous system (Fig. 2, E). Both, as in the Type.

The ventral component of the anterior ganglionic mass is in vi, about 1.0 mm long, and 1.0 mm wide at the anterior end, tapering posteriorly. The lateral commissural trunks are situated immediately posterior to the annular groove; each trunk, about 2.5 mm long, and on each side of the middorsal line, there is a small ganglionic component.

Alimentary tract. The chamber of the anterior sucker, the annular groove, the entrance to the pharynx, and the pharynx, as in the Type, excepting that the inner surface of the pharynx in the Paratype is papillate, the papillae, low, flat, many with a distinct white center, and crowded, arranged as though a rather irregular mosaic.

The crop, the gastroporal duct, as in the Type, excepting the duct slightly swollen near the crop.

There is no indication externally or internally of postcaeca on the crop in xix, xx.

Intestine and rectum, as in the Type.

Reproductive systems. General morphology, as in the Type. Small spherical saccular testes located along the foot of the lateral face of the paramedian palisade, in xviii to xx, about 5 to a somite on each side in xix; none detectable anterior or posterior to these levels; *i.e.* in the order of 15 testes on each side; vas deferens, as in the Type in xvii to xiv, and to the male pore. Female system, as in the Type.

ADDITIONAL MATERIAL

Two specimens, (A) 81.0 mm, (B) 58.0 mm in length. Same locality as Type. Sept. 14, 1974. Collectors, Tetsuya, Miyuki, Kazuko, and Masaharu KAWAKATSU. Dissected. (A) deposited National Science Museum, Tokyo, NSMT–An 54; (B) Hungarian Museum of Natural History, Budapest.

These specimens are of particular interest. In both, v a_1 is complete across the venter, papillate, and forms the ventral portion of the margin of the sucker. The condition described in the Type and Paratype can be recognized from these as due to contraction and infolding of this portion of v a_1.

There is no indication of a gastroporal depression or pit in these two specimens.

Professor M. KAWAKATSU describes the colour in life as a dark brownish black on the dorsum; the venter a slightly lighter hue. The two specimens were found coiled in a shallow hole in the soil beneath a broken wooden plate. They were inactive until placed in water. The anterior sucker is very sharply pointed when the leech moves.

General form. Preserved. Similar in both, the profile in dorsal and lateral view

as in the Type, excepting the dorsum continuous along the postclitellar region and not divided into subregions. In ventral view, (A) as in the Type; (B) the venter flat, depressed across the middle 2/3rds, and the lateral 1/3rd forming each a sharp ridge continuous with the margin. Posterior sucker, both as in the Type.

Colour. Preserved. (A) the dorsum dark slate grey, slightly paler in (B); the venter pale grey in (A), grey tinged with brown in (B); dorsal and ventral aspects of the posterior sucker, of the colour of the dorsum. Under magnification, immaculate on all aspects; the margins each with a narrow longitudinal stripe lighter than the dorsum and the venter, and separating the dorsal and ventral colours.

Annulation. Preserved, moderately extended. In both, no detectable sense organs; no sensillae in (A), minute sensillae obvious in the posterior half of (B) as a transverse row generally posterior in the annulus, the annuli in this region in both with indications of subdivision on the dorsum, emphasized by a wide shallow grove at the margin dividing each annulus into an anterior smaller and posterior larger lobe, but no indication of subdivision of annuli on the venter; nephropores detectable with difficulty in (A) on viii, xi, xvi, xviii, xx, xxi, and none detectable in (B).

In both, no detectable furrow i/ii; iii, iv, as in Type, excepting iv—possibly only a_3, forming a low lobe on the dorsolateral rim of the margin of the sucker, and v complete 3-annulate, a_1 and a_2 both papillate and complete across the venter, a_1 forming the ventrolateral and ventral portions of the margin of the sucker; eyes deep-seated, obscure, lateral at ii/iii in both, and in iv in (B); postclitellar series xiv to xxii with the combination of b_6 and a_1 distinctly>than the combination of a_2 and b_5; xxiii, 4-annulate, $b_1 > a_2 < b_5 = b_6$ in both; xxv/xxvi indicated at the margins; xxvi, xxvii essentially uniannulate in both. Genital pores as in the Type.

(A) and (B) without any indication of a gastroporal depression or pit.

Alimentary tract. In both, the chamber of the anterior sucker, annular groove, entrance to the pharynx as in the Type. The internal surface of the pharynx smooth anteriorly, weakly papillate posteriorly in (A); essentially smooth in (B). Internal primary muscular ridges of the pharynx weakly subdivided in (A); similar to the Type in (B).

In both, the pharynx and crop as in the Type. A weak-walled uniformly cylindrical connection, 0.3 mm in diameter and 4.0 mm long in (A) extends from the midventral line of the crop in xiv a_2 to attach to the midline of the body wall at xiii a_1. The connection appears to be tubular, but no opening from this was detectable in the floor of the crop; a similar connection in (B), 0.2 mm wide and 3.5 mm long.

There is no indication of postcaeca in xix. Intestine in both as in the Type.

Reproductive systems. In both, similar to the Type. Testes recognizable in xviii to xxi.

Discussion

Determination of the systematic status of *kawakatsuorum* requires close analysis of three matters in OKA's description (1895) of *O. whitmani*: the general somital annula-

tion; the possession of postcaeca; the number of testes, and range of testicular somites.

General somital annulation:— Consideration is restricted here to the annulation along the dorsum.

OKA's description of *whitmani* is based on a total of 33 somites, 26 preanal, defined within the somital limits of WHITMAN, *i.e.* the annulus (neuromeric) associated with the somital ganglion and the somital sense organs, recognized as the anterior annulus of the somite, and the nephroporic annulus posterior to this, as the last annulus of the same somite.

For comparison, the general somital annulation of *whitmani* has been revised diagrammatically on the basis of 34 somites, 27 preanal, defined within the somital limits of MOORE, *i.e.* based on a triannulate somite in which the neuromeric annulus is the middle annulus, and the nephroporic annulus immediately anterior to it, is the nephroporic annulus of the same somite.

OKA's description presents some difficulties. Somites i to vii, and xxv to xxvii, are grouped without any indication of the limits of the individual somites. OKA identifies 17 pairs of nephropores, the 1st pair as in ix, the 17th pair as in xxv.

The description (p. 300, etc.) gives a total of 88 preanal annuli on the dorsum. The 1st of these is identified as No. 1, although (p. 299) OKA recognized that this, the "preocular" element, consists of two annuli (*i.e.*=somites i, ii). The annulus identified as No. 3, is described (p. 289) and figured (pl .xxviii, figs. 5, 6) as consisting of two distinct annuli (*i.e.*=somite iv, a_1a_2 much$>a_3$). OKA indicates (figs. 7, 8) an annulus '89' with another annulus (*i.e.* 90) between 89 and the anus.

Counting the "preocular" element and iv as each 2-annulate, gives a total of 90 annuli on the dorsum of *whitmani.*

This total of 90 annuli is one annulus more than the total number (89) of annuli in the Type of *kawakatsuorum* in which iii and iv are each 2-annulate and v 3-annulate, in contrast to *whitmani* in which iii is uniannulate, iv and v both 2-annulate.

In my previous analysis (1971) of the somital annulation of *whitmani* as in OKA, I had taken v as 2-annulate, this being the commonest condition of v in 4-, 5-, and 6-annulate euthylaematous leeches, and the condition of v in *Kumabdella.* This enabled recognition of vi and vii as both 3-annulate, and viii as 4-annulate, as is common, there being some exceptions in which v is 3-annulate and viii 5-annulate (RICHARDSON, 1974).

If on the example of *kawakatsuorum,* v is taken as 3-annulate in *whitmani,* then vi, vii, and viii will all be 3-annulate in this species. A 3-annulate condition of viii is not known in any 4-, 5-, or 6-annulate euthylaematous leeches. For this reason, it is proper to accept v as being 2-annulate in *whitmani.*

Analysis can be continued by considering separately three regions in the body:

1) Anterior region, i to x/xi. In *kawakatsuorum,* this includes 27 annuli; counting the "preocular" element and iv as each 2-annulate in *whitmani,* this region includes 25 annuli. The difference in the two species of two annuli is directly reconciled by the 2-annulate condition of iii, and the 3-annulate condition of v in *kawakatsuorum.*

2) Middle region, x/xi to xxii/xxiii. The number of annuli in this region, 48, is the same in both species.

3) Posterior region, xxii/xxiii to the anus. In the Type of *kawakatsuorum,* there are 14 annuli in this region, 11 annuli in the Paratype. The number in this region in *whitmani* is 17. The difference between the number in the Type and in the Paratype of *kawakatsuorum* is directly reconcilable. The higher number in *whitmani* is not directly reconcilable.

In *kawakatsuorum,* the 17th pair of nephropores are anterior in xxiv, the normal somital level, and there are 9 indicated annuli in the Type, 6 in the Paratype, between xxiv a_1 and the anus.

OKA (pl. xxix, A) shows 12 annuli in *whitmani* between xxiv a_1 (his annulus 76, corrected 78) and the anus, with a '17th' pair of nephropores on the 4th of these, *i.e.* xxv a_1 (OKA's 80, corrected 82), and 8 annuli between xxv a_1 and the anus.

This number of annuli between xxv a_1, the last nephroporic annulus as shown by OKA, and the anus is of the same order as the number of annuli between xxiv a_1 and the anus in *kawakatsuorum,* falling between the number in the Type and the number in the Paratype. It is acceptable even in view of the instability of the annulation of the posterior somites.

The high number, 17, of annuli between xxii/xxiii and the anus in *whitmani,* now becomes suspect as indicative of an error. The only understanding of the nature of this error is in the duplication of a somite in this region in the diagram.

The general somital annulation of the two species becomes reconciled with the recognition of annulus 76 (corrected, 78) in the diagram as xxiv a_1 and the last nephroporic annulus, with 8 annuli between xxiv a_1 and anus.

On this basis, the general somital annulation along the dorsum of *whitmani* is: i, ii, iii, uniannulate; iv, v, 2-annulate; vi, vii, 3-annulate; viii to xxiii, 4-annulate (with xxiii possibly incomplete 4-annulate); and in high probability—xxiv, xxv, 3-annulate; xxvi, incomplete 2-annulate; xxvii, uniannulate; and a total of 86 annuli on the dorsum.

Orobdella kawakatsuorum differs from *O. whitmani* in having: iii and iv, both 2-annulate; v, 3-annulate; (xxvi, incomplete 3-annulate to uniannulate). Otherwise, the two are similar in their general external meristic morphology.

Postcaeca:— OKA (p. 300) refers to *whitmani* and *O. ijimai* as both having postcaeca at the posterior end of the crop, and illustrates (pl. xxx, fig. 2) the postcaeca in *ijimai* as seen in a horizontal longitudinal section.

This shows a pair of reduced caeca no more than a somite in length, restricted at the entrance to the crop, inflated posteriorly. The postcaeca appear to enter the paramedian splanchnic chambers. In these features, these are typical reduced postcaeca.

The initial portion of the intestine between the postcaeca, is narrowly tubular, acaecate, lacking pockets, differing from the following portion of the intestine which is closely pocketed laterally, the pockets opening widely into the lumen of the intestine. The narrowly tubular anterior portion of the intestine is most unusual.

There is no indication externally or internally of postcaeca in xix or xx in the Type of *O. kawakatsuorum.* In the Paratype, there is a lateral elongate pocket low on each side of the intestine in xx, both opening freely into the crop without any restriction.

The initial portion of the intestine is broadly tubular, with small paired "caeca-like" pockets extending between the ventral portions of the muscle strands of the paramedian palisade. These do not appear to be formed permanent structures.

In form and position, the pockets at the end of the crop in the Paratype, are similar to the pockets at the anterior end of the intestine. There is no indication that they are permanent.

Seen in transverse or longitudinal serial sections, these might be interpreted as postcaeca unless it was noted that they open into the crop without any restriction.

In view of this, *O. whitmani* and *O. kawakatsuorum* cannot be separated at this time on the possible presence of postcaeca-like structures in *whitmani.*

Testes:— OKA (p. 300) refers to *O. whitmani, O. ijimai,* and *O. octonaria,* as all having 90 to 100 pairs of small testes.

OKA (pl. xxx, fig. 8) shows in longitudinal horizontal section, one side of three testicular somites in *ijimai,* with 10 testes in two somites, 9 in the third. The testes are small, shown each about 1/2 of the size of a somital ganglion, and ventral in position since the section includes ganglia and the ventral nerve cord.

OKA describes (p. 297) the testes as a longitudinal row medial to the vas deferens which makes several convolutions anteriorly, joins the other vas deferens, and the combined duct "opens into the cavity just within the external male orifice."

The total given, of 90 to 100 on each side, indicates that OKA recognized some 10 testicular somites for all three species.

I could not determine (1971) the range of the testicular somites in *K. octonaria* where I could identify some 16 testes on each side in xix, and none in xiii or xiv.

In the Type of *O. kawakatsuorum,* I identified in xix, 3 testes on one side, 5 on the other; some in xxii; none in xvii or anterior to this; and in the Paratype, testes in xviii to xx, about 5 on each side in xix; none in xvii or anterior to this. With the abrupt change in the nature of the vas deferens in xvii, it seems highly probable that xviii is the most anterior of the testicular somites.

The testes in *kawakatsuorum* are each twice or more the length of a somital ganglion, and relatively larger than in *ijimai.*

Conclusions

Reconciliation of the general somital annulation of *whitmani* and of *kawakatsuorum* the similarity in the location of external land-marks—genital pores, gastroporal depression, nephropores, etc., in the two species, permits the association of *kawakatsuorum* with *whitmani* in the genus *Orobdella,* at least until such time as the alimentary and male reproductive systems are known in better detail for *whitmani.*

If shown to differ, *i.e. whitmani* having postcaeca and a testicular region of 10

somites, it will be proper to give consideration to a separate generic status for *kawakatsuorum*.

Acknowledgements

I am greatly indebted to Professor Masaharu KAWAKATSU, the Fuji Women's College, to Tetsuya and Miyuki KAWAKATSU, for the specimens on which this paper is based. I express my admiration of the detailed and scholarly manner, far above the usual level of that period, in which the late Professor A. OKA described *Orobdella whitmani*, a species exhibiting a high level of difficult novelty. I record my indebtedness to Dr. A. SOOS, the Hungarian Natural History Museum, for his keys and catalogues of the genera and species of the leeches of the world, which are a valuable guide through the complex literature of these animals. Professor Marvin C. MEYER, the University of Maine, has assisted me with difficult literature. The Librarians, C.S.I.R.O., the Linnean Society of New South Wales, the Australian Museum, and the University of New England, have assisted me with other literature.

Abstract

Analysis of the description of *Orobdella whitmani* OKA, 1895, shows *Orobdella kawakatsuorum* differs in having iii and iv both 2-annulate, v essentially 3-annulate. The testicular region is posterior to xvii. Evidence is given of digestive enzyme activity in the intestine. The new species is gastroporous, confirming this for *whitmani*. The function of the gastroporal duct is discussed.

References

GILYAROV, M. S., E. I. LUKIN & T. S. PEREL, 1969. The first terrestrial leech—*Orobdella whitmani* OKA (Hirudinei: Herpobdellidae)—in the fauna of the USSR: a Tertiary relict of forests of the southern Maritime territory. *Akademia Nauk SSSR Doklady*, (Biol. Sci.), **188**: 767–768. (In Russian.)

MOORE, J. P., 1929. Leeches from Borneo with descriptions of new species. *Proc. Acad. nat. Sci. Phila.*, **81**: 267–295.

——— 1930. Leeches (Hirudinea) from China with descriptions of new species. *Ibid.*, **82**: 169–192.

OKA, A., 1895. On some Japanese land-leeches (*Orobdella* nov. gen.). *J. Coll. Sci. Imp. Univ. Tokyo*, **8**: 275–306.

RICHARDSON, L. R., 1971. Gastrostomobdellidae f. nov. and a new genus for the gastroporous *Orobdella octonaria* OKA 1895, of Japan (Hirudinoidea: Arhynchobdellae). *Bull. Natn. Sci. Mus. Tokyo*, **14**: 585–602.

——— 1974. *Domanibdella* gen. nov., a duognathous 5-annulate land-leech genus in New Guinea (Hirudinoidea: Haemadipsidae s. l.), with a discussion on general somital annulation. *Mem. Natn. Mus. Vict.*, **35**: 97–109.

SOOS, A., 1966. Identification key to the leech (Hirudinoidea) genera of the world, with a catalogue of

the species. iii. Family Erpobdellidae. *Acta zool. Hung.*, **12**: 371–407.

ZIA, F. C., 1927. Anatomy of the leech (*Whitmania laevis* BAIRD). *Contrib. Biol. Lab. Sci. China,* **4** (2): 1–20.