

**Bulletin of the Museum of Comparative Zoölogy**

AT HARVARD COLLEGE

VOL. LXXXIX, No. 3

---

NOTES ON VARIOUS PEREGRINE EARTHWORMS

G. E. GATES

Judson College, Rangoon, Burma

LIBRARY  
MUSEUM OF COMPARATIVE ZOOLOGY  
CAMBRIDGE, MASS.

CAMBRIDGE, MASS., U. S. A.

PRINTED FOR THE MUSEUM

FEBRUARY, 1942



LIBRARY  
MUSEUM OF COMPARATIVE ZOOLOGY  
CAMBRIDGE, MASS.

No. 3.—Notes on Various Peregrine Earthworms

By G. E. GATES

TABLE OF CONTENTS

	PAGE
Introduction . . . . .	64
Family Ocneroдрilidae . . . . .	65
Genus <i>Eukerria</i> Michaelsen 1935 . . . . .	67
<i>Eukerria peguana</i> spec. nov. . . . .	67
<i>Eukerria saltensis</i> (Beddard) 1895 . . . . .	73
Genus <i>Gordiodrilus</i> Beddard 1892 . . . . .	75
<i>Gordiodrilus peguanus</i> spec. nov. . . . .	85
Genus <i>Malabaria</i> Stephenson 1924 . . . . .	90
Key to species of <i>Malabaria</i> . . . . .	92
? <i>Malabaria levis</i> (Chen) 1938 . . . . .	92
<i>Malabaria species</i> . . . . .	98
Genus <i>Ocneroдрilus</i> Eisen 1878 . . . . .	99
<i>Ocneroдрilus occidentalis</i> Eisen 1878 . . . . .	99
Genus <i>Thatonia</i> gen. nov. . . . .	101
<i>Thatonia gracilis</i> spec. nov. . . . .	101
Family Megascolecidae . . . . .	107
Genus <i>Woodwardiella</i> Stephenson 1925 . . . . .	107
<i>Woodwardiella javanica</i> (Michaelsen) 1910 . . . . .	108
<i>Woodwardiella pumila</i> Stephenson 1931 . . . . .	112
Genus <i>Pheretima</i> Kinberg 1867 . . . . .	119
<i>Pheretima bicincta</i> (E. Perrier) 1875 . . . . .	119
<i>Pheretima humilis</i> spec. nov. . . . .	120
Genus <i>Ramiella</i> Stephenson 1921 . . . . .	122
<i>Ramiella cultrifera</i> Stephenson 1931 . . . . .	122
Genus <i>Dichogaster</i> Beddard 1888 . . . . .	128
<i>Dichogaster affinis</i> (Michaelsen) 1890 . . . . .	128
<i>Dichogaster bolawi</i> (Michaelsen) 1891 . . . . .	129
<i>Dichogaster modiglianii</i> (Rosa) 1896 . . . . .	130
<i>Dichogaster saliens</i> (Beddard) 1893 . . . . .	134
Family Eudrilidae . . . . .	137
Genus <i>Eudrilus</i> E. Perrier 1871 . . . . .	137
<i>Eudrilus eugeniae</i> (Kinberg) 1867 . . . . .	137
Bibliography . . . . .	144

## INTRODUCTION

The peregrine earthworms of tropical and subtropical regions have not received the attention due them because of their extensive distribution. The anatomy of many of the species is inadequately characterized and the taxonomic status of a number is uncertain.

A previous article (Gates, 1937) is concerned with the synonymy, local distribution and definition of the *Pheretimas* which have been imported into America from the Oriental region. In another article now in press some of the confusion prevailing with regard to the septal displacements in a pantropical form has been cleared up. The portion of the survey of non-Lumbricid, peregrine forms included in the present contribution is merely in the nature of a report on the material that could be obtained during the last five to six years. The study of one *Ocnerodrilid* species naturally led to an examination of one of the most difficult problems of Megadrilid systematics, that provided by the genus *Gordiodrilus*, and several suggestions as to a solution are advanced. Among other results of especial interest may be mentioned the presence in *Eudrilus eugeniae* (Kinberg) 1867, of supra-intestinal glands hitherto known only from three Megascolecoid genera, and of "rolled tube" penial setae, hitherto recorded only from three Eudrilid genera, in a species of a Megascolecoid genus, *Ramiella*.

The tendency in the past has been to regard a species as endemic in the area in which it is first found,<sup>1</sup> in spite of recognizing a tendency to transportation on the part of small-sized species, limited generic representation in the area concerned, and absence of those large species which are less likely to be successfully transported. Forty years or more without further records of distribution seem only to confirm the endemism. Hence the description of new species and especially a new genus (of the *Ocnerodrilidae*) in an article on peregrine forms may at first seem rather surprising. The earthworm faunae of large areas of the world are very incompletely worked out, particularly those of the African and Neotropical regions, regarded as the main areas of *Ocnerodrilid* evolution. Earthworms are known to have been transported widely with frequent colonizations in new areas far from their original homes. In view of the fragmentary knowledge of so many large areas, the spasmodic, casual or superficial nature of most work on megadrilid faunae, it would be premature to conclude that more than a portion of the successful transportations have been recognized hitherto.

<sup>1</sup> *Woodwardiellas*, for instance, have been supposed to be endemic in South India and Ceylon, as also two species of *Eukerria* in Southern California, and species of *Pheretima* in Madagascar. Endemism of three species of *Howascolex* and of two species of *Dichogaster* in South India may also be cited.

Admittedly transportation, as an explanation of the occurrence of two of the new Ocnerodrilid species in the regions in which they are now alone known, remains to be demonstrated. Nevertheless it is most probable that the new species of *Eukerria* is an importation into Burma, either directly or indirectly from South America. Endemicity of a species of *Gordiodrilus* or of *Woodwardiella* in a region including South India and Burma, or of a species of *Malabaria* in a region including Burma and Hainan Island, is highly improbable. In fact there is some justification for doubting endemicity of any Ocnerodrilid in any part of the Oriental region. Likewise there are good reasons for suspecting that the Oriental Woodwardiellas are importations from the Australasian region.

In these circumstances it seems to be preferable to label a species as probably or even only possibly peregrine, rather than spare the label and confuse zoogeographical discussion, particularly for the sake of those who may be quite unfamiliar with the difficulties involved in connection with the distributions of Megadrilids.

The author's thanks are extended to the University of Rangoon for grants to meet costs of Burmese collections, and to Miss Chapman for assistance in measuring penial setae.

#### FAMILY OCNERODRILIDAE

An anterior, pre-intestinal region of the body of earthworms always differs considerably from the intestinal portion. On passing from the intestinal to the pre-intestinal region, the function of the dorsal blood vessel changes from collection to distribution, while that of the ventral trunk changes from distribution to collection; segmental commissures are replaced in part at least by hearts, and other modifications of the vascular system are found, particularly in connection with the subneural system (when present) and the enteric plexi. The excretory system is likewise often modified in a larger or smaller portion of the pre-intestinal region. Calciferous tissues, often in special glands, are associated with the pre-intestinal region and a considerable portion of the gut in that region, if not all of the oesophagus is lined with cuticle.<sup>1</sup> The pre-intestinal region is also often characterized by an

<sup>1</sup> Cuticular secretion seems to be characteristic of ectoderm, and accordingly portions of the gut derived from the stomadeal and proctodeal invaginations may be expected to be lined with cuticle. But in species of *Pheretima* the cuticular lining of the oesophagus has been recognized into x, while in species of *Drawida* the lining has been found as far back as xxv. Although as yet undemonstrated in more posterior portions of the gut, there is a possibility that the cuticular lining extends to the hind end of the oesophagus. In these circumstances an ectodermal origin of the whole of the oesophagus from mouth to oesophageal valve perhaps requires consideration. An ectodermal origin for the whole of the oesophagus would be another distinguishing characteristic of the pre-intestinal region. If on the contrary the gut epithelium of the pre-intestinal region is not ectodermal, it is still distinguished from that of the intestine by its ability to secrete cuticle.

extra-oesophageal system of blood vessels, which may have somewhat of a portal nature, transporting blood between the skin and the calciferous section of the gut.

The pre-intestinal region varies in segmental extent and may include only the first eleven segments as in the Ocnerodrilidae, the anterior-most thirteen as in certain species of *Ramiella*, *Eudrilus*, and *Tonoscolex*, fourteen as in *Pheretima*, *Eutyphoeus* and a number of other Megascolecid genera, fifteen as in *Hoplochaetella*, sixteen as in *Nello-gaster*, seventeen as in *Dichogaster*, *Notoscolex* (part) and *Megascolex* (part), eighteen as in *Notoscolex* (part), *Priodochaeta* and *Priodoscolex*, nineteen or twenty as in certain species of *Diplocardia*, more than twenty in the Moniligastridae.

Assuming that all earthworms have had a common origin, these variations may have resulted from (1) maintenance or reduction of a primitively extensive pre-intestinal region, (2) maintenance or extension of a primitively short region, or (3) simultaneous developments in different ways in different phylogenetic lines. The evidence available is insufficient to warrant much discussion of these possibilities at present. It may however be noted that there seems to be a tendency to extension of the pre-intestinal region in certain evolutionary lines, as for instance in the Megascolecinae and *Diplocardia*, also that Pickford regards the appearance of hearts in xiii as of recent and sporadic occurrence in Acanthodriline groups in which the original condition was three pairs in x-xii. Now if the tendency in the Megascolecidae (in Stephenson's sense) is to extension rather than reduction, the usual phylogenetic derivation of the Ocnerodrilidae from the Acanthodrilinae, as the last of the stems deriving from *Notiodrilus*, will be incorrect. It may be advisable to consider if the Ocnerodrilidae are not more primitive, at least in respect to the pre-intestinal region, than the supposedly ancestral Acanthodrilinae.

The distinguishing character of the Ocnerodrilidae, according to Stephenson, is the presence of an unpaired and ventral or paired calciferous sacs in ix or ix and x. Two genera are now known without such sacs. Much more characteristic, on the basis of the evidence now available, seems to be the short pre-intestinal region, with intestinal origin in xii and restriction of the latero-oesophageal hearts to x-xi.

Of the 44 Ocnerodrilid species recognized by Michaelsen in 1900, the diameter (presumably maximum) of five species is one mm., of fourteen species one to two mm., of nine species two mm., of one species between two and three mm., of one species three mm. Of the fourteen species with thickness unknown, the length is as follows: 15-38 mm.

(1 species), 15–35 mm. (2), 25 mm. (5), 25–50 mm. (1), 25–60 mm. (1), 40 mm. (2), 40–50 mm. (1), even length unknown (1). All of these species of unknown diameter probably are of about the same size as other forms. Of forms described since 1900, the single species of *Paulistus* and the two known species of *Kerriona* are, so far as can be discovered from the literature now available, the only exceptions to the general rule as to size in the family, and those three species are all South American endemics. Probably no earthworms are smaller than the Ocnerodrilids. So far then as size is concerned the Ocnerodrilidae, of all earthworm families, appear to be most favorably adapted for transportation in numbers sufficient to enable colonization when conditions of the new habitat are suitable.

In view of this small-size predisposition to transportation, it is necessary to be cautious in attributing endemicity to any Ocnerodrilid species in any area separated by sea from Africa or America, and even in portions of Africa itself as well as America. The occurrence of a supposed endemic of the "fairly archaic" *Eukerria* in South Africa was one of Michaelsen's reasons for believing that Africa rather than South America is the headquarters of Ocnerodrilid development. The South African form (*gunningi*) is now known to be peregrine, and actually is, according to Pickford, only *saltensis*. Other supposed endemics that might better be regarded as possibly if not probably peregrine are two species of *Eukerria* in Lower California, one species of *Ocnerodrilus* in Paraguay, species of *Gordiodrilus* in the Mediterranean region of Africa, species of *Maheina* in the Seychelles, species of *Gurgia* and *Malabaria* in India, species of *Gordiodrilus* in Madagascar.

According to Michaelsen's criteria of large and small-sized species versus small-sized species only, South America would appear to be of greater importance in Ocnerodrilid development than Africa. Or is the situation comparable to that of *Dichogaster*, which crossed the Atlantic Ocean from Central America into Africa to give rise to the giant forms that enable recognition of African endemicity and major development?

#### Genus EUKERRIA Michaelsen 1935

##### EUKERRIA PEGUANA spec. nov.

*Material examined.* From Burmese collections:

Rangoon, Hanthawaddy district, February, 3 clitellate specimens; June, 53 juvenile or a clitellate specimens and 1 partially clitellate specimen; July, 89 juvenile or a clitellate specimens; August, 11 clitellate specimens. K. John.

Kungyangon, Hanthawaddy district, September, 4 clitellate specimens. K. John.

Thongwa, Hanthawaddy district, September, 1 clitellate specimen. K. John.

Moulmein, Amherst district, October, 2 acitellate and 3 clitellate specimens. K. John.

Pegu, Pegu district, August, 3 clitellate specimens. K. John.

Wanetchaung, Insein district, September, 1 clitellate specimen. K. John.

Myaungmya, Myaungmya district, October, 1 acitellate, 1 partially clitellate and 4 clitellate specimens. Maung Ohn Maung.

Pyinmana, Yamethin district, October, 3 clitellate specimens. K. John.

*External characteristics.* Length 20–50 mm. Diameter  $\frac{3}{4}$ –1 mm. Unpigmented. Prostomium prolobous. Dorsal pores lacking. Nephropores unrecognizable. Setae begin on ii on which all four couples are present; *ab* and *cd* about equal, *aa* and *bc* usually about equal though there is some variation, *dd* ca. =  $\frac{1}{2}$ C.

The clitellum is reddish to light yellowish, annular, not protuberant, apparently extending from a posterior portion of xiii to 19/20 or onto the anteriormost portion of xx but anterior and posterior limits are unrecognizable externally; intersegmental furrows lacking, setae present. In *aa* the clitellar coloration is often lacking but the epidermis is thickened though not as much as lateral to *b*, clitellar thickening lacking ventrally on xiii and probably also on xvii–xx.

The spermathecal pores are transversely placed slits in *ab*, on 7/8 and 8/9, the centres about at mid *ab*. The margins of the apertures are protuberant (occasionally wrinkled) but are not delimited peripherally to form a lip.

The female pores are minute, transversely placed slits slightly behind the site of 13/14, just lateral to *b*.

On xvii–xix, on each side, and extending median to *a* and lateral to *b* is a longitudinally placed, slightly raised, fairly sharply demarcated, rather dumb-bell-shaped area that reaches to or nearly to 19/20 and nearly to 16/17, a central portion of the nearly circular anterior and posterior end parts especially protuberant. Along each of these areas and reaching nearly to the setal arcs of xvii and xix there is a nearly straight band of greyish (epidermal?) translucence. This band usually has a smooth rather than a grooved appearance (*i.e.*, no trace of seminal groove recognizable) but on the clitellate Rangoon worms the band is less obvious, apparently replaced on some specimens by a slight groove. At the anterior and posterior ends of each band or groove and about on the setal arcs of xvii and xix there is a transversely placed

slit-like aperture which opens into a slight parietal invagination with a transversely slit-like lumen. On most of the specimens each aperture is occupied by a transversely placed, shortly ellipsoidal, transparent to translucent vesicle, the anterior vesicle attached to the posterior wall of the invagination, the posterior vesicle to the anterior wall. These vesicles may be conspicuously protuberant from the body wall on short but narrow necks or fully or partially retracted into the invaginations. After forcing the vesicle back against the wall to which it is attached there becomes visible on the roof of the invagination a minute pore which is probably the prostatic aperture. On the setal arc of xviii and on each longitudinal grey band there is a minute opening, probably the male pore. Median to this aperture and also on the grey band setae *a* and *b* of xviii are usually visible, slightly displaced mesially. Occasionally only one of a pair is visible. Ventral setae of xvii and xix are invisible or unrecognizable externally but within the parietes just median to the ectal ends of the prostatic ducts, after separation of the longitudinal muscle fibres, there may be present setae, so closely paired that they appear to be in the same follicle (attempts at removal unsuccessful).

The genital markings are unpaired, transversely placed areas of epidermal thickening with rounded lateral margins, reaching anteroposteriorly to or almost to the intersegmental furrows, and extending laterally on each side into the median portion of *bc*. The epidermal thickening is much more marked laterally than midventrally but there is no other indication of a double origin such as incisions of anterior and posterior margins at the midventral line. Just lateral to *b* on each marking is a minute aperture. Markings are located as follows: on xxi (29 specimens), on xxi — right side only (1), on xxi — left side only (1), on xx and xxi (4, on two of which the anterior marking is asymmetrical). One clitellate specimen has no marking.

On juvenile and acitellate Rangoon specimens the dumb-bell-shaped male porophores are lacking but on the larger specimens prostatic pore invaginations and associated vesicles are developed. Genital markings and gland apertures are quite unrecognizable though the glands are present.

*Internal anatomy.* All septa from 5/6 posteriorly are present; 5/6–8/9 thickened and muscular.

The pharyngeal bulb is small and short. The oesophagus in iv–vi is narrow and with thin, transparent or translucent wall. There are masses of iridescent glands (?) in iv–vi, those in v especially large. The gizzard, in vii, appears to be more muscular than in *saltensis*. Calcif-

erous sacs are like those of *saltensis* except that here the lumen is triangular in section (4 sacs) and the sacs do not reach to 8/9 to which they are connected by strands of tissue. Longitudinal ridges are visible on the inner wall of the sac, the wall so thick and the lumen so small that the walls are almost in contact centrally. The intestine begins in xii, the oesophageal valve distinct and in the anterior part of the segment. No typhlosole.

The dorsal blood vessel is single. The supra-oesophageal trunk extends from a posterior portion of viii into xi where it bifurcates just in front of 11/12, the branches passing laterally onto the anterior face of 11/12 behind the hearts and then ventrally onto the parietes where they can be traced anteriorly into ix. In one specimen, on the left side, a large vessel rises from the parietes onto the anterior face of 10/11 and then passes behind the heart of x to open into the supra-oesophageal trunk. In ix a large vessel from the dorsal face of each calciferous sac joins the supra-oesophageal just anterior to 9/10. Extra-oesophageal trunks are recognizable just ventrolateral to the gut in vi, running posteriorly through vii and viii, in ix passing onto the ventral faces of the oesophageal sacs where they become invisible. The hearts are two pairs, in x-xi, dorsally an anterior branch from each heart opening into a bifurcation of the supra-oesophageal in xi, or into the vessel from the parietes in x, or directly into the supra-oesophageal, a posterior branch opening into the dorsal blood vessel. The commissures of ix may be as large as the hearts of x and xi but only open into the dorsal trunk from which smaller commissures are given off in viii-v. Ventral stumps of the commissures of vii-ix and of the hearts of x-xi join the ventral trunk but the vessels have not been traced completely around the oesophagus. The ventral trunk is unrecognizable anterior to vii. No subneural trunk.

The nephridia from xx posteriorly are large, in contact with both septa of a segment, extending from mid *bc* nearly to the mid-dorsal line. The preseptal funnels are delicate, translucent, small, just median to *a* and close to the ventral parietes, the neck long, very slender and transparent. In xix-xii the nephridia are much smaller and in the anterior portions of the segments just behind the septa (funnels not found). From xi anteriorly nephridia have not been found and if present must be still smaller.

The coelomic cavity of x is filled with a loose, non-iridescent coagulum. The funnels (one pair only) are large, frilled, and characterized by a brilliant pinkish iridescence. The posterior vesicles are large, reaching up into contact with each other above the dorsal blood

vessel, lateromesially flattened, pushing 11/12 back into contact with 12/13 (1) or penetrating 11/12 and dislocating 12/13 posteriorly. The anterior vesicles are large, reaching up into contact with the dorsal trunk and filling all of the available space in ix. Both pairs of vesicles are lobed, those of ix softer and more fragile. The prostates are at least six mm long, reaching back into xxviii-xxx but looped and in part twisted together so that they are long enough to reach several segments further. The ducts are  $\frac{1}{2}$ -1 mm long, much slenderer than the glands, opaque but with no muscular sheen, passing into the parietes in xvii and xix. The vas deferens passes into the parietes in xviii just lateral to a pair of setae.

The spermathecal ampulla is shortly ellipsoidal, filled with a non-iridescent whitish or yellowish material. The coelomic portion of the duct is about as long as the ampulla, slightly narrower, rather flattened, with slight constrictions (2-4) that produce a rather irregularly moniliform appearance, bound down to the parietes. The wall is slightly thicker than that of the ampulla, the lumen transversely slit-like to flatly elliptical in cross section. In the parietes the duct is somewhat narrowed and the wall is tougher but the lumen is still transverse. In an ectal portion of the duct of each of several spermathecae there is an elongate, rather pyriform mass of iridescent material, presumably spermatozoa.

Each ovary contains only a few relatively large ova.

The genital marking glands are stalked and coelomic, tubular. The duct is of about the same length as that of a prostate but is slenderer, translucent, and sinuous. The gland is one to three times as long as the duct,  $\frac{1}{2}$ -1 $\frac{1}{2}$  mm long, much slenderer than the prostates and of course shorter. A delicate connective tissue investment is recognizable at the margin of the gland. In sections the epidermis of the genital markings appears to be about half again as thick as in the surrounding region.

The epidermis is also considerably thickened at the anterior and posterior ends of the dumb-bell-shaped male porophores. The prostatic duct passes into the centre of a fairly sharply demarcated area of circular outline in the parietes but this area is not protuberant into the coelomic cavity. In xvii-xix there are numerous diagonal muscle fibres.

*Remarks.* Although anterior and posterior boundaries of the clitellum are unrecognizable externally in the sectioned body wall at the mid-dorsal incision, the clitellar thickening of the epidermis is clearly visible even on xiii and xx.

Spermathecal apertures of the Kungyangon and a few other speci-

mens are open and occupied by plugs of transparent material that are continued internally for some distances into the coelomic portions of the spermathecal ducts.

A middle portion of the dumb-bell-shaped male porophore may be scarcely recognizable or quite invisible. The longitudinal grey lines may be bent laterally very slightly in the region of the setal arc of xviii or in such a way as to subtend a very wide, obtuse angle.

The transparent vesicle of the prostatic pore invagination appears to be similar to the "clear gland" associated with the ectal end of the prostatic duct of *Aphanascus oryzivorus* Stephenson 1924. Stephenson (1924, p. 362) mentions a possibility that the "clear glands" disappear at full maturity. No evidence for such disappearance is provided by the Burmese specimens of *E. peguana*.

The left calciferous sac of one Moulmein specimen is lacking, the right gland about twice the usual size.

*E. peguana*, with spermathecal pores in *ab*, has affinities with the following species: *E. halophila* (Beddard), 1892, *E. asuncionis* (Rosa) 1895, *E. kükenethali* (Michaelsen) 1908 and *E. selangorensis* (Stephenson) 1930. From each of these species *peguanus* is distinguished by the presence of "clear glands" in prostatic pore invaginations, presence of genital markings and the prostate-like glands associated with the genital markings.

*Diagnosis.* Prostatic pores on roofs of transversely slit-like parietal invaginations with transversely placed apertures in *ab* on protuberant anterior and posterior ends of paired, longitudinally placed, dumb-bell-shaped porophores; a transversely ellipsoidal, protrusible clear gland on the posterior wall of each anterior invagination and the anterior wall of each posterior invagination. Male pores on setal arc of xviii just lateral to *b* which is slightly displaced mesially. Genital marking a transversely placed area of epidermal thickening on xxi, reaching anteroposteriorly nearly to intersegmental furrows and laterally into *bc*, a pore just lateral to *b* on each side. Quadrithecal, spermathecal pores in *ab*, with centres about at mid *ab*. Setae:  $ab = cd$ ,  $aa = bc$ ,  $dd = \frac{1}{2}C$ ; ventral setae of xvii and xix present (?) but unrecognizable externally. Nephropores? Clitellum annular but thinner and colorless in *aa*; on xiii-xx. Prostomium prolobous. Unpigmented. Length 20-50 mm. Diameter  $\frac{3}{4}$ -1 mm.

Gizzard in vii. Seminal vesicles in ix and xi. Spermathecal duct about as long as ampulla and nearly as wide but with slightly thicker wall and transversely slit-like lumen, moniliform and bound to the parietes. Genital marking glands tubular, stalked and coelomic.

*Distribution.* Known at present only from Burma (Amherst, Hantawaddy, Myaungmya, Insein and Yamethin districts) but possibly as widely distributed in the tropics as *E. saltensis* and other peregrine Ocerodrilids.

EUKERRIA SALTENSIS (Beddard)

1895. *Kerria saltensis* Beddard, Proc. Zool. Soc. London, 1895, p. 225. (Type locality Salto, Valparaiso, Chile. Types in the British Museum.)

*Material examined.* From Burmese collections:

Pyinmana, Yamethin district, October, 1 clitellate specimen. K. John.

Monywa, Lower Chindwin district, September, 1 clitellate specimen. Saw San Thwe.

*External characteristics.* Length 27–30 mm. Diameter *ca.* 1 mm. Unpigmented. Prostomium epilobous but with no furrow at posterior margin of tongue. Dorsal pores lacking. Nephropores unrecognizable. Setae begin on ii on which all four couples are present; *ab* and *cd* about equal, *aa* slightly larger than or about equal to *bc*.

The clitellum is light brownish, saddle-shaped (?), not protuberant, reaching ventrally to *b*, extending antero-posteriorly onto xiii and at least to 19/20 but without recognizable anterior and posterior demarcation; intersegmental furrows lacking, setae present. The ventral setae of xiv–xvi appear to be enlarged.

The spermathecal pores are not minute, being definitely larger than other reproductive apertures, shortly elliptical, on 7/8 and 8/9, slightly median to *c*. The margin of each aperture is tumescent as a clearly demarcated, annular lip.

The female pores are on *b*, slightly behind the site of 13/14, the margins slightly tumescent so that the pores appear to be transversely slit-like.

In the male region, on each side, there is a longitudinally placed, slightly raised, rather dumb-bell-shaped area just lateral to *b*, extending anteroposteriorly to just in front of or just behind the setal arcs of xvii and xix. The anterior and posterior portions of each porophore are especially protuberant, a midventral region between the porophores slightly depressed. Along each porophore there is a greyish translucent band on which no seminal groove is visible (possibly grooved on Pyinmana specimen?). Immediately behind the setal arc of xvii (Monywa specimen) there is in the epidermis a transversely placed, slightly crescentic band of greyish translucence, the concave side posteriorly. The minute prostatic pores are at the ends of the longitudinal grey bands of the porophores, the male pores also in the bands, on xviii, on

the setal arc (all pores just lateral to *b*). Ventral setae of xvii–xix are all present but probably are smaller than on neighboring segments.

*Internal anatomy.* (Monywa specimen). All septa from 5/6 posteriorly are present; 6/7–8/9 thickened and opaque but with no muscular sheen.

The pharyngeal bulb is short. At each side of the gut in iv, v and vi there are masses of glandular (?) material with a brilliant iridescence, those in iv especially large. From the pharyngeal bulb to 6/7 the gut is slender, unconstricted septally and with thin wall. The portion of the gut in vii has a smooth surface, rounded shape, and is fairly strong though not greatly muscularized. In ix the gut is quite slender and fairly high in the coelomic cavity. Attached to each side posteriorly and dorsolaterally is a rather pear-shaped calciferous sac which passes below the level of the gut and then anteriorly to the posterior face of 8/9 to which it is adherent (segment ix unusually long). The aperture into the gut is small and rather star-shaped but the lumen of the sac is horizontally slit-like in transverse section. The intestine begins in xii. No typhlosole.

Hearts of x–xi all open into the supra-oesophageal and dorsal trunks. The commissures of ix are slenderer than the hearts and apparently open only into the dorsal blood vessel. No subneural trunk.

Nephridia are rather small, transversely placed against the parietes, extending from *b* to just lateral to *d*, the neck long and slender, the preseptal funnel close to the ventral parietes near *b*. On each post-clitellar nephridium there is a little granular, transparent material. From xvi–x the nephridia are still smaller but were not seen from ix anteriorly.

In the ventral portion of x there is on each side a compact iridescent mass of spermatozoa adherent to the male funnel from which it can be removed only with some care, the funnels with a brilliant iridescence. Testes were not seen. The vas deferens is large in xi–xiii and slightly iridescent throughout so that it can be traced easily in spite of the slenderness of the posterior portion, passing into the parietes in xviii, just lateral to the ventral setae. The seminal vesicles of ix are fairly large, filling all available space in the segment and reaching up into contact with the dorsal trunk. The posterior vesicles are lateromesially flattened, reaching into contact with the dorsal blood vessel, and extending through 11/12 to 12/13 which is pushed into contact with 13/14. Prostates are twisted together but are long enough to extend through several segments. The ducts are much thinner than the glands

and with very slight muscular (?) sheen, passing into the parietes just lateral to the ventral setae of xvii and xix.

Each ovary contains a few, relatively large ova.

The spermathecal ampulla is shortly ovoidal, the narrowed portion ectally. The ampulla is filled with a compact mass of spermatozoa, a slight iridescence visible through the translucent wall. The duct is slightly shorter than the ampulla and slender. There are no diverticula or seminal chambers.

*Remarks.* The saddle-shaped appearance of the clitellum may be due, as in *peguana*, merely to a lack of clitellar coloration midventrally. Some confusion has resulted from attempts to use clitellar characteristics for specific definition in small species of *Dichogaster* as well as certain Ocnero-drilids. Even in larger forms where clitellar characteristics are determinable with more certainty there may be some variation with respect to extent and apparent shape of the clitellum.

*Diagnosis.* Prostatic pores minute and superficial, on setal arcs of xvii and xix and at anterior and posterior ends of grey, translucent bands on paired, longitudinally placed, dumb-bell-shaped porophores just lateral to *b*; male pores on setal arc of xviii and on grey bands. Quadrithecal, spermathecal pores slightly median to *c*. Setae:  $ab = cd$ ,  $aa ca. = bc$ ,  $dd = \frac{1}{2}C$ ; ventral setae of xvii-xix present. Nephropores? Clitellum annular (but thinner and colorless ventrally?); on xiii-xx. Prostomium epilobous. Unpigmented. Length 25-30 mm. Diameter 1 mm.

Gizzard in vii. Seminal vesicles in ix and xi. Spermathecal duct slightly shorter and slenderer than the shortly ovoidal ampulla.

*Distribution.* Probably widely distributed throughout tropical and possibly subtropical regions but recorded hitherto only from Chile, South Africa, Australia, New Caledonia and Burma (central region, Yamethin and Lower Chindwin districts).

#### Genus GORDIODRILUS Beddard 1892

This genus provides one of the most difficult problems in Megadrilid taxonomy. In his 1930 monograph Stephenson characterized *Gordiodrilus* as follows: "Condition of male apparatus very various — incompletely or irregularly microscolecine, or showing a tendency to balantine reduction or megascolecine. Two or one or no gizzards. A single oesophageal sac, or a pair, in ix. Holandric, metandric, or proandric. Spermathecæ without diverticula on the duct, but sometimes with evaginations at the ectal end of the ampulla." (The Oligochaeta,

1930, p. 863). Obviously this is merely a statement of variation in a group of species without morphological or geographical unity and as a "diagnosis is so indefinite as to be meaningless", as is admitted by Stephenson who adds, "I can do nothing with this heterogeneous group of species, extending over nearly the whole African continent" (l.c. p. 863).

Casual comparison of the definition above with those of other *Ocnerodrilid* genera in the same work, suggests that the *Gordiodrilid* chaos resulted, in part at least, from neglect to continue to use those characteristics which were employed, with apparent success, in definition of other genera in the family (in particular characteristics of the digestive system relating to gizzards and calciferous sacs).

A genotype, so far as can be discovered from the literature available, has never been designated. One candidate for the honor is *G. tenuis* Beddard 1892 although this form is probably a ghost species, unembodied in a material type. (The single type was sectioned but whether sections of this as well as of other holotypes have been preserved and are now of use is unknown.) Some characteristics of specific, possibly even of generic importance are unknown but the species does lack a gizzard, does have a single, ventral calciferous sac in ix and four prostates, a combination of characteristics at present capable of distinguishing a genus from all other *Ocnerodrilids* as well as from certain groups of species now included in *Gordiodrilus*. *G. tenuis* is supposedly metandric but mention is made of seminal vesicles in x-xiii. Vesicles are hardly to be expected in xi of a metandric species, and it is quite possible that testis sacs of the *Ocnerodrilus* type, in x and xi (or even masses of coagulum) were mistaken for seminal vesicles. An anterior pair of male funnels may have been lost (as in some sections just examined) or unrecognized. Furthermore it should be noted that metandry may appear in a group of related species without necessity or even possibility of generic or subgeneric division (as in *Eutyphoeus*, and *vide* also subsequent remarks on *Malabaria*). Location of prostates in xx and xxi rather than in xvii and xix as in the supposed ancestral form is evidence for a derived or specialized rather than a primitive status and if *tenuis* is actually metandric, less specialized species in a *tenuis* group might well be holandric. In spite of the posterior location of the male terminalia an approximation to an acanthodriline condition is maintained, as the male pores apparently are midway between the prostatic pores. A *tenuis* group, as will be seen below, can be defined in terms of maintenance of this approximation to an acanthodriline condition but not with respect to a normally acanthodriline segmental

location, a development somewhat similar to that in the North American Megascolecid genus *Diplocardia*, where the male pores may be on xviii, xix, xx or xxi, with corresponding shifts in the four prostates.

A generic definition for a *tenuis* group of species may then be worded somewhat as follows. Quadriprostatic, prostatic pores at termini of seminal grooves, the male pores also in the grooves and intermediate<sup>1</sup> between the prostatic pores (or between the first and last pairs when three pairs are present). Setae closely paired. Clitellum annular.<sup>2</sup> No gizzard, calciferous sac ventromedian in ix. Holandric; seminal vesicles in (ix?) xii.<sup>3</sup>

No mention is made in this definition of the intestinal origin in xii, absence of a typhlosole, restriction of latero-oesophageal hearts to x-xi, or the paired presetal female pores on or close to *b* lines of xiv, as there is evidence to indicate that these characteristics are found in a considerable portion if not a very large majority of the Ocnerodrilidae. Presence of small chambers in or on the ducts of the spermathecae may characterize a definite group of species or even a greater proportion of the genus than is now recognized. "Evaginations" of spermathecal ampullae may be only accidental constrictions.

In a generic group as defined above there would be included: *tenuis* Beddard 1892, *elegans* Beddard 1892, *zanzibaricus* Beddard 1894, *madagascariensis* Michaelsen 1907, *travancorensis* Michaelsen 1910, *habessinus* Michaelsen 1913, *paski* Stephenson 1928, *unicus* Stephenson 1931, *wemanus* Michaelsen 1937, *peguanus* sp. nov., and possibly also the following,—*ditheca* Beddard 1892, *dominicensis* Beddard 1892, *papillatus* Beddard 1901, *mobucanus* Cognetti 1907 and *chuni* Michaelsen 1913.

In accordance with orthodox theory as to Oligochaete evolution, the most primitive species of the restricted *Gordiodrilus* is *unicus* with normally acanthodriline male terminalia. This form is known only from Bhamo in northern Burma but a short distance from the Chinese frontier. It is improbable that this is the original home of the species. A longitudinal area in east Africa apparently characterized by group 2 crosses a transverse area possibly characterized by group 3 in the region of Mt. Ruwenzori where the original home of *unicus* may perhaps be anticipated. Only one specimen of *unicus* is known and this has a

<sup>1</sup> Supposed union of male and prostatic pores on xviii in *travancorensis* needs confirmation.

<sup>2</sup> The clitellum is said to be saddle-shaped in both *tenuis* and *elegans* but a figure of each species apparently shows clitellar development ventrally.

<sup>3</sup> Vesicles, recorded on several occasions from x and xi, may again be only testis sacs of the *Ocnerodrilus* type, at height of sexual development. Seminal vesicles would then be unnecessary and perhaps first lost in ix as apparently in some other genera of the family.

single prostate in xviii, presence of which may be an abnormality. However prostates are present in xviii in certain Ocnero-drilids with a frequency to indicate a possibility at least that the ancestral condition was sexprostatic rather than quadriprostatic as hitherto assumed.

A group of species (2, *unicus* and any related species being 1) including *zanzibaricus* (Zanzibar), *habessinus* (Abyssinia), *paski* (Tanganyika), *wemanus* (Kenya), *peguanus* (Burma) and possibly also *dominicensis* (Dominica but via Kew) and *chuni* (Rhodesia), has prostates in xvii and xviii and male pores on or near to 17/18. This condition may be derived from the sexprostatic merely by elimination of the prostates of xix and dislocation anteriorly of the male pores to points midway between the remaining prostatic apertures. The male pores of *zanzibaricus* according to Beddard are "precisely" as in *elegans* but pores on *elegans* are at 18/19 while seminal grooves of *zanzibaricus* are on xvii and xviii. Assuming that Beddard was correct with regard to the location of the seminal grooves, it is unlikely that the pores are on 18/19, although Beddard confirmed the location of the pores of *elegans* in 1901 (p. 364). Information available from distribution indicates that the statement as to segmental location of the seminal grooves of *zanzibaricus* is to be accepted rather than that as to location of the pores.

The type of *chuni* is abnormal and the absence of a second pair of spermathecae may also be an abnormality. In the description of *dominicensis* prostatic pores are at first said to be on xviii and xix with ventral setae of xviii and xix lacking) while on p. 95 the pores are said to be on xvii and xviii, a location which was confirmed by Beddard in 1901 (p. 364). The athecal condition may be an abnormality as in Burmese species of *Malabaria*. At present the original home of this group would appear to be somewhere in eastern Africa between Rhodesia and Abyssinia.

A third group of species, including *travancorensis* (South India), *madagascariensis* (Madagascar), *elegans* (supposedly from Lagos but actually found at Kew) and possibly also *mobucanus* (Mt. Ruwenzori), has prostates in xviii and xix and male pores on or near to 18/19. This condition may be derived from the sexprostatic by suppression of the prostates of xvii and the dislocation posteriorly of the male pores. *G. mobucanus* is said to be bithecal but the species is so inadequately characterized as to be unrecognizable. Available information is sufficient to indicate nothing more than a possibility that group 3 is endemic in a more western portion of Africa than group 2, possibly from Mt. Ruwenzori to Lagos (Indian and possibly Madagascar record of peregrine forms).

*G. papillatus* (from Lagos) with no gizzards and a single calciferous sac is mentioned here because of a remote possibility that it provides a transition between groups 3 and 4. A part of the difficulty in placing the species is due to another of Beddard's contradictions. On p. 360 the prostatic pores are said to be at the termini of the seminal grooves on xviii and xix which would indicate inclusion in section 3, but on p. 362 the prostatic pores are said to be on xix and xx with the male pores in the region of 19/20. The species is however characterized by the presence in the male terminalia of large muscular bulbs similar to those of *Nannodrilus*. Inclusion in *Nannodrilus* would require an assumption that gizzards in vii and viii and prostates opening into the copulatory chambers had been overlooked. The seminal grooves present here are lacking in *Nannodrilus*. A possibility of independent development of copulatory chambers in non-Nannodrilid forms may have to be considered. Copulatory chambers, though of a much smaller sort, are now known from one species of *Eukerria* and coelomic copulatory chambers apparently have evolved in different groups of the Megascolecid genus *Pheretima*.

The fourth section contains only one species, *tenuis* (supposedly from Assaba, West Africa, but actually from Kew). In this species the prostatic pores are on xx and xxi with the male pores on or near to 20/21. The finding of this species towards the western margin of a group 3 area, together with a possible Lagos origin of *papillatus*, is of interest though perhaps of no particular significance.

In *Diplocardia* with developments somewhat similar to those characteristic of *tenuis* the word usually used is "shift", as if the prostates originally present in xvii and xix had been translocated posteriorly, perhaps as a result of a long series of very slight backward shifts or of a lesser number of more marked mutations. The occasional presence of prostate-like glands in the Ocnerodrilidae behind the usual series of two or three pairs, suggests an alternative, *ie.*, the appearance of one or more pairs of supernumerary structures throwing the primitive relationship out of balance with a consequent posterior dislocation of the male pores to restore the balance. Loss of one or more prostates at the anterior end of the series would again upset the balance and be followed by still further posterior dislocation of the male pores. In this connection it may be noted that a number of interesting problems in earthworms in connection with conditions apparently suggestive of induction, attraction or organ balance effects await investigation.

*G. ditheca* (Lagos via Kew) cannot be placed in any group. Male pores are supposedly on xviii and there is a single pair of prostates but

the location of the prostatic pores is unknown. Supposedly bithecal the location of spermathecal apertures is also unknown. The bithecal condition may be an abnormality as well as the absence of a second pair of prostates.

*Nannodrilus* Beddard 1894 was united with *Gordiodrilus* in 1913 by Michaelsen, who had come to believe that the male genital terminalia in *Kerria* (now *Eukerria*), *Gordiodrilus* and *Nannodrilus* formed a series that should not be interrupted, while gizzards and copulatory chambers were regarded as not providing characteristics of generic value in this particular connection. *Kerria* however was not united with *Gordiodrilus* and the reasons advanced do not appear to be of much importance. Like *Gordiodrilus*, *Nannodrilus* has only a single ventral calciferous sac in ix but this in itself is no more justification for union of the two genera than the presence of a single pair of sacs in ix is for a union of *Eukerria*, *Kerriana*, *Haplodrilus* and *Nematogenia*. A Nannodrilid group of species can be defined generically as follows: Male pores on xviii. Bithecal, spermathecal pores on 7/8. Clitellum annular. No seminal grooves. Gizzards in vii and viii. Calciferous sac ventromedian in ix. Holandric, seminal vesicles in ix and xii. Vasa deferentia of a side after union open into a thickwalled and muscular "copulatory chamber" into which one pair of prostates also opens. Spermathecae adiverticulate. This definition certainly appears to be as good as any now available in the Ocnerodrilid family.

To be included in *Nannodrilus* are: *africanus* Beddard 1894 (Lagos), *staudei* Michaelsen 1897 (Egypt), *phreoryctes* Michaelsen 1903 (Cameroons), *schubotzi* Michaelsen 1915 (French Congo) and possibly *togoensis* Michaelsen 1913 (Togo), as well as another form hitherto unrecognized as specifically distinct. The distribution may indicate an endemic area in Dahomey to French Congo, the Egyptian record a result of transportation.

Here again it seems possible to start with a sexprostatic condition and differing from the primitive Gordiodrilid condition only in the presence of a pair of copulatory chambers into which both pairs of male deferent ducts and the prostates of xviii open. From such a primitive stage, *schubotzi* (in part only) differs merely in the location of the anterior prostatic pores on or near to 17/18 rather than midsegmentally on xvii and the location of the posterior prostatic pores also in front of the setal arc. Some of the types of *schubotzi* have a second pair of prostates opening into the copulatory chambers but with no external prostatic apertures anteriorly. Michaelsen apparently assumed that the anterior prostates had become disengaged from their parietal

attachment in the region of 17/18 and reattached to the copulatory chambers. That such a development can occur as an intraspecific variation seems rather doubtful and the specimens with two prostates on each chamber should perhaps be regarded as specifically distinct. In *staudei* the anterior prostates are on a presetal portion of xviii and perhaps furnish in this respect a condition intermediate between *schubotzi* and the species of the excluded specimens. In *N. africanus*<sup>1</sup> the posterior prostates have been lost but the anterior prostates are retained in the original position on xvii. In *phreoryctes* both anterior and posterior prostates have been lost. It will be interesting to learn if some undescribed species has retained the posterior prostates after loss of the anterior glands.

*G. togoensis* can be included in *Nannodrilus* if gizzards in vii and viii were overlooked and would then differ from the excluded types of *schubotzi* in the absence of prostates with external apertures. If however gizzards were actually lacking in *togoensis* recognition of another genus must be considered. This would be distinguished from *Gordiodrilus* by the absence of seminal grooves and of prostates with external apertures, and from *Nannodrilus* by absence of gizzards and of prostates with external apertures.

Relationships of the quadrithecal (cf. footnote on *africanus*) *johneni* Michaelsen 1936 (Belgian Congo) are even more uncertain, primarily because of doubt as to the calciferous glands which are said to be not wholly unpaired, but with two rounded "Kuppen", accurate characterization impossible because of gaps in serial sections. If an unpaired *Nannodrilid* sac is present and gizzards were overlooked, inclusion in *Nannodrilus* is possible and the predicted stage without anterior prostates is available. If gizzards are actually lacking as well as in *togoensis*, then both of those species might belong to a genus paralleling *Nannodrilus* in the evolution of the male terminalia.

*G. robustus* Beddard 1892, with a gizzard in viii and possibly a rudimentary gizzard in vii, in accordance with procedure followed hitherto must be excluded from *Gordiodrilus*. The presence of seminal grooves and absence of copulatory chambers seem to make consideration of relationships with *Nannodrilus* unnecessary. Again a new generic group seems to be indicated. The calciferous gland of *robustus* is at first said to be single and ventral but whether this was determined

<sup>1</sup> Again we have to do with contradictory statements in Beddard's descriptions. In the definition of *africanus* the species is said to be quadrithecal but on p. 390 only one pair of spermathecae is mentioned and that in vii, the location of the pores not given! Further, in the definition of *Nannodrilus* the anterior pair of prostates is said to open in common with the deferent ducts, but fig. 3 contradicts this.

from the dissection or from sections is not clear. In a footnote on p. 83 Beddard says that a specimen dissected after completion of the account above has paired calciferous sacs! The material studied by Baldasseroni and Michaelsen apparently indicates that the unpaired condition should be accepted as correct, in which case the specimen with paired calciferous sacs must be referable to a distinct genus (vide *Diaphorodrilus*). All of the forms to be considered with *robustus* are characterized by presence of genital markings. Nothing is known as to parietal modification or glands associated with those markings but such glands might also provide characteristics of generic value. A high, lamellar type of typhlosole has been recorded from one of the forms. In view of the apparent rarity of that structure in the Ocnerodrilidæ this might well be a characteristic of generic importance. A *robustus* group of species could then be defined generically as follows: prostatic pores at termini of seminal grooves which also include male pores, midway between the prostatic pores. Genital markings present behind the male genital region. Setæ paired. Clitellum saddle-shaped. Gizzard in (vii? or?) viii; calciferous sac ventromedian in ix; high lamellar typhlosole present from xvii (to ?). Holandric, seminal vesicles in xi and xii. Spermathecae adiverticulate and with unusually long ducts. Genital marking glands? Included in addition to *robustus* (supposedly from Lagos but actually from Kew) are: *pampaninii* Baldasseroni 1913 (Tripolitania) and *congicus* Michaelsen 1936 (Belgian Congo). The area of endemicity appears to be Central Africa while intervention of the Sahara dessert suggests transport of one species to Tripolitania. A sexprostatic form is unknown but presence of prostates in xviii of all species once more suggests a possibility of a sexprostatic ancestral or primitive type. Male pores have not been identified definitely in any of the forms but are thought to be in the region of 18/19 in *pampaninii* with posterior prostates. By analogy with *Gordiodrilus*, forms with anterior prostates should have male apertures on or near 17/18 (also indicated by Beddard's fig. 5) and evolution of similar intra-generic groups may be expected.

Along with *Nannodrilus*, Michaelsen united *Diaphorodrilus* Cognetti 1910 with *Gordiodrilus* as presence of three pairs of prostates and a location of the male pores of 16/17 are inadequate for generic distinction, and further that the third pair of spermathecae is of no significance being merely in correlation with the three pairs of prostates with external apertures. The validity of the criticism as to the taxonomic value of the three pairs of prostates and spermathecae may be accepted, at least for the time being, but it is doubtful if equality in

number of spermathecal and prostatic pores is of any particular significance. Correlations between number of spermathecal pores and male pores (Stephenson) or prostatic pores (Michaelsen) have been assumed, but a hasty survey of various families of earthworms indicates that any equality in number of spermathecal pores with either male or prostatic apertures is only casual.

*Diaphorodrilus* does however have a pair of lateral calciferous sacs in ix which seems to provide much more of an argument for union with *Eukerria* than any other characteristic provides for union with *Gordiodrilus*. The distribution of *Eukerria* (restricted to southern South America, except for *zonalis* and *medonaldi* which are known only from Lower California and should be under suspicion of transportation, though usually regarded as endemics) presumably was the reason for Michaelsen's failure to follow his own suggestion (in spite of the presence of endemics of the subgenus *Illyogenia* in both Africa and America). Leaving aside for the present discussion of possible relationships with other genera having paired sacs in ix only, which would require consideration of all of the remaining African Ocnodrilids, recognition of *Diaphorodrilus* as generically distinct from other Gordiodrilids is necessary. By analogy with *Gordiodrilus* and *Nannodrilus* the sexprostatic genotype should be primitive. Unfortunately the segmental locations of the terminalia are uncertain because of another of the contradictions that characterize so much of the work on Gordiodrilids. According to one statement and one figure the prostates are in xvi, xvii and xviii while according to another statement and figure the last pair of prostates is in xix. The male pores were unrecognizable but Cognetti thought they were on 16/17, certainly a most unusual location either from the standpoint of location in the Megascolecidae (in which the Ocnodrilidae are usually included) or from that of interorgan balance. Quite possibly the confusion as to location of the prostates was due to some sort of segmental abnormality in the region of the male terminalia with an apparent dislocation of male apertures. In that case the normal condition might well be that of the usual primitive form with male pores and apertures of a middle pair of prostates on xviii. If otherwise, *doriae* (Fernando Po) might have been derived from the primitive type by a mutational addition of an extra pair of prostates at the anterior end of the series rather than at the posterior end as in *Gordiodrilus*, followed by suppression of the prostates of xix and anterior dislocation of the male pores. All of the species of *Gordiodrilus* not hitherto mentioned agree with *Diaphorodrilus* in the possession of paired calciferous sacs in ix, adiverticulate spermathecae,

a constant segmental location of spermathecal pores (rather than intersegmental),<sup>1</sup> holandry (seminal vesicles in xi-xii?). Otherwise this group of species at present does not appear to have much in common although here as elsewhere information is lacking with regard to a number of characteristics that may be of taxonomic value. In *luykerleni* Michaelsen 1913 (Rhodesia) the male pores are on xviii, either united superficially with or immediately lateral to the prostatic pores, the anterior prostates suppressed. In *overlaeti* Michaelsen 1936 (Belgian Congo) the male pores are united with the prostatic pores of xix, prostates of xvii and xviii eliminated but prostate-like glands in xx are associated with genital markings somewhat as in *E. peguana*. In *thomsoni* Michaelsen 1933 (Southwest Africa) the male pores apparently are united with the prostatic pores of xviii while prostates associated with genital markings or porophores may or may not be present on xix. If the group is a natural one developments would appear to be along lines of loss of acanthodrilid relationships and of seminal grooves and the evolution of megascolecine and balantine terminalia or approximations thereto.

The suggestions advanced above may be expected to stimulate a natural but superficial criticism of unnecessary generic multiplication. It should however be noted that Africa is the region in which the Ocerodrilid family "took its rise" (Stephenson 1930, p. 853) and presumably greatest development. Yet only four genera are now recognized from the whole of the African continent. Furthermore the generic distinctions that have been suggested above are on the whole and even in spite of the fragmentary nature of our knowledge of the Gordiodrilid groups, as good as, if not better than those in some other portions of the family. Thus for instance *Kerriona* is distinguished from *Eukerria*, aside from the larger size and pigmentation, only by a wider pairing of the setae in a portion of the axis, all of which are characteristics at times of specific value only or none at all. *Haplodrilus* is distinguished from *Ocerodrilus* only by its proandry or from *Eukerria* merely by its microscolecine male terminalia. *Pygmaodrilus* is distinguished from the African section of the subgenus *Ilyogenia* only by diverticulation of the spermathecae (a characteristic apparently not of generic value even in a restricted *Gordiodrilus*) and the approximation (rather than actual union) of male and prostatic pores, a distinction not considered of generic value in *Malabaria* or certain non-Ocerodrilid genera. Admittedly some of the characteristics sug-

<sup>1</sup> In the Megascolecid *Hoplochaetella* the spermathecal pores are almost universally released from an intersegmental location.

gested for generic definition are not of the usual sort but the taxonomist must be concerned first of all with the actual morphology of his animals rather than the vague ghosts of idealized forms born from phylogenetic speculations.

Of the Ocernodrilid fauna of the African continent certainly but a very small fraction is now known, and almost as soon as new material becomes available for study new genera will be necessary. The information available even now indicates that evolution within the family has not been limited to the very restricted series of developments that have been considered hitherto in Megadrilid phylogeny. Whether or not any of the new genera necessitated by more extensive collecting will be definable as suggested above of course remains to be seen. In view of the difficulties associated with the small size of animals one to two mm. in diameter, inability to reexamine old material, lack of newer material from critical localities, the inadequacy and contradictory nature of so much of the information that is available, and the limited series that have been studied in the past,<sup>1</sup> a satisfactory revision of *Gordiodrilus* is impossible at present. Accordingly nothing that has been said above should be taken as a designation of a genotype for *Gordiodrilus* or as in any way restricting the genus. Until such time as revision becomes practicable, the various groups may be referred to as Nannodrilid, Diaphodrilid or by species names, as "a *robustus* group."

#### GORDIODRILUS PEGUANUS sp. nov.

*Material examined.* From Burmese collections:

- Moulmein, Amherst district, October, 3 acitellate and 42 partially clitellate specimens. K. John.
- Mupun, Amherst district, October, 6 partially clitellate specimens. K. John.
- Boyagyi, Thaton district, October, 31 partially clitellate or clitellate specimens. K. John.
- Taungzun, Thaton district, August, 1 clitellate specimen. K. John.
- Kyaikto, Thaton district, August, 1 clitellate specimen; September, 3 clitellate specimens. K. John.
- Sittang, Thaton district, October, 1 juvenile, 53 partially clitellate and 2 clitellate specimens. K. John.
- Kyauktan, Hanthawaddy district, September, 7 clitellate specimens. K. John.
- Syriam, Hanthawaddy district, September, 1 clitellate specimen. K. John.

<sup>1</sup> Twenty eight species known only from types or original descriptions, seven known only from unique types, seven known only from short series of two (3 species), three (3) or four (1) specimens. Much, if not all of the material available has doubtless been of a disappointingly refractory nature for investigation by means of sections.

Kungyangon, Hanthawaddy district, September, 11 clitellate specimens. K. John.

Rangoon, Hanthawaddy district, June, 33 clitellate specimens; February, 21 clitellate specimens; March, 18 clitellate specimens. K. John.

Hmawbi, Insein district, September, 1 clitellate specimen. K. John.

Minbu, Minbu district, September, 5 clitellate specimens. K. John.

Indaw Lake, Katha district, September, 1 clitellate specimen. Saw San Thwe.

From Indian collections:

Bangalore, South India, 3 acitellate and 23 clitellate specimens. Prof. C. R. N. Rao.

*External characteristics.* Length 35–47 mm. Diameter 1–1½ mm. Unpigmented. The prostomium is epilobous, tongue short (30). No dorsal pores. Nephropores? The setae begin on ii on which all four couples are present; behind the clitellum *ab* and *cd* about equal, *aa* slightly smaller than *bc*, *dd ca.* = ½*C*.

The clitellum is dark red, reddish brown, dark yellow, bright yellow or (partially clitellate specimens) light yellow or light brown, annular except on xvii–xviii, not protuberant, extending from a portion of xiii — usually only postsetal — to 18/19 or slightly onto xix, 19/20 or even onto xx (Bangalore worms), the anterior and posterior boundaries indistinct externally but clearly visible at mid-dorsal incisions; intersegmental furrows lacking, setae present.

The spermathecal pores are on 7/8 and 8/9, usually with centers on or close to *b*, a very narrow marginal area immediately in front of and behind the aperture often slightly tumescent so that the aperture at first appears to be large and transversely slit-like. Rarely a single pore may be in the median half of *bc*. Female pores are on or just lateral to *b*, only slightly nearer to the setal arc of xiv than of xiii, hence close to site of 13/14.

On xvii and xviii of a fairly large proportion of the specimens there is a white, transversely placed, slightly raised, almost square male shield, extending anteroposteriorly to or almost to the sites of 16/17 and 18/19 and laterally into the median portion of *bc*, usually fairly level, the boundaries of the shield indicated only by elevation and epidermal whitening. The surface of shield is not as smooth as the epidermis of the surrounding area. The seminal grooves are practically straight, though margins of the grooves are slightly irregular, and extend anteroposteriorly between the setal arcs of xvii and xviii, in the region of *ab*. At the anterior and posterior ends of the grooves the margins may be very slightly swollen. Ventral setae of xvii and xviii

may be lacking (invisible only?) or present in part and displaced mesially; *a* (presumably) of xvii present on both sides (6), *a* and *b* of xvii present on both sides (1), *a* (presumably) of xvii and xviii present on both sides (30). Prostatic and male pores have not been identified definitely but are probably represented by minute, greyish translucent spots at the termini of the grooves (prostatic pores) and midway between the termini (male pores).

On most of the other specimens the unpaired male field is replaced by a pair of longitudinally dumb-bell-shaped, whitened, areas with sharply delimited margins, the wider rounded ends of the porophores much more protuberant than the middle portions. A midventral region between the two areas is usually slightly depressed longitudinally and in addition there may be slight transverse depressions just anterior and just posterior to the areas. The midventral region between the porophores may or may not be colored like the clitellum. On the few remaining specimens the condition of the male field appears to be intermediate between the extremes just described.

Genital markings are lacking. On one worm seta *b* of xvi, on each side, is in a tiny, whitened, transversely placed tumescence.

*Internal anatomy.* All septa from 5/6 posteriorly are present; 5/6 is membranous and delicate, 6/7-9/10 slightly stronger but almost transparent.

There is no gizzard but the oesophagus in v may be slightly widened in such a way as to look somewhat like a very rudimentary gizzard. Anterior to 5/6 on each side there is a large mass of glandular(?) tissue, characterized in part at least by a brilliant iridescence, the masses covering over the gut dorsally. Similar but smaller glands are present in vi-viii on the anterior faces of the septa just lateral to the gut and median to commissures and nephridia, the size decreasing posteriorly. On the posterior face of 8/9, just lateral to the gut on each side, there is a tiny disc also characterized by a brilliant iridescence. The calciferous sac is large, rather squarish, dislocating 9/10 posteriorly, opening into the gut through a transversely or longitudinally slit-like aperture in the floor of the oesophagus posteriorly in ix, the lumen of the sac small, transversely elliptical to triangular in cross section, nearer the ventral surface of the sac in the anterior portion. On the inner wall of the oesophagus in v-viii there are low, longitudinal, somewhat irregular whitish ridges. Midsegmentally or posteriorly in ix the oesophagus is abruptly widened and remains wide through x and xi. The intestine begins in xii (30), the oesophageal valve small and anteriorly in xii. No typhlosole (4).

The dorsal blood vessel (single) is continued anteriorly to the region of the cerebral ganglia. A supra-oesophageal vessel is visible on the gut in the posterior portion of ix where it receives on each side six to eight parallel vessels from the lateral wall of the oesophagus. Posterior to 9/10 the vessel is usually unrecognizable, but in several specimens a partly empty continuation can be traced to a posterior portion of xi where it bifurcates, the branches passing ventrally on the lateral faces of the gut. Extra-oesophageal trunks are recognizable in v–viii just ventrolateral to the gut, in ix passing onto the ventral face of the calciferous sac where they disappear. No subneural. The hearts of x and xi bifurcate dorsally, one branch passing to the supra-oesophageal or its site (in x) or into the bifurcation of the supra-oesophageal trunk (in xi), the other branch into the dorsal trunk. The last pair of hearts is in xi (30). The commissures of ix are usually as large as the hearts of x but open only into the dorsal blood vessel.

Nephridia from ix posteriorly are large, usually flattened out against the parietes and in contact with both septa of a segment, extending from *a* nearly to the mid-dorsal line. The preseptal funnels are close to the parietes in *ab*. The slender ducts pass into the body wall at or median to *c*, in a preseptal portion of the segment. Occasionally median portions of nephridia lack the yellowish, granular investment and are recognizable as tubular loops. Nephridia of xiii–xviii are transversely placed loops, each nephridium with very little or almost none of the granular material. From xii to vi nephridia are located on the anterior faces of the septa and are without investment. Anterior to vi nephridia have not been found.

The male funnels are free in x and xi, usually with a brilliant spermatzoal iridescence. The testes are vertically placed, anteroposteriorly flattened flaps which reach upwards to the level of the gut or rarely even to the dorsal parietes, attached to the posterior faces of 9/10 and 10/11 close to the ventral parietes. The dorsal ends of the largest testes are pointed as a result of an accordion-like folding of a thinner dorsal portion of the organs. When unfolded tiny patches of iridescence, separated by translucent—almost transparent areas, are visible. Deferent ducts are usually recognizable only in xvii or in xvi and xvii, in the latter segment just lateral to the ectal end of the prostatic ducts, passing into the parietes midway between the prostatic ducts of a side. There is a pair of seminal vesicles in xii (30). A structure that appears to be a seminal vesicle was found in ix on the right side of one specimen, paired seminal vesicles present in ix in three Bangalore specimens. Prostates are three to four mm. long, the ducts

about one mm. long, slenderer than the glands and with a very slight (muscular?) sheen, passing into the parietes in xvii and xviii (15), the posterior duct nearer to 18/19 than to 17/18.

The spermathecal duct is longer than the ampulla from which it is sharply demarcated, not especially narrowed in the parietes, the wall thick and the lumen narrow. A middle portion usually somewhat nearer to the ampulla than to the ectal end is slightly thickened so that the duct has a rather spindle-shaped appearance. In the thickened region there are two or more small chambers; one on each side, two on one and one on the other, several on each side, etc., or rarely a complete circle around the duct. Chambers are always empty. No spermatozoal iridescence has been noted in any of the spermathecae but in absence of evidence to the contrary the chambers may be called seminal. Ampullae may contain opaque, white or red material.

*Abnormalities.* One specimen from Thaton has its left seminal groove on xviii and xix, its left ovary in xiv, left hearts, testes and male funnels in xi and xii, left spermathecae in ix and x. The oesophagus in x has a thick wall like that of the calciferous gland, especially ventrally.

Another worm lacks the right prostate of xvii, the left prostatic duct of xviii bifurcating near the ental end, one branch passing to a normal prostate, the other branch to a short and somewhat irregular gland.

One Bangalore worm has a well developed clitellum on xvii and xviii only. The portion anterior to xvii is probably an abnormal regenerate, with more than 16 segments and no calciferous gland.

*Remarks.* The unusual size of the structures referred to as testes and the presence in the dorsal ends of those structures of flecks of iridescence apparently indicates presence in this species of testis sacs similar to those of *Ocnerodrilus occidentalis*.

Oviducts of Bangalore worms may contain ova in a swollen ental portion, seven ova present in one duct, three in another.

*G. peguanus* is distinguished from the Burmese *unicus* by the absence of prostates in xix and restriction of seminal grooves to xvii and xviii; from the Indian *travancorensis* by the presence of prostates in xvii, the discrete and anteriorly located male pores, and the absence of prostates of xix; apparently close to *paski*, from which it is distinguished by the setal ratios ( $aa < bc$  rather than  $aa > bc$ ), slightly greater extent of the clitellum (onto xix or xx), epilobous prostomium, presence of testis sacs, and presence of nephridia anterior to xii. Just how many of these distinctions are actual or taxonomically valid remains to be determined.

*Diagnosis.* Quadriprostatic, pores at termini of straight seminal grooves in *ab*, between the setal arcs of xvii and xviii. Male pores in seminal grooves, midway between prostatic pores and about at site of 17/18. Seminal grooves on paired, longitudinally dumb-bell-shaped porophores or on a transversely placed, slightly elevated shield reaching to or nearly to 16/17 and 18/19 and laterally into the median portion of *bc*. Setae:  $ab=cd$ ,  $aa<bc$ ,  $dd=1\frac{1}{2}C$ ; *a* setae of xvii-xviii usually present. Quadrithecal, spermathecal pores on 7/8-8/9, on *b*. Clitellum annular, on xiii-xix or xx. Nephropores? Prostomium epilobous. Unpigmented. Length 35-47 mm. Diameter 1-1½ mm.

Holandric, seminal vesicles in xii. Spermathecal duct slightly spindle-shaped, longer than the ampulla, with two or more seminal chambers in wall of a thickened middle portion.

*Distribution.* Amherst, Thaton, Hanthawaddy, Insein, Minbu and Katha districts, Burma. Mysore State, India.

#### GENUS MALABARIA Stephenson

1924. *Malabaria* + *Aphanascus* Stephenson, Rec. Ind. Mus. XXVI, pp. 356 and 360. (Genotypes *M. paludicola* and *A. oryzivorus* Stephenson 1924.)
1930. *Malabaria* + *Aphanascus*, Stephenson, The Oligochaeta, pp. 857 and 858.)
1938. *Filodrilus* Chen, Cont. Biol. Lab. Sci. Soc. China, (Zool.), XII, p. 422. (Genotype *F. levis* Chen 1938.)

*Diagnosis.* Male pores on xvii. Biprostatic, prostatic ducts unite with male deferent ducts or open close to male pores. Bithecal, spermathecal pores on 8/9. Setae closely paired. Gizzard in vii. Calciferous diverticula small, paired, in thickened floor of gut in ix and x.

*Distribution.* India (Malabar, 2 species; Travancore, 1 species; possibly one species in Mysore), Burma (1 species) and China (1 species).

*Remarks.* *Aphanascus* is known only from the original account of *oryzivorus* and was distinguished from *Malabaria* by the absence of "prostates" opening to the exterior on xx and by the metandric condition of the male organs. The "prostates" in the genotype of *Malabaria* are associated with genital markings rather than seminal grooves and presumably provide no more justification for generic distinction than do similar glands and genital markings in *Eukerria peguana*. Confirmation of this viewpoint is provided by Aiyer's species, *M.*

*biprostata*, which has only two prostates. Although regarded hitherto as of generic significance in the Ocnerodrilidae (except in *Gordiodrilus*) metandry usually is not recognized, in itself, as of sufficient importance to warrant generic distinction. In absence therefore of other criteria of generic status, retention of *Aphanascus*, merely because of the metandry, seems unnecessary.

*Filodrilus*, according to Chen, differs from *Malabaria* in the absence of a posterior pair of "prostates", lack of union of deferent and prostatic ducts, and presence of an additional pair of testes in ix. Absence of posterior "prostates" and of terminal junction of male deferent and prostatic ducts characterize *M. biprostata* and do not appear to be of generic significance. (In *Microscolex*, to mention only one example, male and anterior prostatic pores may or may not be united.) Super-numerary testes, possibly nonfunctional, even when associated with extra male funnels, scarcely warrant generic distinction any more than in *Pheretima anomala* and *Lamprodrilus satyriscus* Michaelsen 1903. Oesophageal diverticula of *Filodrilus* are so described<sup>1</sup> that it is impossible to determine whether or not these structures are the same as in Indian species but there is no evidence available to indicate that the calciferous region is significantly different from that of *Malabaria*. Unless *Filodrilus* can be distinguished by important characteristics of the calciferous region of the gut there seems to be no justification for its retention.

The distribution of *Malabaria* is of particular interest in connection with the phylogeny of the Ocnerodrilidae. Evolution of the first earthworms, the differentiation of the several families and the evolution of the numerous genera is restricted by Stephenson to the Tertiary and Quaternary. The Ocnerodrilidae, "the last of the stems" derived from the root genus of the Megascolecidae, and by the development of two pairs of external calciferous sacs in ix and x, is thought to have originated in tropical or subtropical Africa from whence it "radiated off branches to America on the west and India on the east" (Stephenson, 1930, p. 835). The eastern branch is composed of *Maheina* with a supposedly endemic species on the Seychelles, *Curgia* with a supposed endemic in South India, and *Malabaria* with endemics in India and Burma. *Malabaria* with calciferous sacs reduced to vestigial structures

<sup>1</sup> Oesophageal diverticula are characterized as follows, "no conspicuous calciferous glands, its wall thickened and vascular in viii-x, ventral wall in ix and x specially thickened with rudimentary lumen" (p. 422) and "Calciferous glands in viii-x no special pouches, its wall thick and invested with loosely connective tissue and blood capillaries, constricted intersegmentally undoubtedly being rudimentary calciferous glands, portion in ix & x thickest on ventral side with rudimentary lumen, sac-like portion about 0.4 mm. in diameter of whole sac, about 0.06 mm. in thickness of dorsal wall; thickest ventral wall about 0.17 mm." No figures. (Chen, 1938.)

concealed within the ventral wall of the oesophagus apparently is to be considered, so far as that characteristic is concerned, the most highly specialized genus of the family.

A number of questions in connection with these ideas need very careful consideration which is not possible here. It should be noted however that all of the Ocnodrilids of the eastern branch are of the small size characteristic of so many of the species that have been transported across oceans and successfully colonized in new areas. Until after rigorous exclusion of the possibility of transportation of species of the eastern branch into the areas from which they are now alone known, endemism in the oriental region, eastward radiation and any zoogeographical conclusions based thereon may be regarded as under suspicion. Arguments for evolution in a portion of the eastern branch by regression of the calciferous sacs to intra-oesophageal rudiments are not very convincing and a possibility that the intra-oesophageal diverticula of *Malabaria* are primitive or even without genetic organ relationship to external oesophageal sacs requires examination.

#### Key to the species of *Malabaria*

1. a. Holandric ..... 2
- b. Metandric ..... *oryzivora* (Stephenson) 1924.
2. a. Prostate-like genital marking glands present, with apertures  
   on xx ..... *paludicola* Stephenson 1924.
- b. Prostate-like genital marking glands lacking ..... 3
3. a. Spermathecal ampulla irregularly saccular and longer than the  
   duct ..... *biprostata* Aiyer 1929.
- b. Spermathecal ampulla shortly ellipsoidal and much shorter  
   than the hypertrophied duct ..... *levis* (Chen) 1938.

A Mysore form, possibly specifically distinct, differs from *biprostata* and *levis* in the location of spermathecal pores in mid *bc* rather than on *b*.

#### MALABARIA LEVIS (Chen) ?

1938. *Filodrilus levis* Chen, Cont. Biol. Lab. Sci. Soc. Zool. XII, p. 423. (Type locality Po-peng, Hainan Island. Types?)

*Material examined.* From Burmese collections:

Kungyangon, Hanthawaddy district, September, 1 acelitellate specimen.

K. John.

Twante, Hanthawaddy district, September, 2 acelitellate specimens. K.

John.

Kayan, Hanthawaddy district, September, 1 acitellate specimen. K. John.

Pyapon, Pyapon district, September, 16 acitellate specimens. Maung Ohn Maung.

Kyaiklat, Pyapon district, September, 1 acitellate specimen. Maung Ohn Maung.

Danubyu, Maubin district, October, 2 acitellate specimens. Maung Ohn Maung.

*External characteristics.* Length 40–87 mm. Diameter ca. 1 mm. Unpigmented. Prostomium epilobous, rarely proepilobous. Dorsal pores lacking. Nephropores unrecognizable (on *b* ?). The setae begin on *ii* on which all four couples are present; *ab* and *cd* about equal, *aa* and *bc* about equal,  $dd\ ca = \frac{1}{2}C$ . No epidermal modification recognizable in clitellar region at mid-dorsal incisions.

Spermathecal pores are small transverse slits on 8/9, on or just lateral to *b*. Female pores have not been identified but the sites are probably indicated by slight tumescences on or just lateral to *b* and just behind 13/14.

The male terminalia are variable. Nine specimens have paired prostatic pores, five specimens have no prostatic pores while the other worms have a single prostatic aperture on the right or the left side. Prostatic porophores are located on *xvii* in the region of *ab* with centers about on *b*, one or (usually) both ventral setae lacking when the porophore is present, setae present and normal when the porophore is lacking. On one specimen each porophore is a tiny, transversely placed area of shortly elliptical outline with a clearly demarcated but narrow rim central to which the surface is slightly depressed and pitted or roughened. Pores are unrecognizable on this marking which is located on an area of slight epidermal thickening that reaches anteroposteriorly towards 16/17 and 17/18. On other specimens a single minute pore may be recognizable in a slight, transversely placed, slit-like depression, the margins slightly tumescent to form anterior and posterior lips. The depression may be an early stage in development of a parietal invagination such as characterizes *Eukerria peguana*. On Pyapon worms prostatic porophores are rudimentary, even at best development, usually only a tiny conical protuberance on line *b* visible, pores unrecognizable.

Genital markings, usually present, are variable in position as shown in the table, and are often rudimentary like the prostatic porophores. At best development the marking has a smooth, flat, opaque, whitened rim and a sharply demarcated, slightly translucent, central protuber-

ance of shortly and transversely ellipsoidal appearance. The protuberance is due to the presence of a transversely placed, clear vesicle which bulges the muscular layers of the body wall rather conspicuously into the coelomic cavity, the vesicle containing a whitish coagulum.

*Internal anatomy.* All septa from 5/6 posteriorly are present; 6/7-8/9 thickened and probably with muscular fibres, 9/10 slightly thickened.

The gizzard, in vii (20), is elongate and with marked muscular sheen. The oesophagus in viii-x is widened, slightly constricted septally, heavily vascularized, with numerous vertical vessels clearly visible in the lateral walls. In ix the wall is thickened, especially so ventrally. Calciferous sacs are lacking, intramural diverticula unrecognizable in dissections. Posteriorly in ix at least, and possibly also in x, there is a very slight median groove on the floor of the gut. The oesophagus in xi-xii is white and without especial vascularity. The intestine begins in xii (20), the oesophageal valve anteriorly in the same segment. No typhlosole.

The dorsal blood vessel (single) is continued anteriorly to the region of the supra-oesophageal ganglia. A supra-oesophageal trunk, as large as the dorsal blood vessel, terminates posteriorly and abruptly in xi at the junction with anterior branches of the hearts of xi, and is unrecognizable anterior to 9/10. Extra-oesophageals are recognizable only in viii-xi where they are located on the ventral face of the gut close to the midventral line. On the parietes, in *bc*, on each side (1 specimen), there is in xi-xvi a longitudinal vessel. No subneural. The last hearts are in xi (20). Hearts of x and xi bifurcate dorsally, the anterior branch large, filled with blood and passing into the supra-oesophageal, the posterior bifurcation empty, white, passing to the dorsal trunk.

Nephridia are large, reaching into contact with both septa of a segment and upwards to the dorsal trunk, filling the coelomic cavities between the gut and body wall. A translucent, slender duct passes into the parietes just behind the septa, on or close to *b*. The neck is even more slender and transparent, the preseptal funnel small and almost transparent, close to the ventral parietes, about at *a*. Anterior to xii or xiii nephridia have not been found and if present must be much smaller.

The testes are delicate, fan-shaped bodies in the usual positions on 9/10 and 10/11. Paired structures resembling testes are present on the posterior face of 8/9 in a number if not all of the specimens. Male funnels are free, delicate and with no spermatozoal iridescence, at the

usual positions in x-xi. In addition there is, in a number of the worms, a pair of funnel-like structures on the anterior face of 9/10. Paired, lobed, very soft seminal vesicles are present in xi and xii (20). Vasa deferentia were not traced but in the Kungyangon specimen a slightly iridescent thread in xvi, probably a posterior portion of the left deferent duct, disappears from sight within a slight protuberance from the parietes into the coelomic cavity close to the ectal end of the prostatic duct. Prostates are nearly circular in section, flecked with whitish spots. A duct is distinguishable only by a slight translucence and absence of whitish flecks. Prostates may extend posteriorly into xxviii though long enough to reach several segments further if straightened out or they may be closely coiled and reaching anteriorly into the region of xiv-xv. In one worm the single prostate passes anteriorly into xv then posteriorly into xx and then anteriorly again. There is always a prostate for each porophore, even that on xviii.

Ovaries are present in xii in several specimens in addition to the usual pair in xiii.

The spermathecal ducts, in the Kungyangon specimen, are of about the same thickness as the prostates, with thin transparent walls except in a short portion close to the parietes, looped irregularly, slightly and irregularly constricted in part to produce a somewhat moniliform appearance, slightly widened at the ental end into a very small, spheroidal to shortly ellipsoidal ampulla only about half again as wide as the duct but sharply marked off and also transparent. The right spermatheca reaches into xix but is looped back on itself. The left spermatheca penetrates into xxiii. There are no diverticula or seminal chambers. In other worms the spermathecae are often coiled in ix or in viii.

The longitudinal musculature is uninterrupted over sites of the genital markings.

*Remarks.* In spite of careful searches in the most favorable months of the year only acelitellate specimens were secured. The largest worms are probably in a late juvenile or pre-sexual stage (note complete absence of iridescence on male funnels and in spermathecae and the juvenile condition of ovaries). The Kungyangon specimen appears to be more mature than the others.

Constant presence of all setae on xviii-xix and absence of epidermal modifications on those segments show that the male pores are not on xviii and xix and the disappearance of the male deferent duct into the parietes along with the prostatic duct indicates a location on xvii. It was impossible, either from dissections or sections, to determine whether deferent and prostatic ducts unite before opening to the exterior.

In *Pheretima anomala* Michaelsen 1907 abnormalities such as presence of supernumerary gonads and genital funnels as well as absence of male genital terminalia and of spermathecae have been attributed to parasitic action and it is therefore of interest to note that in one of the smallest athecal specimens of *levis* coelomic cavities of the anterior end are filled with sporozoan parasites. None of these parasites were found in other specimens. Absence of spermathecae and prostates can scarcely be attributed to immaturity.

Two specimens were sectioned by professional technicians but preservation was unsatisfactory, especially in the portion of the gut belonging to viii-x, and the material was refractory. In sections through the calciferous region of the gut a definite median groove in the thickened floor of the oesophagus is quite obvious but intramural diverticula or non-vascular spaces lined by epithelium are quite unrecognizable. Though intramural diverticula, supposedly characteristic, of *Malabaria*, have not been found the bithecal and biprostatic condition is sufficient justification for the generic identification, at least for the present.

The Burmese worms described above are clearly distinguished from the three Indian species of *Malabaria* by the hypertrophied spermathecae. Distinction from Chen's *levis* is doubtful. Assuming that the calciferous region of the gut is similar in both, the Burmese worms apparently differ only in a very slightly more lateral location of the spermathecal pores and the location of male and prostatic pores in parietal invaginations (in *levis* male and prostatic pores appear to be discrete and superficial, the male pore just median to the prostatic pore, while spermathecal pores are in *ab*). Against these rather unimportant and possibly fictitious differences are to be considered the similarities of such unusual sorts as: hypertrophied spermathecal ducts, presence of testes and male funnels in ix and of ovaries in xii, frequent absence of male genital terminalia and spermathecae.

A satisfactory diagnosis cannot be given until fully mature normal specimens with properly preserved calciferous region have been studied.

*Diagnosis.* Male and prostatic pores in parietal invaginations opening to exterior by transversely slit-like apertures with centers on *b*? Genital markings on 8/9 or viii, rarely on xviii, each marking containing a clear gland. Spermathecal pores on or just lateral to *b*. Setae:  $ab=cd$ ,  $aa=bc$ ,  $dd=\frac{1}{2}C$ ; ventral setae of xvii lacking. Clitellum? Nephropores on *b*? Prostomium epilobous. Unpigmented. Length to 87 mm. Diameter 1 mm.

Holandric; seminal vesicles in xi and xii; an extra pair of testes and

male funnels (occasionally only?) present in ix. Male deferent ducts? Spermathecae long enough to reach posteriorly into region of xxv, duct sharply marked off from and several times longer than the spheroidal to shortly ellipsoidal ampulla.

*Distribution.* Hanthawaddy, Pyapon and Maubin districts, Burma. Hainan Island, China.

Variation in Burmese specimens of *M. levis*

Number.	Length in mm.	Prostatic pores present on xvii. l = left r = right	Genital Markings.	Spermathecae.	Remarks.	Locality.
1	68	l	viii, left side just behind <i>ab</i> .	Right to xix left to xxiii	Genital marking with wide rim.	Kungyangon
2	40	r & l	0	Coiled in ix	Ovaries in xii	Twante
3	52	r	viii, right side just behind <i>ab</i>	Coiled in ix		"
4	85	r & l	xviii, just in front of <i>ab</i>	Into viii		Kayan
5	37	l	viii, left side, just median to <i>a</i> and just in front of 8/9	0		Pyapon
6	65	0	8/9, median to <i>a</i> , left side	0		"
7	70	0	8/9, center just median to <i>a</i>	0		"
8	69	l	8/9, median	0	Testes and male funnels in ix	"
9	58	r & l	0	Coiled in ix		"
10	60	0	viii, left side, just behind <i>ab</i>	0	Testes and male funnels in ix, ovaries in xii	"
11	63	0	8/9, left side, center on <i>a</i>	0		"
12	52	r & l	viii, left side, just behind <i>ab</i>	Into xxv	Prostates into xxxviii	"
13	85	0	8/9, right side	0		"
14	48	r & l	0	Coiled in ix		"
15	35	r & l	8/9, left side, just median to <i>a</i>	Coiled in ix		"
16	31	r & l	0	Into viii, then to xv		"
17	54	r	8/9, right side, just median to <i>a</i>	Coiled in ix	Genital marking with wide rim	"
18	55	r	viii, right side just behind <i>ab</i>	Into xix	Genital marking with wide rim	"
19	41	l	8/9, left side, just median to <i>a</i> ; xviii left side just in front of <i>ab</i>	0	Testes and male funnels in ix	"
20	34	l	8/9, left side, just median to <i>a</i>	Into xxi	Ovaries in xii. Genital marking with wide rim	"
21	40	r & l	8/9, right side, just median to <i>a</i>	Into xi		Kyaiklat
22	38	r & l	0	Coiled in ix		Danubyu
23	49	l	8/9, left side, center just median to <i>a</i>	Into xxi	Prostate 5 mm. long	"

## MALABARIA species

*Material examined.* From Indian collections:

Bangalore, South India, 1 juvenile and 3 acitellate specimens. Prof. C. R. N. Rao.

*External characteristics.* Length to 61 mm. Diameter to  $1\frac{1}{2}$  mm. Unpigmented. Dorsal pores lacking. Setae begin on ii; on xx,  $ab = cd$ ,  $aa > bc$ , ventral setae of xvii lacking.

Spermathecal pores are on 8/9 with centres at mid *bc*. Female pores probably are on *b* close to 13/14. Male porophores are transversely placed, rather translucent, slightly protuberant areas on xvii with centres on or close to *b*, the appearance suggestive of a clear gland in a parietal invagination but with the latter practically in the initial stage of development. Each protuberance is at the center of a circular area of epidermal whitening that extends well into *bc* and *aa*. On one specimen with especially marked protuberances there is on each side a transversely slit-like invagination in which clear glands apparently are lacking.

A single genital marking like a clear vesicle of *levis*, presetal in *ab*, is present on the left side of ix of the juvenile specimen.

*Internal anatomy.* A rudimentary gizzard is present in vii. The intestine begins in xii. No typhlosole. The floor of the gut in ix is markedly thickened. In x the gut wall is slightly thickened but not especially so ventrally. Intramural diverticula if present were unrecognized.

A supra-oesophageal trunk is present in ix-xi. Extra-oesophageals pass onto the ventral surface of the gut in ix. Hearts of x-xi are latero-oesophageal.

Nephridia are large from xiv posteriorly, small in xiii, unrecognizable anteriorly.

Male funnels are present in x and xi and seminal vesicles in xii. Prostates extend into lii but are long enough to reach much further. The vas deferens disappears from sight in a circular patch of parietal thickening into the center of which the prostatic duct passes. In the juvenile specimen there are no prostates or parietal modifications in xvii and the male deferent duct apparently passes into xxiii where it disappears from sight just behind the ventral setae. In this specimen all setae of xvii-xix are present.

The spermathecal duct is about as long as the ampulla, the ectal half thickened and with slight muscular sheen. The ampulla is of shortly elliptical outline, flattened and clearly marked off from the duct.

*Remarks.* The worms were so soft that they broke apart during study of external characteristics or in course of dissection, thus preventing more adequate characterization. Assuming that the structure of the gut in x-xi is such as to warrant generic identification as *Malabarica* (there is no other bithecal genus without calciferous sacs), the more lateral location of the spermathecal pores appears to indicate specific distinctness from forms already named.

The continuation of the male deferent ducts posterior to the male pore segment as if in search of nonexistent prostates, in the juvenile specimen, is an exact parallel of a condition frequently characteristic of aprostatic individuals of *Pheretima anomala*.

### Genus OCNERODRILUS Eisen 1878

#### OCNERODRILUS OCCIDENTALIS Eisen

1878. *Ocnodrilus occidentalis* Eisen, N. Acta Soc. Upsala, (3), X, (4), p. 10.  
(Type locality Fresno County, California. Types?)

*Material examined.* From Burmese collections:

Rangoon, Hanthawaddy district, September, 3 clitellate specimens.  
K. John.

Kayan, Hanthawaddy district, September, 1 clitellate specimen. K. John.

Taik-kyi, Insein district, September, 1 clitellate specimen. K. John.

Wanetchaung, Insein district, September, 1 clitellate specimen. K. John.

Toungoo, Toungoo district, October, 1 clitellate specimen. K. John.

---

Rangoon, Hanthawaddy district, June, 1 clitellate specimen. K. John.

*External characteristics.* Length 20-23 mm. Diameter 1 mm. Unpigmented. Prostomium? (Buccal cavity everted and first two segments softened.) Dorsal pores lacking. Nephropores? The setae begin on ii on which all four couples are present; on segments just behind the clitellum *ab* and *cd* are about equal, *aa* < *bc*. The clitellum is dark reddish, annular, not protuberant, boundaries not clearly demarcated but probably extending from a postsetal portion of xiii to 20/21; intersegmental furrows lacking, setae present. There are no spermathecal pores. The female pores are transversely placed slits on xiv, on *b*, probably about midway between the setal arc and site of 13/14.

The male pores are on xvii at the ventral ends of tiny, conical protuberances from the central portions of nearly circular, fairly sharply demarcated porophores extending from a lateral portion of *aa* into the median portion of *bc*, the male pores just lateral to *b*. Just median to the male pore on the right side of one specimen there are visible the

tips of two setae, *a* and *b*, but on the left side of the same worm only one seta is visible.

*Internal anatomy.* A vertically placed glandular mass on each side of the oesophagus in vii and viii is characterized by an iridescent appearance. Between 6/7 and the posterior end of the pharyngeal bulb there are further iridescent masses. In vi-vii the gut is widened and with stronger wall but no especial muscularity is recognizable. The oesophagus in ix is dorsoventrally flattened and rather broad. Into the lateral face of this portion of the gut there passes on each side the very short stalk of a rather pear-shaped, relatively large calciferous sac which hangs ventrally beneath the oesophagus. The intestine begins in xii. No typhlosole.

The dorsal blood vessel (single) is continued anteriorly into the region of iii. A supra-oesophageal trunk is present in ix-xi. The hearts of x-xi bifurcate dorsally, the anterior branch passing onto the gut, the posterior branch to the dorsal trunk. No subneural.

Nephridia of the Rangoon worms are flattened out against the body wall, in contact with both septa of a segment, extending from *b* well towards the mid-dorsal line. A portion of each nephridium has a yellowish, translucent and granular appearance. From xi anteriorly the yellowish investment is lacking and from xiv anteriorly the nephridia are smaller though still flattened out against the body wall. Nephridia of the Kayan worm are small, slender loops, not flattened, not in contact with either septum of a segment, and with no or almost no granular investment.

The male funnels, two pairs, are free, each funnel with a brilliant orange-red iridescence. The testis sacs, in x and xi, are vertical structures reaching upwards into contact with the dorsal blood vessel. There are no seminal vesicles. The elongately tubular prostates, circular in cross section, extend back into xxv or xxvi but are long enough to reach into xxviii-xxx when uncoiled. A duct is scarcely recognizable. The vas deferens on each side passes into the parietes just anterior to the ectal portion of the prostate, union of deferent and prostatic ducts within the parietes. No setal follicles are visible in the neighborhood of the ectal portion of the prostate nor splits in the longitudinal musculature such as might indicate the presence of setae.

Ovaries are large but with few though large ova. Oviducal funnels are rather large and have thick rims.

*Remarks.* The June specimen from Rangoon differs from the other worms as follows: clitellum light yellowish, male pores minute apertures of about the same size as openings into setal follicles, on xvii,

very slightly posterolateral to *b*, no porophores, no modification of epidermis around the male pores, setae *a* and *b* of xvii present on both sides; prostates short, nearly straight, transversely placed, smaller than the nephridia. The worm appears to be only a slightly abnormal specimen of *occidentalis* but the shortness of the prostates is suggestive of Eisen's var. *arizonae*.

*Distribution.* Probably widely distributed throughout tropical and subtropical regions, already recorded from North America, West Indies, Africa, China, India and Burma (Hanthawaddy, Insein and Toungoo districts).

#### Genus THATONIA gen. nov.

*Diagnosis.* Male pores on xviii. Quadriprostatic, prostatic pores on xvii and xix, at termini of seminal grooves. Quadrithecal, spermathecal pores on 7/8 and 8/9. Setae closely paired. Gizzard in vii. Holandric; seminal vesicles in xi and xii.

*Genotype.* *Thatonia gracilis spec. nov.*

*Distribution.* Burma.

*Remarks.* Close to *Malabaria* from which it is distinguished at present by the acanthodriline male terminalia and the presence of spermathecae opening to the exterior in 7/8. Distinction from *Malabaria* may be questioned. In view of the apparent uniformity of the microscolecine male terminalia and the bithecal condition in *Malabaria*, as well as the apparent validity of such distinctions for generic definition elsewhere in the Ocnerodrilidae and also in other families, generic status seems preferable to inclusion in *Malabaria*.

According to orthodox oligochaete phylogeny, *Thatonia* with a quadrithecal battery, acanthodriline male terminalia and single gizzard is primitive but with regard to the calciferous portion of the oesophagus is highly specialized. Comment on the last assumption has been made in connection with *Malabaria*. A possibility that the primitive ancestral Ocnerodrilid had no gizzard may well be worthy of consideration.

#### THATONIA GRACILIS spec. nov.

*Material examined.* From Burmese collections:

Taungzun, Thaton district, September, 1 clitellate specimen. K. John.

Kyaikto, Thaton district, October, 3 acitellate and 1 clitellate specimens in poor condition. K. John.

- Thongwa, Hanthawaddy district, September, 21 juvenile and 5 acitellate specimens. K. John.
- Kayan, Hanthawaddy district, September, 4 acitellate specimens. K. John.
- Kyaiklat, Pyapon district, September, 8 acitellate specimens. Maung Ohn Maung.
- Maubin, Maubin district, September, 2 juvenile specimens. Maung Ohn Maung.
- Danubyu, Maubin district, October, 6 partially clitellate specimens. Maung Ohn Maung.
- Ingabu, Henzada district, October, 1 acitellate specimen. Maung Ohn Maung.
- Zalun, Henzada district, October, 2 acitellate specimens. Maung Ohn Maung.
- Henzada, Henzada district, October, 17 partially clitellate specimens. Maung Ohn Maung.

*External characteristics.* Length 63–87 mm. Diameter *ca.* 1 mm. Unpigmented. Prostomium proepilobous or epilobous. No dorsal pores. Nephropores have not been identified definitely but may be on or near *b* at the anterior margins of the segments. The setae begin on ii on which all four couples are present; behind the clitellum *ab* and *cd* are about equal, *aa* a trifle larger than *bc*, *dd ca.* =  $\frac{1}{2}C$ ; ventral setae of ii, iii or iv to ix, x, xi or xii enlarged, especially so on viii or viii and ix, lateral setae of the preclitellar segments also somewhat larger than on the postclitellar segments but not as large as those of the ventral couples.

The clitellum is light yellowish, saddle-shaped, not protuberant, reaching ventrally to *b*, extending from 12/13, a posterior portion of xiii or 13/14 to 22/23, onto xxiii or even to 23/24, anterior and posterior limits practically unrecognizable externally but clearly visible at the mid-dorsal incision; intersegmental furrows lacking, setae present. The ventral margin of the clitellum may be unrecognizable or practically so or the non-clitellar mid-ventral region may be distinguished by a white appearance which ends abruptly at or near *b*.

Actual spermathecal apertures have not been seen on most specimens but are represented by transversely slit-like depressions on 7/8 and 8/9 with anterior and posterior margins swollen and lip-like, the centers of the depression in *ab*. On one worm from Danubyu a single spermathecal pore is clearly visible as a small, transversely placed slit

on the ventral face of a markedly protuberant, almost spheroidal swelling. The female pores are on or just lateral to *b*, just behind 13/14.

The genital shield is longitudinally placed, slightly raised, whitish, extending when completely developed from or just behind 16/17 to or nearly to 19/20, widest on xvii and xix where it reaches into *bc*, occasionally nearly to mid *bc*, narrowest on xviii where it may or may not reach to *a* or *b*. The shield is fairly sharply demarcated on the most mature specimens and presumably is an area of epidermal thickening though this is scarcely visible in incisions through the male region, except around the prostatic pores where the body wall is certainly thickened. On less mature specimens there are two longitudinally placed greyish translucent bands extending anteroposteriorly between the setal arcs of xvii and xix in *ab* but bent mesially on xviii. As a result of this median bending on xviii the shield appears to have a rather H-shaped marking. On more mature specimens the greyish bands may be median to *a* and are depressed, with an appearance of rather wide seminal grooves. The prostatic pores are at the termini of the grooves, usually just in front (xvii) or just behind (xix) the ends of the grooves. The male pores, smaller than the prostatic apertures, are on xviii, anteromedian to *a*, on the median margin of or just median to the groove.

On the youngest juveniles the ventral setae of xvii and xix are present. Epidermal modifications in the vicinity of these setae are either lacking or so slight as to be unrecognizable with high magnification and brilliant illumination. Yet in two such specimens, on dissection, two pairs of prostates were found, each gland about one half mm long. Presumably then some epidermal modification has taken place even though unrecognized. On older juveniles the *b* setae or more rarely the *a* setae alone are lacking on one or both segments, or the ventral couples of both segments may be missing. The only epidermal modification recognizable on these worms is a slight tumescence at the sites of the missing setae. On partially clitellate specimens the setae are probably also lacking though on an occasional specimen tiny black dots in the epidermis do look like tips of retracted setae. Ventral setae of xviii are usually present, possibly always, but are small and at times difficult to identify.

*Internal anatomy.* All septa from 5/6 posteriorly are present; 5/6-8/9 thickened and with muscular fibres.

In iv-viii, on each side of the oesophagus there are masses of iridescent glandular (?) material. The gizzard is in vii (10), spheroidal or shortly ellipsoidal, much longer and thicker than the portion of the gut

in viii, usually with only slight muscular sheen but with thick and strong wall. In ix and x the gut is markedly moniliform, constricted septally, much wider than in xi-xii, the wall thickened and extensively vascularized. The floor of the gut in ix may be thicker than the rest of the wall or such thickening may be unrecognizable. There are no calciferous sacs nor are intramural diverticula recognizable. Occasionally there is visible on the floor of the gut in ix a slight, longitudinally placed groove at the median line, the groove not reaching anteroposteriorly to the segmental limits. On the inner wall of the oesophagus in xi there are several thick but low, longitudinal whitish ridges. The intestine begins in xii (15), the valve anteriorly in the same segment. There is no typhlosole. In the region of the prostates the gut may be much narrowed in one or two segments and with a series of transversely placed, unpaired ventral caeca just behind the narrowed region, one caecum in each segment. These conditions were noted in specimens in which the prostates are most compactly coiled—having been unable to push posteriorly. Possibly the supposed ventral caeca are merely the result of unusually deep ventral constriction of the intestine by the septa.

The dorsal blood vessel (single) is continued anteriorly to the region of the supra-pharyngeal ganglia. A supra-oesophageal trunk is present in viii-xi, in the posterior portion of xi bifurcated, the branches passing ventrally on the lateral faces of the oesophagus. The ventral trunk bifurcates just in front of the anterior margin of the subpharyngeal ganglia, the branches passing laterally on the parietes. The extra-oesophageal trunk is first visible as a small vessel on the parietes parallel and slightly lateral to the nerve cord, just anterior to 5/6 receiving a larger vessel from the lateral and dorsal parietes, passing upwards on 5/6 and into vi where it is lateral to the gut as in vii. In viii the trunk is slightly lower, posteriorly in viii or anteriorly in ix passing onto the ventral face of the gut close to the median line whence it is continued into xii. In some specimens each trunk apparently ends by merely disappearing from sight in the posterior part of the segment, in other worms the trunk passes off from the gut in an anterior portion of xii (with no visible continuation posteriorly on the gut) and to the parietes where it runs posteriorly for a short distance parallel and slightly lateral to the nerve cord. No subneural. The hearts of x and xi bifurcate dorsally, one branch passing to the dorsal vessel, the other to the supra-oesophageal (4), both branches empty, white and slender. Commissures of ix can be traced to the dorsal trunk only. The last pair of hearts is in xi (15).

The nephridia from xxii or xxiii posteriorly are large, thick, transversely placed, almost rectangular, compact discs in which looping is scarcely recognizable, in contact with both septa of a segment, extending from *a* to or nearly into contact with the dorsal blood vessel and filling all of the space between the body wall and the gut. A very slender duct (?) passes into the parietes in a presetal portion of the segment at or near to *b*. In an occasional segment of each of several specimens a narrow, neck-like region of a nephridium passes mesially just anterior to the duct nearly to the nerve cord and then turns anteriorly and penetrates not only through the septum but also through septa of the next three or four segments, finally terminating in a bulbous swelling just in front of a septum, the swelling single or in two distinct lobes, in either case quite funnel-like in appearance. Preservation is too poor to warrant further description. In several other specimens structures that appear to be funnels with normal relations to the anterior septa of the segments were found. In xv to xxii or xxiii the nephridia are transversely placed loops, rather delicate, and with a few tiny patches of transparent granular material. In xiv and xiii nephridia are still smaller but readily recognizable. In xii-x or ix nephridia are much smaller, poorly preserved and often lost in washing out masses of coelomic coagulum. From ix or viii anteriorly nephridia have not been found.

The male funnels are free in x and xi, well developed but with no spermatozoal iridescence (15). Small disc-like bodies in the usual locations on the posterior faces of 9/10 and 10/11 appear to be testes. Seminal vesicles of xi reach into contact over the dorsal blood vessel and fill the available space in the coelomic cavity of the segment. Vesicles of xii, in the most mature worms are much larger, in contact above the dorsal trunk and pushing 12/13 and 13/14 back into contact with 14/15. The deferent duct passes lateral to the prostatic duct of xvii and penetrates into the body wall in xviii anterior to seta *a*. The prostates are long, coiled into a compact mass extending through several segments or penetrating posteriorly alongside the nerve cord into the region of l-lx. The margins are somewhat irregular and the surfaces are flecked with whitish spots. The mottled appearance is due to a close crowding of granules in certain cells. The glands are one-cell thick posteriorly. Ducts are slenderer than the glands and may be looped in a rather zigzag fashion, passing into the parietes in xvii and xix in *ab*. A circular region in the body wall into the center of which the duct passes is firm but not protuberant. The ectal portion of the duct can be pulled out from the parietes, apparently intact.

The spermathecae are large, coiled, in viii and ix, reaching into contact with the dorsal parietes. The ampulla which is elongately tubular (length 3+mm.) has a rather thin and translucent wall. The duct is very much shorter than the ampulla and slightly narrower, the wall thick and lumen narrow but slightly irregular, the duct slightly widened as it passes into the parietes. No diverticula or seminal chambers. Spermatozoal iridescence has not been observed in any of the spermathecae.

*Abnormalities.* A number of the worms appear to be abnormal. Of these 17 are posterobiprostatic, the anterior prostates lacking, the genital shield with no anterior widening and ending at or just in front of the site of 17/18, the seminal grooves terminating slightly in front of the male pores. On these specimens (three from Kayan, one from Taungzun, three from Thongwa, one from Zalun, one from Ingabu, three from Danubyu, and five from Henzada) the ventral setae of xvii are present. On three worms one prostate only of xvii is lacking, the anterior widening of the shield lacking on the side of the missing prostate, the seminal groove of that side terminating anteriorly just in front of the site of 17/18, the ventral setae of the abnormal side present (left prostate lacking in two worms from Danubyu, the right lacking in one from Zalun).

Another worm is much more abnormal, the right half of the genital shield about one mm behind the left half, four spermathecae on the left side two of which are in one segment.

*Remarks.* After two failures a complete series of transverse sections (10 u thick) through the calciferous portion of the gut were obtained. In spite of the fact that the specimen had been killed and preserved without benefit of special fixation for histological purposes the preservation must be considered good. Vascular spaces in the thickened floor of the oesophagus are completely filled with blood. There are no vertical clefts in regions between vascular lamellae (as in *Malabaria*, *vide* fig. 38, pl. 33, Stephenson 1924). In the thickened floor of the gut are numerous branching canaliculi, mostly seen in transverse section. The thickness of the wall of each canaliculus is about the same as the diameter of the lumen, the wall very sharply outlined as if by a definite membrane both externally and internally (next to the lumen). Nuclei and cell walls are quite unrecognizable. In just one section there is visible close to the ventral surface of the gut wall and at both sides of a median, vertically placed, blood mass, a pair of spaces similar to those marked "x" in Stephenson's fig. 39. In other sections one or both of these spaces is lacking or one of the spaces may be replaced by

two or even three smaller spaces. Each of the larger spaces (canals) is also provided with a wall sharply marked off externally as well as next to the lumen and with no nuclei or cell walls recognizable. These canals appear to be formed by junction of the smaller canaliculi. None of the canals or canaliculi have been traced into the gut lumen.

In two consecutive sections (and here only), midway between the outer and inner surfaces of the floor of the oesophagus there is a pair of larger spaces, one on each side of the median plane. The walls of these spaces are not as sharply marked off as those of the canals and canaliculi but are cellular with about ten fairly large nuclei recognizable in each section. The width of this cellular wall is much less than that of the lumen which is filled by a fine, webby material. There is no median groove in the floor of the gut in the region of the sections containing the canals or the cell-lined spaces.

Much thinner sections will be necessary for elucidation of the relationships of canaliculi, canals and cell-lined spaces but with the canaliculi ramifying throughout the floor of the gut there is nothing particularly suggestive of external calciferous sacs reduced to diverticula and retracted, as it were, into the floor of the gut.

Blood in the vascular spaces of the floor of the gut is stained as elsewhere a bright red but blood in the vascular spaces of the roof of the gut is uniformly unstained and of a greenish-translucent appearance which is retained clear to the dorsal surface where the red coloration again appears.

*Diagnosis.* Seminal grooves in or median to *ab*, bent mesially on xviii to produce a rather H-shaped figure, on a genital shield extending nearly to 16/17 and 19/20. Prostatic pores on setal arcs and at termini of seminal grooves, male pores anteromedian to *a*. Spermathecal pores in *ab*. Clitellum saddle-shaped (?), on xiii-xxii or xxiii. Setae:  $ab = cd$ ,  $aa > bc$ ,  $dd = \frac{1}{2}C$ ; ventral setae of xvii and xix lacking, setae of some preclitellar segments enlarged, especially *a* and *b*. Prostomium epilobous. Unpigmented. Length 63-87 mm. Diameter 1 mm.

Spermathecal ampulla much longer than the duct, tubular, coiled; duct slightly widened just prior to entrance into parietes.

### Family MEGASCOLECIDAE

#### Genus WOODWARDIELLA Stephenson 1925

In an earlier paper (Gates, 1938, p. 428) it has been pointed out that several Indian species hitherto included in the genus *Woodwardiella*

must be transferred to other genera. One such transfer has already been made, and the exclusion of others leaves but four species in the whole area west of Australia. Of these two may be identical, and all may have been exported from Australia. A Ceylonese species, *W. uzeli* (Michaelsen) 1903, known only from a rather brief description that contains at least one error (with regard to the setal ratios), is distinguished from Indian and Burmese forms by a more posterior location of the first dorsal pore (?), location of spermathecal pores lateral to *b* and just behind 7/8–8/9, constant presence of post-setal papillae on xvii "in den Borstenlinien *b*", presence of paired female pores, and the presence of a typhlosole (location of last hearts unknown).

Australian species are so variable with respect to characteristics that may be of generic importance (such as presence or absence of calciferous glands) as to indicate a need for further revision of the remaining and larger portion of the genus. Most species are so inadequately characterized that such revision is inadvisable until further studies of internal anatomy have been made.

#### WOODWARDIELLA JAVANICA (Michaelsen)

1910. *Woodwardia javanica*, Michaelsen, Mitt. Mus. Hamburg, XXVII, p. 93.  
(Type locality Buitenzorg, Java. Types in the Hamburg Museum.)

*Material examined.* From Burmese collections:

Boyagyi, Thaton district, October, 4 acitellate and 4 clitellate specimens. K. John.

Mupun, Amherst district, October, 1 clitellate anterior fragment. K. John.

*External characteristics.* Length, 55–75 mm. Diameter, 1–1¼ mm. Unpigmented. Prostomium proepilobous. Nephropores not seen. The first dorsal pore is on 6/7 (6).

The setae begin on ii; the setal ratios on xx are, so far as can be determined, about the same as on *pumila*,  $ab < aa < \text{or} = bc < cd$ ,  $dd = \text{or}$  slightly greater than  $aa$ , posteriorly  $dd < aa$ . Anterior to the clitellum *d* seems to be more dorsal than on *pumila*.

The clitellum is usually slightly protuberant, light brownish, annular, extending from 13/14 or from some portion of xiii to 17/18; intersegmental furrows and dorsal pores lacking, setae present but deeply retracted and scarcely visible.

Quadrithecal, spermathecal pores minute and superficial, on 7/8–8/9, on or immediately lateral to *a*.

A single, median female pore is visible just anterior to the setal arc of xiv, on two clitellate and two acitellate specimens.

The male pores (common apertures of the prostatic duct and penisetal follicles) are at the centers of small, slightly protuberant, rather indistinctly demarcated porophores of circular to shortly elliptical outline (in the latter case transversely placed), each porophore about as wide as *ab*, the center of a porophore slightly lateral to *a* to just median to *b*.

Genital markings apparently are lacking, but markings like those of *pumila*, if present, would be unrecognizable on most of these specimens.

*Internal anatomy.* Septum 5/6 is membranous to slightly muscular; 6/7-11/12 muscular; 12/13 slightly muscular.

The gizzard is in v (7), with brilliant muscular sheen. The oesophagus, behind the gizzard, is slightly constricted by the septa and hence somewhat moniliform, the inner wall in vii-xiii or xiv provided with low, longitudinal non-lamelliform ridges, these ridges crossed in vii-ix or viii-ix by circular furrows to mark off rather low, almost conical protuberances. The intestine begins in xviii (7), the part in xviii rather conical, with narrow portion anteriorly, full intestinal width attained only at 18/19. The valve is in xvii or a posterior portion of xvii and the anteriormost part of xviii, and is unusually narrow. The intestine may be slightly constricted at 18/19 but does not have a valvular structure at the constriction. There is no typhlosole (5).

The dorsal blood vessel (single) is continued anteriorly to the region of the cerebral ganglia. A supra-oesophageal is present in vii-xiii, disappearing from sight at 6/7 and 13/14, as large as the dorsal blood vessel when distended with blood, occasionally empty and then unrecognizable. Extra-oesophageals are present, apparently much as in *pumila*, but are always empty in part and then unrecognizable. In xiv-xviii, on each side there is usually visible a fairly large, lateroparietal trunk which passes mesially just anterior to 13/14 and into the extra-oesophageal trunk. In one worm the right lateroparietal vessel terminates abruptly in xv, but a large branch from the left vessel passes underneath the nerve cord to the right side in xvi and then posteriorly into xviii. In one specimen each lateroparietal trunk bifurcates just anterior to 13/14, the larger branch passing to the extra-oesophageal trunk, the smaller passing up onto the dorsal face of the gut. No subneural. The last pair of hearts is in xii (7). The hearts of x-xii bifurcate dorsally, one branch passing into the supra-

oesophageal trunk, the other to the dorsal vessel. Commissures of ix may be as large as the hearts. The commissures of ix and the hearts of x-xii have been traced to the ventral trunk, the commissures of viii-vi not so traced.

The nephridia from xix posteriorly are flattened out against the parietes, in contact or nearly so with both septa, extending from *a* or *b* to *c*. The nephridia of xviii are small and anterior to the prostatic duct. In xvii-xiv of the acitellate specimens the nephridia are also flattened (decreasing in size anteriorly) while in the clitellate specimens the nephridia are not flattened but look like clusters of micronephridia. In xiii-ix the nephridia are on the anterior faces of the septa, small in xiii-ix, slightly larger in viii-vii, large and like clusters of pharyngeal micronephridia in vi-v. In the postprostatic segments the body wall is covered with a layer of coelomic coagulum (?), as in *pumila*.

The male funnels are free in x and xi. The seminal vesicles are fairly large, in contact above the dorsal blood vessel, or reaching to the dorsal trunk, paired in xi and xii; each vesicle acinous, the lobes pear-shaped, the narrowed central portions rather loosely bound together. Segments x and xi are filled with a delicate coagulum in which the anterior vesicles are imbedded. The vesicles are soft, especially in xi of clitellate worms, and may be destroyed in removing the coagulum. The prostates are confined to xviii, slightly dislocating 17/18 and 18/19, or just penetrating into xvii or xix. The duct is  $1\frac{1}{2}$ -2 mm. long, bent into a U-shaped loop or coiled, the ectal half thicker but the whole duct with a brilliant muscular sheen.

On the posterior face of each prostatic duct there are two penisetal follicles, the follicles united at the ental ends, diverging ectally to pass into the parietes separated by a strand of longitudinal musculature. Each follicle contains one functional seta and often a shorter reserve seta. The setal shaft is variously curved, occasionally with two or three curvatures on a single seta. The tip is flattened and narrowed, thin and usually bent over to one side, tapering to a sharp point (triangular tip). The margins of the ectal half of the shaft are sinuous, the sinuosities alternating on opposite sides of the shaft as if due to a groove running in a spiral fashion around the shaft. In each sinuosity towards the tip and close against the shaft a rather triangular tooth is recognizable with oil immersion objective. After drying or twisting of the shaft, teeth may stand out much more conspicuously. Measurements (in mm. by Miss Chapman) are given below.

## PENIAL SETAE

<i>Seta</i>	<i>Length</i>	<i>Width base</i>	<i>Width midshaft</i>	<i>Width tip</i>	<i>Thickness at side</i>
a	0.60	0.006	0.005	0.0015	0.001
b	0.58	0.006	0.005	0.002	0.001
b(r)	0.32	0.003	0.002	....	0.001
a	0.69	0.007	0.005	0.002	0.001
b	0.63	0.006	0.004	0.002	0.001
b(r) <sup>1</sup>	0.41	0.006	0.004	0.002	....
a	0.60	0.005	0.004	0.001	....
b	0.63	0.006	0.004	0.002	....
b(r)	0.15	0.002	0.002	....	....
a	0.55	0.005	0.005	0.002	....
a(r)	0.40	0.004	0.004	0.001	....
b	0.59	0.006	0.004	0.002	....
b(r)	0.47	0.007	0.005	0.002	....
a	0.63	0.007	0.005	0.003	....
a(r)	0.36	0.003	0.003	....	....
b	0.62	0.007	0.006	0.002	....
b(r)	0.23	0.003	0.002	....	....

<sup>1</sup> Ornamentation continued two thirds way down the shaft. (r) reserve.

The spermathecae are large, reaching up into contact with the dorsal parietes. The duct is much shorter than the ampulla. In the ectal half, almost confined to the parietes, the lumen is very narrow and with a smooth wall of high epithelium surrounded by a muscular (?) layer of about the same thickness. Entally the duct is slightly and gradually widened, the lumen enlarged but irregular. This ental portion of the duct is not marked off externally from the ampulla which is also gradually widened entally, the duct distinguished in cleared spermathecae by the thicker wall. The elongate and slenderly club-shaped diverticulum which passes into the lateral face of the duct just above the parietes is about as long as half the combined lengths of duct and ampulla. There is no external demarcation into seminal chamber or stalk, the latter only slightly narrower than the chamber and recognized by the thicker wall and narrow lumen. The chamber is about as long as the stalk, the sperm mass in the latter straight or slightly looped or even with an appearance of slight spiral coiling entally. The diverticulum opens into the widened lumen of the ental portion of the duct, immediately above the aperture into the narrowed lumen.

*Remarks.* The worms are not well preserved, softened just behind the clitellum, the clitellar region as well as a short portion just behind and just in front roughened. Two of the acitellate specimens, with spermatozoa in the seminal chambers of the spermathecae are probably postsexual.

*W. javanica* has been known hitherto only from the types, the original description not quite as complete as is now desirable. There is however no evidence to indicate that the Burmese worms should be distinguished taxonomically from the types. Michaelsen presumably missed the delicate anterior vesicles imbedded in the testicular coagulum. Seminal vesicles are certainly lacking in ix in the Burmese worms.

*W. javanica* is close to *W. callichaeta*, *affinis*, *libferti*, and *molaeleonis* (Michaelsen) 1907, being distinguished from these southwest Australian species mainly by the presence of a single female pore, and the location of the anterior seminal vesicles in xi rather than ix. Earthworms of the Australian region, of the small size of *javanica*, are doubtless very imperfectly known. It is therefore possible that both the Java and Burma records indicate importations from some eastern portion of the Australasian region.

*Diagnosis.* Quadrithecal, spermathecal pores on 7/8-8/9, on *a*. Male pores in *ab*, on xviii, each pore at center of a small, circular to shortly elliptical porophore that is about as wide as *ab*. Female pore median. Seta *d* dorsal, behind the clitellum close to the mid-dorsal line so that  $dd < aa$ . First dorsal pore on 6/7. Unpigmented. Length 38-75 mm. Diameter  $1-1\frac{1}{3}$  mm.

Gizzard in v. Intestine begins in xviii. Hearts latero-oesophageal, in x-xii. Holandric; seminal vesicles in xi-xii. Prostatic duct  $1\frac{1}{2}$ -2 mm. long, looped or coiled. Spermathecal duct much shorter than the ampulla, diverticulum about half the length of main axis, into lateral face of duct near the parietes. Penial setae 0.55-0.69 mm. long, 0.005-0.007 mm. thick at base, 0.004-0.006 at midshaft, 0.0015-0.003 across flattened tip; margins of ectal half of shaft sinuous, sinuosities alternate and at least ectally containing each a rather triangular tooth.

*Distribution.* Boyagyi, Thaton district; Mupun, Amherst district, Burma; Buitenzorg, Java.

#### WOODWARDIELLA PUMILA Stephenson

1931. *Woodwardiella pumila*, Stephenson, Proc. Zool. Soc. London, 1931, p. 51. (Type locality Bhamo. Type in the British Museum.)

*Material examined.* From Burmese collections:

Sittang, Thaton district, October, 3 acitellate specimens. K. John.

Pegu, September, 2 acitellate and 44 clitellate specimens. K. John.

"Jungle", west of Pegu, September, 1 acitellate and 8 clitellate specimens. K. John.

Rangoon, Hanthawaddy district, June, 32 clitellate specimens; September, 45 clitellate specimens; February, 1 acitellate and 8 clitellate specimens; March, 27 clitellate specimens. K. John.

Kungyangon, Hanthawaddy district, September, 12 juvenile or acitellate and 1 clitellate specimens. K. John.

Kyauktan, Hanthawaddy district, September, 2 acitellate specimens. K. John.

Thameintaw, Pyapon district, September, 1 clitellate specimen. Maung Ohn Maung.

Pyapon, September, 1 clitellate specimen. Maung Ohn Maung.

Danubyu, Maubin district, October, 3 juveniles. Maung Ohn Maung.

Wakema, Myaungmya district, October, 3 acitellate and 1 clitellate specimens. Maung Ohn Maung.

Myaungmya, October, 6 acitellate specimens. Maung Ohn Maung.

Bassein, October, 1 juvenile and 2 clitellate specimens. K. John.

Thinbawgyin, Bassein district, October, 1 acitellate specimen. K. John.

Padaukchaung, Bassein district, October, 1 acitellate specimen. K. John.

Toungoo, October, 4 juvenile specimens. K. John.

*External characteristics.* Length, to 76 mm. Diameter 1 mm. Unpigmented. Prostomium proepilobous, occasionally a single median furrow continued from the posterior margin of the prostomium along the mid-dorsal line towards 1/2. Nephropores were not seen.

The setae begin on ii on which all four couples are present (10). Anterior to the clitellum seta *d* is mid-lateral or perhaps a trifle on the dorsal side, from xvii or xviii posteriorly definitely dorsal. On xx,  $ab < aa <$  or  $ca. = bc < cd > dd$ ,  $dd =$  or  $> aa$ , but only a few segments posteriorly *dd* becomes smaller than *aa*.

The first dorsal pore is on 6/7 (18), but on a few other worms the rather pore-like marking on 6/7 may be imperforate.

The clitellum is usually slightly protuberant, reddish to brownish, setae present, dorsal pores (except that on 13/14) and intersegmental furrows lacking; annular, extending from 17/18 to a presetal portion of xiv, 13/14, a postsetal portion of xiii or even slightly onto the presetal half of xiii. The anterior boundary of the clitellum is often quite vague.

Quadrithecal, spermathecal pores minute and superficial, on 7/8-8/9,

on *b* or in *ab*. The location of the pores is variable from one side to the other, from one segment to another and from one specimen to another. Location on *b* is perhaps the most common, just median to *b* also frequent, an occasional pore only slightly lateral to *a*.

The single female pore is median, immediately in front of the setal arc, at the center of a transversely placed, whitish area of shortly elliptical outline in *aa* (32).

The male pores are in *ab*, just lateral to *a*, at or near mid *ab*, or just median to *b*, at or near the center of small transversely placed porophores of shortly elliptical (rarely almost circular) outline that are about as wide as or a trifle wider than *ab* and which may extend to just median to *a* or just lateral to *b*, on xviii. On an occasional specimen (12) a penial seta protrudes to the exterior through the pore, the pore unrecognizable if the seta is conspicuously protuberant.

The genital marking is a transversely placed, whitened area of elongately elliptical outline on 17/18 in *aa*. The marking is not protuberant, not demarcated except by colour differences, often unrecognizable. A somewhat similar but less obvious area may be present on 18/19 but crossed by the intersegment furrow.

*Internal anatomy.* Septum 5/6 is present but membranous or slightly muscular; 6/7-9/10 muscular; 10/11-11/12 slightly muscular.

The pharyngeal bulb is unusually short. Between the hinder end of the bulb and the gizzard there are masses of iridescent (glandular?) tissue which come readily away from the oesophagus. The gizzard is in v (15), dislocating 5/6 posteriorly in a funnel-like fashion. On the inner wall of the oesophagus in ix-xiii there are a number of closely crowded, low, non-lamelliform ridges of a grayish translucent appearance due to the presence of blood beneath the transparent epithelium. The intestine begins in xvi (oesophageal valve anteriorly or posteriorly in xvi) or xvii (2 specimens from Sittang) but may be much narrowed in xviii or xviii and xix presumably as a result of crowding by the prostates. There is no typhlosole.

The dorsal blood vessel (single) is continued anteriorly to the region of the cerebral ganglia where it bifurcates, the two branches passing ventrally on the pharyngeal bulb to the parietes. A supra-oesophageal is present in vii to xiii disappearing just behind 6/7 (or continued into vi) and just in front of 13/14. The ventral trunk bifurcates at the anterior margin of the suboesophageal ganglia, each branch passing to the body wall where it subdivides several times. The extra-oesophageals are first recognizable as longitudinal vessels just behind the circumoesophageal nervous commissures where they are formed by the

union of two or more vertical vessels from the parietes of i-iii, each trunk receiving two connectives from the ventral vessel behind the suboesophageal ganglia, passing up to a level just below the gizzard in v, with a transverse connective to the opposite trunk in viii, passing in ix onto the ventral face of the gut close to the midventral line and thence posteriorly, breaking up into two or three branches which disappear in xiv. In xiv-xviii on each side, on the body wall under the nephridia, there is a lateroparietal trunk which may be nearly as large as the dorsal blood vessel. Immediately anterior to 13/14 this vessel passes mesially behind the heart of xiii, and then directly into the extra-oesophageal or runs upwards to the level of the dorsal face of the gut, then turning ventrally to open into the extra-oesophageal. No subneural. The hearts of x-xiii bifurcate dorsally, the anterior branch passing into the supra-oesophageal, the posterior branch passing into the dorsal trunk. The last pair of hearts is in xiii (15). The commissures of ix-v connect the dorsal and ventral trunks, the hearts of x-xiii also passing into the ventral trunk. The supra-oesophageal receives numerous vertical vessels from the lateral faces of the gut in ix-xiii but these vessels are largest in xiii.

The nephridia from xiv or xv posteriorly are flattened against the body wall, in contact with both septa, extending from *a* or slightly lateral to *a* to *c*. From xiii or xiv anteriorly the nephridia are not on the parietes but on the anterior faces of the septa, small in xiv or xiii-x, larger in ix anteriorly, especially so in v-vi and with the appearance of clusters of micronephridial tubules. In the postclitellar segments the body wall is clothed with fine, whitish threads, the appearance like that of a micronephridial fur, but no tubular structure is recognizable in the threads, the whitish material regarded as coelomic coagulum.

The male funnels are free in x and xi (10). Segment x may be filled with a loose coagulum. The seminal vesicles of xi and xii may be large, filling the coelomic cavities of their segments and reaching up into contact with the dorsal blood vessel (6), or medium-sized to small, vertically placed bodies on the posterior faces of the septa. The prostates are racemose, lobed, compact, much like *Pheretima* prostates in appearance, in xviii (4) or xviii-xix (4). The duct is less than  $\frac{1}{2}$  mm. long, straight, slender, usually with a slight muscular sheen that is especially noticeable ectally.

Median to each prostatic duct there are two distinct penisetal follicles. One of these passes into a cleft in the longitudinal musculature on the median face of the prostatic duct, the other passing into the

body wall slightly more mesially. A follicle usually contains one penial seta; several follicles with two setae, the second presumably a reserve seta. The length of the setae varies from 0.28–0.42 mm., the diameter at the middle of the shaft from 6–8 micra. The shaft is nearly straight or with a slight curvature of the ectal end. The ental end may be shortly curved like the handle of a walking stick in which case the shaft has a slightly bowed appearance. The tip of the seta tapers gradually to a hair-like or filamentous process which may be straight or nearly so or bent or curved to one side. Along the ectalmost portion of the seta the margins have a slightly sinuous appearance. Under the oil immersion objective the margins appear to be slightly incised as if marking off rather elongately spinelike teeth (spirally arranged?). On two setae there is an appearance of very fine, almost hair-like spines, in (5–8) circles around the shaft. Usually penial setae are not recognizable externally and when visible only one protrudes through each male pore.

## PENIAL SETAE

<i>Seta</i>	<i>Length</i>	<i>Width base</i>	<i>Width midshaft</i>	<i>Locality</i>
f	0.31	0.006	0.007	Sittang
f	0.28	0.005	0.007	"
r	0.15	0.009	0.008	"
r	0.13	0.008	0.007	"
f	0.38	0.006	0.008	"
f	0.33	0.005	0.007	"
r	0.07	0.003	0.003	"
f	0.33	0.007	0.006	"
f	0.35	0.008	0.007	"
r	0.24	0.007	0.006	"
f	0.42	0.007	0.008	"
f	0.39	0.007	0.008	"
r	0.23	0.006	0.005	"

f functional

r reserve

The spermathecal duct is slender and usually slightly shorter than the ampulla from which it may or may not be clearly marked off externally. In an ental portion of the duct the lumen is fairly wide and filled with a dark material like that in the ampulla. Ectal to the diverticular junction the lumen appears to be very narrow and the duct wall thick but this portion of the duct usually is not satisfactorily

cleared. The diverticulum usually passes into the lateral face of the duct slightly ental to the middle of its length and is not marked off externally into stalk and seminal chamber, the latter recognizable in the cleared spermatheca by a thinner wall and the shortly ellipsoidal to sausage-shaped mass of spermatozoa within, the stalk only slightly slenderer than the chamber but with a thicker wall and a narrow lumen. In several spermathecae massed spermatozoa are continued from the seminal chamber through the stalk into the duct and in such spermathecae, when cleared, it is possible to see the diverticular lumen turn entally within the duct wall to open into the ental chamber of the duct just above the region where the duct lumen is abruptly narrowed. All spermathecae examined (from clitellate specimens) are characterized by a spermatozoal iridescence in the seminal chamber.

The ovaries are relatively large. Each ovary examined contains 10-16 full sized ova and at or near the center several much smaller ova. On the posterior face of 13/14 there are small paired sacs. In two worms these sacs were empty but in two other specimens the sacs contained ova.

*Parasites.* On some of the Rangoon specimens, especially on the clitellum and around the male pores, there are clusters of rotifers. These were sent to the British Museum but have not been further identified.

*Abnormality.* In a worm from Pyapon the dorsal blood vessel is double from the middle of xvii to 13/14, single to the middle of xiii and double to 12/13, single henceforward. The left heart of xiii is lacking in one of the Sittang specimens.

*Remarks.* *W. pumila* is very close to, if not actually con-specific with, *W. kayankulamensis* Aiyer 1929. The latter can be distinguished, according to the author's account, only by characteristics of doubtful value; more dorsal location of *d* setae on preclitellar segments, location of the male pore "in line with setae *a*", presence of "a single penial setal sac", and absence of "copulatory papillae". In contrast to his usual practice Aiyer failed to state definitely whether there is a single female pore or a pair of pores which may perhaps indicate that he did not actually see these apertures (types possibly not fully mature as there are dorsal pores on the clitellum). Copulatory papillae are certainly lacking in *pumila* but the whitened areas certainly deserve recognition as genital markings though not always recognizable, possibly due to condition.

Prof. Aiyer has kindly supplied three specimens of his species for

study but unfortunately two of these are juvenile while the other is acitellate though nearly sexual (male funnels iridescent but no iridescence in spermathecae). On these worms female pores and genital markings are unrecognizable. Anterior to the clitellum the *d* setae are more dorsal than on *pumila*. Male porophores are unrecognizable but male pores are in *ab*. Spermathecal diverticula pass to the lateral face of the ducts except on the right spermatheca of ix of one specimen. Two penisetal follicles are present in each worm on each side, the follicles separated ectally by a distinct strand of longitudinal musculature. All follicles were removed for examination but several were lost. All setae from *a* follicles except one have truncate tips (worn?) while setae from *b* follicles have tips terminating in a spine much like that of *pumila*. Ectal portions of *a* setae at least are more strongly curved than in *pumila*. The exceptional *a* seta has a terminal spine, shorter and thicker than in *pumila*.

If *pumila* and *kayankulamensis* should prove to be conspecific, the occurrence of the species in two such widely separated localities must indicate either transference from one area to the other or importation into both areas from still a third region, presumably somewhere in eastern Australasia.

Next to *kayankulamensis*, *pumila* appears to be closest to *javanica* from which it is distinguishable by the slightly more lateral location of spermathecal pores, presence of hearts in xiii, more posterior origin of the intestine, and slightly shorter penial setae. The suggestion has already been advanced that *javanica* may be an importation into both Java and Burma from some eastern portion of Australasia.

*Diagnosis.* Quadrithecal; spermathecal pores on 7/8–8/9, on or slightly median to *b*. Male pores in *ab*, on xviii, on or close to the center of small, transversely placed, slightly protuberant porophores of shortly elliptical outline in *ab* or reaching just median to *a* or just lateral to *b*. Genital marking a transversely placed, whitened area of elongately elliptical outline, in *aa*, on 17/18. Female pore median. Seta *d* dorsal behind the clitellum and after the first few postclitellar segments close to the mid-dorsal line so that  $dd < aa$ . First dorsal pore on 6/7. Unpigmented. Length to 76 mm. Diameter 1 mm.

Gizzard in v. Intestine begins in xvi or xvii. Hearts latero-oesophageal, in x–xiii. Prostatic duct  $\frac{1}{2}$  mm. long, straight, slender. Spermathecal duct slightly shorter than ampulla, diverticulum into lateral face of duct nearer ampulla. Penial setae 0.28–0.42 mm. long, 0.005–0.008 thick at base, 0.006–0.008 at midshaft, tip terminating in a hair-like filament.

Genus *PHERETIMA* Kinberg 1867*PHERETIMA BICINCTA* (E. Perrier)

1875. *Perichaeta bicincta* E. Perrier, C. R. Ac. Sci. Paris, LXXXI, p. 1044.  
(Types in the Paris Museum. Type locality unknown but supposed to be on Luzon or Mindoro, Philippine Islands.)

*Material examined.* From Burmese collections:

"Earth in large flower pots on veranda of faculty house", Judson College Compound, Kokine, Rangoon, 1 acitellate and 7 clitellate specimens.

*External characteristics.* The setae of x quite definitely appear to be smaller than those of ix and xi but have not been measured. The numbers of male setae on xviii and of setae on xx are; 8, 8, 8, 7, 7, 8, 8, and 47, 48, 46, 46, 48, 46, 48. The first dorsal pore is on 12/13 (8). Female pores are paired, diagonally placed slits, each pore very slightly anterior and median to *a*. Each male pore is at or near the center of a small, transversely placed, indistinctly demarcated area with outline approximating to shortly elliptical.

Genital markings are unrecognizable. On several specimens a number of minute, greyish translucent, circular areas on the postsetal portion of xviii median to the male pore lines are recognizable under best optical conditions. These areas probably mark sites of gland pores.

*Internal anatomy.* Septum 9/10 is strong and does not rupture easily but is almost transparent. On the oesophagus just anterior to 9/10 there is a ring of slight protuberances, probably rudiments of glands that form a circumoesophageal collar in other species. On the inner wall of the gut in x-xiii there is on each side a series of vertically placed ridges; longitudinal ridges at the median line dorsally and ventrally not noted. In xiv and the anteriormost portion of xv the gut is narrow and provided internally with low, longitudinally placed, whitish ridges. The typhlosole begins abruptly in the caecal segment and is a simple ridge about  $\frac{1}{4}$  mm. high. Passing posteriorly the typhlosole gradually decreases in height and is unrecognizable posterior to 1. There are masses of nephridia in v and vi but blood glands and lymph glands have not been found. Hearts of x-xii connect the ventral and supra-oesophageal vessels, branches to the dorsal trunk not found.

Seminal vesicles of xii are acinous, vertically placed bodies on the posterior face of 11/12, the vesicles of xi also acinous but smaller, included in the testis sac of xi. Posterior and just median to the ectal end of each prostatic duct and sessile on the parietes is a soft mass of

circular outline of glandular tissue which can be scraped away from the body wall leaving little if any evidence of its presence. There is no spermatozoal iridescence in the seminal chambers (4 specimens).

*Remarks.* All specimens are probably in a postsexual condition although the clitellum has regressed on one specimen. As there appears to be no variation with regard to the number of female pores the bipolar condition is regarded as a specific characteristic. Although genital markings appear to be lacking masses of glandular material in xviii are termed genital marking glands since indistinctly outlined genital markings have been noted in other specimens of the species, though there apparently less marked (epidermal modification slight) and more transitory than usual.

*P. bicincta* has not been reported hitherto from Burma though twice recorded from India, and was not obtained in other years when plants were repotted. The original home of the species is still unknown.

#### PHERETIMA HUMILIS spec. nov.

*Material examined.* From Burmese collections:

"Earth in large flower pots on west veranda of faculty house," Judson College compound, Kokine, Rangoon, September, 1936, 6 clitellate specimens (Types).

Same locality but after repotting, June, 1937, 10 clitellate specimens.

*External characteristics.* Length 20–23 mm. Diameter two mm. Segments; 75 (1), 78 (1), 79 (1), 80 (3). Unpigmented. Setae begin on ii on which there is a complete circle (6). Setal formulae are shown below. The first dorsal pore is on 12/13 (6). The clitellum is brownish, slightly protuberant, annular, extending from 13/14 to 16/17; intersegmental furrows and dorsal pores lacking, setae present ventrally on xvi.

#### SETAL FORMULAE

v	vi	xvii	xviii	xix	ii	iii	viii	xii	xvi	xx
29	33	12	7	10	40	47	58	52	6	42
29	29	11	7	11	..	40 +	56	48	6	44
26	27	12	8	12	..	..	55	50	12	40
..	..	10	8	12	..	..	..	48	11	42
..	..	11	6	10	..	..	54	49	8	38
..	..	12	8	11	..	..	57	46	6	41

Bithecal, spermathecal pores minute and superficial, on 5/6. There is a single female pore on four specimens, possibly a single pore on the

other two. Male pores have not been seen but are obviously minute and superficial, at or near centers of disc-like porophores of circular outline. No genital markings.

*Internal anatomy.* None of the septa are thickly muscular; 8/9 complete but membranous, 9/10 apparently lacking. The intestine begins in xv (4). Intestinal caeca are simple (4). The single heart of ix is on the right side (1) or the left side (1), a pair of hearts belonging to ix present in two specimens. The last pair of hearts is in xiii (4). All hearts of ix-xiii pass into the ventral blood vessel (2).

Testis sacs are probably unpaired and annular, except that the sac of xi in one specimen appears to be U-shaped, the limbs of the U reaching nearly to the dorsal blood vessel; hearts of x and xi included in the sacs (3), the dorsal blood vessel included in the sac of x (3) or beneath the sac (1), beneath the testis sac of xi (2). Seminal vesicles of xi are small and are included within the posterior testis sac or sacs (4). Vesicles of xii are small, vertically placed on the posterior face of 11/12, scarcely thicker than the hearts of xii. Prostates extend through xvi or xvii to xix. The prostatic duct is  $1\frac{1}{2}$ -2 mm. long, variously twisted or bent into a U-shaped loop.

The spermathecal duct is slender, longer than the ampulla (3), the wall thick, lumen abruptly narrowed at the diverticular junction. The diverticulum which passes into the median face of the duct near to but not at the parietes is as long as or longer than the combined lengths of duct and ampulla. The ectal half of the diverticulum, the stalk, has a very narrow lumen while the ental half is marked off into three rather ovoidal, equisized seminal chambers separated from each other by short, narrow, neck-like regions, each chamber distended by a hard, practically transparent mass.

*Remarks.* Because of the small size, determination of characteristics of the testis sacs is difficult. The ventral blood vessel appears to be actually within the sacs but filling the lumen so that testicular coagulum is not continuous from one side to the other ventrally. If however the ventral trunk is not within the sacs, characterization must be horseshoe-shaped.

Several small bithecal species with spermathecal pores on 5/6 are known. From these *humilis* may be distinguished as follows; from *P. lompopatangensis* (Michaelsen) 1899 by absence of genital markings and of 9/10, the shape of the spermathecal diverticulum; from *P. nugalis* Gates 1931 by the shape of the testis sacs and inclusion of seminal vesicles; from *P. pusilla* (Ude) 1893 by absence of genital markings; from *P. voeltzkowi* Michaelsen 1907 by absence of genital

markings and of 9/10, the presence of hearts in xiii; from *P. wui* Chen 1935 by the absence of genital markings, the shape of the testis sacs and inclusion of seminal vesicles; from *P. zoysiae* Chen 1933 by the presence of septum 8/9, more dorsal location of the spermathecal pores and the larger number of spermathecal setae.

In spite of extensive collecting throughout Burma over a period of more than fifteen years and the examination of many thousands of specimens from all sorts of situations in and around the city of Rangoon the species has not been found in a natural environment and disappeared from the author's flower pots after the second year of collection. In view of these facts and the association in the same pots with the obviously peregrine *bicineta* it is probable that *humilis* is also an importation into Burma.

The description above is based on the first series only, in order to save the second series for future reference.

*Diagnosis.* Bithecal, spermathecal pores minute and superficial, on 5/6. Male pores minute and superficial, each pore on a circular, disc-shaped porophore. Setae present ventrally on xvi: v/26-29, vi/27-33, xvii/10-12, xviii/6-8, xix/10-12, 40/ii, 47/iii, 54-58/viii, 46-52/xii, 6-12/xvi, 38-44/xx. First dorsal pore on 12/13. Length 20-23 mm. Diameter 2 mm. Segments 75-80.

Septum 8/9 present but membranous. Intestinal caeca simple. Testis sacs annular, seminal vesicles of xi included. Spermathecal duct as long as or longer than ampulla, diverticulum as long as or longer than main axis, with long stalk and three ovoidal seminal chambers separated from each other by short, neck-like regions.

#### Genus RAMIELLA Stephenson 1921

Six species are known of which most are inadequately characterized. In fact there is some doubt as to the correctness of including all of these forms in one genus. All species are small, one to two mm. in diameter and therefore especially liable to accidental transportation.

#### RAMIELLA CULTRIFERA Stephenson

1931. *Ramiella cultrifera* Stephenson, Rec. Ind. Mus. XXXIII, p. 187. (Type locality Rangoon. Types in the British Museum and Judson College.)
1935. (*Ramiella cultrifera*, Michaelsen, Ann. Mag. Nat. Hist. (10), XV, p. 103. (Christmas Island near Java.)

*Material examined.* From Burmese collections:

Rangoon, Hanthawaddy district, July, 1 clitellate specimen; August, 1 a clitellate specimen. K. John.

Hmawbi, Insein district, September, 1 a clitellate specimen. K. John.

Toungoo, October, 1 clitellate specimen. K. John.

Mt. Popa, Myingyan district, September, 1 clitellate specimen. K. John.

*External characteristics.* Length 33–35 mm. Diameter *ca.* 1 mm. The Rangoon worm is only 20 mm. long but may have autotomized a tail portion. Unpigmented. The prostomium is epilobous (tongue not marked off posteriorly — Mt. Popa specimen, tongue pointed posteriorly — Toungoo specimen, normal — Hmawbi specimen).

The clitellum is saddle-shaped, lacking in *aa* (Mt. Popa specimen, condition not determinable on Toungoo specimen as result of damage), from 12/13 to 17/18; intersegmental furrows and dorsal pores lacking.

The spermathecal pores are on viii and ix, on *b*, on the anteriormost margins of the segments just behind the intersegmental furrows. After dissecting the spermathecal ducts out from the parietes a strand of tissue is visible between the aperture and the intersegmental furrow. On one of the types the spermathecal pores are open, the segmental location readily recognizable.

The female pores are paired, slightly anterior and just median to *a*.

The prostatic and male pores are in *ab*, and on the setal arcs of xvii (or just behind), xviii and xix, perhaps a trifle nearer to *b* than *a*, the prostatic pores (common apertures of prostatic ducts and penisetal follicles) usually recognizable without difficulty, the male pores apparently a trifle smaller. The seminal grooves are nearly straight.

Genital markings are tiny, slightly raised tubercles of circular to transversely and shortly elliptical outline, with depressed, greyish translucent central spot: in *ab* just median to the spermathecal pores and at the posterior margin of viii (1 type and the Mt. Popa specimen); on x, in *ab*, between the postsetal secondary furrow and 10/11 (Toungoo specimen); lacking on four types and the a clitellate Hmawbi specimen.

*Internal anatomy.* Septa 5/6–10/11 are muscular and relative to the size of the animal might be called thickly muscular; 11/12 slightly muscular, opaque.

The gizzard is about twice the width and length of the portion of the gut in the segment next behind, with more or less marked muscular sheen, in vi (Toungoo and Hmawbi specimens). The oesophagus in

ix-xii is slightly moniliform, constricted septally, especially wide in x and xi, with low, irregular, closely crowded ridges placed vertically in xi but longitudinally in x, and larger, smoother, white, longitudinal ridges in xii-xiii. The intestine begins in xiv (4), the oesophageal valve in the anteriormost portion of xiv or reaching into xiii. A slightly irregular and low ridge which may be a rudimentary typhlosole is recognizable in one specimen from xvii posteriorly.

The dorsal blood vessel (single) is continued to the region of the cerebral ganglia. A supra-oesophageal trunk is present in x-xiii. Extra-oesophageal trunks are visible in vii or viii to ix or x, but are empty and unrecognizable anteriorly and posteriorly. Lateroparietal trunks from the region of xiv-xvi pass in xiii to the gut. No subneural. The hearts of xii are bifid (2), one branch passing to the supra-oesophageal trunk, the other to the dorsal vessel. Hearts of xi have been traced to the supra-oesophageal only, of x to the dorsal trunk only. The last pair of hearts is in xii (3).

Nephridia, poorly preserved and easily ruptured are flattened against the parietes in the postclitellar segments; in two longitudinal rows on each side, attached about at *b* and *d*. In one specimen there appears to be an additional row, mesially on each side, of much smaller nephridia. The posteriormost segments are filled with coagulum that is adherent to coelomic walls and segmental organs, removal of the coagulum almost impossible without damage to the excretory tubules, but a slender nephridial duct apparently passes into the parietes near seta *b*. Alongside this duct is a delicate filament (neck?) which can be traced occasionally to and through the septum next in front where it is enlarged into a funnel-like structure close to the ventral parietes. The neck and funnel break off and are lost with such ease that all attempts to remove and mount them for microscopic examination have been unsuccessful.

Male funnels are present in x and xi, both pairs with brilliant spermatozoal iridescence (Toungoo specimen), or the anterior funnels with no iridescence and the posterior funnels slightly iridescent (Mt. Popa specimen). The seminal vesicles are paired in xi and xii (Mt. Popa specimen) or present in xii only (Hmawbi and Toungoo specimens), in the Popa specimen reaching into contact with the dorsal blood vessel. The vas deferens of the Popa specimen is visible as a slightly irregular but strongly iridescent filament on or in the parietes and can be traced back to xviii where it disappears into the parietes midway between the prostatic ducts of a side, in xvii passing lateral to the prostatic ducts. The prostates are slightly flattened, shortly

elliptical in transverse section, looped; the anterior pair reaching into xviii, the posterior pair reaching into xx. The prostatic ducts are short, usually with slight (muscular?) sheen.

Two penisetal follicles, each containing two setae, pass into the parietes on the median face of each prostatic duct in the Popa specimen. Presumably one seta in each follicle is to be regarded as a practically mature, reserve seta. In the Hmawbi and Toungoo specimens there appears to be but a single follicle, each containing two setae, associated with each prostatic duct but the tissues are very delicate and readily separate leaving strands attached to each seta that may represent portions of two distinct follicles. In the Popa specimen both setae of any follicle may be alike or of the two types figured by Stephenson. In the Toungoo specimen the two types of setae are associated with each prostatic duct. The supposed differences between the two types of setae appear to be fictitious and of no importance. Actually each seta is ribbon-like, with the lateral margins along the whole of the shaft, or only a part, rolled into contact. Stephenson's figures 10 and 13 show a complete rolling, while figures 9 and 12 show a rolling of an ectal portion of the shaft. In figure 9 one margin only is rolled while in figure 12b both margins are slightly rolled, the bottom margin more so than the other. Pressure on the setae will usually flatten out most of the rolled portion of a shaft. Three setae mounted in water were flattened out or unrolled merely by the cover glass pressure induced by the evaporation of water while an earlier mount was being examined. The longitudinal line along the shaft towards the right in figure 13 represents the region where the edges or margins come into contact or overlap. This line is usually not to be seen, presumably because it runs along the side of the shaft as the seta lies on the slide but on one seta this line runs along the upper side of the shaft and is visible as a very narrow groove from the base of the tip almost to the ental end. When the ectal ends have been partially unrolled a short region ental to the point where the margins first meet or overlap is quite clearly cylindrical but further entally no trace of a hollow or central cavity is visible and the shaft appears to be solid. Each seta is bent in an arc as shown by Stephenson. A terminal ectal portion about 0.03 mm. long is abruptly narrowed, wrinkled and hooked to one side. This part appears to be solid and cannot be flattened out or unrolled. The ornamentation is of 7-15 short, transverse rows of triangular teeth of variable size, the rows not reaching across the whole of the shaft, and unrecognizable as rows until the shaft is unrolled or flattened. In addition, just behind the tip there may be a few scattered

teeth or irregular rugosities. Measurements in mm. (by Miss Chapman) are given below.

## PENIAL SETAE

Segment	Seta	Length	Width at base		Width at midshaft		Locality
			after unrolling	before unrolling	after unrolling	before unrolling	
xvii	a	0.66	0.030	.....	.....	.....	Mt. Popa
xvii	a	0.59	0.024	.....	.....	.....	
xvii	b	0.50	0.028	0.012	.....	.....	
xvii	b	0.58	0.028	0.014	.....	.....	
xvii	a	0.60	0.020	0.016	.....	.....	
xvii	a	0.61	0.027	0.015	.....	.....	
xvii	b	0.58	0.028	.....	.....	.....	
xvii	b	0.52	0.025	.....	.....	.....	Toungoo
xix	a	0.74	0.022	0.014	.....	.....	
xix	a	0.56	0.022	0.015	.....	.....	
xix	a	0.57	0.024	0.019	.....	.....	
xix	b	0.58	0.028	.....	.....	.....	
xix	b	0.60	0.022	.....	.....	.....	
xvii	a	0.93	0.033	0.024	0.022	0.011	
xvii	b	0.84	0.034	.....	0.027	.....	Hmawbi
xix	a	0.95	0.032	0.024	0.024	0.013	
xix	b	0.82	0.036	.....	0.028	.....	
...	.	0.95	0.031	0.022	0.030	0.017	
...	.	0.85	0.034	0.024	0.031	0.016	
...	.	0.92	0.032	0.026	0.029	0.016	
...	.	0.83	.....	0.027	0.030	0.017	

The ovaries contain a few relatively large ova. In the Toungoo specimen there is a pair of small ovisacs in xiv.

The spermathecal duct is slender, longer than the ampulla, erect and straight, nearly circular in cross section, the lumen narrow and slightly irregular, the wall thick, the epithelium lining the lumen high. The unstalked diverticulum may be borne dorsally at the ental end of the duct with the ampulla hanging ventrally, or the diverticulum and the ampulla may be perpendicular to the end of the duct and on opposite sides, or both diverticulum and ampulla may be pendent on opposite sides from the ental end of the duct. In the acitellate Hmawbi specimen diverticulum and ampulla are of about the same size, in other words the ampulla larger. Each diverticulum of the clitellate specimens is characterized by a spermatozoal iridescence, the spermatozoa in a long cord which is twisted and looped in a com-

plicated but quite irregular fashion within the diverticulum. In two diverticula the spermatozoal cord passes out of the diverticulum and straight across the duct lumen and down into the ectal portion of the ampulla. The latter is filled with a whitish, non iridescent material.

*Remarks.* Spermathecal conformations like those shown by Stephenson in fig. 8 or by Michaelsen in fig. 1 have not been found, the ampulla of the Christmas Island worm usually elongated. Nor has any evidence of Michaelsen's seminal chambers been found in the diverticula. The margins of the spermatozoal cord are clearly visible, the coils of the cord apparently filling the whole of a single-chambered diverticulum.

Stephenson found a gizzard in vii in one Rangoon specimen, and a similar location was noted for the Popa specimen but could not be verified after study of later specimens as the worm had been discarded. Michaelsen found the gizzard in vi (the usual location in the genus) in his specimens from Easter Island.

In addition to an apparent intraspecific variation in the segmental location of the gizzard there is variation in the conformation of the prostomium, completeness of the clitellum ventrally, location of the first dorsal pore, setal ratios, presence or absence of ovisacs and the angle of the spermathecal ampulla to the duct. At present these variations do not appear to be of especial importance (the incompleteness of the clitellum mid-ventrally may be due to beginning regression) but most species of the genus are very much alike, distinguished from each other at present rather unsatisfactorily by characteristics of (inadequately described?) penial setae and spermathecae and by the numbers of nephridia.

*Diagnosis.* Spermathecal pores on *b*, just behind 7/8 and 8/9. Prostatic pores (conjoined openings of prostatic ducts and penisetal follicles) in *ab* at termini of seminal grooves that reach from setal arc of xix to or nearly to the arc of xvii. Male pores in the grooves midway between the prostatic pores. Genital markings (when present) post-setal in *ab*, on viii and x. Clitellum annular, on xiii-xvii. First dorsal pore on 6/7-8/9. Length 20-35 mm. Diameter 1-1.2 mm.

Gizzard in vi. Holandric; seminal vesicles in xii. Spermathecal duct slender and longer than the ampulla; diverticulum spheroidal to ellipsoidal, sessile on ental end of duct. Penial setae ribbon-like, but with lateral edges rolled together along a considerable portion or the whole of the shaft, with a narrowed, hooked, and solid (?) tip; 0.50-0.95 mm. long, 0.012-0.027 thick at base unflattened, 0.022-0.034 flattened, 0.011-0.017 at midshaft unflattened or 0.022-0.031 flattened.

## Genus DICHOGASTER Beddard 1888

Although supposedly preserved in the usual manner much of the Burmese Dichogastrid material has been found to be in unsatisfactory condition perhaps because of maceration due to overcrowding in storage tubes. When worms of such small size are softened internally, determination of external characteristics, at best a rather tedious task, may be more than usually difficult or even impossible. Coelomic cavities are often filled with a sticky coagulum adherent to nephridia, ovaries, etc., and in washing out the coagulum considerable damage may be done to internal structures.

Accordingly a complete account of the internal anatomy of each species is impossible and results of studies of two forms in particular are so unsatisfactory that they have been discarded almost *in toto*.

In species of such small size external characteristics that will enable identification are especially needed. As a result of the study of the material listed below it may be stated that Burmese species at least can be recognized by the female pores (number and location) alone or in connection with certain easily recognized external characteristics. It is perhaps unnecessary to point out that for the present at least, any identification made from external characteristics should be confirmed from examination of internal structures with particular attention to the penial setae.

## DICHOGASTER AFFINIS (Michaelsen)

1890. *Benhamia affinis* Michaelsen, Mitt. Mus. Hamburg, VII, p. 9. (Type locality Quilimane, Zanzibar. Type in the Hamburg Museum.)

*Material examined.* From Burmese collections:

Bilin, Thaton district, September, 1 clitellate specimen. K. John.

Duyinzeik, Thaton district, September, 1 clitellate specimen. K. John.

Kyaikto, Thaton district, September, 7 clitellate specimens. K. John.

"Jungle", west of Pegu, Pegu district, August, 2 clitellate specimens. K. John.

Thanbula, Thayetmyo district, August, 1 clitellate specimen. K. John.

Magwe, Magwe district, August, 2 clitellate specimens. K. John.

Taungdwingyi, Magwe district, August, 6 clitellate specimens. K. John.

Pyinmana, Yamethin district, October, 5 clitellate specimens. K. John.

Mt. Popa, Myingyan district, September, 3 clitellate specimens. K. John.

Dwehla, Kyaukse district, September, 2 clitellate specimens. K. John.

Myotha, Sagaing district, September, 21 clitellate specimens. K. John.

Taungyi and Lashio, F. S. S., August-September, 1 acitellate and 30 clitellate specimens. H. Young.

Kyaukmyaung, Shwebo district, August, 1 clitellate specimen. Saw San Thwe.

Tiangzup, Myitkyina district, November, 13 clitellate specimens. F. D. Forbes.

*External characteristics.* Female pores are immediately in front of *a*.

Genital markings, unpaired and median, are located as follows: on 8/9, 72 specimens (1 from Kyaukmyaung, 1 from Thanbula, 1 from Bilin, 2 from Dwehla, 1 from Duiyzeik, 4 from Kyaikto, 3 from Pyinmana, 6 from Taungdwingyi, 2 from Pegu, 18 from Myotha, 12 from Tiangzup, 21 from Lashio and Taungyi); on 8/9 and 9/10, 15 specimens (1 from Mt. Popa, 2 from Magwe, 1 from Pyinmana, 3 from Myotha, 7 from Lashio and Taungyi, 1 from Tiangzup); on 9/10, 6 specimens (1 from Mt. Popa, 3 from Kyaikto, 2 from Lashio); on 9/10-10/11, 2 specimens (from Pyinmana and Mt. Popa); on 7/8-9/10, 1 specimen (Lashio).

#### DICHOGASTER BOLAVI (Michaelsen)

1891. *Benhamia bolavi* Michaelsen, Mitt. Mus. Hamburg, VIII, p. 307. (Type locality Bergedorf, Hamburg. Types in the Hamburg Museum.)

*Material examined.* From Burmese collections:

Sittang, Thaton district, October, 2 clitellate specimens. K. John.

Kyaikto, Thaton district, September, 5 clitellate specimens. K. John.

Prome, Prome district, August, 1 clitellate specimen. K. John.

Toungoo, Toungoo district, October, 10 clitellate specimens. K. John.

Thanbula, Thayetmyo district, August, 1 clitellate specimen. K. John.

Minbu, Minbu district, August, 6 clitellate specimens. K. John.

Taungdwingyi, Magwe district, August, 1 clitellate specimen. K. John.

Pyinmana, Yamethin district, October, 17 clitellate specimens. K. John.

Mt. Popa, Myingyan district, September, 4 clitellate specimens. K. John.

Taungtha, Myingyan district, September, 3 clitellate specimens. K. John.

Dwehla, Kyaukse district, September, 1 clitellate specimen. K. John.

Myotha, Sagaing district, September, 4 clitellate specimens. K. John.

Civil Lines, Mandalay, Mandalay district, October, 3 acitellate specimens. Miss M. Chapman.

Kyaukmyaung, Shwebo district, August, 1 clitellate specimen. Saw San Thwe.

Katha, Katha district, August, 1 clitellate specimen. Saw San Thwe.

Taungyi and Lashio, F. S. S., August, several clitellate specimens. H. Young.

Wasat Hka, Myitkyina district, November, 1 clitellate specimen. F. D. Forbes.

Tingpai, Myitkyina district, November, 7 clitellate specimens. F. D. Forbes.

*External characteristics.* The spermathecal pores are on or close to *a*. The single female pore is median.

#### DICHOGASTER MODIGLIANII (Rosa) 1896

1896. *Benhamia modiglianii* Rosa, Ann. Mus. Genova, XXXVI, p. 510. (Type locality Padang, Sumatra. Type in the Genoa Museum?)

1931. *Dichogaster modiglianii*, Stephenson, Proc. Zool. Soc. London, 1931, p. 65; Rec. Ind. Mus. Calcutta, XXXIII, p. 198;—*D. doveri* Stephenson, J. Fed. Malay States Mus., XVI, p. 276. (Type locality of *doveri* Kuala Lumpur, Selangor, F. M. S. Types in the British Museum.)

*Material examined.* From Burmese collections:

Sittang, Thaton district, October, 3 clitellate specimens. K. John.

Kyaikto, Thaton district, September, 1 clitellate specimen. K. John.

Kayan, Hanthawaddy district, September, 2 clitellate specimens. K. John.

Twante, Hanthawaddy district, September, 6 clitellate specimens. K. John.

Rangoon, Hanthawaddy district, January, 4 clitellate specimens. K. John.

Magwe, Magwe district, August, 1 clitellate specimen. K. John.

Toungoo, Toungoo district, October, 1 clitellate specimen. K. John.

Taungdwingyi, Magwe district, August, 3 clitellate specimens. K. John.

Pyinmana, Yamethin district, October, 12 clitellate specimens. K. John.

Mt. Popa, Myingyan district, September, 7 clitellate specimens. K. John.

Hills near Naba, Katha district, September, 8 clitellate specimens. Saw San Thwe.

*External characteristics.* The prostomium is proepilobous, segment i divided mid-dorsally by a longitudinal groove to 1/2 which is normally developed. Setae begin on ii. The first dorsal pore is probably on 5/6 but on 4/5 of some of the specimens there is a pore-like marking which may be perforate. The clitellum is annular but the epidermal thickening is less developed in *aa* though this is only recognizable in transverse incisions through the body wall.

Spermathecal pores are on or very close to *a*. On each specimen the female pores are on the setal arc or (occasionally) just a trifle behind, and just median to *a*.

Seminal grooves are nearly straight, on or very close to *a*, penial setae protuberant to the exterior from the anterior and posterior ends of the grooves where the prostatic apertures presumably are located. The male pores are represented by dark spots about midway between sites of the prostatic apertures. A longitudinally placed, median and almost rectangular area including the seminal grooves is often slightly whitened but not protuberant.

*Internal anatomy.* Gizzards are large, always anterior to 8/9 and presumably in vii and viii (13), no septum recognizable between the gizzards. Calciferous glands are in xv-xvii (13). The intestine begins in xix (13), the oesophageal valve in xviii or just reaching into xix (2). The typhlosole which begins more or less abruptly in xxii-xxiii (10) is a high, simple lamella, bent back and forth rather regularly, an anterior portion opaque, the posterior half rather translucent. In worms with 110-120 segments the typhlosole ends rather abruptly in lxxviii-lxxxii (10). In one specimen with only 84 segments the typhlosole ends abruptly in lxxviii. In another worm, even shorter, the typhlosole is continued to the hind end of the gut. Just lateral to the median typhlosole, on each side, and in four or five successive segments beginning at xxiii or xxiv there is a lateral typhlosole, a low but quite definite, scarcely lamelliform ridge (13) which is interrupted or very low and scarcely recognizable midsegmentally in each segment.

The dorsal blood vessel (single) is continued anteriorly to the region of the supra-pharyngeal ganglia. The ventral trunk is first recognizable at the anterior margin of the subpharyngeal ganglia. A supra-oesophageal trunk is usually not recognizable and when visible can be seen only in x-xiii. Extra-oesophageal trunks are first visible in the region of the circumpharyngeal nervous commissures from where they run posteriorly in the mass of tissue on and behind the pharynx, receiving several large dorsal branches, with a large transverse connective just anterior to the first gizzard, the trunks well below and lateral to the gizzards, passing onto the ventral face of the gut in ix from whence they gradually approximate to the midventral line until in xii they are actually in contact, unrecognizable posterior to 12/13. In several specimens a parietal vessel in xiv-xix on each side passes up onto the anterior face of 13/14 and apparently into the supra-oesophageal. Anteriorly in xii the extra- and supra-oesophageals are connected by fairly large commissures running around the gut; a smaller pair anteriorly in xi, a still smaller pair on the posterior face of 9/10. The last pair of hearts is in xii (13), the hearts of x-xii bifurcating dorsally, one branch apparently passing into the supra-oesophageal and the other

to the dorsal trunk though it has not been possible to trace both branches of any one heart to connections with the main trunks. All hearts pass into the ventral vessel.

Nephridia, from xx or xxi posteriorly, are fairly large discs flattened against the parietes, at times almost transversely rectangular, in contact or almost so with both septa of a segment, slightly yellowish and with a translucent granular appearance, tubules unrecognizable or recognizable only at the anterior margins of the discs in xx or xxi. These nephridia are in four longitudinal rows on each side, but the medianmost nephridium is quite small, in contact with or actually attached to the nephridium next laterally of which it appears to be a small appendage. From xx or xix to xiii the nephridia have little or no granular investment and are opaque, whitish loops, located in the posterior portions of the segments, just in front of the septa. From xii anteriorly nephridia, in pinned out specimens, are on the anterior faces of the septa.

Septa 10/11 and 11/12 are in contact peripherally to form a testicular chamber that is not opened in carefully dissected specimens. In several worms this chamber, perhaps unusually distended by the testicular coagulum, is herniated anteriorly for some distance along the nerve cord. Beneath the gut in xi is a closed off, transversely placed and median testis sac. In one specimen a herniation from the posterior sac passes forwards into the anterior herniation of the sac of x. Sacs of x and xi are usually filled with coagulum, all male funnels characterized by a brilliant spermatozoal iridescence. Although the worms are sexually functional, seminal vesicles have not been found though tiny whitish structures on the posterior face of 11/12 may represent rudiments of vesicles. Prostates are short and almost straight, slightly flattened, usually confined to xvii and xix, often attached to the anterior faces of 17/18 and 19/20, occasionally penetrating slightly into xviii and xx. The ducts are slenderer than the glands, with slight muscular sheen. Male deferent ducts are easily traced and pass into the parietes in xviii midway between the ectal ends of the prostatic ducts of a side. A column of muscular and connective tissue on the median face of each prostatic duct contains the penial setae. With care it is possible to separate out from this column two follicles (?) each containing one penial seta. In one column, after the supposed follicles containing the functional setae had been removed, two setae were still visible. These are nearly grown reserve setae, one of each type. Close to the base of each reserve seta is a large, ellipsoidal, vesicular nucleus within which a single, spheroidal endosome is visible. The penial setae

are like those of *doveri* Stephenson 1931 but there are usually five to seven teeth visible at each margin of the larger type.

The spermathecal ampulla is shorter than the duct, occasionally much shorter, shortly ellipsoidal and clearly marked off. The duct is slightly bulbous, widened in a middle portion and not especially narrowed in the muscular layers of the body wall, the lumen narrow ectally and with smooth wall, widened in the middle portion, then narrowed again entally though not quite as narrow or with as smooth wall as ectally. The diverticulum comprises a small, spheroidal to shortly ellipsoidal seminal chamber which may be erect or pendent, and a very short and slender stalk that passes into the anterior face of the duct at or just below the region of greatest thickness, opening upwards into the middle chamber of the duct. The seminal chamber is usually characterized by a brilliant iridescence. In a number of spermathecae the middle chamber of the duct is practically filled by a shortly ellipsoidal mass of spermatozoa which is much larger than that of the seminal chamber. In several ampullae there are clumps of rod-like structures that may be crystals or possibly fragments of penial setae. These rods may be transversely segmented.

In xiv there is a pair of small whitish vesicles (13) probably ovisacs.

*Remarks.* The dorsal and ventral trunks, the extra-oesophageals from 9/10 anteriorly and the hearts are always filled with blood and hence can be easily traced but supra-oesophageals, posterior portions of the extra-oesophageals and other vessels are usually quite unrecognizable in whole or in part. The supra-oesophageal and extra-oesophageal trunk and their connectives are distended with blood so that they can be traced in only two worms. Behind the gizzards 8/9-14/15 are closely crowded but can be identified by the organs between. A satisfactory determination of the gizzard segments and of the anterior septa has not however been made.

The lateral typhlosoles are like the lateral ridges in holandric and primitive metandric species of *Eutyphoeus* but here more extended.

In addition to the material listed above several Burmese specimens identified by Stephenson have been studied. Some of these are labelled *modiglianii*, others *doveri*. All are similar to the worms described above. *D. doveri* was erected for material from the Malay Peninsula but Stephenson later came to the conclusion that *doveri* must be suppressed. There are several mistakes in the account of *doveri*. The last hearts are in xii, not xi, the calciferous glands are in xv-xvii not xiv-xvi, and the intestine begins in xix not xvii. An empty testicular chamber is easily mistaken for a slightly thickened septum and segmental recog-

tion is very difficult if ovaries and nephridia are washed out in freeing the specimen from coelomic coagulum. Septum 18/19 is often pushed anteriorly into contact with 17/18 so that the intestine appears to begin in xviii, the true relationship of the parts ascertainable only with very considerable care in dissection.

#### DICHOGASTER SALIENS (Beddard)

1893. *Microdrilus saliens* Beddard, Proc. Zool. Soc. London, 1892, p. 683. (Types in the British Museum? Type locality undesignated, original specimens from Singapore, Penang and Java.)

*Material examined.* From Burmese collections:

Toungoo, Toungoo district, October, 1 acitellate and 4 clitellate specimens. K. John.

Lashio and Taungyi, F. S. S., September, 11 clitellate specimens. H. Young.

Wasat Hka, Myitkyina district, November, 8 clitellate specimens. F. D. Forbes.

Tingpai, Myitkyina district, November, 54 clitellate specimens. F. D. Forbes.

Sumprabum, Myitkyina district, November, 3 clitellate specimens. F. D. Forbes.

"Manure", Mythonkha, Myitkyina district, November, 3 clitellate specimens. F. D. Forbes.

From Malayan collections:

Cameron Highlands, Pahang, F. M. S., 1 acitellate and 15 clitellate specimens. Raffles Museum.

*External characteristics.* Length to 68 mm. The diameter of the largest worms in the clitellar region may be as much as  $2\frac{1}{2}$  mm. though not more than two mm. elsewhere. Unpigmented. The prostomium is proepilobous but there is a definite furrow at the mid-dorsal line from the apex of the prostomium to or nearly to 1/2 or the site of 1/2. Intersegmental furrow 1/2 is usually almost wholly lacking, unrecognizable until after removal of the cuticle and then only faintly indicated for a short distance on the dorsum near the median line. The first segment accordingly appears to be setigerous but is quite definitely longer than the second setigerous segment (iii) unless the prostomium is deeply retracted.

All setae of ii are present; on xxi *ab ca. = cd*, *aa* usually *ca. = bc*, but some variation. Ventral setae of xviii are lacking even on acitellate specimens except as follows: *a* and *b* of left side present (3, from Tingpai), *a* and *b* of right side present (2 from Lashio), *a* of right side

present (1, Tingpai), *b* of left side present (1, Tingpai). When present setae are of the ordinary sigmoid type.

The first dorsal pore is on 4/5 (1), on 5/6 (19, but with a pore-like though apparently imperforate marking on 4/5 of three specimens), on 6/7 (1).

The clitellum is red, usually protuberant, extending from 12/13 onto xix, to 19/20 or onto xx, annular except on xiii, xviii-xx but thinner in *aa*; intersegmental furrows lacking, dorsal pores lacking except on 19/20, setae present.

Spermathecal pores are on 7/8-8/9, on or close to *a*, each pore on a tiny tubercle. Female pores are just median to *a*, on or just behind the setal arc, nearer to *a* than is *b*.

The male genital shield is a transversely placed, almost diamond-shaped area, reaching laterally into *bc*, and possibly slightly onto xvi and xviii (16/17 and 17/18 lacking ventrally), sharply demarcated except in *aa*. On each shield there are two, rather conical protuberances the highest portions of which are about in the region of *ab*, a slight longitudinal groove usually recognizable at the mid-ventral line. Seminal grooves are nearly straight, on the posterior faces of the protuberances, about on *a*, the anterior ends about at the setal arc, the posterior ends approximately at site of 17/18. Male pores, definitely recognized on three specimens only, are at the hind ends of the seminal grooves and hence about on *a*, at or close to site of 17/18. Prostatic pores (usually unrecognizable and always so if penial setae are protuberant to the exterior) are at the anterior ends of the seminal grooves and hence at *a*, on the setal arc. A single penial seta may be protuberant from the anterior end of a seminal groove.

The single genital marking, when present, is on 15/16, in *aa*, with a wide, opaque marginal band and a greyish translucent central area, outline circular or shortly elliptical and then transversely placed. Markings are present on 18 worms; six from Lashio and Taungyi, six from Wasat Hka and six from Tingpai. Of sixteen Malayan worms, six have the marking.

*Internal anatomy.* Gizzards are anterior to 8/9 and presumably in vii and viii, 7/8 lacking or unrecognizable in dissections. Calciferous glands are one pair, each gland with three more or less reniform lobes in xv-xvii, the size of the lobes increasing from xv posteriorly. The common stalk of the three lobes of a side opens by a very small, slit-like aperture into the gut just lateral to the supra-oesophageal in xv. The intestine begins in xix just behind 18/19 (4). The typhlosole which begins abruptly in xxii (1) or xxiii (3) is a simple lamella, ending

abruptly in lxxxvi (1) or lxxxviii (2, one specimen with 119 segments). Slightly lateral to the median typhlosole, in xxiii-xxix on each side, there is a lateral typhlosole, high intersegmentally, low or interrupted midsegmentally.

The dorsal blood vessel (single) is continued anteriorly onto the pharyngeal bulb. A supra-oesophageal is usually recognizable in xi-xii only. Extra-oesophageals are unrecognizable behind xi, connected by transverse commissures just behind 6/7, anterior to 6/7 continued forwards close to the ventral parietes into ii. No subneural. A latero-parietal vessel is recognizable on each side in xiv-xvii, bifurcating on the anterior face of 13/14, one branch passing to the extra-oesophageal, the other to the supra-oesophageal. The last hearts are in xii (6).

Nephridia in the postclitellar portion of the body are in four longitudinal rows on each side, each nephridium a flattened disc on the parietes in contact with both septa of a segment and with transparent granular investment. The medianmost nephridium on each side decreases in size from just behind the clitellum posteriorly. In the last twenty segments the median nephridium of each side has a small, preseptal funnel.

Seminal vesicles are represented only by small rudiments on the posterior face of 11/12. Prostates are restricted to xvii, the duct with muscular sheen, slightly looped once or twice, three quarters to one mm. long. The vas deferens is widened posteriorly, iridescent, readily visible in xv-xvii where it is looped, in xvii lateral to the prostatic duct and passing into the parietes behind the prostatic ducts.

The spermathecal duct is longer than the ampulla, occasionally only slightly so. The ectal half of the duct has a thick wall and narrow lumen lined with cuticle (?). In the ental half the lumen is widened and more or less irregular. The diverticulum comprises a spheroidal to shortly ellipsoidal seminal chamber and a short, slender stalk passing to the anterior face of the duct.

Penial setae are in two follicles, those of the *b* setae smaller, the *a* setae with more marked sinuities and slightly thicker. Reserve setae are present in each follicle examined.

The genital marking gland has a definite but thin, capsular wall; the longitudinal musculature thin, transparent over the gland and bulged upwards slightly above the general level of the parietes. A thin greyish spot in the body wall is however all that is visible internally without some dissection among muscle strands.

*Remarks.* The anteriormost portion of the body is usually softened so that recognition of the first intersegmental furrow, even if present,

would be difficult. The furrow is however clearly undeveloped, except as noted, on several specimens that are almost perfectly preserved.

### Family EUDRILIDAE

#### Genus EUDRILUS E. Perrier

#### EUDRILUS EUGENIAE (Kinberg)

1867. *Lumbricus eugeniae* Kinberg, Öfv. Ak. Förh. XXIII, p. 98. (Type locality St. Helena. Type in the Stockholm Museum.)

*Material examined.* From Ceylonese collections:

Heneratgoda, 40 feet, 56 juvenile or acitellate and 14 clitellate specimens. The Colombo Museum.

From American collections:

Soil, St. Croix, Virgin Islands, 3 acitellate and 7 clitellate specimens. H. A. Beatty per U. S. Nat. Mus.

*External characteristics.* Length 90–130 mm. Diameter 6 mm. The dorsum is dark red anteriorly, gradually fading out in the posterior half of the body, but with a pronounced blueish tinge anterior to the clitellum; pigmentation, associated with the circular muscular layer, red. Ventrums unpigmented. The prostomium is epilobous, *ca.*  $\frac{1}{2}$ , but there is no transverse furrow at the posterior end of the tongue (15). No dorsal pores.

Setae begin on ii on which all four couples are present; on xxiii,  $ab = cd$ ,  $bc \text{ ca.} = \frac{1}{2}aa$ ,  $dd > \frac{1}{2}C$  but only slightly. All setae anteriorly and at the posterior end are sigmoid and ornamented near the tips with short, transversely placed, jagged ridges.

Nephropores begin on iv (25), and are on the anterior margins of the segments, on or just lateral to *c*. Nephropores are unrecognizable on xviii (15 clitellate specimens) or visible but noticeably smaller than on xvii and xix (4 clitellate and several acitellate specimens).

The clitellum extends from 13/14 to 18/19 and ventrally into a lateral portion of *aa* on each side and is reddish; intersegmental furrows slightly indicated, setae usually present, except the ventral couples of xvii which are always lacking (even on smallest juveniles). The lateral setae of xiv may be lacking (1), or the ventral setae (1), while all setae of xiv–xvii except *a* and *b* on the left side of xvi and the right side of xiv are lacking on one worm. The ventral margin of the clitellum is only marked off externally by a disappearance of the red clitellar color, the epidermis gradually thinned passing ventrally.

The spermathecal apertures are transversely placed, presetal slit

on xiv, of about the same width as *cd*, with centers usually on or just median to *c*, occasionally lateral to *c*, the openings just in front of the setal arc. Margins of apertures are smooth or fairly so even when slightly protuberant.

Apertures of the copulatory chambers are transversely placed, on xvii, just in front of 17/18, with centers on or lateral to *b*, reaching mesially to *a*, the margins slightly protuberant, whitish and finely lobed. The male pore is doubtless minute and was not found, probably on or near the tip of the penis. The latter is four mm. or more in length and gradually thickened dorsally, when completely retracted curved in a crescentic fashion, when protruded nearly straight. The aperture of the Y-gland is a tiny, almost minute slit on a porophore which may be protuberant to the exterior along with the penis. The porophore is much shorter than the penis, with a bluntly rounded ventral end, widened passing dorsally and narrowed again close to the parietes. On the lateral face of the porophore slightly below the ventral end there is a tiny, almost conical protuberance bearing at its tip the vertically placed, slit-like aperture of the Y-gland. From a point just above the pore of the Y-gland a groove runs upwards on the lateral face of the porophore, dorsally turning laterally to pass onto the base of the penis, along the median face of which it is continued to or almost to the ventral end.

Definite genital markings are lacking but on each of segments xvii and xviii of several of the clitellate specimens, in a median portion of *aa*, there is a transversely placed, very slightly protuberant and rather distinctly demarcated area of shortly elliptical outline, reaching anteroposteriorly nearly to the intersegmental furrows. The epidermis of these areas is slightly thickened.

In *cd* or a region reaching slightly median to *c* and on each side there is usually present a longitudinal row of tiny, circular spots. Each of these spots is of about the same size and appearance (under low powers of the binocular) as an open nephropore. With brilliant illumination and high magnification no pore is recognizable but each area is slightly depressed (epidermis thin) and with a brownish appearance. The markings are always postsetal, usually fairly close to the setal arcs, two per segment generally, though an extra marking or even two may be present on any segment and when present not far from the normal markings. Locations of the markings on several specimens selected at random are as follows: i-x (3), i-xi (1), i-xii (3), ii-x (1), ii-xi (1), ii-xii (1), iv-x (1), iv-v (1), extra markings not recorded.

*Internal anatomy.* All septa from 4/5 posteriorly are present;

4/5-5/6 transparent, 6/7 and several following septa with muscular fibres but thin and translucent.

The gizzard is in v (13). The oesophagus in iv is wide, narrower in vi-xiv, especially so in x-xii. The inner wall of the gut in vi-xiv is provided with low, longitudinally placed, rather irregular, whitish ridges. Unpaired ventral calciferous glands are large, spheroidal to ovoidal, with dark surfaces, stalks very short, slender and straight, to ventral face of gut in median vertical plane. Paired calciferous glands are smaller, always white, anteroposteriorly flattened, in the posterior portion of xii, adherent to the lateral faces of the gut as well as to the anterior face of 12/13. From about the middle of the posterior face of each gland a stalk is continued to the anterior face of 12/13 and into the gut at or just behind the region of septal attachment. Small circular openings into the median glands are readily recognizable but the still smaller openings of the paired glands are harder to find or recognize. Lamellae, in both paired and unpaired pouches, are vertical, in contact centrally in each gland so that the lumen—except just at the stalk region—is reduced to small slit-like spaces. The intestine begins in xiv posteriorly or in xv immediately behind 14/15. In three specimens the valve is in the region of attachment to the gut of 14/15 and is tightly closed, the oesophageal portion of the gut in xiv clearly differentiated from the intestinal portion in xv. In other specimens the valve is relaxed and the portion of the gut in xiv is widened so that determination of the segment of intestinal origin is difficult or impossible. In four specimens septum 14/15 is attached to the gut behind the anterior end of the intestine and cannot be peeled off from this anterior portion. In these worms the intestine appears to begin quite definitely in a posterior portion of xiv. No typhlosole. In a region extending from approximately lxxxv to cxxx there is a longitudinal series of paired, supra-intestinal glands on the dorsal face of the gut, the glands small and in the anterior portions of the segments, in contact with the anterior septa and the dorsal blood vessel (the two glands of a segment separated from each other by the dorsal trunk). Glands are shortly ellipsoidal to almost spheroidal and increase in size slightly passing posteriorly into a middle region, from thence decreasing in size posteriorly. Anteriorly in a few specimens the glands may be flattened and with a triangular dorsal outline, the base and one side along the dorsal blood vessel and the anterior septum. On lifting the gland slowly and carefully from the gut a short and slender, white hollow cord, presumably a duct becomes visible, passing from the ventral side of the gland into the gut wall. On pulling the gland still

further away from the intestine the stalk may break or may come out from the gut wall leaving a tiny circular aperture. Glands are located as follows: lxxxvii-cxxiv (1), xci-cxxii (1), xcii-cxx (1), xci-cxxxii (1), xcv-cxxix (1). Just behind each gland the transverse blood vessel on the dorsal face of the gut may have around it in irregular masses a slightly yellowish material (chloragogen?).

The dorsal blood vessel (single) is continued anteriorly into vii (13) where it usually terminates abruptly with the hearts of that segment. In several specimens a tiny stub projects anteriorly beyond the commissures or a very small vessel continues the trunk onto the dorsal face of the oesophagus from whence it is impossible to trace the vessel anteriorly. A median supra-oesophageal trunk is replaced by a pair of longitudinal vessels on the oesophagus in vii-xii, in contact mesially in the regions of septal attachment (and united?). These vessels are small, usually empty except at or near to junctions with other vessels and adherent to the gut (from which they can be dissected off) and for these reasons are difficult to trace, unrecognizable posterior to 12/13 or anterior to 6/7. The ventral trunk is continued anteriorly to the region of the subpharyngeal ganglia where it bifurcates, the two branches passing laterally. The extra-oesophageal trunk is first recognizable on each side as a fairly large vessel, just behind and parallel to the circumpharyngeal nervous commissures, that passes posteriorly close to the ventral trunk and at about the same level, receiving a large vessel from the parietes in iv and from the anterior face of the septum in v. Just in front of 5/6 or 4/5 there is a transverse connective between the two trunks. In vi the trunks rise to a level above that of the ventral vessel but still below the ventral face of the gut and are continued posteriorly into ix where they usually decrease in size and become empty and unrecognizable. In one specimen the trunks are traceable through x below the median calciferous gland to which branches are given and possibly continued thence into xi to the ventral face of the posterior gland. In one specimen there are clearly visible two longitudinal vessels on the ventral face of the gut in x and xi, apparently with connections anteriorly to the extra-oesophageal trunks. The subneural trunk is large, behind the prostatic region larger than the ventral vessel and looped laterally on both sides of the nerve cord, continued anteriorly to a region in front of the subpharyngeal ganglia. Connectives with the extra-oesophageal or other longitudinal trunks are unrecognizable.

In xiii a large branch from the dorsal trunk passes ventrally on each side along the posterior face of 12/13 just behind the calciferous gland

to which it apparently gives off branches. In xii, just behind 11/12, a similar large branch from the dorsal trunk on each side passes posteroventrally to the anterior margin of the calciferous gland and after giving off a branch which penetrates into an upper portion of the gland passes ventrally along the anterior or anteromedian aspect of the gland. In vii-xi there are large, heart-like commissures, the last hearts always in xi (13). In viii-xi each heart bifurcates dorsally, the posterior branch passing into the dorsal trunk, the anterior bifurcation passing towards the dorsal face of the gut. In x and xi the anterior bifurcation joins a vertical vessel from the dorsal face of the calciferous gland and then opens into a supra-oesophageal or else passes directly into the supra-oesophageal close to the junction of the latter with the vertical vessel from the gland. In ix-viii the anterior bifurcation passes to a supra-oesophageal trunk. Either anterior or posterior bifurcations of the hearts of x-xi may contain blood but in ix-x blood is present only in the posterior bifurcations, the anterior bifurcations slender, white filaments (functional?). Hearts and commissures of vii-xi all pass into the ventral trunk.

Nephridia are on the parietes close to the anterior septum of a segment and extend laterally well towards mid *dd*. Nephrostomes are small, on the anterior faces of the septa close to the ventral parietes and nearer to the nerve cord than to the *a* line. Nephridia are usually present in xviii. In pinned out specimens nephridia of iii-vii, viii or ix are vertically placed on anterior faces of septa rather than transversely on the parietes as posteriorly.

Testis sacs are unpaired, suboesophageal and transversely placed, in the posterior portions of x-xi. From each sac there are protuberant four distinct lobes. Two smaller lobes from the anterior margin pass to the posterior faces of the septa in front and presumably contain the testes. Two protuberances, usually much larger, from the lateral margin reach up more or less conspicuously at the sides of the gut. Male funnels are small, with smooth lips, without spermatozoal iridescence (13) and seated on the ental ends of shortly ellipsoidal bodies which are thin-walled vesicular enlargements of the deferent ducts, the vesicles filled with a closely packed iridescent material. Testicular coagulum extends from the main portion of the sac into the four lobes, surrounding the testes, funnels and vesicles. The ventral blood vessel is adherent to the floor of each testis sac, the hearts entering through the median faces of the lateral protuberances. Seminal vesicles, two pairs in xi and xii, are large — even in acelitellate specimens, soft, folded back on themselves or passing above the dorsal blood vessel into the other side of

their segments. Copulatory chambers are rather bee-hive-shaped and conspicuously protuberant into the coelomic cavity of xvii, often to a height of two mm. or slightly more, occasionally bent over mesially or anteromesially. Prostates are five to eight mm. long and about one mm. thick, the duct muscular but slender, about one mm. long, passing into the center of the dorsal face of the copulatory chamber. Deferent ducts pass lateral to the copulatory chambers and usually into the ectal third of the prostate but in one specimen pass into both prostates at a point midway between the ectal and ental ends. Ental limbs of the Y-gland are adherent to each other, and are slightly unequal in length, the longer about one mm. The duct is slender but muscular, about two mm. long and passes into the median face of the copulatory chamber slightly above the ventral parietes.

Spermathecae are six to eight mm. long, in xiii and xiv. At a point about two mm. or slightly more from the ectal end of each spermatheca there is attached a diverticulum, comprising a spirally wound, muscular stalk three to five mm. long and a soft terminal chamber with an acinous appearance. Sessile on the other side of the duct and about opposite the diverticular junction there is a nearly spheroidal body. Opening into the duct just above the sessile body and on the same side is a slender, thin-walled tube which passes to the posterior face of 12/13 where it turns mesially and is slightly enlarged. The vesicular enlargement which can be dissected off from the septum without especial difficulty contains the ovary. Ental to the diverticulum the spermathecal duct gradually becomes less muscular and eventually is nearly as thin-walled as the ampulla. The latter is about three mm. long, ovoidal to ellipsoidal, fairly sharply marked off from the duct and (in clitellate specimens) filled with a fairly closely packed material in which there is no iridescence.

*Abnormalities.* One specimen has an extra pair of spermathecal pores on xv, all of the pores just median to *c*. There is an extra pair of spermathecae in xv, the ducts about three mm. long, the left ampulla shrivelled, the right ampulla about one mm. long, vesicular and distended with the same sort of material as in the anterior spermathecae.

Another specimen has a metameric abnormality of the spiral type beginning behind 14/15, a spermathecal pore on the right side only, two male pores on the right side on xix and xxi in addition to a single normal pore on the left side. The left Y-gland is simple, lacking the shorter ental limb. The extra copulatory chamber in xxi is of the usual height but has no prostate, the male deferent duct of the right side opening into the anterior prostate. Associated with the posterior

copulatory chamber is a Y-gland slightly larger than usual and with its duct passing into the center of the dorsal face of the copulatory chamber. Within the chamber is a protuberance just over one mm. long that looks much more like a penis than a Y-gland porophore though of course shorter as well as thicker than a normal penis. There is no groove. The lumen is very small and slit-like.

*Regeneration.* Three specimens have tail regenerates, two, nine, and twelve mm. long. In one of these worms the tail was lost in the middle of the supra-intestinal gland region. No supra-intestinal glands are recognizable on the gut of the regenerated tail.

*Remarks.* Characteristics of the testis sacs, here as in other species, are difficult to determine in dissections under water. If the dissection is allowed to dry for a sufficient time and then studied in that condition it is possible to open the sac and remove the testicular coagulum leaving the major portion of the sac wall intact so that the shape can be accurately determined as well as the relationships of the various parts.

One specimen in a late stage of postsexual clitellar regression (as indicated by the discoloration of the clitellar segments) has a large number of brown discs scattered through the coelomic cavities of vi-xxxi; one disc two and a half mm. long, 16 discs about one mm. long, and a much larger number of small discs.

*Diagnosis.* Apertures of copulatory chambers transverse slits with centers on or lateral to *b* and reaching mesially to *a*, just in front of 17/18. Spermathecal apertures about as wide as *cd*, with centers on or median to *c*. Clitellum saddle-shaped, on xiv-xviii. Setae; *bc ca* =  $\frac{1}{2}aa$ , *dd* >  $\frac{1}{2}C$ , ventral setae lacking on xvii. Nephropores begin on iv, just lateral to *c*. Pigmentation red. Length 90-130 mm. Diameter 6 mm.

Gizzard in v; intestinal origin close to 14/15; supra-intestinal glands in region of lxxxv-cxxx. Last hearts in xi; hearts of viii-xi latero-oesophageal; dorsal blood vessel terminates with commissures of vii. Testis sacs unpaired and ventral, with two small anterior lobes containing testes and two larger laterodorsal lobes containing male funnels and vesicular enlargements of deferent ducts. Copulatory chamber conspicuously protuberant into coelomic cavity and containing a penis about four mm. long and a Y-gland porophore, a groove from the Y-gland aperture passing dorsally along the porophore and then ventrally to tip of penis.

*Distribution.* "The whole of the tropical zone."

## BIBLIOGRAPHY

a. References for *Gordiodrilus*

BALDASSERONI, V.

1913. *Monit. Zool. Ital.* 24.

BEDDARD, F. E.

1892. *Ann. Mag. Nat. Hist.* (6), 10.1894. *Proc. Zool. Soc. London*, 1894.*Quart. J. Mic. Sci.* 36.1895. *A Monograph of the Order Oligochaeta*. Oxford.1901. *Proc. Zool. Soc. London*, 1901.

COGNETTI, L.

1907. *Boll. Mus. Zool. Torino*, 22, 551.1910. *Ann. mus. stor. nat. Genova*, (3), 4.

MICHAELSEN, W.

1897. *Mitt. Mus. Hamburg*, 14.1900. *Das Tierreich*, 10. Berlin.1903. *Ark. Zool. Stockholm*, 1.*Die geographische Verbreitung der Oligochaeten*. Berlin.1907. *Reise in Ostafrika, Voeltzkow*, 2, (46).1910. *Abh. Nat. Ver. Hamburg*, 19, (5).1913. *Zoologica*, Stuttgart, 68.1914. *Beitr. Kenntn. Land- u. Süßwasserfauna Deutsch-Südwestafrikas*, Hamburg, 1.1915. *Ergeb. 2 Deutsch. Zentral-Afrika-Exp. 1910-11*, 1, Zool. 1.1933. *Abh. Senckenberg. Ges.* 40.1936. *Rev. Zool. Bot. Afr.* 29.1937. *Bull. Mus. Comp. Zool. Harvard*, 79.

STEPHENSON, J.

1923. *Oligochaeta*, in *Fauna of British India*. London.1928. *Ann. Mag. Nat. Hist.* (10), 1.1930. *The Oligochaeta*. Oxford.1931. *Proc. Zool. Soc. London*, 1931.

## b. Other References

GATES, G. E.

1937. The genus *Pheretima* in North America. *Bull. Mus. Comp. Zool. Cambridge*, 80, (8).1938. Indian earthworms. V. *Nellogaster gen. nov.*, with a note on Indian species of *Woodwardiella*. *Rec. Indian Mus. Calcutta*, 26.

On some American and Oriental earthworms. In press.

STEPHENSON, J.

1924. On some Indian Oligochaeta, with a description of two new genera of Ocerodrilinae. *Rec. Indian Mus. Calcutta*, 26.



Gates, G. E. 1942. "Notes on various peregrine earthworms." *Bulletin of the Museum of Comparative Zoology at Harvard College* 89, 61–144.

**View This Item Online:** <https://www.biodiversitylibrary.org/item/21134>

**Permalink:** <https://www.biodiversitylibrary.org/partpdf/15097>

**Holding Institution**

Harvard University, Museum of Comparative Zoology, Ernst Mayr Library

**Sponsored by**

Harvard University, Museum of Comparative Zoology, Ernst Mayr Library

**Copyright & Reuse**

Copyright Status: In copyright. Digitized with the permission of the rights holder.

License: <http://creativecommons.org/licenses/by-nc-sa/3.0/>

Rights: <https://biodiversitylibrary.org/permissions>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.