THE AQUATIC EARTHWORMS (MICRODRILI) OF REELFOOT LAKE[1]

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Introduction

Economic importance

The extent to which the Microdrili of Reelfoot Lake, Tennessee, are of economic importance can be indicated only in a general way. On one occasion a Dobson fly larvae of the genus *Corydalis* was observed actively eating a worm of the genus *Limnodrilus*. This indicated that these aquatic earthworms are part of the diet of insect larvae. Probably the most important place they fill is in the food-material circulation of the lake. The Tubificidae are constantly bringing up organic matter from below the surface of the bottom of the lake and throwing it into the water. This gives the bacteria present food which they decompose into various mineral salts. These then become available for the phytoplanktonic organisms. The phytoplankton serve both zooplankton and detritus feeders with food. Wastes from these are constantly sifting to the bottom and being covered with washed-in soil and other material which would make them unavailable for further use were it not for the Tubificids who make their way through this washed-in, foodless layer to the organic layer beneath and through their intestines raise it to the surface, making it again available for the bacteria. These small annelids play a role in the bottom mud of Reelfoot Lake comparable to the role played by the terrestrial earthworms in fertile soil. They are the tillers of the soil which make it possible for the bottom mud to support innumerable small forms which are eaten by larger insect larvae and small crustaceans which in turn form the chief article of diet for the valuable fish.

Review of Literature

The fresh-water Oligochaetes comprise a group of animals that have been the object of few investigations in the United States. They have received considerable study in Europe and the best of the limited amount of literature available on the group is in German, and in most cases relatively inaccessible to the student of the group. This fact, combined with the apparently unappreciated, though really very important, role they play in the circulation of food-material in lakes and

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ponds, and the difficulties in the technique of their manipulation and observation renders it not surprising that little is known concerning their distribution in the United States.

The Microdrili as a group fall within the Phylum Annelida. This Phylum is composed of three classes, one of which, the Chaetopoda, is subdivided into two subclasses, Polychaeta and Oligochaeta. The Orders, Microdrili and Megadrili, sometimes referred to as Limicolae and Terricolae respectively, comprise the subclass Oligochaeta.

> The majority of the species of Oligochaetes are terrestrial; a considerable number, however, are inhabitants of fresh water, and a few are marine. The terrestrial forms (*Terricolae*) are on the whole much larger than the aquatic (*Limicolae*); and it is sometimes convenient to group together the families which comprise the larger worms, mostly terrestrial (*Moniligastridae, Megascolecidae, Eudrilidae, Glossoscolidicae, Lumbricidae*), as Megadrili, and those comprising the smaller, and for the most part aquatic, worms (*Aeolosomatidae, Naididae, Tubificidae, Phreodrilidae, Enchytraeidae, Lumbriculidae, Branchiobdellidae, Haplotaxidae, Allurdididae*), as Microdrili (Stephenson, 1930, P. xvi).

The Microdrili as a group may be described as "Small Oligochaeta with relatively few segments, often multiplying asexually. The male pores are on, or in front of, the seventh segment. The vasa differentia are short, opening on the segment immediately behind that in which the internal apertures are situated. The anterior part of the body is often distinguished from the rest by a difference in the form and arrangement of the setae. The clitellum, which is composed of only one layer of cells, is situated comparatively far forward. Eyespots are frequently present." (Parker and Haswell, 1930, p. 455.)

> It was Cuvier who, in 1798, first called attention to the fundamental difference in structure between the higher and lower worms, and Lamarck who gave the former the name *Annelides*. Savigny (1820) subdivided the group into the *Annelides neridiae, serpuleae, lumbricineae,* and *hirudineae*, and may be considered the founder of the modern classification. Milne-Edwards (1834) introduced the subdivisions *Annelides errantes, tubicoles,* and *terricoles,* which for many years has had a place in the system, and Grube (1851) the subdivisions Polychaeta and Oligochaeta. In more recent times Ehlers has been perhaps most active in the development of the system (Pratt, 1935, p. 322).

At least four large general works have been published dealing with the Order Oligochaeta. "The first of these in time of publication is Professor Franz Vejdovsky's 'System und Morphologie der Oligochaeten,' which appeared in 1884. Six years later Professor Leon Vailant contributed to the volumes on the Annelids of the 'Suites a Buffon' a volume and half dealing with the same group." (Beddard, 1895, p. v.) Then, in 1895, Beddard contributed his enormous volume, *A Monograph of the Order of Oligochaeta.* The fourth work, which was a general review of all the knowledge of the order to date of publication, is J. Stephenson's *The Oligochaeta,* published in 1930.

Besides these larger works there have been many original papers published adding to the knowledge of the group.

> Perrier's researches, particularly his first Memoir, gave the first indication of the very great structural variation exhibited by the terrestrial Oligochaeta. Since that date (1871) our knowledge has rapidly accumulated . . . by investigations of Horst, Michaelsen, Rosa, and others upon the continent, Spencer and Fletcher in Australia, Eisen in America, and Benham and myself in England (Beddard, 1895, p. 1).
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> The aquatic Oligochaeta of Europe were first investigated by O. F. Muller; but d'Udekem's memoir upon Tubifex, and those of Claparede upon that and other forms, are the memoirs from which our modern knowledge dates. Since the publication of Claparede's two memoirs, the aquatic Oligochaeta have been principally studied by Lankester, Benham, and myself in this country; on the continent by Leydig, Dieffenbach, and others; in America by Eisen (Beddard, 1895, p. 2).

Among the outstanding American contributors to the knowledge of the Microdrili are Joseph Leidy, J. Percy Moore, Frank Smith, L. B. Walton, S. A. Forbes, P. S. Welch, M. M. Ellis, T. W. Galloway, and M. C. Hall. In some cases, the work done by these men on the Microdrili appears to be merely incidental. This, in part, accounts for the fragmentary knowledge of certain families of the group. The paucity of contributions during the last thirty years especially is a noteworthy fact.

Little is known of the distribution of Microdrili in the United States. The American Museum of Natural History, New York City, states that their collection consists of less than fifty vials containing unnamed and unstudied specimens, and that none of their specimens came from the Reelfoot Lake region. The records of the United States National Museum of the Smithsonian Institution, Washington, D. C., show that none have been reported from the Reelfoot Lake region. Those that have been recorded for adjacent states are given below: *Stylaria lacustris* Linn., Imboden, Arkansas; *Aulophorus furcatus* Oken, Mississippi; *Haplotaxis emissarius* Forbes, Havana, Illinois; *Cambarincola macrodonta* Ellis, Agricultural College, Mississippi. Excepting the Family Branchiobdellidae, which live on crayfish and are apparently found wherever crayfish occur, the literature at hand shows that Microdrili have been reported from the following states: Arkansas, California, Connecticut, Delaware, Florida, Georgia, Illinois, Iowa, Kansas, Maine, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New Hampshire, Ohio, and Pennsylvania. Perhaps the most exhaustive studies have been made of the Enchytraeidae—in California by Eisen, and in Illinois by Paul S. Welch and Frank Smith.

Methods

The general method used was to collect samples of mud, water, aquatic vegetation and debris from representative sites about the lake and carry these to the laboratory for microscopic inspection. In the laboratory portions of each sample were put into Petri dishes. These portions would contain mud, water, and often the stems and roots of aquatic plants. By thinly spreading the material over the bottom of the dish the tracks of the crawling worms could usually be easily

seen with the binocular microscope. When specimens were thus located they were transferred by means of a pipette to slides where they were measured and then identified. A cover-glass was usually placed over the worms before identification was attempted. This would not crush them if they were in sufficient water. By blotting up the water with a piece of filter paper they could usually be slowed down so as to make observations under high power possible. Thirty-two samples were studied.

In collecting the ecto-parasitic forms which live on crayfish, it was only necessary to collect the crayfish with a hand-net and, in the laboratory carefully scrape them off the surface with some sharp instrument, or, after opening the gill-chamber, remove them from the gill-filaments with a needle.

All the observations recorded were made on living worms, or those purposely crushed by the cover-glass in order to see the setae more distinctly. In the accurate identification of many species, serial sections of the sexually matured specimens are necessary. Sexual maturity is seasonal, and even when it is possible to make serial sections during the period of a short study the absence of mature specimen may tend to nullify one's efforts. This applies more particularly to the family, Tubificidae, which reproduce sexually. In most cases identification was possible from a study of the living worm. In the families, Aeolosomatidae and Naididae, which reproduce asexually, identification can be made in practically all cases from observation of the living specimen.

Key to Families and Genera

(All keys are based upon Galloway, 1911; Michaelsen, 1909; Hall, 1912; Smith, 1918; Walton, 1906; and Welch, 1914)

1 (62) Well developed setae on most somites 2

2 (25) Small, 1-15 mm., but up to 25 mm. in some species; reproduction chiefly asexual by fission, sexual reproduction less frequent. Clitellum, when present on some somites, on V-VIII. Usually quite transparent 3

3 (4) Setae of ventral bundles as well as dorsal setae capilliform; septa imperfectly developed; integument of most species contain bodies which may be some shade of red, green or yellow, or colorless. Usually 1-2 mm. long. Family AEOLOSOMATIDAE. Genus **Aeolosoma.**

4 (3) Ventral setae all uncinate; septa well developed; no bright integumental bodies; bifid setae commonly present together with other kinds; larger, 2-25 mm. Family NAIDIDAE.... 5

5 (8) No dorsal setae 6

6 (7) Ventral bundles of setae on III-V as on other somites..... **Schmardaella**

7 (6) No setae on III-V. Somite III much elongated.. **Chaetogaster**

8 (5) Dorsal setae present 9

9 (12) No capilliform setae in dorsal bundles..... 10

10 (11) Setae of dorsal bundles all uncinate..... **Paranais**

11 (10) Dorsal setae nearly straight; slightly toothed or simple pointed ..... **Ophidonais**

12 (9) Capilliform setae present in dorsal bundles..... 13

13 (22) First anterior dorsal setae on V or VI 14
14 (19) Posterior end not modified into a gill-bearing respiratory organ, first dorsal anterior setae on VI 15
15 (16) One or more capilliform setae of VI much longer than those of other somites and equal to 3 or 4 times the body diameter ..... **Slavina**
16 (15) Dorsal setae of VI similar to those of other somites 17
17 (18) Prostomium elongated to form a proboscis ..... **Stylaria**
18 (17) Without proboscis ..... **Nais**
19 (14) Posterior end modified into a gill-bearing respiratory organ, the branchial area 20
20 (21) Ventral margin of the branchial area with a pair of long processes ..... **Aulophorus**
21 (20) Ventral margin of the branchial area without long processes ..... **Dero**
22 (13) First anterior dorsal setae on II 23
23 (24) Dorsal setae of two kinds, capilliform and shorter needle-form setae which commonly have cleft ends ..... **Naidium**
24 (23) Dorsal setae all capilliform, mostly with very fine teeth on convex side; prostomium commonly elongated into a proboscis ..... **Pristina**
25 (2) Mostly longer, often very much longer; do not reproduce by fission; usually less transparent than number 2. Clitellum mostly on X-XII, if present 26
26 (43) Setae never bifid at extremity, short, 2 or usually more in each bundle; worms 5-30 mm. in length; integument inclined to be whitish and opaque; some aquatic, some terrestrial and burrowing in organic matter, some parasitic on plants. Family ENCHYTRAEIDAE 27
27 (28) Setae not disposed in bundles, occur singly when present, usually absent from many of the somites ..... **Michaelsena**
28 (27) Setae disposed in bundles 29
29 (30) Setae disposed in two bundles on each somite ..... **Distichopus**
30 (29) Setae disposed in four bundles per somite 31
31 (32) Dorsal pores present ..... **Fridericia**
32 (31) Dorsal pores absent 33
33 (34) Esophagus merges suddenly into the intestine ..... **Henlea**
34 (33) Esophagus merges gradually into the intestine 35
35 (36) Setae straight and of equal length ..... **Enchytraeus**
36 (35) Setae sigmoid 37
37 (38) Testes purilobed ..... **Lumbricillus**
38 (37) Testes divided 39
39 (40) Origin of dorsal vessel intraclitellar, blind diverticula in connection with alimentary tract somewhere in VI-VIII ..... **Bryodrilus**
40 (39) Origin of dorsal vessel postclitellar, no diverticula in connection with anterior part of alimentary canal 41
41 (42) Nephridia with a wide, closely wound canal and slight intermediate substance ..... **Mesenchytraeus**
42 (41) Nephridia with narrow, loosely wound canal and well-developed intermediate substance ..... **Marionina**
43 (26) Some bifid setae usually in each bundle, worms usually exceed 20 mm. in length 44
44 (49) Bundles each contains a pair of sigmoid (sometimes bifid) setae, no capilliform setae, blind contractile appendages on the dorsal blood vessel or on its lateral branches. Family LUMBRICULIDAE 45
45 (46) Setae bifid at extremity, prostomium rounded ..... **Lumbriculus**
46 (45) Setae simple pointed (not bifid), prostomium elongated 47

47 (48) Spermathecae without diverticula, paired or two unpaired ones opening separately; long highly muscular, ejaculatory chamber forms part of each otherwise highly differentiated sperm duct ..... **Eclipidrilus**

48 (47) Large median spermathecal sac with numerous tubular diverticula in VIII, with single median external opening ..... **Sutroa**

49 (44) Bristles usually uncinate and pectinate, but capilliform setae may occur in the dorsal bundles; lateral blood vessels form a loop around the gut in nearly every segment; no contractile appendages on the dorsal blood vessel. Family TUBIFICIDAE 50

50 (55) With capilliform setae in dorsal bundles 51

51 (52) Peri-visceral blood vessels gradually increase in size from segments 5-10 ..... **Ilyodrilus**

52 (51) Peri-visceral blood vessels much dilated (hearts) in segment VIII (or VIII and IX) 53

53 (54) Without sensory papillae around segments ..... **Tubifex**

54 (53) With sensory papillae around segments ..... **Tubifex multisetosus**

55 (50) Without capilliform setae in dorsal bundles 56

56 (61) Body not whitish or opaque because of corpuscles about the viscera 57

57 (60) Two pairs of dilated hearts 58

58 (59) In VII and VIII: no prostates ..... **Clitellio**

59 (58) In VIII and IX: prostates present ..... **Limnodrilus**

60 (57) Four pairs of hearts (VII-XI), the fourth enlarged ..... **Telmatodrilus**

61 (56) Body milky white with corpuscles about the viscera; hearts in VII-X ..... **Rhizodrilus**

62 (1) Without setae; pharynx with 2 chitinous jaws, dorsal-ventral. Family BRANCHIOBDELLIDAE 63

63 (68) Trunk region provided with dorsal or ventral appendages 64

64 (65) Trunk region bearing appendages on ventral side ..... **Crrodrilus**

65 (64) Trunk region bearing appendages on dorsal side 66

66 (67) Head not provided with tentaculiform appendages ..... **Pterodrilus**

67 (66) Head provided with tentaculiform appendages ..... **Ceratodrilus**

68 (63) Trunk region smooth, not provided with such appendages 69

69 (70) With 1 pair of testes ..... **Branchiobdella**

70 (69) With 2 pair of testes 71

71 (72) Prostomium plurilobate, with or without digitiform appendages ..... **Stephanodrilus**

72 (71) Prostomium entire or divided into a dorsal and ventral lobe 73

73 (74) Spermatheca bifid, dental plates colorless, penis eversible, pair or large clear glands in each of the 9 post-cephalic segments ..... **Bdellodrilus**

74 (73) Spermatheca not bifid, dental plates colored, penis not eversible, no large clear glands in the 9 post-cephalic segments ..... **Cambarincola**

Descriptions of the Genera and Species Found at Reelfoot Lake

Genus Aeolosoma Ehrenberg

Fresh-water Oligochaetes of small size (1-5 mm.); segmentation not marked by regular septa; prostomium ciliated ventrally; setae in four bundles of one to eight or nine each, usually capilliform (Sometimes both capilliform and sigmoid). Clitellum developed only on

ventral side of segments V-VII; single testes in V; single ovary in VI; no differentiated sperm-ducts; oviduct with external aperture ventral, median on VI. Spermathecae in one or both of segments III-IV. Nervous system represented by cerebral ganglia only. Lateral ciliated pits present.

KEY TO SPECIES

1	(4, 5)	Oil globules orange to crimson 2
2	(3)	Prostomium considerably wider than the following segment ..... *A. hemprichi*
3	(2)	Prostomium not much wider than following segment. *A. quaternarium*
4	(1, 5)	Oil globules bright green, sometimes varying to sparkling bluish ..... *A. headleyi*
5	(1, 4)	Oil globules colorless or yellow or light green, when not wholly lacking 6
6	(7)	Bifid setae among the setae..... *A. tenebrarum*
7	(6)	Bifid setae not occurring 8
8	(9)	Prostomium broader than the following segment..... *A. variegatum*
9	(8)	Prostomium not (or not distinctly) broader than following segment ..... *A. niveum*

Aeolosoma hemprichi Ehrenberg. (Plate I, 1.) Prostomium rounded, strongly oblate, considerably broader than following segment, and ciliated ventrally; oil globules orange red to dark crimson. Setae all capilliform, nearly straight, longer and shorter ones in same bundle. Length of those observed approximately 1 mm. *Aeolosoma hemprichi* was found actively dividing on July 10, 1936.

Aeolosoma tenebrarum Vejdovsky. Oil globules pale yellow to pale green or greenish yellow; capilliform and uncinate setae in same bundle. Prostomium not distinctly broader than following segment. About 2 mm. in length.

Aeolosoma variegatum Vejdovsky. (Plate I, 2.) Prostomium broader than following segments. Setae longer and shorter in same bundle; sharply bent. Oil globules usually colorless, sometimes some yellow or green. Length, 1-1.5 mm.

Genus Aulophorus (Schmarda)

Prostomium distinct. Posterior end with gill basin ending in a long process on each side. Dorsal setal bundles beginning on V or VI, with capilliform setae together with forked or fan-pointed needle setae.

KEY TO SPECIES

1	(2)	First anterior dorsal setae on V; two pairs well-developed gills, one pair secondary ..... *A. furcatus*
2	(1)	First anterior dorsal setae on VI, has only slightly developed gills ..... *A. vagus*

Aulophorus vagus Leidy. (Plate I, 3.) Segments number about 25 per individual; up to 36 or more for chain-worm. Two long non-ciliated processes from the ventral margin of branchial area. The gills are knob-like and are poorly developed. Ventral setae begin on II with 4-7 sigmoid, bifid setae per bundle. Dorsal setae begin on VI with one capilliform and one bent, bifid, needle-like seta per bundle. Colored intestine begins at 5/6; enlargement of intestine in VIII. Head rounded; mouth used as sucker disc in locomotion when pulling about tube-house which is built of bits of vegetation and duck-weed, *Lemna*, etc. *Aulophorus vagus* was found actively dividing on June 15 and 20, 1936.

Genus Chaetogaster K. von Baer

Prostomium rudimentary, or very short. Dorsal setae missing. Ventral setae missing on III and IV. Pharynx large and wide; esophagus short, at best as long as the pharynx. One pair transverse vessels present. Testes and ovaries in V and VI segments respectively. Seminal vesicle in V. Small, at most 15 mm. long, fairly plump. Transparent colorless or whitish worms, mostly parasitic, some herbivorous, one species parasitic in fresh-water snails.

KEY TO SPECIES

1 (2) Prostomium distinctly formed, trilateral, usually with head pores on the anterior margin; free living animal.....*C. diastrophus*
2 (1) Prostomium rudimentary, indistinct, or lacking; in one parasitic form, indistinctly formed 3
3 (4) Animal (chain) 10-15 mm. long, seldom shorter. Setae on second segment longer than 200 micra.....*C. diaphanus*
4 (3) Animal chain at most 5-7 mm. long, usually much smaller. Bristles on second segment shorter than 180 micra..... 5
5 (8) Esophagus shorter than pharynx and indistinct, just a portion of the length of the uniform pharynx..... 6
6 (7) Ventral setae 8-12 in bundle, 1st post-esophageal dilation of intestine covered with anastomosing network of blood vessels..*C. limnaei*
7 (6) Ventral setae 6-7 in bundle, 1st post-esophageal dilation of intestine surrounded by 12 or more pairs of non-anastomosing transverse blood vessels .....*C. pellucidus*
8 (5) Esophagus distinct, as long or almost as long as the pharynx... 9
9 (10) The blood vessels of the pharyngeal region are scanty or entirely absent .....*C. crystallinus*
10 (9) Blood vessels of the pharyngeal region well formed.....*C. langi*

Chaetogaster pellucidus Walton. Tranparent. Prostomium indistinct. Eye-spots absent. Dorsal setae absent. Ventral setae 5-9 to bundle; bifid, sigmoid, with unequal teeth. Esophagus short. This form is closely related to *C. limnaei* K. von Baer which lives in or on certain snails. The first post-aesophageal dilation (first stomach) is surrounded by 12 or more pairs of non-anastomosing, transverse blood vessels. Length of individuals observed about 2 mm.; up to 6 mm. for chainworms. *Chaetogaster pellucidus* was found in the process of division on June 26, 29, 1936.

Genus Dero Oken

Prostomium distinctly formed. Eye-spots absent. Posterior developed into gill-basin with palps. Dorsal setae begin on VI with capilliform and shorter bifid, needle-like setae. Small, up to 15 mm. in length. Inhabit tubes.

KEY TO SPECIES

1 (4, 5) Only two pairs true branchials, no real secondary branchials... 2
2 (3) Branchial basin without dorsal lip, three lamella formed..*D. perrieri*
3 (2) Branchial basin with dorsal lip.....*D. obtusa*
4 (1, 5) In all, three pairs branchials, one pair standing on the edge of the branchial basin (secondary branchials), branchial basin with undivided dorsal lip .....*D. limosa*
5 (1, 4) In all four pairs of branchials (all true or perhaps only two pairs true and two pairs secondary) standing on the edge of the branchial basin 6

6 (7) Branchial basin full brimmed, without dorsal lap.....*D. digitata*
7 (6) Branchial basin with dorsal lip, dividing it through sharp median .....*D. incisa*

Dero limosa Leidy. (Plate I, 4.) Length of observed specimens: individual about 4-5 mm., chain-worm 9 mm. Segments about 30-35, up to about 60 for chain worm. Transparent. Ventral setae on II-V with 4 or 5 longer toothed, sigmoid setae, with distal tooth-fork only a little longer than the proximal tooth, with nodule proximally situated. Ventral setae farther back, sigmoid, bifid, with subequal teeth. Dorsal setae begin on VI with one needle-like and one capilliform setae to bundle. Gill basin rounded ventral-posteriorly, with dorsal anterior lip, on each side an accessory gill is borne, and with two pairs leaf-formed real (primary) gills, these longer than wide. *Dero limosa* was found in the process of division on June 15. 16 and July 22, 1936.

Dero obtusa d'Udekem. (Plate I,5.) Individuals 3-5 mm., chain-worms 5-10 mm. in length. Number of segments about 30-36 for individual, 35-46 for chain-worms. Dorsal bundles with one bifid seta and one capilliform. Gill basin with median dorsal lip. Two pairs rather short, ciliated, contractile, real gills. No secondary (accessory) gills.

Genus Naidium O. Schm.

Prostomium rounded or pointed. Ventral setal bundles composed of double-pointed crotchets. Dorsal bundles beginning in II, composed of hair setae and double-pointed needles. Genital organs two segments further back than is usual in the family; testes and spermathecae in VII, ovaries and male pore in VIII; setal glands with penial setae asymmetrically placed, one in VII and one in VIII; prongs of penial setae of extraordinary length, taking up not far from half the length of the seta. Seven anterior segments formed in the budding zone.

KEY TO SPECIES

1 (2) Number of segments in individual 15-16.....*N. osborni*
2 (1) Number of segments in individual 32-40.....*N. luteum*

Naidium luteum (O. Schmidt). Length of observed specimens 4-5 mm.; segments about 30-35. Both dorsal and ventral setae begin on II. Dorsal setae are 1-3 in number, capilliform together with 1-2 bifid, slightly uncinate, wide-toothed setae. The capilliform setae are not quite as long as body diameter. Ventral setae are bifid and sigmoid, four to bundle towards anterior; fewer towards posterior. Pharynx ends at 3/4; esophagus undulates and gradually enlarges to 9/10 where it enlarges rapidly to form stomach. Coelomic cavity filled with whitish, granular-appearing corpuscles. Blood yellowish. Segments IV-VIII appeared to have a loop (heart) formed by a blood vessel around the intestine. These were largest in VI-VIII. No eye-spots, generally transparent, no long proboscis.

Genus Nais Piquet

Dorsal setae commence on segment VI, capilliform only, or capilliform and uncinate, or straight with bifurcate end. Eye-spots usually present.

KEY TO SPECIES

1 (2) Eyespots missing .....*N. josinae*
2 (1) Eyespots present 3
3 (14) Needle-like setae in dorsal bundles, all bifid..... 4
4 (13) Ventral setal bundles in 7th and 11th segments normally formed, not with a smaller number of enlarged setae..... 5

5 (6) Dorsal bifid setae almost resembling the hooked ventral bifids: the dorsal hairs fewer then double as long as the needle-like dorsal ones ..... *N. blanci*

6 (5) The dorsal bifid setae real needle-like, all others formed like the ventral hooks 7

7 (10) Intestine seem to gradually widen in the 7th segment. The dorsal hairs at least three times as long as the dorsal needle-shaped setae 8

8 (9) Tooth forks in needle-shaped dorsals very long and slender, angle between forks very narrowly divergent..... *N. elinguis*

9 (8) Tooth forks on the short needle-like dorsal setae in moderate points, nearly straight divergent angle..... *N. communis*

10 (7) Intestine in segment 7 seen to suddenly widen..... 11

11 (12) Dorsal hair setae more than three times as long as short needle-like (dorsal) setae ..... *N. variabilis*

12 (11) Dorsal setae less than 3 times as long as short needle-like dorsal setae ..... *N. pardalis*

13 (4) Ventral setae in 7-11 segments either singly or in twos in the bundle, and very strong with an enormous nodulus....*N. bretcheri*

14 (3) Dorsal short-needle setae collectively, or some partly, single pointed 15

15 (16, 17) Coloration of anterior of body yellow, varying to brownish yellow. The dorsal, short-needle setae all simple pointed; dorsal long hair setae almost lance-shaped, heavy, flexible; the average almost twice as long as the short-needle setae, 1-3 in bundle ..... *N. obtusa*

16 (15, 17) Coloring white (pale), dorsal, short needle setae all simple pointed; dorsal long-hair setae fine, light, flexible, 3½-4½ times as long as the short needle setae, 1-2 per bundle..... ..... *N. pseudoobtusa*

17 (15, 16) Coloring red or brownish yellow. Dorsal short needle setae all simple pointed or some simple pointed; if bifid, keen-forked with very refined toothforks; dorsal long hair setae about 3½ times as long as the short needle setae, 1-2 in bundle..... *N. simplex*

Nais pardalis Piquet. (Plate I, 6.) Length 2.5-3.5 mm. Number of segments approximately 22; observed 22-24. Ventral setae begin on II, dorsal on VI. Ventral setae on II-V are bifid, sigmoid, and very slender; the distal tooth-fork very long and the proximal tooth-fork about half as long and thicker. On those segments posterior to V, the setae are much thicker or stouter. Ventral bundles contain 2-5 setae. Dorsal setae consist of one apparently bifid needle-like and one capilliform seta per bundle, these latter shorter than body diameter, and about twice as long as needle setae. Blood yellow. Coelomic corpuscles present in all parts of coelom. Eye-spots present.

Genus Pristina

Key to Species

1 (4) Setae of dorsal bundles smooth..... 2

2 (3) Last segment not provided with finger-like processes, ventral sigmoid setae on IV, or IV and V, with stout enlargements.....*P. tentaculata*

3 (2) Last segment provided with 3 (2 lateral and 1 median) finger-like processes projecting posteriorly.....*P. flagellum*

4 (1) Setae of dorsal bundle provided with numerous fine but distinct teeth 5

5 (6) Dorsal capilliform setae of segment III twice as long as others .....*P. longiseta* var. *leidyi*

6 (5) Dorsal capilliform setae of segment III not longer than others.... 7

7 (8) Teeth of ventral setae subequal. Number of somites about 14 ..... *P. serpentina*
8 (7) Distal teeth of ventral setae longer than proximal teeth. Segments number 18-20 ..... *P. proboscidea*

Pristina flagellum Leidy. Number of segments in observed specimens: 16-38; only one chain-worm observed and it had 27 segments. Length 3-7 mm. Prostomium elongated into a tentacular proboscis. Both dorsal and ventral setae begin on II, the dorsal only of capilliform setae, the ventral bifid, sigmoid, and about 4 to bundle. The posterior end is characteristic and is identified by two long finger-like terminal processes and a shorter median one. The shorter process is usually one-fourth to one-half the length of the longer processes. The intestine is blackish in color, this color beginning at 5/6. There is a gradual enlargement of the intestine through VI and VII. Greenish corpuscular bodies may usually be observed in the coelom of a few of the hinder-most segments. *Pristina flagellum* was found in the process of division on June 12, 1936.

Pristina longiseta var. *leidyi* Smith. (Plate I, 7.) Number of segments in individual approximately 20; chain-worm up to about 50. Length 2.5-4 mm. Has long tentacular snout. Ventral setae bifid, sigmoid. Dorsal bundles contain only capilliform setae and these are with serrations, except those on the third segment which are very elongated and usually about twice as long as those on other segments and sometimes ever longer. Spherical coelomic corpuscles with dark center observed in many specimens. *Pristina longiseta* var. *leidyi* was found in the process of division on the following dates: June 15, 16, 19, 20, 22, 29, July 7, 8, 22, 1936.

Genus Stylaria Lm.

Prostomium prolonged into a long filiform proboscis. Ventral setal bundles of double-pointed crotchets. Dorsal bundles beginning in VI, with hair-setae not specially elongated in any particular segment, and single-pointed needle setae. Stomachal dilatation in VIII. or VIII and IX. Position of genital organs as usual in the family; atrium and lower part of vas deferens clothed with "prostatic" cells; spermathecae bent back and contained in spermsac; penial setae present.

Key to Species

1 (2) Proboscis flanked by prominent lateral prostomial lobes..... *S. lacustris*
2 (1) Proboscis not flanked by prominent lateral prostomial lobes.. *S. fossularis*

Stylaria fossularis Leidy. (Plate I, 9.) Number of segments in chain-worm approximately 50; maximum number observed 55. Length of chain-worms 8-12 mm. Prostomium elongated to form a proboscis; dorsal setae of VI similar in length to those of other somites. Proboscis without lateral prostomial lobes. Posterior end not modified into a gill-bearing organ. Both ventral and dorsal setae begin on VI. Ventral setae 3-5 bifid, sigmoid, in anterior bundles. Dorsal setae capilliform together with 2-3 straight, needle-like setae. Eye-spots present. One (or two) pair of yellow spots observed in each anterior somite which, apparently, are at base of setae. Esophagus undulates through VI and VII. Sudden enlargement of intestine in VIII, decrease in VIII-IX; undulates through X-XII, gradually increasing in size in XI and XII. Intestine dark in color. *Stylaria fossularis* was observed in the process of division on June 26, 1936.

Stylaria lacustris (Linnaeus). (Plate I, 8.) Number of segments in chain-worm approximately 40; in individual about 26. Length 4.5-6 mm. Description same as *Stylaria fossularis* except that lateral prostomial lobes are present. *Stylaria lacustris* was found in the process of division on June 29, 1936.

Genus Limnodrilus Claparede

Fresh-water Oligochaetes with uncinate setae only. Contractile hearts in VIII or in VIII and IX. Perivisceral loops in posterior segments of body give off branches which penetrate body wall. Penis with chitinous lining, prostates present.

KEY TO SPECIES

1 (2) Chitinous penis sheath short, about 4 (or 3) times as long as thick ..... *L. udekemianus*
2 (1) Chitinous penis sheath long, at least 8 times as long as thick..... 3
3 (6) Chitinous penis sheath 8-11 times as long as thick..... 4
4 (5) Pharynx reaches up to 3rd segment, setae short-toothed... *L. hoffmeisteri*
5 (4) Pharynx reaches up to 5th segment, setae with longer, higher toothforks ..... *L. claparedeianus*
6 (3) Chitinous penis sheath more than 20 times as long as thick..... *L. longus*

Limnodrilus sp. (Plate I, 10.) Segments number mostly between 40 and 70, but found up to 110. Length up to 30 mm. Hearts in VIII and IX. Blood reddish, intestine and general appearance red. Dorsal setae begin on II with usually 3-5 bifid, sigmoid setae to bundle. Ventral setae begin on II and are similar in number and form to the dorsal. Found in mud-slime tubes with posterior end waving about in the water while the anterior end is anchored in the mud-tube. They withdrew into the tube on the slightest disturbance of mud or water. Posterior region more vascular than rest of body.

Genus Tubifex Lm.

Dorsal setal bundles consisting of double-pronged crotchets and, at least in the anterior part of the body, of hair-setae; the form of the ventral and of the dorsal crotchets differs, the latter often pectinate or more or less incompletely pectinate (with small teeth intermediate between the two prongs). Vas deferens longer than the atrium; the atrium with a solid prostate. A true penis present. Spermatophores in the spermathecae.

Tubifex multisetosus (Frank Smith). Number of segments approximately 50, only about the anterior half bear setae. Length of those observed from 4-8 mm. Dorsal and ventral setae begin on II. Dorsal with mostly 4-5 capilliform together with 1 or 2 palmate setae in the anterior bundles. Ventral bundles of 2-3 bifid, sigmoid setae in anterior bundles. Pharynx in II and III. Esophagus begins in IV. Hearts in VIII. Anterior six or eight somites more transparent than middle portion of body. Posterior region vascular and transparent. Body apparently covered with a sheath-like covering of slime or mud through which sensory papillae are visible. Blood reddish-yellow. Color of intestine not usually conspicuous. No coelomic corpuscles observed. This worm was first described by Frank Smith (1900) as *Embolocephalus multisetosus*. All specimens observed were found in bottom mud.

Tubifex sp. Segments number mostly 30-50. Length 2-10 mm. Prostomium pointed, whitish integument, blood pale reddish-yellow. Colored intestine begins at end of V, color golden-brown. Hearts and gradual enlargement of intestine in VIII. Gradual decrease in size of intestine in XI and XII. No coelomic corpuscles. Both dorsal and ventral setae begin on II. Dorsal setae 1-3 capilliform with 1-3 bifid, slightly sigmoid, setae per bundle. Ventral 2-4 per bundle, bifid, sigmoid setae. No palmate or pectinate setae observed. No sexually mature worms with clitellum were observed.

Genus Cambarincola Ellis

No trunk or head appendages. A single median dorsal pulsatile papilla carrying the single common opening of the anterior nephridia. Dental plates coloured, dissimilar. No conspicuous clear paired segmental glands in the first nine postcephalic segments. Two pairs testes and vasa deferentia; a long accessory sperm tube connected with the atrium; a non-eversible penis, but an eversible bursa. Spermatheca not bifid.

Key to Species

1 (2) Head as wide as or wider than greatest body width, campanulate; 1 lip, slightly crenate; dorsal plate with 7 teeth, ventral with 10 ..... *C. philadelphica*

2 (1) Head not as wide as greatest body width, tapering anteriorly; 2 lips; dorsal plate with 5 teeth, ventral with 4..... *C. macrodonta*

Cambarincola macrodonta Ellis. Length of those observed 1-2.5 mm. Small leech-like worms, variously reported as parasitic or symbiotic on crayfishes. No setae present. Worm consists of an anterior sucking disc, a head region of three fused segments, 9 biannulated segments, the larger annulus anterior, and a posterior sucker disc. The largest intestinal enlargements are in the 3rd and 4th post-cephalic segments. Anal opening at dorsal surface of post-cephalic segment IX. No dorsal appendages present. Number of teeth in lower jaw 4, number of teeth in upper jaw 5. All specimens were found on the gill filaments of *Cambarus blandingii acutus.*

Habitats and Habits

The habitat of the various families of Microdrili differs to some extent. In general, the fresh-water forms prefer the bottom mud of quiet ponds, lakes or slow-moving streams. Certain Naids such as *Aulophorus vagus, Pristina longiseta* var. *leidyi, Chaetogaster pellucidus,* etc., appear to prefer floating masses of algae and duckweed such as *Lemna,* while others—and sometimes the ones just mentioned—are abundant in the submerged *Ceratophyllum.* Some species, as *Dero limsoa, Dero obtusa, Nais pardalis, Pristina flagellum, Stylaria lacustris,* and *Stylaria fossularis* are most plentiful in and on the stems and roots of submerged and decaying plants and in the mud beneath such plants. Many specimens of *Stylaria* were found in association with *Ceratophyllum demersum. Limnodrilus* sp. and *Tubifex multisetosus* were in all cases found in the bottom mud.

Many of the worms are tube dwellers. *Dero, Aulophorus, Pristina,* and *Limnodrilus* were found in tubes. *Dero* and *Pristina* inhabited tubes which were usually attached longitudinally to a plant stem. The tube of *Limnodrilus* was in the bottom mud from which the worm protruded and waved its posterior end about in the water. *Limnodrilus* could make a tube in a short time and even on the microscope slide while being observed. It apparently discharged a secretion to which any loose matter adhered. If sufficient loose material were close about, an opaque mass would soon be formed from which only the anterior and posterior ends of the coiled worm might be projecting. In the case of the other worms mentioned, they probably

made tubes in a similar way, but were not observed in the act. *Aulophorus vagus* was observed crawling about and pulling a capsule-like case made of pieces of Lemna and other vegetation. Its manner of locomotion was leech-like in that it would extend its body, attach its mouth as a sucking disc and then contract, thus dragging its house-case about.

Of the Microdrili observed none could withstand desiccation. That introduces the problem of their appearance in ponds and streams that dry up each year. When this occurs it is probable that all members of those families studied perish. The families Branchiobdellidae and Tubificidae, which reproduce sexually, are probably replenished from cocoons which can withstand drying. It seems obvious that species of the family Naididae must be reintroduced, probably in mud on the feet of birds, of which there are many kinds about Reelfoot Lake. Members of the family Aeolosomatidae are known to encyst, and that can partly account for their cosmopolitan distribution.

The whole family Branchiobdellidae are ecto-parasites on crayfish. On infested crayfish they are often numerous, but on the crayfish from Reelfoot Lake they were found only on the gill-filaments after careful searching. They move about much as a measuring worm, attaching themselves first by their anterior and then by their posterior discs. They are sturdy worms and withstand considerable mistreatment, such as drying and pressure on the microscope slide, before decomposing. They could apparently withstand greater desiccation than could the other families observed. Since they were found only on the gill-filaments of the crayfish, it is there that they may do damage. The extent of such damage was not apparent. Various Naids live on aquatic plants, but they can hardly be properly called parasites without more evidence than this.

In mud or on aquatic vegetation, the normal mode of locomotion is creeping or crawling by use of the setae. When brought into the laboratory in mud and water and placed in jars, they often come to the surface of the water and sometimes swim quite actively with wide undulations of the body. Only Naids were observed to do this. From their limitations as swimmers, it is, however, evident that they would inevitably be carried away in running water unless protected by anchored vegetation or other stationary objects. Locomotion in the Branchiobdellidae is typically leech-like. By the alternate attachment of the sucking discs to the substratum, "looping" movements are created similar to those of the measuring worm. Free swimming was never observed in these forms.

The usual method of reproduction for the families, Aeolosomatidae and Naididae, is by fission. Practically all stages in this process were observed in most of the genera of these families represented at Reelfoot Lake. The families, Tubificidae and Branchiobdellidae, reproduce exclusively by sexual methods. However, only one mature specimen which bore a clitellum was observed, and it was of the genus *Limnodrilus*. Two other worms of the family, Tubificidae, showed

evidences of partial sexual maturity. Scores of specimens of the genus *Limnodrilus* (Tubificidae) were examined with the view of finding other mature worms which might give a clue to the species, but without success. No cocoons of these Tubificids were observed. It is well known that the formation of cocoons in this family is seasonal and the period of this investigation, from the early part of June until the latter part of July, 1936, evidently did not coincide with their period of cocoon formation. A similar statement might be made concerning the Branchiobdellidae, although fewer specimens of them were examined.

Summary

Thirty-two samples of mud and water, which often included aquatic vegetation and debris, were taken from representative sites about the lake. These samples were examined with the microscope and identification of the worms found was made. All of the observations recorded were made on living worms, or those purposely crushed by the cover-glass in order to see the setae more distinctly.

The following list of species is reported and described: *Aeolosoma hemprichi* Ehrenberg, *Aeolosoma* sp., *Aeolosoma tenebrarum* (?) Vejdovsky, *Aeolosoma variegatum* Vejdovsky, *Aulophorus vagus* Leidy, *Chaetogaster pellucidus* Walton, *Dero limosa* Leidy, *Dero obtusa* d'Udekem, (?) *Naidium luteum, Nais pardalis* Piquet, *Pristina flagellum* Leidy, *Pristina longiseta* var. *leidyi* Smith, *Stylaria fossularis* Leidy, *Stylaria lacustris* (Linnaeus), *Limnodrilus* sp., *Tubifex multisetosus* (Frank Smith), *Tubifex* sp., *Cambarincola macrodonta* Ellis. A key for separating these forms is included.

Certain Naids such as *Aulophorus vagus, Pristina longiseta* var. *leidyi, Chaetogaster pellucidus,* and others appear to prefer floating masses of algae and duckweed such as *Lem* and some-*na,* while other, times the ones just mentioned, are abundant in the submerged vegetation. Some species, as *Dero limosa, Dero obtusa, Nais pardalis, Pristina flagellum, Stylaria lacustris,* and *Stylaria fossularis,* are most plentiful in and on the stems and roots of submerged and decaying plants and in the mud beneath such plants. Many specimens of *Stylaria fossularis* and *S. lacustris* were found in association with *Ceratophyllum demersum. Limnodrilus* sp. and *Tubifex multisetosus* were always found in the bottom mud. Many of the worms are tube dwellers. *Aulophorus vagus* dragged its house-case as it moved from place to place. None of the worms studied could withstand desiccation. The whole family Branchiobdellidae is ecto-parasitic on crayfish. Their mode of locomotion is like that of a leech, while creeping or crawling by making use of the setae is the normal mode for the other families.

The usual method of reproduction for the families, Aeolosomatidae and Naididae, is by fission. The families, Tubificidae and Branchiobdellidae, reproduce by sexual methods. Most stages in the process of fission were observed for those forms belonging to the Aeolosoma-

tidae and Naididae. Only one mature specimen with clitellum was found, and it was of the genus *Limnodrilus,* a Tubificid. No cocoons were observed.

The chief economic importance of the Microdrili of Reelfoot Lake, Tennessee, is due to the fact that they are an indispensable link in the food chain of the larger animals. That they are used as food by insect larvae was proven by an observation of a dobson fly larva actively eating a worm of the genus *Limnodrlius.*

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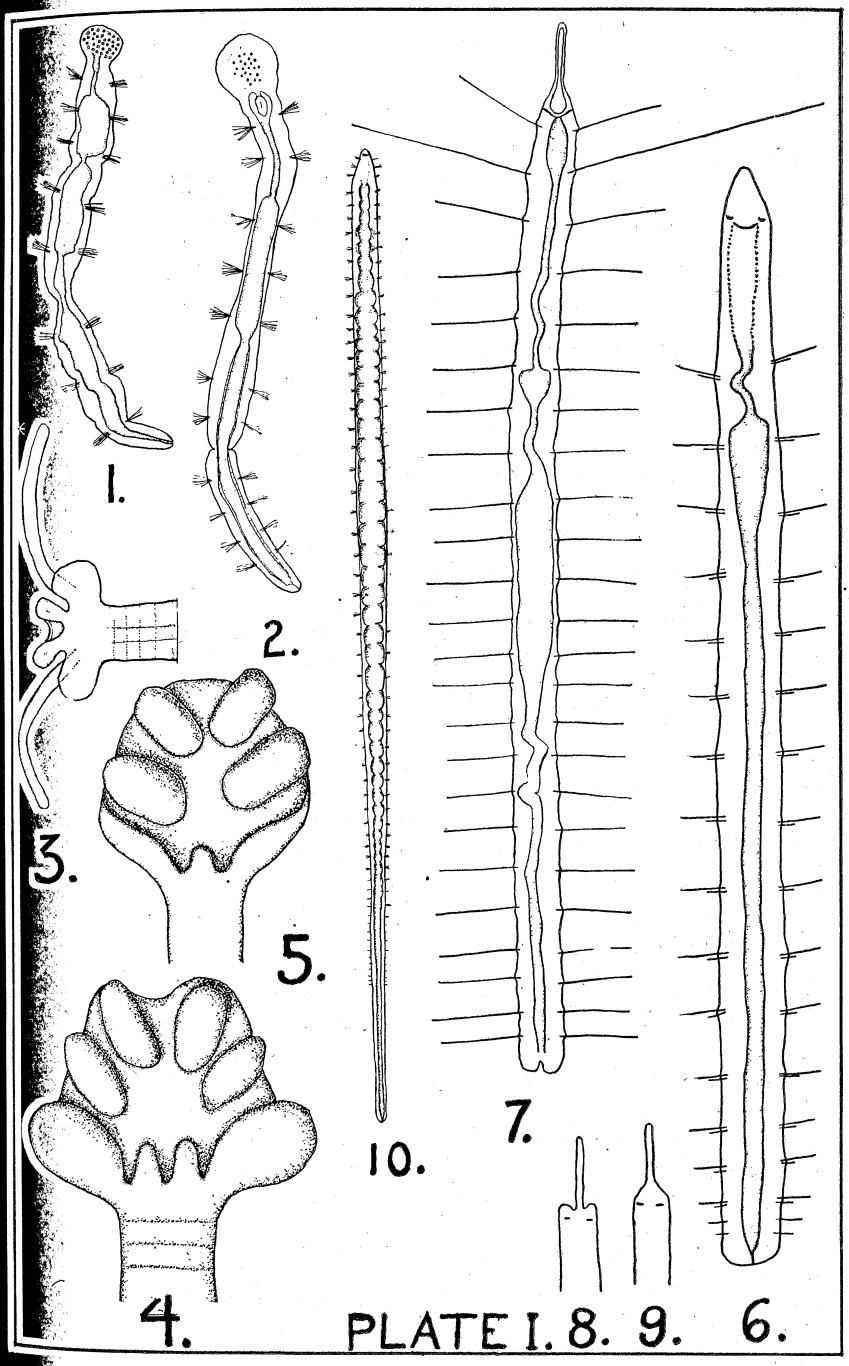
EXPLANATION OF PLATE I

1. Aeolosoma hemprichii
2. Aeolosoma variegatum
3. Aulophorus vagus
4. Posterior end of Dero limosa
5. Posterior end of Dero obtusa
6. Nais pardalis
7. Pristina longiseta variety leidyi
8. Anterior end and proboscis of Stylaria lacustris
9. Anterior end and proboscis of Stylaria fossularis
10. Limnodrilus sp.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2.
3.
5.
4.
10.
7.
6.
PLATE I. 8. 9.