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A Guide to the Freshwater Tubificidae (Annelida: Clitellata: Oligochaeta) of North America

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A GUIDE TO THE FRESHWATER TUBIFICIDAE (ANNELIDA: CLITELLATA: OLIGOCHAETA) OF NORTH AMERICA

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FOREWORD

Environmental measurements are required to determine the quality of ambient water, the character of effluents, and the effects of pollutants on aquatic life. The Environmental Monitoring and Support Laboratory - Cincinnati conducts an Agency-wide quality assurance program to assure standardization and quality control of systems for monitoring water and wastewater and conducts research to develop, evaluate, and promulgate methods to:

* Measure the presence and concentration of physical, chemical, and radiological pollutants in water, wastewater, bottom sediments, and solid waste.
* Concentrate, recover, and identify enteric viruses, bacteria, and other microorganisms in water.
* Measure the effects of pollution on freshwater, estuarine, and marine organisms, including the phytoplankton, zooplankton, periphyton, macrophyton, macroinvertebrates, and fish.
* Automate the measurement of physical, chemical, and biological quality of water.

The effectiveness of measures taken to maintain and restore the biological integrity of the Nation's surface waters is dependent upon our knowledge of the changes in the taxonomic composition of aquatic life caused by discharges of toxic substances and other pollutants, and upon the level of our understanding of the complex relationships that prevail in aquatic ecosystems. Tubificid worms are important components of the benthic fauna and are frequently abundant in a variety of freshwater habitats. The varied response of tubificid species to different kinds of pollution and toxic substances makes them very useful as water quality indicator organisms. While several regional keys to North American Tubificidae have been published, this manual is the first to contain an illustrated key and the distribution for all taxa. The publication was developed to assist aquatic biologists in evaluating data collected in studies of the effects of toxic substances and other pollutants on the communities of benthic macroinvertebrates.

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ABSTRACT

In North America, the freshwater annelid worms (Clitellata: Oligochaeta), belonging in the family Tubificidae, are composed of 18 genera, 54 species, one subspecies, and several variant forms. All taxa can be identified by external and internal morphological features. This guide presents an introduction to the general biology of the Tubificidae, collecting and processing methods, a species list, an artificial illustrated key, a glossary, an annotated systematic list, and a selected bibliography which includes the references cited in the text and other publications which provide additional information on tubificid taxonomy and ecology.

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ACKNOWLEDGMENTS

The authors thank Ralph O. Brinkhurst, Thomas V. Clevenger, and Michael S. Loden for their reviews of the technical contents of the manuscript. We also thank Cornelius I. Weber for reading the manuscript and making valuable suggestions. We are grateful to Kristian Fauchald of the Smithsonian Institution, U.S. National Museum of Natural History, Department of Invertebrate Zoology, Division of Worms, Washington, D.C. for permitting us to examine the collections of Tubificidae. We are also indebted to the following individuals for supplying specimens and distribution records: Ralph O. Brinkhurst, Dale F. Kriewall, Michael S. Loden, Anthony F. Maciorowski, Bruce E. Markert, Bruno Vincent, and Mark J. Wetzel. We extend special thanks to Douglas R. Spencer for his contributions in early stages of preparation of the guide. We would also like to thank Peter M. Chapman for the use of Figure 43.

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SECTION 1

INTRODUCTION

The relationship between benthic macroinvertebrate community structure and the physical and chemical characteristics of aquatic habitats has been examined in great detail in the past several decades. The body of knowledge relating the qualitative and quantitative responses of benthic communities to changes in habitat has grown to the point where an examination of benthic community structure has become a valuable tool for regulatory agencies, water resource managers, and aquatic ecologists in assessing and monitoring water quality and detecting pollution sources. The Oligochaeta, or segmented worms, are an important component of the benthic community in nearly every freshwater biotope. The group comprises 24 families, among which the Tubificidae are the most widely distributed and abundant oligochaetes in freshwater systems. The utility of the Tubificidae for monitoring and detecting changes in water quality and physical habitats has been illustrated by several authors (Brinkhurst, 1966, 1970, 1974a,b; Lang and Lang-Dobler, 1980; Stimpson, et al., 1975). Compared to other macroinvertebrate groups, the Tubificidae are particularly well-suited for use in biological assessments of water quality, water pollution, or other changes in aquatic ecosystems resulting from natural causes or man's activities. Members of the family live longer than many other invertebrate forms; are generally sedentary infaunal forms and, as opposed to, for example, most aquatic insects, are restricted to the aquatic environment throughout their life cycle. Most importantly, the habitat and water quality requirements as well as the pollution tolerance of many species have been documented in the literature (Chapman, Farrell, and Brinkhurst, 1982a,b; Hiltunen, 1967, 1969a, 1969b; Howmiller and Beeton, 1970).

Unfortunately, the Tubificidae have often been overlooked or ignored in sample processing or misidentified by investigators not familiar with their taxonomy. In many instances, investigators have recorded the group only as subclass (Oligochaeta), family, or merely as "worms." The inadequate treatment of the family represents a loss of valuable ecological information that may be attributed, at least in part, to the misconception that the group is taxonomically very difficult, and to the lack of a practical key to the species.

Thus, the guide was composed to assist the USEPA and other biologists in Federal, state, and private water monitoring organizations in identifying specimens of tubificid worms to species. The guide will aid in the monitoring and detection of changes in water quality and the effects of toxic substances and other pollutants on macroinvertebrate

community structure. It will also facilitate an expansion of our knowledge of the ecological requirements of some of the lesser known tubificid species. The guide includes a discussion of methods for the collection, preparation, and examination of specimens, a species list, an artificial illustrated key, a glossary, an annotation for each species, and a selected bibliography. Morphological features utilized in the differentiation of species are defined in the glossary. The reader is referred to Brinkhurst and Jamieson (1971) and Reynolds (1977) for additional morphological terms. The selected bibliography was assembled from literature pertaining directly to the systematics and ecology of the Tubificidae of North America.

Inasmuch as new zoogeographical records are published frequently, this guide may not include the latest North American discoveries. In instances where a species is not keyed in the present work, the reader is directed to consult Brinkhurst and Jamieson (1971), Aquatic Oligochaeta of the World. Complete descriptions that may be helpful in confirming the identity of most species in this guide, may also be found therein.

SECTION 2

METHODS

COLLECTION, PRESERVATION, AND PREPARATION OF TUBIFICIDAE WHOLE MOUNTS

Tubificidae may be collected using any of a variety of methods, ranging from qualitative hand-picking and dip-netting to quantitative dredge, grab or core sampling. Using most conventional collection methods, it is necessary to reduce the volume of sediment in order to discern and sort the organisms. Although Agency procedures for macroinvertebrate studies (Weber, 1973) recommend screening the sample on a U.S. Standard No. 30 mesh sieve (28 meshes per inch, 0.595 mm openings), it should be noted that many small individuals may be lost during the sieving process and that use of a finer sieve (for example, No. 60 mesh) or no sieving at all may be required to insure collection of all individuals. Great care should be taken in sieving samples containing worms; too vigorous agitation may break specimens or damage body parts required for species identification. Tubificidae collected by selective hand-picking in the field may be fixed and preserved by placing them directly in 5% formalin. Sieved samples may, depending on the volume of sediment retained, require a slightly greater concentration of formalin (10%) to assure adequate preservation. Use of alcohol as a fixative should be avoided because worms initially preserved in alcohol without first being fixed in formalin tend to deteriorate.

The initial sorting of specimens from sediment residue should be done at 5-10X using a dissection microscope or magnification lens. Even when sieving has been accomplished carefully, some individuals will fragment. To avoid possible overcount in quantitative studies, only head-end sections and whole worms should be enumerated. Forceps are commonly employed to remove specimens from the sieve residue. The sorted oligochaetes may be stored indefinitely in sealed vials containing 5-10% formalin. Additional instructions for sorting macroinvertebrate samples can be found in the USEPA Biological Methods Manual (Weber, 1973).

To identify oligochaetes to species, they must be cleared and mounted on glass slides for examination under a compound microscope capable of magnification up to 1000X. An 18 mm diameter, No. 0 or 1 round cover glass is appropriate because it will adequately accommodate nearly the size range of tubificids and the shape allows for maneuvering the specimen into the most desired position by gentle rotation of the cover glass. When preparing a temporary or permanent slide mount, an attempt should be made to place the specimen on its side, thereby, revealing both dorsal and ventral fascicles of chaetae. It may be necessary to apply

gentle pressure on the cover glass to flatten the specimen to render the important anatomical features more readily visible. Depending on the need of the investigator, a variety of clearing agents, media, and mounting procedures may be employed. The simplest method is to mount specimens directly in a permanent nonresinous medium (for example, Hydramount[1], or CMC[2]) that contains a clearing agent. This method allows rapid processing of specimens, but further handling of specimens is rendered difficult because of the permanence of the mount. Alternatively, specimens can be cleared in a solution of Amman's lactophenol (Brinkhurst, 1968), prepared by combining 100g phenol, 100mL lactic acid, 200mL glycerine, and 100mL water. Clearing of specimens in Amman's lactophenol may be accomplished either in a stoppered vial or by mounting them temporarily on glass slides and covering with a round coverglass. The clearing process usually takes a few hours to a few days depending on the size and preservation of the specimens. Gentle application of heat will speed the clearing process.

If the specimens are preserved in 70% alcohol, they should be placed in 30% alcohol and then in water for a short time to leach out the alcohol. The alcohol retards the clearing process of Amman's lactophenol. However, do not leave specimens in the water too long (not more than 2 hours) because the worms will begin to deteriorate. Tubificids can be held indefinitely in Amman's lactophenol or 10% formalin for later processing and mounting. After clearing, the specimens can be examined directly or removed and mounted in a permanent medium. Optimal resolution and longevity of mounted material are achieved only in resinous media (for example, Canada balsam, Harleco's Coverbond[3] for xylene, and so forth). These mounting media require dehydration of the specimens through the alcohol series before using the mountant, but they produce the best permanent mounts. This method can be found in standard biological techniques sourcebooks. Nonresinous media are recommended for rapid processing of large numbers of specimens, but for a few or for important reference materials, resinous mounting media are best. Longevity in the quality of a mounted specimen can be increased by sealing the margin of the cover glass with clear fingernail lacquer.

DEPOSITORY FOR TUBIFICID WORMS

Tubificid material no longer needed in a study should be deposited in an appropriate museum. In North America, the specimens with proper collection data can be sent to the Division of Worms, Department of Invertebrate Zoology, U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

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[1]Bio/Medical Specialities (P.O. Box 1687, Santa Monica, CA 90406)
[2]Master's Chemical Co. (P.O. Box 2382, Des Plaines, IL 60018)
[3]Scientific Products (1430 Waukegan Road, McGaw Park, IL 60085)

SECTION 3

SPECIES LIST

Phylum Annelida
Class Clitellata
Subclass Oligochaeta
Order Haplotaxida
Suborder Tubificina
Family Tubificidae

Genus *Aulodrilus* Bretscher, 1899

Aulodrilus americanus Brinkhurst and Cook, 1966
Aulodrilus limnobius Bretscher, 1899
Aulodrilus pigueti Kowalewski, 1914
Aulodrilus pluriseta (Piguet, 1907)

Genus *Bothrioneurum* Stolc, 1886

Bothrioneurum vejdovskyanum Stolc, 1886

Genus *Branchiura* Beddard, 1892

Branchiura sowerbyi Beddard, 1892

Genus *Haber* Holmquist, 1978

Haber cf. *speciosus* (Hrabě, 1931)

Genus *Ilyodrilus* Eisen, 1879

Ilyodrilus frantzi Brinkhurst, 1965
Ilyodrilus frantzi form *capillatus* Brinkhurst and Cook, 1966
Ilyodrilus mastix Brinkhurst, 1978
Ilyodrilus templetoni (Southern, 1909)

Genus *Isochaetides* Hrabě, 1966

Isochaetides curvisetosus (Brinkhurst and Cook, 1966)
Isochaetides freyi (Brinkhurst, 1965)

Genus *Limnodrilus* Claparède, 1862

Limnodrilus angustipenis Brinkhurst and Cook, 1966
Limnodrilus cervix Brinkhurst, 1963

Limnodrilus cervix (variant form)
Limnodrilus claparedianus Ratzel, 1868
Limnodrilus hoffmeisteri Claparède, 1862
Limnodrilus hoffmeisteri (spiralis form)
Limnodrilus hoffmeisteri (variant form)
Limnodrilus maumeensis Brinkhurst and Cook, 1966
Limnodrilus profundicola (Verrill, 1871)
Limnodrilus psammophilus Loden, 1977
Limnodrilus rubripenis Loden, 1977
Limnodrilus silvani Eisen, 1879
Limnodrilus udekemianus Claparède, 1862

Genus Monopylephorus Levinsen, 1884

Monopylephorus helobius Loden, 1980

Genus Phallodrilus Pierantoni, 1902

Phallodrilus hallae Cook and Hiltunen, 1975

Genus Potamothrix Vejdovsky and Mrazek, 1902

Potamothrix bavaricus (Öschmann, 1913)
Potamothrix bedoti (Piguet, 1913)
Potamothrix hammoniensis (Michaelsen, 1901)
Potamothrix moldaviensis Vejdovsky and Mrazek, 1902
Potamothrix vejdovskyi (Hrabě, 1941)

Genus Psammoryctides Hrabě, 1964

Psammoryctides barbatus (Grube, 1861)
Psammoryctides californianus Brinkhurst, 1965
Psammoryctides convolutus Loden, 1978
Psammoryctides minutus Brinkhurst, 1965

Genus Quistadrilus Brinkhurst, 1981

Quistadrilus multisetosus (Smith 1900)

Genus Rhizodrilus Smith, 1900

Rhizodrilus lacteus (Smith, 1900)

Genus Rhyacodrilus Bretscher, 1901

Rhyacodrilus brevidentatus Brinkhurst, 1965
Rhyacodrilus coccineus (Vejdovsky, 1875)
Rhyacodrilus falciformis Bretscher, 1901
Rhyacodrilus montana (Brinkhurst, 1965)
Rhyacodrilus punctatus Hrabě, 1931
Rhyacodrilus sodalis (Eisen, 1879)

Genus Spirosperma Brinkhurst, 1981

Spirosperma beetoni (Brinkhurst, 1965)
Spirosperma carolinensis (Brinkhurst, 1965)
Spirosperma ferox (Eisen, 1879)
Spirosperma nikolskyi (Lastockin and Sokolskaya, 1953)

Genus Telmatodrilus Eisen, 1879

Telmatodrilus vejdovskyi Eisen, 1879

Genus Tubifex Lamarck, 1816

Tubifex harmani Loden, 1979
Tubifex ignotus (Stolc, 1886)
Tubifex kessleri americanus Brinkhurst and Cook, 1966
Tubifex nerthus (Michaelsen, 1908)
Tubifex superiorensis (Brinkhurst and Cook, 1966)
Tubifex tubifex (Müller, 1774)

Genus Varichaeta Brinkhurst, 1981

Varichaeta nevadana (Brinkhurst, 1965)
Varichaeta pacifica Brinkhurst, 1981

SECTION 4

KEY TO FRESHWATER TUBIFICIDAE (ANNELIDA: CLITELLATA: OLIGOCHAETA) OF NORTH AMERICA (NORTH OF MEXICO)

INTRODUCTION

Phylogenetic relationships within the Tubificidae are poorly known. Generic limits within the family are based primarily on the configuration of internal reproductive organs observable only in dissected or differentially stained and sectioned material. A natural, phylogenetic key to the Tubificidae, therefore, would require extensive preparation of individual specimens and would be wholly unworkable for the aquatic biologist interested only in determining the identity of specimens within a given collection. The key provided herein was constructed, therefore, on artificial bases using only external and internal features readily observable in simple whole-mounted material using a conventional light microscope. The key allows the user to proceed directly to the species level of classification without keying out the genera. For discussions of phylogenetic relationships and taxonomic limits of genera, the reader is instructed to consult recent taxonomic literature; for example, Baker and Brinkhurst, 1981; Brinkhurst, 1979b, 1979c, 1981; Brinkhurst and Jamieson, 1971; Holmquist, 1978, 1979; and Loden, 1977, 1978, 1979) cited in the Selected Bibilography.

The principal features used to identify tubificids in this guide are the somatic chaetae, specialized genital chaetae, and structures of the male reproductive system. Chaetae occur in paired fascicles or bundles located ventro-laterally, "ventral chaetae," and dorso-laterally, "dorsal chaetae" (Figure 1). A variety of chaetal types occur. Generalized chaetae and their designated terminology are illustrated in Figure 2. Segments are identified by Roman numerals. An important point to note is that segment I, which includes the peristomium, and mouth, and to which the prostomium is connected, is devoid of chaetae. Therefore, to determine the numerical position of each segment, one must count chaetal fascicles, either dorsal or ventral, posteriad beginning in segment II. This is particularly important in locating the genital segments X and XI that bear the spermathecae and male pores, respectively.

A number of tubificid species must be sexually mature to be identified to species. At two points within the key, the necessity for mature specimens is noted. In each case, if specimens in question are immature, unidentifiable immature reporting categories are provided. Two points need to be emphasized in this regard: first, the majority of individuals within any assemblage may be immature and, therefore, reported

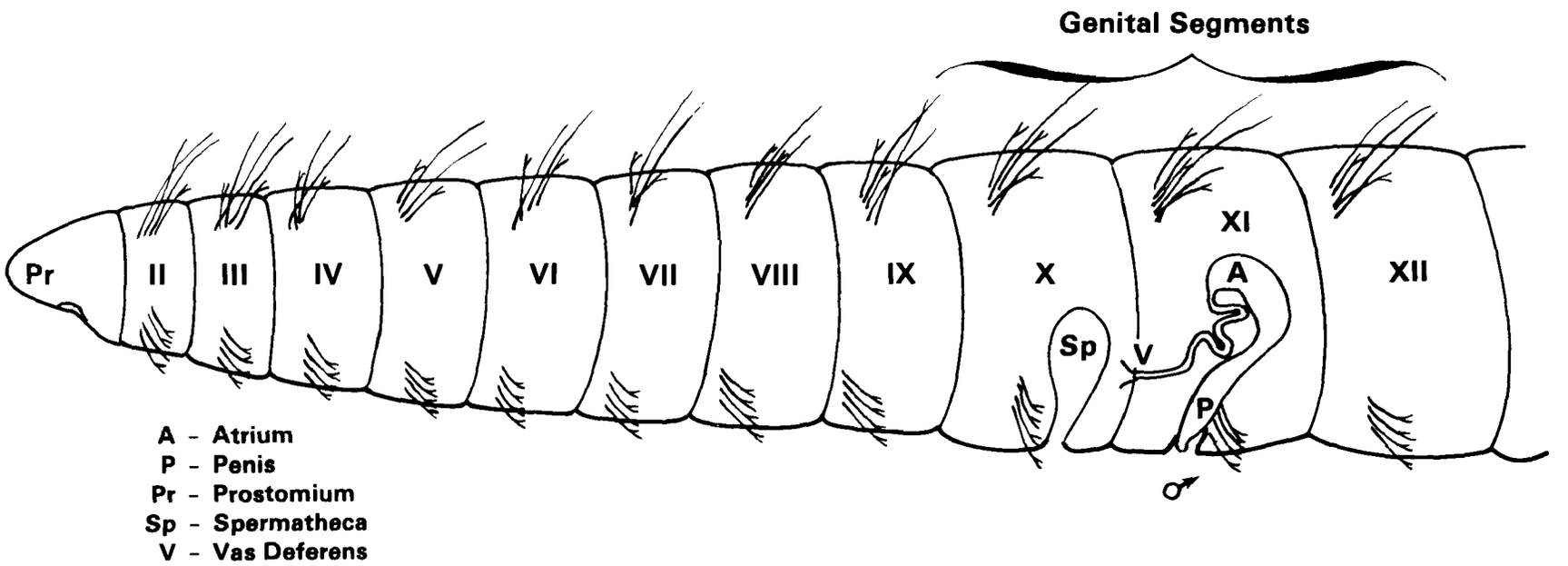


Fig. 1. Generalized tubificid, illustrating external and internal anatomical terminology, lateral view.

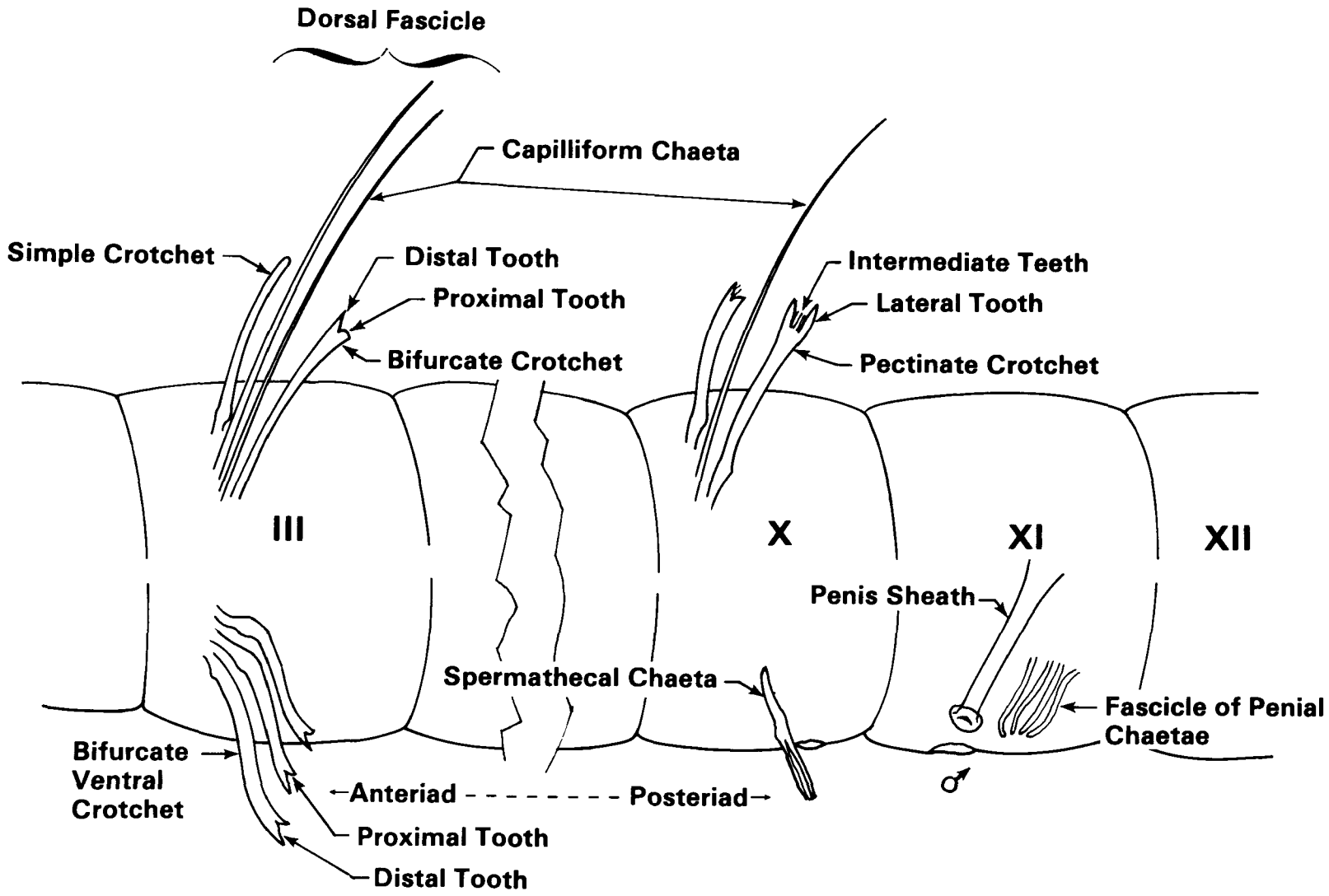


Fig. 2. Generalized tubificid, illustrating types of somatic and genital chaetae and anatomical terminology.

only as unidentifiable; second, the composition of the immature components can generally be assumed to reflect the species composition of the mature, identifiable individuals, present in the same collection.

KEY TO THE TUBIFICIDAE

1 Capilliform chaetae (Fig. 2) present in anterior (segments II-V) dorsal fascicles. 2

Capilliform chaetae not present in anterior dorsal fascicles. . . 37

2(1) Each segment, posterior to approximately segment XXX, bears a dorsal and ventral gill filament (Fig. 3). . . . . *Branchiura sowerbyi*

Posterior segments bear no gill filaments 3

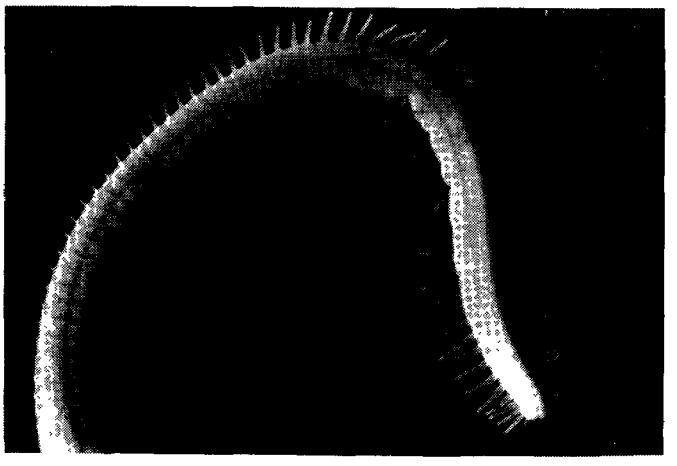
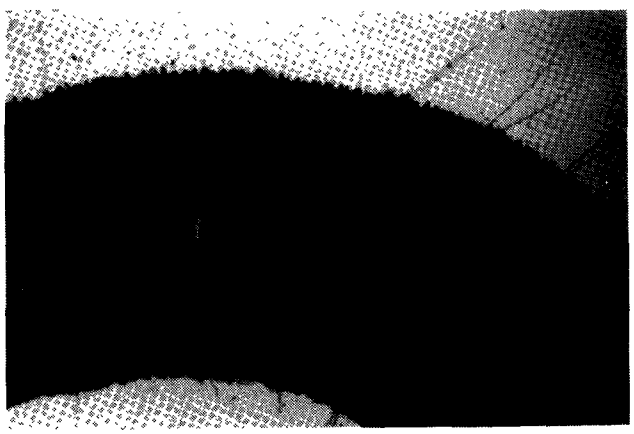


Fig. 3. *Branchiura sowerbyi*, dorsal and ventral gill filaments on posterior segments.

3(2) Dermis opaque or nearly opaque, appearing to be densely papillate and encrusted with sediment materials (Fig. 4) or dermis coarse perhaps slightly opaque and beset with some scattered papillae (Fig. 5a,b). Prostomium often retractile and capilliform chaetae frequently stout and sabre-like. 4

Dermis clear (Fig. 6), or at most, slightly opaque but without encrusted sediment materials or papillae. Prostomium rarely retractile, capilliform chaetae rarely sabre-like. 9



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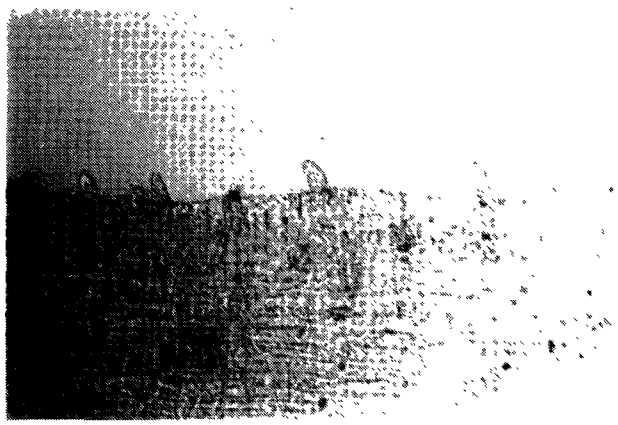

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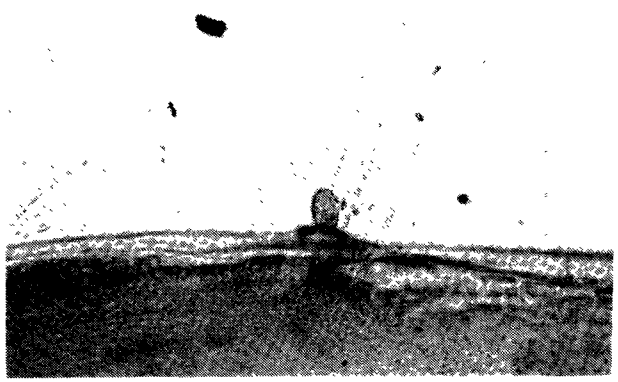

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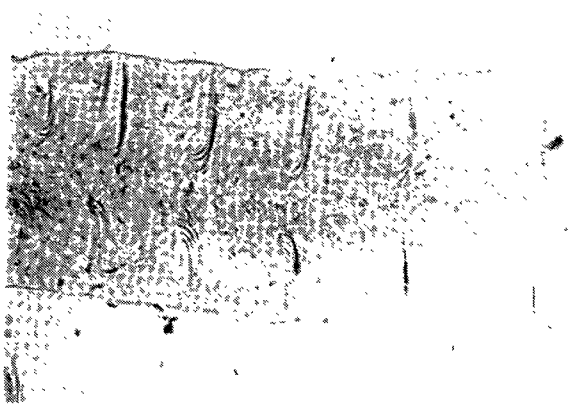

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Fig. 4. Granular-opaque, densely papillate dermis of Spirosperma nikolskyi.
Fig. 5. Quistadrilus multisetosus: (a,b) slightly opaque dermis with scattered papillae.
Fig. 6. Clear dermis, without papillae.

4(3) Dermis coarse but not opaque and without appearance of encrusted sediment materials; variously beset with scattered short, finger-like papillae. Papillae often most readily visible posteriad to approximately segment XI. Anterior dorsal fascicles composed of stout sabre-like capilliform and distinctly pectinate chaetae (Fig. 7). 5

Dermis opaque or nearly opaque, appearing encrusted with sediment materials, densely papillate. Dorsal crotchet chaetae often difficult to differentiate. 6

5(4) Anterior and posterior ventral chaetae similar in shape, distal tooth longer than proximal tooth (Fig. 8). [See Annotations.] . . . . . *Quistadrilus multisetosus* (in part)

Anterior and posterior ventral chaetae differ in shape (Fig. 9a,b). Posterior chaetae thick, with distal tooth shorter and much thinner than proximal tooth. [See Annotations.] . . . . . *Quistadrilus multisetosus* (in part)

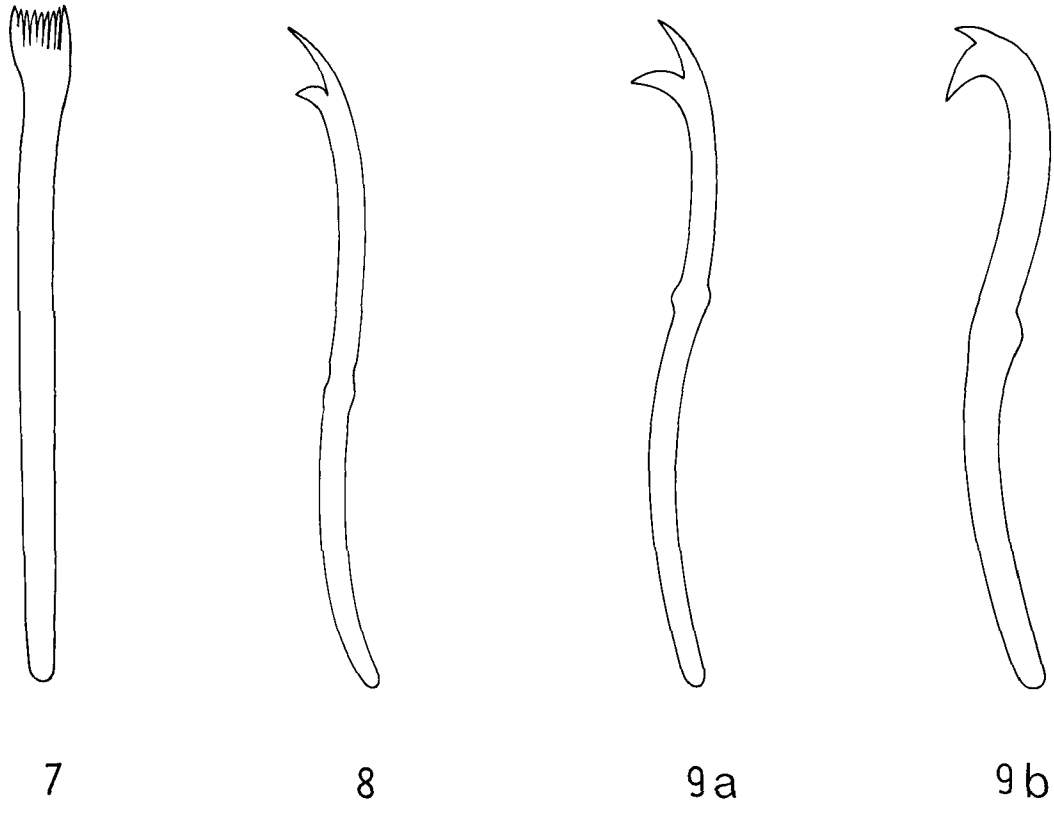


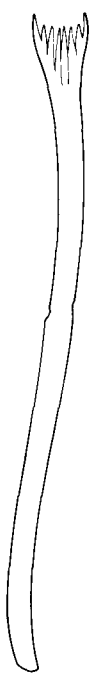
Fig. 7. *Quistadrilus multisetosus*, dorsal pectinate chaeta.
Fig. 8. *Q. multisetosus*, posterior ventral chaeta.
Fig. 9. *Q. multisetosus*: (a) anterior ventral chaeta; (b) posterior ventral chaeta.

6(4) Dorsal fascicles composed of capilliform and distinctly pectinate chaetae (Fig. 10). . . . . *Spirosperma ferox*

Dorsal fascicles composed of capilliform chaetae and other shorter, much thinner capilliform-like chaetae, which may have pectinate tips, but are difficult to differentiate. 7

7(6) All anterior ventral chaetae bifurcate, 2 per fascicle, teeth small (Fig. 11a). Posterior ventral chaetae 1 per fascicle, distal tooth reduced or rudimentary (Fig. 11b). Lake Tahoe. . . . . *Spirosperma beetoni*

Anterior ventral fascicles contain at least some simple-pointed chaetae. 8



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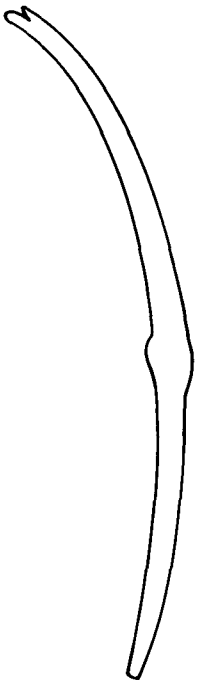


11a

11b

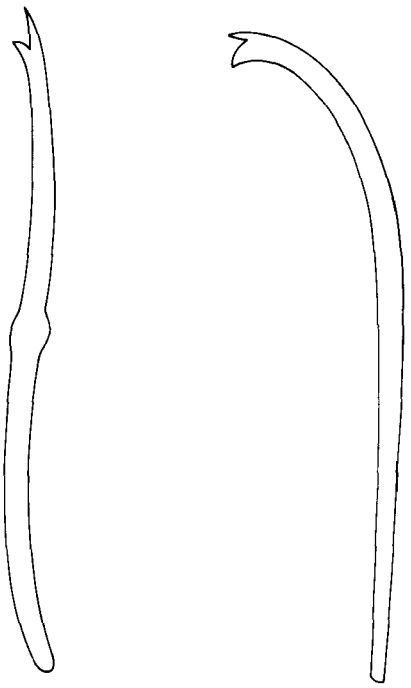
Fig. 10. *Spirosperma ferox*, dorsal pectinate chaeta.
Fig. 11. *S. beetoni*: (a) anterior ventral chaeta; (b) posterior ventral chaeta.

8(7) Ventral fascicles of segments II, III and often segment IV include 1 to 3 simple-pointed crotchet chaetae and 1 to 3 bifurcate chaetae. Posterior ventral chaetae with teeth subequal or distal tooth longer than proximal tooth (Fig. 12). . . . . *Spirosperma nikolskyi*

Ventral fascicles of segments II-VIII or IX composed of 1 simple and 1 bifurcate crotchet chaeta. Posterior ventral chaetae 1 per fascicle, strongly recurved with thin distal tooth (Fig. 13). . . . . *Spirosperma carolinensis*

9(3) Segment I with large mouth and enlarged eversible pharynx (Fig. 14). Dorsal and ventral chaetae of segment II usually single with short, thin distal tooth; chaetae of segment II and often segment IV lacking. Posteriad, dorsal fascicles composed of capilliform and bifurcate crotchet chaetae with distal tooth thinner but about as long as proximal tooth. . . . . *Ilyodrilus mastix*

Segment I with normal mouth, without an enlarged eversible pharynx, anterior dorsal and ventral chaetae other than above. 10



12 13

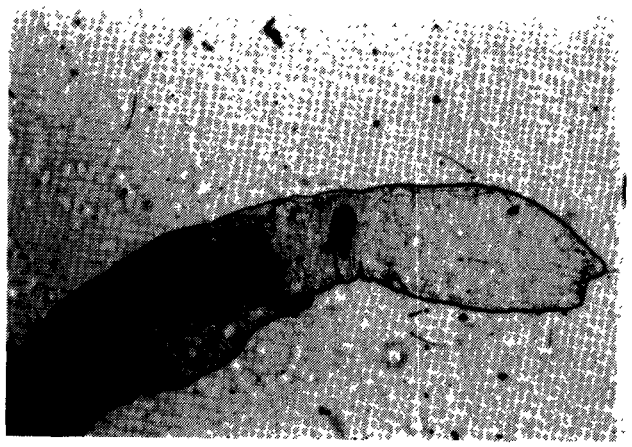


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Fig. 12. *Spirosperma nikolskyi*, posterior ventral chaetae.
Fig. 13. *S. carolinensis*, posterior ventral chaeta.
Fig. 14. *Ilyodrilus mastix*, anterior end illustrating enlarged mouth.

10(9) Anterior dorsal fascicles composed of capilliform and bifurcate crotchet chaetae (Figs. 15, 16a, 17, 18, 19a) without intermediate teeth. 11

Anterior dorsal fascicles composed of capilliform and pectinate chaetae (Figs. 20, 21a, 29). [Intermediate teeth of pectinate chaetae may require approximately 1000X magnification to be observed.] 16

11(10) Dorsal crotchet chaetae from approximately segment VII posteriad modified to a spatulate shape when viewed in facial aspect (Fig. 15a) and appearing compressed when viewed from lateral aspect (Fig. 15b). . . . . *Aulodrilus pigueti*

Dorsal crotchet chaetae not modified into a spatulate form as above. 12

12(11) Anterior ventral crotchet chaetae with greatly reduced distal teeth, essentially simple-pointed. Each posterior segment bearing dorsal and ventral gill filaments (Fig. 3). . . . . *Branchiura sowerbyi*

Anterior ventral crotchet chaetae distinctly bifurcate (although distal tooth may be reduced), *or* if ventral fascicles contain simple crotchet chaetae, then *no* gill filaments on posterior segments. 13

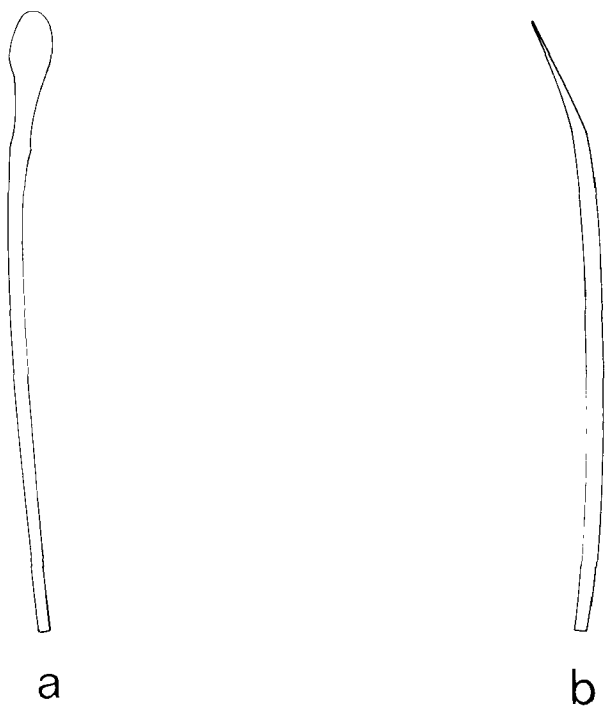


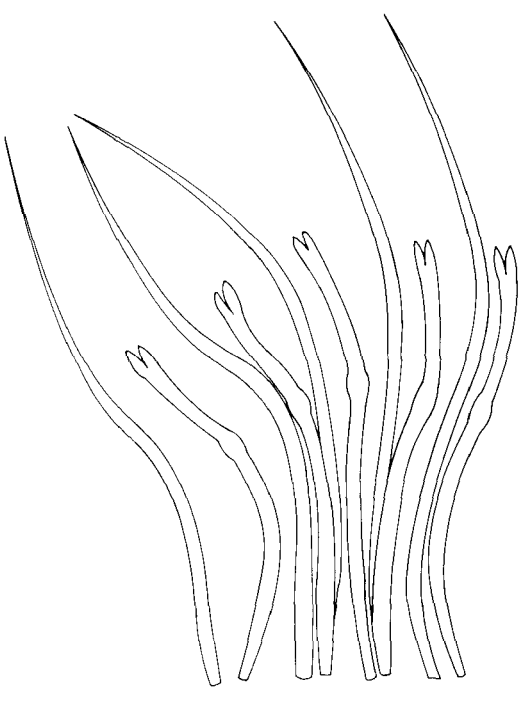
Fig. 15. *Aulodrilus pigueti*, posterior dorsal crotchet chaeta: (a) facial aspect; (b) lateral aspect.

13(12) Teeth of anterior dorsal crotchet chaetae equal in length, somewhat ovate and not strongly divergent (Fig. 16a). Anterior capilliform and crotchet chaetae appear bent to nearly sigmoid in shape or form (Fig. 16a). Mature specimens with spermathecal chaetae in ventral fascicles of segment X (Fig. 16b). . . . . *Potamothrix vejdovskyi*

Teeth of anterior dorsal crotchet chaetae unequal in length (Figs. 17, 18a), or if teeth are similar in length, then strongly divergent (Fig. 19a). 14

14(13) Dorsal fascicles with 1-2 capilliform chaetae, 2-3 bifurcate crotchet chaetae with distal tooth shorter and thinner than proximal tooth (Fig. 17). Ventral fascicles with up to 4 chaetae, either simple-pointed or with distal tooth shorter and thinner than proximal tooth. With coelomocytes. Lake Tahoe. . . . . *Rhyacodrilus brevidentatus*

Dorsal fascicles not as above, ventral crotchet chaetae never simple-pointed. 15



16 a

16 b

17

Fig. 16. *Potamothrix vejdovskyi*: (a) anterior dorsal crotchet and capilliform chaetae; (b) spermathecal chaeta.
Fig. 17. *Rhyacodrilus brevidentatus*, dorsal crotchet chaeta.

15(14) Distal tooth of ventral crotchet chaetae in segment VIII distinctly shorter and/or thinner than proximal tooth (Fig. 18a). Dorsal crotchet chaetae also with distal tooth shorter and thinner than proximal tooth, occasionally dorsal crotchet chaetae may be minutely pectinate (Fig. 18b). Capilliform and crotchet chaetae somewhat arcuate or sigmoid. . . . . *Aulodrilus pluriseta*

Distal tooth of ventral crotchet chaetae in segment VIII neither shorter nor obviously thinner than proximal tooth. Distal tooth of dorsals equal to or slightly longer than proximal tooth (Fig. 19a). Mature specimens with several simple-pointed penial chaetae (Fig. 19b). With coelomocytes. . . . . *Rhyacodrilus coccineus*

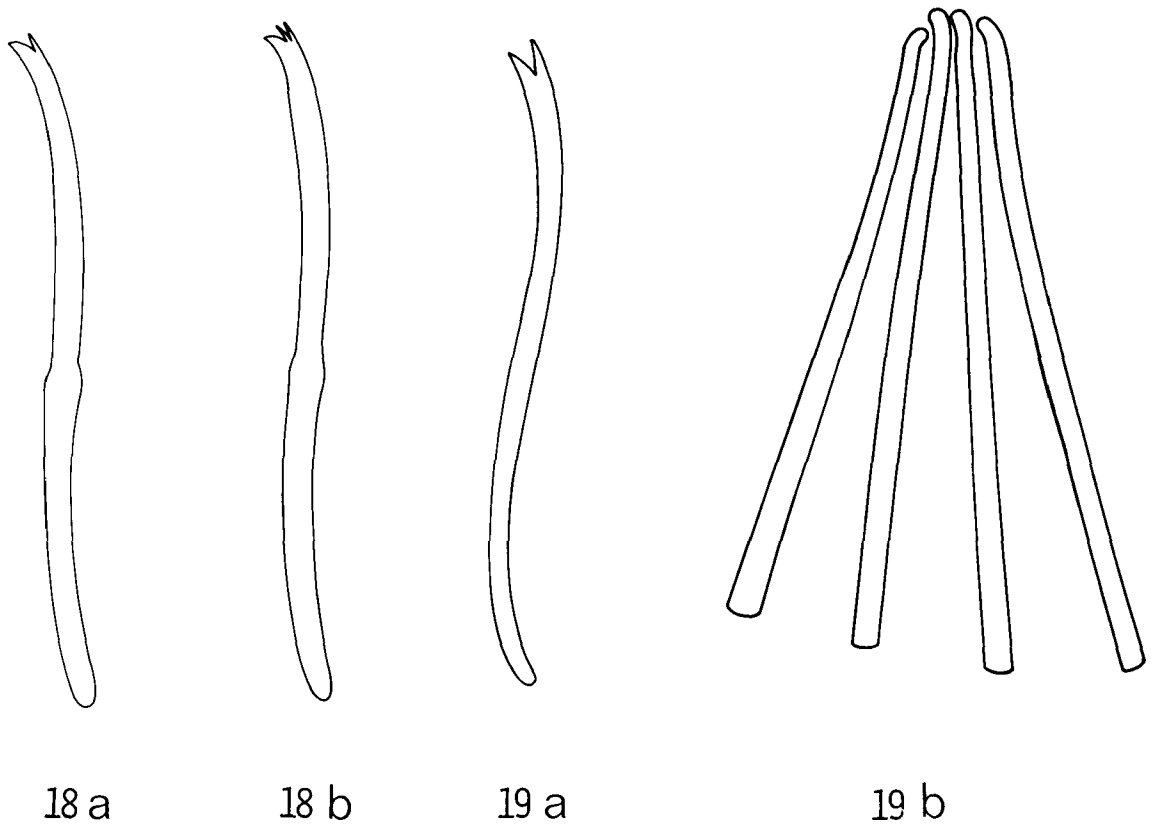


Fig. 18. *Aulodrilus pluriseta*: (a) ventral crotchet chaeta; (b) dorsal pectinate chaeta.
Fig. 19. *Rhyacodrilus coccineus*: (a) dorsal crotchet chaeta; (b) penial chaetae.

16(10) Anterior dorsal fascicles with broadly expanded pectinate crotchet chaetae (Fig. 20). . . . . *Psammoryctides barbatus*

Anterior dorsal fascicles with unexpanded pectinate crotchet chaetae (Figs. 21a, 29). 17

17(16) Teeth of anterior dorsal pectinate chaetae long, distal tooth often much longer than proximal tooth (Fig. 21a). Capilliform chaetae in segment II frequently much longer than posteriad. Anterior ventral crotchet chaetae with distal tooth 1 1/2 times longer than proximal tooth (Fig. 21b). With coelomocytes. . . . . *Rhyacodrilus montana*

Distal tooth of anterior dorsal pectinate chaetae not distinctly longer than proximal tooth. Capilliform chaetae in segment II not distinctly longer than posteriad and ventral chaetae may or may not be pectinate. 18

20

21 a

21 b

Fig. 20. *Psammoryctides barbatus*, pectinate anterior dorsal crotchet chaeta.

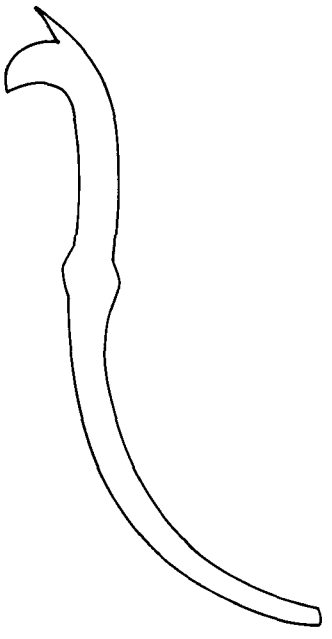
Fig. 21. *Rhyacodrilus montana*: (a) anterior dorsal pectinate chaeta; (b) anterior ventral crotchet chaeta.

18(17) Posterior dorsal and ventral fascicles containing strongly sigmoid, arcuate crotchet chaetae (Fig. 22). . . . . *Tubifex harmani*

Posterior dorsal and ventral fascicles containing no strongly sigmoid or arcuate crotchet chaetae. 19

19(18) Anterior and posterior ventral chaetae pectinate (Fig. 23). With coelomocytes. Lake Superior. . . . . *Rhyacodrilus punctatus*

Anterior and posterior ventral chaetae not pectinate. 20



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23

Fig. 22. *Tubifex harmani*, posterior dorsal crotchet chaeta.
Fig. 23. *Rhyacodrilus punctatus*, anterior ventral chaeta.

20(19) Capilliform chaetae very long and thin, posteriad from segment X capilliform chaetae 2-3 times longer than diameter of respective segment. Long thin worms. . . . . *Tubifex ignotus*

Capilliform chaetae not especially long and thin and progressively diminish in length posteriad to segment X. 21

21(20) Anterior ventral chaetae with distal tooth approximately twice as long as reduced proximal tooth (Fig. 24). . . . . *Tubifex nerthus*

Teeth of anterior ventral chaetae not as above. [Henceforth specimens must have attained sexual maturity in order to be identifiable to species, otherwise specimens can be categorized only as "Unidentifiable immature Tubificidae with capilliform chaetae"]. 22

Fig. 24. *Tubifex nerthus*, anterior ventral chaeta.

22(21) Mature individuals bear a muscular penial bulb attached to a crescent-shaped atrium which constricts into very long annulated vas deferens (Fig. 25). Penis sheath a granular membrane, very thin-walled and often indistinct. No modified genital chaetae present. . . . . Tubifex tubifex

Penial apparatus, atrium and vas deferens not as above. Individuals bear a translucent penis sheath and/or modified genital chaetae in at least one segment between segments VII and XI. 23

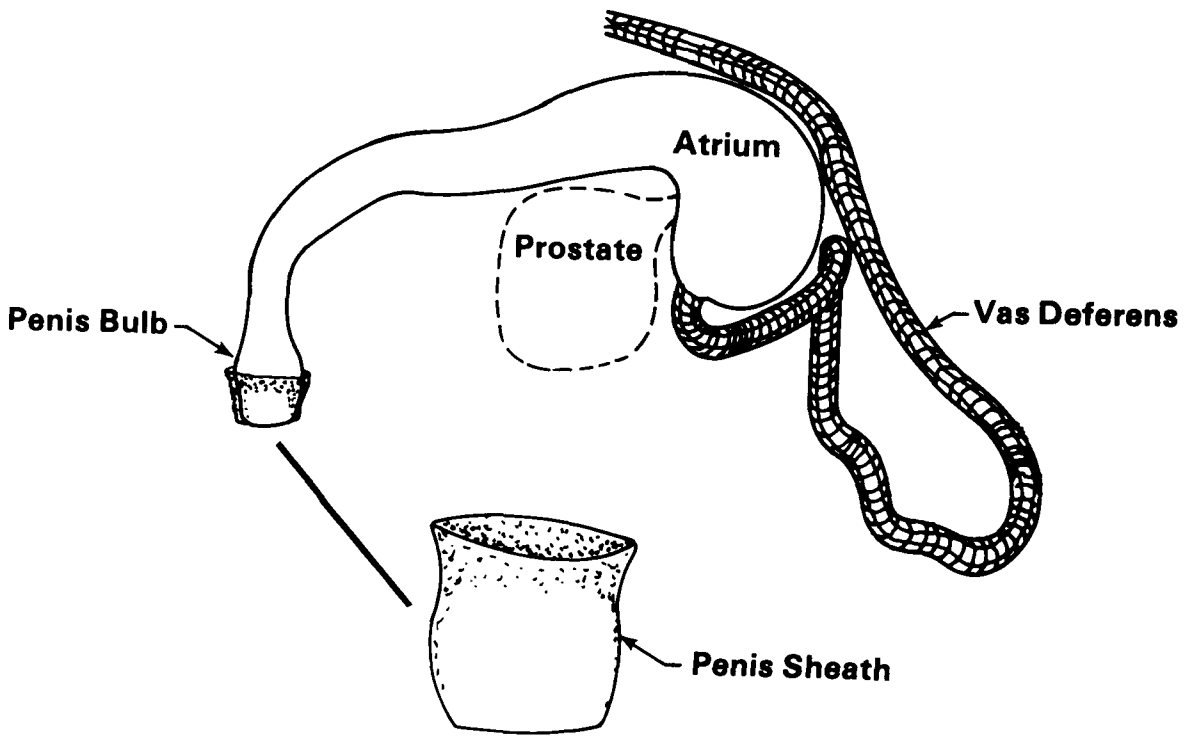


Fig. 25. Tubifex tubifex, penis bulb, atrium, and vas deferens.

23(22) Mature individuals bear a short, broad penis sheath in segment XI (Fig. 26a). Penial and spermathecal chaetae long, thin, parallel-sided (Fig. 26b,c), originating in glandular sacs. . . . . Haber cf. speciosus

Mature individuals bear either a penis sheath or spermathecal or penial chaetae but no combination of a penis sheath and both spermathecal and penial chaetae 24

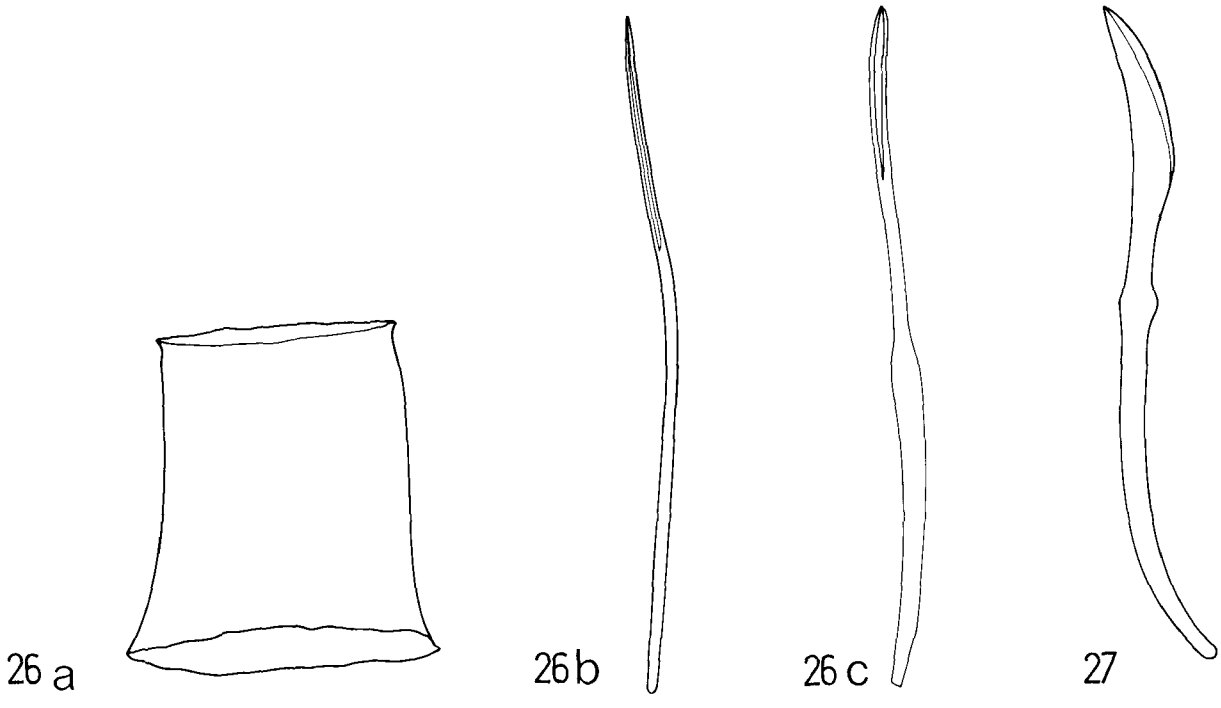


Fig. 26. Haber cf. speciosus: (a) penis sheath; (b) penial chaeta; (c) spermathecal chaeta.
Fig. 27. Potamothrix bedoti, specialized chaeta.

24(23) With or without a cuticular penis sheath. Specialized genital chaetae present in one or more segments ranging between segments VII and XI. 25

With a translucent cuticular penis sheath in segment XI. No genital chaetae in segment X. Ventral chaetae in segment XI similar in size and shape to somatic chaetae, or at most, only slightly thickened. 32

25(24) Scalpel-shaped specialized chaetae (Fig. 27) present in any or all segments ranging between segments VII and XI. . . . . Potamothrix bedoti

Genital chaetae present only in segment X or XI and not scalpel-shaped 26

26(25) With penial chaetae in segment XI, without spermathecal chaetae in segment X. 27

Without penial chaetae in segment XI, with spermathecal chaetae in segment X. 29

27(26) Penial chaetae enlarged with bifurcate tip (Fig. 28). Penis sheath tub-shaped, indistinct. Pectinate chaetae range from bearing parallel lateral teeth to slightly palmate and sigmoid with distal tooth thinner and slightly longer than proximal tooth. Posterior dorsal fascicles consist only of bifurcate crotchet chaetae, no capilliform chaetae. Without coelomocytes. . . . . *Psammoryctides minutus*

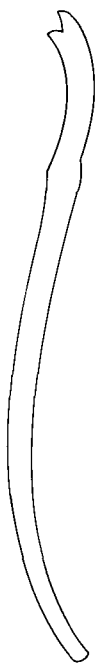
Penial chaetae blunt-tipped and simple-pointed (Fig. 19b); no penis sheath, chaetae not as above. With coelomocytes. . . 28

28(27) Teeth of dorsal crotchet chaetae long, thin, and parallel, intermediate teeth fine (Fig 29). Frequently, distal tooth of dorsal chaetae in segments VIII and IX twice the length of proximal tooth . . . . . *Rhyacodrilus sodalis*

Teeth of dorsal crotchet chaetae not long and parallel and distal tooth of dorsal chaetae in segments VIII and IX not twice the length of proximal tooth. . . . . *Rhyacodrilus coccineus*

29(26) Spermathecal chaetae in segment X parallel sided with teeth fused forming a groove (Figs. 30, 31). 30

Spermathecal chaetae not parallel sided, but are elongate spade-shaped, broadest near the middle and tapering to a pointed tip (Figs. 32, 33). 31



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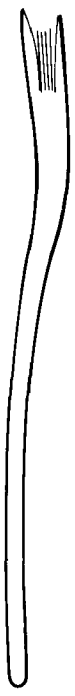

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Fig. 28. *Psammoryctides minutus*, penial chaeta.
Fig. 29. *Rhyacodrilus sodalis*, dorsal pectinate chaeta.

30(29) Anterior ventral chaetae with teeth subequal or distal tooth slightly longer than proximal tooth. Posteriad, ventral chaetae thicker, often with distal tooth more than two times longer than proximal tooth. Penis sheath indistinct, if visible, tub-shaped with reflexed head. . . . . Psammoryctides convolutus

Anterior ventral chaetae with distal tooth longer and thinner than proximal tooth, posteriad, ventral chaetae slightly shorter, but also with distal tooth longer and thinner than proximal tooth. Penis sheath indistinct, tub-shaped but without reflexed head. . . . . Psammoryctides californianus

31(29) Spermathecal chaetae in segment X often two per fascicle, much longer than wide (Fig. 32). [See annotations.]. . . . . Potamothrix hammoniensis

Spermathecal chaetae in segment X usually single, short and broad (Fig. 33) . . . . . Potamothrix bavaricus

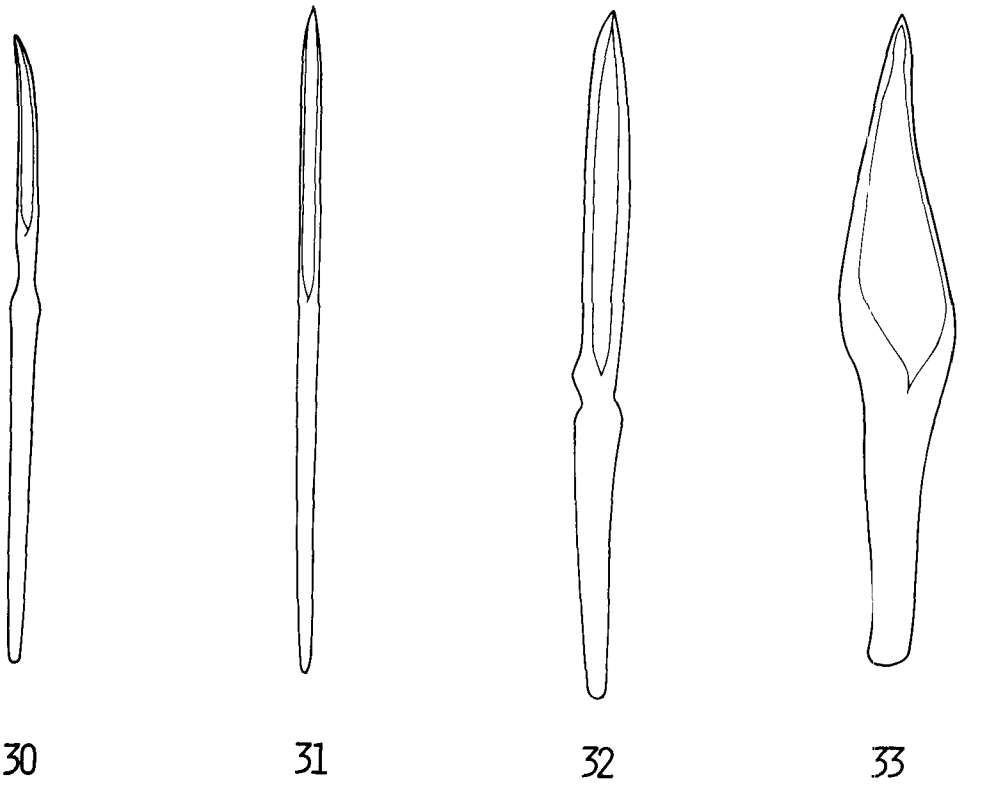


Fig. 30. Psammoryctides convolutus, spermathecal chaeta.
Fig. 31. P. californianus, spermathecal chaeta.
Fig. 32. Potamothrix hammoniensis, spermathecal chaeta.
Fig. 33. P. bavaricus, spermathecal chaeta.

32(24) Penis sheath well developed, cylindrical, conical or conical with an elongate tip. (Figs. 34-37). 33

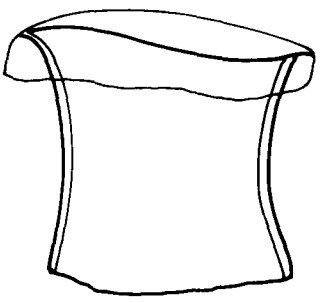
Penis sheath indistinct or short and tub-shaped (Fig. 38). . . . 36

33(32) Penis sheath only slightly longer than wide (Fig. 34a,b). Ventral chaetae of segment XI similar in shape to those in adjacent segments but slightly thicker. . . . . *Varichaeta pacifica*

Penis sheath other than above. Ventral chaetae of segment XI similar in shape, size and thickness to those in adjacent segments. 34

34(33) Penis sheath a cylindrical tube with a reflexed basal portion (Fig. 35). . . . . *Tubifex superiorensis*

Penis sheath other than above. 35



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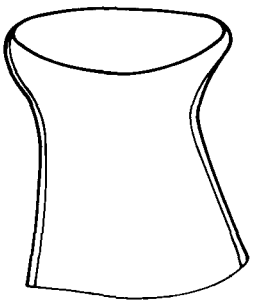

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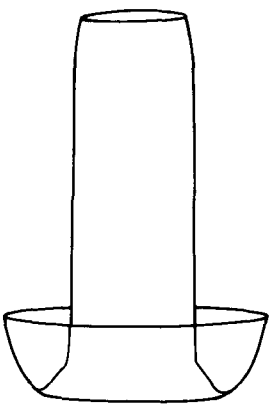

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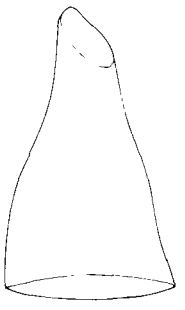
Fig. 34. *Varichaeta pacifica*: (a) penis sheath inverted; (b) penis sheath everted.
Fig. 35. *Tubifex superiorensis*, penis sheath.

35(34) Penis sheath conical, uniformly tapered from base to apex (Fig. 36a,b). . . . . *Ilyodrilus templetoni*

Penis sheath with a conical base abruptly tapered to an elongate apex (Fig. 37). . . . . *Tubifex kessleri americanus*

36(32) Penis sheath tub-shaped (Fig. 38), spermatozeugmata "frying pan" shaped. . . . . *Ilyodrilus frantzi* form *capillatus*

Penis sheath indistinct, delicate. Lake Tahoe. . . . . *Varichaeta nevadana*



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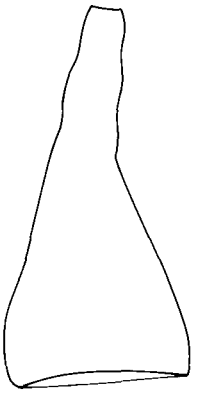

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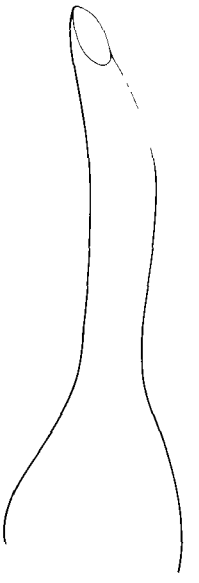

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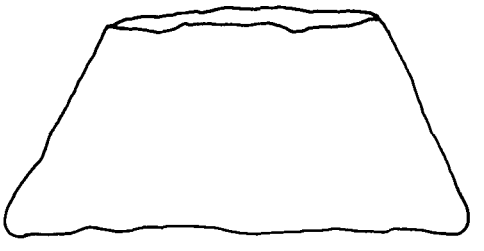

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Fig. 36. *Ilyodrilus templetoni*: (a) penis sheath with distal end absent; (b) penis sheath with distal end present.
Fig. 37. *Tubifex kessleri americanus*, penis sheath.
Fig. 38. *Ilyodrilus frantzi* form *capillatus*, penis sheath.

37(1) All chaetae anterior to approximately segment VII simple to minutely bifurcate with much reduced distal tooth (Fig. 39a,b). 38

Anterior chaetae never simple, teeth distinct. 39

38(37) Anterior chaetae simple. Posteriad from approximately segment VII, dorsal chaetae laterally expanded with several minute teeth (Fig. 40). . . . . *Aulodrilus americanus*

Anterior chaetae appear simple (Fig. 39a) to minutely bifurcate with minute distal tooth. Posteriad, dorsal chaetae bifurcate with reduced distal tooth (Fig. 39b). . . . . *Telmatodrilus vejdovskyi*

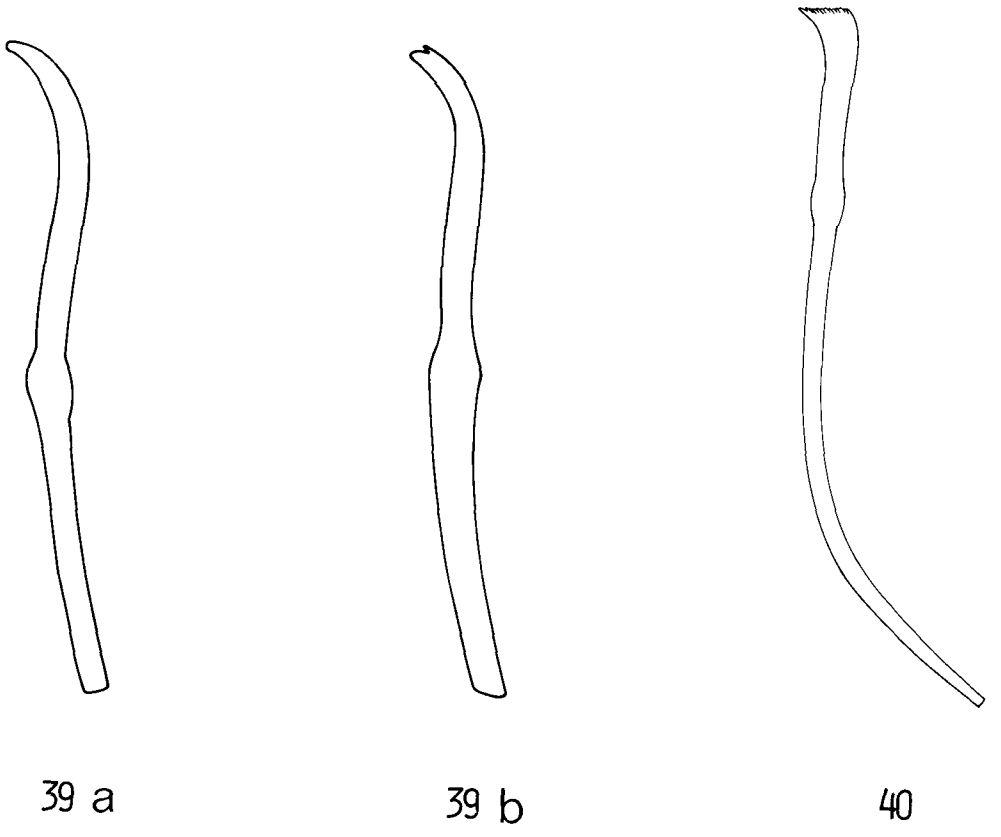


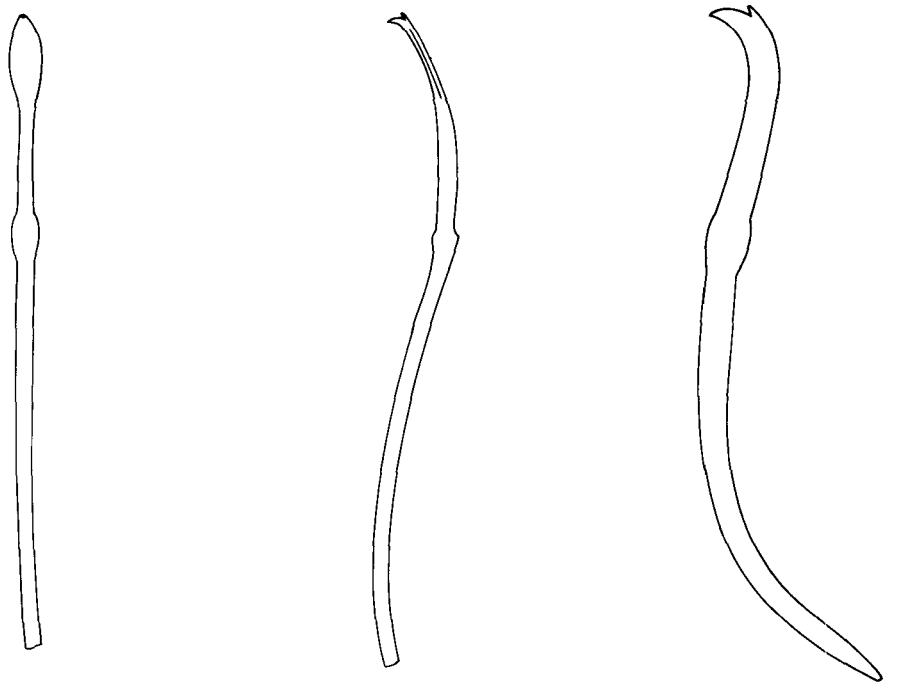
Fig. 39. *Telmatodrilus vejdovskyi*: (a) anterior ventral chaeta; (b) posterior ventral chaeta.
Fig. 40. *Aulodrilus americanus*, posterior dorsal crotchet chaeta.

39(37) Posteriad from approximately segment VII dorsal crotchet chaetae spatulate when viewed from facial aspect (Fig. 41a); viewed laterally, each chaeta appears compressed with tiny teeth (Fig. 41b). . . . . *Aulodrilus limnobius*

Posteriad from approximately segment VII dorsal chaeta not laterally expanded, teeth not reduced. 40

40(39) All chaetae similar; bifurcate crotchet chaetae with distal tooth thinner and shorter than proximal tooth (Fig. 42), anteriorly 3-4 per fascicle, 2 per fascicle posteriad. With coelomocytes. . . . . *Monopylephorus helobius*

All crotchet chaetae not similar, or of different form and number than above. 41

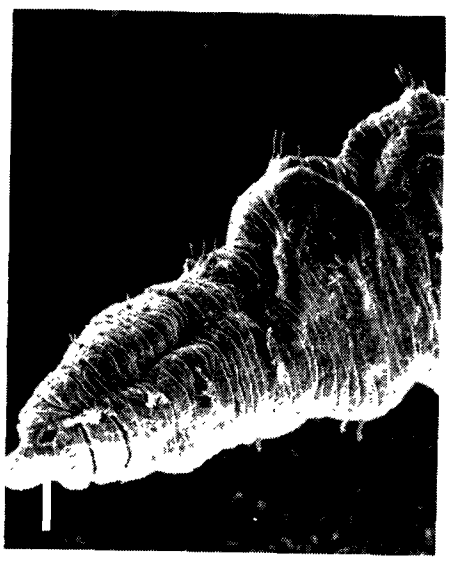


41 a 41 b 42

Fig. 41. *Aulodrilus limnobius*, posterior dorsal crotchet chaeta: (a) facial aspect; (b) lateral aspect.
Fig. 42. *Monopylephorus helobius*, crotchet chaeta.

41(40) Prostomium with a ciliated sensory cavity with an irregular opening on the dorsal surface of the prostomium (Fig. 43). Viewed laterally, the cavity appears as a depression and specialized cells lining the pit are apparent. Chaetae of anterior segments II to approximately IX generally 3-4 per fascicle (Fig. 44a) and often thinner than those posteriad. Posterior chaetae usually number two per fascicle, thicker than anterior chaetae (Fig. 44b). Mature individuals bear hook-shaped penial chaetae in segment XI (Fig. 44c). With coelomocytes. . . . . *Bothrioneurum vejdovskyanum*

Prostomium without a sensory cavity, chaetae other than above. 42



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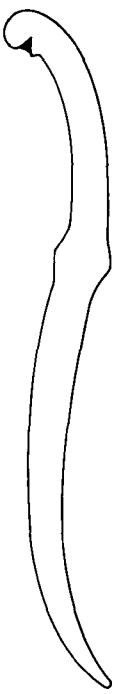


44 c

Fig. 43. *Bothrioneurum vejdovskyanum*, SEM of prostomium showing sensory cavity (from Chapman, 1979).

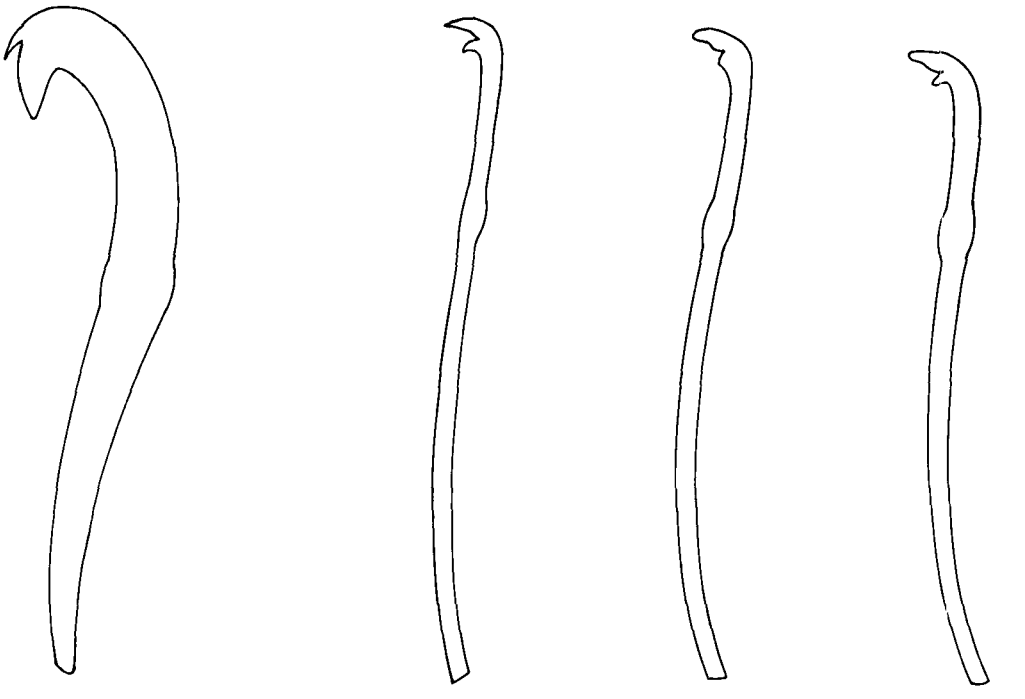
Fig. 44. *B. vejdovskyanum*: (a) ventral crotchet chaeta of segment II; (b) ventral crotchet chaeta of segment XXX; (c) penial chaeta.

42(41) Dorsal crotchet chaetae posteriad from approximately segment XX sharply arcuate and larger than opposing ventral chaetae (Fig. 45). Mature individuals bear short, thin, parallel-sided spermathecal chaetae in segment X. . . . . Isochaetides curvisetosus

Dorsal crotchet chaetae posteriad from approximately segment XX neither sharply arcuate nor larger than opposing ventral chaetae. 43

43(42) Distal tooth of ventral chaetae in segments II through IV longer than proximal tooth and deflected at an angle of approximately 90° to axis of chaetae (Fig. 46a,b,c). . . . . Limnodrilus udekemianus

Distal tooth of ventral chaetae in segments II through IV not deflected 90° to axis of the chaetae. [Henceforth specimens must be sexually mature to be identifiable to species, otherwise specimens must be classified as "Unidentifiable immature Tubificidae without capilliform chaetae"]. 44



45 46 a 46 b 46 c

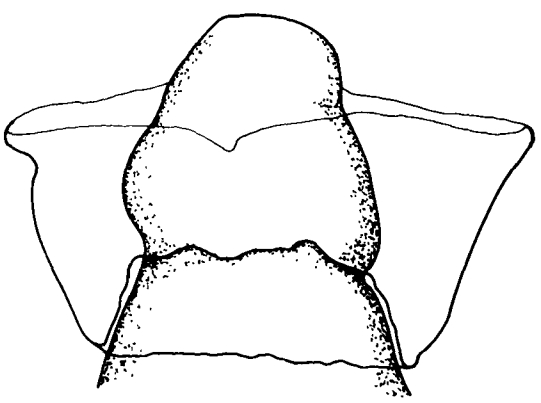
Fig. 45. Isochaetides curvisetosus, posterior dorsal chaeta.
Fig. 46. Limnodrilus udekemianus: (a,b,c) ventral chaetae in segment II, illustrating variation in shape.

44(43) With penis sheath in segment XI (Fig. 47a), and spermathecal chaetae long thin, parallel-sided (Fig. 47b) in segment X. . . . . *Isochaetides freyi*

With spermathecal chaetae in segment X and/or penial chaetae in segment XI or penis sheath but no combination of genital chaetae and a penis sheath. 45

45(44) Genital chaetae in segments IX and XI; spatulate and single in segment IX (rarely segment X) (Fig. 48a), 4-5 knobbed chaetae in segment XI (Fig. 48b). With coelomocytes. . . . . *Rhizodrilus lacteus*

Spermathecal chaetae in segment X or penial chaetae in segment XI but both spermathecal and penial chaetae not present. Penis sheaths present or absent. 46



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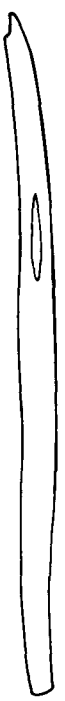

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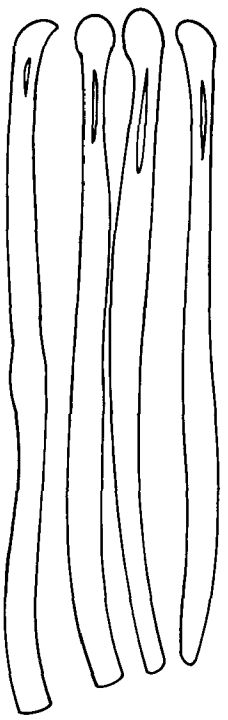


48 b

Fig. 47. *Isochaetides freyi*: (a) penis sheath; (b) spermathecal chaeta.
Fig. 48. *Rhizodrilus lacteus*: (a) specialized chaeta in segment IX; (b) specialized chaetae in segment XI.

46(45) With penis sheaths. 49

Without penis sheaths. 47

47(46) With penial chaetae in segment XI, no spermathecal chaetae in segment X. 48

Spermathecal chaetae present in segment X (Fig. 49a), and eversible penes present in segment XI (Figs 49b,c). . . . . *Potamothrix moldaviensis*

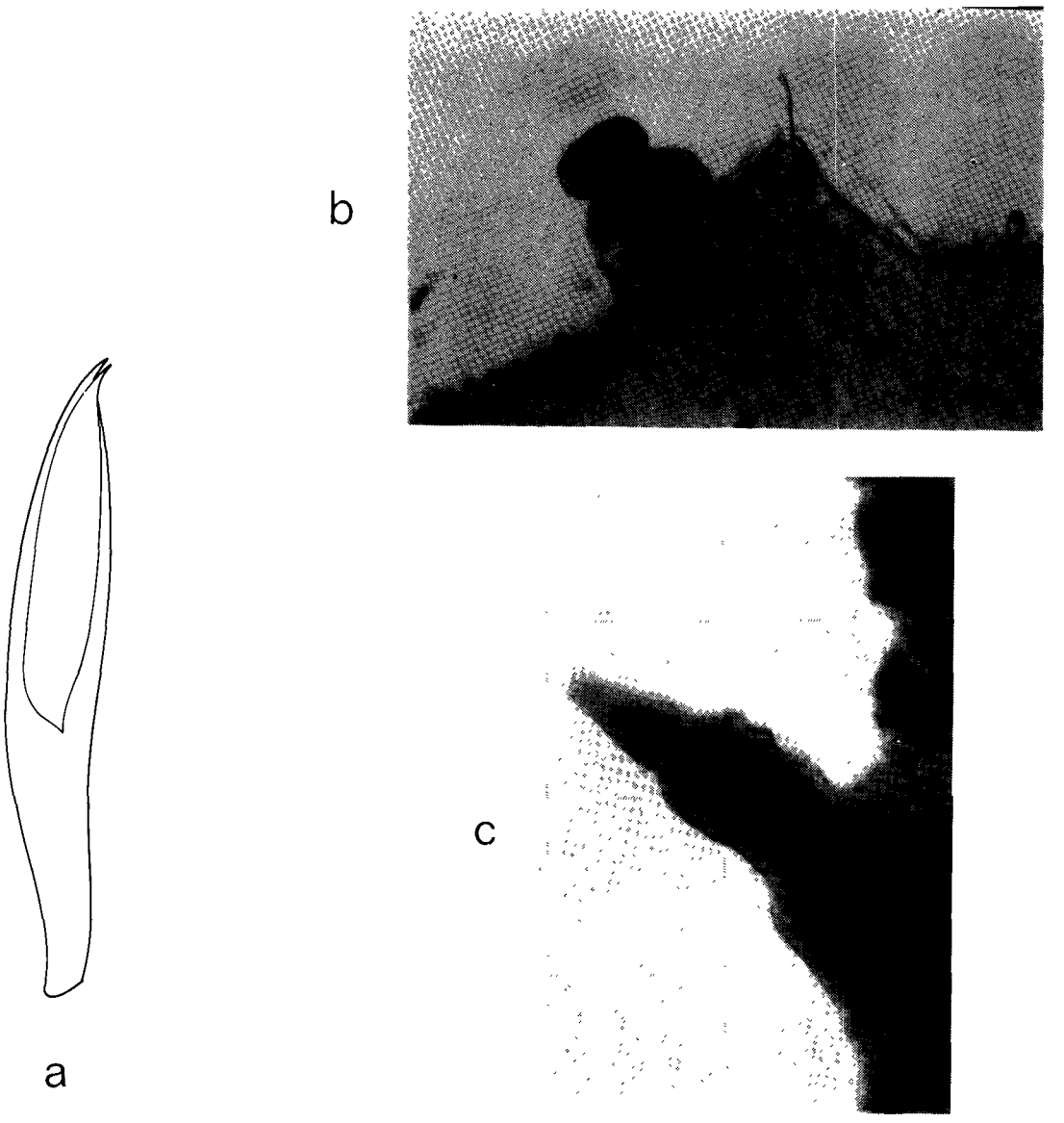


Fig. 49. *Potamothrix moldaviensis*: (a) spermathecal chaeta; (b) partially everted penis; (c) fully everted penis.

48(47) Penial chaetae in segment XI simple-pointed, distally hooked (Fig. 50). Lake Superior. . . . . *Phallodrilus hallae*

Penial chaetae in segment XI sickle-shaped, twice as long and much thicker than somatic chaetae (Fig. 51a,b). With coelomocytes. . . . . *Rhyacodrilus falciformis*

49(46) Penis sheath tub-shaped (Fig. 38). Spermatozeugmata "frying pan" shaped, distal tooth of anterior chaetae longer than proximal tooth. . . . . *Ilyodrilus frantzi*

Penis sheath elongate and cylindrical. 50

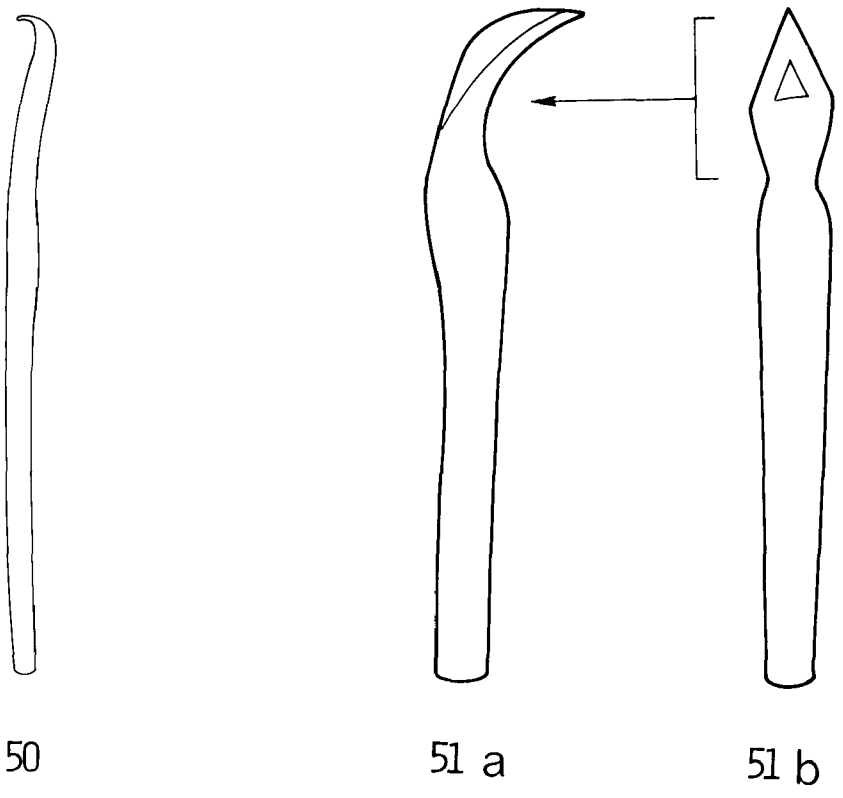


Fig. 50. *Phallodrilus hallae*, penial chaeta.
Fig. 51. *Rhyacodrilus falciformis*, penial chaeta: (a) lateral aspect; (b) facial aspect.

50(49) Margin of head of penis sheath set at essentially right angles to axis of shaft (Figs. 52-57). 51

Margin of head of penis sheath slanted, hooded or otherwise, not at right angles to axis of shaft (Figs. 58-64). 56

51(50) Penis sheath reddish-brown; with two tapered lateral projections (Fig. 52). . . . . *Limnodrilus rubripenis*

Penis sheath clear; distal end without two tapered lateral projections. 52

52(51) Distal 3/4 of penis sheath cylindrical, tube-like, basal 1/4 conical, shaft long in fully developed sheaths (Fig. 53). . . . . *Limnodrilus angustipenis*

Penis sheath not distinctly differentiated into cylindrical distal and conical basal portions, shaft short or long in fully developed sheaths. 53

53(52) Fully developed sheaths long (generally greater than 300 um), shaft uniformly cylindrical with head a round plate set at right angles to shaft. Margin of head may be slightly up-turned on one side (Fig. 54). . . . . *Limnodrilus hoffmeisteri* (*spiralis* form)

Fully developed sheaths short, head of sheath other than above. 54

54(53) Shaft broadly expanded basally, head a round plate (Fig. 55) . . . . . *Limnodrilus psammophilus*

Shaft not broadly expanded basally, head of sheath other than above. 55

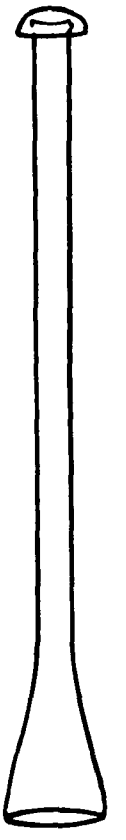
55(54) Anterior ventral chaetae of segment II to approximately segment IV with distal tooth longer than proximal tooth and bent at a 90° angle to axis of chaetae (Figs. 46a,b,c). Penis sheath with a round reflexed head (Fig. 56). . . . . *Limnodrilus udekemianus*

Anterior ventral chaetae with distal tooth subequal or only slightly longer than proximal tooth and teeth set at 45° or less to axis of shaft. Shaft of sheath thin, head small (Fig. 57). . . . . *Limnodrilus profundicola*

56(50) Mature shaft short, head of sheath spade-shaped (Fig. 58). . . . . *Limnodrilus silvani*

Mature shaft long, (generally greater than 300 um) and head of sheath not spade-shaped. 57

52



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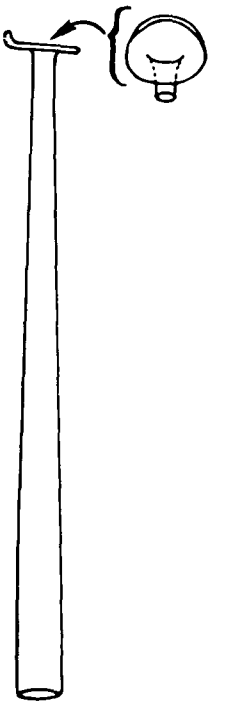

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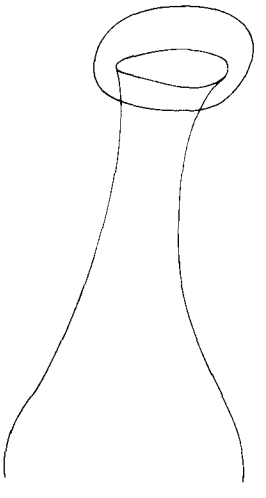

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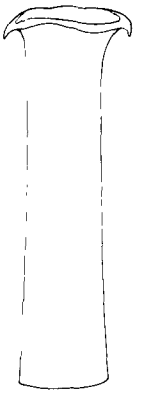

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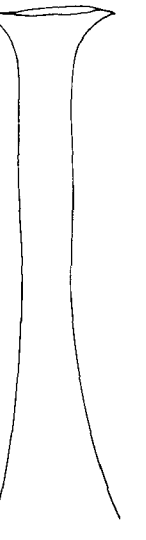

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Fig. 52. Limnodrilus rubripenis, penis sheath.
Fig. 53. L. angustipenis, penis sheath.
Fig. 54. L. hoffmeisteri (spiralis form), penis sheath.
Fig. 55. L. psammophilus, penis sheath.
Fig. 56. L. udekemianus, penis sheath.
Fig. 57. L. profundicola, penis sheath.

57(56) Head of penis sheath with margin scalloped (Fig. 59a), or scalloped with an irregular distal projection (Fig. 59b) . . . . . *Limnodrilus hoffmeisteri* (variant form)

Head of penis sheath not scalloped. 58

58(57) Shaft wall not excessively thickened (Figs. 60, 61) 59

Shaft noticeably thick-walled (Figs. 62-64) perhaps appearing as two layers. 60

59(58) Head of penis sheath with an overhanging hood and a broad, flat proximal lip, distally the diameter of the shaft flares into the head; mature tube length 300-600 um (Fig. 60). . . . . *Limnodrilus hoffmeisteri*

Head of penis sheath without an overhanging hood. Shaft slender, long (600-700 um) sigmoid with head equilaterally triangular and hence bilaterally symmetrical (Fig. 61). . . . . *Limnodrilus claparedianus*

60(58) Head of penis sheath broad, asymmetrically triangular and distal end of shaft canted (Fig. 62). . . . . *Limnodrilus maumeensis*

Head of penis sheath longer than wide, shaft not canted distally. 61

61(60) Head of penis sheath small, pear-shaped, bilaterally symmetrical, apical portion of head often reflexed over orifice, lower proximal portion small (Fig. 63). . . . . *Limnodrilus cervix* (variant form)

Head of penis sheath asymmetrical, with an offset proximal digitate lobe (Fig. 64). . . . . *Limnodrilus cervix*

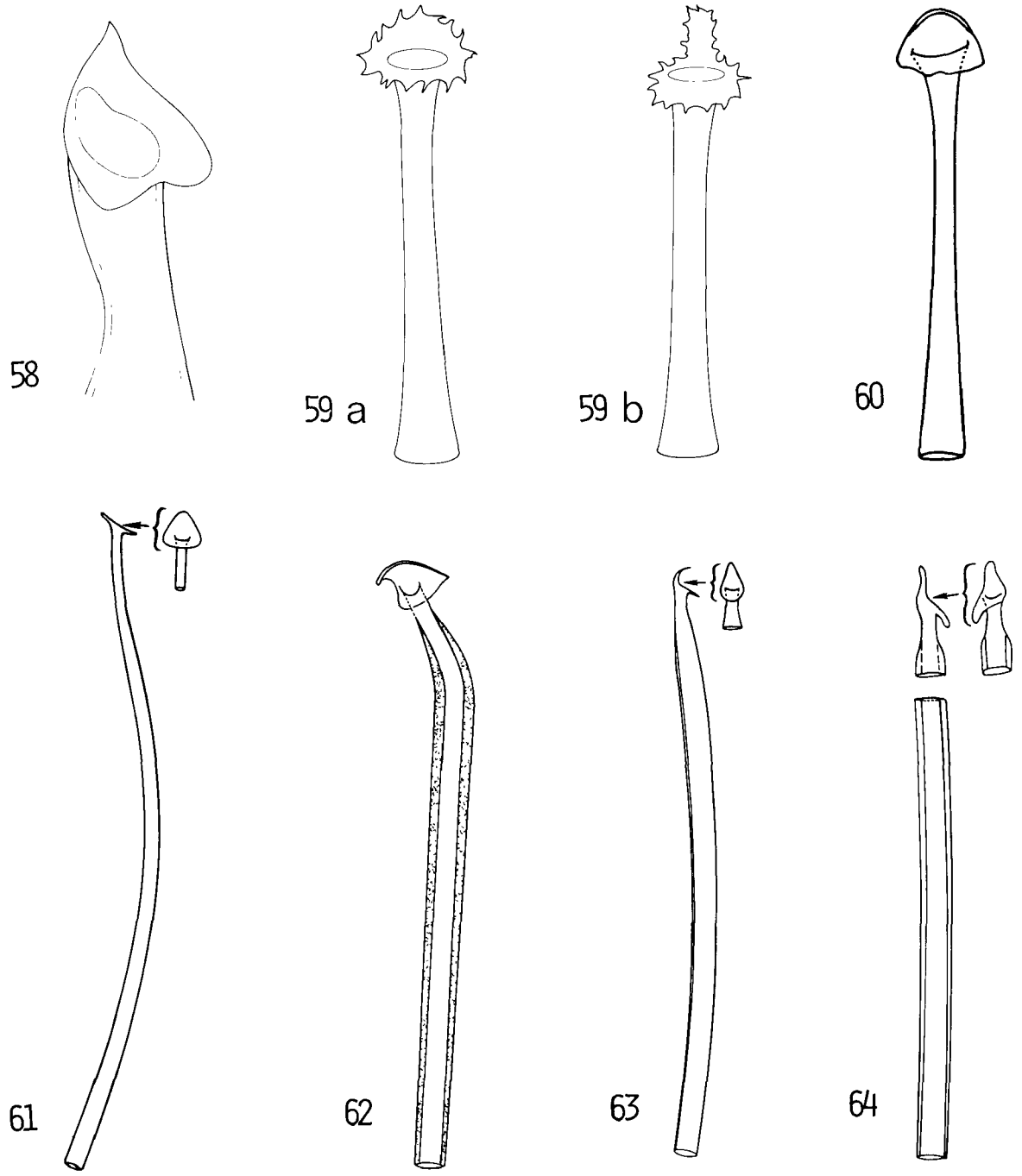

Fig. 58. Limnodrilus silvani, penis sheath.
Fig. 59. L. hoffmeisteri (variant form), illustrating two penis sheath types: (a) scalloped margin; (b) scalloped margin with irregular distal projection.
Fig. 60. L. hoffmeisteri, penis sheath.
Fig. 61. L. claparedianus, penis sheath.
Fig. 62. L. maumeensis, penis sheath.
Fig. 63. L. cervix (variant form), penis sheath.
Fig. 64. L. cervix, penis sheath.

SECTION 5

GLOSSARY*

Anteriad: Direction toward the anterior of an organism.

Arcuate: Curved or shaped like a bow.

Bifurcate: A condition of a chaeta where its apex is cleft, forming two unequal teeth.

Capilliform Chaeta: A dorsal, uncleft, hair-like, somatic chaeta; longer and usually more flexuous than a crotchet chaeta (sometimes called a hair seta).

Chaeta (pl. Chaetae): A bristle, which in various forms, aids primarily in locomotion (somatic chaetae) or can function in connection with reproduction (genital chaetae). (In the literature, "seta" is frequently used instead of "chaeta," but here the former term is reserved for its application in arthropod morphology).

Clitellum: A differentiation of the epidermis in the genital region into a somewhat verrucose "sleeve" which will transform into a cocoon that serves as a repository for the eggs following their fertilization.

Coelomocyte: Free cells within the body cavity (coelom). Granular in appearance, these spherical to ovoid cells may completely fill the body cavity in certain species. A characteristic feature in four of the North American tubificid genera: Bothrioneurum, Monopylephorus, Rhizodrilus, and Rhyacodrilus.

Cosmopoliton: World-wide in distribution.

Crotchet chaeta (pl. Chaetae): A somatic chaeta sometimes simple, but usually bifurcate, with two primary lateral teeth, with or without intermediate teeth between the lateral teeth. Generally refers to simple or bifurcate chaetae without intermediate teeth. See also Pectinate Chaeta.

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*Additional morphological terms applied in oligochaetology can be found in Brinkhurst and Jamieson (1971) and Reynolds (1977)

Fascicle: A "cluster" or "bundle" of chaetae. Generally four fascicles per segment, two located dorso-laterally and two located ventro-laterally.

Genital Chaeta: A chaeta which functions in sexual reproduction; spermathecal and penial chaeta.

Genital Segments: Body segments (ordinarily segments X and XI) which bear the reproductive organs.

Gill Filaments: Paired finger-like extensions of the body wall that function in respiration. Located on the posterior segments of *Branchiura sowerbyi*, two per segment, one positioned dorsally and one ventrally.

Nodulus: A knob or enlarged region on a crotchet chaeta generally located at or near the midlength of the chaeta where it leaves the body wall.

Papilla (pl. Papillae): Projections of the dermis or body wall. Frequently heavily cuticularized and obscured by accumulated foreign particles, thereby giving the worm a very opaque appearance.

Pectinate Chaeta: A crotchet chaeta generally equipped with two primary lateral teeth and few to several finer intermediate teeth. Nearly always dorsal and in fascicles with capilliform chaetae. Intermediate teeth may require 1000X magnification to be resolved.

Penial Chaeta: A chaeta associated with the penes occurring in the ventral fascicles of Segment XI, ordinarily their shape and size is unlike that of the somatic chaetae.

Penis Sheath: A translucent cuticular covering of the penis in segment XI, ranging from a thin, often obscure ring to an elaborate, thick tube.

Posteriad: Direction toward the posterior of an organism.

Prostomium: The anterodorsal part of the cephalic segment (Segment I).

Segments: A series of anatomical divisions of the body (somites or compartments), each usually separated from its neighbor by a septum (partition).

Seta (pl. Setae): See Chaeta.

Simple Chaeta: A chaeta with an uncleft apex.

Somatic Chaeta: A chaeta which functions in connection with locomotion; the somatic segments only, as opposed to specialized genital chaetae that are associated with the genital segments.

Spermathecal Chaeta: Chaeta associated with the spermatheca, generally in the ventral fascicles of Segment X. A characteristic feature of certain genera and species, their shape is usually unlike that of a somatic chaeta.

Spermatozeugma (pl. Spermatozeugmata): Organized bundles of sperm found in the atrium prior to copulation and in the spermatheca following copulation. Of various, often diagnostic shapes and sizes, but generally with an inner lumen surrounded with sperm heads oriented inward and sperm tails radiating outward.

SECTION 6

ANNOTATIONS

1. Aulodrilus americanus

Largest species of the genus. Reproduces primarily by budding and fragmentation. Moderately tolerant to organic enrichment and common in productive habitats. Dwells in tubes that often stay with the individual after sieving. Nearctic. Known from St. Lawrence Great Lakes, the eastern United States, Cayuga Lake, New York, British Columbia, Manitoba, New Brunswick, Northwest Territories, Ontario, Quebec, and Saskatchewan.

2. Aulodrilus limnobius

Exhibits a preferance for silty substrates in mesotrophic habitats. Moderately tolerant organism that reproduces primarily by budding and fragmentation. Often collected within a tube of agglutinated organic materials. The species is often represented in the drift of rivers. Usually sympatric with A. pigueti. Cosmopolitan. Widespread in the United States. Reported from Alabama, Louisiana, North Carolina, South Carolina, Tennessee, Wisconsin, and Canada.

3. Aulodrilus pigueti

Usually sympatric with A. limnobius and with a similar distribution, life history and habitat preferences. Cosmopolitan.

4. Aulodrilus pluriseta

Locally abundant in enriched habitats in silty substrates. Forms a mucoid tube similar to other members of the genus. Reproduces sexually and asexually by budding. Cosmopolitan. In North America, reported from St. Lawrence Great Lakes, Illinois, Indiana, Cayuga Lake, New York, North Carolina, Pennsylvania, Tennessee, Hudson River, Ohio River, Wisconsin River drainage, and British Columbia, Quebec in Canada.

5. Bothrioneurum vejdovskyanum

A widespread species. Generally most abundant in large rivers in coarse sand substrates. Rarely abundant in lentic habitats. Has likely been frequently overlooked in many North American collections due to confusion regarding the characteristic sensory prostomial pit

and infrequent occurrence of sexually mature individuals within a population. Cosmopolitan. Known from St. Lawrence Great Lakes, Indiana, Illinois River, Cayuga Lake, New York, Ohio River, Wisconsin River, Lake Washington, British Columbia and Quebec. Note: M.S. Loden (Personal Communication, 1981) reported B. americanum from Georgia and Louisiana. In the immature state, it is indistinguishable from B. vejdovskyanum and mature specimens lack penial chaetae.

6. Branchiura sowerbyi

Large worms that are rarely abundant. Known to thrive in heated effluents in Europe. Great Lakes records are from Lake St. Clair to Lake Erie. Frequently fragments. Cosmopolitan. Widespread throughout North America, generally in rivers.

7. Haber cf. speciosus

Only two recorded specimens in North America; Susquehanna River, New York, and Hudson River, New York.

8. Ilyodrilus frantzi and Ilyodrilus frantzi form capillatus

Ilyodrilus frantzi was originally described by Brinkhurst (1965) from Suisan Bay, California. The species was redescribed to include I. frantzi form capillatus by the same author in 1978, based upon specimens collected in the Fraser River, British Columbia. No other known distributional records.

9. Ilyodrilus mastix

Recently described by Brinkhurst (1978) from the Fraser River, British Columbia, the only known North America record.

10. Ilyodrilus templetoni

Common in both lake and river habitats, attaining greatest densities in enriched habitats. One of the most common tubificids in North America. Often sympatric with Limnodrilus hoffmeisteri in highly enriched waters. Easily confused with Tubifex tubifex. Holarctic. Widely distributed throughout the United States and is probably widespread in Canada.

11. Isochaetides curvisetosus

Transferred from Peloscolex by Brinkhust (1981). An occasional species apparently not occurring in eutrophic habitats. Nearctic. Known from St. Lawrence Great Lakes, Alabama, Indiana, North Carolina, and Pennsylvania.

12. Isochaetides freyi

Transferred from Peloscolex by Brinkhurst (1981). An occasional species generally occurring only in mesotrophic habitats. Rarely very abundant. Nearctic. Known from St. Lawrence Great Lakes, Mississippi River, Alabama, Indiana, Louisiana, Cayuga Lake, New York, North Carolina, Pennsylvania, Tennessee, Chippewa River and Red Cedar River in Wisconsin, Manitoba and Fraser River, British Columbia, Canada.

13. Limnodrilus angustipenis

An uncommon taxon usually collected in oligotrophic lakes. Nearctic. Known from St. Lawrence Great Lakes, Alabama, Louisiana, North Carolina, Tennessee, New Brunswick, Ontario, and Manitoba.

14. Limnodrilus cervix and Limnodrilus cervix (variant form)

The distinction between the typical and variant forms was first noted by Hiltunen (1969). The taxonomic status of the variant form is a subject that has, to date, not been adequately resolved, and a state of confusion exists as to the correct rank of the variant form. In this treatment, the authors defer from making a taxonomic decision as to the status of variant forms, whether a subspecies, ecomorph, hybrid or other entity, but have maintained the variant form herein based upon apparent distributional discontinuities between the typical and variant forms in relation to habitat and water quality. The typical form is common, although rarely abundant, through large areas of the United States. It is often common in productive, enriched habitats, although it occurs infrequently in grossly degraded situations. In contrast, the variant form has been collected primarily in areas sustaining high degrees of enrichment or in grossly polluted lakes, rivers and harbors in the United States. It is often one of the predominant tubificids, attaining large population densities in such situations. In such cases, the variant form has been collected both sympatric with, and in the absence of typical form. Holarctic. Widespread throughout the United States, including the St. Lawrence Great Lakes, Mississippi River, Illinois River, Ohio River, Hudson River, and known from Ontario, Canada.

15. Limnodrilus claparedianus

A common species in both lakes and rivers. Generally most abundant in enriched habitats but also known from clean water areas. Cosmopolitan. Recorded from throughout the United States and Canada.

16. Limnodrilus hoffmeisteri

A ubiquitous species that is probably the most abundant and widespread species in North America. Known from habitats ranging from pristine to grossly polluted. An extremely tolerant species

that is frequently the most abundant organism in areas sustaining high degrees of organic enrichment. Several forms exist. See L. hoffmeisteri (variant form) and L. hoffmeisteri (spiralis form). Cosmopolitan. Widely reported in the United States and Canada.

17. Limnodrilus hoffmeisteri (spiralis form)

This form was first noted by Hiltunen (1967) in the Great Lakes and applies to individuals possessing a penis sheath with a flat, rounded head set perpendicular to the long axis of the sheath. The name spiralis is applied to individuals of this type due to their similarity to Eisen's (1885) Camptodrilus [=Limnodrilus] spiralis. The correct rank of this taxon has not been satisfactorily resolved. The authors have maintained this form as a distinct taxon because of apparent differences in ecological requirements between the typical and spiralis form. The spiralis form has been reported from a variety of habitats but is generally most abundant in grossly polluted habitats often attaining large population densities in the absence of typical L. hoffmeisteri. Widespread? Known from St. Lawrence Great Lakes, Mississippi River, Ohio River.

18. Limnodrilus hoffmeisteri (variant form)

Herein, this name is applied to any of several forms that possess a scalloped margin on the head of the penis sheath. The status of this taxon has not been satisfactorily resolved. The authors defer from making a decision regarding taxonomic rank of these forms, but concede that the morphology of these types is likely ecologically related. Several authors make no distinction between the variant form and typical specimens. In this treatment the variant form is maintained as a distinct taxon for two reasons: First, the authors have noted a discontinuous distributional pattern between variant and typical forms, and secondly, the distinction is maintained in hopes that ongoing and future investigations will elucidate the ecological factor or factors affecting the occurrence of variant types. Discontinuous distribution. Cosmopolitan? Known from Hudson River, Mississippi River, Missouri River and St. Lawrence Great Lakes.

19. Limnodrilus maumeensis

This species has been reported only from habitats sustaining high degrees of organic enrichment. Frequently very abundant in polluted harbors and river mouths. Nearctic. Known from St. Lawrence Great Lakes, Illinois River, Mississippi River, and Louisiana.

20. Limnodrilus profundicola

Generally restricted to cold oligotrophic habitats. Rarely a dominant species in any tubificid assemblage. Cosmopolitan. Known from St. Lawrence Great Lakes, Nebraska, South Dakota, Wisconsin,

Alberta, British Columbia, Manitoba, New Brunswick, Northwest Territories, Ontario, and Saskatchewan.

21. Limnodrilus psammophilus

Described by Loden (1977) from material collected in Florida, Louisiana, and Tennessee.

22. Limnodrilus rubripenis

Described by Loden (1977) from Louisiana. Subsequently reported by Wetzel (1980) from a stream in southern Illinois.

23. Limnodrilus silvani

Distributional and ecological information sparse. A western species known only from California (Brinkhurst, 1965) and one unpublished record from Lake Ontario at the mouth of the Niagara River. Holarctic.

24. Limnodrilus udekemianus

A long worm, rarely very abundant, usually littoral. Found in organically polluted waters as well as oligotrophic habitats. Cosmopolitan. Widespread in United States and Canada.

25. Monopylephorus helobius

A coastal species described by Loden (1980) from marine, estuarine and freshwater habitats in the southern United States. Not likely to be collected inland from the coast.

26. Phallodrilus hallae

Oligotrophic waters of Lake Huron and Lake Superior.

27. Potamothrix bavaricus

An uncommon species generally collected in littoral habitats. Holarctic. Known from several localities in North America, ranging from Lake Michigan (Green Bay), Illinois, Indiana to Utah, California, and Oklahoma.

28. Potamothrix bedoti

This species, until Spencer's (1978) work, was considered a variant form of P. bavaricus. It appears to prefer a silty, muck substrate in profundal areas of lakes. Holarctic. In North America known only from St. Lawrence Great Lakes and Cayuga Lake, New York.

29. Potamothrix hammoniensis

A common European species reported only twice in North America, from Green Bay, Lake Michigan and one questionable record from Ontario in Canada. The authors have not been able to locate specimens collected in North America. Its occurrence, although possible, awaits confirmation. The figure of P. hammoniensis (Fig. 32) included herein was drawn based upon European material supplied by R.O. Brinkhurst.

30. Potamothrix moldaviensis

A common and often abundant species in mesotrophic waters of the St. Lawrence Great Lakes and its drainage. Often sympatric with P. vejdovskyi. Holarctic.

31. Potamothrix vejdovskyi

A common and often abundant species in mesotrophic waters of the St. Lawrence Great Lakes and its drainage. Often sympatric with P. moldaviensis. Holarctic.

32. Psammoryctides barbatus

Known only from Europe until reported by Vincent (1979) in the freshwater St. Lawrence River upper estuary. Holarctic.

33. Psammoryctides californianus

Uncommon. Originally described in a collection from California (Brinkhurst, 1965). Has subsequently been reported from the St. Lawrence Great Lakes (St. Marys River), Black River, Michigan, and Cayuga Lake, New York. Nearctic.

34. Psammoryctides convolutus

Recently described by Loden (1978) in collections from swamp habitats with fine organic muck substrates. Nearctic. Gulf Coast swamps from Florida to eastern Mexico.

35. Psammoryctides minutus

A western species known only from Lake Tahoe in the United States and Sturgeon Lake in Alberta, Canada.

36. Quistadrilus multisetosus

Common North American species that occurs in a wide range of habitats but is found in greatest densities in organically enriched habitats. Two subspecies, Quistadrilus multisetosus multisetosus and Q. m. longidentus originally described by Brinkhurst and Cook (1966), have been maintained by many investigators but have not been

included here because of the questionable validity of their subspecific rank (Loden and Dugas, 1978). Specimens with anterior and posterior ventral chaetae of similar shape are referable to Q. m. longidentus; those with posterior ventral chaetae bearing reduced distal teeth are referable to Q. m. multisetosus. Nearctic. Known from the St. Lawrence Great Lakes, Mississippi River, Ohio River, Wisconsin and throughout the eastern United States.

37. Rhizodrilus lacteus

This nearctic species is rare in North America, known only from Illinois and South Carolina.

38. Rhyacodrilus brevidentatus

Endemic to Lake Tahoe; not likely to be found elsewhere.

39. Rhyacodrilus coccineus

An occasional species, never very abundant. Ecological requirements poorly known. Cosmopolitan. In North America known from the St. Lawrence Great Lakes and its drainage and the Wisconsin River.

40. Rhyacodrilus falciformis

Small worms, ecology poorly known. Until recently, reported only from Europe. Only one United States record; from Hudson River, New York. In Canada, four specimens reported from Airport Creek, Victoria, British Columbia.

41. Rhyacodrilus montana

An uncommon species generally found only in cold oligotrophic and profundal habitats. Nearctic. In North America, known from the St. Lawrence Great Lakes and its tributaries, British Columbia, Manitoba, Northwest Territories, and Saskatchewan.

42. Rhyacodrilus punctatus

Recently reported in Lake Superior by Cook (1975). Prior to this record, the species was known only from Europe.

43. Rhyacodrilus sodalis

An uncommon species with extremely variable chaetal morphology that suggests taxonomic uncertainty. This species needs considerable attention in a generic revision to verify its correct taxonomic rank or position. Environmental requirements poorly documented. Holarctic. Known in the United States from Alabama, Lake Ontario, Louisiana, Tennessee, and in Canada from British Columbia, Manitoba, Northwest Territories, and Saskatchewan.

44. Spirosperma beetoni

Endemic to Lake Tahoe.

45. Spirosperma carolinensis

Known only from the southeastern United States in North Carolina.

46. Spirosperma ferox

A common, often abundant species in moderately enriched habitats, and uncommon in oligotrophic or grossly polluted areas. Individuals with a non-granular epidermis occur occasionally. Holarctic. In North America patchily distributed in the Great Lakes. Louisiana, and eastern North America.

47. Spirosperma nikolskyi

Based upon a recent revision by Brinkhurst (1981), this taxon includes two formerly well known North American species, Peloscolex oregonensis and P. variegatus (sensu Brinkhurst, 1979c). An uncommon species, generally most abundant in cold, oligotrophic profundal habitats. A dominant organism, abundant in oligotrophic profundal areas of the St. Lawrence Great Lakes. Holarctic. Known from Alabama, Alaska, Great Lakes and the type locality of P. variegatus (sensu Brinkhurst, 1979c) Sckuylkill River, Pennsylvania, Georiga, Louisiana, Mississippi, North Carolina, Oregon, Tennessee, and Washington in North America.

48. Telmatodrilus vejdovskyi

A western species known only from California and British Columbia.

49. Tubifex harmani

Recently described by Loden (1979) from material collected in Louisiana. Reproduces primarily by asexual fragmentation; sexually mature individuals rare. Ecological preferences undocumented. Nearctic. Known only from Florida, Indiana, Lousiana, Wisconsin, and British Columbia.

50. Tubifex ignotus

An uncommon species that in North America is found primarily in harbors and in lakes near river mouths. Holarctic. In North America, known from Alabama, Lake Michigan, Lake Ontario, and the St. Marys River.

51. Tubifex kessleri americanus

An uncommon subspecies found in cold, oligotrophic, profundal areas. Known from Lake Michigan, Lake Superior, and Wisconsin in the United

States and from Alberta, New Brunswick, Northwest Terrestories, Ontario, Saskatchewan, and the Yukon in Canada.

52. Tubifex nerthus

Recently combined with T. newfei by Brinkhurst (1978). A tolerant, coastal species known in both brackish and freshwater. Holarctic. Known from Newfoundland and New Brunswick.

53. Tubifex superiorensis

Transferred from Peloscolex to Tubifex by Brinkhurst (1981). A small worm, occasional in cool, clean waters. Nearctic. Known primarily from the Great Lakes and recently from the Mississippi River, Wisconsin River and Red Cedar River in Wisconsin.

54. Tubifex tubifex

Indifferent to water quality, locally abundant in habitats ranging from grossly polluted and organically enriched, to pristine alpine and subalpine lakes and streams. Often abundant in habitats supporting few other species in both clean and perturbed waters. Frequently confused with Ilyodrilus templetoni. Cosmopolitan. Widespread throughout northern North America, apparently rare in the southern United States.

55. Varichaeta nevadana

Recently transferred from Isochaeta by Brinkhurst (1981). Endemic to Lake Tahoe.

56. Varichaeta pacifica

Described by Brinkhurst (1981) from Washington and Alaska. Apparently a cold stenotherm.

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