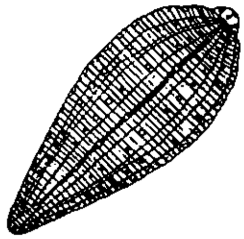

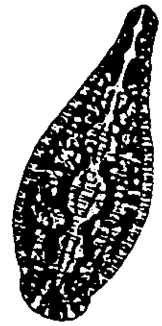

Identification Guide

to the

Freshwater Leeches (Annelida: Hirudinea)

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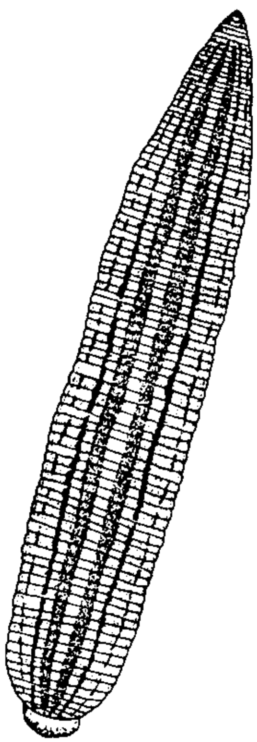
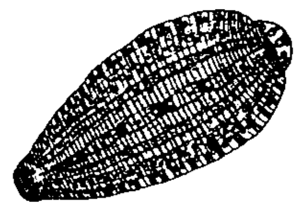
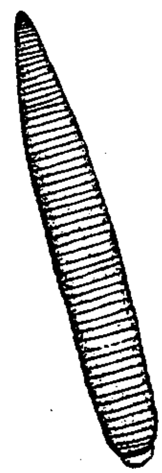



Florida

and

Other Southern States



1995

Donald J. Klemm

Bioassessment and Ecotoxicology Branch
Ecological Monitoring Research Division
Environmental Monitoring Systems Laboratory
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

State of Florida
Department of Environmental Protection
Division of Water Facilities
Tallahassee

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Identification Guide to the Freshwater Leeches

(Annelida: Hirudinea)

of Florida and Other Southern States

by

Donald J. Klemm, Ph.D.
Research Aquatic Biologist
Bioassessment and Ecotoxicology Branch
Ecological Monitoring Research Division
Environmental Monitoring Systems Laboratory
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268
e-mail: klemm.donald@epamail.epa.gov

January, 1995

James L. Hulbert, Project Manager
Surface Water Ambient Monitoring Program Administrator
Division of Water Facilities
Florida Department of Environmental Protection

Requests for copies of this document should be addressed to:
Bureau of Surface Water Management
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

ABSTRACT

This guide contains illustrated keys to orders, families, and species of freshwater leeches (Class Hirudinea) in Florida and ten other southern states. Included are sections on the current systematics and taxonomic status of leeches in North America; methods of collection, preservation, preparation, and identification of specimens; voucher specimens and museum depository for leeches; information on how to use this guide; general ecological criteria for distribution and abundance; anatomical characteristics to the orders and families of leeches in North America; anatomic and diagnostic features for identification, information on indicators and pollution tolerance of leeches; general bibliography; classification, taxonomic synopsis, list of species, and distribution of leeches for Florida and other southern states; and a glossary of terms applied in the morphology of leeches in North America.

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ACKNOWLEDGEMENTS

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I would like to thank and acknowledge the Smithsonian Institution, U.S. National Museum of Natural History, Department of Invertebrate Zoology, Division of Worms, Washington, D.C. for permitting me to examine its collection and records of leeches.

I would also like to thank Robert P. Rutter, State of Florida, Department of Environmental Protection, Punta Gorda, Florida and Dr. David C. Beckett, Department of Biological Sciences, The University of Southern Mississippi, Hattiesburg, Mississippi for supplying specimens and distribution records.

INTRODUCTION

In North America the Class Hirudinea is represented by either 23 genera and 67 nominal species (Klemm, 1985; Sawyer, 1986b) or by 25 genera and 69 nominal species (Davies, 1991), (See Systematics and Current Taxonomic Status for Freshwater Leeches of North America). Thirty-three species have been reported from the region of the southern states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas (see Appendix A). Twenty species (Appendix A) have been reported from Florida. These species belong to the five major families of Hirudinea: Glossiphoniidae, Piscicolidae, Erpobdellidae, Haemopidae, and Hirudinidae. Sawyer (1974) separated the leeches in North American by ecological diversity and distribution into four general groups. These associations include: (1) a group of widely tolerant species, ubiquitously distributed; (2) a group of more commonly northern species; (3) a group of primarily southern species, and (4) a group of species geographically restricted. The species commonly found in polluted waters belong to the ubiquitous group of widely distributed and widely tolerant species (Sawyer, 1974, 1986b; and Klemm, 1991). Some of these same species or closely related species are found in Europe, and much of our earlier knowledge and understanding of the pollution ecology of freshwater leeches were based on studies of these European species. However, our knowledge and understanding of the ecology of the leeches in North America has continued to develop because of the definitive studies by Kopenski (1969), Herrmann (1970), Klemm (1972a, 1975, 1976), Poe (1972), Richmond (1972), and Sawyer (1972, 1986a,b) and because of the extensive review and evaluation of the literature by Sawyer (1974), Klemm (1977, 1991a,b), Davies et al. (1988), and Davies (1991). Unfortunately, the environmental requirements and pollution tolerances for many leech species of North America, including Florida and other southern states, are not known or the knowledge is very fragmentary. Thus far, there have been no definitive leech studies in Florida or the other southern states, and there have been only a few bioassessment studies which have included the leeches at the species level with the other macroinvertebrate groups (e.g., Mason, 1991 and Mason et al., 1994). Also, even though excellent keys are available for identification of the North America taxa (Klemm, 1972b, 1990, 1982, 1985), Sawyer (1972, 1986b), and Davies (1991), few bioassessment studies have included leeches at the species level.

Leeches are predominantly freshwater invertebrates, although marine forms do exist as well as numerous terrestrial species that occur mainly in the subtropics or tropics. The feeding habits of leeches are basically predatory and/or parasitic, with anterior and posterior suckers, that serve as important organs of attachment, locomotion, feeding, and reproduction.

In aquatic ecosystems, leeches are important components of food webs (Klemm, 1975, 1985, 1991; Sawyer, 1974, 1986b; Davies and Everett, 1975; Davies et al., 1981; Young and Spelling, 1989; and Davies, 1991), as predators, parasites, vectors of parasites (Woo, 1991; Jones and Woo, 1990b, 1991, 1992; Siddall and Desser, 1992a,b), and as food of aquatic animals (Isaak et al., 1993). The food habits of leeches are very diverse including a few species in North America with the blood sucking feeding habit that occasionally affects man. Some species are morphologically adapted for obtaining and digesting food consisting primarily of the blood of fishes, turtles, crocodilians, frogs, salamanders, birds, and mammals. Other species can also consume blood fluids, tissues, and whole live or dead invertebrates, such as annelids, crustaceans, insect larvae, and mollusks.

The dichotomous keys to order, family, and species in this guide utilize as many external characters for identification as possible. The drawings were made from living and preserved specimens. All the illustrations except where noted were drawn by the author. The morphological terms for the diagnostic characters used in the distinction and differentiation of the species are defined in the glossary of technical terms (Appendix B). In Addition, the distribution and taxonomic synopsis and list of species for Florida and other southern states are found in Appendix A.

The purpose of this work is to provide regional keys of families and species to help identify freshwater leeches of Florida and other southern states. This will allow students and scientists in aquatic biology to identify most leech specimens that they collect. Species level identifications will help them to interpret more relevantly ecological and distribution data. The literature (see Literature Cited and Bibliography) indicated that the specific responses of some leech species to various kinds of pollution and environmental stressors (e.g., effects and bioaccumulation of toxic substances) makes them potentially useful bioindicators (i.e., those species that have narrow and specific environmental tolerances and show marked responses to extremely small changes in environmental quality) of habitat conditions, and water quality (Sladacek and Kosel, 1984; Sawyer, 1974, 1986b; Slooff, 1983; Metcalfe et al., 1984, 1988; Brown and Pascoe, 1988; Hall and Jacob, 1988; Metcalfe and Hayton, 1989; Klemm, 1991a; Bendall and McNicol, 1991; Davies, 1991; Camargo, 1992). It is important to know the environmental tolerances of the leeches so that one may know if their presence or absence is indicative of specific environmental conditions and to help determine the health and biological integrity of aquatic ecosystems.

This guide is also directed to the needs of students and scientists in fisheries, limnology, parasitology, freshwater biology, aquatic ecology, invertebrate zoology, natural history of invertebrates, water resources, conservation, water quality assessment, and public health who may desire to identify leeches that are encountered in Florida and other southern states. The annotations section of each species is provided with ecological and pollution data, specific distribution records, and taxonomic status of selected species. Also, the text contains methods of collection and processing of specimens, notes on general ecology, cited references, and a bibliography.

The identification of leeches to species during studies of aquatic macroinvertebrates will expand our knowledge about the ecology, natural history, and environmental requirements and pollution tolerance of individual groups or species. With this information aquatic biologists can evaluate data collected during water quality studies concerning the effects of habitat degradation, toxic substances, and other pollutants on aquatic macroinvertebrates. Some of the material presented here has been reworked from Klemm (1985) which new material, including additional unpublished distributional records of the author, and cited material by other authors have been added to this guide.

The emphasis on identification of specimens to the species level in this guide reflects the convictions of the author that the important task now and in the next decade will be the integration of taxonomic and ecological approaches more critically so that the biological data collected in pollution assessment and water quality studies will be more useful. Learning more about the biology, trophic structure, and pollution tolerances, is also very important in understanding the ecology of the species and the environment. If this work successfully provides some of the taxonomic tools to identify specimens of leeches to species more expeditiously and accurately and helps in our understanding and comprehending of the different aquatic ecosystems, then this document will have sufficiently served science and mankind.

SYSTEMATICS AND CURRENT TAXONOMIC STATUS FOR THE LEECHES OF NORTH AMERICA

The nomenclature for the leeches in this guide contain the latest taxonomic changes (Barta and Sawyer, 1990; Jones and Woo, 1990a; Klemm, 1985, 1991; and Sawyer, 1986b). However, there still remains some contradictory opinions and attitudes among students of leeches regarding the application of nomenclature and the current names (e.g., the genus *Haemopis* Savigny, 1822 [= *Percymoorensis*, = *Mollibdella*, = *Bdellarogatis* Richardson, 1969] of certain species of Haemopidae; and the genus *Myzobdella* Leidy, 1850 [= *Illinobdella* Meyer, 1940]) and some species in North America with the generic names (*Batracobdella* Viguier, 1879 and *Helobdella* Blanchard, 1896). The reader is referred to Klemm (1985, 1991), Richardson (1980), Sawyer (1984, 1986b), Davies (1991), Brinkhurst and Gelder (1989), and Brinkhurst (1991, 1992) and the annotations in this guide for discussions, interpretations, dilemmas, and views of these and other systematic and taxonomic problems in the Phylum Annelida, the Class Hirudinea, and the taxonomic status and synonymy of the various leech genera and species.

SPECIMEN COLLECTION, PRESERVATION, PREPARATION (NARCOTIZATION AND FIXATION), AND MICROSCOPE IDENTIFICATION OF LEECHES

Collection: In surveying aquatic ecosystems for leeches, free-living species which avoid strong sunlight are found attached to the sides, in cracks, and under surfaces of a variety of substrates such as rocks, boards and logs, or almost any inanimate object littering both lentic and lotic environments. This includes submergent vegetation, leaf packs, and masses of other organic debris. Some leeches are also collected along with other macroinvertebrates in grabs or dredges, and other types of sampling devices (Klemm et al., 1990, 1993; Davies, 1991).

Many species of Glossiphoniidae and Piscicolidae are well adapted as ectoparasites in that they pierce and suck the blood and tissue contents of their hosts. The collection and examination of vertebrates (amphibians, aquatic reptiles, fishes, and waterfowl) and macorinvertebrates (snails, mussels, etc.) are, therefore, recommended when collecting certain species of leeches. The parasitic forms remain attached to the host and cling there for a period of time, and then drop off after feeding and creep away to seek the shelter of a suitable substrate where they may remain while digesting their meal. Szalai and Dick (1991) evaluated gill nets, fyke nets and mark-recapture methods to estimate the number of leeches and crustaceans on fish. Most parasitic forms are generally found free-living during part of their development or reproductive cycle (deposition of cocoons or eggs and brooding young) and require a substrate for attachment.

Most species of Hirudinidae and some species of Haemopidae have jaws and teeth and are either sanguivorous (blood sucking) or macrophagous (swallowing their invertebrate prey whole), but the few species lacking true muscular jaws and teeth are strictly macrophagous. Species of Erpobdellidae which also lack jaws and teeth are macrophagous. Hirudinids and haemopids are usually collected free-living by hand with a dipnet. Erpobdellids are found free-living and are collected by hand or with various grabs, dredges, or kicknets.

Some species of *Haemopis* (Haemopidae) are amphibious, where as *Haemopis septagon* and some populations of *Haemopis terrestris* are terrestrial. The terrestrial forms are collected from moist places under rocks, boards, logs, or almost any type of inanimate object, usually near water. Sometimes, however, terrestrial populations are found a great distance from bodies of water. On occasion, these leeches can even be collected when they are foraging for food along the shores of bodies of water or on land when moist atmospheric condition exist, especially at night. Leeches are collected either by hand, with forceps, or any other instrument that can be used to gently dislodge them. Some benthic forms may be collected with bottom samplers (e.g., grabs or dredges) and some of the actively swimming species can be collected with a dipnet. In addition, dipnets and other aquatic nets are useful in collecting debris, vegetation, and other organisms (e.g., fish, amphibians) that may be examined for leeches.

Preservation: In most bioassessment studies where sampling time is limited at each sampling station, the sample containing leeches or macroinvertebrates, is usually sieved first or placed directly into a sample jar and preserved with 70% ethanol or 5%-10% buffered formalin. For general sample preservation, 70% ethanol is recommended since it is safer to use. If large specimens are preserved directly into alcohol, they should be injected with 70% ethanol to ensure preservation of the internal organs after they stop moving in the field or back at the laboratory. All samples should be labeled properly in the field (Klemm et al., 1990). Many specimens can be identified to species without resorting to narcotizing and fixing of specimens. However, for special anatomical and histological studies, and determining the eye number and arrangement of some specimens, formalin, which is a fixative, should be used first to fix the tissue before placing the specimen in alcohol since the alcohol is not a fixative.

Narcotization and Fixation: Most leeches contract strongly when placed in fixatives or preservatives. Therefore, the live leeches should be narcotized first (Madill, 1983; Klemm, 1985). Before narcotizing the specimens, the colors of the dorsal and ventral surfaces should be noted as the colors generally dissolve or are altered by most narcotizing agents. Leeches can to narcotized in carbonated water, or by bubbling in CO_2 until movement of the leech stops. Then, straighten the leech out and slowly add 5%-10% buffered formalin to fix the tissues of the specimens for 24 hours or less, depending on the size of the leech. To preserve specimens, wash the fixed leeches with deionized water to remove the formalin and than add either 70% ethanol or 5%-10% buffered formalin. For special studies, small leeches or structures of leeches fixed in formalin, bouin's, or Flemming's fixatives can be stained (e.g., Mayer's paracarmine Harris' hematoxylin) for 12-24 hours, destain (if necessary), then run through an alcohol series to dehydrate the specimens, and finally clearing the specimens in methyl salicylate and mount using a neutral pH mounting medium (Knudsen, 1966). For discussions of other narcotizing and fixing agents, stains, mounting media, more detailed preparation methods, and slide making, the reader is referred to Richardson (1975), Madill (1983), Klemm (1985), Pennak (1989), or Davies (1991)

Microscope for Identification: Specimens should be identified under a dissecting stereomicroscope with 100-400X magnification. The teeth of certain species should be dissected out, mounted on a slide, and examined under a compound microscope 100-1000X magnification.

VOUCHER SPECIMENS AND MUSEUM DEPOSITORY FOR LEECHES

Voucher/Reference Specimens: To aid in identification, one should maintain a voucher specimen collection. Also, one should maintain a reference library and keep up with the literature. Students of leeches and of other macroinvertebrates should be a member a scientific society (e.g., The North American Benthological Society which supplies to its members an annual reference document, *Current and Selected Bibliographies on Benthic Biology*).

Museum Depository: The value of a leech museum depository is that it provides permanent preservation for type-specimens and other voucher specimens, and records of collection data. The leech material would serve biologists in Florida and in North America as reference for further systematic and ecological studies. Specimens no longer needed should be deposited in the United States National Museum of Natural History or some other reputable museum that is concerned with the safety of the specimens and has a reputation for properly maintaining the reference collection. This also makes the voucher specimens accessible for scientific research.

In North America museum specimens need proper collection data (the locality, including state and county, and sufficient information so that the collecting site can be located, date collected, scientific name (if known), habitat, collector(s), name of person who identified the specimen, and other ecological information if available, such as found free-living, or parasitic, and host, the scientific name of the host (if known), etc.). Specimens sent to museums without adequate accompanying data are worthless. In North America the specimens can be sent to the Division of Worms, Department of Zoology, U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. 40560.

In some cases, a specimen may have to be sent to a taxonomic expert for verification or identifications. Unfortunately, there are very few such experts in this country. Before specimens are sent to an expert, contact him/her and find out if he/she has the time to examine your specimens. Generally most students of leeches are willing to identify difficult specimens or to verify the identification of questionable leech specimens.

GENERAL ECOLOGY

The distribution and abundance of leeches is usually determined by the physical, chemical, or biological characteristics of the environment since organisms cannot generally survive in an aquatic ecosystem that does not furnish their physical, chemical, and nutritional requirements. One very important ecological factor in the distribution and abundance of leeches is the availability of prey organisms. Leeches in the family Glossiphoniidae are found in freshwater and feed upon invertebrates (e.g., aquatic worms, mollusks, insect larvae, crustaceans) and certain vertebrates (e.g., amphibians, fish, turtles, aquatic reptiles, and water fowl); Piscicolidae occur in fresh, brackish, or salt waters and feed mainly upon crustaceans, fishes, and reptiles. The Hirudinidae are found in freshwater and feed upon the blood of mammals, including man. Species in Haemopidae are found in freshwater, or are either semi-terrestrial, or terrestrial and are classified as carnivorous, feeding on crustaceans, insect larvae, mollusks, and worms. Species in Erpobdellidae are freshwater forms and are carnivorous, swallowing various kinds of crustaceans, insect larvae, mollusks, and worms whole.

Some other important physical and chemical factors in the abundance and distribution of leeches are composition of substratum, type of water (lentic or lotic), water depth, size and type of water body, hardness and pH, water temperature, dissolved oxygen, siltation and turbidity, and salinity. Generally, leech abundance and diversity is greatest in the littoral zone of lentic habitats where there is an abundance of submergent vegetation which is usually dependent upon depth of water and sunlight penetration. Leeches are less abundant in waters of great depth because of the lack of vegetation, other suitable substrates for attachment, and the availability of food organisms. Species of leeches that are most common and widespread are those that prey on a variety of aquatic invertebrates. Additional information on the ecology and important factors that influence the abundance and distribution of leeches are discussed in Klemm (1972a, 1990, 1991a), Klemm, et al. (1990), Sawyer (1974, 1986a,b), Herrmann (1970), and Davies (1991). However, it must be repeated and stressed that much work still remains to be done on the ecology and pollution biology of leeches.

HOW TO USE THIS GUIDE

Area covered: This guide was written for use in the state of Florida, other Gulf Coast states of Alabama, Mississippi, Louisiana, Texas, and other southern states such as North Carolina, South Carolina, Georgia, Tennessee, Arkansas, and Oklahoma. The keys in the guide identify all species known to occur from this area of the United States. Some of these species have been reported only from various southern states, and the inclusive distribution of these species is not yet known. Additional collecting is needed to determine the distribution of these species. Some species of leeches from North Carolina, South Carolina, and Tennessee have also been included in the keys because the distribution of these species is not known, and they may also be found in specific habitats of Florida and the Gulf Coast states.

Illustrations and abbreviations: The majority of the illustrations of external taxonomic characters in this guide were produced by the author from specimens collected by the author or sent to the author for verification and/or identification. If an illustration was from another source, other than the author, the source of the figure is cited, and the reference is located in the Literature Cited section. All of the illustrations show typical external taxonomic characters that are used in the identification of the leech taxa. There should be no problems in identifying most mature specimens. However, some immature forms can not always be identified to species but should be identified to the lowest taxon (e.g., family, genus, or species) possible.

The Keys: It is assumed that the user of this guide is familiar with the use of dichotomous keys. Numbers in parentheses following the couplet number indicate the couplet that led to that position. Measurements are stated in the couplet containing the species name. Illustrations are arranged by figure numbers.

Things You Can Do To Aid In Identification: The taxonomic keys in this guide are constructed mainly of external anatomical and biological characters (see General Anatomy and Diagnostic Features for Identification). It should be sufficient for the identification of all Florida and other southern state leeches to the species level. If reference is made in a couplet to an internal feature after reference to an external one, the keys can be used first for the identification of some specimens without resorting to dissection, provided the external characters are discernible. Also, some collections will undoubtedly contain specimens that cannot be identified to the species level for various reasons (usually poor handling of specimens during collection and preservation), but they should be identified to the lowest taxonomic category (taxon) possible, based only on characters of the specimens and those used in the keys. A glossary of diagnostic features and other terms is provided in Appendix B. Appendix A contains the currently reported distribution for leeches of Florida and other southern states.

GENERAL ANATOMICAL AND TAXONOMIC CHARACTERISTICS FOR THE TWO ORDERS AND FIVE FAMILIES OF LEECHES IN NORTH AMERICA

Phylum Annelida

Class Hirudinea

I. Order **Arhynchobdellida**: Mouth large, opening from behind into entire sucker cavity; pharynx fixed; with or without jaws, true vascular system lacking, botryoidal tissue; blood red.

A. Family **Haemopidae**: Eyes, five pairs, arranged in an arch on somites II and VI, with the third and fourth pairs of eyes separated by one annulus; body elongate; the pharynx cylindrical and somewhat long with thin walls. North American species are without muscular jaws but have rudimentary jaws, typically with a distichodont series of teeth. A few species are secondarily agnathous; predaceous; somites 5-annulate; testisacs large, in metameric pairs, normally 10; most are aquatic or amphibious forms, with a few species secondarily terrestrial.

B. Family **Hirudinidae**: In North America, eyes, five pairs, arranged in an arch on somites II and VI, with the third and fourth pairs of eyes separated by one annulus; body elongate; the pharynx is short, bulbous. Most species have muscular jaws with a monostichodont series of teeth; haematophagous; somites 5-annulate; testisacs large, in metameric pairs, mostly 10; aquatic forms only.

C. Family **Erpobdellidae**: Eyes, three or four pairs, in separate labial and buccal groups; body elongate; pharynx a crushing tube extending to somite XIII; three muscular pharyngeal ridges, but no true jaws or teeth (denticles); somites 5-annulate, but often further subdivided; testisacs very small and numerous in grape-bunch arrangement.

II. Order **Rhynchobdelida**: Mouth is a small pore, either within the anterior sucker cavity of segment II or III, or apical or subapical on sucker rim; protrusible proboscis; true vascular system separated from coelom; head (anterior) sucker not freely expanded; eyes one to four pairs with various arrangements; blood colorless; aquatic.

A. Family **Glossiphoniidae**: Eyes, one to four pairs, integrated and confined to head (except *Placobdella hollensis* which also has accessary eyes on neck region); body not divided externally into trachelosome and urosome regions, usually flattened and much wider than head region; complete somites mostly 3-annulate (except *Oligobdella biannulata* which has 2-annulate somites); eggs yolky and brooded; cocoons directly deposited on substrate and covered by parent and brooded or cocoons attached to the ventral surface of parent and brooded. All members of this family are found in a variety of aquatic habitats (e.g., streams/rivers, ditches, ponds, reservoirs, and lakes). They feed predacously and/or parasitically on a variety of aquatic invertebrates and/or vertebrates. Many species are found free-living.

B. Family **Piscicolidae**: No Eyes, one, or two pairs; body cylindrical, usually long and narrow; body sometimes divided into a narrow anterior trachelosome and a wider posterior urosome; anterior sucker expanded and distinct from body; pulsatile vesicles along the lateral margins present (in *Piscicola* sp. and *Cystobranchus* sp.) or absent; seven or more annuli per segment (except *Piscicolaria reducta* which is 3-annulate); oculiform eye spots or other shaped eye spots are sometimes present on the posterior sucker and lateral margins of the body; no brooding of eggs (cocoons) or young on ventral surface of adults; hard cocoons attached to substrates of various kinds, including the exoskeletons of assorted crustaceans. The piscicolids possess a protrusible proboscis and are almost exclusively found as ectoparasites of fish, and in some species their feeding cycle includes marine mollusks and crustaceans or other invertebrates.

GENERAL ANATOMY AND DIAGNOSTIC FEATURES FOR IDENTIFICATION

The taxonomic keys in this guide are constructed mainly of external anatomical characters and should be sufficient for the identification of most Florida and other southern states leeches to the species level. However, some collections will occasionally contain a specimen(s) that can not be identified to the species level for various reason (usually poor handling of specimens and preservation), but one should still identify the specimen to the lowest practicable taxonomic category (taxon) possible.

The general external diagnostic features that are important for the identification of the leeches in Florida, other southern states, and North America to order, family, genera, and species include the following: size of mouth, general shape of body, form of suckers, form of cephalic region, number and arrangement of eyes, eyespots (ocelli), papillae, pulsatile vesicles, sensillae, digitate processes on rim of caudal (posterior) sucker, caudal sucker separated from body on narrow pedicle (peduncle), copulatory gland pores, the number of annuli per somite (segments) between male and female gonopores, and the pigmentation patterns. Other minor characters not discussed here will be found appropriately in the keys. A glossary of these diagnostic terms and other terms are provided in Appendix B.

The body of the leech consists of 34 somites (segments), designated by Roman numerals (I through XXXIV). Each somite contains a ganglion in the central nervous system (neuromeric somite). Each neuromeric somite is divided externally by superficial furrows into two to sixteen annuli or rings. Somites that have the full number of annuli (termed complete or perfect somites) are found in the middle of the body, and this number is generally characteristic of the genera or species. Incomplete or abbreviated somites occur at both ends of the body. The annuli are best seen after careful narcotization or proper preservation. Reference to annulation in leech keys is almost always to complete somites. With the aid of a dissecting stereomicroscope the outline of the annuli can be seen most easily in the lateral margins of the ventral surface. Moore (1898) and Castle (1900) independently recognized that the nerve cord ganglia are located in the middle annulus of the somite, and that the triannulate somite is the basic form. In the three- or five-annulate somite, for example, the middle annulus is aligned with the ganglion and is known as the neural or sensory annulus. The annulation suggested by Moore (1898) is found in Table 1. Counting from the cephalic end, the triannulate somite consists of three primary annuli (best seen in middle of body), numbered a1, a2, and a3 (or sometimes written a1-3). Annulus a2 (the neural annulus) contains the ganglion and is marked externally by transverse rows of minute, cutaneous sensillae (segmental receptors), which are difficult to see in some specimens. Repeated bisection of the 3 primary annuli gives rise to more complex annulation.

Other visible organs of the integument are the cephalic eyes (ocelli) and papillae (tubercles). When present on the caudal sucker and lateral margins, eyespots, which are usually embedded in pigment, are also termed ocelli. Varying in number and shape (punctiform, crescentiform) eyespots of the caudal sucker are used in the identification of certain species of piscicolids. They are absent in the Glossiphoniidae. The number and position of the eyes of the cephalic (anterior) region are important taxonomic features.

Primary	Secondary	Tertiary	Quaternary
*a*1	*b*1	*c*1	*d*1
			*d*2
		*c*2	*d*3
			*d*4
	*b*2	*c*3	*d*5
			*d*6
		*c*4	*d*7
			*d*8
*a*2	*b*3	*c*5	*d*9
			*d*10
		*c*6	*d*11
			*d*12
	*b*4	*c*7	*d*13
			*d*14
		*c*8	*d*15
			*d*16
*a*3	*b*5	*c*9	*d*17
			*d*18
		*c*10	*d*19
			*d*20
	*b*6	*c*11	*d*21
			*d*22
		*c*12	*d*23
			*d*24

Table 1. Theoretical table of the annuli produced by repeated bisection of the three primary annuli (after Moore, 1898)

Cephalic Eyes: The glossiphoniids have 1 to 3 pairs of eyes (Figs. 32-43); the piscicolids have none to 2 pairs (Figs. 12-22); the haemopids and hirudinids have 5 pairs of eyes (Fig. 23); and the erpobdellids, typically, have 3 pairs of eyes (Fig. 24), but in some species variation in the number of eyes has been reported (Gadler and Olson, 1984). The relative distance between eyes is another important diagnostic character for identification. If the distance between them is equal to, or greater than the diameter of the eyes, they are termed "well separated" (Figs. 32-34). If the distance between a pair of eyes is less than the diameter of a single eye, they are termed "close together" (Figs. 35-37). When they touch, they are termed "fused" or "confluent" (Figs. 38-41). Some variation in eye location can occur occasionally as a result of rapid preservation. In some specimens the eyes may disappear altogether because the specimens have been inadequately handled during preservation.

In the haemopids and hirudinids the eyes are arranged in a submarginal (parabolic) arch (Fig. 23). In erpobdellids, the eyes are arranged in separate labial and buccal groups (Fig. 24). If the leech has been fixed and/or preserved and the eyes cannot be seen, the head of small specimens can be usually flattened between two glass slides, which will generally make the eyes visible under a dissecting microscope. When the eyes are hidden by dark pigmentation in large specimens, the head of the preserved specimen can be decolorized by immersion in 5% caustic potash or Amman's lactophenol (specimens in formalin work best) for 10 to 30 minutes, but the time will vary with the specimen. Amman's lactophenol is prepared as follows: 100 g phenol, 100 mL lactic acid, 200 mL glycerine, and 100 mL water.

Papillae: The papillae of the dorsal surface vary in size, type, and arrangement. They may be limited to small, minute protrusible sense organs that are often scattered in small or great numbers over the dorsal surface, or are large (tubercleIike) smooth, conical, or rounded cone projections that include some of the dermal tissue and muscles, and which are often themselves covered with minute papillae. For example, numerous large and scattered papillae are present on the dorsum of *Placobdella ornata*, and the surface of these papillae is covered with minute papillae, resulting in a very rough or warty appearance. In *Placobdella multilineata* the papillae are small, less numerous, on the dorsum, but with the larger ones tending to be segmentally arranged in five distinct longitudinal rows. In *Placobdella papillifera*, the dorsal papillae occasionally very from small to inconspicuous, or large and pointed, and are arranged in five to seven distinct longitudinal rows. However, in specimens of the above species, variation occurs in these characters, and they must be used with other diagnostic features, such as body shape and pigmentation, that are indicated in the glossiphoniid key.

Cephalic Region: The form of the cephalic region (anterior somites) of leeches is a diagnostic character. In the Glossiphoniidae, the cephalic region of all the species (except *Placobdella montifera* and *Placobdella nuchalis*) is not, or is only slightly differentiated (Figs. 32-34). The mouth pore is located on the rim or within the oral sucker (Figs. 1-3). Both *Placobdella montifera* and *Placobdella nuchalis* have the cephalic regions in the form of a distinct "discoid" head (Figs. 11, 35). The anterior sucker of the piscicolids is always expanded and usually distinctly marked off from the body, and the mouth pore is in the middle of the sucker (Figs. 4, 12-22). In Erpolbdellidae, Haemopidae, and Hirudinidae, the mouth is medium to large in size and the anterior sucker is little more than the expanded lips of the mouth opening (Figs. 5-7).

Caudal Region: The form of the caudal (posterior) sucker is characteristic of some leech species, and is included in the glossiphoniid key. *Actinobdella inequiannulata* has digitate processes (glands and papillae) on the rim of the caudal sucker (Fig. 72), and the bulbous, hemispherical sucker is separated from the body on a short, narrow pedicel (peduncle). In preserved specimens, the digitate processes are usually retracted, and they are fingerlike when everted. The position of the digitate processes is indicated on the dorsal surface of the caudal sucker by faint radiating ridges (Fig. 72). *Actinobdella pediculata* is without digitate processes, but the thick and bulbous caudal sucker is separate from the body on a short pedicel (Figs. 70-71).

Body Regions: In all the Piscicolidae, with the exception of some specimens of *Piscicolaria reducta* and *Myzobdella lugubris*, the body is characteristically divided into two distinct regions (Figs. 12-14), a narrow anterior trachelosome region and a larger and wider posterior urosome region. However, the separation of these two regions is less conspicuous and not always observable in preserved specimens of *Piscicola* sp. (Figs. 15-16), but they are usually always present in *Cystobranchus* sp. (Fig. 13). Some preserved specimens of *Myzobdella* and *Piscicolaria* also show a distinct separation of these two regions due to contraction (Figs. 19-22).

Pulsatile Vesicles: In the genera *Piscicola* and *Cystobranchus* only, the neural annuli of the urosome (posterior region) bear 11 pairs of pulsatile vesicles (Figs. 12-14). In *Piscicola*, the vesicles are small or usually undifferentiated in some preserved specimens (Figs. 14-16), but in *Cystobranchus*, they are large and clearly visible in both living and preserved individuals (Fig. 13).

Pigmentation: Patterns of pigmentation and color are important diagnostic features for some species of leeches. Coloration features, such as blotches, dots, spots, stripes, bands, and lines are easy to determine in living as well as freshly preserved specimens, and they usually persist for some time. They may fade away in some specimens that have been preserved in alcohol or preserved for a considerable length of time. Green and blue pigments are lost almost immediately in alcohol, although they usually exist longer in formalin. The red color of blood is lost almost as soon as the green and blue, but the other reds and yellows are lost more slowly. The browns and blacks usually remain for years. It should be noted, however, that in some species the color of the dorsal surface changes greatly with the development, age, volume of blood consumed, degree of digestive blood, and environmental condition. Pigment coloration of the dorsal and ventral surfaces that are used in the keys are those that generally persist after preservation.

Size: The average size of each species is given in the key, but many variations appear in the species due to the age and development of the specimen collected, and also due to contraction during processing.

External Reproductive System: The male and female gonopores are visible on the middle of the ventral surface of somites XI and XII and are generally separated by two to seven annuli. The male gonopore is large, more readily visible in the mature specimen, and anterior to the female gonopore. In some specimens the female gonopore can be difficult to find due to its small size. The number of annuli between the male and female gonopores is another important characteristic used in determining species of erpobdellids (Figs. 120-125) and haemopids (Figs. 27-28). The area of the gonopores can be observed under a stereomicroscope. Sawyer (1972) indicated that slight variations in the location and number of annuli between gonopores exist in some specimens of Erpobdellidae and Haemopidae.

External copulatory pores are present on the ventral surface, at about 10-11 annuli posterior to the male gonopores in a pattern of either 4 or 8 (Figs. 29-30) on adult *Macrobdella decora* and *Macrobdella ditetra*. Some immature forms of *Macrobdella* sp. may not have the copulatory pores or a set number of copulatory pores (Sawyer and Pass, 1972), but other characters in the key can be used for identification. The copulatory glands are located on the ventral surface, four to five annuli posterior to the female gonopore. In *Philobdella* sp. the copulatory glands with pores are absent, but the gonopores with copulatory pits are present and are surrounded by an undifferentiated glandular area (Fig. 31).

Internal Features: The only internal features used in the guide are the denticles (teeth) to identify some difficult specimens of *Philobdella gracilis* and *Philobdella floridana*. To examine the jaws and teeth (Figs. 108-110), one must dissect carefully, for the jaws are small, and they are invariably retracted and hidden in the circumpharyngeal pits. The specimen should be positioned ventrally or pinned out in such a manner. A medical incision should be made from the lower lip of the anterior sucker back far enough for the margins to be pinned out to expose the inner surface of the buccal cavity and pharynx. Details of the denticles (Fig. 111) can only be seen by first removing a jaw and making a whole mount, using CMCS or other mounting media, on a microscope slide and examining with a compound microscope to determine the number of teeth.

Other important internal diagnostic features of the digestive tract for certain species of *Haemopis* are the presence (Figs. 108-110) or absence of jaws and teeth, smooth or finely papillated velum, and the number of internal ridges (fleshy pods) of the pharynx (see Klemm, 1982, 1985). In some instances where a North American specimen(s) of *Haemopis* can not be identified by only external characters, the features of the reproductive organs should be used for species identification. The shape of the atrium and atrial cornua (e.g., simply curved, globular, rounded, ellipsoidal, spirally coiled, or short and curved) and presence or absence of long preatrial loops of the reproductive system in certain erpobdellid species are important diagnostic features for helping to identify difficult specimens to the species level from North America. The internal features of the digestive tract and the reproductive system, including diagnostic features and illustrations for difficult specimen identification are discussed in more details in Sawyer (1972, 1986b), Klemm (1982, 1985), and Davies (1991).

Lastly, it should be noted again that most specimens of leeches can be identified to the species level. The keys in this guide will enable the user to identify difficult forms to the lowest practicable taxonomic level at which diagnostic features of the specimens are available to the observer of a particular taxa. For a specimen(s) that can not be identified using this guide, one should consult Klemm (1985), Sawyer (1986b), or Davies (1991) for additional information and discussions on taxonomic status, diagnostic characters of other species not mentioned in this guide, and for other keys to the species of leeches in North America.

KEY TO THE ORDERS AND FAMILIES OF LEECHES (ANNELIDA: HIRUDINEA) FOR FLORIDA AND OTHER SOUTHERN STATES

1 Mouth an obvious small pore on rim or within the oral sucker, through which a muscular proboscis can protrude (Figs. 1-4), or if pore is difficult to see, go to couplet 2. . . . . Order Rhynchobdellida. 2

Mouth medium to large, commonly occupying entire oral sucker, without a proboscis (Figs. 5-7). . . . . Order Arhynchobdellida. 3

2(1) Body dorso-ventrally compressed (with flat venter), and much wider at mid-body than at cephalic region (Figs. 1, 8-11), never cylindrical, somewhat subcylindrical in *Gloiobdella elongata* (Fig. 10); oral sucker ventral and more or less undifferentiated from body (Figs. 1-3), except *Placobdella montifera* and *Placobdella nuchalis* (Fig. 11); no pulsatile vesicles; eggs in membranous sacs either attached to ventral side of adult where young are brooded or to substrates and covered by adult's body . . . . See Key I. Glossiphoniidae (page 22)

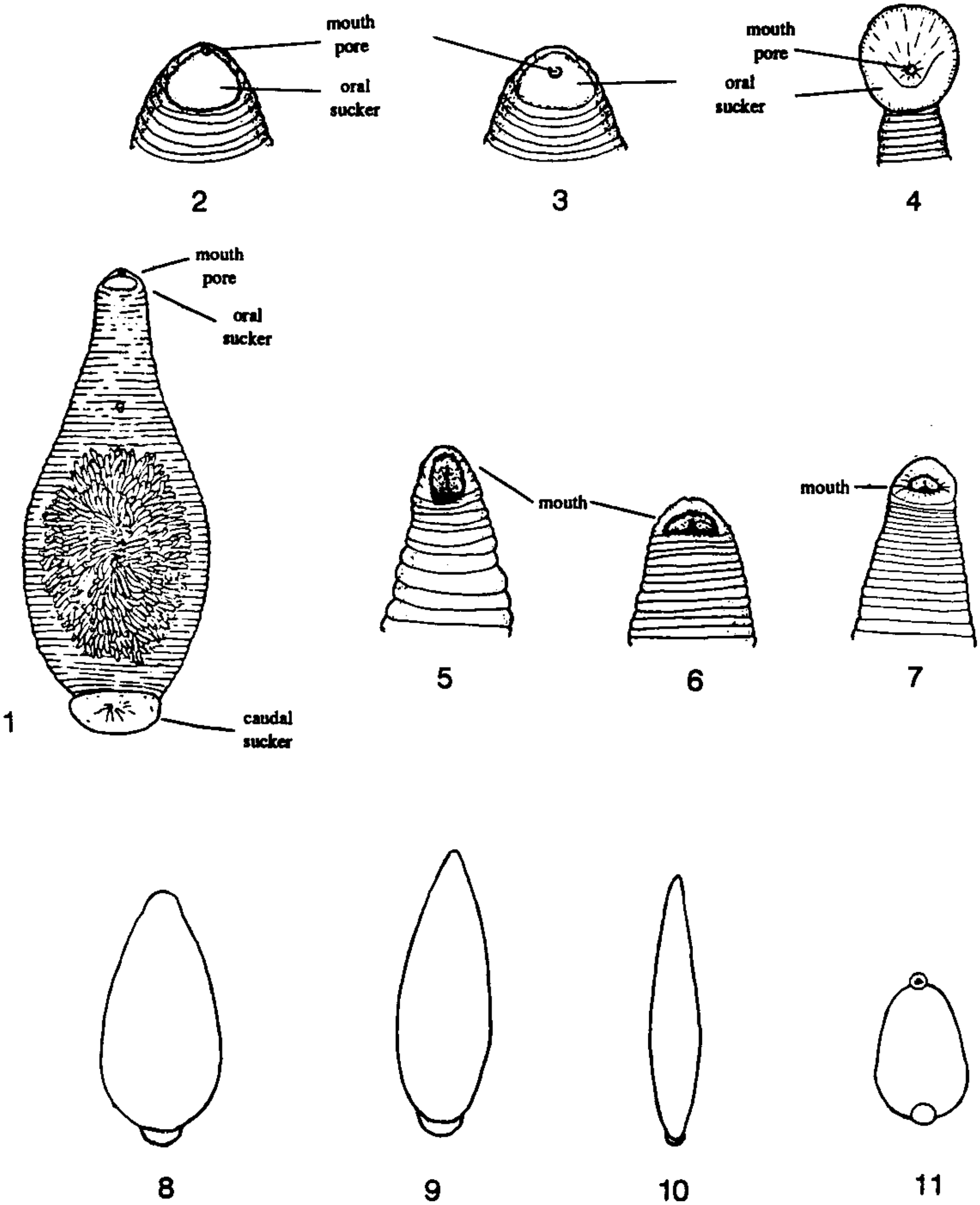
Body cylindrical, narrow (Figs. 12-22), and (especially when contracted or preserved) usually divided into a distinct narrow anterior region (trachelosome) and a wider posterior region (urosome) (Figs. 12-14; 19-22); pulsatile vesicles along lateral margins present (Figs. 12-14) or none (Figs. 15-22); oral sucker usually distinct from body (Figs. 4, 12-20); no eggs or brooding young on venter of adult; almost exclusively found as ectoparasites of fish . . . . See Key II. Piscicolidae (page 37)

3(1) Five pairs of eyes forming a regular arch (Fig. 23); body generally, large, linear, elongate (Fig. 25, 26) Haemopidae and Hirudinidae 4

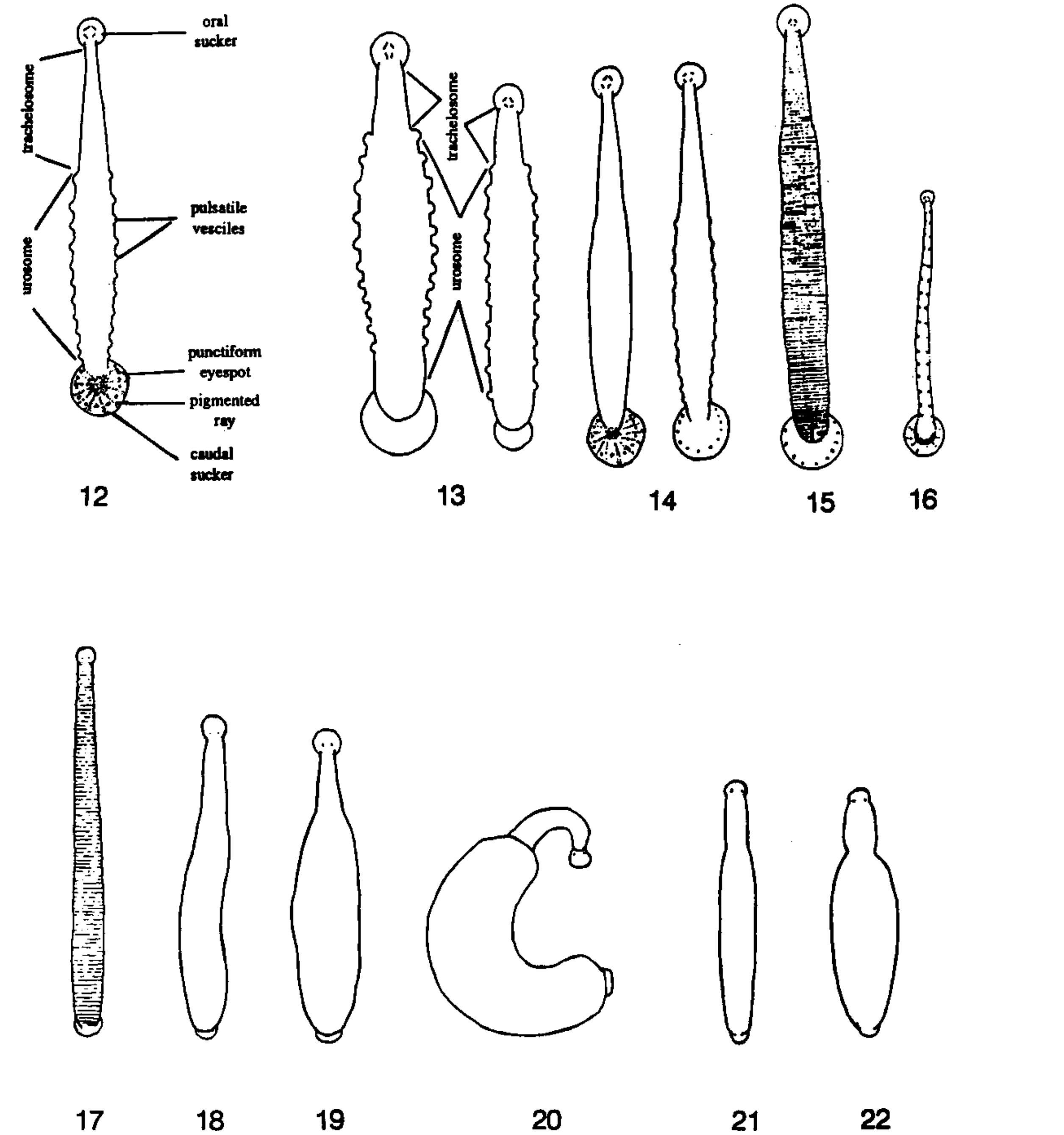
Three pairs of eyes, variously arranged but never in a regular arch (Fig. 24); body small to moderate size, linear, elongate (Fig. 25) . . . . See Key V. Erpobdellidae (page 46)

4(3) Without copulatory gland pores or glandular area around gonopores on ventral surface (Figs. 27-28). See Key III. Haemopidae (page 40)

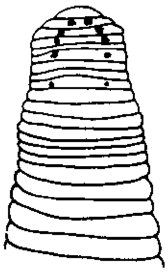
With 4 or 8 copulatory gland pores on ventral surface 10 to 11 annuli posterior to gonopores or with a glandular area (copulating pits and deep depressions) around gonopores on ventral surface (Figs. 29-31). . . . . See Key IV. Hirudinidae (page 44)



Rhynchobdellida: Fig. 1. Ventral view showing oral sucker and mouth pore, young on venter (Redrawn from Richmond, 1972). Figs. 2-4. Ventral views of anterior (oral) sucker showing orientation of mouth pore and oral sucker (pore on rim (2), pore within sucker (3), pore near center (4)). Arhynchobdellida: Figs. 5-7. Mouth occupying entire sucker cavity. Rhynchobdellida (Glossiphoniidae): Figs. 8-l0. General body shapes, dorsal views: ovate-lanceolate (8), lanceolate (9), and subcylindrical (10). Fig. 11. General body shape, ventral view.



Piscicolidae: Fig. l2. General body shape showing taxonomic structures (*Piscicola* sp.). Figs. 13-22. General body shapes: *Cystobranchus* sp. (13), *Piscicola* sp., (14-16), *Myzobdella lugubris* (17-20), *Piscicolaria reducta* (21-22).



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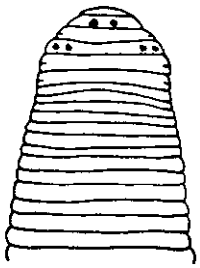

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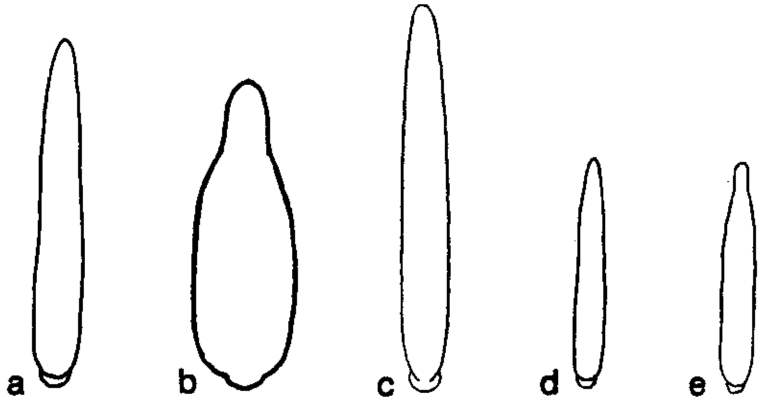

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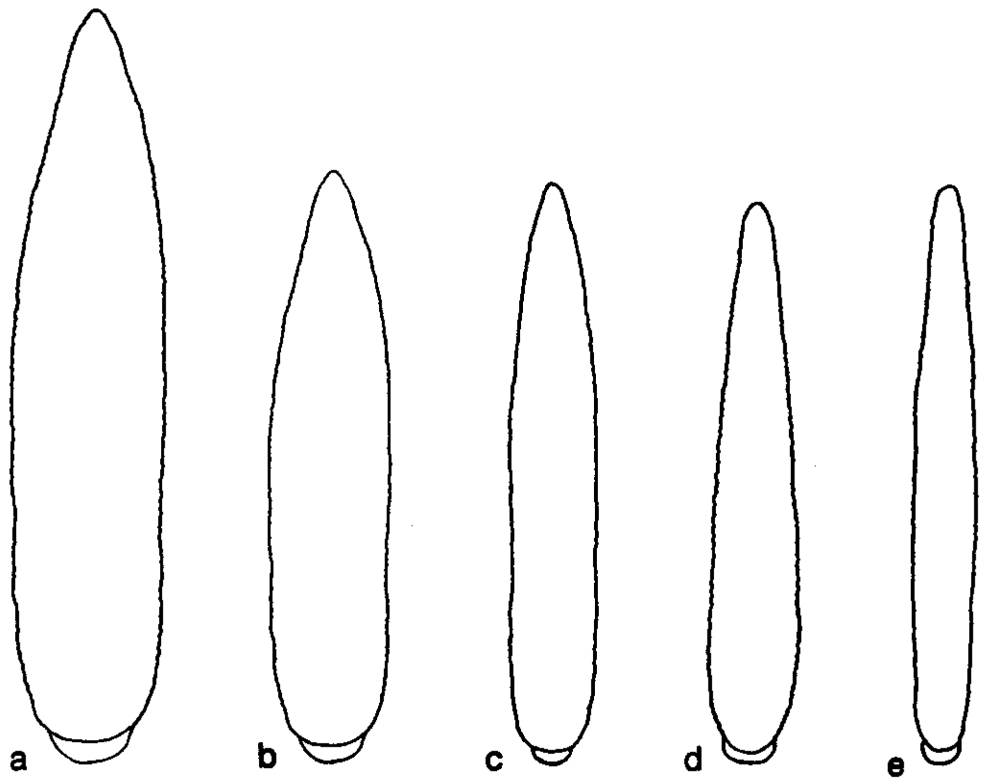

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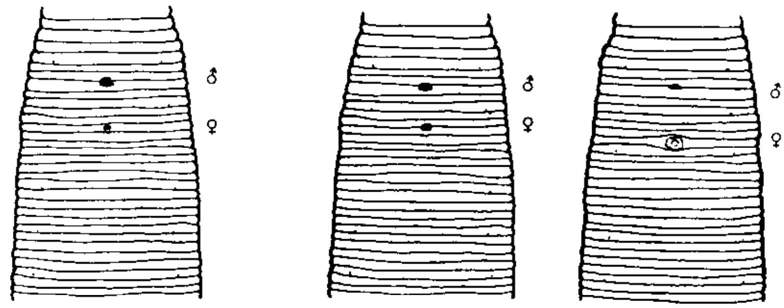
Erpobdellidae: Fig. 23. Eye arrangements. Hirudinidae: Fig. 24. Eye arrangement. Erpobdellidae: Fig. 25. General body shapes of erpobdellids or small hirudinids. Fig. 26. Haemopidae and Hirudinidae: General body shapes of the haemopids and hirudinids.



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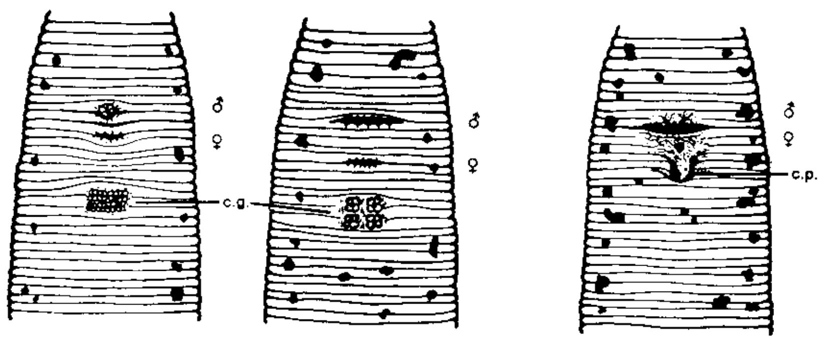

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Haemopidae: Figs. 27-28. External reproductive male and female gonopores, ventral views. Hirudinidae: Fig. 29. *Macrobdella decora*, external reproductive copulatory gland pores, ventral view. Fig. 30. *Macrobdella ditetra*, external reproductive copulatory gland pores, ventral view. Fig. 31. *Philobdella gracilis* and *Philobdella flordiana*, external reproductive glandular area of copulating pits and deep epressions, ventral view. c.g. copulatory glands; c.p. copulatory pits. ♂ ♀ gonopores (male and female).

I. KEY TO SPECIES OF THE FAMILY GLOSSIPHONIIDAE

1 With one pair of eyes (Figs. 32-41), except *Placobdella hollensis* which also has one pair of functional eyes and a series of paired accessory eyes, two to five annuli behind single functional pair of eyes (Fig. 41). 2

With three pairs of eyes (Figs. 42-43); Eyes arranged in an approximately triangular pattern, the lst pair are always closer to each other than are the posterior pairs; body translucent with little pigmentation or at most with a dark median longitudinal stripe, but sometimes with 4-7 middorsal, irregular, transverse bands; 6-9 mm long (Figs. 44-47); free-living or parasitic mainly on mollusks. . . . . *Alboglossiphonia heterocilta*

2(1) Oral sucker not distinctly expanded or otherwise set off from body by a narrow neck, but more or less continuous with body (Figs. 32-41). 4

Oral sucker and cephalic region distinctly expanded forming a discoid head, being set off from the body by a narrow neck constriction (Figs. 11, 35) 3

3(2) Dorsum with 3 prominent tuberculate keels or ridges (discernable when preserved); 9-16 mm long (Figs. 48-49); usually free-living or ectoparasite on fish . . . . *Placobdella montifera*

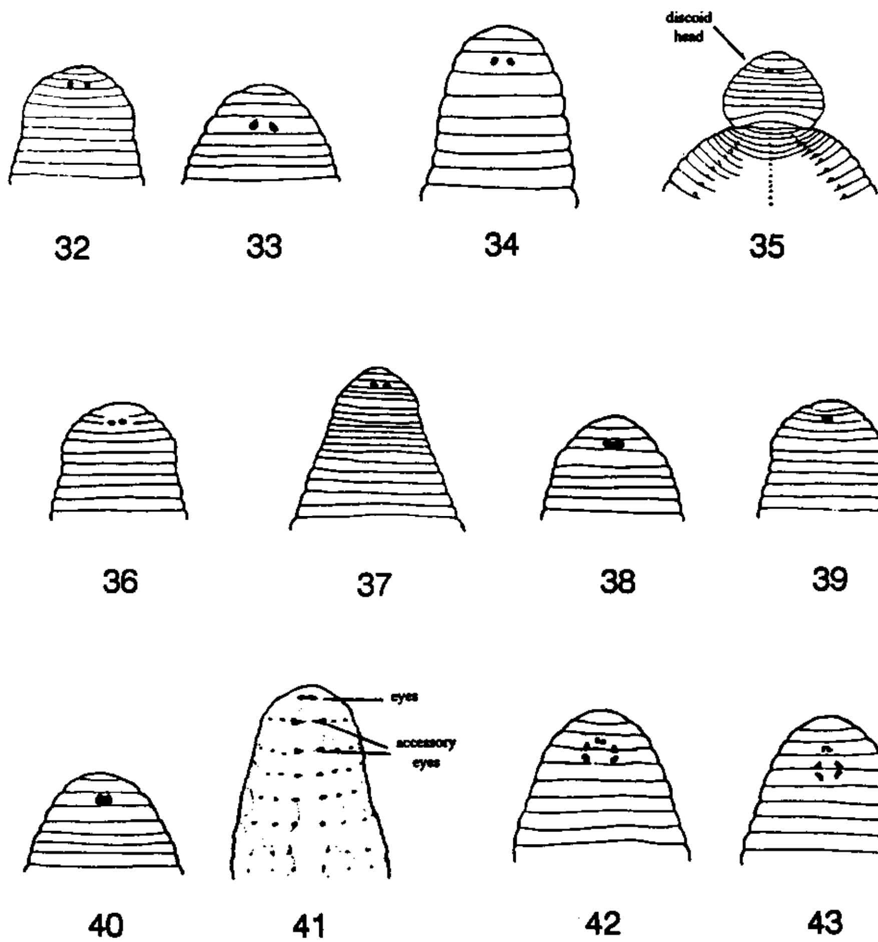
Dorsum smooth; color greenish-gray; free living, parasitic on fish; length 15-25 mm (Fig. 50). . . . . *Placobdella nuchalis*

4(2) With a series of accessory eyes behind single pair of functional eyes in cephalic region (Fig. 41); 20-30 mm long (Fig. 51); free-living, prey unknown. . . . . *Placobdella hollensis*

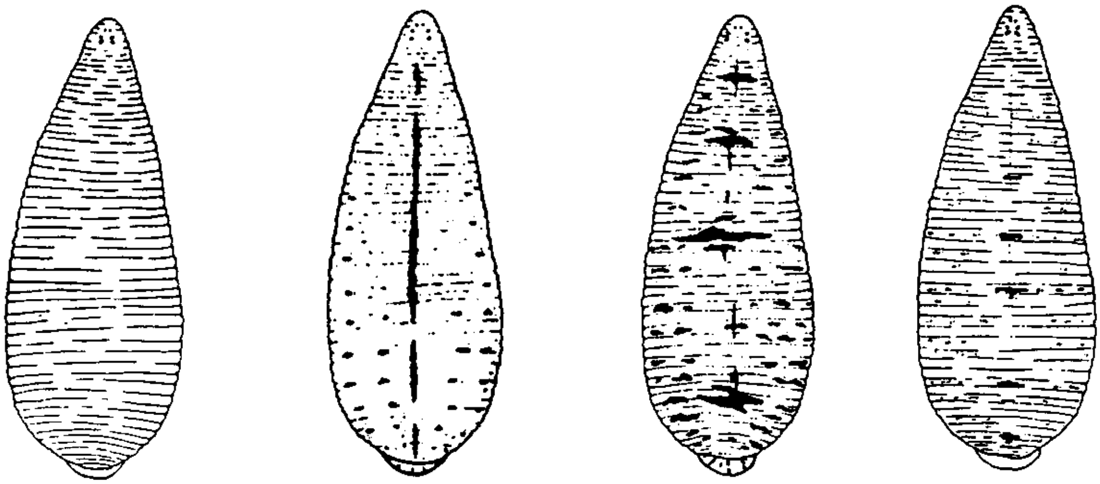
Without accessory eyes. 5

5(4) Eyes distinctly separated or separated by at least the diameter of one eye (Figs. 32-34) 6

Eyes separated by less than the diameter of one eye (Figs. 36-37), or eyes touching or fused (Figs. 38-40). 9



Glossiphoniidae: Figs. 32-43. Dorsal view of anterior end showing eyes. Figs. 32-34. One pair of eyes, well separated, by more than diameter of one eye; cephalic region undifferentiated. Fig. 35. One pair of eyes; cephalic region differentiated into a "discoid head." Figs. 36-37. One pair of eyes, close together, apart less than diameter of one eye. Figs. 38-40. One pair of eyes touching or confluent (fused). Fig. 41. First pair of eyes fused, with accessary eyes posteriad (*Placobdella hollensis*). Figs. 42-43. Three pairs of eyes in approximately triangular arrangement (*Alboglossiphonia heteroclita*).



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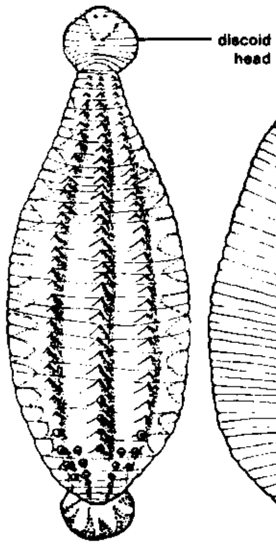
Glossiphoniidae: Figs. 44-47. *Alboglossiphonia heteroclita*, dorsal view of variable pigmented forms.



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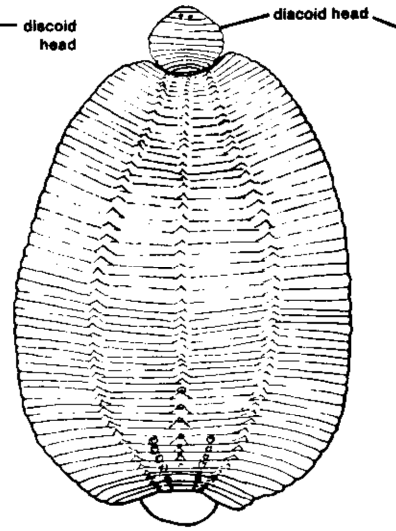

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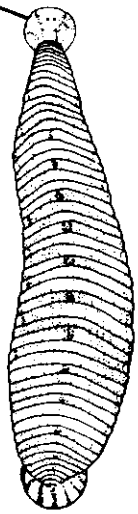

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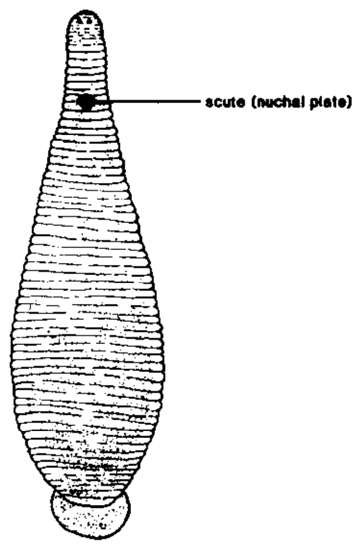

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Glossiphoniidae: Figs. 48-49. *Placobdella montifera*, dorsal views. Fig. 50. *Placobdella nuchalis*, dorsal view. Fig. 51. *Placobdella hollensis*, dorsal view. Fig. 52. *Helobdella stagnalis*, dorsal view.

6(5) Without a chitinous scute in the anterior region 7

With a chitinous scute (nuchal plate) on dorsum in the anterior region; cosmopolitan; 14 mm long (Fig. 52). . . . . . *Helobdella stagnalis*

7(6) Dorsum smooth, without papillae 8

Dorsum with 3 rows or fewer incomplete series of papillae or with scattered papillae; papillae black-tipped or uniformly pale white; pigmentation uniform, or arranged in numerous longitudinal light and dark brown, gray-black lines and/or stripes, or dorsum with 3 broad, longitudinal white stripes, one median row and one on each side submarginal, also at posterior end 2 short white stripes, few or many whitish spots on neural annuli, unaligned or if aligned, then confined to areas lateral to papillae, or color uniform with papillae few, scattered, or in 3 rows; whitish spots on neural annuli unaligned or aligned, a variable species; 10-29 mm long (Figs. 53-58). . . . . *Helobdella triserialis*

8(7) Body unpigmented, elongate and subcylindrical (Fig. 10); lateral margins of body almost parallel, body smoothly round transversely; posterior sucker small, terminal; translucent; one pair of crop caeca; length 5-10 mm (Fig. 59) . . . . *Gloiobdella elongata*

Dorsum color uniform coffee-brown or with longitudinal whitish stripes alternating with coffee-brown stripes and/or lines; with or without small whitish spots in anal region; a morphologically variable species; 14 mm long (Figs. 60-63). . . . . *Helobdella fusca*

9(5) Dorsum with conspicuous white genital and anal patches, one or more medial white patches, and usually a white ring (bar) in neck region) (Figs. 64-69) 10

Dorsum without white patches and white ring (bar) in neck region. 11

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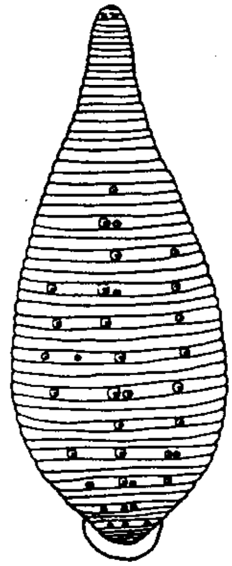

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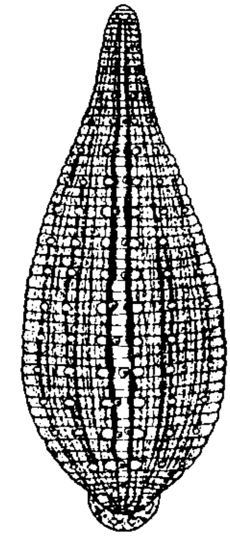

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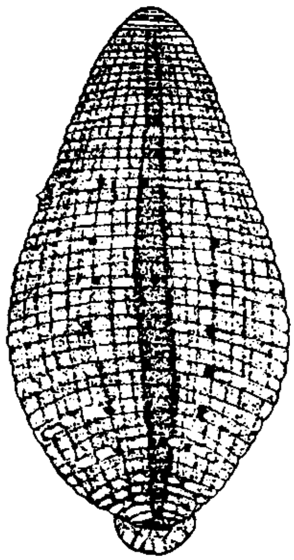

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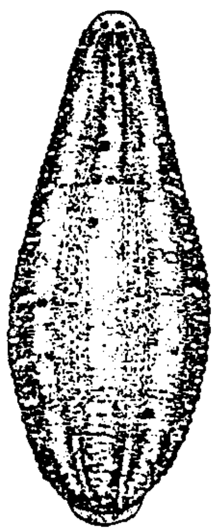

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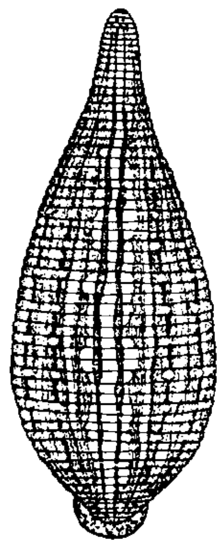

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Glossiphoniidae: Figs. 53-58. *Helobdella triserialis*, dorsal view of variable pigmented forms.

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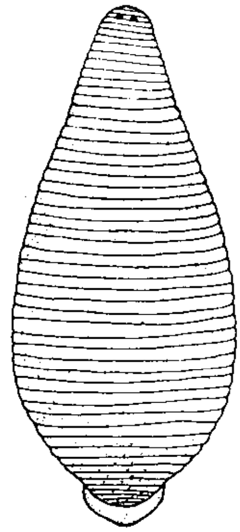

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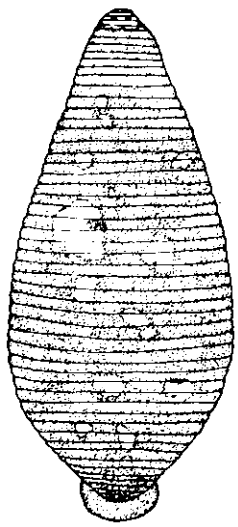

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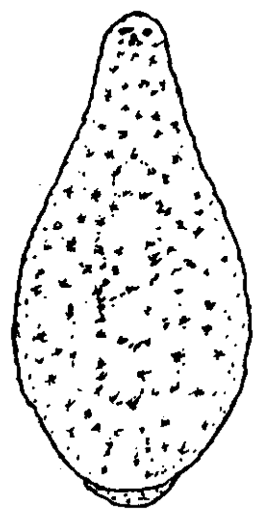

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Glossiphoniidae: Fig. 59. *Gloiobdella elongata*, dorsal view. Figs. 60-63. *Helobdella fusca*, dorsal view of variable pigmented forms.

10(9) Dorsum typically with 3 series of usually dark-tipped papillae or white-pointed papillae, sometimes with a thick band encompassing mid-dorsal series of papillae and marginal spots; with or without white patches approximately between genital and anal patches; body convex, thick; 6-l0 mm long (Figs. 64-67); usually free-living or ectoparasite on fish . . . . *Desserobdella phalera*

Dorsum smooth, no papillae; body lanceolate, excessively flattened, thin, lightly pigmented with small brown, cutaneous chromatophores; or pigmented with a broken longitgudinal median stripe and two rows of submarginal spots; length 8-11 mm (Figs. 68-69). . *Placobdella translucens*

11(9) Caudal sucker separated from body by a distinct pedicel (Figs. 70-72); rim of caudal sucker thick and bulbous; ectoparasite on fish. 12

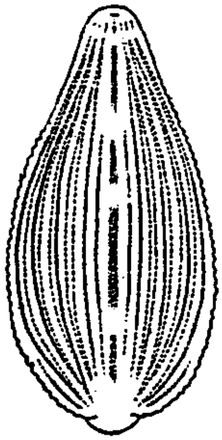
Caudal sucker more or less continuous with body, not separated from body by a distinct pedicel; rim of caudal sucker thin (Figs. 79-85); free-living or ectoparasite of vertebrates 13

12(11) Caudal sucker with about 30 digitate processes on rim (Fig. 72); 1-5 series of acute dorsal papillae, variable, or absent (in some individuals the papillae are replaced by a longitudinal middorsal ridge (Fig. 73) or groove; 7-22 mm long (Figs. 73-75); usually ectoparasite on fish. . . . . *Actinobdella inequiannulata*

Without digitate proceses on caudal sucker (Figs. 70-71); body high dorsally (Fig. 78) and contractile; dorsum smooth; caudal sucker set off from body by a slender pedicel (Figs. 70-71), or absent (extremely short in juveniles smaller than 1 cm) (Fig. 76): 20-35 mm long (Figs. 77-78); parasite in area of gills and gill chamber of freshwater drum (*Aplodinotus grunniens*). . . . . *Actionobdella pediculata*

13(11) Dorsum roughly papillated. 16

Dorsum smooth, with no papillae, with only inconspicuous papillae, or at most with smooth domes-like depressed papillae. 14



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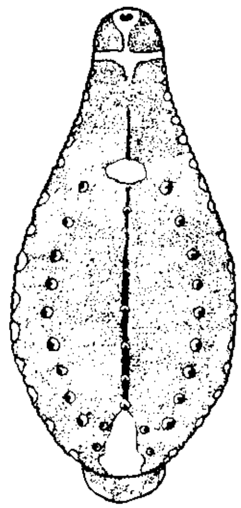

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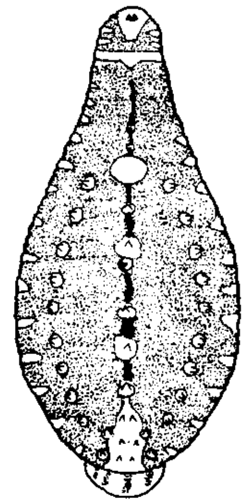

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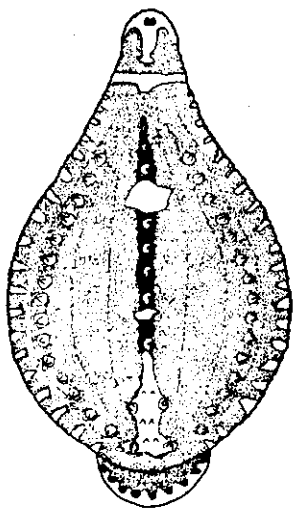

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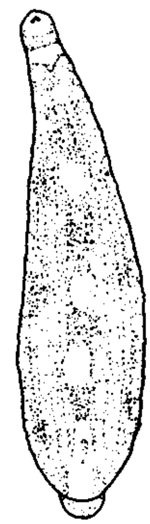

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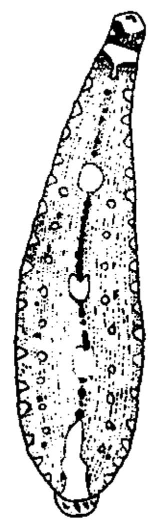

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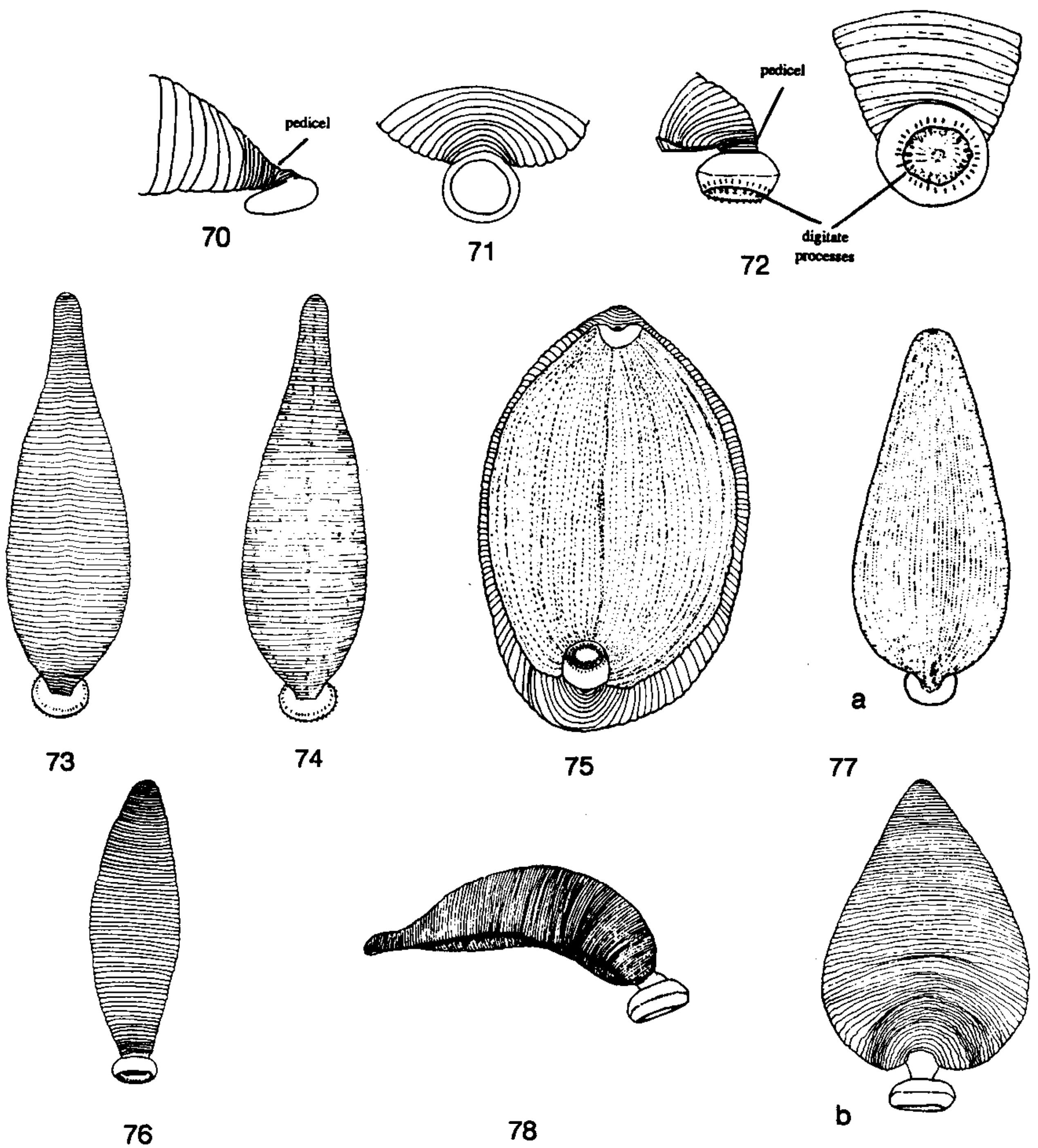
Glossiphoniidae: Fig. 64. *Desserobdella phalera*, immature form. Figs. 65-67. *Desserobdella phalera*, dorsal view of variable pigmented forms. Figs. 68-69. *Placobdella translucens*, dorsal views, variable pigmented forms.



Glossiphoniidae: Figs. 70-71. *Actinodella pediculata*, posterior end, showing lateral and ventral aspects of caudal sucker and slender stalk (Pedicel), respectively. Fig. 72. *Actinobdella inequiannulata*, posterior end, showing respectively, lateral and ventral aspects of caudal sucker and slender stalk (pedicel) and the digitate processes. Figs. 73-74. *Actinobdella inequiannulata*, dorsal views. Fig. 75. *Actinobdella inequiannulata*, ventral view. Fig. 76. *Actinobdella pediculata*, dorsal view of juvenile without pedicel. Fig. 77. *Actinobdella pediculata*, (a,b) dorsal views, different shaped adults. Fig. 78. *Actinobdella pediculata*, lateral view of adult.

14(13) Ventral surface not striped (Fig 79). 15

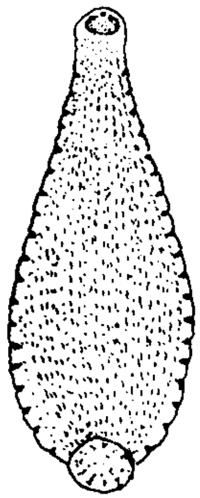
Ventral surface with 8-12 bluish, greenish, or brownish longitudinal stripes (Fig. 80); dorsal pattern variable, often green with a middorsal cream colored-stripe or band of variable width and with irregular lateral patches; 38-64 mm long (Figs. 81-83); free-living or ectoparasite on turtles . . . . *Placobdella parasitica*

15(14) Dorsum dark greenish brown, finely variegated with orange, with a thin, dark median line (may be absent in preserved specimens) and with 4 paramedial rows of yellowish or whitish metameric spots; body somites 3-annulate; caudal sucker small; 13-25 mm long (Figs. 84-85); free-living or commonly parasitic on amphibians (adults and larvae). . . . . *Desserobdella picta*

Dorsum pale olive-green, brown, or gray; body somites 2-annulate; caudal sucker large, conspicuous; known from the mountains of North and South Carolinas; parasitic on desmongnathine salamanders; length 2-7 mm (Fig. 86). . . . . *Oligobdella biannulata*

16(13) Dorsal surface warty, entirely covered with numerous papillae, varying in size or randomly arranged with or without a median interrupted band; dorsal surface a mixture of brown, green, and yellow, with ventral surface unstriped (Fig. 79); up to 40 mm long (Figs. 87-88); typical of the northern United States and Canada; free-living or ectoparasitic on turtles. . . . . *Placobdella ornata*

Dorsum less rough, not entirely covered with papillae, with large and/or small more uniform simple pointed papillae, the larger ones in 5-7 longitudinal metameric rows, some bearing only one or a few secondary, minute papillae at the apex 17



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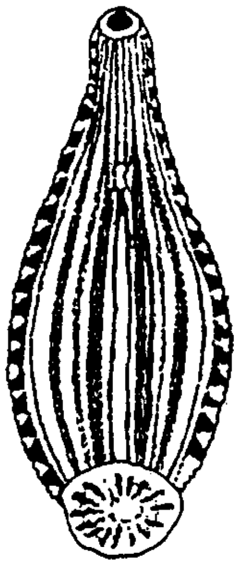

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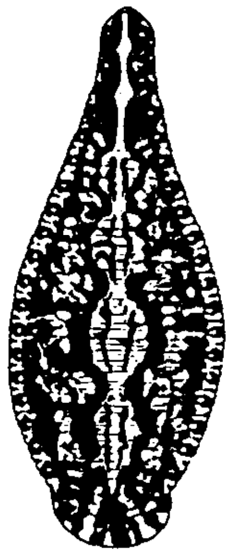

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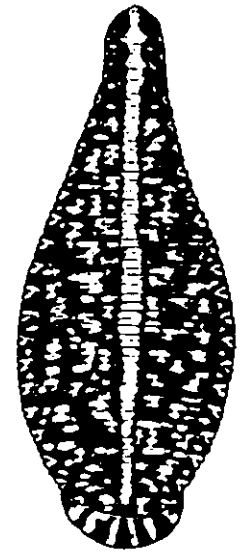

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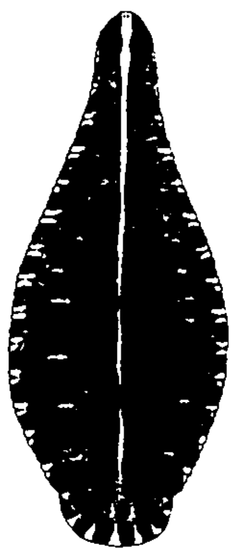

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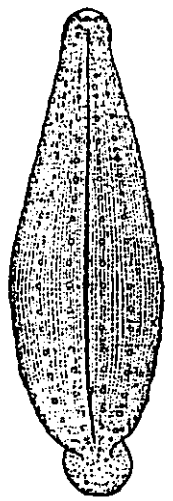

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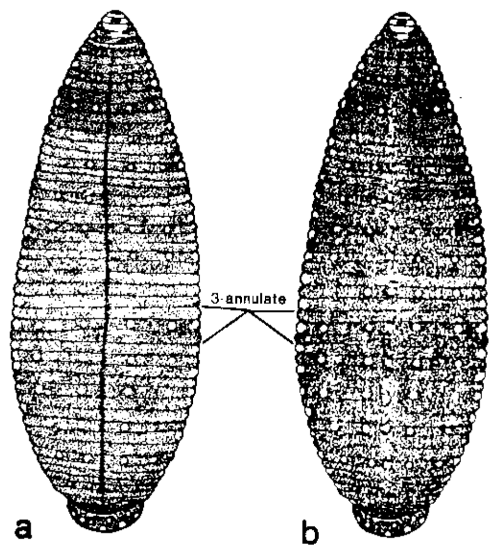

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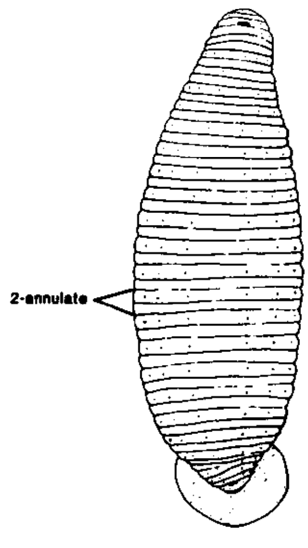
Glossiphoniidae: Fig. 79. Ventral surface plain or with fine black chromatophores (*Placobdella ornata and Placobdella multilineata*). Fig. 80. *Placobdella parasitica*, ventral view, showing longitudinal striping. Figs. 81-83. *Placobdella parasitica*, dorsal views (Redrawn from Richmond, 1972). Figs. 84. *Desserobdella picta*, dorsal view, with dark median line (Redrawn from Barta and Sawyer, 1990). Fig. 85. *Desserobdella picta*, dorsal views: (a) form with dark median line and (b) form lacking median line.



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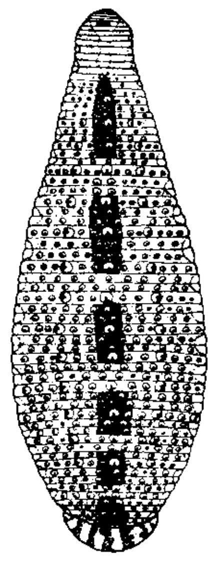

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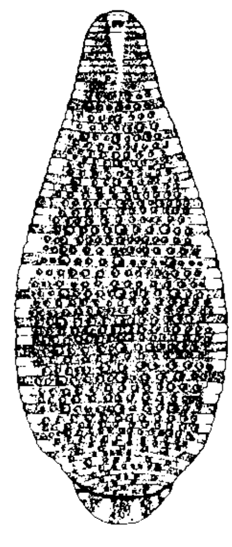

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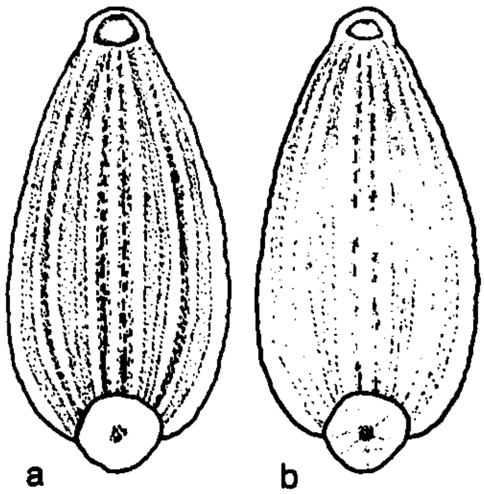
Glossiphoniidae: Fig. 86. *Oligobdella biannulata*, dorsal view. Figs. 87-88. *Placobdella ornata*, dorsal views.

17(16) Body usually ovate-lanceolate, strongly convex; dorsal surface less warty, not entirely covered with papillae; larger papillae arranged in 5-7 longitudinal rows; dorsum with a vague, medium light-colored longidudinal stripe, contained in a wider stripe on either side of a middorsal row of papillae; caudal sucker with single circular row of papillae; ventral surface with 2-8 bluish longitudinal stripes (Fig. 89); 15-45 mm long (Fig. 90-91); free-living or ectoparasite on turtles . . . . *Placobdella papillifera*

Body usually lanceolate, flat; dorsum with few or numerous, uniform, small papillae, with the larger ones in 5 longitudinal rows of varying degree; middorsal stripe narrow, dark, usually continuous; color of dorsum usually with brownish logntitudinal lines, stripes; ventral surface plain or with dark colored chromatophores in vague longitudianl lines (Fig. 79); free living or parasitic on turtles and alligators; length 40-50 mm (Fig. 92-93). . . *Placobdella multilineata*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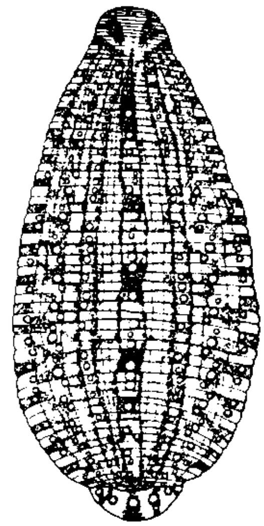
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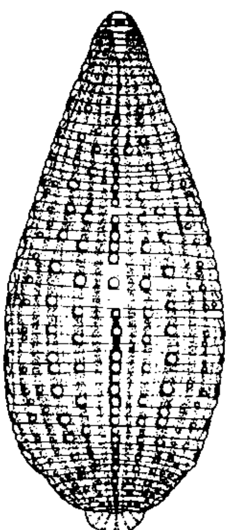
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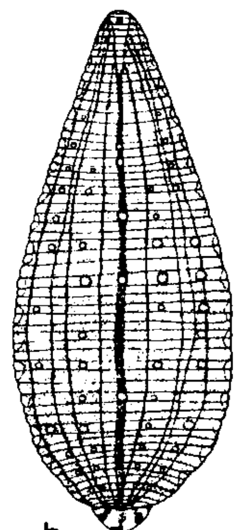
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Glossiphoniidae: Fig. 89. *Placobdella papillifera*, (a,b) ventral views, showing variable longitudinal stripes. Fig. 90. *Placobdella papillifera*, dorsal view. Fig. 91. *Placobdella papillifera*, dorsal view (From Sawyer anbd shelley, 1976). Figs. 92-93. *Placobdella mulltilineata*, (a,b) dorsal views, showing variability in papillae and pigmentation.

II. KEY TO SPECIES OF THE FAMILY PISCICOLIDAE

1 Caudal sucker concave, weakly developed and narrower than widest part of body (Figs. 94-100); cephalic eyes one pair; pulsatile vesicle absent. 2

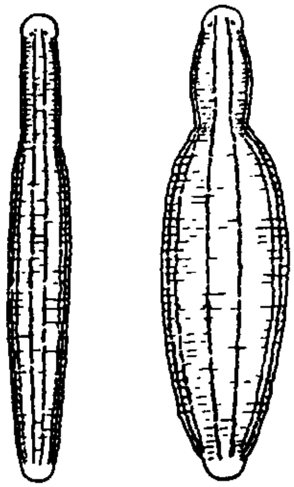
Caudal sucker flattened, as wide or wider than the widest part of the body; cephalic eyes two pairs; with or without pulsatile vesicles (Figs. 101-105). . . . 3

2(1) Dorsum with a series of 6 brownish black longitudinal stripes, medial pair most conspicuous; in some preserved specimens the neck and body are differentiated into distinct regions; length to 8 mm (Figs. 94-95). . . . . *Piscicolaria reducta*

Dorsum without longitudinal stripes; body elongate, narrow, or separated into distinct neck and body regions; body shape variable in preserved specimens; body colorless or with scattered stellate pigment cells; known from fresh and brackish waters; length to 30 mm (Figs. 96-100) . . . . *Myzobdella lugubris*

3(1) Pulsatile vesicles small, each covering 2 annuli (may be absent in preserved specimens); body not usually divided into anterior and posterior parts (Fig. 14); body devoid of pigment; caudal sucker without eyespots (Figs. 101-102); length to l6 mm (Fig. 102). . . . . *Piscicola punctata*

Pulsatile vesicles large, each covering 4 annuli, body sharply divided into anterior and posterior parts especially evident in contraction; devoid of pigment, or with brownish-black stellate flecks profusely distributed over entire body; caudal sucker without eyespots (Fig. 103; 10-30 mm long (Figs. 104-105). . . . . *Cystobranchus verrilli*



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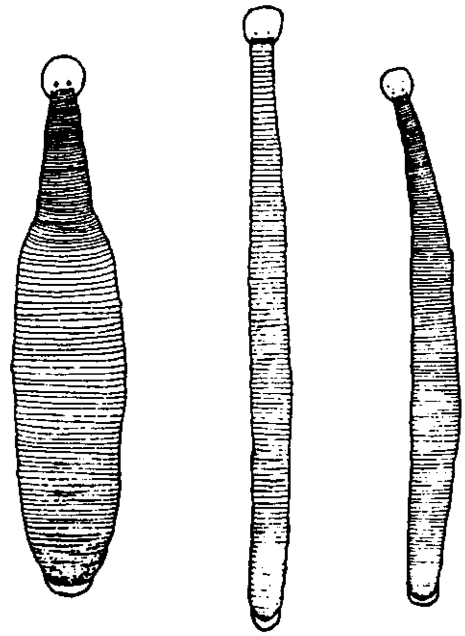

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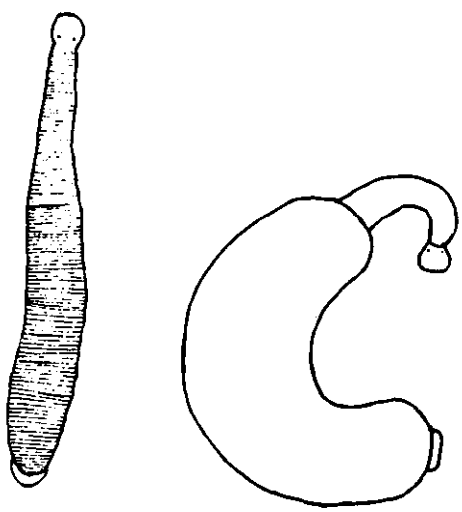

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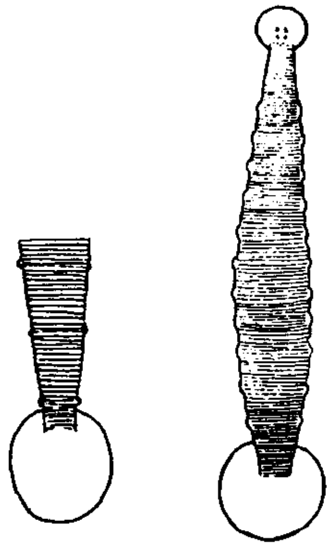
Piscicolidae: Figs. 94-95. *Piscicolaria reducta*, dorsal views (Redrawn from Poe, 1972). Figs. 96-100. *Myzobdella lugubris*, variable body shapes.



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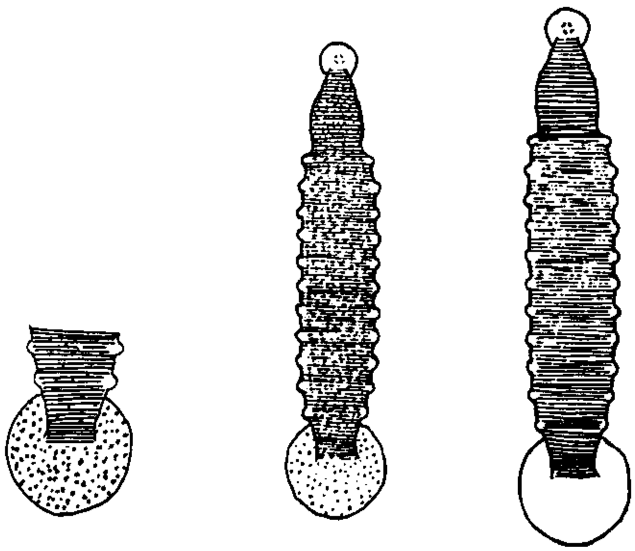

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Piscicolidae: Fig. 101. *Piscicola punctata*, dorsal view of caudal sucker, eyespots absent. Fig. 102. *Piscicola punctata*, dorsal view. Fig. 103. Eyespots absent on caudal sucker, *Cystobranchus verrilli*. Figs. 104-105. *Cystobranchus verrilli*, dorsal views, (104) pigmented form and (105) unpigmented form.

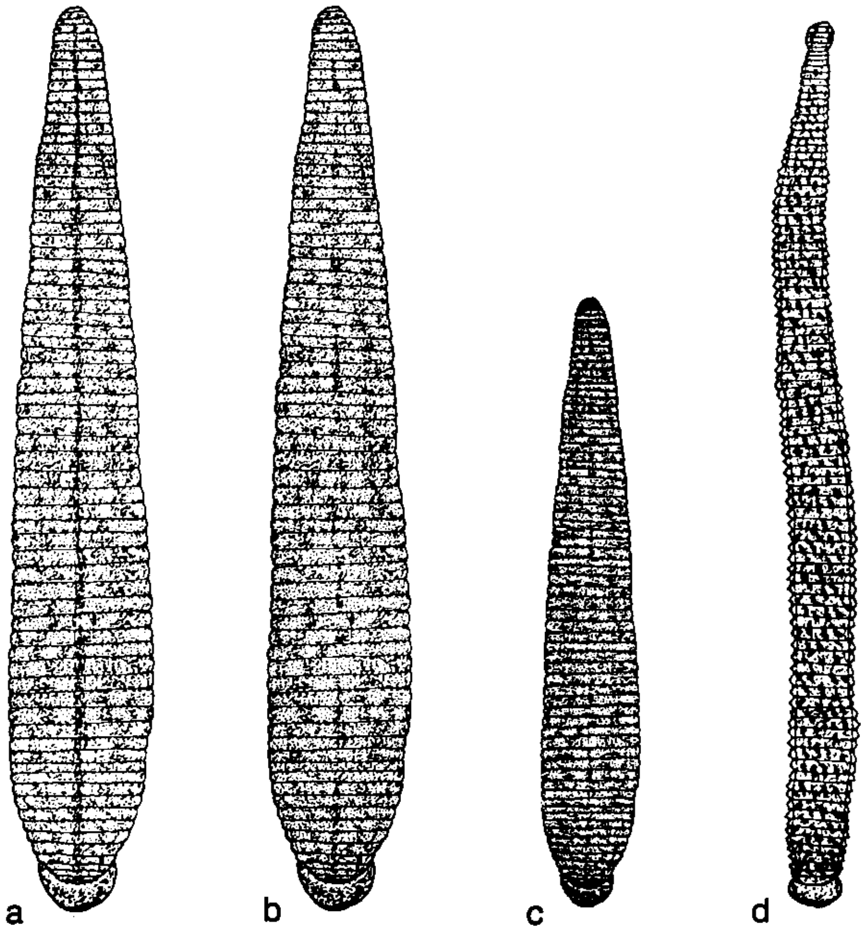
III. KEY TO SPECIES OF FAMILY HAEMOPIDAE

1 Gonopores separated by 5 to 5 1/2 annuli; female gonopore small (Fig. 27). 2

Gonopores separated by 6 1/2 to 7 annuli (Fig. 28); female gonopore large, conical (nipplelike) in adults, flattened in immature individuals; dorsum uniformly dark olive-green with fain longitudinal dark stripes along midline, numerous small irregularly scattered black flecks; ventrum, lighter olive-green without flecks; occasionally with yellow marginal band; length to 200 mm (Fig. 106) . . . . *Haemopis septagon*

2(1) Color of dorsum uniformly slate gray, with a median longitudinal black stripe and reddish to yellowish band along margins (usually absent in long time preserved specimens); ventrally lighter, uniform, few or no dark blotches or flecks; length to 150-250 mm long (Fig. 107) . . . . *Haemopis terrestris*

Color of dorsum and ventrum variable, usually olive-green, yellowish-gray with moderate to heavy black mottling or blotched, or uniformly slate gray with few irregular black blotches; with jaws and teeth (Figs 108-111); without jaws and teeth, *H. grandis* (see Klemm, 1991, 1985); length 70-100 mm, maximum 150 when fully extended (Figs. 112-114). . . . . *Haemopis marmorata*



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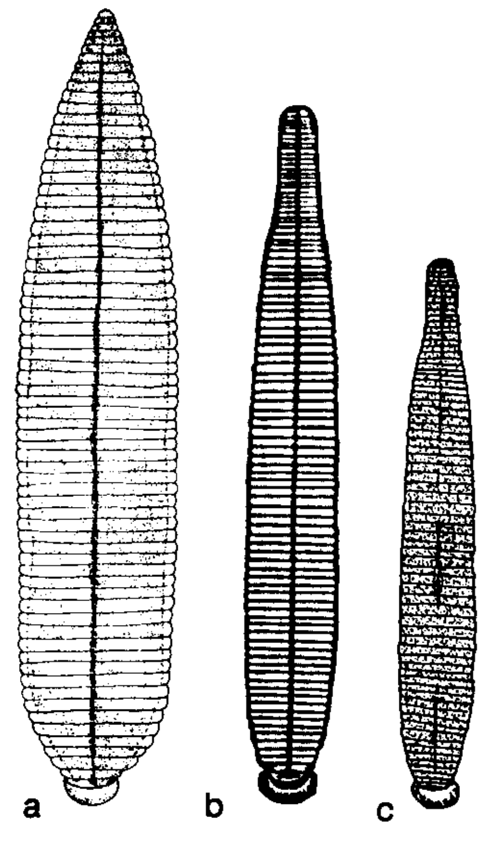
Haemopidae: Fig. 106. *Haemopis septagon*, (a-d) dorsal views, showing variable size, shape, and pigmentation.



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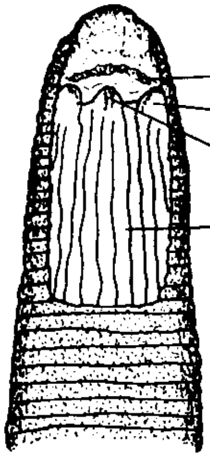
Haemopidae: Fig. 107. *Haemopis terrestris*, (a-c) dorsal views, showing variable shapes, and pigmentation.



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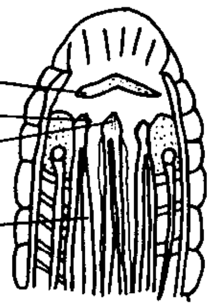

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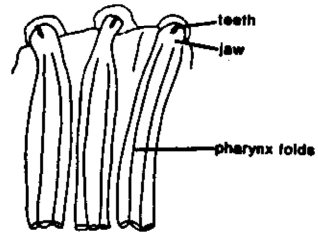

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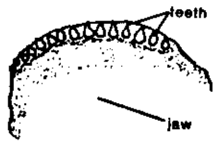

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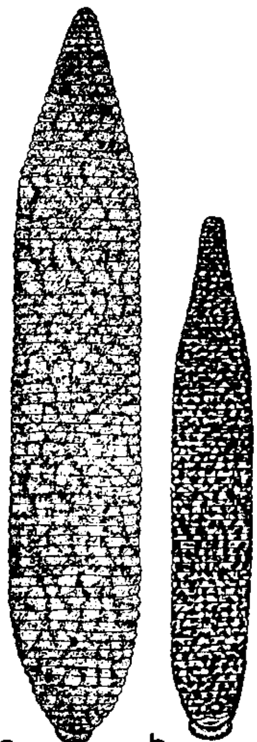

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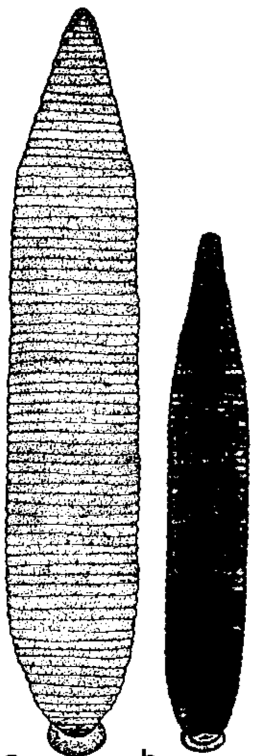

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Haemopidae: Figs. 108-110. Dissected mouth and buccal cavity, *Haemopis marmorata*, ventral views of expanded pharynx and associated structures. Fig. 111. *Haemopis marmorata*, teeth and jaw, lateral view. Figs. 112-114. *Haemopis marmorata*, dorsal views of various color forms.

IV. KEY TO SPECIES OF THE FAMILY HIRUDINIDAE

1 With four or eight copulatory gland pores on ventral surface 10 to 11 annuli posterior to gonopores (Figs. 29-30); no glandular area, copulating pits and deep depressions around gonopores (Figs. 31). 2

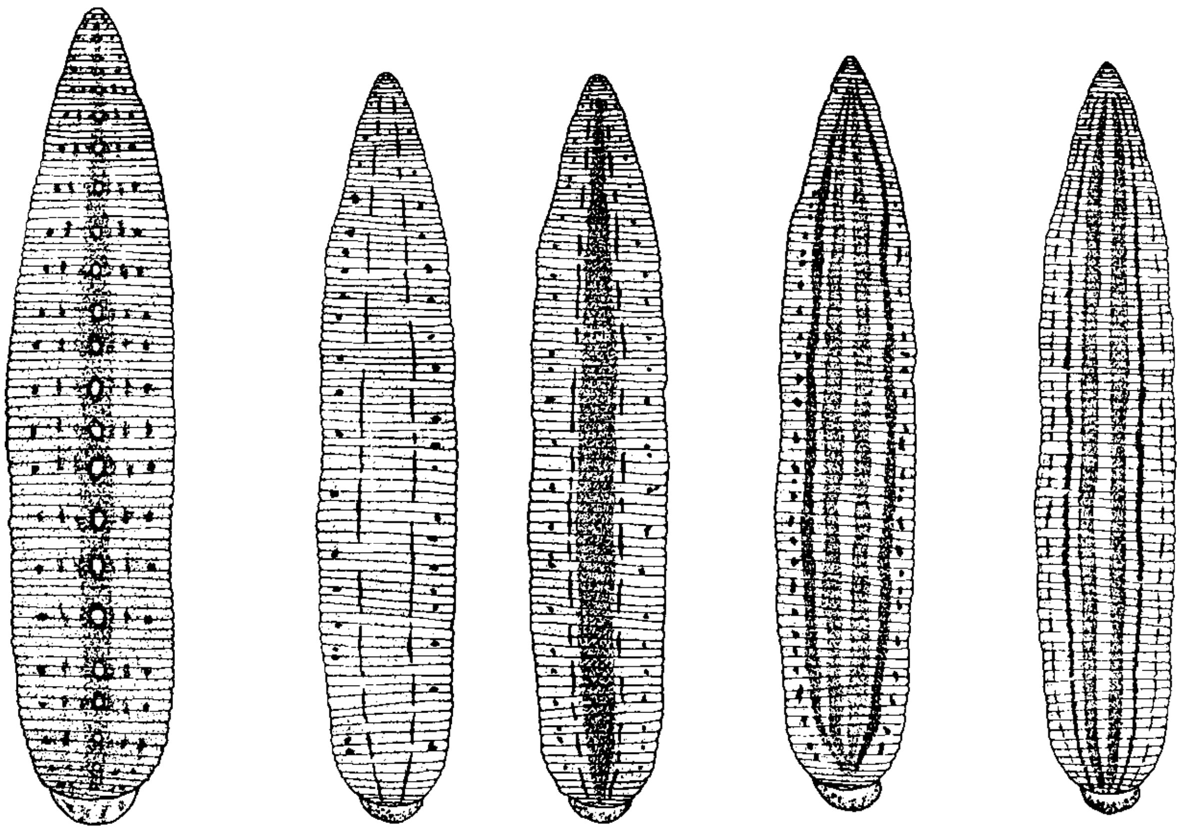
Without copulatory gland pores on ventral surface; with a glandular area around gonopores, the latter composed of copulating pits and deep depressions (Fig. 31) 3

2(1) Ventrum with four copulatory gland pores (two rows of two, Fig. 29); dorsum green with about 21 metameric red or orange dots at mid-line; ventral surface red or orange with some black spots; gonopores separated by 5-5 1/2 annuli; length to 150 mm (Fig. 115). . . . . *Macrobdella decora*

Ventrum with eight copulatory gland pores (two rows of four, Fig. 30); color of dorsum drab brown or gray, usually with a darker median field, one-third body width, usually with lateral black irregular dots; ventrum yellowish with some or no black blotches; gonopores separated by 2 annuli; length to 150 mm (Fig. 116-117). . . . . *Macrobdella ditetra*

3(1) Middorsal stripe light yellow, with dorsolateral brownish-black irregular flecks or spots; ventral surface light yellow with some irregular black flecks or spots near margins; about 35-48 teeth per jaw; gonopores separated by 3 to 4 annuli, difficult to see, hidden by glandular area and deep copulating depression (Fig. 31); lenth to 85 mm (Fig. 118). . . . . *Philobdella gracilis*

Middorsal strip dark brown, if present, with two faint reddish-brown bands along each side toward margins, separated by a narrow black strip, lateral margins with irregular black stripes, sometimes broken but no discrete spots; 20-26 teeth per jaw; gonopores separated by 3 to 4 annuli, difficult to see, hidden by glandular area and deep copulating depression (Fig. 31); length to 85 mm (Fig. 119). . . . . *Philobdella floridana*



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Hirudinidae: Fig. 115. *Macrobdella decora*, dorsal view. Fig. 116. *Macrobdella ditetra*, dorsal view, variable pigmented form. Fig. 117. *Macrobdella ditetra*, dorsal view, variable pigmented form. Fig. 118. *Philobdella gracilis*, dorsal view. Fig. 119. *Philobdella flordiana*, dorsal view.

V. KEY TO SPECIES OF THE FAMILY ERPOBDELLIDAE

1 Dorusm lacking pigment or color, uniformly gray, black, heavily barred or with longitudinal stripes, spots, but never scattered black pigment concentrations. 2

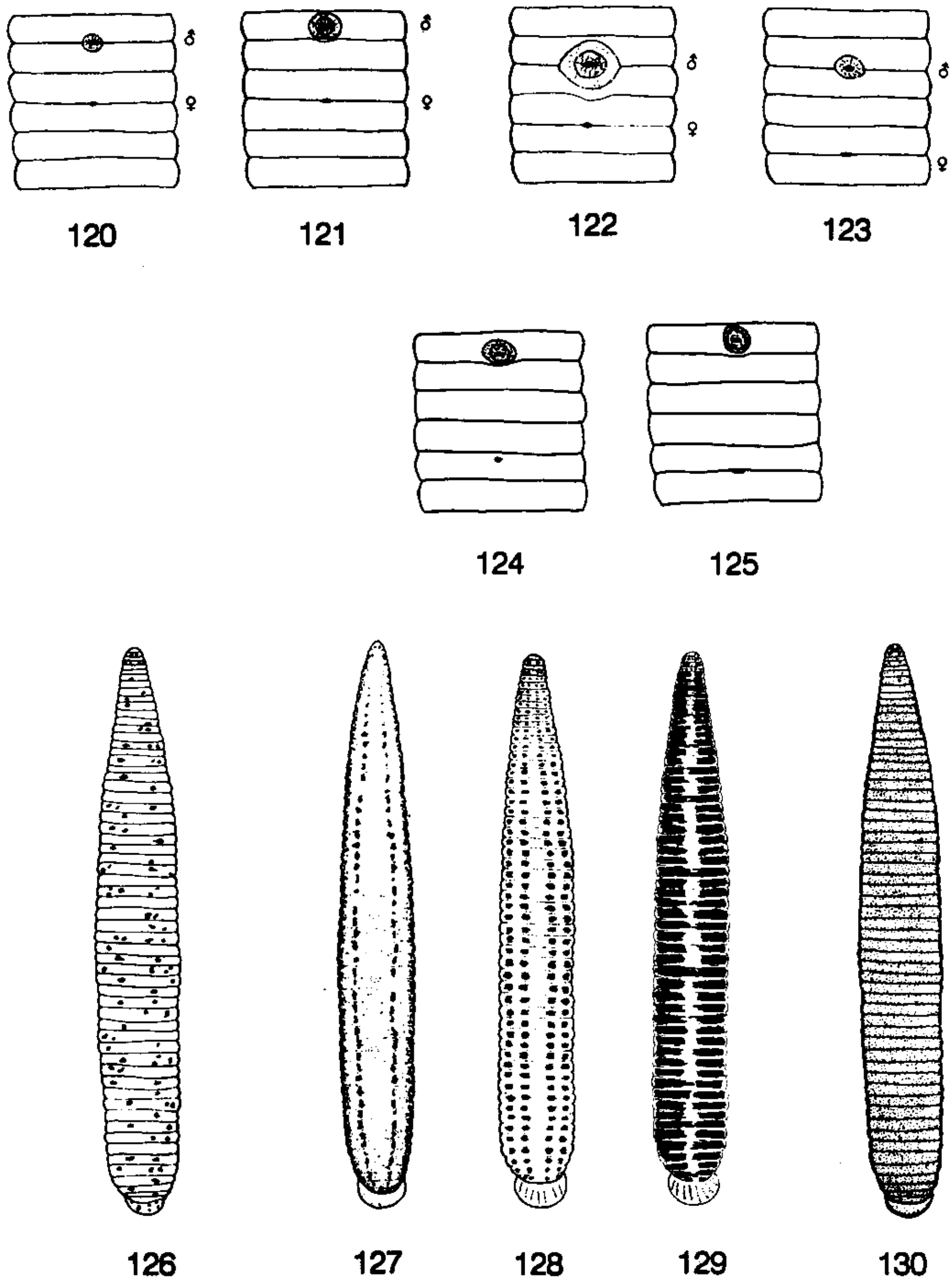
Dorsum with scattered black pigment concentrations, body color whitish; gonopores separated by 2 annuli in furrows (Fig. 120); length to 55 mm (Fig. 126). . . . . *Mooreobdella melanostoma*

2(1) With 2 or 2 1/2 annuli between gonopores in furrows or on the rings (Figs. 121-122); dorsum with 2 or 4 longitudinal rows of black pigment concentrations or with longitudinal black flecks, stripes, or spots, or heavily barred, almost black, or dorsum without paired paramedial black strips and sensillae; color uniform gray; gonopores segarated by 2 1/2 annuli; pigmented; length to l00 mm (Figs. 127-130) . . . . *Erpobdella punctata*

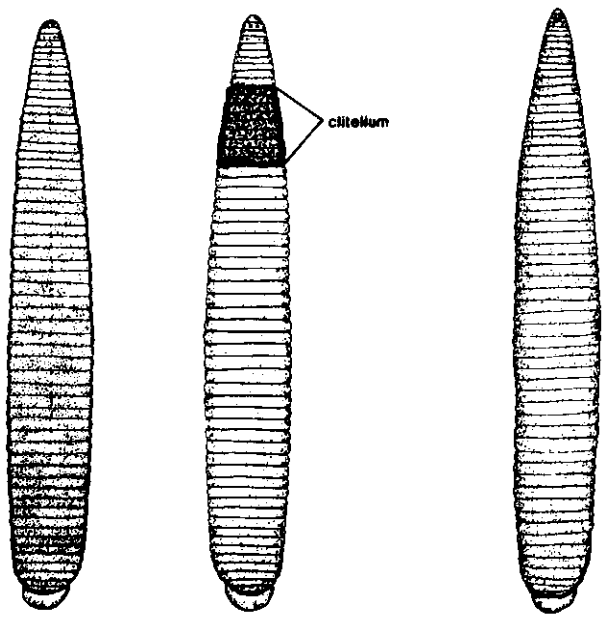
With 3, 4, or 4 1/2 annuli between gonopores in furrows or on rings (Figs. 123-125) 3

3(2) Gonopores separated by 3 annuli, usually in furrows (Fig. 123); color uniformly smokey gray to brownish, without black pigment; length to 50 mm (Figs. 131-132). . . . . *Mooreobdella microstoma*

Male and female gonopores separated by 4 to 4 1/2 annuli, usually on rings (Figs. 124-125); color of dorsal surface uniformly smokey gray without black pigmentation; length to 40 mm (Fig. 133). . . . . *Mooreobdella tetragon*



Erpobdellidae: Fig. 120. *Mooreobdella melanostoma*, showing general location of male and female gonopores. Figs. 121-122. *Erpobdella punctata*, showing general location of male and female gonopores. Fig. 123. *Mooreobdella microstoma*, showing general location of male and female gonopores. Figs. 124-125. *Mooreobdella tetragon*, showing general location of male and female gonopores. Figs. 126. *Mooreobdella melanostoma*, dorsal view. Figs. 127-130. *Erpobdella punctata*, dorsal view of variable color forms. ♂ ♀ gonopores (male and female).



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Erpobdellidae: Fig. 131. *Mooreobdella microstoma*, dorsal view, without clitellum. Fig. 132. *Mooreobdella microstoma*, dorsal view, with clitellum. Fig. 133. *Mooreobdella tetragon*, dorsal view.

ANNOTATIONS TO THE SPECIES OF LEECHES (ANNELIDA: HIRUDINEA) IN FLORIDA AND OTHER SOUTHERN STATES

I. Order **Arhynchobdellida**

A. Family **Haemopidae**

1. *Haemopis marmorata*

This cold-water species is widely distributed and common in some localities in the northern half of the United States and Canada, and less common elsewhere. Being a predator, it feeds on a number of invertebrates such as oligochaetes, mollusks, insect larvae, crustaceans, and tadpoles (Sawyer, 1974; Riggs, 1980). This leech is occasionally associated with organically polluted water conditions (Sawyer, 1974).

2. *Haemopis terrestris*

Sawyer (1990) changed the specific name *terrestris* (Forbes, 1890a,b) to *oenops* (Grube, 1871), but based on Code VI, Article 23, Sections (a,b) and Article 79, Section (c) of the *International Code of Zoological Nomenclature* (1985) and Sawyer (personal communications, 1990), the new name, *oenops*, is considered *nomen oblitum* and the name, *terrestris*, is the valid species taxonomy. This leech is uncommon and known only from the southern Great Lakes region, Mississippi Basin, eastward to New York, westward to Colorado, and southward to the Gulf Coast states (Miller, 1929, 1937; Herrmann, 1970; Sawyer, 1972; Sawyer and Shelley, l976; Klemm, l982, 1985, 1990). It is mainly a terrestrial to semi-terrestrial form, but occasionally it is found in aquatic habitats. Usually collected in damp soil, under stones and logs, but almost nothing is known about its biology. Reported to feed on earthworms, aquatic annelids, insect larvae, mollusks, and even crustaceans. In studying invertebrate fauna from caves and mines, Peck (1988) reported *Haemopis terrestris* from a mine in Ontario, Canada.

3. *Haemopis septagon*

This species has been reported from the coastal plain and eastern piedmont areas of the Carolinas and Virginia (Sawyer and Shelley, 1986). Klemm (1982) identified specimens collected in North Carolina. It inhabits moist floodplains usually near water sources in North Carolina and appears widespread in the Coastal Plain and eastern Piedmont of North Carolina, and has been reported to feed primarily on earthworms (Shelley, Braswell, and Stephan, 1979). This species may be difficult to find because of its terrestrial existance.

B. Family **Hirudinidae**

1. *Macrobdella decora*

A cool-water form found in ponds and wetlands in the northern United States and Canada. It is widely distributed, but in the southern states it is less common, being restricted to the piedmont and montane areas of the Carolinas and Georgia (Sawyer and Pass, 1972; Sawyer and Shelley, l976). A fierce blood-sucker, reported to feed on vertebrate animals, including man, and eggs and tadpoles of amphibians (Cargo, 1960; Klemm, 1972a; Sawyer, l972, 1974).

2. *Macrobdella ditetra*

A taxon that is commonly and widely distributed in the Gulf Coast states and coastal plain areas of the Carolinas; it appears less common elsewhere.

3. *Philobdella gracilis*

Considered a warm-water species, it is widely distributed throughout the southern United States (Sawyer, 1972, 1974; Klemm, 1982, 1985), but in the Great Lakes region it is apparently restricted to Michigan where it has been reported from Otis Lake, Barry County (Kopenski, 1969) and from Illinois (Moore, 1901; Klemm, l982, 1985; Wetzel, 1992). Except for a few reports of its feeding on frog eggs, mammals, and other vertebrate forms (Sawyer, 1972, 1974), little is known about the ecology of this species.

4. *Philobdella flordiana*

This species has been reported from Lake Okeechobee in Florida (Verrill, 1972). Klemm examined specimens that resemble this species from Jacksonville and West Palm Beach, Florida. Most authors continue to distinguish *Philobdella floridana* and *Philobdella gracilis* as separate species, primarily on the basis of pigmentation and number of teeth. Being closely related, Moore (1952) and Klemm (1982, 1985) doubt whether there are two valid species.

C. Family **Erpobdellidae**

1. *Erpobdella punctata*

A species commonly found throughout most of North America as well as Mexico. Its diet is primarily oligochaetes and insect larvae. This species is generally an ubiquitous form consistently associated with polluted and organically enriched lakes and streams. (Sawyer, 1974). Many organisms that this species preys upon are commonly associated with organically enriched habitats (e.g., *Limnodrilus hoffmeisteri*, *Chaetogaster* sp., lumbriculids, and chironomid larvae); this probably accounts for it abundance in polluted habitats. Other prey includes, anisopterans, zygopterans, mollusks, ostracods, *Gammarus lacustrus*, cladocerans, and oligochaetes (Davies and Everett, l975; Davies et al., 1981, 1988). One of the few erpobdellids in which the life history, fecundity, behavior, and feeding habits are known (Sawyer, 1970; Davies et al., 1977, Davies, 1978; Barton and Metcalfe, 1986). The life cycle requires one or two years depending on the local conditions of the habitat. *Erpobdella punctata coastalis* was described as a subspecies of *Erpobdella punctata* by Sawyer and Shelley (1976) from North Carolina and South Carolina, but Sawyer (1986b) did not include this subspecies in his discussion and key for leeches of North America. The taxonomic differnce of this subspecies is that its dorsum does not contain paried paramedial black strips and sensillae, but that the dorsum is uniformly gray. Also, the gonopores of *Erpobdella punctata coastalis* are separated by 2 1/2 annuli, instead of 2 annuli, with the male gonopore on the ring and female gonopoe in the furrow. The author does not include this subspecies in this guide, but has incorporated these anatomical variations with the species, *Erpobdella punctata*.

2. *Mooreobdella melanostroma*

This species has been reported from the Carolinas (Sawyer and Shelley, 1976). Klemm (1982) identified specimens from Massachusetts, North Carolina, and Louisiana in the United States and Quebec in Canada.

3. *Mooreobdella microstoma*

In the Great Lakes Region this taxon is infrequently found, but in the southern United States this warm-water form is commonly found to be abundant (Sawyer, 1972; Sawyer and Shelley, l976; Klemm, 1985). Little is known about the biology of this species. It is reported to comsume aquatic worms, insect larvae, and snails; and is occasionally associated with organic pollution.

4. *Mooreobdella tetragon*

This species is known only from the Atlantic Coast areas and Gulf Coast states of the United States; Klemm (1982) repoted specimens from Massachusetts, New Jersey, North Carolina, Georgia, Florida, and Alabama.

II. Order **Rhynchobdelida**

A. Family **Glossiphoniidae**

1. *Actinobdella inequiannulata*

This species is widely distributed but not frequently encountered (Miller, 1929; Sawyer, l972; Klemm, l985). Daniels and Freeman (1976) found it abundantly infesting white suckers (*Catostomus commersoni*) in Algonquin Provincial Park, Ontario, Canada. Usually collected free-living or as a parasite in the gill chambers or other areas of its fish host (Daniels and Freeman, 1976; Deutsch, 1977). Amin (1981) also reported one specimen from the brown bullhead (*Ictalurus nebulosus*). A second species, *Actinobdella annectens*, was described from a single specimens collected on a snapping turtle (*Chelydra serpentina*) from Lake Erie, Ontario, Canada (Moore, 1906), and has not been collected since its original description. Sawyer (1972) and Klemm (1985) considered it to be an aberrant form of *Actinobdella inequiannulata*.

2. *Actinobdella pediculata*

Sawyer (1986b) transferred this species from *Placobdella* to *Actinobdella*. This uncommon species is mainly reported from the Midwest and Great Lakes region; immature specimens are sometimes found free-living. Records indicate that this species has a high degree of host specificity for the freshwater drum (*Aplodinotus grunniens*) and surely will be found throughout the distriburtional range of its host (Sawyer, 1972; Klemm, 1985). Data show that it is a permanent parasite and that the isthmus, gills, and the inside of the opercula are the usual sites of attachment. Adult specimens examined by Klemm (1982, 1985) were also found parasitizing *Aplodinotus grunniens* from the Mississippi River in Illinolis, Kentucky Lake in southwest Kentucky and northwest Tennessee, and Lake St. Clair in Michigan, and Oklahoma.

3. *Alboglossiphonia heteroclita*

This holarctic species is found rarely but is widely distributed in the eastern United States and throughout Canada (Davies, 1973; Sawyer, 1972, 1986b; Klemm, 1972a, 1985). The species occurs commonly in lentic waters of Eurasia. It is usually found free-living, and in North America, Klemm (1975, 1976, 1985) reported it to feed primarily on small pulmonate snails and possibly inhabiting the mantle cavity of these snails as a parasite, but little is known about its ecology in North America. The animal is found in organically polluted habitats. The species has an annual life cycle, eggs carried in early June-July, young released in August, and old cohorts die soon thereafter (Proctor and Young, 1987).

4. *Desserobdella phalera*

Sawyer (1986b) transferred this species from *Batracobdella* to *Placobdella* and subsequently Barta and Sawyer (1990) transferred it to *Desserobdella*. This morphologically variable species is widely distributed in the United States and Canada but not frequently encountered. Found free-living or as a temporary ectoparasite of fish (Klemm, l972a, 1985; Sawyer, l972; Davies, 1973). This leech was found parasitizing walleye (*Stizostedion vitreum vitreum*), largemouth bass (*Micropterus salmoides*), and channel catfish (*Ictalurus punctatus*) in Michigan Lake, Wisconsin

(Amin, 1981) and bowfin (*Amia calva*) and largemouth bass (*Micropterus salmoides*) in Ontario, Canada, and bowfin (*Amia calva*) in Florida (Jones and Woo, 1990a). Because of the high prevalence of *Desserobdella phalera* on *Amia calva*, Jones and Woo (1990a,b) suggested that bowfin is a preferred host. They also reported that *Desserobdella phalera* fed experimentally on nine species of fish (*Stizostedion vitreum vitreum*, *Amia calva*, *Anguilla rostrata*, *Ictalurus nebulosus*, *Perca flavescens*, *Gasterosteus aculeatus*, *Oncorhynchus mykiss*, *Carassius auratus*, and *Esox lucius*).

5. *Desserobdella picta*

This species was transferred from *Batracobdella* to *Placobdella* by Sawyer (1986b), and later Barta and Sawyer (1990) transferred it to *Desserobdella*. This species can be common in some localities, but is usually uncommon and widespread in northern North America (Sawyer, l972, 1986b; Davies, l973; Klemm, l972a, l985). Usually found inhabiting ponds and woodland pools containing amphibians on which it specifically feeds. It is encountered as a temporary parasite on mating amphibians in early spring (Klemm, 1972a, 1982, 1985; Sawyer, 1974, 1986b; Sawyer and Shelly, 1976). The range of this species extends southward in the Appalachian Mountains (Sawyer and Shelley, 1976). Mature specimens have been collected from an adult spotted salamander (*Ambystoma maculata*) and from a mole salamander larva (*Ambystoma talpoideum*). Sawyer (1974) considered it a cold-water form. A detailed account of its feeding behavior on tadpoles of *Rana catesbeiana* can be found in Barta and Sawyer (1990).

6. *Gloiobdella elongata*

Sawyer (1986b) transferred this species from *Helobdella* to *Gloiobdella* Ringuelet (1978). The species is widely distributed throughout North America (Sawyer, 1972; Klemm, 1982, 1985). Its small size and worm-like behavior may cause it to be overlooked by some investigators. It has been collected in small numbers from the Great Lakes system, including waters inland of the Great Lakes. A method of collecting this species is with grab or dredge sampling devices. Moore (1912), Hilsenhoff (1964), and Sawyer (1974) reported that it feeds on small aquatic insect larvae, oligochaetes, and mollusks. It is often associated with water polluted by organic matter, but otherwise little is known about its biology.

7. *Helobdella fusca*

Common in the Great Lakes region, this species is widely distributed in North, Central, and South America. However, it appears less common in the southern United States. A morphologically variable species closely associated with *Helobdella triserialis*, and needs further taxonomic study (Klemm, 1977; Sawyer, 1986b). It feeds primarily on aquatic snails and other invertebrates (Sarah, 1971; Sawyer, 1972, 1974; Klemm, 1972a, 1974, 1975, 1976, 1982).

8. *Helobdella stagnalis*

Reported from every continent except Australia, this cosmopolitan, world-wide species is found abundantly in North America, but is less common in the southern states. It feeds on invertebrates (e.g., oligochaetes such as *Ilyodrilus templetoni* and *Limnodrilus hoffmeisteri*); and aquatic insect larvae (e.g., *Chironomus plumosus*) (Hilsenhoff, 1963; Sawyer, 1974; Herrmann, 1970; Davies and Everett, 1975; Klemm, 1976; Young and Procter, 1985). In addition to the oligochaetes and chironomids, its prey includes *Asellus* sp., small mollusks, and amphipods, all in decreasing order of importance (Young and Spelling, 1989). A review of its biology is found in Sawyer (1974). It is commonly associated with organic enriched conditions (Carr and Hiltunen, 1965; Sawyer, 1974). This species has an annual life cycle but can produce either one or two generations per year depending on temperature (Davies, 1978; Davies and Reynoldson, 1975, 1976; Murphy and Learner, 1982). *Helobdella californica*, a new and closely related species, is reported from California (Kutschera, 1988), and it also is reported to feed on oligochaetes (*Tubifex* sp.), snails (*Physella gyrina gyrina*), and crustaceans (*Gammarus* sp.). In addition, Platt et al. (1993) reported this predaceous leech of invertebrates as a parasite of the Tiger Salamander, *Ambystoma tigrinum*.

9. *Helobdella triserialis*

Widely distributed in North, Central, and South America, this species is frequently found in some localities and many kinds of aquatic environments, including organically enriched habitats. It is a variable, polymorphic species with several complex forms exhibiting different morphological features (Ringulet, 1943, 1944a,b, 1945; Klemm, l976, 1977, 1985; Sawyer, 1972, 1986b). This leech feeds on aquatic snails and other invertebrates (Sarah, 1971; Klemm, 1972a, 1974, 1975, 1976).

10. *Oligobdella biannulata*

A species that is rearly encountered. Sawyer and Shelley (1976) reported that it may be host specific for desmognathine salamanders and that it is restricted to small streams in the montane areas of only North Carolina and South Carolina.

11. *Placobdella hollensis*

An uncommon, cool-water species occurring usually in permanent ponds in the Great Lakes region, this species is also reported from a few other localities in North America, including Florida (Sawyer, l968, 1972, 1974; Klemm, 1972a, 1974, 1982, l985; Kopenski, 1969, 1972; Davies, 1973). This species is usually found free-living, and the feeding habits and biology of this strong swimming species are unknown but is thought to feed on reptiles (e.g., turtles). This unusual leech needs further taxonomic evaluation.

12. *Placobdella montifera*

This species is widely distributed in North America but considered uncommon. It is found free-living or as a temporary parasite on various fish species (Richmond, 1972; White and Crisp, 1973; Sawyer, 1974, 1986b; Amin, 1977, 1981). Also, *Placobdella montifera* has been reported from the mantal cavity of various freshwater mussels, but the specific leech-mussel relationship has not been determined, thus it is not known whether the leech actually feeds on the mussels (Curry, 1977; Curry and Vidrine, I976, 1977).

13. *Placobdella multilineata*

This species is common in the southern half of the United States and uncommon elsewhere. Sawyer and Shelley (1976) reported this species from the Yellow-belled Turtle (*Pseudemys scripta scripta*) and the Snapping Turtle (*Chelydra serpentina*). Forrester and Sawyer (1974) found it parasitizing the American Alligator (*Alligatror mississippiensis*), and Brantly and Platt (1991) studied the salinity correlations of this leech on alligators.

14. *Placobdella nuchalis*

This species has been reported from several localities of the coastal plains in the Carolinas (Sawyer and Shelley, 1976). Shelley and Braswell (1981) reported collecting an adult specimen under the opercular flap of a bluegill (*Lepomis macrochiruus*) in North Carolina. Klemm (1982) identified specimens of *Placobdella nuchalis*, collected from the chin of a channel catfish (*Ictalurus punctatus*), from Kentucky Lake near Paris Landing, Tennessee. White (1977) found an individual (not *Placobdella parasitica* Say, after re-examination of the specimen (Klemm, 1985)) attached to the eye of a carp (*Cyprinus carpio*) from the Ohio River, Kentucky. Klemm (1982) also examined several specimens collected free-living from the Susquehanna River, Three Mile Island, Pennsylvania, and the Ogeechee and Canoochee Rivers in Gerogia. Platt et al. (1993) reported this species from the Tiger Salamander (*Ambystoma tigrium*).

15. *Placobdella ornata*

Very common and widespread in the northern half of the United States and in Canada; few reports of it in southern localities, including Mexico. It is typically found free-living or encountered on a variety of turtle species (Klemm, 1972a, 1982; Sawyer, 1972; Amin, 1981; Brooks et al., 1990). It is considered to be a cold-water form (Sawyer, 1974). Occasionally collected in organically enriched waters.

16. *Placobdella papillifera*

A widespread species, common in some localities and uncommon elsewhere in the United States (Sawyer, 1972; Klemm, 1985), and Davies and Wilkialis (1982) reported that it was widely distributed and low in abundance in Canada. Typically encountered free-living, Sawyer (1972) and Sawyer and Shelley (1976) reported it from the musk turtle (*Stenothaerus odoratus*), and Klemm (1985) found it on the snapping turtle (*Chelyda serpentina*). In laboratory feeding studies, Davies and Wilkialis (1982) found that *Placobdella papillifera* fed equally on fresh heparinized blood of frogs, ducks, rabbits, sheep, and man, but that live ducks, frogs, and fish were not attacked by this leech. Smith et al. (1977) also recorded it from the American alligator (*Alligator mississippiensis*). It is occasionally associated with organically polluted waters.

17. *Placobdella parasitica*

A common leech widely distributed throughout North America. It is found free-living or parasitizing various turtle species (Klemm, 1972a; Sawyer, 1972; Amin, 1981; Brooks et al. 1990; Saumure, 1990) and occasionally other vertebrates. Koffler et al. (1978) reported the seasonal occurrence of *Placobdella parasitica* on wood turtles (*Clemmys insculpta*) in New York and New Jersey. Sawyer and Shelley (1976) also reported it from the eastern mud turtle (*Kinosternon subrubrum subrubrum*) and the stinkpot (*Sternotherus odoratus*). This species was found on *Sternothesus depressus* in northern Alabama, and Dood (1988) reported that the level of parasitism on *Sternothesus depressus* was inversely correlated with the degree of habitat alteration by coal mining operations. Found occasionally in waters of organic enrichment.

18. *Placobdella translucens*

This species is uncommon and known only from the Gulf States and coastal areas of the southern United States (Sawyer and Shelley, 1976); Klemm (1982) identified specimens collected free-living from North Carolina, Georgia, Alabama, and Louisiana. The prey of this species is unknown.

B. Family **Piscicolidae**

1. *Cystobranchus verrilli*

An uncommon species with several reports from the Great Lakes Region and southern Canada, this species is less common elsewhere. It has been found parasitizing a variety of fish hosts (Meyer, 1940; Poe, 1972; Klemm, 1985, 1990, 1991, and Davies, 1973).

2. *Myzobdella lugubris*

A tolerant, North American species known from both brackish and fresh waters, it is common and widely distributed throughout the continent. It is morphologically variable in size and shape in freshwater (Klemm, 1982, 1985; Daniels and Sawyer, 1975; Sawyer et al., 1975). It parasitizes many fish species (Meyer, 1940, 1946; Klemm, 1972a, 1985; Kopenski, 1972; Poe, 1972; Davies, 1973; White and Crisp, 1973; Sawyer et al. 1975; White, 1977; Amin, 1981; Apply and Dadswell, 1981; Schramm et al., 1981; Apply and Cone, 1982; Muzzall et al., 1987; Woods et al., 1990). It is occasionally associated with waters recognized as organically polluted. The life history of this species on the white catfish (*Ictalurus catus*) and the blue crab (*Callinectes sapidus*) has been thoroughly studied (Daniels and Sawyer, 1975). *M. lugubris* displayed seasonality as a parasite on the fish which was reported to be inversely correlated with water temperature.

3. *Piscicola punctata*

A species widely distributed in North America, where it has been reported from the northern United States and Canada, and infrequently encountered elsewhere. It is occasionally associated with water to be organically polluted and reported to parasitize several fish species (Thompson, 1927; Meyer, 1940, 1946; Davies, 1973; Klemm, 1972a; Poe, 1972).

4. *Piscicolaria reducta*

A species common in some localities throughout North America, especially the Midwest, but uncommon elsewhere. This species parasitizes a variety of fish (Meyer, 1940, 1946; Klemm, 1972a, 1985; Poe, 1972; White and Crisp, 1973; Bauer and Branson, 1975; Erickson, 1976; Maloney and Chandler, 1976; Murray et al., 1977; White, 1977; Sutherland and Holloway, 1979; Schramm et al. 1981, and Kozel and Whittaker, 1982). Price (1993) collected this species from various fishes in Florida.

LITERATURE CITED

Amin, O.M. 1977. Helminth parasites of some southwestern Lake Michigan fishes. Helminthol. Soc. Wash. 44(2):210-217.

Amin, O.M. 1981. Leeches (Hirudinea) from Wisconsin, and a description of the spermatophore of *Placobdella ornata*. Trans. Am. Microsc. Soc. 1(1):42-51.

Apply, R.G. and D.K. Cone. 1982. Attachment of *Myzobdella lugubris* (Hirudinea: Piscicolidae) to Log Perch, *Percina caprodes*, and Brown Bullhead, *Ictalurus nebulosus*. Trans. Am. Microsc. Soc. 101(2):135-141.

Apply, R.G. and M.J. Dadswell. 1981. Marine and estuarine piscicolid leeches (Hirudinea) of the Bay of Fundy and adjacent waters with a key to species. Can. J. Zool. 59(2):183-192.

Barta, J. R. and R. T. Sawyer. 1990. Definition of a new genus of glossiphoniid leech and a redescription of the type species, *Clepsine picta* Verrill, 1872. Can. J. Zool. 68:1942-1950.

Barton, D.R. and J.L. Metcalfe. 1986. Life cycles, reproduction, and diets of *Dina dubia* and *Erpobdella punctata* (Hirudinea: Erpobdellidae) in Canagagigue Creek, Ontario. Can. J. Zool. 64:640-648.

Bauer, B.H. and B.A.Branson. 1975. The leech *Piscicolaria reducta* parasitizing some percid fishes. Trans. Ky. Acad. Sci. 36:18-19.

Bendell, B.E. and D.K. McNicol. 1991. An assessment of leeches (Hirudinea) as indicators of lake acidification. Can. J. Zool. 69(1):130-133.

Brantly, C.G. and S.G. Platt. 1991. Salinity correlations of the leech *Placobdella multilineata* on alligators. Herpetol. Rev. 22(1)4-5.

Brinkhurst, R.O. 1991. Annelida. Oligochaeta and Branchiobdellida. *In*: J.H. Thorp and A.P. Covich (eds.). Ecology and classification of North American freshwater invertebrates. Academic Press, Inc., New York, New York., pp. 401-435.

Brinkhurst, R.O. 1992. Evolutionary relationship within the Clitellata. Soil. Bio. Biochem. 24(12):1201-1205.

Brinkhurst, R.O. and S.R. Gelder. 1989. Did the limriculids provide the ancestors of the branchiobdellidans, acanthobdellidans, and leeches. Hydrobiologia 180:7-16.

Brooks, R.J., D.A. Galbraith, and J.A. Layfield. 1990. Occurrance of *Placobdella parasitica* (Hirudinea) on snapping turtles (*Chelydra serpentina*) in southern Ontario, Canada. J. Parasitol. 76(2):190-195.

Brown, A.F. and D. Pascoe. 1988. Studies on the acute toxicity of pollutants to freshwater macroinvertebrates 5. The acute toxicity of cadmium to twelve species of predatory macroinvertebrates Arch. Hydrobiol. 114(2):311-3119.

Camargo, J.A. 1992. New diversity index for assessing structural alterations in aquatic communities. Bull. Environ. Contamination Toxicol. 48(3):428-434.

Cargo, D.G. 1960. Predation of eggs of the spotted salamander, *Ambystoma maculatum*, by the leech, Macrobdella decora. Chesapeake Sci. 1(2):119-120.

Carr, J.F. and J.K. Hiltunen. 1965. Changes in the bottom fauna of western Lake Erie from 1930-1961. Limnol. Oceanogr. 10:551-569.

Castle, W.E. 1900. Some North American fresh-water Rhynchobdellidae, and their parasites. Bull. Mus. Comp. Zool. Harvard 36:17-64.

Curry, M.G. 1977. Ecology of the leech *Placobdella montifera* Moore (Hirudinea: Glossiphoniidae): Part. I. ASB Bulletin 24(2):45.

Curry, M.G. and M.F. Vidrine. 1976. New fresh-water mussel host records for the leech *Placobdella montifera*, with distributional notes. Nautilus 90:141-144.

Curry, M.G. and M.F. Vidrine. 1977. New fresh-water clam host records for the leech *Placobdella montifera* Moore and *Helobdella stagnalis* L. Proc. La. Acad. Sci. 40:43-46.

Daniels, B.A. and R.S. Freeman. 1976. A review of the genus *Actinobdella* Moore, 1901 (Annelida: Hirudinea). Can. J. Zool. 54(12):2112-2117.

Daniels, B.A. and R.T. Sawyer. 1975. The biology of the leech *Myzobdella lugubris* infesting blue crabs and catfish. Biol. Bull. 148:193-198.

Davies, R.W. 1973. The geographic distribution of freshwater Hirudinoidea in Canada. Can. J. Zool. 51(5):531-545.

Davies, R.W. 1978. Reproductive strategies shown by freshwater Hirudinoidea. Verh. Internat. Verein. Limnol. 20:2378-2381.

Davies, R. W. 1991. Annelida: Leeches, Polychaetes, and Acanthobdellids. James H. Thorp and Alan P. Covich (eds.). *In*: Ecology and classificaton of North American freshwater invertebrates. Academic Press, NY, 437-479.

Davies, R.W., D.W. Blinn, B. Dehdashti, and R.N. Singhal. 1988. The comparative ecology of three species of (Erpobdellidae:Annelida) equals Hirudinoidea. Arch. Hydrobiol. 111(4):601-614.

Davies, R.W. and R.P. Everett. 1975. The feeding of four species of freshwater Hirudinoidea in southern Alberta. Verh. Internat. Verein. Limnol. 19:2816-2827.

Davies, R.W. and T.B. Reynoldson. 1975. Life history of *Helobdella stagnalis* (L.) in Alberta. Verh. Internat. Verein. Limnol. 19:2828-2839.

Davies, R.W. and T.B. Reynoldson. 1976. A comparison of the life-cycle of *Helobdella stagnalis* (Linn. 1758) (Hirudinoidea) in two different geographical areas in Canada. J. Anim. Ecol. 45(2):457-470.

Davies, R.W., T.B. Reynoldson, and R.P. Everett. 1977. Reproductive strategies of *Erpobdella punctata* (Hirudinoidea) in two temporary ponds. Oikos 29:313-3219.

Davies, R.W. and J. Wilkialis. 1982. Observation on the ecology and morphology of *Placobdella papillifera* (Verrill) (Hirudinoidea: Glossiphoniidae) in Alberta, Canada. Amer. Midl. Nat. 107(2):316-324.

Davies, R.W., F.J. Wrona, L. Linton, and J. Wilkialis. 1981. Inter- and intra-specific analyses of the food niche of two sympatric species of Erpobdellidae (Hirudinoidea) in Alberta, Canada. Oikos 37:l05-lll.

Deutsch, W.G. 1977. Fish parasites from the Susquehanna River in Pennsylvania, with new host records. Proc. Pa. Acad. Sci. 51(2):122-124.

Dood, C.K.Jr. 1988. Pattern of distribution and seasonal use of the turtle *Sternotherus depressus* by the leech *Placobdella parasitica*. J. Herpetol. 22(1):74-81.

Erickson, J.E. 1976. New host and distribution records for *Piscicolaria reducta* Meyer 1940. J. Parasitol. 62(3):409.

Forbes, S.A. 1890a. An American terrestrial leech. Bull. Ill. Lab. 3:118-122.

Forbes, S.A. 1890b. An American terrestrial leech. Am. Nat. 24:646-649.

Forrester, D.J. and R.T. Sawyer. 1974. *Placobdella multilineata* (Hirudinea) from the American Alligator in Florida. J. Parasitol. 60(4):673.

Grube, A.E. 1871. Beschreibungen einiger Egelarten. Arch. Naturgesch. 37:118-122.

Hall, K.J. and C. Jacob. 1988. Bioconcentration of chlorophenols by leeches and their use as in situ biololgical monitors. Wat. Pollut. Res. J. Can. 23(1):69-87.

Herrmann, S.J. 1970. Systematics, distribution, and ecology of Colorado Hirudinea. Amer. Midl. Nat. 83(l):1-37.

Hilsenhoff, W.L. 1963. Predation by the leech, *Helobdella stagnalis*, on *Tendipes plumosus* (Diptera: Tendipdidae) larvae. Ann. Entomol. Soc. Amer. 56:252.

Hilsenhoff, W.L. l964. Predation by the leech, *Helobdella nepheloidea*, on *Tendipes plumosus* (Diptera: Tendipedidae). Ann. Entomol. Soc. Amer. 57:l39.

International Code of Zoological Nomenclature. 1985. The International Trust for Zoological Nomenclature, London.

Isaak, L.C., R.M. Neumann, and D.W. Willis. 1993. Food habits of walleyes in Lake Thompson, South Dakota. Prairie Naturalist 24(4):325-330.

Jones, S.R.M. and P.T.K. Woo. 1990a. Redescription of the leech *Desserobdella phalera* (Graf, 1899) n. comb. (Rhynchobdella: Glossiphoniidae), with notes on its biology and occurrence on fishes. J. Can. Zool. 68:1951-1955.

Jones, S.R.M. and P.T.K. Woo. 1990b. The biology of *Trypanosoma phaleri* n. sp. from bowfin, *Amia calva* L., in Canada and the United States. Can. J. Zool. 68:1956-1961.

Jones, S.R.M. and P.T.K. Woo. 1991. Development and infectivity of *Trypanosoma phaleri* in leech and fish hosts. Can. J. Zool. 69(6):1522-1529.

Jones, S.R.M. and P.T.K. Woo. 1992. Vector specificity of *Trypanosoma catastomi* and its infectivity to freshwater fishes. J. Parasitol. 78(1):87-92.

Klemm, D.J. 1972a. The leeches (Annelida: Hirudinea) of Michigan. Mich. Acad. 4/(4):405-444.

Klemm, D.J. 1972b. Freshwater leeches (Annelida: Hirudinea) of North America. Biota of Freshwater Ecosystems. U.S. Environmental Protection Agency Identification Manual No. 8, pp. 1-53.

Klemm, D.J. 1975. Studies on the feeding relationships of leeches (Annelida: Hirudinea) as natural associates of mollusks. Sterkiana. 58:1-50, and 59:1-20.

Klemm, D.J. 1976. Leeches (Annelida: Hirudinea) found in North American mollusks. Malacol. Rev. 9(1-2):63-76.

Klemm, D.J. 1977. A review of the leeches (Annelida: Hirudinea) in the Great Lakes Region. Mich. Acad. 9(4):397-418.

Klemm, D.J. 1982. Leeches (Annelida: Hirudinea) of North America. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268, EPA-600/3-82-025, 177 pp.

Klemm, D. J. 1985. Freshwater leeches (Annelida: Hirudinea). *In*: A guide to the freshwater Annelida (Polychaeta, naidid and tubificid Oligochaeta, and Hirudinea of North America. D. J. Klemm (ed.). Kendal/Hunt Publ. Co., Dubuque, IA, pp. 70-194.

Klemm, D. J. 1990. Hirudinea. *In*: Freshwater macroinvertebratews of northeastern North America. B. L. Packarsky, P. R. Fraissint, M. A. Penton, and D. J. Conklin, Jr. (eds.). Cornell University Press, Ithaca, NY, pp. 398-415.

Klemm, D. J. 1991. Taxonomy and pollution ecology of the Great Lakes Region leeches (Annelida: Hirudinea). Michigan Academician 24:37-103.

Klemm, D.J. 1991. The freshwater Annelida (Polychaeta, naidid and tubificid Oligochaeta, and Hirudinea of the Great Lake Region--An Overview. *In*: Simon, T.P. and W.S. Davis (eds.). EPA/905?R-92/003. Proceedings of the 1991 midwest pollution control biologists meeting environmental indicators: measurement and assessment endpoints. U.S. Environmental Protection Agency, Region V, Instream Biocriteria and Ecological assessments Committee, Chicago, IL, pp. 35-48.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. EPA/600/4-90/030. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

Klemm, D.J., Q.J. Stober, and J.M. Lazorchak. 1993. Fish field and laboratory methods for evaluating the biological integrity of surface waters. EPA/600/R-91/111. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.

Knudsen, J.W. 1966. Biological techniques. Harper and Row, Publishers, New York, New York

Koffler, B.R., R.A. Seigel, and M.T. Mendonca. 1978. The seasonal occurrence of leeches on the wood turtle, *Clemmys insculpta* (Reptilia, Testudines, Emydidae). J. Herpetol. 12(4):571-572.

Kopenski, M. 1969. Selected studies of Michigan leeches. Ph.D. Thesis, Mich. State Univ., East Lansing, MI., 157 pp. (Available from Univ. Microfilms, Ann Arbor, Mich.)

Kopenski, M. I972. Leeches (Hirudinea) of Marquette County, Michigan. Mich. Acad. 4(3):377-383.

Kozel, T.R. and F.H., Whittaker. 1982. Ectoparasites of the rainbow darter, *Etheostoma caeruleum* Storer, from Harrods Creek, Oldham County, Kentucky. Proc. Helminthol. Soc. Wash 49(1):138-139.

Kutschera, U. 1988. A new leech species from North America, *Helobdella californica* nov. sp. (Hirudinea: Glossiphoniidae). Zool. Anz. 220(3/4):173-178.

Madill, J. 1983. The preparation of leech specimens: relaxation, the key to preservation. In: D.J. Faber (ed.). Proceedings of 1981 workshop on care and maintenance of natural history collections. Syllogeus No. 44:37-41.

Maloney, S.D. and C.M. Chandler. 1976. Leeches (Hirudinea) in the upper Stones River drainage of middle Tennessee. Amer. Midl. Nat. 95:42-48.

Mason, W.T., Jr. 1991. A survey of benthic invertebrates in the Suwannee River, Florida, USA. Environ. Monit. Assess. 16(2):163-188.

Mason, W.T., Jr., R.A. Mattson, and J.H. Epler. 1994. Benthic invertebrates and allied macrofauna in the Suwannee River and Esturary ecosystem, Florida. Florida Sci. 57(4):141-167.

Metcalfe, J.L., M.E. Fox, and J.H. Carey. 1984. Aquatic leeches (Hirudinea) as bioindicators of organic chemical contaminants in freshwater ecosystems. Chemosphere 13:143-150.

Metcalfe, J.L., M.E. Fox, and J.H. Carey. 1988. Freshwater leeches (Hirudinea) as a screening tool for detecting organic contaminants in the environment. Environ. Monit. Assess. 11:147-169.

Metcalfe, J.L. and A. Hayton. 1989. Comparison of leeches and mussels as biomonitors for chlorophenol pollution. J. Great Lakes Res. 15()4):654-668.

Meyer, M.C. 1940. A revision of the leeches (Piscicolidae) living on freshwater fishes of North America. Trans. Am. Microsc. Soc. 59(3):354-376.

Meyer, M.C. 1946. Further notes on the leeches (Piscicolidae) living on freshwater fishes of North America. Trans. Am. Microsc. Soc. 65:237-249.

Miller, J.A. 1929. The leeches of Ohio. Ohio State Univ. Contribut. Franz Theodore Stone Laboratory. 2:1-38.

Miller, J.A. 1937. A study of the leeches of Michigan with a key to orders, suborders, and species. Ohio J. Sci. 37:85-90.

Moore, J.P. 1898. The leeches of the U.S. National Museum . Proc. U.S. Nat. Mus. 21:543-563.

Moore, J.P. 1901. The Hirudinea of Illinois. Bull. Ill. State Lab. Natur. Hist. 5:479-547.

Moore, J.P. 1906. Hirudinea and Oligochaeta collected in the Great Lakes Region. Bull. Bur. Fish. 24(598):153-172.

Moore, J.P. 1912. Leeches of Minnesota. Geol. Natur. Hist. Surv. Minn. Zool. 5(P.III, Classification), 64-150.

Moore, J.P. 1952. Professor A.E. Verrill's Fresh-water leeches--A tribute and a critique. Nat. Acad. Nat. Sci. Phila. 245:1-15.

Moore, J.P. 1953. Three undescribed North American leeches (Hirudinea). Nat. Acad. Nat. Sci. Phila. 250:1-13.

Murphy, P.M. and M.A. Learner. 1982. The life history and production of the leech *Helobdella stagnalis* (Hirudinea: Glossiphoniidae) in the River Ely, South Wales. Freshwat. Biol. 12:321-329.

Murray, A.B., W.S. Nance, D.C. Tarter. 1977. The occurrence of the leech *Piscicolaria reducta* on *Etheostoma blennoides* from West Virginia. Trans. Am. Microsc. Soc. 96:412.

Muzzall, P.M., G.E. Whelaln, C.R. Peebles. 1987. Parasites of burbot *Lota lota* family Gadidae from the Ford River in the Upper Pensinsula of Michigan, USA. Can. J. Zool. 65(11):2325-2327.

Peck, S.B. 1988. A review of the cave fauna of Canada, and the composition and ecology of the invertebrate fauna of caves and mines in Ontario. Can. J. Zool. 66:1197-1213.

Pennak, R.W. 1989. Hirudinea (leeches). *In*: Fresh-water invertebrates of the United States. Protozoa to Mollusca. John Wiley and Sons, NY, pp. 314-335.

Platt, T.R., D.M. Sever, and V.L. Gonzalez. 1993. First report of the predaceous leech, *Helobdella stagnalis* (Rhynchobdellida: Glossiphoniidae) as a parasite of an amphibian, *Ambystoma tigrinum* (Amphibia: Caudata). Amer. Midl. Nat. 129(1):208-210.

Poe, T.P. 1972. Leeches (Hirudinea) parasitizing Illinois fish. M.S. Thesis, Northern Illinois Univ., Dekalb, IL.

Price, W.W. and J.V. Nadolny. 1993. *Piscicolaria reducta* (Hirudinea: Piscicolodae) from fishes in a subtropical Florida stream. J. Helminthol. Soc. Wash. 60(1):130-134.

Proctor, R.M. and J.O. Young. 1987. The life history, diet and migration of a lake-dwelling population of the leech *Alboglossiphonia heteroclita* (L.). Hydrobiologia 150:133-139.

Richardson, L.R. 1969a. A contribution to the systematics of the hirudinid leeches with a description of new families, genera, and species. Acta Zool Zda. Sci. Hung. 97-149.

Richardson, L.R. 1969b. The family Ozobrancyhidae redefined, and a novel Ozobranchiform leech from Murray River turtle (Class Hirudinoidea: Order Rhyncholbdelliformes). Pro. Linnean Soc. NSW 94: Part I:61-80.

Richardson, L.R. 1975. A convenient technique for killing and preserving leeches for general study. J. Parasitol. 61(1)78.

Richardson, L.R. 1980. Towards a new Hirudinology. J. Parasitol 56(2):237.

Richmond, S.L. 1972. Leeche (Hirudinea) of northern Illinois. exclusive of the family Piscicolidae. M.S. Thesis, Northern Illinois Univ., Dekalb, IL.

Riggs, M.R. 1980. Helminth parasites of leeches of the genus *Haemopis*. Master's Thesis, Iowa State Univ., Ames, IA, 91 pp.

Ringuelet, R. 1943. Sobre la morfologia y varabilidad de *Helobdella triserialis* (Em.Bl.) (Hirudinea, Glossiphoniidae). Notas Mus. de la Plata (Zoology). 8(69):215-240.

Ringuelet, R. 1944a. Sinopsis sistematica y zoogeografica de los Hirudineos de la Argentina, Brasil, Chile, Paraguay y Uruguay. rev. Mus. de La Plata, n.s. 3 (Zoology). 3(22):163-232.

Ringuelet, R. 1944b. Revision de los Hirudinoeos Argentinos de los generos *Helobdella* R.Bl., *Batracobdella* Vig., Cylicobdella Gr. y *Semiscolex* Kinb. Rev. Mus. de La Plata, n.s. 4 (Zoology). 25:5-93.

Ringuelet, R. 1945. Hirudineos del Museo de La Plata. Rev. Mus. de La Plata, n.s. 4 (Zoology). 26:95-137.

Ringuelet, R.A. 1978. Nuevos generos y especies de Glossiphoniidae Sudamericanos basado en caractaeres ecto y endosomaticos (Hirudinea: Glossiphoniiformes). Limnobios 1(7):269-275.

Sladecek, V. and V. Kosel. 1984. Indicator value of freshwater leeches (Hirudinea) with a key to the determination of European species. Act Hydrochim. et Hydrobiol. 12(5):451-461.

Sarah, H.H. 1971. Leeches (Hirudinea) found on two species *Helisoma* from Fleming's Creek. Ohio J. Sci. 71(1)15-20.

Saumure, R.A. 1990. *Emydoidea blandingi* Blanding's turtle. Herpetol. Rev. 21(3):60.

Sawyer, R.T. 1968. Notes on the natural history of the leeches (Hirudinea) on the George Reserve, Michigan. Ohio J. Sci. 68(4):226-228.

Sawyer, R.T. 1970. Observation on the natural history and behavior of *Erpobdella punctata* (Leidy) (Annelida:Hirudinea). Amer. Midl. Nat. 83(1):65-80.

Sawyer, R.T. l972. North American freshwater leeches, exclusive of Piscicolidae, with a key to all species. Ill. Biol. Monog. (Ill.) 46:1-154.

Sawyer, R.T. l974. Leeches (Annelida: Hirudinea). *In*: Pollution ecology of freshwater invertebrates. Acad. Press, Inc. New York, pp. 81-142.

Sawyer, R.T. 1984. Arthropodization in the Hirudinea: evidence for a phylogenetic link with insects and other Uniramia. Zoological J. Linnean Soc., London 80:303-322.

Sawyer, R. T. 1986a. Leech biology and behaviour. Volume I. Anatomy, physiology, and behaviour. Oxford: Clarendon Press, Oxford.

Sawyer, R. T. 1986b. Leech biology and behavior. Volume II. Feeding biology, ecology, and systematics. Oxford: Clarendon Press, Oxford.

Sawyer, R.T. 1990. Terrestrial Hirudinea. *In*: D.L. Dindal, ed. Soil Biology. Guide. John Wiley & Sons, Inc., New York, pp. 387-391.

Sawyer, R.T., A.R. Lawler, and R.M. Overstreet. 1975. Marine leeches of the eastern United States and the Gulf of Mexico with a key to the species. J. Nat. Hist. 9:633-667.

Sawyer, R.T. and K.A. Pass. 1972. The occurrence of *Macrobdella decora* (Say 1824) (Annelida:Hirudinea) in the Appalachian mountains of Georgia and South Carolina. J. Elish Mitchell Scient. Soc. 88:34-35.

Sawyer, R.T. and R.M. Shelley. l976. New records and species of leeches (Annelida: Hirudinea) from North and South Carolina. J. Nat. Hist. l0:65-97.

Schramm, J.C., C.H. Hardman, and D. Tarter. 1981. The occurrence of *Myzobdella lugubris* and *Piscicolaria reducta* (Hirudinea:Piscicolidae) on fishes from West Virginia. Trans. Am. Microsc. Soc. l00(4):427-428.

Shelley, R.M., A.L. Braswell, and D.L. Stephen. 1979. Notes on the natural history of the terrestrial leech, *Haemopis septagon* Sawyer and Shelley (Gnathobdella (*sic*): Hirudinea). Brimleyana 1:129-133.

Shelley, R.M., and A.L. Braswell. 1981. Host record for the leech *Placobdella nuchalis* (Rhynchobdella: Glossiphoniidae). J. Parasitol. 67(5):748.

Sidall, M.E. and S.S. Desser. 1992a. Prevalence and intensity of *Haemogregarina balli* (Apicomplexa: Adeleina: Haemogregarinidae) in three turtle species from Ontario with observations on intraerythrocytic development. Can. J. Zool. 70(1):123-128.

Sidall, M.E. and S.S. Desser. 1992b. Alternative leech vectors for frog and turtle trypanosomes. J. Parasitol. 7893:562-563.

Slooff, W. 1983. Benthic macroinvertebrates and water quality assessment: Some toxicological considerations. Aquatic Toxicol. 4:73-82.

Smith, E.N., C.R. Johnson, and B. Vorght. 1977. Leech infestation of the American alligator in Texas. Copeia 4:842.

Soos, A. 1969. Identification Key to the leech (Hirudinoidea) genera of the world and a catalogue of the speies. V. Family: Hirudinidae. Acta Zool. Acad. Sci. Hung. 25:151-201.

Streit, B. and H.M. Peter. 1978. Long-term effects of atrazine to selected freshwater invertebrates. Arch. Hydrobiol. Suppl. 55(1):62-77.

Stuart, J. 1982. Hirudinoidea. *In*: S.P. Parker (ed.). Synopsis and classification of living organisms, Vol. 2, pp. 43-50. McGraw-Hill, New York.

Sutherland, D.R. and H.L. Holloway, Jr. 1979. Parasites of fish from the Missouri, James, Sheyenne, and Wild Rice Rivers in North Dakota. Proc. Helminthol. Soc. Wash. 46:128-134.

Szalai, A.J. and T.A. Dick. 1991. Evaluation of gill nets, fyke nets, and markk-recapture methods to estimate the number of Hirudinea and Crustacea on fish. J. Parsitol. 77(6):914-922.

Thompson, D.H. 1927. An epidemic of leeches on fishes in Rock River. Bull. Ill. State Nat. Hist. Surv. 27(III):195-201.

Verrill, A.E. 1872. Descriptions of North American fresh-water leeches. Amer. J. Sci. 3:126-139.

Wetzel, M.J. 1992. Aquatic Annelida of Illinois: Introduction and checklist of species. Trans. Illinois State Acad. Sci. 85(1-2):87-101.

White, G.E. 1977. New distribution records of fish leeches in the Ohio River. J. Parasitol. 63(6):1138.

White, G.E. and N.H. Crisp 1973. The occurrence of four leeches (Hirudinea: Rhynchobdellida: Piscicolidae) on Kentucky River drainage fishes. Trans. Ky. Acad. Sci. 34(3):47-48.

Woo, P.T.K. 1991. Mammalian trypanosomiasis and picine cryptobiosis in Canada and the United States. Bull. Soc. Ecol. 16(1):25-42.

Woods, L.C., III, M.A. McCarthy, J.N. Kraeuter, and D.R. Sager. 1990. Infestation of striped bass *Morone saxatilis* by the leech *Myzobdella lugubris*. *In*: Pathology in Marine Science, (ed. F.O. Perkins and T.C. Cheng), Pages 277-282, Thired Internatinal Colloquim on Pathology in Marine Aquaculture, Gloucester Point, Virginia. San Diego, CA, Academic Press, Inc.

Young, J.O. and R.M. Procter. 1985. Oligochaetes as a food resource of lake-dwelling leeches. J. Freshwat. Ecol. 3(2):181-187.

Young, J.O. and S.M. Spelling. 1989. Food utilization and niche overlap in three species of lake-dwelling leeches (Hirudinea). J. Zool (Oxford) 219(2):231-244.

GENERAL BIBLIOGRAPHY FOR THE LEECHES OF FLORIDA AND OTHER SOUTHERN STATES

Bendell, B.E. and D.K. McNicol. 1991. An assessment of leeches (Hirudinea) as indicators of lake acidification. Can. J. Zool. 69(1):130-133.

Brantly, C.G. and S.G. Platt. 1991. Salinity correlations of the leech *Placobdella multilineata* on alligators. Herpetol. Rev. 22(1)4-5.

Bronmark, C. 1992., Leech predation on juvenile freshwater snails effects of size species and substrate. Oecologia (Heidelb.) 91(4):526-529.

Brown, A.F. and D. Pascoe. 1988. Studies on the acute toxicity of pollutants to freshwater macroinvertebrates 5. The acute toxicity of cadmium to twelve species of predatory macroinvertebrates Arch. Hydrobiol. 114(2):311-3119.

Camargo, J.A. 1992. New diversity index for assessing structural alterations in aquatic communities. Bull. Environ. Contamination Toxicol. 48(3):428-434.

Curry, M.G. 1975. A new leech (Hirudinea: Glossiphoniidae) for Louisiana with ecological notes. ASB (Assoc. Southwest Biol.) Bull. 22(2):49.

Curry, M.G. 1975. Notes on some Louisiana freshwater leeches (Hirudinea), two new to the state. Am. Midl. Nat. 93(2):509-510.

Curry, M.G. 1978. Two new freshwater clam hosts for the leech (*sic*) *Placobdella montifera* Moore and hypotheses for their association. Proc. La. Acad. Sci. 41:144.

Curry, M.G. 1979. New freshwater unionid clam hosts for three glossiphoniid leeches. Wasmann J. Biol. 37(1&2):89-92.

Curry, M.G. and J.E. Leeman. 1975. Salinity ranges of freshwater Glossiphoniid leeches (Annelida: Hirudinea: Glossiphoniidae) in Louisiana. ASB (Assoc, Southwest. biol.) Bull. 25(2):34.

Curry, M.G. and W.G. Kennedy, Jr. 1975. Louisiana turtle leeches with new host record. Proc. La. Acad. Sci. 38:124.

Curry, M.G. and M.F. Vidrine. 1976. New freshwater mussel host records from the leech *Placobdella montifera*, with distributional notes. Nautilus 90(4):141-144.

Curry, M.G. and M.F. Vidrine. 1977. New freshwater clam host records for the leeches *Placobdella montifera* Moore and *Helbdella stagnalis* L. Proc. La. Acad. Sci. 40:43-46.

Davis, J.R. 1982. Macrobenthic diversity of Abolo Creek, an interrupted, south central Texas stream. *In*: J.R. Davis, ed. Proceedings of the symposium on recent benthological investigations in Texas and adjacent states. Aquatic Sci. Sec., Texas Acad. Sci., Austin, Texas. pp. 79-94.

Davies, R.W.; Monita, D.M.A.; Dratnal, E.; Linton, L.R. 1992. The effects of different dissolved oxygen regimes on the growth of a freshwater leech. Ecography 15(2):190-194.

Dermott, R.; Barton, D. 1992. Benthic community associated with zebra mussel colonies. J. Shellfish Res. 11(1):223.

Fernandez, J.; Tellez, V.; Olea, N. 1992. Hirudinea. *In*: Harrison, F.W.; Gardiner, S.L. (eds.). Microscopic Anatomy of Invertebrates 7. Annelida. Wiley-Liss, Inc, New York, N.Y., pp. 323-394.

Forrester, D.J. and R.T. Sawyer. 1974. *Placobdella multilineata* (Hirudinea) from the American alligator in Florida. J. Parasitol. 60(4):673.

Klemm, D.J. 1975. Studies on the feeding relationshiops of leeches (Annelida: Hirudinea) as natural associates of mollusks. Sterkiana 58:1-50 and 59:1-20.

Klemm, D.J. 1976. Leeches (Hirudinea) found in North American Mollusks. Malacological Review 9:73-76.

Klemm, D.J. 1991. Taxonomy and pollution ecology of the Great Lakes region leeches (Annelida: Hirudinea). Michigan Academician 24:37-103.

Lent, C.M. 1986. New medical and scientific uses of the leech. Nature 323:494.

Mason, W.T., Jr. 1991. A survey of benthic invertebrates in the Suwannee River, Florida, USA. Environ. Monit. Assess. 16(2):163-188.

Mason, W.T., Jr., R.A. Mattson, and J.H. Epler. 1994. Benthic invertebrates and allied macrofauna in the Suwannee River and Esturary ecosystem, Florida. Florida Sci. 57(4):141-167.

Platt, T.R.; Sever, D.M.; Gonzalez, V.L. 1993. First report of the predaceous leech, *Helobdella stagnalis*, (Rhynchobdellida: Glossiphonniidae) as a parasite of an amphibian, *Ambystoma tigrinum* (Amphibia: Caudata). Amer. Midl. Nat. 129(1):308-210.

Price, W.W.; Nadolny, J.V. 1993. *Piscicolaria reducta* (Hirudinea: Piscicolidae) from fishes in a subtropical Florida stream. J. Helminthol. Soc. Wash. 60(1):130-134.

Sawyer, R.T. 1967. The leeches of Louisiana, with notes on some North American species (Hirudinea: Annelida). Proc. La. Acad. Sci. 30:32-38.

Sawyer, R.T. 1974. Leeches (Annelida: Hirudinea). *In*: C.W. Hart, Jr., and S.L. H. Fuller, eds., Pollution ecology of freshwater invertebrates. Academic Press, Inc., New York, New York, pp. 81-142.

Sawyer, R.TR. 1985. Scientific rationale behind the medical use of leeches. *In*: Pirkle, H. and F.S. Markland (eds.). Hematology, Vol 7. Hemostasis and animal venoms. Marcel Dekker, Inc., New York, pp. 271-28O.

Sawyer, R.T. 1986. Leech biology and behaviour. Clarendon, Oxford. 1065 pp.

Sawyer, R.T. and R.M. Shelley. 1976. New records and species of leeches (Annelida: Hirudinea) from North and South Carolina. J. Nat. Hist. 10:65-97.

Schramm, H.L., Jr. and K.J. Jirka. 1989. Effects of aquatic macrophytes on benthic macroinvertebrates in two Florida lakes. J. Freshw. Ecol. 5(1):1-12.

Shelley, R.M. 1975. Distributional patterns of leeches in North and South Carolina (Annelida: Hirudinea). ASB (Assoc. Southeast. Biol.) Bull. 22(2):79.

Shelley, R.M. 1977. North Carolina's terrestrial leech. Wildl. N.C. 49(9):42.

Shelley, R.M., A.L. Braswell, and D.L. Stephan. 1979. Notes on the natural history of the terrestrial leech, *Haemopis septon* Sawyer and Shelley (Gnathobdella *sic*): Hirudinea). Brimleyana 1:129-131.

Sladacek, V. and V. Kosel. 1984. Indicator value of freshwater leeches (Hirudinea) with a key to the determination of European species. Acta Hydrochimie und Hydrobiologie 12:451-461.

Smith, E.N., C.A. Johnson, and B. Voight. 1976. Leech infestation of the American alligator in Texas. Copeia 4:842.

Voss, E.G. 1969. Taxonomy. Encyclopedia aBritannica, Inc., pp. 1-6.

APPENDIX A: CHECKLIST AND DISTRIBUTION OF LEECHES FOR FLORIDA AND TEN OTHER SOUTHERN STATES

This checklist registers species known to occur in Florida and ten nearby southern states, based on literature citations and material examined by the author. Some of these species are found in other localities of North America (See Annotations for Leeches (Annelida: Hirudinea) of Florida and Other Southern States) and for the distribution in North America (See Klemm, 1985). The checklist also includes species which have not been reported from Florida, but some of these species may be found there. Some of these species which have not been identified or reported from Florida have been recorded in the middle southern United States, the southeastern coastal plain region, and the Gulf Coast states. The species are arranged in alphabetical grouping by orders, then by families and genera. Key to General Distribution: Florida = FL, Alabama = AL, Arkansas = AR, Georgia = GA, Louisiana = LA, Mississippi = MS, North Carolina = NC, Oklahoma - OK, South Carolina = SC, Tennessee - TN, and Texas = TX.

The general distribution patterns of described leech species in North America are not completely recognized, due primarily to inadequate collecting, to the small number of sites and different habitats sampled, to not reporting specimens found parasitizing vertebrate hosts, and to the infrequent reporting of specimens at the species level in the published literature. Also, the distribution patterns of leech species in Florida and other southern states are very insufficiently determined.

The Biological, chemical, and physical characteristics of the aquatic environment that affect the abundance and distribution of leeches are discussed in the General Ecology section of this document and more extensively in Klemm (1982, 1985, 1991); Sawyer (1974; 1986a,b), and Davies (1991).

Phylum **Annelida** Lamarck, 1809

Class **Hirudinea** Lamarck, 1818

Order **Arhynchobdellida** Blanchard, 1894

Family **Erpobdellidae** R. Blanchard, 1894

Erpobdella punctata (Leidy, 1970)	AR, GA, LA, NC, SC, TN, TX
Mooreobdella melanostoma Sawyer and Shelley, 1976	NC, SC, TX
Mooreobdella microstoma (Moore, 1901)	FL, AL, AR, LA, OK, TX
Mooreobdella tetragon Sawyer and Shelley, 1976	FL, AL, GA, NC, SC

Family **Haemopidae** Sawyer, 1986

Haemopis marmorata (Say, 1824)	NC, TN
Haemopis terrestris (Forbes, 1890)	FL, AL, AR, LA, MS, TN
Haemopis septagon Sawyer and Shelley, 1976	NC, SC

Family **Hirudinidae** Whitman, 1886

Macrobdella decora (Say, 1824)	GA, NC, SC
Macrobdella ditetra Moore, 1953	FL, AL, AR, GA, LA, MS, NC, SC, TX
Philobdella floridana (Verrill, 1874)	FL
Philobdella gracilis Moore, 1901	FL, GA, LA, MS, NC, SC, TX

Order **Rhynchobdellida** Blanchard, 1894

Family **Glossiphoniidae** Vaillant, 1890

Actinobdella inequiannulata Moore, 1901	AL, GA, LA, MS
Actinobdella pediculata (Hemingway, 1908)	OK, TN
Alboglossiphonia heteroclita (Linnaeus, 1761)	NC, SC
Desserobdella phalera (Graf, 1899)	FL, GA, LA, NC, SC, TX
Desserobdella picta (Verrill, 1872)	AR, NC, TX
Gloiobdella elongata (Castle, 1900)	FL, AL, AR, GA, LA, MS, NC, SC, TN, TX
Helobdella fusca (Castle, 1900)	FL, AR, LA, MS, OK, TX
Helobdella stagnalis (Linnaeus, 1758)	FL, AR, GA, LA, MS, NC, SC, TN, TX
Helobdella triserialis (E. Blanchard, 1849)	FL, AL, AR, GA, LA, MS, NC, OK, SC, TN, TX
Oligobdella biannulata (Moore, 1900)	NC, SC
Placobdella hollensis (Whitman, 1892)	FL, GA
Placobdella montifera Moore, 1906	AK, AL, GA, LA, NC, TN, TX
PLacobdella multilineata Moore, 1953	FL, AL, GA, LA, NC, OK, SC, TN, TX
Placobdella nuchalis Sawyer and Shelley, 1976	FL, GA, NC, SC, TN
Placobdella ornata (Verrilli, 1872)	FL, TN, TX
Placobdella papillifera (Verill, 1872)	FL, AL, AR, GA, LA, MS, NC, SC, TX
Placobdella parasitica (Say, 1824)	FL, AL, AR, GA, LA, MS, NC, SC, TN, TX
Placobdella translucens Sawyer and Shelley, 1976	FL, GA, AL, LA, NC, SC

Family **Piscicolidae** Johnston, 1865

Cystobranchus verrilli Meyer, 1940	AR
Myzobdella lugubris Leidy 1851	FL, AL, AR, LA, NC, OK, SC, TN, TX
Piscicola punctata (Verrill, 1871)	GA, TN
Piscicolaria reducta Meyer, 1940	FL, AR, LA, OK, TN

APPENDIX B: GLOSSARY FOR THE LEECHES OF NORTH AMERICA

Arhynchobdellid (pl.-s): A leech in the Order Arhynchobdellida.

Arhynchobdellida: The Order (=Gnathobdellida, =Pharyngobdellida) for the leeches of the families Erpobdellidae, Haemopidae, and Hirudinidae (Sawyer, l986b). In the classification of the leeches, some students still use the order Gnathobdellida for leeches of the family Hirudinidae and use the order Pharyngobdellida for leeches of the family Erpobdellidae.

Accessory eyes: A series of supplementary eyes (ocelli) behind the single pair of functional eyes in the cephalic (head) region of *Placobdella hollensis*.

Agnathus: Mouth unfurnished with true jaws.

Annuli (sing. **Annulus**): External body rings or superficial transverse furrows (annulation) of the somites. Basically there are 3 primary annuli (triannulate) per somite, labelled by convention as a1, a2, a3 (or sometimes written a1-3), (except in *Oligobdella biannulata* which has biannulate somites). In some genera of leeches, each annulus may be subdivided (see Klemm, 1985) into secondary annuli, b1, b2, b3 ... b6 (or b1-6), and still further into tertiary annuli c1, c2, c3 ... (or c1-12), and rarely still further into quaternary annuli d1, d2, d3 ... d24 (or d1-d24). Each somite corresponds with one ganglion in the central nervous system. The ventral nerve cord ganglia are placed in the middle annulus of the somite. Annulation can be most easily seen in the lateral margins of the middle region of the body of the leech.

Anterior sucker: Oral sucker.

Atrial cornua: Horns or hornlike prolongations of the atrium.

Atrium: A variously shaped, male reproductive organ, consisting of three parts: a thin-walled eversible bursa, a thick-walled glandular and muscular medium chamber, and a pair of atrial cornua openings into the latter of similar structures of the male reproductive system. The atrium opens externally through the male gonopores.

Buccal cavity: Mouth cavity.

Bulbous: Bulb shaped caudal sucker of *Actinobdella* species.

Botryoidal Tissue: Tissue of branched canals surrrounding enteric canal in leeches.

Caudal ocelli: Dot-like or crescent-shaped eyespots on the caudal sucker of certain piscicolids. See punctiform and crescentiform ocelli.

Caudal sucker: Posterior sucker.

Cephalic Region: Head Region.

Chaetae (sing. **Chaeta**): 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).

Chromatophore: A cutaneous pigment cell or group of pigment cells which under control of the nervous system can be altered in shape and size to produce a color change in some rhynchobdellids.

Clitellum: A regional epidermal saddle or swollen glandular portion of the integument in the area of the gonopores of certain leeches, especially the Haemopidae, Hirudinidae, and Erpobdellidae, visible in adults during the breeding period. It contains gland cells that secrete material to form cocoons.

Complete somites: Segments having the full number of annuli or body rings.

Copulatory depressions: A glandular area around the gonopores and copulatory pits on the ventral surface in *Philobdella* species.

Copulatory gland pores: Pores present in a linear or transverse pattern of either 4, 6, 8, or 24. They are located on the ventral surface, 4 or 5 annuli, posterior to the female gonopore in *Macrobdella* species.

Copulatory pits: Thick depressions and prominences of the glandular area around the gonopores of *Philobdella* species (See copulatory depressions).

Crescentiform ocelli: Crescent-shaped or crescentic eyespots on the caudal sucker of *Piscicola salmositica*.

Crop (Stomach): Saclike dilatation or largest part of the alimentary canal adapted for storage of blood, and so may be a single, straight tube, or contain several paired diverticula

Crop caeca: Segmental pouches or diverticula of the crop (stomach).

Denticles: (Small teeth-like processes) two rows of teeth (distichodont) wholly or partly in *Philobdella* species and some species of *Haemopis* or one row of teeth (monostichondont) in *Hirudo* and *Macrobdella* species.

Digitate processes: A marginal circle of 30-60 retractable processes, fingerlike when everted on the inside rim of the caudal sucker cavity of *Actinobdella annectens* and *Actinobdella inequiannulata*. The digitate process are usually retracted in preserved specimens, but their position is evident by faint radiating ridges or bands visible on the outer rim of the caudal sucker.

Discoid head: The oral sucker and cephalic region widely expanded, circular demarcated from the body by a constriction (e.g., *Placobdella montifera* and *Placobdella nuchalis*).

Distichodont: See dendicles.

Erpobdellid (pl.-s): A leech in the family Erpobdellidae.

Eyes (Ocelli): Photoreceptors confined to the cephalic "head" region, formed from a number of light sensitive cells (eyespots) backed by a pigmented cup. The eyes are located on the dorsal or lateral surface of the anterior segment, are segmental, and vary in number and arrangement.

Eyepots (Ocelli): Photoreceptors of the cephalic region, lateral region of the urosome, or caudal sucker of certain leeches.

Furrow: A narrow groove between two body rings (annuli or somites).

Ganglia (sing. **Ganglion**): Concentration of nerve cell bodies in the ventral nerve cord. Excluding the supra- and subesophageal mass (six ganglia) and the caudal mass (seven ganglia), there are 21 ganglia in the ventral nerve cord, labeled in Roman numerals VII-XXVII. The neural annulus of segment (somite) l0 would, therefore, be expressed as Xa2 of the triannulate somite.

Ganthobdellid (pl.-s): A leech in the order Ganthobdellida.

Gathobdellida: In some leech classifications the order taxon for the family Erpobdellidae. Some students of leeches prefer to use the order Arhynchobdellida.

Glossiophoniid (pl.-s): A leech in the Family Glossiphoniidae.

Gonopores: External openings of the reproductive tracts, located on or in the furrow of the annulus on the midvenatral surface of somite XI and XII (about one third from tip of cephalic region). The male gonopore is anterior to, larger than, and more conspicuous than the female gonopore. The male and female gonopores generally are separated by l-7 or more annuli, but in a few species open into a common gonopore.

Haemopid (pl.-s): A leech in the family Haemopidae.

Hirudinea: The class name for the leeches. In literature, Richardson (1969a,b), Soos (1969), Stuart (1982), and others have used the class taxon, Hirudinoidea, for the leeches. However, the traditional class name, Hirudinea, is maintained (Klemm, 1985, 1990, 1991; Sawyer, 1986b) for the leeches in conformance with the appropriate word ending specified in the *International Code of Zoological Nomenclature*, Recommendation Article 29A. that the suffix -oidea be added to the stem for the name of a superfamily.

Hirudinid (pl.-s): A leech in the family Hirudinidae.

Hirudinidae: The widely accepted familial name based etymologically on the stem *hirudinis*, the Latin genitive singular of *hirudo*. It should always be used in preference to Hirudidae (Art. 29. of the *International Code of Zoological Nomenclature*).

Hirudinoidea: See Hirudinea.

Hirudofauna: All the leeches peculiar to a country, areas, or period. A treatise on leeches.

Incomplete (abbreviated) **somites**: Occur at both ends of the body of leeches and may have any number of annuli less than the complete somites into which they grade.

Integument: A general term for the covering of the epidermis, or outer layers of an animal. The purpose of the integument is for defense and sensing environmental conditions.

Internal ridges: Fleshy anatomical structures of the pharynx in Haemopidae. Sometimes called pharynx folds or pods.

Jaws: Three large, oval bladelike jaws shaped like a half circular saw occurs just within the mouth cavity of some species of haemopids and hirudinids. Each bears along the edge a large number of small teeth (denticles). The three jaws are arranged in a triangle, one median dorsal and the other two ventrolateral. They have a covering of cuticle, and along the free edges of the disc it is thickened to form rows of numerous, minute teeth (monostichodont or distichodont).

Lateral ocelli: Eyespots on the urosome of *Cystobranchus meyeri*.

Leech: Any segmented worm with terminal suckers used for attachment and locomotion; the various species may be ectoparasites (blooding sucking), predators, or scavengers; most are aquatic in North America.

Metamere: A body segment or somite.

Metameric: Referring to metamerism or segmentation.

Metameric dots, spots, patches, or **prominences**: Yellowish or whitish areas usually metamerically (segmentally) arranged; some represent sensillae or segmental receptors. May be difficult to see in poorly or long time (old) preserved specimens.

Monostichodont: See denticles.

Mouth: A small pore on the rim or within the oral sucker cavity on ventral side of cephalic region from which a pharyngeal proboscis can be protruded of leeches in Glossiphoniidae and Piscicolidae. A medium to large opening on ventral side of cephalic region, occupying the entire oral sucker cavity, and forming rounded lips of leeches in Erpobdellidae, Haemopidae, and Hirudinidae.

Neural annulus (Sensory annulus): The annulus aligned with the ganglion in the central nervous system. In the 3- or 5-annulate somites, it is the middle annulus.

Nephridia (Sing. **Nephridium**): Excretory organs, usually that of macroinvertebrates.

Nuchal plate: See scute.

Ocelli (sing. **Ocellus**): Eyespots found in cephalic, caudal ends, or lateral margins of body of certain leeches. They may be found singly in any body part, including the caudal sucker and lateral margins, and aggregations of them in a common network of chromatophores usually form eyes of piscicolids. Eyes of leeches are confined to the cephalic "head" region. Such eyes are simple when single, and compounded when one or two small ones are attached (fused or coalesced) to the main one. Eyes are arranged, in one, two, three, four, or five pairs.

Oculiform spots: See punctiform ocelli.

Oral sucker: Anterior sucker of cephalic (head) region.

Papillae: Small to large protrusible sensory organs scattered or in a metameric series on the dorsal surface of the leech and thought to be tactile in function. Large papillae are sometimes called "tubercles".

Pedicel (Peduncle): A stem or stalk of annuli supporting the caudal (posterior) sucker in some leeches (e.g., *Actinobdella* species).

Peduncle: See pedicel.

Pharynx: A muscular tube, at the anterior part of alimentary canal, following the buccal cavity.

Pharynx folds: Internal muscular ridges or fleshy pods of the pharynx of *Haemopis* species (See internal ridges).

Pharyngobdellid (pl.-s): A leech in the order Pharyngobdellida.

Pharyngobdellida: In some classifications the order taxon for the family Hirudinidae. Some students prefer to use the order Arhynchobdellida.

Pigment (pl.-s): A dorsal or ventral cutaneous structure of brown, black, red, green, blue coloring in the integument of leeches. They are found in chromatophores and arranged between muscle strands and other organs to give a characteristic color pattern.

Piscicolid (pl.-s): A leech in the family Piscicolidae.

Proboscis: A tubular structure with a crownlike anterior end found in leeches of the families Glossiphoniidae and Piscicolidae. It is a tube lying within the proboscis cavity, which is connected to the ventrally positioned mouth of the cephalic (head) region by a short narrow canal. The proboscis is highly muscular, has a triangular lumen, and is lined internally and externally with cuticle. This organ is an anatomical characteristic of the rhynchobdellids.

Posterior sucker: Caudal sucker.

Preatrial loops: Vasa deferentia or ejaculatory ducts conveying spermatozoa of certain erpobdellids.

Pulsatile vesicles: Eleven small hemispherical vesicular structures filled with coelomic fluid and found along the lateral margins of *Cystobranchus* and *Piscicola* species. They pulsate rhythmically and function as respiratory organs.

Punctiform ocelli: Eyespots or dotlike structures on the caudal sucker or lateral margins of some piscicolids.

Rays: Distinct pigmented areas on the caudal sucker of certain piscicolids.

Rhynchobdellid (pl.-s): A leech in the Order Rhynchobdellida.

Scute (Nuchal plate): A chitinous scalelike structure found on the dorsum of the "neck region" of *Helobdella stagnalis* and *Helobdella californica*; function unknown.

Segment: A somite, metamere, or a series of anatomical divisions of the body (segmentation).

Sensillae (Segmental receptors): Whitish or yellowish, rounded, oval, metameric dots, spots, patches, prominences (sometime raised), which may resemble minute, inconspicuous papillae on neural annuli containing several types of sensory cells that are receptive to light and water movement.

Seta (pl. **Setae**): See Chaeta.

Somite (Segment, Metamere): A true body segment or metamere make up of superficial transverse annuli or rings. All leeches have 34 somites (Sawyer, 1986a), each of which corresponds to a nerve ganglion.

Stomach: See crop.

Taxon (pl. **Taxa**): Any taxonomic group, for example, a race, subspecies, species, subgenus, genus, subfamily, family, suborder, order, subclass, class, and so forth.

Teeth: See denticles.

Testisacs: Coelomic sacs containing the testes.

Trachelosome: Narrow neck region of some piscicolids.

Tubercles: Large papillae.

USNM: An abbreviation, usually associated with museum specimen catalogue numbers, for the United States National Museum (National Museum of Natural History, Washington, D.C.).

Urosome: The thicker or wider body region of some piscicolids.

Velum: A flap of skin which separates the buccal cavity from the cavity of the oral opening (mouth) in Haemopidae.

White prominences: The raised, irregular-shaped areas on the dorsum of certain leeches and functioning as segmental receptors.

Whitish or **yellowish dots, patches, spots** (sometimes raised): Sensillae, segmental receptors usually metamerically arranged.