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Annelida, Euhirudinea (leeches)
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Synopsis: Worldwide, there are over 600 species of leeches described which occur in freshwater, marine, estuarine, and moist-terrestrial ecosystems. Leeches are included in the Class Clitellata, Subclass Hirudinida, and Superorder Euhirudinea. Seven of the ten families of leeches occur in freshwater environments. Approximately half of the leech species are predaceous on invertebrates and the other half are blood-feeding.

Leeches are hermaphrodites with both male and female reproductive structures. The typical life cycle of leeches consists of egg (which is deposited inside a cocoon), juvenile, and reproductive hermaphrodite adult. Most leeches secrete a hard, albuninotrophic cocoon which is slipped anteriorly off the cephalic region and deposited aquatically. The cocoons of members of the Family Glossiphoniidae are thin, membranous, contain large yolky eggs, and are brooded by the leech parent. Freshwater leeches typically breed in the spring, lay eggs in the summer, and overwinter in the benthos or on a host. The typical life span for leeches is 1-3 years. Leeches are remarkably tolerant of polluted waters and are useful screening tools for biomonitoring of certain organic contaminants. They are also indirectly associated with organically rich waters, because they thrive on the abundant prey that are directly connected with organic enrichment.

Readily recognized by their segmented bodies and suction discs, leeches are an interesting and diverse group within the Phylum Annelida. The word “leech” is derived from the Anglo-Saxon word *loece*, “to heal,” in reference to the early blood-letting practices of western medicine. Worldwide, there are over 600 species described which occur in freshwater, marine, estuarine, and moist-terrestrial ecosystems. In freshwater systems, leeches are an integral benthic component, functioning as predators or ectoparasites. They are reliable indicators of aquatic chemistry and biodiversity, thus, the presence of specific leech species often are related closely to basic aquatic conditions and the presence of certain animals. However, leeches are largely ignored in many ecological investigations or simply identified only as Hirudinea.

Taxonomy

The former Class status of Hirudinea, originally coined by Lamarck, is no longer recognized. Leeches are currently included in the Class Clitellata, Superorder Euhirudinea (Table 1). Members of the Class Clitellata include the Euhirudinea, Acanthobdellida, Branchiobdellida and Oligochaeta, all of which are hermaphroditic, deposit eggs within a cocoon that is secreted by a clitellum, and the young undergo direct development (lack a larval stage). The Euhirudinea or “true leeches” are further divided into two Orders, Arhynchobdellida and Rhynchobdellida. Species of Euhirudinea are further classified into ten families. Seven families, Glossiphoniidae, Piscicolidae, Ozobranchidae, Haemopidae, Hirudinidae, Erpobdellidae, and Salifidae, contain species which occur in freshwater environments (Table 2).

Anatomy

The basic leech body shape is cylindrical with anterior and posterior suction discs. The anterior suction disc is circular and may be very prominent or a minor expansion of the lips of

the mouth. The posterior suction disc is circular (or elliptical in the Haemadipsidae), directed ventrally, and can be either larger or smaller than the body of the leech. Although generally cylindrical in body shape, most Piscicolid leeches are divided into two body regions, a narrow anterior trachelosome and wider, posterior urosome (Figure 1). Members of the family Glossiphoniidae have a dorsoventrally flattened body that is typically wider in the posterior half and tapers at the anterior end (Figure 1). One of the few exceptions to the leaf-shaped Glossiophoniid body shape is *Helobdella elongata*, which has a subcylindrical body. The body shape of Archynchobdellid leeches is cylindrical (Figure 1).

Euhirudinea have a constant number of 34 segments, of which there are two preoral and 32 postoral segments. Segments are further divided into annuli and the number of annuli (2-16) varies among leech groups. The sensory annulus of a segment contains the neural ganglia internally and the metameric sensory organs (sensillae) externally. The anterior ganglionic mass is comprised of six fused segments, the posterior ganglionic mass is comprised of seven fused segments, and 21 free ganglia in between.

Leeches possess numerous sensory structures to detect the environment around them, specifically to find food and to reproduce. The sensory structures are typically metamerically arranged and include ocelli (eye-spots), sensillae, and touch/pressure sensors. These sensory structures enable the leech to detect light, water disturbances, chemicals, heat, touch, and pressure. Ocelli are typically on the first few anterior segments and their arrangement has taxonomic significance. The ocelli in Hirudinidae, Haemopidae, and Haemadipsidae form a parabolic arch (Figure 2). Erpobdelliform ocelli are arranged at an angle and the ocelli of Rhynchobdellid leeches are arranged linearly (Figure 2). Some Piscicolids have additional ocelli on the mid-body and caudal sucker.

Based upon their digestive anatomy, leeches are placed into two Orders, Arhynchobdellida or Rhynchobdellida. Arhynchobdellid leeches have a large mouth opening with or without jaws and denticles (teeth) on the muscular ridged pharynx. Jawed Arhynchobdellids posses two or three muscular jaws arranged at 45 degree angles and armed with one (monostichodont) or two (distichodont) rows of denticles. The buccal cavity of jawless arhynchobdellids contains muscular ridges and in some genera (*Salifa* and *Barbronia*), the ridges are armed with small conical piercing stylets. Rhynchobdellid leeches posses a cylindrical, muscular proboscis that is protruded through a small mouth pore on the anterior sucker.

Additional structures of the foregut include the salivary glands and esophagus (Figure 3). Leech salivary glands are typically scattered diffusely in the anterior third of the body, but in some Glossiphoniids, they are in discrete clusters. The salivary glands in sanguivorous species are primarily involved in the mechanics of blood-feeding by the secretions of anticoagulation, vasodilation, spreading factor, and inflammatory response inhibition compounds. The salivary glands in predaceous leeches are primarily involved in the digestion of food. In sanguivorous Rhynchobdellids, the esophagus is adorned with structures that harbor endosymbiotic microorganisms. These structures are called mycetomes and can be a glandular esophageal organ, or evaginated sacs or bulbous.

The midgut of leeches is comprised of the crop and intestine-rectum (Figure 3). The crop is an expandable food storage compartment. In predaceous species, the crop can be a simple tube, however in sanguivorous species, the crop has many branched caeca, which greatly increases the storage space. The posterior end of the crop in both predaceous and sanguivorous species contains the post-caeca, which extend down to the intestine. Absorption of nutrients occurs in the intestine and also the crop in predaceous species. The intestine is acaecate, except

in the Glossiphoniidae where the anterior portion of the intestine contains four pairs of caeca. The size of the anus is typically related to feeding habits. Sanguivorous leeches have a small anus and predaceous leeches have a larger anus.

Like other members of the Clitellata, leeches are segmented protandric hermaphrodites that secrete cocoons, although, there may be periods of the leech life cycle when it is a simultaneous hermaphrodite. The male reproductive system is comprised of testisacs, vas deferens, epididymus, sperm-sacs, ejacultary ducts, atrium and a male gonopore. The female reproductive system is comprised of ovisacs, oviducts, and a female gonopore. The male gonopore is larger than the females gonopore, and they are separated by various species-specific number of annuli. The structure and arrangement of male and female reproductive systems are important taxonomic separating characters (Figure 4).

Arhynchobdellid, Ozobranchid and Piscicolid leeches secrete a hard, albuminotrophic cocoon which is slipped anteriorly off the cephalic region and deposited directly on substrate. The cocoons of Hirudinform leeches are covered by a spongy substance, contain 5-10 eggs, and are deposited in moist-terrestrial environments. Erpobdelliform, Ozobranchid and Piscicolid leech cocoons are helmet-shaped, contain 1-10 eggs, and deposited aquatically (Figure 4). The cocoons of Glossiphoniid leeches have a thin, flexible membrane, which contain numerous yolky eggs, and are brooded by the parent (Figure 4). After hatching, Glossiphoniid leeches continue to brood their young and carry them to their first meal.

Life History

Leeches are hermaphrodites with both male and female reproductive structures. Many undergo a brief protandrous stage where the male tissues (testisacs) mature before the female tissue (ovisacs). Most species will reproduce only with another individual and may have more

than one mate, but some Glossiphoniids may self fertilize when mates are not available. Many leeches are capable of breeding multiple times (iteroparous) and exhibit saltatory (irregular) growth after reaching reproductive maturity. The typical life cycle of leeches consists of egg (which is deposited inside a cocoon), juvenile, and reproductive hermaphrodite adult. Freshwater leeches typically breed in the spring, lay eggs into a secreted cocoon in the summer, and overwinter in the benthos or on a host. Juveniles of sanguivorous species require a minimum of 3-5 blood-meals to reach sexual maturity. The typical life span for leeches is 1-3 years.

Leeches (except for members of the Glossiphoniidae) produce thickened cocoons filled with both the eggs and a nutrient solution for the developing eggs and young. These cocoons are typically attached to substrates and abandoned by the parent. The cocoons of Glossiphoniidae are very thin membranes or egg cases and are either attached to the substrate and immediately covered by the body of the parent, or they are directly attached to the ventral surface of the parent and remain attached until the eggs hatch. Hatchlings will typically attach themselves to the ventral surface of the parent and will be carried and tended by the parent. This parental care period can last for several months and helps to ensure that the young survive and find food resources.

Reproduction and parental care are costly processes that involve the investment of time and resources into ensuring the survival of offspring. In many invertebrates, these costs are limited to providing a nest or cocoon with resources. In the Glossiphoniidae, parental care can follow a variety of both pre- and post-hatching behaviors, ranging from brooding egg clusters in an external nest, to brooding eggs and young on the parent's body (ventral surface), to keeping eggs and young within an internal marsupial-like pouch (akin to vivipary). For each of these three different parental care types, parents are able to protect the eggs from predators and also

expend energy to ventilate the eggs by undulating their body across them in order to insure that the eggs are adequately oxygenated. Following hatching, parents continue to ventilate the young, protect them from predators, and will also provide energy for them either by capturing and providing prey (gastropods, oligochaetes, insect larvae, etc.) to the attached young or by directly transferring nutrients across the body wall to the developing young in a manner reminiscent of a "placenta." These behaviors may be costly for the parent, but help to ensure that the offspring grow quickly and are able to survive to the point where they can take care of themselves.

Feeding

A general assumption is that all leeches are sanguivorous (blood-feeding). However, leeches exhibit a diverse range of feeding strategies with approximately half of the leech species being predaceous on invertebrates, such as earthworms, gastropods, crustaceans and insect larvae, and the others being temporary blood-feeding ectoparasites. Arhynchobdellid leeches feed by either swallowing their prey whole or creating a hemorrhage with their jaws and teeth, and consuming the pooled blood or invertebrate body fluids. Rhynchobdellid leeches feed by protruding their proboscis into host tissue, which is aided by releasing salivary proteolytic enzymes at the tip, and sucking fluid.

Salivary glands open into the pharynx of both sanguivorous and predaceous leech species, however the salivary secretions of each type vary in function. In predators, the salivary glands primarily secrete digestive enzymes used to break down the fluids and tissues of their prey. In sanguivorous species, the salivary glands secrete additional compounds primarily related to the process of bloodsucking rather than digestion. These compounds perform functions such as: lubrication of the mouth parts (mucus), a spreading factor to increase the permeability of mammalian skin (hyaluronidase), blood vessel dilation (vasodilation - an histamine-like

secretion), inhibition of an inflammatory response (eglins), and blood clot prevention or breakdown (anticoagulants). The salivary compounds (including anticoagulants and vasodilators) of most species have not been studied extensively and most research has focused on the European *Hirudo medicinalis*, Asian *Hirudo nipponia*, North American *Macrobdella decora*, Central American *Haementeria officinalis*, and the South American *Haementeria ghilianii* and *Haementeria depressa*.

Digestion and absorption of food and nutrients occurs within the intestine of both predaceous and sanguivorous species with only the predaceous species additionally utilizing the crop for these functions. In sanguivorous species, symbiotic bacteria aid in the digestion of blood meals by producing enzymes that aid in the breakdown of blood and producing vitamins. Non blood-feeding leeches lack bacterial endosymbionts. Several species of bacteria have been found to colonize sanguivorous leeches such as *Hirudo medicinalis*, especially members of the genus *Aeromonas* (*A. hydrophila* and *A. veronii biovar sobria*). Bacterial endosymbionts are passed from hermaphroditic parent to the young when the cocoon is being secreted. Predaceous leech species, utilizing their own enzymes, digest their food rapidly (within a few days). Therefore, they are normally active and feed frequently. Digestion in sanguivorous leech species may take several weeks or even months due to the reliance on endosymbiotic bacteria. Sanguivorous leeches therefore feed infrequently, becoming active once their blood-meal is gone.

Typically, sanguivorous leeches attach to a host, feed until engorgement (up to a eleven-fold increase in body weight), detach and retreat to a dark, protected area to digest their blood meal. However, some Gossiphoniid species (*e.g. Oligobdella biannulata* and *Actinobdella inequiannulata*) are seasonally attached to their hosts, detaching only in the spring/summer to breed and brood young.

Ecology

Leeches occur worldwide in a wide range of ecosystems including marine, estuarine, moist terrestrial, and freshwater ecosystems. In freshwater systems, leeches are found in ponds, lakes, swamps, streams and rivers where they are an integral component of the benthic and occasionally pelagic communities. Leeches are most abundant along the shallow vegetated shoreline.

Predaceous leeches are often cryptically colored or camouflaged and are often found attached to stones, aquatic vegetation or other submerged substrates. Very few predaceous species are pelagic; most are benthic sit-and-wait predators feeding on a variety of invertebrates such as insect larvae, oligochaetes, amphipods, and gastropods. Some species in the Families Glossiphoniidae and Erpobdellidae, (particularly in the Erpobdellid genus *Motobdella)* actively seek prey using chemoreception (chemical sensation) or mechanoreception (vibration sensation). Other leeches such as some Glossiphoniids, Piscicolid, Hirudinid and Haemadipsid species are temporary ectoparasites feeding on the blood (sanguivory) of vertebrates such as fish, reptiles (turtles and crocodiles), amphibians, waterfowl, and mammals. In addition, leeches are an important component of the diet of predaceous invertebrates (dragonfly and damselfly nymphs) and vertebrates (fish, amphibians and waterfowl).

Many leeches (particularly terrestrial and some freshwater species), as well as Acanthobdellids use an inch-worm like or looping form of locomotion that consists of elongating and shortening the body and alternating between using the anterior (Euhirudinea and *Acanthobdella livanowi* only) and posterior suckers to attach to substrates. Most aquatic Euhirudinea species are also able to swim by flattening their body and using dorsoventral undulations of the body to propel the leech in an 'eel-like' motion. Erpobdellids and Hirudinids

are typically very good swimmers but only a few Glossiphoniids and Piscicolids are good swimmers. Some Glossiphoniid species (*Placobdella hollensis*) can swim readily as juveniles and as adults, but others (*Placobdella ornata* and *Placobdella parasitica*) can swim only as juveniles losing the ability as they mature. The Erpobdellid genus *Motobdella* is unique in being a pelagic predator feeding almost exclusively on pelagic amphipods by using specialized sensilla and mechanoreception to identify and track its prey in the water column. Because of their swimming ability, Erpobdelliform leeches are consumed regularly by fish, birds, amphibians and reptiles. This predator-prey relationship is so widely recognized that some fishing lures have been designed to mimic leech movement and live leeches also are sold as fishing bait. Swimming Erpobdellid and Hirudinid leeches also serve as intermediate hosts for Cestodes and Trematodes with the parasite life-cycle being completed when the leech is consumed.

An important factor in leech distribution is the availability of prey or host organisms. Due to host specificity in some sanguivorous species (especially Glossiphoniids), the presence of specific leech species indicates the presence of certain prey or host animals. For example, members of the genus *Placobdella* in North America are typically temporary ectoparasites on turtles. If *Placobdella ornata, P. parasitica, P. multilineata,* or *P. papillifera* are present in a pond or stream, one can assume that there are turtles in the locality. Predaceous leech species are also typically prey specific with *Helobdella* spp. feeding on insect larvae, aquatic oligochaetes or gastropods.

Ecotoxicology & Bioassessment

Although, leeches have not been used often at the species level for bioassessment and monitoring water quality, their habitats and certain environmental requirements have been documented in ecological investigations. More studies on the pollution and water quality

tolerances of leeches are required before the effects of environmental stresses and chemical pollution on this group of animals.

Heavily organically polluted areas contain large numbers of tubificid oligochetes, chironomid larvae, sphaeriid clams, gastropods, and predaceous leeches. Downstream from an outfall of the sewage treatment plant of Boulder, Colorado there were large numbers of leeches, *Helobdella stagnalis, Haemopis marmorata, Erpobdella parva, E. punctata,* and *Mooreobdella microstoma,* along with large numbers of chironomid larvae, tubificids, and gastropods. Many leech species are considered to be indirectly associated with organically rich waters because they thrive on the abundant prey that are directly connected with organic enrichment. Species of leeches in North America that are commonly or occasionally associated with organically enriched polluted waters are indicated in Table 3. Since leeches have a relatively wide range of ecological tolerance and that their application for determining the degree of organically impacted waters is meaningful only in connection with other types of indicators.

The toxic effects of heavy metals on leeches in the aquatic environment vary, but there have been too few studies to reach solid conclusions. Leeches found in streams polluted by waste from abandoned mines are usually more tolerant of dissolved copper and lead than zinc. Copper sulfate has been found ineffective in field application as a control of bloodsucking leeches in such environments. A concentration of 1.0 ppm killed 100% of *Macrobdella decora* in 5-5.5 hours, and a concentration of 0.2 ppm caused death in 16-86 hours, and toxicity increased with temperature. No fatalities occurred in field tests at a concentration of 200 ppm, probably because the leeches are able to leave the area.

Glossiphonia complanata and *Erpobdella octoculata* are tolerant of lead at concentrations of 0.02 to 0.1 ppm under field conditions. *Haemopis sanguisuga,* a European

leech closely related to the North American Haemopids, survived for 18 days in a solution of 3 ppm of lead nitrate.

The reproductive capacity of the European leech, *Erpobdella octoculata* has been adversely affected at 0.32 ppm and 0.18 ppm of zinc, resultanting in production of flattened, misshapen cocoons devoid of eggs, a delay in deposition of cocoons, and prolonged development of eggs in cocoons. Avoidance of zinc by adults has been observed, and active uptake at low concentrations of zinc in solution by the species has been confirmed. Cadmium concentrations also have affected North American Erpobdellids similarly.

The effects of pesticides on leeches have been studied in the laboratory and field with varying results. Leeches were exposed to Baygon, Baytex, and Dylox under laboratory conditions, and were affected by all three pesticides. *Placobdella parasitica* was found to be the most sensitive species, and *Erpobdella punctata* was found most tolerant to these pesticides. In other pesticide studies, *Helobdella stagnalis* and some Asian leeches have shown an unusual tolerance to Dichloro-Diphenyl-Trichloroethane (DDT); the LC50 is greater than 100 ppm. *Helobdella stagnalis* can dehydrochlorinate DDT producing a nontoxic metabolite Dichlorodiphenyldichloroethylene (DDE). The LC50 of other major pesticides varied in laboratory studies from 0.5 to 10.0 ppm, but indicated that few if any of these pesticides (e.g., Dinex, Chlordane, diazinon, lindane, Mirex, and malathion) are effective on leeches under field conditions.

In 48-hour acute toxicity tests, *Erpobdella octoculata* was found to be slightly more tolerant than a chironomid and tubificids to various chemical compounds. Tolerance of macroinvertebrate species are pollutant-specific. Differences in sensitivity to general toxic conditions due to pollution by several toxicants may be insignificant. The reliability of using

biological criteria only (based on macroinvertebrate distribution) to classify surface waters polluted with complex chemical pollutants is questionable. Chronically exposing *Glossiphonia complanata* and *Helobdella stagnalis* over a month to the herbicide, atrazine, caused harmful effects at concentrations that are about 2% of the acute 96-hour LC50 values - (6.3 ppm and 9.9 ppm respectively).

Leeches have been shown to be useful as screening tools for biomonitoring certain organic chemical contaminants, especially as bioindicators of aquatic organic contamination. The bioaccumulation and depuration of 16 organic compounds for *Erpobdella dubia, E. punctata,* and *Helobdella stagnalis* were compared. *Erpobdella dubia* had the highest bioaccumulation capacity for most contaminants, but residues persisted longest in *E. punctata*. *Helobdella stagnalis* appeared capable of degrading some organic compounds. Bioconcentration factors for contaminants in leeches were higher than those reported for other aquatic organisms, suggesting that leeches would be excellent biomonitors of both continuous and intermittent contamination of waters containing chlorophenols (CPs) and DDT, because leeches bioconcentrate these compounds for long periods of time after exposure. As a screening tool for lindane and benzothiazoles, leeches could be used but should be limited to chronically contaminated environments.

Leeches have been used as biomonitors of the availability of CPs to estimate the degree of contamination in the Fraser River estuary, British Columbia, where several forest industries use CPs as wood preservatives. Leeches readily bioconcentrated CPs (28-2946 µg TTCP/g wet wt. and 29-846 PCP/g wet wt.). The leeches also had slow depuration rates.

Leeches placed 100 km downstream of a pulp mill complex accumulated elevated levels of CPs (21-121 ng/g versus 4-5 ng/g pre-exposure). The proportions of the various CPs

concentrated by the leeches reflected the proportions of the CPs in mill effluent. Concentrations of CPs in mussels were 1-2 orders of magnitude lower than in leeches. Leeches in Thunder Bay Harbor, Ontario, accumulated four CPs, with concentrations of the dominant CP, pentachlorophenol (PCP), ranging from 817-5,300 ng/g at 100 m beyond the discharges, 55-85 ng/g at 300 m, and <50 ng/g at 600 m. Leeches (*Nephelopsis obscura* and *Haemopis grandis*) were found to be far superior to mussels as biomonitors of CPs. These species can be used successfully, when contained, for routine monitoring where CPs pollution is suspected. If certain leeches are to be used for biomonitoring chemical pollution, their species profiles (life histories and specific environmental requirements) should be considered and accommodated.

Glossary

Arhynchobdellida - Order of Leeches (Euhirudinea) with or without jaws and teeth on a muscular ridged pharynx.

Metameric – The division of the body into a series of similar or identical repeating units (*e.g.* segments).

Predaceous – consuming other animals (specifically invertebrates) for nutrients.

Protandric hermaphrodite- individual with both male and female sexual systems, where the male sexual system matures before the female sexual system.

Rhynchobdellida – Order of Leeches (Euhirudinea) with a protrusible proboscis.

Saltatory growth- noncontinous irregular increase in size, characterized by periods of time with no growth, and periods of time of rapid growth.

Sanguivorous- consuming blood for nutrients.

Segment – A serially repeated body segment that corresponds with one ganglion in the central nervous system. All leeches have 34 segments which correspond to 34 ganglia in the nervous system.

Further Reading

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Key Words: Arhynchobdellida, Clitellata, Erpobdelliformes Euhirudinea, Hirudinea, Hirudiniformes, leeches, Rhynchobdellida, sanguivorous.

Table 1 Classification of Leeches

- Phylum Annelida
  - Class Clitellata
    - Subclass Hirudinida
      - Superorder Acanthobdellinea
        - Order Acanthobdellida
          - Family Acanthobdellidae
      - Superorder Euhirudinea
        - Order Arhynchobdellida
          - Suborder Hirudiniformes
            - Family Americobdellidae
            - Family Cylicobdellidae
            - Family Haemopidae
            - Family Hirudinidae
            - Family Haemadipsidae
          - Suborder Erpobdelliformes
            - Family Erpobdellidae
            - Family Salifidae
        - Order Rhynchobdellida
          - Family Glossiphoniidae
          - Family Piscicolidae
          - Family Ozobranchidae

Table 2. Key to the Freshwater Leech Families

1a. Leeches with a small mouth pore located in the centre or near the anterior rim of the anterior sucker; eyes, if present, near dorsal centreline; protrusible proboscis present; midbody somites typically three-annulate (may be reduced in some genera)……..**2**

1b. Leeches with a large mouth filling the entire anterior sucker; eyes, if present, along the dorsal margin of ’head;' jaws either present or absent; midbody somites five or six-annulate (but some may be seven-annulate); body margins parallel and not ’leaf’ shaped……**4**

2a. (**1a**) Body not divided in body regions……...**3**

2b. Body divided into distinct regions, trachelosome (neck), urosome (body)…… ……**Piscicolidae**

3a.(**2a**) Branchiae (finger-like or paddle-like projections) along body; freshwater parasites on fish……. **Ozobranchidae**

3b. No branchiae or projections along body; body typically flattened and ’leaf’ shaped; typically transparent with internal organs visible; freshwater predators on invertebrates or sanguivorous (bloodsucking) on reptiles, amphibians, birds and rarely mammals……. ……**Glossiphoniidae**

4a.(**1b**) Two or three pairs of jaws present; five pairs of eyes; digestive system with multiple caeca including postcaeca; no accessory copulatory pits; terrestrial and freshwater sanguivorous (bloodsucking) species……**6**

4b. Jaws absent although pharyngeal stylets may be present; eyes three or four pairs; digestive system without caeca, or with only a simple pair of postcaeca; some species with accessory copulatory pits; freshwater predators of invertebrates…….. **5**

5a.(**4b**) Pharyngeal stylets present; digestive system with only a simple pair of postcaeca; accessory copulatory pits; freshwater predators of invertebrates…….. **Salfidae**

5b. Jaws and pharyngeal stylets absent; digestive system without caeca, except in the genus Motobdella where there are one or two pairs of postcaeca; no accessory copulatory pits; freshwater predators of invertebrates……**Erpobdellidae**

6a.(**4a**) Three pairs of jaws; typically freshwater or amphibious; sanguivorous on mammals, birds, reptiles and amphibians; no auricles; no ocular areolae…… **Hirudinidae**

6b. Two pairs of jaws; terrestrial leeches; sanguivorous on mammals, birds, reptiles and amphibians; auricles typically present, posterior suckers with distinct rays, ocular areolae on head……. **Haemadipsidae**

Table 3. Pollution Tolerance Values of Selected Leech Species

	Tolerance to Organic Wastes*		
Taxa	Tolerant	Facultative	Intolerant
Haemopidae			
Haemopis		6.0	
grandis		6.0	
marmorata		6.0	
Erpobdellidae			
Erpobdella		6.0	
dubia		6.0	
microstoma		6.0	
parva	8.0		
punctata	8.0		
Glossiphoniidae			
Alboglossiphonia			
heteroclita		6.0	
Glossiphonia			
complanata	8.0		
Helobdella			
elongata	8.0		
stagnalis	8.0		
papillata		6.0	
Placobdella			
hollensis		6.0	
ornata		6.0	
papillifera		6.0	
parasitica		6.0	
Piscicolidae			
Myzobdella			
lugubris		6.0	
Piscicola			
geometra		6.0	
milneri		6.0	
punctata		6.0	

*Pollution Tolerance Values (PTV) range from 0 (most intolerant) to 10 (most tolerant) and were obtained by determining the tolerance values of organisms to various types of stressors and calculating an average value.

Figure Legends:

Figure 1: Body shapes of five representative leech families. Hirudinidae (a.), Erpobdellidae (b.), Glossiphoniidae (c.), Piscicolidae (d.), Ozobranchidae (e.).

Figure 2: Eyes position of representative leeches. Glossiphoniidae (a.), Erpobdellidae (b.), Hirudinidae (c.), Piscicolidae (d.).

Figure 3: Digestive system of *Helobdella papillata* (a.) and *Erpobdella punctata* (b.).

Figure 4. Reproductive system of *Helobdella papillata* (a.) and *Erpobdella punctata* (b.) and a cocoons from *Erpobdella punctata* (c.) and eggs and young attached to a parent *Helobdella papillata* (d.).