# Freshwater Mollusk Conservation Society

# Freshwater Gastropod

# Identification Workshop

"Showing your Shells"

A Primer to Freshwater Gastropod Identification

Editors

Kathryn E. Perez, Stephanie A. Clark and Charles Lydeard

University of Alabama, Tuscaloosa, Alabama

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# Acknowledgments

We must begin by acknowledging Dr. Jack Burch of the Museum of Zoology, University of Michigan. The vast majority of the information contained within this workbook is directly attributed to his extraordinary contributions in malacology spanning nearly a half century. His exceptional breadth of knowledge of mollusks has enabled him to synthesize and provide priceless volumes of not only freshwater, but terrestrial mollusks, as well. A feat few, if any malacologist could accomplish today. Dr. Burch is also very generous with his time and work.

## Shell images

Shell images unless otherwise noted are drawn primarily from Burch's forthcoming volume *North American Freshwater Snails* and are copyright protected ().

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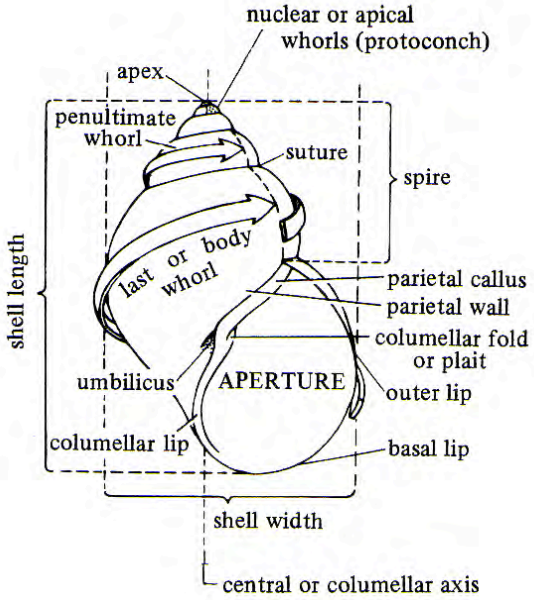


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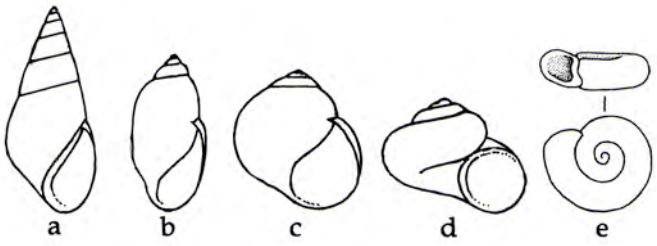


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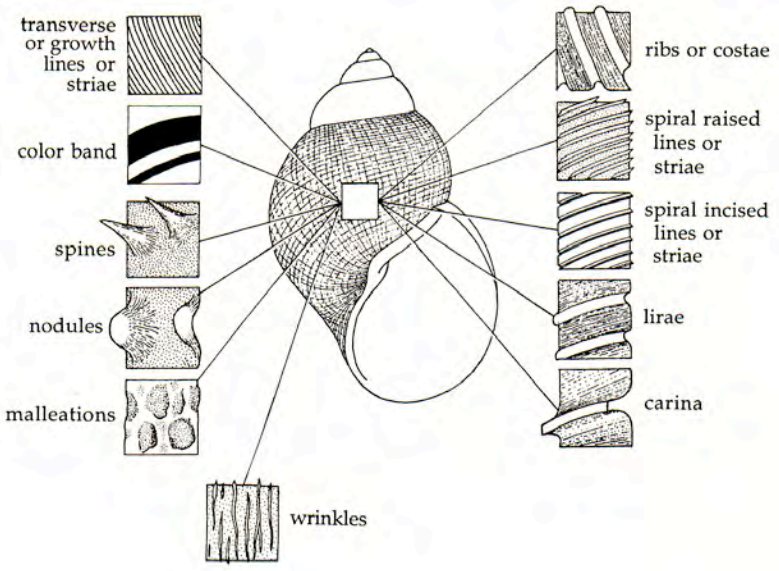


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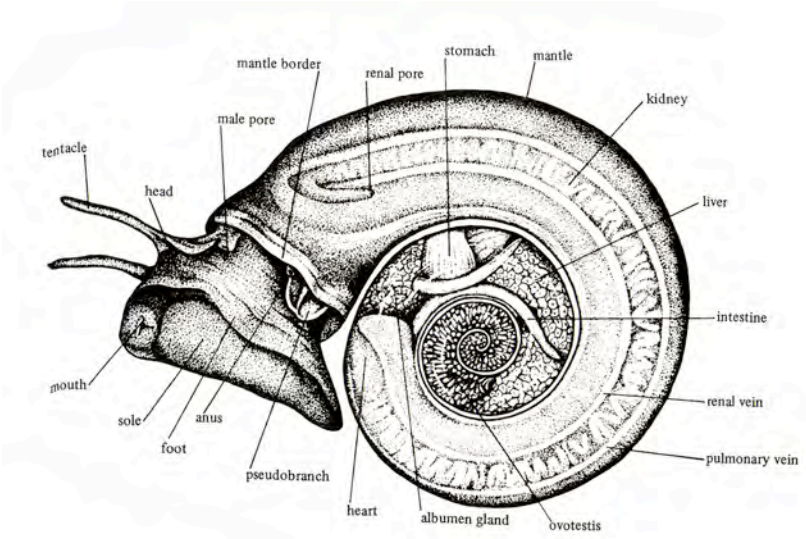



**Figure 4**. Gastropod (*Biomphalaria*) internal anatomy.

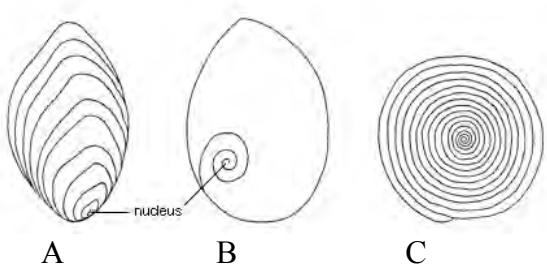



**Figure 5**. Operculum types, showing position of nucleus. A. terminal; B. paucispiral; C. spiral.

# Global Heritage Ranks

**Global Heritage Ranks**

| | |
|---|---|
| GX | Presumed Extinct |
| GH | Historical |
| G1 | Critically Imperiled |
| G2 | Imperiled |
| G3 | Vulnerable |
| G4 | Apparently Secure |
| G5 | Secure |
| GU | Unrankable |
| G? | Not Yet Ranked |
| | |
| GHYB | Hybrid plants and animals |
| * | Introduced |
| ^ | Extirpated |

**Endangered Species Status Codes**

LE – Listed, Endangered
LT – Listed, Threatened
C – Candidate taxon, Ready for Proposal

The Freshwater Gastropod Status Review Committee, which is a special subcommittee of the American Fisheries Society, Endangered Species Committee is currently developing a database including the Global Heritage Ranks of all recognized freshwater species of gastropod recorded from North America. The 'samples' provided in the present volume are provisional and subject to further review.

# Phylogeny and Classification of North American Freshwater Gastropods

**Ellen Strong and Charles Lydeard**
**Bell Museum, University of Minnesota, St. Paul, MN**
**University of Alabama, Tuscaloosa, AL**

The international community of systematic biologists proposed Systematics Agenda 2000 to achieve several scientific missions including to discover, describe, and inventory global species diversity using modern systematic methods and synthesize the information derived into a predictive classification scheme that reflects the history of life.

Regrettably, current taxonomy of many invertebrate groups, including freshwater gastropods, dates back to the late 1800s and early 1900s and is based on extremely limited understanding of how phenotypic variation is partitioned geographically and phylogenetically. Most early monographs of freshwater gastropods relied exclusively on morphological differences of the shell including sculpture, color, and qualitative shape differences. For species-groups exhibiting considerable shell variation, the result was the description of literally dozens or hundreds of species. For example, the family Pleuroceridae has nearly 1000 nominal species! In contrast, for species-groups with limited shell variation, the result was the description and recognition of single or few widely distributed species (e.g., many species in the family Hydrobiidae).

Recent systematic studies of pleurocerid and hydrobiid gastropods using modern systematic approaches have shown that these early studies do not adequately summarize nor reflect real evolutionary entities (i.e., species). Our view of species boundaries directly impinge on our view of conservation status and management. In other words, if we consider the morphologically-conservative, widely distributed species **X** to have a conservation status of "currently stable," but it is actually a composite of several narrowly distributed evolutionary species with some actually threatened or endangered, our view of biological diversity of the group, conservation, and recommended management strategies will be completely erroneous.

The identification of species boundaries involves the search for useful *characters* or *attributes* of the organisms. Characters provide the foundation for basic taxonomic monography including those that are unique or diagnostic of a species and others serve to help describe it, but may not be unique to the species. Characters also can provide the means for delimiting species boundaries using a genealogical or phylogenetic approach. Characters also provide the means for placing a species in a broader evolutionary framework and the construction of a classification scheme. Different characters will be useful at different levels in the hierarchy of the *Tree of Life*, but this usually can only be determined *a posteriori* by phylogenetic analysis. Therefore, we consider phylogenetics and taxonomy to be coupled disciplines linked by the fundamental desire to delimit species boundaries and higher groups and describe character evolution.

## Phylogeny of Gastropoda

In addition to our changing concepts and understanding of species diversity among freshwater gastropods, the past 10-15 years has witnessed renewed interest in re-evaluating relationships among gastropod higher taxa using large suites of anatomical, ultrastructural, and molecular characters (e.g. Haszprunar, 1985c, 1988a,b; Healy 1988, 1996; Tillier *et al*., 1992; Rosenberg *et al*., 1994, 1997; Winnepenninckx *et al*., 1998; Ponder & Lindberg, 1996, 1997; Harasewych *et al*., 1998; Colgan *et al*., 2000; Strong 2003). These studies are converging on a broad outline of the evolutionary history of the Gastropoda (Figure 6), one significantly different from the taxonomic scheme formulated earlier this century that still appears in most textbooks, reference works and databases currently in use. The traditional tripartite subdivision of the gastropods into Prosobranchia, Opisthobranchia and Pulmonata has been largely abandoned in recognition of the fact that only the Pulmonates represented a monophyletic clade, while the "prosobranchs" and "opisthobranchs" were paraphyletic grades of organization rather than natural entities. Thus, our understanding of the placement and/or composition of a number of key freshwater taxa is much different than that a mere decade ago.

## Overview of North American Freshwater Gastropod Diversity

Only those species and/or higher taxa that are native to North America are included here. The following provides a brief overview of characters (particularly of the shell and external morphology) that may be useful for identification and have value for classification but is not intended to provide details sufficient for species identification.

### Neritimorpha

#### Superfamily Neritoidea

Family Neritidae

Freshwater neritids possess heavy, semi-globose, dextrally coiled shells that are often smooth and glossy and thinner than their marine relatives. The columella forms a plate that partially extends across the aperture. This plate is elaborated with finely serrate denticles. The operculum is thick and calcareous and bears pegs (apophyses) to which muscles of the foot attach and aid in closing and locking the operculum in place. Like the aperture, the operculum is half-moon shaped and is capable of completely sealing the aperture. Individuals possess a single monopectinate gill in the mantle cavity on the left. Many nerites are algal grazers and possess a rhipidoglossate radula with numerous, brush-like marginal teeth. The sexes are separate and males possess a penis on the cephalic lappet to the left of the right cephalic tentacle. Females deposit numerous small egg capsules on hard substrates.

### Architaenioglossa

#### Superfamily Viviparoidea

Family VIVIPARIDAE

The dextrally coiled shells of viviparids are medium to large in size with rounded whorls, deeply impressed sutures and a closed umbilicus. Shells are relatively thin, but some may

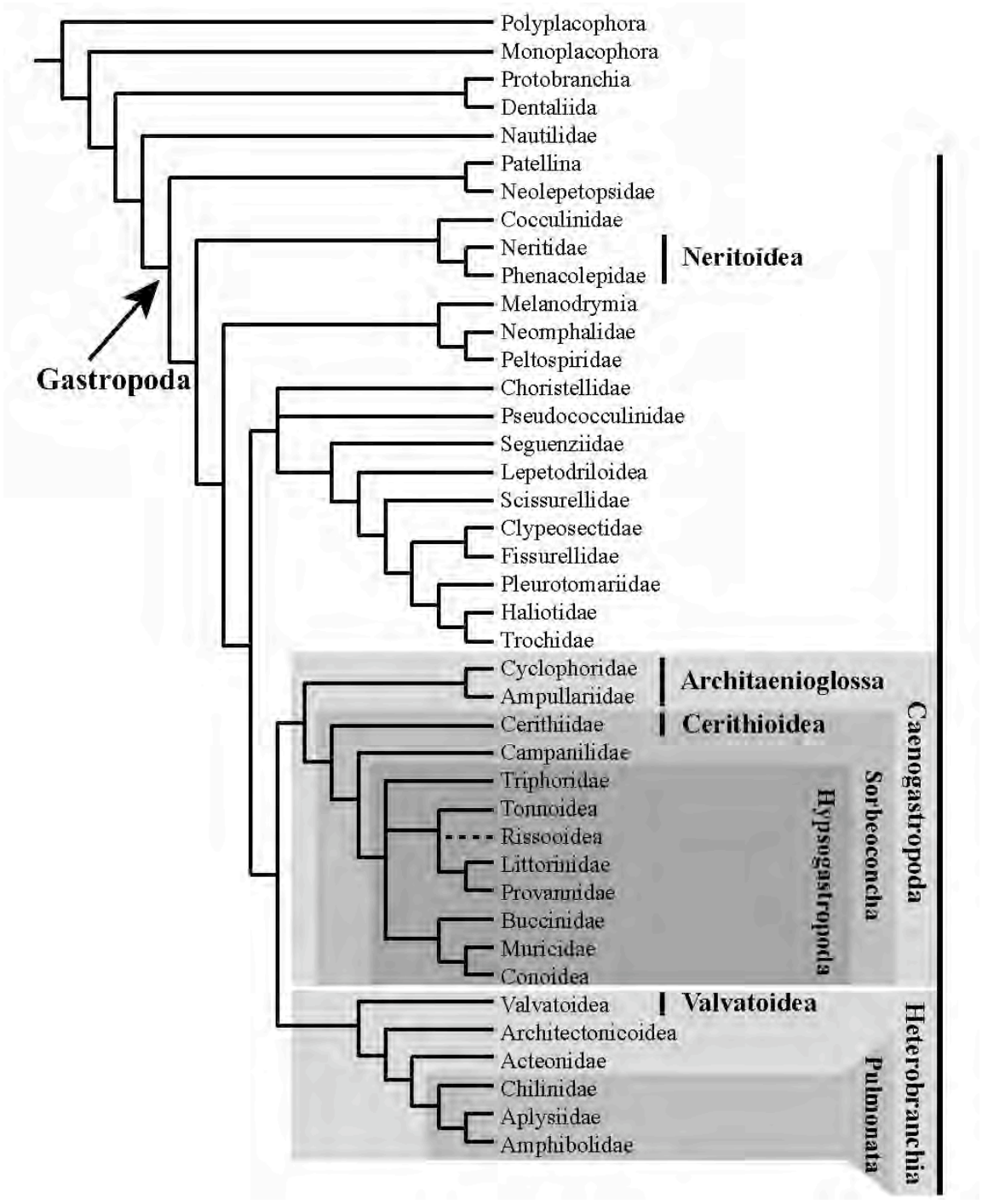



**Figure 6.** Phylogeny of the Gastropoda modified from Ponder & Lindberg (1997), indicating the placement of key freshwater groups. Shading highlights major gastropod clades with freshwater representatives. Dotted line indicates approximate placement of the Rissooidea which was not included in their analysis.

be more solidly constructed (*Campeloma*). Color banding may be present (e.g. *Viviparus*) and is often variable within species. The chitinous operculum is concentric and may have

a small, central, spiral nucleus (*Lioplax*). Viviparids are omnivores and detritivores, using the robust teeth of their taenioglossate radula (i.e. 7 teeth per row) to collect a variety of algae, bacteria, and other microorganisms and fine particulate organic material. However, they may also use the large filaments of their single, left monopectinate gill to filter suspended particles from the water (Dillon, 2000). Sexes are separate and males possess a right cephalic tentacle that has been modified to function as a penis. Females are ovoviviparous and brood their young within a "uterus" inside the mantle cavity. Reproduction is usually sexual, but some populations of *Campeloma* undergo parthenogenetic reproduction.

**Superfamily Ampullarioidea**

Family AMPULLARIIDAE

The medium to large shells of *Pomacea* are globose with a depressed spire, deeply impressed sutures and an open umbilicus. The concentric operculum is corneous (Burch 1982). A monopectinate gill is present, but the mantle cavity is modified to also function as a lung with an opening in the mantle roof (pneumostome) leading to a vascularized chamber enabling the species to survive out of water or in low oxygen conditions. The eyes are borne on prominent ocular peduncles at the bases of the cephalic tentacles. Sexes are separate. Males possess a penis at the edge of the mantle cavity on the right. Some females deposit calcareous eggs above the water surface but *Pomacea paludosa* forms gelatinous egg masses within the water (http://www.applesnail.net).

**Sorbeoconcha**

**Superfamily Cerithioidea**

Family PLEUROCERIDAE

Pleurocerid shells are extremely variable and range from tall and conical to short, globose forms and may be thin or relatively robust. The surface of the shells may be smooth or possess a diversity of ornament including growth striae, ribs, spiral threads or cords, nodules and spines; the shell may be unicolor or with spiral bands. The foot bears a horny operculum that is ovate in shape and is paucispiral with a large, sub-central nucleus (Burch, 1982). Pleurocerids lack the distinctive mantle papillae present in other introduced species of freshwater Cerithioidea (*Melanoides tuberculatus*, *Tarebia granifera*). Sexes are separate and can be distinguished on the basis of a more or less prominent egg groove that conveys fertilized eggs to a glandular ovipositor – a pit on the side of the foot below the right cephalic tentacle through which eggs pass before being molded to a solid substrate by the sole of the foot (Dazo, 1965). In contrast to all other freshwater gastropods with separate sexes, males are aphallate.

**Hypsogastropoda**

**Superfamily Rissooidea**

Hydrobiids, pomatiopsids, and assimineids are all members of the extremely diverse Superfamily Rissooidea (Ponder & de Keyzer, 1998). Higher order relationships continue to be examined using both morphological and molecular data, yet no consensus has emerged (e.g. Ponder, 1988; Wilke *et al*., 2000).

Family ASSIMINEIDAE
The small, thin, dextral shells are ovate- to globose- conic in shape with an open umbilicus. The paucispiral operculum is thin and usually corneous with a large subcentral nucleus. Individuals have a prominent snout. Sexes are separate and males possess a muscular penis attached to the neck on the right behind the cephalic tentacle.

Family HYDROBIIDAE
Hydrobiids possess highly uniform shells with few distinguishing characteristics that allow accurate species recognition based on shell features alone. Most diagnostic features reside in aspects of female and male (penis) anatomy and characters of the radular teeth. Thus, examination of the radula and/or penis and consultation with relevant literature is essential for identification to the species level.

However, in general, hydrobiids possess small to medium sized, conical shells; sculpture is often limited to fine growth striae but small conical spines or costae may be present. The umbilicus may be open or closed and the spire may be conical or depressed. An operculum is present and is spiral to paucispiral with a subcentral nucleus. Sexes are separate and males possess a prominent penis on the side of the neck behind the right cephalic tentacle. The penis may be elaborated with a variety of processes, glands and or papillae. Females may be oviparous or may brood their young within a "uterus" in the mantle cavity. The shells of some species are sexually dimorphic (Burch, 1992).

Family POMATIOPSIDAE
The dextral shells are elongate and conical to low-spired; the first whorl is not emergent giving the apex a flattened appearance (Baker, 1928). The eyes are partially surrounded by prominent granular white to yellowish-white glands. The snout is usually very long and the central tooth of the radula possesses characteristic large basal cusps that distinguish it from hydrobiid radulae (Davis, 1967). Perhaps the most characteristic trait of the family is their step-like mode of locomotion. Like hydrobiids, sexes are separate but female pomatiopsids differ from hydrobiids in details of the reproductive anatomy. Males possess a penis on the side of the neck behind the right cephalic tentacle.

**Heterobranchia**

**Superfamily Valvatoidea**
Family VALVATIDAE
The dextral shells are umbilicate and discoidal or with depressed to slightly elevated spires. Some species are characterized by the presence of distinct spiral carinae but the number and position of these carinae is often variable within species. The operculum is circular and multispiral. In addition to these distinctive features, a bipectinate gill and small pallial tentacle can be seen extending from the mantle margin while the snail is crawling across the substrate. Valvatids are hermaphroditic and tend to participate in cross fertilization; the penis is located below the right eye. In addition to the shell, shape of the snout and pattern of pigmentation on the head-foot are useful for distinguishing between species.

**Pulmonata**

Freshwater pulmonates possess shells that can be distinguished from other freshwater gastropods by their characteristically thin and light construction. In addition, they possess a suite of internal and external characters that set them apart from other groups, including: absence of an operculum, absence of a gill (although several families have secondarily evolved a pseudobranch), presence of a modified mantle cavity that acts as a lung, and a valve-like pneumostome that controls the opening to the mantle cavity limiting evaporation. They are also all hermaphroditic, with each individual possessing both male and female reproductive organs; unlike other groups, the male copulatory organ (when present) is internal during periods of sexual inactivity.

**Superfamily Acroloxoidea**

Family ACROLOXIDAE

The small, thin, transparent shells are limpet-like in form. The prominently pointed apex is directed posteriorly and to the left and fundamentally dextral organization (external openings of renal, reproductive and alimentary tracts are on the right) distinguish members of the genus from those in the Ancylidae (Paul & Clifford, 1991). A pseudobranch is present.

**Superfamily Lymnaeoidea**

Family LYMNAEIDAE

The thin shells of North American lymnaeids range from high spired dextral forms in the subfamily Lymnaeinae (readily distinguishing them from the sinistral physids) to limpet-like forms in the subfamily Lancinae that are restricted to Pacific drainages. Like other pulmonates, an operculum is absent. Unlike physids, the mantle lacks digitations and cephalic tentacles are broad, flat and triangular. A pseudobranch is absent. Individuals are hermaphroditic and undergo cross fertilization but may also self fertilize.

**Superfamily Planorboidea**

Family ANCYLIDAE

The family is characterized by small (<8 mm), thin, limpet-like shells with bluntly rounded apices on the right. Like planorbids, a pseudobranch is present on the left reflecting their underlying sinistral organization. Due to the fact that shell shape may be influenced by the underlying substrate, species identification using features of the shell can be difficult, but the presence/absence of radial striae on the apex, number of pseudobranch lobes, features of the penis and pattern of mantle pigment and muscle attachment to the shell are useful for distinguishing genera and species. Cephalic tentacles are long and thin. Individuals are simultaneous hermaphrodites.

Family PLANORBIDAE

Members of the family are fundamentally sinistral, yet some appear dextral due to their planispiral form with greatly depressed spires. Shells range from discoidal to globose with elevated, flat-topped spires; the whorl profile may be rounded or sharply angulate. The lip of the aperture may be simple or flaring and may contain a variable number of teeth. An operculum is lacking. The respiratory blood pigment is hemoglobin, giving the body a reddish appearance. Cephalic tentacles are long and thin and a pseudobranch is

present on the left. Individuals are hermaphroditic and undergo mutual cross fertilization but may facultatively self fertilize (Vianey-Liaud & Dussart, 2002).

Family PHYSIDAE

Physids possess smooth, thin, sinistrally coiled shells that are typically elliptical to ovate in shape with a large ovate aperture and a short spire. Like other pulmonates, an operculum is lacking and individuals come to the surface periodically to breathe using their lung.

Physids display a large amount of ecophenotypic variation, rendering species and even generic discrimination notoriously difficult. Accurate species identification often relies on features of the penial complex and radular morphology. In addition, the prominence and distribution of mantle digitations (lacking in other pulmonate groups) has been used to aid in distinguishing between species and higher taxonomic groupings (e.g. subgenera). Cephalic tentacles are long and thin. Individuals are all hermaphroditic and can self-fertilize.

# Viviparidae

**Paul Johnson**
**Tennessee Aquarium Research Institute, Cohutta, GA**

This family of gastropods is widely distributed across the Mississippi River, Gulf Coast, and Atlantic drainages in the eastern United States and Canada. Species distributions are generally centered in river drainages, but less so than other families of freshwater prosobranchs. Viviparid species range's cross river basins on occasion. However species from the genera *Campeloma* and *Viviparus* are found in reservoirs, oxbow lakes, bogs and other bodies of standing water that are connected to rivers. Commonly some *Viviparus* or *Campeloma* species are also introduced or invasive into ponds and lakes. Taxonomy is problematic, especially in *Campeloma*, which likely has been over-described. The adult snails of most species are > 25 mm shell length.

As the family name implies, females bear live young that hatch inside a specialized marsupium in the female's mantle cavity, and the right antenna (tentacle) of the male snail is modified to serve as a penis. Juvenile snails feed and grow inside the mantle for several weeks before they leave the marsupium. Viviparids live several years, and a maximum longevity of 5 years or more for some species is likely. Viviparids feed primarily on particulate detritus suspended in soft sediments; although *Tulotoma magnifica* and some species of *Viviparus* can filter feed. In rivers and streams, viviparids are most commonly found in depositional areas on the channel margins where a mix of detritus and soft sediments often accumulate. As such, many of these species do not appear to be impacted by sedimentation, hydrologic instability, or other environmental threats common to other freshwater prosobranch families. However, recent survey evidence suggests that some species may be extremely sensitive to sediment toxicity.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Campeloma decampi* (Binney, 1865) | G1 | LE | AL |
| *Campeloma exile* (Anthony, 1860) | GUQ | | undetermined |
| *Lioplax sulculosa* (Menke, 1827) | G3 | | AL, AR, *IA, IL, *IN, KY, MN, MO, OH, TN, WI |
| *Tulotoma magnifica* (Conrad, 1834) | G1 | LE | AL |
| *Viviparus subpurpureus* (Say, 1829) | G4 | | AL, AR, IA, IL, KY, LA, MO, MS, TN, TX |

| General Description | Illustration |
|---|---|
| ***Campeloma***<br>Outer periostracum green in color with no banding, nacre white to light blue. Shoulders of whorls rounded and distinct from previous whorl. Whorls are smooth with no sculpturing other than fine striae present in some species. Sutures that separate whorls are indented. Shell aperture oval, operculum concentric, including the nucleus. *Campeloma* spp are widely distributed across the eastern United States and Canada. *Campeloma decisum* and *C. crassula* are the most widely distributed species. |  <br>*Campeloma decisum* (Say, 1817) |

| General Description | Illustration |
|---|---|
| ***Viviparus***<br>Outer periostracum generally brown to tan, banding is common. Nacre usually white, but some species have purplish hue. Shoulders between shell whorls weak or not, sutures are indented. The shell aperture and operculum nearly circular. Operculum concentric including nucleus. Viviparidae are most common in the midwest and southern states, with *V. georgianus* (4 bands), *V. subpurpureus* (3 bands), and *V. intertextus* the most common species. |  <br>*Viviparus subpurpureus* (Say, 1829) |
| ***Lioplax***<br>Outer periostracum green to light brown, without banding. Nacre usually white but sometimes a blue tint is present. Shoulders of whorls are prominent and a distinct sulcus is present on whorls of many species. Sutures are strongly indented. Anterior-medial edge of the aperture prominent and distinct from main body whorl. Operculum concentric with a spiral nucleus. *Lioplax* spp. are most commonly sampled in moderate to strong currents in soft depositional areas that gather around and under large stones. *Lioplax sulculosa* (Mississippi River Basin) and *L. subcarinata* (Atlantic Slope) are the most commonly encountered species. |  <br>*Lioplax sulculosa* (Menke, 1827) |
| ***Tulotoma***<br>Shell conical, with one or two bands of heavy nodules each whorl, up to 30 mm in height. Outer periostracum light tan to black in color, banding present (usually 3). Nacre white and banding usually obvious. Operculum reflected inward along columellar margin. Anterior shell margin of aperture is also reflected inward (concave) toward columella. The genus is only known from a few locations in the Coosa River basin and is found under rocks in large rivers***. The genus contains a single species, which is federally listed as endangered. |  <br>*Tulotoma magnifica* (Conrad, 1834) |

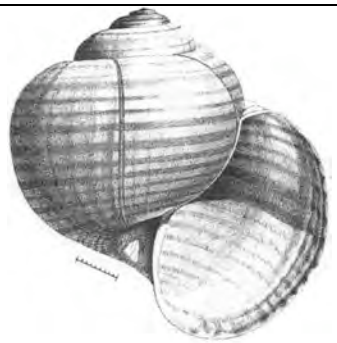
Distribution of Viviparidae in North America.

# Ampullariidae

**Paul Johnson**
**Tennessee Aquarium Research Institute, Cohutta, GA**

This family of gastropods is represented by a single species (*Pomacea paludosa*) that is restricted to the river basins of south Alabama, Georgia, and throughout Florida. This species is amphibious, and can easily survive long periods out of water (immersion). The family is characterized by a mantle cavity that has a split function. The mantle cavity contains both a gill and modified lung for both aquatic and terrestrial respiration. This characteristic has assisted the spread of the species across river basins. *Pomacea paludosa* is the largest native species in North America and can often exceed 60 mm in shell height. These animals have separate sexes and the female lays a large gelatinous egg mass attached to firm substrates. This snail is the major diet of the Snail Kite (*Rostrhamus sociabilis*) which is restricted in distribution to the Florida Everglades. These snails are commonly referred to as apple snails.

| Taxa | G-Rank | Listed | Distribution |
|---|---|---|---|
| *Pomacea miamiensis* (Pilsbry, 1899) | GU | | FL |
| *Pomacea paludosa* (Say, 1829) | G3 | | AL FL GA |

| General Description | Illustration |
|---|---|
| ***Pomacea***<br>The shell is globose, and exceeds 60 mm in height. The periostracum is dark to light olive green, with a dozen or more red brown bands, a light blue and the banding is obvious on the inside of the shell. The inner lining of the aperture is white to light blue, and opaque with the banding obvious. Whorls have rounded shoulders, with prominent, indented sutures. Operculum concentric. *Pomacea paludosa* is found in southern Alabama, Georgia, and Florida. Several snails belonging to the Ampullariidae are introduced east of the Continental Divide, but *P. paludosa* is the only recognized taxa native to North America. |  <br>*Pomacea paludosa* (Say, 1829) |

Distribution of Ampullariidae in North America.

**NOTES:**

# Pleuroceridae

**Jeffrey D. Sides**
**University of Alabama, Tuscaloosa, AL**

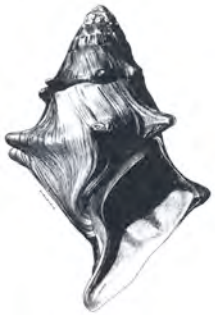
Members of the family Pleuroceridae appear to be restricted to North America; however, the majority of pleurocerid diversity occurs in the central and southeastern United States. There are seven recognized genera of pleurocerids in North America, of these genera, *Gyrotoma*, is believed to be extinct, probably due to impoundment of the Coosa River in Alabama. Most pleurocerids continue to be threatened by the effects of widespread impoundment, as well as stream pollution, habitat loss, and siltation. Many of the remaining pleurocerid populations represent disjunct fragments of their former ranges. Pleurocerids are found in a variety of habitats from small springs, streams, medium to large creeks, rivers, and reservoirs. *Juga* is restricted to streams west of the continental divide, in Great Basin or Pacific slope drainages and is more closely related to Asian taxa than eastern North American taxa. The remaining genera of the family are found east of the continental divide, with particular species diversity in the Tennessee and Mobile River basins.

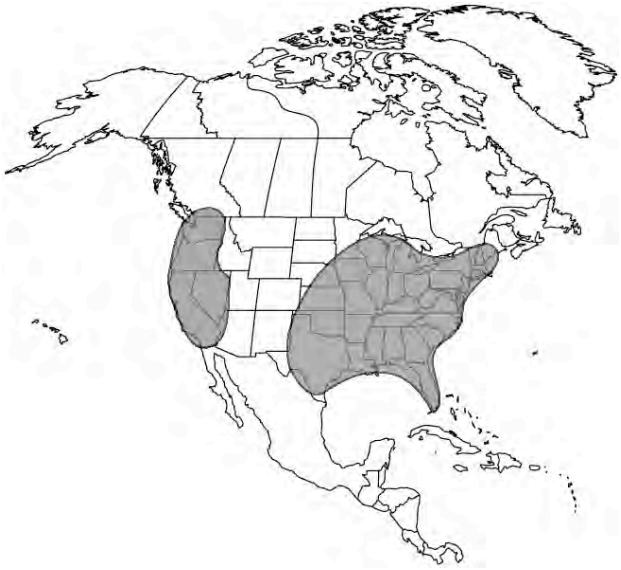
The taxonomy of the Pleuroceridae, like most freshwater gastropods, has been based almost exclusively on shell morphology. Given the environmental plasticity of gastropod shell morphology and tremendous variation exhibited, the current taxonomy of the family is problematic, often making species identification difficult. Work using a combination of reproductive anatomy and molecular data is being used to help resolve some of the taxonomic problems. For example, recent molecular studies of the *Pleurocera* of the Mobile River basin have revealed that traditional shell-based morphology needs to be revised. The Mobile River basin *Pleurocera* species boundaries are correlated with the drainage in which they are found (Alabama, Cahaba, Coosa, Tombigbee, and Black Warrior River basins). For example, the molecular data does not support the currently recognized *Pleurocera vestitum*, historically considered widely distributed in the Mobile River basin (Sides, unpublished data).

Pleurocerids are all dioecious (separate sexes), the males lack penises, and the females possess an egg-laying pore or groove on the right side of the foot. Not much is currently known about the ecology of the family. *Pleurocera* prefer the silty, low-flow areas along the bank of streams, while *Elimia* and *Leptoxis* are commonly found in fast-moving waters in the mid-channel, attached to or underneath rocks. Pleurocerids are primarily algal grazers. They often occur in large numbers, frequently far outnumbering species of other gastropod families in freshwater streams. *Elimia* can be particularly abundant in some locales, often numbering hundreds per square meter. Pleurocerid adults have thick shells, making them less susceptible to predation than thinner-shelled gastropods like physids.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Athearnia anthonyi* (Redfield, 1854) | G1 | E,XN | AL TN |
| *Elimia carinifera* (Lamarck, 1822) | G5 | | AL GA TN |
| *Gyrotoma excisa* (Lea, 1843) | GX | | AL |
| *Io fluvialis* (Say, 1825) | G2 | | AL TN VA |
| *Leptoxis praerosa* (Say, 1821) | G4 | | AL IL *IN KY OH TN VA |

| General Description | Illustration |
|---|---|
| ***Athearnia***<br>Shell ovate, body whorl suture bordered by 4-5 large, blunt tubercles, up to 25 mm in height. Shell olive-green to yellowish-brown in color. The genus contains a single species which is listed as endangered. Historically the genus was known from Tennessee River, Knox County, Tennessee to Lauderdale County, Alabama; lower French Broad and Clinch Rivers, eastern Tennessee; Elk River, Alabama; smaller tributaries of the Tennessee River from the Little Tennessee River, Tennessee, to Limestone County, Alabama. It is now known from only two sites, small reaches in the Sequatchie River, Marion County, Tennessee and Limestone Creek, Limestone County, Alabama. |  <br>*Athearnia anthonyi* (Redfield, 1854) |
| ***Elimia***<br>Shell narrowly or elongately conic, or cylindrical, 15-30 mm in height. Many species have dark bands parallel to whorls on nacre. Aperture ovate, anterior end of aperture without canal. Suture indentation none to moderate. Whorls may be smooth or costate and/or lirate. *E. hydei* has short, sharp spines. *Elimia* are most often found in faster flowing water near the midchannel of streams, attached to rocks. *Elimia* can be found in the Mississippi and Great Lakes drainages (including into Ontario and Quebec, Canada), the Hudson River basin, the Gulf of Mexico drainages, and the Atlantic slope drainages. |  <br>*Elimia gerhardti* (Lea, 1862) |
| ***Gyrotoma***<br>Shell cylindrical or globosely conic, with a slit along the posterior sutural margin of the last whorl, aperture ovate, 15-25 mm in height. Whorls may be smooth, carinate, or lirate. Sutures are deeply indented. The genus is only known from the Coosa River, Alabama. It contains six species which are all believed to be extinct. |  <br>*Gyrotoma excisum* (Lea 1843) |
| ***Pleurocera***<br>Shell narrowly to elongately conic, or cylindrical, aperture rectangular, with a short anterior canal, 20-40 mm in height. Shell sculpture varies from smooth to with spiral ribs, lirates or malleations and occassionly short blunt spines. The genus is found in the Mississippi River and Great Lakes drainages (including into Ontario and British Columbia, Canada), in the Hudson River basin and in the Gulf of Mexico drainages is. It prefers slow flow areas of streams and rivers near the bank and often leave trails in the substrate. |  <br>*Pleurocera canaliculata* (Say, 1821) |

| General Description | Illustration |
|---|---|
| ***Leptoxis***<br>Shell ovate, globosely conic, or subglobose, aperture broadly ovate to semi-circular, 10-20 mm in height. Anterior end of aperture without canal. Shell colour varies from uniformly dark and or with parallel bands. Whorls of most species are smooth, while some have lirae or striae. The genus is found in the Mississippi River basin, the Gulf of Mexico drainages and in the Atlantic slope drainages. It is prefers the faster flowing areas of streams and river, on or under rocks. *L. plicata* is listed as endangered and was historically found in the headwaters of the Black Warrior River; in Valley Creek, Jefferson County, Alabama; in the Tombigbee River. Now it is restricted to a short reach of the Locust Fork of the Black Warrior River in Jefferson County, Alabama. |  <br>*Leptoxis plicata* (Conrad, 1834) |
| ***Lithasia***<br>Shell cylindrical, ovate, elongately conic, or subglobose, aperture rectangular or fusiform, 20-30 mm in height. Columellar margin of aperture thickened. Suture indentation moderate to deep. Whorls are smooth or body whorl may have short, blunt spines. *Lithasia* occurs in the Ohio and Tennessee Rivers and their tributaries, in the Black and Spring Rivers of Arkansas and in the Big Black River of Mississippi. |  <br>*Lithasia geniculata* (Haldeman 1840) |
| ***Juga***<br>Shell narrowly or elongately conic, aperture ovate, without a canal, 15-25 mm in height. Typically sculptured with both radial and spiral ribs, striae or lirae. This genus is found entirely west of the continental divide in the United States and Canada. |  <br>*Juga plicifera* (Lea 1838) |
| ***Io***<br>Shell fusiform, aperture fusiform, with long anterior canal, 30-50 mm in height. A row of prominent spines is often present. The genus contains a single species. It is found in the Tennessee River and its tributaries in western Virginia and eastern Tennessee, including the Clinch, French Broad, Holston, Nolichucky and Powell Rivers. It has been extirpated from the Alabama portion of the Tennessee River. |  <br>*Io fluvialis* (Say 1825) |



Distribution of Pleuroceridae in North America.

**NOTES:**

# Hydrobiidae

**Stephanie Clark**
**University of Alabama, Tuscaloosa, AL**

This large group of predominately freshwater gastropods is found across the world, within the Americas the group is widely distributed from small isolated desert springs, small to large streams and rivers, lakes to estuarine marshes. The group is morphologically diverse and contains over 500 genera and several thousand species worldwide. Recent molecular and anatomical studies indicate that the Hydrobiidae as typically considered is polyphyletic with the group divisible into several families and subfamilies including the Hydrobiidae (with the following subfamilies Hydrobiinae, Pseudamnicolinae, Nymphophilinae, Islamiinae and Horatiinae), Amnicolidae, Cochliopidae, Lithoglyphidae and Moitessieriidae. However, not all genera and species to date have been examined genetically, therefore for simplicity; the group will be referred to as Hydrobiidae.

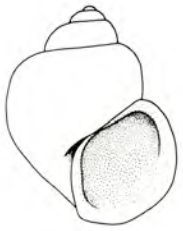
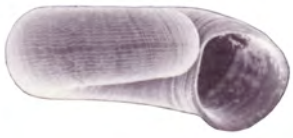
The fauna of the United States and Canada is among the most diverse of the world, with 49 genera and 500 plus species (350 currently named). The most widespread genera are *Amnicola*, *Birgella*, *Cincinnatia*, *Probythinella*, *Pyrgulopsis*, *Somatogyrus* and *Tryonia*. The largest genus is *Pyrgulopsis* with over 140 species known, with the vast majority of the described species restricted to springs and small streams of the arid western areas of the country.

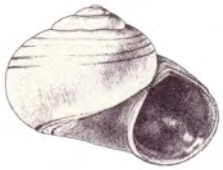
The shell morphology varies widely from flattened planispiral shaped to conic to elongated, the size varies from about a 1mm to almost 10 mm in height. Anatomically the group is very diverse with most generic and species designations primarily determined by anatomical characters, particularly penial morphology. The group feeds on detritus and bacterial/algal films and can be found from slow to fast moving water. All the American taxa have separate sexes and lay single egg capsules, however the introduced species, *Potamopyrgus antipodarum* is parthenogenetic, which partially accounts for its success as an invasive species.

The following genera are found in estuarine situations and are not dealt with further: *Heleobops*, *Hydrobia*, *Littoridina*, *Onobops, Spurwinkia* and *Texadina*.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Antrorbis breweri* Hershler & Thompson, 1990 | G1 | | AL |
| *Antroselates spiralis* Hubricht, 1963 | GX | | IN KY |
| *Fluminicola nuttallianus* (Lea, 1838) | G1 | | OR |
| *Gillia altilis* (Lea, 1841) | G5 | | *MD NC NY *PA SC VA |
| *Holsingeria unthanksensis* Hershler, 1989 | G1 | | VA |
| *Ipnobius robustus* (Hershler, 1989) | G1 | | CA |

Genera not figured: *Texapyrgus, Antrorbis, Holsingeria* and *Phreatoceras.*

| General Description | Illustrations |
|---|---|
| ***Amnicola***<br>This genus occurs throughout most of the United States and Canada. It occurs in a wide variety of habitats from small springs to large rivers and lakes. The genus contains seven species and several undescribed species; the most widespread species is *Amnicola limosa*. |  <br>*Amnicola limosa* (Say, 1817) |
| ***Antrobia***<br>This genus is only known from the streams of Tumbling Creek Cave, Missouri. Currently only a single species is known. |  <br>*Antrobia culveri* Hubricht, 1972 |
| ***Antroselates***<br>This genus is found in springs and small streams associated in caves including Mammoth Cave, in Indiana and Kentucky. Currently only a single species is known. |  <br>*Antroselates spiralis* Hubricht, 1971 |
| ***Aphaostracon***<br>This genus is found in the springs and small streams of Florida. The genus contains nine species, several undescribed species are known. |  <br>*Aphaostracon rhadinus* Thompson, 1968 |
| ***Balconorbis***<br>This genus is known only from a few springs of the Edwards Aquifer, Uvalde County, Texas. Currently only a single species is known.<br>Image from Hershler & Longley, 1986. |  <br>*Balconorbis uvaldensis* Hershler & Longley, 1986 |
| ***Birgella***<br>This genus has a wide distribution across the United States and Canada. It has been recorded from Alabama, Arkansas, Iowa, Kentucky, Michigan, Missouri, New York, Manitoba, Ontario and Quebec. It is found in large streams, rivers and lakes. The genus currently contains a single widespread species. |  <br>*Birgella subglobosa* (Say, 1825) |

| General Description | Illustrations |
|---|---|
| ***Cincinnatia***<br>This genus has a wide distribution across the United States and Canada. It has been recorded from Alabama, Arkansas, Indiana, Iowa, Louisiana, Maine, Maryland, Michigan, Missouri, Minnesota, Mississippi, Nebraska, New York, North Dakota, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Vermont, Virginia, Manitoba, Ontario and Saskatchewan. It is found in a wide range of habitats from springs to small and large streams. The genus contains a single widespread species. |  <br>*Cincinnatia cincinnatiensis* (Anthony, 1840) |
| ***Clappia***<br>This genus has only been recorded from the Cahaba and Coosa River systems of Alabama. It was reported to live on rocks and stones in the main channels of the rivers. The genus is currently considered to be extinct and was thought to contain two species. |  <br>*Clappia umbilicata* (Walker, 1904) |
| ***Cochliopa***<br>This genus is only known from Phantom Lake, Texas. Currently only a single species is known. |  <br>*Cochliopa texana* Pilsbry, 1935 |
| ***Cochliopina***<br>This genus is known from a several springs and streams of Texas and extends into Mexico. The genus contains a single species with additional undescribed species known. |  <br>*Cochliopina riograndensis* Pilsbry & Ferriss, 1906 |
| ***Colligyrus***<br>This genus is only known from one small creek system, in Oregon. The genus contains two species. |  <br>*Colligyrus greggi* (Pilsbry, 1935) |
| ***Dasyscias***<br>This genus is only known from a subterranean stream at Blue Spring Cave. Currently only a single species is known.<br><br>Image from Thompson, 2000. |  <br>*Dasyscias franzi* Thompson & Hershler, 1991 |

| General Description | Illustrations |
|---|---|
| ***Durangonella***<br>This genus is found in springs and small streams in New Mexico and extends into Mexico. The genus contains several species with one species known from the United States.<br><br>Image from Hershler, 2001. |  <br>*Durangonella kosteri* (Taylor, 1987) |
| ***Eremopyrgus***<br>This genus is only known from a group of springs in Nevada. Currently only a single species is known.<br><br>Image from Hershler, 1999. |  <br>*Eremopyrgus eganensis* Hershler, 1999 |
| ***Floridobia***<br>This genus is found along the eastern United States from Maine south to Florida. It is found in a range of aquatic habitats from springs to streams. The genus contains 14 species and a number of undesdescribed species.<br><br>Image from Thompson, 2000. |  <br>*Floridobia floridana* (Frauenfeld, 1863) |
| ***Fluminicola***<br>This genus is restricted to a large area of the western United States and extends into Canada. It has been recorded from California, Idaho, Oregon, Utah, Washington, Wyoming, Nevada and British Columbia. It occurs in springs, streams and rivers. The genus contains 11 species and several undescribed species. |  <br>*Fluminicola nuttalliana* (Lea, 1838) |
| ***Fontigens***<br>This genus is found over a wide part of the eastern United States. It has been recorded from Alabama, Georgia, Illinois, Indiana, Kentucky, Maryland, Michigan, Missouri, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and Wisconsin. The genus contains 10 species and several undescribed species. |  <br>*Fontigens nickliniana* (Lea, 1838) |
| ***Gillia***<br>This genus has been recorded from Maryland, New York, North Carolina, Pennsylvania, South Carolina and Virginia. It is found in springs, streams and rivers. Currently only a single species is known. |  <br>*Gillia altilis* (Lea, 1841) |
| ***Hoyia***<br>This genus known from a small area of Lake Michigan, Wisconsin. Currently only a single species is known. |  <br>*Hoyia sheldoni* (Pilsbry, 1890) |

| General Description | Illustrations |
|---|---|
| ***Ipnobius***<br>This genus is known from a few springs and small streams in California. Currently only a single species is known.<br><br>Image from Hershler, 2001. |  <br>*Ipnobius robustus* (Hershler, 1989) |
| ***Juturnia***<br>This genus is found in springs and small streams of New Mexico and extends into Mexico. The genus contains three species.<br><br>Image from Hershler *et. al*., 2002. |  <br>*Juturnia tularosae* Hershler, Liu & Stockwell, 2002 |
| ***Lepyrium***<br>This genus is currently restricted to a few localities of the Cahaba and Coosa Rivers of Alabama. Currently only a single species is known. |  <br>*Lepyrium showalteri* (Lea, 1861) |
| ***Littoridinops***<br>This genus is found in coastal areas of the eastern United States. It has been recorded from Connecticut, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Virginia and New Brunswick. It is found in estuarine and freshwater habitats. The genus contains two species.<br>Image from Thompson, 2000. |  <br>*Littoridinops tenuipes* (Couper, 1844) |
| ***Lyogyrus***<br>This genus is found in the eastern United States and Canada. It has been recorded from Connecticut, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Virginia and New Brunswick. It is found in springs, streams and rivers. The genus contains eight species and a few undescribed species. |  <br>*Lyogyrus pupoidea* (Gould, 1841) |
| ***Marstonia***<br>This genus is found over a wide area of the eastern United States and Canada. It has been recorded from Alabama, Arkansas, Georgia, Florida, Illinois, Indiana, Iowa, Maine, Massachusetts, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Tennessee, Texas, Virginia, Wisconsin, Manitoba, New Brunswick, Ontario and Quebec. It is found in a wide variety of habitats from springs and streams to lakes. The genus contains 13 species and several undescribed species. |  <br>*Marstonia lustrica* (Pilsbry, 1890) |

| General Description | Illustrations |
|---|---|
| ***Notogillia***<br>This genus is has been recorded from Alabama, Georgia and Florida. It is found in streams and rivers. The genus contains two species.<br><br>Image from Thompson, 2000. |  <br>*Notogillia wetherbyi* (Dall, 1885) |
| ***Phreatodrobia***<br>This genus has been recorded from Texas and Alabama. It is found in springs and streams associated with caves. The genus contains ten species. |  <br>*Phreatodrobia micra* (Pilsbry & Ferriss, 1906) |
| ***Pristinicola***<br>This genus has been recorded from California, Idaho, Oregon and Washington. It is found in streams and rivers. Currently only a single species known. |  <br>*Pristinicola hemphilli* (Pilsbry, 1890) |
| ***Probythinella***<br>This genus is found over a wide area of the United States and Canada. It has been recorded from Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Wisconsin, Alberta, Manitoba, Northwest Territories, Nunavut, Ontario, Quebec and Saskatchewan. It is found in a wide range of aquatic habitats from streams to rivers. The genus contains a single widespread species. |  <br>*Probythinella emarginata* (Küster, 1852) |
| ***Pseudotryonia***<br>This genus is found in Alabama, Florida, Nevada, New Mexico and Texas. It is found in saline springs and small streams. The genus contains four species.<br><br>Image from Thompson, 2001. |  <br>*Pseudotryonia grahamae* Thompson, 2001 |
| ***Pyrgophorus***<br>This genus is found in freshwater and estuarine habitats of Texas and Florida in the United States, and extends into Mexico and the Caribbean. In the United States two species are recognised, with several undescribed species known. The two species vary in sculpture from smooth to ribbed and are very similar to the introduced New Zealand *Potamopyrgus antipodarum* but differ in a number of characters in the reproductive anatomy.<br>Image from Thompson, 2000. |  <br>*Pyrgophorus platyrachis* Thompson, 1968 |

| General Description | Illustrations |
|---|---|
| ***Pyrgulopsis***<br>This genus is found across a large part of the western United States. It has been recorded from Arizona, California, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah and Wyoming. It is found in a variety of habitats ranging from small springs to rivers. The genus contains 115 species and several undescribed species. |  <br>*Pyrgulopsis nevadensis* (Stearns, 1883) |
| ***Rhapinema***<br>This genus is found in small streams and rivers of Alabama, Georgia and Florida. Currently only a single species is known.<br><br>Image from Thompson, 2000. |  <br>*Rhapinema dacryon* Thompson, 1969 |
| ***Somatogyrus***<br>This genus is found in small to large rivers on and under stones and rocks. It has been recorded Alabama, Arkansas, Georgia, Florida, Illinois, Indiana, Iowa, Kentucky, Minnesota, Mississippi, Missouri, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and Wisconsin. The genus contains 37 species and several undescribed species. |  <br>*Somatogyrus depressa* (Tyron, 1862) |
| ***Spilochlamys***<br>This genus is found in springs and streams of Georgia and Florida. The genus contains three species.<br><br>Image from Thompson, 2000. |  <br>*Spilochlamys conica* Thompson, 1968 |
| ***Stiobia***<br>This genus is only known from Coldwater Spring, Alabama. Currently only a single species is known. |  <br>*Stiobia nana* Thomson, 1978 |
| ***Stygopyrgus***<br>This genus is only known from a spring in a Cave in Texas. Currently only a single species is known.<br><br>Image from Hershler & Longley, 1986. |  <br>*Stygopyrgus bartonensis* Hershler & Longley, 1986 |
| ***Taylorconcha***<br>This genus is found in springs and rivers around the Lake Idaho, Idaho. Currently only a single species is known. |  <br>*Taylorconcha serpenticola* Hershler, Frest, Johannes, Bowler & Thompson, 1994 |

| General Description | Illustrations |
|---|---|
| ***Tryonia***<br>This genus is found across a wide area of the southern United States. It has been recorded from Arizona, California, Florida, Nevada, New Mexico, Texas and Utah. It can be found in a wide range of habitats from small springs to large rivers. The genus contains 19 species and several undescribed species. |  <br>*Tryonia clathrata* Stimpson, 1865 |

Distribution of Hydrobiidae in North America.

**NOTES:**

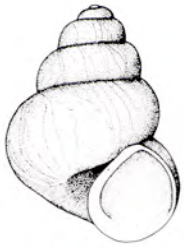
# Assimineidae

**Russ Minton**
**University of Louisiana at Monroe, Monroe, LA**

Assimineids are amphibious snails associated with estuarine, freshwater and terrestrial environments. They have small (<10 mm) ovate to conic shells often with spiral colored bands, threads or grooves. The spire varies from depressed to tall, aperture rounded to ovate and the outer lip is sometimes angled above. The operculum is thin, and paucispiral, sometimes with a thin calcareous layer with a low projection on the inner side. Body (mantle) color is formed from a combination of black dots and whitish to yellowish granules in the skin. The broad snout is usually distinctly cleft anteriorly. This family occurs worldwide in tropical and temperate regions, generally confined to estuarine coastal areas and saline springs. They are mostly nocturnal and negatively phototropic. Assimineids are detrital feeders, feeding on organic matter in the sediments on which they live.

Four species have been recorded from the United States, two from estuarine habitats (*A. californica* and *A. succinea*) and two from small saline springs (*A. pecos* and *A. infima*). *Assiminea pecos* is proposed for listing as federally endangered, it occurs in two spring systems in Texas (Diamond Y) and New Mexico (Bitter Creek). It is threatened by sewage leeching and water use from the springs. *Assiminea infima* is known only from Badwater, a stretch of stagnant water in Death Valley National Park.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Assiminea infima* Berry, 1947 | G1 | | CA |
| *Assiminea pecos* Taylor, 1987 | G2 | C | NM TX |

| General Description | Illustration |
|---|---|
| ***Assiminea***<br>Shell conical, whorls rounded, suture indented, aperture oval, umbilicus open, up to 10 mm in height. Two species are known from springs in Texas, New Mexico and California.<br><br>Image from Taylor, 1987. |  <br>*Assiminea pecos* Taylor, 1987 |

Distribution of Assimineidae in North American**.**

# Neritidae

**Russ Minton**
**University of Louisiana at Monroe, Monroe, LA**

This family of gastropods is common on intertidal rocks and mangroves on tropical and subtropical coasts worldwide, though some occur in brackish water habitats and in freshwater. *Neritina usnea* can be found in brackish environments from Florida west to the gulf coast areas of Texas. *N. clenchi* from Florida, has a small globose black shell with tiny white spots and resembles certain morphs of *N. virginea* and *Puperita pupa*. It is found at the mouth of coastal streams and rivers. However, its taxonomic and distribution statuses are poorly known.

Neritid shells are porcellaneous, heavy, and tend to be globose. The columella is thickened to form a septum or "shelf" that extends across the aperture and may bear teeth, striations or papillae. The operculum is thick and shelly, with a peg-like protrusion on the inner side, which articulates with the septum. Neritids are generally algae grazers, though some brackish and freshwater species are omnivorous. Larval development tends to be temperature dependent, with adults reaching maturity in less than two years. The average life span of neritids is up to five years. Though common across their ranges, neritids are sensitive to both oil and dispersant pollution. In oil, individuals exhibit hyperactivity at low pollutant concentrations, and total immobilization and death as concentrations increase.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Neritina clenchi* Russel, 1940 | GU | | range undetermined |
| *Neritina usnea* (Roding, 1798) | G5 | | AL FL NC |

| General Description | Illustration |
|---|---|
| ***Neritina***<br>Shell globose, yellowish green to olive green, crossed with very thin black lines. Whorls round, smooth, with even sutures. Aperture half-moon shaped with a whitish septum sometimes with two small protrusions. Operculum light grey. Known to occur in brackish areas from Florida west to the gulf coast of Texas. |  <br>*Neritina usnea* (Röding, 1798**)** |

Distribution of *Neritina usnea*.

Distribution of freshwater Neritidae in North America.

# Valvatidae

**Russ Minton**
**University of Louisiana at Monroe, Monroe, LA**

Valvatidae is a family of Holarctic snails that occur in cold, clean lakes and rivers. Shells are small (<8 mm) with short depressed spires, umbilicus and multispiral circular opercula. Unlike other North American prosobranchs valvatids are hermaphroditic egg layers, though selfing is not common. Individuals possess a single feather-like gill on the left side and a single pallial tentacle carried on the right side, both externally visible as the snail crawls. Shells tend to be smooth or with a few (two to three) carinae. Snails are often found in neutral pH waters and are frequently associated with submerged vegetation. Worldwide about 25 species, 11 occur in North America, all in the genus *Valvata*. Many of these are common throughout their range. However, two species, *V. utahensis* and *V. virens*, are imperiled or extirpated. Like other freshwater mollusks generally, these species have experienced declines due in part to habitat and water system modification and decreased water quality due to pollution. *V. piscinalis*, introduced from Europe, occurs in the northeastern United States and southern Canada.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Valvata utahensis* Call, 1884 | G1 | LE | ID UT |
| *Valvata virens* Tryon, 1863 | GH | | CA |
| *Valvata winnebagoensis* Baker, 1928 | G2 | | MI MN WI |

| General Description | Illustration |
|---|---|
| ***Valvata***<br>Shell, with a short to depressed spire, whorls with prominent ribs, or keels, umbilicus wide. Genus widespread throughout North America, 10 species. |  <br>*Valvata tricarinata* (Say, 1817) |

Distribution of Valvatidae in North America.

# Pomatiopsidae

**Russ Minton**
**University of Louisiana at Monroe, Monroe, LA**

This large morphologically diverse family is found primarily in freshwater, with a number of species found in saline springs and lakes, most species are amphibious. This worldwide family of gastropods is freshwater or semi-terrestrial with elongate to low-spired shells and a simple operculum. They have small (<15 mm), conical, to elongated shells. Sculpture varies from smooth to very ornate, with a paucispiral operculum. Pomatiopsids are closely related to the Hydrobiidae, differing mainly in details of the female reproductive system. The cephalic tentacles are short to long, and the eyes have glands above them giving the appearance of "eyebrows." The snout is usually very long. Like many closely related groups, pomatiopsids are likely detritus (dirt) feeders. Females lay single eggs in capsules in sand or mud. Movement is in 'steps', likely how they

received the common name of walkers. Two genera of Asian pomatiopsids are well known first intermediate hosts for blood flukes (*Schistosoma*) and other trematode parasites. They are known to be sensitive to soil and water chemistry, but most studies have been conducted in relation to reducing schistosome transmission in the tropics.

The most common pomatiopsid in North America, *Pomatiopsis lapidaria*, is listed as endangered in some states. The three Pacific coast endemics, *P. binneyi, P. californica* and *P. chacei*, along with *P. hinkleyi* are highly imperiled with global heritage ranks of G1.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Pomatiopsis binneyi* Tryon, 1863 | G1 | | CA OR |
| *Pomatiopsis californica* Pilsbry, 1899 | G1 | | CA OR |
| *Pomatiopsis chacei* Pilsbry, 1937 | G1 | | CA OR |
| *Pomatiopsis cincinnatiensis* (Lea, 1840) | G4 | | IA IL IN KY MI OH TN VA |
| *Pomatiopsis hinkleyi* Pilsbry, 1896 | GX | | AL TN |

| General Description | Illustration |
|---|---|
| ***Pomatiopsis***<br>Shell 6 to 8 mm long, dark brown to chestnut in color with rounded whorls and apparent axial growth lines. Tends to occur in permanent wetlands, living in damp areas along stream sides under leaf litter and other detritus. |  <br>*Pomatiopsis lapidaria* (Say, 1817) |

Distribution of Pomatiopsidae in North American.

**NOTES:**

# Pulmonata

# Lymnaeidae

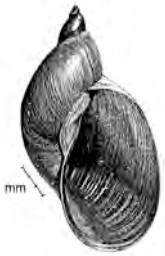
**Jack Burch**
**University of Michigan, Department of Zoology, Ann Arbor, MI**

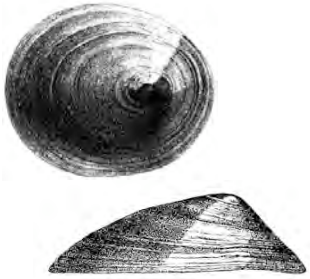
The Lymnaeidae are world-wide in distribution, but their greatest diversity is found in the northern United States and central Canada. Their shells range in shape from the coiled, needle-like *Acella haldemani* (Binney) to the uncoiled, limpet-shaped *Lanx* and *Fisherola*. Lymnaeids with coiled shells are easily distinguished by their dextral shells from the sinistral Physidae (the lone naturally occurring exception in the Lymnaeidae is the sinistral *Pseudisidora producta* (Mighels), which is restricted to Hawaii). No lymnaeids have planispiral shells, which immediately distinguishes them from the North American Planorbidae. The patelliform Lancinae, which occur only in the Pacific drainage region, can be distinguished from the Ancylidae by their larger size, and thicker, sturdier shells.

The tentacles of lymnaeids are broad, flat and triangular, rather than being long, thin and filamentous as in the Physidae, Planorbidae and Ancylidae. Also, in contrast to the Physidae, lymnaeids lack mantle digitions, and in contrast to the Planorbidae and Ancylidae, lymnaeids lack a pseudobranch.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Acella haldemani* (Binney, 1867) | G3 | | IL MI MN NY OH ON QC VT *WI |
| *Fisherola nuttalli* (Haldeman, 1841) | G2 | | BC ID MT OR WA |
| *Fossaria cyclostoma* (Walker, 1908) | GH | | MI NY |
| *Lanx alta* (Tryon, 1865) | G2 | | CA OR |
| *Lymnaea atkaensis* Dall, 1884 | G3 | | AK BC NT YT |

| General Description | Illustration |
|---|---|
| ***Acella***<br>Adult shell medium in size (length 18-25 mm), elongate and narrow, periphery of whorls almost flat-sided, shell without spiral sculpture; aperture elongate, narrow, peristome solute; columella without a plait; periostracum pale horn or tannish-horn to tan. Commonly found on the underwater stems of emergent vegetation (e.g., rushes). *Acella haldemani* is a northern species, found from Vermont and eastern Ontario west to Minnesota. |  <br>*Acella haldemani* (Binney, 1867) |

| General Description | Illustration |
|---|---|
| ***Bulimnea***<br>Adult shell large (length 35-52 mm), bulimoid, spiral sculpture moderate or nearly absent; shell surface often with noticeable transverse surface undulations; aperture ovate, adnate; columellar plait modest; periostracum tannish-brown to olive-brown. Found in quiet water in swamps, ditches, ponds, and shallow protected backwaters of lakes and rivers. *Bulimnea megasoma* is a northern species, occurring in Canada to northern USA (Great Lakes and St. Lawrence drainage area). |  <br>*Bulimnea megasoma* (Say, 1824) |
| ***Fossaria***<br>Adult shell small to (rarely) medium (3-13 mm), turreted, nearly always without spiral striae and without a columellar plait; periostracum horn, tan or brown. Found throughout North America, commonly on mud flats just above the water line, or on debris at the water's edge. *Fossaria galbana* lives in lakes. |  <br>*Fossaria cyclostoma* (Walker, 1908) |
| ***Lymnaea***<br>Adult shell large (usually) to medium (seldom) (length 30-53 mm), thin and fragile, spire long and narrow; columella with a strong plait; periostracum horn to tannish-horn. *Lymnaea stagnalis* is Holarctic in distribution. In the Western Hemisphere it is a northern species that lives in a variety of habitats, including large lakes, swamps and small spring-fed ditches. |  <br>*Lymnaea stagnalis* (Linnaeus, 1758) |
| ***Pseudosuccinea***<br>Adult shell medium in size (length 10-22 mm), succiniform (i.e., *Succinea*-like), having a thin and fragile shell that has a large oval body whorl and shell aperture, and a small spire. The surface sculpture consists of microscopic, spiral, raised, periostracal striae - nearly unique in the Lymnaeidae. Periostracum yellowish-horn to olive-tan. The head, foot and mantle vary from light yellow to black. *P. columella* has been introduced into distant lands, where it has become a ready intermediate host for the liver fluke, *Fasciola hepatica.* |  <br>*Pseudosuccinea columella* (Say, 1817) |
| ***Stagnicola***<br>Adult shell medium to large in size (length 16-40 mm) elongate, spirally striate; columellar plait well developed; periostracum horn or tan to dark brown. *Stagnicola* is the most speciose of the North American lymnaeids, occupying both lotic and lentic environments. The shell surface of *Stagnicola caperata* - like *Pseudosuccinea columella* - has microscopic, spiral, raised periostracal striae. *Stagnicola* is Holarctic in distribution, and in the Western Hemisphere it has a northern and western distribution. It is not found in the southeastern and southwestern states. |  <br>*Stagnicola elodes* (Say, 1821) |

| General Description | Illustration |
|---|---|
| ***Fisherola***<br>Adult shell small (length 5-8 mm), patelliform (limpet-shaped, cap-shaped, ancyliform). Early descriptions of *Fisherola nuttalli* assigned it to the genus *Ancylus* because of its limpet-shaped shells. However, later studies showed these freshwater limpets to be lymnaeids. *Fisherola* is found in rivers in Idaho, Washington and Oregon. *Fisherola* differs from *Lanx* by the eccentric position of its apex. |  <br>*Fisherola nuttalli* (Haldeman, 1841) |
| ***Lanx***<br>Adult shell patelliform, medium in size (length 11-18 mm); apex nearly centrally placed; periostracum brown to reddish-brown. Early descriptions of species of *Lanx* assigned them to the genus *Ancylus* because of their limpet-shaped shells. However, the radulae are lymnaeid-like rather than ancylid-like, and a subsequent anatomical study (Baker, 1925) showed these small freshwater limpets to be lymnaeids. *Lanx* is found in rivers in California and Oregon. |  <br>*Lanx patelloides* (Lea, 1856) |

Distribution of Lymnaeidae in North America.

**NOTES**:

# Physidae

**Stephanie Clark & Kathryn E. Perez**
**University of Alabama, Tuscaloosa, AL**

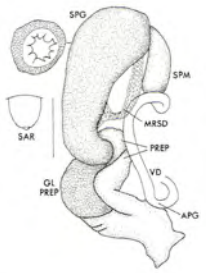
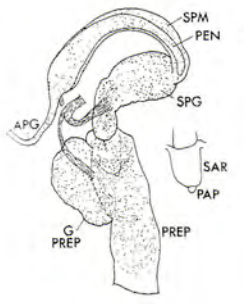
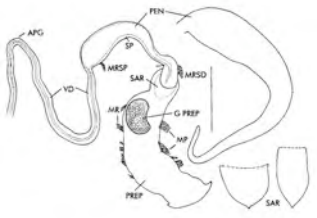
This family has a mainly Holarctic distribution, but is also found throughout middle and central America, the Caribbean and as far south as Argentina. This group is found in a wide variety of habitats, both permanent and temporary, from small springs to large lakes, and they tend to favor the slow to still moving water. A few species, for example *Haitia* (=*Physella*) *acuta* has been widely introduced around the world. It is a habitat generalist and can thrive in a variety of environments from ditches to glacial lakes and can tolerate a wide range of water quality. Frequently the group makes up a significant component of the lentic aquatic fauna.

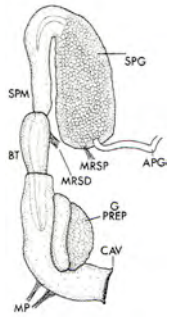
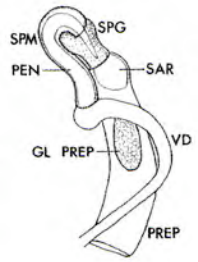
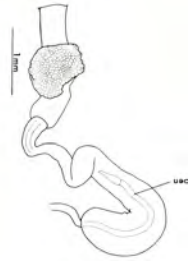
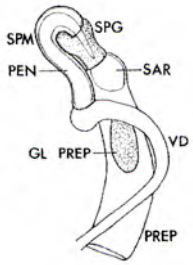
Due to the lack of distinctive shell characters, the taxonomy of the group both at the species and generic level has been unstable. The most recent treatment of this family is D. W. Taylor's "Introduction to the Physidae (Gastropoda: Hygrophila) biogeography, classification, morphology" (2003). This work relies largely on anatomical characters and recognizes two subfamilies, Aplexinae and Physinae, with 23 genera and about 80 species worldwide. In the United States and Canada Taylor recognizes 9 genera and at least 34 recognized species. Taylor's monograph provides an important anatomically-based classification scheme for future systematic studies to evaluate and test further. Taylor's (2003) classification differs markedly from that proposed by Te in 1980 and subsequently followed by Burch in his series of publications on North American freshwater molluscs, by the recognition of a number of new genera. This workbook incorporates (in parentheses) the most recent taxonomic work however; we place the more familiar generic names according to Burch.

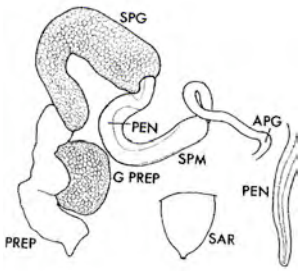
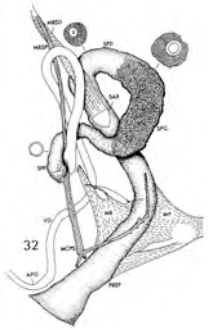
The shell morphology varies from tall and narrow to broad and globose, with typically smooth shells (the exception is *Costatella* with raised ridges) and often have a polished appearance. The group ranges in size from about 5 mm to over 20 mm in height and / or diameter. It is known that for some species, shell shape can be varied according to the environmental conditions to which it is exposed. All species are hermaphroditic and are capable of self-fertilization. The group has a number of attributes that make them an ideal study species. As they are very easy to maintain in the laboratory, have a short life cycle and reproduce very easily.

Names in parentheses are the names in Burch.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Archiphysa* (=*Physella*) *lordi* (Baird, 1863) | G5 | | AB BC CA ID MT NV OR *UT WA |
| *Costatella* (=*Physella*) *costata* (Newcomb, 1861) | G1 | | CA |
| *Petrophysa* (=*Physella*) *zionis* (Pilsbry, 1926) | G2 | | UT |
| *Physella johnsoni* (Clench, 1926) | G3 | | AB CO MT WY |
| *Physella vinosa* (Gould, 1847) | GU | | MI MN MT NY ON WI |

| General Description | Illustration | Penial morphology |
|---|---|---|
| ***Archiphysa (=Physella)*** Shell obovate, with very short, broad spire, and a dull appearance. This genus is sporadically distributed across the United States and Canada and is found predominately in lake habitats. The genus contains seven species. Figure on right Taylor, 2003. |  *Archiphysa lordi* (Baird, 1863) |   *A. lordi* (Baird, 1863) |
| ***Beringophysa (=Physa)*** Shell narrow oval in shape, with a dull appearance and fine spiral microsculpture, up to 9 mm in height. This genus is found from central Siberia to Alaska and northern Canada. Currently only a single species is known. |  *Beringophysa jennessi* (Dall, 1919) | |
| ***Costatella (=Physella)*** This genus is sculptured with prominent axial ribs and has a dull appearance. The genus is only known from a few lakes in California. Currently only a single species is known. Figure on right Taylor, 2003. |  *Costatella costata* (Newcomb, 1861) |   *C. costata* (Newcomb, 1861) |
| ***Haitia (Physella in part, Physa in part)*** Shell narrow to broad, spire tall, suture strongly impressed, appearance dull not glossy, up to 20 mm in height. The genus is widely distributed across the United States and Canada and extends into central America and the Caribbean. It is found in a wide variety of aquatic habitats. *Haitia acuta* has been widely introduced around the world. The genus contains at least 15 species, with four species recorded from the United States and Canada. Figure on right Taylor, 2003. |  *Haitia acuta* (Draparnaud, 1805) |   *Haitia cubensis* (Pfeiffer, 1839) |

| General Description | Illustration | Penial morphology |
|---|---|---|
| ***Laurentiphysa (=Physa)***<br>Shell narrow oval to oval, appearance dull to shinning, with fine spiral microsculpture, up to 11 mm in height. The genus is found in the eastern United States and Canada. It is found in small ponds and lakes. The genus contains two species.<br><br>Images from Taylor, 2003. |  <br>*Laurentiphysa vernalis* Taylor & Jokinen, 1985 |  <br>*Laurentiphysa chippevarum* Taylor, 2003 |
| ***Petrophysa (=Physella)***<br>Shell globose, spire short, aperture wide, appearance dull, up to 5mm in height. This genus is known only from Zion National Park, Utah, where it lives on wet vertical walls, under waterfalls. Currently only a single species is known.<br><br>Figure on right Taylor, 2003. |  <br>*Petrophysa zionis* (Pilsbry, 1926) |  <br>*P. zionis* (Pilsbry, 1926) |
| ***Physa***<br>Shell oval to elongated oval in shape, and have a glossy, polished appearance and fine spiral sculpture, up to 12 mm in height. The genus has a Holarctic distribution, and is found widely throughout the United States and Canada. The genus contains nine species with two recorded from North America.<br><br>Figure on right Taylor, 2003. |  <br>*Physa skinneri* Taylor, 1954 |  <br>*P. skinneri* Taylor, 1954 |
| ***Utahphysa* (=*Physella*)**<br>Shell narrowly oval, up to 18 mm in height. The genus is only known from Fish Lake, Utah. Currently only a single species is known. However, recent molecular data (Wethington unpublished) does not support the recognition of this genus.<br><br>Figure on right Taylor, 2003. |  <br>*Utahphysa microstriata* (Chamberlin & Berry, 1930) |  <br>*U. microstriata* (Chamberlin & Berry, 1930) |

| General Description | Illustration | Penial morphology |
|---|---|---|
| ***Physella***<br>Shell oval to elongated oval, with a dull to silky appearance but not polished or glossy, up to 25 mm in height. The genus is found throughout the United States and Canada and can be found in a wide variety of aquatic habitats. The genus contains seven species.<br><br>Figure on right Taylor, 2003. |  <br>*Physella gyrina* (Say,1821) |  <br>*Physella ancillaria* (Say, 1825) |
| ***Sibirenauta (=Aplexa)***<br>Shell elongated, smooth and glossy, up to 20 mm in height. The genus is distributed from Siberia to the northern United States and is typically found in temporary pools and ditches. Two species have been recorded from the United States and Canada.<br><br>Figure on right Taylor, 2003. |  <br>*Sibirenauta elongatus* (Say, 1821) |  <br>*S. elongatus* (Say, 1821) |

Abbreviations for morphology figures: SPG, glandular portion of penial sheath; SPM, muscular portion of penial sheath; MRSD, distal retractor muscle of penial sheath; PREP, preputium; VD, vas deferens; APG, paragonoporal angle; GLPREP, preputial gland; SAR, sarcobelum; PAP, papilla; GPREP, preputial gland; PEN, penis; MRSP, proximal retractor muscle of penial sheath; MP, protractor muscle of preputium; MR, retractor muscle of preputium; BT, terminal bulb; CAV, wall of body cavity.


Distribution of Physidae in North America.

**NOTES:**

# Planorbidae

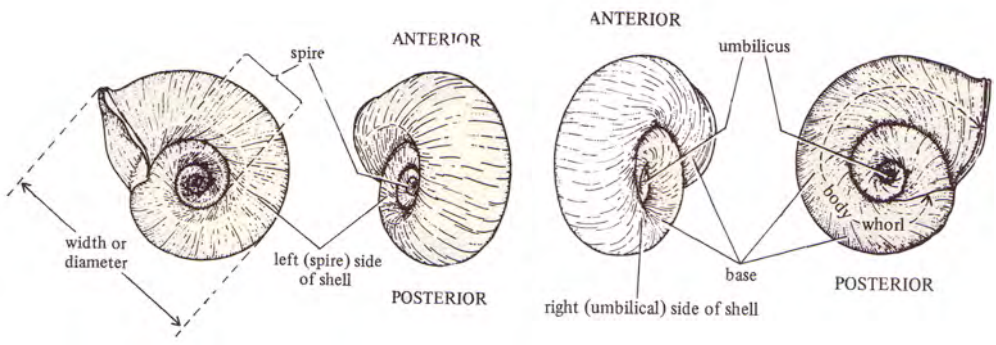
**Kathryn E. Perez**
**University of Alabama, Tuscaloosa, AL**

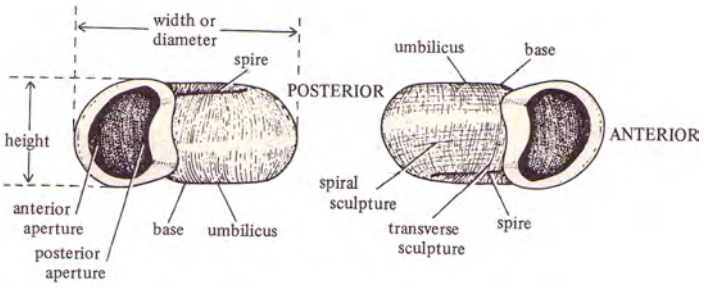
The Planorbidae are a large morphologically diverse group found throughout the world. They are found in a wide variety of habitats, both permanent and temporary, from springs to large lakes, with some group preferring fast flowing water while most prefer slower flowing to still waters. They tend to occur in bodies of water with a firm mud bottom, with high levels of decaying organic matter. Most species seem to prefer lakes or ponds. With the exception of *Helisoma anceps* which occurs more often in river pools, they prefer minimal current. They have been shown to eat bacterial films and algae.

Several genera are significant both medically and economically as intermediate hosts for schistosomatid trematode worms and have been studied extensively. Our understanding of the relationships among the genera within the Planorbidae is rudimentary and based on internal anatomy and shell morphology. Most genera have received relatively minor attention, and systematic relationships are uncertain. Few of the North American species have been studied to the extent that their taxonomy, geographic distributions, life histories, and ecology are documented. In a recent phylogenetic work on the family, two representatives of the family Ancylidae fall within the Planorbidae highlighting the need for further analysis and possible reclassification of this group.

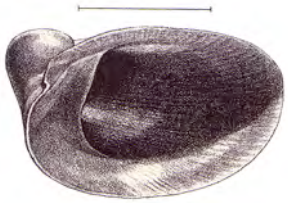
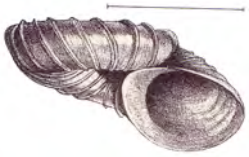
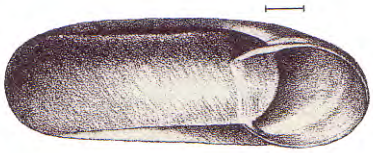
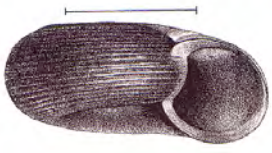
These snails, although aquatic, are lung breathers. Gills are lacking; instead there is a large pulmonary sac for gaseous exchange; a pseudobranch or false gill is located near the pneumostome or anus. The haemolymph in nearly all species is red due to the presence of haemoglobin. The Planorbidae are coiled in one plane, i.e., they are planispiral, a characteristic from which the family name is derived. Shell is discoidal, with a sunken spire. They range in size from 1 mm to 30 mm in diameter.

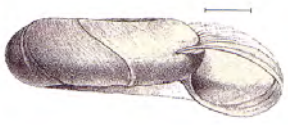
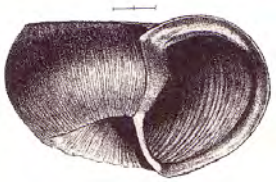
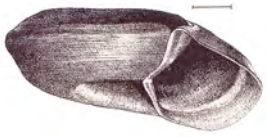
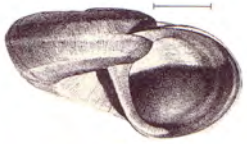
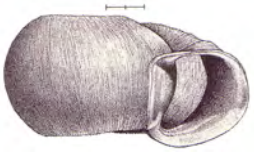
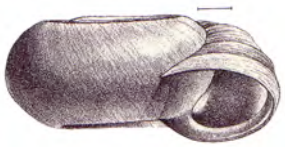
**Planorbidae shell morphology**

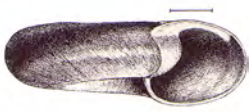





| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Amphigyra alabamensis* Pilsbry, 1906 | GX | | AL |
| *Helisoma newberryi* (Lea, 1858) | G1 | | CA ID NV OR UT WY |
| *Menetus opercularis* (Gould, 1847) | G5 | | AB AK *BC CA MT OR *UT WA |
| *Micromenetus alabamensis* (Pilsbry, 1895) | G2 | | NC |
| *Neoplanorbis carinatus* Walker, 1908 | GX | | AL |

| General Description | Illustration |
|---|---|
| ***Amphigyra***<br>Shell minute, crepiduliform in shape, i.e., limpet-like shape with a small coil at the apex, adults <2 mm in diameter, *Amphigyra alabamensis*, Coosa River, Alabama. Now extinct. |  <br>*Amphigyra alabamensis* Pilsbry, 1906 |
| ***Armiger***<br>Monotypic, small shells, adults >8 mm in diameter, shell heavily ribbed (costate). Holarctic in distribution. |  <br>*Armiger crista* (L. 1758) |
| ***Biomphalaria***<br>Shell planispiral, thin and fragile, body whorl depressed, up to 20 mm in diameter. The genus has a wide distribution in the Caribbean, Central and South America. The genus contains several species, with two recorded from the United States. One native (*B. havanensis*) the other introduced (*B. glabrata*). *B. glabrata* occurs in the West Indies, Venezuela to Brazil and was introduced to Florida, shell medium-sized >15 mm in diameter, , that of adults with 5 or more whorls *B. havanensis*, occurs naturally in FL, LA, AZ, Mexico, Central America, Cuba, Puerto Rico, shell small <10 mm diameter, with 5 or more whorls. |  <br>*Biomphalaria havanensis* (Pfeiffer, 1839) |
| ***Drepanotrema***<br>Shell between 2-8 mm diameter, not costate. Shell flattened and multi-whorled, Florida, Texas and southern Arizona. *D. aeruginosum* shell not extremely flattened, with fewer rapidly enlarging whorls, sculptured with numerous, low lirae, Southern Arizona, Texas. *D. kermatoides* without lirae, having a strongly keeled periphery, Florida, Texas; *D. cimex* without lirae, having shell periphery rounded or obtusely angular, southern Texas. 3 species in the US. |  <br>*Drepanotrema aeruginosum* (Morelet, 1851) |

| General Description | Illustration |
|---|---|
| ***Gyraulus***<br>The genus is worldwide in distribution. Shell small, 2-8 mm diameter, spire height varying from high to flattened or depressed, spire pit shallow and wide, height of body whorl equal across the whorl. *G. deflectus* is highly variable: may have slight keel to periphery of body whorl or a hirsute periostracum or a malleated surface; only *Gyraulus* species with these shell-sculptures. *G. hornenesis* has a high spire. *G. circumstriatus* shell whitish or yellowish, semi-transparent, nearly planispiral (appearing almost the same from both sides), found in aquatic habitats that periodically dry. *G. parvus* has a brownish shell, translucent, not planispiral, found in more permanent aquatic habitats. |  <br>*Gyraulus deflectus* (Say, 1824) |
| ***Helisoma***<br>Shell spire strongly inverted, with a more or less deep conical depression; spire side of body whorl may have a strong keel, body whorl without lamellae or teeth, shell thicker, usually solid, shell between 8-14 mm. *H. anceps*, shell with no colored spiral bands, basal carina variously developed. |  <br>*Helisoma anceps* (Menke, 1830) |
| ***Menetus***<br>One species, *M. opercularis*, has a western distribution. Shell with carinate periphery, spire pit relatively deep and narrow, shell flattened, but not extremely so, not multi-whorled, without spiral ridges or costae, shell very compressed, body whorl relatively flattened; aperture or body whorl without teeth or lamellae, periphery of body whorl angular or subangular shell between 2-8 mm. |  <br>*Menetus opercularis* (Gould, 1847) |
| ***Micromenetus***<br>Shell with carinate or angular periphery, spire pit relatively deep and narrow, shell flattened, not multi-whorled; usually with a peripheral carina, without spiral lines or costae, aperture or body whorl without teeth or lamellae, shell <4 mm, aperture relatively large compared with body whorl. |  <br>*Micromenetus dilatatus* (Gould, 1841) |
| ***Neoplanorbis***<br>Shells minute, <2 mm, with a flatten spire, wide ovate aperture and open umbilicus. This distinctive genus has only been recorded from a short section of the Coosa River, Alabama. It is found on and under rocks. The genus contains four species, which are presumed to be extinct. |  <br>*Neoplanorbis tantillus* (Pilsbry, 1906) |
| ***Planorbella***<br>This genus is morphologically diverse, varying widely in size, shape and sculpture, 4-30 mm in diameter. Spire not strongly inverted, with either a shallow depression, no depression or everted; spire side of body whorl rounded or angular. Shell relatively thick, not fragile. |  <br>*Planorbella campanulata* (Say, 1821) |
| ***Planorbula***<br>Body whorl moderately high; inside aperture or body whorl with teeth or lamellae. *P. armigera*, shell between 2-8 mm, lower palatal lamellae in last whorl prominent. *P. campestris*, shell larger up to 20 mm, shell thin, fragile, periphery rounded with slight lower palatal lamellae, spire not inverted as in *Biomphalaria*. |  <br>*Planorbula armigera* (Say, 1821) |

| General Description | Illustration |
|---|---|
| ***Promenetus***<br>Shell flattened, not multi-whorled, without spiral lines, spire pit relatively deep and narrow, aperture without teeth or lamellae, shell 2-8 mm in diameter. *P. exacuous*, periphery of body whorl, carinate, relative height of body whorl nearly equal from one side to the other. *P. umbilicatellus*, periphery of body whorl rounded. |  <br>*Promenetus umbilicatellus* (Cockerell, 1887) |
| ***Vorticifex***<br>Shell large, 8-30 mm in diameter, with few, rapidly increasing whorls and wide rounded aperture. Shell thick and relatively solid. |  <br>*Vorticifex effusa* (Lea, 1856) |

Distribution of Planorbidae in North America.

**NOTES**:

# Ancylidae

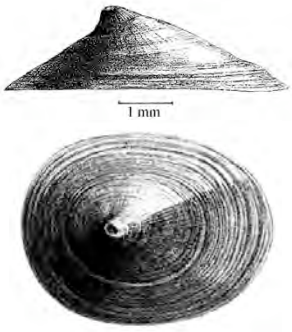
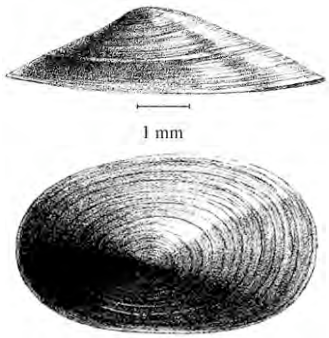
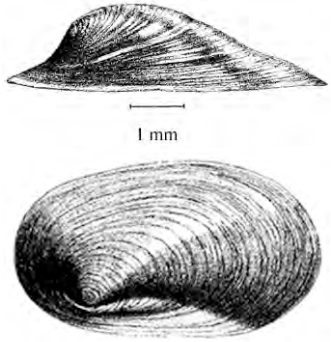
**Andrea Walther**
**University of Michigan, Department of Zoology, Ann Arbor, MI**

Ancylids have a worldwide distribution, being found in a wide range of habitats from small streams to large lakes, representatives of the family may be found on every continent, covering a wide expanse on each. The vast range of ancylids is the result of both natural dispersal and, in some cases, human, avian, or insect contributions to passive transport of the animals. The exact number of species in Ancylidae has yet to be resolved, partly because the tiny specimens are difficult to identify confidently without the aid of scanning electron microscopy (SEM) for looking at features of the shell surface. Additionally, it is difficult to discern what observable variations are characteristics of different species and which just constitute individual variation. Molecular techniques are currently being utilized to help distinguish between and among species.

A flattened, cap-shaped shell characterizes members of this family, comprised entirely of freshwater limpets. Generally ranging from just a couple of millimeters up to approximately 8 millimeters in length as adults, these small gastropods are often overlooked in the freshwater environment. In rivers and streams, ancylids are most commonly found attached to the undersides of rocks or debris with hard, smooth surfaces. Because of their brown or horn-colored shells, they often are camouflaged with the substrate, and even on overturned rocks they may be difficult to see. In lakes, ancylids tend to dwell on the stems of aquatic vegetation and on the undersides of water lilies and dead leaves. For those that live on the stalks of plants, as is common in the case of *Ferrissia parallela*, it has been observed that the outline or shape of the shell may conform to that of the surface on which they live.

The patelliform shape of ancylids is believed to have evolved from sinistrally coiled ancestors more than once as a response to living in turbulent habitats and possibly for increased protection from predators. Ancylids themselves are therefore sinistral, with the pseudobranch and all major body openings located on the left side of the animal. Morphological studies and molecular data reveal that ancylids are closely related to planorbids, but unlike their close relatives, freshwater limpets lack hemoglobin in their blood, instead having hemocyanin or lacking blood pigment altogether.

| Taxa | G-rank | Listed | Distribution |
|---|---|---|---|
| *Ferrissia mcneili* Walker, 1925 | G2 | | AL FL |
| *Hebetancylus excentricus* (Morelet, 1851) | G5 | | AL FL GA LA *MS OK TX |
| *Laevapex peninsulae* (Pilsbry, 1903) | G5 | | FL |
| *Rhodacmea filosa* (Conrad, 1834) | GH | | AL |
| *Rhodacmea hinkleyi* (Walker, 1908) | GU | | AL IL IN KY TN |

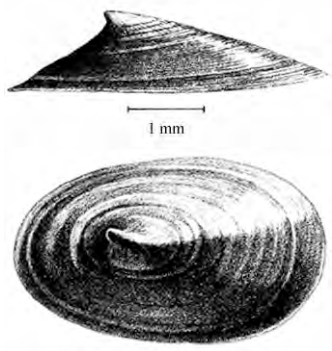
| General Description | Illustration |
|---|---|
| ***Ferrissia***<br>The most widespread of the freshwater limpets, *Ferrissia* may be identified by distinct radial striae on the shell apex. Concentric growth rings are present from the apex to the margin of the adult shell. Shell shape varies slightly from one species to the next, with some more ovate and others narrower with nearly parallel sides. In *Ferrissia*, as in most ancylids, the apex is generally located just to the right of the midline and is slightly closer to the posterior end of the animal. The pseudobranch of *Ferrissia* has a single lobe and the male genitalia possesses a flagellum. The range of *Ferrissia* extends across the United States and up into southern Canada. |  <br>*Ferrissia rivularis* (Say 1817) |
| ***Rhodacmea***<br>Members of this genus may be distinguished from all other ancylids by their indented, pink, prominently striate apex. Strong radial striations extend down to the margin of the oval, rather highly elevated shell. Though few morphological studies have been completed on the soft anatomy of *Rhodacmea*, dissections of *R. elatior* reveal a simple penis lacking a flagellum. A unique radular structure has also been observed in this genus. Damming and pollution of rivers in the southeast United States threaten *Rhodacmea* populations, but nonetheless they are believed to occur in Alabama and possibly in surrounding states. |  <br>*Rhodacmea hinkleyi* (Walker 1908) |
| ***Laevapex***<br>The shell of *Laevapex* is ovate with conspicuous concentric growth lines and sometimes fine, radiating riblets along the surface. The shell may be circular or elliptical in shape and is not highly elevated. Exact placement of the apex may vary slightly from one species to the next, but it is generally located just right of the midline and towards the posterior end of the shell. The color of the shell is generally a darker brown than that of *Ferrissia*. *Laevapex* has a two-lobed pseudobranch, and the penis lacks a flagellum. The tentacles and mantle of members of this genus are oftentimes covered to some degree with black pigmentation. Having the second widest distribution of the ancylids in North America, its range encompasses much of the eastern half of the continent. |  <br>*Laevapex fuscus* (Adams 1841) |
| ***Hebetancylus***<br>The most conspicuous feature of the shell in *Hebetancylus* is the location of the apex far to the right of the midline. The shell is widely ovate, and its surface displays prominent concentric growth lines and only faint radial lines at the apex. Like *Laevapex*, *Hebetancylus* has a two-lobed pseudobranch, but the male genitalia has a flagellum. *Hebetancylus excentricus* is found along the edge of the southeastern United States, from Florida to Texas. Its range extends down along the east coast of Mexico and Central America and into northwestern South America. |  <br>*Hebetancylus excentricus* (Morelet 1851) |

Distribution of Ancylidae in North America.

# Acroloxidae

**Andrea Walther**
**University of Michigan, Department of Zoology, Ann Arbor, MI**

This family has a mainly Eurasian distribution and is found mostly in lakes, particularly ancient ones such as Lake Baikal and Ohrid. The family is unique among freshwater limpets as it has a dextral organization while the Ancylidae are sinistral. In North America the group is represented by a single species (Acroloxus coloradensis) found in a few localities in the Rocky Mountains and Quebec and Ontario.

| General Description | Illustration |
|---|---|
| ***Acroloxus***<br>Though not an ancylid, *Acroloxus* is useful for comparative purposes. Unlike all of the ancylids which are "left-handed," *Acroloxus* is an example of a "right-handed" or dextral freshwater limpet, with its apex to the left of the median line. Also noteworthy is that the apex is very acute and comes to a sharp point angled to the left. Aside from concentric growth lines, these limpets are clearly radially striate from apex to margin. *Acroloxus coloradensis* is known from a few localities in Colorado and Canada. |  <br>*Acroloxus coloradensis* (Henderson 1939) |

NOTES:

# Non-Native Freshwater Gastropods

David C. Campbell
University of Alabama, Tuscaloosa, AL

Several freshwater gastropod species have been introduced to North America, either accidentally or deliberately. In addition, some native species now occur outside their original ranges. Many of these species are mentioned in the discussion of their respective families, but some introduced taxa do not belong to native families.

These species have arrived by several means. A few were deliberately imported for food. The aquarium trade is responsible for both deliberate and accidental import of snails. Other species have arrived as stowaways on boats or in cargo. Within North America, species have spread as a result of human changes, such as, canals and habitat modification.

Introduced species may pose numerous threats. *Marisa cornuarietis* (Linnaeus, 1758) may prey on smaller snails, but most freshwater gastropods are strictly herbivorous. Introduced species often compete with native species, and can produce at least local extinction. Gradual increases in invasive populations may eventually eliminate native species, even when no impact is evident for decades. This gradual risk makes long-term monitoring critical. Most successful invasives do well in human-impacted habitats, though they may also invade pristine areas. Species that are capable of tolerating a wide range of habitats, are much more likely to become established. Impact on native species can have a cascading effect up the food chain. For example, the introduction of South American ampullariids which compete with the native apple snail may pose a threat to the snail kite, a specialized predator on the native species.

Many introduced snail species serve as intermediate hosts for parasites. These may pose a threat to humans, to commercially important species such as livestock or edible fish, and native wildlife, including molluscs. The most notorious example is schistosomiasis, carried by *Biomphalaria* species. However, numerous other parasites are known from invasive gastropods. To note just a few, the Asian lymnaeid *Fossaria viridis* (Quoy & Gaimard, 1832) hosts cattle liver flukes in several Pacific islands, including Hawaii. *Melanoides tuberculatus* (Müller, 1774), a widely introduced species, hosts fish parasites that threaten both aquacultured and wild fish in Texas and Mexico, and *Bithynia tentaculata* (Linnaeus, 1758) hosts an introduced parasite that kills native waterfowl.

*Pomacea canaliculata* (Lamarck, 1828), the channeled apple snail, is a South American species widely introduced in warm climates worldwide through the aquarium industry and through misguided efforts at aquaculture or aquatic weed control. Although some populations (possibly distinct species within a complex) will feed on weeds, especially if not given a choice, all varieties appear fond of rice and taro. As a result, they are major agricultural pests and are banned from several states, yet they are available through the aquarium industry. An additional problem is the difficulty of distinguishing this from

algae-eating species of *Pomacea*, some of which are very popular in the aquarium trade as "mystery snails" and one of which is native to Florida.

Some invasive species may reach enormous population densities, causing problems for municipal water supplies and other human water use. *Bithynia* was nicknamed the "faucet snail" because they were so abundant as to come out of taps in Chicago in the early 1900's. *Bellamya*, the thiarids, and *Potamopyrgus* likewise may form extremely dense populations, and thus are potential nuisances for water intakes.

## Identification

Identification of many species can be difficult, and in some cases it is not entirely clear what species are present. However, invasives should be relatively easy to distinguish from native species in most cases. Major invasive taxa in North America are discussed below. Species from Hawaii or Puerto Rico, species that have been found but are not established in North America, and native species that have spread within North America are listed in Table 1. For more information on the families and on native species, see the respective chapters in this volume.

Several publications provide good descriptions of invasive species and Robinson has provided a list of non-native species nationwide, as of 1999. Many additional references deal with regional faunas or particular species and genera. Useful online sources include NatureServe (faunal lists and distribution), the Gulf States Marine Fisheries Commission "non-native aquatic species summaries" at http://nis.gsmfc.org/nis_alphabetic_list.php (confusingly, the mollusks are divided between "invertebrates" and "mollusks", and include terrestrial species and native species), the USGS nonindigenous aquatic species site at http://nas.er.usgs.gov/default.asp, and many others.

## Viviparidae

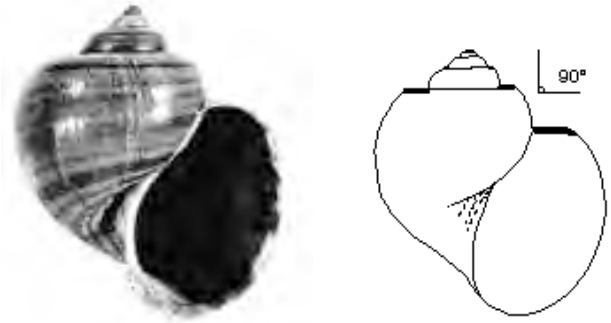
Two species of viviparids were introduced near 1900 from Asia for human consumption. Most references cite them as the genus *Cipangopaludina*; however, Smith (2000), in the most recent review, assigned them to *Bellamya*. Smith (2000) showed that there are two species present and questions the recognition of subspecies in the North American populations due to probably mixed origins. One native species has invaded new areas in North America, and other non-native species have been intercepted in shipments entering the U.S., but are not known to have established populations (Table 1).

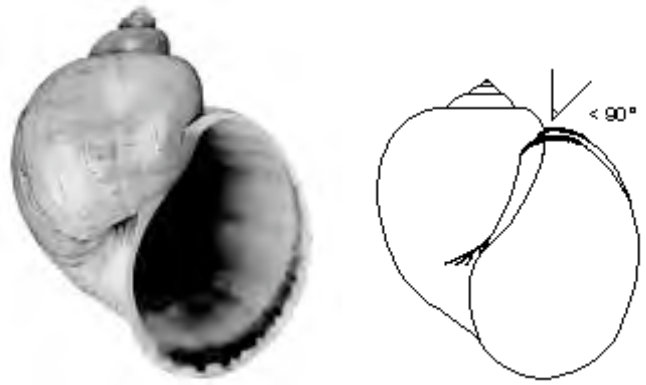
| General Description | Illustration |
|---|---|
| Chinese mysterysnail. Differs from *B. japonica* in its wider shape and loss of carination at about 35 mm length. Shells over about 45 mm are very similar. Form of the juvenile shell, periostracum sculpture, and anatomical details also differ. Both species differ from native viviparids in their large size (over 35 mm), relatively thin shells, and lack of a well-developed shoulder on the whorls.<br><br>Image from Thompson, 2000. |  <br>*Bellamya chinensis* (Gray, 1817) |

| General Description | Illustration |
|---|---|
| Japanese mysterysnail. Proportionally narrower than *B. chinensis*. |  *Bellamya japonica* (von Martens, 1861) |

## Ampullariidae

This family includes several popular aquarium snails and is commonly referred to as either apple snails or mystery snails. *Pomacea paludosa* is native to Florida but is introduced elsewhere, including Hawaii, Puerto Rico, and isolated warm-water locations in the continental U.S., and several species have been intercepted (Table 1). Identification of invasive species is somewhat problematic, and there may be several species complexes involved, but the native species is readily distinguished from the invasives. Two genera are established in the U.S. An excellent guide to the family is available online at http://www.applesnail.net/.

| General Description | Illustration |
|---|---|
| Giant rams-horn. This species superficially resembles a giant planorbid. However, the large size (over 50 mm maximum), frequent stripes, and presence of an operculum easily distinguish it from planorbids.<br><br>Images from Thompson, 2000. |  *Marisa cornuarietis* (Linnaeus, 1758) |
| Spiketop applesnail. This is the standard "mystery snail" of the aquarium trade, available in many color forms. The shoulders of the whorls are relatively flat, with a relatively tall spire. It eats algae and thus does not pose an agricultural threat, unlike *P. canaliculata.* Up to 60 mm Figure: *Pomacea bridgesii*: flat shoulders and 90° sutures. The flat shoulder, however, becomes less apparent in the last whorls of the shell.<br>Images from Thompson, 2000 (l) and Ghesquiere, 2000 (r). |  *Pomacea bridgesii* (Reeve, 1856) |

| General Description | Illustration |
|---|---|
| Channeled applesnail. This species is available through the aquarium trade and is widely introduced in tropical areas. The suture is channeled. Up to 100 mm.<br>Figure: *Pomacea canaliculata* group (includes *P. haustrum*): indented sutures, less than 90°angle. This shell is rounder than the *Pomacea bridgesii* shell.<br><br>Images from Thompson, 2000 (l) and Ghesquiere, 2000 (r). |  <br>*Pomacea canaliculata* (Lamarck, 1828) |
| Titan applesnail. Very similar to *P. canaliculata*; tends to have a higher, less rounded shell. Like *P. canaliculata*, it eats aquatic macrophytes.<br><br>Image from Alderson, 1925. |  <br>*Pomacea haustrum* (Reeve, 1858) |
| Florida applesnail. This species is native to Florida but may be a problem when introduced elsewhere (including Hawaii and Puerto Rico). It has a very low spire slope compared with the introduced *Pomacea* spp. Like *P. bridgesii*, it eats algae. Up to 70 mm.<br>Figure: *Pomacea paludosa*: Almost flat sutures with an over 90° angle, which gives the snail a low, cone shaped spire.<br>Images from Thompson, 2000 (l) and Ghesquiere, 2000 (r). |  <br>*Pomacea paludosa* (Say, 1829) |

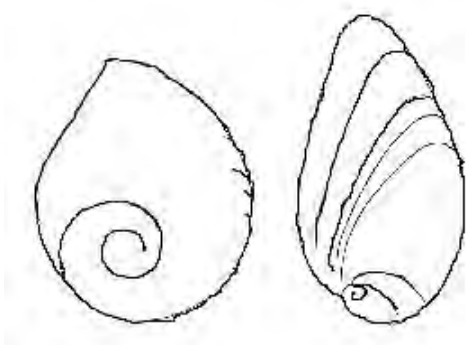


**Figure 7**. Operculae. Thiaridae (right) and Pleuroceridae (left). Images from Thompson, 2000.

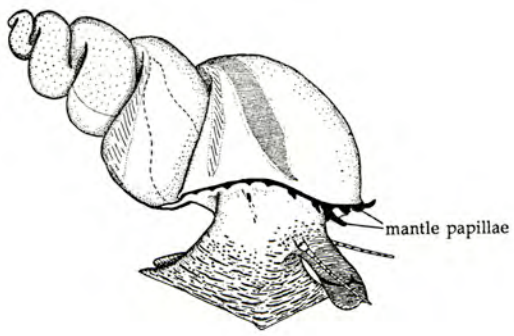



**Figure 8**. Showing position of thiarid mantle papillae.
Image modified from Burch, 1988.

# Thiaridae

Members of Thiaridae resemble some of the native Pleuroceridae such as *Pleurocera* and *Elimia*. However, the operculum is quite different, with a large, more central nucleus in the pleurocerids (Figure 7, left) and a small, nearly marginal nucleus in the thiarids. Thiarids also have papillae on the mantle edge (Figure 8) and distinctive anatomy. The shell sculpture of *Tarebia* is distinctive, but that of *Melanoides* is more similar to that of some native pleurocerids (see figures). The invasive thiarids are more tolerant of pollution and still water than are most pleurocerids. Taxonomy of thiarids is problematic. Species are generally variable, and largely parthenogenetic, so variant morphologies may easily be established. The invasive populations represent several independent lineages and multiple invasions, with multiple morphotypes. New morphologies can be generated by crossing between lineages. At least three species are established in the North American mainland. Additional taxa in Table 1, including those in Hawaii, may merely represent forms of a few species rather than multiple species, but resolving this question will require extensive sampling of populations throughout the Old World tropics.

Thiarids are popular aquarium snails and have also been introduced for biological control of schistosomiasis hosts because they out compete *Biomphalaria* spp. However, they can host the human lung fluke and other parasites. They can become extremely abundant and compete with native snails.

| General Description | Illustration |
|---|---|
| Red-rim melania. Brown, usually with reddish-brown markings. Vertical ribs on upper and middle whorls well-developed; fine spiral striations. Up to 40 mm.<br><br>Images from Thompson, 2000. |  <br>*Melanoides tuberculatus* (Müller, 1774) |
| Fawn melania. Similar to *M. tuberculatus* and possibly an ecophenotype of it. Vertical sculpture much weaker, only on uppermost whorls. Shell color olive with reddish-brown markings rather than brown. Favors cleaner habitat than *M. tuberculatus*. Up to 40 mm.<br><br>Images from Thompson, 2000. |  <br>*Melanoides turriculus* (Lea, 1850) |

| General Description | Illustration |
|---|---|
| Quilted melania. Uniformly brown in color. Sculpture nodulose. Up to 30 mm.<br><br>Images from Thompson, 2000. |  <br>*Tarebia granifera* (Lamarck, 1822) |

## Bithyniidae

This family is closely related to the hydrobiids, assimineids, and pomatiopsids, along with several marine and terrestrial forms. It differs in its larger size relative to most of these (up to 13 mm), concentric growth of the operculum, white calcareous operculum, and various anatomical features. A second species is introduced into Hawaii (Table 1). It reaches extremely high densities. *Bithynia tentaculata* competes with native snails and has probably eliminated populations of pleurocerids. The extralimital populations of pleurocerids recorded in Table 1 have largely been eliminated by *Bithynia*. It is also tolerant of pollution and is able to filter planktonic algae, providing an alternative food source not available to native species.

| General Description | Illustration |
|---|---|
| Mud bithynia. |  <br>*Bithynia tentaculata* (Linnaeus, 1758) |

## Hydrobiidae

This very diverse family includes numerous native species, as well as a few that have been intercepted or introduced into Hawaii (Table 1). One invasive species from New Zealand has been introduced nearly worldwide. It reproduces parthenogenetically, making it easy to start new populations. It reaches extremely high population densities in areas such as Yellowstone National Park and may compete with native species. It has been recorded from Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, New York, Oregon, Utah, Washington, Wyoming and Ontario.

| General Description | Illustration |
|---|---|
| This genus has been established in a number of states across the United States and Canada. It can be found in a wide range of aquatic habitats from freshwater to slightly estuarine. This species is superficially very similar to *Pyrgophorus spinosa* and related species.<br><br>Image from USGS web site. |  <br>*Potamopyrgus antipodarum* (Gray, 1843) |

## Valvatidae

This family includes about ten native species in the genus *Valvata* as well as one introduced species. Being very similar to native species, it does not seem to have had a major impact on native faunas. All of the valvatids are small, up to about 5 mm.

| General Description | Illustration |
|---|---|
| European stream valvata. This species differs from native *Valvata* species in its lack of angulation, carinas, or flattened shoulder, its narrow umbilicus, its closed coiling, its moderately high spire, and its flat, truncated-looking apex (Burch, 1982). |  *Valvata piscinalis* (Müller, 1774) |

## Lymnaeidae

Lymnaeidae includes numerous native species, as well as some invasive species in Hawaii and additional intercepted species (Table 1). Tropical species host various parasites.

| General Description | Illustration |
|---|---|
| ***Galba*** Shell elongate conic, aperture oval, whorls rounded, occasionally with slight shoulder, up to 11 mm in height. This species is native to Eurasia, Africa, and extreme northwestern North America (Alaska and Yukon). It is probably introduced into the Columbia River drainage. The species is often assigned to *Fossaria*. The native North American population may be a distinct species. *F. truncatula* hosts the sheep liver fluke. |  *Galba truncatula* (Müller, 1774) |
| ***Radix*** Adult shell medium in size (length 14-24 mm), oval, thin and fragile, and with a very large body whorl and a very short spire; spiral striae sparse, or absent; columella with a strong plait; periostracum pale tan to horn. *Radix* is a widespread Eurasian genus, extending from western Europe to Japan, and is not native to the Western Hemisphere. *Radix auricularia* was introduced by human commerce many years ago and now is widely, albeit sporadically, distributed in North America. |  *Radix auricularia* (Linnaeus, 1758) |

## Physidae

This family includes a wide range of native species. *Haitia acuta* (Draparnaud, 1805) has often been listed as an invasive species from Europe; however, recent genetic evidence indicates that the European populations are probably invasive from a North American source. It probably has spread within North America as well, and several species are introduced to Hawaii (Table 1). Two tropical species of *Stenophysa* have been introduced to Texas; however, they have not been found in recent surveys. *Stenophysa* has a

serrated mantle edge, unlike the digitated or smooth margins of other genera in the family. The mantle edge overlaps onto the shell.

| General Description | Illustration |
|---|---|
| Marbled aplexa. Maximum size about 16 mm, usually translucent and rarely variegated in pattern. |  *Stenophysa marmorata* (Guilding, 1828) |
| Tawny aplexa. Maximum size over 30 mm, opaque, and commonly variegated. |  *Stenophysa maugeriae* (Gray, 1837) |

## Planorbidae

This family includes numerous native species, as well as several invasive forms not yet established in continental North America (Table 1). Several North American species are invasive elsewhere. Both North American and foreign species do well in artificially warm habitats outside their normal range.

| General Description | Illustration |
|---|---|
| Bloodfluke planorb. This species is of particular concern as a potential host for schistosomiasis. It has a relatively large, thin shell, over 15 mm, and very flat coiling, and occurs in warm habitats (Florida and warm-water outfalls). |  *Biomphalaria glabrata* (Say, 1818) |

**Table 1**. Additional non-native species

| Family | Taxon | Status[1] | Notes |
|---|---|---|---|
| Viviparidae | *Bellamya costulata* (von Martens, 1892) | I | |
| Viviparidae | *Filopaludina* species | I | from Singapore |
| Viviparidae | *Idiopoma ingallisiana* (Lea, 1856) | I | |
| Viviparidae | *Viviparus georgianus* (Lea, 1834) | N | may include overlooked introduced *V. viviparus* |
| Ampullariidae | *Lanistes varicus* (Müller, 1774) | I | |
| Ampullariidae | *Pila ampullacea* (Linnaeus, 1758) | I | |
| Ampullariidae | *Pila conica* (Gray, 1828) | HI | |
| Ampullariidae | *Pila polita* (Deshayes, 1830) | I | |
| Ampullariidae | *Pomacea cumingii* (Reeve, 1843) | PR | |
| Pleuroceridae | *Pachychilus laevissimus* (Sowerby, 1825) | I | |
| Pleuroceridae | *Pleurocera acuta* (Rafinesque, 1820) | N | |
| Pleuroceridae | *Elimia livescens* (Menke, 1830) | N | |
| Pleuroceridae | *Elimia virginica* (Say, 1817) | N | |
| Thiaridae | *Adamietta housei* (Lea, 1856) | I | |
| Thiaridae | *Brotia asperata* (Lamarck, 1822) | I | |

| | | | |
|---|---|---|---|
| Thiaridae | *Tarebia lateritia* (Lea, 1850) | HI | taxonomy problem |
| Thiaridae | *Tarebia scabra* (Müller, 1774) | I | invasive species |
| Thiaridae | *Thiara baldwini* (Ancey, 1899) | HI | taxonomy problem |
| Thiaridae | *Thiara indefinita* (Lea & Lea, 1850) | HI | taxonomy problem |
| Thiaridae | *Thiara kauaiensis* (Pease, 1870) | HI | taxonomy problem |
| Thiaridae | *Thiara verrauiana* (Lea, 1856) | HI | taxonomy problem |
| Bithyniidae | *Bithynia robusta minor*(Möllendorff, 1888) | HI | |
| Bithyniidae | *Gabbia pygmaea* (Preston, 1908) | I | |
| Bithyniidae | *Gabbia wykoffi* (Brandt, 1968) | I | |
| Bithyniidae | *Wattebledia siamensis* Möllendorff, 1902 | I | |
| Assimineidae | *Assiminea nitida* (Pease, 1865) | I | invasive species |
| Assimineidae | *Cyclotropis bedaliensis* (Rensch, 1934) | I | |
| Assimineidae | *Cyclotropis carinata* (Lea, 1856) | I | |
| Hydrobiidae | *Gillia altilis* (Lea, 1841) | N | |
| Hydrobiidae | *Paludina porrecta* (Mighels, 1845) | HI | ?=*Tryonia protea* |
| Hydrobiidae | *Pyrgophorus coronatus* (Pfeiffer, 1840) | HI | |
| Hydrobiidae | *Tryonia protea* (Gould, 1855) | HI | doubtful native to Hawaii |
| Lymnaeidae | *Fossaria viridis* (Quoy & Gaimard, 1832) | I, HI | |
| Lymnaeidae | *Lymnaea* species | I | from Italy |
| Lymnaeidae | *Lymnaea* species | I | from Korea |
| Lymnaeidae | *Pseudosuccinea columella* (Say, 1817) | HI | |
| Lymnaeidae | *Radix auricularia rubiginosa* (Michelin, 1831) | I | invasive species |
| Lymnaeidae | *Radix auricularia swinhoei* (Adams, 1861) | I | |
| Lymnaeidae | *Radix luteola* (Lamarck, 1822) | I | |
| Lymnaeidae | *Radix peregra* (Müller, 1774) | ? | doubtful native to Newfoundland |
| Physidae | *Haitia compacta* (Pease, 1870) | HI | doubtful native to Hawaii |
| Physidae | *Physella elliptica* (Lea, 1834) | HI | |
| Physidae | *Haitia virgata* (Gould, 1855) | HI | |
| Physidae | *Haitia acuta* (Draparnaud, 1805) | N, I | |
| Physidae | *Physella* species | I | from Mexico |
| Planorbidae | *Amerianna carinata* (Adams, 1861) | I | invasive species |
| Planorbidae | *Bulinus* species | I | from Singapore |
| Planorbidae | *Camptoceras jiraponi* Hubendick, 1967 | I | |
| Planorbidae | *Drepanotrema aeruginosus* (Morelet, 1851) | N? | |
| Planorbidae | *Drepanotrema cimex* (Moricand, 1839) | N? | |
| Planorbidae | *Drepanotrema kermatoides* (d'Orbigny, 1835) | N? | |
| Planorbidae | *Gyraulus convexisulcus* (Hutton, 1849) | I | |
| Planorbidae | *Gyraulus siamensis* (von Martens, 1867) | I | |
| Planorbidae | *Indoplanorbis exustus* (Deshayes, 1834) | I, HI | invasive species |
| Planorbidae | *Planorbarius corneus* (Linnaeus, 1758) | ? | |
| Planorbidae | *Planorbella duryi* (Wetherby, 1879) | HI | |
| Planorbidae | *Planorbella trivolvis* (Say, 1817) | I | |
| Ancylidae | *Ferrissia baconi* (Bourguignat, 1858) | I | |
| Ancylidae | *Ferrissia sharpi* (Sykes, 1900) | HI | doubtful native to Hawaii |
| Ancylidae | *Ferrissia* species | I | from Sri Lanka |

[1]I=intercepted in shipments but not established in U.S.; HI=introduced in Hawaii; PR=introduced in Puerto Rico; N=native to continental North America but expanding range; ? status unclear

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