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FRESHWATER SNAILS

OF

THE UNIVERSITY OF MICHIGAN
BIOLOGICAL STATION AREA

J. B. Burch and Younghun Jung

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FRESHWATER SNAILS
OF
THE UNIVERSITY OF MICHIGAN
BIOLOGICAL STATION AREA

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A contribution

from

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PREFACE

This publication is the second in a series on the fauna of the University of Michigan Biological Station area. This manual is on the freshwater snails; the first manual was on the land snails. Both manuals are designed to provide the information necessary to identify the various species of snails that occur in the area, and to give various other pertinent data, when known, about the snails.

There was another purpose in preparing these manuals, *i.e.*, to advertise the size and prominence of the molluscan fauna of the Biological Station area to the biological community of teachers, research scholars and students, thereby facilitating and encouraging the use of mollusks in teaching and research endeavors. Such activities by scientists at the Biological Station will assist in the expansion of knowledge about these interesting animals.

We wish to acknowledge the generous support of the Director of the Biological Station, James A. Teeri, the former Associate Director, Markley W. Paddock, the Administrative Manager, Thomas F. Crandell, and the Dean of the College of Literature, Science and the Arts, Edie N. Goldenberg.

We thank Timothy Pearce for reading and commenting on the manuscript.

FORWARD

This manual is mainly a taxonomic guide, intended primarily to be used to determine the identification of freshwater snail species of the University of Michigan Biological Station (UMBS) area. With this in mind, we have provided dichotomous identification keys, the sole purpose of which is to lead the reader in an easy, stepwise fashion to the proper scientific determination of the specimen in hand. Augmenting the keys are illustrations of all the species, and descriptive figures illustrating molluscan structures and descriptive concepts used in malacology. The latter are especially helpful to beginning students.

In addition to the purely taxonomic identification aspects, the manual presents the species in their systematic framework, gives a pertinent nomenclatural synonymy, provides verbal descriptions of their shells and animals (when known), their habitats, general North American distribution, and distribution as known for the UMBS area.

The appendices contain information more general in nature that we thought would be helpful in using the preceding sections of the book. The section on Identification and Morphology (pp. 146-176) illustrates the descriptive terms in common usage in malacology, and the gross anatomy of representatives of the various families of freshwater mollusks occurring in the UMBS area. Some species of snails need to be dissected in order to observe internal structures that are diagnostic for definitive species identifications. The section on gross anatomy provides the background information for making such dissections.

Freshwater snails generally are easy to collect. The section on collection (pp. 177-178) is provided to assist inexperienced collectors.

If snails are to be kept for future scientific study, it is especially important that they are properly fixed and preserved, otherwise information that can be obtained from the specimens will be limited. The sections in the appendices on fixing, preparing and preserving mollusks (pp. 178-180), while not an exhaustive account of such techniques, provides adequate procedures for most purposes. For more narrow, specialized studies requiring very particular fixation and preservation techniques, the reader should refer to more specialized technique texts on those particular subjects.

The section on Fresh Waters in the UMBS Area (pp. 181-185) provides greater detail about the hydrology of the three counties under consideration. If yet more detail is desired, the reader is referred to United States Geological Survey quadrangle maps of the area.

The section on References Pertinent to the Freshwater Snails of Northern Michigan (pp. 208-210) lists those publications that are especially important for freshwater malacology in the UMBS area. Citations to these references in the text are given by authors' names and dates of publication only. References cited in the text that do not have special relevance *per se* to the UMBS area are not listed in this References section; for such text references, more information is given with each where they are cited.

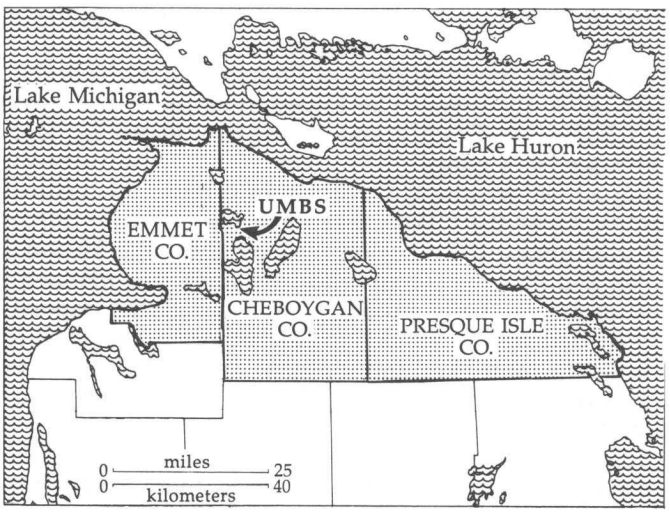
FRESHWATER SNAILS OF THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION AREA, NORTHERN LOWER PENINSULA, MICHIGAN

CONTENTS

FRESHWATER SNAILS OF THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION AREA, NORTHERN MICHIGAN

INTRODUCTION

The purpose of this publication is to describe the freshwater snails (snails and limpets) of the University of Michigan Biological Station (UMBS) area, *i.e.*, the northern portion of the Lower Peninsula of Michigan. As considered here, this area comprises the three northern-most counties of the Lower Peninsula (Map 1), *i.e.*, Emmet, Cheboygan and Presque Isle counties. This area is nearly 2,200 square miles, bordered on the west by Lake Michigan, on the north and east by the Straits of Mackinac and Lake Huron, and on the south by Charlevoix, Otsego, Montmorency and Alpena counties. The climax vegetation of the area consists mainly of Northern Hardwood, Pine, and Conifer Bog and Swamp communities.



MAP 1. Northern end of the lower peninsula of Michigan showing the area covered by this guide.

Physiography of the Area

The UMBS area is divided into three physiographic regions, the Lake-Border Plains, the Rolling Plains, and the Hill-Lands[1]. The

[1]Lawrence M. Sommers (Ed.), 1977, *Atlas of Michigan*, Michigan State University Press, East Lansing, Michigan. 242 pp.

northern/northeastern quarter of Emmet County, the northern two-thirds of Cheboygan County, and the northern/eastern half of Presque Isle County are in the Huron Lake-Border Plain physiographic region. The southeastern one-sixth of Cheboygan County and the southwestern half of Presque Isle County are in the Presque Isle Rolling Plain physiographic region. The southern three quarters of Emmet County and the southwestern one-sixth of Cheboygan County are in the Hill-Lands physiographic region.

The UMBS area varies from less than 600 feet to more than 1000 feet elevation above mean sea level. The lowest parts are the rather narrow shore areas of lakes Michigan and Huron, and the contiguous shore areas of Crooked Lake-Crooked River/Burt Lake-Indian River/Mullett Lake-Cheboygan River. The largest portion of the three counties is between 600 and 800 feet elevation, and lies adjacent to the lower shore areas. The southwestern quarter of Presque Isle County, the southern quarter of Cheboygan County, and various central and southern areas of Emmet County are between 800 and 1,000 feet elevation. Several small areas of central and southern Emmet County rise above 1,000 feet elevation.

The eastern and southern parts of Emmet County have the greatest surface relief in the area. The lowest relief is in the northeastern third of Cheboygan County and the northwestern tip and eastern half of Presque Isle County.

The bedrock of the area is Devonian in origin. The geological surface formations of the UMBS area have been greatly influenced by the past glaciation of the region. Along the Lake Huron shore of Cheboygan and Presque Isle counties, the surface formations are composed of sandy lake beds, probably partly of glacial deposition, and in places drifted by the wind into low ridges[2]. The northern shore area of Emmet County and the southern shore of Little Traverse Bay are composed of wind-drifted sand dunes. These sand dunes may be formed into rather sharp ridges.

Next inland from the shore in Cheboygan and Presque Isle counties are the clayey portions of the old lake beds, followed by either landlaid or waterlaid moraines. The moraines are the undulating glacial deposits formed at the border of the ice sheet. Landlaid moraines form the surface deposits of much of the western and southeastern parts of Emmet County, as well as much of the southern part of Cheboygan County and the western part of Presque Isle County. Also common in the southern half of Cheboygan County, in western and central Presque Isle County, and in the southern part of Emmet County

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[2]Frank Leverett, 1911, *Map of the surface formations of the Southern Peninsula of Michigan*, Geol. Surv. Mich., pl. 7, publ. 25.

are boulder clay plains, formed under the ice sheet. Intermixed among the latter two types of surface formations are areas of sandy old lake beds and clayey portions of old lake beds. These formations often contain swamps.

The eastern part of Presque Isle County is composed of areas of rock or thin drift. Boulder belts are frequent in the northern half of Cheboygan County, and the northwestern tip of Presque Isle County. Outwash plains occur in southern Cheboygan County along the Sturgeon River, including its West Branch, the Pigeon River, and Milligan and Stoney creeks, in Emmet County along Van Creek, and in Presque Isle County along the Little Ocqueoc River and the upper Ocqueoc River.

The soils in most of the UMBS area are predominantly spodosols, *i.e.*, they have accumulations of iron, aluminum and humus in the subsoil horizon. However, there are a few exceptions. Eastern Emmet and western Cheboygan counties have a contiguous north-south band of predominantly histosols, *i.e.*, they have developed from organic materials, and sections of northwestern and southcentral Presque Isle County have predominantly inceptisols, *i.e.*, they have weakly developed subsoil horizons.

Fresh Waters of the Area

The most imposing hydrological features of the UMBS area are the two Great Lakes, lakes Huron and Michigan, by which the area is bounded on the east, north and west. These lakes are great expanses of fresh water, and provide a long, continuous shoreline. This shore is composed of boulders, stones, pebbles and sand, and is quite exposed to the elements of weather. During storms, the shore is pounded by large waves, providing generally unsatisfactory conditions for freshwater mollusks. Higher aquatic vegetation is virtually absent.

The largest river drainage in the UMBS area is that of the Cheboygan River. This drainage comprises the southeastern third of Emmet County, most of Cheboygan County, and the southwestern one-third of Presque Isle County. Many tributaries, all flowing generally northward, are included in the Cheboygan River system. The Cheboygan River empties into the upper end of Lake Huron at the city of Cheboygan.

Another relatively large watershed, that of the Thunder Bay River, reaches into the southern part of Presque Isle County. The rest of the streams in the three-county area are classified as short drainages flowing directly into Lake Huron or Lake Michigan.

Several significant lakes (*i.e.*, lakes listed among Michigan's ten largest) occur in the UMBS area. These are Burt and Mullett lakes in

Cheboygan County, Black Lake, which is divided between Cheboygan and Presque Isle counties, and Grand and Long lakes in Presque Isle County. (The southern part of Long Lake is in Alpena County.)

For a more detailed description of the streams and lakes in the three counties, see the Appendix (pp. 181-185) "Fresh Waters in the UMBS Area."

Freshwater Snails

There are a few published records of the freshwater snails of the three counties under consideration. These will be found in some of the references listed on pp. 208-210. The records of freshwater snails in the three counties given in the sections to follow come almost entirely from our own collecting in the area and the specimens housed in the Museum of Zoology, University of Michigan.

The species of freshwater snails now known to occur in the Cheboygan, Emmet and Presque Isle counties are presented in the list below. The species are arranged in their proper systematic order, together with their subclasses, orders, families, etc. Included are the authors of the taxa and dates the names were first published. Type species are placed in parentheses after each generic-group name.

Outline of Classification and List of Species

Habitats

The physiography of the North American continent is reflected in the differential makeup of the snail fauna. For example, much of the waters of southcentral and southeastern Canada and the northcentral and northeastern United States are dominated by lentic environments, and so there is a preponderance of pond and lake species. In contrast, in the southern United States, most of the fresh waters were

lotic in nature before the advent of man-made impoundments, so the aquatic habitats of that region were originally dominated by snails adapted to flowing-water environments.

The UMBS area is liberally supplied with fresh waters. Living in these waters is a significant fauna of aquatic snails, a molluscan fauna that ranks among the richest in the world. Although some snail species are wide-spread and common, others are very restricted in distribution, several species being known only from a single locality.

Freshwater snails have adapted to nearly all natural freshwater habitats, and a few species (*e.g., Physa gyrina* (Say)) are tolerant enough to live successfully in all but the most heavily polluted waters. In general, however, freshwater snails do not tolerate much pollution, or chemical changes and physical disturbance of their habitats, and there has been a noticeable general decline in the last several decades in the local distribution and abundance of many species of freshwater snails.

North American aquatic snails have radiated into various kinds of freshwater habitats, with most species being restricted more or less to one or only several types of habitats. There are a few ubiquitous species, of course, but the restriction of species to specific types of habitats is the general rule. Habitats for freshwater snails in the UMBS area follow.

Deep water lake species: *Valvata perdepressa, V. sincera.*

Open shore lake species: *Elimia livescens, Fossaria galbana, Stagnicola emarginatus, Physa (Physella) magnalacustris, P. (Physella) parkeri, P. (Physella) sayi, P. (Costatella) crassa, Gyraulus (Torquis) huronensis.*

Quiet bay or pond species: *Valvata bicarinata, Amnicola (Lyogyrus) walkeri, Fontigens nickliniana, Bulimnea megasoma, Stagnicola elodes, Gyraulus (Torquis) parvus, Planorbella campanulata, Planorbella smithi, Planorbula armigera, Laevapex fuscus.*

Marsh species: *Stagnicola elodes.*

Mud-flat species: *Fossaria obrussa, F. exigua.*

Species burrowing in sand or mud in rivers or lakes: *Campeloma decisum, Pleurocera acuta.*

Amphibious species: *Fossaria parva, F. (Bakerilymnaea) dalli.*

Intermittent pool or intermittent stream species: *Fossaria peninsulae, Stagnicola exilis, S. elodes, S. (Hinkleyia) caperatus, Aplexa elongata, Physa (Physella) gyrina, G. (Torquis) circumstriatus.*

Stream species: *Valvata bicarinata, Fontigens nickliniana, Stagnicola petoskeyensis, Ferrissia rivularis.*

Species with a general aquatic distribution in both perennial and intermittent waters: *Physa (Physella) gyrina, Gyraulus deflectus, Promenetus exacuous.*

Species with a general aquatic distribution, but restricted to perennial waters: *Valvata sincera, V. tricarinata, Amnicola limosus, Pyrgulopsis lustricus, Elimia livescens, Fossaria exigua, Fossaria obrussa, Lymnaea stagnalis appressa, Gyraulus (Armiger) crista, G. (Torquis) parvus, Helisoma anceps, Planorbella (Pierosoma) trivolvis, Ferrissia parallela.*

Identification Key to the Freshwater Snail families in the UMBS Area

1 Animal with an operculum (which seals the shell aperture when the snail's body is withdrawn into the shell) (Fig. 1); respiration by gills; mantle opening facing anteriorly. Subclass **Prosobranchia,** Order **Mesogastropoda** 2

Animal without an operculum to seal its shell aperture when withdrawn (Fig. 2); respiration by the vascularized lining of the mantle cavity (true gills are lacking) or by a pseudobranch (false gill) permanently outside the mantle cavity; mantle opening directed to the side (to the right or left, depending on whether the animal is dextral [right coiled] or sinistral [left coiled] (Fig. 7). Subclass **Pulmonata,** Order **Lymnophila** 5

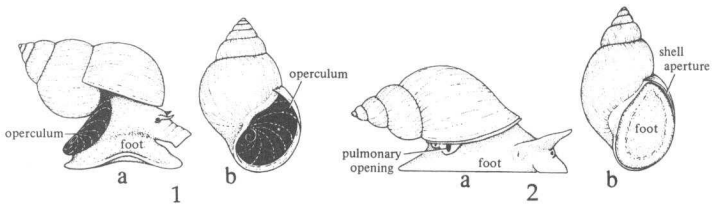


FIG. 1. An operculated snail, *i.e.*, one that carries an operculum attached to its dorsal posterior foot. **a**, Position of the operculum when the snail is active; **b**, position of the operculum when the snail has withdrawn into its shell. FIG. 2. A non-operculated (*i.e.*, a pulmonate) snail. It does not have a protective operculum to seal the shell aperture when the snail has withdrawn into its shell. **a**, An active snail; **b**, an inactive snail, with only the surface of its foot showing.

2(1) Shell small (8 mm or less in diameter), with or without carinae; spire generally depressed, operculum multispiral (Fig. 3a); gill bipectinate or feather-like, protruding from the mantle cavity when the snail is active (Fig. 4); pallial tentacle (Fig. 4) present ..... Family **VALVATIDAE** (p. 11)

Shell small to large, spire depressed to elongate; operculum multispiral (Fig. 3a), paucispiral (Fig. 3b) or concentric (Fig. 3c); gill monopectinate and inside the mantle cavity; pallial tentacle absent 3

3(2) Operculum concentric (Fig. 3c) .....Family **VIVIPARIDAE** (p. 22)

Operculum multispiral or paucispiral (Fig. 3a,b) 4

4(3) Adult shells small, less than 5 mm in length; males possess a verge (see Fig. 15a) .....Family **HYDROBIIDAE** (p. 27)

Adult shells of medium to large size, more than 15 mm in length; males lack a verge.....Family **PLEUROCERIDAE** (p. 39)

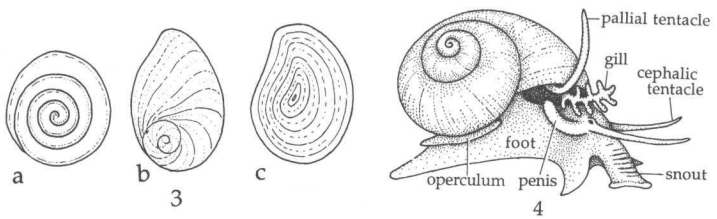


FIG. 3. Types of opercula. **a**, Multispiral; **b**, paucispiral; **c**, concentric. FIG. 4. A valvatid snail, showing the bipectinate gill, the pallial tentacle and penis.

5(1) Shell an uncoiled, obtuse cone (limpet- or cap-shaped) (Fig. 5) ....Family **ANCYLIDAE** (p. 137)

Shell coiled (Fig. 6) 6

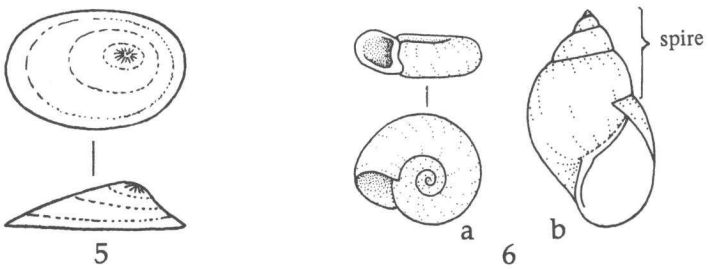


FIG. 5. A limpet- or cap-shaped shell, without coiling; dorsal and left side views. FIG. 6. **a**, Apertural and inverted spire views of a discoidal shell; **b**, a shell with raised spire.

6(5) Shell discoidal, with a sunken spire (Fig. 6a); blood (hemolymph) is red (contains hemoglobin); a pseudobranch (false gill) or siphon is situated near the pneumostome or anus (Fig. 105) .... Family **PLANORBIDAE** (p. 104)

Shell with a raised spire (Fig. 6b); blood (hemolymph) nearly colorless (the respiratory pigment is hemocyanin); animal without pseudobranch (false gill), but a siphon may be present 7

7(6) Animal and shell sinistral (coiled to the left) (Fig. 7a); mantle margin of most species digitate or lobed .... Family **PHYSIDAE** (p. 85)

Animal and shell dextral (coiled to the right) (Fig. 7b); mantle margin simple, not digitate ..... Family **LYMNAEIDAE** (p. 46)

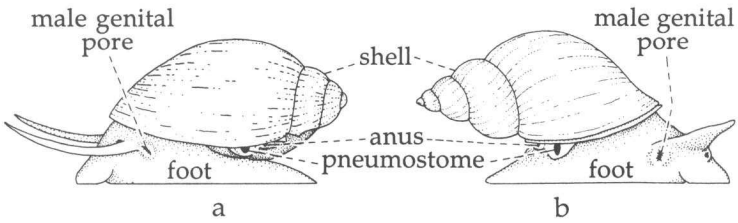


FIG. 7. Left-coiled (sinistral) and right-coiled (dextral) snails. **a**, A snail with a sinistral organization of its body, *i.e.*, respiratory, excretory and reproductive openings are on the left side; **b**, a snail with a dextral organization of its body, *i.e.*, respiratory, excretory and reproductive openings are on the right side.

FRESHWATER SNAILS OF THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION AREA

THE OPERCULATES (PROSOBRANCHS)

The Prosobranchia are one of the three great groups (subclasses) of snails, the other two being the Pulmonata (see p. 46) and the marine Opisthobranchia. These three subclasses have been named in reference to the position or character of the respiratory apparatus. In the Prosobranchia, the respiratory organ (the gill), is located in front of the heart; in the Opisthobranchia, it is behind the heart. The Pulmonata have replaced the gill with a vascular lung. In addition to these and other anatomical differences, the prosobranch snails can be distinguished from pulmonate snails by the presence of a cover, the operculum, used to close the shell aperture after the snails are withdrawn into their shells (see Fig. 1). Pulmonate snails lack such an operculum (see Fig. 2).

The prosobranchs account for nearly half of all the snail species. They occur in most habitats available to mollusks, and have many species living in fresh waters throughout the world. Prosobranch snails are divided into several groups or orders, based on characteristics of their anatomy. One of these groups, the Mesogastropoda, is represented in the UMBS area.

Order MESOGASTROPODA

The largest and most diverse group of prosobranch snails is the Mesogastropoda. These snails differ from the more primitive Archaeogastropoda by having only one auricle (rather than two) in the heart, a single muscle (rather than two) attaching the shell to the animal, narrow radulae that have lost the rhipidoglossan character (including the reduction of the large number of marginal teeth to only two on each side), etc. The Mesogastropoda differ the evolutionarily more advanced order Neogastropoda (an almost totally marine group) by seemingly minor differences, such as possessing unipectinate (rather than bipectinate) osphradia, less concentrated nervous systems, shells which usually lack siphonal canals, and different types of radulae.

Family VALVATIDAE

In North America, there are about 11 species of Valvatidae, all belonging to the genus *Valvata.* Four species occur in the UMBS area. The Valvatidae are hermaphrodites, a very peculiar feature among

the Prosobranchia. Also, peculiar are the single bipectinate gill, and the pallial tentacle, both of which stick out from the mantle cavity (see Fig. 4) when the snail is active.

The shells of *Valvata* in the Western Hemisphere are comparatively small (diameter up to 5 mm), have up to 4½ whorls, are dextral, and vary in form from discoid to high-turbinate. The nuclear whorls possess both axial and spiral sculpture; depending on the species, the rest of the shell contains lamellate to obsolete axial sculpture and is either spirally angulated, carinated or smooth. Several species are polymorphic in shell form and sculpture. The operculum is corneous, thin, flattened but slightly concave, circular in outline and multispiral (see Fig. 3a).

Shell features are used to identify North American species of *Valvata,* several of which are polymorphic. For example, the "kinds" of *V. tricarinata s.lat.* are characterized by differing numbers and locations of spiral carinae or angulations. A single population usually contains several of these variants, which have often been treated taxonomically as subspecies. However, these variants are neither geographical races nor environmental forms (ecophenotypes) Heard (1982). The nature of the variation is not well understood.

Genus *Valvata* Müller

Species of this genus are found in North America, Eurasia and the Near East, and northeast Africa. Their shells are small, umbilicate and generally depressed. The sculpture on post-nuclear whorls may consist of lamellate axial riblets, well developed growth lines, or obsolete striae, depending on the species. The shell may lack spiral sculpture, or may have one, two or three carinae. The operculum is thin, corneous and multispiral. Polymorphic species may have individuals with differing numbers of spiral carinae or angulations. Such individuals are now treated as morphs (Heard, 1982). Other distinguishing characteristics are mentioned above under the family.

Key to Species of *Valvata* in the UMBS Area

1 Shell with one to three spiral carinae or angulations 2

Shell without spiral carinae or angulations 3

2(1) Shoulder on the body whorl sloping downward from the dorsal carina to the suture ..... *V. bicarinata* (p. 13)

Shoulder on the body whorl sloping upward from the dorsal carina or angulation to the suture ..... *V. tricarinata* (p. 18)

3(1) Shell depressed, spire only slightly elevated ..... *V. perdepressa* (p. 15)

Shell with noticeably elevated spire ..... *V. sincera* (p. 16)

Valvata bicarinata Lea

(Fig. 8; Map 2)

Valvata bicarinata Lea 1841, *Proc. Am. Philos. Soc.*, 2(19), p. 83.
Valvata bicarinata normalis Walker 1902, *Nautilus*, 15 (11), p. 125, fig. 5.
Valvata bicarinata connectans Walker, Walker (1911, p. 125).
Valvata bicarinata connectans Walker, Winslow (1926b, p. 18).
Valvata bicarinata (Lea), F.C. Baker (1928, p. 18, pl. 1, fig. 6).
Valvata bicarinata normalis Walker, F.C. Baker (1928, p. 20, pl. 1, figs. 11-13).
Valvata bicarinata connectans Walker, Goodrich (1932, p. 76).
Valvata bicarinata bicarinata Lea, Heard, in Burch & Tottenham (1980, pp. 81, 82, fig. 23).
Valvata bicarinata morph *normalis* Walker, Heard, in Burch & Tottenham (1980, pp. 81, 82, fig. 24).
Valvata bicarinata bicarinata Lea, Heard (1982, pp. 15, 69, fig. 23).
Valvata bicarinata morph *normalis* Walker, Heard (1982, pp. 15, 69, fig. 24).
Valvata bicarinata bicarinata Lea, Heard, in Burch (1982b, p. 225, fig.).
Valvata bicarinata morph *normalis* Walker, Heard, in Burch (1982b, p. 225, fig.).
Valvata bicarinata Lea, Burch & Jung (1987, p. 235, fig. 1).
Valvata bicarinata bicarinata Lea, Heard, in Burch (1989b, pp. 81, 82, fig. 23).
Valvata bicarinata morph *normalis* Walker, Heard, in Burch (1989b, pp. 81, 82, fig. 24).
Valvata bicarinata Lea, Burch (1991, p. 127).

Shell: The shell of *Valvata bicarinata* is solid, more or less discoidal with a completely depressed or only slightly raised spire. The shell is glossy and horn-colored, tinged with green. Adult shells with 3½ to 4 whorls measure up to 6.5 mm. A sharply defined carina is present at the shoulder on the upper side of the whorls. There is also a basal carina and, usually, a median carina. Additional sculpture consists of fine transverse growth lines. The embryonic whorls have fine spiral striae (seen as microridges with the scanning electron microscope) that are distinctive for the family. The aperture is round, accommodating a similarly shaped operculum. The umbilicus is wide.

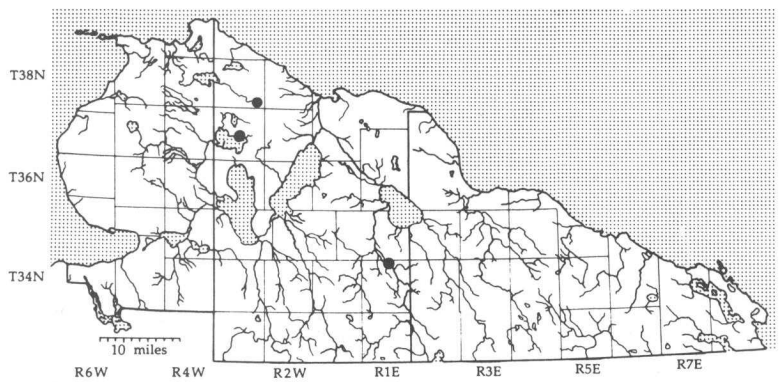
FIG. 8. Shell of *Valvata bicarinata.*

Animal: The following comparison between *Valvata bicarinata* and *V. tricarinata* is paraphrased from Lea (1841, *Proc. Am. Philos. Soc.*, 2: 83): The head of *V. tricarinata* is more cylindrical and enlarged at the termination, where it somewhat resembles the snout of a hog, while the head of *V. bicarinata* is more conical and without so sudden an enlargement at the end. The color of *V. bicarinata* is lighter. The two species also differ in their black markings. In *V. tricarinata*, there is a single blotch anterior to the area between the eyes. In *V. bicarinata*, the blotch also extends behind this area, and additionally two quite black marks above the mouth can be observed, which *V. tricarinata* does not seem to have. The tentacles of *V. bicarinata* are larger and more filiform. When in motion, the anterior portions of the lobes of the foot are pointed and recurved or hooked.

Habitat: The three localities in which we found *Valvata bicarinata* in the UMBS area were all lentic in nature. However, in Wisconsin *V. bicarinata* "appears to be a river form and not found in lakes" (F.C. Baker, 1928).

General Distribution: Of discontinuous distribution: New Jersey and Pennsylvania; and Iowa, Illinois, Tennessee, Alabama, Georgia and North Carolina (Heard, 1982).

Distribution in UMBS area: Cheboygan Co.: Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, T34N, R1E, Forest Township, John B. Burch, 15 July 1985, UMMZ[3] 250435; Sedge Point, beach pool between Douglas Lake and beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5b; roadside drainage ditch along highway C 66 (Cheboygan Road), 0.5 mile northeast of highway I 75, Section 36, T38N, R3W, Hebron Township, John B. Burch, August 1991.



MAP 2. Localities of *Valvata bicarinata*.

[3]Abbreviation, associated with museum specimen catalog numbers, for the University of Michigan Museum of Zoology.

Remarks: *Valvata bicarinata* may be tricarinate (the *normalis* form) as well as bicarinate, and *V. tricarinata*, in addition to being tricarinate, may be bicarinate, unicarinate or acarinate. However, after gaining familiarity with the two species, workers can readily separate them. In addition to the differentiating character given in the key above, *V. bicarinata* has a more depressed, discoidal shell with a wider and shallower umbilicus than does *V. tricarinata*.

Valvata perdepressa Walker
(Fig. 9; Map 3)

Valvata bicarinata perdepressa Walker 1906, *Nautilus*, 20 (3), pp. 30-31, pl. 1, figs. 15-16.
Valvata bicarinata perdepressa Walker, Walker (1911, p. 125).
Valvata bicarinata perdepressa Walker, Winslow (1926b, p. 18).
Valvata bicarinata perdepressa Walker, F.C. Baker (1928, p. 21, pl. 1, figs. 15-18).
Valvata perdepressa walkeri F.C. Baker 1930, *Trans. Ill. State Acad. Sci.*, 22, p. 188, fig. 1.
Valvata bicarinata perdepressa Walker, Goodrich (1932, p. 76).
Valvata perdepressa Walker, Heard, in Burch & Tottenham (1980, pp. 83, 84, fig. 29).
Valvata perdepressa? form *walkeri* F.C Baker, Heard, in Burch & Tottenham (1980, p. 84).
Valvata perdepressa Walker, Heard (1982, pp. 16, 71, fig. 29).
Valvata perdepressa? form *walkeri* F.C. Baker, Heard (1982, p. 16).
Valvata perdepressa Walker, Heard, in Burch (1982b, pp. 83, 84, fig. 29).
Valvata perdepressa? form *walkeri* F.C. Baker, Heard, in Burch (1982b, p. 84).
Valvata perdepressa Walker, Burch & Jung (1987, p. 236, fig. 3).
Valvata perdepressa Walker, Heard, in Burch (1989b, pp. 83, 84, fig. 29).
Valvata perdepressa? form *walkeri* F.C. Baker, Heard, in Burch (1989b, p. 84).
Valvata perdepressa Walker, Burch (1991, p. 127).

Shell: Solid, depressed, nearly discoidal, with or without a slightly raised spire, umbilicus wide and deep. The whorls are rounded or occasionally subangular, but without carinae. The shell is glossy and uniformly horn-colored, or, as seen with most beach-worn shells, white with several of the spire whorls purple or pink above. The sculpture consists of fine transverse growth lines.

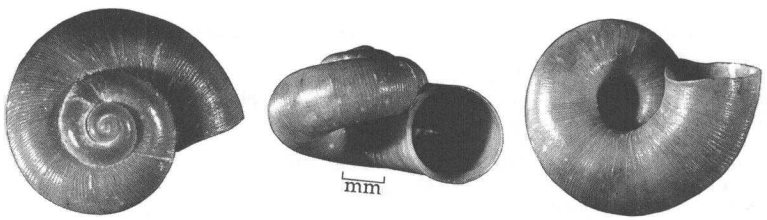
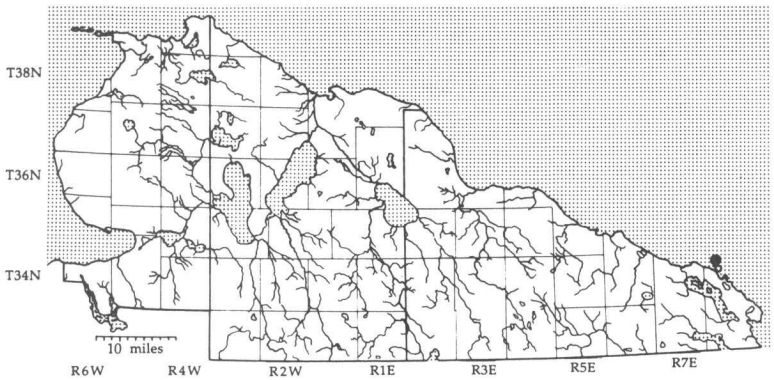


FIG. 9. Shell of *Valvata perdepressa*.

Animal: Unknown; living specimens have never been taken.
Habitat: *Valvata perdepressa* is a species of the Great Lakes and several medium-sized lakes in New York. Its exact habitat is not known; the species has been found only as beach drift.

General Distribution: Lakes Michigan, Huron, Erie and Ontario, and Little Lakes, New York.

Distribution in UMBS Area: **Cheboygan Co.:** drift of Lake Michigan, 10 miles southwest [?] of Mackinaw, Calvin Goodrich, August 1935, UMMZ 253241. **Presque Isle Co.:** Lake Huron, Presque Isle Point, UMMZ 250665.



MAP 3. Locality of *Valvata perdepressa.*

Remarks: *Valvata perdepressa* is basically a species of the Great Lakes, but it has been reported also from the Little Lakes, New York (Walker, 1906). F.C. Baker (1930, *Trans. Ill. State Acad. Sci.*, 22, pp. 186-194) differentiated *Valvata perdepressa walkeri* from *V. perdepressa s.str.* by its "flattened, planorboid shell, the spire often depressed below the level of the body whorl."

Valvata sincera Say

(Fig. 10; Map 4)

Valvata sincera Say 1824, Mollusca, in Keating's *Narr. Exped. Source St. Peter's R.*, etc., vol. 2, appendix, p. 264, pl. 15, fig. 11.
Valvata sincera Say, Walker (1893, p. 137).
Valvata sincera danielsi Walker 1906, *Nautilus*, 20(3), p. 28, pl. 1, figs. 10, 11.
Valvata sincera Say, Walker (1911, p. 125).
Valvata sincera Say, Winslow (1926, p. 18).
Valvata sincera Say, F.C. Baker (1928, p. 23, pl. 1, figs. 19-22).
Valvata sincera Say, Goodrich (1932, p. 76).
Valvata sincera Say, Goodrich (1939, p. 25).
Valvata sincera sincera Say, Heard, in Burch & Tottenham (1980, pp. 84, 85, fig. 31).
Valvata sincera sincera Say, Heard (1982, pp. 16, 73, fig. 31).
Valvata sincera sincera Say, Heard, in Burch (1982b, pp. 84, 85, fig. 31).
Valvata sincera sincera Say, Burch & Jung (1987, pp. 237, 238, fig. 5).
Valvata sincera sincera Say, Heard, in Burch (1989b, pp. 84, 85, fig. 31).
Valvata sincera Say, Burch (1991, p. 127).

Shell: Turbinate, with rounded whorls lacking carinae or distinct angulations; sculptured with well developed growth lines; narrowly and deeply umbilicate; translucent; greenish-horn in color. The nuclear whorls are spirally striate. Adult shells with about four whorls measure 4.5 to 5.0 mm.

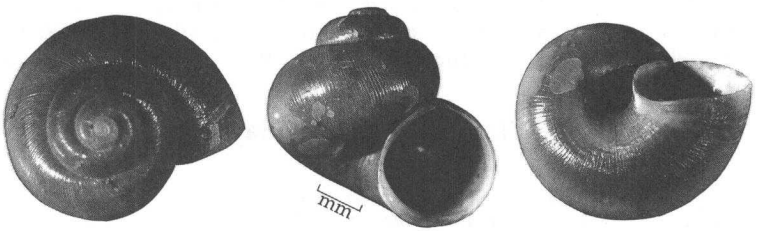
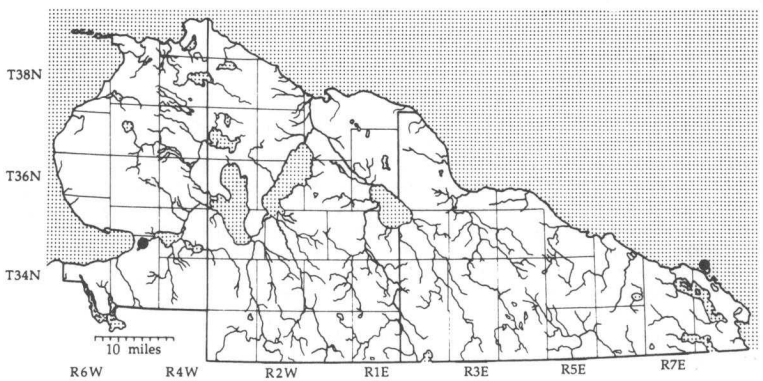


FIG. 10. Shell of *Valvata sincera* (form *danielsi*).

Habitat: Found in lakes, and in rather deep water in Lake Superior and Lake Michigan (F.C. Baker, 1928). Clarke (1973, *Malacologia*, 13, p. 224) found *Valvata sincera* in large and small lakes, in a permanent pond, and in large and small rivers, always associated with aquatic vegetation, and nearly always associated with mud substrates. In the UMBS area, *V. sincera* has been found at two localities only, for which definite habitat information is not available.

General Distribution: Maine west to Alberta, and south to South Dakota and Indiana (Heard, 1982).

Distribution in UMBS Area: **Emmet Co.:** Round Lake, Petoskey, Frederick Stearns Collection, UMMZ 253233. **Presque Isle Co.:** Lake Huron, Presque Isle Point, Calvin Goodrich, 1933, UMMZ 253242.



MAP 4. Localities of *Valvata sincera.*

Remarks: Type specimens of Say's *Valvata sincera* are not available, but Walker (1906, *Nautilus*, 20, pp. 25-31, pl. 1) carefully evaluated Say's original description, put it into context of the valvatid fauna as he (Walker) knew it, and more precisely described the species. Say referred to *V. sincera* as having a wider umbilicus than that of *V. tricarinata* (with which Walker, 1906, *op. cit.*, agreed). The specimen we have illustrated is Walker's (1906, *op. cit.*) "variety" *danielsi*, which has a higher spire and narrower umbilicus.

Valvata tricarinata (Say)

(Figs. 11, 12; Map 5)

Cyclostoma tricarinata Say 1817, *J. Acad. Nat. Sci. Philad.*, 1, p. 13.
Valvata simplex Gould 1841, *Rep. Invert. Mass.*, p. 226.
Valvata unicarinata De Kay 1843, Moll; pt. 5, *Zool. N. Y.*, pp. 118-119, pl. 6, fig. 129.
Valvata tricarinata Say, Walker (1893, p. 137).
Valvata tricarinata confusa Walker 1902, *Nautilus*, 15, p. 124, fig. 2 [preoccupied].
Valvata tricarinata Say, Walker (1911, p. 125).
Valvata tricarinata confusa Walker, Walker (1911, p. 125).
Valvata tricarinata simplex Gould, Walker (1911, p. 125).
Valvata tricarinata unicarinata De Kay, Walker (1911, p. 125).
Valvata tricarinata Say, H.B. Baker (1914, pp. 18-45).
Valvata tricarinata confusa Walker, H.B. Baker (1914, pp. 18-45).
Valvata tricarinata infracarinata Vanatta 1915, *Nautilus*, 28 (9), pp. 104-105, figs. 1, 2.
Valvata tricarinata perconfusa Walker 1917, *Nautilus*, 31, p. 36.
Valvata tricarinata Say, Winslow (1926, p. 18).
Valvata tricarinata infracarinata Vanatta, Winslow (1926, p. 18).
Valvata tricarinata perconfusa Walker, Winslow (1926, p. 18).
Valvata tricarinata simplex Gould, Winslow (1926, p. 18).
Valvata tricarinata unicarinata De Kay, Winslow (1926, p. 18).
Valvata tricarinata (Say), F.C. Baker (1928, p. 11, pl. 1, figs. 1-3).
Valvata tricarinata perconfusa Walker, F.C. Baker (1928, p. 16, pl. 1, fig. 4).
Valvata tricarinata unicarinata De Kay, F.C. Baker (1928, p. 16, pl. 1, fig. 5).
Valvata tricarinata infracarinata Vanatta, F.C. Baker (1928, p. 18).
Valvata tricarinata simplex Gould, F.C. Baker (1928, p. 18, pl. 1, figs. 8, 9).
Valvata tricarinata Say, Eggleton (1931, p. 258).
Valvata tricarinata perconfusa Walker, Eggleton (1931, p. 258).
Valvata tricarinata (Say), Goodrich (1932, p. 75, fig.).
Valvata tricarinata Say, Goodrich (1939, p. 25).
Valvata tricarinata, Eggleton (1952, p. 217).
Valvata tricarinata Say, Heard (1963, pp. 64-68).
Valvata tricarinata morph *perconfusa* Walker, Heard (1963, pp. 64-68).
Valvata tricarinata morph *unicarinata* De Kay, Heard (1963, pp. 64-68).
Valvata tricarinata (Say), Heard, in Burch & Tottenham (1980, pp. 84, 85, fig. 33).
Valvata tricarinata morph *infracarinata* Vanatta, Heard, in Burch & Tottenham (1980, p. 84).
Valvata tricarinata morph *perconfusa* Walker, Heard, in Burch & Tottenham (1980, p. 84).
Valvata tricarinata morph *simplex* Gould, Heard, in Burch & Tottenham (1980, p. 84).
Valvata tricarinata morph *unicarinata* De Kay, Heard, in Burch & Tottenham (1980, p. 84).
Valvata tricarinata (Say), Heard (1982, pp. 16, 73, fig. 33).
Valvata tricarinata morph *infracarinata* Vanatta, Heard (1982, p. 16).
Valvata tricarinata morph *perconfusa* Walker, Heard (1982, p. 16).
Valvata tricarinata morph *simplex* Gould, Heard (1982, p. 16).
Valvata tricarinata morph *unicarinata* De Kay, Heard (1982, p. 16).
Valvata tricarinata (Say), Heard, in Burch (1982b, p. 225, fig.).
Valvata tricarinata morph *infracarinata* Vanatta, Heard, in Burch (1982b, p. 224).
Valvata tricarinata morph *unicarinata* De Kay, Heard, in Burch (1982b, p. 224).
Valvata tricarinata morph *perconfusa* Walker, Heard, in Burch (1982b, p. 225).

Valvata tricarinata morph *simplex* Gould, Heard, in Burch (1982b, p. 225).
Valvata tricarinata (Say), Burch & Jung (1987, p. 239, fig. 7).
Valvata tricarinata (Say), Heard, in Burch (1989b, pp. 84, 85, fig. 33).
Valvata tricarinata morph *infracarinata* Vanatta, Heard, in Burch (1989b, p. 84).
Valvata tricarinata morph *perconfusa* Walker, Heard, in Burch (1989b, p. 84).
Valvata tricarinata morph *simplex* Gould, Heard, in Burch (1989b, p. 84).
Valvata tricarinata morph *unicarinata* De Kay, Heard, in Burch (1989b, p. 84).
Valvata tricarinata Say, Burch (1991, p. 127).

Shell: Turbinate, deeply and rather narrowly umbilicate, tricarinate (usually), glossy, translucent, horn-colored tinged with green. The aperture is round and fitted with a round, multispiral operculum. The embryonic whorls are densely sculptured with fine spiral striae that end abruptly where the neanic whorls begin. Fine lines of growth mark the post-embryonic whorls. Shells with 3½ to 4 whorls measure 4.5 - 5.5 mm in greatest diameter. Although the tricarinate condition is most common, all combinations of fewer carinae have been found (and named as species, subspecies, variants or forms).

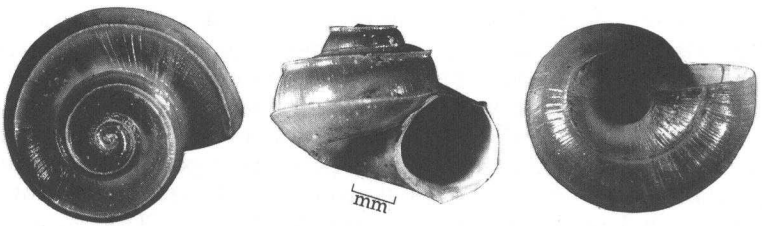


FIG. 11. Shell of *Valvata tricarinata.*

Operculum: The operculum is thin, circular in outline, corneous and sinistrally multispiral, with a central nucleus and spirals increasing very slowly in width during growth.

Animal: The dorsal mantle is covered with black pigment, except for the last third of the body whorl, which, except for two large black blotches, lacks pigment. The mantle collar is black. The foot is short and wide, rounded behind, and has the operculum attached to a non-pigmented lobe on its dorsal posterior surface. When the snail is active, the shell rests on the operculum. The sole of the foot, and the dorsum of the foot anterior to the operculum, lacks pigment. The foot ends anteriorly in two acutely pointed velar lobes. The sides of the foot are dark gray to black, the foot margins white. The tentacles are attenuate, round in cross-section, and black. The head projects forward into a snout, flared at the end and weakly bilobed. The snout is black, except at the tip, which is pale gray. A black pallial tentacle protrudes from the forward-facing pallial cavity. Also protruding from the pallial cavity when the snail is undisturbed is a medium gray, bipectinate gill. Cilia cover the gill surfaces.

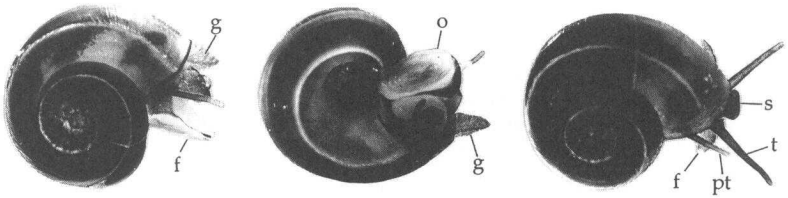


FIG. 12. Shell and animal of *Valvata tricarinata.* f, foot; g, gill; o, operculum; pt, pallial tentacle; s, snout; t, tentacle.

Unlike most prosobranchs, the Valvatidae are hermaphroditic. The female gonopore is on the right side between the gill and rectum. The non-retractile penis is located under the right eye and posterior to the right tentacle. The penis is black, except for its non-pigmented tip. When not in use, the penis is folded back.

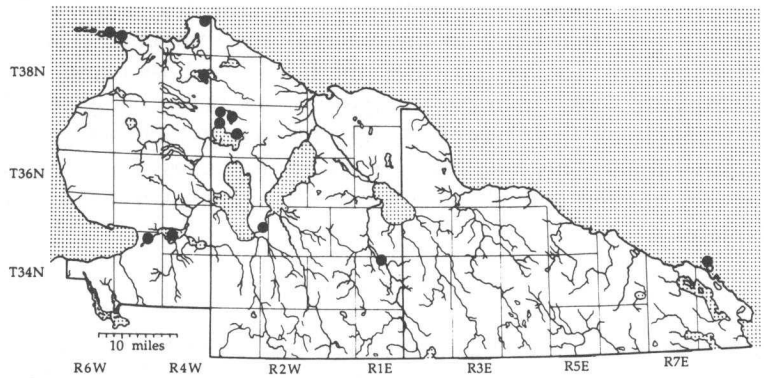
F.C. Baker (1928) described the body color of *Valvata tricarinata* as "pinkish-white, sometimes quite pinkish, more or less transparent, with brown blotches on mantle showing through the shell." Perhaps Baker was observing an albino population.

Habitat: Clarke (1973, *Malacologia,* 13, p. 237) found *Valvata tricarinata* in large and small lakes, in permanent ponds, and in large and small rivers, nearly always associated with aquatic vegetation, and associated with bottom sediments of all types. "Occurs among vegetation and only in perennial-water habitats, namely lakes, rivers, streams and muskeg pools" (Clarke, 1981, *Freshw. Moll. Can.,* Nat. Mus. Can., Ottawa, p. 52). However, in the UMBS area, we also found *V. tricarinata* in two rather transient and widely separated beach pools.

General Distribution: Quebec and New Brunswick west to Alberta, and south to Wyoming, Arkansas and Virginia (Heard, 1982).

Distribution in UMBS Area: Cheboygan Co.: Indian River, Metzelaar and Langlois, 14 June 1925, UMMZ 37644; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 41950; mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 41951; North Fishtail Bay, Douglas Lake, Mina L. Winslow and Crystal Thompson, 3 July 1926, UMMZ 41952; drift of Lake Michigan, 10 miles southwest [?] of Mackinaw, Calvin Goodrich, August 1935, UMMZ 63852; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 99197; Mackinaw City, A.C. Lane, Bryant Walker Collection, UMMZ 99600; Lancaster Lake, Royal Bruce Brunson, 12 July 1945, UMMZ 198398; Douglas Lake, Bessey [Bessy; Bessie; Lancaster] Creek cove, Section 18, T37N, R3W, James W. Moffett, 6 July 1937, UMMZ 232340; Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250437; Hook Point Bay, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250438; Sedge Point pool and beach, Douglas Lake, Mina L. Winslow and Crystal Thompson, 5 July 1926, UMMZ 250663; Sedge Point, beach pool between Douglas Lake and beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5b; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T. 37 N., R. 3 W., Munro Township, John B. Burch, 4 July 1985; UMBS-85-7. **Emmet Co.:** Carp Lake [Lake Paradise], Bryant Walker,

Bryant Walker Collection, UMMZ 99000; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 99001; Round Lake, Kent Science Institute Collection, UMMZ 143570; Goose Pond, Wilderness Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170469; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253243; beach pool near shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 13 July 1988, UMBS-88-13. **Presque Isle Co.:** Lake Huron, Presque Isle Point, Calvin Goodrich, 1933, UMMZ 57781.



MAP 5. Localities of *Valvata tricarinata.*

Remarks: According to Baker (1928; 1930), the typical form of *Valvata tricarinata* is found principally in rivers and occurs only rarely in beach debris.

Furrow (1931, *Trans. Ill. State Acad. Sci.*, 24, pp. 241-246) believed that the valvatid gill represents the molluscan left ctenidium and that the pallial tentacle is the rudimentary right gill. Rath (1988, *Malacol. Rev.*, Suppl. 4, pp. 194-204) contends that embryology does not support such an assumption, and that the valvatid gill itself is secondarily derived (*i.e.*, is a "pseudobranch").

In Douglas Lake, Heard (1963) found that reproduction in *Valvata tricarinata* begins late in spring or early summer and continues into late summer. He observed that *V. tricarinata* had a pronounced preference for egg-laying surfaces, preferring the leaves of aquatic vegetation (*Potamogeton illinoisensis, P. strictifolius, Vallisneria americana, Myriophyllum heterophyllum* and *Chara vulgaris*) and leaves of deciduous trees (*Quercus rubra, Betula alba* var. *papyrifera* and *Acer saccharum*).

Furrow (1935, *Z. Zellforsch. mikrosk. Anat.*, 22, pp. 282-304) observed cyclic protandry during sexual activity in *Valvata tricarinata,* each individual going first through a male phase, followed by a female phase.

Family VIVIPARIDAE

The Viviparidae are nearly world-wide in distribution, and in North America the various species occur throughout the eastern United States and Canada. The Viviparidae are all "live-bearers," *i.e.*, are ovoviviparous, giving birth to young crawling snails, rather than laying eggs that hatch in the external environment. It is this reproductive trait that has provided the family with its name.

The sexes are separate in the Viviparidae, the males being readily distinguishable by their modified right tentacle, which serves as a copulatory organ. This modified tentacle in the males is shorter and thicker than the left tentacle or either of the equal-sized tentacles of the females.

Genus *Campeloma* Rafinesque

Campeloma is one of five genera of Viviparidae in North America. The other genera do not occur in the UMBS area. The shells of *Campeloma* lack nodules, spiral angles, ridges and spiral color bands, and the opercula lack spiral nuclei; thereby they are easily distinguished from the other North American viviparid genera.

The animal of *Campeloma* is gray in color, with orange spots on the dorsum of the foot. The foot is large, and when the snail is crawling, it extends in front beyond the rostrum. The anterior end of the foot is truncate with square corners; the posterior end is rounded. The rostrum is relatively short and narrow. The eyes are at the outer base of the tentacles, situated on short peduncles.

Many populations of *Campeloma* are parthenogenetic, consisting entirely of females. Such is the case for *Campeloma decisum* (Say), the only species of the genus occurring in the UMBS area.

Campeloma decisum (Say)

(Fig. 13; Map 6)

Lymnaea decisa Say 1817, Conchology, in Nicholson, 1816-1817, *Am. Ed. Brit. Encyclop., Dict. Arts, Sci.*, etc., 1st ed., vol. 2, pt. 2 [no pagination], pl. 2, fig. 6.
Paludina integra Say 1821, *J. Acad. Nat. Sci. Philad.*, 2, p. 174.
Paludina milesii Lea 1863, *Proc. Acad. Sci. Philad.*, 15, p. 163.
Melantho gibba Currier 1867, *Am. J. Conchol.*, 3(2), p. 112, pl. 6, fig. 3.
Campeloma decisa Say, Walker (1893, p. 138).
Campeloma decisa flava Currier Mss., Walker (1893, p. 138).
Campeloma melanostoma Currier Mss., Walker (1893, p. 138).
Campeloma integra Say, Walker (1893, p. 138).
Campeloma rufa Hald., Walker (1893, p. 138).

Campeloma Milesii Lea, Walker (1893, p. 138).
Campeloma milesii Lea, Walker (1903, pp. 121-124).
Campeloma decisa (Say), Walker (1911, p. 125).
Campeloma milesii (Lea), Walker (1911, p. 125).
Campeloma decisum (Say), H.B. Baker (1912, pp. 209-211).
Campeloma decisum (Say), H.B. Baker (1914, pp. 18-45).
Campeloma decisa (Say), Winslow (1917, p. 10).
Campeloma milesii Lea ?, Winslow (1917, p. 10).
Campeloma decisum (Say), Winslow (1926, p. 18).
Campeloma integrum (Say), Winslow (1926, p. 18).
Campeloma milesii (Lea), Winslow (1926, p. 18).
Campeloma rufum (Haldeman), Winslow (1926, p. 18).
Campeloma rufum gibbum (Currier), Winslow (1926, p. 18).
Campeloma decisum (Say), F.C. Baker (1928, p. 57, pl. 5, figs. 1-7).
Campeloma milesii (Lea), F.C. Baker (1928, p. 61, pl. 2, figs. 1-5).
Campeloma integrum (Say), F.C. Baker (1928, p. 63, pl. 3, figs. 10-18; pl. 4, figs. 1-8, 10).
Campeloma rufum (Haldeman), F.C. Baker (1928, p. 68, pl. 4, figs. 9, 11-22).
Campeloma rufum gibbum (Currier), F.C. Baker (1928, p. 73, pl. 5, figs. 8-12).
Campeloma decisum (Say), Eggleton (1931, p. 257).
Campeloma rufum (Haldeman), Eggleton (1931, p. 257).
Campeloma decisum (Say), Goodrich (1932, p. 74, fig.).
Campeloma decisum (Say), Goodrich (1939, p. 23).
Campeloma decisum, Eggleton (1952, p. 217).
Campeloma rufum, Eggleton (1952, p. 217).
Campeloma decisum (Say), Burch & Tottenham (1980, pp. 86, 89, fig. 57).
Campeloma decisum form *integrum* Say, Burch & Tottenham (1980, pp. 86, 87, fig. 38).
Campeloma decisum form *exilis* Anthony, Burch & Tottenham (1980, p. 86).
Campeloma decisum form *milesi* Lea, Burch & Tottenham (1980, pp. 86, 87, fig. 39).
Campeloma decisum form *gibbum* Currier, Burch & Tottenham (1980, pp. 86, 89, fig. 60).
Campeloma decisum (Say), Burch & Vail (1982, pp. 17, 79, fig. 57).
Campeloma decisum form *integrum* Say, Burch & Vail (1982, pp. 17, 74, fig. 38).
Campeloma decisum form *milesi* Lea, Burch & Vail (1982, pp. 17, 74, fig. 39).
Campeloma decisum form *gibbum* Currier, Burch & Vail (1982, pp. 17, 79, fig. 60).
Campeloma decisum (Say), Burch & Vail, in Burch (1982b, p. 230, fig.).
Campeloma decisum (Say), Burch & Jung (1987, p. 240, fig. 9).
Campeloma decisum, Laman, Boss & Blankespoor (1984, pp. 20-25).
Campeloma decisum (Say), Burch & Vail, in Burch (1989b, pp. 86, 89, fig. 57).
Campeloma decisum form *integrum* Say, Burch & Vail, in Burch (1989b, pp. 86, 87, fig. 38).
Campeloma decisum form *milesi* Lea, Burch & Vail, in Burch (1989b, pp. 86, 87, fig. 39).
Campeloma decisum form *gibbum* Currier, Burch & Vail, in Burch (1989b, pp. 86, 89, fig. 60).
Campeloma decisum (Say), Burch (1991, p. 127).

Shell: Medium to large, that of adults ranging from a bit less than 2 cm to more than 4 cm in length; usually imperforate, but specimens in some populations exhibit a small umbilical chink. The whorls may or may not be shouldered. The spire height ranges from about half the shell length, to (usually) somewhat more than half the shell length. Very attenuate shells have a proportionately higher spire. The aperture is entire, oval, with an obtuse posterior angle. The shell color ranges from pale Light Yellowish Olive to Olive Buff and Olive Citrine (Ridgeway's color nomenclature[4]). The surface of

[4]Robert Ridgeway, 1912, *Color standards and color nomenclature.* Published by the author, Washington, D.C., pp. i-iv, 1-113, 53 pls.

shells of some populations are further colored by environmental deposits of tan, brown or rust.

Operculum: The shape is more or less the same oval form as the shell aperture, except that the operculum is somewhat narrower. The anterior margin of the operculum is rounded, the posterior margin ends in an obtuse angle. The operculum is concave, thin, corneous, concentrically ringed, with the eccentric nucleus situated nearer the inner (columellar) margin. The color of the operculum is tanner or browner than the periostracum of the shell. In addition to its concentric growth lines, the operculum is marked with darker concentric rest marks, which apparently correspond to, and are made at the same time as, the varices on the shell.

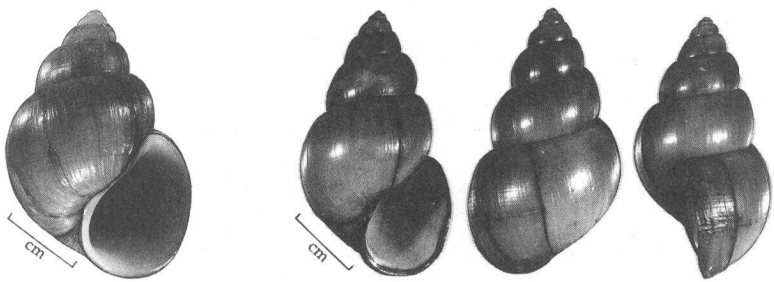


FIG. 13. Shell of a, *Campeloma decisum;* b, *C. decisum* form *milesi.*

Animal: The head-foot is light lead or bluish-white in color. Dorsally, the cervical lappets, foot, operculigerous lobe, tentacles and proboscis are further marked by irregularly scattered bright orange-yellow dots. On the tentacles and proboscis, these dots are arranged in somewhat regular transverse rows, giving a barred appearance to each row. The tentacles and proboscis are also marked by an abundant deposition of black pigment. The sole of the foot shows the large longitudinal pedal muscles, which, when contracted, withdraw the animal into the shell. When this occurs, the anterior margin of the foot is reflected upwards and backwards over the proboscis and tentacles. This reflected portion is then bent backwards and downwards to be finally covered by the posterior portion of the foot, which carries the operculum. (Call, 1988, *Am. Nat.*, 22, pp. 491-497).

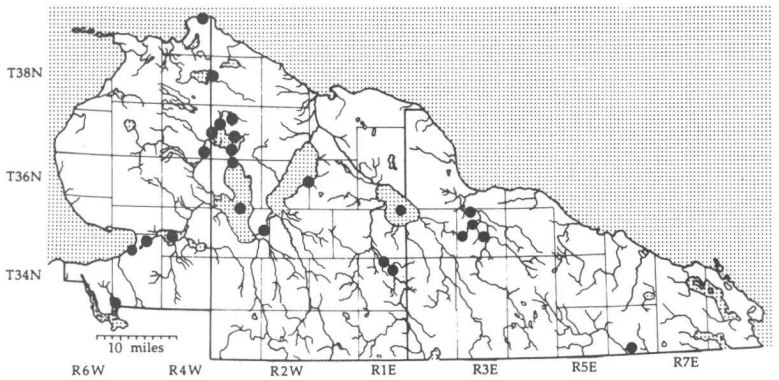
Habitat: Sand, mud or clay substrates in lakes and slow or moderately flowing streams. *Campeloma decisum* may be found crawling on

the substrate, but more generally it burrows. *Campeloma decisum* is often found in large numbers around decaying organic matter.

General Distribution: Eastern North America, from Nova Scotia, southern Ontario and southern Manitoba south to Texas, Louisiana, Mississippi, Alabama, northern Georgia and Virginia (Burch & Tottenham, 1980).

Distribution in UMBS Area: Cheboygan Co.: Carp Lake [Lake Paradise], UMMZ 36160; Marl Bay and mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36707; Indian River, Metzelaar and Langlois, 14 June 1925, UMMZ 37694; Beaver Pond on Carp Creek [Little Carp River], Carl L. Hubbs and Greene, 7 August 1925, UMMZ 38922; Burt Lake, Hubbs and Metzelaar, 1921, UMMZ 39721; Burt Lake, UMMZ 42934; Grapevine Point, Douglas Lake, Mina L. Winslow, 6 July 1926, UMMZ 43201; Douglas Lake, North Fishtail Bay, Mina L. Winslow, 3 July 1926, UMMZ 43205; Black River, near Tower, Mina L. Winslow, 7 July 1926, UMMZ 43212; Carp Lake [Lake Paradise] inlet, Carl L. Hubbs, 17 July 1927, UMMZ 43432; Douglas Lake, west shore, Peter Okkelberg, 20 August 1925, UMMZ 46970; Douglas Lake, Elmer Cheatum, 1932, UMMZ 57368; Douglas Lake, Bryant Walker Collection, UMMZ 95467; Black River, Tower, Calvin Goodrich, Bryant Walker Collection, UMMZ 95612; Douglas Lake, Bryant Walker Collection, UMMZ 96273; Lake Michigan, Mackinaw City, D.S. Bullock, Bryant Walker Collection, UMMZ 156819; Mullett Lake, Bryant Walker, Bryant Walker Collection, UMMZ 156820; Burt Lake, Calvin Goodrich, Bryant Walker Collection, UMMZ 156880; Lancaster Lake, Royal Bruce Brunson, 12 July 1945, UMMZ 198366; Douglas Lake, Grapevine Point, Royal Ontario Museum Collection, 6 July 1926, UMMZ 203272; Douglas Lake, Bryant Walker Collection, Royal Ontario Museum Collection, UMMZ 203273; Mackinaw City, 16 June 1938, Phil L. Marsh Collection, UMMZ 205250; Mullett Lake, east shore, 400 feet south of Needle Point, Aloha Township, L. Goine and Harold J. Walter, 19 July 1956, UMMZ 249156; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, John B. Burch, 15 July 1985, UMMZ 250410; Douglas Lake, north shore of Fishtail Bay, at Fresh Air Camp, Munro Township, John B. Burch, 3 July 1985, UMMZ 250411; Sedge Point, Douglas Lake, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250414; Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250441; Hook Point Bay, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250444; Douglas Lake, shoal at UMBS, South Fishtail Bay, at northern part of sections 33 and 34, at their boundary, T37N, R3W, Munro Township, John B. Burch, 23 June 1985, UMBS-85-1; Sedge Point, Douglas Lake, beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5c; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R4W, Munro Township, John B. Burch and Younghun Jung, 29 June 1988, UMBS-88-6. **Emmet Co.:** Carp Lake [Lake Paradise], Calvin Goodrich Collection, UMMZ 28729; Carp Lake [Lake Paradise], UMMZ 36153; Carp Lake [Lake Paradise], R.J. Kirtland , Bryant Walker Collection, UMMZ 95458; Petoskey, DeCamp Collection, Bryant Walker Collection, UMMZ 95589; Crooked Lake, Petoskey, DeCamp Collection, Bryant Walker Collection, UMMZ 95691; Carp Lake [Lake Paradise], Bryant Walker Collection, UMMZ 95693; Round Lake, M.L. Leach, Bryant Walker Collection, UMMZ 95695; northeast Walloon Lake, Section 30, Bear Creek Township, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170717; Paradise Lake [formerly Carp Lake], at public access site, northern end of Section 15, T38N, R4W, Carp Lake Township, John B. Burch, 25 June 1985, UMBS-85-3; East Branch of Maple River, southeastern corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 7 July 1985, UMBS-85-8a(1). **Presque Isle Co.:** Sunken Lake, Carl L. Hubbs and Jones, 17 September 1925, UMMZ 37696; outlet of Sunken Lake, Mina L. Winslow, 9 July 1926, UMMZ 43208; outlet of Sunken Lake, Mina L. Winslow, 9 July 1926, UMMZ 43209; Lake Huron, Presque Isle Park, UMMZ 57774; Black Lake, M.L. Leach, Bryant

Walker Collection, UMMZ 95689; Section 17, Ocqueoc Township, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170553; Ocqueoc River at Ocqueoc Falls, Harold W. Harry and Henry van der Schalie, 14 September 1948, UMMZ 171471; Ocqueoc River at Ocqueoc Falls, southcentral part of Section 22, Ocqueoc Twp, John B. Burch, 18 July 1985, UMMZ 250412; Ocqueoc River just below outlet from Ocqueoc Lake, southeastern part of Section 19, T36N, R3E, Ocqueoc Township, John B. Burch, 18 July 1985, UMMZ 250413; Ocqueoc River at outlet from Ocqueoc Lake, southeastern part of Section 19, T36N, R3E, Ocqueoc Township, John B. Burch, 18 July 1985, UMBS-85-12b; Ocqueoc River at Ocqueoc Falls, southcentral part of Section 22, T35N, R3E, Ocqueoc Township, John B. Burch 18 July 1985, UMBS-85-13a.



MAP 6. Localities of *Campeloma decisum.*

Remarks: Old specimens that are noticeably larger than the average *Campeloma decisum* are found occasionally in the UMBS area. However, these large specimens do not approach the size of *C. crassula* Rafinseque, and do not have the cylindrical body whorl commonly associated with *C. crassula.* Judging from the varices on the shells of old specimens found in the UMBS area, *C. decisum* may live for 12 or more years. Medcof (1940, *Can. J. Res.,* 18: 165-172) concluded that the life span of *C.* cf. *decisum* is at least five years.

Walker (1903, *Nautilus,* 16(11), pp. 121-124, pl. 5) recognized more attenuate campelomas in Michigan as *Campeloma milesi* Lea: "Compared with *decisa* as it is commonly found, *milesii* is a thinner, more elongated shell, with a more acute apex; the upper whorls are more convex and the suture rather more deeply impressed; the aperture is smaller and narrower. ... There is [also] a marked difference in the shape of the young when ready for extrusion. ... The young of *milesii* ... is uniformly larger [4.75 x 3.50 mm] than the young of *decisa* [4.25 x 3.50 mm]. The shell is more slender and noticeably more elon-

gated, the apex being well elevated above the next whorl, while in *decisa* the apex is depressed, giving a planorboid shape to the apex, and rises scarcely if at all above the second whorl."

Goodrich (1939), in dealing with the campelomas of the Upper Peninsula, came to the conclusion that slight differences in shell surface gloss or brightness, and retention of apical whorls into maturity were environmentally induced and that coloration of the shell material is related to the age of the shell or, in beachworn specimens, to the process of disintegration of shell material. Presumably, he also gave little weight to the more attenuate shape of "*C. milesi.*" Accordingly, he relegated all specimens from the Upper Peninsula to one species, and used the oldest applicable name for them, *C. decisum.* Clarke (1973, *Malacologia,* 13, p. 220) also concluded that the *C. milesi* form falls within the normal range of variation of *C. decisum.* In observing shell specimens from the UMBS area, we have come to similar conclusions. The shells of some populations are more globose (Fig. 13a), some are more attenuate (Fig. 13b), some exhibit interpopulational variation in coloration, surface gloss, etc.

However, in relation to interpopulational variation, it should be mentioned that normal reproduction in the *Campeloma decisum* group is by parthenogenesis (males are rarely found), which restricts or prevents gene flow, resulting in clonal populations. How this relates to populational morphology and systematics in *Campeloma* has not been investigated.

Family HYDROBIIDAE

The Hydrobiidae are one of the most common and widely distributed gastropod families, occurring in temperate, subtropical and tropical regions throughout much of the world. The family is a large one, containing more than 100 genera. Three genera occur in the UMBS area, *Amnicola, Fontigens* and *Pyrgulopsis.*

Shells of hydrobiid snails are small (many are minute), generally elongate, dextral (Fig. 82b), nearly always drab and unicolored, and generally have relatively few whorls. The shells of most species lack surface sculpturing. The shell aperture is closed by an operculum, which is generally paucispiral (Fig. 3b), but some species have nearly round, multispiral opercula. Like most prosobranch snails, the sexes are separate in the Hydrobiidae, and the shells of some genera exhibit sexual dimorphism.

Because of the similarity of the shells of many species occurring in different genera and subfamilies, reliance must be placed on anatomical characters, especially those of the verge (male copula-

tory organ), in making identifications and for assigning species to genera.

Key to Genera in the UMBS Area

1 Verge with two ducts and without glandular apical and subapical crests ..... *Amnicola* (p. 28)

Verge with three ducts and without glandular apical and subapical crests ..... *Fontigens* (p. 34)

Verge with a single duct and glandular apical and subapical crests ..... *Pyrgulopsis* (p. 37)

Genus *Amnicola* Gould & Haldeman

The foot is broad and spatulate, truncate anteriorly and rounded posteriorly. The tentacles are long, when extended are about one and one-half times as long as the snout. The eyes are located at the outer base of the tentacles. The snout, mantle and tentacles are mottled with melanin pigment. The bifid verge originates on the nape of the neck, and when erect the verge extends anteriorly over the right side of the body; when contracted it is recurved beneath the mantle, pointing posteriorly. The left margin of the verge bears a truncate flagellar lobe that is nearly equal to the length of the penis. The penis is cylindrical in shape and may be stocky or slender.

No conspicuous sexual dimorphism is seen in the shells, except that females tend to be more robust than the males. The female lays relatively large eggs that bear a wide chitinous ring.

The genus *Amnicola* is widely distributed in North America east of the Rocky Mountains. Two subgenera are recognized in North America, *Amnicola s.str.* and *Lyogyrus* (Thompson, 1968, *The aquatic snails of the family Hydrobiidae ...*, Univ. Fla. Press, pp. 162-163).

Key to Species of *Amnicola* in the UMBS Area

1 Adult shell larger, more than 3.0 mm in length with four whorls; nuclear whorl of shell relatively large (0.38 - 0.48 mm in diameter); mantle heavily mottled with black; penis and penial lobe relatively stout. Subgenus *Amnicola s.str.* (Figs. 90d, 92) ..... *A. limosus* (p. 29)

Adult shell very small, 2.5 mm or less in length with four whorls; nuclear whorl of shell small (0.29 - 0.36 mm in diameter); mantle diffusely shaded with pigment; penis and penial lobe relatively slender and elongate. Subgenus *Lyogyrus* ..... *A. (L.) walkeri* (p. 32)

Subgenus *Amnicola s.str.*

Amnicola s.str. is distinguished from the subgenus *Lyogyrus* by its generally larger shell with relatively larger nuclear whorl, its

thicker verge, and its mottled mantle. *Lyogyrus* has a minute shell with relatively smaller nuclear whorl, a more slender verge, and a more heavily and diffusely black-pigmented mantle.

Amnicola limosus (Say)

(Figs. 14, 15, 92, 94-96; Map 7)

Paludina limosa Say 1817, *J. Acad. Nat. Sci. Philad.*, 1, pp. 125, 126.
Amnicola porata Say, Walker (1893, p. 139).
Amnicola limosa (Say), Walker (1911, p. 126).
Amnicola limosa (Say), H.B. Baker (1914, pp. 18-45).
Amnicola limosa (Say), Winslow (1917, p. 10).
Amnicola limosa (Say), Winslow (1926, p. 19).
Amnicola limosa (Say), F.C. Baker (1928, p. 93, pl. 6, figs. 1-6).
Amnicola limosa (Say), Eggleton (1931, p. 257).
Amnicola limosa (Say), Goodrich (1932, p. 78, fig.).
Amnicola limosa (Say), Goodrich (1939, p. 25).
Amnicola (Amnicola) limosa (Say), Berry (1943, p. 23; fig. 1; pl. 1., fig. 1; pl. 3, fig. 1; pl. 5, figs. 1-3; pl. 7, fig. 1).
Amnicola limosa, Eggleton (1952, p. 217).
Amnicola limosa limosa (Say), Burch & Tottenham (1980, pp. 121, 123-125, 127, figs. 268, 286, 288-290, 299).
Amnicola limosa limosa (Say), Burch (1982a, pp. 29, 108, 111-113, figs. 268, 286, 288-290, 299).
Amnicola limosa limosa (Say), Burch (1982b, p. 239, fig.).
Amnicola limosa limosa (Say), Burch & Jung (1987, pp. 243, 244, fig. 15).
Amnicola limosa (Say), Hershler & Thompson (1988, p. 82, figs. 1-8).
Amnicola limosa limosa (Say), Burch (1989b, pp. 121, 123-125, 127, figs. 268, 286, 288-290, 299).
Amnicola limosa (Say), Burch (1991, p. 127).

Shell: Adult shells with 4.0 - 6.0 whorls measure 3.0 - 7.0 mm in length. They are ovately to subglobosely conic in shape, and have well rounded whorls; the spire outline is slightly convex; the body whorl is large and inflated. The aperture is roundly ovate, entire. The outer lip is thin; the inner lip is somewhat thickened and slightly reflected anteriorly. The umbilicus is relatively narrow to broadly open. The protoconch has 1¼ - 1½ whorls, is smooth throughout, sometimes having a few fine spiral threads or lines whorls. The apex is even with or slightly depressed below the beginning of the teleoconch. The teleoconch has strong collabral growth lines. (Hershler & Thompson, 1988, *Malacol. Rev.*, 21, p. 82).

Operculum: corneous, paucispiral, thin, amber colored, with up to four spirals.

Animal: Black epithelial pigment is concentrated on the head/foot in three places: as a single narrow band along much of the length of the tentacles, between the eyespot and the distal tip; as a narrow to broad band along the width of the proximal snout; and as a narrow-broad band along the sides of the head/foot, extending posteriorly from a point just ventral to the eyespots. The visceral mass is pigmented with a characteristic streak along the dorso-anterior edges of the intestine and pallial oviduct, and with a dark patch covering

most of the dorsal surfaces of the stomach and digestive gland. The snout is broad, with obvious distal lips; the dorsal surface (posterior to lips) is covered with relatively dense cilia. The tentacles are elongate, non-tapering, with several narrow bands of hypertrophied cilia regularly spaced around the circumference and extending along much of the tentacle length between the eyespot and the distal tip. The foot is broad and densely ciliated ventrally. The anterior edge of the foot has an obvious slit and large, central opening of the pedal glands.

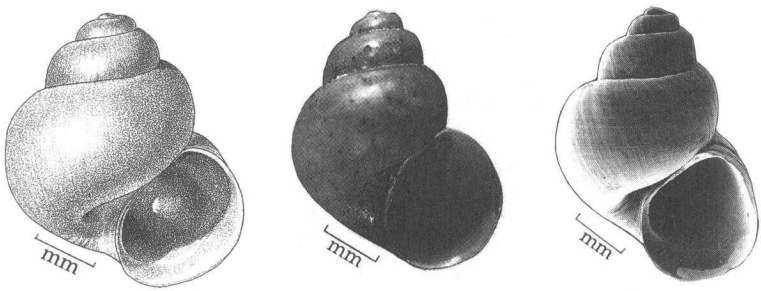


FIG. 14. Shells of *Amnicola limosus.* The figure on the right is from Hershler & Thompson (1988, p. 82, fig. 1).

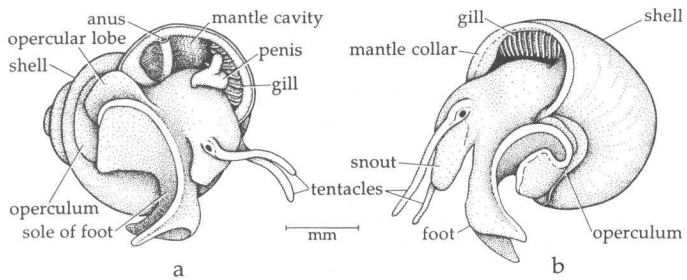


FIG. 15. *Amnicola limosus.* The animals, removed from the substrate, are twisting, exposing the mantle cavity enough to show the gill. **a**, A male; **b**, a female.

The gill has 25 - 35 broadly triangular filaments, covered with cilia. The osphradium is centered in the posterior half of the ctenidium, filling about one-fourth of the length of the ctenidium length. The hypobranchial gland is absent. (Hershler & Thompson, 1988, *Malacol. Rev.*, 21, pp. 82-83).

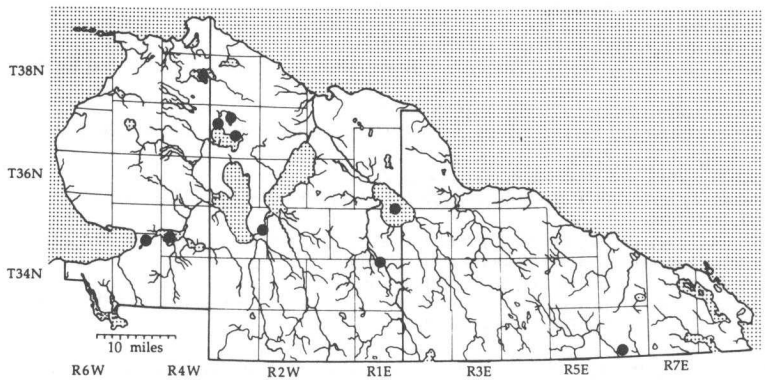
For aspects of internal anatomy, see p. 154 ff., Figs. 94-96.

Habitat: Found on aquatic vegetation in lakes, ponds and streams. "*Amnicola limosa* occurs in all unpolluted, permanent aquatic habi-

tats where microscopic aquatic vegetation grows" (Clarke, 1973, *Malacologia,* 13, p. 259).

General Distribution: Newfoundland south to the Carolinas and west to Manitoba and Saskatchewan; in the United States, generally east of the Mississippi River (Clarke, 1973, *Malacologia,* 13, p. 259; Hershler & Thompson, 1988, *Malacol. Rev.*, 21, p. 82).

Distribution in UMBS Area: **Cheboygan Co.:** mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1929, UMMZ 41929; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1929, UMMZ 41930; small pond near Douglas Lake, N.A. Wood, 1915, UMMZ 42924; Douglas Lake, N.A. Wood, UMMZ 42926; Douglas Lake, Mina L. Winslow, 1926, UMMZ 43146; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 120484; Douglas Lake, University of Michigan Expedition, 1908, Bryant Walker Collection, UMMZ 120487; Black Lake, UMMZ 150104; Lancaster Lake, Royal Bruce Brunson, UMMZ 198362; Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250434; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Cheboygan Co., John B. Burch, 15 July 1985, UMMZ 250439; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R4W, Munro Township, John B. Burch, 4 July 1985, UMMZ 253231. **Emmet Co.:** Round Lake, Petoskey, Frederick Stearns Collection, UMMZ 31559; Carp Lake [Lake Paradise], Bryant Walker, Bryant Walker Collection, UMMZ 120099; Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 120100; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 120101. **Presque Isle Co.:** outlet of Sunken Lake, UMMZ 41935.



MAP 7. Localities of *Amnicola limosus.*

Remarks: F.C. Baker (1928) gave the subspecific name *superiorensis* to "the Great Lakes manifestation of the *limosa* type of *Amnicola,* characterized by a large, thick shell, which is usually more globose than the variety *porata* of the smaller lakes." The relationships between the large and small lake varieties, and the riverine variety, need to be critically assessed. Clarke (1973, *Malacologia,* 13, p. 257) considered *A. limosus superiorensis* to be merely an ecophenotype [as did Baker, who gave nomenclatural recognition to ecophenotypes], and thus not warranting subspecific distinction.

Amnicola limosus can be distinguished from *Pyrgulopsis lustricus* by its wider, more depressed shell and its less oblique and rounder aperture with more obtuse posterior angle.

Subgenus *Lyogyrus* Gill

The shells of this subgenus are all minute with very small nuclear whorls. The shells are light tan, gray or brown. The opercula are round and multispiral, either tightly or loosely coiled. The mantle is heavily and diffusely pigmented with melanin. The reproductive anatomy of the various species are alike, and very similar to that of the subgenus *Amnicola s. str.*, except that their verges are not as robust. For further details of *Lyogyrus*, its taxonomy and relationships, see Thompson (1968, *The ... Hydrobiidae ...*, Univ. Fla. Press, pp. 162-163).

Amnicola (Lyogyrus) walkeri Pilsbry

(Fig. 16; Map 8)

Amnicola grana Say, Walker (1893, p. 139).
Amnicola walkeri Pilsbry 1898, *Nautilus*, 12 (4), pp. 43-44.
Amnicola walkeri Pilsbry, Walker (1911, p. 126).
Amnicola walkeri (Pilsbry), H.B. Baker (1914, pp. 18-45).
Amnicola walkeri Pilsbry, Winslow (1926, p. 19).
Amnicola (Marstonia) walkeri Pilsbry, F.C. Baker (1928, p. 114, pl. 7, figs. 1-4; text fig. 47, 3-5).
Amnicola walkeri Pilsbry, Goodrich (1932, p. 78).
Amnicola (Amnicola) walkeri Pilsbry, Berry (1943, p. 26; fig. 2; pl. 1., figs. 2, 3; pl. 3, fig. 2; pl. 5, figs. 4, 5; pl. 7, fig. 1).
Amnicola wakeri [*walkeri*], Eggleton (1952, p. 217).
Amnicola (*Lyogyrus*) *walkeri* Pilsbry, Burch & Tottenham (1980, pp. 123, 126-128, figs. 282, 307, 309).
Amnicola (*Lyogyrus*) *walkeri* Pilsbry, Burch (1982a, pp. 30, 111, 113, figs. 282, 307, 309).
Amnicola (*Lyogyrus*) *walkeri* Pilsbry, Burch (1982b, p. 239, fig).
Amnicola (*Lyogyrus*) *walkeri* Pilsbry, Burch & Jung (1987, pp. 244, 245, fig. 16).
Amnicola (*Lyogyrus*) *walkeri* Pilsbry, Burch (1989b, pp. 123, 126-128, figs. 282, 307, 309).
Amnicola (Lyogyrus) walkeri Pilsbry, Burch (1991, p. 127).

Shell: Ovately conic in shape. Adult shells with four whorls measure about 2.5 mm in length. The whorls are convex, shouldered, with deep sutures. The aperture is nearly round, the aperture lip continuous. The umbilicus is relatively wide. The surface is sculptured with fine, closely spaced growth lines. The color of the shell (periostracum) is light tan.

Animal: Heavily pigmented with melanin, especially on the head, becoming a bit more diffuse posteriorly. The verge is bifid, with the penis and penial lobe about equal in length. The penis tapers gradually to a point; the penial lobe has an equal diameter throughout and is truncate.

Habitat: In heavily vegetated habitats with mud substrates in

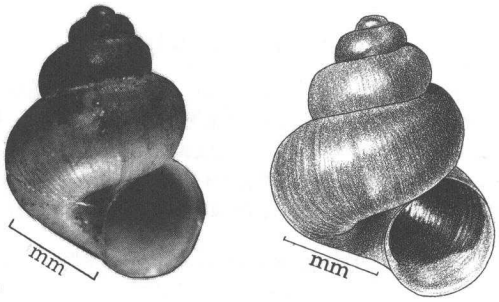
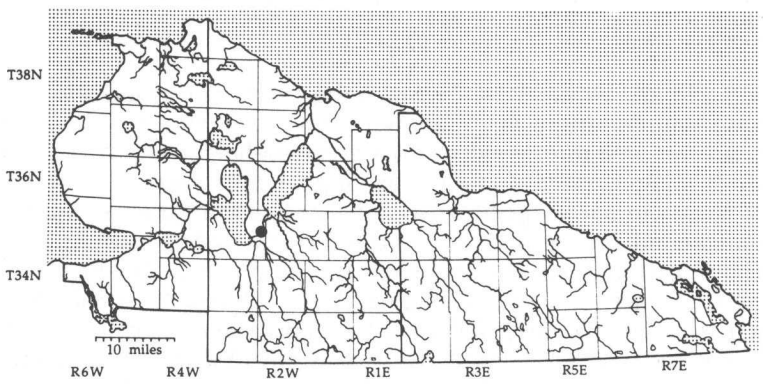


FIG. 16. Shells of *Amnicola (Lyogyrus) walkeri.*

large or small lakes or in sluggish streams (Clarke, 1973, *Malacologia,* 13, p. 256).

General Distribution: St. Lawrence River and Great Lakes drainages, upper Mississippi drainage, the Canadian Interior Basin in the Albany and Winnipeg river systems and in Lake Winnipeg (Clarke, 1973, *Malacologia,* 13, p. 256).

Distribution in UMBS Area: Cheboygan Co.: Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 121231.



MAP 8. Locality of *Amnicola (Lyogyrus) walkeri.*

Remarks: *Amnicola walkeri* is the smallest prosobranch snail found in Michigan, which is probably the reason it has not been collected more often. *Amnicola walkeri* is often confused with juvenile *A. limosus* or *Pyrgulopsis lustricus,* so it is important to compare shell size and number of whorls when making identifications.

Genus *Fontigens* Pilsbry

Pilsbry (1933, *Nautilus*, 47: 12) proposed the name *Fontigens* as a substitute name for Clessin's (1878, *Malakozool. Blätter*, 25: 151) *Stimpsonia* (preoccupied). F.C. Baker (1928, p. 131) pointed out the distinctiveness of the trifid verge of *Fontigens*. Hershler *et al.* (1990) recognized nine species for the genus in the United States.

Fontigens nickliniana (Lea)

(Figs. 17-20; Map 9)

Paludina nickliniana Lea 1838, *Trans. Am. Philos. Soc.*, (new ser.), 6, p. 92, pl. 23, fig. 109.
Bythinella attenuata Hald. and *B. nickliniana* Lea, DeCamp (1881, pp. 10, 11).
Bythinella attenuata Hald. and *B. nickliniana* Lea, Walker (1893, p. 139).
Bythinella attenuata Hald. and *B. nickliniana* Lea, Walker (1895a, p. 19).
Paludestrina nickliniana (Lea) and *P. nickliniana attenuata* (Hald.), Walker (1911, p. 126).
Paludestrina nickliniana (Lea), Winslow (1926, p. 19).
Paludestrina nickliniana attenuata (Haldeman), Winslow (1926, p. 19).
Stimpsonia nickliniana (Lea), F.C. Baker (1928, p. 132, figs. 57-59, pl. 7, figs. 9-12).
Paludestrina nickliniana (Lea), Goodrich (1932, p. 80, fig.).
Hydrobia nickliniana (Lea), Berry (1943, p. 44; fig. 7; pl. 1, fig. 16; pl. 4, fig. 2; pl. 6, fig. 5; map 7).
Fontigens nickliniana (Lea), Burch & Tottenham (1980, pp. 123, 126, 129; figs. 283, 319).
Fontigens nickliniana (Lea), Burch (1982a, pp. 31, 111, 116; figs. 283, 319).
Fontigens nickliniana (Lea), Burch (1982b, p. 238, fig.).
Fontigens nickliniana (Lea), Burch (1989a, p. 75).
Fontigens nickliniana (Lea), Burch (1989b, pp. 123, 126, 129, 238; figs. 283, 319).
Fontigens nickliniana (Lea), Hershler *et al.* (1990, pp. 1, 4; figs. 1-11).
Fontigens nickliniana (Lea), Burch (1991, pp. 127, 133).

Shell: Small, about 3.5-4.75 mm long, with about 4½-7½ well rounded whorls, attenuate, narrowly conic to narrowly subovately conic, sutures well impressed. "Color greenish-horn, or whitish under a black coating; surface shining, lines of growth numerous, crowded, rather rough in some specimens; ... peristome continuous, sharp, a little thickened on the inside; ... inner lip somewhat rounded over the umbilical region; base of shell rounded" (F.C. Baker, 1928). "Aperture ovate, somewhat angled above. Inner lip moderately thickened [and] reflected, slightly separated from or adnate to small portion of body whorl. Umbilicus usually slit-like, but varying from absent to open. Apex protruding slightly; protoconch striae faint but numerous. Periostracum often covered by deposits" (Hershler *et al.*, 1990).

Operculum: Corneous, ovate, paucispiral, with 4-5 spirals.

Animal: Foot small, somewhat squarish in front, rounded behind, covered with light gray blotches, interspersed with dark spots; snout long, black, lighter at the distal end; tentacles long, cylindrical, tapering slightly, blunt at the end, gray, translucent; base of each tentacle with a swelling containing the blackly pigmented eye. Each eye is surrounded by a circular white area. (F.C. Baker, 1928).

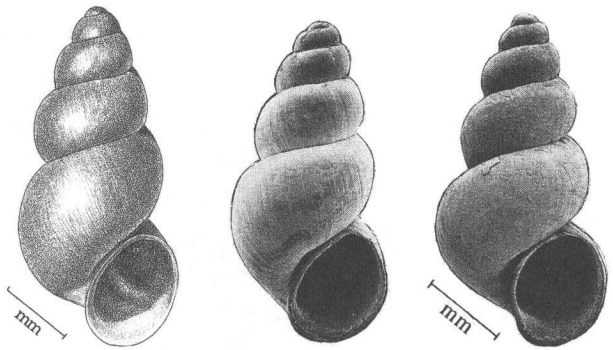


FIG. 17. Shells of *Fontigens nickliniana*. The two figures on the right are from Hershler *et al.* (1990).

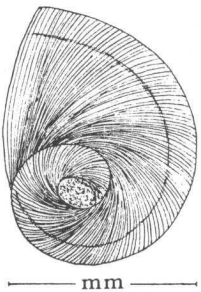


FIG. 18. Operculum of *Fontigens nickliniana* (from F.C. Baker, 1928).

"Epigean animals often near-uniformly covered with dark brown pigment. ... Dense yellow-white subepithelial granules clustered in small areas posterior to (and sometimes slightly overlapping) eyespots and scattered in proximal half of tentacles. Visceral coil deeply pigmented, ... particularly on dorsal surface" (Hershler *et al.*, 1990).

Extending beyond the edge of the mantle collar in the right nuchal region in males, there is a large, trifid, darkly pigmented verge.

Habitat: Among water plants in small lakes and ponds, springs, spring-fed streams, and streams in caves (F.C. Baker, 1928; Hershler *et al.*, 1990).

General Distribution: Eastern Wisconsin and Illinois, west to New York, south through Ohio, Pennsylvania, Virginia and West Virginia to central Alabama.

Distribution in UMBS Area: **Emmet Co.**: Round Lake, Petoskey [Academy of Natural Sciences of Philadelphia (ANSP 68453) record.]

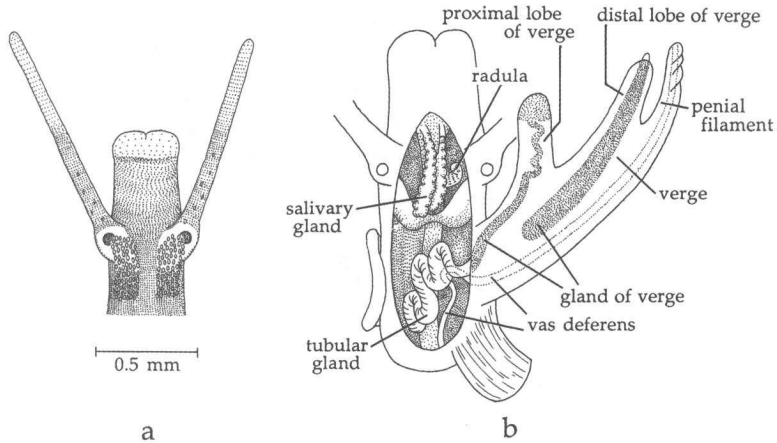


FIG. 19. Aspects of the anatomy of *Fontigens nickliniana* (from Hershler *et al.*, 1990). **a**, Dorsal head; **b**, head end of animal with cut-away showing contents of the anterior head-foot cavity.

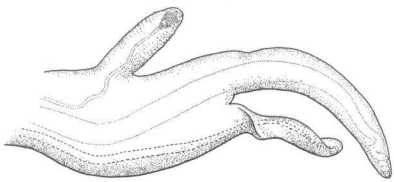
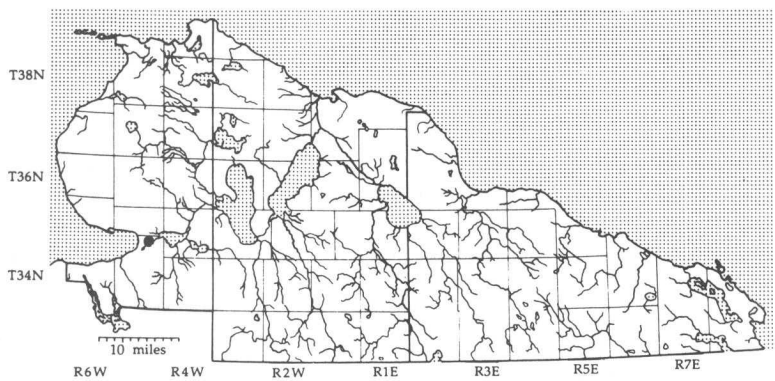


FIG. 20. Trifid verge of *Fontigens nickliniana* (from Berry, 1943).



MAP 9. Locality of *Fontigens nickliniana* (after Hershler *et al.*, 1990).

Remarks: *Fontigens nickliniana* can be distinguished from other hydrobiid snails of the UMBS area by its attenuate shell with relatively small aperture, well rounded whorls and deep sutures. Anatomically, the verge is trifid: in addition to the penis, there are two elongate accessory lobes, each with a tubular gland inside.

Genus **Pyrgulopsis** Call & Pilsbry

The genus *Pyrgulopsis* has recently been redefined (Hershler & Thompson, 1987, *Nautilus*, 101, pp. 25-32). The shells of the various species vary in shape, size and surface sculpture. Diagnostic characters of the reproductive system are of prime importance. The penis, which is easier to observe than the organs of the female system, has a small distal lobe, a narrow, elongate filament, and a surface with one to 15 glandular ridges, which are sometimes on stalked crests.

Pyrgulopsis lustricus (Pilsbry)

(Fig. 21; Map 10)

Amnicola lustrica Pilsbry 1890, *Nautilus*, 4(5), p. 53.
Amnicola lustrica Pils., Walker (1893, p. 139).
Amnicola lustrica Pilsbry, Walker (1911, p. 126).
Amnicola lustrica Pilsbry, Winslow (1926, p. 19).
Amnicola (Marstonia) lustrica Pilsbry, F C. Baker (1928, p. 104, pl. 6, figs. 16, 17, 26, 27; text fig. 45).
Amnicola lustrica Pilsbry, Goodrich (1932, p. 78).
Amnicola lustrica Pilsbry, Goodrich (1939, p. 26).
Amnicola (Marstonia) lustrica Pilsbry, Berry (1943, p. 29; fig. 3; pl. 1., figs. 4-6; pl. 3, fig. 3; pl. 5, fig. 6; pl. 7, fig. 4).
Amnicola lustrica, Eggleton (1952, p. 217).
Marstonia lustrica (Pilsbry), Thompson (1977, p. 124, figs. 2, 4D, 5, 15, 16, 25A).
Marstonia lustrica (Pilsbry), Burch & Tottenham (1980, pp. 113, 117-119, figs. 218, 219, 245, 246, 250, 251).
Marstonia lustrica (Pilsbry), Burch (1982a, pp. 27, 101, 106, 107, figs. 218, 219, 245, 246, 250, 251).
Marstonia lustrica (Pilsbry), Burch (1982b, p. 237, fig.).
Marstonia lustrica (Pilsbry), Burch & Jung (1987, p. 247, fig. 20).
Pyrgulopsis lustricus (Pilsbry), Hershler & Thompson (1987, *Nautilus*, 101(1), p. 29).
Marstonia lustrica (Pilsbry), Burch (1989b, pp. 113, 117-119, figs. 218, 219, 245, 246, 250, 251).
Pyrgulopsis lustrica Pilsbry, Burch (1991, p. 127).

Shell: Subovately conic, moderately thin, weakly translucent to opaque, dull olivaceous-gray in color, sculptured with fine, rather widely-spaced, incremental striations. The sutures are deeply impressed. Adults with 4.4 to 6.0 whorls vary in length from 3.3 to 4.9 mm. The whorls are moderately shouldered. The aperture is complete, broadly elliptical or ovate in shape and has a weakly angular or rounded posterior end (Thompson, 1977).

Animal: The verge is relatively simple in structure, having a single apical gland on the apical lobe and a rather short and stocky penis

(Thompson, 1977). Other details of external anatomy have not been described.

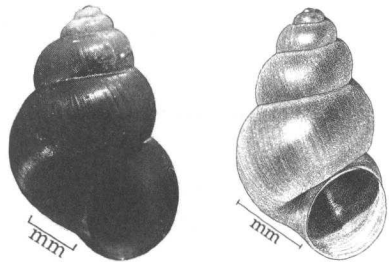
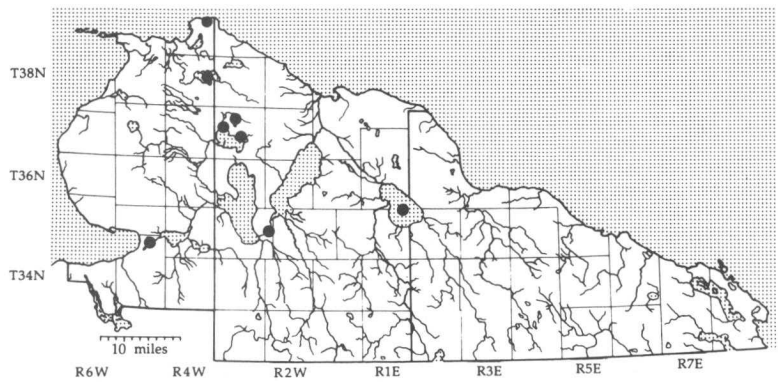


FIG. 21. Shells of *Pyrgulopsis lustricus.*

Habitat: Eutrophic lakes or eutrophic areas of mesotrophic lakes, with vegetation and sand or mud bottoms (Clarke, 1973, *Malacologia,* 13, p. 252). Found in a variety of habitats that are usually characterized by clear water with submerged aquatic plants, including lakes, ponds, marshes, rivers, and small streams (Thompson, 1977).

General Distribution: Canada: southern Quebec and Ontario; United States: Maine and New York west through northwestern Pennsylvania, Ohio, northern Indiana and northern Illinois to Iowa and Minnesota (Thompson, 1977).



MAP 10. Localities of *Pyrgulopsis lustricus.*

Distribution in UMBS Area: **Cheboygan Co.:** mouth of Bessie Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1929, UMMZ 41923; North Fishtail Bay, Douglas Lake, Mina L. Winslow and Crystal Thompson, 3 July 1929, UMMZ 41924; Douglas Lake, Mina L. Winslow, 1926, UMMZ 43153; Douglas Lake, Mina L. Winslow, 1926, UMMZ 43154; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 120692; Black Lake, UMMZ 150142; Lake Michigan, Mackinaw City, A.C. Lane, Bryant Walker Collection, UMMZ 160622; Lancaster Lake, Royal Bruce Brunson, UMMZ 253228; Hook Point, North Fishtail Bay, Douglas

Lake, Section 22, T37N, R3W, Munro Township, Cheboygan Co., John B. Burch, 15 July 1985, UMMZ 253229. **Emmet Co.:** Round Lake, Petoskey, UMMZ 42855; Carp Lake [Lake Paradise], Bryant Walker, Bryant Walker Collection, UMMZ 120659; Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 120660; Carp Lake [Lake Paradise], Bryant Walker, Bryant Walker Collection, UMMZ 160675; Round Lake, Petoskey, Frederick Stearns Collection, UMMZ 253232; Outlet, Carp Lake [Lake Paradise] (Thompson, 1977); Carp Lake [Lake Paradise] near Mackinaw City (Thompson, 1977). **Presque Isle Co.:** Orchard Lake (Thompson, 1977); Black Lake (Thompson, 1977).

Remarks: *Pyrgulopsis lustricus* shows considerable ecologically-associated variation throughout its range. Individuals from lentic habitats have more slender shells than those found in lotic habitats (Thompson, 1977).

In the UMBS area, *Pyrgulopsis lustricus* can be distinguished from *Amnicola limosa* by its narrower, more elongate shell and its more oblique and more oval aperture with more acute posterior angle.

Family PLEUROCERIDAE

The Pleuroceridae are widely distributed, occurring not only throughout most of North America, but also in Central and South America, Africa and Asia as well. But, it is in North America that the family has reached is greatest development. The family is dioecious, with the females having an egg-laying sinus on the right side of the foot. Males do not have a copulatory organ. The generic groups traditionally have been distinguished by shell characters, and the classification of these groups as based on shells is not entirely satisfactory. Nevertheless, shell characters are useful for species identification.

The shells of pleurocerids are thick and solid, and the majority of species are elongately conical in shape. The operculum is paucispiral and corneous.

Key to Species of Pleuroceridae in the UMBS Area

1 Shell elongately to narrowly subovately conic (spire angle = 37-50°); anterior or "basal" end of aperture not noticeably channeled or auger-shaped (Fig. 23a). Genus *Elimia* ..... *Elimia livescens* (p. 40)

Shell narrowly conic (spire angle = 19-24°); anterior or "basal" end of aperture prolonged into a short canal, producing an auger-shaped base to the shell (Fig. 23b). Genus *Pleurocera* ..... *Pleurocera acuta* (p. 44)

Genus *Elimia* H. & A. Adams

The name *Elimia* was proposed by H. & A. Adams in 1854 (*Genera Recent Moll.*, Van Voorst, London, 1, p. 300), but the genus long went under the name *Goniobasis* Lea (1862, *J. Acad. Nat. Sci.*, 5, p. 217). Most of the species occur in rivers in the southeastern United States.

Only one species, *E. livescens*, occurs in Michigan (Winslow, 1926); it is common and widespread in the state. Goodrich (1945) and Dazo (1965) made special studies of *E. livescens* in Michigan.

Elimia livescens (Menke)

(Figs. 22, 23a, 97-99; Map 11)

Lymnaea virginica Lister, Say (1817, Conchology, in Nicholson, 1816-1817, *Am. Ed. Brit. Encyclop., Dict. Arts, Sci.*, etc., 1st ed., vol. 2, pt. 2, 9th page, pl. 2, fig. 4).
Melania virginica Say 1824, Mollusca, in Keating's *Narr. Exped. Source St. Peter's R.*, etc., vol. 2, appendix, p. 265.
Melania livescens Menke 1830, *Synopsis Method. Moll.*, p. 135.
Goniobasis livescens Mke., Walker (1893, p. 140).
Goniobasis livescens cuspidatus Anth., Walker (1893, p. 140).
Goniobasis Milesii Lea, Walker (1893, p. 140).
Goniobasis translucens Anth., Walker (1893, p. 140).
Goniobasis brevispira Anth., Walker (1893, p. 140).
Goniobasis pulchella Anth., Walker (1893, p. 140).
Goniobasis gracilior Anth., Walker (1893, p. 140).
Goniobasis Niagarensis Lea, Walker (1893, p. 140).
Goniobasis brevispira (Anthony), Walker (1911, p. 126).
Goniobasis depygis Say, Walker (1911, p. 126).
Goniobasis gracilior (Anthony), Walker (1911, p. 126).
Goniobasis livescens (Menke), Walker (1911, p. 126).
Goniobasis livescens translucens (Anthony), Walker (1911, p. 126).
Goniobasis pulchella (Anthony), Walker (1911, p. 126).
Goniobasis semicarinata (Anthony), Walker (1911, p. 126).
Goniobasis livescens (Menke), H.B. Baker (1912, p. 209).
Goniobasis livescens (Menke), Winslow (1926, p. 19).
Goniobasis livescens (Menke), F.C. Baker (1928, p. 180, pl. 9, figs. 15-26).
Goniobasis livescens (Menke), Goodrich (1932, p. 82, fig.).
Goniobasis livescens (Menke), Goodrich (1939, p. 26).
Goniobasis livescens (Menke), H.B. Baker (1942, *Nautilus*, 56(1), pp. 33-34).
Goniobasis livescens (Menke), Goodrich (1945, pp. 1-36, pl. 1).
Goniobasis livescens (Menke), Dazo (1965, *Malacologia*, 3(1), pp. 1-80).
Elimia livescens livescens (Menke), Burch & Tottenham (1980, pp. 140, 143, fig. 393).
Elimia livescens livescens (Menke), Burch (1982a, pp. 37, 129, fig. 393).
Elimia livescens livescens (Menke), Burch (1982b, p. 246, fig.).
Goniobasis livescens, Laman, Boss & Blankespoor (1984, pp. 20-25).
Elimia livescens livescens (Menke), Burch & Jung (1987, pp. 249, 250, fig. 24).
Elimia livescens livescens (Menke), Burch (1989b, pp. 140, 143, fig. 393).
Elimia livescens (Menke), Burch (1991, p. 127).

Shell: Medium in size, adults in the UMBS area with nine whorls reach 2.6 cm in shell length, elongately to narrowly subovately conic, sturdy, imperforate, opaque, dull, dark horn, Diamine Brown, Olive Lake or Green-Blue Slate[5] in color, or nearly black, generally unicolored, but often with a darker broad spiral band. The aperture is entire with a palatal callus, is broadly ovate in shape, and has a pointed posterior angle. The outer lip is sharp, slightly curved in side view; the columellar lip is evenly curved. The whorls are gen-

[5]Ridgeway's color standards (see footnote, p. 23).

erally flat-sided, but some specimens/populations have somewhat rounded whorls. The sutures are not impressed. The surface is generally smooth, except for fine growth lines and obsolete spiral lines, sometimes low spiral ridges, and a single carina on the early whorls.

Shells from marl lakes are usually covered with marl.

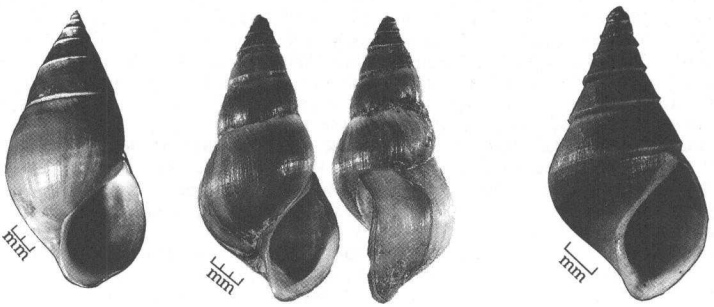


FIG. 22. Shells of *Elimia livescens*. The shell on the right is a young shell at higher magnification, showing the single carina.

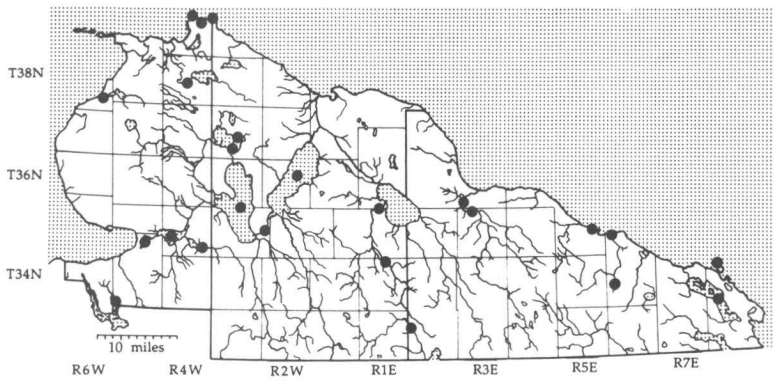
Animal: The body is rather short, rounded posteriorly, with a subconical or wedge-shaped rostrum (proboscis; snout). The mouth is a vertical slit at the end of the rostrum. The tentacles are attenuate, with the eyes located at the outside of their slightly swollen bases. The mantle is white and nearly transparent with a slightly yellow collar. The mantle margins are smooth. A groove extends from the mantle cavity to the base of the right tentacle. The color of the head-foot is yellowish to grayish-orange, varying to dark gray with irregular spots sparsely scattered over the sides of the foot. The sole of the foot is bluish-white, flecked with dark spots. The rostrum is yellowish-orange with black stripes; the black stripes are more prominent near the mouth, gradually changing to spots near the neck. The antero-ventral surface of the rostrum is bluish-yellow to bluish-white. (See also F.C. Baker, 1928; Goodrich, 1945; Dazo, 1965.)

For aspects of internal anatomy, see p. 159 ff., Figs. 97-99.

Habitat: *Elimia livescens* "is found in almost any clean and permanent type of fresh-water environment (springs, swift flowing streams, inland lakes); this species is usually found crawling on rocks and stones" (Dazo, 1965). "Occurs in lakes, rivers, streams of all sizes, and springs. Frequently found crawling on stones in a few centimetres of water in clear, rapid streams, but also lives at several metres in lakes" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 84).

General Distribution: St. Lawrence River drainage from the Great Lakes to Lake Champlain and Quebec; tributaries of the Ohio River, east to Scioto River in Ohio; Wabash River and branches, west to the Illinois River; through the Erie Canal it has invaded the Hudson River basin (Goodrich, 1940; 1945).

Distribution in UMBS Area: **Cheboygan Co.:** Indian River, Metzlaar and Langlois, 14 June 1925, UMMZ 40533; Black River, Metzelaar and Langlois, 15 August 1925, UMMZ 40545; Lake Huron, Straits of Mackinac, Langlois and Moody, 3 September 1926, UMMZ 40552; Burt Lake, Carl L. Hubbs and Greene, 7 August 1925, UMMZ 40553; tributary to Burt Lake, Carl L. Hubbs and Greene, 7 August 1925, UMMZ 40554; Douglas Lake, Elmer P. Cheatum, 1932, UMMZ 55646; drift of Lake Michigan, 10 miles southwest of Mackinaw, UMMZ 63844; upper Black River, L.D. Golcynski, UMMZ 130299; Mackinaw City, 16 June 1938, Phil L. Marsh Collection, UMMZ 241700; Burt Lake, 20 July 1960, UMMZ 246532; Mullett Lake, 20 July 1960, UMMZ 246533; Burt Lake, west shore, Harold J. Walter, 18 July 1956, UMMZ 246537; Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250436; Douglas Lake, Sedge Point, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5a; Pine Point, Douglas Lake, Section 22, T37N, R3W, Munro Township, John B. Burch and Younghun Jung, 22 July 1988, UMBS-88-16a. **Emmet Co.:** Crooked Lake, Metzlaar and Langlois, 10 August 1925, UMMZ 37598; Pickerel Lake, Metzlaar and Langlois, 7 August 1925, UMMZ 40555; Carp River [Little Carp River], near mouth, Carl L. Hubbs, 17 July 1927, UMMZ 42618; Wycamp Creek, near Cross village, UMMZ 63830; Round Lake, Bryant Walker Collection, UMMZ 133596; Crooked Lake, Conway, Bryant Walker Collection, UMMZ 133605; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 143525; Crooked Lake, Oden, Kent Science Institute Collection, UMMZ 143526; Round Lake, Kent Science Institute Collection, UMMZ 143527; Round Lake, Petoskey, Phil L. Marsh Collection, UMMZ 241713. **Presque Isle Co.:** mouth of Swan creek, UMMZ 40548; Lake Huron, Presque Isle Point, UMMZ 57775; Grand Lake, UMMZ 57782; Lake Huron, Rogers City, Bryant Walker Collection, UMMZ 133615; Ocqueoc River just below Ocqueoc Lake, Henry van der Schalie, 13 September 1948, UMMZ 171479; Ocqueoc River at outlet from Ocqueoc Lake, southeastern part of Section 19, T36N, R3E, Ocqueoc Township, John B. Burch, 18 July 1985, UMBS-85-12b; Ocqueoc Lake at outdoor camp, southeastern part of Section 19, T36N, R36, Ocqueoc Township, John B. Burch and Younghun Jung, 30 July 1988, UMBS-88-23.



MAP 11. Localities of *Elimia livescens*.

Remarks: *Elimia livescens* has long gone under the name *Goniobasis livescens*. However, the generic name *Goniobasis* Lea 1862 is a synonym of the older name *Elimia* H. & A. Adams 1854.

F.C. Baker (1928) named from the Lake Michigan shore, Wisconsin, a subspecies *michiganensis* as the Great Lake form of *"G." livescens*, an "ecological form, the heavier shell, wider body whorl, and larger aperture being a response to the rough environment of the lake shore." However, there is little value in having Latin names for the many forms of *E. livescens*.

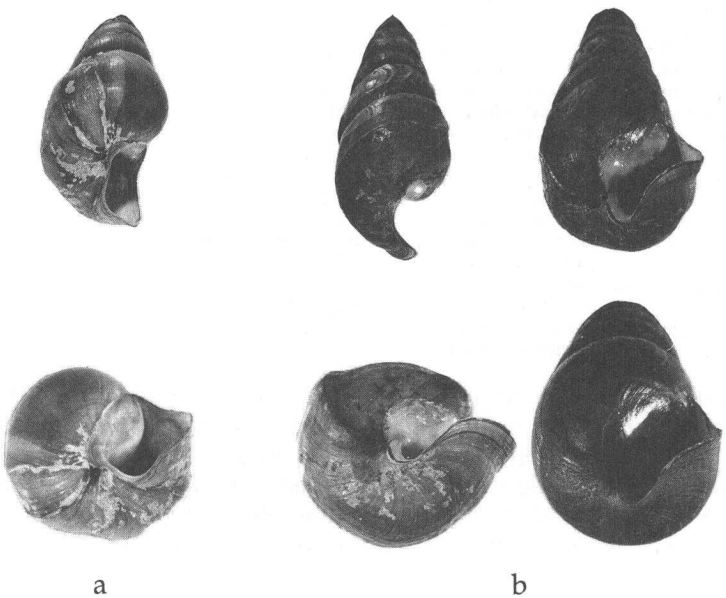


FIG. 23. Anterior ("basal") ends of the shells of (a) *Elimia livescens* and (b) *Pleurocera acuta*, showing the auger-shaped basal shell of *P. acuta* contrasted with *E. livescens*.

Genus *Pleurocera* Rafinesque

The generic name for this group of snails was long embroiled in controversy. The nomenclatural problems were solved in 1981 by a ruling (Opinion 1195) of the International Commission on Zoological Nomenclature (*Bull. Zool. Nomencl.*, 38(4), pp. 259-265).

Like *Elimia*, most of the species of *Pleurocera* occur in the rivers of the southeastern United States. Michigan has only one species, *P. acuta*, which is common in rivers of the southern part of the state, but

rare in northern Michigan. Dazo (1965) made a special study of *P. acuta* in Michigan.

Pleurocera acuta Rafinesque

(Figs. 23b, 24; Map 12)

Pleurocerus acutus Rafinesque (in Blainville) 1824, *Man. Malacol. Conchyliol.*, p. 442.
Pleurocera acuta Rafinesque 1831, *Enumer. Acct. Some Remark. Nat. Objects*, p. 3.
Pleurocera subulare Lea, Walker (1893, p. 139).
Pleurocera subulare intensum Anth., Walker (1893, p. 139).
Pleurocera neglectum Anth., Walker (1893, p. 140).
Pleurocera elevatum Say, Walker (1893, p. 140).
Pleurocera labiatum Lea, Walker (1893, p. 140).
B. [Pleurocera] pallidum Lea, Walker (1893, p. 140).
Pleurocera subulare (Lea), Walker (1911, p. 126).
Pleurocera subulare intensum (Reeve), Walker (1911, p. 126).
Pleurocera elevatum (Say), Walker (1911, p. 126).
Pleurocera neglectum (Anthony), Walker (1911, p. 126).
Pleurocera acuta Rafinseque, Winslow (1926, p. 19).
Pleurocera acuta Rafinesque, F.C. Baker (1928, p. 171, pl. 9, fig. 4).
Pleurocera acuta Rafinesque, Goodrich (1932, p. 81, fig.).
Pleurocera acuta Rafinseque, Goodrich (1939, p. 26).
Pleurocera acuta Rafinesque, Dazo (1965, *Malacologia*, 3(1), pp. 1-80).
Pleurocera acuta acuta Rafinesque, Burch & Tottenham (1980, pp. 162, 163, fig. 521).
Pleurocera acuta acuta Rafinesque, Burch (1982a, pp. 45, 142, fig. 521).
Pleurocera acuta acuta Rafinesque, Burch & Jung (1987, pp. 250, 251, fig. 26).
Pleurocera acuta acuta Rafinesque, Burch (1989b, pp. 162, 163, fig. 521).
Pleurocera acuta Rafinesque, Burch (1991, p. 127).

Shell: Medium to large in size, adults in the UMBS area with 12½ whorls reach 3.2 cm in shell length, narrowly conic, sturdy, imperforate, opaque, dull, Olive-Buff to Dusky Brown, generally unicolored, but often with a darker broad spiral band. The aperture is entire, has a palatal callus, and is rather quadrilateral in shape. The outer lip is sharp and is rather strongly curved in side view; the

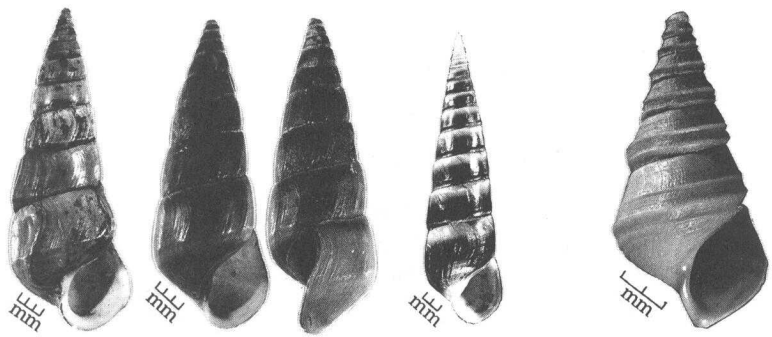


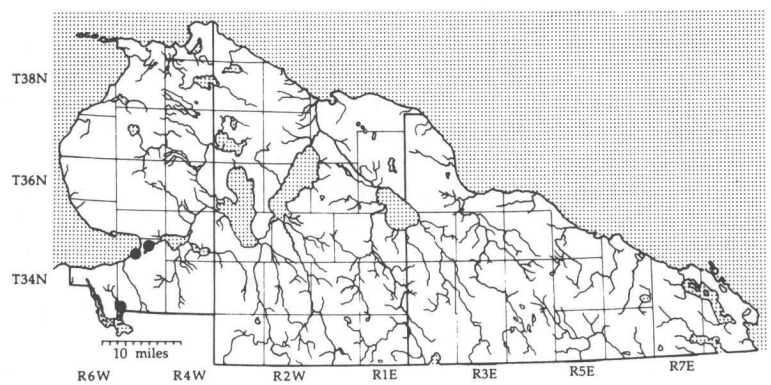
FIG. 24. Shells of *Pleurocera acuta*. The shell on the right is a young shell at higher magnification, showing two prominent carinae on the spire whorls.

columellar lip is nearly straight to slightly curved. The whorls are exceptionally flat-sided. The sutures are not impressed. The surface is generally smooth, except for fine growth lines and obsolete spiral lines, sometimes low spiral ridges, and a single carina or two carinae or the early whorls.

Animal: The foot is wide, rather short and thick, rounded posteriorly and truncated anteriorly. The head is prominent and has a subconical rostrum (proboscis; snout) capable of considerable extension. The rostrum is yellowish-orange, its dorsal surface marked with transverse black bands that are more prominent near the mouth, changing gradually to spots near the neck. The antero-ventral surface of the rostrum is bluish-yellow to bluish-white. The mouth is a vertical slit at the end of the rostrum, dividing the rostrum into a double disk. The tentacles are attenuate, very narrow, with the eyes located at their outer, swollen bases. The mantle is dark gray to black, with smooth margins. The foot is black, with a yellowish sole, and has a conspicuous operculigerous lobe on its posterior dorsal surface. A groove extends from the mantle cavity to the base of the right tentacle. (F.C. Baker, 1928; Dazo, 1965.)

Habitat: "Typical *acuta* is a species of the Great Lake shores where the wave action is strong" (F.C. Baker, 1928). "Found in quiet areas of large streams and in lakes. A burrowing species that prefers mixed sand and mud bottoms" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can, Ottawa, p. 82).

General Distribution: Ohio River head streams and tributaries; Great Lakes and tributaries; Mississippi River and westward to Nebraska and Kansas; through the Erie Canal into the basin of the



MAP 12. Localities of *Pleurocera acuta.*

Hudson River; Cumberland and Duck rivers, Tennessee (Goodrich, 1940).

Distribution in UMBS Area: Emmet Co.: Petoskey, Bryant Walker Collection, UMMZ 133065; Round Lake, Petoskey, Bryant Walker Collection, UMMZ 133066; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 143501.

THE PULMONATES

In the Pulmonata, the gill found in the Prosobranchia has been replaced by a vascularized pulmonary cavity (lung), which can breath either water or air, depending on the habits of the particular species. The great majority of the pulmonate species are land inhabitants, but many pulmonate species are restricted to fresh waters. Only a few pulmonate snails live in marine environments.

Order LYMNOPHYLA (Basommatophora, in part)

The freshwater-dwelling pulmonate snails are placed in the Order Lymnophila (a name that means literally "fresh-water-loving"). In contrast to the land-dwelling pulmonate snails, the lymnophiles have only one pair of tentacles, at the base of which the eyes are situated (*e.g.*, see Fig. 104c). [In terrestrial pulmonate snails, the eyes are situated on the distal tips of the upper pair of tentacles (except for the acteophile Carychiidae).] The Lymnophila contains four important freshwater snail families, the Lymnaeidae, Physidae, Planorbidae and Ancylidae.

Family LYMNAEIDAE

The Lymnaeidae are world-wide in distribution, but their greatest diversity is found in the northern United States and central Canada. The shells range in shape from the coiled, needle-like *Acella haldemani* (Binney) of northcentral and northeastern North America to the uncoiled, limpet-shaped *Lanx* and *Fisherola* of the Pacific drainage. Those with coiled shells are easily distinguished from the Physidae by their dextral shells (the lone 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 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 last two families, all Lymnaeidae lack a respiratory pseudobranch.

Many authors have placed all spired lymnaeids into a single all inclusive genus, *Lymnaea.* However, because we can observe several *groups* of species among the lymnaeids, we find it more practical to use generic names for these smaller groups. These names in the UMBS area are *Bulimnea, Fossaria, Lymnaea s.str.,* and *Stagnicola.* Within the genus *Fossaria* are two subgroups of species, the subgenera *Bakerilymnaea* and *Fossaria s.str.* Within the genus *Stagnicola* are also two subgroups, the subgenera *Hinkleyia* and *Stagnicola s.str.*

A species of another genus, now widely spread in North America, including Michigan, is the Eurasian *Radix.* While it has been reported from the southern part of Michigan, and we collected it at Sugar Island in the Upper Peninsula, we have not found it in the UMBS area. It will probably show up in our area sooner or later.

Identification Key for the Genera in the UMBS Area

1 Shell large, that of adults more than 35 mm in length 2

Shell smaller, that of adult less than 35 mm in length 4

2(1) Shell with a relatively wide, expanded, elongately oval to globose body whorl 3

Shell with a relatively narrow body whorl. Genus *Stagnicola* (p. 68), in part 4

3(2) Shell with a narrow, pointed spire ..... *Lymnaea* (p. 65)

Shell with a wider, less attenuate spire ..... *Bulimnea* (p. 47)

4(1,2) Adult shell medium to large, generally more than 13 mm (but occasionally 13 mm or less) in length; surface sculptured with microscopic spiral striations; columella usually with a well-developed twist or plait (Fig. 87b) .....*Stagnicola* (p. 68)

Adult shell small, generally less than 13 mm (but occasionally up to 15 or 16 mm) in length; spiral sculpture usually absent, very weak when present; columella generally without a twist or plait ....*Fossaria* (p. 51)

Genus ***Bulimnea*** Haldeman

Bulimnea is a monotypic genus, named by Haldeman (1841) for Say's (1824) *Lymnaeus megasomus. Bulimnea megasoma* gets its name from its bulimoid shape and large size. Its shell is so distinctive in appearance and so uniform in character throughout its range that the

species has not been cursed by a long synonymy. *Megasoma* seems to be the only name to have been assigned to it.

Bulimnea megasoma (Say)

(Figs. 25, 26; Map 13)

Lymneus megasomus Say 1824, Mollusca, in Keating's *Exped. Source St. Peter's R.*, etc., vol. 2, appendix, p. 263, pl. 15, fig. 10.
Lymnaea megasoma Say, Walker (1892, p. 323).
Lymnaea megasoma Say, Walker (1911, p. 124).
Lymnaea (Bulimnea) megasoma Say, Winslow (1926, p. 10).
Bulimnea megasoma (Say), F.C. Baker (1928, p. 277, pl. 8, figs. 19-23; pl. 17, figs. 31, 35).
Lymnaea megasoma Say, Goodrich (1932, p. 48, fig.).
Lymnaea megasoma Say, Cheatum (1934, p. 348).
Lymnaea megasoma Say, Goodrich (1939, p. 14).
Lymnaea megasoma (Say), Hubendick (1951, p. 194).
Bulimnea megasoma (Say), Burch & Tottenham (1980, pp. 169, 170, fig. 566).
Bulimnea megasoma (Say), Burch (1982a, pp. 48, 146, fig. 566).
Bulimnea megasoma (Say), Burch (1982b, p. 249, fig.).
Bulimnea megasoma (Say), Burch & Jung (1987, pp. 252, 253, fig. 28).
Bulimnea megasoma (Say), Burch (1989b, pp. 169, 170, fig. 566).
Bulimnea megasoma (Say), Burch (1991, p. 127).

Shell: Large, adults with 7 whorls up to 5.3 cm in length, ovately conic, imperforate, opaque, slightly glossy to dull, Saccardo's Umber to Brownish Olive[6] in color and streaked with tan or Ecru-Olive transverse bands. The aperture is oval. The outer lip sharp, straight in side view. The columellar lip is reflected over the umbilicus. The columella is twisted. The whorls are rounded and sculptured with

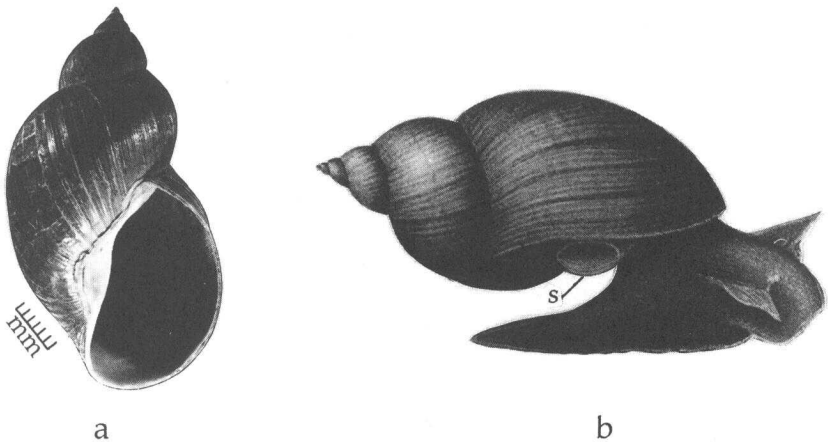


FIG. 25. *Bulimnea megasoma*. **a**, Shell; **b**, active animal; s, siphon. Fig. b is from Whitfield (1882, *Bull. Am. Mus. Nat. Hist.*, 1(2), pl. 5, fig. 3).

[6]Ridgeway's color standards (see footnote, p. 23).

obsolete fine spiral lines, well marked growth lines and larger transverse undulations. The shell surface is frequently malleated. The sutures are impressed.

Animal: "Blackish, the head and tentacles marked with small yellow spots which give a brownish color on close inspection; and when the animal is in motion the surface has the appearance of being covered with a superficial bloom of a russet color. Foot of blackish gray, lighter beneath; mantle bluish gray, slightly tinged with yellow toward the posterior angle of the shell aperture. Head broadly semicircular, spreading below, obtusely angular at the posterior lateral margins and slightly emarginate in front. Foot disc broadly rounded in front and tapering behind to an obtusely rounded point; about five-eighths of an inch wide near the anterior end, and together with the head measures about one inch and five-eighths in length when the animal is in motion. Tentacles broad and thin, more than half an inch long, slightly curved inward and irregularly tapering to an obtuse point. Eye spots small, situated at the inner base of the tentacles; yellow in color with a black center. Respiratory orifice of the pulmonary sac situated a little less than half an inch from the posterior angle of the shell aperture, and when fully dilated, as in the act of receiving air, is about one-fourth of an inch in its greatest diameter, and regularly oval in outline. The portion of the pulmonary sac near the respiratory orifice is very flexible, and is often protruded fully half an inch beyond the margin of the shell in the form of a long, slender, siphonal process, in the efforts of the animal to reach the surface of the water for the purposes of respiration" (R.P. Whitfield, 1882, *Bull. Am. Mus. Nat. Hist.*, 1(2): 30-31).

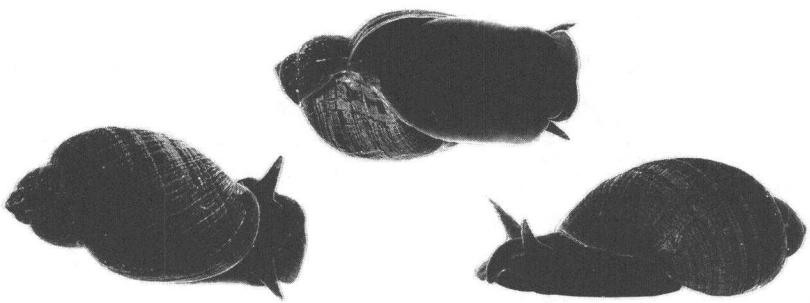


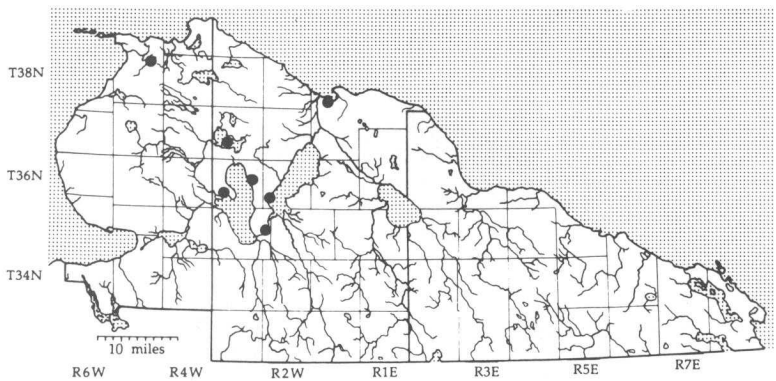
FIG. 26. *Bulimnea megasoma.* An active animal in three views.

Habitat: *Bulimnea megasoma* is a quiet bay or pond species, "where the environment is protected from the force of waves and wind by barriers of one kind or another. The water is shallow and

there is usually an abundance of vegetation, such as *Scirpus, Potamogeton, Castalia, Nymphaea, Typha* and filamentous algae which provide much of the food of the snails" (F.C. Baker, 1919). *Bulimnea megasoma* "is usually an inhabitant of small, quiet bodies of water or swamps;" sometimes present (*e.g.*, in Georgian Bay) in deep water which is rather rough (F.C. Baker, 1928). "Occurs in large and small lakes, in slow-moving rivers, and in pond areas of creeks. Vegetation is variable and the usual bottom is mud" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 122).

General Distribution: Great Lakes and St. Lawrence River drainage area, upper tributaries of the Mississippi drainage area, parts of the Albany, Winnipeg and Nelson river systems in the Canadian Interior Basin (see Clarke, 1973, *Malacologia*, 13, p. 295).

Distribution in UMBS Area: Cheboygan Co.: Burt Lake near mouth of Maple River, Carl L. Hubbs, 7 August 1921, UMMZ 21187; Fontinalis Run, Douglas Lake [?], M.E. Jewell, 10 July 1924, UMMZ 47062; Mullett Lake, Bay View, Elmer P. Cheatum, 1932, UMMZ 55514; Bourasau Bay, east side of Burt Lake, at bridge on Topinabee Road, 29 July 1914, Frank Smith, Bryant Walker Collection, UMMZ 76181; pond on north side of Indian River at village, Frank Smith, 30 July 1914, Bryant Walker Collection, UMMZ 76182; pond on point next south of Colonial Point, on west side of Burt Lake, Frank Smith, Bryant Walker Collection, UMMZ 76183; pool north of Cheboygan, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170592; Fontinalis Run, west side of Burt Lake, Harold J. Walter, 11 September 1955, UMMZ 197937; Fontinalis Run, near bridge, T36N, R3W, S14, James W. Moffett, 3 August 1937, UMMZ 232357; Fontinalis Creek, M.J. Lindenschmidt, 20 June 1949, UMMZ 246661; Beach pool, public beach at Cheboygan, Harold W. Harry, 23 July 1949, UMMZ 246662. **Emmet Co.:** O'Neal Lake, 21 July 1945, UMMZ 198381.



MAP 13. Localities of *Bulimnea megasoma.*

Remarks: Although the shells of *Bulimnea megasoma* exhibit unusual conformity throughout the species' geographic range, the shells of snails born and reared in captivity show noticeable morphological

change in response to the different environment (Whitfield, 1882, *op. cit.;* Burch & Lindsay, 1973, *Malacol. Rev.*, 6(1), pp. 61-62).

Genus *Fossaria* Westerlund

This genus contains most of the small lymnaeid species in the UMBS area. Their shells are generally less than 13 mm in length, usually lack spiral sculpture, and generally are without a twist or plait on the columella. The dubious name *Galba* Schrank 1803 has been used frequently for this group of lymnaeid snails and is still being used today by Europeans for European *Fossaria* species.

North American fossarias are difficult to deal with in a survey such as this because their taxonomy is in such an unsatisfactory state. They are widespread and common, and their shells exhibit considerable variability. Snails with those characteristics have always spawned many synonyms. The names we have given to the UMBS area fossarias are *dalli* F.C. Baker, *exigua* Lea, *galbana* Say, *obrussa* Say, *parva* Lea and *peninsulae* Walker. *Fossaria dalli* is a member of the subgenus *Bakerilymnaea,* characterized by radulae with bicuspid lateral teeth. The other nominal species are members of the subgenus *Fossaria s. str.,* which have tricuspid lateral teeth. Among the latter group, *galbana* seems distinct enough, but the taxonomic validity of the other four is more difficult to assess. *Fossaria obrussa* is the oldest name, and so has priority. *Fossaria peninsulae* is noticeably larger and has a stronger columellar plait (resembling members of *Stagnicola*), a long and evenly tapered spire, and a reflected columellar lip and an expanded basal lip. *Fossaria exigua* shells that are about the same size as *F. obrussa* are more attenuate and may appear more delicate. *Fossaria parva* in the UMBS area is smaller than *F. obrussa,* and its outer lip in side view is straight rather than sinuous.

Hubendick (1951) synonymized with *Fossaria humilis* (Say) all North American fossarias, as well as *Stagnicola petoskeyensis,* and questionably, *Stagnicola (Hinkleyia) caperatus.* Serious American malacologists give little credence to this system.

Key to Subgenera of *Fossaria* in the UMBS Area

1 Adult shells (with 4+ whorls) larger, more than 5 mm in length; lateral teeth of the radula tricuspid (*i.e.,* with three prominent cusps; see Fig. 27a) ..... Subgenus *Fossaria s. str.* (p. 52)

Adult shells (with 4+ whorls) smaller, less than 5 mm in length; lateral teeth of the radula bicuspid (*i.e.*, with only two prominent cusps; see Fig. 27b) ..... Subgenus *Bakerilymnaea* (p. 63)

Subgenus *Fossaria s. str.*

Various lymnaeids are characterized by having radulae with either bicuspid or tricuspid lateral teeth. In the genus *Fossaria*, members of the subgenus *Fossaria s. str.* have tricuspid lateral teeth (Fig. 27a), whereas members of the subgenus *Bakerilymnaea* have bicuspid lateral teeth (Fig. 27b).

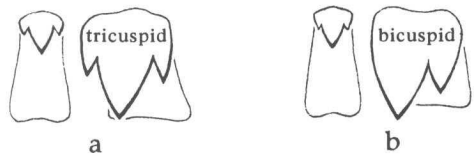


FIG. 27. Lymnaeid radular teeth. **a**, a central tooth and a tricuspid 1st lateral tooth; **b**, a central tooth and a bicuspid 1st lateral tooth.

Key to the Species of *Fossaria s.str.* in the UMBS Area

1 Shells rather bulimoid, adult shells (with 5+ whorls) less than 10 mm in length, apertural lip generally straight in side view ..... *F. parva* (p. 60)

Shells turreted, cylindrical or attenuate, but not especially bulimoid in shape, adult shells (with 5+ whorls) more than 10 mm in length, lip curved or sigmoid in side view 2

2(1) Shell whitish to horn-colored, solid, usually shouldered, body and spire whorls often flat-sided or cylindrical ..... *F. galbana* (p. 55)

Shell horn-colored to tan or brown, neither solid nor shouldered, body and spire whorls rounded 3

3(2) Shell noticeably attenuate, spire long and narrow .... *F. exigua* (p. 53)

Shell elongate but not especially attenuate, spire not especially narrow 4

4(3) Adult shell larger, 13 mm or more in length ..... *F. peninsulae* (p. 61)

Adult shell smaller, less than 13 mm in length ..... *F. obrussa* (p. 57)

Fossaria exigua Lea

(Figs. 28d, 29, 30; Map 14)

Lymnea exigua Lea 1841, *Proc. Am. Philos. Soc.*, 2(17), p. 33.
Lymnaea obrussa exigua Lea, Walker (1911, p. 124).
Lymnaea obrussa exigua Lea, Winslow (1917, p. 6).
Lymnaea (Galba) obrussa exigua Lea, Winslow (1926, p. 12).
Fossaria exigua (Lea), F.C. Baker (1928, p. 301, pl. 16, fig. 9; pl. 18, figs. 34-37).
Lymnaea obrussa exigua (Lea), Say, Goodrich (1932, p. 53).
Lymnaea obrussa exigua (Lea), Goodrich (1939, p. 15).
Lymnaea humilis (Say), in part, Hubendick (1951, p. 187).
Fossaria exigua (Lea), Burch & Tottenham (1980, pp. 171, 172, fig. 573).
Fossaria exigua (Lea), Burch (1982a, pp. 49, 153, fig. 573).
Fossaria exigua (Lea), Burch & Tottenham (1982b, p. 251, fig.).
Fossaria exigua (Lea), Burch (1989b, pp. 171, 172, fig. 573).
Fossaria exigua (Lea), Burch (1991, p. 127).

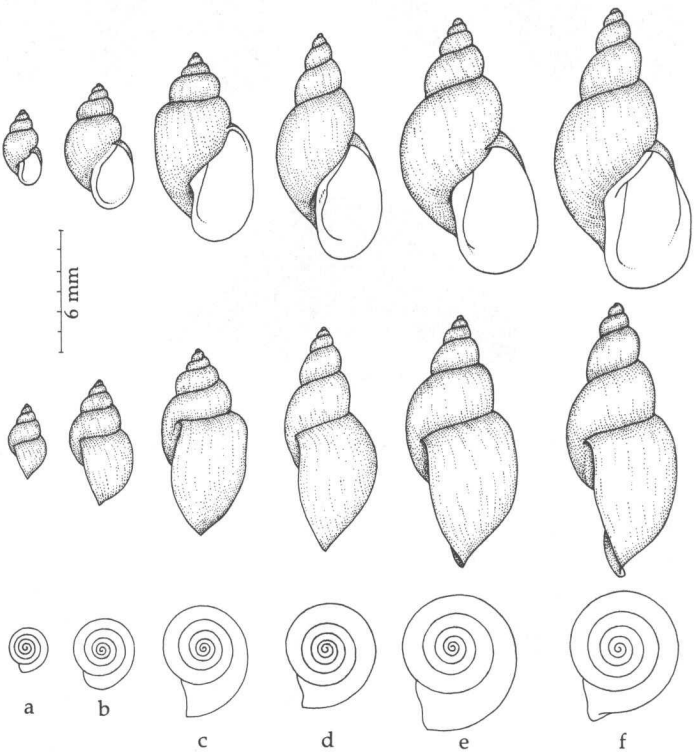


FIG. 28. Shells of *Fossaria* in the UMBS area. **a**, *Fossaria dalli;* **b**, *F. parva;* **c**, *F. galbana;* **d**, *F. exigua;* **e**, *F. obrussa;* **f**, *F. peninsulae.*

Shell: Small, adults with 5½ whorls up to 11 mm in length, attenuate, narrowly subovately conic, opaque to slightly translucent, moderately glossy, pale horn to tannish horn in color. The aperture is

oval to D-shaped. The outer lip is sharp, sinuate in side view. The columellar lip is reflected over the umbilicus, leaving an umbilical chink. The columella is straight or a little twisted. The whorls are rounded, not shouldered, and are sculptured with growth lines and a few obsolete spiral lines. The sutures are noticeably impressed.

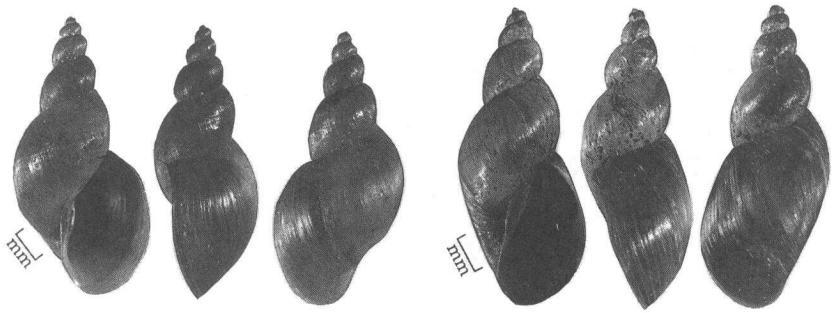
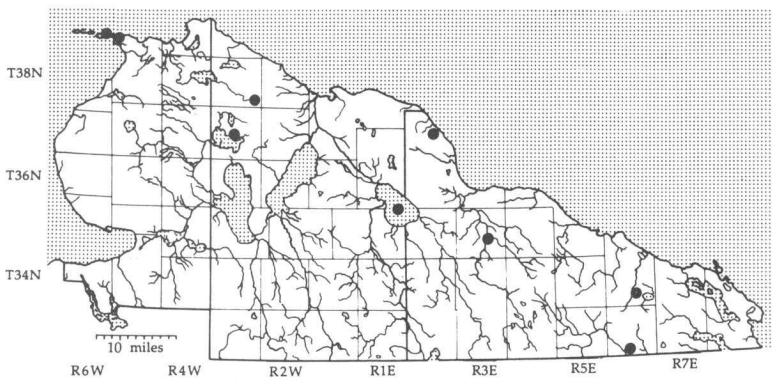


FIG. 29. Shells of *Fossaria exigua.*

FIG. 30. Animal and shell of *Fossaria exigua.*



MAP 14. Localities of *Fossaria exigua.*

Habitat: Small ponds, ditches, protected shores of small and large lakes and sluggish streams and, on mudflats along protected shores.

General Distribution: Throughout the St. Lawrence River system, south to Alabama in the Mississippi-Missouri river basin, north to the Hudson Bay lowlands in northern Ontario, and west to the Red River and Lake Winnipeg region in Minnesota and Manitoba (Clark, 1973, *Malacologia*, 13, p. 275).

Distribution in UMBS Area: **Cheboygan Co.:** Black Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39845; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39874; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39876; brook, Petoskey, Bryant Walker Bryant Walker Collection, UMMZ 75964; Black Lake, Mina L. Winslow, Bryant Walker Collection, UMMZ 78071; roadside drainage ditch along highway C 66 (Cheboygan Road), 0.5 mile northeast of highway I 75, Section 36, T38N, R3W, Hebron Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253227. **Emmet Co.:** Goose Pond, Wilderness Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 253181; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253184. **Presque Isle Co.:** Ocqueoc River, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39854; Sunken Lake, UMMZ 42684; pond 0.5 miles east of Hawks, Elmer P. Cheatum, 1932, UMMZ 55632; Ognioc [? Ocqueoc] River, Mina L. Winslow, Bryant Walker Collection, UMMZ 78065.

Remarks: The relationship of *Fossaria exigua* to *F. obrussa* is uncertain. We have recognized *F. exigua* as a distinct species with some hesitation, realizing that the *exigua* shape may be only a form of *F. obrussa* and not worthy of formal taxonomic recognition. Our concept of *F. exigua* is a species with a shell that is more attenuate and often more delicate than that of *F. obrussa*. We have found populations with such shells in the UMBS area. Other shells can be assigned to one or the other of the species only with difficulty. More in depth studies are necessary before the relationships of *F. exigua* to other fossarias can be ascertained.

Fossaria galbana (Say)

(Figs. 28c, 31; Map 15)

Lymneus galbanus Say 1825, *J. Acad. Nat. Sci. Philad.*, 5(2), pp. 123-124.
Limnaea desidiosa De Campi Streng 1896, *Nautilus*, 9(11), p. 123.
Lymnaea galbana Say, Walker (1892, p. 34).
Lymnaea galbana Say, Walker (1911, p. 124).
Lymnaea obrussa decampi Streng, Walker (1911, p. 124).
Lymnaea (Galba) galbana Say, Winslow (1926, p. 11).
Lymnaea (Galba) obrussa decampi Streng, Winslow (1926, p. 12).
Fossaria obrussa decampi (Streng), F.C. Baker (1928, p. 299, pl. 18, figs. 30-33; pl. 16, fig. 12).
Fossaria galbana (Say), F.C. Baker (1928, p. 304, pl. 16, fig. 13; pl. 18, figs. 40-42).
Lymnaea obrussa decampi (Streng), Say, Goodrich (1932, p. 53).
Lymnaea galbana Say, Goodrich (1932, p. 54).
Lymnaea obrussa decampi (Streng), Goodrich (1939, p. 15).
Lymnaea humilis (Say), in part, Hubendick (1951, p. 188).
Fossaria galbana (Say), Burch & Tottenham (1980, pp. 169, 170, fig. 568).
Fossaria galbana (Say), Burch (1982a, pp. 48, 146, fig. 568).
Fossaria galbana (Say), Burch (1982b, p. 250, fig.).

Fossaria galbana (Say), Burch & Jung (1987, pp. 253, 254, fig. 30).
Fossaria galbana (Say), Burch (1989b, pp. 169, 170, fig. 568).
Fossaria galbana (Say), Burch (1991, p. 128).

Shell: Small, adults with 5¾ whorls up to 9 mm in length, subovately to ovately conic, sometimes cylindrical and turreted, narrowly umbilicate, opaque, relatively solid, slightly glossy, white to pale tan in color. The aperture is oval. The outer lip is sharp, not expanded, and is sinuate in side view. The columellar lip is straight; the columella is straight or slightly twisted. The whorls are flattened and shouldered, and are sculptured with growth lines; spiral lines are lacking. The sutures are impressed.

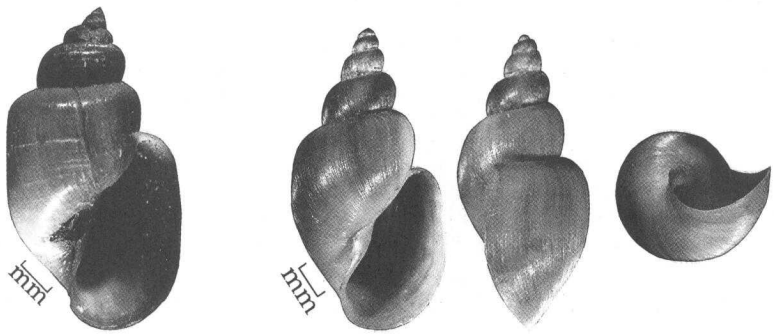
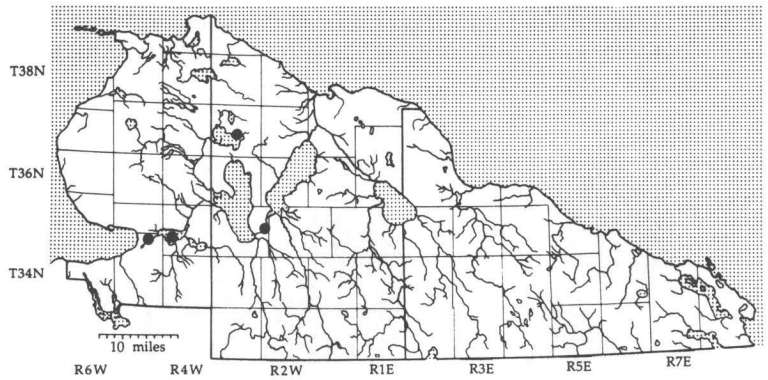


FIG. 31. Shells of *Fossaria galbana.*

Habitat: The habitat of *Fossaria galbana* is quite different from other members of the genus found in Michigan. While the latter are mostly amphibious species living generally out of water in seepage areas or on exposed mud flats, or just above the water line at the edge of ponds, lakes and streams, *F. galbana* lives submerged in lakes. Generally found in medium or large lakes or large rivers, with abundant aquatic vegetation; needs cold, highly oxygenated water (Clarke, 1973, *Malacologia,* 13, p. 271 – "*Lymnaea decampi* Streng"). "A cold-water species occurring only in large lakes in the southern part of its range and in both lakes and rivers in the northern part. It lives among submersed vegetation and on various kinds of bottom" (Clarke, 1981, *Freshw. Moll. Can.,* Nat. Mus. Can., Ottawa, p. 25, "*L. decampi* Streng").

General Distribution: Great Lakes-St. Lawrence River basin northward in the region west of James Bay to the Attawapiskat and Severn river systems, and northwestward in the boreal forest region to the vicinity of the Great Slave Lake (Clarke, 1973, *loc. cit., decampi* Streng).

Distribution in UMBS Area: **Cheboygan Co.:** Sedge Point, drift, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36789; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39873; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 78027; Sedge Point, Douglas Lake, August 1986, John B. Burch and Younghun Jung, August 1986, UMMZ 253185; Hook Point bay, North Fishtail Bay, Douglas lake, John B. Burch, 15 July 1985, UMMZ 253187. **Emmet Co.:** Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 75562; Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 78009.



MAP 15. Localities of *Fossaria galbana.*

Remarks: Thomas Say's (1825, *J. Acad. Nat. Sci. Philad.*, 5(2), p. 123) original specimens were fossils from a marl pit near Franklin, New Jersey. There do not seem to be any significant differences between Say's species and that named later by Streng (1896, *Nautilus*, 9(11), p. 123) from specimens collected by William H. DeCamp in Brook's Lake, Newaygo County, Michigan. Michigan specimens have long been known under Streng's name.

Fossaria obrussa (Say)

(Figs. 28e, 32, 33; Map 16)

Lymneus obrussus Say 1825, *J. Acad. Nat. Sci. Philad.*, 5(2), p. 123.
Lymnaea humilis Say, Walker (1892, p. 34).
Lymnaea obrussa Say, Walker (1911, p. 124).
Lymnaea obrussa Say, H.B. Baker (1914, pp. 18-45).
Fossaria obrussa (Say), F.C. Baker (1928, p. 293, pl. 16, fig. 14; pl. 18, figs. 14-24).
Lymnaea obrussa Say, Goodrich (1932, p. 52, fig.).
Lymnaea obrussa Say, Goodrich (1939, p. 15).
Lymnaea humilis (Say), in part, Hubendick (1951, p. 197).
Fossaria obrussa (Say), Burch & Tottenham (1980, pp. 169, 172, fig. 570).
Fossaria obrussa (Say), Burch (1982a, pp. 49, 146, 153, fig. 570).
Fossaria obrussa (Say), Burch (1982b, p. 250, fig.).
Fossaria obrussa (Say), Burch & Jung (1987, pp. 253, 254, fig. 31).
Fossaria obrussa (Say), Burch (1989b, pp. 169, 172, fig. 570).
Fossaria obrussa (Say), Burch (1991, p. 128).

Shell: Small, adults with 5½ whorls up to 12 mm in length, narrowly subovately to subovately conic, narrowly umbilicate or with a small umbilical chink, translucent to nearly opaque, slightly to moderately glossy, pale horn to tannish-horn in color. The aperture is oval. The outer lip is sharp, expanded or slightly reflected, and is sinuate in side view. The columellar lip is straight; the columella is straight or slightly twisted. The whorls are rounded, sometimes having a tendency for shouldering. The shell sculpture consists of growth lines, usually well developed, but sometimes obscure; spiral lines are usually lacking, but occasionally a few obsolete spiral striae occur. The sutures are impressed.

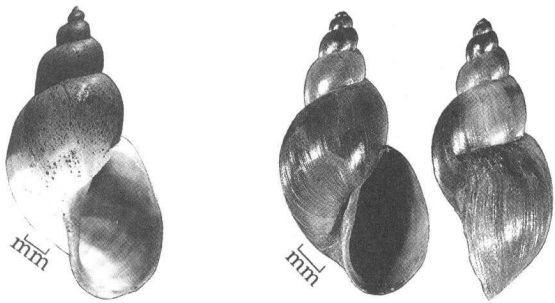


FIG. 32. Shells of *Fossaria obrussa.*

Animal: Dark gray or blackish, lighter below, sometimes yellowish. The whole surface of the head-foot is dotted with whitish or yellowish dots, especially noticeable about the eyes. The foot is very small, more or less oblong when viewed from the base, its anterior and posterior borders rounded. The tentacles are triangular, flat, short, and more or less transparent. The black eyes are on prominences at the inner base of the tentacles. (F.C. Baker, 1928, p. 294).

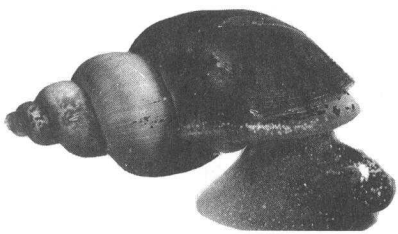
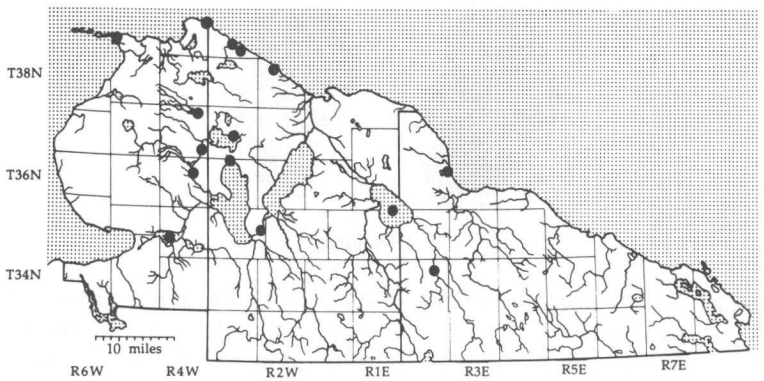


FIG. 33. Animal and shell of *Fossaria obrussa.*

Habitat: Marshes, "where the water is shallow, seldom more than three or four feet deep, and where there is an abundance of swamp vegetation such as *Typha, Pontederia, Decodon* and a few *Nymphaea.* The bottom is usually of mud and accumulated vegetable débris" (F.C. Baker, 1919). "The normal habitat of this species is in small bodies of water, as creeks, ponds, sloughs, bays, and marshy spots along river banks" (F.C. Baker, 1928).

General Distribution: From the Atlantic to the Pacific oceans, and from Mackenzie territory, Canada, south to Arizona and northern Mexico (F.C. Baker, 1928).

Distribution in UMBS Area: **Cheboygan Co.:** Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39861; Sedge Point beach pool, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39864; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39872; Indian River, Metzelaar and Langlois, 15 June 1925, UMMZ 41447; north side of Douglas Lake, UMMZ 42948; pool near Burt Lake, Elmer P. Cheatum 1932, UMMZ 55637; drift of Lake Michigan, 10 miles southwest of Mackinaw, UMMZ 63848; Mackinaw City, Bryant Walker, Bryant Walker Collection, UMMZ 76001; Mackinaw City, Bryant Walker, Bryant Walker Collection, UMMZ 78008; Douglas Lake, University of Michigan Expedition, 1908, Bryant Walker Collection, UMMZ 78033; Lake Huron at Mill Creek, Section 27-28, Mackinaw Township, Harold W. Harry, 23 July 1949, UMMZ 197954; Hook Point lagoon, North Fishtail Bay, Douglas Lake, John B. Burch and Younghun Jung, 20 August 1987, UMMZ 253178; Sedge Point beach pool, Douglas Lake, August 1986, John B. Burch and Younghun Jung, August 1986, UMMZ 253179. **Emmet Co.:** Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 75968; Goose Pond, Wilderness [State] Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170462; A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 9 July 1985, UMMZ 250420; roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253180. **Presque Isle Co.:** Rainy River, M.L. Leach, Bryant Walker Collection, UMMZ 76003; Lake Huron, Section 15, Bearinger Township, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170755.



MAP 16. Localities of *Fossaria obrussa.*

Remarks: *Fossaria obrussa* is the most common fossaria in the midwest, and perhaps other parts of North America as well. It may be the same as the South Carolinian *F. humilis*, but a careful comparison has not yet been made. The relationships within the *humilis-obrussa* species group need serious study.

Fossaria parva (Lea)

(Figs. 28b, 34; Map 17)

Lymnea parva Lea 1841, *Proc. Am. Philos. Soc.*, 2(17), p. 33.
Lymnaea parva Lea, Walker (1911, p. 124).
Lymnaea (Galba) parva Lea, Winslow (1926, p. 12).
Fossaria parva (Lea), F.C. Baker (1928, p. 285, pl. 16, fig. 7; pl. 18, figs. 1-5).
Lymnaea parva Lea, Goodrich (1932, p. 54).
Lymnaea humilis (Say), in part, Hubendick (1951, p. 198).
Fossaria parva (Lea), Burch & Tottenham (1980, pp. 169, 172, fig. 571).
Fossaria parva (Lea), Burch (1982a, pp. 49, 146, fig. 571).
Fossaria parva (Lea), Burch (1982b, p. 249, fig.).
Fossaria parva (Lea), Burch (1989b, pp. 169, 172, fig. 571).
Fossaria parva (Lea), Burch (1991, p. 128).

Shell: Small, adults with 5¼ whorls up to 6 mm in length, subovately conic, narrowly umbilicate, nearly opaque to slightly translucent, moderately glossy, tannish-horn to olive-horn in color. The aperture is oval. The outer lip is sharp, and is straight in side view. The columellar lip is straight or curved, rarely with a twist. The whorls are rounded, sometimes slightly shouldered. The shell sculpture consists of well developed growth lines; spiral lines are generally lacking. The sutures are well impressed.

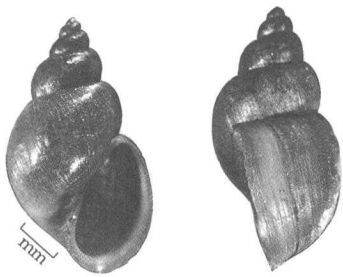


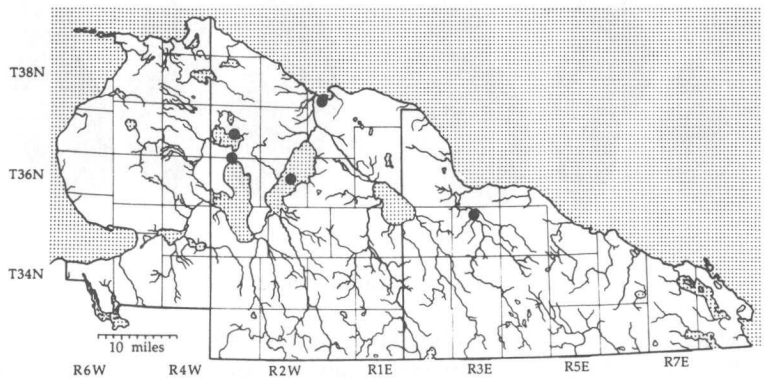
FIG. 34. Shell of *Fossaria parva*.

Animal: "Blackish, very thickly dotted with fine white dots. The upper whorls are pinkish in the living animal, and the spotted mantle shows through the almost transparent shell" (F.C. Baker, 1928, p. 286).

Habitat: Mud flats or wet marshy places, generally out of the water, on sticks and stones or the mud surface. This species is more prone to leave the water than any other lymnaeid species (F.C. Baker, 1928).

General Distribution: Connecticut west to Idaho, James Bay and Montana south to Maryland, Kentucky, Oklahoma, southern New Mexico and Arizona (F.C. Baker, 1928); in Canada, from eastern James Bay drainage to Alberta and north to the region of Great Slave Lake (Clarke, 1973, *Malacologia*, 13, p. 281).

Distribution in UMBS Area: **Cheboygan Co.:** Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39875; Carp Creek [Little Carp River], near Burt Lake, Elmer P. Cheatum, 1932, UMMZ 55521; small lake 12 miles north of Douglas Lake, Elmer P. Cheatum, 1932, UMMZ 55532; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 76030; Mullett Lake, Bryant Walker, Bryant Walker Collection, UMMZ 78695; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Cheboygan Co., John B. Burch, 15 July 1985, UMMZ 250422. **Presque Isle Co.:** East [?] Lake, Elmer P. Cheatum, 1932, UMMZ 55525; Ocqueoc River, 3 miles northeast of Ocqueoc, Henry van der Schalie et al., 13 September 1948, UMMZ 249449.



MAP 17. Localities of *Fossaria parva.*

Remarks: *Fossaria parva* is distinguished by its shell: small size, rather bulimoid appearance and straight (in side view) outer lip. Its radula should be inspected to avoid confusing the species with *F. dalli,* with which there may be some overlap in shell size.

Fossaria peninsulae (Walker)

(Figs. 28f, 35; Map 18)

Lymnaea desidiosa var. *peninsulae* Walker 1908, *Nautilus,* 22(1, 2), pp. 9, 16, pl. 2, fig. 7.
Lymnaea peninsulae Walker, Walker (1911, p. 124).
Lymnaea obrussa peninsulae (Walker), H.B. Baker (1914, pp. 18-45).
Lymnaea obrussa peninsulae Walker, Winslow (1917, p. 6).

Lymnaea (Galba) obrussa peninsulae Walker, Winslow (1926, p. 12).
Fossaria obrussa peninsulae (Walker), F.C. Baker (1928, p. 298, pl. 16, fig. 6; pl. 18, figs. 25-29).
Lymnaea humilis (Say), in part, Hubendick (1951, p. 198).
Fossaria penninsulae (Walker), Burch (1991, p. 128).

Shell: The shell of *Fossaria peninsulae* is the largest of any of the fossarias in Michigan. Shells with 6¾ whorls attain a length of 2 cm. The shells are attenuate with long tapering spires, narrowly subovately conic, slightly translucent, tannish-horn in color and sculptured with well developed growth lines and weak to obsolete spiral striae. The whorls are rounded and may or may not be shouldered; the sutures are impressed; a columellar plait is present, as well as a narrow umbilical chink; the apertural lip is a little reflected and sinuate in side view. Some specimens are malleated.

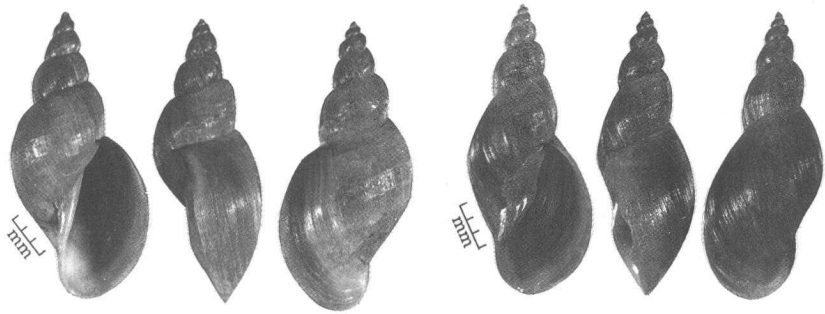


FIG. 35. Shells of *Fossaria peninsulae.*

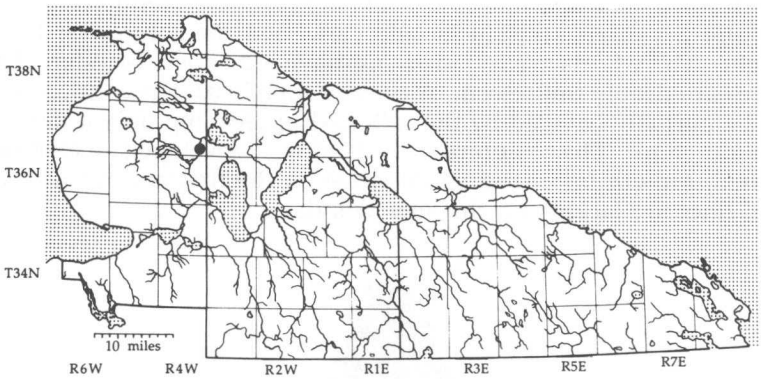
Habitat: Small, clean streams. The habitat in the UMBS area was a small, clear, intermittent stream, generally less than a meter wide (except at the mouth), a few centimeters deep, and with a substrate of black silty mud and many decaying maple and aspen leaves. (A beaver dam on the Maple River has since produced an impoundment that obliterated this small tributary stream.)

General Distribution: southern Ontario and northern Maine west to Wisconsin, south to Ohio.

Distribution in UMBS Area: Emmet Co.: A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, August 1989.

Remarks: These are giant fossarias, and without careful inspection specimens might be confused with smallish *Stagnicola elodes.* However, *Fossaria peninsulae*'s more delicate nature, the thinness and tannish-horn color of its shells, the smaller nuclear whorls, and yellowish, pale-gray body color indicates that they are fossarias.

The presence of three to four varices on the shells indicates a life span of three to four years.



MAP 18. Localities of *Fossaria peninsulae.*

Subgenus *Bakerilymnaea* Weyrauch

The main distinguishing feature of the subgenus *Bakerilymnaea* is the bicuspid lateral teeth of the radula, in contrast to the tricuspid lateral teeth of *Fossaria s.str.* Because of their bicuspid lateral teeth, F.C. Baker (1928) grouped the bakerilymnaeas (as the subgenus *Nasonia* [preoccupied by *Nasonia* Ashmead 1904]) with *Stagnicola.* However, the bakerilymnaeas are more closely allied to *Fossaria.*

The only species of *Bakerilymnaea* in the UMBS area is *Fossaria (B.) dalli,* which is readily distinguished by its small size.

Fossaria (Bakerilymnaea) dalli (F.C. Baker)

(Figs. 28a, 36; Map 19)

Lymnaea dalli F.C. Baker 1907, *Nautilus,* 20(11), p. 125.
Lymnaea dalli Baker, Walker (1911, p. 123).
Lymnaea (Galba) dalli Baker, Winslow (1926, p. 11).
Fossaria dalli (F.C. Baker), F.C. Baker (1928, p. 288, pl. 16, fig. 11).
Fossaria (Bakerilymnaea) dalli (F.C. Baker), Burch & Tottenham (1980, pp. 173, 174, fig. 588).
Fossaria (Bakerilymnaea) dalli (F.C. Baker), Burch (1982a, pp. 50, 154, fig. 588).
Fossaria (Bakerilymnaea) dalli (F.C. Baker), Burch (1982b, p. 253, fig.).
Fossaria (Bakerilymnaea) dalli (F.C. Baker), Burch (1989b, pp. 173, 174, fig. 588).
Fossaria (Bakerilymnaea) dalli (F.C. Baker), Burch (1991, p. 128).

Shell: Small, adults with 4½ - 5 whorls measure 3.25 - 4.5 mm. The shell is subovately conic, turreted, moderately translucent to nearly opaque, somewhat glossy with a satin sheen, and brown, tan or olive-horn in color. The aperture is oval to elliptical, often reduced in size, the outer lip sharp, straight in side view, and the columellar lip is straight. The whorls are rounded and have a distinct shoulder. The sutures are deeply impressed. A narrow umbilicus is present, which may be partially covered by the reflected lip, leaving only a narrow umbilical chink. The sculpture consists of well developed, sometimes elevated, growth lines, and spiral striae on the first several whorls. Spiral lines are lacking on the later whorls.

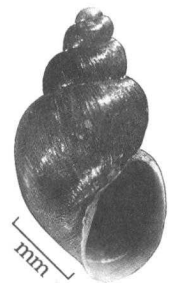
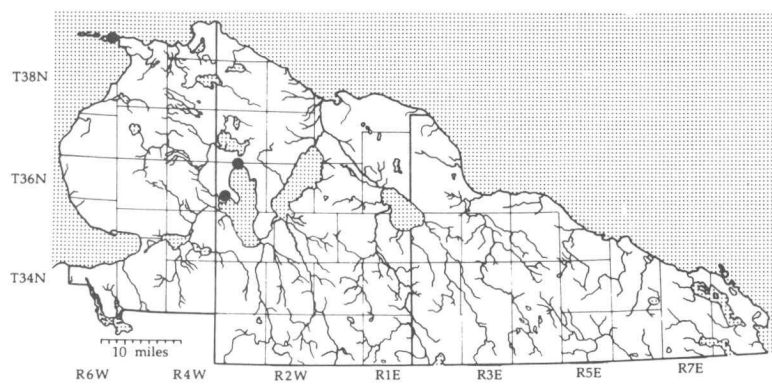


FIG. 36. Shell of *Fossaria dalli.*

General Distribution: Ohio to northern Michigan and Montana, south to Kansas and Arizona (F.C. Baker, 1928); in the Canadian Interior Basin from southern Manitoba to Alberta (Clarke, 1973, *Malacologia,* 13, p. 289).



MAP 19. Localities of *Fossaria (Bakerilymnaea) dalli.*

Distribution in UMBS Area: **Cheboygan Co.:** Reese's Bog [Swamp], north end Burt Lake, H. Harry, UMMZ 178416; woods pool at public access and park, Burt Lake, Section 29, Burt Township, T36N, R3W, John B. Burch and Younghun Jung, August 1986, UMMZ 253186. **Emmet Co.:** beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253182.

Habitat: *Fossaria dalli* is semiaquatic, being found more often out of the water than in it. It lives on wet mud or among moist leaves and debris next to the water beside streams and ponds, or in marshes. (Hibbard & Taylor, 1960, *Contr. Mus. Paleont. Univ. Mich.*, 16, p. 94).

Remarks: This is the smallest species of the Lymnaeidae and care must be taken not to mistake it for the very young of another species. In making species determinations, it is essential to relate shell size to number of whorls. Also, in the case of *Fossaria dalli*, it is important to look at the radula.

Genus *Lymnaea* Lamarck

The genus *Lymnaea* has been variously used to include nearly all members of the family Lymnaeidae (*e.g.*, see Hubendick, 1951) or only the Holarctic *Lymnaea stagnalis*, its varieties, and several closely related species. In the latter system, the family is considered to contain a number of species groups (genera) equal in rank to the genus *Lymnaea s.str.* That system is used here. A third system, more or less a compromise between the previous two, uses *Lymnaea* as a large inclusive genus, but recognizes various subgeneric groups within it. These subgenera (for example, *Stagnicola, Fossaria* and *Bulimnea*) correspond to genera in the second system above.

Lymnaea stagnalis appressa Say

(Fig. 37; Map 20)

Lymnaea jugularis Say 1817, Conchology, in Nicholson, 1816-1817, *Am. Ed. Brit. Encyclop., Dict. Arts, Sci.*, etc., 1st ed., vol. 2, pt. 2 [no pagination] [*nomen dubium*].
Lymneus appressus Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), pp. 168-169.
Lymnaea stagnalis L., Walker (1892, p. 31, pl. 1, fig. 6).
Lymnaea stagnalis jugularis Say, Walker (1892, p. 31, pl. 1, figs. 1, 2, 3).
Lymnaea stagnalis v. *perampla* Walker 1908, *Nautilus*, 22(1), p. 8, pl. 2, figs. 5, 6.
Lymnaea stagnalis appressa Say, Walker (1911, p. 124).
Lymnaea stagnalis lillianae Baker, Walker (1911, p. 124).
Lymnaea stagnalis perampla Walker, Walker (1911, p. 124).
Lymnaea stagnalis perampla Walker, H.B. Baker (1912, pp. 209-211).
Lymnaea stagnalis appressa (Say), H.B. Baker (1914, pp. 18-45).
Lymnaea stagnalis perampla Walker, H.B. Baker (1914, pp. 18-45).
Lymnaea stagnalis appressa Say, Winslow (1926, p. 9).
Lymnaea stagnalis lillianae Baker, Winslow (1926, p. 9).
Lymnaea stagnalis perampla Walker, Winslow (1926, p. 10).
Lymnaea stagnalis jugularis Say, F.C. Baker (1928, p. 198, pl. 11, figs. 9-13; pl. 12, figs. 1-4, 11-12).
Lymnaea stagnalis perampla Walker, F.C. Baker (1928, p. 204, pl. 12, figs. 5-7).
Lymnaea stagnalis lillianae F.C. Baker, F.C. Baker (1928, p. 205, pl. 12, figs. 8-10).
Lymnaea stagnalis appressa Say, Goodrich (1932, p. 42, fig.).

Lymnaea stagnalis appressa (Say), Cheatum (1934, p. 348).
Lymnaea stagnalis appressa (Say), Goodrich (1939, p. 12).
Lymnaea stagnalis perampla Walker, Goodrich (1939, p. 12).
Lymnaea stagnalis (Say), Hubendick (1951, p. 181).
Lymnaea stagnalis appressa Say, Burch & Tottenham (1980, pp. 173, 174, fig. 591).
Lymnaea stagnalis appressa Say, Burch (1982a, pp. 50, 154, fig. 591).
Lymnaea stagnalis appressa Say, Burch (1982b, p. 248, fig.).
Lymnaea stagnalis appressa Say, Burch & Jung (1987, pp. 255, 256, fig. 32).
Lymnaea stagnalis appressa Say, Burch (1989b, pp. 173, 174, fig. 591).
Lymnaea stagnalis appressa Say, Burch (1991, p. 128).

Shell: Large, adults with 7 whorls measure 5.2 in length, with a very large body whorl and rapidly tapering, very acute spire, thin-shelled, narrowly subovately conic, opaque to slightly translucent, pale horn to Tawny-Olive[7] in color, dull to somewhat glossy. The aperture is oval, its outer lip thin and sharp, and slightly sigmoid in side view. The apertural columella has a plait. The shell is imperforate, or with a minute umbilical chink. The sutures are moderately impressed. The surface is marked by well developed growth lines and fine spiral sculpture.

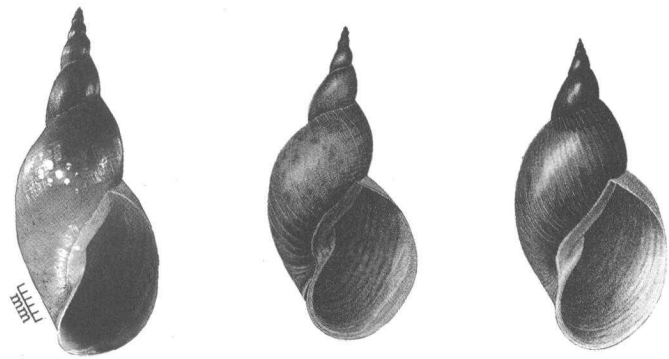


FIG. 37. Shells of *Lymnaea stagnalis appressa.* The two figures on the right are from Haldeman (1841, *Monogr. Limn. ... N. Am.*, (3), pl. 5, fig. 4; pl. 4, fig. 2).

Animal: The body is light or dark horn-colored, tinged with bluish on the foot. The tentacles are triangular, flat, and rather long and tapering. The foot is relatively short and wide, and is truncated anteriorly and roundly pointed posteriorly. (F.C. Baker, 1928).

Habitat: *Lymnaea stagnalis appressa* is a quiet bay or pond species, "where the environment is protected from the force of waves and wind by barriers of one kind or another. The water is shallow and there is usually an abundance of vegetation, such as *Scirpus,*

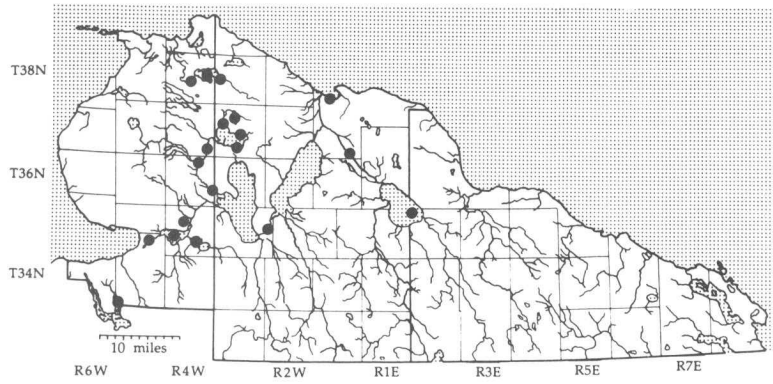
[7]Ridgeway's color standards (see footnote, p. 23).

Potamogeton, Castalia, Nymphaea, Typha and filamentous algae which provide much of the food of the snails" (F.C. Baker, 1919). May inhabit any permanent water bodies that support substantial vegetation (Clarke, 1973, *Malacologia,* 13, p. 299): lakes of various sizes, permanent ponds, streams of all sizes, and backwaters, canals and swamps, living on substrates of all kinds, but mud, sand or rocks being the most frequent; vegetation present in all localities. F.C. Baker (1919, *Science,* 49(1274), pp. 519-521) listed *Lymnaea stagnalis lillianae* Baker [a form of *appressa*] as an open shore lake species "exposed to the full force of the winds and waves."

General Distribution: Great Lakes-St. Lawrence River drainage area, northwest to the Mackenzie and Yukon river drainage areas, west to the Rocky Mountains, south in the Rocky Mountains to Colorado, and in Illinois and Ohio in the Mississippi drainage (Clarke, 1973, *Malacologia,* 13, p. 298).

Distribution in UMBS Area: **Cheboygan Co.:** Douglas Lake, N.A. Wood, 28 June 1915, UMMZ 5646; Douglas Lake, Mina L. Winslow and Crystal Thompson, 6 July 1926, UMMZ 36595; Sedge Point beach pools, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36596; Marl Bay and mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36597; Sedge Point pool and beach, Douglas Lake, Mina L. Winslow and Crystal Thompson, 5 July 1926, UMMZ 36598; Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 5 July 1926, UMMZ 36600; Sedge Point, drift, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36641; Indian River, Langlois and Metzelaar, 14 June 1925, UMMZ 37675; Black Lake, Langlois and Metzelaar, 15 August 1925, UMMZ 37676; Maple River, Metzelaar, 2 August 1926, UMMZ 38900; Carp Lake [Lake Paradise] inlet, Carl L. Hubbs, 17 July 1927, UMMZ 43433; Douglas Lake, Paul Welch, Peter Okkelberg Collection, UMMZ 47057; Douglas Lake, Elmer P. Cheatum, 1932, UMMZ 55647; Carp Lake [Lake Paradise], DeCamp Collection, Bryant Walker Collection, UMMZ 80174; Douglas Lake, Bryant Walker Collection, UMMZ 80270; pool north of Cheboygan, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170593; Douglas Lake, Bessey Creek cove, T37N, R3W, S18, James W. Moffett, 6 July 1937, UMMZ 232363; Douglas Lake, near Sedge Point, Henry van der Schalie, October 1975, UMMZ 249385; Douglas Lake, north shore of Fishtail Bay, at fresh air camp, Munro Township, John B. Burch, 3 July 1985, UMMZ 250440; in watercress in roadside spring, highway US 31 at southern edge of Alanson, John B. Burch and Younghun Jung, 19 July 1986, UMMZ 253194; Douglas Lake, shoal at UMBS, South Fishtail Bay, at northern part of sections 33 and 34, at their boundary, T37N, R3W, Munro Township, John B. Burch, 23 June 1985, UMBS-85-1; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R3W., Munro Township, John B. Burch, 4 July 1985, UMBS-85-7; Hook Point bay, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, John B. Burch, 15 July 1985, UMBS-85-11a; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R4W, Munro Township, John B. Burch, 29 June 1988, UMBS-88-6. **Emmet Co.:** Crooked Lake, Langlois and Metzelaar, 10 August 1925, UMMZ 37672; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 80154; Round Lake, Petoskey, James H. Ferriss, Bryant Walker Collection, UMMZ 80163; Bear [Walloon] Lake, Petoskey, DeCamp Collection, Bryant Walker Collection, UMMZ 80173; Pickerel Lake, northeast of Petoskey, Calvin Goodrich, Bryant Walker Collection, UMMZ 80224; Crooked Lake, Kent Science Institute Collection, UMMZ 142832; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 142835; Carp Lake [Lake Paradise], Kent Science Institute Collection, UMMZ 142839; Carp River [Carp Lake River], near exit from Carp Lake [Lake Paradise], 15 August 1949, UMMZ 246695; Kathleen Lake, impounded by dam on Maple River, eastern side of Section 10, T. 36 N., R. 4 W., Maple River

Township, John B. Burch, 8 July 1985, UMBS-85-9a. **Presque Isle Co.:** East [?] Lake, Elmer P. Cheatum, 1932, UMMZ 55626; Black Lake, M.L. Leach, UMMZ 80158.



MAP 20. Localities of *Lymnaea stagnalis appressa.*

Remarks: *Lymnaea stagnalis* is one of our largest lymnaeids. Its large size, long tapering spire, bulbous body whorl and thin shell distinguish it from other species. It has a Holarctic distribution, being found also in northern Europe and northern Asia. The North American form is given the subspecific name *appressa.* Detailed genetic comparisons between the forms of *L. stagnalis* on the two continents have not been made.

There is not much variability in the shells of *Lymnaea stagnalis,* although the body whorls of some individuals/populations are narrower than those of others, and the last half of the body whorl on some specimens is rather strongly shouldered (the form *perampla* Walker).

Genus *Stagnicola* Leach (in Jeffreys)

The largest group of Lymnaeidae in North America are the stagnicoline lymnaeids, members of the genus *Stagnicola.* Their taxonomy, based largely on shell shape, has always been troublesome. Conditions of the water in which stagnicoline snails live can have some influence on the shape of their shells (ecophenotypic variation), whole populations exhibiting the variant characters when they occur. However, other cases of constant population differences seem to be due to small genetic differences between populations. The great problem in systematics of stagnicoline snails is in accurately assessing which characters are ecophenotypic and which are genetic,

and of the genetic differences which are great enough to conclude that any particular population(s) is (are) distinct enough to deserve a binomial (or trinomial) name of its (their) own. Since there have been almost no experimental breeding studies to evaluate the taxonomic importance of any shell characters in *Stagnicola,* schemes for classifying the genus have all been quite subjective. Accordingly, systematic interpretations have varied widely, from the "splitters" to the "lumpers."

The stagnicolas in the UMBS area grouped into two subgenera, *Stagnicola s.str.* and *Hinkleyia.* In Michigan, *Hinkleyia* has but one species, *S. (H.) caperatus* (Say). *Stagnicola s.str.* has several species, which fall into two general groups, the *Stagnicola elodes* group and *Stagnicola catascopium/emarginatus* group. Typically, species of the *Stagnicola elodes* group have an elongated, rather narrow, brown shell, and are inhabitants of quiet, standing waters, such as ponds, pools, ditches, marshes, swamps, etc. The *Stagnicola catascopium/emarginatus* group typically have more compressed spires and subglobose body whorls, broader, light-colored shells, and are inhabitants of rivers and lakes.

The genus *Stagnicola* Leach (in Jeffreys) 1830 is based on the European *Buccinum palustre* Müller 1774. However, several distinct species have masqueraded under the name *palustris,* and it is not known which anatomical type is represented by Müller's species. Until that is settled, and it is determined that such a species does indeed occur in North America, then it seems advisable not to use *S. palustris* here but rather the first name applied specifically to a North American *palustris*-like snail, *i.e.,* Say's (1821) *Lymneus elodes.*

Key to the Subgenera of *Stagnicola* in the UMBS Area

1 Shell sculptured with fine growth lines and spiral striae, but lacking spiral periostracal ridges ..... Subgenus *Stagnicola s.str.* (p. 69)

Shell sculptured with fine spiral periostracal ridges .... Subgenus *Hinkleyia* (p. 82)

Subgenus *Stagnicola s. str.*

Stagnicola s. str. is a large taxonomic group with a distribution that includes much of continental North America south to southern Mexico. Many of the species are poorly defined and each probably includes one or more synonyms. In the UMBS area, all species of *Stagnicola* except one belong to subgenus the *Stagnicola s. str.* In this

subgenus, the adult shells range in length from 2 cm to more than 4 cm, are sculptured with well developed spiral and transverse striae, and have a twisted columella that is seen as a plait on the parietal aperture. Spiral periostracal ridges, characteristic of the subgenus *Hinkleyia* in the UMBS area, are absent.

Key to the Species of *Stagnicola s.str.* in the UMBS Area

1 Shell of living animal dark brown to tan, elongate 2

Shell of living animal white, gray or tan, subglobose to elongate 3

2(1) Whorls rounded ..... *S. elodes* (p. 70)

Whorls flat-sided ..... *S. exilis* (p. 73)

3(1) Shell subglobose to attenuate; whorls evenly rounded; whorls without spiral ridges ..... *S. emarginatus* (p. 76)

Shell attenuate; posterior half of each whorl flattened; whorls generally with spiral angulations ..... *S. petoskeyensis* (p. 81)

Stagnicola elodes (Say)

(Figs. 38, 39; Map 21)

Lymneus reflexus Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), pp. 167-168.
Lymneus elodes Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), p. 169.
Limneus umbrosus Say 1832, *Am. Conchol.*, 1(4), 4th and 5th pp., pl. 31, fig. 1.
Lymnaea reflexa Say, Walker (1892, p. 32, pl. 1, fig. 8).
Lymnaea reflexa zebra Tryon, Walker (1892, p. 32).
Lymnaea reflexa kirtlandiana Say, Walker (1892, p. 32).
Lymnaea reflexa scalaris Say, Walker (1892, p. 33, pl. 1, fig. 7).
Lymnaea palustris Mull., Walker (1892, p. 33).
Lymnaea palustris michiganensis, Walker (1892, p. 33, pl. 1, figs. 9, 10).
Lymnaea elodes Say, Walker (1911, p. 123).
Lymnaea reflexa Say, Walker (1911, p. 124).
Lymnaea reflexa walkeri Baker, Walker (1911, p. 124).
Lymnaea reflexa zebra Tryon, Walker (1911, p. 124).
Lymnaea palustris Müll., Walker (1911, p. 124).
Lymnaea palustris (Mueller), H.B. Baker (1914, pp. 18-45).
Lymnaea elodes Say, Winslow (1917, p. 7).
Lymnaea (Galba) elodes Say, Winslow (1926, p. 11).
Lymnaea (Galba) palustris Müller, Winslow (1926, p. 12).
Lymnaea (Galba) elodes jolietensis Baker, Winslow (1926, p. 11).
Lymnaea (Galba) reflexa Say, Winslow (1926, p. 13).
Lymnaea (Galba) reflexa walkeri Baker, Winslow (1926, p. 13).
Lymnaea (Galba) reflexa zebra Tryon, Winslow (1926, p. 13).
Stagnicola palustris elodes (Say), F.C. Baker (1928, p. 213, pl. 13, figs. 3-7, 9-13).
Stagnicola umbrosa (Say), F.C. Baker (1928, p. 218, pl. 13, figs. 14-22; pl. 17, figs. 12-14).
Stagnicola umbrosa jolietensis (F.C. Baker), F.C. Baker (1928, p. 220, pl. 13, figs. 23-26).
Stagnicola reflexa (Say), F.C. Baker (1928, p. 221, pl. 14, figs. 1-6; pl. 17, fig. 15).
Lymnaea palustris (Müller), Goodrich (1932, p. 54, fig.).
Lymnaea elodes Say, Goodrich (1932, p. 56).

Lymnaea reflexa Say, Goodrich (1932, p. 56).
Lymnaea palustris (Müller), Cheatum (1934, p. 348).
Lymnaea palustris (Müller), Goodrich (1939, p. 13).
Lymnaea palustris Müller, in part, Hubendick (1951, p. 186).
Stagnicola elodes (Say), Burch & Tottenham (1980, pp. 175-177, figs. 600-602, 605).
Stagnicola elodes (Say), Burch (1982a, pp. 51, 155, 156, figs. 600-602, 605).
Stagnicola elodes (Say), Burch (1982b, p. 274).
Stagnicola elodes (Say), Burch & Jung (1987, pp. 258, 259, fig. 36).
Stagnicola elodes (Say), Burch (1989b, pp. 175-177, figs. 600-602, 605).
Stagnicola elodes (Say), Burch (1991, p. 128).
Stagnicola elodes form *reflexa* (Say), Burch (1991, p. 128).

Shell: Medium to large, shells with six or more whorls measure up to 3.4 cm in length (the *reflexa* form can exceed 4 cm in length), elongately conic to subovately conic, imperforate or with a very small umbilical chink, moderately translucent, dull to slightly glossy, tan to Buffy Brown or Light Brownish Olive[8] in color, sometimes zebrated. The whorls are moderately rounded, sculptured with fine growth lines and fine spiral striae, often malleated. The sutures are impressed. The aperture is oval to D-shaped, its outer lip thin, slightly curved in side view. The columella is twisted, the columellar lip has a plait, and there is a calloused pad on the parietal surface.

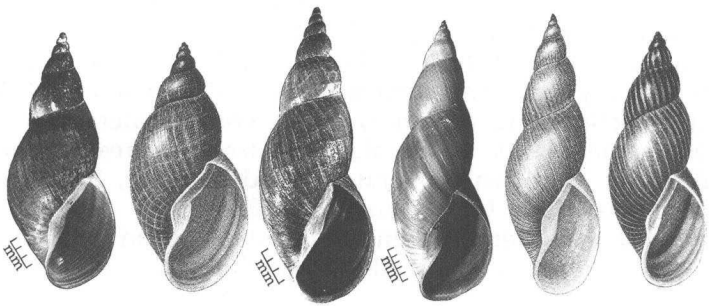


FIG. 38. Shells of *Stagnicola elodes*. The four shells on the right are the *reflexa* form. The shell on the far right is also zebrated (form *zebra* Tryon). The second (from the left), fifth and sixth figures are from Haldeman (1842, *Monogr. limn. ... N. Am.*, (4), pl. 7, fig. 2; pl. 8, fig. 3; pl. 7, fig. 2).

Animal: The body is black, sprinkled with tiny white dots. The foot is relatively wide and short, rounded behind, and slightly rounded in front. The velum is large, bilobed. The tentacles are elongately triangular. The mantle collar is rather thick, and black or dark gray in color.

Habitat: Marshes, "where the water is shallow, seldom more than three or four feet deep, and where there is an abundance of swamp

[8]Ridgeway's color standards (see footnote, p. 23).

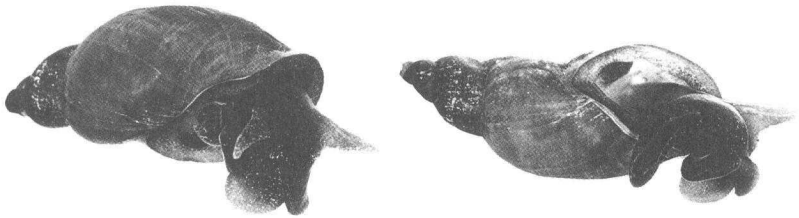


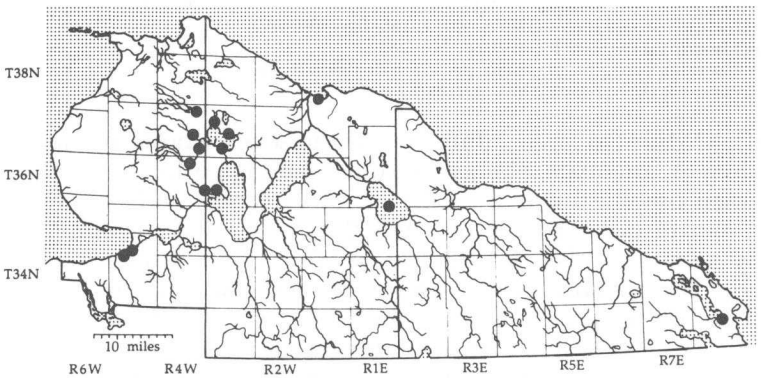
FIG. 39. Animals of *Stagnicola elodes.*

vegetation such as *Typha, Pontederia, Decodon* and a few *Nymphaea.* The bottom is usually of mud and accumulated vegetable débris" (F.C. Baker, 1919, for *"Galba [Stagnicola] palustris* (Müll)," *"G." [S.] reflexa* (Say) and *"G." [S.] elodes*). "Found plentifully in bodies of water of greater or less size, on floating sticks and submerged vegetation, on stones and on the muddy bottom. Inhabits both clear and stagnant water, but prefers a habitat in which the water is not in motion. ... In lakes and rivers where the water is quiet and where vegetation is more or less abundant. The margins of rivers and protected bays of lakes and ponds appear to be the natural habitats" (Baker, 1928). Ordinarily found in swampy bayous of small lakes, mucky ponds, and the stagnant parts of streams (Goodrich & van der Schalie, 1939, *lanceata* Gould). Small pools or ponds that dry up in the summer (Baker, 1928, *reflexa*). "Occurs among vegetation in a variety of perennial-water and vernal habitats, namely lakes, ponds, sheltered areas of streams, swamps, and ditches. The usual substrate is mud" (Clarke, 1981, *Freshw. Moll. Can.,* Nat. Mus. Can., Ottawa, p. 148, *reflexa*).

General Distribution: New England west to Oregon and California, south to New Mexico; widely distributed throughout Canada below the tree line.

Distribution in UMBS Area: Cheboygan Co.: Marl Bay and mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36651; mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36753; swamp of Black Lake, Elmer P. Cheatum, 1932, UMMZ 55515; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 78594; woods pools, Grapevine Point, Douglas Lake, Harold W. Harry, 10 July 1949, UMMZ 246673; woods pool, Grapevine Point, Douglas Lake, Section 28, Munro Township, John B. Burch, 10 July 1985, UMMZ 250442; woods pool, Grapevine Point, Douglas Lake, Section 28, Munro Township, John B. Burch and Younghun Jung, 23 June 1987, UMMZ 253191; woods pool at public access and park, Burt Lake, Section 29, Burt Township, T36N, R3W, John B. Burch and Younghun Jung, August 1987, UMMZ 253193. **Emmet Co.:** pond at Bay View, M.L. Leach, Bryant Walker Collection, UMMZ 78548; Petoskey, Phil L. Marsh Collection, UMMZ 215257; Van Creek, a small tributary of the east branch of Maple River, southeastern corner of Section 25, McKinley Township, John B. Burch, 26 July 1985, UMMZ 250415; A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 26 July 1985, UMMZ 250416; Roadside ditch and swamp along Levering Road,

0.35 mile east of crossroads (highways US 31 and C 66) at Levering, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch, 25 June 1985, UMBS-85-4a; Kathleen Lake, impounded by dam on Maple River, eastern side of Section 10, T. 36 N., R. 4 W., Maple River Township, John B. Burch, 8 July 1985, UMBS-85-9a. **Presque Isle Co.:** south end of Grand Lake along highway US 23, Harold W. Harry and Henry van der Schalie, 11 September 1948 [form *reflexa*], UMMZ 171650.



MAP 21. Localities of *Stagnicola elodes.*

Remarks: Much of the previous literature on *Stagnicola elodes* refers to it as *"Lymnaea palustris,"* a European species named by O.F. Müller in 1774. The work of Jackiewicz (1959, *Poznan. Towarz. Przy. Nauk,* 19(3), pp. 1-86) has shown that in Europe *Stagnicola* [or *Lymnaea*] *palustris is* really several distinct species. Whether or not one of these occurs in North America is not known. Therefore, it seems best to use the truly North American name for our *palustris*-like snail, *i.e.,* Say's (1821) *Lymneus* [*Stagnicola*] *elodes.*

The *reflexa* form of *Stagnicola elodes* was given its name (Say, 1821, *J. Acad. Nat. Sci. Philad.,* 2, p. 167) because of the reflected last whorl. Such shells are characteristic of old animals in many populations.

Stagnicola exilis (Lea)

(Figs. 40, 41; Map 22)

Lymnaea exilis Lea 1831, *Trans. Am. Philos. Soc.,* 5, p. 114, pl. 19, fig. 82.
Limnea lanceata Gould, *Proc. Boston Soc. Nat. Hist.,* 3, p. 64.
Lymnaea reflexa exilis Lea, Walker (1892, p. 32).
Lymnaea lanceata Gould, Walker (1892, p. 33).
Lymnaea exilis Lea, Walker (1911, p. 123).
Lymnaea lanceata Gld., Walker (1911, p. 124).
Lymnaea lanceata (Gould), H.B. Baker (1914, pp. 18-45).
Lymnaea exilis Lea, H.B. Baker (1914, pp. 18-45).
Lymnaea lanceata Gld., Winslow (1917, p. 7).

Lymnaea (Galba) exilis Lea, Winslow (1926, p. 11).
Lymnaea (Galba) lanceata Gould, Winslow (1926, p. 11).
Stagnicola exilis (Lea), F.C. Baker (1928, p. 226, pl. 14, figs. 7-11; pl. 17, fig. 16).
Stagnicola lanceata (Gould), F.C. Baker (1928, p. 228, pl. 14, figs. 12-15; pl. 17, fig. 17).
Lymnaea exilis (Lea), Goodrich (1932, p. 56).
Lymnaea lanceata Gould, Goodrich (1932, p. 56).
Lymnaea lanceata Gould, Goodrich (1939, p. 13).
Lymnaea palustris Müller, in part, Hubendick (1951, p. 187).
Stagnicola exilis (Lea), Burch & Tottenham (1980, pp. 175, 176, figs. 596, 597).
Stagnicola exilis (Lea), Burch (1982a, pp. 51, 155, figs. 596, 597).
Stagnicola exilis (Lea), Burch (1982b, p. 249, fig.).
Stagnicola exilis (Lea), Burch (1989b, pp. 175, 176, figs. 596, 597).
Stagnicola exilis (Lea), Burch (1991, p. 128).

Shell: Medium to large, adults with six to seven whorls are up to 4 cm in length, attenuate, elongately conic, thin, imperforate or with a very small umbilical chink, moderately translucent, dull to slightly glossy, tan to Buffy Brown or Light Brownish Olive[9] in color, frequently zebrated. The whorls are flat-sided; the sutures not impressed. The columella has a well developed plait. There is a calloused pad on the parietal surface of the body whorl. The aperture is elongate, D-shaped, its outer lip thin, slightly curved in side view. The whorls are sculptured with well developed spiral striae and transverse growth lines, and are often malleated.

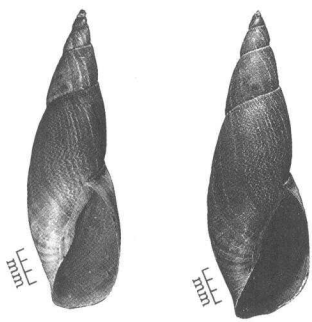


FIG. 40. Shells of *Stagnicola exilis.*

Animal: Similar to *Stagnicola elodes.* The head, foot and sole are heavily pigmented with melanin.

Habitat: Temporary ponds and woods pools, and intermittent small streams.

General Distribution: Midwestern United States from northern Michigan and Minnesota south to Ohio and west to Kansas.

Distribution in UMBS Area: Cheboygan Co.: Sedge Point pool and beach, Douglas Lake, Mina L. Winslow and Crystal Thompson, 5 July 1926, UMMZ 36652; beach pool at Sedge Point, Douglas Lake, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39880; small pond

[9]Ridgeway's color standards (see footnote, p. 23).

near Douglas Lake, UMMZ 42353; pond on north side Douglas Lake, N.A. Wood, 1915, UMMZ 42950; pool near Burt Lake, Elmer P. Cheatum, 1932, UMMZ 55638; Sedge Point, Douglas Lake, S.T. Brooks, Bryant Walker Collection, UMMZ 76139; temporary pond, Sedge Point; Douglas Lake, John B. Burch, September 1982, UMMZ 250285; Sedge Point, Douglas Lake, Beach Pond # 2, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250417; Hebron Township, Section 22, John B. Burch, 20 June 1960, UMMZ 253189. **Emmet Co.:** Carp Lake [Lake Paradise], Calvin Goodrich Collection, UMMZ 27797; Petoskey, Kent Science Institute Collection, UMMZ 142826; Carp River at highway U.S. 31, William H. Heard, 20 July 1959, UMMZ 253188.

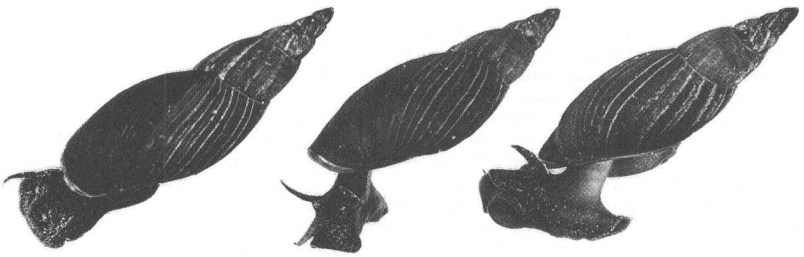
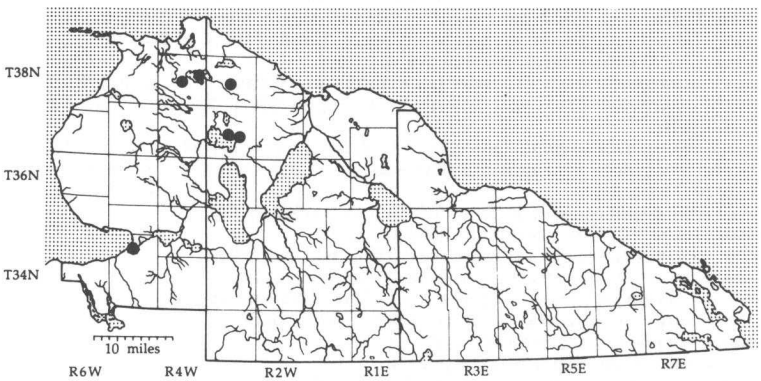


FIG. 41. Animals of *Stagnicola exilis.*



MAP 22. Localities of *Stagnicola exilis.*

Remarks: *Stagnicola exilis* can be confused with *S. elodes,* but the flatness of *S. exilis'* whorls and its non-impressed sutures distinguish it.

A statistical study of shell variation in *Stagnicola "reflexa"* (= *S. lanceata,* see H.B. Baker, 1914, p. 29, footnote [= *exilis*]) was published by H.B. Baker (1910, *Twelfth Rep. Mich. Acad. Sci.,* pp. 60-63).

Stagnicola emarginatus (Say)

(Figs. 42, 43, 100-103; Map 23)

Lymneus emarginatus Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), p. 170.
Limnea serrata Haldeman 1841, *Monogr. Limn. Freshwater Univalve Shells N. Am.*, no. 3, p. 12, pl. 2, figs. 6-8.
Limnaeus emarginatus ontariensis "Mühlfeldt" Küster 1862, *Syst. Conchyl.-Cab. Martini & Chemnitz*, 17B, p. 45, pl. 8, fig. 10.
Lymnaea canadensis Sowerby 1872, *Monogr. gen.* Limnaea, in Reeve's *Conchol. Icon.*, London, sp. 45, pl. 7, figs. 45a, a.
Limnaea angulata Sowerby 1872, *Monogr.. Gen.* Limnaea, in Reeve's *Conchol. Icon.*, London, sp. 47, pl. 7, fig. 47.
Lymnaea ampla Migh., Walker (1892, p. 32).
Lymnaea emarginata Say, Walker (1892, p. 34).
Lymnaea nasoni F.C. Baker 1906, *Trans. Acad. Sci. St. Louis*, 16(2), pp. 12, 13, pl. 1, figs. 1-4.
Lymnaea emarginata Say, Walker (1911, p. 123).
Lymnaea emarginata angulata Sby., Walker (1911, p. 123).
Lymnaea emarginata canadensis Sby., Walker (1911, p. 123).
Lymnaea emarginata ontarioensis "Muhl" Kust., Walker (1911, p. 123).
Lymnaea nasoni Baker, Walker (1911, p. 124).
Lymnaea emarginata Say, H.B. Baker (1912, pp. 209-211).
Lymnaea emarginata angulata Sowerby, H.B. Baker (1914, pp. 18-45).
Lymnaea decollata Mighels, Robertson (1915, Suppl., *47th Ann. Rep. Dept. Mar. Fish., Fish Br.*, Sessional Pap. 39b, pp. 96-99, pl. 10, fig. 7).
Lymnaea emarginata Say, Winslow (1917, p. 7).
Lymnaea (Galba) emarginata Say, Winslow (1926, p. 11).
Lymnaea (Galba) emarginata angulata Sowerby, Winslow (1926, p. 11).
Lymnaea (Galba) emarginata canadensis Sowerby, Winslow (1926, p. 11).
Lymnaea (Galba) emarginata ontariensis "Mühlfeldt" Küster, Winslow (1926, p. 11).
Lymnaea (Galba) emarginata wisconsinensis Baker, Winslow (1926, p. 11).
Lymnaea (Galba) nasoni Baker, Winslow (1926, p. 11).
Stagnicola emarginata (Say), F.C. Baker (1928, p. 234, pl. 15, figs. 1-3; pl. 16, figs. 15-20).
Stagnicola emarginata canadensis (Sowerby), F.C. Baker (1928, p. 239, pl. 15, figs. 4-11; pl. 17, fig. 19).
Stagnicola emarginata angulata (Sowerby), F.C. Baker (1928, p. 241, pl. 15, figs. 12-18).
Stagnicola emarginata wisconsinensis (F.C. Baker), F.C. Baker (1928, p. 245, pl. 15, figs. 19-25; pl. 17, fig. 20).
Lymnaea emarginata canadensis (Sowerby), Goodrich (1932, p. 58).
Lymnaea nasoni F.C. Baker, Goodrich (1932, p. 46).
Lymnaea emarginata angulata Sowerby, Goodrich (1932, p. 57, fig.).
Lymnaea emarginata angulata (Sowerby), Cheatum (1934, p. 348).
Stagnicola emarginata serrata (Haldeman), F.C. Baker (1936, p. 129).
Lymnaea emarginata angulata (Sowerby), Goodrich (1939, p. 13).
Lymnaea emarginata (Say), Hubendick (1951, p. 187).
Stagnicola emarginata, Eggleton (1952, p. 217).
Stagnicola emarginata angulata, Eggleton (1952, p. 217).
Lymnaea catascopium form *angulata* (Sowerby), Walter (1969, *Malacol. Rev.*, 2(1), pp. 1-102).
Lymnaea emarginata angulata (Sowerby), Clampitt (1973b, *Malacologia*, 12(2), pp. 379-399).
Stagnicola emarginata form *canadensis*, Burch & Tottenham (1980, p. 178, fig. 616).
Stagnicola nasoni, Burch & Tottenham (1980, p. 179, fig. 627).
Stagnicola emarginata (Say), Burch & Tottenham (1980, pp. 176, 178, fig. 614).
Stagnicola emarginata form *serrata*, Burch & Tottenham (1980, p. 178, fig. 615).
Stagnicola emarginata form *canadensis*, Burch (1982a, p. 157, fig. 616).
Stagnicola nasoni, Burch (1982a, p. 158, fig. 627).
Stagnicola emarginata form *serrata*, Burch (1982a, p. 157, fig. 615).
Stagnicola emarginata Burch & Jung (1987, pp. 260, 261, fig. 39).
Stagnicola nasoni, Burch & Jung (1987, p. 261, fig. 40).
Lymnaea catascopium, Laman, Boss & Blankespoor (1984, pp. 20-25).

Stagnicola emarginata (Say), Burch (1989b, pp. 176, 178, fig. 614).
Stagnicola emarginata form *serrata*, Burch (1989b, p. 178, fig. 615).
Stagnicola emarginata form *canadensis*, Burch (1989b, p. 178, fig. 616).
Stagnicola nasoni, Burch (1989b, p. 179, fig. 627).
Stagnicola emarginata (Say), Burch (1991, p. 128).
Stagnicola nasoni, Burch (1991, p. 128).

Shell: The shell is medium in size, adults with 6½ whorls measure up to 2.6 cm in length (the *canadensis* form can measure up to 3.3 cm). The shell is imperforate or with a slight umbilical chink, ovately to subglobosely conic (the more usual form), varying to globosely conic (in individuals of the *nasoni* form), to narrowly subovately conic (the *canadensis* form). White to tan, tannish horn or slate gray in color. Shells more than one year old have a transverse white varix. The shell is sturdy, frequently thick, opaque to moderately translucent, rather dull or with a slight gloss. The whorls are well rounded, or slightly shouldered on some specimens, sculptured with microscopic spiral striae and well developed growth lines, and often malleations, which frequently cause irregular spiral ridges. The sutures are moderately impressed. The aperture is oval or D-shaped, the outer lip sharp, often expanded, sometimes thickened, and slightly curved in side view. The columellar lip is reflected over the umbilicus. There is a callus on the parietal wall. The columella is twisted.

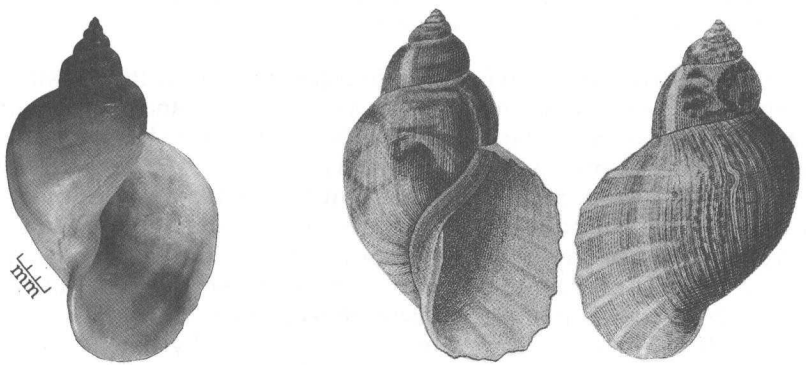


FIG. 42. Shells of *Stagnicola emarginatus*. The two figures on the right are from Haldeman (1841, *Monogr. Limn. ... N. Am.*, (3), pl. 2, figs. 6, 8).

Animal: The color varies from nearly black to pale tan or yellow, the latter color being more usual in the UMBS area. In lighter specimens, the red color of the buccal mass and the gizzard can be seen through the body wall. The body is flecked with very small white spots. The surfaces of the mantle covering the lung and the mantle collar are generally covered with black blotches. The foot is wide

and rather short, roundly truncate anteriorly, round posteriorly. The head and rostrum are short. The velum is variable in size and somewhat in shape, depending on the activity of the animal. When the animal is crawling, the velar surface is appressed to the substratum. The tentacles flat and broadly triangular. The black eyes are located on swellings at the inner base of the tentacles, and are conspicuous, their pigmented area surrounded by a lighter zone.

For aspects of internal anatomy, see p. 162 ff., Figs. 100-103.

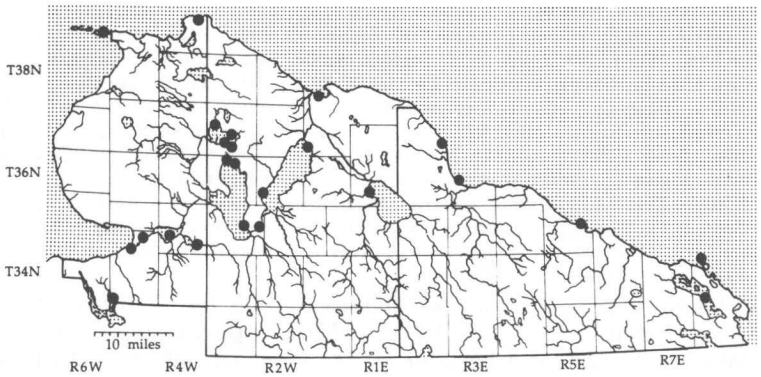
FIG. 43. Shells of *Stagnicola emarginatus.* **a**, Form *canadensis* (with an unusually flared outer lip); **b**, form *nasoni.*

Habitat: *Stagnicola emarginatus* is found crawling on the substrate in medium to large oligotrophic lakes with sand or sand mixed with marl, pebbles, stones or boulders. It is found on open shores of lakes "exposed to the full force of the winds and waves" (Baker, 1919, *Science,* 49(1274), p. 520). In water about three feet in depth, on a gravel or stone bottom; stony shore in shallow water, exposed to the waves of the open bay (*canadensis* Sowerby); 0.3 - 3 m depth on sand (partly buried) or pebble bottom (*angulata* Sowerby) (F.C. Baker, 1928). Exposed shore of Lake Huron (Baker, 1906, *nasoni* Baker; see also 1919). "On rocky shores and in shallow rocky bays of outer islands [of Georgian Bay]" (Robertson, 1915, *decollata* Mighels). "In pools of water in ledges of limestone which are accessible to the waves of the lakes during storms or high water" (William A. Nason in F.C. Baker, 1906, *nasoni* Baker). On wave-exposed black shale rocks (in Lake of the Woods) (Clarke, 1981, *Freshw. Moll. Can.,* Nat. Mus. Can., Ottawa, p. 138, *nasoni* Baker).

General Distribution: Maine west to Minnesota and central Wisconsin, Canadian Interior Basin south to Pennsylvania and New York and the upper third of the southern peninsula of Michigan.

Lakes Superior, Michigan, Ontario and Geneva (Wisconsin), and Rainy River system and Lake of the Woods (Minnesota/Canada) (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 138, *nasoni* Baker).

Distribution in UMBS Area: **Cheboygan Co.:** Burt Lake, Calvin Goodrich Collection, UMMZ 27732; Marl Bay and mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, Mina L. Winslow and Crystal Thompson, 4 July 1926, UMMZ 36637; Douglas Lake, Mina L. Winslow and Crystal Thompson, 6 July 1926, UMMZ 36638; Sedge Point, pool and beach, Douglas Lake, Mina L. Winslow and Crystal Thompson, 5 July 1926, UMMZ 36646; North Fishtail Bay, Douglas Lake, Mina L. Winslow and Crystal Thompson, 3 July 1926, UMMZ 36647; north end of Burt Lake, Mina L. Winslow and Crystal Thompson, 5 July 1926, UMMZ 36659; Burt Lake, Carl L. Hubbs and Metzelaar, 1927, UMMZ 39702; Mullett Lake, Mina L. Winslow and Crystal Thompson, 18 August 1926, UMMZ 39849; Carp Creek [Little Carp River], tributary to Burt Lake, Carl L. Hubbs and Greene, 7 August 1925, UMMZ 41472; Indian River, Metzelaar



MAP 23. Localities of *Stagnicola emarginatus.*

and Langlois, 14 June 1925, UMMZ 41473; Douglas Lake, Elmer P. Cheatum, 1932, UMMZ 55516; drift of Lake Michigan, 10 miles southwest [?] of Mackinaw, UMMZ 63847; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 73830; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 73831; Mullett Lake, Bryant Walker, Bryant Walker Collection, UMMZ 75444; Lake Michigan, Mackinaw City, A.C. Lane, Bryant Walker Collection, UMMZ 75454; Douglas Lake, Kent Science Institute Collection, UMMZ 142738; Douglas Lake, Kent Science Institute Collection, UMMZ 142755; Silver Strand, Douglas Lake, John B. Burch, 27 August 1955, UMMZ 197482; Mullet Lake, northeast end, Harold J. Walter, 19 July 1956, UMMZ 197927; northwest shore Black Lake, Harold J. Walter, 18 July 1956, UMMZ 197928; Mackinaw City, (Straits), 1938, Phil L. Marsh Collection, UMMZ 215162; Douglas Lake, Grapevine Point cove, T37N, R3W, S28, James W. Moffett, UMMZ 232358; Grapevine Point, Douglas Lake, Harold W. Harry, 10 July 1949, UMMZ 244922; Sedge Point and Grapevine Point, Douglas Lake, Harold J. Walter, 11 September 1955, UMMZ 244923; Sedge Point and Grapevine Point, Douglas Lake, Harold J. Walter, 11 September 1955, UMMZ 244924; west [?] shore Burt Lake, Columbus Beach, north of Indian River mouth, Harold J. Walter, 18 July 1956, UMMZ 244935; west side of Mullett Lake, L. Goine and Harold J. Walter, 20 July 1956, UMMZ 244936; Douglas Lake, C.O. Berg, 14 July 1954, E.J. Karlin Collection, UMMZ 248110; Sedge Point, Douglas Lake, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250418; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, Munro

Township, John B. Burch, 16 July 1985, UMMZ 250419; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250421; Sedge Point, Douglas Lake, John B. Burch, July 1964, UMMZ 250666; Douglas Lake, shoal at UMBS, South Fishtail Bay, at northern part of sections 33 and 34, at their boundary, T37N, R3W, Munro Township, John B. Burch, 23 June 1985, UMBS-85-1. **Emmet Co.:** Petoskey, UMMZ 3079; Crooked Lake, Calvin Goodrich Collection, UMMZ 27708; Crooked Lake, Calvin Goodrich Collection, UMMZ 27735; Walloon Lake, Mina L. Winslow, 1923, UMMZ 42673; Pickerel Lake, Northeast of Petoskey, Calvin Goodrich, Bryant Walker Collection, UMMZ 73851; Crooked Lake, Conway, Bryant Walker, Bryant Walker Collection, UMMZ 75442; Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 75451; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 75500; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 142764; Crooked Lake, Kent Science Institute Collection, UMMZ 142765; northeast Walloon Lake, Section 30, Bear Creek Township, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170726; Crooked Lake, Bryant Walker, UMMZ 185864; Bryant Walker exchange, 1885, F.R. Latchford Collection, Royal Ontario Museum Collection, UMMZ 189164; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253192; rocky shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 14 July 1988, UMBS-88-14. **Presque Isle Co.:** Lake Huron beach pools, north of Rogers City, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39878; Lake Huron beach pools, north of Rogers City, Mina L. Winslow and Crystal Thompson, 1926, UMMZ 39899; Lake Huron, Presque Isle Point, UMMZ 57778; Lake Huron, Presque Isle Point, UMMZ 57780; Grand Lake, UMMZ 57784; Black Lake, M.L. Leach, Bryant Walker Collection, UMMZ 75445; Lake Huron, Rogers City, Mina L. Winslow, Bryant Walker Collection, UMMZ 75473; Lake Huron, north of Rogers City, Mina L. Winslow, Bryant Walker Collection, UMMZ 75474; Lake Huron, Section 15, Bearinger Township, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170754; shore of Lake Huron, Hammond Bay, Bearinger Township, August, 1991, John B. Burch, UMMZ 253190.

Remarks: *Stagnicola emarginatus* was named by Thomas Say in 1821 (*J. Acad. Nat. Sci. Philad.*, 2(1), p. 170) for specimens sent to him from lakes in Maine, and he later (1834, *Am. Conchol.*, 1(6), 13th p.) also recorded it from "Upper Canada." The distribution of *S. emarginatus* includes many oligotrophic lakes of northeastern North America, from Maine through the Great Lakes region and beyond. Throughout this large area, *S. emarginatus* exhibits a certain amount of shell variation, some lakes clearly inhabited by distinct microgeographic races. As in other morphologically variable freshwater species, such forms have been named as though they were distinct species or subspecies. Recognizing these populations with their own individual Latin names is neither practical nor taxonomically correct (Burch & Thompson, 1958, *Syst. Zool.*, 7(1), p. 48).

The common shell form of *Stagnicola emarginatus* in our area is *serratus* Haldeman (Fig. 38) (synonym: *angulata* Sowerby). It has a white, subglobose shell with a large body whorl and a short spire. This is the form found, for example, in Douglas Lake. A form with a more elongate spire was named *canadensis* by Sowerby (1872, Monogr. gen. *Limnaea*, in Reeve's *Conchologia iconica*, sp. 47). Sometimes whole populations consist of this elongate form, while other popula-

tions comprise both the long- and short-spired forms, and various intergrades between the two.

Specimens along the western shore of northern Lake Huron were named *nasoni* by Baker (1906, *Trans. Acad., Sci. St. Louis,* 16(2), p. 12); type locality: Thunder Bay Island, Alpena County). The specimens Baker named are not fully grown, and are of the short-spired form of *Stagnicola emarginatus.* Other specimens/populations along the northwestern shore of Lake Huron have longer spires, *i.e.,* are like *canadensis.*

Stagnicola emarginatus populations around the shores of the Great Lakes, and especially in many of the medium and larger inland lakes, occur in isolated populations closed geographically to gene flow from outside. Therefore, it is not surprising that the various populations show small but rather constant morphological differences of the shell.

Stagnicola petoskeyensis (Walker)

(Fig. 44)

Lymnaea petoskeyensis Walker 1908, *Nautilus,* 22(1), pp. 6-7; 22(2), pl. 1, figs. 3, 5-7.
Lymnaea petoskeyensis Walker, Walker (1911, p. 124).
Lymnaea (Galba) petoskeyensis Walker, Winslow (1926, p. 12).
Lymnaea petoskeyensis Walker, Goodrich (1932, p. 53).
Lymnaea humilis (Say) ?, Hubendick (1951, p. 199).
Stagnicola petoskeyensis (Walker 1908), Burch & Tottenham (1980, pp. 178, 180, fig. 623).
Stagnicola petoskeyensis (Walker 1908), Burch (1982a, pp. 52, 157, fig. 623).
Stagnicola petoskeyensis (Walker 1908), Burch (1989b, pp. 178, 180, fig. 623).
Stagnicola petoskeyensis (Walker), Burch (1991, p. 128).

Shell: The 13 shells in the type lot (UMMZ 78776) range in length from slightly more than 1.5 cm (shell of a young specimen) to nearly 2.45 cm. A shell with a broken tip would have measured about 2.6 cm. The shell is attenuate, narrowly subovately conic, with a long, pointed spire, is pale horn to white and translucent, and is sculptured with spiral striae and growth lines. Most specimens are malleated. Such shells have several low spiral ridges on each whorl. The columellar lip is broadly reflected over the umbilicus, resulting in a rimate shell. The umbilical chink varies from rather small to one relatively large for a stagnicoline snail. The aperture is entire, even on younger specimens. The whorls are especially flattened in their posterior half.

Habitat: The only known habitat (and locality) for *Stagnicola petoskeyensis* is a small spring-brook, only a few hundred feet long, flowing into Lake Michigan's Little Traverse Bay. The shells are coated with marl.

General Distribution: Known only from the type locality (see below).

FIG. 44. Shell of *Stagnicola petoskeyensis.*

Distribution in UMBS Area: Emmet Co.: A small spring-brook flowing into Little Traverse Bay, near Petoskey, UMMZ 78776. This is the type locality.

Remarks: Walker (1908) at first thought the Petoskey specimens belonged to "the elongate variety of *Stagnicola catascopium*" [? = *Stagnicola emarginatus* form *canadensis*], but was dissuaded by the straight rather than twisted columella. The latter feature led him to compare *S. petoskeyensis* to "*Lymnaea desidiosa*" [*i.e., Fossaria obrussa*]. F.C. Baker (1911) placed *S. petoskeyensis* with the *F. obrussa* group. Goodrich followed this placement. Burch (in Burch & Tottenham, 1980, and later publications) placed *petoskeyensis* with the stagnicolas.

Stagnicola petoskeyensis has not been found since Walker's original description. The exact locality of the spring-brook has not been determined, and it is not known if it still exists. If this species is found to be still living, then it should join the State's list of rare and endangered species.

Subgenus *Hinkleyia* F.C. Baker

The stagnicoline subgenus *Hinkleyia* contains three species. The most widespread species, *Stagnicola (H.) caperatus,* occurs in the UMBS area. The other two species occur in the western United States, and have limited distributions. F.C. Baker (1928) erected the subgenus *Hinkleyia* specifically for S. *caperatus* because of its periostracal sculpture and straight, non-twisted columella.

Stagnicola (Hinkleyia) caperatus Say
(Figs. 45-47; Map 24)

Lymneus caperatus Say 1829, *N. Harmony Dissem. Useful Knowl.*, 2(15), p. 230.
Lymnaea caperata Say, Walker (1892, p. 34).
Lymnaea caperata Say, Walker (1911, p. 123).
Lymnaea (Galba) caperata Say, Winslow (1926, p. 10).
Stagnicola caperata (Say), F.C. Baker (1928, p. 260, pl. 18, figs. 43-47).
Lymnaea caperata Say, Goodrich (1932, p. 51, fig.).
Lymnaea caperata Say, Goodrich (1939, p. 14).
Lymnaea humilis (Say) ?, Hubendick (1951, p. 183).
Stagnicola (Hinkleyia) caperata (Say), Burch & Tottenham (1980, pp. 179, 180, figs. 628, 629).
Stagnicola (Hinkleyia) caperata (Say), Burch (1982a, pp. 52, 158, figs. 628, 629).
Stagnicola (Hinkleyia) caperata (Say), Burch (1989b, pp. 179, 180, figs. 628, 629).
Stagnicola (Hinkleyia) caperata (Say), Burch (1991, p. 128).

Shell: Medium in size, adults with about 6 whorls reach about 1.2 cm in shell length, subovately conic with a rather bulimoid body whorl, translucent, tannish-horn to medium tan in color, moderately glossy, with well rounded whorls lacking shoulders. Specimens more than a year old have a two-toned varix, pale and darker tan. The sutures are moderately impressed. The aperture is oval, its length less than that of the spire. The outer lip is sharp, and straight in side view; the columellar lip is reflected over the umbilicus, leaving a small chink. The columella is straight or slightly twisted.

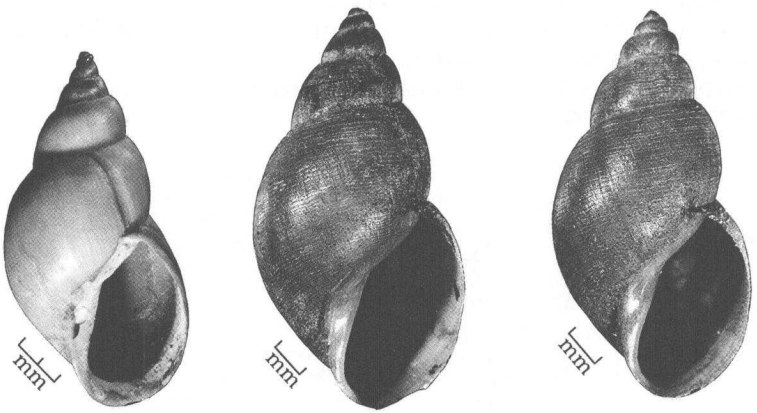
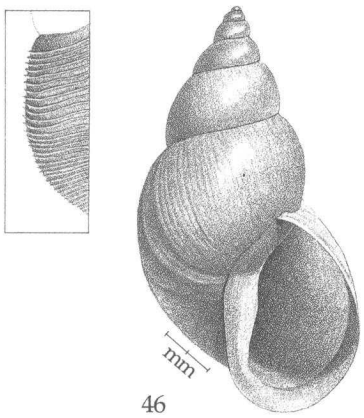


FIG. 45. Shells of *Stagnicola (Hinkleyia) caperatus.*

Animal: "Black or bluish-black, lighter below and minutely flecked with small, whitish dots, which are scarcely visible except on the top of the head; head distinct; tentacles short, flat, triangular; foot

short and wide. ... The animal is very rapid and decisive in its movements." (F.C. Baker, 1928, p. 261).



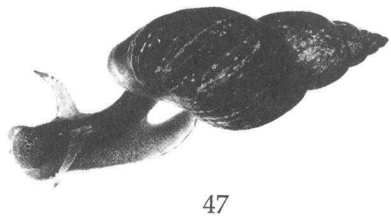
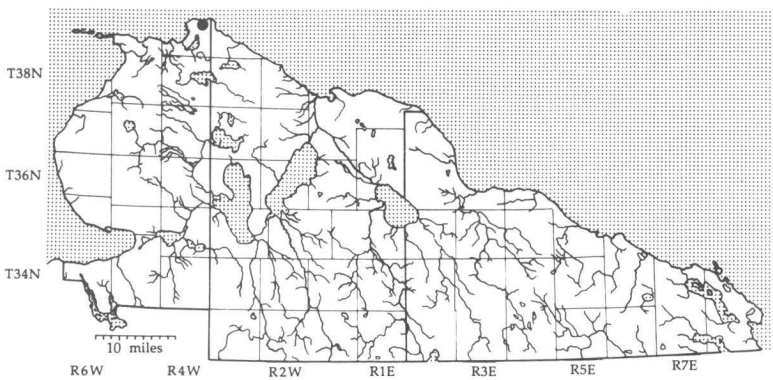


FIG. 46. Shell of *Stagnicola (Hinkleyia) caperatus.* The periostracal spiral ridges are shown in the inset. FIG. 47. Animal of *S. (H.) caperatus.*

Habitat: Intermittent pools, shallow ponds, streams and ditches, as well as similar but more perennial habitats.

General Distribution: Quebec and Massachusetts west to California; Yukon Territory and James Bay south to Maryland, Indiana, Colorado and California (F.C. Baker, 1928).

Distribution In UMBS Area: Cheboygan Co.: Mackinaw City, Bryant Walker, Bryant Walker Collection, UMMZ 73709.



MAP 24. Localities of *Stagnicola (Hinkleyia) caperatus.*

Remarks: *Stagnicola caperatus* has more rounded, bulbous whorls than those of the similar-appearing *S. elodes*. Fresh shells also have a more dark-greenish appearance. However, the surest distinguishing character of *S. caperata* is its microscopic spiral periostracal ridges.

Stagnicola caperata has not yet been collected in northern Michigan by the authors. Its existence in the UMBS area rests on the lone but authentic record of Bryant Walker, who collected it many years ago when northern Michigan was a remote region less subjected to human influence.

Family PHYSIDAE

The Physidae are mainly a New World family, with only a few species occurring in Eurasia and Africa. One of two species have been widely distributed to other parts of the world by human agency. In North America, the physids are readily recognized by a combination of several characters. Their lack of an operculum distinguishes them from all of the Prosobranchia. Their high-spiral shell separates them from the Planorbidae and Ancylidae, and their sinistral (left coiled) shell marks them as being different from the Lymnaeidae.

In North America, the Physidae are the most abundant and widespread of the freshwater gastropods. They may be found in all types of aquatic habitats, and some species seem to be the most resistant to pollution of all the freshwater mollusks. In addition to being highly adaptable, the physids have undergone considerable diversification, much of which is not clearly exhibited in their shells. Many of the species are not easy to identify on shell characters alone.

In recent publications that have dealt with the taxonomy of North American Physidae (Burch, 1979; 1982a,b; 1989a,b; 1991; Burch & Tottenham, 1980), the latest systematic revision of the Physidae was followed, that of Te (1980, *Arch. Molluskenk.*, 110(4/6), pp. 179-184). Unfortunately, Te did not present enough data to enable an evaluation of the merits of his classification. Our recent observations on the shells and anatomy of Michigan physids has raised enough questions regarding Te's classification to warrant a full-scale reappraisal of the taxonomy of the Physidae. That study is now underway.

In the UMBS area, we have recognized two genera and seven species of Physidae. However, it should be emphasized that more intensive studies are needed to fully clarify the taxonomy and phylogenetic relationships of the nomenclatural taxa found here and elsewhere.

Key to Genera in the UMBS Area

1 Mantle edge smooth, without digitations; shell elongate, high-spired, very narrow in outline, spindle-shaped, very glossy, apex pointed ..... *Aplexa* (p. 86)

Mantle edge digitate (with finger-like projections); shell elongate to globose, low- to high-spired, dull to glossy, apex pointed or round ..... *Physa* (p. 89)

Genus *Aplexa* Fleming

The single North American species of *Aplexa* has long been called *A. hypnorum* Linnaeus, a species of Europe and formerly considered to be Holarctic in distribution. However, the European and American populations have some anatomical differences (Te, 1975), and so the two are now treated as separate species. The name of the North American species is *A. elongata* (Say). Very large specimens (adult shells 18 mm or more in length) have been called *A. elongata tryoni* (Currier).

The terminal male genitalia of the Physidae have differentiating characters that are useful in taxonomy (Baker, 1928; Te, 1975). In *Aplexa,* the penial complex lacks an externally discernible preputial gland. In *Physa,* on the other hand, the penial complex has a very noticeable preputial gland. Other differences between the two genera are given in the key above.

Aplexa elongata (Say)

(Fig. 48; Map 25)

Physa elongata Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), pp. 171, 172.
Bulinus Tryoni Currier 1867, *Am. J. Conchol.*, 3(2) p. 112, pl. 6, fig. 2.
Aplexa hypnorum L., Walker (1892, p. 35).
Aplexa hypnorum tryoni Currier, Walker (1892, p. 35).
Aplexa hypnorum (Linné), Walker (1911, p. 125).
Aplexa hypnorum glabra (DeKay), Walker (1911, p. 125).
Aplexa hypnorum tryoni (Curr.), Walker (1911, p. 125).
Aplexa hypnorum (L.), Winslow (1917, p. 8).
Aplexa hypnorum (Linné), Winslow (1926, p. 17).
Aplexa hypnorum glabra (DeKay), Winslow (1926, p. 17).
Aplexa hypnorum tryoni (Currier), Winslow (1926, p. 17).
Aplexa hypnorum (Linné), F.C. Baker (1928, p. 473, pl. 19, figs. 1-4).
Aplexa hypnorum (Linnaeus), Goodrich (1932, p. 72, fig.).
Aplexa hypnorum (Linnaeus), Goodrich (1939, p. 23).
Aplexa elongata (Say), Burch & Tottenham (1980, pp. 190, 192, fig. 699).
Aplexa elongata morph *tryoni* (Currier), Burch & Tottenham (1980, pp. 190, 192, fig. 700).
Aplexa elongata (Say), Burch (1982a, pp. 56, 167, fig. 699).
Aplexa elongata morph *tryoni* (Currier), Burch (1982a, pp. 56, 167, fig. 700).
Aplexa elongata (Say), Burch (1982b, p. 254, fig.).
Aplexa elongata (Say), Burch (1989b, pp. 190, 192, fig. 699).
Aplexa elongata morph *tryoni* (Currier), Burch (1989b, pp. 190, 192, fig. 700).
Aplexa elongata (Linnaeus), Burch (1991, p. 128).

Shell: Attenuate, fusiform, narrowly subovately conic, of medium size, with an elongate aperture about ½ the length of the shell. An adult of average size (*ca.* 15 mm in length) has about 6¾ whorls. Exceptionally large shells of 20 mm or more in length have about 7½ whorls. The anterior aperture is relatively broad, narrowing to a point posteriorly. The shell is very glossy, and is generally devoid of any transverse or spiral sculpture. A few weak spiral lines of *Physella*-type spiral sculpture may appear on the first several neanic whorls, but these do not continue on later whorls. At the suture, the part of the whorl attached to the preceding whorl is about 0.5 mm in length and is white; its inner leading edge is darker than the shell, and can be seen through the shell. The color of the shell is tan, its apex dark brown. The first nuclear whorl is globular, and set off from the rest of the shell. There are 1¾ to 2 nuclear whorls. These are nearly smooth, except for fine radiating groovelets on both sides of the suture. These groovelets weaken on the first and second neanic whorls and disappear on later whorls.

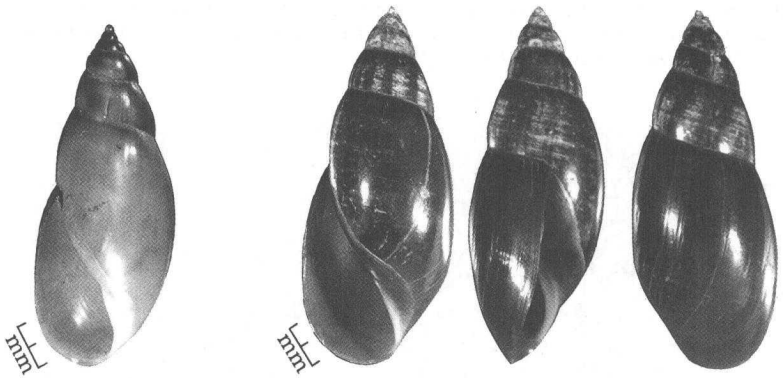


FIG. 48. Shells of *Aplexa elongata.*

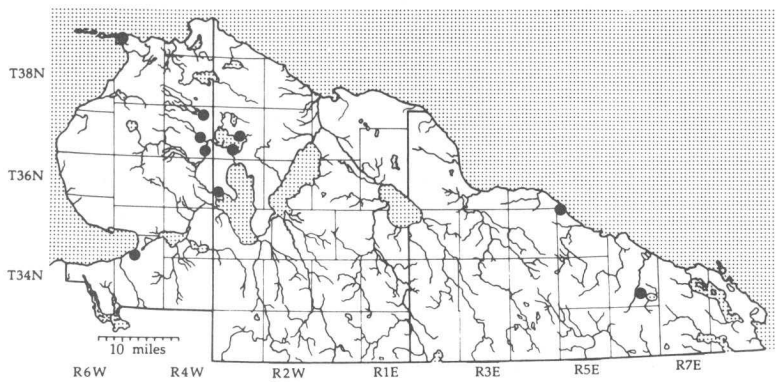
Animal: Deep black, immaculate, dorsally and ventrally; tentacles attenuated to the tip, with a white annulation at their bases (Say, 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), p. 172). Foot long, rounded in front and pointed behind; mantle does not come up over the shell and is without digitations or lobes (F.C. Baker, 1928).

Habitat: "A species of swales and intermittent streams or stagnant pools ... ; especially abundant in woodland pools which become dry in summer"; sometimes in clean brooks a few centimeters deep on a mud bottom (F.C. Baker, 1928, *hypnorum* Linnaeus). Found rarely in large

permanent rivers and lakes (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 172, *hypnorum* Linnaeus).

General Distribution: Ontario to Saskatchewan, Canada, and Alaska; New England through the Great Lakes states to Washington; south to Idaho, Utah and Wyoming; Siberia.

Distribution in UMBS Area: **Cheboygan Co.:** Grapevine Point, beach pool, Douglas Lake, T37N, R3W, S28, James W. Moffett, 27 July 1937, UMBS Invertebrate Collection, UMMZ 232351; woods pool, Grapevine Point, Douglas Lake, Section 28, Munro Township, John B. Burch, 10 July 1985, UMMZ 250424; woods pool next to shore of Burt Lake, Maple Bay park and public access, Younghun Jung and John B. Burch, July 1986, UMMZ 253205; Sedge Point, Douglas Lake, beach pond #2, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5d; Sedge Point, Douglas Lake, beach pond #3, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5e. **Emmet Co.:** Bayview, M.L. Leach, Bryant Walker Collection, UMMZ 115738; Goose Pond, Wilderness Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170455; Van Creek, a small tributary of the East Branch of Maple River, southeastern corner of Section 25, McKinley Township, John B. Burch, 26 July 1985, UMMZ 250432; Roadside ditch and swamp along Levering Road, 0.35 mile east of crossroads (highways US 31 and C 66) at Levering, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch, 25 June 1985, UMBS-85-4a; A small tributary on the west side of the East Branch of the Maple River, southeastern corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 9 July 1985, UMBS-85-8b. **Presque Isle Co.:** pond 0.5 mile east of Hawks, Elmer P. Cheatum, UMMZ 55630; Lake Huron, north edge Rogers City, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170566.



MAP 25. Localities of *Aplexa elongata*.

Remarks: North American snails of the genus *Aplexa* have generally been referred to the Eurasian species *A. hypnorum* (Linnaeus). Starobogatov & Streletzkaja (1967) and Te (1978, 1980) recognized the Western Hemisphere *Aplexa* as *A. elongata* (Say). Starobogatov & Streletzkaja reported *A. elongata* also in eastern Siberia.

Genus *Physa* Draparnaud

The genus *Physa* has undergone much more evolution than has *Aplexa*, as demonstrated by the anatomical and ecological diversity within the genus. *Physa s.lat.* can be subdivided into four subgenera by characters of the penial complex. Subgenera of pertinence to Michigan are *Physa s.str.*, *Beringophysa*, *Physella* and *Costatella*. The diagnostic anatomical characteristics of the male genitalia that have been given for each of these subgenera follows.

In the subgenus *Physa s.str.*, the penial sheath is entirely glandular, larger at the proximal end, tapering distally to the preputium, enlarging just before entering the preputium; the penis is long and thin, flagellar, with a stylet at its tip; the preputium has an enormous sarcobellum (Taylor, 1988, *Malacol. Rev.*, 21, p. 44).

In the subgenus *Beringophysa*, the penial sheath is glandular proximally, non-glandular distally, larger at the proximal end, tapering distally to the preputium; the penis is long and thin, flagellar, with or without a stylet at its tip; the preputium has a well developed sarcobellum (Taylor, 1988, *Malacol. Rev.*, 21, p. 44).

In the subgenus *Physella*, the penial sheath is divided into morphologically distinct proximal and distal sections, one of which (the proximal) is non-glandular and the other (the distal) is glandular (Fig. 49a). In the UMBS area, *Physella s.str.* is represented by *P. gyrina*, *P. magnalacustris*, *P. parkeri.* and *P. sayi.*

In the subgenus *Costatella*, the penial sheath is non-glandular in external appearance and, for species in the UMBS area, it is not divisible into two morphologically distinct sections (Fig. 49b). In our area, the subgenus has two species, *P. integra* and *P. crassa.*

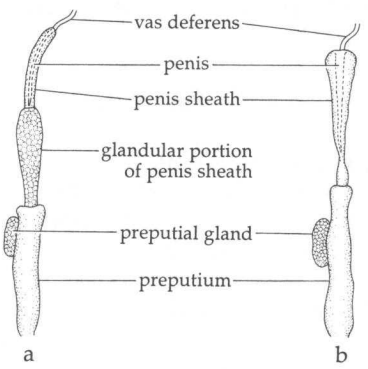


FIG. 49. Terminal male genitalia of (a) the subgenus *Physella;* and (b) the subgenus *Costatella.*

Since the glandular portion of the penial sheath in *Physa fontinalis* is greatly swollen in breeding snails, but largely absent in non-breeding snails (Duncan, 1958, *Proc. Zool. Soc.*, London, 131, pp. 55-84), the taxonomic usefulness of relative proportions of glandular to non-glandular tissue on the penis sheath in the Physidae may be limited.

Subgenus *Physa s.str.*

The subgenus *Physa s.str.* in North America has several small species with very glossy shells, conspicuously long apertures, and rounded apices. The long, slender mantle digitations are especially well developed. On active individuals of some species, the right and left mantle lobes may almost meet on the top of the shell. The type species of the genus is *P. fontinalis* (Linnaeus) of Europe, which has the mantle digitations and the mantle's envelopment of the shell especially pronounced.

Species of *Physa s.str.* have not yet been reported from the UMBS area, but with more collecting they may be found in one or more of the surrounding counties. The species of *Physa s.str.* previously reported for Michigan is *P. skinneri* Taylor. In this species, the mantle is not capable of noticeably covering external portions of the shell.

Subgenus *Beringophysa* Starobogatov & Budnikova

Taylor (1988, *Malacol. Rev.*, 21, p. 62) describes the shells of *Beringophysa* as narrow-ovoid to ovoid-fusiform, dull, with spiral crescentic microsculpture; aperture lip weakly convex in side view; parietal callus narrow; apex blunt; shell length up to 11 mm. In Michigan, *Beringophysa* may be represented by the species *Physa aplectoides* Sterki 1902.

Subgenus *Physella* Haldeman

The physellas present problems for their identification because these common freshwater snails are another of the groups that exhibit considerable diversity in the appearance of their shells. Accordingly, they have received numerous scientific names to distinguish portions of the observed diversity. However, because they have not been sufficiently studied, morphological boundaries of distinct species units have not been determined. Our approach has been to note morphological groups that correspond to named entities (nominal species) that seem distinct enough to possibly be good species. Hopefully, future studies employing not only shell morphology and reproductive anatomy, but also cytology and molec-

ular genetics, will clarify the taxonomy of North American Physidae.

Because of inter- and intra-populational variability in *Physa*, it is difficult to make a taxonomic key without resorting to anatomical characters. However, after some experience in identifying physid snails, and a familiarity with shell shapes, thicknesses, colors, etc., for the family in any given geographic region, it is not necessary to always resort to dissections.

For convenience, and to separate subgenera cleanly, the first couplet of the key below includes anatomical characters. However, the shells of, for example, *Physa parkeri*, or *P. crassa*, are so distinctive that making anatomical dissections is not necessary in order to recognize them.

Key to the Species of *Physella* and *Costatella* in the UMBS Area

1 Adult shell sizes relatively small to relatively large (up to nearly 30 mm in shell length); sutures generally weakly or moderately indented; penial sheath subdivided into a non-glandular proximal section and a glandular distal section. Subgenus *Physella* 2

Adult shell relatively small to medium (12-20 mm in shell length); sutures generally relatively strongly indented; penial sheath not subdivided into sections. Subgenus *Costatella* 5

2(1) Adult shells globose, strongly shouldered, relatively large (up to nearly 30 mm in shell length). Fig. 52 ..... *P. (P.) parkeri* (p. 96)

Adult shells elliptical or ovate, not strongly shouldered, small to relatively large 3

3(2) Shell elliptical or elongate-ovate. Fig. 50 ..... *P. (P.) gyrina* (p. 92)

Shell ovate or broadly ovate 4

4(3) Shell generally relatively thin, with thin outer apertural lip; inhabits streams and smaller lakes. Fig. 54 ..... *P. (P.) sayi* (p. 98)

Shell generally thicker, with thicker outer lip; inhabits shore areas of lakes Huron and Michigan, clinging to stones and boulders. Fig. 51 ..... *P. (P.) magnalacustris* (p. 94)

5(1) Shell ovate to elongate-ovate, solid, with high spire; inhabits streams, ponds, smaller lakes. Fig. 55 ..... *P. (C.) integra* (p. 100)

Shell broadly ovate, solid, with short spire; mainly an inhabitant of medium to rather large, marly lakes. Fig. 56 .... *P. (C.) crassa* (p. 102)

Physa (Physella) gyrina (Say)

(Fig. 50; Map 26)

Physa gyrina Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), p. 171.
Physa gyrina Say, Walker (1892, p. 35).
Physa gyrina Say, Walker (1911, p. 124).
Physa gyrina Say, Winslow (1917, p. 7).
Physa gyrina Say, Winslow (1926, p. 16).
Physella gyrina (Say), F.C. Baker (1928, p. 449, pl. 27, figs. 30-35, 37-40; pl. 28, figs. 1, 5, 6).
Physa gyrina Say, Goodrich (1932, p. 68, fig.).
Physa gyrina Say, Goodrich (1939, p. 22).
Physella gyrina gyrina (Say), Burch & Tottenham (1980, pp. 183, 184, fig. 647).
Physella gyrina gyrina (Say), Burch (1982a, pp. 54, 161, fig. 647).
Physella gyrina gyrina (Say), Burch (1982b, p. 253, fig.).
Physella gyrina gyrina (Say), Burch & Jung (1987, pp. 262, 263, fig. 43).
Physella gyrina gyrina (Say), Burch (1989b, pp. 183, 184, fig. 647).
Physella gyrina gyrina (Say), Burch (1991, p. 128).

Shell: Medium, adults with six whorls measure 2 cm or more in length, elliptical to elliptically ovate, imperforate, translucent, glossy, tannish horn to Brownish Olive or Buffy Brown[10], sculptured with fine spiral striae, fine growth lines, and, on shells that have over-wintered, a white and tan varix. The body whorl is well rounded, without a shoulder, the spire whorls rounded or somewhat flattened. The sutures are not impressed. The aperture is elongately oval, considerably longer than the spire, and has a sharp posterior angle. The outer lip is sharp, curved in side view. The columella is twisted, usually having a weak plait. A very thin parietal callus may be present on the parietal wall.

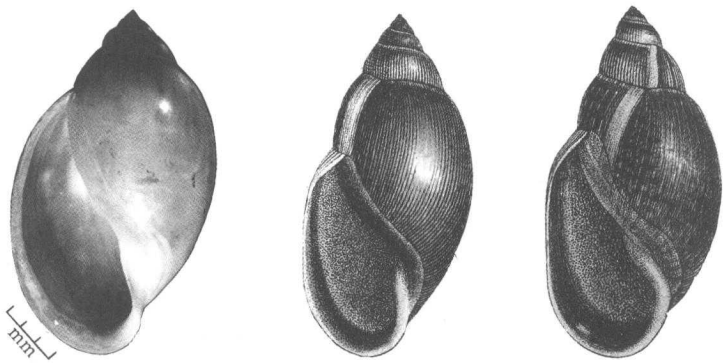


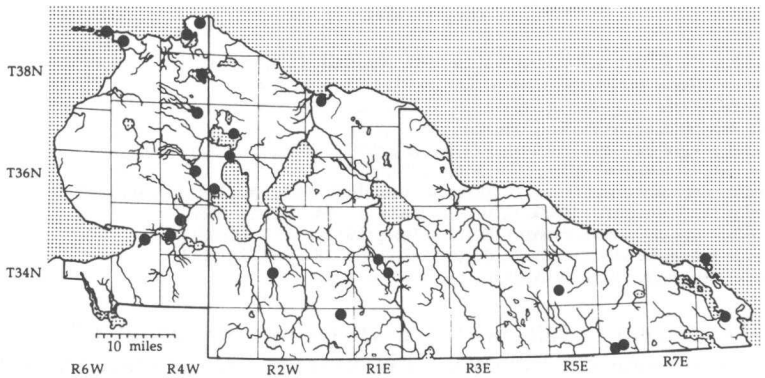
FIG. 50. Shells of *Physa (Physella) gyrina*. The two figures on the right are from Haldeman (1843, *Monogr. Freshw. Univalve Moll. U.S.*, (6), pl. 4, figs. 4, 6).

[10]Ridgeway's color standards (see footnote, p. 23).

Animal: The body is dark to medium gray, covered with minute white or yellow dots. The foot is narrow, rounded in front and tapers to an acute point behind. The velum is well developed, somewhat bilobed, with the mouth on the ventral surface. The tentacles are long, thin and cylindrical. The eyes, on the dorsal surface of the head, are located at the inner bases of the tentacles. The mantle has digitations on its anterior and posterior parietal margins. Digitations are lacking on the palatal side.

Habitat: "Occurs in almost all perennial-water habitats and in temporarily flooded pools and swamps. Often abundant in mildly polluted water bodies; in fact, where it occurs alone in abundance, it is indicative of water pollution" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 152).

General Distribution: In Canada, Quebec to Ontario; south in the U.S.A. to Nebraska and east to New York.



MAP 26. Localities of *Physa (Physella) gyrina.*

Distribution in UMBS Area: **Cheboygan Co.:** Black River, near Tower, Mina L. Winslow and Crystal Thompson, 7 July 1926, UMMZ 36680; Douglas Lake, N.A. Wood, 1915, UMMZ 42957; outlet of Dog Lake, Metzelaar and Langlois, 12 August 1925, UMMZ 43167; Little Black River, near its mouth, UMMZ 43176; creek at north end of Burt Lake, UMMZ 50451; Carp Creek [Little Carp River], near Burt Lake, Elmer P. Cheatum, 1932, UMMZ 55522; pool near Burt Lake, Elmer P. Cheatum, 1932, UMMZ 55640; Mackinaw City, Bryant Walker, Bryant Walker Collection, UMMZ 116426; Cheboygan, M.L. Leach, Bryant Walker Collection, UMMZ 118070; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 120433; upper Black River, L.D. Golcynski, U.S. Bureau of Fisheries, UMMZ 130304; pool north of Cheboygan, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170595; Mackinaw City, 16 June 1938, Phil L. Marsh Collection, UMMZ 214972; Little Sturgeon River, Wolverine, Phil L. Marsh Collection, UMMZ 215077; Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250426; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, John B. Burch, 15 July 1985, UMMZ 250427; woods pool next to shore of Burt Lake, Maple Bay park and public access, Younghun Jung and John B. Burch, July 1986, UMMZ 253201. **Emmet Co.:** Carp Lake [Lake Paradise], Bryant Walker, Bryant Walker Collection,

UMMZ 120417; Crooked Lake, Kent Science Institute Collection, UMMZ 143154; Round Lake, Kent Science Institute Collection, UMMZ 143155; Little Sucker Creek, Royal Bruce Brunson, 10 July 1945, UMMZ 198386; Cecil Bay, T39N, R4W, Section 27, Willrwin, 27 June 1937, UMMZ 232335; Roadside ditch and swamp along Levering Rd., at Levering, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch, 25 June 1985, UMMZ 250423; roadside spring, highway US 31 at southern edge of Alanson, John B. Burch and Younghun Jung, 19 July 1986, UMMZ 253202; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253203; roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253211. **Presque Isle Co.:** Thunder Bay River below Sunken Lake, UMMZ 50382; Sunken Lake, UMMZ 50386; Sunken Lake, UMMZ 50429; East [?] Lake, Elmer P. Cheatum, 1932, UMMZ 55526; pond 0.5 miles east of Hawks, Elmer P. Cheatum, 1932, UMMZ 55634; south end of Grand Lake along US 23, Harold W. Harry and Henry van der Schalie, 11 September 1948, UMMZ 171651.

Remarks: *Physa gyrina* is perhaps the most common and widespread physid in North America. This, and its variability, has led to a large synonymy (not presented here).

Physa (Physella) magnalacustris (Walker)

(Fig. 51; Map 27)

Physa ancillaria magnalacustris Walker 1901, *Nautilus*, 14(9), pp. 97, 98.
Physa ancillaria magnalacustris Walker, Walker (1911, p. 124).
Physa ancillaria magnalacustris Walker, H.B. Baker (1912, pp. 209-211).
Physa magnalacustris Walker, Winslow (1926, p. 16).
Physella magnalacustris (Walker), F.C. Baker (1928, p. 435, pl. 26, figs. 1-6).
Physa magnalacustris Walker, (Goodrich, 1932, p. 70).
Physella magnalacustris (Walker), Burch & Tottenham (1980, pp. 184, 187, fig. 668).
Physella magnalacustris (Walker), Burch (1982a, pp. 54, 164, fig. 668).
Physella magnalacustris (Walker), Burch & Jung (1987, p. 264, fig. 45).
Physella magnalacustris (Walker), Burch (1989b, pp. 184, 187, fig. 668).
Physella magnalacustris (Walker), Burch (1991, p. 128).

Shell: Medium, adults with 5¼ whorls measure about 1.7 cm in length, moderately solid, ovate, imperforate, very slightly translucent, dull to moderately glossy, light tan to dark tannish horn, shells that have over-wintered have a white varix. The first several

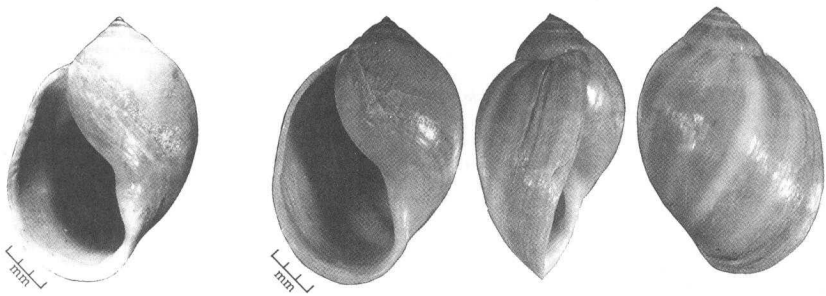


FIG. 51. Shells of *Physa (Physella) magnalacustris.*

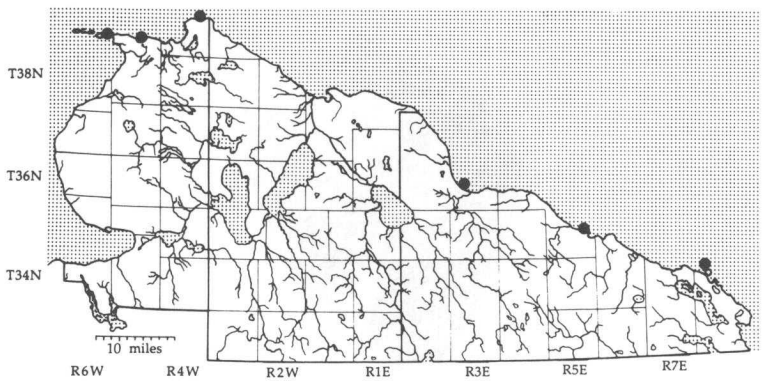
whorls are chestnut brown. The body whorl is well rounded, without a shoulder, the spire whorls rounded or somewhat flattened. The sutures are not impressed. The aperture is elongately oval, and very long. The spire is very short. The outer lip is sharp, slightly curved in side view. The columella is weakly twisted. A thin but rather wide parietal callus is present.

Animal: Similar to *Physa gyrina,* but somewhat shorter and wider. The most noticeable characteristic is its densely black head-foot and mantle. The heavy pigmentation of the mantle makes the slightly translucent shell appear dark reddish brown.

Habitat: On stones and boulders in shallow water on the wave-swept shores of large lakes. "This form is the characteristic *Physa* [*Physella*] of the lake shore, and is commonly found clinging to the large stones along the rocky or stony beaches" (Walker, 1901). In Sturgeon Bay (Lake Michigan, Wisconsin) on "rocky ledges of the wave-beaten shore, always in shallow water" (F.C. Baker, 1928).

General Distribution: Ontario south to the Great Lakes states and Indiana, east to Vermont and Maine.

Distribution in UMBS Area: **Cheboygan Co.:** Lake Michigan, Mackinaw City, Calvin Goodrich Collection, UMMZ 29482; Lake Michigan, Mackinaw City, UMMZ 34556; Mackinaw City, Bryant Walker, Bryant Walker Collection, UMMZ 124169. **Emmet Co.:** Lake Michigan, Big Stone Bay, Carl L. Hubbs, 17 July 1927, UMMZ 43459; Lake Michigan, Big Stone Bay, Stanley T. Brooks, Bryant Walker Collection, UMMZ 124176; rocky shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 14 July 1988, UMBS-88-14. **Presque Isle Co.:** beach pools on Lake Huron, north of Rogers City, Mina L. Winslow and Crystal Thompson, 8 July 1926, UMMZ 36825; Lake Huron, drift, north of Rogers City, Mina L. Winslow and Crystal Thompson, 8 July 1926, UMMZ 36827; bayou of Lake Huron, 2 miles north of Presque Isle, Elmer P. Cheatum, 1932, UMMZ 55642; Lake Huron, Presque Isle Point, UMMZ 57779; Lake Huron, Rogers City, F.E. McCain, Bryant Walker Collection, UMMZ 124175.



MAP 27. Localities of *Physa (Physella) magnalacustris.*

Physa (Physella) parkeri (Currier)

(Figs. 52, 53; Map 28)

Physa parkeri Currier (in DeCamp) 1881, p. 15, pl. 1, fig. 3.
Physa lordi Baird, Walker (1892, p. 34).
Physa lordi Bd., Walker (1911, p. 124).
Physa ancillaria parkeri (Currier), H.B. Baker (1912, pp. 210-211).
Physa ancillaria parkeri, Henderson & Daniels (1917, *Proc. Acad. Nat. Sci. Philad.*, vol. 69, p. 75).
Physa parkeri (Curr.) DeCamp, Clench (1925, p. 34, pl. 1, fig. 4).
Physa parkeri "Currier" DeCamp, Winslow (1926, p. 16).
Physella parkeri (Currier), F.C. Baker (1928, pp. 408, 491, pl. 25, fig. 6).
Physa parkeri "Currier" DeCamp, Goodrich (1932, p. 71, fig.).
Physa parkeri Currier, Cheatum (1934, p. 348).
Physella parkeri, Eggleton (1952, p. 217).
Physa parkeri "Currier" DeCamp, Clampitt (1973b, pp. 379-399).
Physella parkeri parkeri (Currier (in DeCamp)), Burch & Tottenham (1980, pp. 184, 187, fig. 669).
Physella parkeri parkeri (Currier (in DeCamp)), Burch (1982a, pp. 54, 164, fig. 669).
Physa parkeri, Laman, Boss & Blankespoor (1984, pp. 20-25).
Physella parkeri parkeri (Currier (in DeCamp)), Burch (1989b, pp. 184, 187, fig. 669).
Physella parkeri ("Currier" DeCamp), Burch (1991, p. 128).

Shell: Medium, adults with 5½ whorls measure up to 2.4 cm in length, subglobose, imperforate, nearly opaque to translucent, dull to moderately glossy, nearly white to dark horn, with a lighter colored varix, the first several whorls are usually dark brown. The whorls are sculptured with fine spiral striae and fine growth lines. The body whorl is shouldered, usually strongly so, and very large. The spire is very short. The sutures are not impressed. The aperture is oval or reverse D-shaped. The outer lip is sharp, slightly curved in side view, and may be thickened internally with a brown deposit. The columella is strongly twisted. A very thin parietal callus is present on the parietal wall.

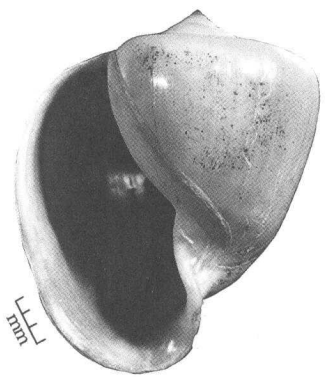


FIG. 52. Shell of *Physa (Physella) parkeri.*

Animal: "Bluish-gray ... flecked with small white spots, lighter on the neck. The mantle has several large black blotches which show conspicuously through the shell" (Baker, 1928). Douglas Lake specimens vary in head-foot coloration, with very pale yellow predominating.

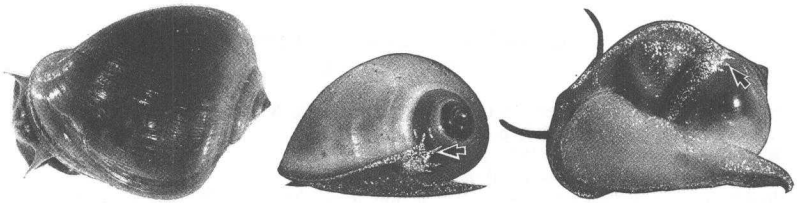
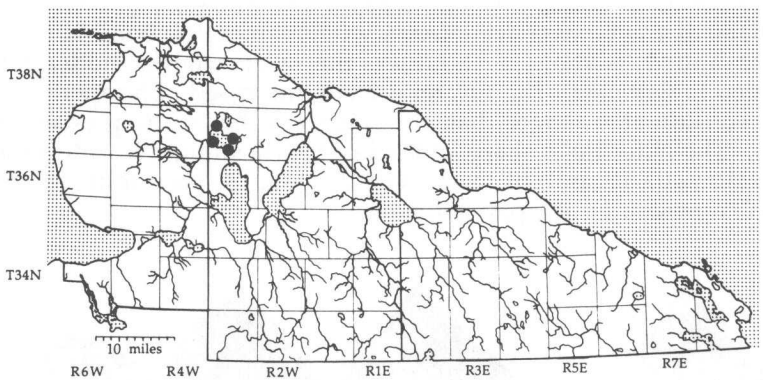


FIG. 53. Animals of *Physa (Physella) parkeri.* Arrows indicate mantle digitations.

Habitat: On sand or marl substrates, often clinging to stones and other objects, in medium to large oligotrophic lakes.

General Distribution: Northern lower peninsula of Michigan; Wisconsin.



MAP 28. Localities of *Physa (Physella) parkeri.*

Distribution in UMBS Area: **Cheboygan Co.:** Douglas Lake, N.A. Wood, 1915, UMMZ 5644; Marl Bay and mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, UMMZ 36660; near shore beyond camp, engineers' camp, Douglas Lake, UMMZ 36661; north Fish Tail Bay, Douglas Lake, UMMZ 36662; Sedge Point pools and beach, Douglas Lake, UMMZ 36663; Douglas Lake, Elmer P. Cheatum, 1932, UMMZ 55520; Douglas Lake, Bryant Walker Collection, UMMZ 123603; Ingelside, Douglas Lake, D.W., 7 July 1950, UMMZ 186456; Douglas Lake, F.R. Latchford Collection, UMMZ 193187; Grapevine Point cove, Douglas Lake, Section 28, T37N, R3W, James W. Moffett, 29 June 1937, UMBS Invertebrate Collection, UMMZ 232331; Douglas Lake, depth 0-1 foot, 16 June 1940, UMMZ 246354; Douglas Lake, Clifford O.

Berg, E.J. Karlin Collection, UMMZ 246355; Douglas Lake shore, E.M.G., 23 June 1955, UMBS Invertebrate Collection, UMMZ 246356; northeast end of Douglas Lake, UMMZ 249584; Sedge Point, Douglas Lake, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250430; Hook Point bay, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250431; Sedge Point, Douglas Lake, John B. Burch, July 1964, UMMZ 250667; Douglas Lake, shoal at UMBS, South Fishtail Bay, at northern part of sections 33 and 34, at their boundary, T37N, R3W, Munro Township, John B. Burch, 23 June 1985, UMBS-85-1.

Physa (Physella) sayi (Tappan)

(Fig. 54; Map 29)

Physa sayii Tappan 1839, *Am. J. Sci.*, 35(2), p. 269, pl. 3, fig. 3.
Physa sayi Tapp., Walker (1892, p. 34).
Physa sayii Tappan, Walker (1911, p. 124).
Physa sayii Tappan, Winslow (1926, p. 16).
Physella sayii (Tappan), F.C. Baker (1928, p. 430, pl. 25, fig. 18; pl. 26, figs. 19-32; pl. 27, figs. 17-20).
Physa sayii Tappan, Goodrich (1932, p. 69, fig.).
Physella gyrina sayi (Tappan), Burch & Tottenham (1980, pp. 184, 186, fig. 660).
Physella gyrina sayi (Tappan), Burch (1982a, pp. 54, 163, fig. 660).
Physella gyrina sayi (Tappan), Burch & Jung (1980, p. 263, fig. 44).
Physella gyrina sayi (Tappan), Burch (1989b, pp. 184, 186, fig. 660).

Shell: Medium, adults with 5½ whorls measure almost 2 cm in length, ovate, imperforate, translucent to nearly transparent, moderately glossy, tannish horn to nearly white, the first several whorls darker, sculptured with fine spiral striae and fine growth lines, and, on shells that have over-wintered, a white varix. The body whorl is well rounded, without a shoulder, the spire whorls moderately rounded to flattened. The sutures are not impressed. The aperture is oval, considerably longer than the spire, and has a sharp posterior angle. The outer lip is sharp, curved or nearly straight in side view. The columella is straight to slightly twisted. A very thin parietal callus is present on the parietal wall.

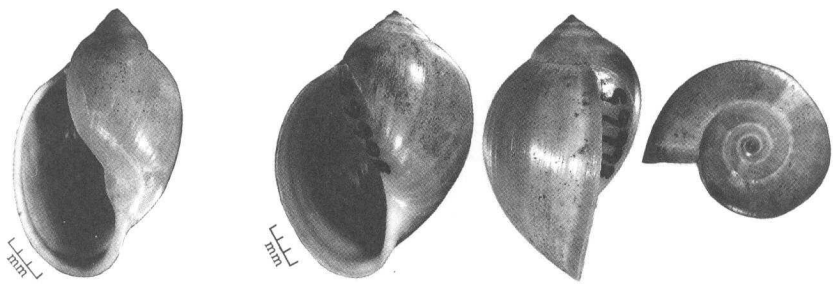


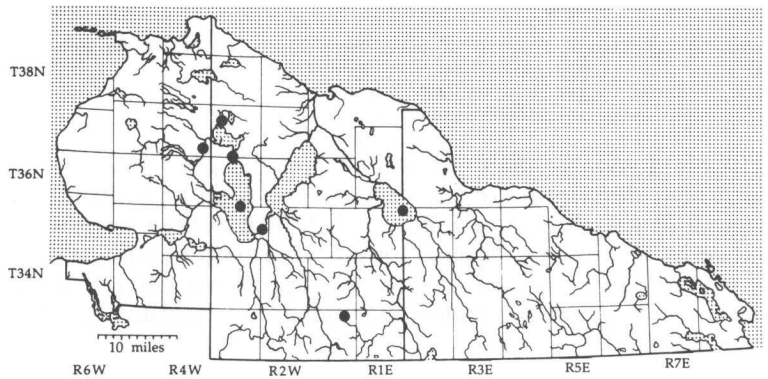
FIG. 54. Shells of *Physa (Physella) sayi.*

Animal: F.C. Baker (1928) described the animal of Wisconsin specimens of *Physa sayi* as yellow to yellowish-white, the mantle with whitish or greenish spots; the mantle with long and narrow digitations – 4-8 columellar and 4-5 apical digitations.

Habitat: F.C. Baker (1928) reports *Physa sayi* in various lakes, on bottoms of mud, sand, gravel, rock and boulder. "Near Sturgeon Bay, it was found on rocks on the open shore of Lake Michigan."

General Distribution: Quebec to Northwest Territories, south to Saskatchewan, the Dakotas and New York.

Distribution in UMBS Area: **Cheboygan Co.:** Burt Lake, UMMZ 29612; Marl Bay and mouth of Bessie [Bessy; Lancaster] Creek, Douglas Lake, UMMZ 36665; Indian River, UMMZ 36890; outlet of Dog Lake, Metzelaar and Langlois, 12 August 1925, UMMZ 43174; Carp Creek [Little Carp River], tributary to Burt Lake, UMMZ 50401. **Presque Isle Co.:** Black Lake, M.L. Leach, Bryant Walker Collection, UMMZ 124771.



MAP 29. Localities of *Physa (Physella) sayi.*

Subgenus *Costatella* Dall

Costatella was established originally as a subgenus for *Physa costata* (Newcomb) of Clear Lake, California. Te (1980) added many species to the subgenus, and divided it into two sections, *Costatella s.str.* and *Alampetista* Zilch. Only members of the *Alampetista* section occur in the UMBS area. Te (1978) described the shells of this section as being smaller than in *Physella* (adult shells measuring about 5.5 - 15.5 mm in length) and more acutiform. The shell is elongate-ovate in shape, has a shiny (not glossy) surface, and the acute spire has strongly indented sutures. Anatomically, the penial complex has a preputial gland and an undivided, non-glandular penis sheath.

Physa (Costatella) integra (Haldeman)

(Fig. 55; Map 30)

Physa (*Diastropha*) *integra* Haldeman 1841, *Monogr. Limn. Freshwater Univalve Shells N. Am.*, (3), cover p. 3.
Aplexa integra Hald., Walker (1892, p. 35).
Physa walkeri Crandall 1901, *Nautilus*, 15(5), pp. 57, 58.
Physa integra Hald., Walker (1911, p. 124).
Physa walkeri Crandall, Walker (1911, p. 124).
Physa integra Hald. var., Winslow (1917, p. 8).
Physa integra Haldeman, Winslow (1926, p. 16).
Physa walkeri Crandall, Winslow (1926, p. 17).
Physella (Physodon) integra (Haldeman), F.C. Baker (1928, p. 460, pl. 28, figs. 24-31).
Physa integra Haldeman, Goodrich (1932, p. 71, fig.).
Physa integra Haldeman, Goodrich (1939, p. 22).
Physella (*Costatella*) *integra integra* (Haldeman), Burch & Tottenham (1980, pp. 190, 192, fig. 695).
Physella (*Costatella*) *integra integra* (Haldeman), Burch (1982a, pp. 56, 167, fig. 695).
Physella (*Costatella*) *integra integra* (Haldeman), Burch (1982b, p. 253, fig.).
Physella (*Costatella*) *integra integra* (Haldeman), Burch & Jung (1987, pp. 264, 265, fig. 47).
Physella (*Costatella*) *integra integra* (Haldeman), Burch (1989b, pp. 190, 192, fig. 695).
Physella (*Costatella*) *integra integra* (Haldeman), Burch (1991, p. 128).
Physella (*Costatella*) *integra brevispira* (Lea), Burch (1991, p. 128).
Physella (*Costatella*) *integra walkeri* (Crandall), Burch (1991, p. 128).

Shell: Haldeman's (1843, *Monogr. Freshw. Univalve Moll. U.S.*, (6), pp. 33-34) description of the shell, which is an amplification of his original description, is as follows: shell oval, with a lengthened, pointed spire; whorls five, convex; suture deep; aperture obtuse posteriorly, peritreme continuous; labium not appressed anteriorly, and without a fold. Color very pale yellowish-brown; labium, aperture, and varicose bands, white.

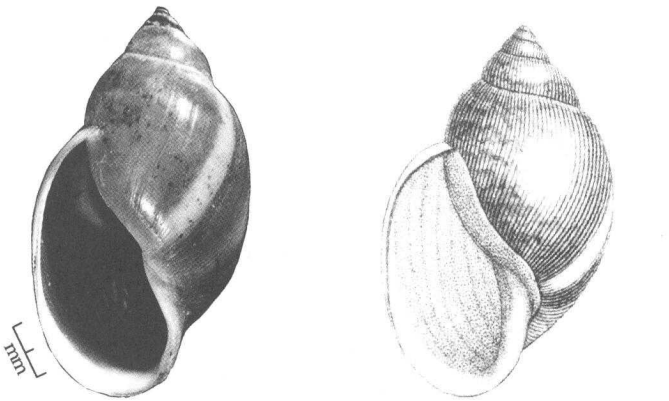


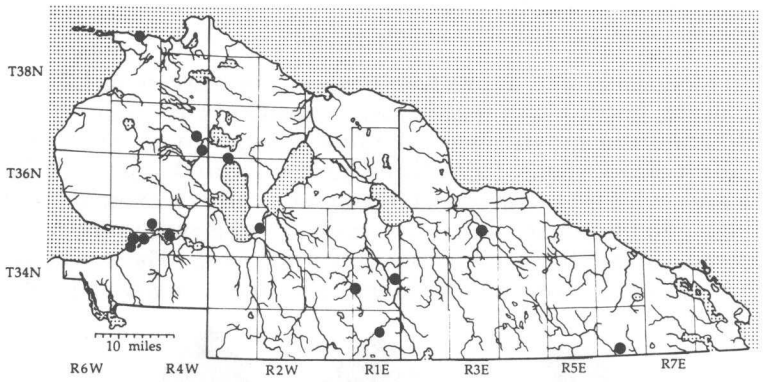
FIG. 55. Shells of *Physa (Costatella) integra*. The figure on the right is from Haldeman (1843, *Monogr. Freshw. Univalve Moll. U.S.*, (6), pl. 4, fig. 8).

In the UMBS area, the shell of *Physa integra* is small to medium in size, adults with 5¼ whorls measuring 1 cm (± 0.2 cm) in length, ovately conic, imperforate or with a very small umbilical chink, translucent to opaque, moderately glossy, tannish horn to dark horn, with pale tan varices, the first several whorls are chestnut brown. The whorls are sculptured with well developed growth lines and fainter spiral striae. The body whorl is well rounded, or with a very slight shoulder. The sutures are impressed. The aperture is oval. The outer lip is sharp, nearly straight or slightly curved in side view. The columella is straight or moderately twisted. A thin parietal callus is present on the parietal wall.

Animal: Baker (1901, *Bull. Chicago Acad. Sci.*, 2(4), p. 226; 1928, p. 461) described the digitations of the mantle collar. These digitations occur in two groups, one anterior and the other posterior, with a non-digitate space between the two. The posterior apical digitations vary from three to seven, and the anterior digitations vary from three to five.

Habitat: Rivers and lakes of various sizes, especially those connected to the Great Lakes.

General Distribution: Quebec to Manitoba, Canada, and the Great Lake states, Iowa, South Dakota, Tennessee, Kentucky and West Virginia.



MAP 30. Localities of *Physa (Costatella) integra.*

Distribution in UMBS Area: Cheboygan Co.: Milligen Creek, west of Tower, UMMZ 36683; Milligen Creek, UMMZ 36816; Milligen Creek, UMMZ 36863; Indian River, UMMZ 36888; Little Black River, Metzelaar and Langlois, 3 August 1925, UMMZ 43189; Carp Creek [Little Carp River], near Burt Lake, UMMZ 55523. **Emmet Co.:** Petoskey, UMMZ 29621; Crooked Lake, UMMZ 50396; Conway, Bryant Walker, Bryant Walker Collection, UMMZ 118830; Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 120956; brook, Petoskey, Bryant Walker, Crandall Collection, Bryant Walker Collection, UMMZ 124675; Petoskey, Crandall Collection, Bryant Walker Collection, UMMZ 124676; Little Traverse Bay, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 124678; Petoskey,

Bryant Walker, Crandall Collection, Bryant Walker Collection, UMMZ 129171; tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 8 July 1985, UMMZ 250428; tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 7 July 1985, UMMZ 250429; Van Creek, tributary of the East Branch of the Maple River, southeast corner of Section 25, McKinley Township, John B. Burch, 26 July 1985, UMMZ 250433. **Presque Isle Co.:** outlet of Sunken Lake, Fletcher State Park, UMMZ 36672; Ocqueoc River, UMMZ 36812; Ocqueoc River, at Ocqueoc Falls, southcentral part of Section 22, Ocqueoc Township, John B. Burch, 18 July 1985, UMMZ 250443.

Remarks: F.C. Baker (1930) considered the form of *Physa integra* (Haldeman) with smaller shell and more regular aperture to be a subspecies (*Physa integra billingsi* F.C. Baker) restricted to lakes and river estuaries.

Physella (Costatella) crassa (Walker)

(Fig. 56; Map 31)

Physa ancillaria var. *crassa* Walker 1901, *Nautilus*, 14(9), p. 98.
Physa ancillaria crassa Walker, Walker (1911, p. 124).
Physa ancillaria var., H.B. Baker (1914, pp. 18-45).
Physa ancillaria crassa Walker, Winslow (1917, p. 7).
Physa sayii crassa Walker, Winslow (1926, p. 16).
Physella sayii crassa (Walker), F.C. Baker (1928, p. 434, pl. 25, figs. 19-21, 24-27).
Physa sayii crassa Walker, Goodrich (1932, p. 70).
Physa sayi crassa Walker, Cheatum (1934, p. 348).
Physella sayii crassa, Eggleton (1952, p. 217).
Physella sayii magnalacustris (Walker), Te (1975, p. 9).
Physa integra Haldeman, Clampitt (1973, pp. 379-399).
Physa integra Haldeman, Clampitt (1974, pp. 275-300).
Physa integra Haldeman, Clampitt (1975, p. 121).
Physa integra, Laman, Boss & Blankespoor (1984, pp. 20-25).

Shell: Medium in size, adults with 6 whorls measure up to 1.7 cm in length, ovate, imperforate, translucent to nearly opaque, glossy, horn to dark tannish or grayish horn, the first several whorls are darker. Most adult-sized shells have three to six (white) varices. The whorls are sculptured with fine spiral striae, nearly obsolete on some specimens and fine growth lines. The body whorl is well rounded, not shouldered. The sutures are moderately impressed. The aperture is oval or reversed D-shaped. The outer lip is sharp, nearly straight or

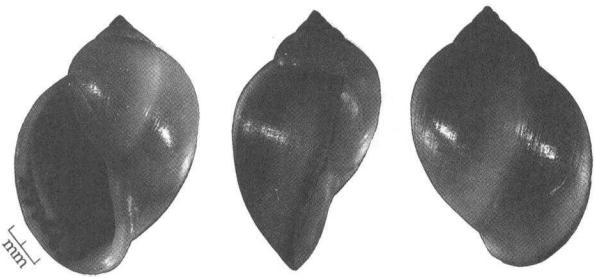


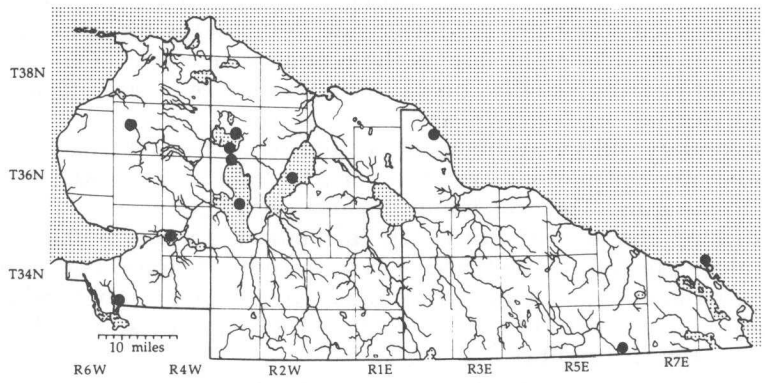
FIG. 56. Shell of *Physa (Costatella) crassa*.

slightly curved in side view. The columella is twisted. A thin parietal callus is present on the parietal wall.

Habitat: Marl, sand and stone substrata in medium to large inland oligotrophic lakes and perhaps their tributaries.

General Distribution: New York to Ohio, Michigan, Wisconsin and Minnesota.

Distribution in UMBS Area: **Cheboygan Co.:** Douglas Lake, UMMZ 5647; Douglas Lake, Mina L. Winslow and Crystal Thompson, 6 July 1926, UMMZ 36810; Burt Lake, UMMZ 36814; Carp Creek [Little Carp River], tributary to Burt Lake, Carl Hubbs and Greene, 7 July 1925, UMMZ 43191; Douglas Lake, Bryant Walker Collection, UMMZ 120993; Mullett Lake, Bryant Walker, Bryant Walker Collection, UMMZ 123557; Douglas Lake, Stanley T. Brooks, Bryant Walker Collection, UMMZ 124156; Grapevine Point cove, Douglas Lake, James W. Moffett, 29 June 1937, UMMZ 232370; Douglas Lake shore, E.M.G., 23 June 1955, UMBS Invertebrate Collection, UMMZ 246269; Grapevine Point, Douglas Lake, Harold W. Harry, 10 July 1949, UMMZ 246270; Sedge Point and Grapevine Point, Douglas Lake, John B. Burch and Harold J. Walter, UMMZ 246271; Sedge Point, Douglas Lake, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250425; Sedge Point, Douglas Lake, John B. Burch, July 1964, UMMZ 250668; Hook Point, North Fishtail Bay, Douglas Lake, John B. Burch and Younghun Jung, August 1986, UMMZ 253198; Hook Point, North Fishtail Bay, Douglas Lake, John B. Burch and Younghun Jung, August 1986, UMMZ 253204. **Emmet Co.:** Walloon Lake, UMMZ 41426; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 120924; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 143181; west shore Larks Lake, Section 17, Center Township, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170528; northeast Walloon Lake, Section 30, Bear Creek Township, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170727. **Presque Isle Co.:** Sunken Lake, UMMZ 36817; bayou of Lake Huron, 2 miles north of Presque Isle, UMMZ 55643; Lake Huron, Section 15, Bearinger Township, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170756.



MAP 31. Localities of *Physa (Costatella) crassa.*

Remarks: Traditionally, the small *Physa* species in Douglas Lake was called *Physa sayi crassa* Walker (*e.g.*, Cheatum, 1934; and invertebrate zoology classes until 1973). [The type locality of Walker's (1901, *Nautilus*, 14(9), p. 98) *crassa* is Higgins Lake, Roscommon County, Michigan.] Clampitt (1973a, 1973b, 1974, 1975) referred this

Douglas Lake physid to *Physa integra*, because characteristics of its terminal male genitalia placed it with that species group. While the *Costatella* subgenus is indeed the appropriate taxon, the Douglas Lake specimens are noticeably shorter-spired than typical *Physa integra*. Until the physid snails of our region are better studied, we believe it desirable to identify these *Costatella* lake forms with their own name. We were tempted to use the name *brevispira* Lea rather than *crassa* Walker, but, Lea's (1864, *Proc. Acad., Nat. Sci. Philad.*, 16, p. 115) specimen's were from the "Ottowa River, Canada West," and their relationship to Walker's Michigan lake form *crassa* has not been studied.

Family PLANORBIDAE

The Planorbidae in North America range in size from minute to relatively large (*i.e.*, from a bit over 1 mm in diameter for adult shells to over 30 mm), but with few exceptions their shells are all discoidal, *i.e.*, coiled in one plane. The animals are all sinistral, *i.e.*, coiled to the left or in a counter-clockwise manner and having respiratory, excretory and reproductive systems terminating on the left side. However, their shells do not always appear to be sinistral; those of many species seem to be dextral. This is because such shells tip to the left side in life and the type of apertural margin that develops in such cases is correspondingly slanted. In shells tipped to the left in such a fashion, the lower side (left side) is the spire side and the upper side (right side) is the umbilical side (Fig. 57). Such dextral-appearing shells on a sinistral animal are termed "pseudodextral" or "ultrasinistral."

A secondary gill (pseudobranch) is situated on the left side of the animal in most planorbids, near the pneumostome and in close proximity to the anus. The pseudobranch aids in respiration.

A striking characteristic of nearly all planorbid snails is that the respiratory pigment of the blood or hemolymph is hemoglobin. This gives a reddish appearance to the animal, if the color is not masked by melanin pigments of the skin. Albino snails, and those with little pigment, appear bright red.

During the early period of American malacology, all North American planorbid snails were placed in the all-inclusive genus *Planorbis*, the genus from which the family Planorbidae derives its name. With taxonomic progress in the Planorbidae, additional taxa between the genus and species were proposed, dividing the genus *Planorbis* into subgenera and sections. Subsequently, these subgenera were raised to generic status equal to *Planorbis*, and *Planorbis* is now used in a much more restricted sense, including only a few species

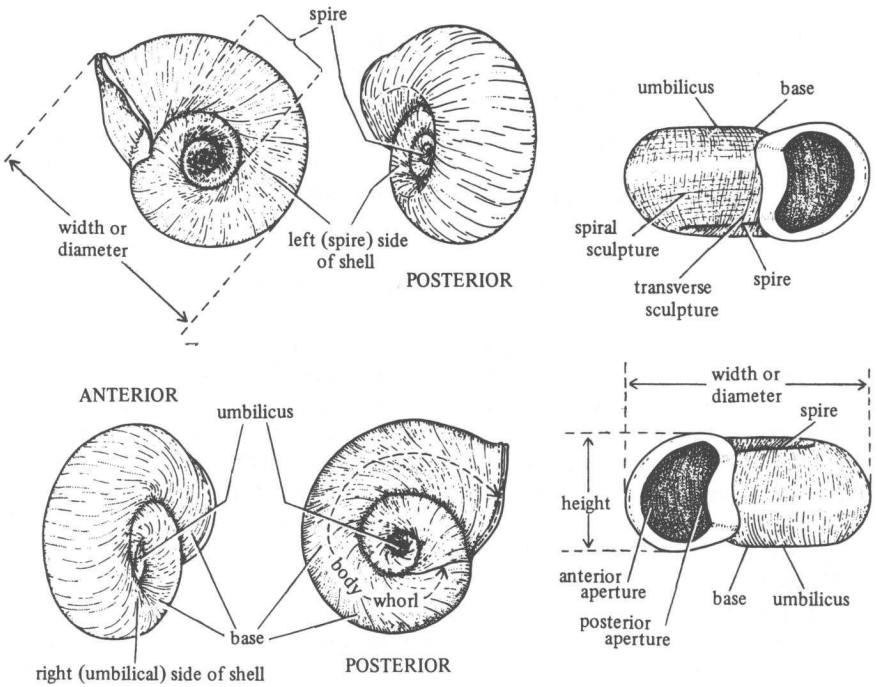


FIG. 57. Terminology of a planorbid shell.

found in Eurasia and Africa. The genera occurring in the UMBS area are *Gyraulus, Helisoma, Planorbella, Planorbula* and *Promenetus.*

The Planorbidae appear to be closely related to the Ancylidae, and some authors have combined the two as a single family.

Key to Genera in the UMBS Area

1 Shell small, that of adults less than 8 mm in diameter 2

Shell larger, that of adults more than 8 mm and up to or more than 30 mm in diameter 4

2(1) Shell higher, body whorl moderately high; inside aperture or body whorl with "teeth" or lamellae ..... *Planorbula* (p. 132)

Shell very compressed, body whorl relatively flattened; aperture or body whorl without "teeth" or lamellae 3

3(2) Shell with rounded or only weakly angular periphery; spire pit (on left side of shell) shallow and wide ..... *Gyraulus* (p. 106)

Shell with carinate periphery; spire pit (on left side of shell) relatively deep and narrow ..... *Promenetus* (p. 135)

4(1) Shell spire (left side) strongly inverted, with a deep conical depression; basal side of shell with an obtuse conical depression, but without a narrow, deep umbilicus ..... *Helisoma* (p. 120)

Shell spire (left side) not strongly inverted, with a shallow depression, no depression or everted (raised above body whorl); basal side of shell with a narrow, deep umbilicus ..... *Planorbella* (p. 123)

Genus *Gyraulus* 'Agassiz' Charpentier

Many of the planorbid subgenera of the early division of the old all-inclusive genus *Planorbis* have been raised one taxonomic level higher, and are now recognized as full genera. Such is the case for *Gyraulus*, which is no longer considered a subgenus, but as a full genus. Dall (1905) characterized *Gyraulus s.str.* as follows: "Shell small, flattish, with few, rapidly increasing whorls, fully exposed above and below, with a nearly median periphery, spirally striate and hispid; aperture simple, sharp-edged, oblique. Type: *Planorbis albus* Müller."

The genus *Gyraulus* has the widest distribution of any taxon in the Planorbidae, occurring on all continents except Antarctica. Its members have small (7.5 mm or less in major diameter), discoidal, umbilicate shells. Anatomically, they are characterized by a simple penial complex without flagellae or accessory preputial organs, but the penis has a chitinous tip (Fig. 108).

Key to Subgenera of *Gyraulus* in the UMBS Area

1 Shell costate ..... Subgenus *Armiger* (p. 109)

Shell not costate 2

2(1) Shell larger (adults with 3½ - 4½ whorls are 6.0 - 7.5 mm in major diameter), with higher whorls, often hirsute, with a narrow spire depression ..... Subgenus *Gyraulus s.str.* (p. 106)

Shell smaller (adults with 3½ - 4½ whorls are 3.5 - 6.0 mm in major diameter), with lower whorls, never hirsute, with a wide or narrow spire depression ..... Subgenus *Torquis* (p. 110)

Subgenus *Gyraulus s.str.*

The subgenus *Gyraulus s.str.* in North America (north of Mexico) contains only one species, *G. deflectus.* A hirsute form is often recog-

nized as a species, as *G. hirsutus*, but this is probably only a variant of the less hirsute *G. deflectus*.

Gyraulus deflectus (Say)

(Fig. 58; Map 32)

Planorbis deflectus Say 1824, Mollusca, in Keating's *Narr. Exped. Source of St. Peter's R.*, etc., vol. 2, appendix, p. 261, pl. 15, fig. 8.
Planorbis hirsutus Gould 1840, *Am. J. Sci.*, 38, p. 96.
Planorbis deflectus Say, Walker (1893, p. 137).
Planorbis deflectus Say, Walker (1911, p. 125).
Planorbis hirsutus Gld., Walker (1911, p. 125).
Planorbis deflectus Say, H.B. Baker (1914, pp. 18-45).
Planorbis hirsutus Gould, H.B. Baker (1914, pp. 18-45).
Planorbis hirsutus Gld., Winslow (1917, p. 9).
Planorbis deflectus Say, Winslow (1917, p. 9).
Planorbis deflectus Say, Winslow (1926, p. 15).
Planorbis hirsutus Gould, Winslow (1926, p. 15).
Gyraulus hirsutus (Gould), F.C. Baker (1928, p. 367, pl. 23, figs. 8-14).
Gyraulus deflectus (Say), F.C. Baker (1928, p. 370, pl. 23, figs. 15-21).
Gyraulus deflectus (Say), Goodrich (1932, p. 66).
Gyraulus hirsutus (Gould), Goodrich (1932, p. 66).
Gyraulus deflectus (Say), Goodrich (1939, p. 18).
Gyraulus hirsutus (Gould), Goodrich (1939, p. 18).
Gyraulus deflectus (Say), Burch & Tottenham (1980, pp. 194, 196, fig. 705).
Gyraulus deflectus (Say), Burch (1982a, pp. 57, 177, fig. 705).
Gyraulus deflectus (Say), Burch (1982b, p. 256, fig.).
Gyraulus deflectus (Say), Burch & Jung (1987, pp. 265, 266, fig. 48).
Gyraulus deflectus (Say), Burch (1988b, pp. 194, 196, fig. 705).
Gyraulus deflectus (Say), Burch (1991, p. 128).
Gyraulus hirsutus (Say), Burch (1991, p. 128).

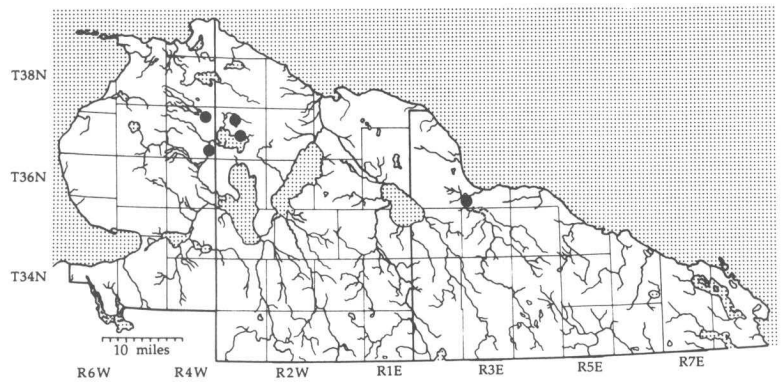
Shell: Small, adults with 4¼ to 4½ whorls measure 4.5 to 5.8 mm in major diameter, horn-colored, tinged with pale olive, translucent, and moderately glossy. The whorls increase rapidly in diameter, are rounded or angular, and are not shouldered. The last part of the body whorl is deflected toward the spire side (a characteristic by which the species got its name). The spire depression is wide, moderately depressed; the umbilical whorls are slightly to moderately depressed. The sculpturing consists of well developed growth lines, well developed or obsolete spiral striae, and often spiral periostracal ridges or hairs. The sutures are moderately impressed. The shell aperture is roundly oval in side view.

FIG. 58. Shell of *Gyraulus deflectus*.

Habitat: "Occurs in all kinds of permanent-water, eutrophic habitats. The usual substrate is mud. Commonly lives on vegetation but is occasionally found on the bottom" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 178).

General Distribution: Along the Atlantic Coast from Prince Edward Island south to Virginia, west to Ohio, Illinois, Alberta and Idaho (Miller, 1966); north to near the Arctic Coast in the Ungava, Coppermine River and Mackenzie River districts (Clarke, 1973, *Malacologia*, 13, p. 394).

Distribution in UMBS Area: **Cheboygan Co.:** pool near Burt Lake (ex 55638), UMMZ 250664; Lancaster Lake, Royal Bruce Brunson, 12 July 1945, UMMZ 253244; Sedge Point, beach pool between Douglas Lake and beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5b; Sedge Point, Douglas Lake, beach pond #2, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5d; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R3W, Munro Township, John B. Burch, 4 July 1985, UMBS-85-7. **Emmet Co.:** roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253214; A small tributary on the west side of the East Branch of the Maple River, southeastern corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 7 July 1985, UMBS-85-8b. **Presque Isle Co.:** Ocqueoc Lake at outdoor camp, near outlet of Ocqueoc River, southeastern part of Section 19, T36N, R3E, Ocqueoc Township, John B. Burch, 18 July 1985, UMBS-85-12a.



MAP 32. Localities of *Gyraulus deflectus*.

Remarks: *Gyraulus deflectus* (Say) and *G. hirsutus* (Gould) have been treated by malacologists both as separate species and as one species with *G. hirsutus* as a synonym. The question is whether hirsuteness is a specific character or an inter/intrapopulational conspecific character. Here we have lumped the two shell forms, nonhirsute and hirsute, under the oldest name, *G. deflectus*, but we realize that further study may show that the two are specifically distinct.

Subgenus *Armiger* Hartmann

The monotypic subgenus *Armiger* Hartmann was instituted to separate the very distinctively costate *Gyraulus crista* from the other small planorbid species that lack such costae on their shells. *Gyraulus crista* was first named as a species of *Nautilus,* then, together with the species name *nautileus,* it was assigned to the marine genus *Turbo. Armiger* frequently is raised to full generic rank. The latest comprehensive study of *Gyraulus crista* is that of Meier-Brook (1983).

Gyraulus (Armiger) crista (Linnaeus)

(Fig. 59; Map 33)

Nautilus crista Linnaeus 1758, *Syst. Nat.,* 10th ed., p. 709, no. 234.
Planorbis costatus De Tarr & Beecher 1878, author publ., p. 1.
Planorbis costatus DeTar and Beecher, Walker (1893, p. 137).
Planorbis crista L., Walker (1911, p. 125).
Planorbis crista (Linnaeus), H.B. Baker (1914, pp. 18-45).
Planorbis crista Linné, Winslow (1926, p. 15).
Gyraulus (Armiger) crista (Linn.), F.C. Baker (1928, p. 385, text fig. 164).
Gyraulus cristus (Linnaeus), Goodrich (1932, p. 65, fig.).
Gyraulus (Armiger) crista (Linnaeus), Burch & Tottenham (1980, pp. 194, 196, fig. 706).
Gyraulus (Armiger) crista (Linnaeus), Burch (1982a, pp. 57, 177, fig. 706).
Gyraulus (Armiger) crista (Linnaeus), Burch (1982b, p. 254, fig.).
Gyraulus crista (Linnaeus), Meier-Brook (1983, p. 42).
Gyraulus (Armiger) crista (Linnaeus), Burch (1989b, pp. 194, 196, fig. 706).
Gyraulus (Armiger) crista (Linnaeus), Burch (1991, p. 128).

Shell: Minute, adult shells with 3¼ to 3½ whorls measure less than 2 mm in major diameter, fragile, pale horn to darker horn in color, moderately glossy, sculptured with well developed growth

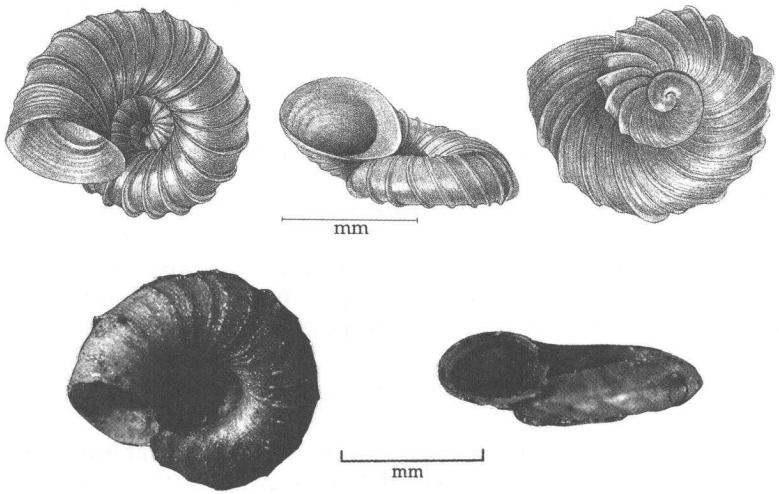


FIG. 59. Shells of *Gyraulus (Armiger) crista.*

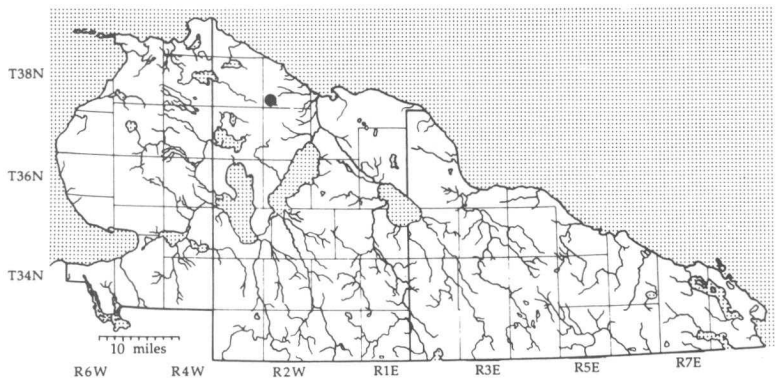
lines and spiral striae, and by many transverse periostracal ribs on transverse shell ridges. The nuclear whorls are sculptured with impressed spiral striae. The whorls are shouldered, increasing rapidly in diameter. The spire depression is one third or less the major shell diameter, and is relatively deep.

Animal: Weakly pigmented, the head-foot light gray and the mantle with a light and diffuse melanin pigmentation (Meier-Brook, 1983).

Habitat: Found on fallen logs and decaying leaves and other vegetation in quiet eutrophic waters – ponds, swamps, perennial drainage ditches, impoundments of rivers, etc.

General Distribution: Holarctic. In North America from Ontario and Maine to Minnesota, northwestern Northwest Territories and Alaska (Clarke, 1973, *Malacologia*, 13, p. 407).

Distribution in UMBS Area: **Cheboygan Co.:** Roadside drainage ditch, along highway C-66 (Cheboygan Road), 0.5 mile northeast of highway I-75, Section 36, T38N, R3W, Hebron Township, Younghun Jung and John B. Burch, August 1988.



MAP 33. Locality of *Gyraulus (Armiger) crista.*

Remarks: This is the smallest freshwater snail in North America, and because of its small size is undoubtedly overlooked by collectors. It has been known for a long time in Michigan, first having been named as a new species *(Planorbis costatus)* from Ann Arbor by De Tar and Beecher in 1878 in a privately printed one page leaflet.

Subgenus *Torquis* Dall

The name *Torquis* was introduced to the nomenclatural literature by Dall (1905) as a section of the subgenus *Gyraulus* of the nearly all-inclusive genus *Planorbis*. In subdividing *Gyraulus*, he characterized

his new subtaxon as "Section *Torquis* Dall, *nov. sect.* Like *Gyraulus s. str.* but with more rounded, less rapidly increasing whorls, not hispid or spirally striate, the aperture expanded and slightly thickened in the adult. Type *P. parvus* Say."

Many of the planorbid subgenera of Dall's day have since been raised one taxonomic level higher, and are now recognized as full genera. Such is the case for *Gyraulus*, which is no longer considered a subgenus, but as a full genus, and its former section *Torquis* has been raised accordingly to the subgeneric level.

Key to Species of *Torquis* in the UMBS Area

1 Shell with a wide spire depression, horn colored; found in quiet lakes, ponds, pools, ditches, etc. 2

Shell mahogany red or russet in color, with a narrow spire depression; found on exposed shores of northern lakes Huron and Michigan ..... *G. (T.) huronensis* (p. 114)

2(1) Shell more tightly coiled, whorls increasing more slowly in size, body whorl narrower; found in temporary woods pools, intermittent streams and transient seepage areas ..... *G. (T.) circumstriatus* (p. 111)

Shell less tightly coiled, whorls increasing more rapidly in size, body whorl wider; found in small lakes, ponds, swales, etc., more or less perennial ..... *G. (T.) parvus* (p. 117)

Gyraulus (*Torquis*) *circumstriatus* (Tryon)

(Figs. 60, 104, 106, 107; Map 34)

Planorbis (*Gyraulus*) *circumstriatus* Tryon 1866, *Am. J. Conchol.*, 2(2), p. 113, pl. 10, figs. 6-8.
Planorbis circumstriatus Tryon, Winslow (1926, p. 14).
Gyraulus (Torquis) circumstriatus (Tryon), F.C. Baker (1928, p. 378, text fig. 162).
Gyraulus (Torquis) circumstriatus walkeri (Vanatta), F.C. Baker (1928, p. 379, text fig. 162; pl. 23, figs. 32, 33).
Gyraulus parvus variety *circumstriatus* Tryon, Goodrich (1932, p. 65).
Gyraulus (*Torquis*) *circumstriatus* (Tryon), Burch & Tottenham (1980, pp. 194, 196, fig. 707).
Gyraulus (*Torquis*) *circumstriatus* (Tryon), Burch (1982a, pp. 57, 177, fig. 707).
Gyraulus (*Torquis*) *circumstriatus* (Tryon), Burch (1982b, p. 256, fig.).
Gyraulus (*Torquis*) *circumstriatus* (Tryon), Burch (1989b, pp. 194, 196, fig. 707).
Gyraulus (*Torquis*) *circumstriatus* (Tryon), Burch (1991, p. 128).

Shell: Small, adults usually about 4 mm or less in major diameter (although some old individuals reach almost 7 mm in diameter), medium horn in color, spire depression relatively wide, and may be relatively deep, sculptured with fine but distinct growth striae and a few spiral striae, sometimes raised, sometimes impressed (the num-

ber varies from specimen to specimen). The last whorl on the spire side may have low spiral malleated ridges.

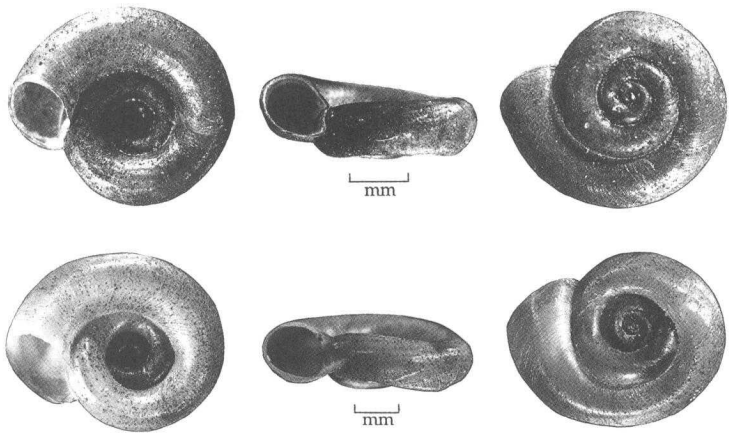


FIG. 60. Shells of *Gyraulus (Torquis) circumstriatus*. The bottom shell is somewhat deformed; such specimens are frequently found in some populations of *G. (T.) circumstriatus*.

Animal: The headfoot of *Gyraulus circumstriatus* is pale to medium gray. The pigmentation on the sides of the foot is lighter preceding ventrally. The sole of the foot is nearly devoid of pigment. The mantle collar and lower mantle are also almost without pigment, except for that associated with the area of the kidney. The upper mantle lacks pigment. The longitudinal central core of the tentacles is very black; the outer surrounding area is without pigment.

Other than pigmentation, external aspects of the animals of *Gyraulus circumstriatus* are like those of *G. huronensis*, described in detail on pp. 115-116.

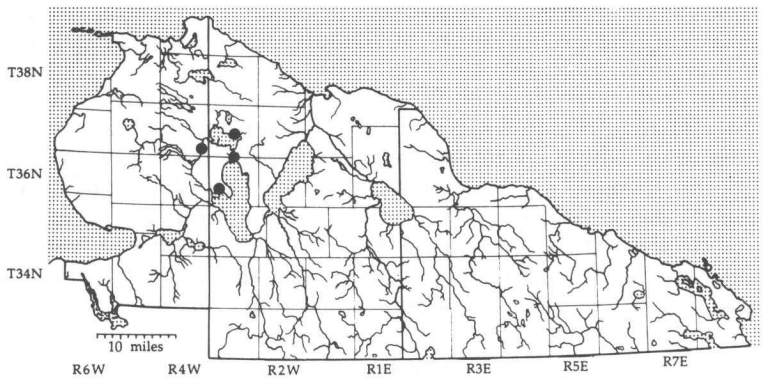
For aspects of internal anatomy, see p. 166 ff., Figs. 104, 106, 107.

Habitat: *Gyraulus circumstriatus* is found in ephemeral habitats – temporary woods pools, intermittent streams, transient seepage areas. See also "Remarks" below.

General Distribution: Connecticut north to Quebec, west to Alberta and south in the Rocky Mountains to New Mexico (Clarke, 1973, *Malacologia*, 13, p. 398).

Distribution in UMBS Area: Cheboygan Co.: Reese's Swamp, north end of Burt Lake, Harold W. Harry, UMMZ 178425; Douglas Lake, UMMZ 181006; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 30 June 1986, UMMZ 250585; woods pool next to shore of Burt Lake, Younghun Jung and John B. Burch, 30 July 1986, UMMZ 250595; woods pool next to shore of Burt Lake, Maple Bay park and public access, Younghun Jung and John B. Burch, July 1985, UMMZ 253223; woods pool next to shore of Burt Lake, Maple Bay park and public access, Younghun Jung and John B.

Burch, July 1986, UMMZ 253224. **Emmet Co.:** A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, Younghun Jung and John B. Burch, 20 August 1985, UMMZ 250576; A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, Younghun Jung and John B. Burch, 30 June 1986, UMMZ 250577; A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, Younghun Jung and John B. Burch, 1 July 1986, UMMZ 250578; A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, Younghun Jung and John B. Burch, 7 July 1986, UMMZ 250579; A tributary on the west side of the East Branch of the Maple River, southeast corner of Section 25, T37N, R4W, McKinley Township, Younghun Jung and John B. Burch, 30 July 1986, UMMZ 250580.



MAP 34. Localities of *Gyraulus (Torquis) circumstriatus.*

Remarks: The two species, *Gyraulus circumstriatus* and *G. parvus*, are very similar in shell characteristics. The shells of both species are small and planorbiform in shape. On the average, the shell of *G. circumstriatus* is slightly larger than that of *G. parvus*. In shells of the same diameter, *G. circumstriatus* has more whorls than *G. parvus* and is more tightly coiled. The whorls in *G. parvus* increase more rapidly in diameter than those of *G. circumstriatus*. This is especially noticeable in comparing the last whorls of the two species. The adjoining surface of the whorl with the preceding whorl is wider in *G. parvus* than in *G. circumstriatus*. These two species have a flat umbilicus and shallow, wide spire. The shape of the outer aperture is a rounded-ovate in *G. parvus* and elongated-ovate in *G. circumstriatus* when the shell is viewed from the umbilical side. However, when the shell is seen in apertural (side) view, the shape of the inner and outer aperture is more rounded-ovate in *G. circumstriatus* than in *G. parvus* because *G. parvus* is deflected to the umbilical side. The average of the body whorl height in *G. parvus* is greater than in *G. circumstriatus* when measured in side view. The color of *G. cir-*

cumstriatus is brown to very dark brown, which may be the result of its eutrophic habitat. The shell of *Gyraulus parvus* has a fresh yellowish-brown color, which may be the result of living in clean, circulating water.

A noticeable characteristic of the shells in almost any population of *Gyraulus circumstriatus* is the irregularity in the direction of growth of the last one or more whorls. Such irregularly formed shells are not found in the other two *Torquis* species.

There are no remarkable differences in the body pigmentation between *Gyraulus parvus* and *G. circumstriatus,* although there are sometimes some noticeable differences between individuals. In general, however, the pigmentation of *Gyraulus circumstriatus* is a little darker than in *G. parvus.*

Gyraulus circumstriatus and *G. parvus* do not occur together, *i.e.,* their habitat requirements are different enough to prevent that. In the one locality where we found the two species at the same place, at Hook Point, Douglas Lake, each species lives in a different habitat. *Gyraulus parvus* is restricted to submerged vegetation in the lagoon, while *G. circumstriatus* is restricted to several centimeters of water in a seepage area at the black muddy shoreline. Here *G. circumstriatus* is found on decaying leaves from the surrounding forest.

Gyraulus (Torquis) huronensis Burch & Jung

(Figs. 61, 105; Map 35)

Gyraulus (*Torquis*) *huronensis* Burch & Jung 1989, *Walkerana,* 3(10), p. 217, figs. 1-5.
Gyraulus (*Torquis*) *huronensis* Burch & Jung, Jung & Burch (1990, 3(10), pp. 59-77, figs. 3, 6, 7c, 10c, 14b, 15a).
Gyraulus (*Torquis*) *huronensis* Burch & Jung, Burch (1991, p. 128).

Shell: Small, the major diameter of the shell of large specimens with four whorls reaches 5 mm, discoidal, with relatively narrow and deep inverted spire and a somewhat dome-shaped umbilical side (the topographically right side, but actually the dorsal side in reference to the way the crawling snail carries its shell). The shell is solid, thick, only slightly translucent, Mahogany Red or Hay's Russet[11] in color and has a relatively narrow and deeply inverted spire (on topographically the left side, but actually the "base" or ventral side in reference to the active shell). The last one-fifth of the body whorl is deflected toward the spire side of the shell. The shell is sculptured with fine but distinct growth striae. On some specimens, the transverse striae of the first part of the body whorl, the penultimate whorl and earlier whorls, have some individual

[11]Ridgeway's color standards (see footnote, p. 23).

coarser, more widely spaced striae, appearing almost like low riblets. There are faint raised spiral striae on the spire side of the shell; they are scattered and rather indistinct. The nuclear whorls, on both the spire and umbilical sides, have evenly spaced, raised spiral striae.

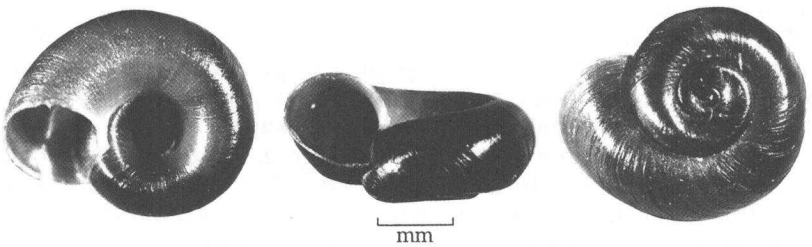


FIG. 61. Shell of *Gyraulus (Torquis) huronensis.*

Animal: In frontal view, the visible head-foot in an active snail is wedge-shaped, tapering inwardly up from the sole. In side view, the head has a blunt, rounded anterior end. On its ventral side, the velum is separated from the head and anterior foot by a deep groove or invagination. The foot, when compared to the size of the shell, is noticeably short. Posteriorly, in side view, the foot tapers distally and ventrally to a terminal point. In dorsal view, this terminus is bluntly rounded.

The surface of the sole of the foot appears homogeneous when the snail is active, having no longitudinal or transverse furrows or any areas of apparent different structure or texture. The sides of the foot and the head (sides and front) are black. On the front of the head is a median longitudinal stripe with less pigment. The sole is uniformly dark-gray in color, except for the edges, where a narrow band surrounding the sole lacks pigment. The translucent surface layer of the sole itself does not appear to have melanin granules. The sole of the foot in outline when the snail is crawling is a modified oval, tapering behind and truncated in front. However, this outline is rather flexible, changing with the different motions and activities in which the snail is engaged.

The ventral surface of the velum, just anterior to the anterior part of the foot, appears as a broad isosceles triangle, creased medially by the mouth. The mouth, when the snail is not feeding, appears as a longitudinal ventral slit (sometimes Y- or T-shaped), dividing the triangular velum into two equal smaller isosceles triangles. When the snail is feeding, the sides of the longitudinal slit expand laterally, making a fusiform opening of varying widths.

The mantle, which covers the viscera externally under the shell, is heavily pigmented with melanin pigment.

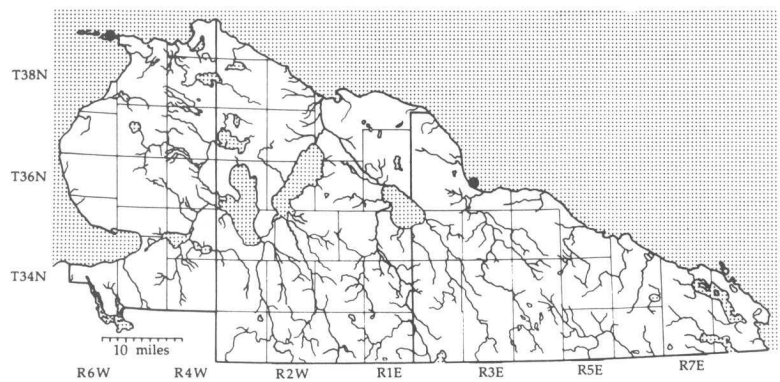
The mantle collar usually rests at the rim of the shell aperture in an active snail, but it may also extend slightly past the aperture, especially on the spire side. The collar is rounded in contour, and encircles the body stalk. The central core of the mantle collar has black melanin pigment.

The siphon (also called mantle lobe), located on the left side of the animal just anterior to the anal papilla (Fig. 105), hangs ventrally between the snail's body and the overhanging mantle. It is a thin flap-like structure, capable of considerable extension.

The tentacles in active snails are elongate, relatively thin structures located on the anterior dorsal head. They are capable of considerable extension and contraction. They taper gradually distally and end as bluntly rounded truncations. The base of each tentacle, where it joins the snail's body, is broad and tapers more rapidly than does the remainder of the tentacle. The central core of the tentacle is blackly pigmented. The eye, also blackly pigmented, is located at the anterior base of the tentacle, in the area of the tentacle's maximum expansion. The male genital pore is located at the posterior end of the base of the left tentacle.

The anterior end of the head, the "snout" or "face," is roundly and bluntly truncated.

Immediately behind the mantle collar is a short cavity that terminates at a transverse septum that forms the anterior wall of the lung. The septum contains the pneumostome, nephridiopore, anal papilla and the siphon.



MAP 35. Localities of *Gyraulus (Torquis) huronensis.*

Habitat: On stones and boulders in shallow water on the wave-swept shores of northern lakes Huron and Michigan.

General Distribution: Known only from the Michigan shores of upper lakes Huron and Michigan.

Distribution in UMBS Area: Emmet Co.: Lake Michigan, Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, July 1988; **Presque Isle Co.:** Lake Huron, north of Hammond Bay, T37N, R2E, Sec. 14, Presque Isle Co., 18 Nov. 1988, Burch & Jung, UMMZ 250571; Lake Huron, north of Hammond Bay, T36N, R2E, Sec. 14, Presque Isle Co., 18 Nov. 1988, Burch & Jung, UMMZ 250572.

Remarks: Compared to the other species of the *Torquis* group, *Gyraulus huronensis* has a smaller, reddish-brown shell, with a smaller and deeper umbilicus and a noticeably deflected last whorl. Its habitat, on the wave-swept shores of lakes Huron and Michigan, is very different from the habitats of the other two *Torquis* species.

Gyraulus (Torquis) parvus (Say)

(Fig. 62; Map 36)

Planorbis parvus Say 1817, Conchol., in Nicholson, 1816-1817, *Am. Ed. Brit. Encyclop., Dict. Arts. Science*, etc., vol. 2, pt. 2, 6th p., pl. 1, fig. 5.
Planorbis parvus Say, Walker (1893, p. 137).
Planorbis parvus Say, Walker (1911, p. 125).
Planorbis parvus walkeri Van., Walker (1911, p. 125).
Planorbis parvus Say, H.B. Baker (1914, pp. 18-45).
Planorbis parvus walkeri Vanatta, H.B. Baker (1914, pp. 18-45).
Planorbis parvus Say, Winslow (1917, p. 9).
Planorbis parvus Say, Winslow (1926, p. 15).
Planorbis parvus walkeri Vanatta, Winslow (1926, p. 15).
Gyraulus (Torquis) parvus (Say), F.C. Baker (1928, p. 374, pl. 23, figs. 27-31, 39).
Planorbis parvus Say, Eggleton (1931, p. 257).
Gyraulus parvus (Say), Goodrich (1932, p. 65, fig.).
Gyraulus walkeri Vanatta, Goodrich (1932, p. 65).
Gyraulus parvus (Say), Goodrich (1939, p. 18).
Gyraulus parvus, Eggleton (1952, p. 217).
Gyraulus (Torquis) parvus (Say), Burch & Tottenham (1980, pp. 194, 196, fig. 709).
Gyraulus (Torquis) parvus (Say), Burch (1982a, pp. 57, 177 fig. 709).
Gyraulus (Torquis) parvus (Say), Burch (1982b, p. 256, fig.).
Gyraulus (Torquis) parvus (Say), Burch & Jung (1987, pp. 266, 267, fig. 49).
Gyraulus (Torquis) parvus (Say), Burch (1989b, pp. 194, 196, fig. 709).
Gyraulus (Torquis) parvus (Say), Burch (1991, p. 128).

Shell: Small, adults with about 3½+ whorls measure up to about 5 mm in major diameter, pale horn (the shells of younger specimens may be dark horn in color), spire depression wide and shallow, sutures deeply impressed; whorls sculptured with fine but distinct growth striae and a few spiral striae. The nuclear whorl is sculptured with fine transverse and spiral striae. The last whorl is rather rapidly enlarging, very little deflected, and in side view rounded, or occasionally flattened.

Animal: The headfoot of *Gyraulus parvus* is pale gray. The pigmentation on the sides of the foot is less dense (and hence lighter)

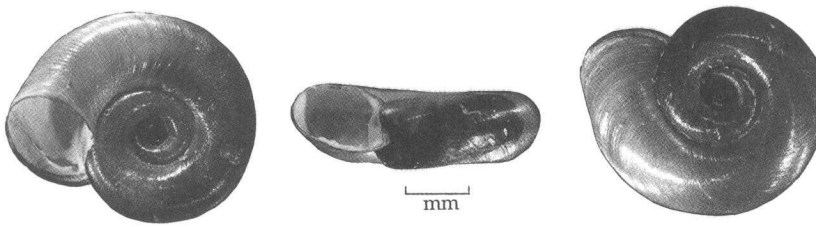
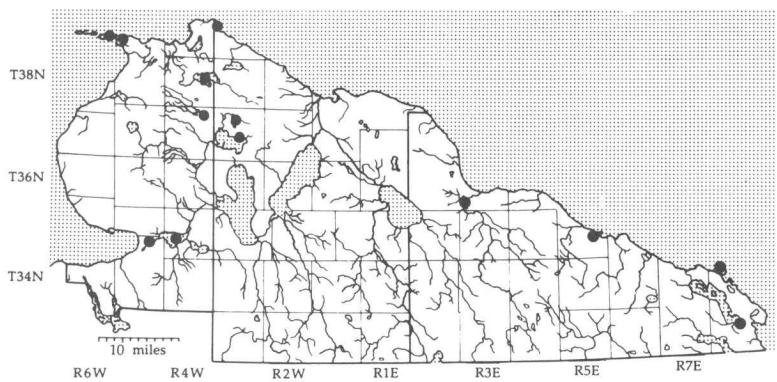


FIG. 62. Shell of *Gyraulus (Torquis) parvus.*

proceeding ventrally. The sole of the foot is almost without pigment. The mantle collar and lower mantle are also almost devoid of pigment, except that associated with the area of the kidney. The upper mantle (covering the digestive gland and ovotestis) lacks pigment. The longitudinal central core of the tentacles is very black; the outer surrounding area has no pigment.

Other than pigmentation, external aspects of the animal of *Gyraulus parvus* are like that of *G. huronensis,* described in detail on pp. 115-116.

Habitat: *Gyraulus parvus* is found in quiet habitats — in small lakes, ponds, swales and road-side ditches (often but not always in perennial waters). "Habitats variously have mud, sandy mud, sand, gravel and boulder bottoms. Partial to habitats that have rather thick vegetation" (F.C. Baker, 1928). Dredged in deep water in Lake Michigan (Walker, 1895) and "in Lake Superior at a depth of 8-13 fathoms (Baker)" (Walker & Ruthven, 1906).



MAP 36. Localities of *Gyraulus (Torquis) parvus.*

General Distribution: North America, from Alaska and northern Canada to Cuba and from the Atlantic to the Pacific Coast (Taylor, 1960).

Distribution in UMBS Area: **Cheboygan Co.:** Sedge Point, Douglas Lake, UMMZ 46283; North Fishtail Bay, Douglas Lake, UMMZ 46284; drift of Lake Michigan, 10 miles southwest of Mackinaw, UMMZ 63845; Lancaster Lake, James W. Moffett, 17 July 1937, UMMZ 232327; Mackinaw City, 16 June 1938, Phil L. Marsh Collection, UMMZ 237281; Lancaster Lake, T37N, R3W, Section 8, Munro Township, Younghun Jung and John B. Burch, 4 July 1985, UMMZ 250573; Lancaster Lake, T37N, R3W, Section 8, Munro Township, Younghun Jung and John B. Burch, 30 July 1985, UMMZ 250574; Lancaster Lake, T37N, R3W, Section 8, Munro Township, Younghun Jung and John B. Burch, 20 August 1985, UMMZ 250575; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 15 July 1985, UMMZ 250582; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 17 July 1985, UMMZ 250583; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 30 July 1985, UMMZ 250584; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 30 June 1986, UMMZ 250586; Roadside drainage ditch, along highway C-66 (Cheboygan Road), 0.5 mile northeast of highway I-75, Section 36, T38N, R3W, Hebron Township, Younghun Jung and John B. Burch, 25 June 1985, UMMZ 250587; Roadside drainage ditch, along highway C-66 (Cheboygan Road), 0.5 mile northeast of highway I-75, Section 36, T38N, R3W, Hebron Township, Younghun Jung and John B. Burch, 19 July 1985, UMMZ 250588; Roadside drainage ditch, along highway C-66 (Cheboygan Road), 0.5 mile northeast of highway I-75, Section 36, T38N, R3W, Hebron Township, Younghun Jung and John B. Burch, 30 July 1985, UMMZ 250589; Roadside drainage ditch, along highway C-66 (Cheboygan Road), 0.5 mile northeast of highway I-75, Section 36, T38N, R3W, Hebron Township, Younghun Jung and John B. Burch, 20 August 1985, UMMZ 250590; Roadside drainage ditch, along highway C-66 (Cheboygan Road), 0.5 mile northeast of highway I-75, Section 36, T38N, R3W, Hebron Township, Younghun Jung and John B. Burch, 9 July 1986, UMMZ 250591; Sedge Point, beach pool between Douglas Lake and beach pond 1, southwestern corner of Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 1 July 1985, UMMZ 250592; Sedge Point, beach pool between Douglas Lake and beach pond 1, southwestern corner of Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 15 July 1986, UMMZ 250593; Sedge Point, beach pool between Douglas Lake and beach pond 1, southwestern corner of Section 22, T37N, R3W, Munro Township, Younghun Jung and John B. Burch, 20 August 1985, UMMZ 250594. **Emmet Co.:** Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 88839; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 88863; Carp Lake [Lake Paradise], Bryant Walker, Bryant Walker Collection, UMMZ 88864; Round Lake, Kent Science Institute Collection, UMMZ 143413; Goose Pond, Wilderness Park, Harold W. Harry and H. van der Schalie, 16 September 1949, UMMZ 170457; roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253215; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253218; roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253219; drift beside boat ramp at western end of park road, near shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, July 1986, UMMZ 253220; Sedge Point beach pool, Douglas Lake, John B. Burch and Younghun Jung, July 1986, UMMZ 253221; Hook Point lagoon, North Fishtail Bay, Douglas Lake, John B. Burch and Younghun Jung, 20 August 1985, UMMZ 253222. **Presque Isle Co.:** Lake Huron, Presque Isle Point, UMMZ 57776; Lake Huron, north edge Rogers City, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170571; south end of Grand Lake along highway US 23, Harold W. Harry and H. van der Schalie, 11 September 1948, UMMZ 171648; Ocqueoc Lake, outdoor camp, T36N, R3E, Section 19, Younghun Jung and John B. Burch, 18 July 1985, UMMZ 250581.

Remarks: The basal side of the whorls is generally more flattened on *Gyraulus parvus* than on either *G. circumstriatus* or *G. huronensis*.

For comparisons of shells and habitats of *G. parvus* with the morphologically very similar *G. circumstriatus*, see "Remarks" under the latter species (pp. 112-113).

Genus *Helisoma* Swainson

The genus *Helisoma* comprises two subgroups, the widely distributed *Helisoma s.str.* and the western subgenus *Carinifex*. *Helisoma s. str.* contains *H. anceps*, which is distributed throughout most of North America, exhibiting many variations in shell characteristics across this wide geographic range. *Helisoma anceps* also has several well-defined varieties, or subspecies (none of which occur in the UMBS area).

The shell is of moderate size for a planorbid, and is generally bicarinate with a conically inverted spire (and base as well in *Helisoma s.str.*) and few rapidly enlarging whorls. The body whorl ends in a flared, thickened aperture.

Helisoma anceps (Menke)

(Figs. 63, 64; Map 37)

Planorbis bicarinatus Say 1817, Conchol., in Nicholson, 1816-1817, *Am. Ed. Brit. Encyclop., Dict. Arts. Science*, etc., 1st ed., vol. 2, pt. 2, 4th and 5th pp., pl. 1, fig. 4.
Helix angulata Rackett 1821, *Trans. Linn. Soc. London*, 13(1), pp. 42, 43, pl. 5, fig. 1.
Planorbis anceps Menke 1830, *Synopsis Method. Moll.*, p. 36.
Planorbis antrosus Conrad 1834, *Am. J. Sci. and Arts*, 25, p. 343.
Planorbis bicarinatus Say, Walker (1893, p. 136).
Planorbis bicarinatus major Walker 1893, *Nautilus*, 6(12), p. 136.
Planorbis bicarinatus var. *percarinatus* Walker 1909, *Nautilus*, 23(1), p. 6, pl. 1, fig. 12.
Planorbis bicarinatus var. *aroostookensis* Pilsbry, Walker (1909, p. 7, pl. 1, figs. 1, 2).
Planorbis bicarinatus var. *striatus* Baker, Walker (1909, p. 7).
Planorbis bicarinatus var. *portagensis* Baker, Walker (1909, p. 8).
Planorbis bicarinatus Say, Walker (1911, p. 125).
Planorbis bicarinatus aroostookensis Pils., Walker (1911, p. 125).
Planorbis bicarinatus corrugatus Curr., Walker (1911, p. 125).
Planorbis bicarinatus percarinatus Walker, Walker (1911, p. 125).
Planorbis bicarinatus portagensis Baker, Walker (1911, p. 125).
Planorbis bicarinatus striatus Baker, Walker (1911, p. 125).
Planorbis bicarinatus (Say), H.B. Baker (1912, pp. 210-211).
Planorbis bicarinatus approaching var. *aroostookensis* Pilsbry, H.B. Baker (1912, p. 210).
Planorbis bicarinatus portagensis Baker, H.B. Baker (1912, pp. 210-211).
Planorbis bicarinatus percarinatus Walker, H.B. Baker (1912, p. 210).
Planorbis bicarinatus percarinata Walker, H.B. Baker (1914, pp. 18-45).
Planorbis bicarinatus portagensis F.C. Baker, H.B. Baker (1914, pp. 18-45).
Planorbis antrosus (Con.), Winslow (1917, p. 9).
Planorbis antrosus striatus Baker, Winslow (1917, p. 9).
Planorbis antrosus Conrad, Winslow (1926, p. 13).
Planorbis antrosus aroostookensis (Pilsbry), Winslow (1926, p. 13).
Planorbis antrosus corrugatus "Currier" Walker, Winslow (1926, p. 13).
Planorbis antrosus percarinatus (Walker), Winslow (1926, p. 13).
Planorbis antrosus portagensis (Baker), Winslow (1926, p. 14).
Planorbis antrosus striatus Baker, Winslow (1926, p. 14).
Helisoma antrosum (Conrad), F.C. Baker (1928, p. 317, pl. 19, figs. 8-15).

Helisoma antrosum unicarinatus (Haldeman), F.C. Baker (1928, p. 321, pl. 19, figs. 17-19).
Helisoma antrosum percarinata (Walker), F.C. Baker (1928, p. 324, pl. 19, figs. 24-27).
Helisoma antrosum striata (F.C. Baker), F.C. Baker (1928, p. 328, pl. 19, figs. 28-31).
Helisoma antrosum (Conrad), Goodrich (1932, p. 62, fig.).
Helisoma antrosum percarinatum (Walker), Cheatum (1934, p. 348).
Helisoma antrosum (Conrad), Goodrich (1939, p. 15).
Helisoma anceps (Menke), Pilsbry (1950, *Nautilus*, 64(2), p. 68, pl. 4, fig. 44).
Helisoma antrosa percarinata, Eggleton (1952, p. 217).
Helisoma antrosa percarinata (Walker), Clampitt (1973, pp. 379-399).
Helisoma anceps anceps (Menke), Burch & Tottenham (1980, pp. 197, 198, fig. 714).
Helisoma anceps anceps (Menke), Burch (1982a, pp. 58, 178, fig. 714).
Helisoma anceps anceps (Menke), Burch (1982b, p. 258, fig.).
Helisoma anceps, Laman, Boss & Blankespoor (1984, pp. 20-25).
Helisoma anceps anceps (Menke), Burch & Jung (1987, p. 268, fig. 51).
Helisoma anceps anceps (Menke), Burch (1989b, pp. 197, 198, fig. 714).
Helisoma anceps anceps (Menke), Burch (1991, p. 128).

Shell: Adult shells vary greatly in size, from about 8 mm to 16 mm in greatest diameter. The inverted spire is conical, deep and rather narrow. The umbilical side is also shaped like an inverted cone, but it is more obtuse. The lip of adult shells is thickened and flared. The sculpture consists of well-defined growth lines and fine spiral striae. Shell color is tannish-horn, horn or white. The shell coloration seems to depend on the type of habitat in which the snails live.

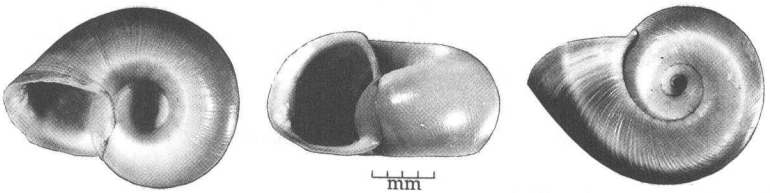


FIG. 63. Shell of *Helisoma anceps.*

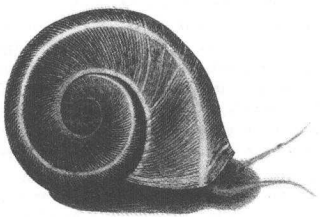


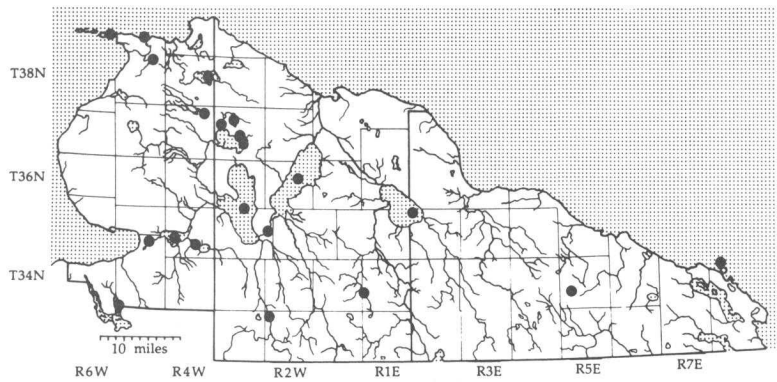
FIG. 64. Shell and animal of *Helisoma anceps* (from Haldeman, 1844, *Monogr. freshw. univalve Moll. U.S.*, (7), pl. 1, fig. 1).

Animal: Foot rather wide and rounded in front and back; tentacles rather long and filiform, as long as or longer than the foot; head rounded and not as auriculated as that of *Planorbella trivolvis;*

pseudobranch large; color blackish, flecked with tiny white dots on the foot, tentacles and pseudobranch. (F.C. Baker, 1928).

Habitat: Among vegetation and on various substrates in lakes, ponds, rivers and streams; absent from temporary-water habitats (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 198).

General Distribution: Throughout North America and James and Hudson bays south to Georgia, Alabama, Texas and north-western Mexico, west to Northwest Territories, Alberta and Oregon (see Walker, 1909b; Clarke, 1973, *Malacologia*, 13, p. 430).



MAP 37. Localities of *Helisoma anceps*.

Distribution in UMBS Area: **Cheboygan Co.:** Burt Lake, Frederick Stearns Collection, UMMZ 28131; Douglas Lake, UMMZ 36618; Marl Bay and mouth of Beach Creek, Douglas Lake, UMMZ 36621; Mullett Lake, UMMZ 36737; Milligen Creek, west of Tower, UMMZ 36740; Wolverine Hatchery, Sturgeon River, UMMZ 37539; Milligen Creek, Walker Township, UMMZ 37540; Burt Lake, UMMZ 37546; Cheline Creek, UMMZ 39650; Burt Lake, UMMZ 39706; Carp Lake [Lake Paradise] inlet, UMMZ 43434; drift of Lake Michigan, 10 miles southwest [?] of Mackinaw, UMMZ 63846; Mullett Lake, Bryant Walker, Bryant Walker Collection, UMMZ 82277; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 82510; Sedge Point, Douglas Lake, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250448; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, Munro Township, John B. Burch, 4 July 1985, UMMZ 250451; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250454; roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253213; Sedge Point, Douglas Lake, beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5c; Pine Point, Douglas Lake, Section 22, T37N, R3W, Munro Township, John B. Burch and Younghun Jung, 22 July 1988, UMBS-88-16a. **Emmet Co.:** Walloon Lake, H.B. Baker, UMMZ 28106; Crooked Lake, UMMZ 30211; Crooked Lake, UMMZ 37520; Lake Michigan, Big Stone Bay, UMMZ 43460; Round Lake, M.L. Leach, Bryant Walker Collection, UMMZ 82282; Carp Lake [Lake Paradise], Bryant Walker, Bryant Walker Collection, UMMZ 82303; Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 82304; Bear [Walloon] Lake, Petoskey, Kent Science Institute Collection, Bryant Walker Collection, UMMZ 82313; Crooked Lake, Conway, Bryant Walker, Bryant Walker Collection, UMMZ 82486; Pickerel Lake, near Petoskey, Calvin Goodrich, Bryant Walker Collection, UMMZ 82521; Bear [Walloon] Lake, Kent Science

Institute Collection, UMMZ 143332; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 143352; O'Neal Lake, UMMZ 198374; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253183. **Presque Isle Co.:** pond 1/2 mile east of Hawks, UMMZ 55631; Lake Huron, Presque Isle Point, UMMZ 57777; Black Lake, M.L. Leach, Bryant Walker Collection, UMMZ 82489.

Remarks: The shells of many populations, especially those in the UMBS area, are bicarinate. This characteristic led Say (1817, see ref. in synonymy above) to name the species *"Planorbis" bicarinatus* (a name preoccupied by an older *"Planorbis bicarinatus"* for a different species). Rackett (1821, *Trans. Linn. Soc. Lond.*, 13(1), p. 42) named the species *"Helix" angulata*, but that name is preoccupied also, leaving the bicarinate (or angulate-whorled) species with Menke's (1830) name *anceps* (which means two-sided or two-headed, referring no doubt to the carinae on both sides of the shell).

Although the last whorl of *Helisoma anceps* terminates with a thickened and flared aperture, the nature of the flare differs from that of *Planorbella s.str.* species *(P. campanulata* and *P. smithi).* The shell of *H. anceps* can be further distinguished from the latter two species by its deep, conical spire and base depressions, and by the lack of an umbilicus.

The shells of *Helisoma anceps* exhibit some morphological variation over the wide range of the species, which has resulted in various varietal names, most of which will be found to be synonyms of *H. anceps s.str.*

Judging from the varices on adult shells, *Helisoma anceps* normally lives for two or three years.

Genus ***Planorbella*** Haldeman

The planorbellas present some problem in identification, because they are another of the freshwater snail groups that exhibit diversity in appearance of their shells and accordingly have received scientific names to distinguish portions of the observed diversity. However, because *Planorbella* has been insufficiently studied, morphological boundaries of distinct specific or subspecific units have not been determined for the genus.

Species of *Planorbella* in the older literature on North American mollusks were all referred to the genus *Planorbis* (a genus now restricted to the Old World), and in the later literature to the genus *Helisoma.*

Subgenus *Planorbella s.str.*

The main distinguishing characteristic about the shells of *Planorbella s.str.* is the strong constriction behind the flared, bell-

shaped aperture. The narrowed aperture suggests that it functions in restricting entrance to predators.

Twelve Recent nominal specific or subspecific names are associated with *Planorbella s.str.* Several of these seem to be clearly synonyms. Others may have some taxonomic validity, but to ascertain that will require more research. Two species in the *Planorbella s.str.* group have been found in the UMBS area, *Planorbella campanulata* (Say) and *P. smithi* (F.C. Baker).

Planorbella campanulata (Say)

(Fig. 65; Map 38)

Planorbis campanulatus Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), pp. 166, 167.
Planorbis campanulatus Say, Walker (1893, p. 137).
Planorbis campanulatus minor Currier, Walker (1893, p. 137).
Planorbis campanulatus Say, Walker (1911, p. 125).
Planorbis campanulatus minor Dkr., Walker (1911, p. 125).
Planorbis campanulatus rudentis Dall, Walker (1911, p. 125).
Planorbis campanulatus (Say)?, H.B. Baker (1912, p. 210).
Planorbis campanulatus Say, Winslow (1926, p. 14).
Helisoma (Planorbella) campanulata (Say), F.C. Baker (1928, p. 345, pl. 21, figs. 1, 2, 4, 5, 8, 9, 13, 14).
Helisoma campanulatum (Say), Goodrich (1932, p. 63, fig.).
Helisoma campanulata collinsi F.C. Baker 1939, *Can. J. Res,* D, 17, pp. 97, 98, fig. 1.
Helisoma campanulatum (Say), Goodrich (1939, p. 16).
Helisoma campanulatum, Eggleton (1952, p. 217).
Planorbella campanulata campanulata (Say), Burch & Tottenham (1980, pp. 202, 203, fig. 728).
Planorbella campanulata collinsi (F.C. Baker), Burch & Tottenham (1980, p. 202).
Planorbella campanulata campanulata (Say), Burch (1982a, pp. 59, 182, fig. 728).
Planorbella campanulata collinsi (F.C. Baker), Burch (1982a, p. 59).
Planorbella campanulata campanulata (Say), Burch (1982b, p. 259, fig.).
Helisoma campanulata, Laman, Boss & Blankespoor (1984, pp. 20-25).
Planorbella campanulata campanulata (Say), Burch & Jung (1987, p. 270, fig. 54).
Planorbella campanulata collinsi (F.C. Baker), Burch & Jung (1987, p. 270).
Planorbella campanulata campanulata (Say), Burch (1989b, pp. 202, 203, fig. 728).
Planorbella campanulata collinsi (F.C. Baker), Burch (1989b, p. 202).
Planorbella campanulata (Say), Burch (1991, p. 128).

Shell: Discoidal, with spire sunken slightly below the periphery of the body whorl, or spire whorls even with the body whorl, or projecting slightly above (the latter condition named form *collinsi*). The basal and spire sides of the whorls are generally rounded, but some specimens may have an obtuse angulation at either or the other places. The whorls are relatively high. The spire whorls are rounded. The most conspicuous characteristic of the shell, and the one for which the species gets its name, is the campanulate (bell-shaped) aperture. In formation of the peculiar aperture, the body whorl is first constricted, then outwardly flared. (Formation of the flared aperture indicates the beginning of sexual maturity.) The umbilicus is narrow and deep. The shell surface lacks spiral striae, but

is marked by distinct and regularly spaced transverse ridgelets. These become very closely spaced and dense on the terminal flared part of the body whorl. The shell is tan to horn in color.

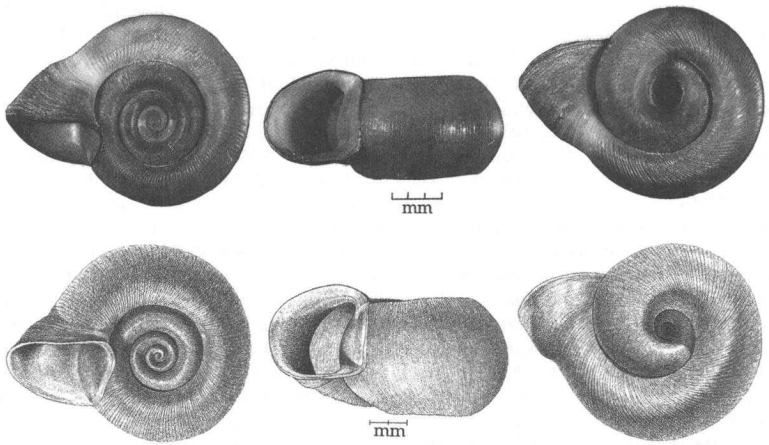


FIG. 65. Shells of *Planorbella campanulata.*

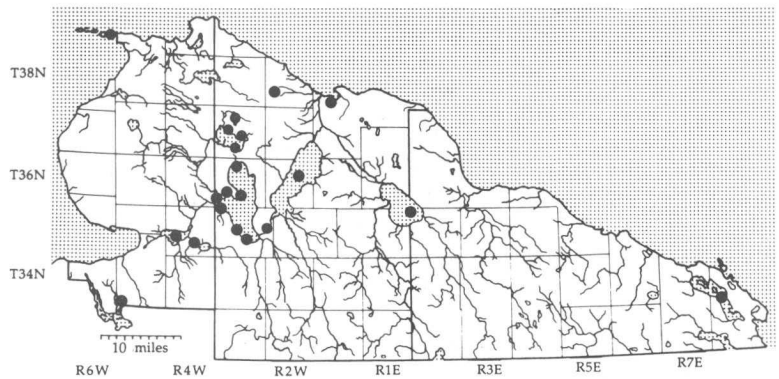
Animal: Black; foot broadly rounded in front and rather pointed behind; head very wide and somewhat auriculated; tentacles relatively short and blunt. (F.C. Baker, 1928).

Habitat: "A species of lakes" (F.C. Baker, 1928). On all types of bottoms in lakes and ponds of all sizes and in slow-moving or backwater portions of rivers; vegetation is usually present. (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 202). *Planorbella campanulata* form *collinsi* is found "in lakes and in medium-sized rivers. Substrates are sand or sand and gravel; vegetation is present but varies in abundance" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 204).

General Distribution: Vermont west to North Dakota, south to Ohio and Illinois, northward to Great Slave Lake (F.C. Baker, 1928). *Planorbella campanulata* form *collinsi* is found in northwestern Ontario in the head-waters of the Albany, Winnipeg and Severn river systems (Clarke, 1973, *Malacologia*, 13, p. 202), and it is also found in the UMBS area (see below).

Distribution in UMBS Area: Cheboygan Co.: Burt Lake, Frederick Stearns Collection, UMMZ 28209; north Fish Tail Bay, Douglas Lake, UMMZ 36615; north end of Burt Lake, UMMZ 36745; Burt Lake, UMMZ 38869; Mullett Lake, UMMZ 41953; small lake, 12 miles north of Douglas Lake, UMMZ 55530; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 83381; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 83383; Douglas Lake, Bryant Walker Collection, UMMZ 83386; Lancaster Lake, Royal Bruce Brunson, 12 July 1945, UMMZ 198373; Cheboygan County, 7 July 1947, UMMZ 248695; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, Munro Township, John B. Burch, 4

July 1985, UMMZ 250453; Lancaster Lake, Section 8, T38N, R. 4W, Munro Township, July 1987, Kelly West, UMMZ 253164; Mullett Creek estuary, Mullett Lake, Section 16, T36N, R2W, Mullett Township, Kelly West, July 1987, UMMZ 253166; King's Point, Burt Lake, Section 6, T35N, R4W, Tuscarora Township, Kelly West, July 1987, UMMZ 253171; Indian Point, Burt Lake, Section 28, T36N, R. 3W, Burt Township, Kelly West, July 1987, UMMZ 253174; Hook Point, north Fishtail Bay, Douglas Lake, Section 22, T37N, R3W, Munro Township, Kelly West, July 1987, UMMZ 253195; near Bentley Point, Douglas Lake, Section 17, T37N, R4W, Munro Township, Kelly West, July 1987, UMMZ 253196; south Burt Lake, Section 27, T35N, R. 3W, Tuscarora Township, Kelly West, July 1987, UMMZ 253197; south Burt Lake, Section 21, T36N, R. 3W, Tuscarora Township, Kelly West, July 1987, UMMZ 253198; Maple Bay, Burt Lake, Section 29, T36N, R3W, Burt Township, Kelly West, July 1987, UMMZ 253199; Burt Lake, Section 31, T36N, R3W, Burt Township, Kelly West, July 1987, UMMZ 253200; Douglas Lake, shoal at UMBS, South Fishtail Bay, at northern part of sections 33 and 34, at their boundary, T37N, R3W, Munro Township, John B. Burch, 23 June 1985, UMBS-85-1. **Emmet Co.:** Crooked Lake, Conway, Bryant Walker, Bryant Walker Collection, UMMZ 83322; Pickerel Lake, near Petoskey, Calvin Goodrich, Bryant Walker Collection, UMMZ 83425; Bear [Walloon] Lake, Kent Science Institute Collection, UMMZ 143353; northeast Walloon Lake, Section 30, Bear Creek Township, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170724; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253210; Extension of marsh behind sand dunes, beside boat ramp at western end of Park road, near shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch, UMBS-86-20. **Presque Isle Co.:** East [?] Lake, UMMZ 55524; Grand Lake, UMMZ 57783; Black Lake, M.L. Leach, Bryant Walker Collection, UMMZ 83327.



MAP 38. Localities of *Planorbella campanulata.*

Remarks: There seems to be considerable variation within some populations and between some populations in adult shell size, varying from about 9 mm in major diameter with 4½ whorls to more than 16 mm with 5¾ whorls. The smaller populations have been named *minor,* but recognizing these small specimens with a Latinized name is not taxonomically correct. Size may be genetically determined for each individual, or may be influenced by environmental

conditions, or by time of hatching and growth in relation to seasonal cycles.

Planorbella campanulata form *collinsi* differs from typical *Planorbella campanulata s.str.* by having a spire that projects slightly above the body whorl. In our area, this seems to be a variable character, occurring in occasional individuals in some populations (*e.g.*, in Lancaster Lake).

Planorbella smithi (F.C. Baker)

(Figs. 66, 67; Map 39)

Planorbis campanulatus smithi F.C. Baker 1912, *Nautilus*, 25(10), pp. 118-120.
Planorbis campanulatus smithii (Baker), H.B. Baker (1912, p. 210).
Planorbis campanulatus smithii F.C. Baker, H.B. Baker (1914, pp. 18-45).
Planorbis campanulatus smithi Baker, Winslow (1926, *Occ. Paps. Mus. Zool. Univ. Mich.*, 180, pp. 4, 5, pl. 2, figs. 11-13).
Planorbis campanulatus smithii Say, Winslow (1926, p. 14).
Helisoma (Planorbella) smithi (F.C. Baker), F.C. Baker (1928, pp. 353, 489, pl. 21, figs. 25-29).
Helisoma campanulatum smithi (Baker), Goodrich (1932, p. 64).
Helisoma campanulatum smithi (Baker), Cheatum (1934, p. 348).
Helisoma campanulatum smithi (Baker), Clampitt (1973b, *Malacologia*, 12(2), pp. 379-399).

Shell: Discoidal, with spire noticeably sunken below the shoulder of the body whorl. The whorls are relatively high, their spire and basal sides sharply angular or carinate. From the carina to the suture, the spire whorls are flattened. The last part of the body whorl is strongly deflected basally. The aperture is campanulate. The umbilicus is narrow and deep. The shell surface lacks spiral striae, but is marked by distinct and regularly spaced transverse

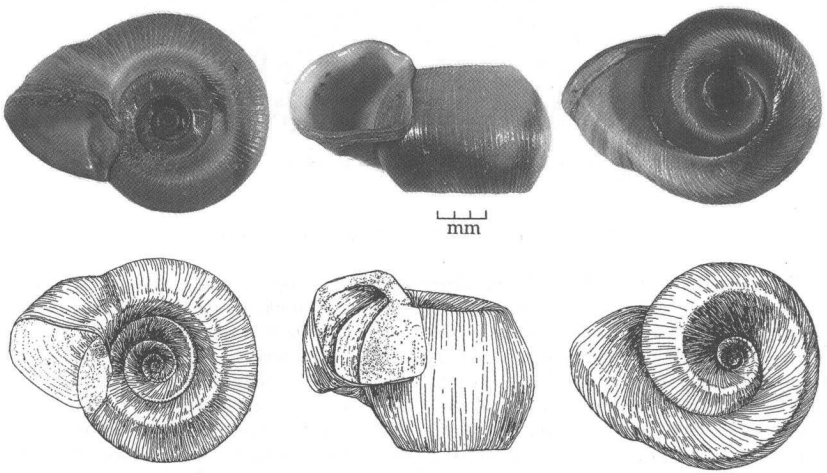


FIG. 66. Shells of *Planorbella smithi*. The bottom figure is from Winslow (1926a).

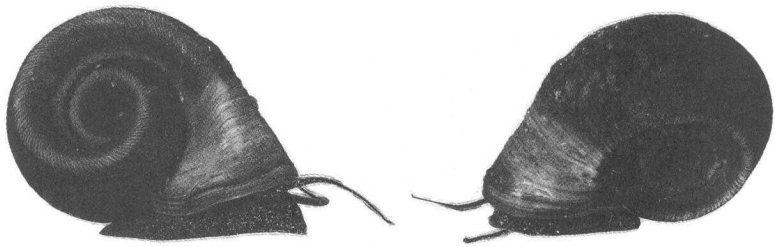
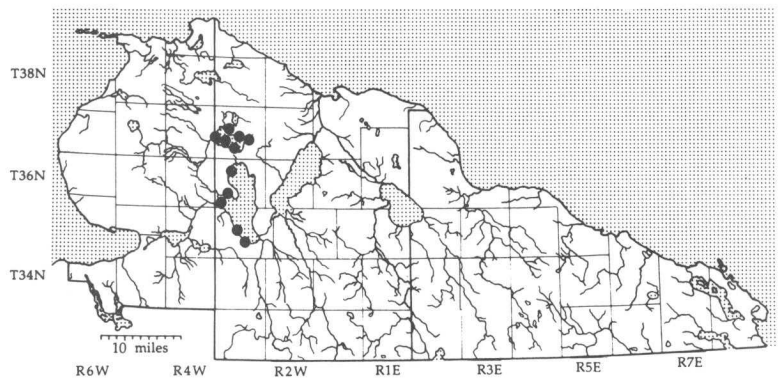


FIG. 67. *Planorbella smithi* in normal crawling position.

ridgelets, which become more closely spaced on the flared whorl just before the aperture. Adult shells range in size from 12 to 19 mm in major diameter. The color of the shells of living animals varies from horn to tan, gray or white.

Habitat: The marl, sand or mud substrates of Douglas and Burt lakes. Both of these are rather large oligotrophic lakes.

General Distribution: Known only from Douglas and Burt lakes, northern Lower Peninsula of Michigan.



MAP 39. Localities of *Planorbella smithi.*

Distribution in UMBS Area: Cheboygan Co.: Sedge Point, Douglas Lake, southwestern corner of Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250447; Hook Point, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250450; eastern shore of North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 16 July 1985, UMMZ 250456; Grapevine Point, south Fishtail Bay, Douglas Lake, Section 33, T37N, R. 3W, Munro Township, Kelly West, July 1987, UMMZ 253163; Hook Point, north Fishtail Bay, Douglas Lake, Section 22, T37N, R. 3W, Munro Township, Kelly West, July 1987, UMMZ 253165; Pell's Island, Douglas Lake, Section 29, T37N, R4W, Munro Township, Kelly West, July 1987, UMMZ 253167; near Bentley Point, Douglas Lake, Section 17, T37N, R4W, Munro Township, Kelly West, July 1987, UMMZ 253168; south

Burt Lake, Section 27, T35N, R3W, Tuscarora Township, Kelly West, July 1987, UMMZ 253169; south Burt Lake, Section 21, T35N, R3W, Tuscarora Township, Kelly West, July 1987, UMMZ 253170; west Douglas Lake, Section 30, T36N, R3W, Munro Township, Kelly West, July 1987, UMMZ 253172; north Burt Lake, Section 9, T36N, R3W, Burt Township, Kelly West, July 1987, UMMZ 253173; Maple Bay, Burt Lake, Section 29, T36N, R3W, Burt Township, Kelly West, July 1987, UMMZ 253175; Burt Lake, Section 31, T36N, R3W, Burt Township, Kelly West, July 1987, UMMZ 253176; North Fishtail Bay, Hook Point, near lagoon, Douglas Lake, John B. Burch, August 1991, UMMZ 253207; North Fishtail Bay, Hook Point, near lagoon, Douglas Lake, John B. Burch and Younghun Jung, 20 August 1987, UMMZ 253208; North Fishtail Bay, Hook Point, near lagoon, Douglas Lake, John B. Burch and Younghun Jung, August 1987, UMMZ 253209; Pine Point, Douglas Lake, Section 22, T37N, R3W, Munro Township, John B. Burch and Younghun Jung, 22 July 1988, UMBS-88-16a.

Remarks: *Planorbella smithi* was named (F.C. Baker, 1912) for specimens from Douglas Lake having carinated or sharply angled whorls, high last whorl, depressed and rather funnel-shaped spire, and with heavy, more or less rib-like transverse striae. This population was named in honor of Frank Smith (Illinois State University), one of the UMBS professors during that time.

Planorbella smithi was originally named as a subspecies of *P. campanulata,* a taxon which also occurs in Douglas and Burt lakes. F.C. Baker later concluded that since "the genitalia and radula differ somewhat from *campanulata," P. smithi* "would seem to rank as a species. The praeputium is very large and the penis sheath is attached at the side of the summit as in *trivolvis* and is two-thirds the length of the praeputium. The center tooth of the radula measures 25μ instead of 20μ as in the typical form. The shell characters are sufficient to separate the two forms as distinct at once." Therefore, it seems best – until more in depth studies are made on the taxa and forms of the *P. campanulata* group – to regard *P. campanulata* and *P. smithi* as distinct species.

The shell of *Planorbella smithi* has many of the characteristics of *P. campanulata,* to which it is obviously related. *Planorbella smithi* differs by its more depressed, almost funnel-shaped spire, its flattened and sharply angular or carinate spire whorls, in the carinate or angulate basal whorls, and in the strong deflection of the last half or one-third of the body whorl.

Subgenus *Pierosoma* Dall

Shell large, high, with few transversely sculptured whorls; the early whorls are carinate and flattened above, funicular below; in the adult the flattened spire is usually depressed below the upper level of the body whorl; at the end of last whorl, the aperture is expanded and thickened. (Dall, 1905, Harriman Alaska Ser., 8, p. 85).

This group of *Planorbella* contains the largest species of the family. Several of these species have distinctive morphological characteristics, but in the *P. trivolvis* complex there many dubious nominal species.

Planorbella (Pierosoma) trivolvis (Say)

(Figs. 68, 69; Map 40)

Planorbis trivolvis Say 1817, Conchology, in Nicholson, 1816-1817, *Am. Ed. Brit. Encyclop., Dict. Arts, Sci.*, etc., 1st ed., vol. 2, pt. 2, 11th page, pl. 2, fig. 2.
Planorbis trivolvis Say, Walker (1893, p. 136).
Planorbis trivolvis Say, Walker (1911, p. 125).
Planorbis trivolvis Say, H.B. Baker (1914, pp. 18-45).
Planorbis trivolvis Say, Winslow (1917, p. 8).
Planorbis trivolvis Say, Winslow (1926, p. 15).
Helisoma (Pierosoma) trivolvis (Say), F.C. Baker (1928, p. 330, pl. 20, figs. 1-13, 22, 23).
Helisoma trivolvis (Say), Goodrich (1932, p. 59, fig.).
Helisoma trivolvis (Say), Cheatum (1934, p. 348).
Helisoma trivolvis (Say), Goodrich (1939, p. 16).
Planorbella trivolvis trivolvis (Say), Burch & Tottenham (1980, pp. 204, 206, fig. 736).
Planorbella trivolvis trivolvis (Say), Burch (1982a, pp. 60, 184, fig. 736).
Planorbella trivolvis (Say), Burch (1982b, p. 261, fig.).
Planorbella trivolvis trivolvis (Say), Burch & Jung (1987, pp. 271, 272, fig. 56).
Planorbella trivolvis trivolvis (Say), Burch (1989b, pp. 204, 206, fig. 736).
Planorbella (Pierosoma) trivolvis (Say), Burch (1991, p. 128).

Shell: Adult shells are relatively large, up to 32 mm in greatest diameter. They vary in color from pale tannish-horn to deep brown. The spire is slightly to moderately depressed. The spire whorls may be flat with a small peripheral carina at the shoulder, or the spire whorls may be rounded. The umbilicus is deep and narrow. The sculpture consists of well-defined transverse ridgelets.

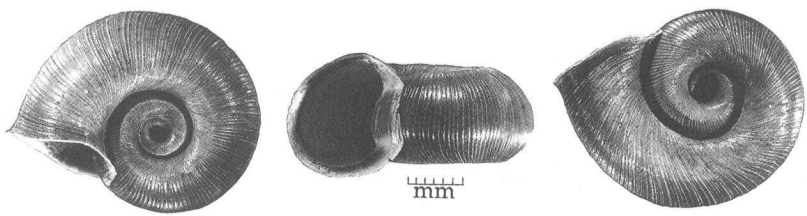


FIG. 68. Shell of *Planorbella (Pierosoma) trivolvis.*

Animal: Body long and somewhat narrow, rounded in front, pointed behind. Head with large velar area; eyes on the dorsal surface, at the base of the tentacles; tentacles cylindrical, long and slender. (F.C. Baker, 1928).

Habitat: *Planorbella trivolvis* has been found in a variety of habitats in the UMBS area – marshes, ponds, beach pools, roadside drainage ditches, quieter, less exposed areas of lakes, and back-

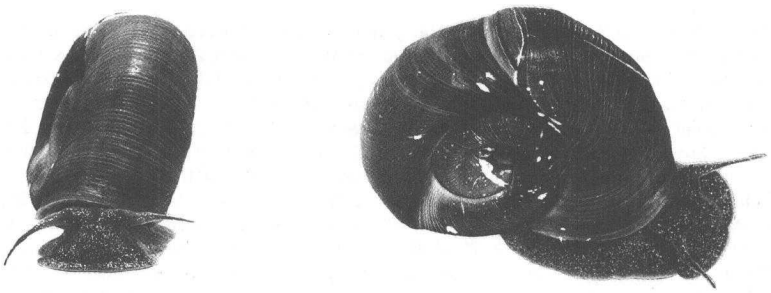
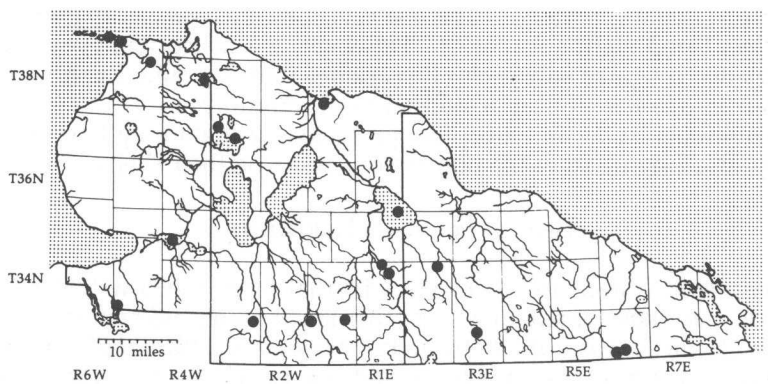


FIG. 69. *Planorbella (Pierosoma) trivolvis* in its natural crawling position.

waters of slow moving areas of streams. The substrate on which *P. trivolvis* is found is usually mud.

General Distribution: The distribution of *Planorbella trivolvis s. str.* has been given (Burch, 1982b, p. 282) as northern North America east of the Rocky Mountains, south to Nebraska, northern Illinois, Pennsylvania and New Jersey. *Planorbella trivolvis s.lat.*. extends over most of North America.



MAP 40. Localities of *Planorbella (Pierosoma) trivolvis.*

Distribution in UMBS Area: **Cheboygan Co.:** Douglas Lake, UMMZ 5642; Sedge Point, pool and beach, UMMZ 36604; Sedge Point, beach pools, UMMZ 36605; Black River, near Tower, UMMZ 36610; MacAndrews Lake, UMMZ 37489; Silver Lake, UMMZ 37492; Dog Lake, UMMZ 37493; Douglas Lake, mouth of Bessie [Bessy; Lancaster] Creek, UMMZ 42831; Fontinalis Run, Douglas Lake [?], UMMZ 46935; Hook Point, Douglas Lake, UMMZ 46936; Douglas Lake, UMMZ 55519; small lake 12 miles north of Douglas Lake, UMMZ 55531; Carp Lake [Lake Paradise], near Mackinaw City, DeCamp Collection, Bryant Walker Collection, UMMZ 85731; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 85764; Douglas Lake, University of Michigan Expedition, 1909, Bryant Walker Collection, UMMZ

85767; Black River at Tower, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170561; pool north of Cheboygan, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170591; Cheboygan Co., 23 July 1949, UMMZ 248736; Cattail marsh (old beach pools), north of Cheboygan, 16 July 1949, UMMZ 248737; Tower Pond (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250449; Sedge Point, Douglas Lake, beach pond # 1, southwestern corner Section 22, Munro Township, John B. Burch, 1 July 1985, UMMZ 250455; Sedge Point, Douglas Lake, beach pond #2, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5d; Sedge Point, Douglas Lake, beach pond #3, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 3 July 1985, UMBS-85-5e. **Emmet Co.:** Crooked Lake, Bryant Walker, Bryant Walker Collection, UMMZ 85735; Goose Pond, Wilderness Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170460; northeast Walloon Lake, Section 30, Bear Creek Township, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170725; O'Neal Lake, UMMZ 198374; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253206. **Presque Isle Co.:** Rainy River, UMMZ 28390; Fletcher State Park, UMMZ 36631; north bridge, Thunder Bay River, below Sunken Lake, UMMZ 37510; Sunken Lake, UMMZ 37511; Rainy Lake, M.L. Leach, Bryant Walker Collection, UMMZ 85219.

Remarks: *Planorbella trivolvis* was originally described from juvenile specimens, hence its name, which means literally "three whorls." Adult shells have up to five or more whorls.

Like so many freshwater pulmonate snails, *Planorbella trivolvis* exhibits a great amount of morphological variation in its shell over its large geographic range. The last revision (F.C. Baker, 1945) of *P. trivolvis* listed eight subspecies. However, we do not believe it advisable to recognize subspecies or varieties in the common and widespread *P. trivolvis* until it is studied more carefully.

Individuals living in eutrophic, protected habitats may live up to five years, judging from the number of varices on their shells.

Genus ***Planorbula*** Haldeman

Planorbula is a genus of small snails that have shells with higher whorls than those of adults of our other small planorbid genera. Two other characteristics are helpful in recognizing *Planorbula* in the UMBS area: the rounded whorls and the lamellae or "teeth" near the aperture in the body whorl. The aperture is but slightly expanded, although it may be considerably thickened within.

***Planorbula armigera* (Say)**

(Fig. 70; Map 41)

Planorbis armigerus Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), p. 164.
Segmentina armigera Say, Walker (1893, p. 137).
Segmentina wheatleyi Lea (?), Walker (1893, p. 137).
Segmentina crassilabris Walker 1907, *Nautilus*, 20(11), p. 122.
Segmentina armigera Say, Walker (1911, p. 125).
Segmentina crassilabris Walker, Walker (1911, p. 125).

Segmentina armigera (Say), H.B. Baker (1914, pp. 18-45).
Segmentina crassilabris Walker, H.B. Baker (1914, pp. 18-45).
Segmentina armigera (Say), Winslow (1917, p. 9).
Segmentina armigera (Say) var., Winslow (1917, p. 9).
Segmentina armigera (Say), Winslow (1926, p. 15).
Segmentina armigera crassilabris Walker, Winslow (1926, p. 15).
Planorbula armigera (Say), F.C. Baker (1928, p. 355, pl. 8, figs. 27-30).
Planorbula crassilabris (Walker), F.C. Baker (1928, p. 359, pl. 8, figs. 24-26).
Planorbula armigera (Say), Goodrich (1932, p. 67, fig.).
Planorbula armigera (Say), Goodrich (1939, p. 18).
Planorbula armigera armigera (Say), Burch & Tottenham (1980, pp. 207, 208, figs. 741, 742).
Planorbula armigera armigera (Say), Burch (1982a, pp. 61, 185, figs. 741, 742).
Planorbula armigera armigera (Say), Burch (1982b, p. 258, fig.).
Planorbula armigera (Say), Burch & Jung (1987, p. 273, fig. 58).
Planorbula armigera armigera (Say), Burch (1989b, pp. 207, 208, figs. 741, 742).
Planorbula armigera (Say), Burch (1991, p. 128).

Shell: Small, adult shells with 4½ to 5 whorls measure up to 7 mm in major diameter, translucent, glossy, pale horn to darker, often tinged with tan or pale olive. Many specimens have a well developed varix. The spire depression is deep, conical; the umbilical depression is obtusely conical, very shallow. The whorls are shouldered, their outer periphery rounded. On the umbilical side the whorls are rounded, on the spire side they are angular. The last part of the body whorl is deflected toward the spire side. The sutures are moderately impressed. The aperture is broadly lunate; the outer lip is thickened within. Deep within the aperture are 5 to 6 teeth or lamellae. These can be seen through the shell.

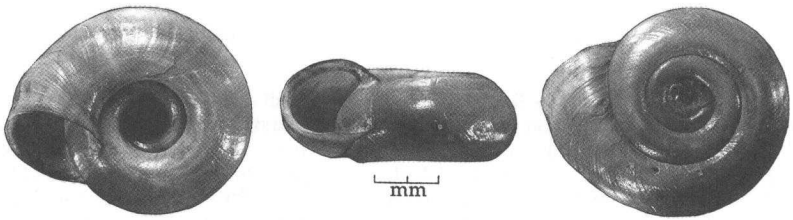
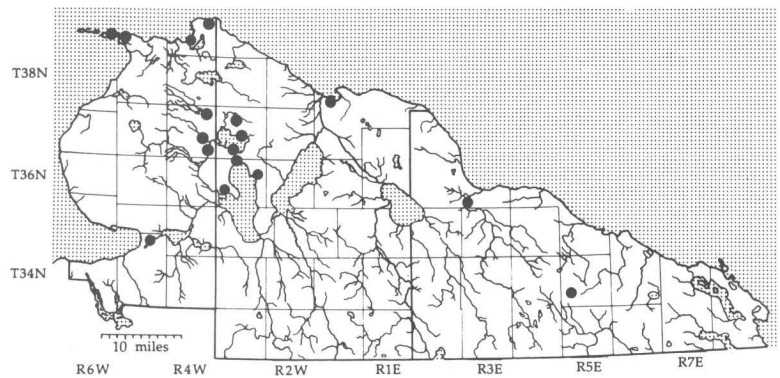


FIG. 70. Shell of *Planorbula armigera.*

Animal: The head and foot are almost black, with lighter edges on the foot. The top of the head is reddish, the sides of the body lighter. A blackish band borders the head and neck above the foot and velum. The velum is wide, extending beyond the foot when the snail is active. The tentacles are very long, 1½ times as long as the foot, tapering and black, each with a light area near its base. The mantle is irregularly covered with dark gray dots. The pseudobranch is long and pointed, thin and transparent. (F.C. Baker, 1928, 1945).

Habitat: "Largely a species of swales or of small and stagnant bodies of water" (F.C. Baker, 1928). "Lives among vegetation in most kinds of perennial-water habitats, especially stagnant, heavily-vegetated water bodies. The usual substrate is mud" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 194).

General Distribution: New Brunswick west to southeastern Ontario, west to Saskatchewan, northwest to the Mackenzie River system (Clarke, 1973, *Malacologia*, 13, p. 421); south to Georgia and Louisiana and west to Nebraska (F.C. Baker, 1928).



MAP 41. Localities of *Planorbula armigera*.

Distribution in UMBS Area: **Cheboygan Co.:** small creek entering Burt Lake, N.A. Wood, UMMZ 42979; pool near Burt Lake, N.A. Wood, UMMZ 42980; Fontinalis Run, Burt Lake, UMMZ 49577; Cheboygan, Sister M. Catherine, Bryant Walker Collection, UMMZ 90398; Douglas Lake, Bryant Walker Collection, UMMZ 90401; pool north of Cheboygan, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170594; Grapevine Point beach pool, Douglas Lake, T37N, R3W, S28, James W. Moffett, 27 July 1937, UMMZ 232345; Mackinaw City, Phil L. Marsh, 16 June 1938, Phil L. Marsh Collection, UMMZ 243087; Hook Point lagoon, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, John B. Burch, 15 July 1985, UMMZ 250452; Sedge Point, beach pool between Douglas Lake and beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5b; Sedge Point, Douglas Lake, beach pond #2, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5d; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R3W, Munro Township, John B. Burch, 4 July 1985, UMBS-85-7; pond on Pine Point, Douglas Lake, Section 22, T37N, R3W, Munro Township, Cheboygan Co., John B. Burch and Younghun Jung, 23 July 1988, UMBS-88-16b. **Emmet Co.:** Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 90339; Goose Pond, Wilderness Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170466; NW1/4, Section 27, Wawatam Township, Harold W. Harry, UMMZ 178404; Van Creek, a small tributary of the East Branch of Maple River, southeastern corner of Section 25, McKinley Township, John B. Burch, 26 July 1985, UMMZ

250446; beachdrift behind sand dunes, shore of Lake Michigan, Wilderness State Park, Section 19, T39N, R5W, John B. Burch and Younghun Jung, 23 July 1986, UMMZ 253216; roadside ditch along Levering Road, 0.35 mile east of crossroads of highway US 31 and C 66, northeast corner of Section 3, T37N, R4W, McKinley Township, John B. Burch and Younghun Jung, August 1987, UMMZ 253217; a small tributary on the west side of the East Branch of the Maple River, southeastern corner of Section 25, T37N, R4W, McKinley Township, John B. Burch, 7 July 1985, UMBS-85-8b. **Presque Isle Co.:** pond 0.5 miles east of Hawks, UMMZ 55635; Ocqueoc Lake at outdoor camp, near outlet of Ocqueoc River, southeastern part of Section 19, T36N, R3E, Ocqueoc Township, John B. Burch, 18 July 1985, UMBS-85-12a.

Genus *Promenetus* F.C. Baker

Promenetus is another genus with many lower level nominal taxa, but probably with only two valid species. One species, and the only one occurring in the UMBS area (*P. exacuous*), has a very distinctive shell, with sharply angular or carinate whorls.

The main diagnostic characters of the genus are in the male genital system (*e.g.*, see Fig. 108).

Promenetus exacuous (Say)

(Fig. 71; Map 42)

Planorbis exacuous Say 1821, *J. Acad. Nat. Sci. Philad.*, 2(1), pp. 165, 166.
Planorbis exacutus Say, Walker (1893, p. 137).
Planorbis exacuous Say, Walker (1911, p. 125).
Planorbis exacuous Say, H.B. Baker (1914, pp. 18-45).
Planorbis exacuous Say, Winslow (1926, p. 15).
Menetus exacuous (Say), F.C. Baker (1928, p. 361, pl. 23, figs. 1-5).
Menetus exacuous (Say), Goodrich (1932, p. 68, fig.).
Menetus exacuous, Eggleton (1952, p. 217).
Promenetus exacuous (Say), Burch & Tottenham (1980, pp. 208, 209, fig. 746).
Promenetus exacuous (Say), Burch (1982a, pp. 61, 186, fig. 746).
Promenetus exacuous (Say), Burch (1982b, p. 257, fig.).
Promenetus exacuous (Say), Burch & Jung (1987, pp. 273, 274, fig.).
Promenetus exacuous (Say), Burch (1989b, pp. 208, 209, fig. 746).
Promenetus exacuous (Say), Burch (1991, p. 128).

Shell: Small, adults with about 3¼ whorls are about 4.4 mm in major diameter, translucent to nearly opaque, pale horn. The whorls increase rapidly in diameter. The spire depression is relatively narrow and moderately deep; the umbilical side is flat. The whorls are sharply angular to carinate, and are sculptured with well developed and well curved growth striae, and well developed incised spiral striae. The sutures are deeply impressed.

Habitat: Generally in more or less marshy, quiet places (Baker, 1928). "In various kinds of temporary-water and permanent-water habitats, that is large and small lakes, ponds, streams of various widths, roadside ditches, and swamps. Submersed vegetation is al-

ways present and the usual substrate is mud" (Clarke, 1981, *Freshw. Moll. Can.*, Nat. Mus. Can., Ottawa, p. 186).

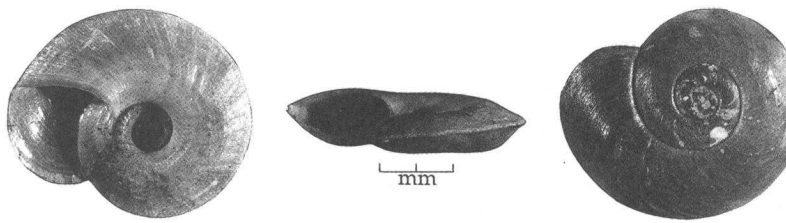
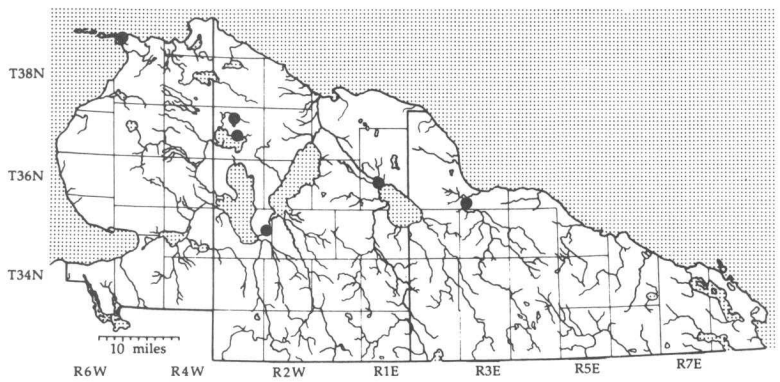


FIG. 71. Shell of *Promenetus exacuous.*

General Distribution: United States east of the Rocky Mountains, north to Alaska and the Mackenzie River, south to New Mexico (F.C. Baker, 1928); in Canada absent from Quebec, but widely distributed east of James and Hudson bays, mainly south of the tree-line (Clarke, 1973, *Malacologia,* 13, p. 411).

Distribution in UMBS Area: Cheboygan Co.: Sedge Point, drift, Douglas Lake, UMMZ 36778; Sedge Point, Douglas Lake, UMMZ 46288; Indian River, A.C. Lane, Bryant Walker Collection, UMMZ 86781; Douglas Lake, University of Michigan Expedition, 1908, Bryant Walker Collection, UMMZ 86783; Black Lake, near Black River, Section 21, T36N, R1E, James W. Moffett, 22 July 1937, UMMZ 232347; Sedge Point, beach pool between Douglas Lake and beach pond #1, southwestern corner of Section 22, T37N, R3W, Munro Township, John B. Burch, 1 July 1985, UMBS-85-5b; Lancaster Lake, southwestern shore, at public access site, northwestern part of Section 8, T37N, R3W, Munro Township, John B. Burch, 4 July 1985, UMBS-85-7. **Emmet Co.:** Goose Pond, Wilderness Park, Harold W. Harry and Henry van der Schalie, 16 September 1949, UMMZ 170463. **Presque Isle Co.:** Ocqueoc Lake at outdoor camp, near outlet of Ocqueoc River, southeastern part of Section 19, T36N, R3E, Ocqueoc Township, John B. Burch, 18 July 1985, UMBS-85-12a.



MAP 42. Localities of *Promenetus exacuous.*

Family ANCYLIDAE

The Ancylidae are another of the gastropod families with a world-wide distribution. They all have small cap-shaped (patelliform, ancyliform, limpet-shaped) shells in which the apices are on the right side, or tilted toward the right (Fig. 72). Among freshwater limpets in eastern North America, such a shell has been derived from ancestors with sinistrally coiled shells, and in the Ancylidae the arrangement of the body morphology is always sinistral, *i.e.*, the "gill" (pseudobranch), and the pulmonary reproductive and excretory openings are all on the animal's left side. The low conical shape of freshwater limpets obviously evolved as a result of the stress of a turbulent aquatic environment (either riverine or wave-washed shore). Subsequently, many species invaded lentic habitats.

The Ancylidae seem to be closely related to the Planorbidae, but they differ conspicuously from planorbid snails in having hemocyanin as their blood pigment rather than hemoglobin (which gives the planorbids their red body color).

Among the ancylid subfamilies, the Ferrissiinae have the widest distribution, both naturally and by human dispersal. Pond species seem to be easily transported through human and avian activities; riverine species are less tolerant to passive transportation.

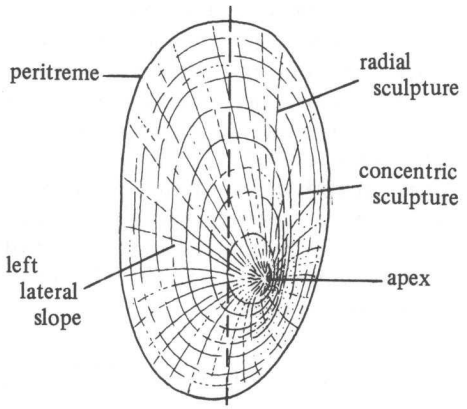


FIG. 72. Morphological terminology for an ancylid shell.

When limpets live on the long, narrow stems of aquatic plants, the shape of the shell may be influenced by the habitat, *i.e.*, the shells are long, narrow, the sides are nearly parallel, and the right and left margins of the shell aperture are ventrally curved (Walker, 1903, *Nautilus*, 7(2), p. 17; Basch, 1963).

Key to Genera in the UMBS Area

1 Shell horn-colored, elevated or depressed; apex subacute, with fine radial striae; aperture broadly ovate to narrow, completely open or, rarely, partly closed posteriorly by a septum; pseudobranch flat, with a single lobe; penis with a flagellum ..... *Ferrissia* (p. 138)

Shell brownish, usually depressed; apex obtuse, without radial striae (as seen under a light microscope); aperture ovate, never with a septum; pseudobranch with two lobes, the lower one folded; penis without a flagellum ..... *Laevapex* (p. 143)

Genus *Ferrissia* Walker

The genus *Ferrissia* has a wide distribution in North America, occurring in lotic and lentic fresh waters over most of the continent. Shells of its species are readily distinguished from those of *Laevapex* by the striate apices and, in Michigan at least, by the pale horn-color.

The apically striate part of the shell is the embryonic shell (the shell formed within the egg capsule). (The shells of most species are covered in nature by deposits from their habitat, and therefore have to be cleaned so that their apical sculpture can be observed.)

In occasional populations, some or all individuals form a partial septum over the aperture under certain environmental conditions. Formerly, such septate specimens were described as different species and placed in a separate genus, *Gundlachia. Gundlachia,* as now understood, is a valid genus based on other characters, of both apical shell sculpture and reproductive anatomy, and is restricted geographically to the Caribbean area and further south.

Anatomically, *Ferrissia* is distinguished by its simple penis with a club-shaped flagellum. Some specimens lack the terminal male intermittent organ, *i.e.*, are aphallate.

Key to Species in the UMBS Area

1 Shell elevated to depressed, aperture variable, from elliptical to oblong with nearly parallel right and left margins; in standing water (eutrophic lakes, ponds, swamps, swales or backwaters of streams) .... *F. parallela* (p. 139)

Shell generally elevated, aperture oval or elliptical; in streams, generally in the current ..... *F. rivularis* (p. 141)

Ferrissia parallela (Haldeman)

(Figs. 73, 74; Map 43)

Ancylus parallelus Haldeman 1841, *Monogr. Limn. Freshw. Univalve Shells N. Am.*, (2), cover p. 3.
Ancylus parallelus Hald., Walker (1893, p. 137).
Ancylus parallelus Hald., Walker (1911, p. 125).
Ancylus parallelus Haldeman, H.B. Baker (1914, pp. 18-45).
Ancylus parallelus C.B. Adams, Winslow (1917, p. 10).
Ferrissia parallela (Haldeman), Winslow (1926, p. 18).
Ferrissia parallela (Haldeman), F.C. Baker (1928, p. 395, pl. 29, figs. 1-5).
Ferrissia parallela (Haldeman), Goodrich (1939, p. 23).
Ferrissia parallelus (Haldeman), Burch & Tottenham (1980, p. 212).
Ferrissia parallelus (Haldeman), Burch (1982a, p. 62).
Ferrissia parallelus (Haldeman), Burch (1982b, p. 262).
Ferrissia parallelus (Haldeman), Burch (1989b, p. 212).
Ferrissia parallelus (Haldeman), Burch (1991, p. 128).

Shell: Adults measure up to 6 mm in length. Elongately rounded to rather narrow, depending on the substrate on which the animal has grown. The left posterior shell margin tends to taper posteriorly more than does the right posterior margin. The anterior and left slopes are slightly convex, the right and posterior slopes are slightly concave. The shell is almost colorless or slightly tannish, or, in some dried specimens, horn-colored. The apex is subacute, radially striate, and located near the midline of the shell. The radial striae end where the neanic shell begins. The neanic and adult shells are marked with concentric rings and less obvious radial lines or subobsolete low ridges.

FIG. 73. Shell of *Ferrissia parallela*. The anterior end of the shell is on the left.

Animal: The dorsal mantle is faintly to moderately pigmented with melanin granules, with most of the pigment occurring between the anterior mantle edge and the anterior adductor muscles, and near the mantle periphery. Pigmentation on the dorsal mantle between the anterior and posterior adductor muscles is sparse. Accessory muscles or patches of adhesive epithelium are not evident on the dorsal mantle. The sides of the foot and head are very faintly pigmented,

appearing pale gray. The sole of the foot is without pigment. The pseudobranch is long, arising near the neck on the left side and continuing to near the end of the foot.

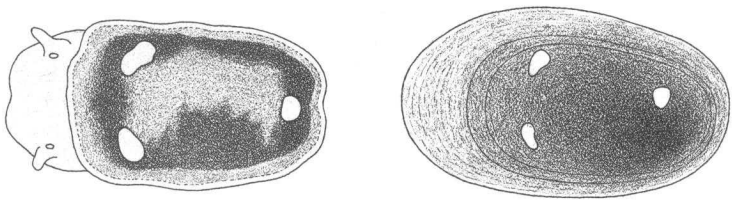
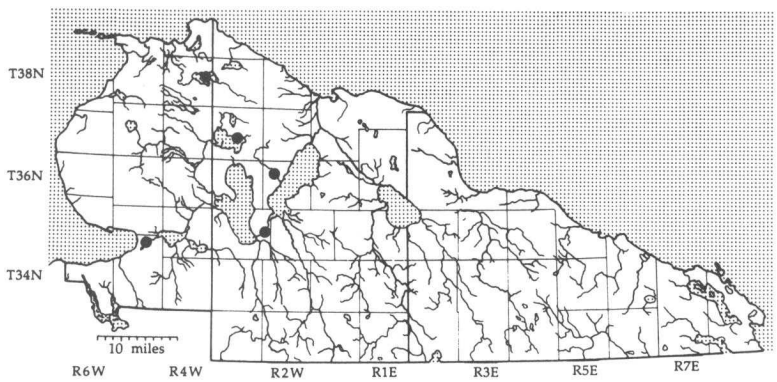


FIG. 74. *Ferrissia parallela.* **a**, Dorsum of animal with its shell removed (alcohol-preserved specimen, with mantle somewhat contracted), showing the two anterior and one posterior adductor muscles; **b**, underside of shell showing adductor muscle attachment scars.

Habitat: On aquatic vegetation, fallen leaves and logs in shallow lakes, ponds, roadside drainage ditches, etc., where the water is quiet.

General Distribution: In Canada and the northern United States from the Atlantic coast westward (Basch, 1963); Nova Scotia and New England west to Manitoba, Minnesota and Illinois in the Atlantic, St. Lawrence River, Hudson Bay and upper Mississippi River drainage areas (Clarke, 1973, *Malacologia,* 13, p. 482).

Distribution in UMBS Area: Cheboygan Co.: Carp Lake, DeCamp Collection, Bryant Walker Collection, UMMZ 101997; Douglas Lake, Bryant Walker Collection, UMMZ 100643; Indian River, G.C. Lane, Bryant Walker Collection, UMMZ 100642; Nigger [Negro] Creek, T36N, R2WS8, William H. Heard, UMMZ 237868; **Emmet Co.:** Round Lake, Petoskey, Bryant Walker, Bryant Walker Collection, UMMZ 100631; Carp Lake, Bryant Walker, Bryant Walker Collection, UMMZ 161602.



MAP 43. Localities of *Ferrissia parallela.*

Remarks: Haldeman's (1841, *Monogr. Limn. Freshwater Univalve Shells N. Am.*, (3), cover p. 3) description was meager ("shell brown, low, much appressed, aperture oblong oval, apex subcentral. Length .15 [ca. 3.8 mm] breadth .10 in. [ca. 2.5 mm] HAB. Vermont."), but later (1844, *op. cit.*, (7), pp. 11-12, pl. 1, fig. 6) he improved on the description ("shell pale, thin, and delicate; lengthened, sides subrectilinear, diverging slightly forwards: apex rather sharp, conspicuous, with two-fifths of the shell posterior to it. DIMENSIONS. Long. 0.25 [ca. 6.3 mm], lat. 0.15 [ca. 3.8 mm], elev. 0.08 inch [ca. 1.9 mm]. – Adams. GEOGRAPHICAL DISTRIBUTION. Inhabits New England"). With the latter description, Haldeman gave a good illustration. Basch (1963) pointed out that *Ferrissia parallela* is a variable species, which we have also noted in specimens from the UMBS area (if our specimens do indeed represent only one species).

Ferrissia rivularis (Say)

(Fig. 75; Map 44)

Ancylus rivularis Say 1817, *J. Acad. Nat. Sci. Philad.*, 1, p. 125.
Ancylus rivularis Say, Walker (1893, p. 137).
Ancylus tardus Say, Walker (1893, p. 137).
Ancylus rivularis Say, Walker (1911, p. 125).
Ancylus tardus Say, Walker (1911, p. 125).
Ferrissia rivularis (Say), Winslow (1926, p. 18).
Ferrissia tarda (Say), Winslow (1926, p. 18).
Ferrissia rivularis (Say), F.C. Baker (1928, p. 398, pl. 24, figs. 16-18).
Ferrissia tarda (Say), F.C. Baker (1928, p. 399, pl. 24, figs. 6-9).
Ferrissia rivularis (Say), Goodrich (1932, p. 73, fig.).
Ferrissia tarda (Say), Goodrich (1939, p. 23).
Ferrissia rivularis (Say), Burch & Tottenham (1980, pp. 212, 215, figs. 761, 767).
Ferrissia rivularis (Say), Burch (1982a, p. 63, 190-192, figs. 761, 767).
Ferrissia rivularis (Say), Burch (1982b, p. 262, fig.).
Ferrissia rivularis (Say), Burch & Jung (1987, p. 274, fig.).
Ferrissia rivularis (Say), Burch (1989b, pp. 212, 215, figs. 761, 767).
Ferrissia rivularis (Say), Burch (1991, p. 128).

Shell: Adults measure up to 5 mm in length. Oval to elliptical in outline. The left posterior shell margin tends to taper posteriorly more than does the right posterior margin. The anterior and left slopes are convex, the right and posterior slopes are slightly concave. The shell is nearly colorless or horn-colored to tannish. The apex is acute, radially striate, and located near the midline of the shell or to the right (form *tarda*). The apex is radially striate; the neanic and adult shell are concentrically striate, with subobsolete radiating striae or ridges.

Animal: The dorsal mantle is faintly to moderately heavily pigmented with melanin granules. The heaviest area of pigmentation is an area in front of the anterior adductor muscles. The area between the anterior and posterior adductor muscles is devoid of pigment.

Patches of adhesive epithelium are not evident. The sides of the foot are faintly to moderately pigmented. The top of the head is more heavily pigmented. The sole of the foot is either faintly pigmented or entirely devoid of pigment. The single flap of the pseudobranch runs under the left free mantle from the anterior adductor to the posterior adductor muscle.

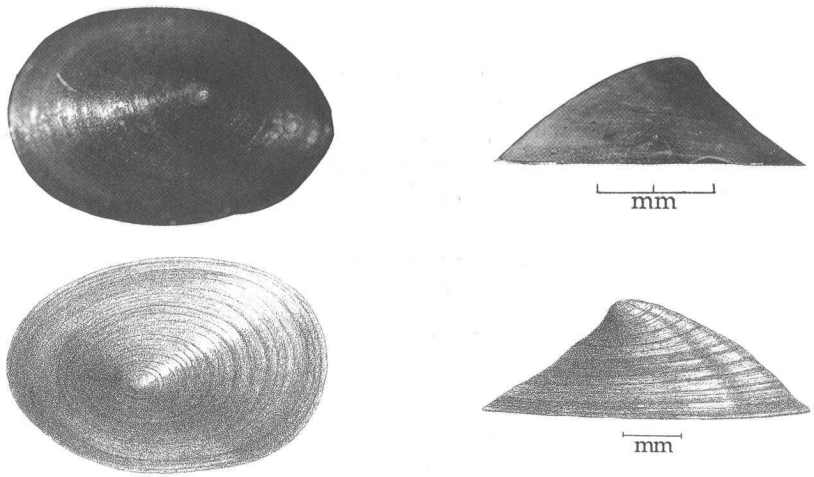


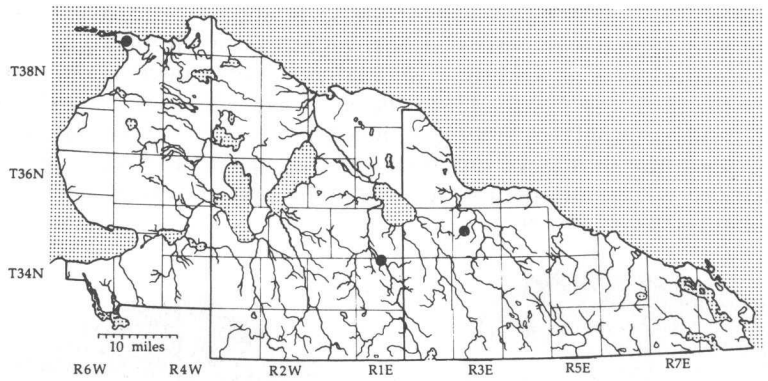
FIG. 75. Shell of *Ferrissia rivularis*. In the top row, the anterior end of the shell is on the left; in the bottom row, the anterior end of the shell is on the right.

Habitat: *Ferrissia rivularis*, as its name implies, is found in rivers. It occurs in both large and small streams, generally in the current, so it needs hard surfaces on which to cling – stones, gravel, or other hard objects.

General Distribution: Found throughout most of North America, but probably absent in the southern United States; it extends northward into the Hudson Bay lowlands and northwestward at least to central Saskatchewan, and southward to North Carolina and perhaps to New Mexico, California and Oregon in the west (see Clarke, 1973, *Malacologia*, 13, p. 480).

Distribution in UMBS Area: Cheboygan Co.: subfossil, Tower Pond, (an impoundment of Black River) at Tower, southcentral part of Section 3, Forest Township, John B. Burch, 15 July 1985, UMMZ 250445. **Emmet Co.:** Little Sucker Creek, Royal Bruce Brunson, UMMZ 198368. **Presque Isle Co.:** oak-pine, Section 17, Ocqueoc Township, Harold W. Harry and Henry van der Schalie, 17 September 1949, UMMZ 170554.

Remarks: Basch (1963) suggested a simple annual life cycle for *Ferrissia rivularis,* individuals living from the spring or summer of one year until the fall of the next.



MAP 44. Localities of *Ferrissia rivularis.*

Genus *Laevapex* Walker

Laevapex is a genus of eastern North America, its species living in lentic habitats. The shells of its several species lack the striate apices that characterize *Ferrissia.* (To determine this apical characteristic accurately, encrustations must be removed from the shells [see p. 179].)

Anatomically, the terminal male genitalia are in some ways more complex than those found in *Ferrissia,* but they lack the flagella that are characteristic of *Ferrissia.*

Laevapex fuscus (Adams)

(Figs. 76, 109-113; Map 45)

Ancylus fuscus Adams 1841, *Boston J. Nat. Hist.,* 3(3), pp. 329, 330, pl. 3, fig. 17.
Ancylus fuscus Ad., Walker (1893, p. 137).
Ancylus fuscus C.B. Ads., Walker (1911, p. 125).
Ferrissia fusca (C.B. Adams), Winslow (1926, p. 17).
Ferrissia (Laevapex) fusca (C.B. Adams), F.C. Baker (1928, p. 404, pl. 24, figs. 10-13).
Laevapex diaphanus (Haldeman), Hubendick (1964, pp. 38-43, figs. 128-130, 132-139,145-148).
Laevapex fuscus (C.B. Adams), Burch & Tottenham (1980, pp. 213-215, figs. 763, 771).
Laevapex fuscus (C.B. Adams), Burch (1982a, pp. 63, 191-193, figs. 763, 771).
Laevapex fuscus (C.B. Adams), Burch (1982b, p. 263, fig.).
Laevapex fuscus (C.B. Adams), Burch & Jung (1987, p. 275, fig. 61).
Laevapex fuscus (C.B. Adams), Burch (1989b, pp. 213-215, figs. 763, 771).
Laevapex fuscus (C.B. Adams), Burch (1991, p. 128).

Shell: Adults measure up to 6 mm in length. Depressed; elliptical in outline. The left posterior shell margin tends to taper posteriorly more than does the right posterior margin. The anterior and left slopes are slightly convex, the right slope is either straight or slightly convex, and the posterior slope is slightly concave. The shell without periostracum is almost colorless or slightly tannish. The periostracum is tan or brown and extends a little beyond the margins of the shell (as Adams [1841, *Boston J. Nat. Hist.*, 3, p. 329] observed in his original description). The obtuse apex is marked by concentric sculpture, but lacks radial striae. The neanic and adult shells are marked with prominent concentric rings and less obvious radial lines or subobsolete low ridges.

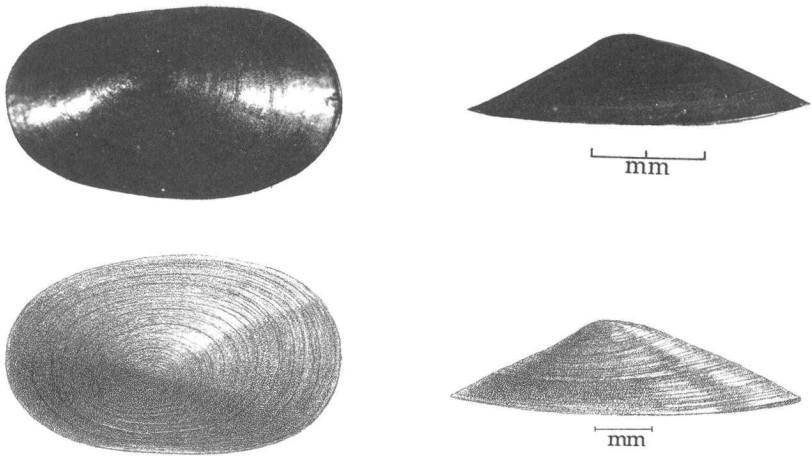


FIG. 76. Shells of *Laevapex fuscus*, top and side views. The anterior ends are on the right.

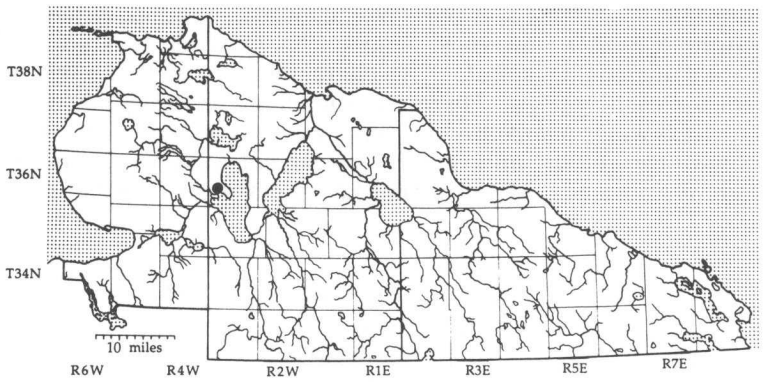
Animal: The dorsal mantle is moderately to heavily pigmented with melanin granules, but the granules are generally sparser toward the mantle margins and mantle apex. Between the two anterior adductor muscles and the right anterior and posterior adductors are patches of unpigmented spots (adhesive epithelium?). The sides of the foot and head are faintly pigmented, or devoid of melanin pigment. The pseudobranch has two lobes, the lower one possessing folds.

For aspects of internal anatomy, see p. 172 ff., Figs. 109-113.

Habitat: Found on vegetation, submerged twigs, logs, boards and other debris in lentic conditions: ponds, drainage ditches, swamps, shallow areas of lakes and backwaters of streams.

General Distribution: United States and Canada, generally east of the Great Plains; Great Lakes area, Florida and southeastern states; generally absent from mountainous areas (Basch, 1963); west to Iowa, Kansas and Oklahoma (Clarke, 1973, *Malacologia*, 13, p. 475).

Distribution in UMBS Area: **Cheboygan Co.:** beach pool at mouth of Maple River, Burt Lake, Creaser, 7 August 1921, Bryant Walker Collection, UMMZ 100473.



MAP 45. Localities of *Laevapex fuscus*.

Remarks: At the beginning of North American malacology, all freshwater limpets were assigned to the European genus *Ancylus* simply because of their limpet-shaped shells. Later, Walker (1903, *Nautilus*, 17(2), p. 15), noting the differences in the shells of ancylids from the two continents, especially their apices, named two new "sections" for North America, *Ferrissia* and *Laevapex*. *Ferrissia* was named after James H. Ferriss, and *Laevapex* means literally "smooth apex." The section *Ferrissia* was later raised to generic status, with *Laevapex* as a subgenus (*e.g.*, see Walker, 1918, *Misc. Publ. Mus. Zool. Univ. Mich.*, (6), pp. 118, 120). Basch (1959, *ibid.*, (108), pp. 1-56) raised *Laevapex* to full generic status because of its anatomical peculiarities.

APPENDICES

IDENTIFICATION AND MORPHOLOGY

Shell Morphology

All freshwater snails possess a shell, which is a hard, calcareous structure that covers the soft parts of the animals' bodies, providing protection (Fig. 77). In most snails, the shell is twisted in a continually increasing spiral. The characteristics of this shell are different for each species. Therefore, the characters (Fig. 78) of the shells of freshwater snails are very important in species recognition and usually for generic and familial placement as well. Especially useful are the adult size (Fig. 79) and the general form (Fig. 80) of the shell.

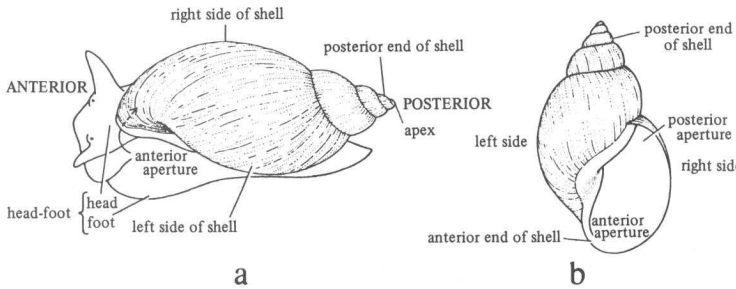


FIG. 77. **a**, An active crawling snail, showing the position and orientation of its protective shell; **b**, the same shell, in apertural view, in which the animal is not shown.

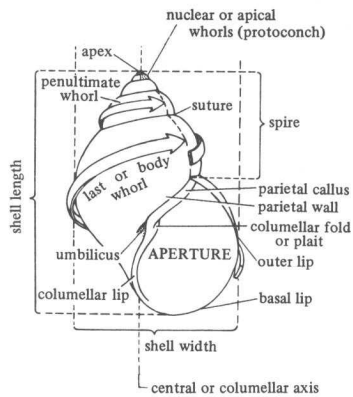


FIG. 78. Shell terminology.

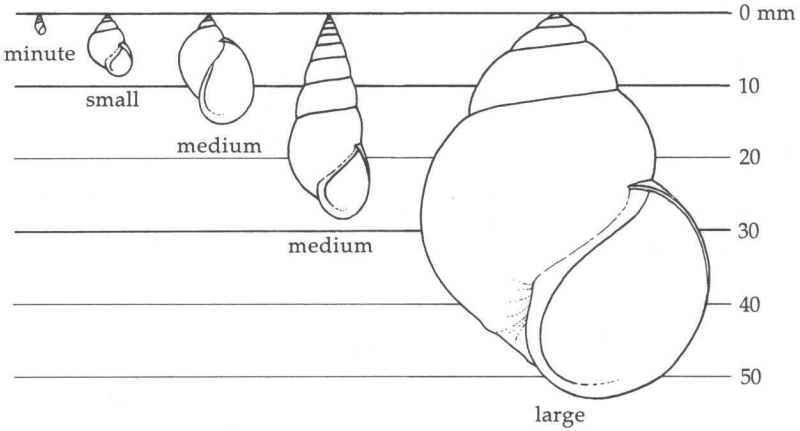


FIG. 79. Shell sizes: up to 3 mm = minute; 3+ to 10 mm = small; 10+ to 30 mm = medium; over 30 mm = large.

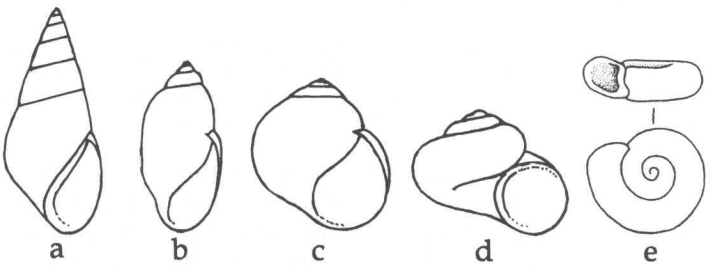


FIG. 80. Shell shapes. **a**, Elongate conic; **b**, elongate cylindrical; **c**, globose; **d**, depressed; **e**, discoidal.

Among the many species, the shell may take various shapes, yet, for any one species, the shell shape is usually quite constant (excepting, of course, individual differences and the minor clinal, populational and ecophenotypic variations exhibited by some species). The shells among the various species may vary from very elongate (Fig. 80a) to nearly globose (Fig. 80c), depressed (Fig. 80d) and discoidal (Fig. 80e). The shell may be longer than wide (Figs. 80a,b) or wider than long (Fig. 80d) [the columella determining the anteroposterior shell axis].

Because of the spiral direction and the constantly increasing diameter of the whorls during the snail's growth, shells with an everted spire have a conical shape. This shape may be expressed as a spire angle (Fig. 81) and the different shapes relating to the different angles can be named to facilitate communication about shell shapes.

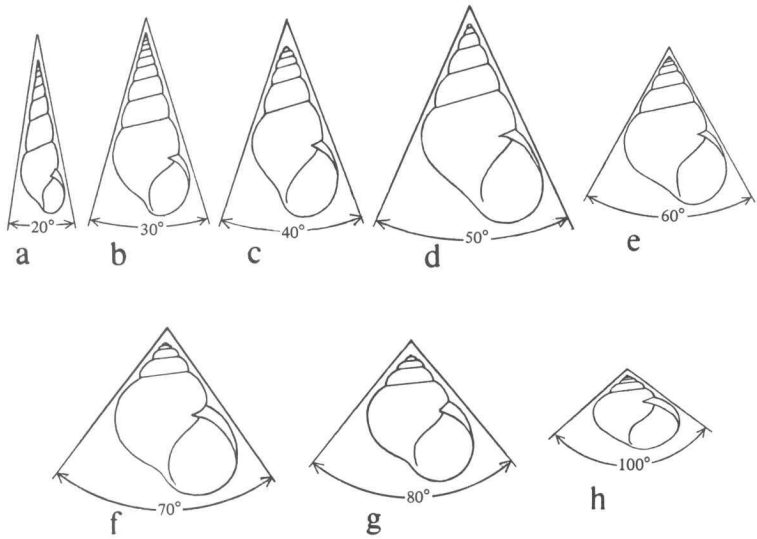


FIG. 81. Terminology of conical shells. The degrees of the various spire angles are given below each shell. **a**, Narrowly conic; **b**, elongately conic; **c**, narrowly subovately conic; **d**, subovately conic; **e**, ovately conic; **f**, subglobosely conic; **g**, globosely conic; **h**, widely (depressed) conic.

The shell's coil (whorls) may turn either to the left (Fig. 82a) or to the right (Fig. 82b), be round (Fig. 83a), angular (Fig. 83b), flattened (Fig. 83d), or shouldered (Fig. 83c) and may have shallow (Fig. 84a) or impressed sutures (Fig. 84b). The shell may have few (Fig. 85a) or many (Fig. 85b) whorls, may lack an opening (umbilicus) at its "base" (Fig. 86a), or may have either a narrow (Fig. 86b) or relatively wide (Fig. 86d) opening. The columella or central axial column of the shell may be straight (Fig. 87a) or twisted (Fig. 87b). The outer margin of

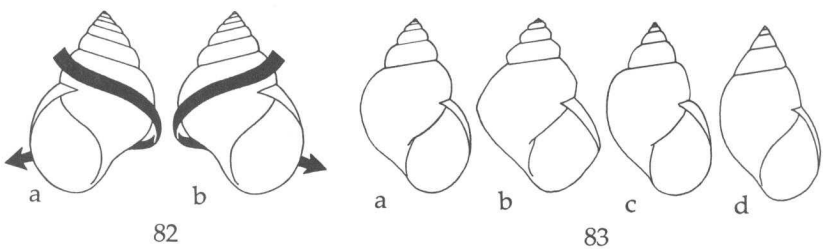


FIG. 82. Direction of coiling of snail shells. **a**, A shell coiled to the left, *i.e., sinistral;* **b**, shell coiled to the right, *i.e., dextral.* FIG. 83. Shell terminology. **a**, Shell with well-rounded whorls; **b**, shell with angular whorls; **c**, shell with shouldered whorls; **d**, shell with flattened whorls.

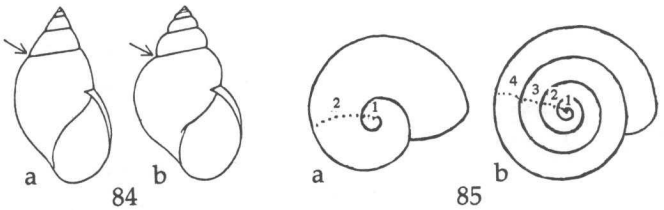


FIG. 84. Shell suture terminology. **a**, Shallow sutures; **b**, indented or impressed sutures. FIG. 85. **a**, Shell with few rapidly increasing whorls; **b**, shell with many, slowly increasing whorls. The dotted lines on the whorls illustrate the method of counting whorls; the shell in **a** has 2½ whorls; the shell in **b** has 4½ whorls.

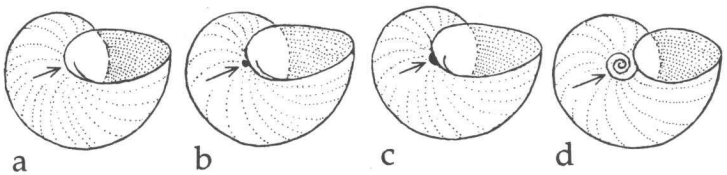


FIG. 86. Shell characters. **a**, Imperforate shell; **b**, perforate shell; **c**, rimately perforate shell; **d**, umbilicate shell.

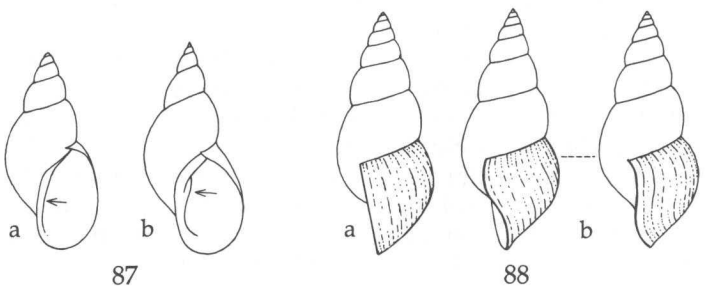


FIG. 87. Shell characters. **a**, Straight columella; **b**, twisted columella, with plait. FIG. 88. Shell characters. **a**, Straight apertural lip; **b**, curved apertural lips.

the shell aperture in side view may be either straight (Fig. 88a) or variously curved (Fig. 88b). The surface of the shell (Fig. 89) may be marked in various ways, *i.e.*, it may be differentially colored or sculptured, or it may be simply unicolored and smooth. The sculpturing of the shell, *i.e.*, its surface texture, is sometimes almost perfectly smooth, but usually there is a definite three-dimensional pattern that is characteristic for the species. One pattern possessed by nearly all shells, in addition to any other pattern they may have, is a series of close-set, more or less equidistant lines paralleling the shell aperture. These are lines indicating incremental shell growth, and

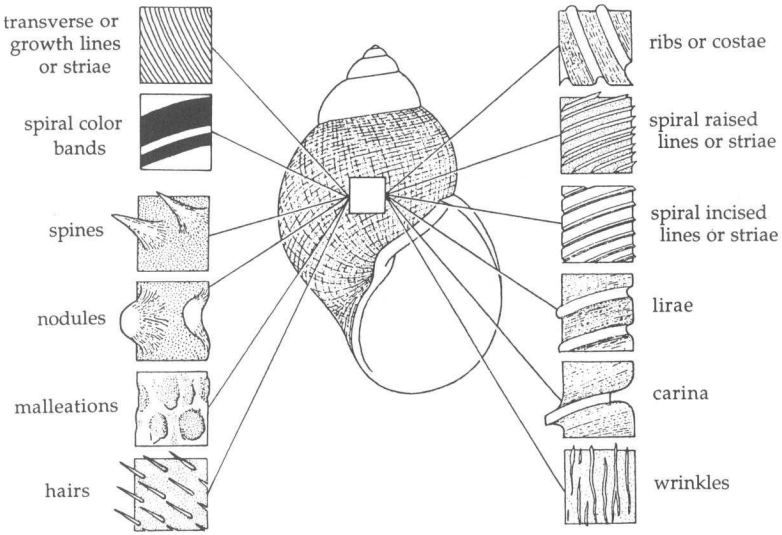


FIG. 89. Shell surface characters.

are most commonly referred to as "growth lines," but also as "transverse lines" or "transverse striae." On the shells of some species, somewhat larger and more noticeable transverse elevations more distantly apart are superimposed on the growth lines. These are called "riblets." When such shell surface structures are even larger and strikingly noticeable, they are called "ribs" or "costae." Similar shell surface elevations running perpendicular (*i.e.*, in the direction of the shell's spiral) to the growth lines are called "lirae." When such surface structures are exceptionally large and reduced in number to one or several, they are called "carinae." Small and fine spiral lines are called "spiral lines" or "spiral striae," and may be either raised or incised. Other shell surface sculpture may consist of wrinkles, malleations, hairs, spines or nodules. (Especially useful in viewing the very fine sculpture of snail shells is the scanning electron microscope (SEM). Such fine sculpture is often difficult to see clearly with light microscopes.)

The outline of the shell aperture may take various forms due to the shape and relation of the whorls to each other. The aperture may or may not be closed by an operculum (see Fig. 1). The operculum also has important recognition characters (see Fig. 3). It may be round, oval or spindle-shaped, and its growth lines spirally (Fig. 3a,b) or concentrically (Fig. 3c) arranged.

Freshwater gastropods with cap-shaped shells that have lost their coiled nature would seem certainly to have evolved because of

the need to have a more hydrodynamic contour necessary to withstand strong water currents, which would tend to dislodge higher shells with more drag. (Once the cap-shaped shells evolved, some of the "limpets" invaded lentic, quiet-water habitats.) The simple shape of the ancylid shell offers fewer taxonomic characters than does a coiled shell, but the general contour of the ancylid shell, the position of the apex, and the microsculpture, especially of the apex, are useful in taxonomy and species recognition.

Soft Anatomy

External Anatomy

Shelled snails have a peculiarly coiled body with asymmetrically arranged visceral organs. Because of the coiled body, most snails have a coiled shell, which exhibits spiral symmetry. However, in the limpet-shaped aquatic gastropods, the shell has lost its spiral form and may be more or less bilaterally symmetrical (Fig. 5). External aspects of the head and foot may appear to be bilaterally symmetrical as well (Fig. 74), but the internal organs nevertheless display the typical asymmetry of gastropods. This asymmetry of the gastropods makes dissection difficult for beginning students of molluscan anatomy and taxonomy.

When a shelled snail is active, the head and foot protrude from the shell aperture, while the visceral mass remains within the shell. Nearly all snails can withdraw their head-foot into the shell (Figs. 1, 2) when disturbed or during unfavorable climatic periods. This withdrawal is accomplished by the contraction of the columellar muscle, which is formed by a coalescence of muscle fibers from the foot which attach to the shell's columella. In a coiled shell, the columellar muscle insertion is the only attachment of the snail's body to the shell. In operculated snails (*i.e.*, mostly the prosobranchs), the operculum, which is attached to the posterior dorsal surface of the foot, reaches the peristome last when the snail withdraws and thus effectively seals the shell aperture (Fig. 1b).

In gastropods, the foot is a wide, dorsally convex and ventrally flat, muscular organ, covered with a tough skin containing numerous mucous glands. The integument is generally pigmented by melanin granules, especially on the dorsum and sides.

The head may be rather well separated from the foot in prosobranch snails, but in pulmonate snails it is not externally delimited from the foot (hence the term "head-foot" is often applied to these two combined structures in pulmonates). The head bears two tentacles in freshwater snails; at the base of each of the tentacles is

an eye. The tentacles are tactile sensory structures, and may vary from one taxon to another in degree, color and arrangement of pigment, in shape, in bluntness of the tip, in length, and in possession and arrangement of surface ciliation.

Externally, gastropods have a number of orifices for various of the organ systems. These openings are the mouth, anus, mantle cavity or

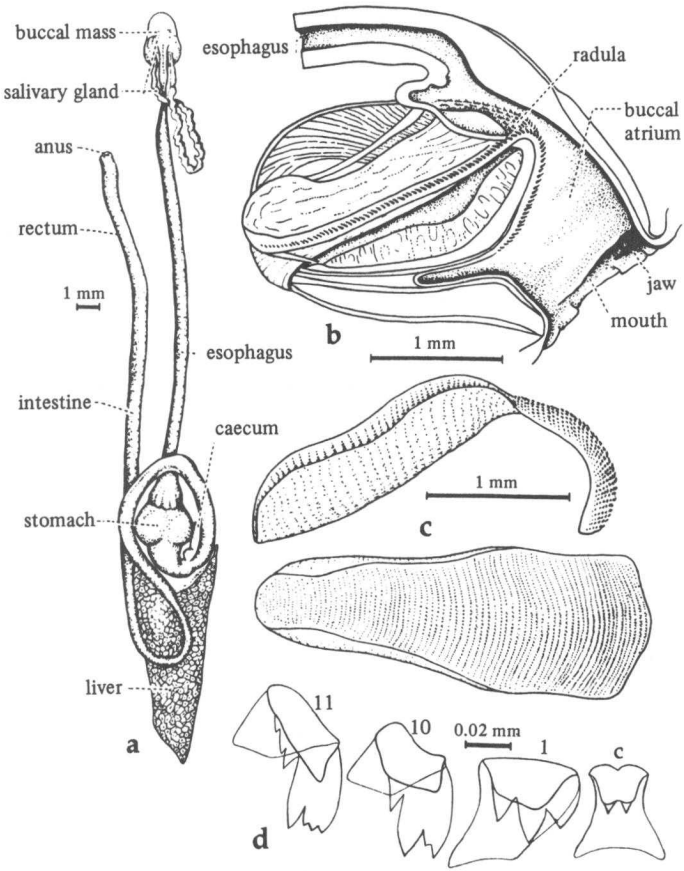


FIG. 90. The radula of a planorbid snail and its relation to the alimentary system. **a**, The alimentary system, mainly dorsal view; **b**, longitudinal section through the buccal mass, showing the orientation of the radula as viewed from the right side; **c**, right side and dorsal views of the radula; **d**, four teeth from one transverse row of the radular ribbon; c = central tooth, 1 = 1st tooth (a lateral tooth) to the side of the central tooth; 10, 11 = 10th and 11th teeth (marginal teeth) to the side of the central tooth. From Barbosa *et al.* (1968, Pan. Am. Hlth. Org., Pan Am. Sanit. Bur., Washington, D. C., Sci. Publ., (168), pp. 1-122), after Demian.

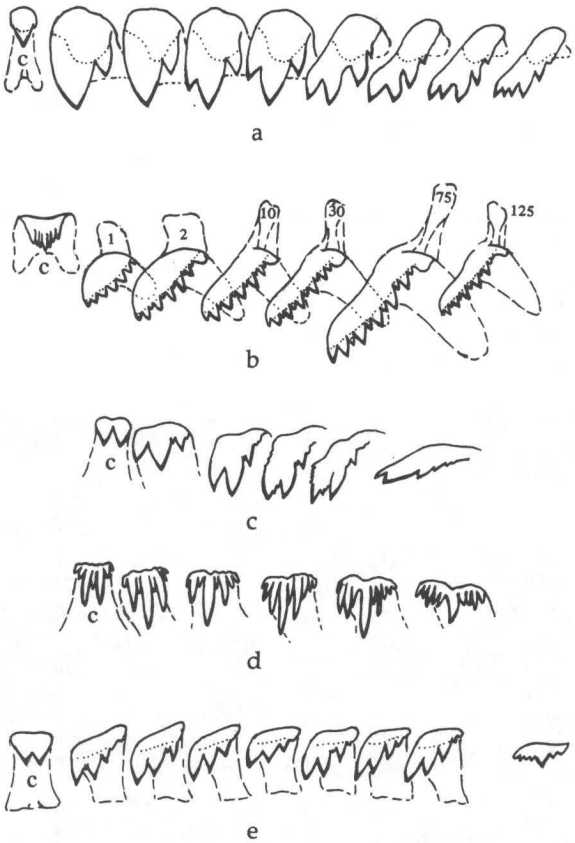


FIG. 91. Radulae of some pulmonate snails. **a**, Lymnaeidae; **b**, Physidae; **c, d**, Planorbidae; **e**, Ancylidae. c = central tooth; numbers refer to vertical rows of radular teeth counted distally from the median row of central teeth. Fig. a adapted from F.C. Baker (1928); Fig. e adapted from Basch (1963).

pulmonary cavity, the nephridiopore and the male and female reproductive openings. The mouth may be little more than an opening in the head, but in many snails it is placed at the end of a rather long antero-ventrally directed proboscis or "snout." This snout is especially noticeable in the prosobranchs (Figs. 4, 94a). In the pulmonates, the proboscis is much shorter.

The mouth of gastropods is at the anterior end, medially placed on the ventral side, as would be expected. However, the other end of the digestive tract, the anus, is not located posteriorly, but, because of torsion, is placed anteriorly. Near it are the nephridiopore and,

on the side of the foot, the female gonopore. The male opening in pulmonate snails is on the head-foot, near one of the tentacles (*e.g.*, see Figs. 102a, 104a, 109b). Torsion also brings the mantle cavity and its external opening forward. Except for the medially placed mouth, the side of the body on which these various openings are located depends on the direction of coiling of the snail. The openings are on the right side in dextral snails and on the left side in sinistral snails (see Fig. 7).

The external characteristics of the snails' bodies are useful in identification and are often especially pertinent in classification. For example, among the prosobranchs, the Valvatidae have two structures lacking in other North American freshwater operculates

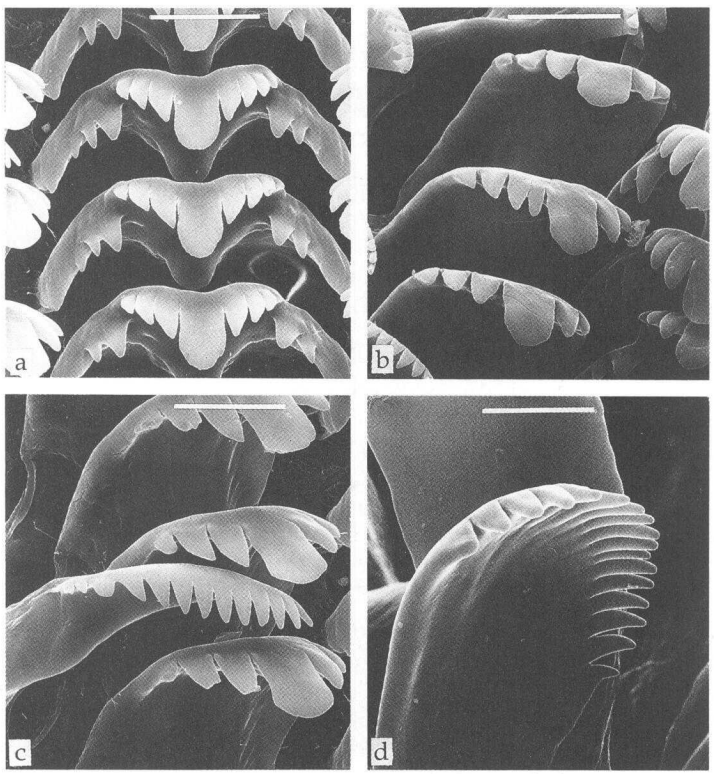


FIG. 92. SEM photographs of radular teeth of an operculate snail, *Amnicola limosus*. **a**, central teeth (scale bar = 20.0 μm); **b**, lateral teeth (scale bar = 17.6 μm); **c**, lateral and inner marginal teeth (scale bar = 17.6 μm); **d**, outer marginal tooth (scale bar = 5.0 μm). (From Hershler & Thompson, 1988.)

(Fig. 4): an externally protruding bipectinate gill and a mantle tentacular appendage. In the Valvatidae, an external penis is located on the head under the right tentacle. In other North American freshwater prosobranch snails, the penis, when present, is located elsewhere. In the Viviparidae, each male has a noticeable thickened right tentacle, that functions as a modified penis. In the Hydrobiidae (Fig. 15a), the males have a large external male organ located dorsally behind the head. Males in the Pleuroceridae (Fig. 99a) lack male intromittent organs.

The pigmentation patterns of the mantle in the Hydrobiidae often have distinctive specific patterns. But especially useful for taxonomic recognition in the Hydrobiidae are the external male copulatory organs, the verge and penis, which are distinctive for

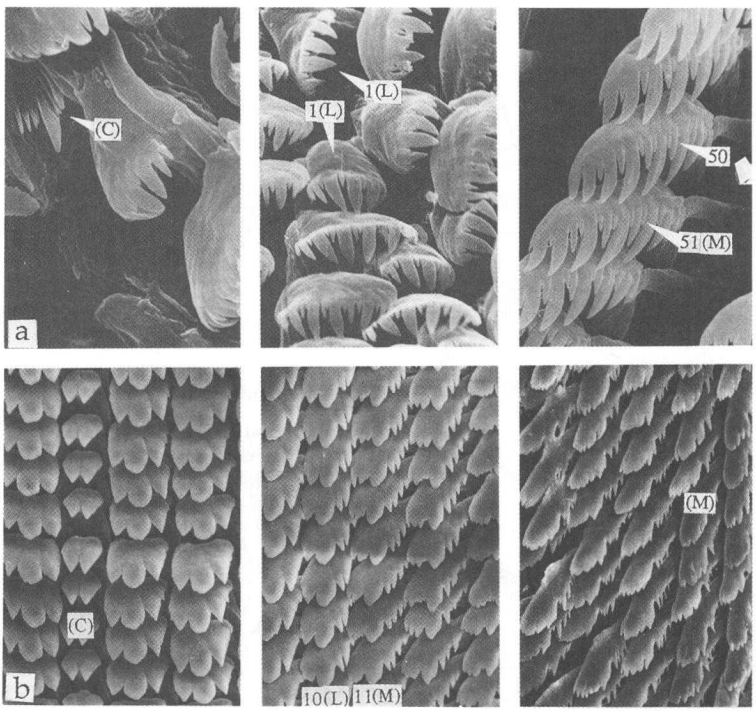


FIG. 93. SEM photographs of radular teeth of two pulmonate snails. **a**, *Physa gyrina* (Physidae); **b**, *Planorbella trivolvis* (Planorbidae). (C) = central tooth; (L) = lateral tooth; (M) = marginal tooth; 1 = a tooth of the 1st vertical row [counted distally from the central tooth]; 50 = tooth of the 50th vertical row; etc. Fig. a is from Te & Mardinly (1974, *Malacol. Rev.*, 8: 119). Fig. a, ca. x1660; Fig. b, ca. x595.

many of the genera, and can be used also to recognize subfamilies. In some hydrobiid groups, such aspects of the external soft anatomy are *essential* for identification, because the various taxa in these groups have shells that are relatively uniform or have few distinctive characteristics. In groups such as these, identification is very difficult for samples in which only empty shells are available. In these cases, tentative identification can be aided by taking into account the known distributions of the various species, and by making especially careful observations of shell characters. Hydrobiid snail identification in the UMBS area is simplified by the few (only three) species found there.

Among the pulmonates in the UMBS area, most Planorbidae and the Ancylidae have pseudobranchs (false gills) (*e.g.*, see Fig. 109),

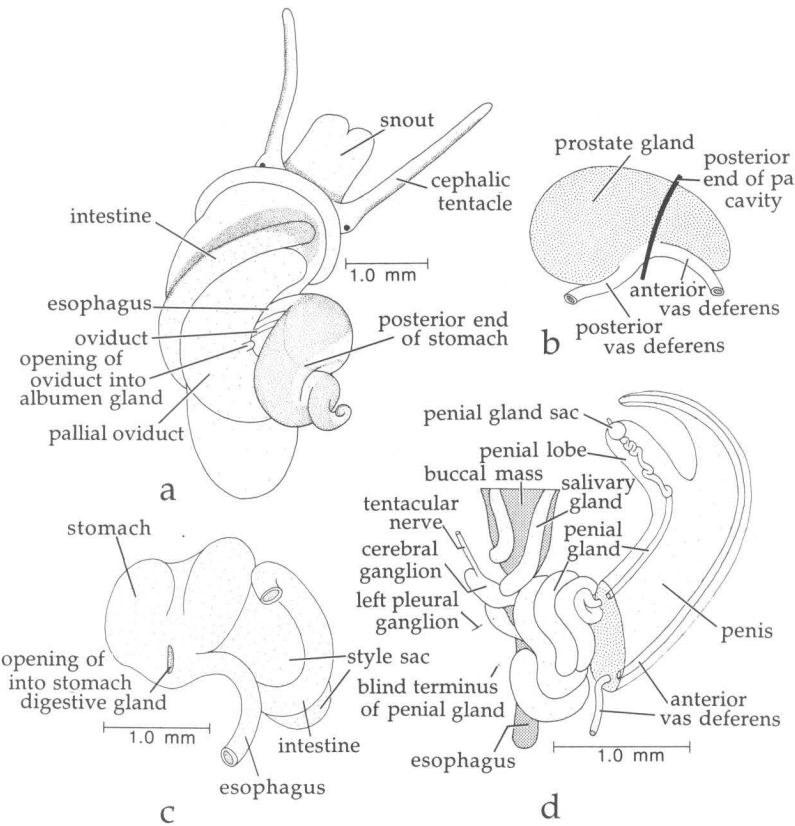


FIG. 94. *Amnicola limosus.* **a**, Dorsal view of a female; **b**, right lateral aspect of prostate gland; **c**, right lateral aspect of stomach; **d**, dorsal view of penis and contents of nuchal cavity. (From Hershler & Thompson, 1988.)

but the Lymnaeidae and Physidae do not; the lymnaeids have broad, flat, triangular tentacles (see Figs. 39, 100), while the tentacles of members of the other freshwater pulmonate families are filiform; all Physidae, except *Aplexa*, have mantle digitations or lobes (Fig. 53), while the mantle border is smooth in all members of the other pulmonate families; and the Ancylidae have a simple, non-coiled body (and shell).

Since there is no longer a columella in the cap-shaped ancylid shell, the columellar muscle attachments have moved to the shell surface, and in more advanced limpets (*e.g.*, *Ferrissia* and *Laevapex*) the shell attachment muscle is divided into three major sections, with two main attachment points on each side of the mantle anteriorly and one near the posterior left side of the mantle (Fig. 74).

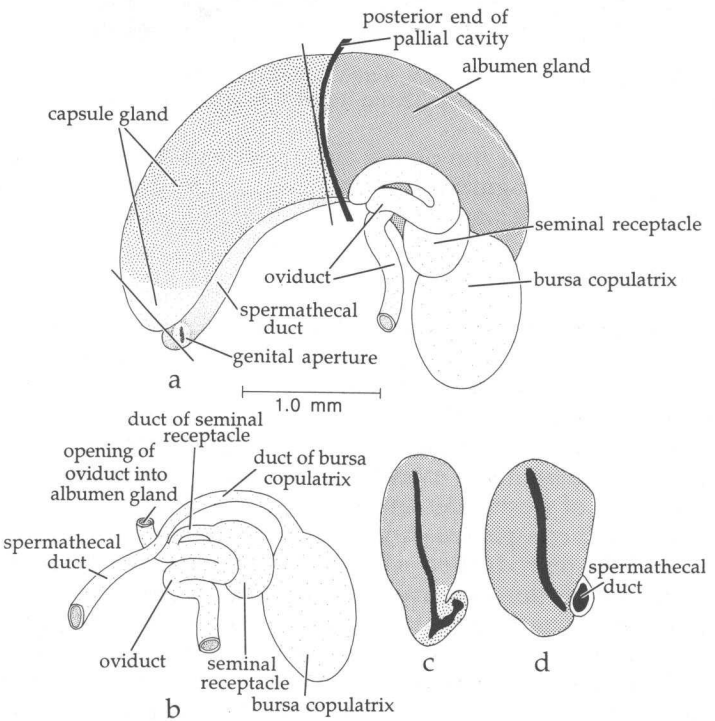


FIG. 95. *Amnicola limosus*, female reproductive anatomy. **a**, Left lateral aspect of pallial oviduct complex, with dark lines through capsule gland showing positions of thin sections in **c** and **d**; **b**, same view as **a**, with pallial oviduct removed and oviduct coil rotated ventrally; **c**, **d**, sections from anterior and posterior ends of capsule gland. (From Hershler & Thompson, 1988.)

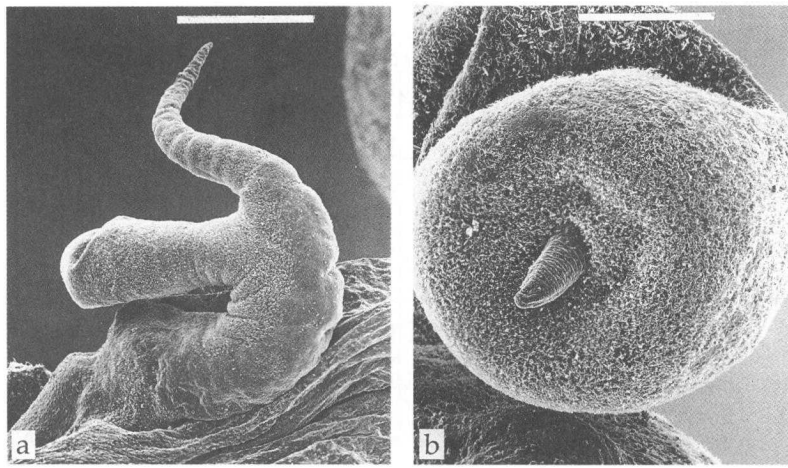


FIG. 96. *Amnicola limosus.* **a**, Verge; **b**, distal end of penial lobe, showing the simple terminal opening. (From Hershler & Thompson, 1988).

The arrangement of the dorsal shell adductor muscles have some value in generic recognition, and mantle pigmentation patterns may be useful in species recognition.

Internal Anatomy

In some families, characters of the internal soft anatomy are important in classification, and often identification as well, because the shells of various of the lower taxa do not exhibit clearly any distinguishing features. For this reason, it is of some practical value to be familiar with the organ systems of freshwater snails. Also, a knowledge of anatomy is essential in studying various other aspects of the biology of freshwater snails.

The two most conspicuous organ systems in a snail are the digestive system and the reproductive system. Together, the two systems make up the greater portion of a snail's body mass. In the digestive system, the mouth opening leads into a short buccal atrium, the pharynx or oral cavity (Fig. 90). The alimentary tract then expands into a relatively large, highly muscular buccal mass, which contains the radula, radular sac, jaw and odontophoral cartilage. Salivary ducts open into the oral cavity near the radular sac. Leading posteriorly from the buccal mass is the esophagus, a long, narrow tube that leads to the stomach. Running along side the esophagus are the salivary glands.

In freshwater pulmonate snails, the stomach consists of an anterior expanded crop, a large bulbous gizzard, and a posterior pylorus (see

Fig. 101). The crop is a vestibule for food accumulation before it passes into the gizzard. The gizzard is a highly muscular organ for grinding food. The pylorus is a short expansion of the alimentary tube between the gizzard and the intestine. Into the posterior pylorus

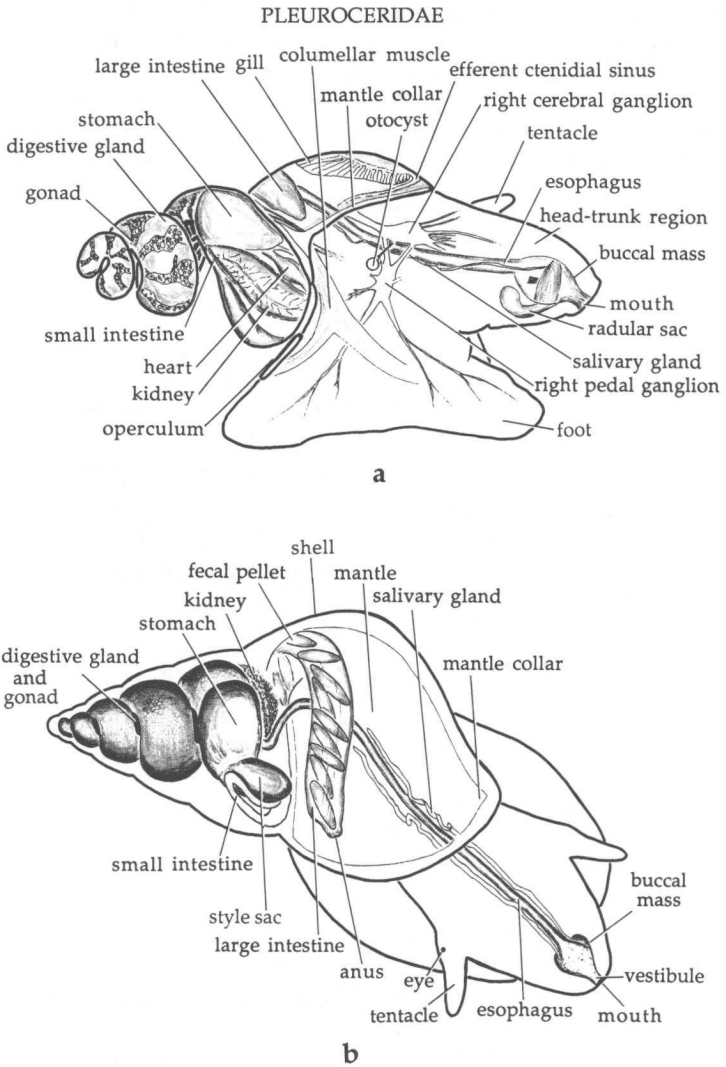


FIG. 97. *Elimia livescens.* **a**, Lateral view, right side; **b**, digestive system, dorsal view. (From Dazo, 1965.)

empty the ducts from the digestive glands. Leading from the posterior pylorus is a small, short pocket, the cecum. The pylorus leads into the pro-intestine, at the beginning of which is a relatively thin-walled cavity, the atrium. After the atrium, the prointestine continues a short distance to the muscular pellet compressor. Between the atrium and pellet compressor, the intestine has a large inner fold, the typhlosole. From the pellet compressor to the rectum, the intestine is a long, relatively thin-walled tube. This part of the intestine lacks a typhlosole. The terminal section of the digestive tract is the rectum. It is thick-walled, and apparently glandular. The anus is located near the posterior mantle collar, close to the

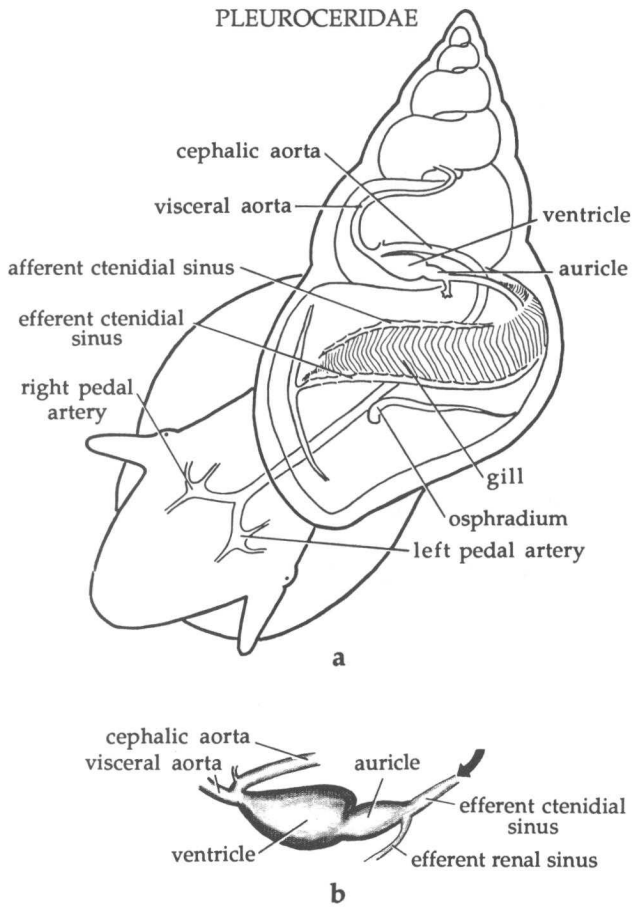


FIG. 98. *Elimia livescens.* **a**, Circulatory system; **b**, heart. (From Dazo, 1965.)

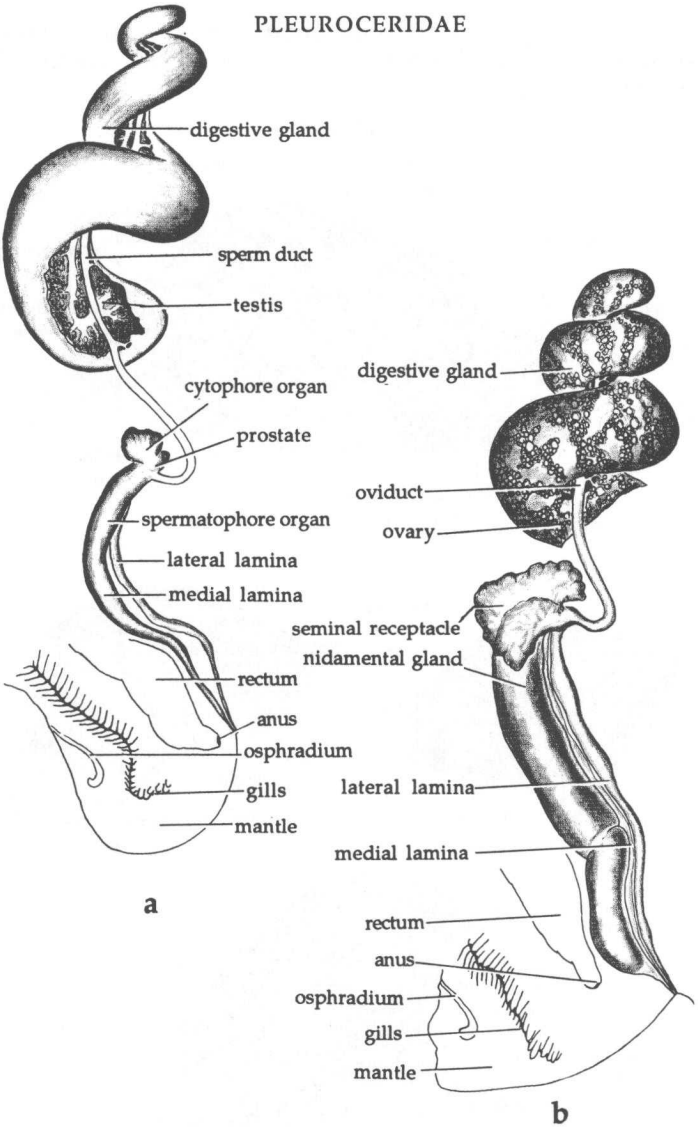


FIG. 99. *Elimia livescens.* Reproductive system. **a** Male; **b**, female. (From Dazo, 1965.)

pneumostome.

The digestive tract of prosobranch snails is, in general, similar to that described above, except in place of the cecum is a large sac (Figs.

94c; 97b) containing the crystalline style. The crystalline style aids in digestion mechanically by grinding food, and chemically by releasing an enzyme.

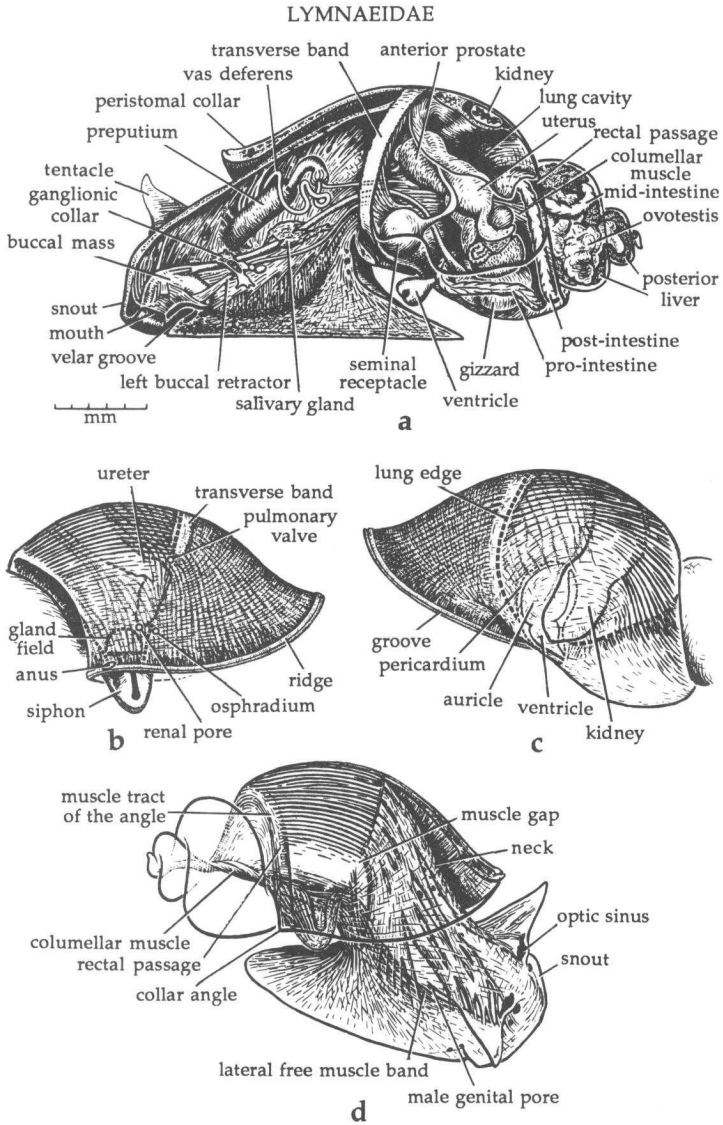


FIG. 100. *Stagnicola emarginatus.* **a**, Section through left side, showing organs; **b,c**, right and left sides of lower mantle and underlying structures; **d**, musculature. (From Walter, 1969.)

The radula (Fig. 90b,c), and particularly its teeth (Figs. 90-93), both part of the buccal apparatus and essential for feeding, are also useful in identification and classification. The radula is especially valuable at the ordinal and often the familial levels of classifica-

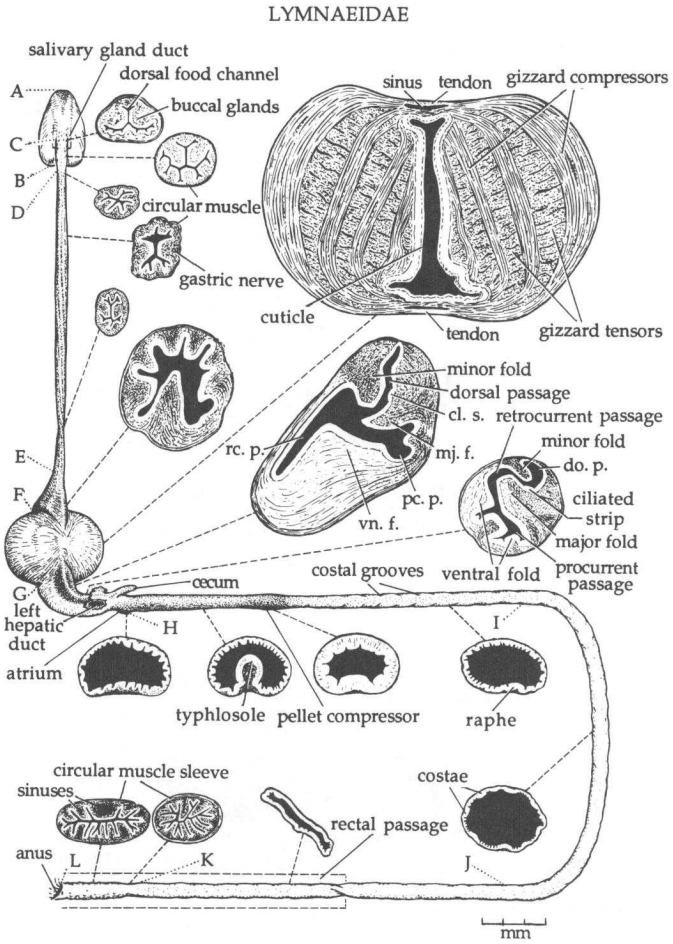


FIG. 101. *Stagnicola emarginatus.* Digestive tract. The liver lobes and the salivary glands are omitted. A to B = buccal mass; C to D = proesophagus; D to E = postesophagus; E to F = crop; F to G = gizzard; G to H = pylorus; H to I = prointestine; I to J = midintestine; J to K = postintestine; K to L = rectum. cl.s. = ciliated strip; do.p. = dorsal passage; mj.f. = major fold; pc.p. = procurrent passage; rc.p. = retrocurrent passage; vn.f. = ventral fold. (From Walter, 1969.)

tion, and it is useful in the lower systematic categories as well. As with fine sculpture of the shell, the scanning electron microscope is especially useful for clearly distinguishing characteristics of the microscopic radular teeth (Figs. 92, 93).

The reproductive system of a gastropod accounts for a significant part of its body mass, especially during reproductively active periods. Prosobranch snails generally are monosexual, individuals being either female or male. Sexual dimorphism occurs in many freshwater species, but, other than the presence or absence of the obvious external male intromittent organ, the dimorphism is confined

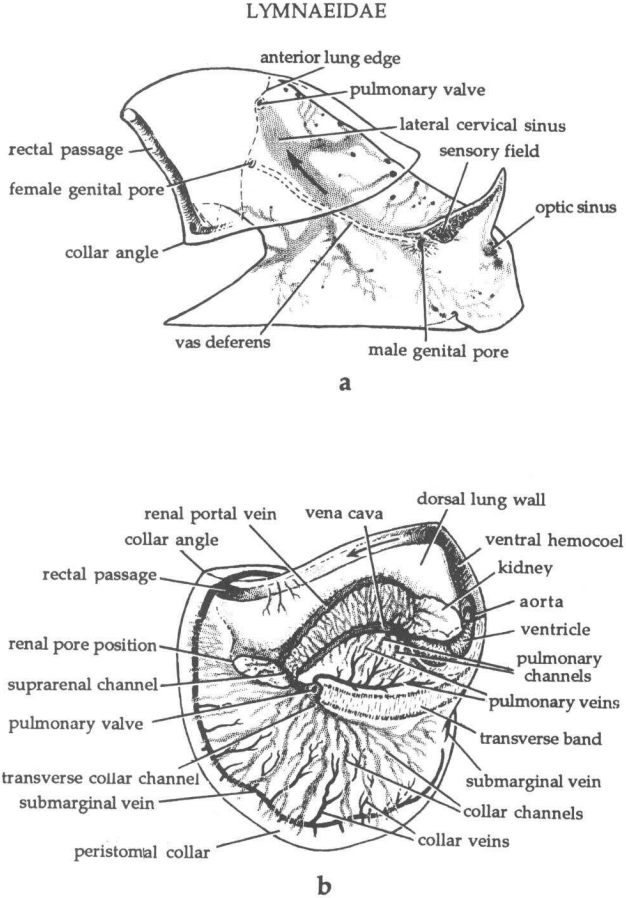


FIG. 102. *Stagnicola emarginatus.* **a**, Venous pathways in the wall of the anterior part of the animal; **b**, venous sinuses in the peristomal collar, roof of the lung and kidney. (From Walter, 1969.)

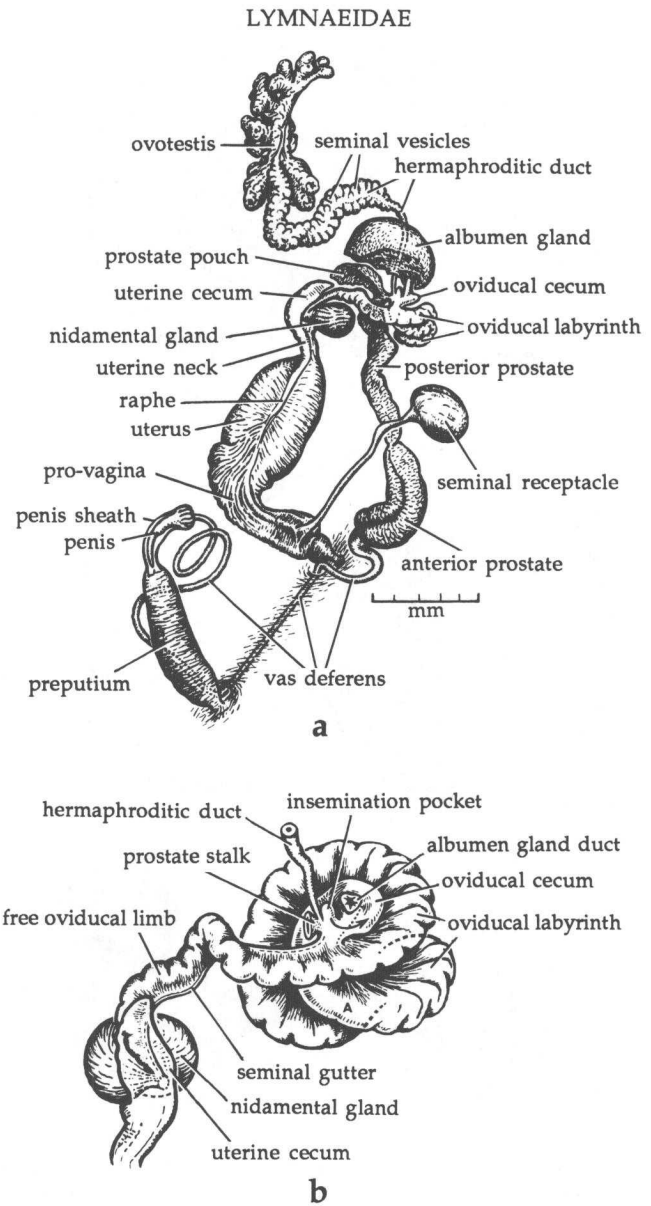


FIG. 103. *Stagnicola emarginatus.* **a**, Reproductive system; **b**, the carrefour complex and adjacent portions of the oviducal and uterine divisions of the female tract. (From Walter, 1969.)

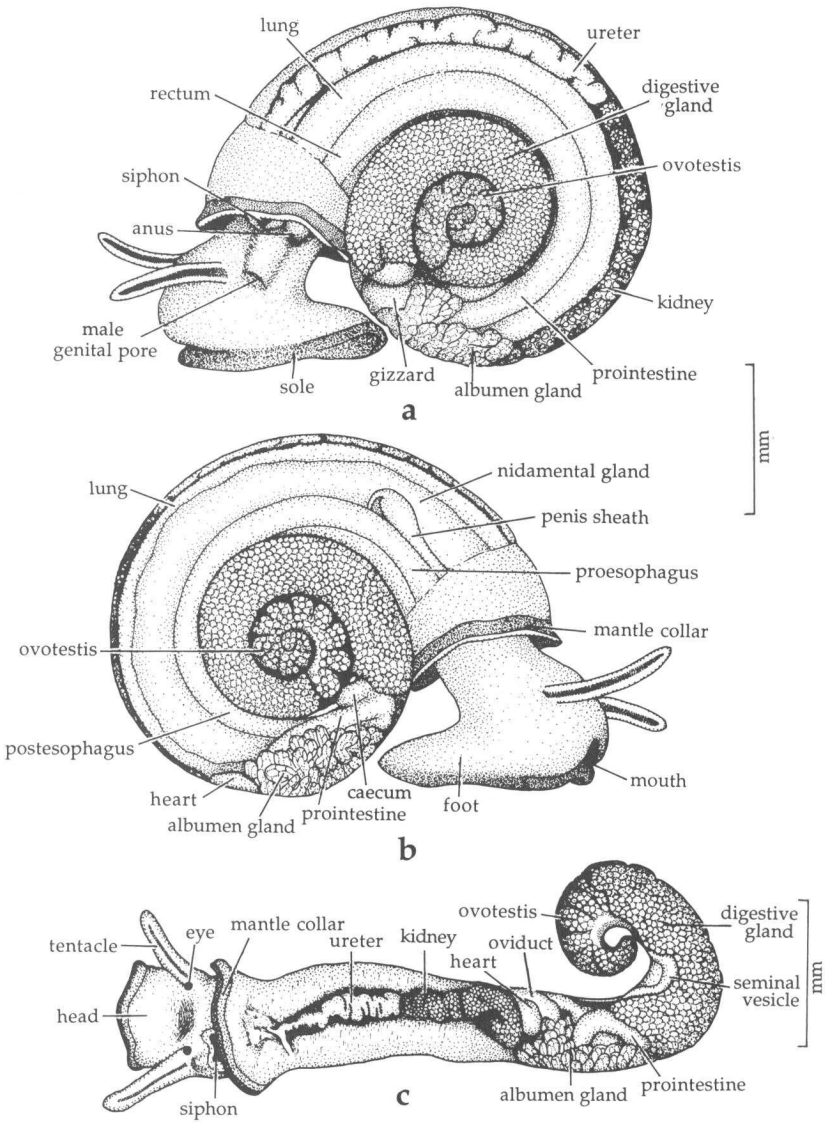


FIG. 104. *Gyraulus circumstriatus.* Gross anatomy (*in situ* with shell removed) showing the typographic placement of organs. **a**, Spire side; **b**, umbilical side; **c**, dorsal view of animal mostly uncoiled.

mainly to size, females in some species being somewhat larger than males.

The snail's primary sex gland, the gonad, is located posteriorly or apically in the visceral mass, and generally is covered by or embedded in the digestive gland. The male gonad, the testis, produces great numbers of male sex cells, spermatozoa (sperm), which are stored until copulation in one or more seminal vesicles in the proximal part of the male tract. During mating, the sperm pass from the seminal vesicle(s) through the sperm duct, past or through the prostate gland and continue on through the narrow ciliated vas deferens to the genital pore for transfer to the female for fertilization. Among the various taxa are many variations in the parts of this basic system. For example, the seminal vesicle may be a single sac-like structure, or it may consist of many acini along the sperm duct, or it may be simply an enlargement of the sperm duct (vas deferens). The prostate gland also may take many forms, and may have a separate duct leading to the vas deferens, or the acini of the gland may empty directly into the vas deferens, or the prostate gland may be simply a glandular enlargement of the sperm duct.

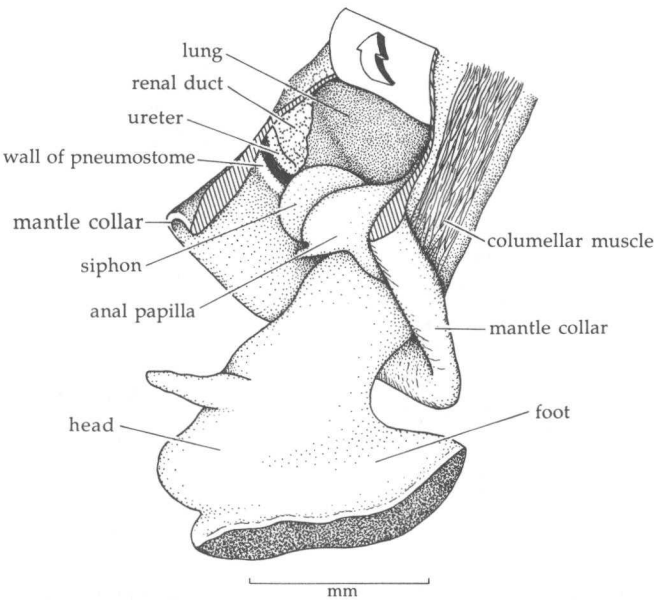


FIG. 105. *Gyraulus huronensis.* Lower body with left mantle collar and lower left mantle cut away to show internal structure.

The male genital pore is usually located at the end of the male intromittent organ, the penis, or, in families where there is no penis (*e.g.*, in the Pleuroceridae), it may be on a small papilla.

The female gonad, the ovary, is generally a lobulate structure lying next to or embedded in the digestive gland. From the ovary leads a duct, the oviduct, for passage of eggs to the outside of the female's body. Various parts of the oviduct are specialized to secrete food material and protective layers to the ovum as it passes down the tract. The first of these accessory structures is the albumen gland, which coats the egg with albumen to nourish the developing embryo. Next distally is either a jelly gland or a capsule gland, which secretes a protective layer. Other specializations of the tract include a bursa copulatrix, which receives the male intromittent organ during copulation, and a seminal receptacle, which is a pouch for storing male sex cells from the mating partner until they are needed for fertilization. The nature of the various parts of the female tract may vary considerably among the various gastropod families.

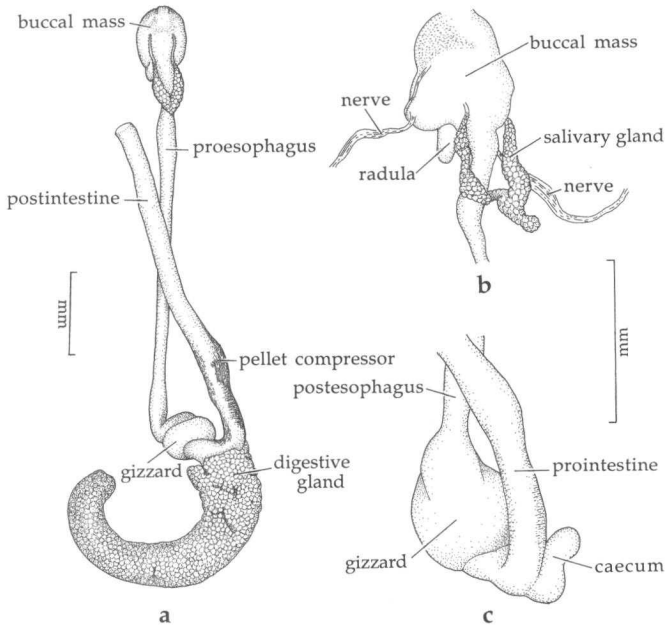


FIG. 106. *Gyraulus circumstriatus.* **a**, Complete alimentary system; **b**, buccal mass and salivary glands; **c**, stomach region.

The Valvatidae differ from the other freshwater prosobranch families in being hermaphroditic. Here the gonad produces both male and female sex cells, and the duct leading from the gonad is a hermaphrodite duct, which allows passage of both types of sex cells.

In *Valvata,* each animal has two genital openings, the male opening at the tip of the penis (Fig. 4) on the head or neck, and the female opening near the entrance into the mantle cavity.

Pulmonate snails are *all* hermaphroditic, and like *Valvata,* each individual has a complete male and female system (*e.g.,* see Figs. 103a; 107a; 113b). The gonad, an ovotestis, is embedded in the digestive gland, or as in the Planorbidae, precedes the digestive gland apically. The hermaphrodite duct also serves as a seminal vesicle, being either enlarged and convoluted, or having outpocketings along its course. Where the genital duct bifurcates into separate male and female tracts, there is a small insemination pocket where fertilization takes place (Fig. 103b). Here the sperm from the male-functioning mating partner, which have travelled up the female tract, meet the ovum, which has just arrived from the ovotestis.

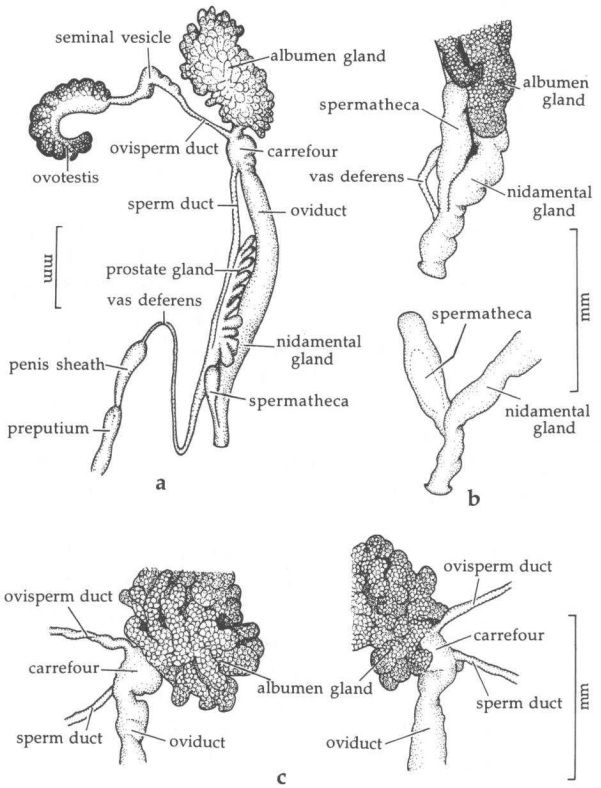


FIG. 107 *Gyraulus circumstriatus.* **a,** Complete reproductive system; **b,** lower female genitalia, umbilical side (top figure), spire side (bottom figure); **c,** carrefour region (part of the albumen gland is shown).

The male system in pulmonate snails consists of a prostate gland (Figs. 103a; 107a; 113b), of differing shapes and construction in different taxa, from which leads a long, narrow, muscular vas deferens. The vas deferens courses through the body wall along the side of the foot (Figs. 102a; 103a) before entering the head-foot hemocoel near the male genital opening. The vas deferens joins the penis, which is also in the hemocoel (Fig. 103a). The penis in freshwater pulmonates is contained in a penis sheath, which connects distally to the tubular preputium (Figs. 103a; 109; 113b). The pre-putium is attached to the body wall at the male gonopore.

Pulmonate snails differ from prosobranchs in carrying the penis internally when not sexually active. The preputium and penis sheath are everted by turgor pressure during copulation, and withdrawn by penial retractor muscles after completion of mating. In some families, the penis and preputium vary considerably between various taxa, in which case these structures are given considerable taxonomic attention (*e.g.*, see Fig. 108).

The female system in pulmonate snails (see Figs. 103a; 107a,b,c; 113b) consists of the albumen gland, nidamental gland, uterus, seminal receptacle (spermatheca) and vagina (that part of the female duct between the opening of the seminal receptacle and the female genital pore).

Freshwater gastropods obtain oxygen by gills (in the Prosobranchia) or by a lung (in the Pulmonata). The gill is usually well hidden within the protective enclosure of the mantle cavity (Figs. 15; 98a). In most of the freshwater prosobranchs, the unipectinate gill is attached to the wall of the mantle cavity and consists of a long series of parallel, often triangularly-shaped, leaflets. In the Valvatidae, the gill is bipectinate, and, when the snail is active, it protrudes to the exterior from the mantle cavity (Figs. 4; 12).

The lung in freshwater pulmonate snails is located in the same general area as the mantle cavity in prosobranchs (Figs. 100a; 104a,b). The surface of the lung is highly vascularized to facilitate O_2/CO_2 exchange. The lung is generally reduced in fresh-water limpets, where oxygen uptake is mainly through other body surfaces. While freshwater pulmonates do not have true gills, two families in the UMBS area, the Planorbidae and Ancylidae (see Fig. 109b,c) have secondarily derived gills, called "pseudobranchs."

The respiratory pigment in nearly all gastropods is hemocyanin, but in the Planorbidae it is hemoglobin, which gives the planorbid body a red appearance (unless the color of the blood is masked by body melanin pigment).

The excretory system of mollusks consists of a metanephridium (kidney) and its duct(s). The kidney is closely associated with both

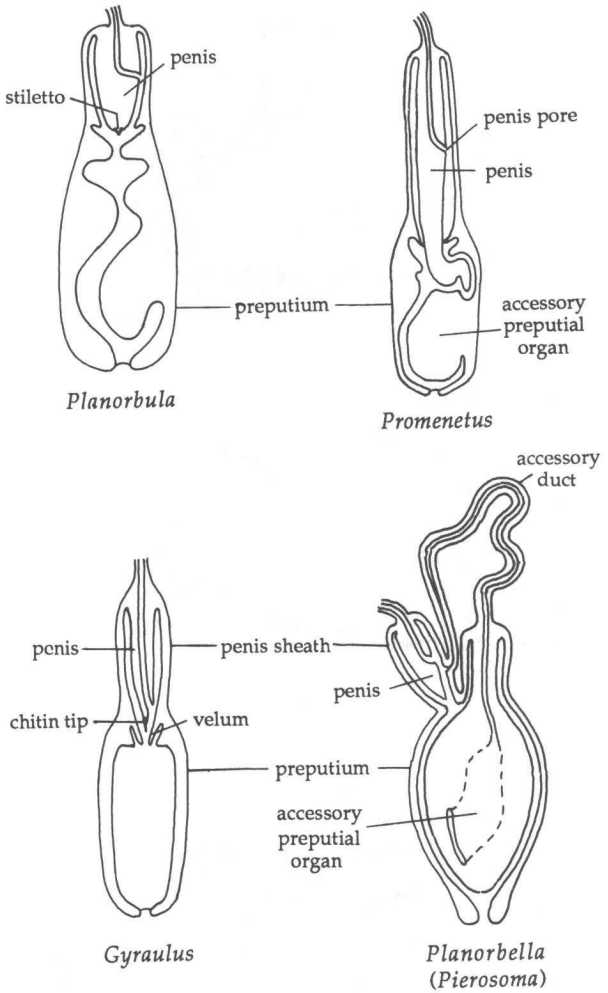


FIG. 108. Diagrammatic sagittal sections of terminal male genitalia of genera of North American Planorbidae (after Hubendick, 1955, *Trans. Zool. Soc. London*, 28(6): 453-542).

the reproductive and circulatory systems. In freshwater gastropods, the kidney lies alongside the pericardium, with its contained heart (Figs. 100c; 102b; 112a).

The peculiarities in the anatomy of freshwater limpets is mainly the result of the compression of the body into the low, obtuse-conical shape, which has some major effects on anatomy. The mantle cavity in freshwater limpets is greatly reduced and the kidney (nephridi-

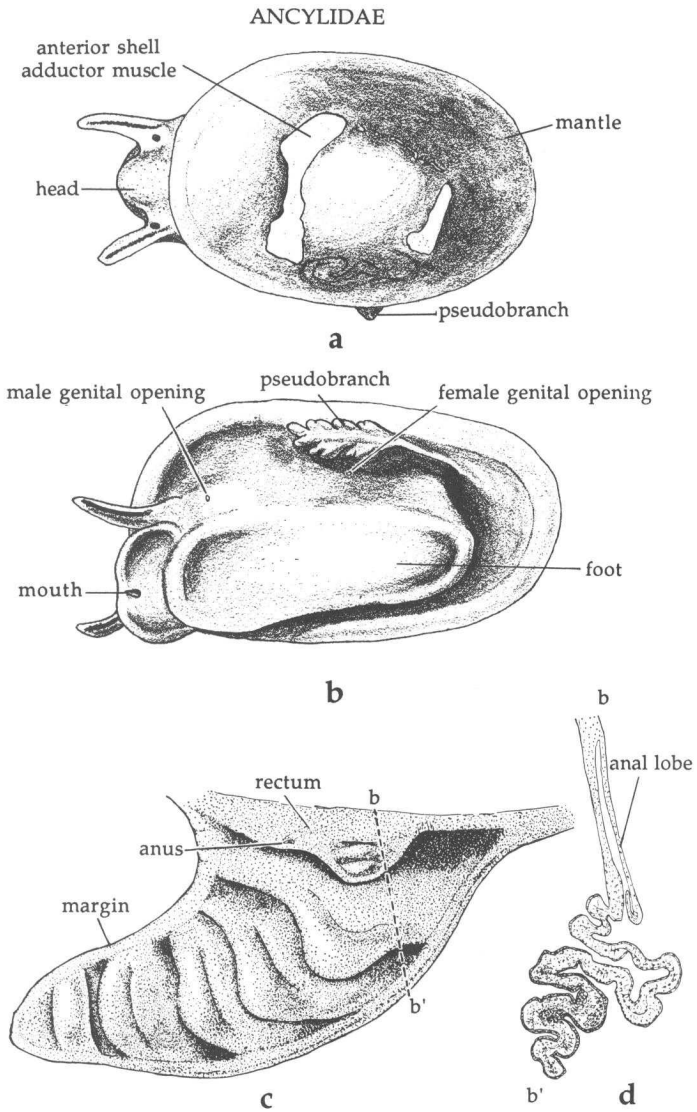


FIG. 109. *Laevapex fuscus.* **a**, Dorsal view; **b**, left oblique ventral view; **c**, pseudobranch; **d**, cross section of pseudobranch at dotted line (b---b') on Fig. c. (From Basch, 1959, *Misc. Publ. Mus. Zool. Univ. Mich.*, (108): 1-56.)

-um) is displaced toward the mantle collar (to the left side in the Ancylidae). In the Ancylidae, the kidney additionally takes on a very convoluted shape (Figs. 112a; 113a).

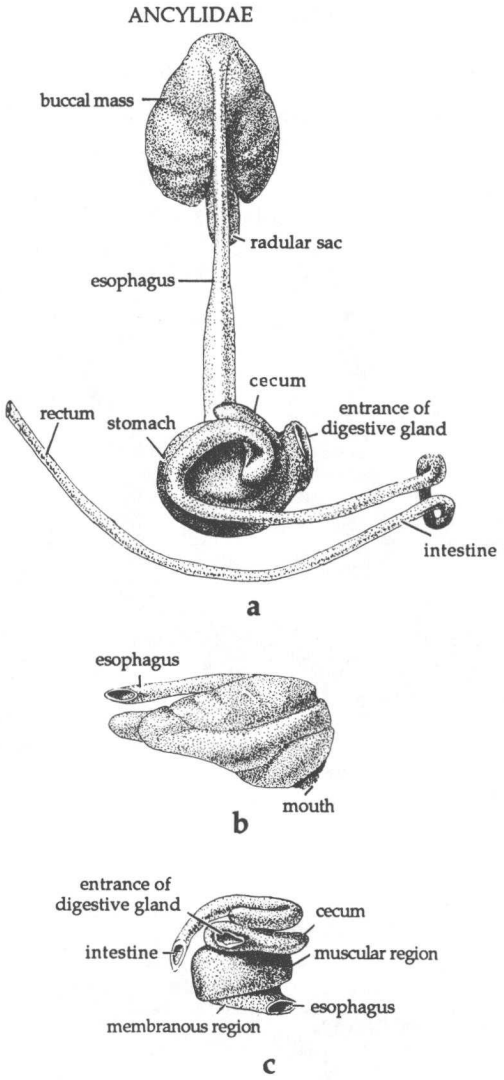


FIG. 110. *Laevapex fuscus.* Digestive system. **a**, Entire system (dorsal view), except for the digestive gland; **b**, buccal mass, right side; **c**, stomach, right side. (From Basch, 1959, *Misc. Publ. Mus. Zool. Univ. Mich.*, (108): 1-56.)

The nervous system in freshwater gastropods (Figs. 97a; 100a; 111) has a concentration of paired nerve centers (ganglia) in the anterior hemocoel. The cerebral ganglia receive nerves from the eyes and ten-

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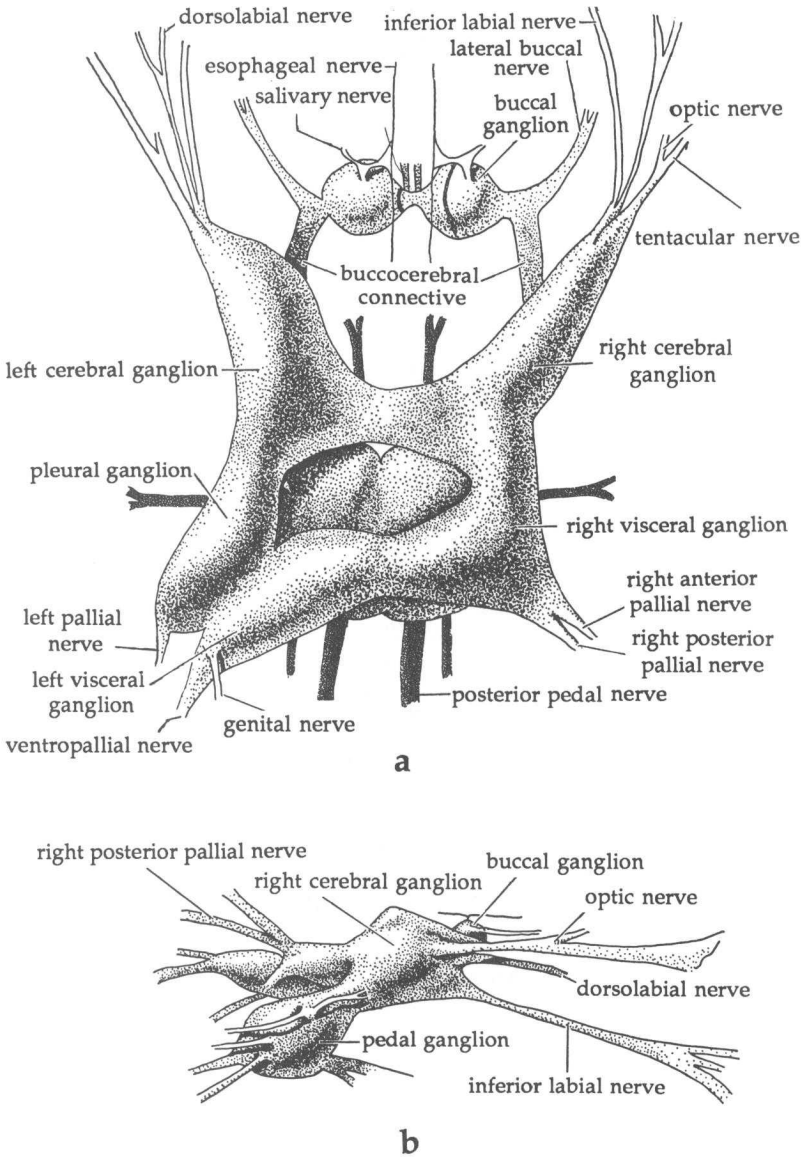

FIG. 111. *Laevapex fuscus.* Brain. **a**, Dorsal view; **b**, right side. (From Basch, 1959, *Misc. Publ. Mus. Zool. Univ. Mich.*, (108): 1-56.)

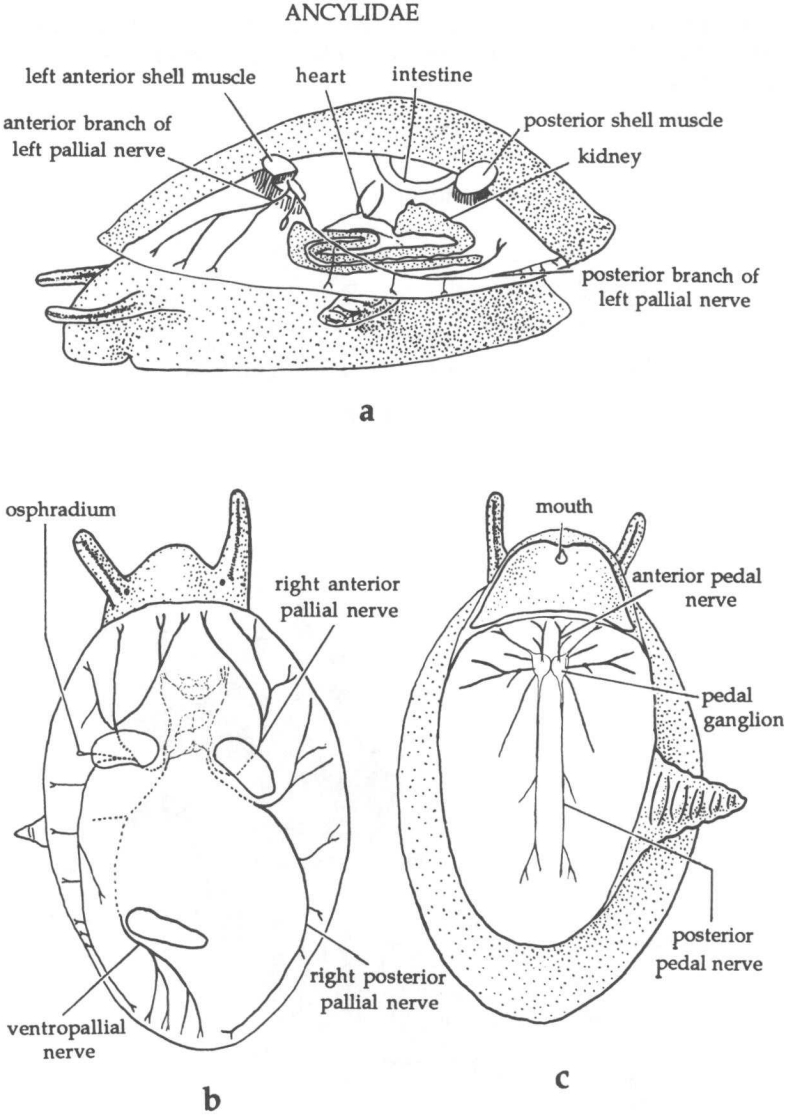

FIG. 112. *Laevapex fuscus.* Nervous system. **a**, Major nerves to left side of mantle; **b**, dorsal superficial nerves; **c**, nerves from pedal ganglia. (From Basch, 1959, *Misc. Publ. Mus. Zool. Univ. Mich.*, (108): 1-56.)

tentacles, the pleural ganglia receive nerves from the body walls, and the pedal ganglia receive nerves from the foot. The cerebral and pleural ganglia are arranged around the anterior esophagus, and the

pedal ganglia are beneath the esophagus. The nervous systems of North American freshwater prosobranchs and pulmonates are basically similar.

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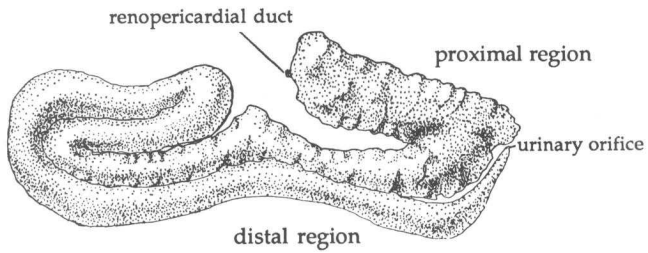
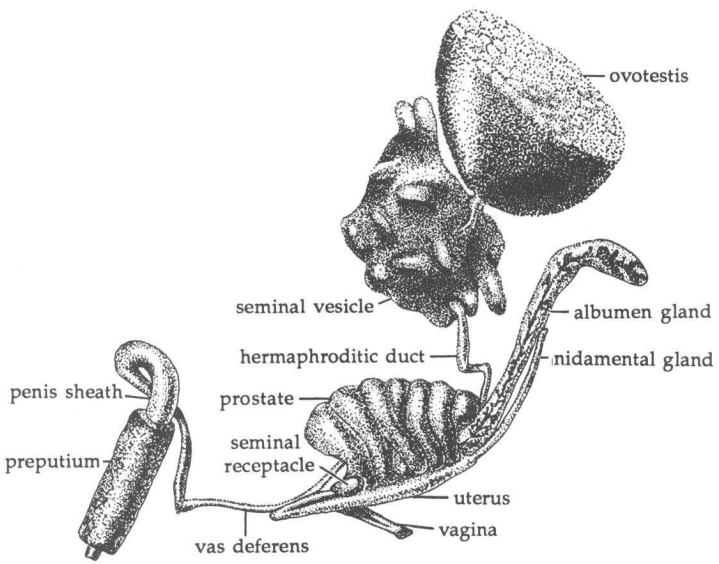


a



b

FIG. 113. *Laevapex fuscus.* **a**, Kidney; **b**, reproductive system. (From Basch, 1959, *Misc. Publ. Mus. Zool. Univ. Mich.*, (108): 1-56.)

COLLECTION AND PRESERVATION

Collecting

Freshwater snails can be found in almost any body of water, unless it is badly polluted or too acidic. They occur in large and small rivers, creeks, lakes, ponds, marshes, swamps, ditches and swales, bogs, seepage areas, and temporary woods pools. Some species prefer quiet bodies of water, crawling on the bottom or on objects such as sticks, stones or submerged bottles and cans, and on aquatic vegetation. Other species prefer the flowing water of streams, and a few live in the often turbulent wave-swept shore of medium and large lakes.

Lakes usually contain many species of snails that live among the aquatic vegetation near the shore or on rocky beaches. Often beach pools, areas of water behind barriers that have been formed by the waves of the lake, afford good collecting localities. Few species of snails can be found in the deep part of lakes. Nearly all species are confined to rather shallow water or are limited to the areas of rooted vegetation. Roadside drainage ditches where there is limited water but much vegetation is a good place to find various species. Few or no snails can be found in water polluted by sewage or industrial wastes.

The methods of collecting freshwater snails are rather simple, and usually consist merely of searching habitats favorable to mollusks (which is almost any body of water, flowing or standing), inspecting every possible place a snail might be located: on aquatic vegetation, submerged objects such as logs, sticks, fallen leaves of emergent vegetation and surrounding forest trees, rocks, mud, sand and clay substrates, etc. Once located, the snails are simply hand-picked. When submergent vegetation is particularly abundant, the plants can be placed in buckets and shaken vigorously to dislodge the snails, or the contents of the bucket can be brought to the laboratory for inspection. Lake collecting is often done best from a row boat. In some situations, aquatic vegetation can be pulled ashore with a rake. Large burrowing snails, such as *Campeloma* and *Pleurocera,* often can be located by running the hand through the sand and mud in shallow water of the lakes and rivers they inhabit.

A useful tool for collecting is the Walker dipper (invented by Bryant Walker). The dipper is 3 inches (7.6 cm) deep, and about 6 inches (15.2 cm) in diameter at the top and 5 inches (12.7 cm) at the bottom. The bottom is covered with wire screening of a sufficiently large mesh to allow sand, mud and water to escape and yet retain all except the smallest mollusks. The dipper is fastened to a handle 5 or 6 feet (*ca.* 1.5 to 1.8 meters) in length (*e.g.,* a broom handle). With

this efficient collecting tool, the vegetation of any body of water can be swept for snails with little difficulty. The dipper may be used also to sweep through the bottom sand and mud in water to a depth of about 6 feet (1.8 meters).

Containers used for field collecting may be of various kinds: buckets or pails, empty plastic or tin cans, or wide-mouthed bottles of various sizes. It is a good practice to separate very small snails from large ones; otherwise the small snails may not be found later in sorting. After collecting at one locality and before going to another, the snails, if not already placed in appropriate bottles or vials with identifying labels, should be. This will keep them separate from the specimens collected from the next locality; specimens from different localities or habitats should be kept separate. If the bottles or vials will be jostled during transit, their tops should be covered with a cap. If the snails will be in their containers for some period of time while not actually in transit, the container tops should be loosened or removed to allow air to circulate over the contained water. Snails in containers should have adequate quantities of water. If they are crowded, they will die. Also, their containers should not be left unprotected in the sun, or in a closed vehicle during hot weather. During long trips in hot weather, the bottles and vials should be packed in a container (*e.g.*, a cooler) with ice, if ice is available.

A canvas bag or knapsack is useful for keeping bottles or vials during collecting trips. If a vehicle is used for transportation, bottles and vials may be conveniently kept in a bucket or box.

Snails may be preserved in the field, but generally this is not acceptable if the soft anatomy of the snails will be studied later. Snails withdraw into their shells before fixation and contracted snails are unsatisfactory for anatomical observations. Narcotizing snails in the field generally is not satisfactory because the time period is too short, and motion of traveling will disturb the process.

Preservation of Shells

For preserving shells dry, small species of snails, such as *Amnicola, Valvata, Gyraulus,* etc., can be placed in a solution of 65-75% ethanol. On immersion, the snails will retract well within their shells and away from the shell aperture. After 12 to 24 hours in the ethanol, the shells should be removed, air dried, and stored. With this procedure, the opercula of small prosobranchs will be preserved *in situ.*

Larger species, and those small species from which the animal can be easily removed, can be prepared by first placing them for a few minutes in boiling water to break the attachment of the columellar

muscle to the shell. The animal then can be removed with forceps or a hooked needle. In such large snails, the digestive gland may break and remain within the first few whorls of the shell. In such cases, a hooked wire with corkscrew turn or a small fish hook is helpful for removing the hidden tissue. Finally, a syringe is useful for rinsing out any remaining animal matter.

Often there are incrusations of foreign materials deposited from the habitat on the shells of freshwater snails. Sometimes these deposits detract very little from the preserved shell. In other cases, the deposits may mask the color of the shell or hide the surface sculpture. Mud and other looser material usually can be scraped off with an old toothbrush. If the deposits are algal lime incrustations, they can be scraped off with a sharp object, such as a knife blade. Incrustations, especially those more tightly affixed, can be removed with oxalic acid. The oxalic acid can be applied with a brush, or on large shells, with a soft cloth. Sometimes it may be necessary to dip the whole shell for several minutes into a container of oxalic acid. But, soon after application, and before the oxalic acid can affect the calcium carbonate of the shell, the acid should be washed off with water. [Oxalic acid should be used with caution; see p. 198.]

In addition to the shell, the prosobranch operculum should preserved. In larger snails, the operculum first must be freed from the posterior foot where it is attached. If practical, each operculum should be kept with its respective shell. This can be done by gluing the operculum to a small piece of cotton and stuffing the cotton into the empty shell with the operculum exposed. The operculum should be air dried, along with its shell; heat should not be used in the drying process. After the shell and operculum are dry, they can be lightly smeared with Vaseline to retard cracking of the periostracum. Shells of non-operculate (pulmonate) snails should be treated in a similar manner.

The shell and animal of freshwater limpets can be separated with fine forceps or a dissecting needle. It is important to remove deposits from ancylid shells, because the microsculpture of the apex is important in their identification. Limpet shells may be cleaned by floating them upside down on the surface of oxalic acid, after which they must be carefully washed with water.

Fixing and Preparing Snails for Anatomical Studies.

Except for their shells, snails are soft-bodied creatures, with well developed muscles. When placed in a caustic or irritating fluid, snails immediately withdraw into their shells and remain highly contracted. Such snails are difficult to dissect, and their bodies are

highly compressed and distorted. Therefore, when preserving snails for anatomical studies, it is desirable to first anesthetize them so that they remain in a life-like shape. This is done with various narcotizing agents, the most common being menthol crystals (see p. 196). Menthol crystals are not very soluble in water, so from a few crystals scattered on the water surface about the right amount of menthol dissolves in the container. However, the water in the container needs to be shallow (*i.e.*, only a few mm or a cm over the snails). Anesthetization takes several hours for very small snails to several days for large prosobranchs. About eight hours is the average time for medium-sized pulmonate snails. Such snails can conveniently be left overnight.

If the snails are not fully anesthetized, they will slowly contract when fixed. To test whether or not a snail is fully relaxed, touch a tentacle. If it moves however so slightly, the snail is not yet ready to fix.

Some freshwater snail species cannot be properly anesthetized with menthol; other chemicals, such as Nembutal (see p. 197) or chloretone (see p. 188), must be used instead. Which chemical is best for any particular species can be determined only by trial and error.

Fixing fluids are 65-70% ethanol, 10% formalin (p. 192), Bouin's fluid (p. 187) or formalin-alcohol [ethanol]-acetic acid (FAA) (pp. 191, 192). The latter fluids contain acid that will facilitate penetration but will dissolve the snail's shell. Bouin's fixative is a general purpose fixative prior to histological preparations, but it can also be used to fix snails for gross anatomical studies. FAA also can be used for either histology or study of gross anatomy. If the shells are important for later reference in FAA fixation, then the snails should be removed from the fixative after a brief time and washed and stored in ca. 65-70% ethanol. Formalin will also dissolve the snails' shells, so neutralized formalin is usually used for fixation, especially if the snails also will be preserved (stored) in formalin. If ethanol is used to fix the snails, then it should be changed one or several times because of dilution of the original fluid with water from the snails' bodies.

Preservation (storage) is usually in either 65-70% ethanol or 4% neutralized formalin.

FRESH WATERS IN THE UMBS AREA

The major stream drainage in the three-county area is that of the Cheboygan River. The major streams in the Cheboygan River drainage, in addition to the rather short Cheboygan River, are the Black, Indian and Maple rivers. Three of these rivers have their own tributaries. For the Black River, they are Long Lake, Stoney, Milligan and Gokee creeks. Tributaries of the Sturgeon River in Cheboygan County are the Little Sturgeon River (with Crumley and Johnson creeks), West Branch of the Sturgeon River (with Marl Creek), and Beebe, Blackjack, Bradley and Stewart creeks. The tributaries of the Maple River are the East and West branches of the Maple River, Brush and Cold creeks (tributaries of the West Branch of the Maple River), and Van Creek (a tributary of the East Branch of the Maple River).

Other drainages in the three-county UMBS area are the Ocqueoc, Pigeon and Thunder Bay rivers, and small streams emptying directly into lakes Michigan and Huron. Tributaries of Ocqueoc River are Little Ocqueoc River (and Fox Creek), and Indian and Silver creeks. Tributaries of the Pigeon River in Cheboygan County are the Little Pigeon River (with Molby Creek), and Cornwall and Wilkes creeks.

The southcentral part of Presque Isle County is part of the Thunder Bay River drainage. Tributaries of the Thunder Bay River in Presque Isle County are the North Branch of the Thunder Bay River and its tributaries, Quinn and Erskine creeks.

Small streams emptying directly into Lake Michigan are the Bear and Carp Lake rivers, and Big Sucker, Little Sucker, Collins, Five Mile, Tannery and Webster (via Wycamp Lake and Collins Creek) creeks.

Small streams emptying into Lake Huron are the Black Mallard [also called Carp Creek], Little Black, Little Trout, Swan and Trout rivers, and Elliot, Green, Lone Pine, Mill, Mulligan, Schmidt and Three creeks.

The major lakes of the Cheboygan River system are Black, Burt, Douglas and Mullett lakes. Bessie Creek [also called Lancaster Creek], leading from Lancaster and Munroe lakes, flows into Douglas Lake from the north. Maple River flows out of the western end of Douglas Lake and into the western side of Burt Lake, bringing with it water from Larks Lake (via Brush Creek and the West Branch of the Maple River). Also flowing into Burt Lake from the west is Crooked River, bringing water from Crooked and Pickerel lakes, and from its McPhee and Whites creeks. Flowing into Crooked Lake is Minnehaha Creek and the outlet stream from Round Lake. Flowing into Pickerel Lake is Berry Creek and its tributary, Cedar Creek. Water

from Burt Lake flows into Mullet Lake via the very short Indian River.

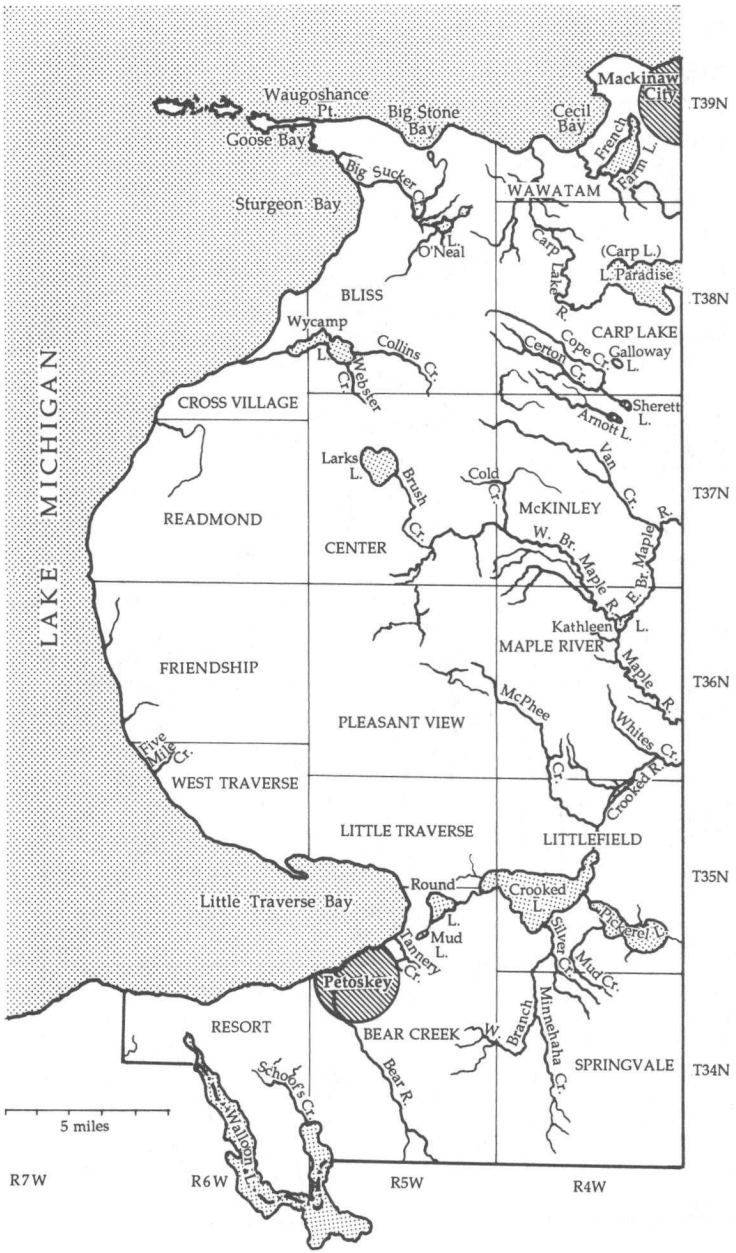
The Black River flows into the western side of Black Lake and out the northwestern end of the lake. Tributaries of the upper Black River (south of Black Lake) in Cheboygan and Presque Isle counties are Bowen, Canada (with Oxbow Creek), Gregg, Little McMasters, McMaster's, Milligan (with Gokee and Weed creeks), Stoney, Tomahawk and Welch creeks. Tributaries of the lower Black River (north of Black Lake) are Cains, Myers and Owens creeks. Mud Creek (with water from its tributary Little Mud Creek) flows into Black Lake on the west side, between the inlet and outlet of Black River into the lake. Other creeks flowing directly into Black Lake are Fisher, Stewart and Stony creeks. On the southeast side of Black Lake Rainy River enters, bringing with it water from its tributaries Little Rainy River, West Branch of the Upper Rainy River, and Cold Creek.

The two large lakes of Presque Isle County are Grand and Long lakes. [Part (the lower half) of Long Lake is also in Alpen County.] There is also a smaller Long Lake in Presque Isle County. Additionally, Presque Isle County has many other small lakes, such as Ann, Augusta, Bear Den, Big Trout, Black Mallard, Clear, Clinton, Drum, Ella, Emma, Esau, Ferdelman, Francis, Gifford, Hackett, Healy, Hessler, Horseshoe, Kelsey, Krauth, Little, Little Tomahawk, Loon, Lost, Lower Barnhart, May, McAvoy, Moore, Nettie, Ocqueoc, Orchard, Penny, Rainy, Richard, Shoepac, Sixteen, Sunken, Swan, Tomahawk, Trapp and Upper Barnhart lakes. There are also the Twin Lakes, and three different Mud lakes in Presque Isle County.

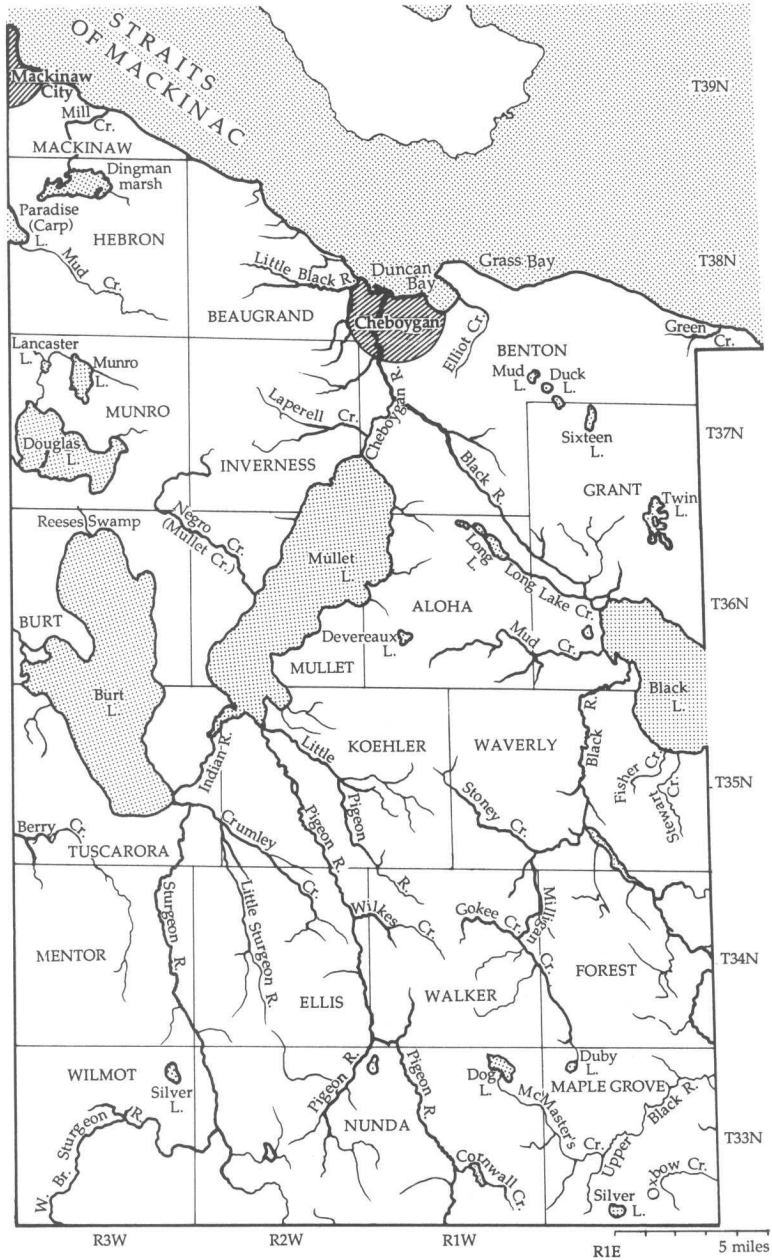
In addition to the lakes mentioned above for Emmet County, there are other lakes, mostly small, such as Arnott, Dow, Duck, French Farm, Kathleen, Lawrence, O'Neal, Paradise, Sherett and Sommers lakes. There is also a Twin Lake, as well as the Twin Lakes, in Emmet County.

Cheboygan County also has its smaller lakes, such as Barhite, Cornwall, Devereaux, Dog, Duby, Fulmer, Hackett, Lance, Long, McLavey, Osmun, Penny, Roberts, Twin and Weber lakes. There are also two Silver lakes and five Mud lakes in Cheboygan County.

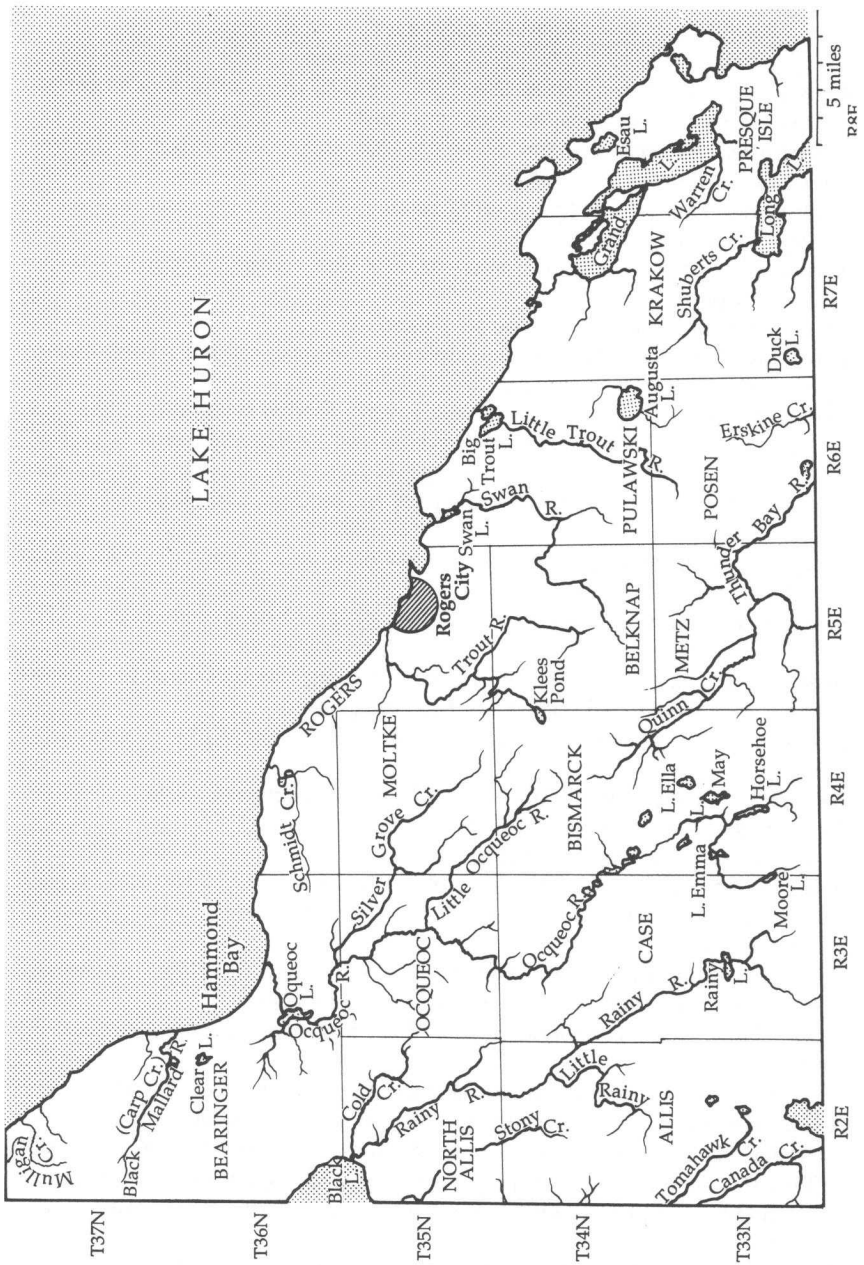
We have not been able to find East Lake on maps of Presque Isle County. This is a locality name on UMMZ labels with freshwater snails collected during the first half of this Century. Perhaps this is a locality name used in the past, but now changed, *e.g.*, as was Bear Lake in Emmet County (now called Walloon Lake), or perhaps East Lake is a very small lake simply not listed on current maps of Presque Isle County.



MAP 46. Major fresh waters of Emmet County.



MAP 47. Major fresh waters of Cheboygan County.



MAP 48. Major fresh waters of Presque Isle County.

GLOSSARY

Abaxial. Directed away from the shell axis (*i.e.*, the central line or central column of a coiled gastropod shell) outward.

Acteophile. A common name adjective referring to a member of the pulmonate snail order Acteophila.

Acuminate. Having a long, tapering point.

Acute. Sharp at the end.

Acutiform. Sharply pointed; shell narrow and terminating in a sharply pointed spire.

AFA. See formalin-alcohol-acetic acid fixative.

Afferent. Refers to a blood vessel, siphon or nerve that takes a substance or impulse to the primary organ.

Albumen gland. A gland of the female reproductive system (*e.g.*, see Figs. 103a, 104c, 107) that supplies an envelope of nutritive material (albumen) to the egg immediately after the egg is fertilized. In most pulmonate snails, the albumen gland is embedded in the digestive gland just apical to the lung.

Ancylid. A common name adjective referring to a member of the freshwater snail family Ancylidae.

Ancyliform. Limpet-shaped; patelliform; shaped like an obtuse cone (Fig. 5).

Angular, angulate. Having an angle or having the tendency to form an angle (*e.g.*, see Fig. 83b), in contrast to being round.

Angulation. Edge along which two surfaces in different planes meet at an angle.

Annulated. Marked with differently colored or sculptured rings.

Annulation. A ring of different color or form.

Anterior. At or towards the head.

Anterior end of shell. That part of the shell closest to the snail's head when the animal is active; generally that part of the shell farthest from the apex (Fig. 77).

Aperture. The opening or "mouth" of a snail shell (see Fig. 78) through which the head-foot protrudes when the snail is active.

Apex. The tip of a gastropod shell farthest from the aperture (see Figs. 77, 78).

Apical. Situated at or close to, or referring to, the apex of a snail shell.

Apical digitations. In the physine Physidae, the posterior mantle collar digitations that extend onto the parietal wall at the posterior shell aperture (Fig. 53). In very short-spired physid snails, the apical digitations extend noticeably close to the shell apex. Also called posterior digitate projections.

Apical viscera. The internal organs (*e.g.*, liver; upper parts of the reproductive, renal and digestive systems, etc.) outside the head-foot hemocoel.

Attenuate. Slender; elongated; long and slender.

Auger-shaped. Shaped like an auger, *i.e.*, with a flattened base terminating in a sharp, pointed twist.

Auriculated. Lobed; having a lobe (or ear-like appendage) on each side.

Axial. Parallel to the axis or columella of a snail's shell, *i.e.*, transverse to the direction of the shell's spiral coil.

Axial sculpture. Surface markings on a snail shell that are parallel to the axis and lip or peristome of the shell and at right angles to the direction of the whorls; transverse sculpture (*e.g.*, see Fig. 89).

Base (*adj.* basal). The part of a snail's shell opposite the apex. When a shell is held with the apex directed upward, the base is the "bottom" part of the shell. In regard to the natural position of the shell as carried by the snail, in an elongate shell the "base" is the anterior end.

Basommatophoran. A common-name adjective referring to a member of the pulmonate snail order Basommatophora (= Acteophila + Lymnophila).

Bicarinate. Having two carinae or spiral ridges.

Bicuspid. Having two cusps (in reference to a radular tooth with two cusps, *i.e.*, cutting projections; see Fig. 27b).

Bifid. Divided into halves by a linear sinus, with straight margins.

Bilobed. Consisting of two lobes.

Biramose. Having two lateral branches.

Body whorl. The last complete whorl or volution of a spiral snail shell, measured from the outer lip back to a point immediately above the outer lip (Fig. 78); ultimate whorl. The body whorl is normally the largest whorl of the shell and is called the body whorl because it encloses the greatest part of the snail's body.

Boreal. Referring to or located in northern regions; northern.

Boss. A protuberance; a prominence; a projecting knob or stud.

Bouin's fluid (Bouin's picro-formol). A general purpose fixing and preserving fluid consisting of 75 parts by volume of saturated aqueous picric acid, 25 parts formalin, and 5 parts glacial acetic acid.

Buccal. Refers to the structures in the anterior part of the alimentary canal that are associated with and assist the radula and jaws, *i.e.*, the musculature, innervation and supporting cartilage.

Bulbous. Rounded, globular or pear-shaped; swollen like a bulb.

Bulimoid. Shaped like the genus *Bulimus* [*Megalobulimus*] or many members of the land snail family Bulimulidae, in which the body whorl is relatively large, ovate, moderately rounded and not shouldered, the shell aperture is oval, the spire is relatively small, with convex sides and moderately rounded whorls, and the apex is more or less blunt.

Bursa copulatrix. A sac-like diverticulum in the female reproductive system close to the gonopore, used to store sperm obtained during mating (Fig. 95b); also called spermatheca (107a,b) or seminal receptacle (103a).

Calcareous. Formed of calcium carbonate (carbonate of lime).

Callus (*adj.* callous). A layer of calcareous material on a shell (*e.g.*, see parietal callus, Fig. 78) secreted by the snail's mantle.

Campanulate. Flared at the end; bell-shaped.

Canaliculate. Bearing a channel or groove.

Cancellate. Meshed with lines crossing each other (*e.g.*, spiral and transverse lines) forming a lattice-like appearance.

Carina (*pl.* carinae). A sharp spiral edge, ridge or "keel" on the outer shell surface (see Fig. 89).

Carinate. Having one or more sharp spiral edges, ridges or keels on the outer shell surface.

Carrefour. In the freshwater snail reproductive system, a complex of structures (a juncture of pathways) consisting [*e.g.*, in a lymnaeid snail] of the insemination pocket, oviducal caecum and oviducal labyrinth, and the distal end of the hermaphroditic and albumen gland ducts and the seminal gutter, and the proximal end of the prostate gland duct (see Fig. 103b).

Central tooth. The median or rachidian tooth of a transverse row of radular teeth. It is flanked by lateral teeth. (See Figs. 90-93).

Channeled. Bearing a channel or groove.

Chink. A narrow slit, cleft or crack at the columellar opening of a snail shell; often formed by the expanded or reflected columellar lip partially covering the narrow umbilicus.

Chitinous. Formed of or containing chitin, and often or generally brown in color.

Chitin. A hard, amorphous, nitrogenous polysaccharide that forms the base for the cuticle of arthropods and is of limited occurrence in other invertebrates, including mollusks.

Chloretone (chlorobutanol; $C_4H_7Cl_3O$). An anesthetizing agent for mollusks and other invertebrates. One gram dissolves in 1 ml of ethanol. It is used as a 1% (by volume) aqueous solution.

Circumboreal. Distributed around the boreal regions of the globe; holarctic.

Collabral. Having the same shape as the labrum or outer lip of the shell under examination.

Color bands. Revolving spiral stripes of a darker hue or different color from the ground or background color that occur on some species of gastropod shells (see Fig. 89).

Columella. A small column; the internal column around which the whorls revolve; the axis of a spiral shell.

Columellar digitations. In the physine Physidae, the anterior mantle collar digitations that extend over the columellar portion of the shell aperture onto the anterior parietal wall of the body whorl; also called columellar-parietal digitate projections.

Columellar lip. The apertural margin at the columellar region of a coiled gastropod shell (see Fig. 78).

Compressed. Refers to the spire of a gastropod shell that is relatively flattened, *i.e.*, is not elongated; depressed (see Fig. 80d).

Concave. Curved or rounded inward.

Concentric. From the same center; having a central point or nucleus about which succeeding lines, each with a slightly larger circumference, encircle (*e.g.*, see Fig. 3c).

Conchology. The science dealing with molluscan shells, *i.e.*, the nature and formation of molluscan shells, and the practice of classifying mollusks by their shells; the science dealing with mollusks, especially in a narrow sense, relating mostly to their shells (as opposed to the study of mollusks as whole animals and as biological entities).

Conical. Shaped like a cone, *i.e.*, tapering evenly from a wide, circular base to a point.

Contractile. Capable of reducing length by shortening and thickening, *e.g.*, the tentacles of most acteophile and lymnophile (basommatophoran) snails.

Convex. Bulging or rounded outward.

Corneous. Resembling horn in color or consisting of a horn-like material.

Corroded. Dissolved away by abrasion or chemical action, or both.

Costa (*pl.* costae). A transverse rib or rounded ridge of substantial size on the surface of a shell (see Fig. 89).

Costate. Refers to a shell in which the surface is sculptured with heavy, regular transverse ridges or ribs.

Couplet. In a taxonomic identification key, two opposing sets of contrasting characters, from which a choice must be made in order to pass on to the next couplet. The object of the taxonomic key is to lead the observer to the correct taxonomic determination for the taxon in question.

Crenulate, crenulated. Notched on the edges.

Crescentic. Shaped like a crescent, or new moon.

Crop. A temporary storage area for ingested food formed by the widening of the posterior esophagus (*e.g.*, see Fig. 101).

Ctenidium (*pl.* ctenidia). The characteristic respiratory appendage or gill of mollusks.

Cusp. The cutting blade or blades projecting from each tooth of the molluscan radula.

Cylindrical. Round and elongate with parallel sides; shaped like a cylinder (Fig. 80b).

Decollate. Cut off, *i.e.*, as in the shell of some snails where the top several whorls or the spire break off or erode away.

Deflected. Bent downward from the natural plane of growth, as in the terminal part of the last whorl in some snail shells.

Depressed. Flattened dorso-ventrally or postero-anteriorly, as the spire of a snail shell (see Fig. 80d).

Depressed conic. Designation for a snail shell with a spire angle of about

100° (± 5°) (see Fig. 81h); widely conic.

Dextral. Coiled to the right (Fig. 82b). The direction of coil of a snail's shell can be determined by holding its apex up and its aperture toward the viewer. In such a position, if the aperture is on the right of the columella, the shell is dextral.

Diameter. The width of a shell at a right angle to the shell axis or columella (see shell width in Fig. 78). The "diameter" of a shell usually refers to its largest diameter, *i.e.*, as measured at the outer lip to the opposite side of the whorl.

Dichotomous key. A taxonomic identification guide that is composed of a series of couplets (statements), each of which opposes the other, giving the reader the choice between two sets of contrasting characters. By successively choosing between the two presented choices of each couplet, and thereby being brought to the next couplet, the reader is led eventually to a name that is the proper identification (if the correct choices were made along the way) for the taxon in question.

Dichotomy. A branching which results from the division of one part into two succeeding parts; repeated forking.

Diffuse. Widely spread, as certain types of pigment on a snail's body.

Dilated. Expanded; spread out; as the adult shell lip of some snail specimens or species.

Dioecious. Having separate sexes, *i.e.*, a species with the male sex in one individual and the female sex in another individual; gonochoristic.

Discoidal. Round and flat like a disc (see Fig. 80e).

Disk. The flat ventral part, or sole, of the gastropod foot (as used in the older literature).

Distal. At a distance or more distant from the organ or part under consideration; located at a distance from the origin or point of attachment.

Dorsal. The back; the upper side; in non-planate snails, the side opposite the shell aperture or the sole of the foot.

Dorsoventral. Refers to the direction or axis from dorsal to ventral; in a snail shell from the apex to the base.

Early whorls. The first whorls of a spiral snail shell; the first several whorls of the spire, beginning with the nuclear whorl.

Eccentric. Away from the center; positioned off-center, as the nucleus of the operculum of some species; excentric.

Ecophenotype. A non-hereditary form or phenotype produced by ecological or environmental conditions.

Efferent. Refers to a blood vessel, siphon or nerve that conducts a substance or impulse away from a source.

Elevated. Raised or lengthened, as the spire of a shell, in contrast to a species with a more depressed spire.

Elliptical. Having the form of an ellipse.

Elongate. Lengthened; extending length-wise; especially higher than wide

(see Fig. 80a,b).

Elongately conic. Designation for a snail shell with a spire angle of about 30° (± 5°) (see Fig. 81b).

Emarginate. Bluntly notched, as the shell lip margin; terminating in a notch.

Embryonic shell. The shell formed by the embryo; protoconch (see Fig. 78). The embryonic shell of many species has a different surface sculpture from the shell formed after hatching or settling.

Encrustation. See incrustation.

Entire. Refers to the lip or peritreme of a shell that forms a continuous circle or oval, *i.e.*, it is not broken by a space where it meets the parietal wall of the body whorl.

Equidistant. Equally spaced; having the same interval between objects or structures, as the spiral or transverse sculpture of a shell's surface.

Esophagus. The tube through which food passes from the buccal mass to the stomach (*e.g.*, see Figs. 90a, 97b, 101, 106a, 110a).

Evaginate. To evert; to turn inside out.

Evert. To evaginate; to turn inside out.

Excentric. Away from the center; positioned off-center, as the nucleus of the operculum of some species; eccentric.

Expanded. Spread out; trumpet shaped; as the adult shell aperture of some snail species.

Extralimital. Refers to outside the geographical area under consideration (*e.g.*, in the case of this manual, to outside the UMBS area).

FAA. See formalin-alcohol-acetic acid fixative.

Family (*adj.* familial). A taxonomic group of genera sharing certain basic features that set them off from other such groups of genera. (A few families contain only one genus.) The family is a level of classification between the genus and the order. Names of families end in *-idae.*

Fathom. A nautical unit of depth (or length). One fathom is equal to six feet or 1.83 meters.

Fauna. The animals occupying a given area.

Filamentous. Slender, thread-like; filiform.

Filiform. Long and slender; thread-like; filamentous.

Flagellum. In some Hydrobiidae, *e.g.*, the genus *Amnicola,* a protuberance or lobe on the verge in addition to the penis proper; penial lobe (Figs. 94d, 96). In *Amnicola,* the flagellum contains a duct from the penial or accessory gland.

Fold. A structure made by, or appearing to be made by, folding, *i.e.*, a bending of one part over itself; a spiral ridge on the columella.

Foot. The muscular ventral part of a snail's body functioning mainly in locomotion (Figs. 1, 2, 77a); the ventral surface of the foot is the sole.

Form (*abbr.* f.). A particular variation or aggregate of variations within a population. The terms "form" or "forms" have some utility in discussing

interpopulational variations, but a "form" has no formal standing in our system of zoological nomenclature.

Formalin. A widely used zoological fixing and preserving fluid, prepared by mixing formaldehyde [CH_2O] gas (about 37% by weight) with water. As commercial formalin, such a solution is regarded as 100%. A 10% formalin solution, for example, is 10 parts (by volume) of commercial formalin mixed with 90 parts water. A 10% formalin solution is commonly used as a fixative. A 4% or 5% solution is used for long term preservation. With shelled mollusks, the formalin must be neutralized to prevent dissolution of the calcium carbonate of the shell.

Formalin-alcohol-acetic acid fixative (FAA; AFA; Lavdowsky's fluid). A zoological fixative that penetrates and preserves tissues well. After fixation, the fluid is replaced with 65% to 70% ethanol for storage. FAA contains commercial [37% formaldehyde] formalin (10 parts by volume), 95% ethanol (50 parts), glacial acetic acid (2 parts) and distilled water (40 parts).

Formaldehyde. An organic chemical (HCHO), the simplest aldehyde, used as a fixative and preservative for biological specimens; formol; methylene oxide.

Fragile. Delicate; easily broken.

Funicular. Funnel-shaped.

Furrow. A shallow groove.

Fusiform. Spindle-shaped, *i.e.*, with a relatively thick middle and tapered to a point at each end.

Gastropod. A snail; a member of the molluscan class Gastropoda.

Genital pores. The separate openings to the outside of the male and female reproductive systems in lymnophile snails; gonopores.

Genus (*pl.* genera; *adj.* generic). A basic category of biological classification above the species level that contains (usually) two or more related species that share certain features. A few genera are monotypic, *i.e.*, contain only one species.

Gill (branchia, *pl.* branchiae). The filamentous outgrowth, usually located within the mantle cavity, serving as the respiratory organ of aquatic mollusks. The basic structure of the molluscan gill ("ctenidium") is characteristic throughout the phylum.

Gill filament. One of the leaflets of the gill.

Gizzard. A muscular portion of the alimentary canal used to process food (*e.g.*, see Figs 101, 104a, 106a).

Glassy. Smooth and very glossy; polished; shiny.

Globose. Globular or spherical; approaching a globe or sphere in shape (Fig. 80c).

Globosely conic. Designation for a snail shell with a spire angle of about 80° (± 5°) (see Fig. 81g).

Glossy. Smooth and shining; highly polished.

Gonochoristic. Having separate sexes, *i.e.*, a species with the male sex in

one individual and the female sex in another individual; gonochoristic; dioecious.

Gonopore. An opening of the reproductive system to the outside.

Gradate. Arranged in steps, as a spire with shouldered whorls.

Greatest (or major) diameter. The greatest diameter of a discoidal shell, as measured from the outermost edge of the outer lip directly across the shell to the opposite periphery of the body whorl (as opposed to minimum diameter, which is measured on the body whorl at the inner (parietal) lip to a point at the shell periphery directly opposite).

Groove. A narrow channel in the surface; furrow.

Growth lines. Minute lines on the outer shell surface indicating minor rest periods during growth (see Fig. 89). Not to be confused with the major "rest marks" (called "varices" on snail shells) caused by prolonged growth arrest (as during winter). There are many growth lines on any shell (but only one, several or no varices per whorl).

Headfoot. The combined head and foot organ of a snail. The foot (the snail's locomotory organ) anteriorly is in close proximity to and is generally not separated from the snail's head (see Fig. 77).

Helicoid. In the form of a low three-dimensional spiral; with a somewhat depressed spire and whorls that increase regularly in diameter.

Hemocoel. An expanded portion of the circulatory system that replaces the true coelom. In gastropods, there are two main hemocoels, one in the head-foot and the other around the viscera.

Hemocoelic viscera. The internal organs (*e.g.*, the anterior parts of the digestive system, the terminal genitalia and the central nervous system) located in the hemocoel of the head-foot.

Hemocyanin. The copper-containing respiratory pigment in the hemolymph (blood) of most mollusks.

Hemoglobin. The iron-containing respiratory pigment in the hemolymph (blood) of most Planorbidae.

Hemolymph. The fluid in the tissues, vessels of the circulatory system and hemocoels of mollusks; blood.

Hermaphroditic. Having both sexes in the same individual; monoecious.

Hirsute. Covered with hairs or hair-like processes.

Holarctic realm. The zoogeographic region that consists of the combined Palearctic and Nearctic realms.

Holotype. The single specimen on which a species is based, and being specifically designated as the "type" by the author, or, if not so designated, being the only specimen before the author when the species was originally described.

Hyaline. Glassy; glossy and translucent or nearly transparent.

Hydrobiid. A common name adjective referring to a member of the freshwater snail family Hydrobiidae.

Imperforate. Refers to a spiral gastropod shell that has no opening or ex-

ternal cavity at its base (Fig. 86a). In such a case, the inner sides of the coiled whorls are appressed, leaving no cavity, or, if they are not appressed and a cavity is formed, then in adult shells its opening is completely covered by a callus or the reflected columellar apertural lip.

Impressed. With a distinct groove or furrow, as the suture of some shells (Fig. 84b); lines below the surface, as the surface sculpture of some shells (see incised lines on Fig. 89).

Inflated. Swollen; expanded; distended; tumid; in gastropods refers to shells or individual whorls that are bulbous or swollen in appearance.

Incised. Grooved; engraved (see Fig. 89).

Incrustation (encrustation). A deposit of material from the habitat, usually inorganic, on the surface of the shell.

Inoperculate. Without an operculum; in the UMBS area, the pulmonate snails (subclass Pulmonata).

Invaginable. Capable of withdrawing by being inverted, *e.g.*, the tentacles of geophile (stylommatophoran) snails. Freshwater snails cannot invert their tentacles.

Inverted. Turned inward; in a reversed position from normal.

Keel. A prominent ridge; a carina.

Key. [See "Dichotomous key."]

Kidney. The excretory organ; renal organ; nephridium (metanephridium). In a mollusk, the kidney is usually developed from the left urogenital duct and normally lies against the apical wall of the mantle cavity or lung.

Labial palp. One of the two velar lobes on either side of the mouth, especially seen in acteophile and lymnophile snails.

Labium. The inner or parietal or columellar lip; it extends on the parietal side of the body whorl from the posterior labrum to the basal lip.

Labrum. The outer (palatal) part of the mantle collar, or shell apertural lip, of a coiled gastropod, as opposed to the parietal mantle or umbilical lip and the basal (anterior) mantle or shell lip.

Lamella (*pl.* lamellae). A calcareous plate, blade, "tooth" or scale-like structure.

Lamellate (Lamellar, Laminate). Formed in thin plates, composed of thin plates or covered with them.

Lamina. A thin leaf-like structure or tissue.

Lateral teeth. The teeth on each side of the central or rachidian tooth in a transverse row of radular teeth.

Large (in reference to shell size). A term used to refer to a snail shell that is more than 30 mm in length or diameter (Fig. 79).

Last whorl. The terminal whorl on a snail shell, and on snails in the UMBS area, it is the largest; the body whorl.

Lateral teeth. The teeth on each side of the central or rachidian tooth in a transverse row of radular teeth (see Figs. 90d; 92b,c; 93).

Lectotype. One of the syntypes of a species that is later selected (usually by

a different author) to serve as the "type."

Length. The longest dimension of an object. In snail shells, the length is measured along the shell's columellar axis, and is a term used mainly in regard to elongate shells (see Fig. 78).

Limpet. A snail with an uncoiled shell, shaped like a low, obtuse cone (Fig. 5). In the UMBS area, a member of the family Ancylidae (pp. 137-145).

Limpet-shaped. Flattened, cup- or cap-shaped, or shaped like a very obtuse cone (Fig. 5); ancyliform.

Lip. Edge of the aperture of a shell (see Fig. 78); peristome; peritreme.

Lira (*pl.* lirae). A large ridge, specifically a spiral ridge, on the outer surface of a snail shell (see Fig. 89).

Lirate. Refers to a shell with lirae or spiral ridges on its external surface.

Liver. A name often used for the digestive or mid-gut gland in snails, so-called because of its appearance and its close proximity to the stomach and intestine. Since it does not function like a vertebrate liver, a more appropriate name is digestive gland.

Longitudinal. Refers to shell sculpturing that is at right angles to the spiral direction of the shell's coil; transverse (see Fig. 89).

Lunate. In the shape of a half-moon; crescent-shaped.

Lung. An internal, vascularized space used for respiration, formed from, or an extension of, the mantle cavity. All members of the large gastropod subclass Pulmonata possess a lung (pulmonary cavity).

Lymnaeid. A common name adjective referring to a member of the freshwater snail family Lymnaeidae.

Lymnophile. A common-name adjective referring to a member of the pulmonate snail order Lymnophila. This group includes all of the freshwater pulmonate snails.

Major diameter. The widest diameter of a snail's shell as measured from the outer apertural lip to the outer edge of the body whorl opposite the aperture; greatest diameter. When only the single word "diameter" is used in giving a shell's measurement, it is always the major diameter. See diameter.

Malacology. The science dealing with mollusks, *i.e.*, members of the Phylum Mollusca.

Malleated. Dented as if hit by a hammer (see Fig. 89).

Mantle. The skin covering the apical viscera of a mollusk. Also called pallium. It is an extension of the dorsal body wall as a fold (or, in bivalved mollusks, a pair of folds) that usually secretes a shell and encloses a mantle cavity, typically containing gills. The mantle normally lies next to and under the shell.

Mantle collar. The edge of the mantle (*e.g.*, see Figs. 97b; 104b,c; 105), often thickened, that lies next to and under the apertural lip of a snail's shell; sometimes called peristomal collar.

Mantle digitations. In the physine Physidae, finger-like or triangular lobes of the mantle collar that extend onto the parietal wall of the shell when the

snail is active. The anterior lobes are called columellar or collumellar-parietal digitations and the posterior lobes are called apical or posterior digitations (*e.g.*, see Fig. 53).

Mantle lobe. In freshwater pulmonate snails, a flexible, flap-like structure under the mantle collar that can be rolled into a tube for breaking the water surface and admitting air into the lung; also called siphon (*e.g.*, Figs. 100b, 104a) and, loosely, "pneumostome."

Mantle margin. The edge of the mantle or pallium, the characteristic outer fold of integument covering the body of mollusks. In snails, the mantle margin is adjacent to the shell aperture.

Marginal. At or toward the outer edge, *e.g.*, the margins of the molluscan radula (Figs. 90d[10,11]; 92c,d; 93[M]). The teeth at the radular margins, often having their own distinctive morphology, are called "marginal teeth."

Median cusp. The middle cusp of a molluscan radular tooth, generally flanked by smaller lateral cusps.

Median tooth. The central or rachidian tooth of a transverse row of radular teeth. It is flanked by lateral teeth.

Medium (in relation to shell size). A term used to refer to a snail shell that is 10-30 mm in largest dimension (length or diameter); see Fig. 79.

Menthol [$C_{10}H_{20}O$]. An anesthetizing agent for mollusks, obtained from mint oils or prepared synthetically. It is used by floating a few crystals on the surface of the water containing the snails. Menthol is only slightly soluble in water.

Minimum (or minor) diameter. The smallest diameter of a discoidal shell, measured on the body whorl at the inner (parietal) lip to a point at the shell periphery directly opposite (as opposed to the major diameter, which is measured from the outermost edge of the outer lip directly across the shell to the opposite periphery of the body whorl).

Minute (in relation to shell size). A term used to refer to a snail shell that is less than 3 mm in length (for an elongate shell) or width (for a depressed shell that is wider than high); see Fig. 79.

Monoecious. Having both sexes in the same individual; hermaphroditic.

Monotypic. A taxon (*e.g.*, genus, family) consisting of only one species.

Mottled. Irregularly covered with spots or marks of different sizes and shapes; blotched.

Mouth. The anterior opening of the digestive tract (*e.g.*, see Figs. 97, 100a); the aperture of a snail's shell.

Mucin. A glycoprotein that is the one of the main constituents of mucus.

Mucus (*adj.*, mucous). A viscous, lubricating fluid secreted by glands, consisting mainly of mucin and water.

Multispiral. Refers to an operculum in which there are numerous, very slowly increasing spirals, coils or whorls (Fig. 3a).

Narrowly conic. Designation for a snail shell with a spire angle of about

20° (± 5°) (see Fig. 81a).

Narrowly subovately conic. Designation for a snail shell with a spire angle of about 40° (± 5°) (see Fig. 81c).

Neanic. The adolescent, pre-adult stage, from hatching to the beginning of adulthood; nepionic.

Nearctic realm. The zoogeographic region that consists of all of North America (including Greenland) south to central Mexico.

Neck. The posterior termination of the head.

Nembutal (sodium pentobarbital; $C_{11}H_{17}N_2NaO_3$). A narcotizing agent for mollusks and other animals, used in various aqueous concentrations, depending on the species being studied and the preferences of the researcher.

Nephridial pore; nephridiopore; renal pore. The opening of the renal system to the outside (*e.g.*, see renal pore in Fig. 100b).

Nephridium. The tubular renal organ of mollusks and various other invertebrates; kidney (see Figs. 100a, 104, 112a, 113a).

Nepionic. Juvenile; post-embryonic and pre-adult; neanic.

Nidamental gland. A glandular structure in the female reproductive system (see Figs. 103a, 113b) that secretes covering material for eggs or egg masses.

Nodule. A small prominence or knob.

Nomenclature. [See "Zoological Nomenclature."]

Nomen dubium (pl. *nomina dubia*)**.** A dubious name; one that cannot be applied with certainty to any known taxon.

Nomen nudum (pl. *nomina nuda*)**.** A newly introduced species name without sufficient description to justify its acceptance in the zoological literature.

Nomen oblitum (pl. *nomina oblita*)**.** A forgotten name. A name that has not been used as a senior synonym in the primary zoological literature for more than 50 years. Such a name lacks validity in zoological nomenclature.

Nominal. Existing in name only, *e.g.*, a "species" named for a minor growth or ecological form of an already named species; any species name, without regard to the biological validity of the species.

Nuchal. An adjective referring to the neck region (hence sometimes meaning simply an anterior region).

Nuclear whorl(s). The first whorl(s) of a shell, formed by the embryo; embryonic whorl(s); protoconch (see nuclear whorls in Fig. 79). The nuclear whorls often have a surface sculpture differing from that of the rest of the shell.

Nucleus. The first-formed (earliest) part or beginning of a shell or operculum (*e.g.*, see Fig. 79).

Oblique. Slanting, as some ridges that are not parallel to the concentric growth lines; greater or less than a right angle; neither parallel with nor

perpendicular to.

Obsolete. Rudimental; poorly developed; obscure; indistinct; atrophied.

Obtuse. Blunt or rounded at the end, not acute or pointed.

Opaque. Not emitting or transmitting light; neither translucent nor transparent.

Operculigerous lobe. The lobe on the posterior dorsal surface of the foot of prosobranch snails that secretes and bears the operculum.

Operculate. A snail bearing an operculum to close the aperture when the snail has withdrawn into its shell; in the UMBS area, a member of the Subclass Prosobranchia.

Operculum (*pl.* opercula). A corneous or calcareous plate borne on the dorsal posterior foot of prosobranch snails that closes the aperture when the snail withdraws into its shell (Fig. 1).

Osphradium. Chemical sense organ of freshwater snails.

Outer lip. The outer or palatal edge of the shell aperture (see Fig. 79).

Oval, ovate. In the shape of the longitudinal section of a hen's egg, *i.e.*, oblong and curvilinear, with one end narrower than the other.

Ovate-conic. Oval in shape, and somewhat conically elongated.

Ovately conic. Designation for a snail shell with a spire angle of about 60° (± 5°) (see Fig. 81e).

Oviduct. The tube through which the eggs travel from the ovary or ovotestis to reach the outside of the snail; uterine duct. (See Figs. 94; 95a; 99b.)

Oviparous. Laying eggs that develop and hatch externally. See also ovoviviparous and viviparous.

Ovotestis. A gonad (see Figs. 100a; 103a; 104; 107a; 113b) that produces both eggs (ova) and sperm within the same acinus, often, or usually, simultaneously. Such a gonad is a characteristic of all pulmonate snails, and differentiates them from nearly all prosobranchs.

Ovoviviparous. Condition in which young snails are formed within eggs inside the mother snail, but hatch after they are laid, *i.e.*, the eggs are laid with already well developed infant snails within the egg shell or membranes. Also commonly used simply for giving birth to live young. See viviparous and oviparous.

Oxalic acid [$C_2H_2O_4$]. A poisonous, weak organic acid used for removing natural incrustations on the shells of mollusks. Oxalic acid is found in the cell sap of many plants, including *Oxalis*, from which it gets it's name. Oxalic acid should be used with caution, because it is caustic and corrosive to skin and mucous membranes.

Palatal. Pertaining to the outer lip or terminal part of the body whorl of a snail shell.

Palearctic realm. The zoogeographic region that includes Europe, the Near East, Africa, Asia south to the Himalayas, and some islands (Iceland, Canary Islands, Cape Verde Islands, Japan).

Parallel. Equidistant apart throughout the length, *e.g.*, the growth lines of

most snails' shells; the growth lines may be curved, but throughout their length they are equidistantly apart.

Paratype. A specimen of the type series in addition to the holotype that was before the author at the time the species was described, where a "type" or holotype was designated.

Parietal. That part of the body whorl of a snail shell that is near and adjoins the columellar lip of the aperture; pertaining to the inner wall of the shell aperture (see Fig. 79).

Patelliform. Limpet-shaped; ancyliform; shaped like an obtuse cone (see Fig. 5).

Paucispiral. Refers to an operculum in which there are few rapidly enlarging spirals, coils or whorls (Fig. 3b).

Pellet compressor. A muscular segment of the intestine that compresses fecal material (*e.g.*, see Fig. 101).

Penial lobe. In some Hydrobiidae, *e.g.*, the genus *Amnicola*, a protuberance or lobe on the verge in addition to the penis proper (Figs. 94d, 96); flagellum. In *Amnicola*, the penial lobe contains a duct from the penial or accessory gland.

Penial retractor muscle. One of the muscles that introverts the penis in a pulmonate snail following copulation.

Penis. The male copulatory organ. In pulmonate snails, it is an introvert, which is everted when functioning, but it is usually described and illustrated when introverted (see Figs. 103a; 108).

Penis sheath. A wall around the penis or penial complex that is distinct (and separated) from the muscular walls of the penis (see Figs. 103a, 108).

Penultimate whorl. The next to last complete whorl or volution of a spiral snail shell (Fig. 78). The penultimate whorl immediately precedes the ultimate whorl.

Perforate. Refers to a spiral gastropod shell that has a very narrow perforation at its base, formed where the inner sides of the coiled whorls do not join (Fig. 86b).

Periostracal rib, ridge or spine. A projection, *e.g.*, a "rib," ridge or spine, on the shell surface composed of periostracal material rather than shell (calcareous) material.

Periostracum (*adj.* periostracal). The thin proteinaceous external layer covering most mollusk shells.

Periphery. The edges of a shell as seen in outline; the part of the whorls farthest from the shell's axis of coiling.

Peristomal collar. The edge of the mantle (*e.g.*, see Figs. 100a; 102b), often thickened, which lies next to and under the apertural lip of a snail's shell; mantle collar.

Peristome. Around the mouth. Conchologically, the edge of the aperture (peritreme) of a snail shell; anatomically, the area around the snail's mouth.

Peritreme. The peristome, apertural "lip" or apertural margin of a gastropod shell. (Does not include the parietal wall in shells without an entire (continuous) apertural margin.)

Physid. A common name adjective referring to a member of the freshwater

snail family Physidae.

Physine. A common name adjective referring to a member of the freshwater snail subfamily Physinae.

Plait. A fold or strong twist, such as occurs on the columella of some snails (Fig. 87b).

Planispiral. Coiled in one plane (Fig. 80e).

Planorbid. A common name adjective referring to a member of the freshwater snail family Planorbidae.

Planorboid. Shaped like a planorbid snail; planispiral; disk-shaped.

Pleurocerid. A common name adjective referring to a member of the freshwater snail family Pleuroceridae.

Plica (*pl.* plicae). A transverse or "vertical" ridge or "rib" on the outer shell surface.

Plicate. Bearing plicae, which are transverse or "vertical" ribs on a shell.

Plicate-striate. Refers to a shell having longitudinal (transverse) folds or ribs on its surface that are crossed by raised spiral lines.

Pneumostome. The opening from the outside into the respiratory cavity (pulmonary cavity; lung) of a pulmonate snail; breathing pore. The pneumostome usually has a sphincter muscle to close it.

Ponderous. Very heavy; very thick.

Posterior. Towards the rear. In gastropod anatomy, posterior usually means toward the apical end of the viscera.

Posterior end of shell. The end of a snail's shell opposite to that in which its head normally points when the animal is active (see Fig. 77a). In an elongate or high-spired shell, the posterior end is the apical end.

Postintestine. The distal part of the intestine (see Fig. 101); in snails, because of their torsion, it is the anterior-most part of the intestine (see Fig. 106a).

Preoccupied. A term used in zoological nomenclature for the scientific name of a taxon that has been used earlier as the name of a different taxon.

Preputium. In the reproductive system of lymnophile snails, the most distal tubular part of the male intromittent complex, terminating at the male gonopore. It is a thin-walled, sac-like structure next distal from the penis/penis sheath. The preputium is everted during copulation. (See Figs. 100a, 103a, 107a, 108, 113.)

Prointestine. The proximal part of the intestine, near the stomach (Fig. 101); in snails, because of their torsion, it may be the posterior-most part of the intestine.

Proboscis. The anterior extension of the head on prosobranch snails that bears the mouth at its tip. Also called rostrum or snout.

Prosobranch. A common name adjective referring to a member of the gastropod subclass Prosobranchia. As a result of torsion, these snails have their gill (ctenidium) in front of the heart, as opposed to the opisthobranch gastropods (detorted) and other mollusks, which have their gills behind the heart.

Prostate gland. A gland of the male reproductive system that adds seminal fluid to the masses of passing sperm during mating (*e.g.*, see Figs. 94b; 99a; 103a; 107a; 113b).

Protoconch. The first whorl(s) of a shell, formed by the embryo; embryonic whorl(s) (see fig. 78). The protoconch often has surface sculpture differing from that of the rest of the shell (*i.e.*, the teleconch).

Proximal. Near the organ or part under consideration; nearest the origin or point of attachment.

Pseudobranch. A "false" or secondarily derived gill; a vascularized, fleshy outgrowth near the opening to the pulmonary cavity (pneumostome) of aquatic pulmonate snails which aids in respiration (*e.g.*, see Fig. 109b,c). Not a true ctenidium.

Pulmonate. A common-name adjective referring to a member of the gastropod subclass Pulmonata. These snails have a lung as a respiratory organ rather than the gills that characterize the other two gastropod subclasses.

Quadrilateral. Having four sides and four angles.

Race. A geographically or ecologically isolated group of individuals or populations that differ in one or more characters from other individuals or populations of the same species in other locations; a subspecies.

Radiating. Extending outward from a common center, as the "spiral" sculpture of an ancylid shell.

Radula (*pl.* radulae). A rasp-like structure in the anterior end of the digestive tract of all mollusks except pelecypods that is used to scrape food off surfaces and into the mouth during feeding. The radula consists typically of a number of longitudinal and transverse rows of minute sharp "teeth," each with one or more cutting blades or "cusps" (see Fig. 90).

Reflected. Turned outward, *e.g.*, a portion of the apertural lip of some snails' shells.

Rest mark. A darker or thicker part of the shell characteristically formed during a rest period in growth.

Reticulate. Having lines crossing each other like a network; constructed like the meshes of a net.

Revolving lines. A term sometimes used for spiral striae (see Fig. 89); occasionally also called "spirals."

Rhomboidal. Having the shape of a rhomboid, *i.e.*, quadrilateral with opposite sides and angles equal, but neither equilateral nor equiangular.

Rib. A transverse elevation or ridge of significant size on the surface of a shell; costa (see Fig. 89).

Riblet. A small rib.

Ridgelet. A small transverse ridge on a snail shell.

Rimate. Refers to a coiled gastropod shell that has at its base a rather narrow "umbilical" opening that is partially closed by the expansion of the anterior columellar lip (Fig. 86c).

Rostrum. The anterior extension of the head on prosobranch snails that bears the mouth at its tip. Also called proboscis or snout.

Rounded. Having a more or less evenly curved contour, in contrast to being angular (see Fig. 83a).

Rudimentary. Vestigial; not or barely functional in one species as contrasted to being developed in others.

Sarcobellum. In lymnophile snails, a fleshy ring around the outlet of the penis sheath, or an extension of the distal end of the penis sheath into the

preputium.

Scalar. Pertaining to or like a flight of steps, *i.e.*, a shell with elevated spire formed of right-angular whorls.

Scalariform. Shell form, usually pathologically produced, in which the whorls are disjoined or tend to become so.

Sculpture. The natural surface markings, other than those of color, usually found on snail shells, and often furnishing identifying marks for species recognition (see Fig. 89).

Seminal receptacle. A sac-like diverticulum in the female reproductive system (Figs. 95a,b, 99b) at the head of the oviduct used to receive sperm obtained during mating; sometimes also used (*e.g.*, see Fig. 103a) for the spermatheca or bursa copulatrix, which is a diverticulum near the female gonopore.

Seminal vesicle. A sac-like (or differently shaped) structure in the male reproductive system used to store sperm until they can be discharged during mating (Figs. 103a, 107a, 113b).

Sensu lato (abbr. *s.lat.* or *s.l.*). In the broad sense.

Sensu stricto (abbr. *s.str.* or *s.s.*). In the strict sense.

Serrated. Notched on the edge.

Serpentine. Resembling a serpent; moving in a winding fashion, turning one way and the other, like a serpent.

Sexually dimorphic. Males and females of the same species being morphologically different.

Sheen. Luster; gloss; brightness.

Shell mouth. The opening or aperture of a snail shell (see aperture in Fig. 79) through which the head-foot protrudes when the snail is active.

Shoulder. A bend in the curvature of a snail shell at the periphery just below (anterior to) the suture, which resembles a human shoulder in shape (Fig. 83c).

Shouldered. Refers to the appearance (in outline) of the posterior outer peripheral part of a whorl that is sharply rounded in contrast to the more even curvature of the rest of the shell (Fig. 83c).

Sigmoid. S-shaped; in the shape of the letter S; sinuous (*e.g.*, see lip edge in Fig. 88b).

Sinistral. Coiled to the left (Fig. 82a). The direction of coil of a snail's shell can be determined by holding its apex up and its aperture toward the viewer. In such a position, if the aperture is on the left of the columella, the shell is sinistral.

Sinuate, sinuous. Having the edge alternately curving inward and outward; wavy or S-shaped (*e.g.*, see lip edge in Fig. 88b).

Siphon. In freshwater pulmonate snails, a flexible, flap-like structure under the mantle collar that can be rolled into a tube for breaking the water surface and admitting air into the lung (Figs. 25b, 100b, 104a); also called mantle lobe and, loosely, "pneumostome."

S.lat. or ***s.l.*** See *sensu lato.*

Slough. A muddy, water-filled depression; a swamp or marsh.

Small (in reference to shell size). A term used to refer to a snail shell that is more than 3 mm in length (or diameter for a shell with a depressed spire), and less than 10 mm (Fig. 79).

Snail. A member of the molluscan class Gastropoda. Gastropods all undergo torsion, *i.e.*, a developmental process during early embryology in which the viscera, mantle and mantle cavity are twisted 180° in relation to the head-foot. Most snails are characterized by possessing a spirally coiled external shell consisting largely of calcium carbonate and used for protection.

Snout. The anterior extension of the head on prosobranch snails that bears the mouth at its tip (see Fig. 94a). Also called proboscis or rostrum.

Sole. The flat ventral part of a snail's foot (called the "disk" in older literature), on which the snail crawls during locomotion.

Solid. A term applied to snail shells that are thick and strong.

Spatulate. Shaped like a spoon; having a broad, rounded apex and tapering to the opposite end.

Species (*pl.* species; *adj.* specific). A taxonomic group comprising the same 'kinds' of closely related individuals potentially able to breed with one another, and unable to breed with other 'kinds.'

Spermatheca. An organ at the end of the apex of the vagina (see Fig. 107a,b) in the female genital system for storage of sperm received from the mating partner. Also called bursa copulatrix or seminal receptacle (103a).

Spermatophore. A bundle or packet of sperm.

Spindle-shaped. Shaped like a spindle, *i.e.*, with a relatively thick middle and tapered to a point at both ends; fusiform.

Spiral. Winding, coiling or circling obliquely around a central axis, so as to resemble a spire; winding around a fixed point and continually receding from it; the form of the shell of most snails.

Spiral sculpture. Surface markings on a snail shell that follow the direction of the shell's spiral and pass continuously around the whorls more or less parallel to the suture (see Fig. 89).

Spire. The whorls of a snail shell, excepting the last or body whorl (see Figs. 6b, 78). The spire is measured as the distance (parallel to the columella) from the suture where the apertural lip meets the body whorl to the shell apex.

S.str. or ***s.s.*** See *sensu stricto.*

Stomach. The muscular enlargement of the alimentary tract between the esophagus (or crop) and the intestine; gizzard (*e.g.*, see Figs. 94c; 97; 110a). The stomach (gizzard) lies in the apical viscera.

Stria (*pl.* striae). A slight superficial spiral groove or fine furrow on the outer shell surface (see Fig. 89), or a fine spiral threadlike line or streak. Commonly used also, in a less precise sense, for raised spiral threads on the shell surface.

Striate. Refers to a shell having fine, spiral, incised lines or striae on its surface (see Fig. 89). Also used, less precisely, for shells with spiral raised lines, or for shells covered with fine transverse lines.

Stylet. A chitinous or calcareous dagger-like tip on end the penis of some snails (*e.g.*, see chitin tip in Fig. 108).

Subcentral. Not quite central; off-center.

Subfamily (*adj.* subfamilial). A taxonomic category or group between the genus and family in the hierarchy of animal classification. Subfamilies are

used when it is necessary to divide a family into more than one group of closely related genera. The subfamily is therefore a subordinate category to the family. Each subfamily contains one or more genera. Names of subfamilies end in *-inae*.

Subgenus (*pl.* subgenera; *adj.* subgeneric). A taxonomic category or group between the species and genus in the hierarchy of animal classification. Subgenera are used when it is necessary to divide a genus into more than one group of closely related species. The subgenus is therefore a subordinate category to the genus. Each subgenus contains one or more species.

Subglobose. Not exactly globular or spherical in shape, but approaching such a form.

Subglobosely conic. Designation for a snail shell with a spire angle of about 70° (± 5°) (see Fig. 81f).

Subobsolete. Hardly visible.

Subovate. Not exactly oval in shape, but approaching such a form.

Subovately conic. Designation for a snail shell with a spire angle of about 50° (± 5°) (see Fig. 81d).

Subspecies (*pl.* subspecies; *adj.* subspecific; *syn.* race, variety). One or more populations of a species that inhabit a distinct geographic area and that share morphological features setting them off from other populations of the species.

Superfamily. A taxonomic category or group between the family and order in the hierarchy of animal classification. Superfamilies are used when it is necessary to divide an order into more than one group of closely related families. Names of superfamilies end in *-oidea* (although it also has been common practice in malacology to use the ending *-acea*).

Suture. The external line on the shell where the surfaces of two adjacent whorls meet (see Fig. 84).

Synonym. A name for something that has another name; in zoological nomenclature, one of two or more names for the same taxon (species, genus, etc.). The earliest name is the "senior synonym" and has priority. The more recent name is a "junior synonym" and is rejected for nomenclatural purposes.

Synonymy. A list of synonyms. In taxonomy, a synonymy is a list of scientific names, in chronological order (with authors and dates, and generally with bibliographic references, including volume, page and figure numbers) that have been used (either correctly or as misidentifications) for a particular taxon.

Syntype. One of two or more specimens examined by the author of a species when the species was first described, where the author did not specifically select one of the specimens as the "type" or holotype. Syntype specimens of any particular species have equal nomenclatural rank.

Tail. The posterior end of the foot in a land snail.

Taxon (*pl.* taxa). Any taxonomic group, *e.g.*, a subspecies, species, genus, family, order, etc.

Taxonomic key. A device, using "key characters," whose object is the identification of taxa (as simply as possible). This is accomplished by recognizing, separating and segregating key characters of the taxa under consideration and arranging the characters into sets of two (dichotomous)

characters that give the reader a succession of alternative choices, leading eventually to a taxon (species, genus, family, etc.) name, which is the name of the object under consideration.

Teleconch (teleoconch). All of the whorls of a snail shell formed after the protoconch.

Tentacle. One of a pair of elongated, flexible organs on the head of snails used for feeling, or tasting or smelling, or for sensing light. Geophile snails have two pairs of tentacles, with an eye at the tip of each tentacle of the larger, upper pair. The freshwater snails have one pair of tentacles, with an eye at the base of each tentacle (*e.g.*, see Figs. 15, 94a).

Tessellate; tessellation; tesselloid. Formed into or of squares (tessellae; tesserae); checkered.

Tongue-shaped. Shaped like a tongue, *i.e.*, elongate and bluntly round at the end.

Tooth (*pl.* teeth). A hard, sharp, chitinous projection of the molluscan radula that tears away or punctures the food surface, or is modified for food capture (see Figs. 90-93). Also, a hard, calcareous nodule or projection in or around the aperture of the shell of some snail species (*e.g.*, *Planorbula armigera*) that functions to restrict entry into the shell by predators. Also called a barrier.

Topotype. A specimen of the nominal species collected at the type locality at a later time than the holotype, paratype(s), or syntypes were collected.

Translucent. Partially transparent; allowing diffused light to be transmitted.

Transparent. Clear; transmitting light without scattering, so that structures lying beyond are clearly visible.

Transverse. At right angles to the spiral direction of the whorls; parallel to the columella or axis of the shell; in the same direction (*i.e.*, parallel to) the growth lines of a snail shell (see Fig. 89).

Transverse sculpture. Surface markings on a snail shell that are parallel to the axis and lip of the shell and at right angles to the direction of coiling of the whorls (see Fig. 89); axial sculpture.

Trapezoidal. Having a quadrilateral shape, no two sides of which are parallel.

Tricuspid. Having three cusps (in reference to a radular tooth with three cusps, *i.e.*, cutting projections; see Fig. 27a).

Trifid. Divided into three parts, or terminating in three elongated projections.

Truncate, truncated. Having the end cut off more or less squarely; terminating abruptly; ending in a transverse line.

Tumid. Swollen or enlarged.

Turbinate, turbiniform. Shaped like a turban; refers to a shell in which the whorls decrease rapidly in diameter and taper broadly from a circular base to the apex.

Turreted. Shaped like a tower.

Type species. The one particular species on which a nominal genus or subgenus is based, and is either the only species in the nominal genus or subgenus, or is specifically designated as the "type species" of the nominal genus or subgenus.

Type specimen. The specimen, nearly always housed in a museum (and usually in a large, well-known one), on which a species or subspecies name is based; holotype.

Type locality. The geographic locality at which a holotype or the syntypes were collected. In older literature, the type locality was often imprecise.

Typhlosole. A longitudinal invagination of the intestinal wall (see Fig. 101) that functions to increase absorptive area.

Ultimate whorl. The last complete whorl or volution of a spiral snail shell, measured from the outer lip back to a point immediately above the outer lip; body whorl (Fig. 78). The ultimate whorl is normally the largest whorl of the shell.

Ultradextral. A descriptive term applied to a species that, because of the shape of its shell aperture or the inversion of its "spire" and relatively less inversion (or eversion) of its basal (or "umbilical") whorls, appears to be sinistral, but has a dextral body (*i.e.*, the distal openings of the digestive, renal, reproductive [and respiratory systems in pulmonate snails] are on the right side); pseudosinistral; hyperstrophic.

Ultrasinistral. A descriptive term applied to a species that, because of the shape of its shell aperture or the inversion of its "spire" and relatively less inversion (or eversion) of its basal (or "umbilical") whorls, appears to be dextral, but has a sinistral body (*i.e.*, the distal openings of the digestive, renal, reproductive [and respiratory systems in pulmonate snails] are on the left side); pseudodextral.

Umbilical chink. A very small, rimate, umbilical opening.

Umbilical side of shell. The side or end of the shell in which the umbilicus is located; the side of the shell opposite the apex (see Figs. 57; 78).

Umbilicate. Refers to a spiral gastropod shell that has an opening or cavity at its base, and more specifically to one in which the opening is more than a very narrow perforation (Fig. 86d). This cavity is formed in those shells in which the inner sides of the coiled whorls do not join.

Umbilicus. An opening or cavity in the center of the columella or axis of the shell (see Figs. 78; 86d), formed in those shells in which the inner walls of the whorls at the central axis do not coalesce to form a solid center.

UMMZ. Abbreviation, usually associated with museum specimen catalog numbers, for the University of Michigan Museum of Zoology.

Univalve. Consisting of one valve, as the shell of a gastropod (in contrast to the bivalved shell of a bivalve or pelecypod, or to the eight-valved shell of a Polyplacophoran).

Ureter. A tube conveying nitrogenous wastes from the renal organ (kidney) to the nephridiopore for discharge to the outside.

USNM. Abbreviation, usually associated with museum specimen catalog numbers, for the National Museum of Natural History (formerly the United States National Museum), Smithsonian Institution.

Vagina. The copulatory sheath of the female system. It extends from the female genital pore to the spermathecal duct.

Valve. The single undivided shell of a gastropod, scaphopod and monoplacophoran mollusk, or one of the opposing halves of the divided shell of a pelecypod mollusk, or one of the eight dorsal plates of a polyplacophoran mollusk.

Valvatid. A common name adjective referring to a member of the freshwater snail family Valvatidae.

Varicose. Having several or many varices.

Varix (*pl.* varices). A prominent transverse collabral mark on a snail shell that is the result of thickening of the outer lip by calcium deposition during a period when linear growth was halted (usually during the winter in temperate regions). A varix is usually discolored, making it particularly evident.

Velum. The fleshy lobe, or bilobed flap, on which the mouth is situated in lymnophile snails; a proximal inner collar around the opening into the preputium from the penis sheath.

Ventral. The lower side.

Verge. The non-introversible male copulatory organ of prosobranch snails, through or along which sperm are discharged during copulation. In some taxa, the verge is variously branched (*e.g.*, see Figs. 15a, 19, 20, 96a), with one or two branches containing a duct or ducts from accessory glands. In the latter type of verge, the penis is that branch (or papilla or filament) that contains the sperm duct.

Viscera. The internal organs, especially those of the apical viscera, *i.e.*, the internal organs (*e.g.*, liver; upper parts of the reproductive, renal and digestive systems, etc.) outside of the head-foot hemocoel.

Viviparid. A common name adjective referring to a member of the freshwater snail family Viviparidae.

Viviparity. The state or condition of giving birth to infant crawling snails, in contrast to laying eggs externally (oviparity), which subsequently hatch outside the mother's body. Viviparity includes ovoviviparity, where the eggs are laid with already well developed infant snails within the egg shell or membranes. See also ovoviviparous and oviparous.

Viviparous. See viviparity.

Whirl. See "whorl."

Whorl (spelled 'whirl' in early literature). One complete turn (through 360 degrees) or coil of a spiral gastropod shell.

Widely conic. Designation for a snail shell with a spire angle of about 100° (± 10°) (see Fig. 81h); depressed conic.

Width. The diameter of a snail's shell (see Fig. 78).

Zebrated. Shell surface marked with zebra-like alternating light and dark transverse bands (*e.g.*, see Figs. 38 [shell on far right], 41).

Zoological nomenclature. The scientific names used to denote species of animals, and groups of species; the system of taxon names, intended to provide universality and stability, used in zoology. The nomenclatural system in use by zoologists employs the Linnean, or binomial system, whereby each animal species is given a unique combination of two names, a generic name combined with a specific or trivial name. The use of zoological taxon names is regulated by the periodically revised and published International Rules of Zoological Nomenclature. The latest (3rd) edition of the Rules was published in 1985, and can be obtained from the American Association for Zoological Nomenclature, c/o National Museum of Natural History, Washington, D.C. 20560.

REFERENCES PERTINENT TO THE FRESHWATER SNAILS OF NORTHERN MICHIGAN

The references below are those that are particularly pertinent to the UMBS area. They are either recent taxonomic revisions that include species that occur in the UMBS area (although the UMBS area may not be specifically mentioned), or are publications specifically mentioning species as occurring in the UMBS area, or are studies in the UMBS area on freshwater snails.

Throughout the preceding text various additional references are cited that are pertinent where mentioned, but otherwise are not of special significance to the UMBS area. Such publications are not listed in the references below, but, where mentioned in the text, the full citations regarding author(s), journal, volume, and pertinent pages and illustrations are given.

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INDEX TO SCIENTIFIC NAMES

The index that follows contains the scientific names in the preceding text and the old names as they appear in the synonymies of each of the UMBS species. The synonyms are included in this manual as an aid in reconciling past and current nomenclature when referring to previous literature. In the index below, synonyms and extralimital genera and species are in regular italics. Names of most higher taxa (*i.e.*, subclasses, orders, superfamilies, subfamilies and tribes) are in regular Roman characters. The names of families, genera, subgenera and species in the UMBS area, and the primary page numbers for UMBS area taxa, are in bold type.