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A Guide to Freshwater Mollusks of the Laurentian Great Lakes with Special Emphasis on the Genus *Pisidium*

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July 1980

A GUIDE TO FRESHWATER MOLLUSKS OF THE LAURENTIAN GREAT LAKES WITH SPECIAL EMPHASIS ON THE GENUS *PISIDIUM*

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FOREWORD

Our nation's freshwaters are vital for all animals and plants, yet our diverse uses of water--for recreation, food, energy, transportation, and industry--physically and chemically alter lakes, rivers, and streams. Such alterations threaten terrestrial organisms, as well as those living in water. The Environmental Research Laboratory in Duluth, Minnesota develops methods, conducts laboratory and field studies, and extrapolates research findings

--to determine how physical and chemical pollution affects aquatic life

--to assess the effects of ecosystem on pollutants

--to predict effects of pollutants on large lakes through use of models

--to measure bioaccumulation of pollutants in aquatic organisms that are consumed by other animals, including man

This guide will aid in the identification of mollusks in the freshwater environment. To provide an accurate assessment as to the impact of pollutants on the ecosystem, accurate identification of the organisms inhabiting these zones is required. The taxonomy of mollusks will be greatly enhanced through the descriptions provided in this guide.

Norbert Jaworski, Ph.D.
Director
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ABSTRACT

Presented here are keys and notes on distribution and ecology for the freshwater snails (Gastropoda), mussels (Unionidae), and fingernail clams (Sphaeriidae) which have been collected from the Laurentian Great Lakes. Including subspecies and forms, 121 taxa are discussed: 47 Gastropoda, 39 Unionidae, and 35 Sphaeriidae. Relations to substrate preferences and pollution are summarized where known. Special emphasis is given to the sphaeriid genus *Pisidium* in discussions of morphological variability and characters which will separate the species and forms both in the adult and immature stages. Both drawings and scanning electron microscope photomicrographs are presented for all sphaeriid taxa. A limited synonymy has been compiled from publications and reports on the Laurentian Great Lakes and the expanded reference section includes not only citations used in the text but also publications and reports which may aid researchers in more indepth studies of the fauna.

CONTENTS

Foreword . . . iii
Abstract . . . iv
Acknowledgments . . . vi

I. Introduction . . . 1
Sphaeriidae . . . 3
Unionidae . . . 4
Gastropoda . . . 5
II. Checklist of Freshwater Mollusks in the Laurentian Great Lakes . . . 6
Gastropoda . . . 6
Unionidae . . . 6
Sphaeriidae . . . 7
III. Key to Freshwater Mollusks of the Laurentian Great Lakes . . . 8
Gastropoda . . . 8
Unionidae . . . 23
Sphaeriidae . . . 36
IV. Ecology and Distribution of Gastropoda . . . 97
V. Ecology and Distribution of Unionidae . . . 101
VI. Ecology, Distribution, and Variation of Sphaeriidae . . . 103

Synonymy . . . 120
Glossary . . . 124
References . . . 130
Index to Species, Subspecies, and Forms . . . 139

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SECTION I

INTRODUCTION

In the Laurentian Great Lakes, considerable emphasis has been placed on the use of benthic macroinvertebrates for the biological assessment of water quality. The macroinvertebrate community, or parts of it, has been utilized to determine areas of enrichment within the lakes (e.g., Cook and Powers, 1964; Carr and Hiltinen, 1965; Powers and Alley, 1967; Johnson and Brinkhurst, 1971; Mozley and garcia, 1972; Kinney, 1972; Mozley and Alley, 1973; Mozley and Howmiller, 1977) and to relate species distributions to physical-chemical parameters of the water or sediment (e.g., Henson and Herrington, 1965; Johnson and Matheson, 1968; Adams and Kregar, 1969; Hiltunen, 1969; Schneider et al., 1969). Others have investigated species composition and productivity of the communities (e.g., Shelford and Boesel, 1942; Teter, 1960; Powers and Robertson, 1965, 1968; Thomas, 1966; Robertson and Alley, 1966; Freitag et al., 1976).

Most of the studies cited above, to some extent, have attempted to examine populations at the species level and most refer to the mollusk community. The lack of up-to-date keys for Great Lakes' macroinvertebrates, particularly the mollusks, has prevented more extensive analysis of community dynamics. Many of the studies have not been consistant in the level of identification, especially with the juvenile stages. By example, juvenile *Pisidium* collected from deeper portions of the lakes often are lumped under *Pisidium conventus* because it is the major profundal species. When this is done, populations of *Pisidium lilljeborgi* or *Pisidium casertanum*, although not common in very deep waters, may be overlooked. There are even greater problems with immatures and variants from near-shore areas where mollusks show the greatest densities and diversity.

This publication has been motivated by the need for a more comprehensive key to the Sphaeriidae, notably the genus *Pisidium*, as they exist in the Laurentian Great Lakes. Previous identification manuals (Herrington, 1962; Burch, 1972, 1975a), are broad in scope and not designed to examine the various life history stages nor the variability among more localized populations. The above texts plus works by Kuiper (1956, 1962), Herrington (1965), Heard (1966, 1969), and Clarke (1973) should be consulted for greater general treatments of distributions, ecology, and systematics. As a supplement to the key, comparative notes are provided for adults and immatures of the Great Lakes' *Pisidium*. It should be stressed that the annotations are most applicable to specimens from the Great Lakes, and the references listed above should be used for collections from other systems.

To complete the list of known freshwater mollusks from the Laurentian Great Lakes, keys and short annotations are included for the Unionidae or freshwater mussels and the Gastropoda or freshwater snails. We hope that the keys will allow workers to more readily identify specimens from the Great Lakes as the often unwieldy number of species not found in these waters is excluded. It is recognized that there is the distinct possibility of other species either existing in, being introduced, or invading the Great Lakes from tributaries. To aid in their identifications, the keys have been made open-ended with couplets leading to more comprehensive references for particular families and genera.

The final section of this manual is devoted to annotations of habitats, distributions, and relative abundances. This information is highly qualitative because there have been few good quantitative studies. Fig. 1 shows the areas of the Laurentian Great Lakes which have received the majority of benthological attention. Clearly, even more qualitative surveys are required before the basics of general distributions are fully known. Little is known about large areas of Lakes Superior and Huron.

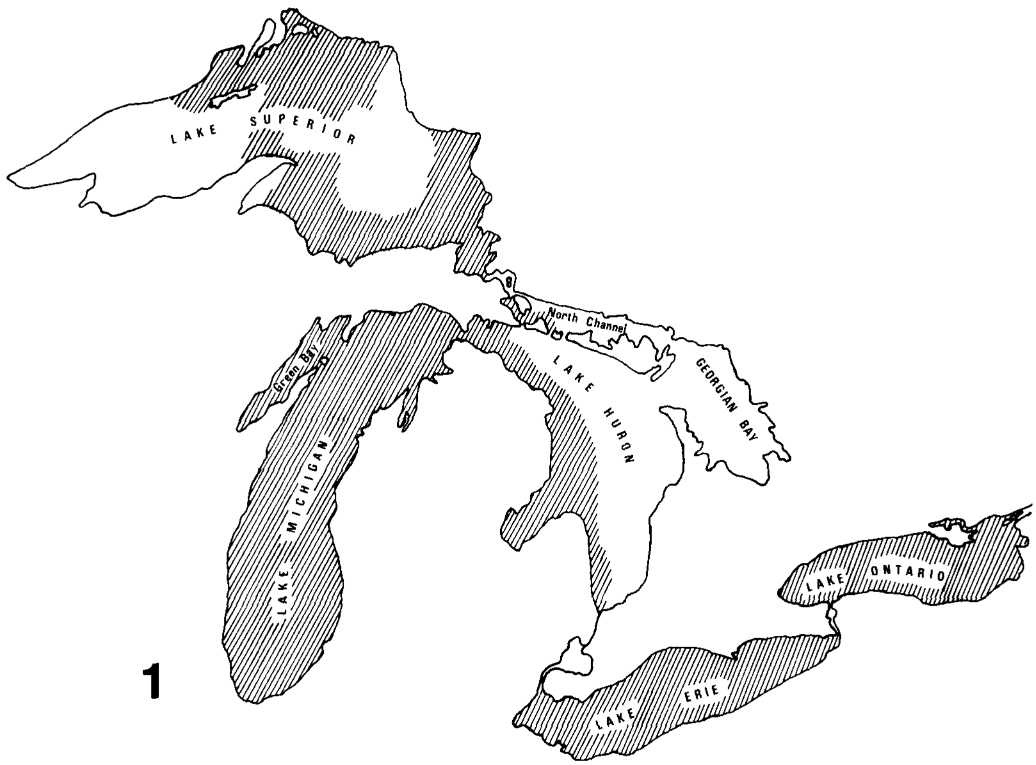

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Figure 1. Outline map of the Laurentian Great Lakes showing areas (shaded) which have had qualitative or quantitative surveys and for which there are lists of freshwater mollusks at the species level.

SPHAERIIDAE

The Sphaeriidae, or fingernail clams, are the numerically dominant component of the open lake mollusk fauna. of the 37 distinct North American species, 29 have been recorded from the Laurentian Great Lakes. Including subspecies and forms, 35 taxa are present and included in the key and checklist. Maximum densities and diversity occur in the 20-40 m depth interval in silty-sand where there may be several hundred individuals per square meter. Few species are found at depths greater than 50 m and only *Pisidium conventus* is known to inhabit the deepest parts of the lakes (Heard, 1963; Henson and Herrington, 1965; Robertson, 1967). Densities have been shown to be enhanced by mild organic enrichment, but many species cannot tolerate severer pollutants (Carr and Hiltunen, 1965); thus, there may have been a general increase in the sphaeriid populations over the past few decades.

Because of habitat, densities, and small sizes of most Sphaeriidae, standard benthological techniques for collecting in open water have proven adequate for clams when samples are washed through seives with mesh openings of 0.400 mm or less (e.g., Petersen, Ekman, and Ponar grabs and various coring devices; see Flannagan, 1970; Mozley and Howmiller, 1977; and Resh 1979 for review and criticisms of sampling methods). Several species of *Sphaerium* and *Musculium* are associated with shallow, rocky areas and rooted aquatic macrophytes, and special collection methods must be used (dip nets, hand picking from vegetation, etc.). Sphaeriids are ovoviviparus, and some adults may prematurely abort the young when distrubed or preserved. If collections are to be used for life history studies, larger clams should be preserved individually in vials.

For most general taxonomic work required in benthological studies, only the shells need be examined; therefore, whole samples can be preserved in 70-80% ethyl alcohol or 4-10% formalin buffered by saturating with calcium carbonate. Unbuffered formalin is slightly acidic and will dissolve shells in a short period to time. Therefore, if formalin is the innitial preservative (even if buffered), samples should be washed and transferred to alcohol after a few days. Other preservatives which have proven successful for long-term storage include 40% isopropyl alcohol and 1% propylene phenoxetol. If soft anatomy is to be studied, specimens must be relaxed and fixed before preservation (see Burch, 1972, 1975a, 1975b).

For the purposes of this key, the soft anatomy of sphaeriids may be ignored because fairly reliable characters are found in differences between hinge teeth and shell shape, even for immatures. A good stereomicroscope with magnification to 100× is needed to examine hinge teeth, and shells should be examined dry.

Shells of sphaeriids tend to be yellowish or brownish when alive and have little or no surface sculpture other than striae. The right valve contains only one cardinal tooth and two pairs of lateral teeth. Conversely, the left valve contains two cardinal teeth and only two lateral teeth (Figs. 117, 118). The three genera known from the Great Lakes can be distinguished by the shells. In *Sphaerium* and *Musculium* the beaks are subcentral

(Figs. 124, 132) or on the anterior side of center (Figs. 154, 162), while in *Pisidium* the beaks are posterior of center (Figs. 117, 118). The shells of *Musculium* generally differ from those of *Sphaerium* by having raised umbonal caps and thinner shells (Figs. 132, 162).

UNIONIDAE

The Unionidae or freshwater mussels usually are confined to the shallower or littoral portions of the Great Lakes where there is some constant water movement (Walker, 1913; Goodrich and van der Schalie, 1932a, 1932b; Langlois, 1954; Stansbery, 1961; van der schalie, 1961; Wood, 1963; Carr and Hiltunen, 1965; Wolfert and Hiltunen, 1968). While each of the Laurentian Great Lakes has at least limited populations, the western basin of Lake Erie has been noted for its extensive mussel beds. In the past few decades, the populations in western Lake Erie have declined markedly and may be limited in the open lake to small mumbers of *Lampsilis radiata siliquoidea* (Wood, pers. comm.). Reasons for declines in densities and diversity have been attributed to several factors including physicochemical changes in the open water and loss of host fishes for the parasitic glochidia or larval stage of the mussels (Wood, 1963, per. comm.; Carr and Hiltunen, 1965; Wolfert and Hiltunen, 1968). In the key we have included most of the recent species; however, many of these may no longer be present in the Laurentian Great Lakes but may be found in adjacent streams, rivers, and ponds.

When existing in a variety of habitats, unionids exhibit distinct forms and morphological variations. This has been noted particularly in Lake Erie where those species living in the wave zone are markedly different from their counterparts from other bodies of water (Grier, 1918, 1920; Ball, 1922; Brown et al., 1938; van der Schalie, 1941). The differences should be taken into account when attempting to use the guide presented here, although we have tried to illustrate typical Lake Erie forms and similar adjustments have been made in the keys.

With their larger size and generally low densities, standard benthos collection devices are of little help in surveys and quantitative studies. Special dredges, crowfoot bars, SCUBA, and seines must be used to estimate populations (see Starrett, 1971, for review of some commonly used methods).

Keys to the families (only Unionidae has been recorded from the Laurentian Great Lakes), subfamilies, and tribes require the use of soft anatomy. Most species, however, may be identified on the basis of hinge and shell characters, many of which may be qualitative. Therefore, it has been difficult historically to create workable keys to the unionid fauna. Even with the fauna of the Great Lakes being somewhat limited, the key presented here must make use of both shell characters and the soft anatomy of mature specimens. Live mussels should be relaxed and fixed before preservation and will be the easiest to identify. Empty shells in good condition may be identified by going past the couplets where soft anatomy is used and then by examining the figures. If difficulties remain, the guides of Clarke (1973) and Burch (1973, 1975b) should be consulted.

GASTROPODA

General distributions of most snails in the Laurentian Great Lakes are not well known, and the systematics of many families and genera are in need of much work. The list and keys presented here are as close to 'state-of-the-art' as possible but in no way are definitive. As with unionids, gastropods reach their greatest abundance and diversity in the near-shore, rocky zones and areas of emergent vegetation, though a few species are associated with the soft sediments of the open lake. The litoral zones of Lake Erie, Michigan, and the north shore of Ontario are composed of varying combinations of mud, clay and sand which have a diverse mollusk fauna including many species of snails. Much of the littoral zones of Lakes Superior, Huron, and the southern shore of Ontario are quite rocky and the fauna consequently is limited to gastropods.

Some aquatic pulmonates such as Physidae, Lymnaeidae, and the planorbid *Gyraulus circumstriatus* estivate under logs, rocks, and leaves where they may be collected by hand during dry periods. Several of the Physidae, Lymnaeidae, Planorbidae, and Hydrobiidae are associated with submerged, emergent, or floating gevetation and are collected by washing or shaking the plants in a pail of warm water. Ancylidae must be gathered by hand since they tend to cling tightly to smooth or "bottle like" surfaces of submerged objects. Pleuroceridae and Viviparidae inhabit the rocky and softer sediments of the open lake and standard benthological collecting techniques may be adequate to estimate their populations. Very few quantitative studies of snails are in the literature because of the variety of sampling methods needed to examine the whole fauna.

With few exceptions, the snail fauna of the Laurentian Great Lakes may be identified using shell characters alone. Preserved live specimens will be easiest to identify particularly for the operculate species where the operculum is a key character and it has remained attached. Although the teeth of the radula are not diagnostic features of the keys, it may be necessary to examine the radula for some species (e.g., the *Lymnaea*) thought to be new to the Great Lakes (see Clarke, 1973 for methods).

SECTION II

CHECKLIST OF FRESHWATER MOLLUSKS IN THE LAURENTIAN GREAT LAKES

The following list is based on museum records, benthological surveys, and combines previously published and unpublished species lists.

GASTROPODA

Viviparidae
Campeloma decisum (Say)
Campeloma rufum (Haldeman)
Viviparus georgianus (Lea)
Valvatidae
Valvata bicarinata Lea
Valvata lewisi Currier
Valvata perdepressa Walker
Valvata piscinalis (Müller)
Valvata sincera (Say)
Valvata tricarinata f. *basalis* Vanatta
Valvata tricarinata f. *perconfusa* Walker
Valvata tricarinata f. *tricarinata* Say
Hydrobiidae
Amnicola limosa (Say)
Amnicola walkeri Pilsbry
Bithynia tentaculata (Linnaeus)
Cincinnatia cincinnatiensis (Anthony)
Marstonia decepta (Baker)
Probythinella lacustris (Baker)
Somatogyrus subglobosus (Say)
Pleuroceridae
Goniobasis livescens (Menke)
Pleurocera acuta (Rafinesque)
Lymnaeidae
Bulimnea megasoma (Say)
Fossaria decampi (Streng)
Fossaria humilis Say
Fossaria obrussa Say
Lymnaea stagnalis appressa Say
Pseudosuccinea columella (Say)
Radix auricularia (Linnaeus)
Stagnicola caperata (Say)
Stagnicola catascopium f. *catascopium* Say
Stagnicola catascopium f. *nasoni* Baker
Stagnicola emarginata (Say)
Stagnicola reflexa (Say)
Physidae
Physella gyrina sayi (Tappan)
Physella integra (Haldeman)
Physella vinosa (Gould)
Planorbidae
Gyraulus circumstriatus (Tryon)
Gyraulus deflectus (Say)
Gyraulus parvus (Say)
Helisoma anceps (Menke)
Helisoma campanulatum (Say)
Helisoma corpulentum (Say)
Helisoma trivolvis (Say)
Promenetus exacuous (Say)
Ancylidae
Ferrissia parallela (Haldeman)
Ferrissia tarda (Say)
Laevapex fuscus (Adams)

UNIONIDAE

Alasmidonta calceolus (Lea)
Amblema plicata Say
Anodonta cataracta Say
Anodonta grandis grandis Say
Anodonta grandis simpsoniana Lea
Anodonta imbecillis Say
Anodontoides ferussacianus (Lea)
Carunculina parva (Barnes)
Cyclonaias tuberculata (Rafinesque)
Dysnomia sulcata Lea
Dysnomia triquetra (Rafinesque)

Elliptio complanata (Lightfoot)
Elliptio dilatata (Rafinesque)
Fusconaia flava (Rafinesque)
Lampsilis fasciola Rafinesque
Lampsilis ovata (Say)
Lampsilis radiata radiata (Gmelin)
Lampsilis radiata siliquoidea (Barnes)
Lasmigona complanata (Barnes)
Lasmigona costata (Rafinesque)
Leptodea fragilis (Rafinesque)
Ligumia nasuta (Say)
Ligumia recta (Lamarck)
Obliquaria reflexa Rafinesque
Obovaria olivaria (Rafinesque)
Obovaria subrotunda (Rafinesque)
Pleurobema cordatum f. *coccineum* (Rafinesque)
Proptera alata (Say)
Proptera laevissima (Lea)
Ptychobranchus fasciolare (Rafinesque)
Quadrula nodulata Rafinesque
Quadrula pustulosa (Lea)
Quadrula quadrula (Rafinesque)
Simpsoniconcha ambigua (Say)
Strophitus undulatus (Say)
Truncilla donaciformis (Lea)
Truncilla truncata Rafinesque
Villosa fabilis (Lea)
Villosa iris (Lea)

SPHAERIIDAE

Musculium lacustre f. *lacustre* (Müller)
Musculium lacustre f. *jayense* Prime
Musculium partumeium (Say)
Musculium securis (Prime)
Musculium transversum (Say)
Pisidium adamsi Stimpson
Pisidium amnicum (Müller)
Pisidium casertanum (Poli)
Pisidium compressum Prime
Pisidium conventus Clessin
Pisidium dubium (Say)
Pisidium equilaterale Prime
Pisidium fallax Sterki
Pisidium ferrugineum Prime
Pisidium henslowanum (Sheppard)
Pisidium idahoense Roper
Pisidium lilljeborgi f. *lilljeborgi* Esmark & Hoyer
Pisidium lilljeborgi f. *cristatum* Sterki
Pisidium milium Held
Pisidium nitidum f. *nitidum* Jenyns
Pisidium nitidum f. *pauperculatum* Sterki
Pisidium punctatum Sterki
Pisidium subtruncatum Malm
Pisidium supinum Schmidt
Pisidium variabile Prime
Pisidium ventricosum f. *ventricosum* Prime
Pisidium ventricosum f. *rotundatum* Prime
Pisidium walkeri f. *walkeri* Sterki
Pisidium walkeri f. *mainense* Sterki
Sphaerium corneum (Linnaeus)
Sphaerium nitidum Westerlund
Sphaerium occidentale (Prime)
Sphaerium rhomboideum (Say)
Sphaerium simile (Say)
Sphaerium striatinum (Lamarck)

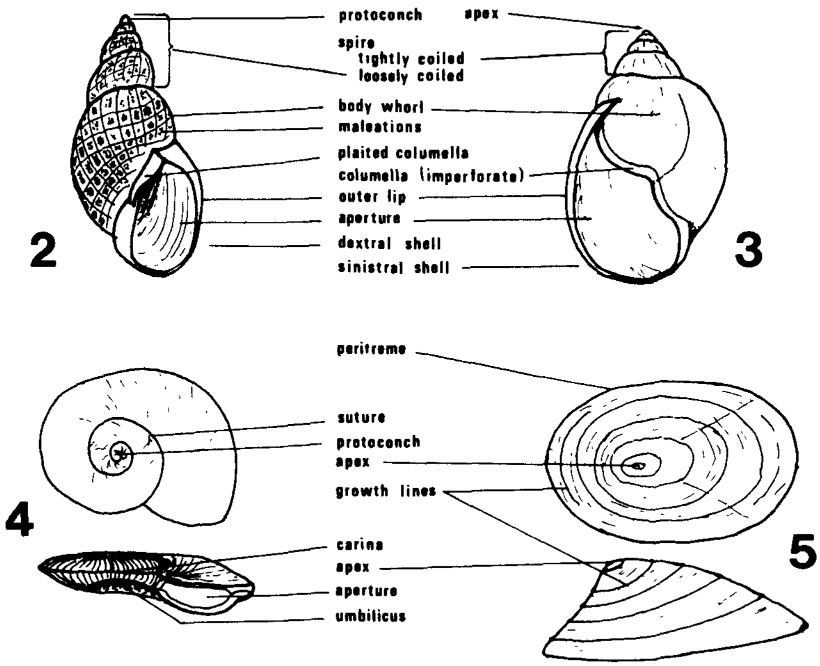
SECTION III

KEY TO THE FRESHWATER MOLLUSKS OF THE

LAURENTIAN GREAT LAKES

GASTROPODA

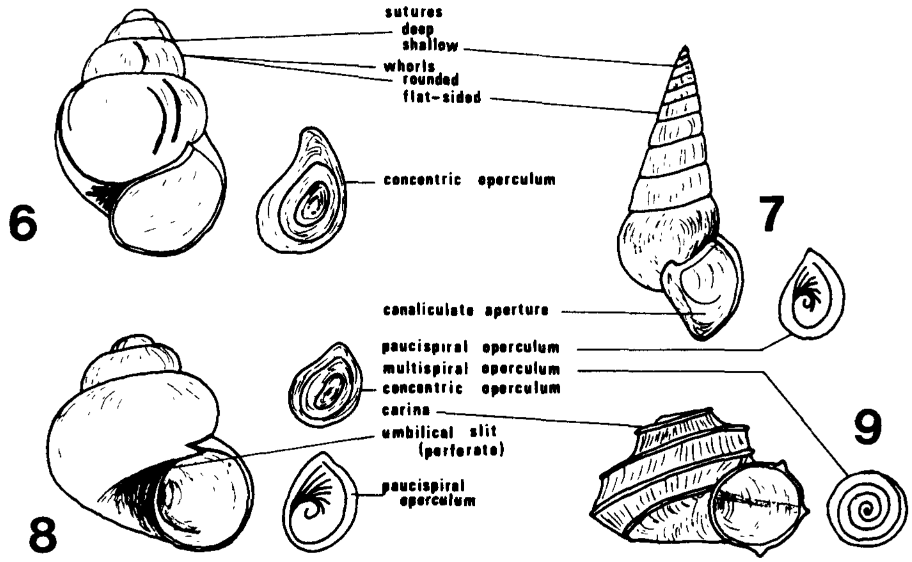
1 Shells whorled (Figs. 2, 3, 4) 2
Shells limpet-like (Fig. 5) ....ANCYLIDAE.......... 9



Figures 2-5. General shell shape and characters: 2- Lymnaeidae (*Stagnicola elodes*); 3- Physidae (*Physella* sp.); 4- Planorbidae (*Promenetus exacuous*); 5- Ancylidae (*Ferrissia parallela*).

2 (1) Whorls in one plane, operculum absent (Fig. 4) .PLANORBIDAE....... 12
Whorls in more than one plane, operculum present or absent (Figs. 2, 5, 6) 3

3 (2) Whorls sinistral (Fig. 3) ....PHYSIDAE.......... 21
Whorls dextral (Fig. 2) 4



Figures 6-9. General shell shape and characteristics: 6- Viviparidae (*Campeloma decisum*); 7- Pleuroceridae (*Goniobasis livescens*); 8- Hydrobiidae (*Amnicola limosa*); 9- Valvatidae (*Valvata tricarinata* f. *tricarinata*).

4 (3) Without an operculum (Fig. 2); mantle cavity a lung ... .LYMNAEIDAE........ 24
Operculum present (Figs. 6, 7, 8, 9); with gills 5

5 (5) Spire only slightly elevated; operculum circular and multispiral (Fig. 9) ....VALVATIDAE........ 37
Spire moderately to extremely elevated; operculum spiral or concentric but not circular (Figs. 6, 7, 8) 6

6 (5) Operculum concentric (Fig. 6) 7
Operculum spiral (Figs. 7, 9) 8

7 (6) Whorls flattened; umbilicus imperforate; adult shell
less than 13 mm high (Fig. 10): *Bithynia tentaculata*
Whorls inflated; umbilicus perforate; adult shell
greater than 15 mm high (Fig. 8) ....VIVIPARIDAE....... 45

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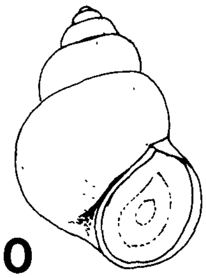
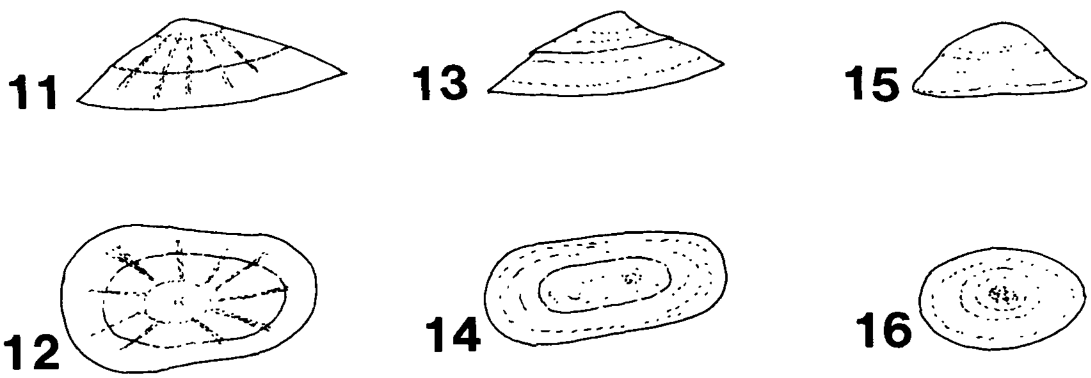


Figure 10. *Bithynia tentaculata* (Hydrobiidae) showing concentric operculum.

8 (6) Whorls flattened; umbilicus imperforate; adult shell
greater than 15 mm high (Fig. 7) ............PLEUROCERIDAE..... 48
Whorls inflated; umbilicus perforate; adult shell less
than 12 mm high (Fig. 8) ....HYDROBIIDAE....... 49

9 (1) ANCYLIDAE. Apex smooth; shell with fine radial striae
on newer parts (Figs. 11, 12): *Laevapex fuscus*
Apex finely striate (may be eroded in older specimens)
shell with no striations on newer parts (Figs. 13-16) 10



Figures 11-16. *Laevapex fuscus*: 11- lateral aspect; 12- dorsal aspect.
Ferrissia parallela: 13- lateral aspect; 14- dorsal aspect.
Ferrissia tarda: 15- lateral aspect; 16- dorsal aspect.

10 (9) Aperture with straight parallel sides; shell thin (Figs. 5, 13, 14): *Ferrissia parallela*

Aperture ovate, sides curved; shell moderately thick; apex may be pointed and recurved (Figs. 15, 16) 11

11 (10) Shell small, strongly elevated; apex dome-shaped; peritreme ovoid (Figs. 15, 16): *Ferrissia tarda*

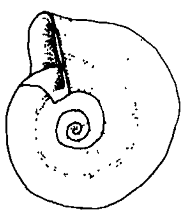
Shell large, moderately elevated; apex acute; peritreme broadly ovoid (see Basch, 1963; Hubendick, 1964; Harman and Berg, 1971).

12 (2) PLANORBIDAE. Axial height 4 mm or more, diameter 7 mm or more in post-juveniles; shell sinistral or dextral; aperture length/shell diameter ration >0.51 or, if less, never hirsute (Figs. 17-26) ....*Helisoma*.......... 13

Axial height 1-4 mm, diameter less than 8 mm in post-juveniles; shell dextral; aperture length/shell diameter ratio <0.50 or, if greater, shell hirsute or multicarinate (Figs. 27-33) 17

13 (12) Shell dextral; whorls flattened forming smooth-sided funnel-shaped depressions on both sides of shell (Figs. 17-19): *Helisoma anceps*

Shell sinistral; whorls rounded or flattened on one side of shell (Figs. 21, 23, 26) 14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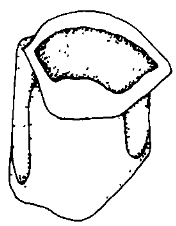
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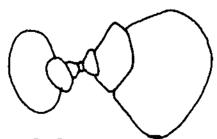
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Figures 17-19. *Helisoma anceps*: 17- dorsal aspect; 18- aperture aspect; 19- cross-section view.

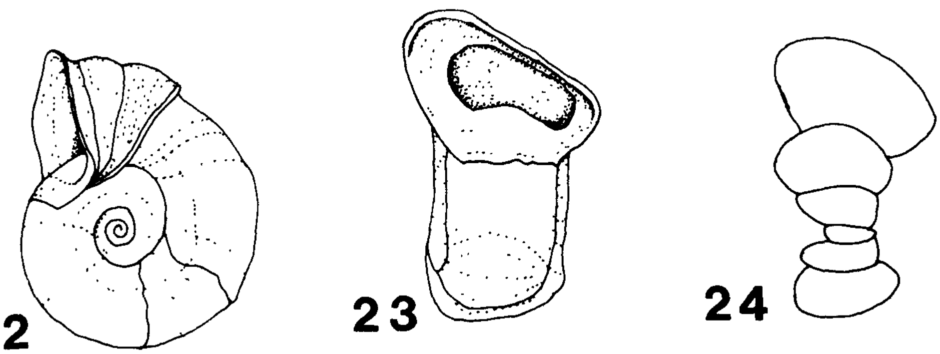
14 (13) Aperture bell-shaped; whorls compressed with rounded surfaces dorsally and ventrally (Figs. 20, 21): *Helisoma campanulatum*

Aperture flaring; whorls rounded on one side, flattened on the other (Figs. 23, 24, 26) 15

20 21

Figures 20-21. *Helisoma campanulatum*: 20- dorsal aspect; 21- cross-section view.

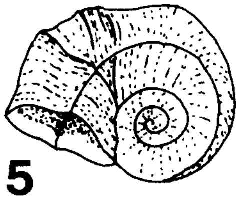
15 (14) Carinae present on body whorl (Fig. 25) 16
Carinae absent; whorls rounded ventrally and flattened dorsally forming broad, flat surfaces, enclosed by body whorl to create a flat-bottomed depression (Figs. 22-24): *Helisoma trivolvis*



22 23 24

Figures 22-24. *Helisoma trivolvis*: 22- dorsal aspect; 23- aperture aspect; 24- cross-section view.

16 (15) Carinae present at outer edge of upper and lower surfaces of body whorl (Fig. 25); body whorl abaxially flattened, either partly or completely (Fig. 26) (see Clarke, 1963 for subspecies): *Helisoma corpulentum*
Carinae present at least on early whorls and near centers of both upper and lower surfaces; body whorl abaxially rounded (see Clarke, 1973).



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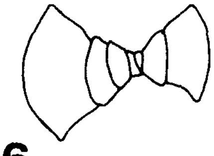

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Figures 25-26. *Helisoma corpulentum*: 25- dorsal aspect; 26- cross-section view.

17 (12) Shell ornamented with denticles on inside with raised growth lines; H:W ratio 1:2 or less or adult shell less than 2 mm diameter (see Clarke, 1973; Harman and Berg, 1971).

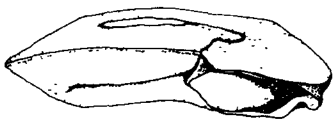
Shell smooth or with periostracal hairs or carinate or H:W ratio greater than 1:2; adult diameter greater than 2 mm diameter 18

18 (17) Shell extremely flattened, body whorl with a distinct carina on outer circumference (Fig. 27): *Promenetus exacuous*

Shell not flattened (Figs. 29, 31, 33) 19

19 (18) Shell with hirsute periostracum and/or carina (Figs. 28, 29): *Gyraulus deflectus*

Shell without periostracal hairs and carina (Figs. 30-33) 20



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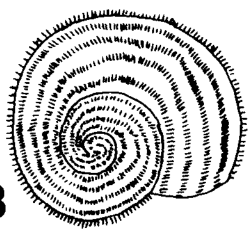

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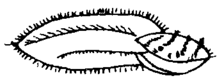

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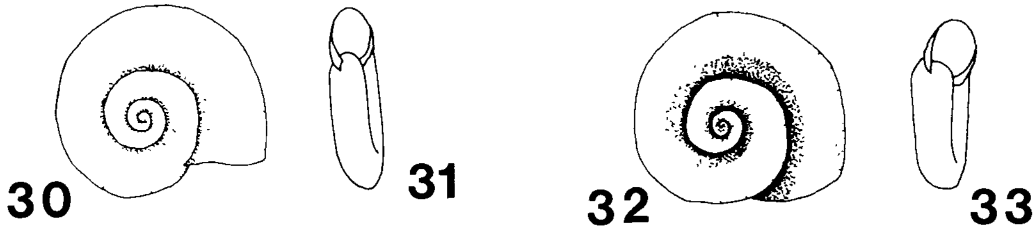
Figures 27-29. *Promenetus exacuous*: 27-lateral aspect. *Gyraulus deflectus*: 28- dorsal aspect; 29- lateral aspect.

20 (19) Shell whitish or yellowish, semi-transparent; nearly or entirely planospiral (Figs. 30, 31): *Gyraulus circumstriatus*

Shell brownish, translucent but not transparent; less planospiral, with dorsal and ventral aspects distinctly different (Figs. 32, 33): *Gyraulus parvus*



Figures 30-33. *Gyraulus circumstriatus*: 30-dorsal aspect; 31- lateral aspect. *Gyraulus parvus*: 32- dorsal aspect; 33- lateral aspect.

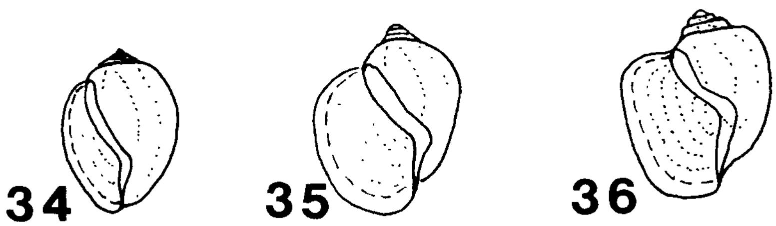
21 (3) PHYSIDAE. Shell elongate with very tall spire (*Aplexa*, see Te, 1978).

Shell only moderately elevated above body whorl ....*Physella*...... 22

22 (21) (This portion of key extracted from the recent revision by Te, 1978, and includes only species he records from the Great Lakes. Note that the key differs substantially from Harman and Berg, 1971, and Te, 1975)

Shell symmetrical; whorls with only slight suture indentations (Fig. 34): *Physella gyrina sayi*

Shell asymmetrical; whorls with distinct suture indentations (Figs. 35, 36) 23



Figures 34-36. 34-*Physella gyrina sayi*; 35- *Physella vinosa*; 36- *Physella integra*.

23 (22) Whorls strongly indented and rounded (Fig. 35); shell reddish: *Physella vinosa*

Whorls sharply indented and box-shaped (Fig. 36); shell horn-colored: *Physella integra*

24 (4) LYMNAEIDAE. Shell narrow and elongate (W/L less than 0.40) (Fig. 37) 25

Shell wider (W/L greater than 0.40) (Figs. 38-40) 26

25 (24) Shell 3 to 4 times higher than wide; columella plaited (Fig. 37): *Stagnicola reflexa*

Shell more than 5 times higher than wide; columella almost striaght (see Harman and Berg, 1971).

26 (24) Aperture more than 5 times higher than spire; shell almost as wide as high (W/L greater than 0.90) (Fig. 38): *Radix auricularia*

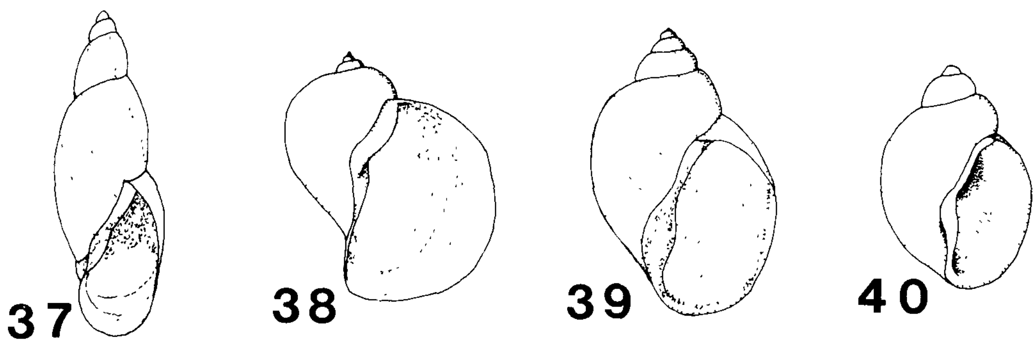
Aperture less than 3 times higher than spire; shell much higher than wide (W/L less than 0.70) (Figs. 39-41) 27

27 (26) Aperture more than 1.5 times higher than spire (Figs. 41, 42) 28

Aperture less than 1.5 times higher than spire; shell usually thin (Figs. 43-48) 29

28 (27) Shell solid and inflated; columella plait (Fig. 2) moderately developed, poorly gyrate; adult shell less than 0.50 mm high (Fig. 40): *Stagnicola catascopium* f. *nasoni*

Shell thin, only slightly inflated; columella plait, clearly visible and gyrate but not well developed; adult shell up to 0.75 cm high (Fig. 41): *Pseudosuccinea columella*



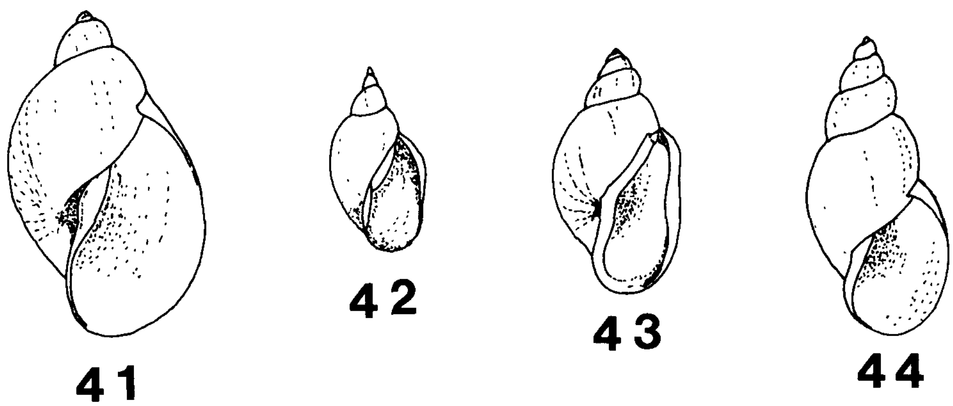
Figures 37-40. 37- *Stagnicola reflexa*; 38- *Radix auricularia*; 39- *Stagnicola catascopium* f. *catascopium*; 40- *Stagnicola catascopium* f. *nasoni*.

29 (27) Whorls loosely coiled; sutures deeply impressed 30
Whorls tightly coiled;, sutures shallow 35

30 (29) Body whorl near outer lip flattened laterally (Figs. 42, 43) 31
Body whorl near outer lip rounded (Figs. 44, 46) 32

31 (30) Whorls stongly shouldered; aperture narrowed adapically; adult shell less than 12 mm (Fig. 42): *Fossaria decampi*
Whorls weakly shouldered; aperture wider adapically; adult shell less than 20 mm (Fig. 43): *Fossaria obrussa*

32 (30) Spiral striae indistinct or absent (Fig. 44): *Fossaria humilis*



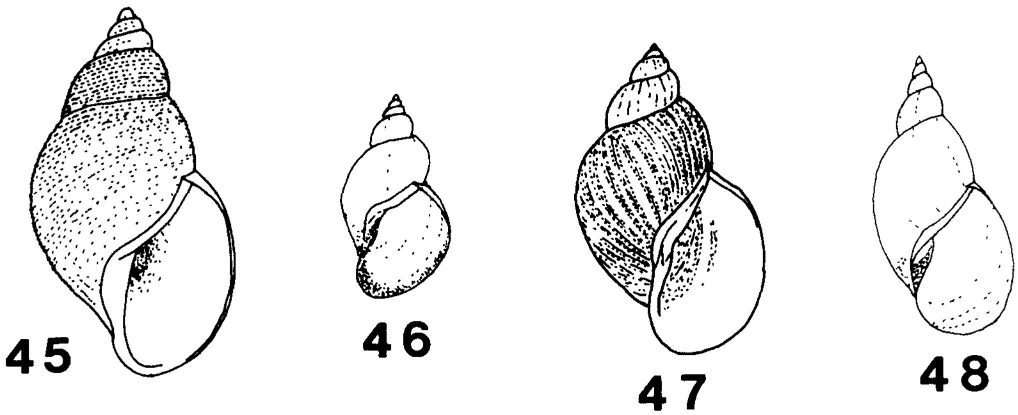
Figures 41-44. 41- *Pseudosuccinea columella*; 42- *Fossaria decampi*; 43- *Fossaria obrussa*; 44- *Fossaria humilis*.

33 (32) Body whorl with spiral, microscopic, blade-like periostracal ridges; adult shell less than 15 mm high (Fig. 45): *Stagnicola caperata*
Body whorl with spiral striae but not blade like; adult shell more than 15 mm high (Figs. 46, 47) 34

34 (33) Inner lip of aperture strongly plaited with a small umbilical chink; aperture not brownish or purplish within (Fig. 46): *Stagnicola emarginata*
Inner lip of aperture gyrate plait and umbilical chink absent; aperture brownish or purplish within (Fig. 47): *Bulimnea megasoma*

35 (29) Spire elevated, whorls flattened; adults higher than 35 mm (Fig. 48): *Lymnaea stagnalis appressa*
Spire short, whorls more rounded; adults shorter than 35 mm (Fig. 39) 36

36 (35) Shell broad (W/L greater than 0.55); whorls not
malleated (Fig. 39): *Stagnicola catascopium* f. *catascopium*
Shell narrower (W/L less than 0.55); whorls often
malleated (see Harman and Berg, 1971; Clarke 1973).



Figures 45-48. 45- *Stagnicola caperata*; 46- *Stagnicola emarginata*; 47- *Bulimnea megasoma*; 48- *Lymnaea stagnalis appressa*.

37 (5) VALVATIDAE. Whorls angulate or carinate (Figs. 9, 49) 38
Whorls rounded and inflated (Figs. 51-54) 42

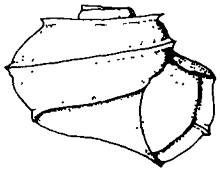
38 (37) Body whorl with 3 carinae (Fig. 49):
Valvata tricarinata f. *tricarinata*
Body whorl with 2 or fewer carinae (Fig. 50) 39

39 (38) Body whorl with 2 carinae (Fig. 50) 40
Body whorl with 1 carina (see Harman and Berg, 1971).

40 (39) Shell planospiral with nuclear whorl at same plane
as or sunken below following whorl (Fig. 50): *Valvata bicarinata*
Shell with a short spire (see Fig. 49) 41

41 (40) Upper and lower carinae present (see Fig. 49):
Valvata tricarinata f. *perconfusa*
Upper and middle carinae present (see Fig. 49):
Valvata tricarinata f. *basalis*

42 (37) Whorls with coarse growth lines (Fig. 51): *Valvata lewisi*
Whorls with fine growth lines (Figs. 52-54) 43



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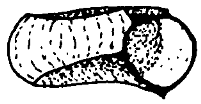

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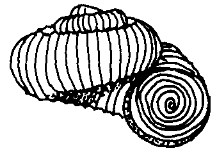

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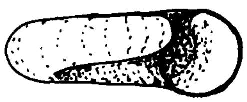
Figures 49-51. 49-*Valvata tricarinata* f. *tricarinata*; 50- *Valvata bicarinata*; 50- *Valvata lewisi*.

43 (42) Shell planospiral with nuclear whorl at same plane
as or sunken below following whorl (Fig. 52): *Valvata perdepressa*
Shell with a short spire (Figs. 53, 54) 44

44 (43) Spire conic (Fig. 53): *Valvata sincera*
Spire attenuate (Fig. 54): *Valvata piscinalis*



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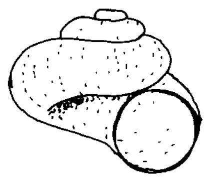

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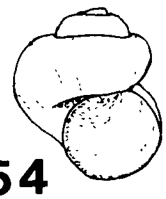

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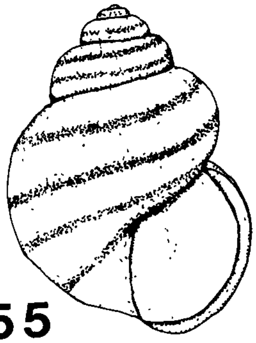
Figures 52-54. 52-*Valvata perdepressa*; 53- *Valvata sincera*; 54- *Vlavata piscinalis*.

45 (7) VIVIPARIDAE. H:W ratio less than 1.35:1; whorls
inflated, outer lip usually straight (Figs. 55, 56) 46
H:W ratio greater than 1.5:1 47

46 (45) Yellow-green with 4 brown bands on body whorl (Fig. 55):
Viviparus georgianus
Without brown bands; surface malleated; whorls
flattened on spire; large up to 70 mm high (Fig. 56):
Viviparus japonicus

47 (45) Apex of shell and interior aperture with a reddish color;
whorls of spire slightly impressed (Fig. 57): *Campeloma rufum*
Apex of shell and interior aperture without reddish color;
whorls of spire deeply impressed (Fig. 58): *Campeloma decisum*



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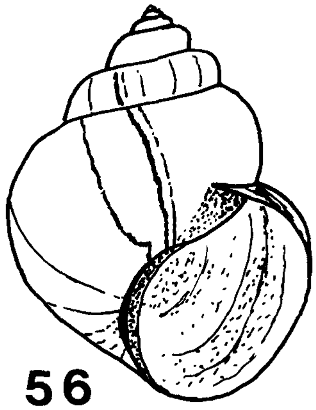

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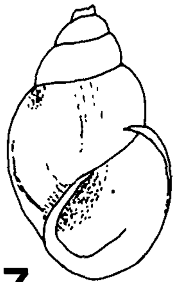

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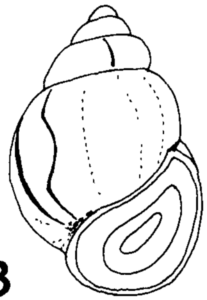

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Figures 55-58. 55- *Viviparus georgianus*; 56- *Viviparus japonicus*; 57- *Campeloma rufum*; 58- *Campeloma decisum*.

48 (8) PLEUROCERIDAE. Whorls very flat sided, often shouldered, sutures shallow, aperture strongly canaliculate (Fig. 59): *Pleurocera acuta*

Whorls moderately flat sided, never shouldered, sutures impressed, weakly canaliculate (Fig. 60): *Goniobasis livescens*

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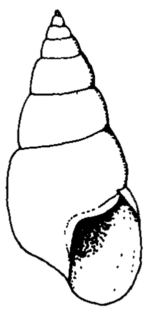

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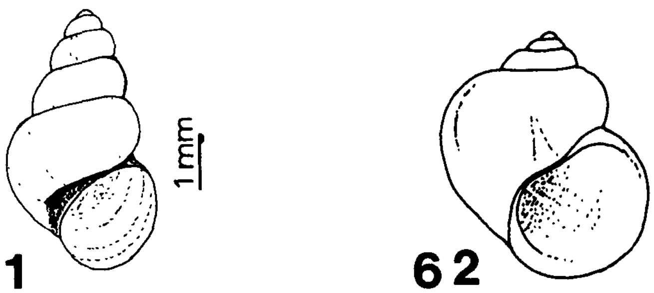
Figures 59-60. 59- *Pleurocera acuta*; 60- *Goniobasis livescens*.

49 (8) HYDROBIIDAE. Nuclear whorl elevated above second whorl (Figs. 61-64) 50
Nuclear whorl level with second whorl or depressed below it (Figs. 65, 66) 54

50 (49) Shell attenuate (Fig. 61) 51
Shell conic (Fig. 62) 52

51 (50) 4 or 5 whorls, umbilicus narrow or absent, columella not reflected; 3 to 5 mm high (Fig. 61): *Marstonia decepta*
6 or 7 whorls, umbilicus wide, columella reflected; 4 to 6 mm high (see Berry, 1943; Harman and Berg, 1971).

52 (50) Body whorl very large; adult shell higher than 9 mm (Fig. 62): *Somatogyrus subglobosus*
Whorls increasing gradually in size; adult shells less than 8 mm high (Figs. 63-66) 53



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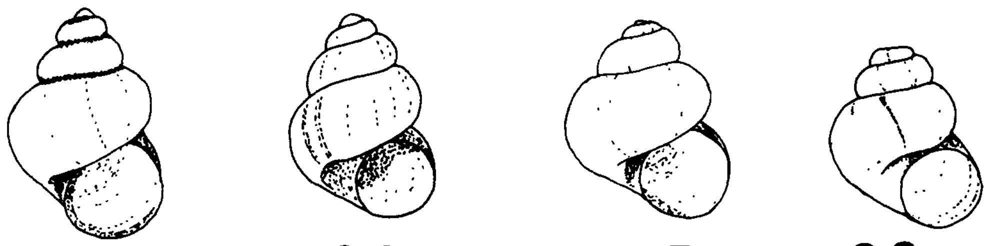
Figures 61-62. 61- *Marstonia decepta*; 62- *Somatogyrus subglobosus*.

53 (52) Adult shell 3 to 5 mm high; aperture broadly lacrimate (Fig. 63): *Cincinnatia cincinnatiensis*
Adult shell 1.5 to 2.5 mm high; aperture subcircular (Fig. 64): *Amnicola walkeri*

54 (49) Nuclear whorl at same plane as second whorl (Fig. 65): *Amnicola limosa*
Nuclear whorl sunken below second whorl (Fig. 66): *Probythinella lacustris*



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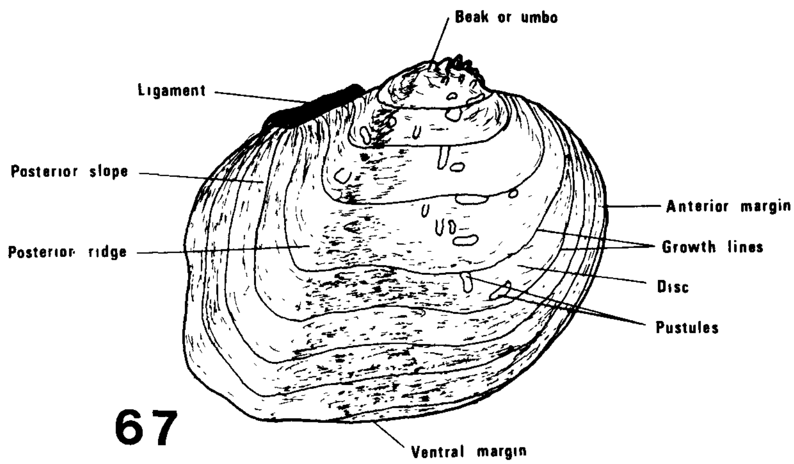
Figures 63-66. 63- *Cincinnatia cincinnatiensis*; 64- *Amnicola walkeri*; 65- *Amnicola limosa*; 66- *Probythinella lacustris*.

ADDENDUM TO GASTROPOD KEY

At about the same time or possibly before the publication of the Gastropoda keys used here, a guide the the Gastropoda of North America will have been completed by Dr. John B. Burch of the University of Michigan Museum and Department of Zoology. Burch's work should be consulted for any changes in systematics and synonymy of those species occurring in the Laurentian Great Lakes. Both this study and that by Burch are being published by the United States Environmental Protection Agency.

1 All 4 dimibranchs serve as marsupia (i.e., appear swollen in gravid females or water tubes numerous with extra septa as seen in cross-section of the females (Figs. 83, 84, 88-90) .....subfamily Ambleminae......... 2

Only outer 2 demibranchs serve as marsupia (Figs. 88-90) ....subfamily Unioninae.......... 9



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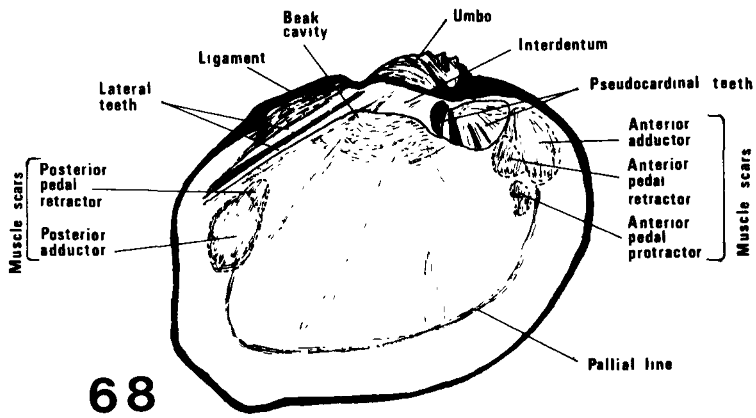


68

Figures 67-68. General features of a Unionidae shell: 67- exterior of right valve; 68- interior of left valve.

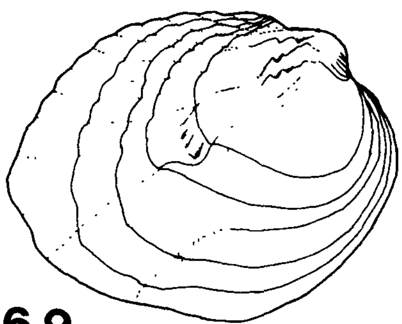
2 (1) Shell surface with distinct corrugations on posterior slope (Fig. 69) 3
Shell surface without distinct corrugation on posterior slope (Fig. 73) 5

3 (2) Shell surface with distinct pustules (see Burch, 1975b).
Shell surface without distinct pustules (Fig. 73) 4

4 (3) Adult shell small (less than 6 cm long); shell corrugations fine (see Burch, 1975b).
Adult shell large (often up to 13 cm and sometimes to 18 cm long); corrugations heavy (Fig. 69): *Amblema plicata*

5 (2) Shell surface pustulose (Figs. 70-72) 6
Shell surface smooth (Fig. 73) 8

6 (5) Shell lacking median sulcus on disc and umbonal region (Figs. 71, 72) 7
Shell with median sulcus on surface which extends from umbo to ventral margin; shell usually moderately to heavily pustulose but occasionally smooth (Fig. 70): *Quadrula quadrula*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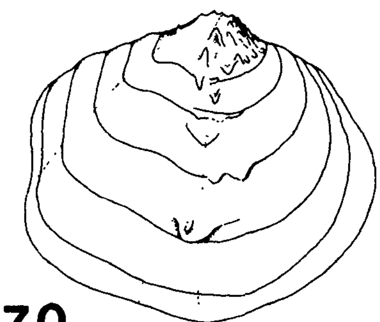
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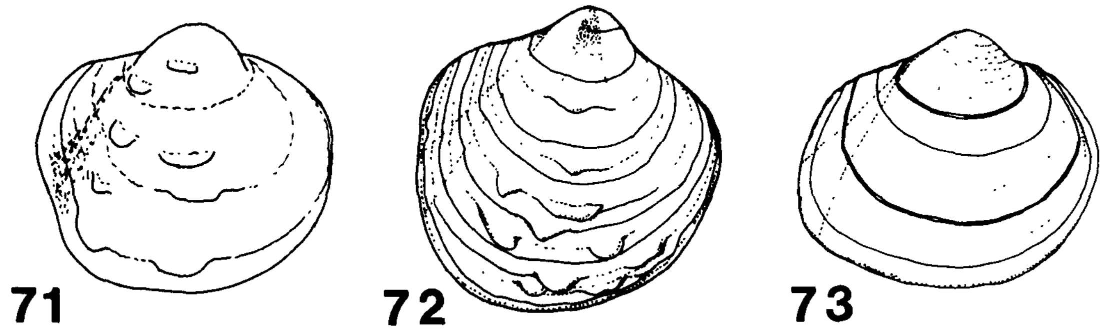
Figures 69-70. 69- *Amblema plicata*; 70- *Quadrula quadrula*.

7 (6) Pustules on disc arranged in 2 divergent rows; shell without green rays on umbonal region (Fig. 71): *Quadrula nodulata*
Pustules on disc evenly scattered over shell surface; green rays present on umbonal region (Fig. 72); some Lake Erie shells may be smooth: *Quadrula pustulosa*

8 (5) Shell triangular and high, inflated and heavy, with very prominent and swollen beaks; posterior ridge well developed (see Burch, 1975b)
Shell triangularly-rhomboidal or if triangular then not as high as above; posterior ridge concave or straight (Fig. 73): *Fusconaia flava*



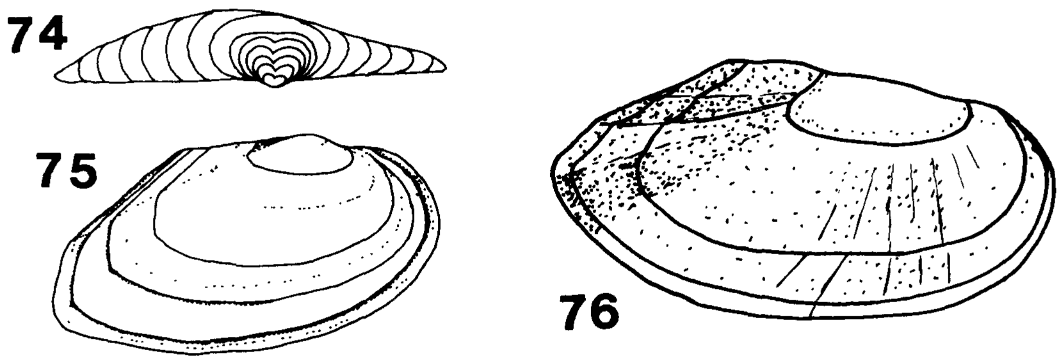
Figures 71-73. 71- *Quadrula nodulata*; 72- *Quadrula pustulosa*; 73- *Fusconaia flava*.

9 (1) Articulating hinge teeth absent or vestigial with only pseudocardinal teeth present 10
Articulating hinge teeth present (Fig. 67) 17

10 (9) Pseudocardinal teeth absent with, at most, depressions present 11
Pseudocardinal teeth present but vestigial (Fig. 67) 16

11 (10) Beak sculpture double-looped (Fig. 74) with lower apices of loops elevated and nodulus and forming two short radial rows on each valve (Figs 74, 75): *Anodonta grandis grandis*
Beak sculpture single or double looped (Fig. 78) but not nodulus ....-.................. 12

12 (11) Beak raised, forming a smooth line along the dorsal margin (Fig. 76): *Anodonta imbecillis*
Beak distinctly raised from side view (Fig. 79) 13



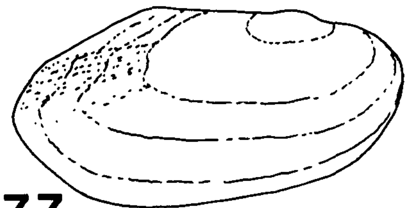
Figures 74-76. *Anodonta grandis grandis*: 74- dorsal view showing beak sculpture; 75- lateral aspect. *Anodonta imbecillis*: 76- lateral aspect.

13 (12) Beak sculpture single looped (Fig. 78), or faintly double-looped 14

Beak sculpture distinctly double-looped (Fig. 74); nacre white or iridescent (if pink see Burch, 1975b) (Fig. 77): *Anodonta cataracta*

14 (13) Major ridges of beak sculpture relatively coarse (Figs. 78, 79); depression for pseudocardinal teeth present but tooth blades or tubercles absent: *Strophitus undulatus*

Major ridges of beak sculpture relatively fine 15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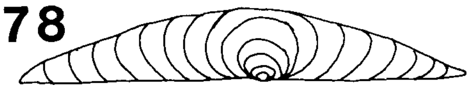

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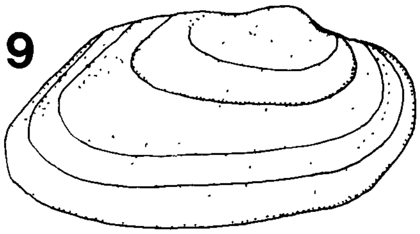
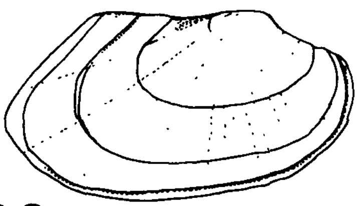


Figures 77-79. 77- *Anodonta cataracta*. *Strophitus undulatus*: 78- dorsal view showing beak sculpture; 79- lateral aspect.

15 (14) Ridges of beak sculpture not parallel to concentric growth lines of beak, but cross them obliquely (Fig. 80): *Anodontoides ferussacianus*

Ridges of beak sculpture parallel to concentric growth lines of beak (Fig. 81): *Anodonta grandis simpsoniana*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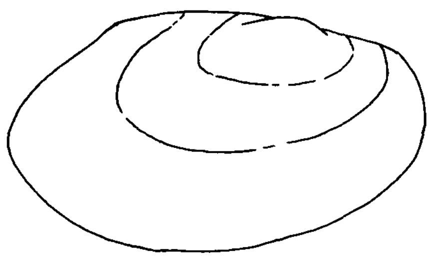
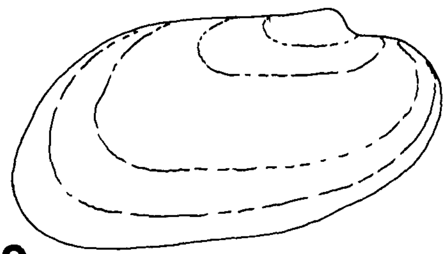

81

Figures 80-81. 80-*Anodontoides ferussacianus*; 81- *Anodonta grandis simpsoniana*.

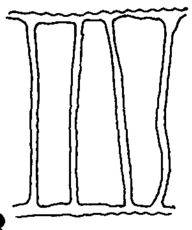
16 (10) Pseudocardinal teeth thin and blade-like or posterior slope with corrugated sculpture (see Burch, 1975b).
Pseudocardinal teeth tubercular and posterior slope without corrugated sculpture (Fig. 82): *Simpsoniconcha ambigua*



82

Figure 82. *Simpsonichocha ambigua.*

17 (9) Gills of gravid females with secondary septa dividing each water tube into 3 tubes (Fig. 83) 18
Septa and water tubes of gills undivided (Fig. 84) 21



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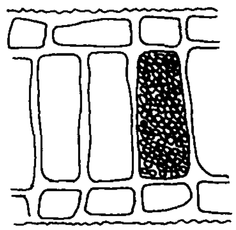

84

Figures 83-84. Female gills: 83- division of water tubes by secondary septa into three tubes; 84- unmodified gill; glochidia shown in one main water tube.

18 (17) Beak sculpture concentric; posterior end flatly truncate (Fig. 85) (if rounded see Burch, 1975b): *Alasmidonta calceolus*
Beak sculpture double-looped (Fig. 74) 19

19 (18) Posterior ridge with undulations; hinge teeth heavy and rough 20
Posterior ridge without undulations; hinge teeth smooth and more delicate (see Burch, 1975b).

20 (19) Shell with prominent wing; posterior slope with gentle undulations (Fig. 86): *Lasmigona complanata*
Shell without wing; posterior slope strongly corrugated (Fig. 87): *Lasmigona costata*

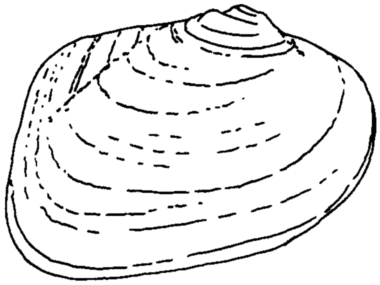
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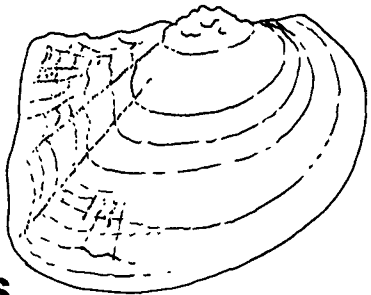
Figure 85. *Alasmidonta calceolus.*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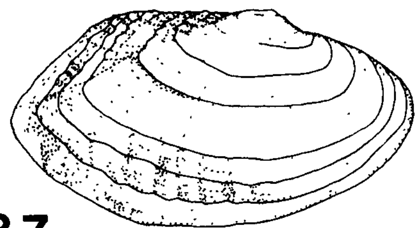
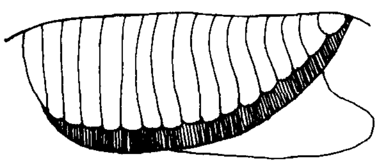

87

Figures 86-87. 86- *Lasmigona complanata*; 87- *Lasmigona costata.*

21 (17) Marsupium filling entire outer pair of gills (Fig. 88); shells not sexually dimorphic 22
Marsupium confined to restricted regions of outer demibranchs (Figs. 89, 90); shells commonly sexually dimorphic (Figs 101, 102) 25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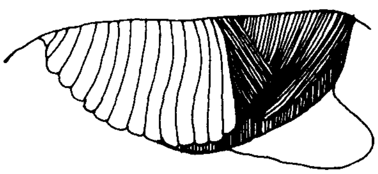
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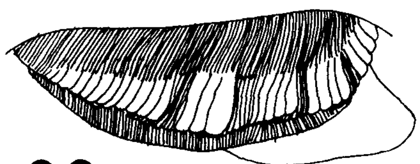
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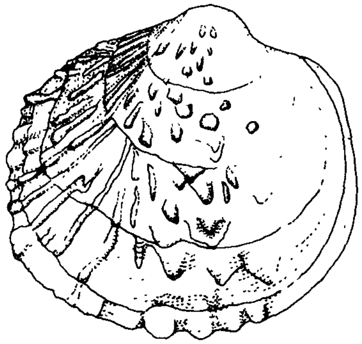
Figures 88-90. Marsupial gills: 88- outer section serving entirely as a marsupium; 89 and 90- only restricted regions of outer gill serving as a marsupium.

22 (21) Shell surface sculpture with pustules (Fig. 91);
nacre purple: *Cyclonaias tuberculata*
Shell surface without pustules; nacre with, pink,
or purple 23

23 (22) Shell triangular; beaks high and arched forward;
nacre white (Fig. 92): *Pleurobema cordatum* f. *coccineum*
Shell elongate, rhomboidal (Figs. 93, 94); beaks
low, not arched; nacre purple, pink, or iridescent 24



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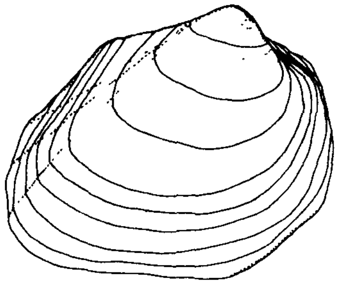

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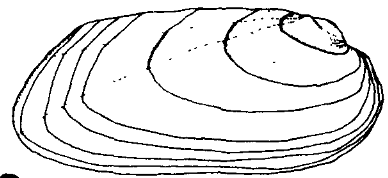
Figures 91-92. 91- *Cyclonaias tuberculata*; 92 *Pleurobema cordatum* f. *coccineum*.

24 (23) Posterior ridge relatively close to dorsal margin
and bowed upward (Fig. 93): *Elliptio dilatata*
Posterior ridge more median in position and nearly
straight (Fig. 94): *Elliptio complanata*



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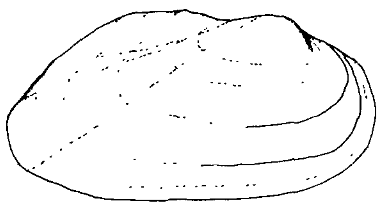

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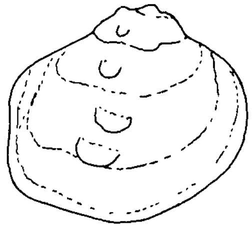
Figures 93-94. 93- *Elliptio dilatata*; 94- *Elliptio complanata*.

25 (21) Shell with single median row of large tubercles (Fig. 95); tubercles alternate on each valve: *Obliquaria reflexa*
Shell without tubercles 26

26 (25) Shell elongate, L/H ratio greater than 2.0 (Figs. 96-98) 27
Shell higher, L/H ratio less than 2.0 (Figs. 99-106) 29

27 (26) Females with caruncle on inner edge of each side of mantle in fromt of branchial opening; beak sculpture of strong concentric ridges; adult shell less than 4 cm long (Fig. 96): *Carunculina parva*
Females lack caruncles; beak structure of 1 or 2 subconcentric bars followed by 3 to 5 double-looped bars; adult shell more than 5 cm long (Figs. 97, 98) 28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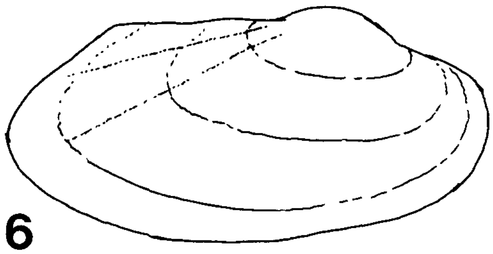
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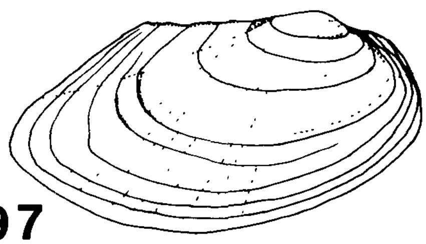
Figures 95-96. 95- *Obliquaria reflexa*; 96- *Carunculina parva*.

28 (27) Shell medium in size (adult less than 10 cm long), usually compressed; posterior ridge extends to near umbo; posterior slope usually concave; posterior margin meets dorsal margin at angle forming a low wing; periostracum olive green to olive brown (Fig. 97): *Ligumia nasuta*
Shell larger (adults greater than 10 cm long), usually inflated; posterior ridge indistinct near posterior margin of shell and is broadly rounded near umbo; posterior slope usually not concave; without dorso-posterior wing; periostracum dark green to black (Fig. 98): *Ligumia recta*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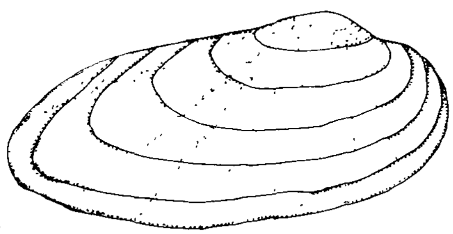
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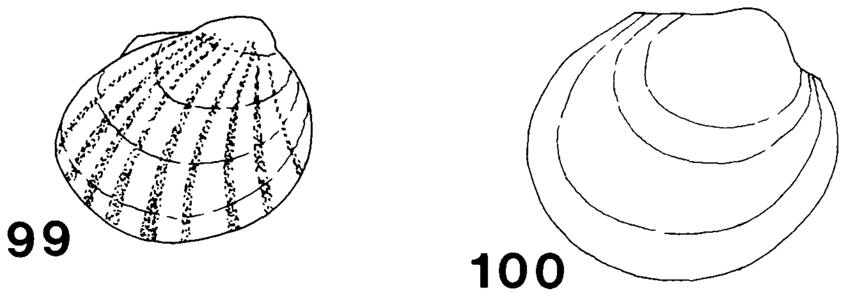
Figures 97-98. 97- *Ligumia nasuta*; 98- *Ligumia recta*.

29 (26) Shell high-oval; teeth heavy; nacre white (Figs. 99, 100) 30
Shell elongate, subelliptical, subrhomboidal, triangular, or oval; teeth heavy or thin (Figs. 101-110) 31

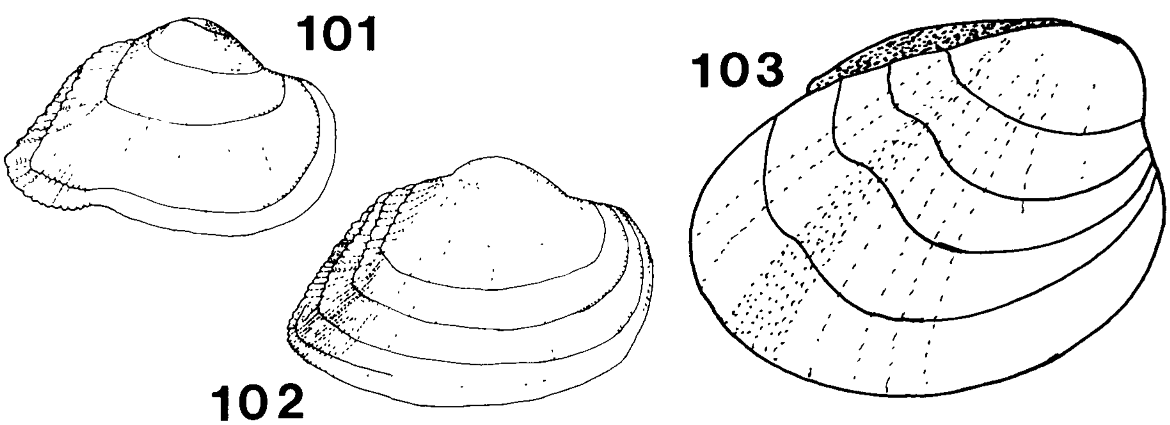
30 (29) Beaks of shell high and arched strongly anteriorly (Fig. 99): *Obovaria olivaria*
Beaks of shell lower, central in positon and not strongly arched (Fig. 100): *Obovaria subrotunda*



Figures 99-100. 99- *Obovaria olivaria*; 100- *Obovaria subrotunda*.

31 (29) Shell small (adults less than 6 cm long), solid, strongly sexually dimorphic (females with a greatly expanded projection where shell covers marsupial area of gills); posterior end with radiating raised ridges (Figs. 101-102) 32
Shell without above combination of characters (Figs. 104-110) 33

32 (31) Rays discontinuous, especially on posterior ridge, giving chevroned appearance (Figs. 101-102): *Dysnomia triquetra*
Rays continuous, shell high, inflated (Fig. 103): *Dysnomia sulcata*



Figures 101-103. *Dysnomia triquetra*: 101- female; 102- male. *Dysnomia sulcata*: 103- male.

33 (31) Posterior ridge angular (Fig. 67) 34
Posterior ridge rounded or absent 36

34 (33) Shell compressed; beak cavities shallow; color rays on shell with or without U-shaped markings (Figs. 105, 106) 35
Shell inflated in upper half; beak cavities deep; color rays present (without U-shaped markings) (Fig. 104): *Lampsilis ovata*

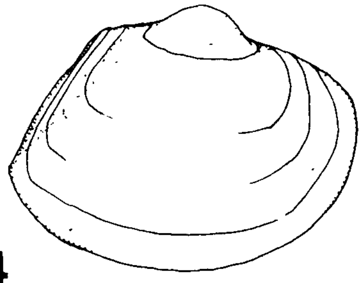


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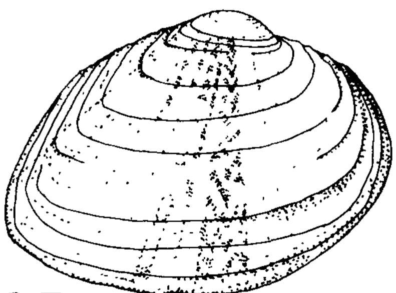
Figure 104. *Lampsilis ovata.*

35 (34) Posterior ridge sharp, distinct down to ventral margin of shell; posterior slope very short and very steep (Fig. 105): *Truncilla truncata*
Posterior ridge angular but becoming round and fading out near ventral margin of shell (Fig. 106): *Truncilla donaciformis*



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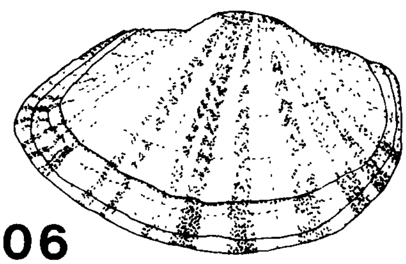


106

Figures 105-106. 105- *Truncilla truncata*; 106- *Truncilla donaciformis*.

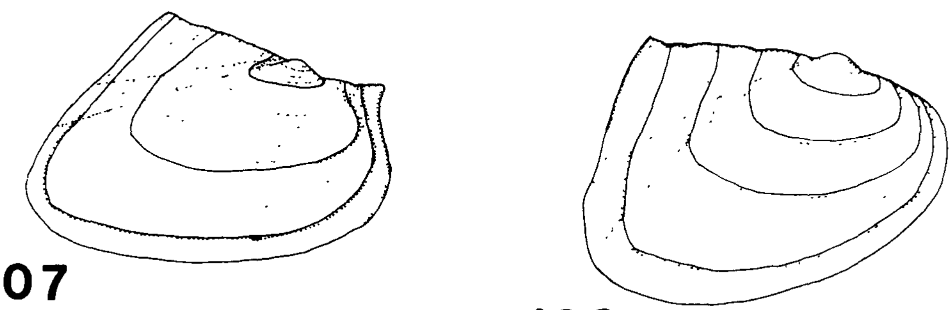
36 (33) Pseudocardinal teeth well developed; dorso-posterior wing present or absent (Figs. 108-112) 37

Pseudocardinal teeth (Fig. 68) poorly developed; dorso-posterior wing conspicuous (Fig. 107): *Proptera laevissima* and *Leptodea fragilis**

*It is difficult to distinguish between these species in old or worn shells. In live specimens, *L. fragilis* has a yellow to light green shell with white to pink nacre and may be abundant along the shores of western Lake Erie. *P. laevissima* is rare in the lakes, the shell is purple to brownish-purple, and the nacre is very dark pink to dark purple.

37 (36) Well-developed wing present (Fig. 108): *Proptera alata*

Wing usually lacking, but if present very low and poorly developed (Figs. 109, 110, 116) 38



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Figures 107-108. 107-*Leptodea fragilis*; 108- *Proptera alata*.

38 (37) Posterior mantle margin in front of branchial opening undifferentiated; disc with broad, green rays (Fig. 109): *Ptychobranchus fasciolare*

Posterior mantle margins differentiated into papillate or flap-like structures (Figs. 111, 114); disc with or without rays 39

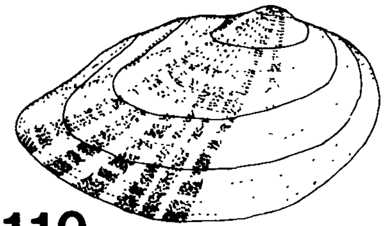
109

Figure 190. *Ptychobranchus fasciolare*.

39 (38) Posterior mantle margins with long papillate
projections (Fig. 111); shell rayed (Fig. 110):
Villosa iris and *Villosa fabilis**

*The species of *Villosa* are difficult to distinguish but the above two have been recorded from the Great Lakes. Burch (1975b) gives outlines of other eastern North American forms.

Posterior mantle margins with ribbon-like flaps (Fig. 114) 40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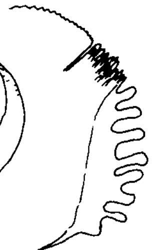
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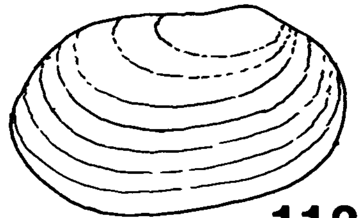
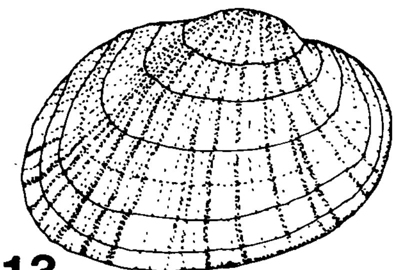

112

Figures 110-112. *Villosa iris*: 110- lateral aspect; 111- papillate mantle margin. *Villosa fabilis*: 112- outline of lateral aspect.

40 (39) Shell elongate (L/H ratio of males greater than 1.6)
(Figs. 115-116) 41

Shell higher (L/H ratio of males less than 1.6);
beaks sculptured with small double-looped ridges;
color rays extend evenly over shell (Fig. 113):
Lampsilis fasciola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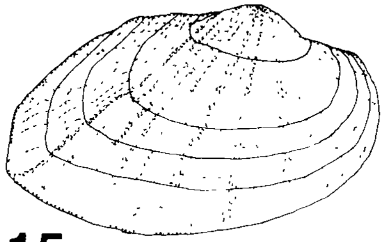
114

Figures 113-114. *Lampsilis fasciola*: 113- lateral aspect; 114- flap-like mantle margin.

41 (40) Color rays extend over entire shell and extend
to ventral margin without fading in color (Fig. 115):
Lampsilis radiata radiata

Color rays absent or limited to posterior slope
or fading before reaching ventral margin (Fig. 116):
Lampsilis radiata siliquoidea



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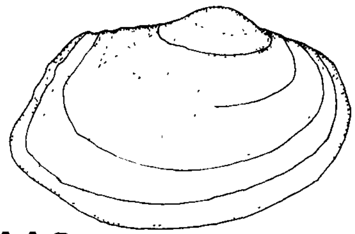
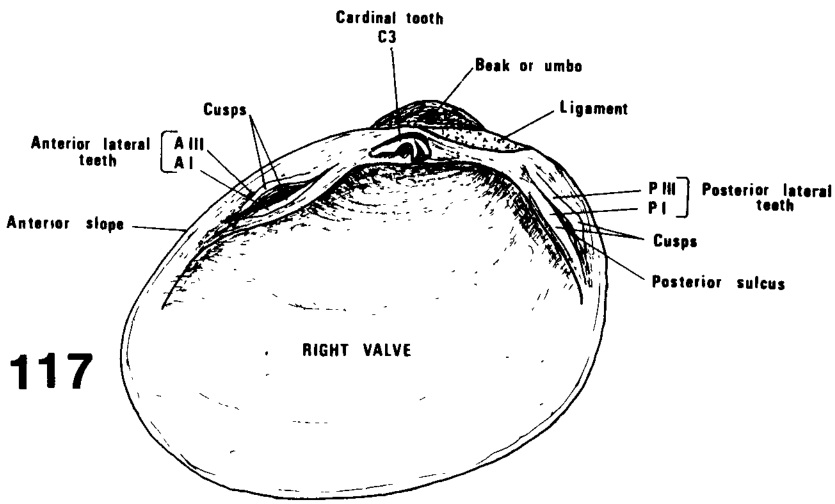


116

Figures 115-116. 115- *Lampsilis radiata radiata*; 116- *Lampsilis radiata siliquoidea*.

SPHAERIIDAE

General hinge characters for Sphaeriidae are given in Figs. 117, 118. Though a typical *Pisidium* is figured, the tooth placement remains the same for both *Musculium* and *Sphaerium*. In all other drawings in the key, the position of cusps on the lateral teeth is indicated by an "X". Scale lines indicate 1.0 mm. Photographs were taken with the aid of a scanning electron microscope and are 10 to 150x.



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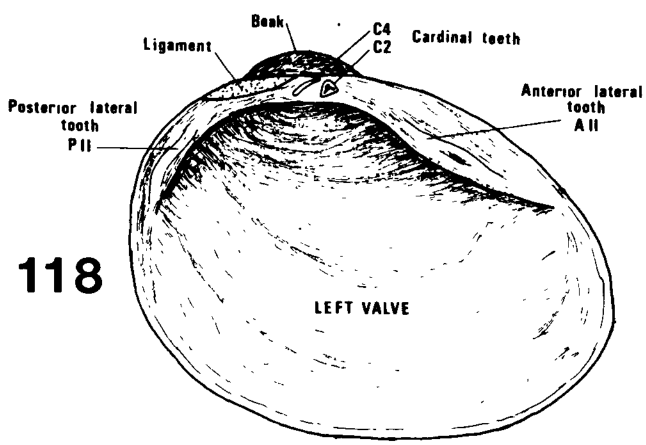


118

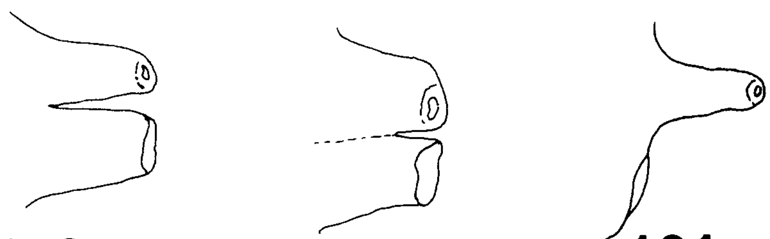
Figures 117-118. General hinge and shell characters for Sphaeriidae: 117- interior of right valve of *Pisidium dubium*; 118- interior of left valve of *Pisidium dubium*.

1 Beaks anterior, or if subcentral, on the anterior side of center (Figs. 124, 132); both anal and branchial siphons present (Figs. 119, 120) ......subfamily Sphaeriinae... **2**

Beaks posterior, or if subcentral, on the posterior side of center (Figs. 117, 118); only the anal siphon present, the branchial siphon being represented by the mantle cleft (Fig. 121) ....subfamily Pisidiinae.... **13**

2 (1) True calyculae (caps) present on adults born near the end of summer (Figs. 124, 140); absent on those born during summer; living adult shells thin, yellowish, and semitransparent; siphons united only at basal half (Fig. 119); sulcus of AI, AIII, and PI, PIII not distinctly tuberculated ....*Musculium*......... **3**

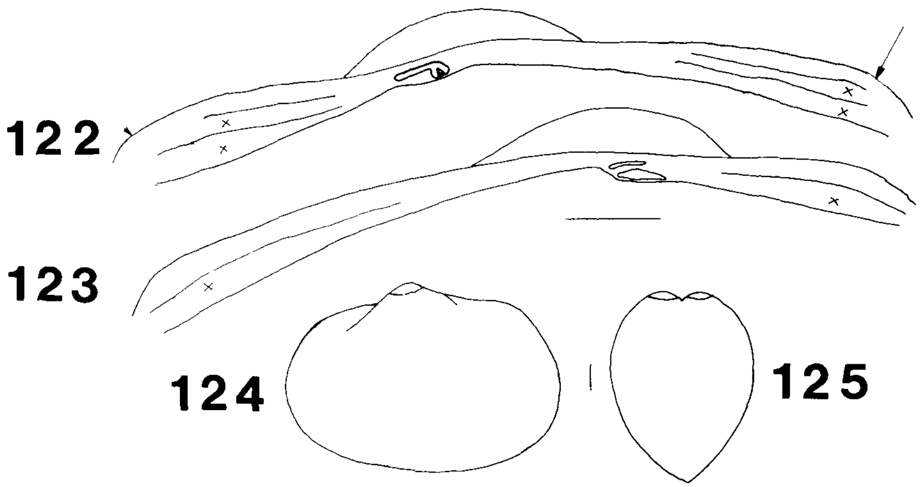
Caps absent, or if present, are not true calyculate; living adult shells usually heavy and/or opaque, periostracum usually brownish or blackish (juveniles yellowish; sulcus of.AI, AIII and PI, PIII usually with distinct tubercles (Fig. 160); siphons united for entire length (Fig. 120) ....*Sphaerium*......... **8**



Figures 119-121. Branchial (lower) and anal (upper) siphons of Sphaeriidae: 119- *Musculium*; 120- *Sphaerium*; 121- *Pisidium*.

3 (2) H/L ratio less than 0.75; cusps of lateral teeth occur before the dorso-anterior and dorso-posterior angles (Figs. 122, 123, 127, 129); posterior end of C3 greatly enlarged and triangular, usually bifid; anterior part narrow and of uniform thickness throughout (Figs. 122, 126); shell shape as in Figs. 124, 125: *Musculium transversum*

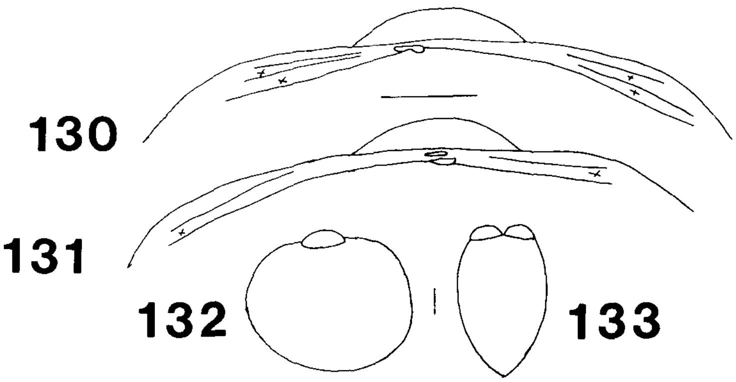
H/L ratio greater than 0.76; cusps of lateral teeth occur before or after the dorso-anterior and dorso-posterior angles; posterior end of C3 usually not greatly swollen, but if so, not triangular; anterior part thick or thin (Figs. 130-133, 138-141) **4**



Figures 122-125. *Musculium transversum*: 122- right hinge; 123- left hinge; 124- lateral aspect of left valve; 125-end view. Also see Figs. 126-129, page 39.

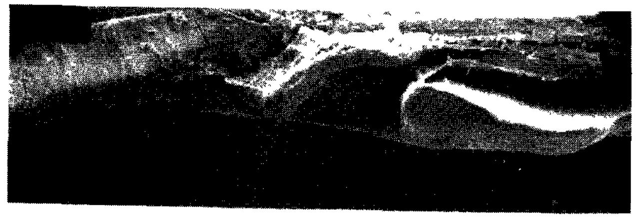
4 (3) Cusps of lateral teeth arising before dorso-anterior and dorso-posterior angles of shell (Figs. 130-135); C3 usually enlarged posteriorly and anteriorly (Figs. 130, 134) (also Figs. 131-133, 136, 137): *Musculium partumeium*

Cusps of lateral teeth arising on or after the dorso-anterior and dorso-posterior angles of shell (Fig. 138); C3 only slightly enlarged posteriorly or of uniform thickness throughout (Figs. 138, 142) 5



Figures 130-133. *Musculium partumeium*: 130-right hinge; 131- left hinge; 132- lateral aspect of left valve; 133- end view. Also see Figs. 134-137, page 40.

126



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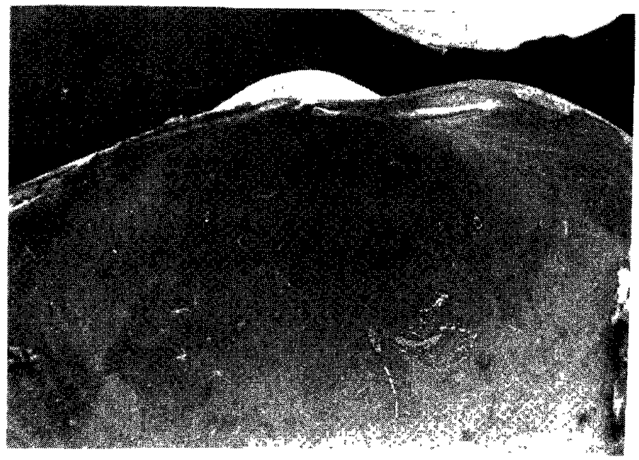

Figures 126-129. *Musculium transversum*:
126- cardinal teeth of left valve;
127- outline of left valve;
128- cardinal teeth of left valve;
129- outline of left valve.

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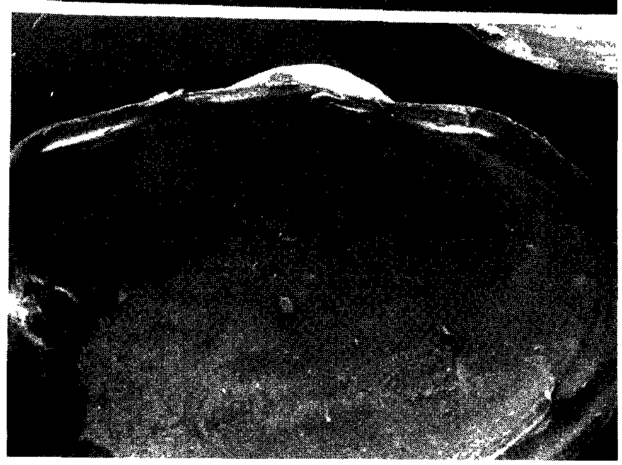

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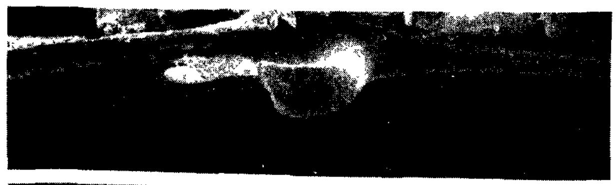
Figures 134-137. *Musculium partumeium*:
134- cardinal tooth of right valve;
135- outline of right valve;
136- cardinal teeth of left valve;
137- outline of left valve.

136



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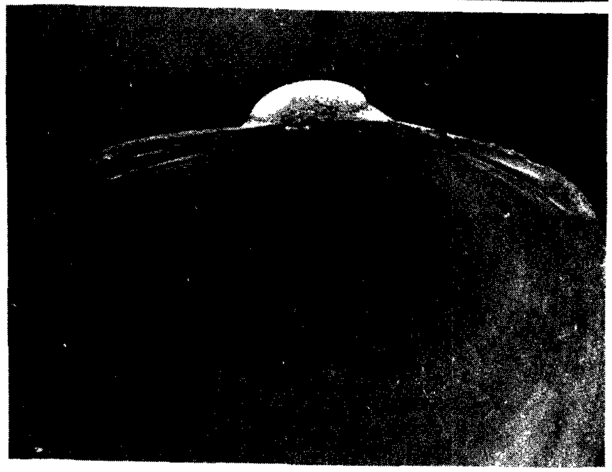
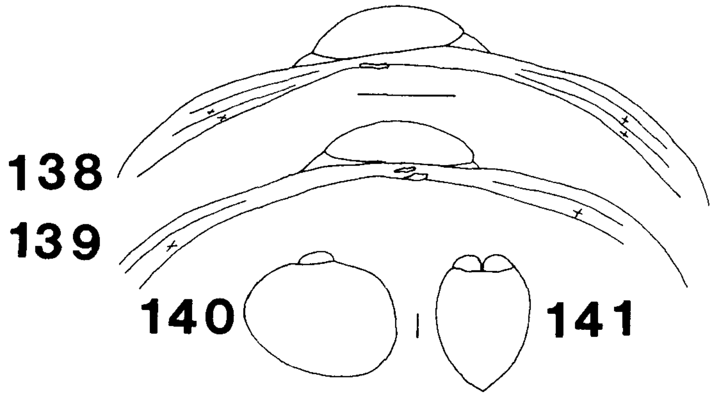


5 (4) Ventral margin sloped steeply upward beginning near posterior end, anterior margin rounded (Fig. 140) (also Figs. 138-145): *Musculium securis*

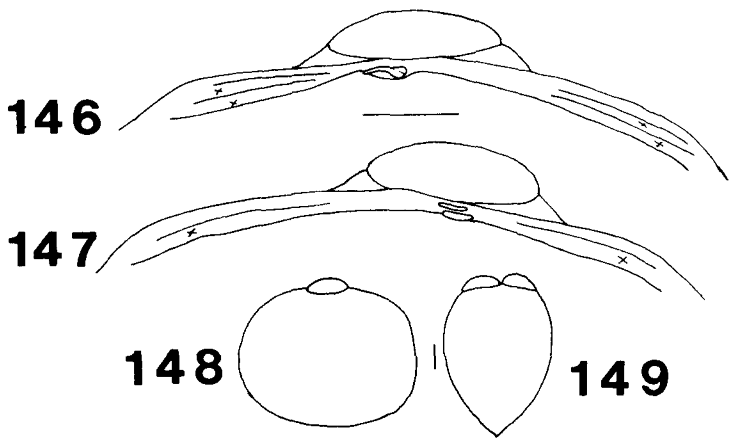
Ventral margin with only a slight upward slope or none, anterior margin angled (Fig. 154) 6



Figures 138-141. *Musculium securis*: 138- right hinge; 139- left hinge; 140- lateral aspect of left valve; 141- end view. Also see Figs. 142-145, page 42.

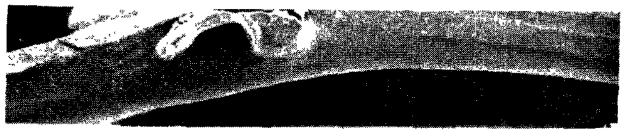
6 (5) Shell more or less square in outline, dorsal margin straight (Fig. 148) (also Figs. 146-151): *Musculium lacustre* f. *jayense*

Shell more or less triangular in outline, dorsal margin curved (Fig. 154) 7



Figures 146-149. *Musculium lacustre* f. *jayense*: 146- right hinge; 147- left hinge; 148- lateral aspect of left valve; 149- end view. Also see Figs. 150, 151, page 43.

142



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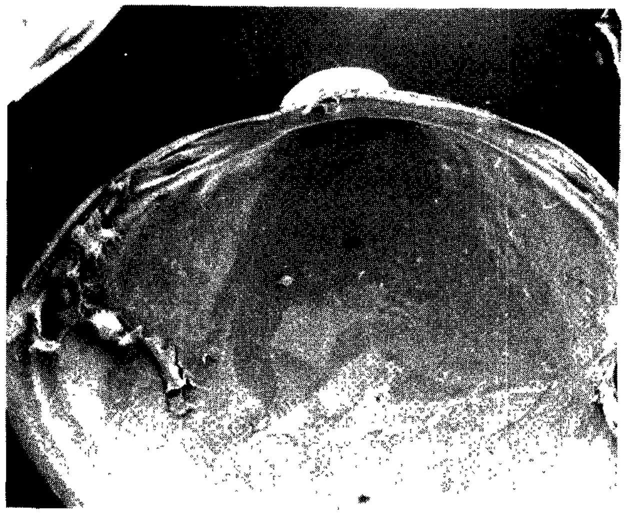

Figures 142-145. *Musculium securis*:
142- cardinal tooth of right valve;
143- outline of right valve;
144- cardinal teeth of left valve;
145- outline of left valve.

144

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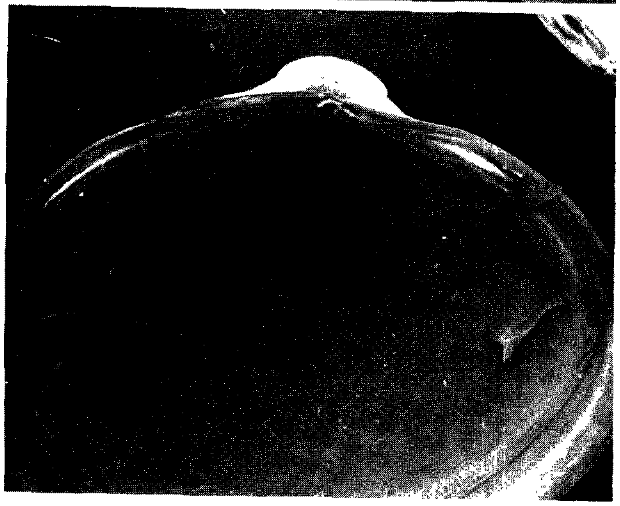

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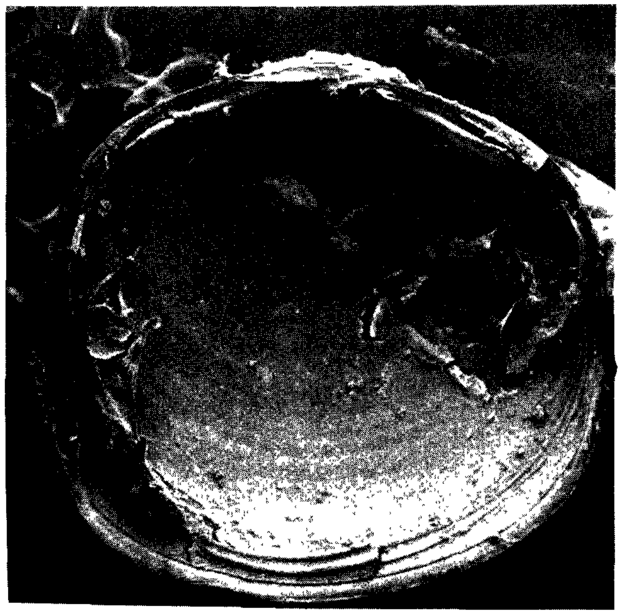
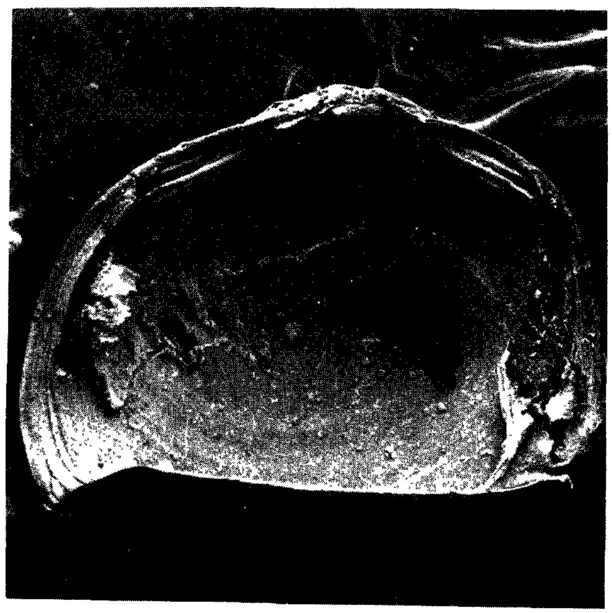
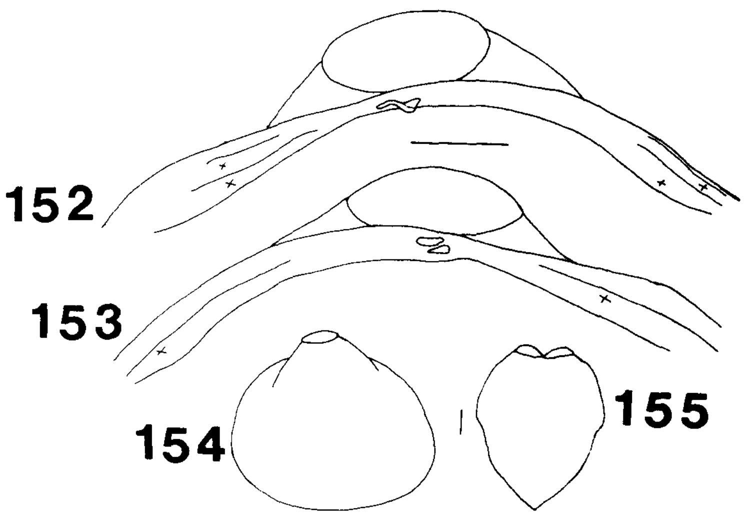


Figures 150-151. *Musculium lacustre* f. *jayense*:
150- outline of right valve;
151- outline of left valve.

151



7 (6) Dorsal margin joined by posterior and anterior margins with similar, usually steep, angles; C2 straight (see Herrington, 1962; Burch, 1975a).
Dorso-posterior margin with less slope than dorso-anterior margin (Fig. 154); C2 curved or bent (Figs. 152-159): *Musculium lacustre* f. *lacustre*

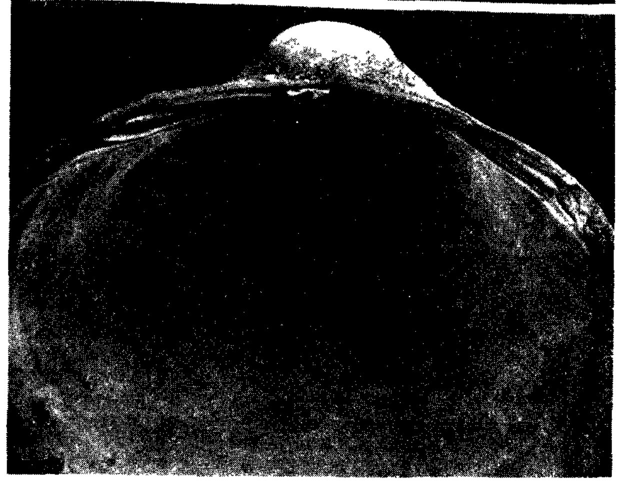


Figures 152-155. *Musculium lacustre* f. *lacustre*: 152- right hinge; 153- left hinge; 154- lateral aspect of left valve; 155- end view. Also see Figs. 156-159, page 45.

8 (2) Shell sculptured with coarse striae (8 or fewer per mm in middle of shell); shell heavy; C2 stump-like (Fig. 167) or canine shaped (Fig. 161) 9
Shell sculptured with fine striae (12 or more per mm in middle of shell); shell usually thin; C2 thin, straight and incisor-shaped or bent and chevron-shaped (Figs. 179, 185) 10

156

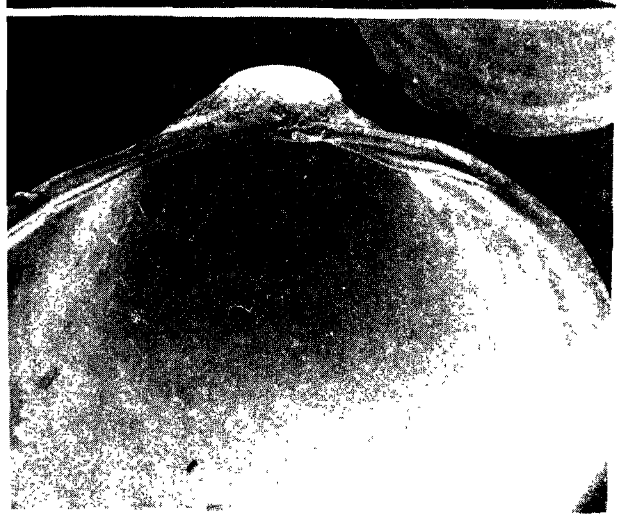
157



Figures 156-159. *Musculium lacustre* f. *lacustre*:
156- cardinal tooth of right valve;
157- outline of right valve;
158- cardinal teeth of left valve;
159- outline of left valve

158

159



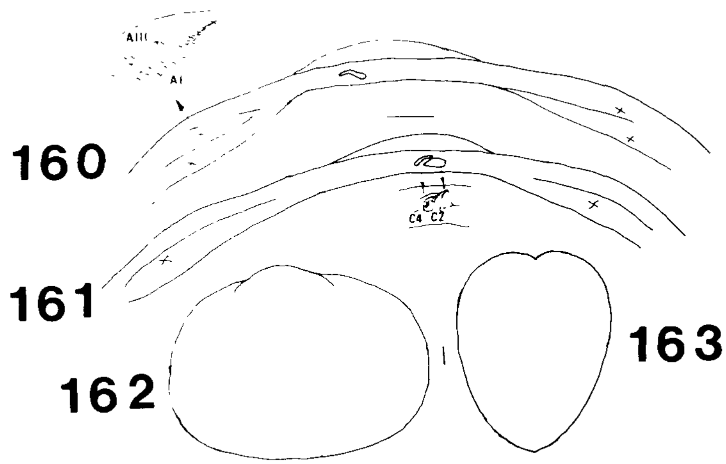
9 (8) Striae evenly spaced; adults longer than 1.6 cm; shell long in outline (Fig. 160-165): *Sphaerium simile*

Striae not evely spaced; adults shorter than 1.5 cm; shell usually short in outline (Figs 166-177): *Sphaerium striatinum**

*Two forms have been recorded from the Great Lakes which differ in shell shape and position of C2 and C4; the forms may not always be distinct.

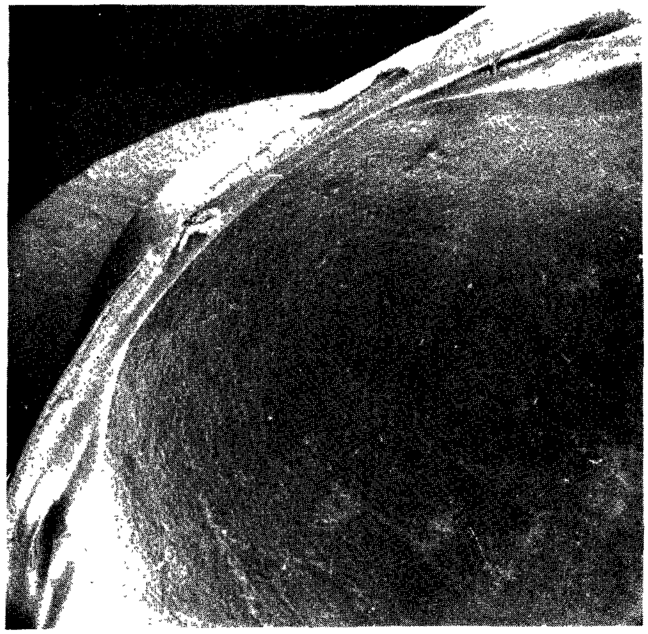
(Figs. 166-169, 174-177): *Sphaerium striatinum* f. *emarginatum*

(Figs. 170-173): *Sphaerium striatinum* f. *acuminatum*



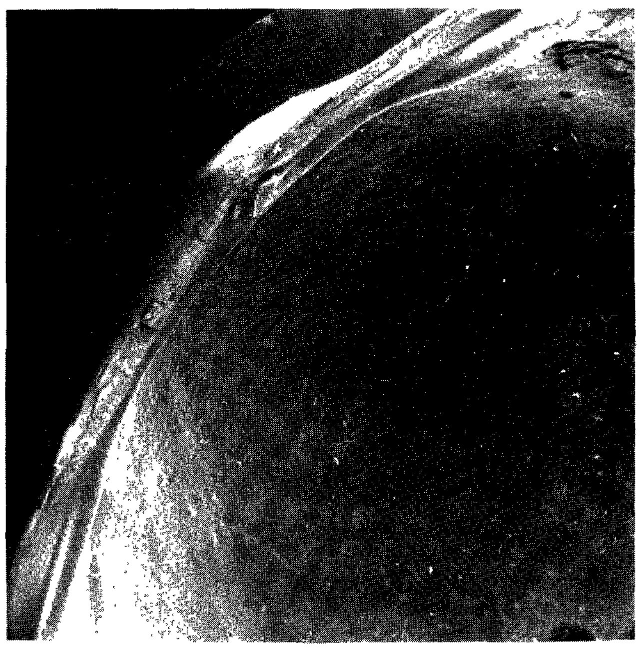
Figures 160-163. *Sphaerium simile*: 160- right hinge showing detail of AI and AIII; 161- left hinge showing shape of C2 and C4 from medial view; 162- lateral aspect of left valve; 163- end view. Also see Figs. 164-165, page 47.

164



Figures 164-165. *Sphaerium simile*:
164- right valve;
165- left valve.

165



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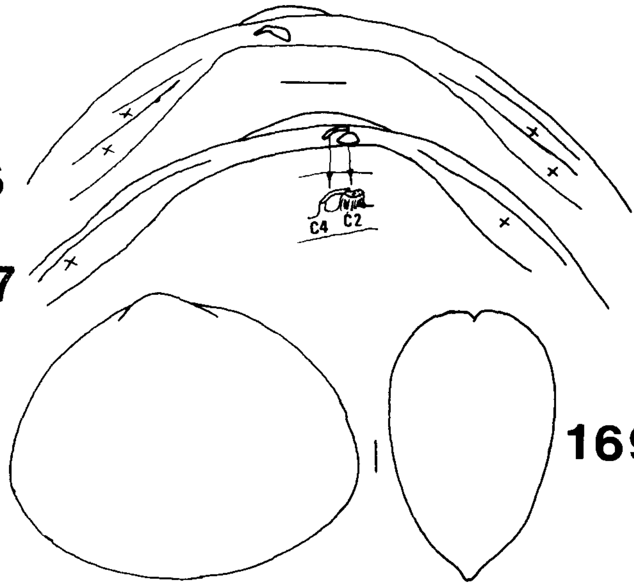
169



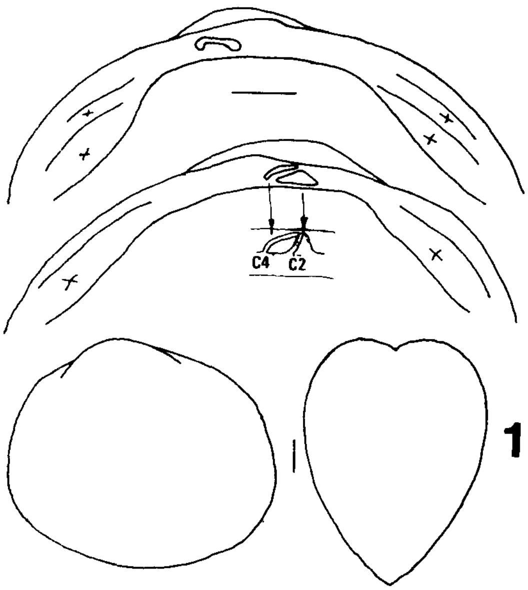
Figures 166-169. *Sphaerium striatinum* f. *emarginatum*: 166- right hinge; 167- left hinge showing shape of C2 and C4 rom medial view; 168- lateral aspect of left valve; 169- end view. Also see Figs. 175-177, page 49.

170

171

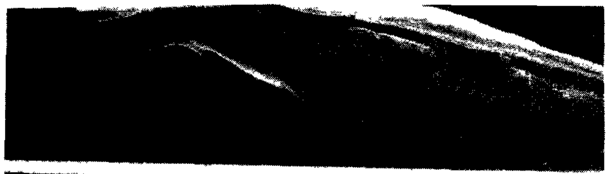
172

173

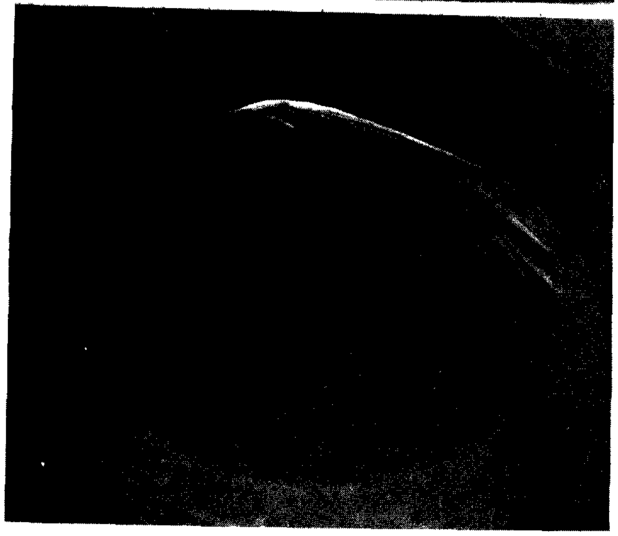


Figures 170-173. *Sphaerium striatimum* f. *acuminatum*: 170- right hinge; 171- left hinge showing shape of C2 and C4 from medial view; 172- lateral aspect of left valve; 173- end view.

174



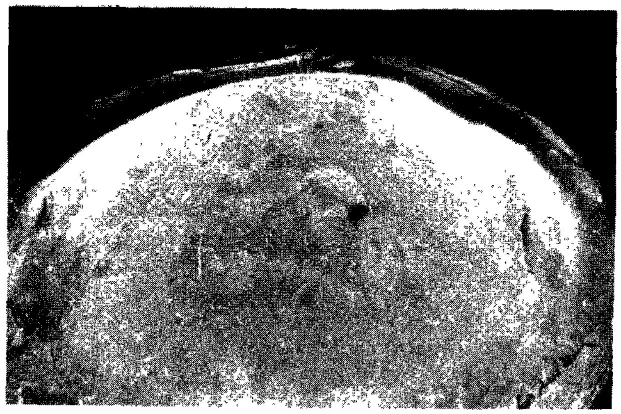
175



Figures 174-177. *Sphaerium striatinum* f. *emarginatum*:
174- cardinal tooth of right valve;
175- right valve;
176- cardinal teeth of left valve;
177- left valve.

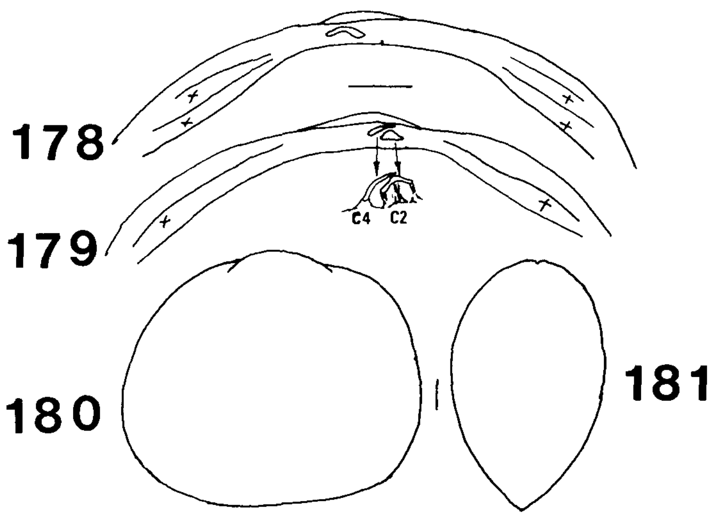
176

177



10 (8) AIII and usually PIII of right valve less than 1.5 times longer than C3, or cusp of AII less than 1.5 times longer than combined length of C2 and C4; adults usually less than 8 mm long (Figs. 188, 194, 200) 11

AIII and usually PIII of right valve more than twice the length of C3, or cusp of AII more than twice the combined length of C2 and C4; adults longer than 8 mm; shell rectangular in outline (Figs. 178-183): *Sphaerium rhomboideum*



Figures 178-181. *Sphaerium rhomboideum*: 178- right hinge; 179- left hinge showing shape of C2 and C4 from medial view; 180- lateral aspect of left valve; 181- end view. Also see Figs. 182-183, page 51.

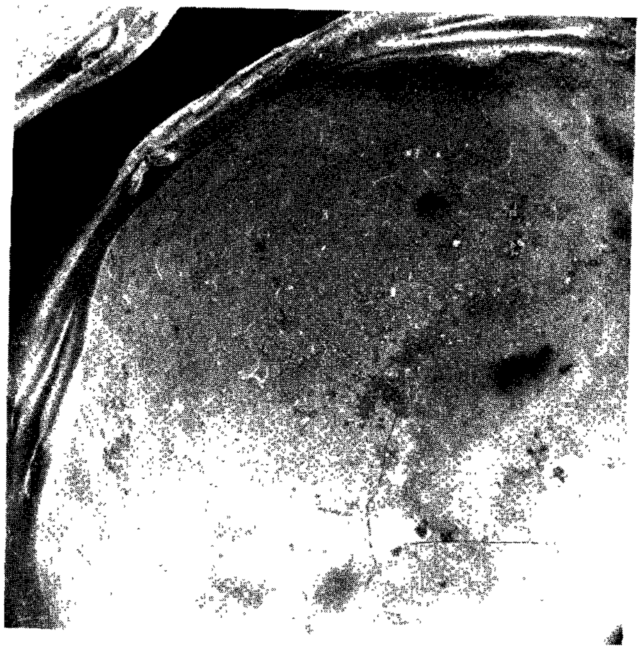
11 (10) Shell glossy; striae maintain spacing and height in region of beaks; C3 of more or less uniform thickness throughout, only slightly curved and parallel with hinge plate (Figs. 184-189): *Sphaerium nitidum*

Shell dull; striae fade in region of beaks; C3 bent and swollen posteriorly (Figs. 190-195) 12

12 (11) Umbo slightly raised above dorsal margin; posterior margin truncate, ventral margin sloped slightly upward anteriorly; C4 almost completely overlapping C2 and more or less parallel (Figs. 190-195): *Sphaerium corneum*

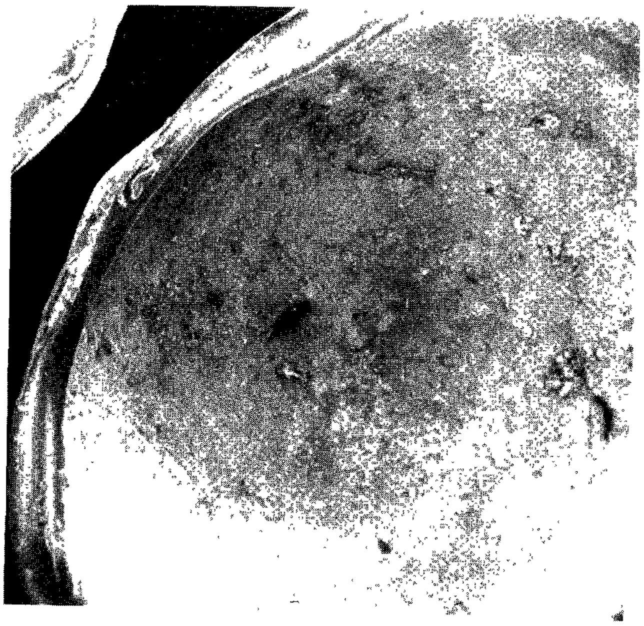
Umbo distinctly raised above dorsal margin; posterior end rounded, ventral margin symmetrical; C2 and C4 slope in opposite directions with little overlapping; in habitats wihich dry up part of the year (Figs. 196-201): *Sphaerium occidentale*

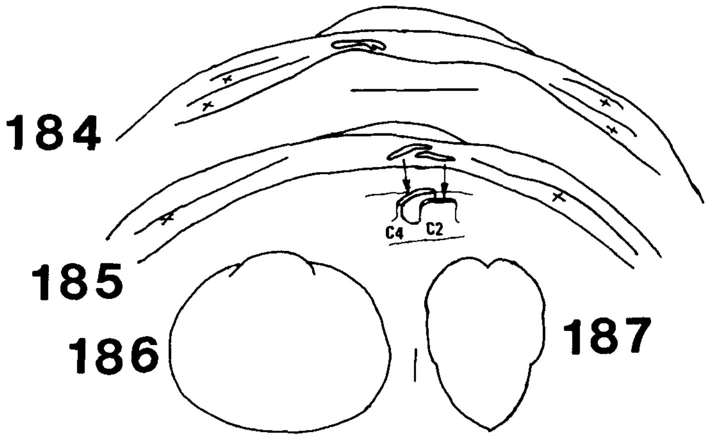
182



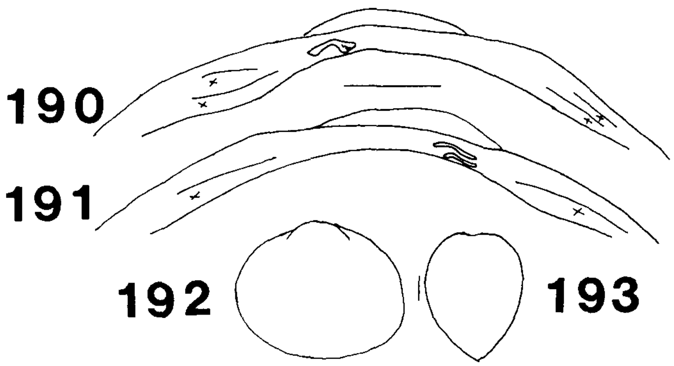
Figures 182-183. *Sphaerium rhomboideum*:
182- right valve;
183- left valve.

183



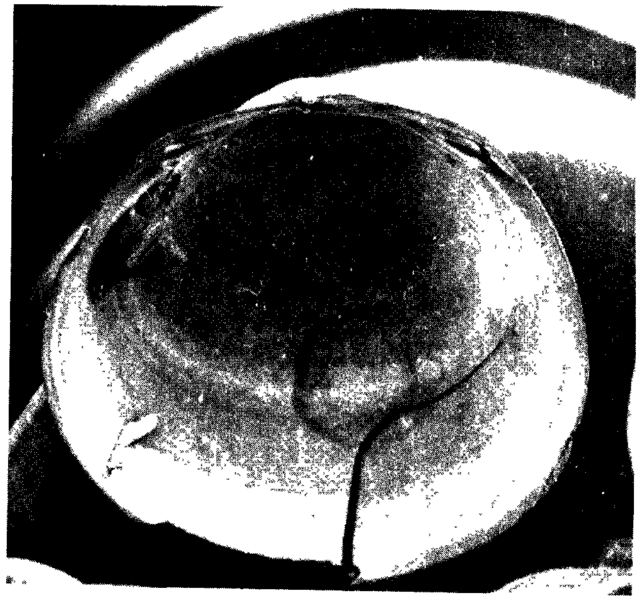


Figures 184-187. *Sphaerium nitidum*: 184- right hinge; 185- left hinge showing shape of C2 and C4 from medial view; 186- lateral aspect of left valve; 187- end view. Also see Figs. 188-189, page 53.



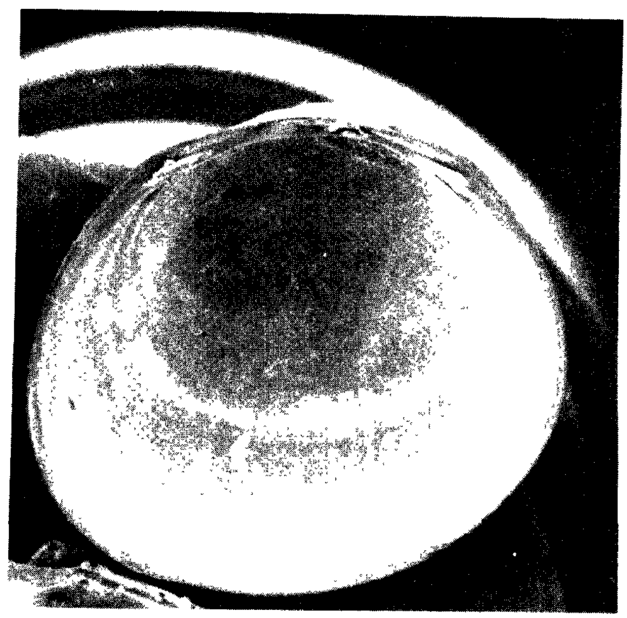
Figures 190-193. *Sphaerium corneum*: 190- right hinge; 191- left hinge; 192- lateral aspect of left valve; 193- end view. Aslo see Figs. 194-195, page 54.

188

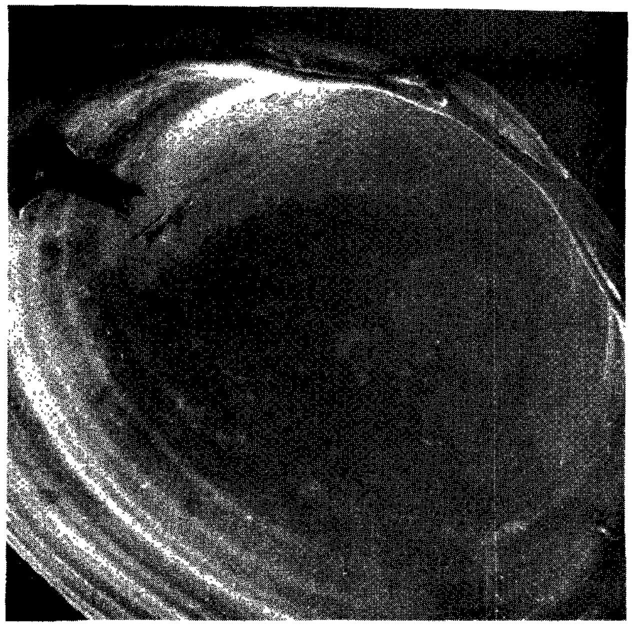


Figures 188-189. *Sphaerium nitidum*:
188- right valve;
189- left valve.

189

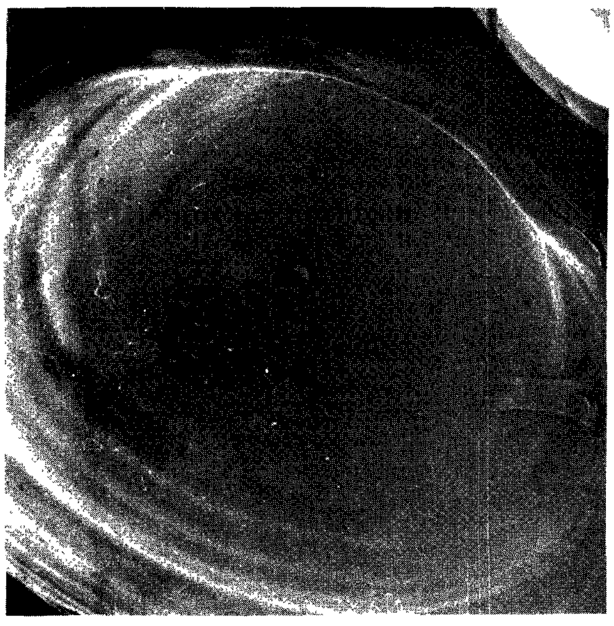


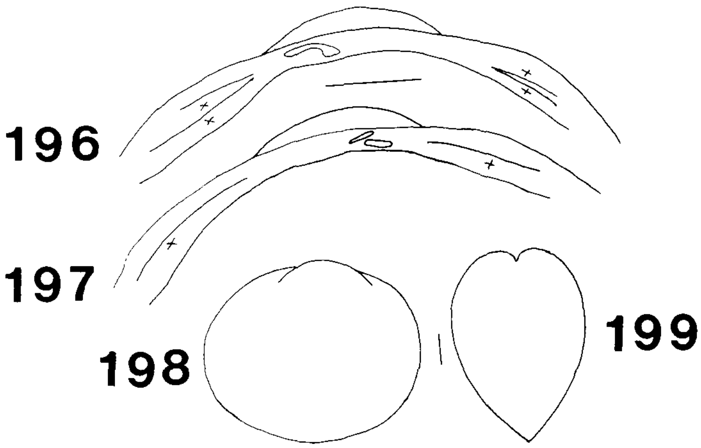
194



Figures 194-195. *Sphaerium corneum*:
194- right valve;
195- left valve.

195





Figures 196-199. *Sphaerium occidentale*: 196- right hinge; 197- left hinge; 198- lateral aspect of left valve; 199- end view. Also see Figs. 200-201, page 56.

13 (1) C3 greatly recurved and an inverted J or U shape (Figs. 202, 206, 208, 212); striae coarse, 10 or fewer per mm; adults 6 mm long or more 14

C3 only slightly curved, never an inverted J or U shape (Figs. 214, 222); striae fine, 15 or more per mm; except for *Pisidium adamsi*, adults less than 6 mm long 15

14 (13) Striae fade on beaks; umbo positioned vary far back, near posterior margin (Fig. 204); C3 and inverted U with both anterior and posterior ends enlarged (Figs. 202, 206); cardinals nearer posterior end than anterior end (Figs. 202, 203): *Pisidium dubium*

Striae prominent on beaks; umbo more central and not as close to posterior margin (Fig. 210); C3 an inverted J with only the posterior end enlarged (Figs. 208, 212); cardinals nearer anterior end than posterior end (Figs. 208, 209): *Pisidium amnicum*

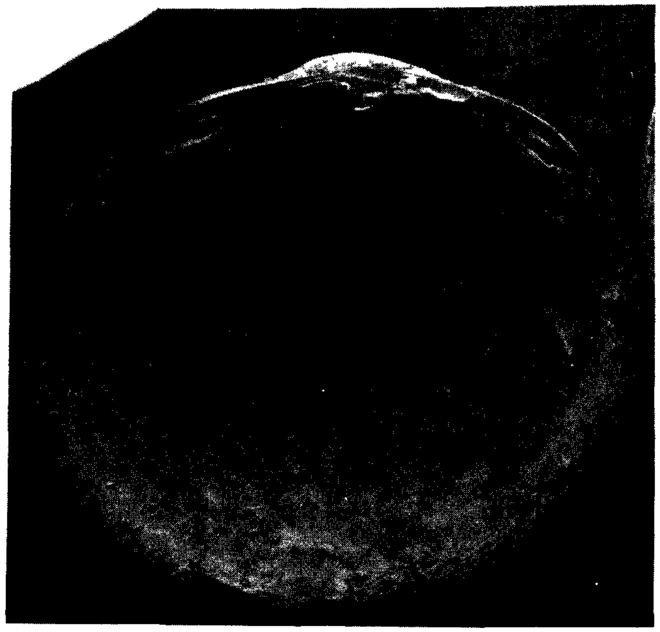
15 (13) Shell with one or more prominent dorsal ridges (Figs. 217- 225, 231, 239) 16

Shell without prominent dorsal ridges (Fig. 249) 19

16 (15) Cardinals on anterior side of center of hinge (Figs. 242, 250) 17

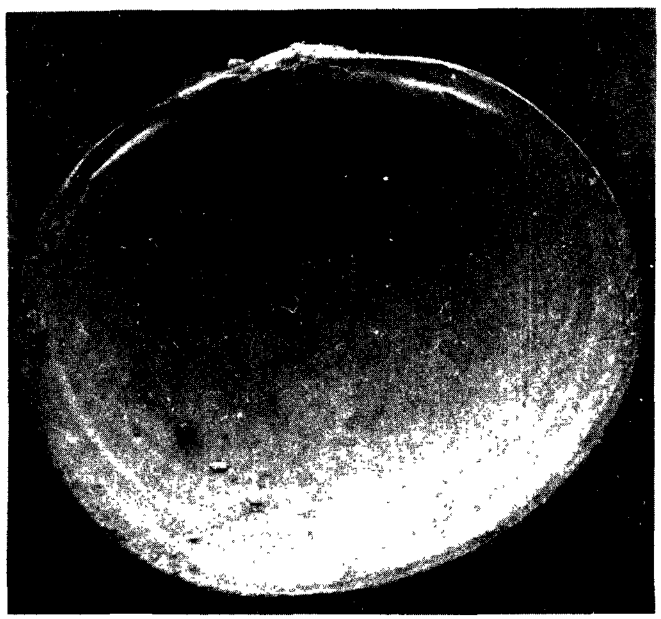
Cardinals central in position (Figs. 228, 229, 233, 235) 18

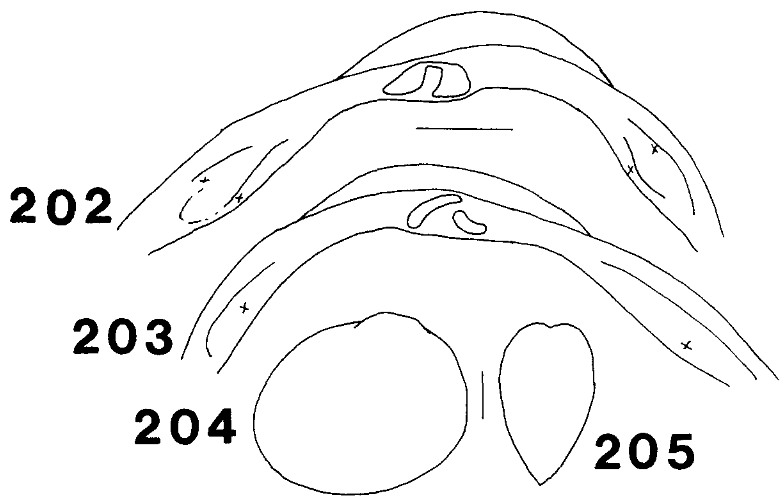
200



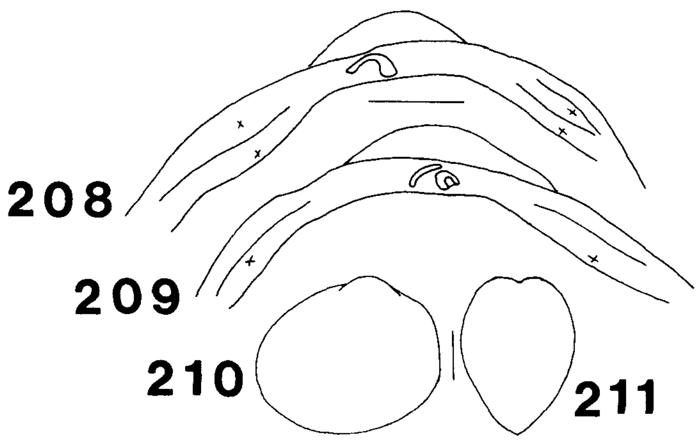
Figures 200-201. *Sphaerium occidentale*:
200- right valve;
201- left valve.

201



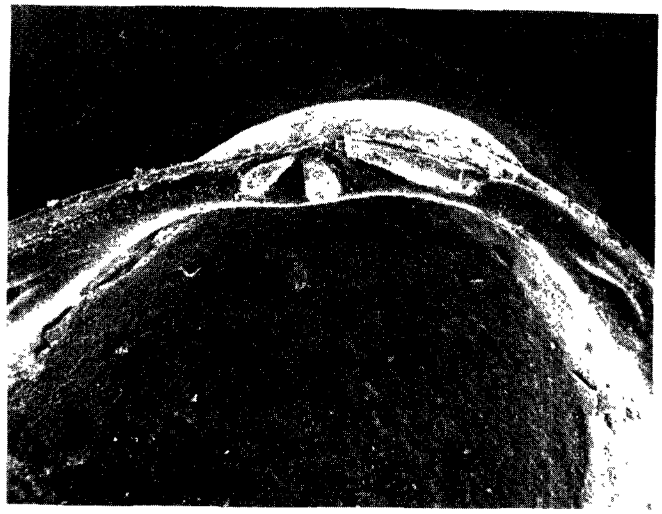


Figures 202-205. *Pisidium dubium*: 202- right hinge; 203- left hinge: 204- lateral aspect of left valve; 205- end view. Also see Figs. 206-207, page 58.



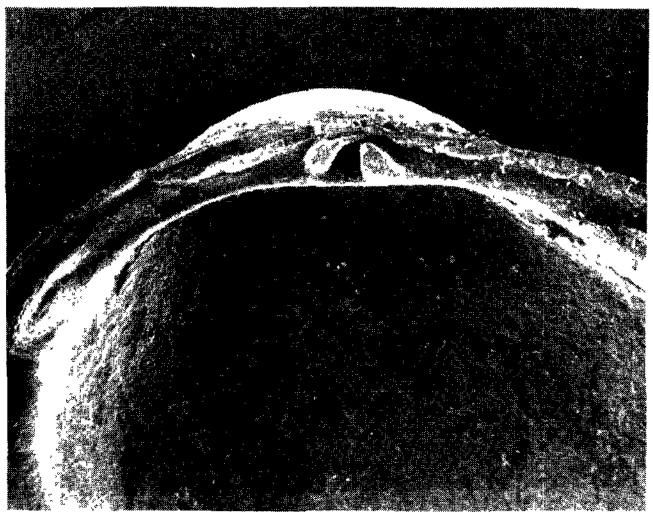
Figures 208-211. *Pisidium amnicum*: 208- right hinge; 209- left hinge; 210- lateral aspect of left valve; 211- end view. Also see Figs. 212-213, page 59.

206



Figures 206-207. *Pisidium dubium*:
206- right valve;
207- left valve.

207



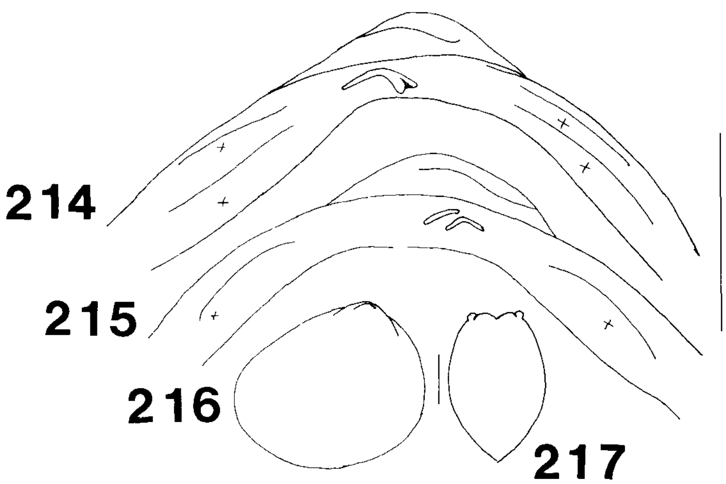
212

Figures 212-213. *Pisidium amnicum*:
212- right valve;
213- left valve.

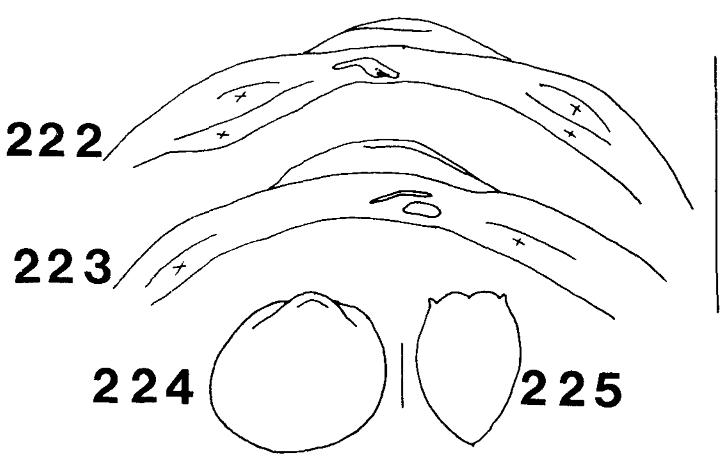
213

17 (16) Shell dull; striae distinct and evenly spaced; shell longer in outline; C2 chevron-shaped and longer than C4 (Figs. 214-221): *Pisidium henslowanum*

Shell silky to glossy, short in outline; striae fine, indistinct, irregular; C2 stump-like and shorter than C4 (Figs. 222-227): *Pisidium lilljeborgi* f. *cristatum*

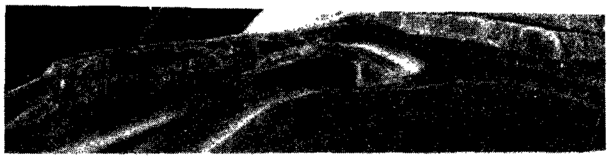


Figures 214-217. *Pisidium henslowanum*: 214- right hinge; 215 left hinge; 216- lateral aspect of left valve; 217- end view showing umbonal ridges at arrow. Also see Figs. 218-221, page 61.



Figures 222-225. *Pisidium lilljeborgi* f. *cristatum*: 222- right hinge; 223- left hinge; 224- lateral aspect of left valve; 225- end view showing umbonal ridges. Also see Figs. 226-227, page 62.

218

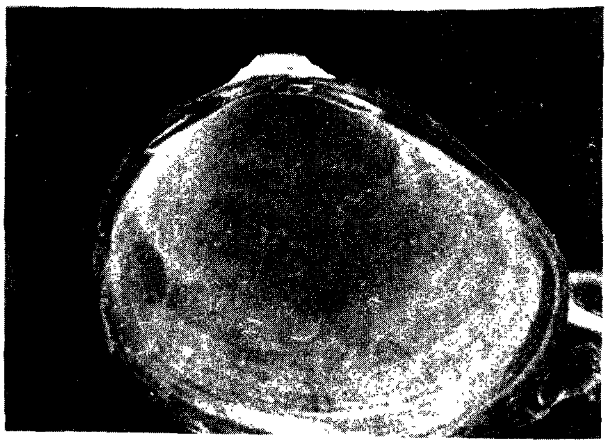


219

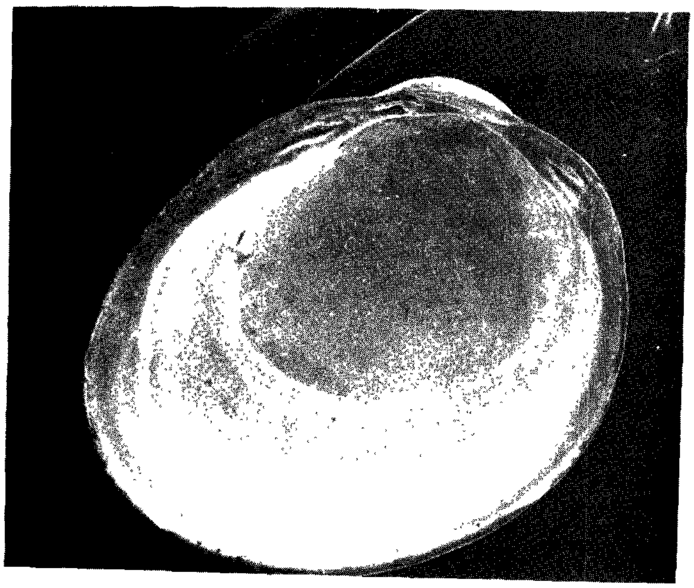
Figures 218-221. *Pisidium henslowanum*:
218- cardinal tooth of right valve;
219- right valve;
220- cardinal teeth of left valve;
221- left valve.

220

221

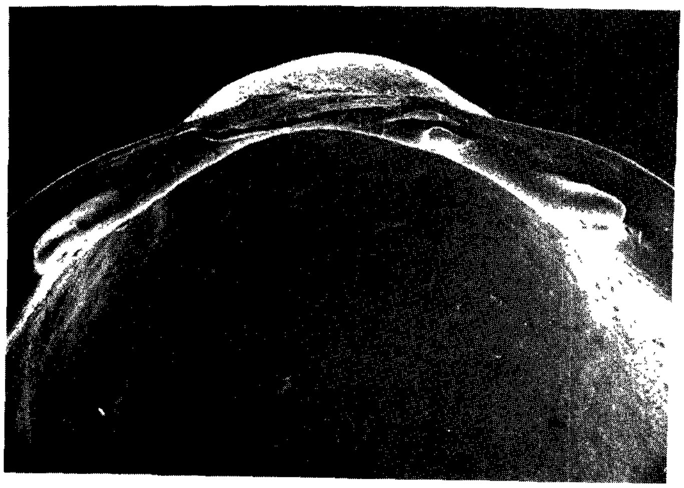


226



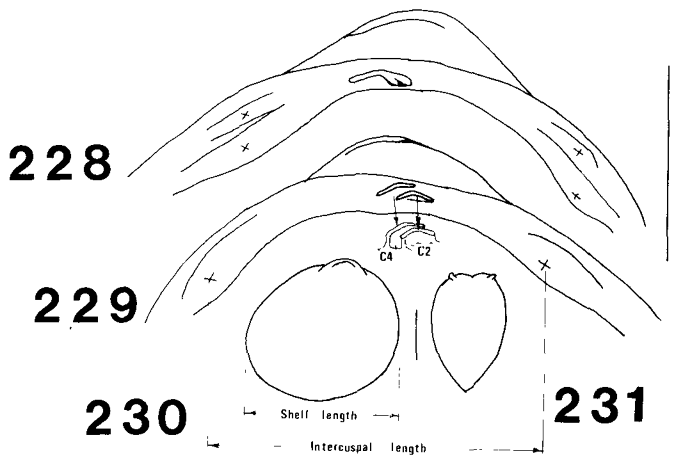
Figures 226-227. *Pisidium lilljeborgi* f. *cristatum*:
226- right valve;
227- left valve.

227

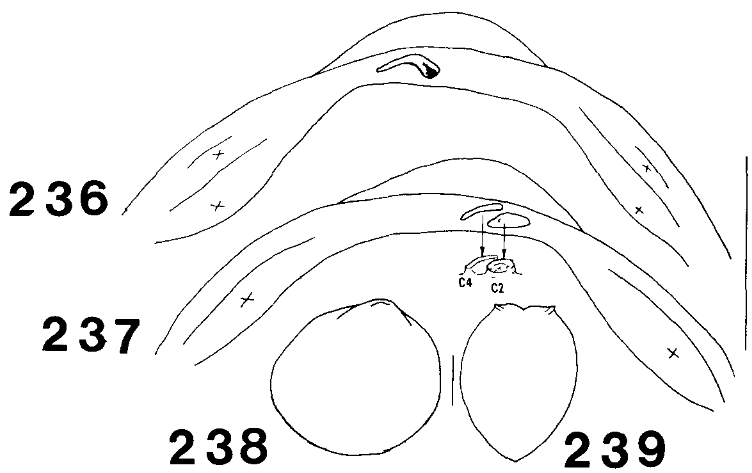


18 (16) Intercuspal to shell length ratio greater than 0.50 (Fig. 229); C2 chevron-shaped (Figs. 229, 234, 235, also Figs. 228-235): *Pisidium supinum*

Intercuspal to shell length ratio less than 0.45 (Fig. 237); C2 stump-like (Figs. 237, 241, also Figs. 236-241): *Pisidium compressum*

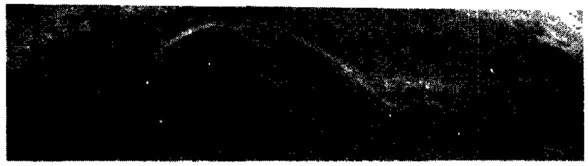


Figures 228-231. *Pisidium supinum*: 228- right hinge; 229- left hinge showing shape of C2 and C4 from medial view, and method of measuring intercuspal length; 230- lateral aspect of left valve; 231- end view. Also see Figs. 232-235, page 64.

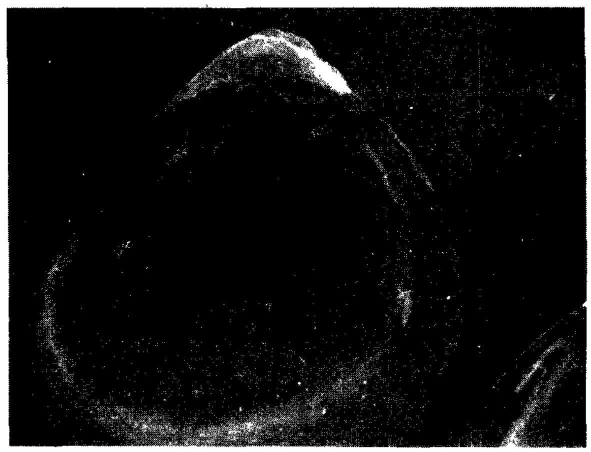


Figures 236-239. *Pisidium compressum*: 236- right hinge; 237- left hinge showing shape of C2 and C4 from medial view; 238- lateral aspect of left valve; 239- end view. Also see Figs. 240-241, page 65.

232

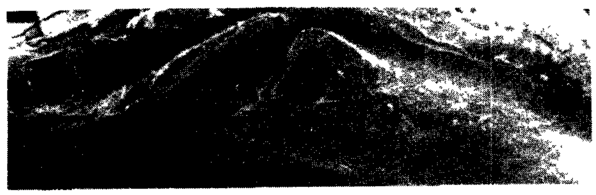


233

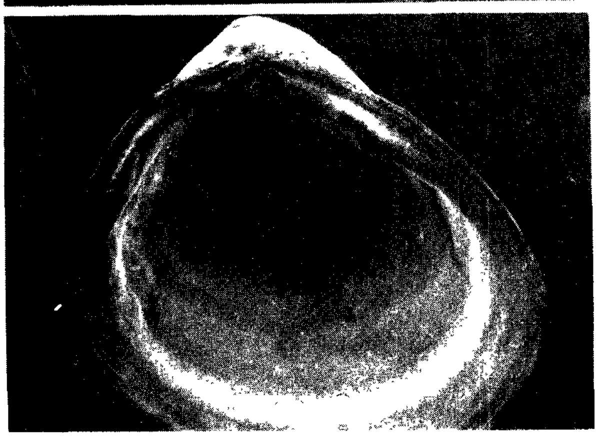


Figures 232-235. *Pisidium supinum*:
232- cardinal tooth of right valve;
233- right valve;
234- cardinal teeth of left valve;
235- left valve.

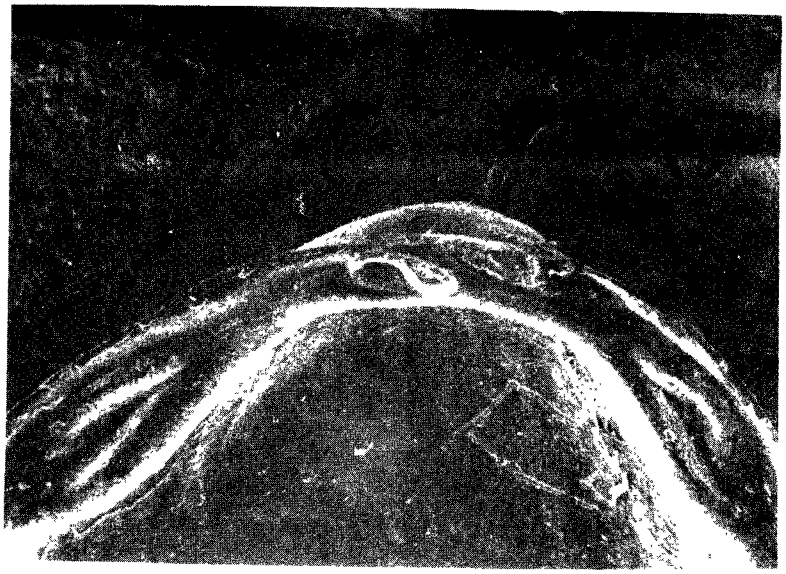
234



235



240



Figures 240-241. *Pisidium compressum*:
240- right valve;
241- left valve.

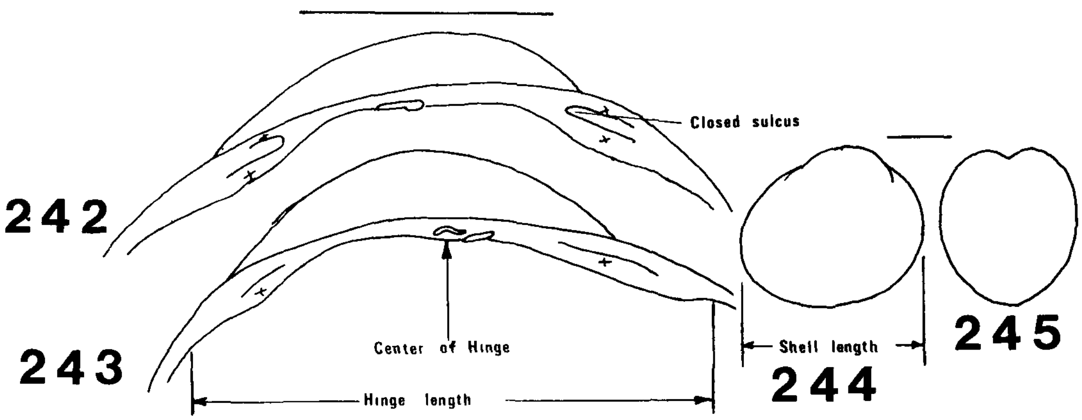
241

19 (15) Cardinals on anterior side of center of hinge (Figs. 242, 243, 250, 251) 20
Cardinals central on hinge (Figs. 323, 324, 327, 328) 30

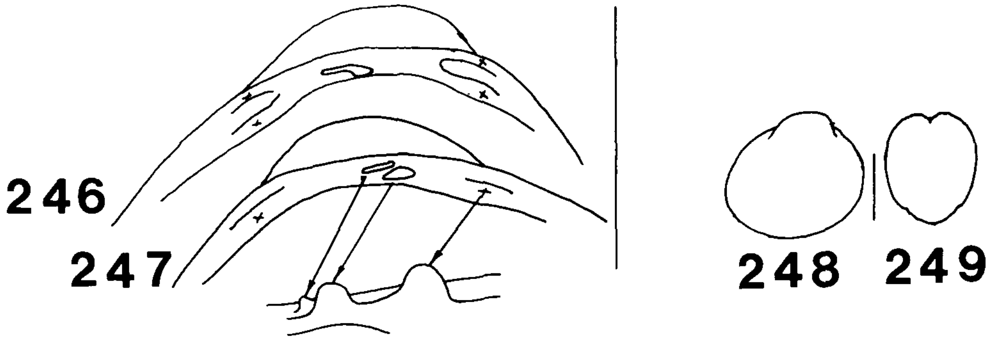
20 (19) Hinge short, less than 3/4 shell length (Figs. 242, 243, 250, 251) 21
Hinge long, more than 3/4 shell length (Figs. 315, 316, 320, 322) 29

21 (20) Anterior end of posterior sulcus in right valve closed (Figs. 242, 250); length of hinge plate very short, distance between AII and PII only 1/3 of shell length (Fig. 243); shell inflated (Figs. 245, 255) 22
Anterior end of posterior sulcus in right valve open (Figs. 268, 272); distance between AII and PII greater than 1/3 of shell length; shell inflated or not inflated 23

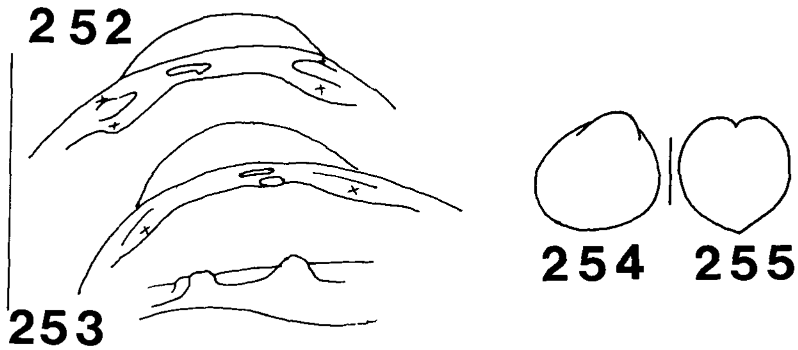
22 (21) Beaks subcentral; space between C2 and cusp of PII less than 1.5 times length of C2 (Figs. 243, 251, also Figs. 242-251): *Pisidium ventricosum* f. *rotundatum*
Beaks terminal; space between C2 and cusp of PII more than 1.5 times the length of C2 Figs. 253, 257, also Figs. 252-257): *Pisidium ventricosum* f. *ventricosum*



Figures 242-245. *Pisidium ventricosum* f. *rotundatum*: 242- right hinge; 243- left hinge showing method of determining hinge length (distance between junction of posterior lateral tooth with shell and junction of anterior lateral tooth with shell) and center of hinge (1/2 hinge length): 244- lateral aspect of left valve showing method of determining shell length; 245- end view. Also see Figs. 246-249, page 67 and Figs. 250-251, page 68.

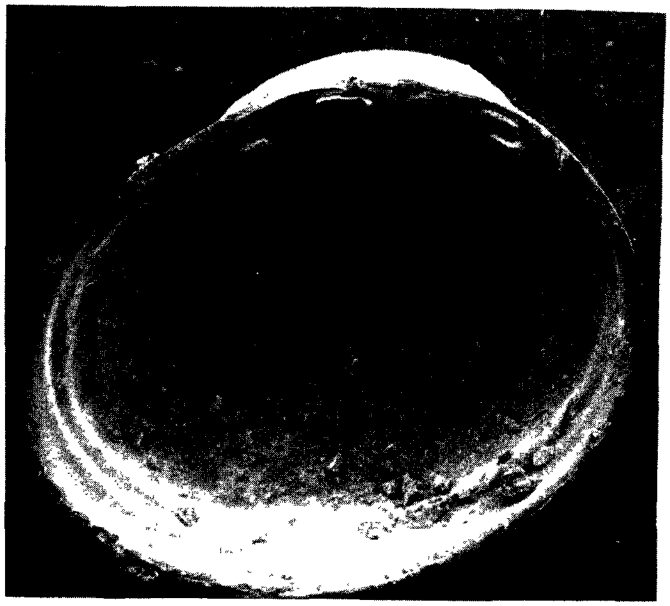


Figures 246-249. Variant of *Pisidium ventricosum* f. *rotundatum*: 246- right hinge; 247- left hinge showing shape of C2, C4, and AII from medial view; 248- lateral aspect of left valve; 249- end view. Also see Figs. 242-245, page 66 and 250-251, page 68.



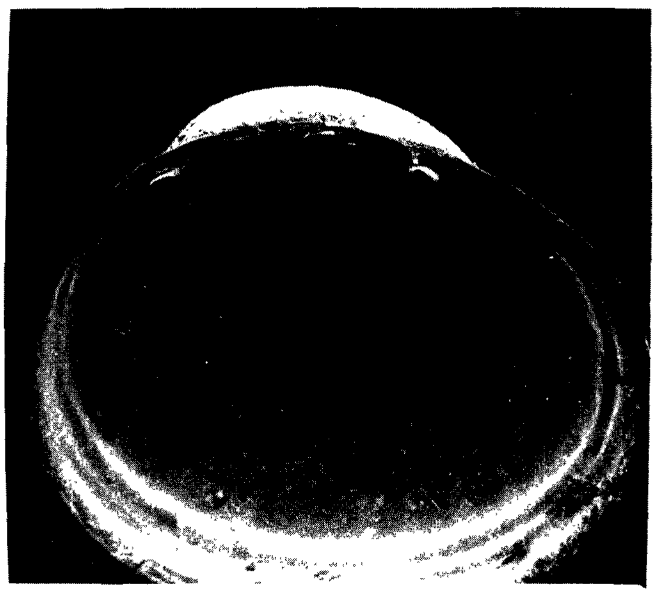
Figures 252-255. *Pisidium ventricosum* f. *ventricosum*: 252- right hinge; 253- left hinge showing shape of C2, C4 and AII from medial view; 254- lateral aspect of left valve. Also see Figs. 256-257, page 69.

250

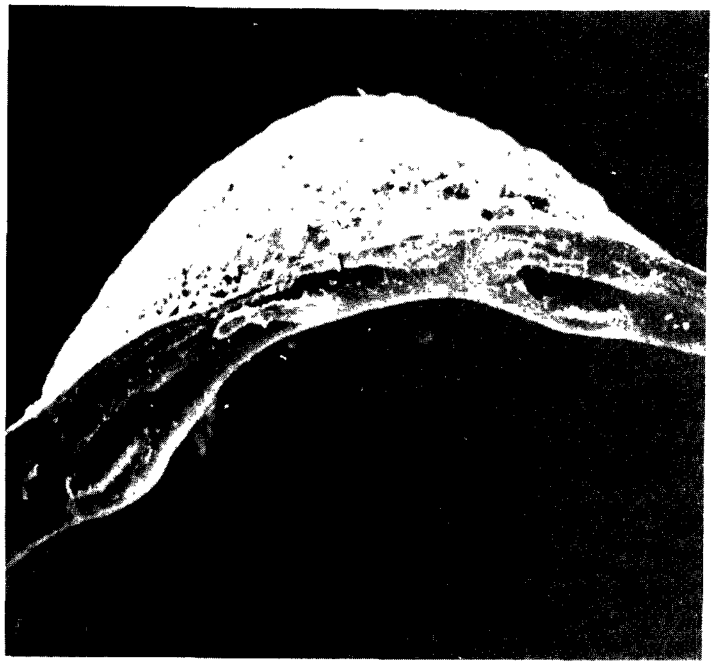


Figures 250-251. *Pisidium ventricosum* f. *rotundatum*:
250- right valve;
251- left valve.

251



256

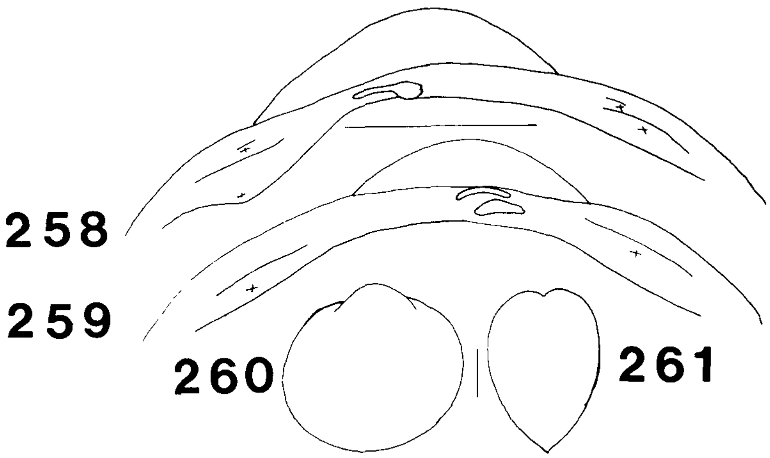


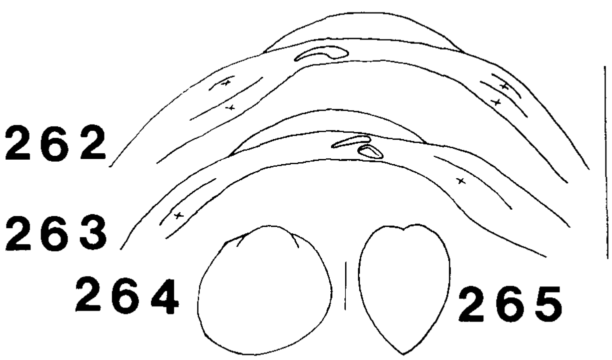
Figures 256-257. *Pisidium ventricosum* f. *ventricosum*:
250- right valve;
251- left valve.

257

23 (21) Posterior end of C3 enlarged 3 to 5 times more than anterior end (Figs. 268, 272), often toothbrush-shaped (Fig. 258): shell dull or glossy 24
Posterior end of C3 less than twice the thickness of anterior end (Figs. 280, 284); shell glossy 26

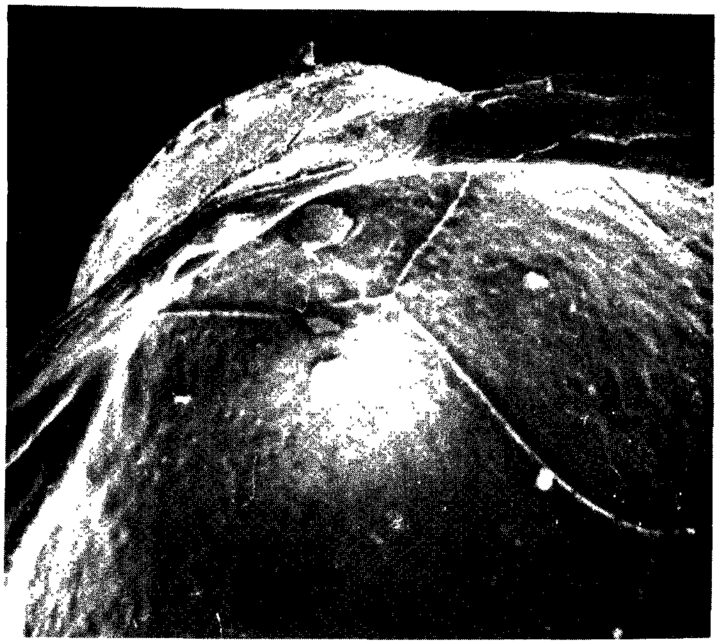
24 (23) Shell dull; umbo clearly posterior; dorso-anterior margin rounded (Fig. 270) 25
Shell glossy; umbo more central; dorso-anterior margin angulate (Figs. 258, 260, also Figs. 258-267): *Pisidium lilljeborgi* f. *lilljeborgi*





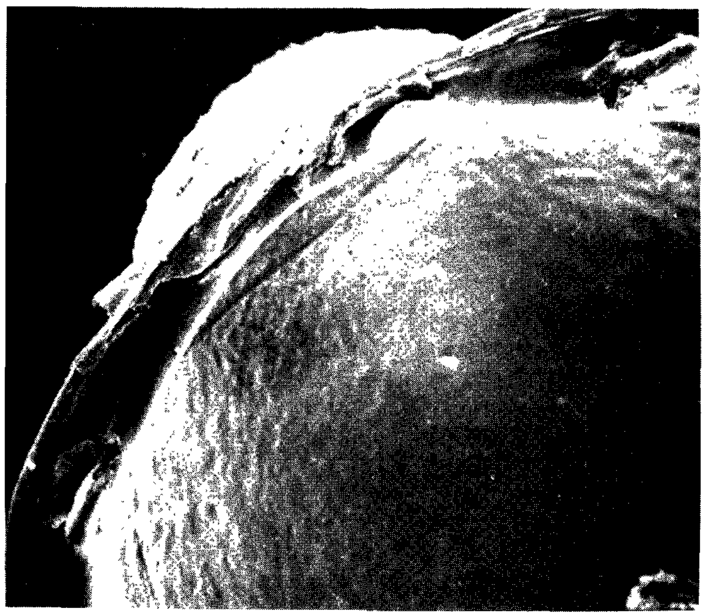
Figures 258-265. *Pisidium lilljeborgi* f. *lilljeborgi*: 258- right hinge; 259- left hinge; 260- lateral aspect of left valve; 261- end view. Variant of *Pisidium lilljeborgi* f. *lilljeborgi*: 262- right hinge; 263- left hinge; 264- lateral aspect of left valve; 265- end view. Also see Figs. 266-267, page 71.

266



Figures 266-267. *Pisidium lilljeborgi* f. *lilljeborgi*:
266- right valve;
267- left valve.

267



25 (24) C2 low and canine-shaped (Figs. 269,273); shell pointed anteriorly (Fig. 270, also Figs. 268-273): *Pisidium walkeri* f. *walkeri*

C2 high and incisor shaped (Figs. 275, 279); shell rounded anteriorly (Fig 275, also Figs. 274-279): *Pisidium walkeri* f. *mainense*

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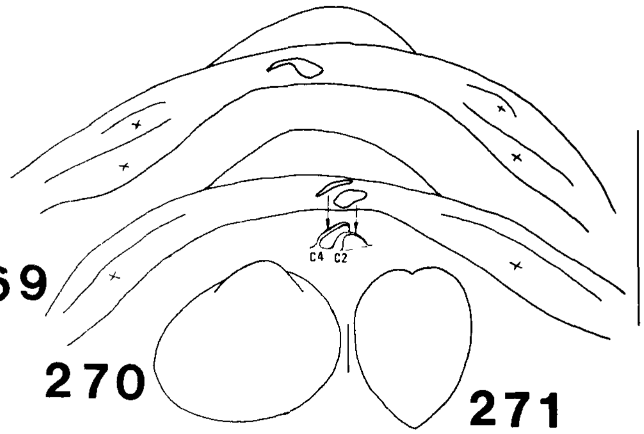

Figures 268-271. *Pisidium walkeri* f. *walkeri*: 268- right hinge; 269- left hinge showing shape of C2 and C4 from medial view; 270 lateral aspect of left valve; 271- end view. Also see Figs. 272-273, page 73.

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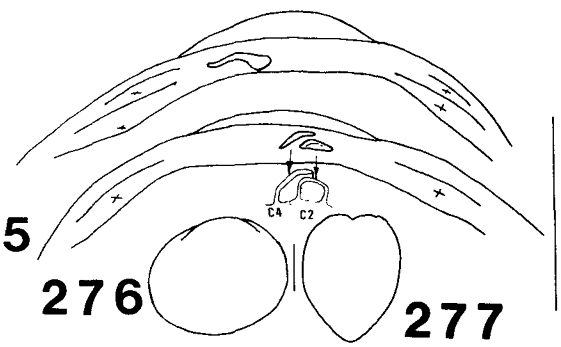
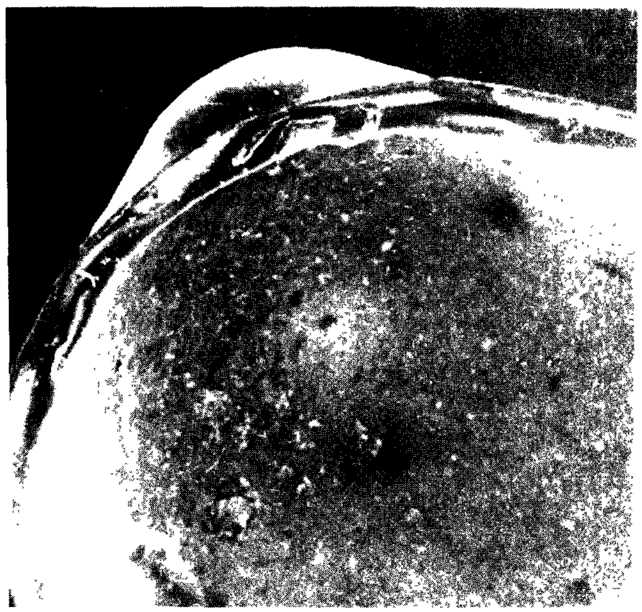


Figures 274-277. *Pisidium walkeri* f. *mainense*: 274- right hinge; 275- left hinge showing shape of C2 and C4 from medial view; 276- lateral aspect of left valve; 277- end view. Also see Figs. 278-279, page 74.

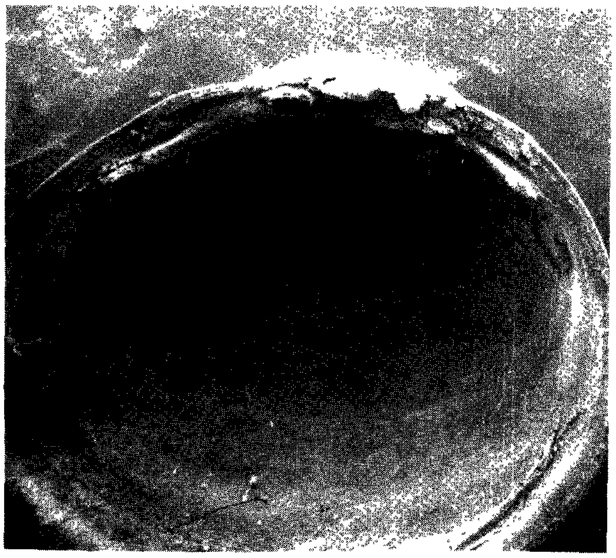
272

Figures 272-273. *Pisidium walkeri* f. *walkeri*:
272- right valve;
273- left valve.

273



278

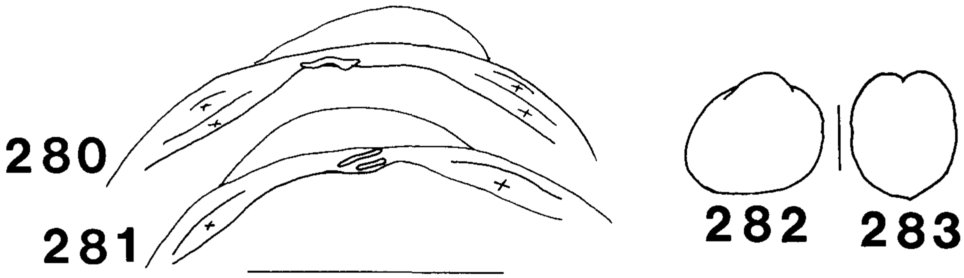


Figures 278-279. *Pisidium walkeri* f. *mainense*:
278- right valve;
279- left valve.

279

26 (23) Shell inflated, ventral margin more or less straight in side view and truncated in end view (Figs. 282, 283, also Figs. 280-287): *Pisidium milium*

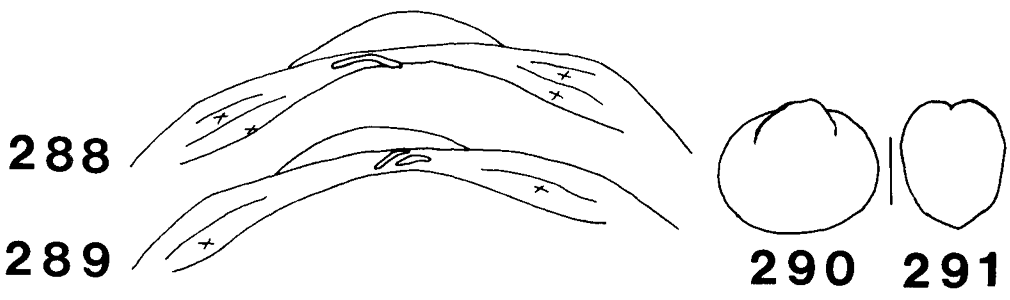
Shell not inflated, or if so, without a truncated or straight ventral margin (Figs. 290, 304) 27



Figures 280-283. *Pisidium milium*: 280- right hinge; 281- left hinge; 282- lateral view of left valve; 283- end view. Also see Figs. 284-287, page 76.

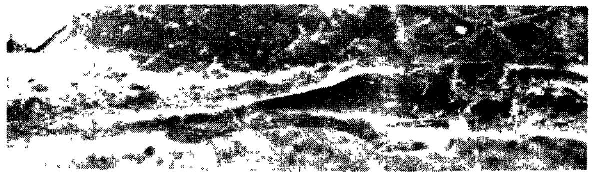
27 (26) Space between cardinals and AII small, less than 1.5 times length of C3 (Figs. 288, 289, 295); beaks often tuberculate (Figs. 288-295): *Pisidium ferrugineum*

Space between cardinals and AII large, usually more than twice the length of C3 (Figs. 296, 297); beaks never tuberculate (Figs. 289-304) 28

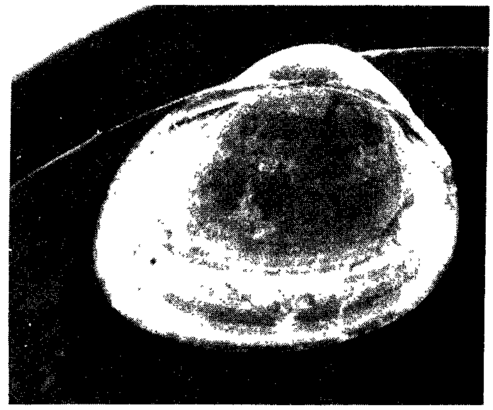


Figures 288-291. *Pisidium ferrugineum*: 288- right hinge; 289- left hinge; 290- lateral aspect of left valve; 291- end view. Also see Figs. 292-295, page 77.

284



285



Figures 284-287. *Pisidium milium*:
284- cardinal tooth of right valve;
285- right valve;
286- cardinal teeth of left valve;
287- left valve.

286

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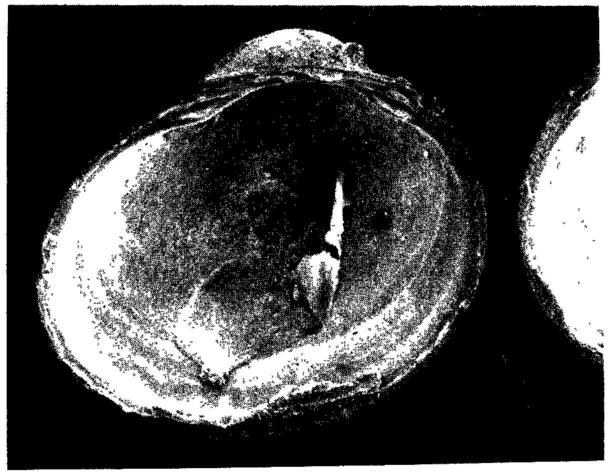
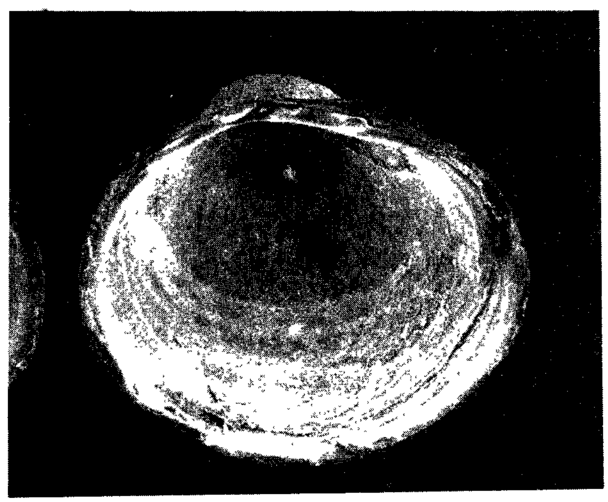
293



Figures 292-295. *Pisidium ferrugineum*:
292- cardinal tooth of right valve;
293- right valve;
294- cardinal teeth of left valve;
295- left valve.

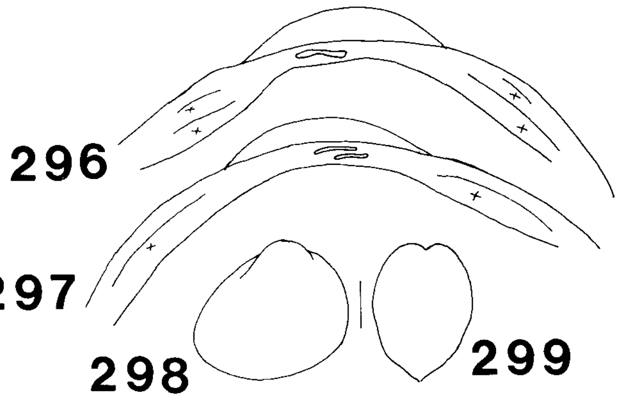
294

295

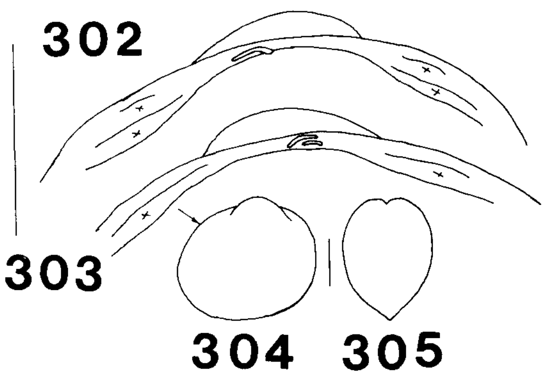


28 (27) Anterior slope long and gradual, the angle at dorso-anterior margin beginning above the cusps of anterior laterals; dorsal and ventral margins not parallel; dorso-anterior margin without angle (Fig. 298, also Figs. 296-301): *Pisidium subtruncatum*

Anterior slope short and steep, the angle at dorso-anterior margin beginning below the cusps of anterior laterals (Figs. 302-303); dorsal and ventral margins nearly parallel and dorso-anterior margin distinctly angulate (Fig. 304, also Figs. 302-307): *Pisidium nitidum* f. *nitidum*

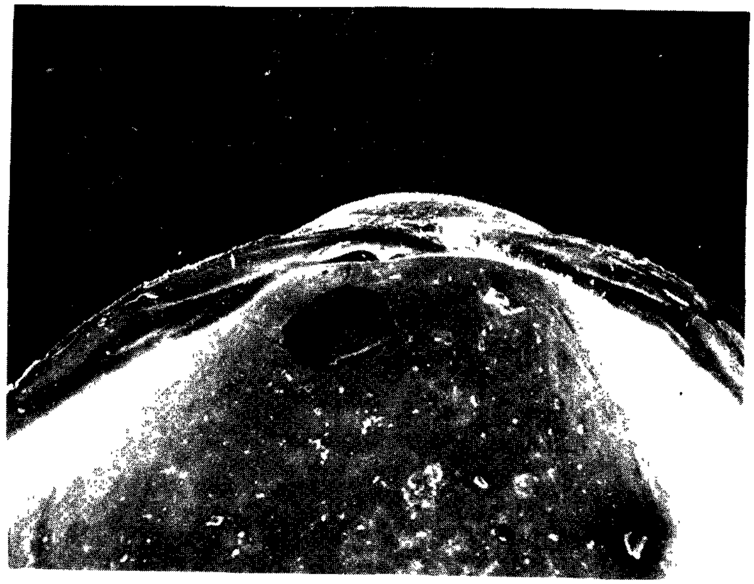


Figures 296-299. *Pisidium subtruncatum*: 296- right hinge; 297- left hinge; 298- lateral aspect of left valve; 299- end view. Also see Figs. 300-301, page 79.



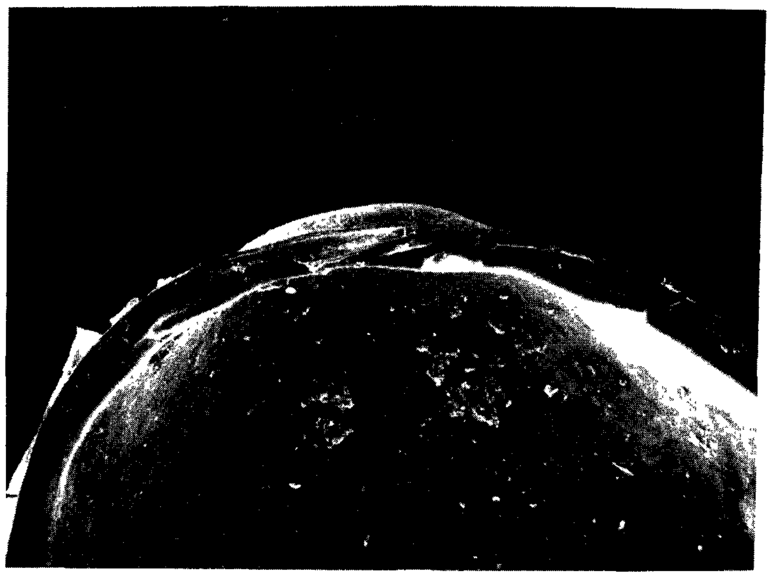
Figures 302-305. *Pisidium nitidum* f. *nitidum*: 302- right hinge; 303- left hinge; 304- lateral aspect of left valve; 305- end view. Also see Figs. 306-307, page 80.

300



Figures 300-301. *Pisidium subtruncatum*:
300- right valve;
301- left valve.

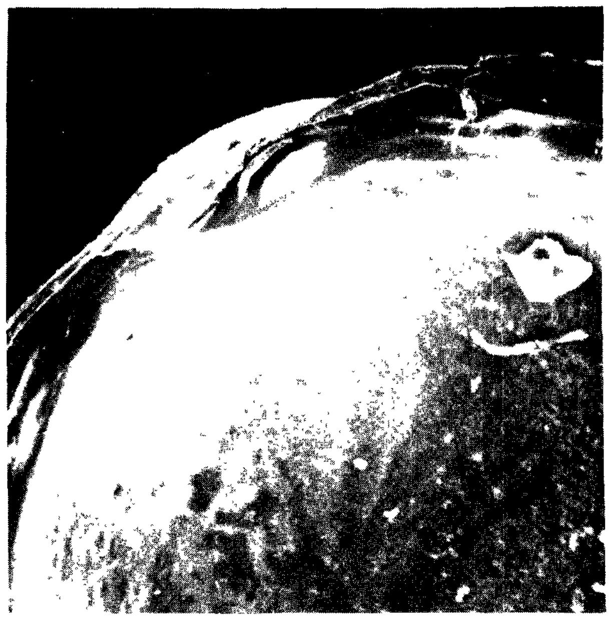
301



306

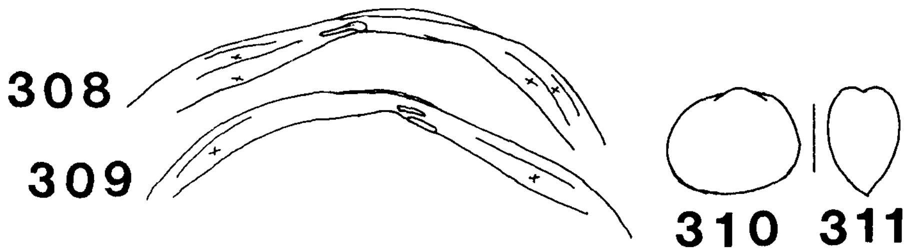
Figures 306-307. *Pisidium nitidum* f. *nitidum*:
306- right valve;
307- left valve.

307

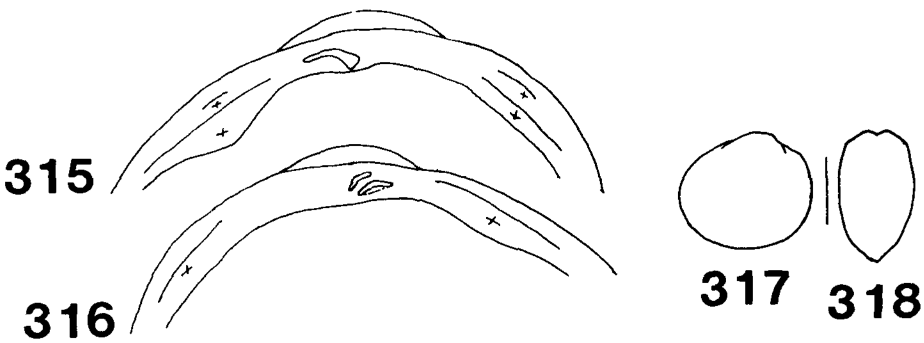


29 (20) C3 club-shaped, C2 and C4 short and of similar shape and parallel with each other (Figs. 308, 309, 312-314); shell shaped like a parallelogram (Fig. 310); shell thin; found only in cold waters, northern or deep lakes (Figs. 308-314): *Pisidium conventus*

C3 bent and usually enlarged posteriorly, C2 and C4 of different shapes and usually not parallel (Figs. 315, 316); anterior and posterior margins sloped at different angles, not parallel; shell thin to heavy (Figs. 315-322); umbones often flattened (Fig. 318): *Pisidium fallax*

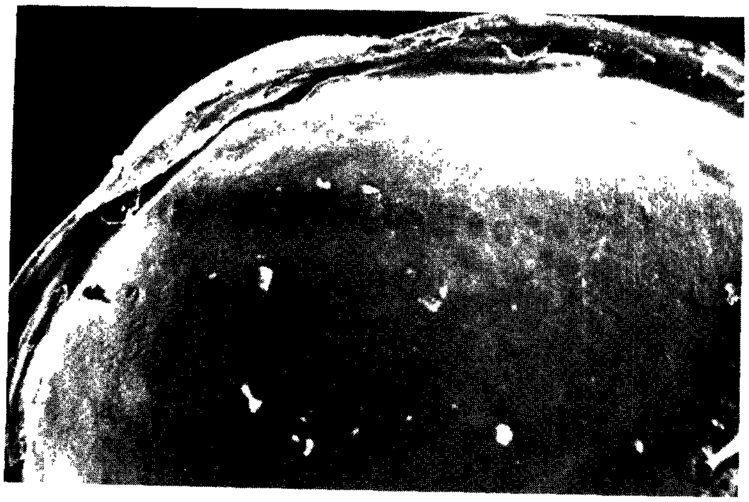


Figures 308-311. *Pisidium conventus*: 308- right hinge; 309- left hinge; 310- lateral aspect of left valve; 311- end view. Also see Figs. 312-314, page 82.



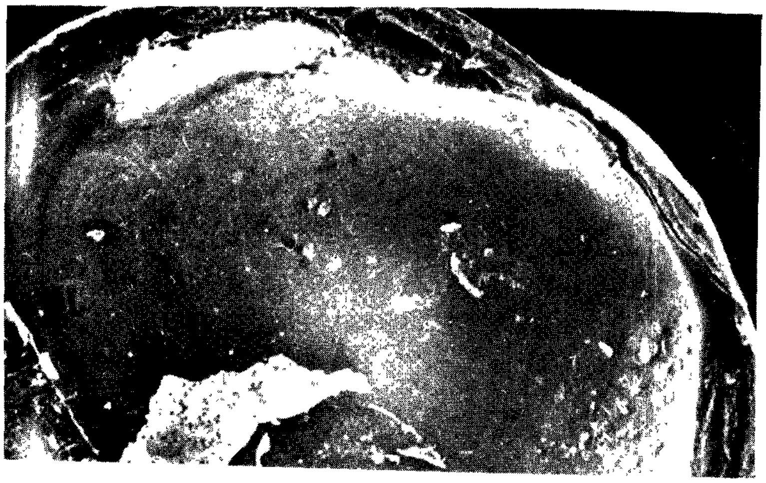
Figures 315-318. *Pisidium fallax*: 315- right hinge; 316- left hinge; 317- lateral aspect of left valve; 318- end view. Also see Figs. 319-322, page 83.

312

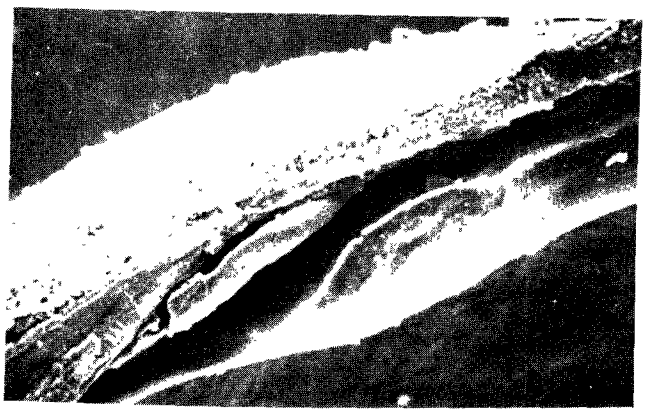


Figures 312-314. *Pisidium conventus*:
312- left valve;
313- right valve;
314- cardinal teeth of left valve.

313



314



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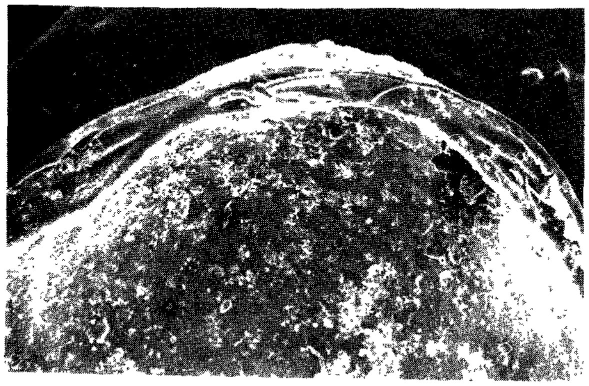
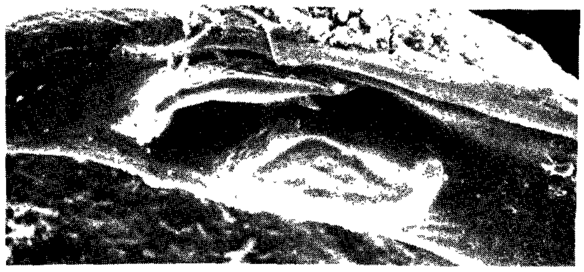
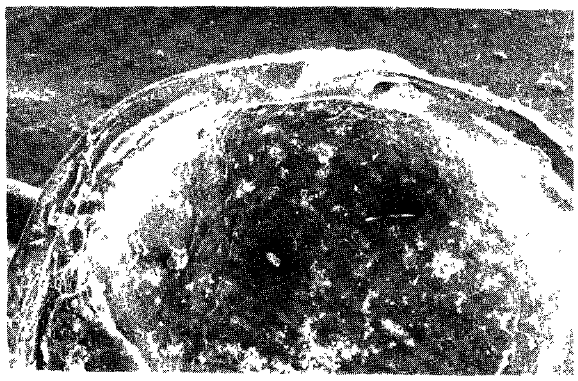


Figures 319-322. *Pisidium fallax*:
319- cardinal tooth of right valve;
320- right valve;
321- cardinal teeth of left valve;
322- left valve.

321

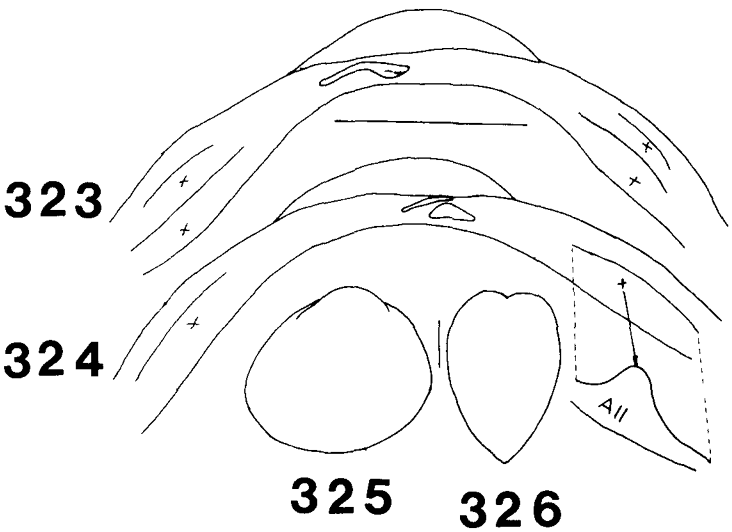


322



30 (19) Hinge short, less than 3/4 shell length (see Figs. 243, 244) 31
Hinge long, more than 3/4 shell length (see Figs. 243, 244) 33

31 (30) Cusp of AII proximal (nearest umbo) or on proximal side of center (Fig. 324); hinge heavy; shell very glossy (Figs. 323-328): *Pisidium variabile*
Cusp of AII distal (farthest from umbo) or on distal side of center (Fig. 330); hinge light; shell glossy to dull 32

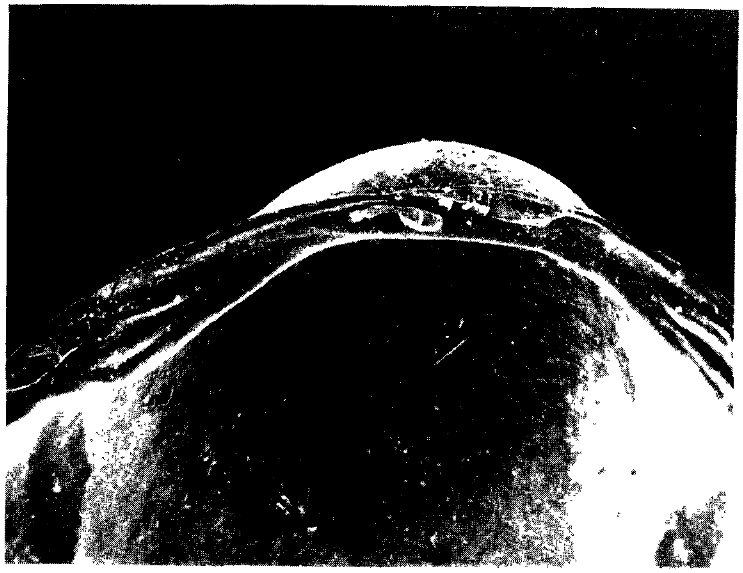


Figures 323-326. *Pisidium variabile*: 323- right hinge; 324- left hinge showing proximal position of cusp of AII; 325- lateral aspect of left valve; 326- end view. Also see Figs. 327-328, page 85.

32 (31) H:L ratio more than 0.86; shell glossy and laterally compressed (Fig. 332); adults longer than 6 mm (Figs. 329-334): *Pisidium idahoense*
H:L ratio less than 0.85; shell silky to dull, not laterally compressed (Fig. 338); adults less than 6 mm long Figs. 335-344): *Pisidium casertanum*

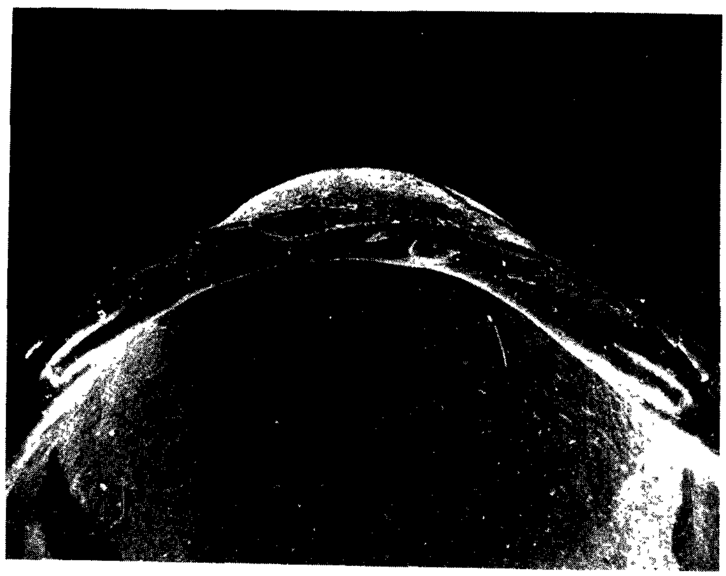
33 (30) C3 long and thin and usually of similar thickness throughout (Figs. 245, 249); C2 and C4 long, thin, of similar shape but may be of different lengths, more or less parallel with each other and with hinge (Figs. 345-350): *Pisidium nitidum* f. *pauperculum*
C3 enlarged posteriorly (Figs. 351, 355); C2 and C4 short and parallel, or if of different shapes, not parallel with each other or with hinge (Figs. 352-356) 34

327



Figures 327-328. *Pisidium variabile*:
327- right valve;
328- left valve.

328



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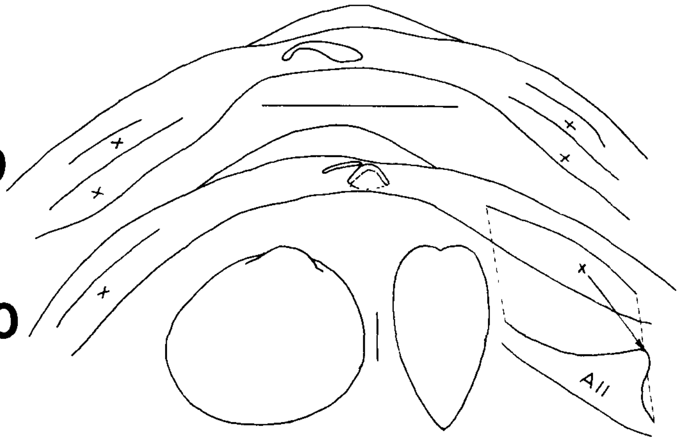
330

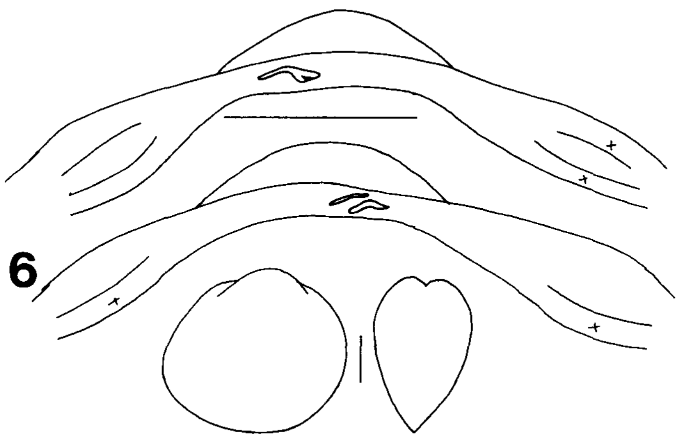


331 332

Figures 329-332. *Pisidium idahoense*: 329- right hinge; 330- left hinge showing distal position of cusp of AII; 331- lateral aspect of left valve; 332- end view. Also see Figs. 333-334, page 88.

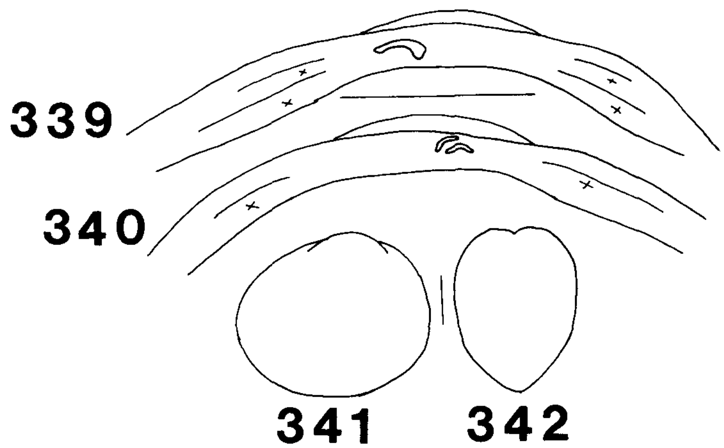
335

336

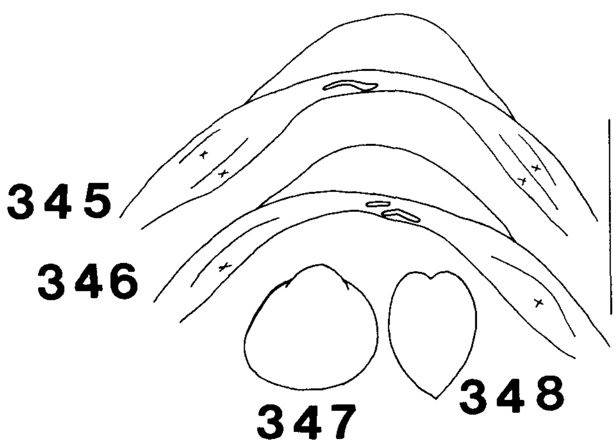


337 338

Figures 335-338. *Pisidium casertanum*: 335- right hinge; 336- left hinge; 337- lateral aspect of left valve; 338- end view. Also see Figs. 339-342, page 87, Figs. 343-344, page 89, and Figs. 396-374, page 96.

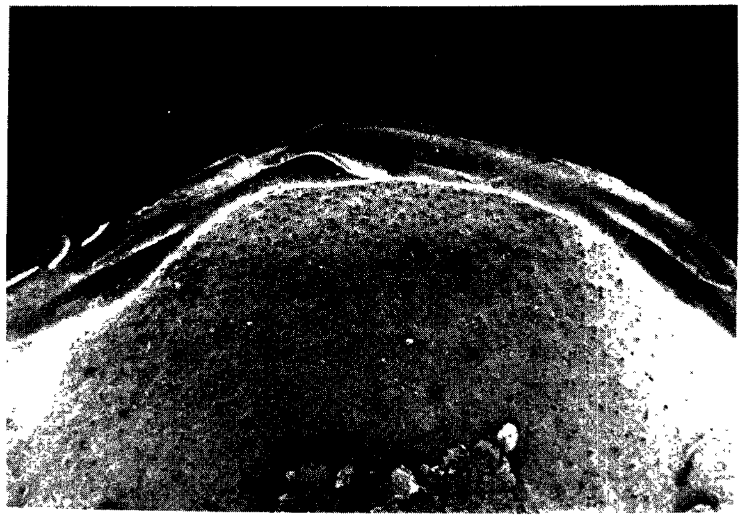


Figures 339-342. Variant of *Pisidium casertanum*: 339- right hinge; 340- left hinge; 341- lateral aspect of left valve; 342- end view. Also see Figs. 335-338, page 86, Figs. 343-344, page 89, and Figs. 369-374, page 96.



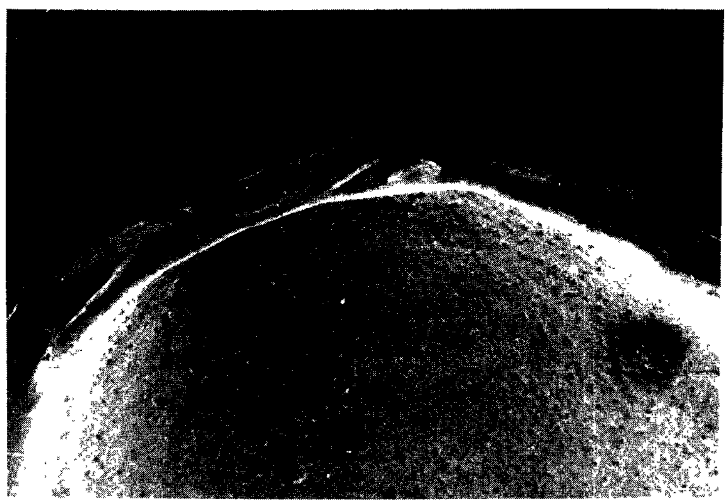
Figures 345-348. *Pisidium nitidum* f. *pauperculum*: 345- right hinge; 346- left hinge; 347- lateral aspect of left valve; 348- end view. Also see Figs. 349-350, page 90.

333



Figures 333-334. *Pisidium idahoense*:
333- right valve;
334- left valve.

334



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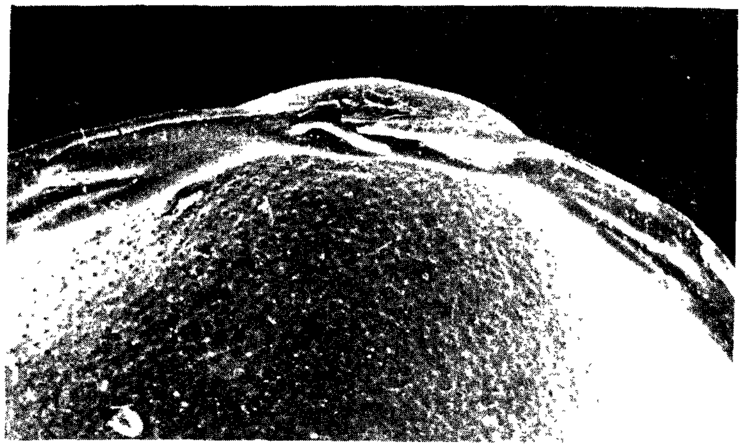
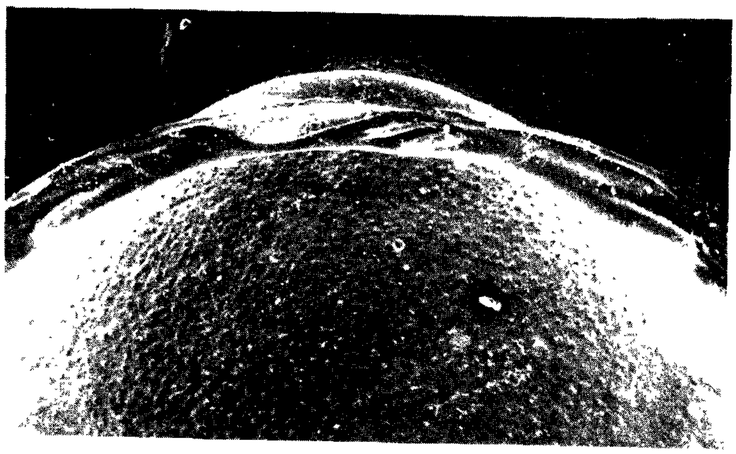


Figures 343-344. *Pisidium casertanum*:
343- right valve;
344- left valve.

344

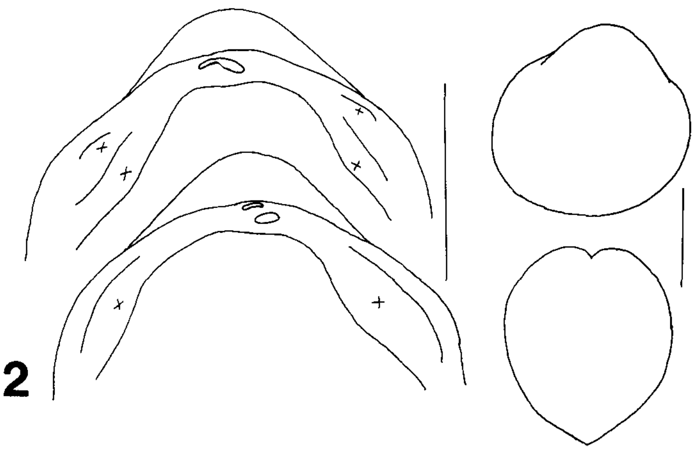


349

Figures 349-350. *Pisidium nitidum* f. *pauperculum*:
349- right valve;
350- left valve.

350

34 (33) Shell glossy; hinge very heavy (Figs. 351-356): *Pisidium equilaterale*
Shell dull to glossy; hinge heavy or light 35



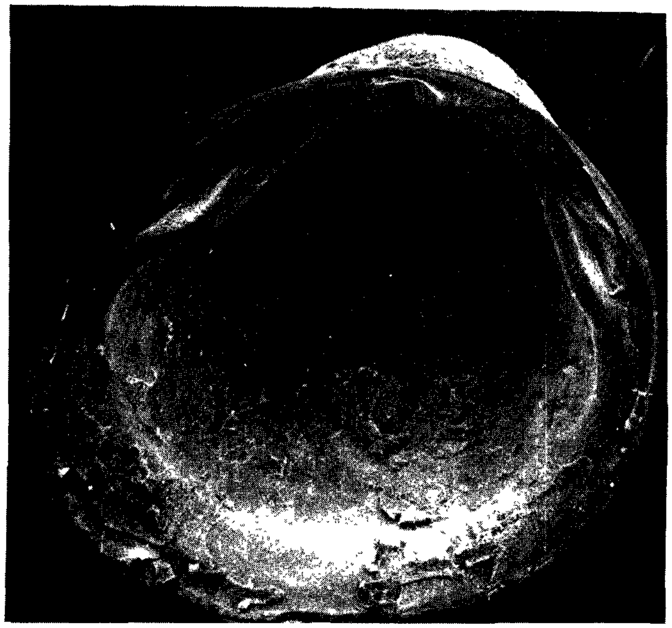
Figures. 351-354. *Pisidium equilaterale*: 351- right hinge; 352- left hinge; 353- lateral aspect of left valve; 354- end view. Also see Figs. 355-356, page 92.

35 (34) C2 and C4 short and parallel with hinge and with each other (Figs. 358, 362): C3 club-shaped (Figs. 357, 361); striae distinct, evenly spaced; adult shell less than 2 mm long (Figs. 357-362): *Pisidium punctatum*
C2 and C4 of different shapes (Figs. 364, 368); C3 enlarged posteriorly but not club-shaped (Figs. 363, 367); striae usually not distinct and evenly spaced; adult shell more than 3 mm long 36

36 (35) H:L ratio more than 0.86; hinge heavy (Figs. 237, 241, 324, 327: adults always less than 6 mm long 37
H:L ratio less than 0.85; shell silky to dull; hinge light adults may be more than 6 mm long (Figs. 363-368) 38

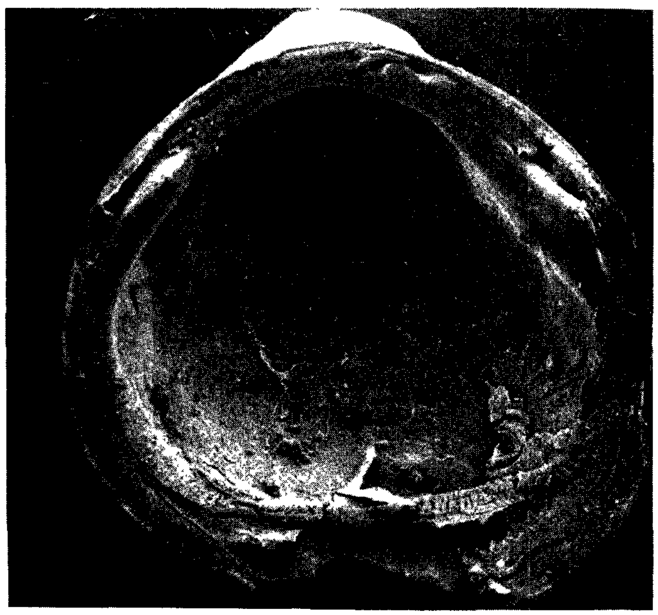
37 (36) Shell dull; umbo narrow and prominent; ridge on umbo present or absent (Figs. 236-241): *Pisidium compressum*
Shell glossy; umbo broad and prominent; ridge never present on umbo (Figs. 323-328): *Pisidium variabile*

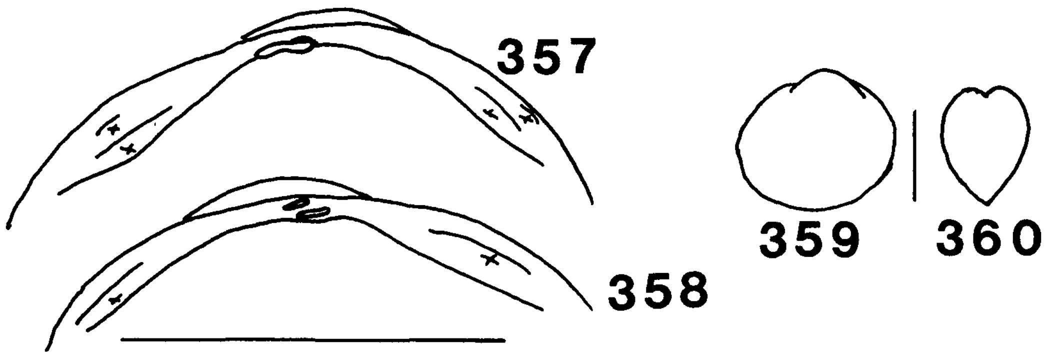
355



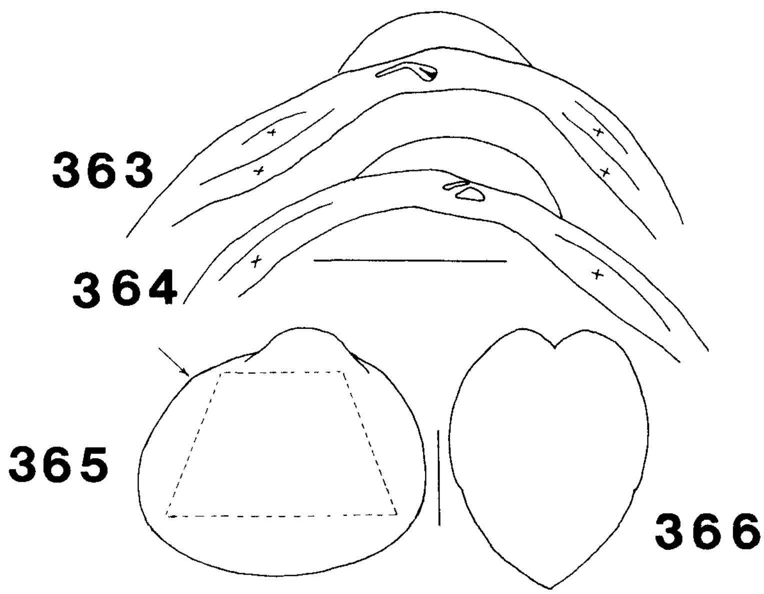
Figures 355-356. *Pisidium equilaterale*:
355- right valve;
356- left valve.

356



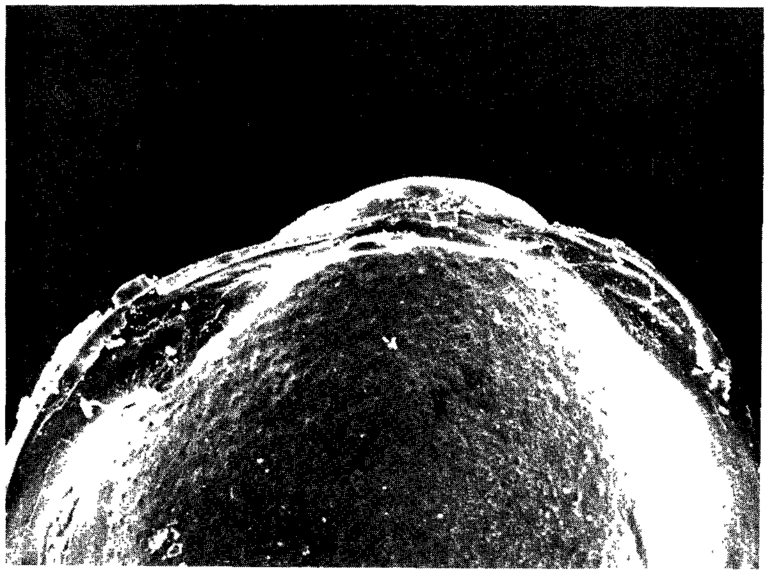


Figures 357-360. *Pisidium punctatum*: 357- right hinge; 358- left hinge; 359- lateral aspect of left valve; 360- end view. Also see Figs. 362, page 94.



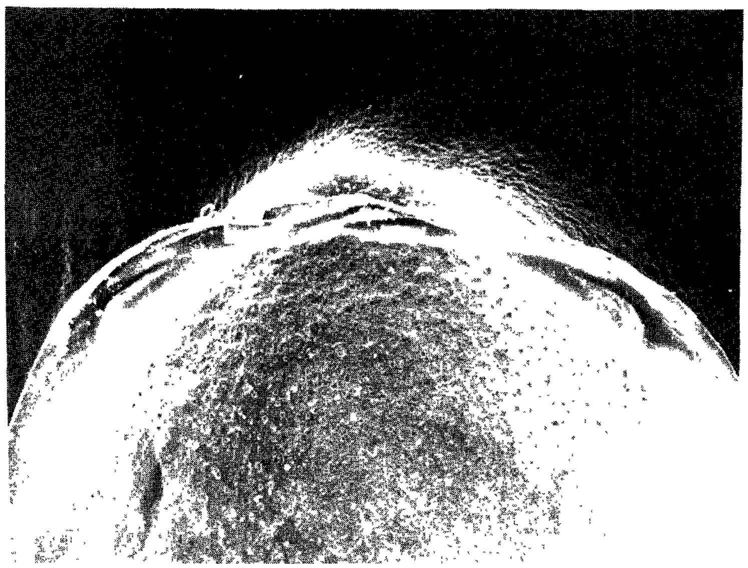
Figures 363-366. *Pisidium adamsi*: 363- right hinge; 364- left hinge; 365- lateral aspect of left valve showing trapezoidal outline; 366- end view. Also see Figs. 367-368, page 95.

361



Figures 361-362. *Pisidium punctatum*:
361- right valve;
362- left valve.

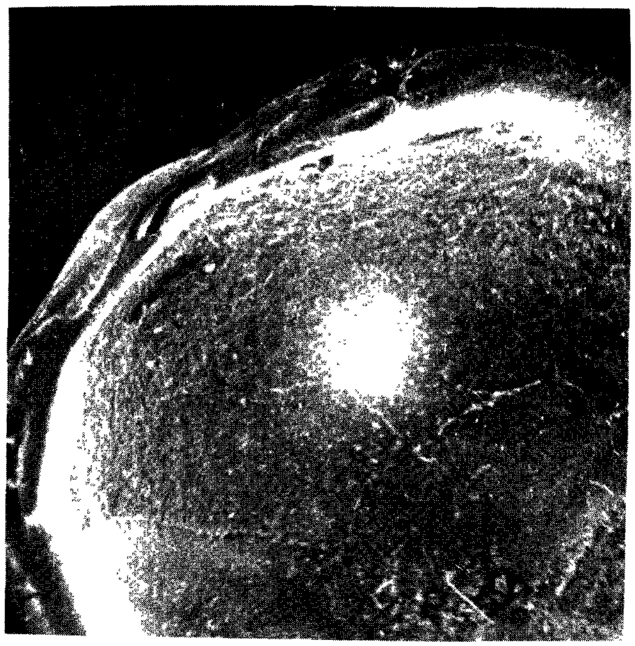
362



367

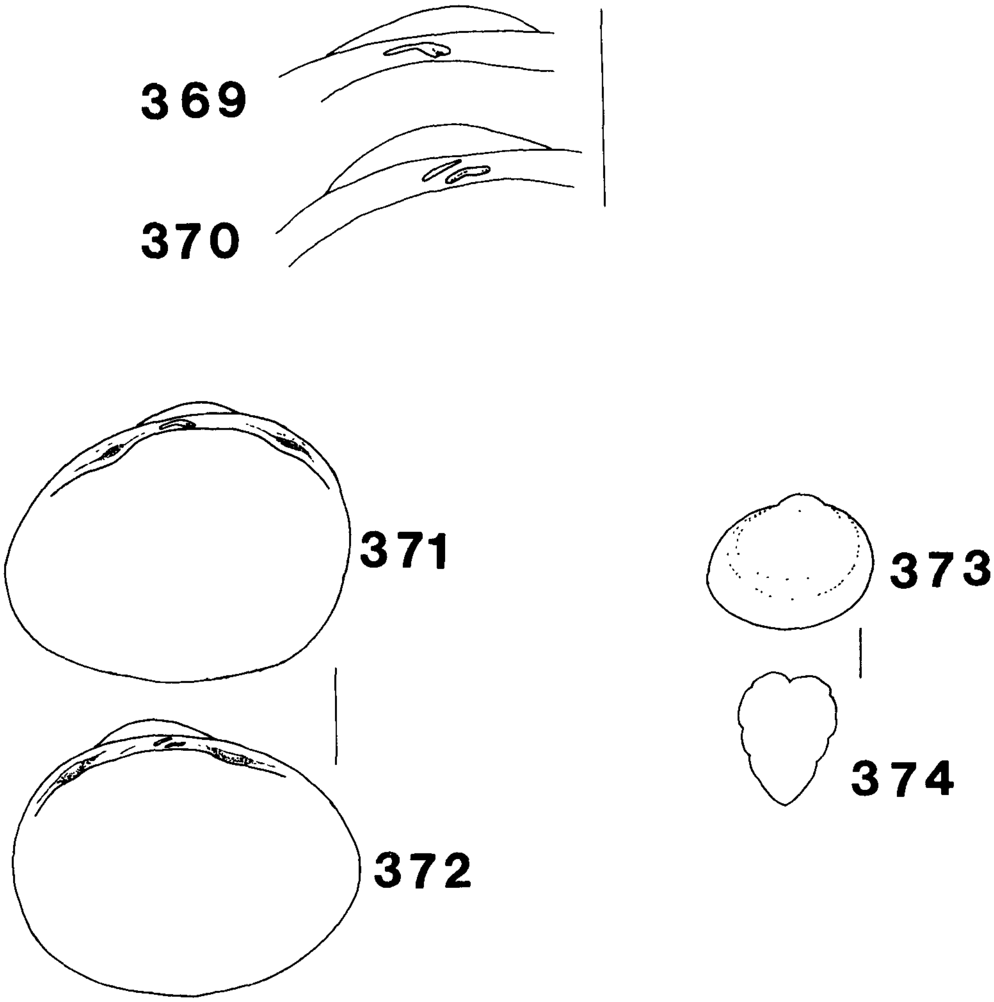
Figures 367-368. *Pisidium adamsi*:
367- right valve;
368- left valve.

368



38 (36) Anterior slope distinctly angled at dorsal margin or shell trapezoidal in shape (dorsal and ventral margins are parallel but anterior and posterior slopes diverge at nearly equal angles from dorsal margin, Fig. 365); adults usually longer than 6 mm (Figs. 363-368): *Pisidium adamsi*

Anterior slope evenly rounded (Fig. 371); shell not trapezoidal in shape; adults less than 6 mm long (Figs. 335-344, 369-374): *Pisidium casertanum*



Figures 369-374. *Pisidium casertanum*: 369- C3 of right hinge; 370- C2 and C4 of left hinge; 371- right hinge; 372- left hinge; 373- lateral aspect of left valve; 374- end view. Also see Figs. 335-338, page 86, Figs. 339-342, page 87, Figs.343-344, page 89.

SECTION IV

ECOLOGY AND DISTRIBUTION OF GASTROPODA

VIVIPARIDAE

Campeloma

C. decisum has been reported from Superior, Huron, and Ontario where it may be common in quiet waters with soft substrates containing some organic matter (Bovbjerg, 1952; Chamberlain, 1958; Mackie, 1971; Mackie and Quadri, 1971a; Clarke, 1973). *C. rufum* apparently is quite rare and recorded only by Baker (1928a); Goodrich (1932) and Van Cleave and Altringer (1937) list it as a species of smaller lakes.

Viviparus

The Great Lake's species of *Viviparus* are most abundant in moderately eutrophic areas. *V. georgianus* has been collected in Huron. *V. japonicus* and its apparent synonym *V. malleatus* is an Asian introduction particularly abundant in Sandusky Bay, other areas of western Lake Erie, and Green Bay of Michigan (Wolfert and Hiltunen, 1968).

VALVATIDAE

Valvata

Most species and forms of this genus occur in limited numbers throughout the lakes. *V. bicarinata* (possibly a subspecies of *V. tricarinata*)is known from Lake Michigan (LaRocque, 1953), *V. lewisi* from Superior, *V. piscinalis* from Ontario, *V. tricarinata* (including the morphs *basalis and perconfusa*) from eutrophic bays of Ontario and Superior, and *V. sincera* from Erie, Ontario and Superior. *V. perdepressa* is abundant in many areas of Lake Michigan (Shelford, 1913; Baker, 1928a, 1930) and common in the open lake down to 18 m near Waukegan (Industrial Bio-Test, 1973).

HYDROBIIDAE

Amnicola

A. limosa and *A. walkeri* are most common in dense masses of aquatic macrophytes and also are present in open areas protected from strong wave action and currents (Berry, 1943; Harman and Berg, 1971). *A. limosa* is recorded from Ontario, Michigan and Superior; *A. walkeri* is from Michigan.

Bithynia

B. tentaculata is listed from Ontario and Erie but probably will continue to spread throughout the Great Lakes (Berry, 1943) where there are submerged macrophytes and eutrophic conditions (Harman, 1968).

Cincinnatia

C. cincinnatiensis is recorded only from Michigan where it occurs on a variety of substrates from soft ooze to sand with or without aquatic vegetation (Berry, 1943; Harman and Berg, 1971; Clarke, 1973) but "is largely a species of rivers" (Baker, 1928a).

Marstonia

M. decepta is often associated with *A. limosa* in Ontario and Superior (Berry, 1943). Clarke (1973) found it in mesotrophic to eutrophic waters where vegetation was moderately thick, but Harman and Berg (1971) collected the species only from inorganic substrates.

Probythinella

Berry (1943) states that *P. lacustris* is common in the Great Lakes. Clarke (1973) and Harman and Berg (1971) suggest that it may require cold water particularly in the southern part of the range as it is found only in large, deep lakes.

Somatogyrus

A few specimens of *S. subglobosus* have been reported from western Lake Erie and Lake Michigan (Baker, 1928a, 1930).

PLEUROCERIDAE

Goniobasis

G. livescens is common and recorded from all the Great Lakes from "unprotected, rocky lettoral habitats ... on limestone rock ... and on piers of wharves, etc.", (Lake Michigan, Baker, 1911), "in sand runs or along rocky shores or on rocky shoals" (Lake Huron, Robertson, 1915a, 1915b), on pebbles and small stones of a bar "subject to almost continuous wave action" (Lake Erie, Wiebe, 1926), and "on marly clay bottom in water 0.3-1.3 m deep, among *Chara*, on sand bottom" (Lake Michigan, Baker, 1928a) (see also Goodrich, 1945, for a list of other habitats).

Pleurocera

P. acuta is known from Lake Erie where it has a limited and localized distribution and can be found in quiet, sheltered areas (Dazo, 1965) as well as shores exposed to wave action (Baker, 1928a; Harman and Berg, 1971).

LYMNAEIDAE
(The genera listed below are often regarded as subgenera under *Lymnaea*.)

Bulimnea

B. megasoma is reported from Lake Superior (LaRoque, 1962), Georgian Bay (Rush, in Baker, 1928a), and western Lake Erie (Wolfert and Hiltunen, 1968). It occurs mainly in muddy, heavily vegetated habitats (Clarke, 1973) but has been collected from rocky shores exposed to constant wave action (Baker, 1928a).

Fossaria

F. decampi usually is considered a subspecies of *F. obrussa*, but Clarke (1973) considers both as distinct species with the Great Lakes and St. Lawrence River as the dividing point for their distributions; *F. decampi* occurs in the northwest in cold-water lakes and rivers, and *F. obrussa* extends south to the Gulf of Mexico in smaller bodies of water. Both have been recorded for Lake Superior (Clarke, 1973). Baker (1911) and LaRoque (1953) list *F. humilis* from Lake Superior.

Lymnaea

L. stagnalis appressa occurs in all the Great Lakes and is characteristic of all permanent bodies of water which support macrophytes (Baker, 1911; Mozley, 1938). Lake Superior is cited as the type locality for *Lymneus appressus* Say by Clarke (1973).

Pseudosuccinea

P. columella is rare but may be found on aquatic macrophytes (Baker, 1911).

Radix

R. auricularia is rare in the Great Lakes and recorded only from Lake Ontario. The habitat is quite variable (Harman and Berg, 1971).

Stagnicola

Species of *Stagnicola* occur on a wide variety of substrates from silt in open waters to aquatic vegetation in protected bays. *S. caperata* is recorded from southwestern Lake Michigan (Limnetics, 1973), *S. catascopium* f. *catascopium* from Lake Ontario, *S. catascopium* f. *nasoni* from exposed shores of Lake Huron and drift along Lake Michigan, *S. emarginata* from shallow areas of Lake Superior, and *S. reflexa* from areas of Erie and Superior (Baker, 1911, 1928a; Harman and Berg, 1971; Clarke, 1973). Lakes Erie and Superior are cited as type localities for *Lymnaea reflexa* Say and the synonym *L. lanceata* Gould by Clarke (1973).

PHYSIDAE

Physella

Following the recent revision by Te (1978) it is difficult to describe the distributions and habitats of *P. gyrina sayi*, *P. integra* and *P. vinosa*. Species of *Physella* have been recorded from all the Great Lakes and are most abundant on hard surfaces and aquatic vegetation.

PLANORBIDAE

Gyraulus

The species of *Gyraulus* are most abundant on aquatic vegetation and are tolerant of polluted and harsh environments. *G. deflectus* probably is present in all the Great Lakes but reported only from Ontario but is more characteristic of temporary waters (Taylor, 1960); *G. parvus* is a cosmopolitan species occurring in great abundance on aquatic vegetation (Baker, 1928a; Clarke, 1973).

Helisoma

H. anceps and *H. trivolvis* are widespread and often occur together. Both occur in shallow waters with or without vegetation; however, *anceps* is found at the upper edge of the profundal zone while *trivolvis* remains in shallow waters (Baker, 1928a; Harman and Berg, 1971). *H. campanulatum* is not common but may be found on bare stones and rock faces and is recorded from Ontario and Superior. *H. corpulentum* has been collected from Lake Erie but is very uncommon (Kalas, pers. comm.).

Promenetus

P. exacuous is widespread in shallows and among decaying and living vegetation.

ANCYLIDAE

Ferrissia

F. parallela is fairly common on aquatic vegetation and in substrates ranging from mud to sand (Basch, 1963). *F. tarda* usually does not occur directly in the lakes but in the mouths of rivers entering the lakes where the substrate is cobble (Clarke, 1973).

Laevapex

L. fuscus is very rare but may be found in backwaters and densely vegetated portions of the lakes (Ward, 1896; Basch, 1963).

SECTION V

ECOLOGY AND DISTRIBUTION OF UNIONIDAE

The Unionidae are not uniformly distributed throughout the Laurentian Great Lakes nor within any one of the lakes. In general, it can be said that areas which once had the most developed unionid populations are those which have come under the greatest biological disturbance due to pollution (e.g., western Lake Erie, Saginaw Bay in Lake Huron, Green Bay in Lake Michigan). In this light, it is most practical to discuss the ecology and distribution by habitat and by lake rather than at the generic or specific level. For indepth notes on the ecology and biology of the Great Lakes' taxa, one should consult the references listed in the introduction in addition to the more general works by Baker (1928b), van der Schalie (1938), Goodrich and van der Schalie (1944), Mirray and Leonard (1962), Parmalee (1967), Clarke (1973), Taylor (1975) and Burch (1975b).

Of the 39 taxa recorded here from the Laurentian Great Lakes, 36 are known from Lake Erie, primarily western Lake Erie. The exceptions are *Anodonta grandis simpsoniana* known only from Lake Ontario, *Lampsilis radiata radiata* from Lakes Ontario and Superior, and *Quadrula nodulata* from Lake Michigan. The taxonomy and status of the two former species in the Great Lakes has been questioned by some, and the latter species has not been recorded since before the turn of this century (Ward, 1896). The following list of 19 species records those unionids collected only from Lake Erie. None are particularly common but may occur in isolated patches along protected shorelines and shallow areas of the western basin. Some may now be extinct from the lake or their populations eliminated from or greatly reduced in open waters. Included after each name is the most probable substrate type.

Anodonta imbecillis - soft substrates, particularly soft, silty mud.
Carunculina parva - soft substrates, particularly soft, silty mud.
Cyclonaias tuberculata - soft substrates.
Dysnomia sulcata - substrate variable.
Lampsilis fasciola - substrate variable.
Lasmigona costata - substrates of hard gravel and rock to soft mud.
Obliquaria reflexa - firm substrates, hard sand to rocky shoals.
Obovaria olivaria - substrate variable, usually sand and gravel.
Obovaria subrotunda - substrate variable, usually sand and gravel.
Pleurobema cordatum f. *coccineum* - substrate variable.
Proptera laevissima - firm to silty sand.
Ptychobranchus fasciolare - firm substrates with wave action.
Quadurla pustulosa - more common on firm substrates, particularly clay.

Quadrula quadrula - generally firm substrates.
Simpsoniconcha ambigua - substrate variable.
Truncilla donaciformis - quiet waters with firm, sandy substrates, clay.
Truncilla truncata - moving waters with firm, sandy substrates, gravel.
Villosa fabilis - substrate variable, usually sandy.
Villosa iris - substrate variable, usually sandy.

The following 5 species have been recorded for both Lake Erie and Lake Huron. None are wide spread but may be locally common in protected, shallow areas of the lakes which are relatively free from organic enrichment.

Amblema plicata - firm substrates (Lake Erie specimens tend to be stunted by their environment, Brown et al., 1938).
Dysnomia triquetra - substrate variable, usually firm.
Eliptio dilatata - substrate variable.
Fusconaia flava - usually firm substrates, hard mud.
Ligumia nasuta - soft to fairly firm substrates, hard sand.

The remaining unionid species have been recorded from Lake Erie and one or more of the other Great Lakes.

Leptodea fragilis - (Erie and Ontario) - firm, sandy substrates.
Proptera alata - (Erie and Ontario) - substrate variable, often in rocky shoals with some wave action.
Alasmidonta calceolus - (Erie and Michigan) - substrate variable.
Strophitus undulatus - (Erie and Superior) - substrate variable, fine but firm sediments.
Anodonta cataracta - (Erie, Michigan, and Ontario) - soft substrates, particularly silt and mud.
Lasmigona complanata - (Erie, Huron and Superior) - substrate varies from soft silt in still waters to rocky, wave swept areas.
Ligumia recta - (Erie, Huron and Ontario) - usually firm but sandy substrates, mud.
Anodontoides ferussacianus - (Erie, Huron, Michigan, and Superior) - soft substrates.
Lampsilis ovata - (Erie, Huron, Michigan, and Superior) - substrate quite variable.
Anodonta grandis grandis - (Erie, Michigan, Ontario, and Superior) - soft substrates.
Eliptio complanata - (Erie, Huron, Ontario, and Superior) - substrate variable.
Lampsilis radiata siliquoidea - (present in all the Great Lakes) - substrate quite variable. This species possibly is the only freshwater mussel still present in the deeper waters of the western basin of Lake Erie (Wood, 1953, per. comm.). Where it occurs in soft sediments, it may be of great importance in the reworking of bottom materials (McCall et al., 1979).

Most of the unionids listed for Lake Michigan have been recorded for Green Bay; those recorded for Lake Huron are primarily from Saginaw Bay. It is doubtful if populations are still present in these areas but if found, most likely will be away from sources of pollution.

SECTION VI

ECOLOGY, DISTRIBUTION, AND VARIATION OF SPHAERIIDAE

MUSCULIUM

Musculium lacustre f. *lacustre* and *Musculium lacustre* f. *jayense*

Of the two forms, *jayense* appears to be the most common and has been recorded from all except Lake Superior. The preferred habitat is hard mud. Form *lacustre* has a distribution similar to *jayense* but is uncommon. Its habitats range from shallow, temporary pools and streams to deep, permanent lakes and rivers (Herrington, 1962). Both have been recorded from depths down to 20 m.

Musculium partumeium

Uncommon but reported from Lakes Michigan and Ontario. It usually is found on silty or muddy bottoms of large lakes or among plant debris where oxygen content often falls to near anoxic levels. Usually in less than 10 m of water.

Musculium securis

Reported from Lakes Michigan, Ontario, and Superior. As with *M. partumeium*, this species is common in mud and plant debris. It is unlikely that the distribution is limited by oxygen supply although it is not common in organically rich waters. Usually in less than 10 m of water.

Musculium transversum

This is the most common *Musculium* in Lakes Michigan, Erie, and Ontario. Unlike other *Musculium*, *transversum* inhabits permanent bodies of water on a variety of substrates from mud to stones. Soft mud in less than 10 m of water has been shown to be the preferred habitat (Gale, 1971).

PISIDIUM

Pisidium adamsi

Uncommon and localized in all the Great Lakes (yet to be recorded from Superior). Herrington (1962) and Henson and Herrington (1965) give the preferred habitat as mud and decaying vegetation in small lakes, ponds, rivers, and (rarely) creeks, also from "black sand caly" and shallow pockets of debris in the Great Lakes. Generally found in very shallow water less than 5 m deep.

P. adamsi typically has a long trapezoidal outline with the dorsal and ventral margins parallel (Fig. 365). The relative length of the shell is variable, and shorter individuals may resemble either *P. compressum* or *P. casertanum*. The umbo of *P. adamsi* barely protrudes over the dorsal margin (Fig. 366) and does not exhibit the flattening or ridge formation found on most *P. compressum* (Figs. 238, 239). In contrast to *P. casertanum*, the periostracum of *P. adamsi* is quite dull, striae are coarse, and the lateral teeth are broad and blunt on top. *P. casertanum* is moderately glossy, finely striated, and the lateral teeth are well-develloped and pointed (Fig. 344). Young *P. adamsi* are proportionally shorter than adults making the trapezoidal shape less obvious. Separation of young specimens may be based on the parallel dorsal and ventral margins, coarse striae, and the dull-iridescent periostracum.

Pisidium amnicum

Recorded from Lakes Ontario, Erie, and Michigan, this species generally is not abundant and too few collections have been make to determine substrate and depth relationships. It may prefer sandy substrates (Herrington, 1962) but has been collected on mud in waters less than 10 m deep.

P. amnicum is distinct in its longish-oval outline (Fig. 210), laterally compressed shell, strong and widely spaced striae, and relatively large size. The striations are uniform but may fade in the area of the umbo thereby resembling *P. dubium*. The umbo of *P. amnicum* usually is positioned 2/3 back along the length of the shell (Fig. 210). Occasionally, placement closer to the dorsal margin may create further confusion with *P. dubium*. Doubts may be resolved by examining the cardinal teeth. C3 of *P. amnicum* is "J" shaped with the anterior arm much thinner than the posterior (Figs. 208, 212). In *P. dubium*, C3 is "U" shaped and both arms are of equal thickness or neraly so (Figs. 212, 206). C2 of *P. amnicum* is a peg-like structure overlapped by the thinner, gently arched C4 (Figs. 209, 213). The corresponding teeth in *P. dubium* are each approximately as thick (Figs. 203-207). Young *P. amnicum* are separable from *P. dubium* on the same basis.

Pisidium casertanum

Occurring in all the Great Lakes on clay, mud, sand, and gravel substrates, this cosmopolitan species is very common in water down to 25 m deep but has been collected as deep as 100 m.

P. casertanum is the most variable and widely distributed of the *Pisidium*. The average shell is long in appearance with an extended, fully rounded anterior margin. There are two general morphotypes; a short, high, heavy shelled form, and a long, low, thin to moderately thick form. The short, high form (Figs. 335-338). is most commonly confused with *P. subtruncatum*, *P. walkeri* f. *mainense*, and *P. variabile*. *P. subtruncatum* is distinguished by cardinal teeth C2 and C4 which take the appearance of thin, parallel plates (Fig. 297). In *P. casertanum*, C2 is either a "D" shaped peg or a bent, thickened plate which is overlapped by a curving C4 pointing at or interior of PII (Figs. 336, 340, 344). Additionally, the umbo of *P. subtruncatum* is narrow and prominent, not broad as *P. casertanum*; and the dorsal and ventral margins are skewed (Fig. 289), not parallel as in *P. casertanum* Figs. 337, 341). Finally, the anterior and posterior margins of *P. subtruncatum* are nearly straight or gently curved (Figs. 337, 341). Long, low specimens of *P. variabile* have low, blunt lateral teeth, highly glossed periostracum, and often a prominent umbo. The lateral teeth of *P. casertanum* are long and sharp, the periostracum moderately dull to slightly glossy, and the umbo barely projects over the dorsal margin. *P. walkeri* f. *mainense* is distinguished by its shorter hinge (Fig. 279) which is less than 3/4 of the total shell length. *P. casertanum* exhibits a hinge which is 3/4 or greater of the total shell length.

The long, low form of *P. casertanum* (Figs. 338-342) is most often confused with small *P. adamsi* or *P. nitidum* f. *nitidum*. *P. adamsi*, however, has coarse striae, a long dorsal margin (Fig. 365) and the lateral teeth are low and blunt as in *P. variabile* above. *P. casertanum* has fine striae and moderately long but an evenly rounded dorsal margin (Fig. 341). The separation of *P. casertanum* from *P. nitidum* f. *nitidum* may be difficult without a large series of each for reference. Cardinal teeth are the primary diagnostic trait. C3 of *P. casertanum* typically is club-shaped, the posterior end greater than twice the width of the anterior (Figs. 335, 339), and C2 and C4 are as described above. The cardinal teeth C2 and C4 of *P. nitidum* f. *nitidum* are similar to *P. subtruncatum* above (Fig. 303); however, C2 varies somewhat in thickness (Fig. 307). The posterior arm of C3 usually is less than twice the thickness of the anterior arm (Figs. 302, 306). In specimens of *P. nitidum* f. *nitidum* with a thickened C2 and C3, the cardinal teeth are less diagnostic. In such a case, an evaluation of the ligament, periostracum, and dorsal margin should be made. The ligament of *P. nitidum* f. *nitidum* is short and wide, often not much longer than C3 (Fig. 306); the periostracum is glossy; and the dorsal margin generally intersects the anterior and posterior margins with an angle or rounded corner (Fig. 304). In contrast, the ligament of *P. casertanum* is long and wide, usually twice the length of C3 (Fig. 343); the periostracum ranges from dull to only a slight gloss; and the dorsal margin is evenly rounded, the intercepting anterior and posterior margins smooth without an angle (Figs. 337, 341).

Pisidium compressum

Rarely abundant but occurs in all the Great Lakes on clay, mud, sand, and gravel in shallow water usually less than 25 m deep. *P. compressum* may prefer sandy bottoms with some vegetation (Herrington, 1962) or fine sand (Henson and Herrington, 1965).

The shell outline of *P. compressum* varies from short and high to moderately long. The shorter form closely resembles *P. supinum*: however, the hinge plate of *P. supinum* is shorter, the striae are more widely spaced, and the cusp of AII is proximal (Fig. 234), not distal as in *P. compressum* (Fig. 241). The low, long from of *P. compressum* exhibits a broader umbo and may be mistaken for *P. casertanum*. Such individuals may be distinguished from *P. casertanum* by their short, blunt lateral teeth (Fig. 241). The laterals are well-developed and pointed in *P. casertanum* (Fig. 344). Further distinctions can be made by comparing the generally coarse striae and dull-iridescent periostracum of *P. compressum* with the finely striate, moderately glossy shell of *P. casertanum*. The umbo of *P. compressum* usually shows some degree of flattening on the dorsal face similar to *P. fallax* (Fig. 318) and may exhibit a ridge or plate not unlike *P. henslowanum* (Fig. 217). *P. compressum* is distinguishable from *P. fallax* by the well-inflated shell (Fig. 239) and the position of AII which is parallel to the anterior margin (Fig. 241). In contrast, *P. fallax* is laterally compressed (Fig. 318) and AII twists inwardly creating a thickening of the hingeplate at the anterior laterals in both valves (Figs. 319, 321). The hinge characters and outlines of most *P. compressum* are the same as *P. variabile* (Figs. 323-328), but the periostracum of *P. compressum* is dull, not glossy, the umbo is ridged or flattened, and the striae of *P. compressum* are coarse while those of *P. variabile* are quite fine. Young *compression* have a short dorsal margin, dull periostracum, and a well developed hingeplate; however, the characteristic flattening of ridge on the umbo may not be present. See also *P. adamsi*.

Pisidium conventus

Abundant and widely distributed throughout the Great Lakes, *P. conventus* has been recovered from all types of substrates including stones, gravel, sand and mud. In Lake Michigan, it seems to be most abundant in sand to coarse silt (Phi 4-5 on the Wentworth, 1922, grade scale). A review of the biology of *P. conventus* was given by Heard (1963), and additional notes on habitat and distribution for the Great Lakes can be found in Herrington (1950, 1962), Heard (1962), Henson and Herrington (1965), Brinkhurst (1969), and Clarke (1973). *P. conventus* is considered an oligothermal relect of the primarily tropical subgenus *Neopisidium* and, with few exceptions, is limited to high altitudes or to cooler, boreal lakes where it rarely is found above the limits of the thermocline. Maximum densities in the Great Lakes occur between 35 and 40 m; living specimens may be collected in less than 7 m to nearly 200 m of water. Herrington (1950) recorded a few *P. conventus* from 219 m in Great Slave Lake, and it is the only mollusk to be collected deeper than 150 m in the Great Lakes.

Shell morphology and diagnostic traits of *P. conventus* are quite constant throughout the Great Lakes. The periostracum is very dull or iridescent in deep waters (greater than 25 m) but may exhibit a glossy quality at shallower depths. Glossy *P. conventus* may be mistaken for young *P. casertanum* but are distinguished by the nearly parallel and flattened anterior and posterior margins (Fig. 310). *P. casertanum* differs in having well-rounded margins (Figs. 337-341). The degree of prominence of the umbo of *P. conventus* varies from no overlap of the dorsal margin to a sizeable protrusion which may be similar to young *P. illjeborgi* f. *lilljeborgi* and *P. variabile*. Shell outline of the three species will help to separate them; *P. conventus* has a long dorsal margin approximately 2/3 of the total shell length (Fig. 310); *P. variabile* has an extremely short dorsal margin beginning and ending at the umbo (Fig. 325); and *P. lilljeborgi* f. *lilljeborgi* has a well-rounded, symmetrical outline (Figs. 260,264) which contrasts to the long rectangular shape of *P. conventus*. If the external traits are not definitive, hinge characters (Figs. 308, 309) should be the final basis for diagnosis as they seem to be less variable.

Pisidium dubium

Not a common species but recorded for all the Great Lakes with the exception of Erie. Distributions appear to be localized and patchy, usually associated with areas of fine sand in less than 5 m of water (Henson and Herrington, 1965).

With few exceptions, *P. dubium* rarely is confused with other *Pisidium*. The shell is large, laterally compressed, and heavily striated except on the umbo where the striations fade to near smoothness. *P. amnicum* is similar, but the striations continue onto the umbo. Occasionally, *P. dubium* may possess striations on the umbo, and the cardinal teeth should be used as the final indicator. *P. dubium* has a "U" shaped C3 (Figs. 202, 203) with C2 and C4 of equal thickness (Figs. 203, 207). C3 of *P. amnicum* is "J" shaped with the anterior arm much thinner than the posterior (Figs. 208, 212), and C2 is a peg which is overlapped by a thin, gently arching C4 (Figs. 209, 213). Young *P. dubium* may be recognized by their larger size (rarely less than 3 mm long), their laterally compressed shell, and the heavy striae divided by widely spaced furrows.

Pisidium equilaterale

This species is quite rare in the Great Lakes with most specimens having been collected from Lake Ontario in the Bay of Quinte where it inhabits the fine, sandy substrates (Herrington, 1962).

There is little significant variation of the diagnostic traits within *P. equilaterale*. The short, high form of *P. variabile* resembles this species quite closely; however, the umbo of *P. equilaterale* is central (Fig. 353) while that of *P. variabile* is further back (Fig. 325). Also, the space between C2 and C4 is a slit directed toward the cusp of PII in *P. equilaterale* (Fig. 352) while this space in *P. variabile* usually is much greater owing to the enlargement of the posterior end of C3 (Fig. 324). Immature *P. equilaterale* may be confused with heavy-shelled *P. nitidum* f. *nitidum* but there are differences in the umbo, striae and periostracum. The umbo of *P. equilaterale* is swollen and prominent (Figs. 353-356), the striae are coarse, and the periostracum dull to moderately glossy. *P. nitidum* f. *nitidum* exhibits a broad umbo which barely projects over the dorsal margin (Figs. 304-307). The striae are quite fine, and the periostracum of *P. nitidum* f. *nitidum* is very glossy, often mirror-like.

Pisidium fallax

Recording *P. fallax* from all the Great Lakes except Superior, Herrington (1962) states that it "has a preference for coarse sand or gravel, even sandy gravel in cracks on a flat rock bottom ... and appears to like water in motion ... i.e. lakes, or bays where there is considerable wave action". Though most abundant at less than 10 m, it is common at depths down to 20 m.

P. fallax ranks among the least protean of the *Pisidium* species. The extent of flattening of the dorsal surface of the umbo is the only trait subject to variation in Great Lakes specimens. Individuals with a high degree of flattening often exhibit low, incipient ridges or ripplings at the apex of the umbo. These specimens are similar to *P. henslowanum*, but the shell of *P. fallax* is laterally compressed (Fig. 318) and the umbo rarely protrudes over the dorsal margin owing to the flattening on the dorsal face of the beak (Fig. 317). *P. henslowanum*, in contrast, is not compressed but moderately inflated (Fig. 217) and its narrow umbo generally protrudes quite significantly over the dorsal edge (Fig. 216). The thickening of the hingeplate at the anterior lateral cusps AI and AIII due to the inward twist of AII which is present in *P. fallax* (Figs. 315, 319) is not present in *P. henslowanum* (Figs. 215, 218). Shells in which the flattening of the umbo is slight or not apparent may be mistaken for *P. compressum*. These shells are distinguished on the basis of the position of the anterior laterals or the prominence of the umbo for the reasons discussed above. Additionally, the dorsal margin of *P. fallax* generally extends beyond the umbo to join the anterior and posterior margins (Fig. 317) whereas the dorsal edge of *P. compressum* is very short with the anterior and posterior margins often beginning at the umbo (Fig. 238). Young *P. fallax* are separated from their closest morphotypes, *P. henslowanum* and *P. compressum* on the same bases stated above. In distinguishing *P. fallax* from all other *Pisidium*, the diagnostic traits are the silky-iridescent periostracum, the flattened umbo, and the laterally compressed shell.

Pisidium ferrugineum

This species is common in all the Great Lakes. The habitat ranges from clay, mud, sand, to gravel; maximum abundance is reached at about 10 m, but it commonly is taken at depths down to 30 m.

There are two general forms of *P. ferrugineum*: one is short with a prominent umbo, the other is long with the umbo barely protruding over the dorsal margin. The shorter form of this species is similar to individuals of both *P. lilljeborgi* f. *lilljeborgi* and *P. nitidum* f. *pauperculum*. *P. ferrugineum* has a glossy periostracum (often concealed beneath brownish accretions) and a gently rounded dorsal margin which blends easily into the anterior and posterior edges (Figs. 290, 293, 295). *P. lilljeborgi* f. *lilljeborgi* usually has a silky periostracum and a straighter dorsal margin which creates an elbow or corner with the anterior and posterior margins (Figs. 260, 264). In distinguishing *P. nitidum* f. *pauperculum* one must examine hinge characters. The lateral teeth of *P. ferrugineum* are short and pointed and cardinal teeth are situated close to the anterior lateral cusps (Figs. 288, 293). The laterals of *P. nitidum* f. *pauperculum* are large and long with blunt cusps and the cardinals are central (Figs. 345, 349).

The longer form of this species resembles specimens of *P. milium* and glossy *P. conventus*. In end view, the outline of *P. milium* is truncate at the ventral margin (Figs. 282, 283) whereas *P. ferrugineum* exhibits an even taper from the apex of the umbo to the ventral edge (Figs. 290, 291). As stated above, the dorsal margin of *P. ferrugineum* is evenly rounded and blends into the anterior and posterior margins without an angle. *P. conventus*, in contrast, has a long dorsal margin which is 2/3 or more of the total shell length and intercepts the anterior and posterior margins with distinct angles or corners (Fig. 310). The characters above will separate young *P. ferrugineum* from closely related *Pisidium*.

Pisidium henslowanum

This species is common in Lakes Michigan, Erie, and Ontario. Herrington (1962) lists *P. henslowanum* mainly from shore debris; however, most Lake Michigan collections are from sandy substrates down to 20 m deep. This species is an introduction from Europe.

The shell features of *P. henslowanum* are quite consistant. The most significant variation occurs in the development of the umbonal ridge which towers from the apex of the umbo and diverges from opposite shell halves (Fig. 217). In some stunted specimens, the ridge may develop only to the point of a slight rippling of the calcified shell at the umbo. These stunted forms may resemble *P. variabile*; however, the longer dorsal margin, the angular intersection with the anterior and posterior margins, and the silky-iridescent periostracum of *P. henslowanum* serve to distinguish it from the glossy, more triangular shell of *P. variabile*. Additional variability is found in both the striae and umbo of *P. henslowanum*. While the striae are generally uniform, coarse, and concentric, the degree of uniformity and coarseness is subject to variation. Specimens often exhibit moderately fine striae, and the uniformity of the striae may be interrupted by the presence of two or three deeper growth rings in mature specimens. Individuals with finer striae appear to have a glossier periostracum, but the degree of gloss in *P. henslowanum* never reaches that of *P. nitidum* or *P. variabile*. The umbo of *P. henslowanum* is quite narrow and prominent in adult specimens; however, in some instances a broader and less prominent umbo similar to *P. casertanum* or *P. nitidum* f. *nitidum* is observed. *P. henslowanum* is distinguished from *P. casertanum* by the lamella-like ridge on the umbo and the angular intersection of the dorsal edge with the anterior and posterior margins in *P. henslowanum* (Figs. 216, 217). *P. casertanum* exhibits no plate on the umbo and the dorsal margin flows in a continuous curve to the anterior and posterior margins (Figs. 337, 338, 341, 342). In contrast to *P. nitidum* f. *nitidum*, the striae of *P. henslowanum* never reach the degree of fineness exhibited by *P. nitidum* f. *nitidum*. Additionally, the periostracum of *P. henslowanum* does not attain the usual mirror-like glossiness of *P. nitidum* f. *nitidum*, and the cardinal tooth C3 is much thickened posteriorly (Figs. 214, 218) whereas C3 of *P. nitidum* f. *nitidum* is a narrow, evenly tapering plate (Figs. 302, 306).

The character traits used to distinguish adult specimens (lamella-like ridge on the umbo, angular intersection of the dorsal margin, and coarse, evenly spaced striae) are present in the nepionic shell and may be used to distinguish immature *P. henslowanum* from other *Pisidium*.

Pisidium idahoense

With the exception of Lake Erie, this species is common in all the

the Great Lakes in muddy and sandy substrates. It often is found as deep as 40 m, but greatest abundance occurs at 20 m or shallower. Herrington (1962) suggests that *P. idahoense* may be restricted to cold waters of northern lakes; however, many recent collections have come from warmer waters of temperate climates.

P. idahoense varies significantly only in shell length. The large (adults 5 mm or longer), heavy, high shell usually is quite short with a height to length ratio greater than 0.86. Some specimens will appear longer and may be confused with *P. amnicum*. The striae of *P. amnicum* are very coarse, widely spaced, and uniform over the shell; those of *P. idahoense* generally are fine and uniform, broken only by deeper growth rings sculptured into the calcified surface. Cardinal teeth of *P. amnicum* are larger and heavier than *P. idahoense*, C3 is tightly arched and well-thickened posteriorly (Figs. 208, 212), and C4 follows the curvature quite closely so that it points to the interior of the shell (Figs. 209, 213). In contrast, C3 of *P. idahoense* is gradually curved and less thickened posteriorly (Figs. 329, 333) and C4 is directed to the posterior lateral cusp of AII. Young individuals of this species may strongly resemble *P. variabile*; however, the anterior margin of *P. variabile* is straight or nearly so (Fig. 325) while that of *P. idahoense* is well rounded.

Pisidium lilljeborgi f. *lilljeborgi*

This species is very common in all Great Lakes in clay, mud, sand, and gravel substrates, although Meier-Brook (1969) demonstrated that it prefers an endopelic mode of life in fine-grained organic sediment. Herrington (1957) found empty shells in depths exceeding 45 m in Lake Huron. Collections of *P. lilljeborgi* f. *lilljeborgi* from Lake Michigan show that maximum abundance is reached at about 20 m; however, this taxon is not uncommon at 70 m with only *P. conventus* being recorded from greater depths.

The form *lilljeborgi* differs from form *cristatum* in having the shell much longer and ridges absent from the umbo. Glossy specimens of *P. lilljeborgi* f. *lilljeborgi* often resemble *P. nitidum* f. *pauperculum*, but the umbo of the form *pauperculum* is broad and not very prominent (Figs. 348, 350) while *P. lilljeborgi* f. *lilljeborgi* has a narrow umbo which overlaps the dorsal margin to a considerable degree (Figs. 265, 267). The ligament of *P. lilljeborgi* f. *lilljeborgi* is long and thin while that of *P. nitidum* f. *pauperculum* is short and wide. *P. lilljeborgi* f. *lilljeborgi* with a dull periostracum may resemble *P. compressum*, but there are significant differences. In *P. compressum* the dorsal margin is very short, often yielding a three-cornered appearance, there usually is a flattening or incipient ridge on the umbo (Fig. 239); and, the lateral cusps AII and PII are short and blunt (Fig. 241). *P. lilljeborgi* f. *lilljeborgi* exhibits no ridge or flattening (Figs. 261, 265), the dorsal margin extends beyond the umbo, and the cusps of AII and PII tend to be rather sharp on top (Fig. 267).

When the dorsal margin of *P. lilljeborgi* f. *lilljeborgi* is short, confusion with *P. subtruncatum* may occur. The umbo of *P. subtruncatum* lies in the last two-thirds of the shell and the posterior margin slopes nearly vertically from the posterior lateral teeth, becoming undercut at the ventral margin (Fig. 298). In contrast, the umbo of *P. lilljeborgi* f. *lilljeborgi* is centrally situated and the curvature of the posterior margin is evenly rounded, not undercut at the ventral margin (Figs. 260, 264). Specimens with longer dorsal margins are the predominant type of *P. lilljeborgi* f. *lilljeborgi*. These may resemble *P. nitidum* f. *nitidum* with both having the hinge area with the dorsal edge forming corners at the intersection with the anterior and posterior margins; however, the umbo of *P. nitidum* f. *nitidum* is broad and and barely protrudes over the dorsal margin (Figs. 306, 307), and the degree of inflation exhibited by the shell of *P. nitidum* f. *nitidum* never approaches that of *P. lilljeborgi* f. *lilljeborgi*. Young *P. lilljeborgi* f. *lilljeborgi* may be mistaken for *P. ventricosum* f. *ventricosum* or *P. ventricosum* f. *rotundatum* but the dorsal margins of the latter two do not extend out from the umbo as in *P. lilljeborgi* f. *lilljeborgi* (Figs. 260, 264), rather this edge follows the curvature of the umbo (Figs. 244, 248, 254).

Pisidium lilljeborgi f. *cristatum*

This taxon is most likely a valid species, but until further analysis of the soft anatomy is done, it will be considered a form of *P. lilljeborgi* Often having been lumped with *P. lilljeborgi* f. *lilljeborgi*, we are unsure of its actual distribution; however, specimens from Lake Michigan rarely are collected in more than 10 m of water and are most abundant on sandy substrates.

As with *P. lilljeborgi* f. *lilljeborgi* there is little variation among populations of *P. lilljeborgi* f. *cristatum*. The latter differs from the former by the presence of a ridge on the umbo and the shorter shell (Figs. 224, 225). *P. lilljeborgi* f. *cristatum* may be confused with *P. henslowanum* and *P. supinum* both of which have umbonal ridges. *P. lilljeborgi* f. *cristatum* (Fig. 224) is bulbous and rotund while *P. henslowanum* and *P. supinum* are laterally compressed (Figs. 217, 231). The anterior margin of the form *cristatum* is fully and evenly rounded (Fig. 224) whereas those of *P. henslowanum* and *P. supinum* often are straight along the middle or mildly curved and long (Figs. 216, 230). Finally, the umbo of *P. lilljeborgi* f. *cristatum* is very narrow and prominent (Fig. 224) while that of both *P. henslowanum* and *P. supinum* is broad and projects only slightly over the dorsal margin (Figs. 216, 230). The form *cristatum*, including young specimens, is distinguished from the remaining *Pisidium* by its swollen shell, narrow and prominently ridged umbo, and by the angles created at the intersection of the dorsal margin with the anterior and posterior margins.

Pisidium milium

P. milium is rare in the Great Lakes reported only for the Bay of Quinte, Lake Ontario. More characteristically, it is a species of mud or ooze in creeks, rivers, small lakes, and ponds (Herrington, 1962). A few additional specimens have since been taken from Lake Michigan.

Intraspecific variation of *P. milium* is confined to inflation of the shell and the degree of truncation. Individuals of this species ordinarily exhibit a well-inflated, bulbous shell, but specimens in which the inflation is less pronounced often resemble the glossy form of *P. conventus*. The parallel anterior and posterior margins give *P. conventus* a rectangular outline (Fig. 310) whereas the rounded anterior and posterior edges of *P. milium* yield an overal appearance (Figs. 282, 285, 287). In end view, the well-inflated shell of *P. milium* cuts off abruptly at the ventral margin (Fig. 283). This truncate outline contrasts to the gentle, evenly-tapering slope from the apex of the umbo to the ventral margin found in *P. conventus* (Fig. 311).

The degree of truncation is also somewhat variable within this species. Specimens from Lake Michigan are generally less inflated and truncate than their counterparts in smaller bodies of water. Individuals with a lesser degree of truncation are similar to *P. ventricosum* f. *ventricosum*, but the hinge length of this form is less than one-half of the shell length (Figs. 252, 254) while the hinge length of *P. milium* is greater than one-half the total shell length (Fig. 287).

In overall outline and degree of inflation, *P. milium* resembles *P. punctatum* but is separable by the fine striae and highly glossed periostracum of *P. milium* which contrasts to the very coarse striae and flat-dull periostracum of *P. punctatum*. Young *P. milium* may be confused with *P. conventus* or *P. casertanum*. From *P. conventus*, they may be separated as described above. Young *P. milium* are lower and longer than nepionic *P. casertanum* and exhibit a greater degree of inflation.

Pisidium nitidum f. *nitidum*

Common in all the Great Lakes in sandy substrates in water up to 40 m deep. Meier-Brook (1969) states, " *P. nitidum* is strongly restricted to biotopes below the sediment surface ... but prefers coarse organic sediment with large-pored interstitial spaces which enable the animal to provide itself with water sufficiently rich in oxygen".

The ecological morph *P. nitidum* f. *nitidum* is distinct from *P. nitidum* f. *pauperculum* in several characters. The shell of form *pauperculum* is short, high, and heavy with a short, tightly-curved dorsal margin and a prominent umbo (Fig. 347). In contrast, *P. nitidum* f. *nitidum* is longer, less inflated with a straight or gently curved dorsal margin, and the umbo barely projects above the dorsal edge (Fig. 304).

P. nitidum f. *nitidum* exhibits much variation in structure and appearance. Of particular importance are the gradations in (1) the sharpness of the angle formed at the intersection of the dorsal margin with the anterior and posterior margins, (2) the thickness of the posterior arm of C3, and (3) the degree of glossiness of the periostracum. Where the angle of the intersection of the dorsal margin is rounded, specimens closely resemble *P. casertanum* and *P. subtruncatum*. The posterior arm of C3 in *P. casertanum* generally is greater than two times the thickness of the anterior arm (Figs. 335, 339), the ligament is long and wide, and the dorsal margin blends easily into the anterior margin (Fig. 341). *P. nitidum* f. *nitidum* contrasts in the posterior arm of C3 being two times or less the thickness of the anterior arm (Fig. 302), the ligament is short and wide, and the dorsal margin creates angles or corners with the anterior and posterior edges (Fig. 304). An additional point of distinction is the anterior margin which is generally well-rounded and evenly curved in *P. casertanum* (Fig. 341) while *P. nitidum* f. *nitidum* is straight or abruptly curved (Fig. 304) and does not flow into the dorsal and ventral margins in a continuous curve. *P. subtruncatum* is distinguished by its long and wide ligament, nearly vertical and undercut posterior margin, and shorter hinge. The hingeplate length of *P. subtruncatum* is less than half the total shell length, where that of *P. nitidum* f. *nitidum* is half or greater. Also, the posterior margin of *P. nitidum* f. *nitidum* is evenly rounded (Fig. 301) in contrast to the very steep slope of *P. subtruncatum* (Fig. 298). While the thickness of C3 of this species varies, the posterior arm never exceeds twice the thickness of the anterior arum. In its thickest form, C3 may resemble thin-toothed specimens of *P. casertanum*, but these species may be distinguished on the alternative bases noted above.

The periostracum of *P. nitidum* f. *nitidum* varies from a moderate degree of gloss to a mirror-like finish, often resembling broad-beaked specimens of *P. variabile*. Distinctions between these two species are made by an examination of C3 and the dorsal margin of the specimen. The posterior arm of C3 in *P. variabile* is consistantly greater than twice the thickness of the anterior arm (Figs. 323, 327), while that of *P. nitidum* f. *nitidum* is twice or less as previously mentioned (Figs. 302, 306). Additionally, the dorsal margin of *P. variabile* is tightly covered, barely extending much beyond the umbo (Fig. 326). The margin in *P. nitidum* f. *nitidum* invariably extends beyond the curve of the umbo. Young *P. nitidum* f. *nitidum* may be separated from other *Pisidium* on the shell shape characters given above.

Pisidium nitidum f. *pauperculum*

The form *pauperculum* most likely is a species distinct from form *nitidum*. The distribution within the Great Lakes is incomplete and overlaps with *P. nitidum* f. *nitidum* with which it is often included without reference. Where the two have been distinguished, *pauperculum* is less common but habitat characteristics are similar with both occurring on sandy substrates to a depth of 40 m.

There is little variation among specimens of *P. nitidum* f. *pauperculum*. This form differs from *P. nitidum* f. *nitidum* by its short, high, heavy shell; shorter and much curved dorsal margin; and narrow, often prominent umbo (Fig. 348). *P. nitidum* f. *nitidum* is longer and less inflated, the dorsal margin is long and nearly straight, and the umbo barely projects above the dorsal margin if at all (Fig. 305).

P. variabile and *P. lilljeborgi* f. *lilljeborgi* have some similarities to *P. nitidum* f. *pauperculum*. The cardinal tooth C3 of *P. variabile* is well-thickened posteriorly (Figs. 323, 327), the posterior arm often three times the thickness of the anterior arm, and the anterior margin is a straight slope or nearly so (Fig. 325). In contrast, *P. nitidum* f. *pauperculum* has a broad and prominent umbo, and the dorsal margin is very short, often blending into the anterior and posterior margins imperceptively

(Fig. 347). In some specimens, the hinge characters of *P. variabile* are similar to those of *P. nitidum* f. *pauperculum*. The cardinal tooth C3 may not exhibit the degree of thickening in nepionic *P. variabile* that is observed in the adults. Thus, any distinction of these immature specimens must be based on the slope of the anterior margin as above.

Pisidium punctatum

This species has been recorded from all areas of the Great Lakes with the exception of Superior. It is not common but may be found in relatively small and localized populations in sandy substrates.

Variation of *P. punctatum* occurs in shell outline and prominence and position of the umbo. Specimens in which the umbo is central and prominent may be confused with *P. ferrungineum*, *P. lilljeborgi* f. *lilljeborgi*, or *P. compressum*. The invariably coarse, uniformly spaced striae and dull periostracum of *P. punctatum* serve to distinguish it from *P. ferrugineum* and most specimens of *P. lilljeborgi* f. *lilljeborgi*, and *P. compressum*. Additionally, *P. lilljeborgi* f. *lilljeborgi* has a longer dorsal margin which creates an elbow or angle where it intercepts the anterior and posterior margins (Figs. 260, 264) while this transition in *P. punctatum* is a gradual, continuous curve, and the dorsal margin is short (Fig. 359). *P. compressum* is often separable on the basis of a flattening or incipient ridge on the umbo (Figs. 238, 239), and the striae are generally fine and closely spaced rendering them less distinct than in *P. punctatum*. Individuals on which the umbo is prominent and posteriorly situated are similar to *P. ventricosum* f. *ventricosum*; however, differences in periostracum, striae, and the degree of inflation distinguish the two. The periostracum of *P. ventricosum* f. *ventricosum* is glossy, the striae quite fine and the shell is very bulbous, often resembling a hazel or hickory nut (Fig. 255). In contrast, *P. punctatum* exhibits a dull periostracum with coarse, uniform striae and the degree of inflation does not approach the bulb-like appearance of *P. ventricosum* f. *ventricosum* but rather tapers evenly and gradually from the apex of the umbo to the ventral margin (Fig. 360). Young *P. punctatum* are separable on the same characters.

Pisidium subtruncatum

Records exist from all the Great Lakes where it is relatively common in clay, mud, and sand substrates. Maximum abundance is reached at about 12 m, but live specimens often are taken in as much as 40 m of water.

Major sources of variability within *P. subtruncatum* are the prominence and breadth of the umbo and the relative thickness of the posterior arm of cardinal tooth C3. Specimens exhibiting a prominent umbo are similar to *P. lilljeborgi* f. *lilljeborgi*, but there are differences in the posterior end of the umbo and the dorsal margin. In *P. lilljeborgi* f. *lilljeborgi* the umbo is situated centrally on the shell, yielding a symmetrical outline, and the dorsal margin extends beyond the umbo, creating elbows or corners with the anterior and posterior margins (Figs. 260, 264). In *P. subtruncatum* the umbo is positioned in the last two-thirds of the shell and the dorsal margin is short, blending with the anterior and posterior margins (Fig. 298).

Specimens of *P. subtruncatum* with a broader, less prominent umbo are morphologically close to *P. casertaunum* and *P. nitidum* f. *nitidum*. From *P. casertanum*, this species is distinguished by the general anterio-ventral extension of the shell, the thin and evenly tapering C3, and the posterior margin which slopes nearly vertically from the posterior-lateral cusps and cuts under to the ventral margin (Fig. 289). In contrast, C3 of *P. casertanum* is club-shaped rather than evenly tapering (Figs. 355, 339), and the posterior margin extends in a gradual but even curve from the posterior-lateral teeth to the ventral margin (Figs. 337, 341).

P. subtruncatum differs from *P. nitidum* f. *nitidum* in the dorsal margin, relative hingeplate length and the ligament. The dorsal margin of *P. nitidum* f. *nitidum* extends beyond the umbo to form corners or elbows with the lateral margins (Fig. 304) and the distance between the cusps of AII and PII is half or greater of the total shell length. The dorsal margin of *P. subtruncatum* is short, rarely protruding much beyond the curve of the umbo (Fig. 298), and the distance between AII and PII is always less than half the total shell length. The ligament of *P. subtruncatum* generally is long and wide (Fig. 301) in contrast to the short, wide ligament of *P. nitidum* f. *nitidum* (Fig. 307), but this trait is less consistent in *P. subtruncatum* than the hinge and dorsal margin traits discussed above.

Immature *P. subtruncatum* may be separated from morphologically similar *Pisidium* species on the basis of characters discussed above.

Pisidium supinum

This species is rare in the Great Lakes and recorded only from shoreline debris of Lake Ontario (Herrington, 1962). It most likely is an introduction from Europe.

There is little apparent variation in the species *P. supinum*. Herrington (1962) recognized *P. supinum* only as an ecological form of *P. henslowanum*. The two are remarkably similar but most likely represent separate species. *P. supinum*, however, is shorter in length rendering it nearly symmetrical (Fig. 230) whereas *P. henslowanaum* is clearly asymmetrical in outline (Fig. 216). Additionally, the striae of *P. supinum* are coarse and widely spaced, and the cardinal teeth are situated near the center of the hingeplate (Figs. 228, 229). *P. henslowanum* has coarse by closely spaced striae and the cardinal teeth are located near the anterior cusps (Figs. 214, 215). Another possible source of confusion is with the morphotype *P. lilljeborgi* f. *cristatum*. The dorsal margin of *P. cristatum* is gradually curved, joining the lateral margins with an angle (Figs. 224, 226). *P. supinum* contrasts by the greater curve of its dorsal margin and lack of angles or elbows where it joins the anterior and posterior margins (Figs. 230, 233, 235). Alternatively, the anterior margin of *P. supinum* is long and not much curved while that of *P. lilljeborgi* f. *cristatum* is fully rounded. This may be used as a basis for distinction, even among the immatures, where the characters of the dorsal margin are ambigous.

Pisidium variabile

This species is relatively common in all the Great Lakes, particularly on mud and fine sand substrates where it may be locally abundant. Specimens have been collected from 1-30 m but are most common at depths less than 10 m.

The most significant diagnostic traits in *P. variabile* are the degree of gloss of the periostracum, the extent of prominence of the umbo, and the shape of cardinal tooth C2. Individuals of this species vary from a short, high, heavy, triangular shell to a long, low, thinner shell which is not triangular but exhibits a short dorsal margin. Short, high shells tend to have prominent umbos and may generate confusion with both *P. lilljeborgi* f. *lilljeborgi* and *P. subtruncatum*. In *P. lilljeborgi* f. *lilljeborgi*, however, the dorsal margin extends well beyond the umbo creating corners or elbows with the anterior and posterior margins (Figs. 260, 264), the periostracum is slightly dull to moderately glossy, and the lateral cusps AII and PII tend to be sharp on top. These traits contrast to the shorter margin of *P. variabile* which blends smoothly into the side margins (Fig. 325), the glossy periostracum which is often mirror-like in its luster, and the blunt cusps of AII and PII. *P. subtruncatum* is distinct in that the umbo is positioned in the last two-thirds of the shell (Fig. 298) and cardinal tooth C3 is not much thickened posteriorly; the posterior end is never more than twice the thickness of the anterior end (Figs. 296, 300). The umbo of *P. variabile* is situated centrally on the shell (Fig. 325), the tooth C3 is club-shaped, and the posterior end is invariably greater than twice the thickness of the anterior end (Figs. 323, 327).

Long, lower shells have broad, less prominent umbos and may be confused with specimens of *P. casertanum* and *P. nitidum* f. *nitidum*. However, *P. casertanum* usually has sharp cusps at AII and PII and the periostracum never reaches the mirror-like quality found in many *P. variabile*. Additionally, the anterior margin of *P. casertanum* is evenly and continously rounded (Figs. 337, 341) while this edge of *P. variabile* is straight or only mildly curved (Fig. 325). With respect to *P. nitidum* f. *nitidum*, C3 exhibits the same qualities as *P. subtruncatum* above (Figs. 302, 306). The dorsal margin creates corners or elbows as in *P. lilljeborgi* f. *lilljeborgi* (Fig. 304) and C2 is never peg-like (Figs. 303, 307) as is often the case with *P. variabile* (Figs. 321, 328). *P. nitidum* f. *pauperculum* also resembles *P. variabile* in hinge characters, as discussed earlier. The degree of gloss exhibited by the periostracum ranges from a mirror-like luster to a moderate glossiness. The degree of gloss in *P. variabile* is similar to *P. nitidum* spp., but these two species are separable on the bases discussed above. Finally, C2 varies from a plate-like structure to a stout D-shaped peg. Where C2 is plate-like, the hinge characters largely resemble those of *P. casertanum*, but these species are distinguished as previously described. Where C2 is peg-like, the specimen will be close in form to *P. compressum*, but the periostracum of *P. compressum* is dull or silky-luster and the shell usually shows a flattening or incipient ridge on the umbo (Figs. 238, 239).

All of the above characters should hold for immature specimens of *P. variabile*.

Pisidium ventricosum f. *ventricosum*

This form is very common in the Great Lakes with the exception of Lake Superior. It occurs on mud and sandy substrates but prefers soft sediments in quiet shallow waters. Live specimens have been taken in up to 20 m of water, but greater densities are reached at depths less than 5 m.

P. ventricosum f. *ventricosum* is quite distinct, and variation is minimal. It differs from *P. ventricosum* f. *rotundatum* in hingeplate characters and umbo placement. The umbo of *P. ventricosum* f. *ventricosum* is positioned well posterior yielding an asymmetrical appearance (Fig. 254) while the umbo of *P. ventricosum* f. *rotundatum* is central thus giving a symmetrical outline (Figs. 244, 248). Additionally, the hingeplate of *P. ventricosum* f. *rotundatum* is very narrow (Figs. 242, 246, 250, 251) while that of *P. ventricosum* f. *ventricosum* is relatively wide (Figs. 252, 256, 257). The above coupled with other anatomical and ecological characters have lead some workers to propose elevating *rotundatum* to species status.

The shell of *P. ventricosum* f. *ventricosum* is the most bulbous of the *Pisidium*, resembling a hazel or hickory nut (Fig. 255). The other species which may approach this degree of inflation are *P. lilljeborgi* f. *lilljeborgi*, *P. nitidum* f. *pauperculum*, *P. milium*, *P. ventricosum* f. *rotundatum* and *P. ferrugineum*. *P. lilljeborgi* f. *lilljeborgi* is symmetrical and the dorsal margin intercepts the anterior and posterior edges with a distinct angle (Figs. 260, 264); *P. ventricosum* f. *ventricosum* is asymmetrical because of the posterior placement of the umbo and exhibits a very short, tightly curved dorsal margin (Fig. 254). From *P. ferrugineum* this species is separable on the basis of hingeplate length and umbo placement. As in *P. lilljeborgi* f. *lilljeborgi*, the umbo of *P. ferrugineum* is central yielding a symmetrical shell (Fig. 290). The hinge length of *P. ventricosum* f. *ventricosum* is only one-third of the shell length (Figs. 252, 254); in *P. ferrugineum*, the hingeplate length is one-half or more of the total shell length (Figs. 293, 295). *P. nitidum* f. *pauperculum* has a longer dorsal margin (Fig. 347), its hinge plate length is one-half the total shell length, it is symmetrical or nearly so, and it exhibits a short and wide ligament (Fig. 349). As noted above, *P. ventricosum* f. *ventricosum* has a short dorsal margin, it is asymmetrical, and the ligament is generally quite long and thin (Fig. 257).

The young of *P. ventricosum* f. *ventricosum* are separable from the remaining *Pisidium* species by their rotund, nut-like end view and very short hingeplate length.

Pisidium ventricosum f. *rotundatum*

As with the nominal form, this taxon is common in most of the Great Lakes, but its distribution may be obscured by reports only at the species level. *P. ventricosum* f. *rotundatum* occurs most frequently in shallow, calm waters over soft substrates but may be locally abundant on firm, coarse sand.

P. ventricsoum f. *rotundatum* is separable from *P. ventricosum* f. *ventricosum* in having the umbo centrally placed giving the shell a symmetrical appearance (Figs. 244, 248), and the hingeplate is quite thin (Figs. 242, 246, 250, 251) in contrast to the moderately wide hinge of *P. ventricosum* f. *ventricosum* (Figs. 252, 256, 257). This and other characters may indicate that *rotundatum* is a distinct species.

The umbo of *P. ventricosum* f. *rotundatum* overlaps the dorsal margin to varying degress. Specimens which exhibit little overlap may resemble *P. nitidum* f. *pauperculum*, but the two are distinguishable by the hinge plate length, degree of inflation, and ligament. The distance between AII and PII in *P. nitidum* f. *pauperculum* is one-half or more of the shell length while that of *P. ventricosum* f. *rotundatum* is invariably less than one half (Figs. 250, 251). In end view, *P. ventricosum* f. *rotundatum* is very bulbous and similar to a hazel nut (Figs. 245, 249); whereas *P. nitidum* f. *pauperculum* exhibits an evenly tapering slope from the apex of the umbo to the ventral margin (Fig. 348). Finally, the ligament of *P. ventricosum* f. *rotundatum* is generally long and thin while that of *P. nitidum* f. *pauperculum* is short and wide. Specimens in which the amount of umbo overlap is great may be confused with *P. lilljeborgi* f. *lilljeborgi* or *P. ferrugineum*. The dorsal margin of the form *rotundatum* is very short and tightly curved (Figs. 244, 248) while this edge in both *P. ferrugineum* and *P. lilljeborgi* f. *lilljeborgi* extends well beyond the umbo (Figs. 260, 264, 290). The dorsal margin of *P. lilljeborgi* f. *lilljeborgi* forms distinct angles or corners with the anterior and posterior margins while in *P. ventricosum* f. *rotundatum* the anterior and posterior margins begin at the umbo.

Nepionic *P. ventricosum* f. *rotundatum* are distinguished from the remaining *Pisidium* by the characteristic, rotund, nut-like end view and short hingeplate length which extends only one-third of the total shell length.

Pisidium walkeri f. *walkeri* and *Pisidium walkeri* f. *mainense*

These forms are considered together because they differ only slightly in ecological and morphological characteristics. Both are common and occur together on soft, muddy to firm, sandy substrates in water less than 10 m deep where wave action and current are not too pronounced. They have been recorded from all the Great Lakes with the exception of Lake Superior.

Pisidium walkeri f. *walkeri* varies only slightly from *P. walkeri* f. *mainense*. The latter is generally smaller with finer striae and a short dorsal margin. The anterior margin of *P. walkeri* f. *mainense* begins at or very near the umbo; whereas, that of *P. walkeri* f. *walkeri* is more distant from the umbo owing to the longer, more extended dorsal margin. C2 of *P. walkeri* f. *walkeri* is short, bent plate and C4 is curved and directed toward the interior of the shell (Figs. 269, 273), while C2 of *P. walkeri* f. *mainense* is nearly as long as C4 and parallel to it as in *P. subtruncatum* (Fig. 275). Specimens of *P. walkeri* f. *walkeri* in which the umbo is not prominent are similar to *P. casertanum*; however, the umbo of *P. walkeri* f. *walkeri* is generally narrower (cf. Figs. 270 with 337, 341), the ligament is long and thin rather than long and wide, and the anterior margin is long and barely curved (Fig. 270); the anterior margin of *P. casertanum* is fully rounded anteriorly (Figs. 337, 341, 373). Where the umbo of *P. walkeri*

f. *walkeri* is prominent it may resemble *P. subtruncatum, P. lilljeborgi* f. *lilljeborgi* or *P. variabile*. In *P. walkeri* f. *walkeri*, C3 is enlarged posteriorly (Figs. 268, 272) and C2 is short and bent with C4 overlapping C2 as it curves toward the interior of the shell (Figs. 269, 273). In contrast, C3 of *P. subtruncatum* is not thickened posteriorly (Figs. 296, 300), and C2 and C4 are parallel and often nearly the same length (Figs. 297, 301). *P. lilljeborgi* f. *lilljeborgi* differs from *P. walkeri* f. *walkeri* in that the dorsal margin forms corners or elbows with the anterior and posterior margins, and the umbo is positioned centrally yielding a nearly symmetrical outline (Figs. 260, 264). Even where extended significantly, the dorsal margin of *P. walkeri* f. *walkeri* does not intersect the lateral margins with an angle, and the umbo is situated at or near the last two-thirds of the shell giving an asymmetrical appearance (Fig. 270). *P. variabile* is distinct on the basis of periostracal features and the lateral cusp. The periostracum of *P. variabile* is glossy, often mirror-like in appearance, and the lateral cusps are short and blunt. *P. walkeri* f. *walkeri* generally exhibits a dull to silky periostracum and the lateral cusps are rather long and sharp on top.

There is little variability among specimens of *P. walkeri* f. *walkeri* however, they may be confused with *P. nitidum* f. *pauperculum, P. lilljeborgi* f. *lilljeborgi*, and *P. variabile*. C2 and C4 are of the same length and parallel in *P. walkeri* f. *mainense*. In both *P. lilljeborgi* f. *lilljeborgi* and *P. variabile* C2 is short and thick or a bent plate and C4 is curved and directed interior of PII (Figs. 263, 328). The umbo of *P. nitidum* f. *pauperculum* is broad while that of *P. walkeri* f. *mainense* is narrow and generally projects above the dorsal margin. The periostracum of *P. nitidum* f. *pauperculum* is very glossy, almost mirror-like; the ligament is very short and thick, covering more than half of the hingeplate width. *P. walkeri* f. *mainense* exhibits a dull to silky periostracum; the ligament is long and thin, covering less than half the hingeplate width.

The above characters will hold for immature *P. walkeri* forms.

SPHAERIUM

Sphaerium corneum

This species is locally abundant in Lake Erie and common in localized populations in Lake Ontario and Lake Michigan but uncommon in Lake Huron or Lake Superior. The usual habitat is fairly quiet water with little or no wave action, and there is an association with organic enrichment (Wurtz, 1956). Live specimens have been taken from Lake Michigan in water down to 10 m deep on substrates ranging from soft mud to hard gravel.

Sphaerium nitidum

Clarke (1973) and Herrington (1962) consider *S. nitidum* to be a cold water species typically occurring only in deep or unusually cold waters, particularly in the southern part of its range. The species has been recorded from all the Great Lakes with the exception of Lake Erie which would tend to confirm its cold stenothermic nature. However, *S. nitidum* is common in warm, shallow areas of southern Lake Michigan. Greatest abundances are found at about 20 m where the substrate is sandy. Live specimens are not uncommon at 40-50 m in Lake Michigan.

Sphaerium occidentale

Heard (1962) records this species for all the Great Lakes with the exception of Lake Michigan. These records seem anomolous since the species is characteristic of vernal pools and "has a preference for, or requires, a habitat that dries up for part of the year" (Herrington, 1962). The explanation for its presence in the Great Lakes may be that it occurs only in shore zones that partly dry up during the year. This has yet to be confirmed. There is little ecological data with museum records or in Heard (1962).

Sphaerium rhomboideum

Records exist only for Lake Ontario. Its habitat preference in the Great Lakes is unknown, but Herrington (1962) associates it with muddy bottoms in creeks and small rivers and quiet, sheltered places in small lakes.

Sphaerium simile

S. simile is locally common in sandy substrates less than 10 m deep in Lake Ontario. It has not been recorded for the other Great Lakes.

Sphaerium striatinum

This is the most common species of *Sphaerium* and occurs in all the Great Lakes. It may be collected in a variety of substrates from clay and mud to sand and gravel at depths from 0-30 m. Gale (1973) showed that adult stream specimens exhibit no real substrate preferences, although small clams did select mud over sand and sandy-mud.

SYNONYMY

The synonyms listed below are for the convenience of those working with the fauna of the Laurentian Great Lakes and reflect names frequently encountered in museum catalogues and the literature. The list is not complete for many species as it includes only synonyms used in a Great Lakes publication or report. More comprehensive synonymies can be found in Baker (1928a, 1928b), Berry (1943), Robertson and Blakeslee (1948), Herrington (1962), Clarke (1973), Burch (1975a, 1975b), and Te (1978).

Synonym	Present Status
GASTROPODA	
altissimus Baker	status unknown (=?*Gyraulus parvus* (Say))
antrosus Conrad	*Helisoma anceps* (Menke)
appressus Say	*Lymnaea stagnalis appressa* (Say)
arcticus Beck	status unknown (=?*Gyraulus circumstriatus* Tryon)
auricularia Linnaeus (*Lymnaea*)	*Radix auricularia* (Linnaeus)
bicarinatus Say	*Helisoma anceps* (Menke)
binneyana Hannibal (*Amnicola*)	*Probythinella lacustris* (Baker)
caperata Say (*Lymnaea*)	*Stagnicola caperata* (Say)
catascopium Say (*Lymnaea*)	*Stagnicola catascopium* (Say)
columella Say (*Lymnaea*)	*Pseudosuccinea columella* (Say)
contectoides Binney	*Viviparus georgianus* (Lea)
decampi Streng (*Lymnaea*)	*Fossaria decampi* (Streng)
desidiosa Say (*Lymnaea*)	*Fossaria decampi* (Streng)
emarginata Kuster (*Lymnaea*)	*Probythinella lacustris* (Baker)
emarginata Say (*Lymnaea*)	*Stagnicola emarginata* (Say)
exilis Lea (*Lymnaea*)	*Stagnicola reflexa* (Say)
hirsutus Gould	*Gyraulus deflectus* (Say)
humilis Say (*Lymnaea*)	*Fossaria humilis* (Say)
hypnorum Linnaeus	*Aplexa elongata* Say
integra Say (*Amnicola*)	*Cincinnatia cincinnatiensis* Anthony
kirklandi (*Ferrissia*)	status unknown
lacustre Pilsbry (*Amnicola*)	*Marstonia decepta* (Baker)
lanceata Gould (*Lymnaea*)	*Stagnicola reflexa* (Say)
lustrica Pilsbry (*Amnicola*)	*Marstonia decepta* (Baker)
malleatus Martens	*Viviparus japonicus* Martens
megasoma Say (*Lymnaea*)	*Bulimnea megasoma* (Say)
palustris Müller (*Lymnaea*)	*Stagnicola elodes* (Say)
pilsbryana Walker (*Lymnaea*)	*Stagnicola catascopium* (Say)
porata Say	*Amnicola limosa* (Say)

Synonym	Present Status
reflexa Say (*Lymnaea*)	*Stagnicola reflexa* (Say)
sheldoni Pilsbry (*Hoyia*)	status unknown
tentaculata Linnaeus (*Bulimus*)	*Bithynia tentaculata* (Linnaeus)
truncatum Miles	status unknown (=?*Helisoma trivolvis* (Say))
walkeriana Baker (*Lymnaea*)	*Stagnicola catascopium* (Say)
woodruffi Baker (*Lymnaea*)	*Stagnicola catascopium nasoni* (Baker)

SPHAERIIDAE

abditum Haldeman	*Pisidium casertanum* (Poli)
acuminatum Prime	form of *Sphaerium striatinum* (Lamarck) not considered here
aequilaterale Prime	*Pisidium equilaterale* Prime
altile Prime	*Pisidium compressum* Prime
cinereum Alder	*Pisidium casertanum* (Poli)
emarginata Prime	form of *Sphaerium striatinum* (Lamarck) not considered here
kirklandi Sterki	*Pisidium fallax* Sterki
medianum Sterki	*Pisidium ferrugineum* Prime
obtusale Herrington	*Pisidium ventricosum* Prime
ryckholti Normand	form of *Musculium lacustre* (Müller) not considered here
stamineum Conrad	*Sphaerium striatinum* (Lamarck)
subtransversum Prime	*Musculium transversum* (Say)
sulcatum Lamarck	*Sphaerium simile* (Say)

UNIONIDAE

attenuata Rafinesque	*Ligumia nasuta* Say
borealis Gray	*Lampsilis radiata* Gmelin
buchanensis Lea	*Anodontoides ferussacianus* (Lea)
canadensis Lea	*Lampsilis ovata* (Say)
corpulenta Cooper	*Anodonta grandis* Say
costata Rafinesque	*Amblema plicata* (Say)
footiana Lea	*Anodonta grandis* Say
gibbosus Barnes	*Elliptio dilatata* (Rafinesque)
gracilis Barnes	*Leptodea fragilis* (Rafinesque)
hippopaeus Lea	*Amblema plicata* (Say)
iris Lea (*Micromya*)	*Villosa iris* (Lea)
katherinae Lea	*Lasmigona complanata* (Barnes)
kennicottii Lea	*Anodonta grandis simpsoniana* Lea
latissima Rafinesque	*Ligumia recta* (Lamarck)
marginata Say	*Anodonta cataracta* Say
parvula Grier	*Fusconaia flava* (Rafinesque)
recta Lamarck (*Unio*)	*Ligumia recta* (Lamarck)
rugosus Swainson	*Strophitus undulata* (Say)
siliquoidea Barnes	*Lampsilis radiata siliquoidea* Barnes
simpsoniana Lea	*Anodonta grandis simpsoniana* Lea
sterkii Grier	*Elliptio dilatata* (Rafinesque)

Synonym	Present Status
superiorensis Marsh	*Lampsilis radiata siliquoidea* Barnes
triquetra Rafinesque (*Truncilla*)	*Dysnomia triquetra* (Rafinesque)
undata Barnes	*Fusconaia flava* (Rafinesque)
ventricosus Barnes	*Lampsilis ovata* (Say)
viridis Rafinesque	*Alasmidonta calceolus* (Lea)

GLOSSARY

abaxially: Situated outside of or facing away from the axis.

adapically: Towards or facing the apex of the shell.

anal siphon: The dorsal exhalant tube derived from mantle-margin epithelium and located near the anus at the posterior end of the animal.

aperture: The opening at the larger end of the shell of a gastropod.

apex: The tip or oldest part of a shell.

apical: At or belonging to the apex or oldest portion of a gastropod shell.

attenuate: Tapering gradually.

basal: Relating to or situated at the base.

beak: The raised part on the dorsal margin of a valve. It is formed by the embryonic shell around which the later shell develops. Also called the "umbo."

beak cavity: The cavity on the inside of each valve of a mussel shell going into the beak. In some species the cavity is quite deep, in others it is shallow so as to be little more than a weak depression.

bifid: Incised; cut in so as to be divided into two parts.

body whorl: The last whorl of the shell, it supports the aperture. The term "body whorl" is misleading since the organs of the animal are distributed through all the whorls.

branchial opening: The ventral posterior opening or siphon through which water enters the mantle cavity of a mollusc such as a freshwater mussel. Also called the "incurrent opening" or "siphon."

branchial siphon: The ventral inhalant tube derived from the mantle-margin epithelium located at the posterior end of the animal.

calycle (calyculae): A growth variation of the beak or umbo, typical of *Musculium* born at or near the end of the summer, yielding a cap-like appearance.

canaliculate: Grooved or channeled longitudinally.

cardinal teeth: Lamellae on the center of the hinge of both valves of a bivalve which serve to stabilize the two valves against shearing forces. The opposing cardinal teeth of the two valves fit together in a complimentary fashion. There are usually two cardinal teeth in the left valve (C2, C4) and one in the right (C3).

carinae: Small, sharp, raised ridges or keels.

caruncle: A fleshy elevation or outgrowth; a characteristic protuberance on the inner edge of each side of the mantle in front of the branchial opening of members of the genus *Carunculina*.

chevron-shaped: Shaped like a wide-angled V, normally positioned or inverted.

color ray: A more or less straight band of color, continuous or discontinuous, contrasted to the ground color of the shell and radiating from the umbonal area distally towards or to the peripheral margins of the valve.

columella: The central axis or "column" of a gastropod shell; seen only as the inner lip of the aperture.

compressed: Flattened or pressed together laterally, such as the appearance of some freshwater molluscs in end view.

corrugations: Alternating ridges and furrows on the surface of a unionid shell.

cusps: The highest elevations on the lateral teeth.

demibranch: One-half of one of the paired gills of a lamellibranch pelecypod; i.e. the two opposing rows of gill filaments on one side of the gill; a half-gill.

denticle: A toothlike projection usually at or just interior of the aperture in some gastropod shells.

dextral: Coiled to the right. When held with the apex up and aperture facing viewer, the aperture of a dextral shell is on the right side.

disc: The middle, central, or main portion of the exterior of a mussel valve as distinct from the posterior slope and other areas immediately adjacent to the marginal peripheries.

distal: Farthest from the beak or umbo of the shell in an anterior-posterior axis.

gill (branchia): The platelike or filamentous growth, usually located within the mantle cavity, serving as the respiratory organ of aquatic molluscs. In lamellibranch molluscs the gills are greatly enlarged, serving also as a food gathering organ through filter-feeding.

gravid female: A female with a marsupium containing young embryos.

ground color: The basic or background color of a shell against which any additional color markings are contrasted.

growth lines: Minute lines on the outer shell surface indicating a minor rest period during growth. Not to be confused with the major "rest marks" caused by prolonged growth arrest (as during winter).

gyrate: Circular, rounded; winding or coiled round.

hinge: (Unionidae) The portion of the dorsal margin between and including the pseudocardinal teeth and lateral teeth.
(Sphaeriidae) The part of the dorsal margin of the shell between and including the anterior and posterior lateral teeth of each valve.

hinge teeth: The opposing lamellae on the hinge plates of bivalved molluscs which serve to stabilize the two valves against shearing forces.

hirsute: Covered with hairs.

imperforate: Not open; used in reference to the umbilicus or columella of a gastropod shell.

inflated: Swollen or bulbous.

interdentum: The space on the hinge plate between the pseudocardinal and lateral teeth in unionid clams.

lateral teeth: The elongated lamellae at each end of the hinge plate.

malleated: With flattened areas, appearing like beaten metal.

mantle: An extension of the dorsal body wall of molluscs as one or a pair of folds which usually secretes a shell and encloses a mantle cavity, typically containing gills.

marsupium: The pouchlike structure used to hold the young. In unionids, internal spaces in the gills perform this function.

multicarinate: Having small, sharp, raised ridges or keels.

nacre: The white or iridescent inner layer of the shell in many molluscs lying next to the mantle and often characteristically colored in many unionacean clams.

nodule: A small knot, lump, or irregularly shaped mass such as the projections occurring on the shell surface of some freshwater mussels.

nodulous: Having small knobs, nodules, or projections.

nuclear whorl: The whorl located at the apex or oldest part of a gastropod shell, also called a "protoconch."

operculum: A stiff corneous or calcareous plate attached to the odrsal part of the foot of certain gastropods, arranged so that when the animal withdraws into the shell the operculum seals the aperture.

pallial line: The line of attachment of the mantle to the shell on the inside surface of a bivalved shell, often marked by a depression or scar.

papillate: Having many small papillae or bumps on the surface.

perforate: With an opening; used in reference to the umbilicus or columella of a gastropod shell.

periostracum: The pigmented outside layer of a molluscan shell.

peritreme: The lips of the aperture in limpets.

plaited: Having flattened folds, pleated.

planospiral: Spiraling in a single plane.

posterior ridge: A ridge on the external surface of many mussel shells extending from the umbo posterioventrally to the shell margin.

posterior slope: The area on the external surface of a mussel shell between the posterior ridge and the dorsal margin of the shell.

protoconch: The whorl located at the apex or oldest part of a gastropod shell.

proximal: Nearest the beak or umbo of the shell in an anterior-posterior axis.

pseudocardinal teeth: The anterior, opposing lamellae located on the hinge plates of bivalved molluscs which serve to stabilize the two valves against shearing forces.

pustule: A blister-like prominence found on the shell surface of some freshwater mussels.

ray: A streak or linear mark. It may be continuous or interrupted at intervals.

ridge: A wrinkle or raised part on the beaks of some species of *Pisidium*.

septa: Partitions formed by interlamellar connections separating spaces occurring between the two lamellae.

sinistral: Coiled to the left. When held with the apex up and aperture facing viewer, the aperture of a sinistral shell is on the left side.

siphon: A tubular structure formed by the opposing posterior mantle margins in mussels; a pair are commonly present on bivalves, providing restricted incurrent and excurrent opening to the mantle cavity.

spire: All whorls of a gastropod shell except the last, or body, whorl.

striae: (Bivalvia) Concentric raised striations or lines on the exterior surface of a shell. These may vary from very fine to coarse, sometimes resembling ribs.
(Gastropoda) Small ridges running perpendicular to the growth lines on the exterior surface of the shell.

subcentral: Not quite central; off-center.

sulcus: A groove, furrow, or channel.

suture: The line of junction between two contiguous whorls of the shell of a gastropod.

terminal: Located at or near the posterior end.

truncate: Having the end cut off more or less squarely.

tubercle: A nodule or small eminence, such as a solid elevation, occurring on the shell surface of some freshwater mussels.

tuberculated: Containing many small nodules or eminences.

umbilical: Of or pertaining to the umbilicus of a gastropod shell.

umbilicus: The depression in the base of the shell (opposite the spire) around which the body whorl is coiled; it is hollow in tube-like columella.

umbo: The oldest part of the bivalve shell identified as the raised portion at or overlapping the dorsal margin of a valve. Also called the "beak."

undulation: A wavy form, resembling that of a wave or waves.

vestigial: A small, degenerate or imperfectly developed bodily part or organ that remains from one more fully developed at an earlier stage of the individual or in past generations.

whorl: A single volution of the spiral shell of a gastropod.

wing: The dorsal, thin, flat, plate-like extension of the posterior slope of some freshwater mussels.

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INDEX TO SPECIES, SUBSPECIES, AND FORMS

Page numbers in italics refer to figures.

acuminatum (see *Sphaerium striatinum*)
acuta, *Pleurocera*, 6, *19*, 98
adamsi, *Pisidium*, 7, 55, *93*, *95*, 96, 103, 104, 105, 106
Alasmidonta calceolus, 6, 27, *28*, 102
alata, *Proptera*, 7, *33*, 102
ambigua, *Simpsoniconcha*, 7, *27*, 102
Amblema plicata, 6, *24*, 102
Amnicola
  limosa, 6, *9*, 20, *21*, 97
  walkeri, 6, 20, *21*, 97
amnicum, *Pisidium*, 7, 55, *57*, *59*, 104, 107, 110
anceps, *Helisoma*, 6, *11*, 100
Anodonta
  cataracta, 6, *26*, 102
  grandis grandis, 6, *25*, 102
  grandis simpsoniana, 6, *26*, 101
  imbecillis, 6, *25*, 101
Anodontoides ferussacianus, 6, *26*, 102
appressa (see *Lymnaea stagnalis*)
auricularia, *Radix*, 6, *15*, 99
basalis (see *Valvata tricarinata*)
bicarinata, *Valvata*, 6, 17, *18*, 97
Bithynia tentaculata, 6, *10*, 98
Bulimnea megasoma, 6, 16, *17*, 99
calceolus, *Alasmidonta*, 6, 27, *28*, 102
campanulatum, *Helisoma*, 6, 11, *12*, 100
Campeloma
  decisum, 6, *9*, 18, *19*, 97
  rufum, 6, 18, *19*, 97
caperata, *Stagnicola*, 6, 16, *17*, 99
Carunculina parva, 6, *30*, 101
casertanum, *Pisidium*, 1, 7, 84, *86*, *87*, *89*, *96*, 104, 105, 106, 109, 112, 113, 115, 116, 118
cataracta, *Anodonta*, 6, *26*, 102
catascopium f. *catascopium*, *Stagnicola*, 6, *15*, 17, 99
catascopium f. *nasoni*, *Stagnicola*, 6, *15*, 99
Cincinnatia cincinnatiensis, 6, 20, *21*, 98
cincinnatiensis, *Cincinnatia*, 6, 20, *21*, 98
circumstriatus, *Gyraulus*, 6, *14*, 100
coccineum (see *Pleurobema cordatum*)
columella, *Pseudosuccinea*, 6, 15, *16*, 99
complanata, *Elliptio*, 7, *29*, 102
complanata, *Lasmigona*, 7, 27, *28*, 102
compressum, *Pisidium*, 7, *63*, *65*, 91, 104, 105, 106, 108, 110, 114, 116
conventus, *Pisidium*, 1, 3, 7, *81*, *82*, 106, 108, 109, 110, 112
cordatum f. *coccineum*, *Pleurobema*, 7, *29*, 101
corneum, *Sphaerium*, 7, 50, *52*, *54*, 119
corpulentum, *Helisoma*, 6, 12, *13*, 100
costata, *Lasmigona*, 7, 27, *28*, 101
cristatum (see *Pisidium lilljeborgi*)
Cyclonaias tuberculata, 6, *29*, 101
decampi, *Fossaria*, 6, *16*, 99
decisum, *Campeloma*, 6, *9*, 18, *19*, 97
deflectus, *Gyraulus*, 6, *13*, 100
dilatata, *Elliptio*, 7, *29*, 102
donaciformis, *Truncilla*, 7, *32*, 102
dubium, *Pisidium*, 7, *36*, 55, *57*, *58*, 104, 107
Dysnomia
  sulcata, 6, *31*, 101
  triquetra, 6, *31*, 102

Elliptio
complanata, 7, *29*, 102
dilatata, 7, *29*, 102
elodes, *Stagnicola* (used for illustrative purposes only), *8*
emarginata, *Stagnicola*, 6, 16, *17*, 99
emarginatum (see *Sphaerium striatinum*)
equilaterale, *Pisidium*, 7, *91*, *92*, 107
exacuous, *Promenetus*, 6, *8*, *13*, 100
fabilis, *Villosa*, 7, *34*, 102
fallax, *Pisidium*, 7, *81*, *83*, 106, 107, 108
fasciola, *Lampsilis*, 7, *34*, 101
fasciolare, *Ptychobranchus*, 7, *33*, 101
Ferrissia
paralella, 6, *8*, *10*, 11, 100
tarda, 6, *10*, 11, 100
ferrugineum, *Pisidium*, 7, *75*, *77*, 108, 109, 114, 117, 118
ferrussacianus, *Anodontoides*, 6, *26*, 102
flava, *Fusconaia*, 7, 24, *25*, 102
Fossaria
decampi, 6, *16*, 99
humilis, 6, *16*, 99
obrussa, 6, *16*, 99
fragilis, *Leptodea*, 7, *33*, 102
Fusconaia flava, 7, 24, *25*, 102
fuscus, *Laevapex*, 6, *10*, 100
georgianus, *Viviparus*, 6, 18, *19*, 97
Goniobasis livescens, 6, *9*, *19*, 98
grandis grandis, *Anodonta*, 6, *25*, 102
grandis simpsoniana, *Anodonta*, 6, *26*, 101
Gyraulus
circumstriatus, 6, *14*, 100
deflectus, 6, *13*, 100
parvus, 6, *14*, 100
gyrina sayi, *Physella*, 6, *14*, 100
Helisoma
anceps, 6, *11*, 100
campanulatum, 6, 11, *12*, 100
corpulentum, 6, 12, *13*, 100
trivolvis, 6, *12*, 100
henslowanum, *Pisidium*, 7, *60*, *61*, 106, 108, 109, 111, 115
humilis, *Fossaria*, 6, *16*, 99
idahoense, *Pisidium*, 7, 84, *86*, *88*, 110
imbecillis, *Anodonta*, 6, *25*, 101
integra, *Physella*, 6, *14*, 15, 100
iris, *Villosa*, 7, *34*, 102
japonicus, *Viviparus*, 6, 18, *19*, 97
jayense (see *Musculium lacustre*)
lacustre f. *jayense*, *Musculium*, 7, *41*, *43*, 103
lacustre f. *lacustre*, *Musculium*, 7, *44*, *45*, 103
lacustris, *Probythinella*, 6, 20, *21*, 98
Laevapex fuscus, 6, *10*, 100
laevissima, *Proptera*, 33, 101
Lampsilis
fasciola, 7, *34*, 101
ovata, 7, *32*, 102
radiata radiata, 7, 34, *35*, 101
radiata siliquoidea, 4, 7, 34, *35*, 102
Lasmigona
complanata, 7, 27, *28*, 102
costata, 7, 27, *28*, 101
Leptodea fragilis, 7, *33*, 102
lewisi, *Valvata*, 6, 17, *18*, 97
Ligumia
nasuta, 7, *30*, 102
recta, 7, *30*, 102
lilljeborgi, *Pisidium*, 1
lilljeborgi f. *cristatum*, *Pisidium*, 7, *60*, *62*, 110, 111, 115
lilljeborgi f. *lilljeborgi*, *Pisidium*, 7, *70*, *71*, 106, 108, 110, 111, 113, 114, 116, 117, 118, 119
limosa, *Amnicola*, 6, *9*, 20, *21*, 97
livescens, *Goniobasis*, 6, *9*, *19*, 98
Lymnaea stagnalis appressa, 6, 16, *17*, 99
mainense (see *Pisidium walkeri*)
Marstonia decepta, 6, *20*, 98
megasoma, *Bulimnea*, 6, 16, *17*, 99
milium, *Pisidium*, 7, *75*, *76*, 108, 111, 112, 117
Musculium
lacustre f. *jayense*, 7, *41*, *43*, 103

lacustre f. *lacustre*, 7, *44*, *45*, 103
partumeium, 7, *38*, *40*, 103
securis, 7, *41*, *42*, 103
transversum, 7, 37, *38*, *39*, 103
nasoni (see *Stagnicola catascopium*)
nasuta, *Ligumia*, 7, *30*, 102
nitidum, *Pisidium*, 109
nitidum f. *nitidum*, *Pisidium*, 7, *78*, *80*, 105, 107, 109, 111, 112, 113, 115, 116
nitidum f. *pauperculum*, *Pisidium*, 7, 84, *87*, *90*, 108, 110, 112, 113, 114, 117, 118, 119
nitidum, *Sphaerium*, 7, 50, *52*, *53*, 119
nodulata, *Quadrula*, 7, 24, *25*, 101
Obliquaria reflexa, 7, *30*, 101
Obovaria
olivaria, 7, *31*, 101
subrotunda, 7, *31*, 101
obrussa, *Fossaria*, 6, *16*, 99
occidentale, *Sphaerium*, 7, 50, *55*, *56*, 120
olivaria, *Obovaria*, 7, *31*, 101
ovata, *Lampsilis*, 7, *32*, 102
paralella, *Ferrissia*, 6, *8*, *10*, 11, 100
partumeium, *Musculium*, 7, *38*,*40*, 103
parva, *Carunculina*, 6, *30*, 101
parvus, *Gyraulus*, 6, *14*, 100
pauperculum (see *Pisidium nitidum*)
perconfusa (see *Valvata tricarinata*)
perdepressa, *Valvata*, 6, *18*, 97
Physella
gyrina sayi, 6, *14*, 100
integra, 6, *14*, 15, 100
vinosa, 6, *14*, 15, 100
piscinalis, *Valvata*, 6, *18*, 97
Pisidium
adamsi, 7, 55, *93*, *95*, 96, 103, 104, 105, 106
amnicum, 7, 55, *57*, *59*, 104, 107, 110
casertanum, 1, 7, 84, *86*, *87*, *89*, *96*, 104, 105, 106, 109, 112, 113, 115, 116, 118
compressum, 7, *63*, *65*, 91, 104, 105, 106, 108, 110, 114, 116
conventus, 1, 3, 7, *81*, *82*, 106, 108, 109, 110, 112
dubium, 7, *36*, 55, *57*, *58*, 104, 107
equilaterale, 7, *91*, *92*, 107
fallax, 7, *81*, *83*, 106, 107, 108
ferrugineum, 7, *75*, *77*, 108, 109, 114, 117, 118
henslowanum, 7, *60*, *61*, 106, 108, 109, 111, 115
idahoense, 7, 84, *86*, *88*, 110
lilljeborgi, 1
lilljeborgi f. *cristatum*, 7, *60*, *62*, 110, 111, 115
lilljeborgi f. *lilljeborgi*, 7, *70*, *71*, 106, 108, 110, 111, 113, 114, 116, 117, 118, 119
milium, 7, *75*, *76*, 108, 111, 112, 117
nitidum, 109
nitidum f. *nitidum*, 7, *78*, *80*, 105, 107, 109, 111, 112, 113, 115, 116
nitidum f. *pauperculum*, 7, 84, *87*, *90*, 108, 110, 112, 113, 114, 117, 118, 119
punctatum, 7, 91, *93*, *94*, 112, 114
subtruncatum, 7, *78*, *79*, 104, 105, 110, 112, 113, 114, 115, 116, 118, 119
supinum, 7, *63*, *64*, 105, 111, 115
variabile, 7, *84*, *85*, 91, 104, 105, 106, 107, 109, 110, 113, 114, 116, 119
ventricosum f. *rotundatum*, 7, *66*, *67*, *68*, 111, 117, 118
ventricosum f. *ventricosum*, 7, *67*, *69*, 111, 112, 114, 117, 118
walkeri f. *mainense*, 7, *72*, *74*, 104, 105, 118, 119
walkeri f. *walkeri*, 7, *72*, *73*, 118, 119
Pleurobema cordatum f. *coccineum*, 7, *29*, 101
Pleurocera acuta, 6, *19*, 98
plicata, *Amblema*, 6, *24*, 102
Probythinella lacustris, 6, 20, *21*, 98
Promenetus exacuous, 6, *8*, *13*, 100
Proptera
alata, 7, *33*, 102
laevissima, 33, 101

Pseudosuccinea columella, 6, 15, *16*, 99
Ptychobranchus fasciolare, 7, *33*, 101
punctatum, *Pisidium*, 7, 91, *93*, *94*, 112, 114
pustulosa, *Quadrula*, 7, 24, *25*, 101
Quadrula
nodulata, 7, 24, *25*, 101
pustulosa, 7, 24, *25*, 101
quadrula, 7, *24*, 102
quadrula, *Quadrula*, 7, *24*, 102
radiata radiata, *Lampsilis*, 7, 34, *35*, 101
radiata siliquoidea, *Lampsilis*, 4, 7, 34, *35*, 102
Radix auricularia, 6, *15*, 99
recta, *Ligumia*, 7, *30*, 102
reflexa, *Obliquaria*, 7, *30*, 101
reflexa, *Stagnicola*, 6, *15*, 99
rhomboideum, *Sphaerium*, 7, *50*, *51*, 120
rotundatum (see *Pisidium ventricosum*)
rufum, *Campeloma*, 6, 18, *19*, 97
sayi, *gyrina*, *Physella*, 6, *14*, 100
securis, *Musculium*, 7, *41*, *42*, 103
siliquoidea (see *Lampsilis radiata*)
simile, *Sphaerium*, 7, *46*, *47*, 120
simpsoniana, *grandis*, *Anodonta*, 6, *26*, 101
Simpsoniconcha ambigua, 7, *27*, 102
sincera, *Valvata*, 6, *18*, 97
Somatogyrus subglobosus, 6, *20*, 98
Sphaerium
corneum, 7, 50, *52*, *54*, 119
nitidum, 7, 50, *52*, *53*, 119
occidentale, 7, 50, *55*, *56*, 120
rhomboideum, 7, *50*, *51*, 120
striatinum, 7, 46, 120
striatinum f. *acuminatum*, 46, *48*
striatinum f. *emarginatum*, 46, *48*
stagnalis appressa, *Lymnaea*, 6, 16, *17*, 99
Stagnicola
caperata, 6, 16, *17*, 99
catascopium f. *catascopium*, 6, *15*, 17, 99
catascopium f. *nasoni*, 6, *15*, 99
elodes (used for illustrative purposes only), *8*
emarginata, 6, 16, *17*, 99
reflexa, 6, *15*, 99
striatinum, *Sphaerium*, 7, 46, 120
striatinum f. *acuminatum*, 46, *48*
striatinum f. *emarginatum*, 46, *48*, *49*
Strophitus undulatus, 7, *26*, 102
subglobosus, *Somatogyrus*, 6, *20*, 98
subrotunda, *Obovaria*, 7, *31*, 101
subtruncatum, *Pisidium*, 7, *78*, *79*, 104, 105, 110, ,,2, 113, 114, 115, 116, 118, 119
sulcata, *Dysnomia*, 6, *31*, 101
supinum, *Pisidium*, 7, *63*, *64*, 105, 111, 115
tarda, *Ferrissia*, 6, *10*, 11, 100
tentaculata, *Bithynia*, 6, *10*, 98
transversum, *Musculium*, 7, 37, *38*, *39*, 103
tricarinata f. *basalis*, *Valvata*, 6, 17, 97
tricarinata f. *perconfusa*, *Valvata*, 6, 17, 97
tricarinata f. *tricarinata*, *Valvata*, 6, *9*, 17, *18*, 97
triquetra, *Dysnomia*, 6, *31*, 102
trivolvis, *Helisoma*, 6, *12*, 100
truncata, *Truncilla*, 7, *32*, 102
Truncilla
donaciformis, 7, *32*, 102
truncata, 7, *32*, 102
tuberculata, *Cyclonaias*, 6, *29*, 101
undulatus, *Strophitus*, 7, *26*, 102
Valvata
bicarinata, 6, 17, *18*, 97
lewisi, 6, 17, *18*, 97
perdepressa, 6, *18*, 97
piscinalis, 6, *18*, 97
sincera, 6, *18*, 97
tricarinata f. *basalis*, 6, 17, 97
tricarinata f. *perconfusa*, 6, 17, *97*
tricarinata f. *tricarinata*, 6, *9*, 17, *18*, 97
variabile, *Pisidium*, 7, *84*, *85*, 91, 104, 105, 106, 107, 109, 110, 113, 114, 116, 119
ventricosum f. *rotundatum*, *Pisidium*, 7, *66*, *67*, *68*, 111, 117, 118
ventricosum f. *ventricosum*, *Pisidium*, 7, 66, *67*, *69*, 111, 112, 114, 117, 118

Villosa
fabilis, 7, *34*, 102
iris, 7, *34*, 102
vinosa, *Physella*, 6, *14*, 15, 100
Viviparus
georgianus, 6, 18, *19*, 97
japonicus, 6, 18, *19*, 97
malleatus, 97
walkeri, *Amnicola*, 6, 20, *21*, 97
walkeri f. *mainense*, *Pisidium*, 7, *72*, *74*, 104, 105, 118, 119
walkeri f. *walkeri*, *Pisidium*, 7, *72*, *73*, 118, 119

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16. ABSTRACT

Presented here are keys and notes on distribution and ecology for the freshwater snails (Gastropoda), mussels (Unionidae), and fingernail clams (Sphaeriidae) which have been collected from the Laurentian Great Lakes. Including subspecies and forms, 121 taxa are discussed: 47 Gastropoda, 39 Unionidae, and 35 Sphaeriidae. Relations to substrate preferences and pollution are summarized where known. Special emphasis is given to the sphaeriid genus *Pisidium* in discussions of morphological variability and characters which will separate the species and forms both in the adult and photomicrographs are presented for all sphaeriid taxa. A limited synonymy has been compiled from publications and reports on the Laurentian Great Lakes and the expanded reference section includes not only citations used in the text but also publications and reports which may aid researchers in more indepth studies of the fauna.

17. KEY WORDS AND DOCUMENT ANALYSIS

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