KEYS TO THE FRESHWATER MACROINVERTEBRATES OF MASSACHUSETTS

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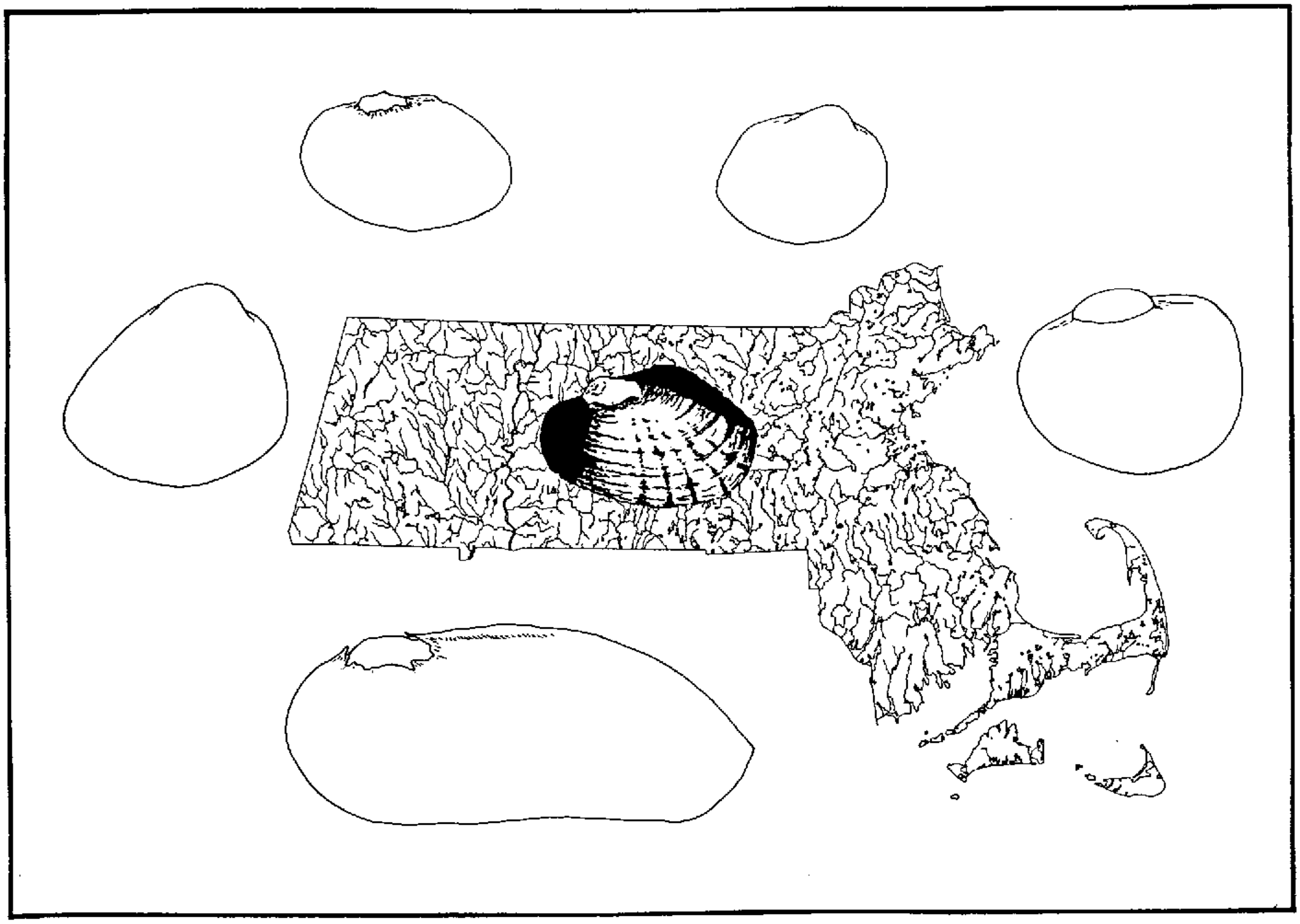

NO.1 : MOLLUSCA PELECYPODA
(Clams , Mussels)

Massachusetts Department of Environmental Quality Engineering

DIVISION of WATER POLLUTION CONTROL

Thomas C. McMahon, Director

KEYS TO THE FRESHWATER MACROINVERTEBRATES OF MASSACHUSETTS (No. 1): Mollusca Pelecypoda

(clams, mussels)

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In Cooperation With

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PREFACE

The present work, concerning the identification of freshwater bivalve mollusks occurring in Massachusetts, represents the first of hopefully a series of guides dealing with the identification of benthic macroscopic invertebrates inhabiting the inland freshwaters of Massachusetts. The purpose of this and succeeding guides or handbooks is to introduce various groups of freshwater invertebrates to persons working in any of several areas of the freshwater ecology of Massachusetts. Although the guides are limited in their geographic scope to areas within the political boundaries of Massachusetts, many of the organisms treated, and information regarding their ecology and biology, will be applicable to neighboring regions. To increase the usefulness of this and following guidebooks, complete regional bibliographies of the distribution of included species are provided. Also, general information discussing the usefulness of the particular invertebrate groups covered as biological indicators of water quality is provided. An attempt has been made to be as complete and thorough as possible in the coverage of the species of each group living in Massachusetts. Additionally, all the known published accounts relevant to each discussed invertebrate group as it occurs in the state has been presented. Nevertheless, omissions will become evident and new or overlooked information regarding these animals, particularly previously undocumented occurrences of species within the state should be submitted to the author. The author accepts responsibility for any and all mistakes of fact or interpretation appearing hereafter.

Over the years, a number of people have assisted this project in acquiring specimens in the field for study or allowing access to museum collections containing material relevant to the present document. These people are (in alphabetical order); Thomas Andrews, Kenneth Boss, Jenifer Bush, Karsten Hartel, Richard Johnson, Stuart Ludlam, Lawrence Master, Betty Anne McGuire, Ann Pratt, Alan Richmond, Isabella Sprague, Ruth Turner, William Wall, Kirk Wright, and the students of the Biology of Higher Invertebrates course at the University of Massachusetts.

The drawings appearing in the following keys are based on specimens collected in Massachusetts except where noted otherwise.

INTRODUCTION

The use of benthic macroinvertebrates as both indicators of various forms of pollution and as test organisms for determining the presence of toxic substances is well established (Mackenthun and Ingram, 1967; Myslinski and Ginsburg, 1977; James, 1979). Early studies on the changes in the diversity of macroinvertebrates in large North American (Forbes and Richardson, 1913; Richardson, 1921) and European rivers (see Hawkes, 1979, for review) first illuminated the importance of community structure of benthic invertebrates in determining the presence and degree of pollution. Later studies in North America which employed quantification methods and added chemical parameters (Mason et al., 1971; Starrett, 1971) reiterated what was previously observed and further evidenced the value of invertebrates as biological indicators of changing water quality. As a result of the earliest observations, and subsequent refinement of sampling and measurement procedures, increasingly diverse and complex methods for analyzing invertebrate community structure have been developed. Hynes' (1974) pioneering treatise represents one of the first attempts to synthesize these methods. Additional discussions and reviews of methods for analyzing invertebrates as indicators of pollution have been prepared by the United States Department of the Interior (USDI, 1969), Goodnight (1973), and Hawkes (1979).

The effects of toxins and ways of measuring toxins in macroinvertebrates has emerged recently as an important area of research. Information gathered from such studies adds to the usefulness of macroinvertebrates as pollution indicators by establishing lethal limits of various substances in particular species. Furthermore, assessing the ability of macroinvertebrates to bioaccumulate and biomagnify toxic substances can provide a means to monitor the health of the aquatic environment. Recent syntheses which have brought together much of the data on the effects and measurement of toxicity in invertebrates (Hart and Fuller, 1974; Buikema and Cairns, 1980; Buikema et al., 1981) provide the foundation for further study, particularly in areas of heavy metal and pesticide contamination. Concerning Massachusetts, the application of certain toxicity tests which utilize macroinvertebrate species has been discussed by Szal (1984).

A necessary requirement of any form of pollution indicator or toxic substance assessment is the proper identification of the animal utilized. Improper identification of a particular species used in analysis can lead to erroneous interpretations and, consequently, dubious conclusions. Additionally, the inability, due to the lack of sufficient documentation, to confidently identify an organism to species limits investigators to genus or family level identification upon which they must base their conclusions. On a regional basis, assessments based on limited taxonomic information are greatly reduced in value.

For those who are engaged in the study of organisms inhabiting Massachusetts, this and other planned manuals are an attempt to alleviate some of the problems associated with inaccurate taxonomic identification. Animals covered in this volume include the freshwater bivalve Mollusca.

Freshwater bivalve mollusks are often "participating" organisms in both pollution indicator and toxic substance assessment studies. Their large size, which makes them less difficult to identify, lack of great mobility, and relatively long life spans make them ideal candidates as preferred indicator and test organisms (Myslinski and Ginsberg, 1977). Furthermore, the apparent sensitivity of many species to aquatic contamination, as indicated by the decline of certain species throughout the country (Jorgenson and Sharp, 1971) as well as locally (Smith, 1981, 1984), necessitates the determination and subsequent reduction of toxic pollutants in order to conserve remaining species. Although the usefulness of bivalve mollusks as models for bioaccumulaton and biomagnification studies has been questioned with regard to certain metals (Terhaar et al, 1977), the general acceptance of the use of these animals in such studies is broad (USDI, 1969). Recent reviews of toxic substances in freshwater bivalve mollusks can be found in Fuller (1974), Mackie (1978), Imlay (1982), and Mackie and Huggins (1983).

THE PELECYPODA

The bivalve mollusks (Class Pelecypoda) are represented in North American freshwaters by two unrelated groups. The first group comprises the freshwater mussels or naiades as they have sometimes been called. These animals are large (up to 150 mm in length) rostrate bivalves possessing a hinge which is most developed posterior of the beaks or umbos (Fig. 1a). The shells are typically covered by a thick periostracum that is variously colored and sometimes rayed on the disk depending upon the species. Internally, the shell has a "pearly" appearance due to the nacreous lining of the inner shell surfaces. In the region of the hinge, articulating "teeth" are variously developed (Fig. 1a) or absent. When present these teeth radiate from the beaks. The anterior teeth (Fig. 1a), when present, are called pseudocardinals and are thick, short, and when well developed, grooved and serrated. The posterior teeth (Fig. 1a), when present, are called laterals and are always elongate and lamellate.

The gross anatomy of North American freshwater mussels is characterized by the presence of a large muscular foot which is used for digging and anchorage. The gills are composed of a series of folded plates; two plates (demibranchs) occur on either side of the foot (Fig. 2a). Surrounding the animal and lining the inner surfaces of the shell is a mantle which is open for the most part along the margins of the shell. Posteriorly, the mantle margins, in conjunction with the demibranchs, form the inhalent and exhalent openings through which water enters and departs the animal (Fig. 2a). These openings in no North American species form true siphons.

All freshwater mussels belong to the order Unionoida, a solely freshwater group. Species of Unionoida, exclusively among bivalve mollusks, produce a larva, called a glochidium in North American forms, which is parasitic on fish or amphibians. The larvae, prior to release, are brooded in the parent's demibranchs (inner and/or outer gills) for a varying period of time depending upon the species. Metamorphosis to the adult morphology occurs while attached to the host. The vast majority of freshwater mussels, including all Massachusetts' species, are dioecious. Adult freshwater mussels are infaunal filter feeders. Typically, the only movements undertaken are vertical adjustments of the animal's position in the substrate in response to changing environmental conditions. Migrations occur, but are usually of short duration and distance and, for the most part, are undertaken to withdraw from unsuitable habitats. Dispersal is principally accomplished during the parasitic larval stage.

Two families of unionoid mussels are present in Massachusetts. One, the Margaritiferidae, is represented by a single species, Margaritifera margaritifera, which is widespread in New England and northwestern Europe and Scandinavia. In North America, scattered populations occur in New York and Pennsylvania as well. Margaritiferids are chiefly distinguished from other unionoid mussels by the structure of the gills, which in margaritiferids lack vertical septa (Fig. 2a, "b") and in the formation of the diaphragm, which separates incoming water in the branchial chamber from outgoing water in the suprabranchial chamber. The diaphragm in margaritiferids is formed by mechanical means and involves the sealing of the free posterior portion of the demibranchs by use of septa-like extensions of the mantle which are held over the outer demibranchs by a muscular process.

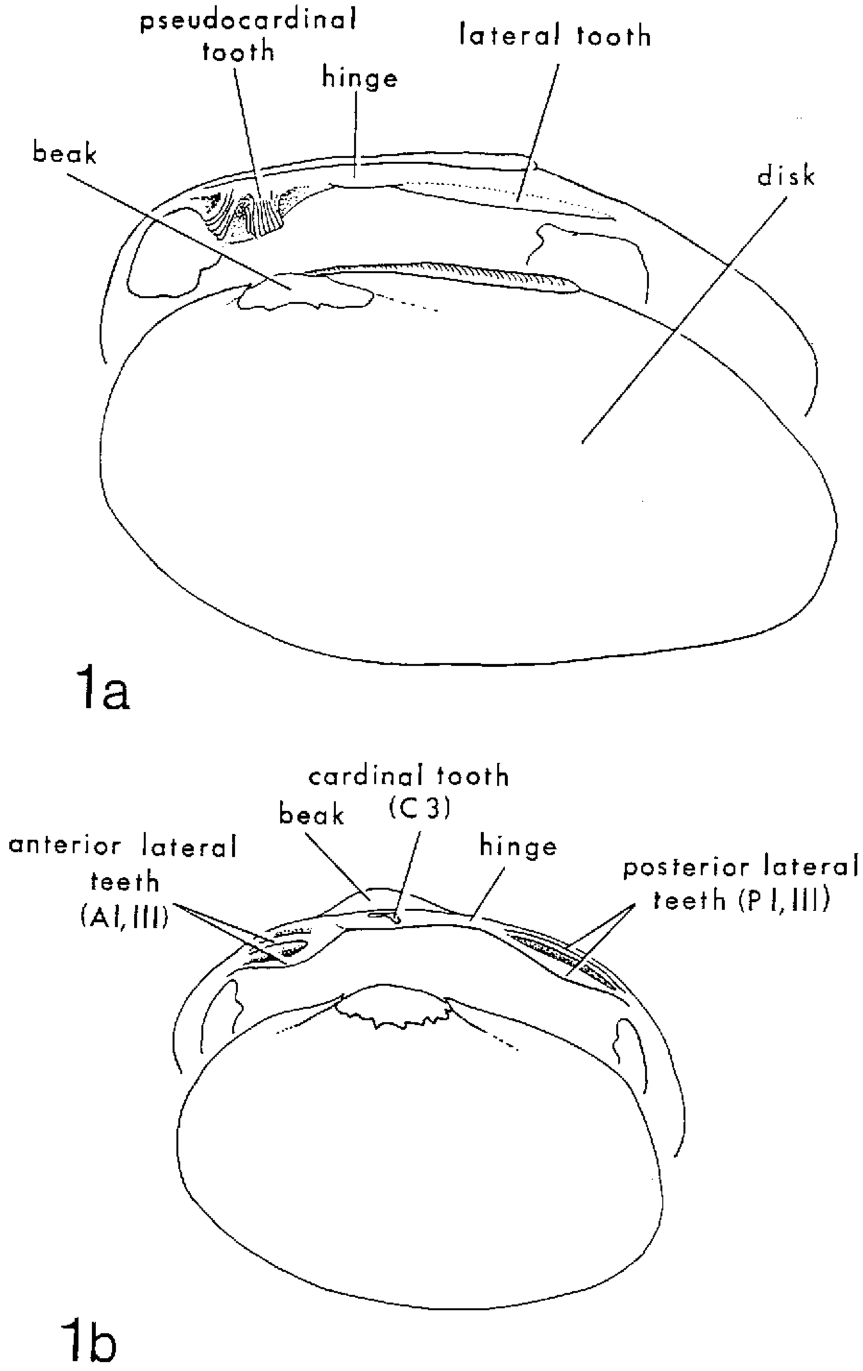
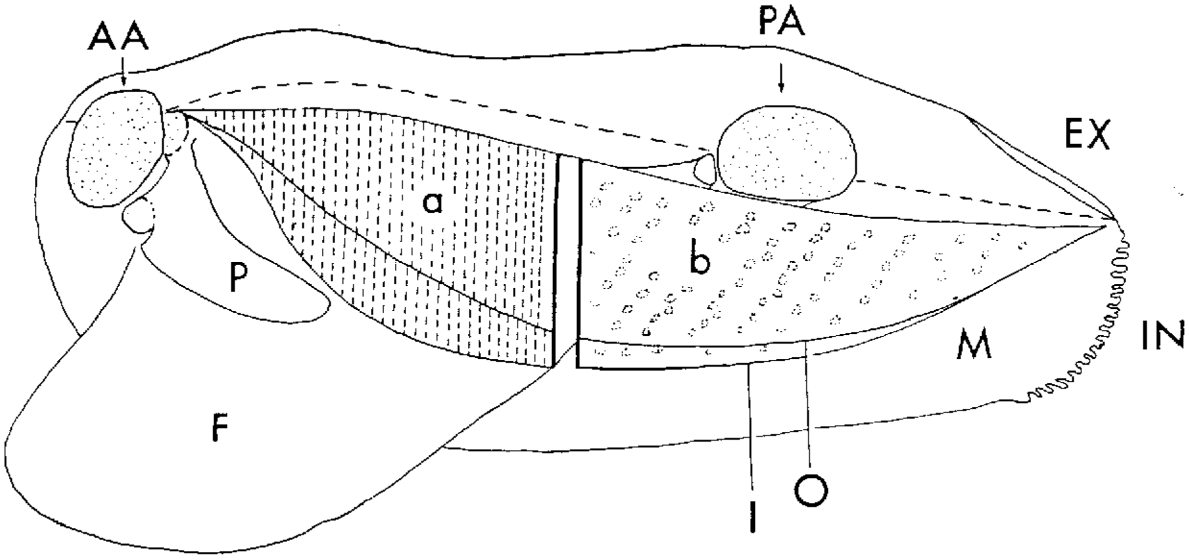
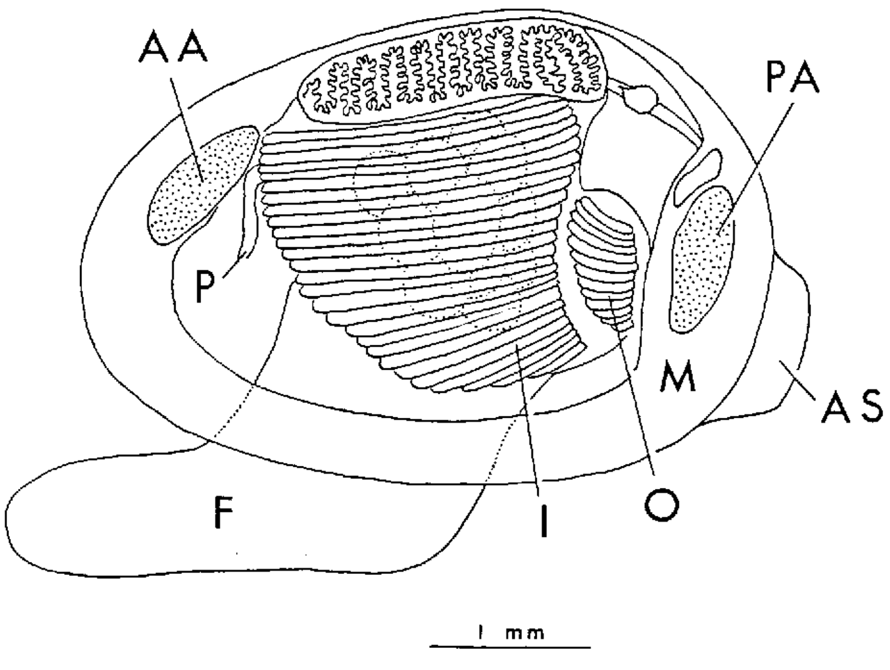


Figure 1. Shell morphologies of a typical unionacean, (a) Elliptio complanata, and (b) a typical pisidiid, Sphaerium simile. The internal view is of the right valve.



2a



2b

Figure 2. Anatomy of a generalized unionacean (a) and a typical pisidiid, Pisidium casertanum (b). Inner gill in (b) containing juveniles.

Glossary of structures in Figure 2a and b.

AA = anterior adductor muscle

AS = anal siphon

EX = exhalent aperture

F = foot

I = inner gill (in pisidiids this gill is also called the anterior gill)

IN = inhalent aperture

M = mantle

O = outer gill (in pisidiids this gill is also called the posterior gill)

NOTE: In the Unionidae the gill lamellae contain vertical septa (O,a), whereas in the Margaritiferidae the gills have diagonally arranged interlamellar junctions (O,b).

P = palp

PA = posterior adductor muscle

The other family occurring in Massachusetts is the Unionidae. This is the largest family of unionoid mussels and contains species living in North and Central America, and throughout the Palearctic region. Eleven species live in Massachusetts. All belong to a zoogeographical assemblage called the Atlantic Slope fauna. Nine of the species are restricted to the northern section of the slope and constitute a subdivision, the Northern Atlantic Slope fauna (van der Schalie and van der Schalie, 1950; Johnson, 1970). The Unionidae are characterized by the possession of vertical gill septa in the demibranchs (Fig. 2a, "a") and a diaphragm formed structurally by a union of the outer demibranchs with the mantle wall posteriorly.

The second group of freshwater bivalves are the fingernail clams, also known as the pea or pill clams. The fingernail clams are small (less than 25 mm in length) bivalves with a hinge line equally developed on either side of the beaks (Fig. 1b). The external covering of the shell is a thin or moderately thick periostracum which is typically dull colored and rayless. The internal surface of the shell is shiny but is composed of material other than nacre. The hinge region always contains teeth. The teeth lying directly or nearly beneath the beaks are the cardinals. In the right valve, which is the valve referred to throughout the key, a single cardinal tooth is present (C3) (Fig. 1b). The teeth occurring on both sides and away from the beaks are the laterals (Fig. 1b). Normally there are two pairs in the right valve and one in the left; however, occasionally it will be found that the teeth are reversed (Heard, 1969). The anatomy of fingernail clams includes a muscular, somewhat ambulatory foot used for digging and crawling (Fig. 2b). Unlike the foot of unionoid mussels the foot is grooved, presumably for better "traction." The structure of the gills is primitively like that of unionoid mussels; but in the more advanced species of fingernail clams, the outer demibranchs decrease in size (Fig. 2b). In some forms, the outer demibranchs are lost altogether. The mantle, which encloses the animal within the shell, is fused somewhat along the posterior margin, depending upon the species. True tubular siphons are present in all species. However, in the genus Pisidium (s.l.) the tubular inhalent siphon is greatly reduced or lost entirely (Fig. 2b).

Fingernail clams are infaunal or epifaunal filter feeders. Development includes no specialized larva. The young are brooded in modified areas of the parent's inner (anterior) gill (Fig. 2b) and are subsequently released as young free living clams. All forms of fingernail clams are hermaphroditic.

All fingernail clams occurring in Massachusetts belong to the family Pisidiidae, one of the few freshwater families constituting the otherwise largely marine order Veneroida. No specific zoogeographical groupings of fingernail clams exist and species appear to be dispersed randomly by several forms of phoretic agents (Burky, 1983).

CLASSIFICATION OF MASSACHUSETTS' FRESHWATER BIVALVES

An arrangement of species and higher taxonomic categories of freshwater bivalves occurring in Massachusetts is provided in Tables 1 and 2. The higher classification (family and above) follows Boss (1982). The list of unionacean species (Table 1) is taken from Gould (1870) and Johnson (1915), using the current nomenclature of Johnson (1980). Subgenera are recognized in some of the genera of unionids occurring in Massachusetts; however, they do not display any diagnostic value for the determination of species in Massachusetts and are not listed.

The family Pisidiidae[1] (Table 2) is sometimes split into two subfamilies, the Pisidiinae and Sphaeriinae (Heard, 1965), but these are not used here. The generic categories *Sphaerium*, *Musculium*, and *Pisidium* follow Burch (1975a), but regarding *Sphaerium* and *Musculium*, it has been argued (Herrington, 1962) that separating *Musculium* as a full genus is not supported by morphological evidence. One character normally used to separate the two groups as distinct genera is the degree of fusion of the siphons (Burch, 1975a). Species of *Musculium* have the siphons fused for much their length whereas in *Sphaerium* the siphons are fused only at their bases. Specimens of *Sphaerium simile* from Massachusetts can greatly extend their siphons such that the siphons appear fused for much of their length (Smith, pers. obser., and see Fig. 30). Additionally, there is confusion in the literature with regard to which genus has fused siphons (compare Heard (1965) and Burch (1975a) with Heard (1977), Boozer and Mirkes (1979), and Mackie and Huggins (1983)). The subgenera of *Sphaerium*, *Sphaerium* and *Herringtonium*, included in Burch (1975a) are adopted here. *Herringtonium* is monotypic and was erected by Clarke (1973) for *S. occidentale* which occurs in Massachusetts.

Three subgenera, as discussed by Heard (1966), are generally recognized within the genus *Pisidium*. These are *Pisidium* (s.s.), *Cyclocalyx*, and *Neopisidium*. All three subgenera are found in Massachusetts; however, the great majority of species are in *Cyclocalyx*. The list of pisidiid species occurring in Massachusetts is after Gould (1870), Johnson (1915), Sterki (1916), and Herrington (1962). The nomenclature follows Herrington (1954) and Burch (1975a). *Pisidium henslowanum* has been recently found in Massachusetts (Smith, in review).

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[1] The long established family name Sphaeriidae is giving way to Pisidiidae, an earlier name currently recognized by the International Commission of Zoological Nomenclature (I.C.Z.N.). Recent decisions by ICZN have established *Sphaerium* as a valid mollusk genus name (Bull. I.C.Z.N. (1981) 38:157-161) and have suppressed an even earlier name, Cycladidae (genus *Cyclas*) (Bull. I.C.Z.N. (1985) 42:43-45).

Table 1. The classification and species of unionacean mussels found in Massachusetts.

Subclass Paleoheterodonta

Order Unionoida

Superfamily Unionacea

Family Margaritiferidae

Margaritifera margaritifera (Linn. 1758)

Family Unionidae

Elliptio complanata (Lightfoot 1786)

Alasmidonta heterodon (Lea 1830)

Alasmidonta undulata (Say 1817)

Alasmidonta varicosa (Lamarck 1819)

Anodonta cataracta cataracta Say 1817

Anodonta implicata Say 1829

Strophitus undulatus (Say 1817)

Ligumia nasuta (Say 1817)

Leptodea ochracea (Say 1817)

Lampsilis cariosa (Say 1817)

Lampsilis radiata radiata (Gmelin 1791)

Table 2. The classification and species of Corbulaceans found in Massachusetts.

Subclass Heterodonta

Order Veneroida

Superfamily Corbulacea

Family Pisidiidae

Sphaerium *(Herringtonium)* *occidentale* (Prime (Lewis) 1856)

Sphaerium *(Sphaerium)* *rhomboideum* (Say 1822)

Sphaerium *(Sphaerium)* *simile* (Say 1816)

Sphaerium *(Sphaerium)* *striatinum* (Lamarck 1818)

Musculium *lacustre* (Muller 1774)

Musculium *partumeium* (Say 1822)

Musculium *securis* (Prime 1852)

Pisidium *(Pisidium)* *dubium* (Say 1816)

Pisidium *(Cyclocalyx)* *adamsi* Stimpson 1851

Pisidium *(Cyclocalyx)* *casertanum* (Poli 1791)

Pisidium *(Cyclocalyx)* *compressum* Prime 1852

Pisidium *(Cyclocalyx)* *equilaterale* Prime 1852

Pisidium *(Cyclocalyx)* *fallax* Sterki 1896

Pisidium *(Cyclocalyx)* *ferrugineum* Prime 1852

Pisidium *(Cyclocalyx)* *henslowanum* (Sheppard 1825)

Pisidium *(Cyclocalyx)* *lilljeborgi* Esmark and Hoyer 1886

Pisidium *(Cyclocalyx)* *nitidum* Jenyns 1832

Pisidium *(Cyclocalyx)* *variabile* Prime 1852

Pisicium *(Cyclocalyx)* *ventricosum* Prime 1851

Pisidium *(Cyclocalyx)* *walkeri* Sterki 1895

Pisidium *(Neopisidium)* *punctatum* Sterki 1895

HOW TO USE THE KEY

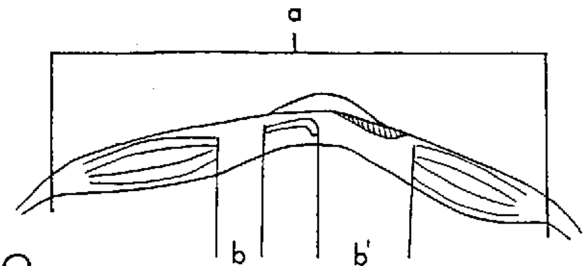
The key is provided in two parts; one designed to be used in the field and the other in the field or laboratory. The field key is an abbreviated pictorial form that can be used primarily for the identification of rare and endangered species of unionacean clams occurring in Massachusetts, though it can be used in conjunction with the general key as well. It has been supplied because freshwater mussels throughout North America are imperiled by pollution and habitat destruction probably more so than any other group of aquatic organisms. Because freshwater mussels are relatively large and easily examined, a means of identifying specimens without harming them is both possible and necessary. The field key employs observable anatomical and external shell characters of live animals. To use the field key, specimens should be placed in a clear container free of soap or chemicals and supplied with water from the collection locality. Specimens should then be allowed to relax without disturbance. Good light and a hand lens are necessary for observation.

Specimens to be run through the general key should be examined both alive, if possible, and dead. Material examined alive should be maintained in the same manner as for the field key. Following collection, and once settled, the animals should be allowed to rest undisturbed. Eventually, the mantle and foot tissues will extend and can be observed. Killing is best accomplished by placing the specimens in hot water until the shells gape. Specimens must then be fixed in a 10 percent formalin solution (one part 38 percent commercial formalin to nine parts of water) that has been buffered with borax or marble chips. Animals can be left in formalin for a few hours (for pisidiids) to a few days (for unionaceans). Subsequent to fixation, specimens must be washed several times in water before being examined. This is done to remove as much formalin as possible from specimens. Formalin is irritative and toxic and direct contact with the fixative should be avoided. For permanent storage shells can be either dried separately or stored with the rest of the animal in 70 percent ethyl alcohol or 50 percent isopropyl alcohol. Investigators seriously interested in determining identifications of these animals must be willing to properly prepare living or dead specimens for examination. Preserved specimens, with identifications, should be maintained in a reference collection or offered to recognized museums.

Couplets in the general key utilize anatomical and shell features. Certain couplets in the present key are nearly identical to couplets presented in other keys. This is because the number of available characters that will separate certain groups of similar species, particularly among pisidiids, is often very limited. Reference is frequently made to other keys or works for confirmation and for additional ecological or bibliographical information.

Material to be identified should be initially sorted into categories based on general shell shape, morphology and size. Critical examinations, particularly of smaller specimens, require the use of a binocular dissecting microscope with magnification available up to 30X. When examining fluid preserved specimens it is best to place the specimens in water during examination.

Species of the genus *Pisidium* are very difficult to identify. This is primarily because few of the presently recognized species contain known characters which are consistently present and reliable as diagnostic of the species. Additionally, certain species of *Pisidium*, especially the more common ones, are quite variable. General and regional keys and descriptions



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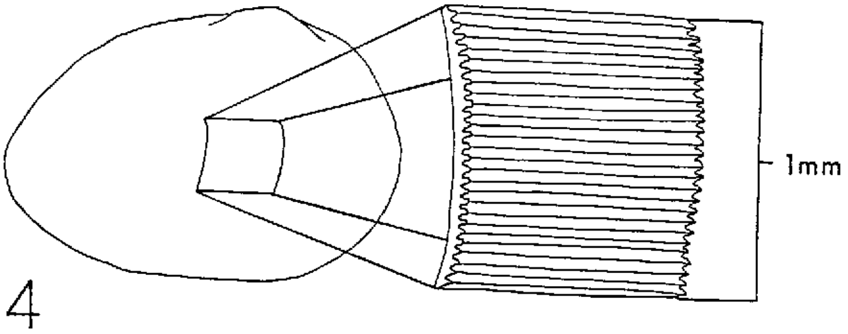

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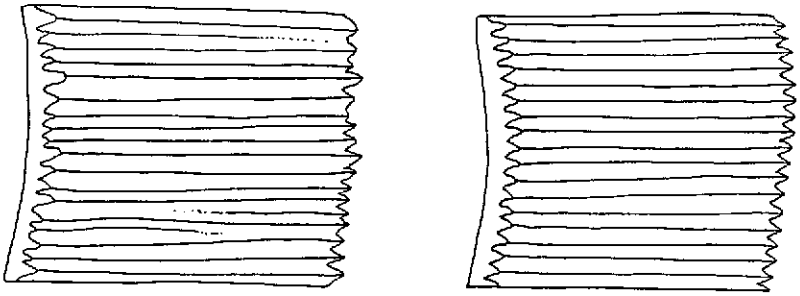

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5b

Figure 3. Method of determining hinge length (a) and relative position of cardinal tooth C3 (b,b1) in pisidiid clams. Figure 4. Method of counting striae on the external shell surface of pisidiids. Figure 5. Morphology of striae in pisidiid clams: (a), coarse and uneven, and (b), coarse and even.

already in practice rely on certain traits to distinguish various species or species groups within the genus. Among these traits are hinge length (relative to shell length), position of the cardinal teeth (relative to the lateral teeth and beaks), and striation of the shell. The major problem in using hinge length is that there is no specific place at either the posterior or anterior extremity of the hinge line that clearly marks the end-point of the hinge. That is, it is not usually apparent whether it extends between the lateral constrictions of the thickened dorsal border or if it runs between the distal end-points of the anterior and posterior lateral teeth. Indecision here on the part of an investigator can lead to variations of up to several tenths of a millimeter. Since the species involved (of Pisidium) are mostly less than five millimeters in total length, such variation in hinge length measurements can substantially affect the hinge length/shell length ratio. Mackie et al. (1980) have advised using the point of convergence of the distal ends of the lateral teeth, which can be interpreted as the constriction of the hinge plate at distal points. For purposes of the present key the hinge length is taken to be the distance between the obvious distal constrictions of the thickened dorsal border of the shell (Fig. 3a). Hinge length and shell length must be measured using an ocular micrometer or grid mounted in a dissecting microscope and done so at the highest possible magnification.

The matter of the position of the cardinal teeth is another case of unclear definition. Nearly all species of Pisidium occurring in Massachusetts have the cardinal teeth placed nearer the anterior lateral teeth than the posterior lateral teeth, whether they are situated directly beneath the beaks or not. Interpretation of cardinal tooth position as used in existing keys (eg., Herrington, 1962; Clarke, 1973; Burch, 1975a; Mackie and Huggins, 1983) is at best subjective and as such is of limited use. In the present key the position of the cardinal teeth is represented by the distance between the cardinal tooth of the right valve (C3) and the anterior lateral teeth (AI and AIII) (Fig. 3b) divided into the distance between the distal border of C3 and the posterior lateral teeth (PI and PIII) (Fig. 3b1).

Shell striation is a character used to differentiate groups of otherwise very similar species. Measurement of the degree of striation is accomplished by counting the number of striae per millimeter occurring in the middle of the external surface of the shell (Fig. 4). Striae must be examined using high magnification and adequate light in order to observe individual, raised striae. The shell should be dry during examination. An additional ratio is used to determine species of Pisidium and this is the maximum height of the shell simply divided by the maximum length of the shell. These measurements are straight forward and require no explanation.

When attempting to identify species of Pisidium it is desirable to have available both a moderate number of specimens of the species (10 or more specimens) and a sample which is known to contain adults. Determination of maturity is easily done by placing live specimens in hot water (not boiling) for a few seconds. The shells will gape and one can then see if the gills contain young clams (Fig. 2b), indicating maturity. Adults of most species of Pisidium inhabiting Massachusetts contain young during the spring and summer months. The heating method will also permit the easy removal of the animal. Removal of the animal from the shell will facilitate examination of gill and mantle morphology.

Eventually, and hopefully, future systematic study of the genus Pisidium will further clarify some of the morphological limits of certain species. Although most recent accounts of Pisidium in North America have maintained the taxonomy of Herrington (1962), a few investigators have treated the genus more conservatively by synonymizing certain established species (eg., Wu, 1978).

A section is provided at the end of the general key that gives brief accounts of the distribution of each species described in the key. The nomenclature and definitions of drainage systems in this section follows Halliwell et al. (1982).

Legend for pictorial key

(NOTE: Endangered, Threatened, and Special Concern listings refer to Massachusetts only.)

1. Shell less than 25 mm in length, specimens with plain beaks and tubular siphons (a) - (Pisidiidae); or with papillate inhalent aperture (b) and strongly ridged beaks (c) - (immature Unionacea).

2. Shell 25 mm or over in length, inhalent aperture papillate (a), shell with color rays (b) or not - (Unionacea).

3. Mantle edges fused (a) forming separate exhalent openings, exhalent aperture without papillae (b).

4. Mantle edges entire, no fusion forming two openings (a), exhalent aperture margin crenulate, shell brownish to black, rayless - (Margaritifera margaritifera).

5. Mantle edges fused (a) forming separate exhalent openings, lower exhalent aperture with minute but distinct papillae (b), shell rayed or not.

6. Dorso-posterior shell surface with series of raised ridges perpendicular to growth lines (a) - (Alasmidonta varicosa, Endangered).

7. Shell wedge-shaped in lateral view, particularly in female, and rarely over 40 mm in length, oblique dorso-posterior ridge present (b), shell usually rayless - (Alasmidonta heterodon, Endangered).

8. Shell elongate-rostrate, pointed posteriorly, females with ventral expansion of shell; mantle darkly pigmented (a), mantle edge with digitiform extensions (b) in both sexes, though more obvious in female - (Ligumia nasuta, Special Concern).

9. Shell either rounded, oval or broadly oval, with a rounded ventral expansion. Shell light colored or rayed, valves swollen.

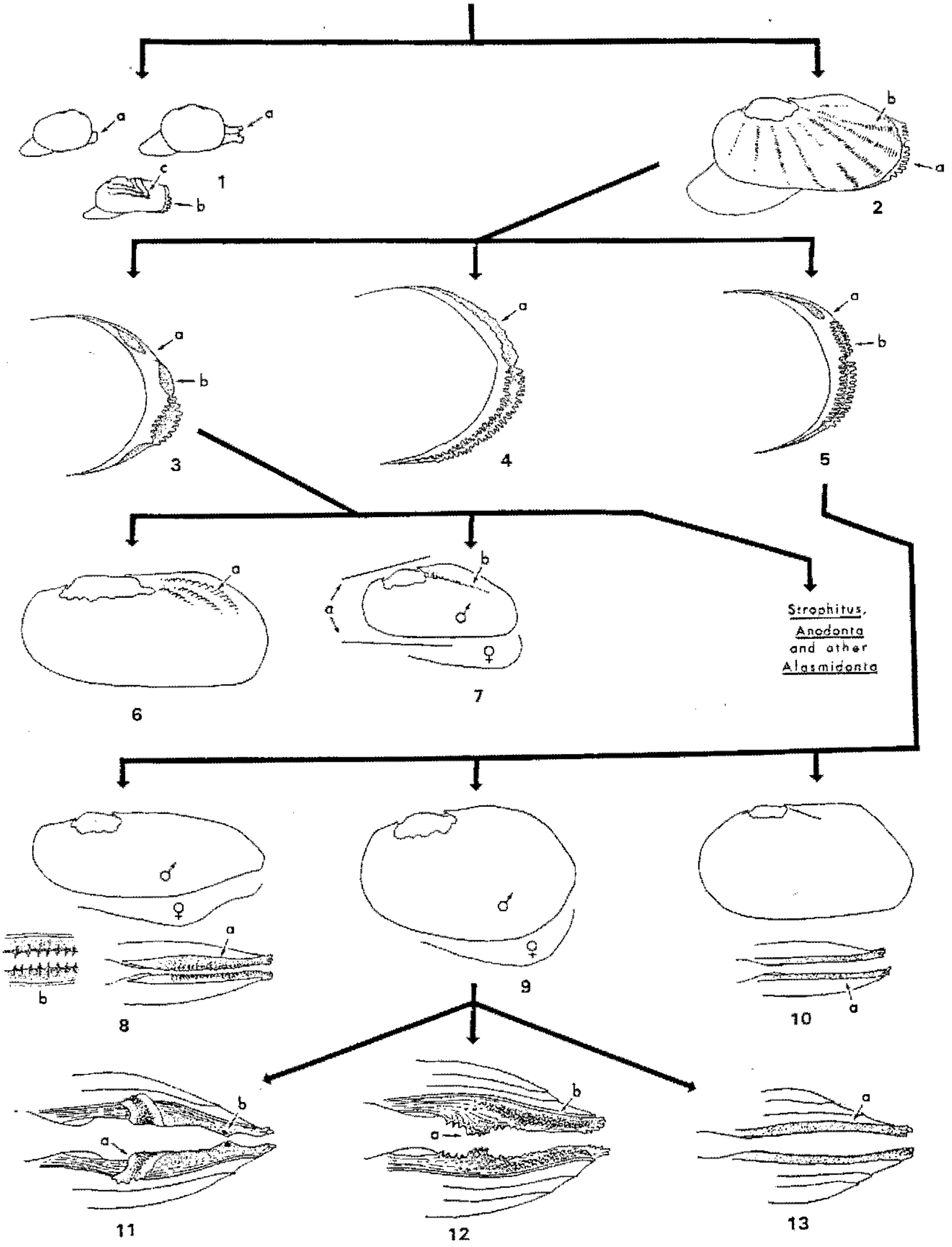
10. Shell either trapezoidal or quadrate to elongate-quadrate, with a straight ventral margin. No sexual dimorphism, valves compressed and usually rayed in younger specimens (<50 mm). Mantle margin (a) greyish without pattern or modification -(Elliptio complanata).

11. Mantle margin smooth with greyish streaks or dots, and with a well developed and brightly pigmented flap-like extension (a); a dark eyespot present (b). Mantle characters most pronounced in female. Shell yellow to yellowish-brown and without rays on disk - (Lampsilis cariosa, Endangered).

12. Mantle margin rough with greyish streaks and a small darkly pigmented flap-like extension (a), and with conspicuous fleshy tubercles (b). No eyespot present. Mantle characters most pronounced in female. Shell yellow, green or brown, often rayed on disk - Lampsilis r. radiata).

13. Mantle margin (a) smooth and greyish, without pattern or modification. Shell copper, pink, or brassy colored, sometimes finely rayed on disk - (Leptodea ochracea, Special Concern).

PICTORIAL KEY TO MASSACHUSETTS UNIONACEANS



GENERAL KEY TO THE UNIONACEA AND CORBULACEA OF MASSACHUSETTS

1a Shell length less than 25 mm 2

1b Shell length equal to or greater than 25 mm........................3

2a (1) Shell beaks without strong ridges extending out onto shell (Fig. 6); siphons, if visible, tubular (Figs. 6,25); gills unequal in size, outer (posterior) gill smaller or absent (Figs. 2b,21,22,33) ......CORBULACEA...14

2b Shell beaks with strong, angular ridges extending out onto shell (Fig. 7), inhalent aperture, if visible, with papillae (Fig. 7); outer gill fully overlapping inner gill (Fig. 2a)......... ....juvenile UNIONACEA (note 1)

3a (1) Shell with well developed pseudocardinal teeth but without lateral teeth (Fig. 8); inner surface of fresh shells containing several small punctations with trails radiating from beaks (Fig. 8); gills without vertical septa (Fig. 2a), separate from mantle posteriorly (Fig. 9) ....MARGARITIFERIDAE ..Margaritifera margaritifera (note 2)

3b Shell with or without pseudocardinal and lateral teeth, no punctations on inner shell surface; gills with vertical septa (Fig. 2a) and attached to mantle posteriorly (Fig. 10) ....UNIONIDAE...4

4a (3) Shell hinge straight or gently curved, without any trace of hinge teeth (Figs. 11,12,13a); beak sculpture, if visible, with double looped ridges (Fig. 13b)..5

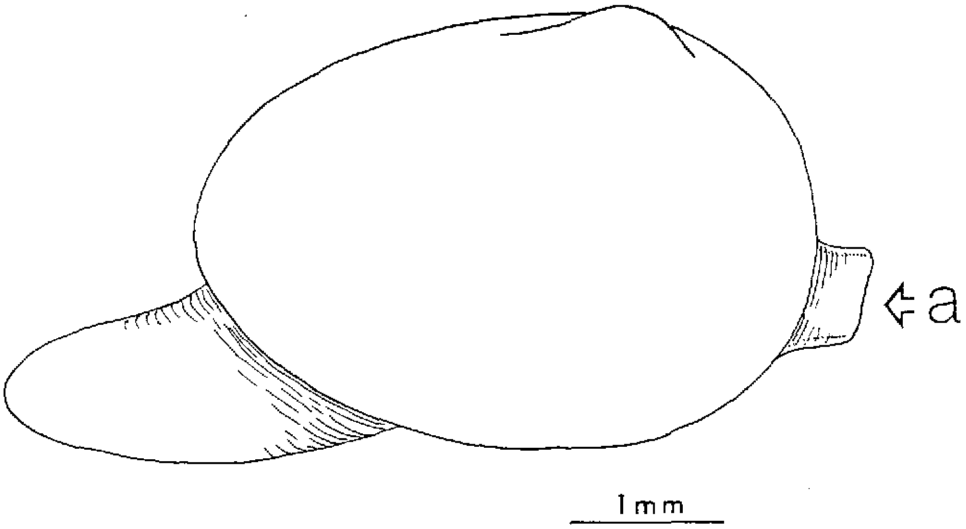
4b Shell hinge uneven, with only a weak or moderate swelling along hinge (Fig. 16a,b) or with well developed hinge teeth (Figs. 13c, e,16c,d); beak sculpture, if visible, consisting of unlooped bars (Fig. 13d)..6

5a (4) Shell of uniform thickness throughout (Fig. 11).................... ....Anodonta c. cataracta

5b Shell with distinct extra-thickening along antero-ventral border (Fig. 12) ....Anodonta implicata (note 3)

6a (4) Shell with distinct pseudocardinal teeth and one (1) lateral tooth in right valve (Figs. 13c,e,14a,15a); ventral mantle margin with patterned pigment and modifications to inner edge (Pictorial key, 8,11,12) or plain (Pictorial key, 10,13); exhalent aperture minutely papillate (Pictorial key, 5b)............................7

6b Shell with pseudocardinal teeth variously developed and without lateral teeth or with two (2) lateral teeth in right valve (Fig. 16a-d); ventral mantle margin plain; exhalent aperture without papillae (Pictorial key 3b)...11



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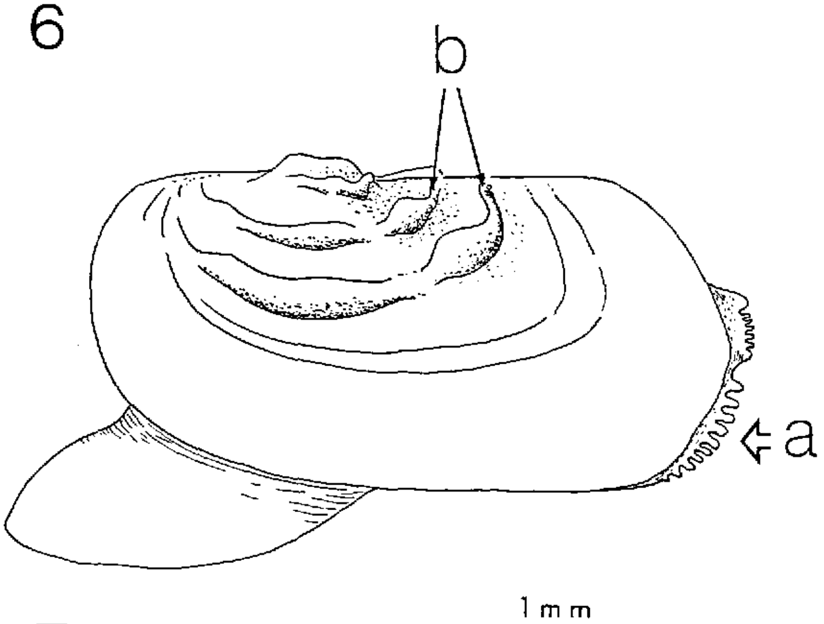

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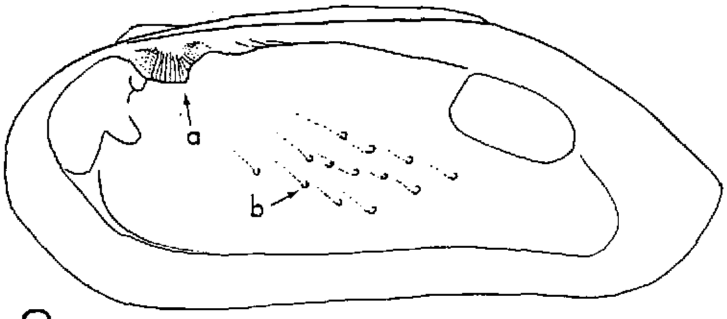
Figure 6. Adult *Pisidium casertanum* (from life), a=anal siphon. Figure 7. Juvenile *Elliptio complanata* (from life), a=inhalent aperture, b=ridges.



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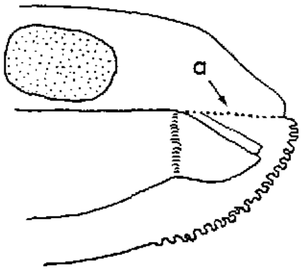

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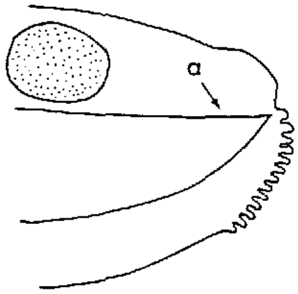

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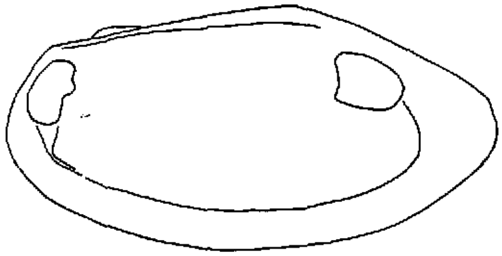

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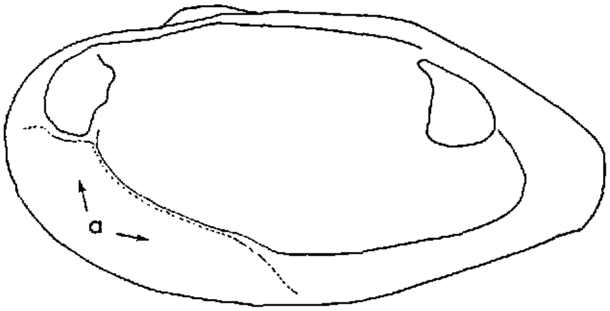

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Figure 8. Internal view of shell of *Margaritifera margaritifera* (actual size) showing pseudocardinal teeth (a) and punctations (b). Figure 9. Posterior gill and mantle morphology of *M. margaritifera* showing free posterior portion of gills (a) (actual size). Figure 10. Posterior gill and mantle morphology of the Unionidae showing attached posterior portion of gills (a) (actual size). Figure 11. Interior of *Anodonta c. cataracta* shell (actual size). Figure 12. Interior of *Anodonta implicata* shell showing area of thickening (a) (actual size).

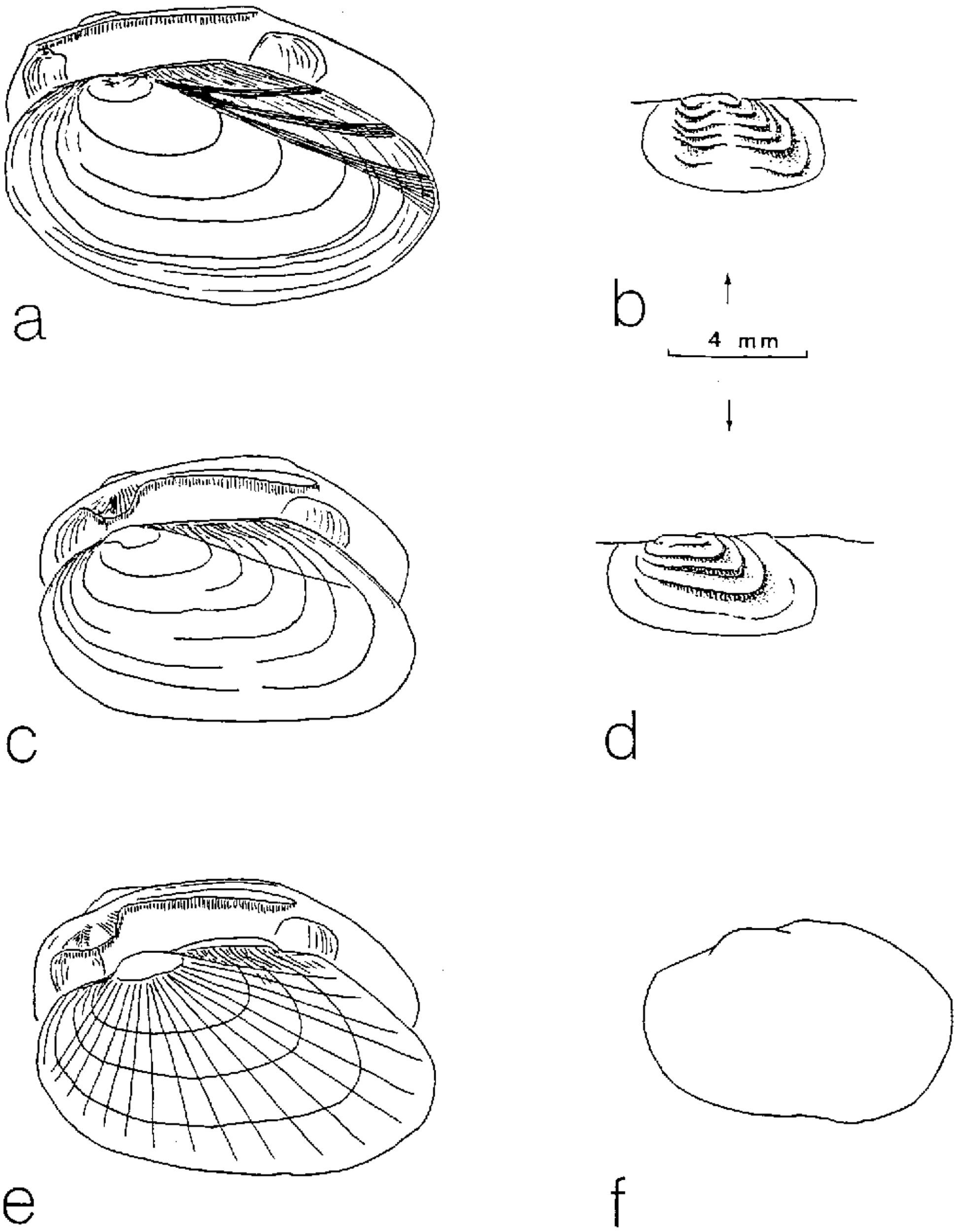
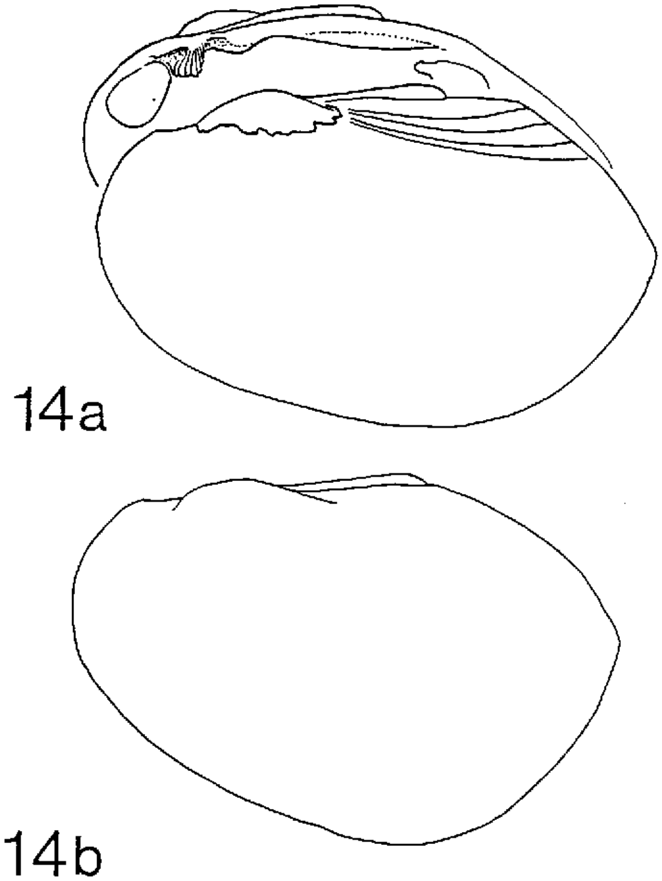


Figure 13. Shells of three of the most common species of Unionidae in Massachusetts: (a), *Anodonta c. cataracta*; (b), beak sculpture of *A. c. cataracta*; (c), *Elliptio complanata*; (d), beak sculpture of *E. complanata*; (e), male *Lampsilis r. radiata*; (f),female *L. r. radiata*. All except b and d are actual size.



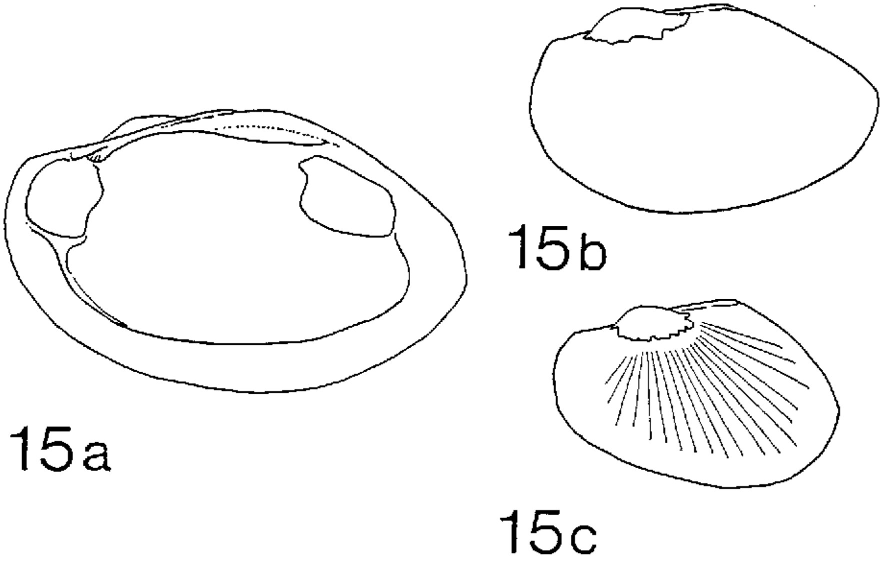


Figure 14. *Lampsilis cariosa* shells: (a), male; (b), female (actual size). Figure 15. *Leptodea ochracea* shells: (a), shell interior; (b), male; (c), female with rayed periostracum (actual size).

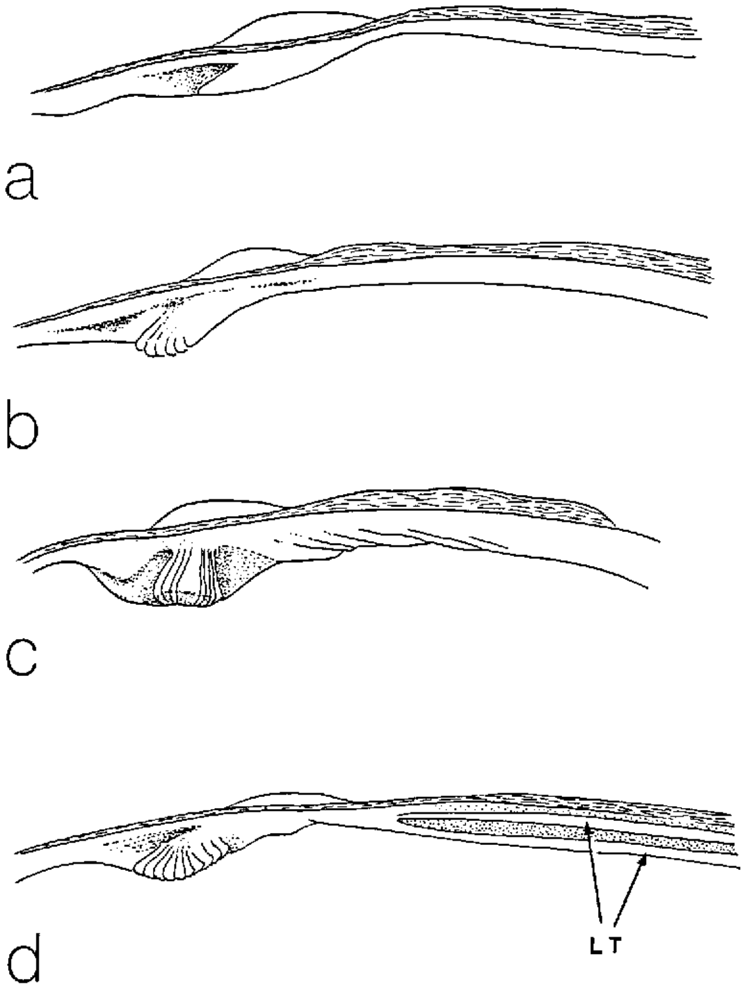
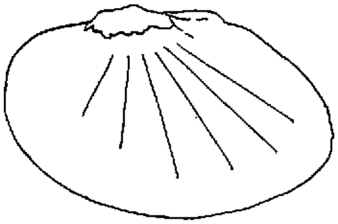


Figure 16. Hinge morphology of four unionid species: (a), *Strophitus undulatus*; (b), *Alasmidonta varicosa*; (c), *A. undulata*; (d), *A. heterodon*. LT=lateral teeth.



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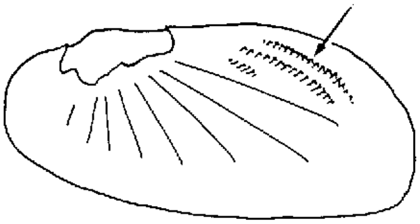

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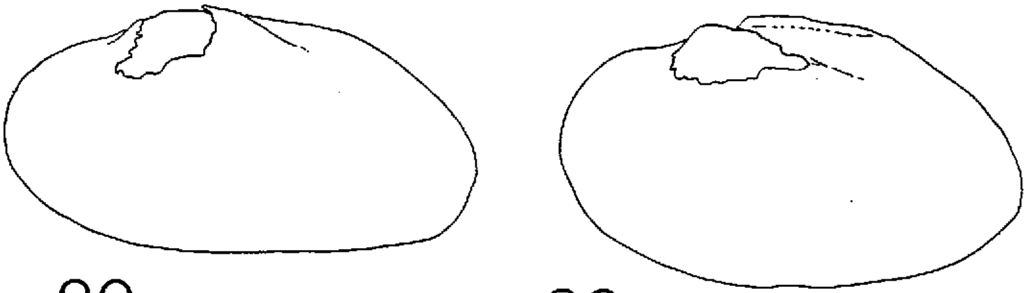
19a

19b



20a

20b

Figure 17. *Alasmidonta undulata* (actual size). Figure 18. *Alasmidonta varicosa* (actual size). Figure 19. *Alasmidonta heterodon*, (a), male; (b), female (actual size). Figure 20. *Strophitus undulatus* shells (a and b) (actual size).

7a (6) Shell trapezoidal, quadrate or elongate quadrate (Figs. 1a,13c) without sexual dimorphism, periostracum rayed in juveniles (<50 mm), brown to black in older specimens; ventral mantle margin plain .... Elliptio complanata

7b Shell rounded (Figs. 13e,14a,b,15a-c) or elongate with pointed posterior (Pictorial key, 8), sexually dimorphic, periostracum rayed or not; ventral mantle margin with patterned pigment and modifications to inner edge or plain 8

8a (7) Shell elongate-rostrate with pointed posterior, periostracum rayed in juveniles and occasionally in adults, otherwise black; ventral mantle margin patterned with ochre and brown, with medially directed extensions (Pictorial key, 8b)...............Ligumia nasuta

8b Shell oval, broadly oval or circular, periostracum rayed or not, color variable but never black; ventral mantle margin patterned, modified, or plain 9

9a (8) Periostracum bright yellow or yellowish-brown, without rays on disc (Figs. 14a,b); ventral mantle margin smooth and patterned with grey, ochre, and cream, with edge modified into a flap and with a distinct eyespot (Pictorial key, 11a,b)........... Lampsilis cariosa

9b Periostracum usually not yellow, or if so with rays on disc; ventral mantle margin not as in 9a 10

10a (9) Periostracum yellowish-green to brown, usually with rays on disc (Fig. 13e); ventral mantle margin patterned with grey, cream, and black, roughened with numerous tubercles, edge modified into a small flap, eyespot absent (Pictorial key, 12a,b) ....Lampsilis r. radiata

10b Periostracum copper, pink, or brassy colored, sometimes with fine rays on disc (Fig. 15a-c); ventral mantle margin plain (Pictorial key, 13)..Leptodea ochracea

11a (6) Pseudocardinal teeth well developed with distinct cusps, lateral teeth absent (Figs. 16c,17).....................Alasmidonta undulata

11b Pseudocardinal teeth without well developed cusps or lateral teeth, or with cusps and two (2) lateral teeth in right valve 12

12a (11) Pseudocardinal teeth developed but delicate, two (2) lateral teeth in right valve (note 4), one in left (Fig. 16d), shell rarely over 40 mm (Fig. 19a,b)........................... Alasmidonta heterodon

12b Pseudocardinal teeth not well developed, no lateral teeth (Fig. 16a,b)..13

13a (12) Pseudocardinal teeth simple swellings along hinge line (Fig. 16a), shell without external sculpturing (Fig. 20a,b)........... ....Strophitus undulatus

13b Pseudocardinal teeth produced as weak knobs with a few serrations (Fig. 16b), shell exterior sculptured with a series of small ridges perpendicular to growth lines (Pictorial key, 6; Fig. 18)...*Alasmidonta varicosa*

14a (2) Shell with beaks central or anterior relative to foot (Figs. 1b, 25-31); animal with two well formed tubular siphons, outer (posterior) gills as high as inner (anterior) gills, juveniles in gills separated by size class (Figs. 21,22); shells usually over 6 mm in length (note 5) 15

14b Shell with beaks posterior relative to foot (Figs. 6,34,43-48); animal with a single well formed siphon (anal), outer (posterior) gill as high or not as high as inner (anterior) gill, or outer gill absent, juveniles in gills not separated into individual size groups (Figs. 2b,33,35-37); shells usually less than 6 mm in length (note 6)..21

15a (14) Shell with a weak longitudinal ridge in center of shell interior (Fig. 23), beaks without "caps" (note 7) (Fig. 28), cusp AIII of anterior lateral teeth reduced, cusps with few, weak tubercles (Fig. 24d)....................*Sphaerium* (*Herringtonium*) *occidentale*

15b Shell without internal longitudinal ridge, beaks with or without "caps," anterior lateral teeth with well developed cusps and many tubercles (Fig. 24a-c) or without tubercles 16

16a (15) Shell delicate and usually with "caps" (Fig. 25) on beaks, anterior lateral teeth without tubercles; adults containing several larvae of different sizes (Fig. 21) .... *Musculium* 17

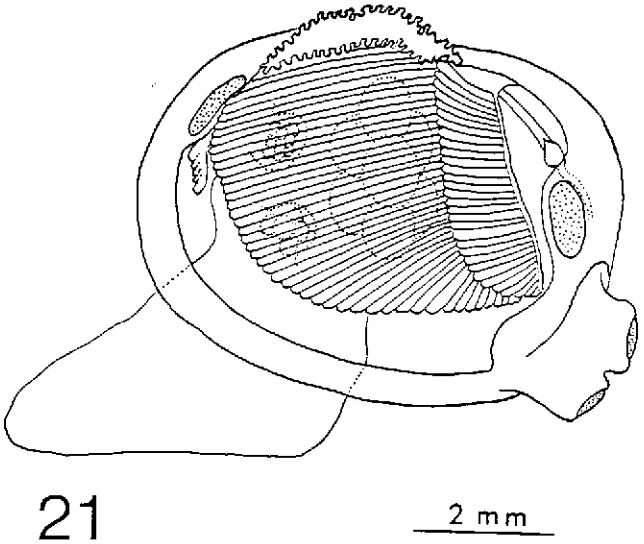
16b Shell strong and without "caps" anterior lateral teeth with well developed tubercles (Fig. 24a-c); larvae of each size class few in number (Fig. 22)..................*Sphaerium* (in part) 19

17a (16) Shell, in lateral view, with ventral margin curving sharply upward anteriorly (Fig. 25), adult shell usually less than 8 mm; occurring in temporary and permanent habitats ....*Musculium securis*

17b Shell with ventral margin evenly curved (Fig. 26a,b), adult shell usually over 8 mm; occurring in temporary and permanent habitats 18

18a (17) Dorsal margin fairly straight, junction of dorsal and posterior margins of shell forming a sharp angle (Fig. 26a,b); typically found in temporary habitats ....*Musculium partumeium*

18b Dorsal margin curved, junction of dorsal and posterior margins rounded (Fig. 27); typically found in permanent habitats .... *Musculium lacustre* (note 8)



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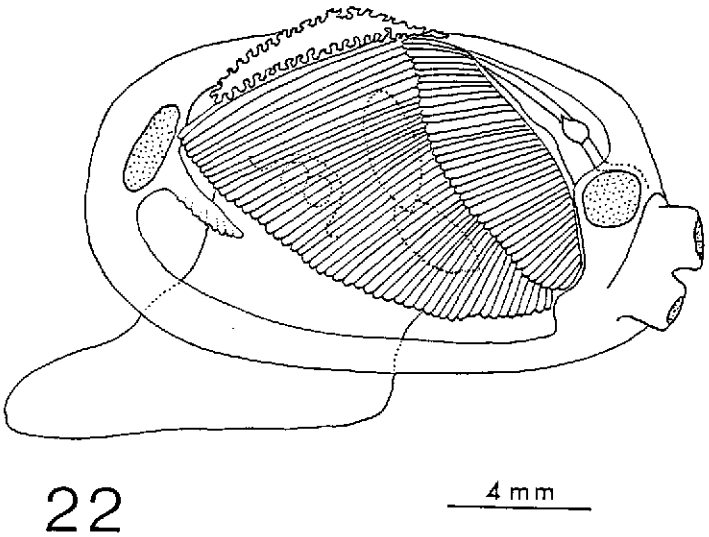

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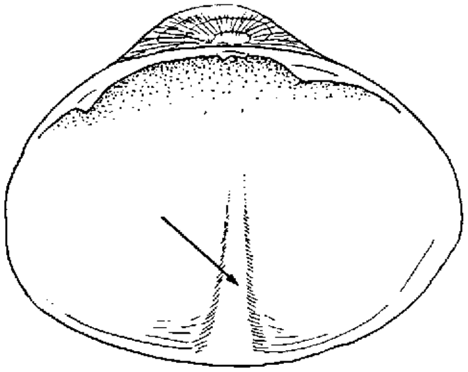
Figure 21. Anatomy of Musculium partumeium showing juveniles in inner gill. Figure 22. Anatomy of Sphaerium simile showing juveniles in inner gill.



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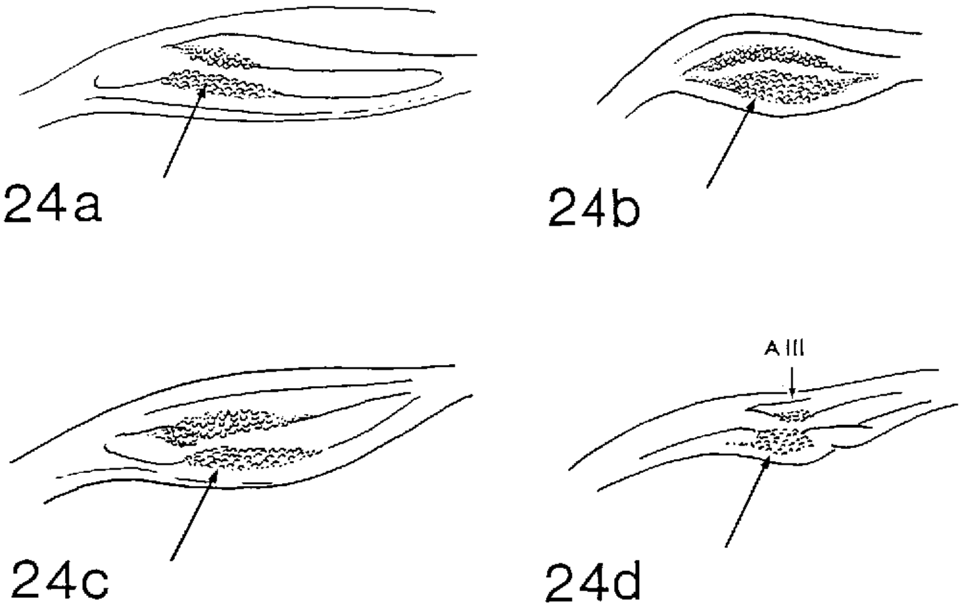


Figure 23. Internal surface of shell of Sphaerium occidentale showing longitudinal ridge (arrow). Figure 24. Anterior lateral teeth (AI and AIII) of four Sphaerium species (X30): (a), S. rhomboideum; (b), S. striatinum; (c), S. simile; (d), S. occidentale. Tubercles indicated by long arrows.

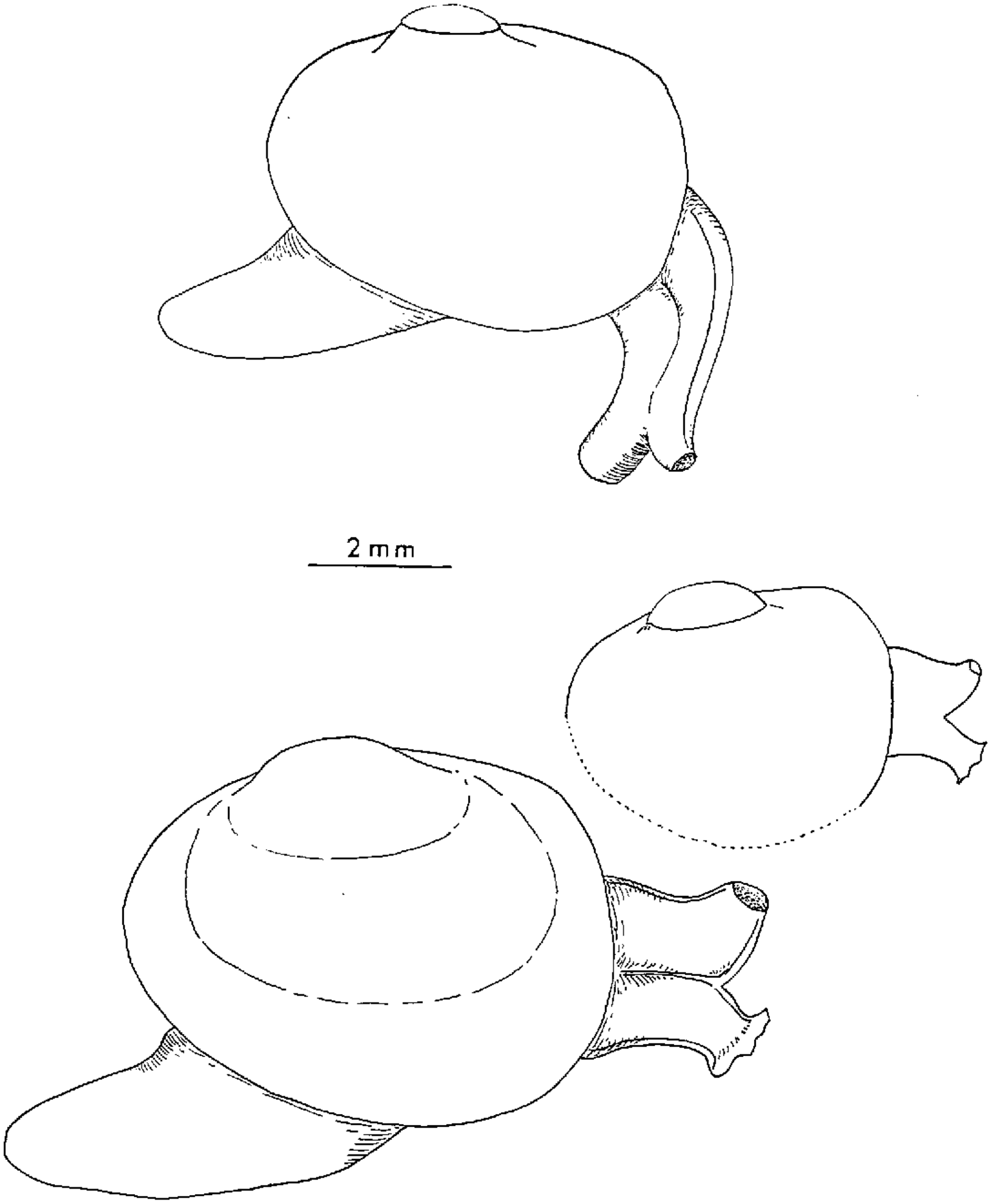
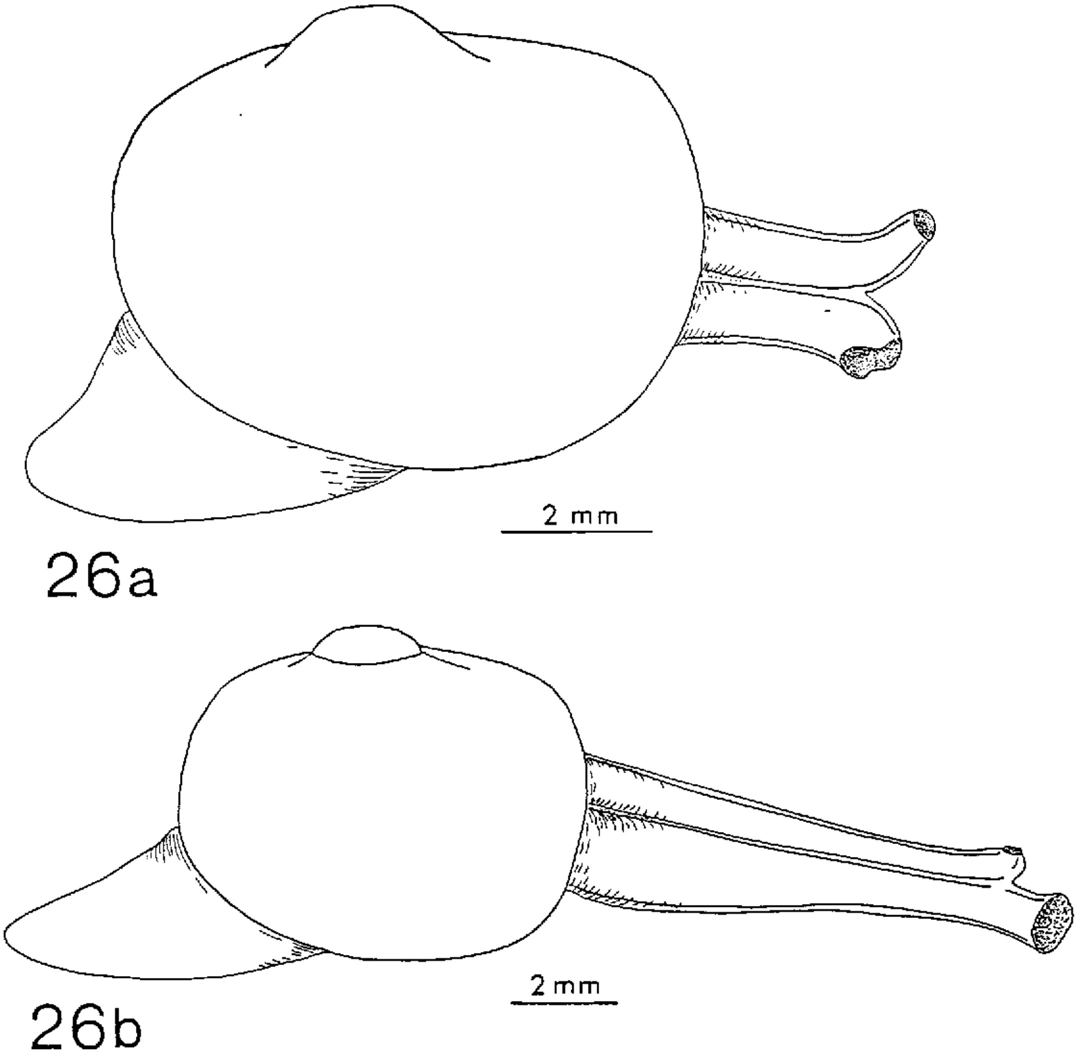


Figure 25. Musculium securis (from life). "Capped" and plain individuals.



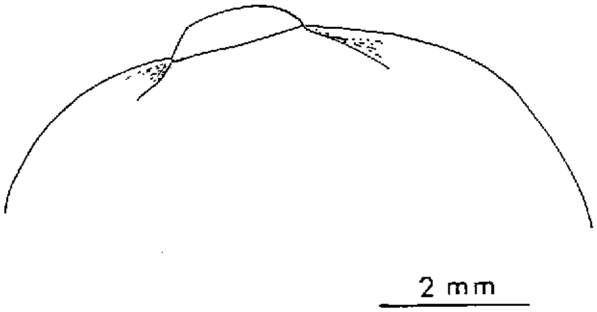


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Figure 26. *Musculium partumeium* (from life); (a), plain; and (b), "capped" individuals. Figure 27. *Musculium lacustre*, hinge and beaks of shell.

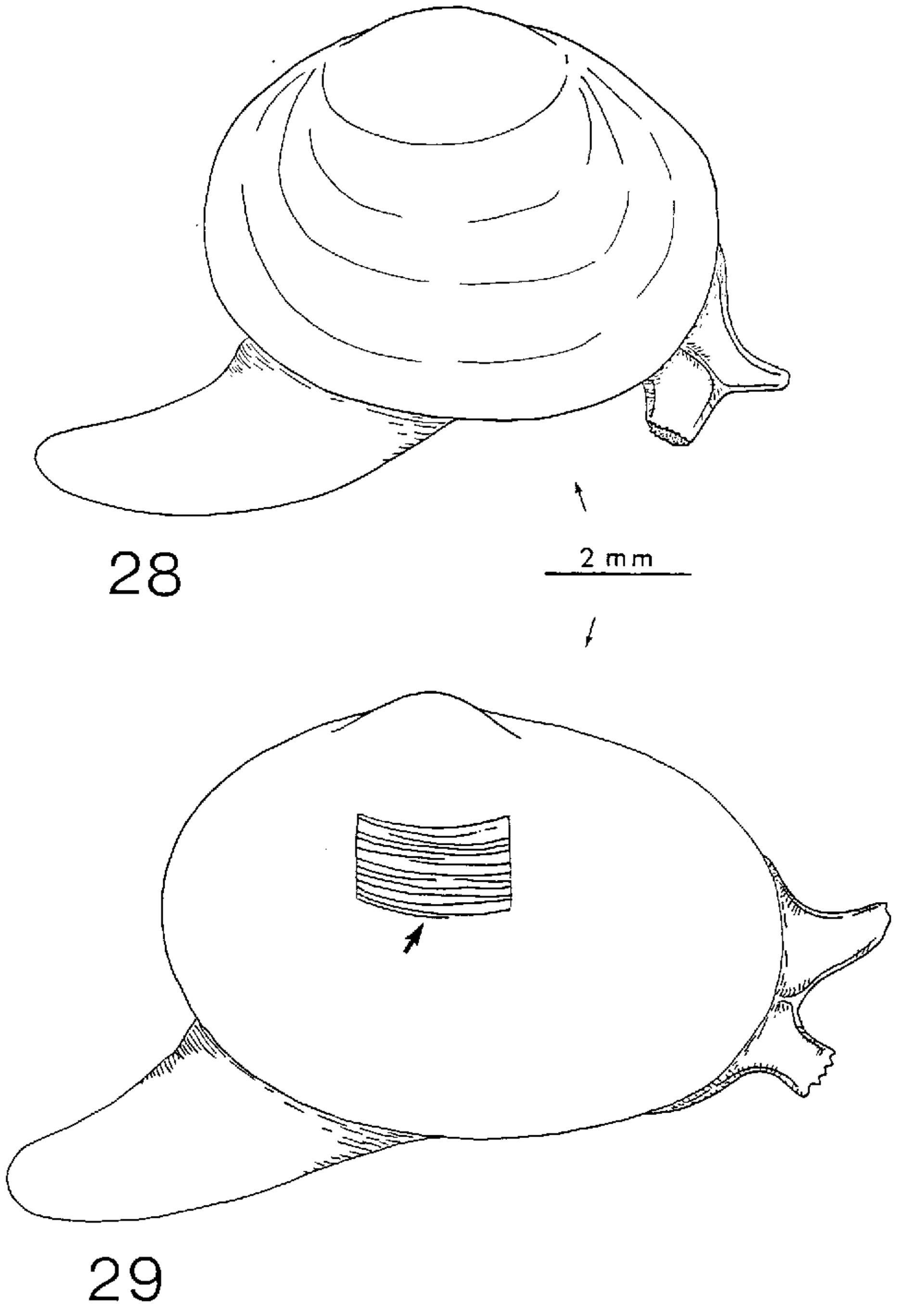
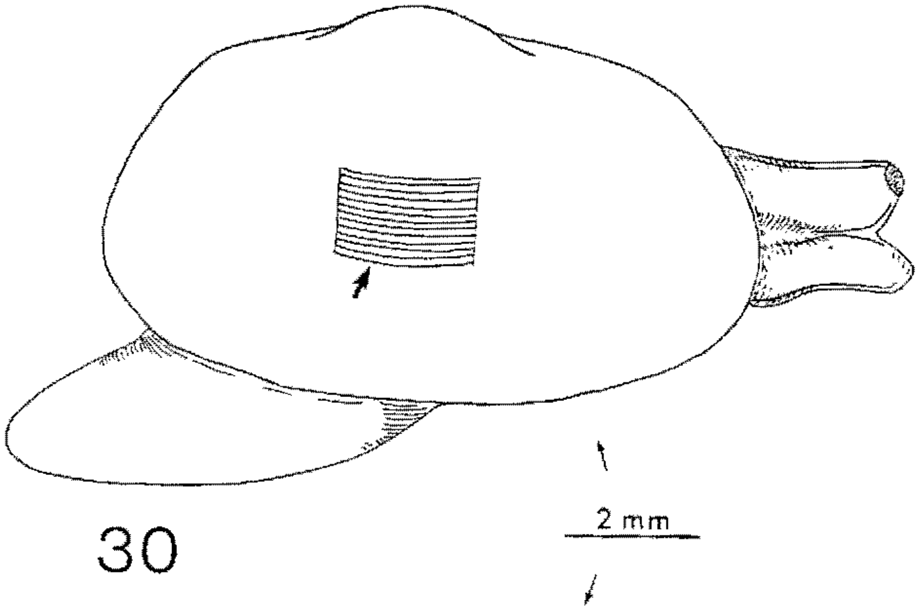


Figure 28. Sphaerium occidentale (from life). Figure 29. Sphaerium striatinum (from life), with example of striae (arrow).



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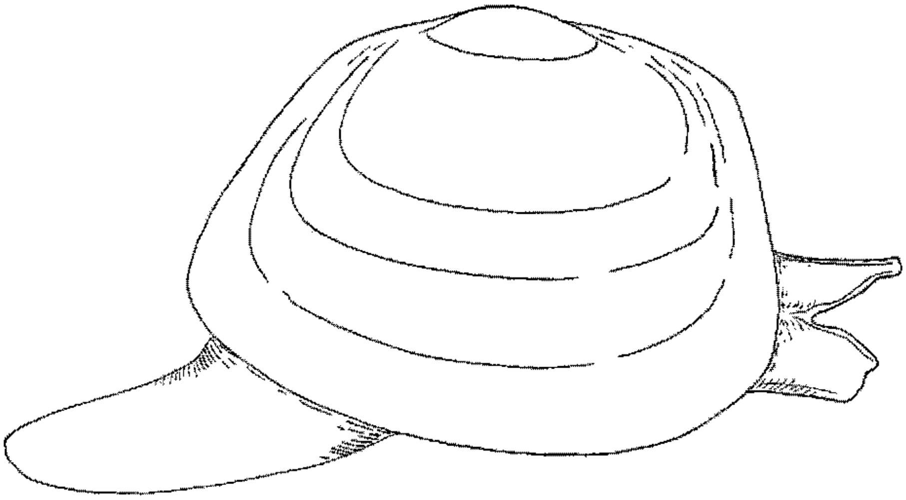

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Figure 30. *Sphaerium simile* (from life), with example of striae (arrow). Figure 31. *Sphaerium rhomboideum* (from life).

19a (16) Tubercles on anterior lateral teeth covering most of the inner surface of each cusp (Fig. 24b), shell with coarse, uneven striae (Figs. 5a,29); typically found in lotic habitats...*Sphaerium striatinum*

19b Tubercles not covering most of inner surface of cusp of each anterior lateral tooth (Fig. 24a,c), striae fine giving the shell a glossy appearance, or if coarse then evenly distributed 20

20a (19) Shell length greater than height, anterior and posterior margins broadly curved (Figs. 1b,30), striae coarse (Figs. 5b,30) ....*Sphaerium simile*

20b Shell length and height subequal, anterior and posterior margins straight (Fig. 31), striae fine ....*Sphaerium rhomboideum*

21a (14) Shell of adult less than or equal to 2 mm in length, mantle without distinct, separate branchial opening (Fig. 32b), outer (posterior) gills absent (Fig. 33)..*Pisidium* (*Neopisidium*) *punctatum* (note 9)

21b Adult shell usually greater than 3 mm, mantle with separate branchial opening (Fig. 32a), outer (posterior) gill present 22

22a (21) Adult shell greater than 6 mm in length (Fig. 34)................ 23

22b Adult shell less than 6 mm in length .... subgenus *Cyclocalyx* (in part) 24

23a (22) Animal with outer (posterior) gill large, as high as inner gill (Fig. 35), typically found in lotic habitats ....*Pisidium* (*Pisidium*) *dubium*

23b Animal with outer (posterior) gills small, half the height of the inner gills (Fig. 36), typically found in lentic habitats ....*Pisidium* (*Cyclocalyx*) *adamsi*

24a (22) Shell with beaks flattened and dish-like (Fig. 40a,b), anterior lateral teeth and sulcus curved towards inner part of shell (Fig. 41a,b)... *Pisidium fallax*

24b Shell beaks and anterior teeth not as in 24a. (Fig. 42a,b) 25

25a (24) Mean length of hinge in sample equal to or less than 3/4 length of shell (see Fig. 3) 26

25b Mean length of hinge in sample greater than 3/4 length of shell (see Fig. 3) 29

26a (25) Shell beaks with flange-like ridges oblique to shell axis (Fig. 38) ....*Pisidium henslowanum*

26b Shell beaks without ridges 27

27a (26) Mean height of shell in sample about 85% or less of shell length, beaks narrow and well posterior (Fig. 6) .... Pisidium casertanum (note 10)

27b Mean height of shell in sample about 90% or greater of shell length, beaks broad (Figs. 43,48) 28

28a (27) Periostracum shiny, sulcus between the posterior lateral teeth (PI,PIII) rounded (closed) anteriorly (Fig. 43) .... Pisidium ventricosum

28b Periostracum dull, sulcus between the posterior lateral teeth (PI,III) typical, not rounded anteriorly (Fig. 42a) .... Pisidium walkeri (note 11)

29a (25) Shell beaks with low heavy ridges parallel to shell axis (Figs. 39,45) .... Pisidium compressum

29b Shell beaks without ridges 30

30a (29) Mean height of shell in sample about 87% or less of shell length, maximum shell length =<3 mm, mean bl/b (see Fig. 3) >2 beaks not pronounced (Figs. 44,47) 31

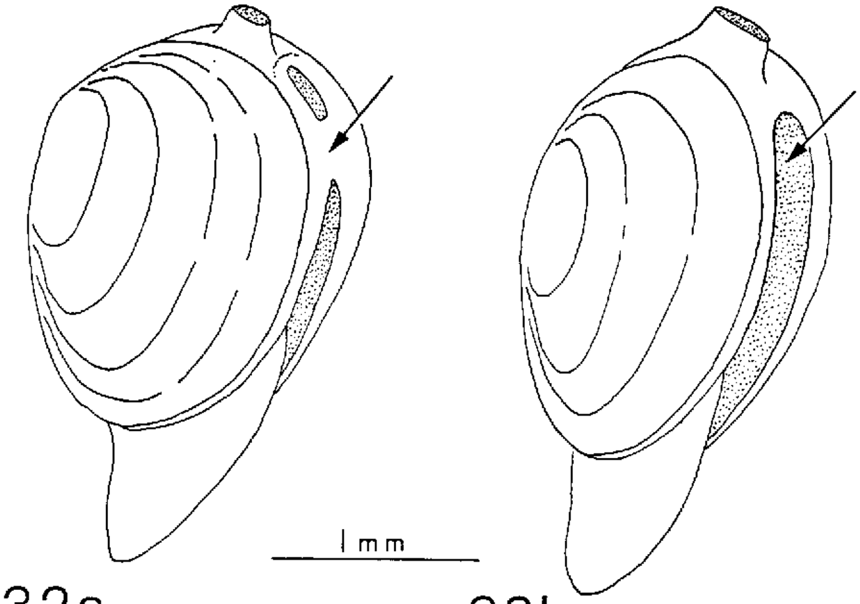
30b Mean height of shell in sample about 90% or greater of shell length, maximum shell length =>3 mm, mean bl/b (see Fig. 3) <2, beaks very pronounced (Fig. 46) or not (Figs. 44,47) 32

31a (30) Posterior slope of shell somewhat straight, not rounded, and directed vertically or slightly anteriorly (Fig. 47) .... Pisidium nitidum

31b Posterior slope of shell rounded, not as in 31a (Fig. 44) .... Pisidium ferrugineum

32a (30) Beaks pronounced, posterior slope directed posteriorly (Fig. 46) .... Pisidium variabile (note 12)

32b Beaks not pronounced, posterior slope directed vertically or slightly anteriorly (Fig. 47) .... Pisidium nitidum (note 13)



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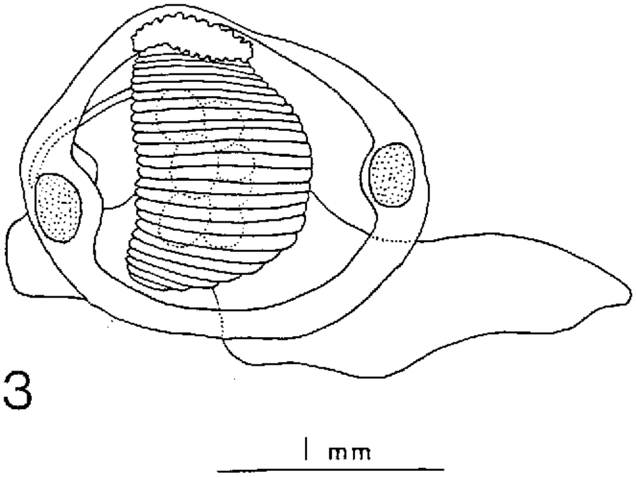

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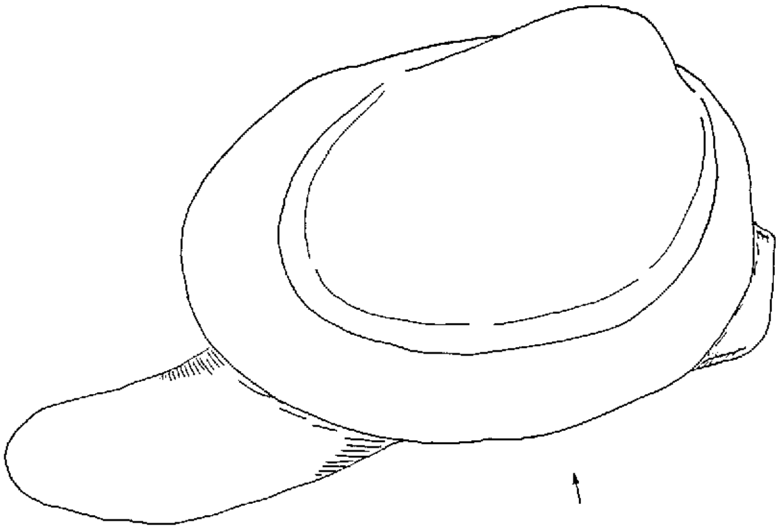
Figure 32. *Pisidium* (s.l.) spp. mantle anatomy: (a), subgenera *Pisidium* and *Cyclocalyx*; and (b), *Neopisidium*. Note lack of fusion of mantle to form separate branchial opening in *Neopisidium* (arrow). Figure 33. Anatomy of *Pisidium punctatum*.



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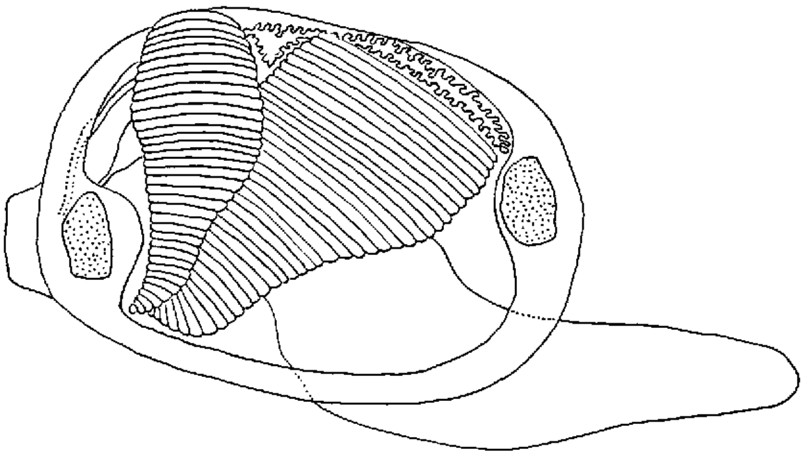

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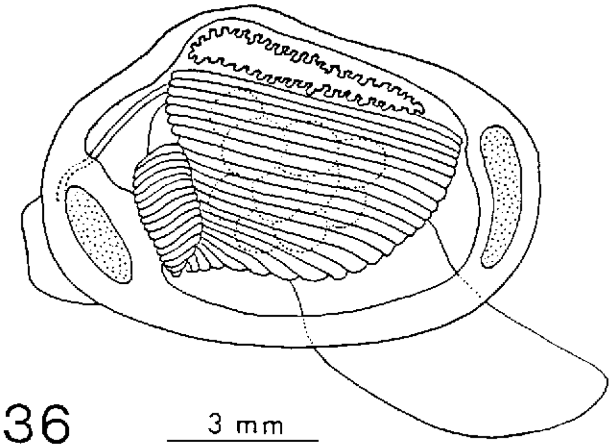
Figure 34. *Pisidium dubium* (from life). Figure 35. Anatomy of *Pisidium dubium*.



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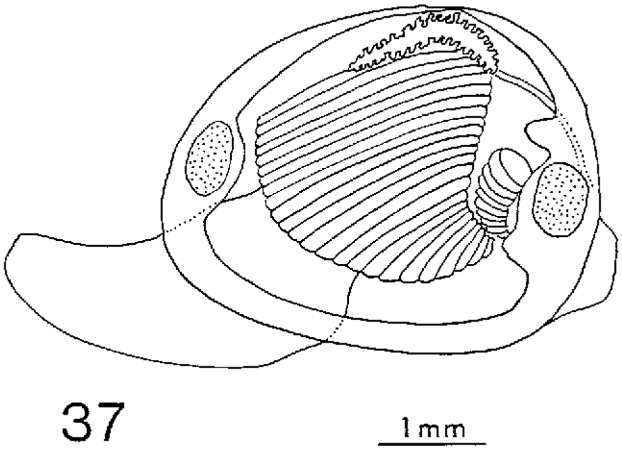

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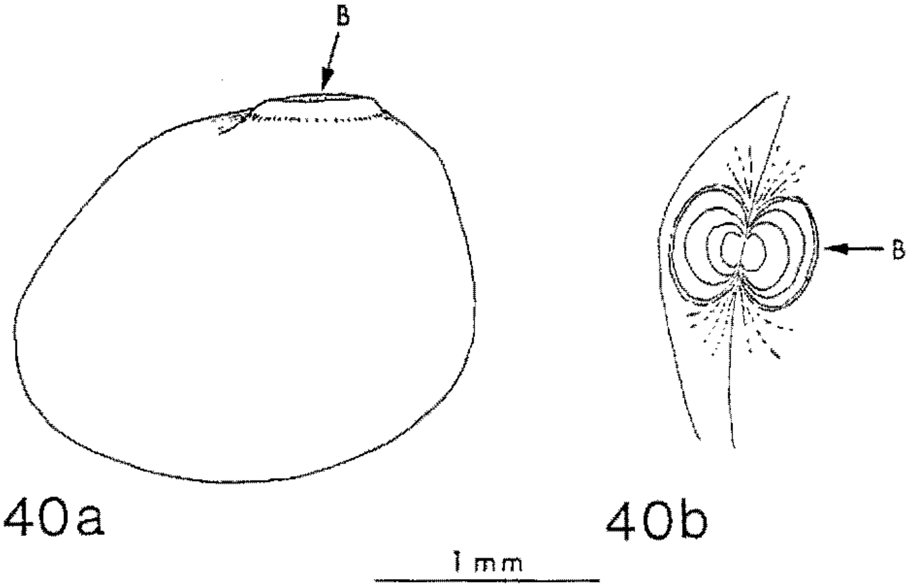
Figure 36. Anatomy of *Pisidium adamsi*. Figure 37. Anatomy of *Pisidium nitidum*. Figure 38. Beak of *Pisidium henslowanum*. Arrow denotes ridge. Figure 39. Beak of *Pisidium compressum*. Arrow denotes ridge.



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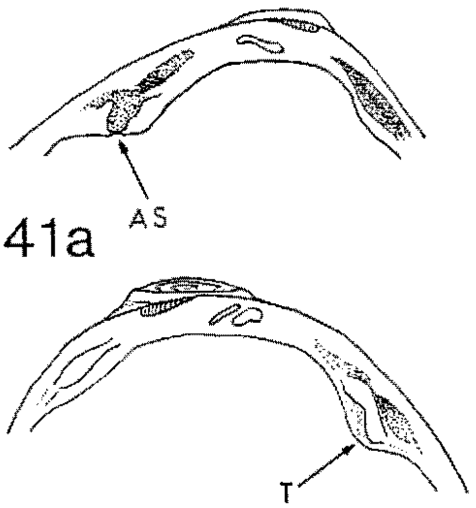

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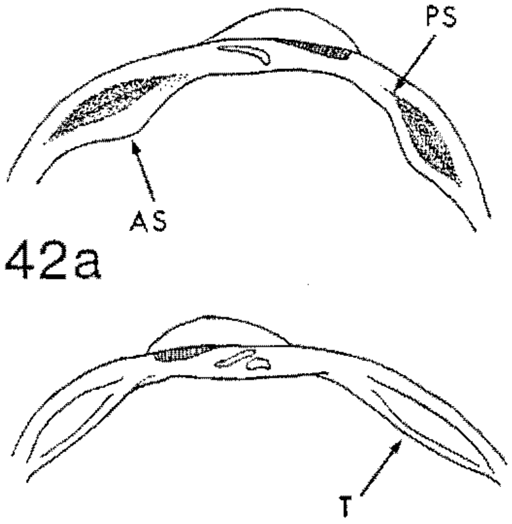

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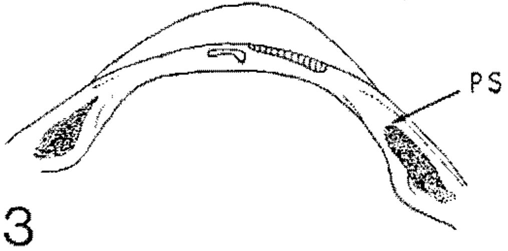

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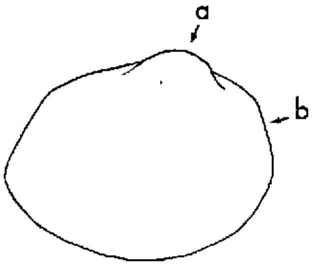
Figure 40. Shell of Pisidium fallax (cotype, MCZ 88389, Ohio): (a), lateral view of shell; (b), "dorsal" view of beaks (B). Figure 41. Hinge of (a), right, and (b), left valves of Pisidium fallax. AS=anterior sulcus (shaded), T=lateral tooth. Figure 42. Hinge of (a), right, and (b), left valves of Pisidium ferrugineum. AS=anterior sulcus (shaded, PS=posterior sulcus (shaded), T=lateral tooth. Figure 43. Hinge of right valve of Pisidium ventricosum. PS=posterior sulcus (shaded). Scale line applies to figures 40 to 43.



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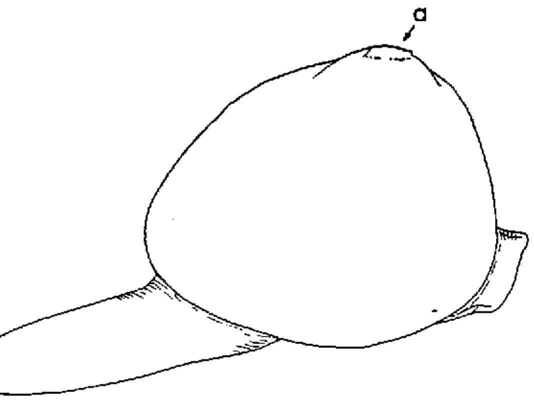

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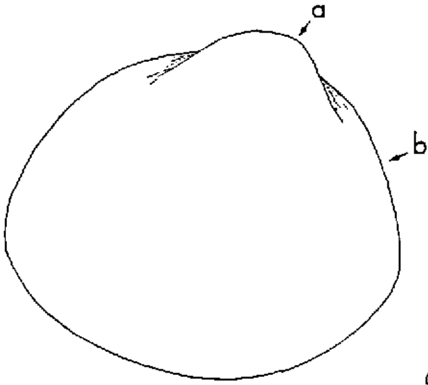
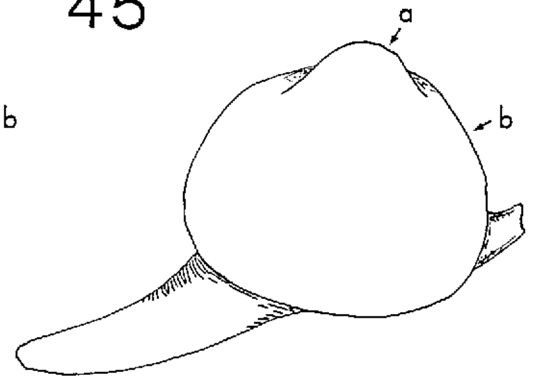
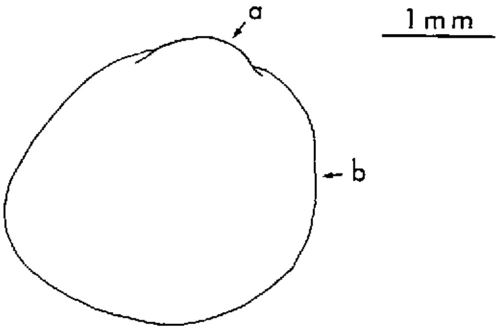


46a



46b



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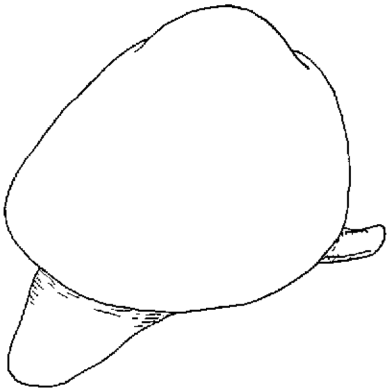

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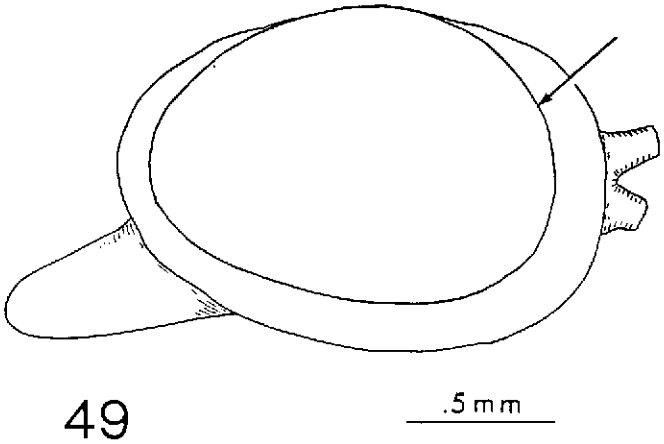
Figure 44. Shell of *Pisidium ferrugineum*. Figure 45. *Pisidium compressum* (from life). Figure 46. *Pisidium variabile*; (a), shell, and (b), from life. Figure 47. Shell of *Pisidium nitidum*. Figure 48. *Pisidium walkeri* (from life). Scale line applies to figures 44 to 48; a=beak, b=posterior shell border.



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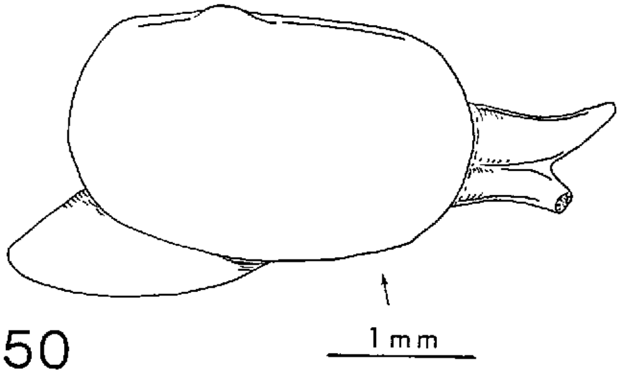

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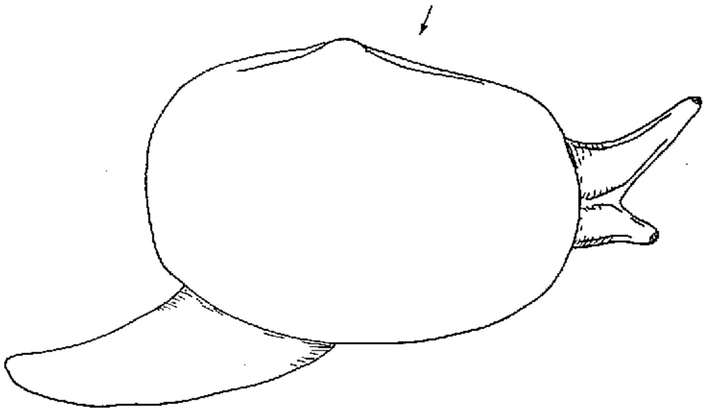

51

Figure 49. Juvenile <u>Musculium</u> <u>partumeium</u> (from life), arrow denotes margin of nepionic shell characteristic of <u>Musculium</u> species ("cap" in adults). **Figure 50.** Juvenile <u>Sphaerium</u> <u>simile</u> (from life). **Figure 51.** Juvenile <u>Sphaerium</u> <u>striatinum</u> (from life).

Notes in key

1. User may continue with 3a, but juveniles are difficult to identify to species.

2. Unlike most unionids, *M. margaritifera* never contains color rays anywhere on the shell at any time during its life. In young specimens the periostracum is brown, in older adults it is black.

3. These two species of *Anodonta* can be further distinguished by their geography (see page 42) and by larval morphology (see Rand and Wiles, 1982).

4. In *A. heterodon* the upper lateral tooth in the right valve is sometimes obscured by wear along the hinge. Other characters distinguishing this species are its wedge shape and well developed dorso-lateral ridge (Pictorial key, 7).

5. Young *Musculium* and *Sphaerium* (shell length 2-4 mm) can always be distinguished from *Pisidium* spp. by the anal and branchial siphons (in live specimens) and the central or anterior position of the beaks (Figs. 49-51). The shells of juveniles tend to be whitish and translucent, and in young *Musculium* the raised nepionic shell is often clearly seen (Fig. 49).

6. *Pisidium dubium* and *P. adamsi* are the only two pisidiids in Massachusetts normally over 6 mm in length.

7. "Caps" or calyculate beaks are typical of most species of *Musculium*. They are also occasionally present in *Pisidium casertanum*. They are usually found on specimens living in temporary habitats.

8. *Musculium lacustre* and *M. partumeium* are very similar and may be difficult to separate. Both species can be found together. In their key, Mackie et al. (1980) indicate that the lateral teeth in *M. partumeium* do not extend beyond the angle between the dorso-anterior and dorso-posterior borders of the shell whereas in *M. lacustre* they do. Additionally, Mackie and Huggins (1983) state that the capped beaks of *M. lacustre* are "directed toward each other" unlike *M. partumeium* in which they are vertical.

9. Juvenile pisidiids of other subgenera may key out here on the basis of shell size alone. However, shells of juvenile *Cyclocalyx* and *Pisidium* (s.s.) are usually translucent and have undeveloped beaks.

10. The rare *P. lilljeborgi* is very similar to *P. casertanum* in having a short and usually slender hinge and has about the same or slightly higher height/length ratio as *P. casertanum* (Clarke, 1973; Mackie and Huggins, 1983). *Pisidium lilljeborgi* tends to have coarser striae (<20 per mm) (Burch, 1975a) (see Fig. 4 for method of counting) and is most often found in very fine sand or silt of clean, undisturbed upland lakes or ponds.

11. Both *P. ventricosum* and *P. walkeri* are very similar but can be diagnosed additionally by the extreme inflation of the shell of *P. ventricosum*, so much so that Wu (1978) synonymized this species with *P. milium*, a greatly inflated species presently not known from Massachusetts.

12. *Pisidium equilaterale* keys out here as well. The species can be confidently distinguished from *P. variabile* only by experienced investigators. According to Burch (1975a) the beaks are "subcentral" in *P. equilaterale* and "posteriorly placed" in *P. variabile*.

13. *Pisidium nitidum* can be separated from *P. variabile* (and *P. equilaterale*) additionally by having more than 40 striae per mm (see Fig. 4 for method counting), while the latter species have less than 30 per mm (Burch, 1975a). Actually, Massachusetts' specimens of *P. variabile* typically have up to 35 striae per mm.

DISTRIBUTION OF MASSACHUSETTS' FRESHWATER BIVALVES

UNIONACEA

Margaritifera margaritifera

Relatively common in small to medium sized streams of the Connecticut drainage system, but uncommon in the Merrimack drainage system where it has been historically known from the Concord River, Shawsheen River and Merrimack River basins, possibly still extant in the Nashua River basin. A few relict populations may persist in the Charles River basin (Boston Harbor drainage), otherwise the species is absent from the southeastern coastal regions (Cape Cod) and the Housatonic River and Hudson River drainage systems. This species is confined to moderate gradient streams.

Elliptio complanata

Probably the most common and widespread mussel species in the state. Potentially occurring in any permanent water body biologically, chemically and physically able to support mussel populations.

Alasmidonta heterodon

Formerly distributed in many streams and rivers in the eastern and central parts of the state. Now almost extinct, probably confined to only a few streams in the Connecticut River drainage system. A few populations may still occur in the Merrimack River, Mount Hope Bay and Boston Harbor drainage systems. Historically absent from the Housatonic and Hoosic drainage systems in Massachusetts. This species does not live in standing water.

Alasmidonta undulata

Found in most drainage systems of the state, but no longer common. Occurs in most permanent types of aquatic habitats.

Alasmidonta varicosa

Confined to low lying streams and natural ponds of most major drainages in the state. This species has never been common, so its exact distribution in the state remains unclear. Most populations have been reported from the Connecticut River, Merrimack River and Boston Harbor drainage systems. This species is probably declining as some historical populations no longer exist.

Anodonta c. cataracta

Very common and occurring in every drainage system in the state. This species prefers standing or slow moving water and is often the only species found in impounded sections of streams and rivers. It is the only species known from the Hoosic River drainage system in Massachusetts.

Anodonta implicata

Historically confined to streams, rivers and natural ponds draining to the sea in coastal drainages of the state. This species is expanding its range in the Connecticut River basin where it is common and the Merrimack River drainage system.

Strophitus undulatus

Lives in almost every drainage system in the state. Ranging from common in some Connecticut River drainages to uncommon or rare elsewhere. Found in both lotic and lentic environments.

Ligumia nasuta

Uncommon in natural "Great" ponds and lowland streams of most of the coastal drainage systems and the Connecticut River basin.

Leptodea ochracea

Known only from "Great" ponds in the South Shore, Buzzards Bay, and Cape Cod coastal drainage areas.

Lampsilis cariosa

In the past, found in both the Merrimack and Connecticut Rivers. Now occurring only in the latter where it is rare. The species is probably close to extinction in Massachusetts.

Lampsilis r. radiata

Present in all drainage systems in the state except the Hudson and Housatonic River drainages. Occurs in most permanent habitats, but prefers larger streams and natural ponds. Large populations are found in many "Great" ponds in the southeastern portion of Massachusetts.

CORBULACEA

(The ranges of most species of this group in Massachusetts are poorly known and the following accounts are undoubtably incomplete. Specific records are from the University of Massachusetts Department of Zoology or the Museum of Comparative Zoology, Harvard University.)

Sphaerium occidentale

An inhabitant of woodland ponds which are subject to periodic drying. The species is presently known in Massachusetts from only the Connecticut River drainage system, but is probably more widespread. The species is typically found alone.

Sphaerium rhomboideum

Widely distributed but uncommon in Massachusetts. Found in permanent habitats in company with *S. simile*.

Sphaerium simile

Locally abundant in most drainage systems of the state. Particularly numerous in backwaters of slow streams and river impoundments.

Sphaerium striatinum

In Massachusetts this species is found in lotic habitats, including streams and rivers, in most drainage systems. The species can be locally abundant at certain localities.

Musculium lacustre

Historically widespread, especially in the eastern portions of the state. Apparently uncommon in western Massachusetts.

Musculium partumeium

Found throughout the state and most frequently encountered in temporary (vernal-autumnal) ponds and flood plain pools of larger streams.

Musculium securis

A common and ubiquitous species occurring in most aquatic habitats including permanent and temporary ponds and streams. Often found in company with species of Pisidium and M. partumeium.

Pisidium dubium

Known in Massachusetts only from the Connecticut River basin. Generally, this species is found in flowing water.

Pisidium adamsi

An uncommon species, the only records are from the Coastal and Boston Harbor drainage systems in the east and the Housatonic River drainage system in the western part of the state.

Pisidium casertanum

The most common and widespread pisidiid clam in Massachusetts. Found in virtually all aquatic habitats, natural or manmade. This species is amphibious as well and is frequently found living in the damp soils of stream banks and in moist leaf litter of dry vernal pond basins.

Pisidium compressum

Very common in permanent waters in all drainages in the state. Pisidium compressum shows no particular preference for specific habitats.

Pisidium equilaterale

Historically reported from several drainages in the eastern part of the state. The species has not been collected from central or western Massachusetts. Pisidium equilaterale seems to be confined to permanent standing water.

Pisidium fallax

Very rare in Massachusetts, reported only from the town of Groton (Nashua River basin).

Pisidium ferrugineum

A common species found in most drainages in the state. The species occurs in both lotic and lentic habitats, and is often found in river impoundments.

Pisidium henslowanum

In Massachusetts this species is known, so far, only from the Connecticut River.

Pisidium lilljeborgi

Reported by Herrington (1962) as occurring in Massachusetts. Most likely a very rare species in the state and probably confined to waters which remain cool throughout the summer.

Pisidium nitidum

This species has been reported from drainages in eastern Massachusetts. It is apparently rare in western parts of the state. Of the morphologically similar species *P. equilaterale*, *P. nitidum* and *P. variabile* in Massachusetts, *P. nitidum* is probably the most common.

Pisidium variabile

The distribution of this species is similar to *P. equilaterale* except that *P. variabile* is known from western drainages as well.

Pisidium ventricosum

An uncommon species in eastern Massachusetts. The species has not been collected from other parts of the state.

Pisidium walkeri

Rare in Massachusetts; among the few records is Stockbridge Bowl (Lake Mahkeenak) in the Housatonic River drainage system. Possibly occurring in other hardwater (calcium rich) lakes and ponds in western Massachusetts.

Pisidium punctatum

The only records for this species in the state are from Wareham (Buzzards Bay drainage area) and the Connecticut River in Longmeadow.

GLOSSARY OF TERMS USED IN KEY

Aperture. In bivalves any one of two or three openings formed by the lobes of the posterior mantle margin.

Beak. Rounded prominence of the shell valve extending above the hinge line.

Branchial. The aperture opening most ventral on the animal through which inhalent water passes.

Cusp. A distinct swelling or prominence of a hinge tooth.

Foot. A fleshy muscular extension of the body, projected antero-ventrally and used for digging and locomotion.

Gill. Flat plate-like organ situated on either side of the foot and used primarily for food gathering, brooding of young, and respiration.

Hinge. The point of articulation of the shell valves, typically elongate and the area of the shell containing the teeth.

Lateral teeth. Elongate lamellar hinge teeth extending away from the beak of each valve. The lateral teeth of each valve interlock and assist in the articulation process of the two valves.

Mantle. The fleshy lining of the inner surface of the valves, thickened along the ventral margin and involved with forming either the apertures or siphons.

Papillae. fleshy tubercles in the apertural region of the mantle.

Periostracum. The thick fibrous external coating of the shell, often colored.

Pseudocardinal teeth. Thick and often massive hinge teeth located below and slightly anterior to the beaks of species of the Unionidae and Margaritiferidae only.

Ray. A colored stripe on the shell exterior (periostracum) of species of the Unionidae.

Septa. Vertical strips of muscular tissue visible as parallel light colored lines within the gill.

Shell. Hard external covering of the animal, in two parts in bivalves.

Siphon. A tubular extension of the posterior mantle margin which functions as a pathway for water either to or from the animal, characteristic of only pisidiid species in this manual.

Striae. Raised concentric and parallel lines on the shell exterior.

Tubercles. On the cusps of hinge teeth, small cone-like projections. On the mantle margin, large fleshy extensions of the mantle.

Valve. One of two articulating parts of the bivalve shell.

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