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A publication of the
New York State College of Agriculture,
a unit of the State University,
at Cornell University,
Ithaca, New York

Received for publication October 10, 1958

MEMOIR 367
OCTOBER 1959

The Freshwater Mussels of Central New York

With an Illustrated Key to the Species of Northeastern North America

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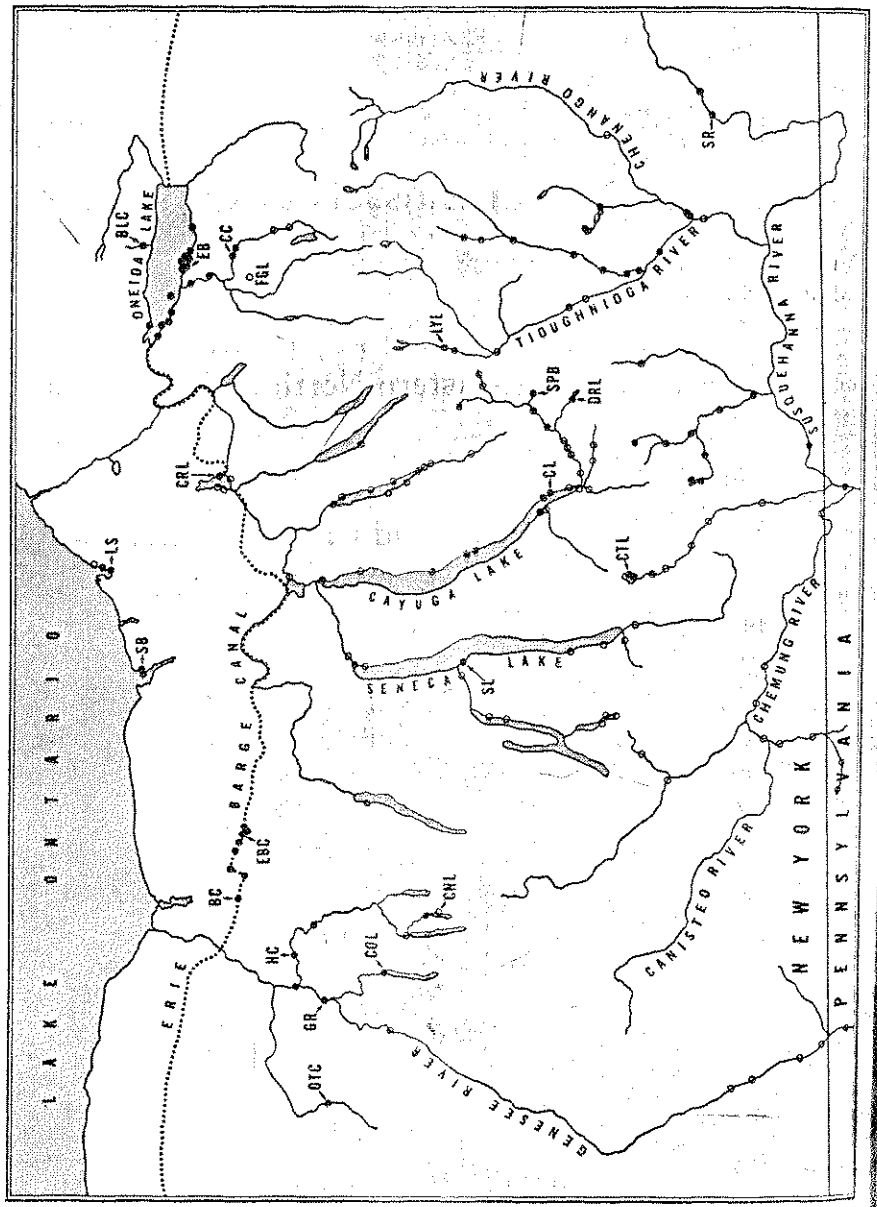

Stations visited in central New York.
● = stations where mussels were found.
○ = stations where no mussels were found.
Abbreviations refer to stations listed in tables 1 through 5.

Foreword

The fresh-water mussels are bivalve mollusks belonging to the superfamily Unionacea. The other group of fresh-water bivalves, the smaller and less conspicuous fingernail clams (family Sphaeriidae), are not treated in this report. North America contains the richest and most varied fresh-water mussel fauna in the world, and many species occur in Central New York. Although this interesting fauna is being depleted by widespread pollution and siltation, mussels or clams can still be found in most of our lakes and rivers and in many ponds and brooks.

Central New York is drained by the Susquehanna River System in the southeast and by the St. Lawrence River System throughout the rest of its area. Both systems contain unionid species common to the Atlantic Coastal Plain. The St. Lawrence System contains additional species derived from the Ohio-Mississippi System by post-glacial confluence during the Pleistocene epoch. Recently, Ohio-Mississippi species have again invaded this system in Central New York by way of the Erie Barge Canal. This has resulted in a further enrichment of the fauna and an intermingling of closely related species. Gene exchange between species (introgressive hybridization) is suggested by the results of some of these natural experiments, and a rare opportunity is presented to evaluate the taxonomic status of some of the species from evidence indicating the degree of reproductive isolation which they have achieved.

The purposes of this report are to provide descriptions, illustrations, and a usable key to simplify the identification of fresh-water mussels of Central New York and Northeastern North America; to present information on the distribution, biology, and ecology of the group; to evaluate in some degree the taxonomy of the species; and to relate the present distribution of the unionids of Central New York to the limnology and drainage history of the region.

Authors' acknowledgements

This publication was partially financed by a contribution from the Grace H. Griswold Fund, Department of Entomology and Limnology. The authors are grateful to H. D. Athearn, J. P. Barlow, H. W. Charnley, Louise R. Clarke, W. J. Clench, B. A. Foote, R. I. Johnson, E. J. Karlin, J. P. E. Morrison, S. E. Neff, H. A. Rehder, Ruth D. Turner, and H. van der Schalie for supplying locality records, for helpful discussions, or for reading the manuscript.

Contents

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Introduction

Morphology and biology of fresh-water mussels

Detailed descriptions of the external and internal morphology of mussels have been given by Baker (1928), Coker, *et al.* (1921), Ortmann (1911, 1912), Utterback (1916), and others. For more complete information than that given in the following brief outline, those papers should be consulted.

The gross morphology of the shell and the animal are shown in figures 19, 20, and 21. The mantle covers the animal and is appressed to all parts of the inner side of the shell. It is attached to the shell by a band of muscles at the pallial line. Other scars on the inner surface of the shell are formed at the attachment of the large adductor muscles that close the valves and the pedal retractor and protractor muscles. A number of small muscle scars are also present in the beak cavity. The edge of the mantle secretes the periostracum, the thin, horny layer on the outside of the shell, and the prismatic (intermediate) layer. The periostracum functions to protect the underlying shell, made up mostly of calcium carbonate, from dissolution by the carbonic acid present in natural water. The entire mantle surface secretes the nacreous inner layer of the shell, and foreign objects entering between the mantle and the shell, if retained, are covered with a layer of nacre. Thus pearls of some value are formed occasionally, but they are so rare that indiscriminant prospecting would probably be fruitless and result only in the needless destruction of large quantities of mussels.

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At the posterior edge the 2 mantle lobes are united except for 3 openings: the supra-anal opening, which is smooth; the anal opening or exhalent siphon, which may be smooth or have small crenulations; and the branchial opening or inhalent siphon, which is distinctly papillose. Two gills lie on each side of the visceral mass and mesial to the mantle. Beneath the visceral mass and projecting anteriorly is the thick, muscular foot which is thrust forward into the substrate, expanded at the end, and retracted into the shell, thus pulling the animal along.

Each gill consists of 2 lamellae made up of a large number of gill filaments. Interlamellar partitions or septa between the two lamellae divide the gill, in most species, into many vertical water tubes. The gills are ciliated on their outer surfaces and produce a complex current which moves water over the gills for respiration and moves food particles toward the labial palps. Here the food particles, i.e., plankton and organic detritus, are sorted and received through the mouth or rejected.

In addition to serving in respiration and food-getting, the gills of female mussels, in whole or in part, are permanently differentiated to serve as brood pouches for the glochidia, or larval mussels. In the female the eggs are fertilized by the sperm which is taken in with the water through the inhalent siphon, the eggs having already found their way from the ovaries to the water tubes of the marsupial parts of the gills. The fertilized eggs develop rapidly into glochidia, and the gills become swollen and distended from the mass present. After being held for definite periods of time, depending on the species, the glochidia are discharged into the water. In most unionids further development can occur only if the glochidia soon come into contact with the fins or gills of a species of fish with which they are compatible and to which they are able to attach and become encysted. Here they metamorphose to the adult form, and in about 3 weeks they detach and begin free-living existence as juvenile mussels. If the proper species of fish is not available to the glochidia, or if the metamorphosed juveniles fall onto silt or other inimical substrate, they die.

Mussels are often widely distributed throughout a drainage system during their periods of parasitism on fish. During times of flood after extensive rains or during the melting and recession of glaciers, as in the Pleistocene epoch, headwater streams occasionally overflow into other channels and into other drainage systems. At such times it is possible for glochidia-bearing fish to migrate into new drainage systems and to establish themselves and the mussels in previously unpopulated regions. Many modern workers feel that stream capture is the most important mechanism, or perhaps the only mechanism, by which unionid species are naturally distributed from one drainage system to an adjacent one (see Van der Schalie, 1945). Other workers consider passive transfer by birds the usual mechanism for dispersal (see McMichael, 1954). In Central New York the present distribution of unionids can be explained on the basis of stream confluences already known from geological evidence.

Drainage evolution and its effects

During the last glacial advance (the Wisconsin Stage), the Great Lakes basin was covered by a thick layer of ice and the preglacial fauna was either displaced or destroyed. When the glacier finally melted and receded toward the north, the river valleys and lake basins that were uncovered were flooded by the tremendous volume of melt water and in many places they overflowed into new channels. One of the first proglacial lakes was Lake Maumee which occupied the western part of the Lake Erie basin and drained southwestward through the valley of the Wabash River to the Mississippi. A little later a similar lake, Lake Chicago, occupied the southern end of the Lake Michigan basin and discharged southwestward via the Des Plains River and the Illinois River to the Mississippi (Flint, 1947). These confluences allowed the invasion of the Mississippi unionid fauna into the region of the Central Great Lakes and account for the present dominance of that fauna in the area.

At approximately the same time the ice sheet that had covered nearly all of New York was also receding. The Finger Lakes Basin was inundated by Lake Newberry which, in its earlier stages, drained southward into the Susquehanna River drainage basin. As the glacier continued to recede, a lower channel was uncovered to the west and the water drained westward into the Erie Basin. Later, when a still lower outlet was uncovered, the lake in the Erie Basin encroached eastward and merged with the Finger Lakes water body to escape through the Mohawk and Hudson river valleys.

When glacial recession began in Western New York, the headwaters of the Genesee River were also flooded. The lakes that formed overflowed into both the Allegheny Basin (Ohio-Mississippi drainage) and the Susquehanna Basin (Fairchild, 1928:142), and later the lakes merged and flowed into the Allegheny Basin only.

These interpretations of drainage history have been made entirely on the basis of geological evidence. It is of interest that the mussel fauna corroborates these conclusions.

In the Finger Lakes region and Lake Ontario the unionid fauna is dominated by *Elliptio complanatus* and *Lampsilis r. radiata*, both species of the Atlantic Drainage, and *Anodonta grandis*, a species of the Interior Basin, and contains other species native to both areas. The Interior Basin species were probably derived from the Erie Basin. The Atlantic Drainage species were probably derived from the Susquehanna Basin via Lake Newberry, and not from the Mohawk River valley as stated by Matteson (1948 a:14) for *Elliptio complanatus*. The Mohawk and Hudson valleys are entirely north of the terminal moraine and mussels could not have survived there during Pleistocene glaciation. As discussed in the systematic section below, the *Lampsilis r. radiata* are not typical, but show affinities to *L. r. siliquoidea*, a western taxon.

The Genesee River and its tributaries, on the other hand, are popu-

lated almost entirely with Interior Basin species. This may have been caused by postglacial confluence with the Allegheny, or it may be largely due to the influences of the Erie Barge Canal, to be discussed below. Probably both agencies have contributed elements to its fauna.

As the glacier continued to recede, the present basins of Lake Superior, Lake Michigan, and Lake Huron were filled to overflowing and a single large lake was formed, Lake Algonquin IV. At first the Trent Valley was used, an outlet east from Georgian Bay emptying into northern Lake Ontario, but soon the North Bay outlet was opened which allowed the water to flow from the northern end of the Georgian Bay basin out through the Ottawa River valley to the Ottawa Sea. After the vast weight of glacial ice was removed by further recession, a general unwarping of the land occurred and the Ottawa Valley was elevated. The Ottawa Valley outlet was abandoned, the salt water receded from the Ottawa Sea and the Champlain Sea, and the St. Lawrence System assumed the aspect it presents today.

Elliptio complanatus, an abundant Atlantic Drainage species, is found in the St. Lawrence River, Lake Ontario, and northern Lake Huron and Lake Superior, but not in Lake Erie nor in Lake Michigan. Walker (1913) discussed this anomalous distribution and concluded that the species immigrated to Lake Huron and Lake Superior during the Trent Outlet Stage or the Nipissing (Ottawa River) Outlet Stage. However, since the Ottawa Outlet emptied into the saline Ottawa Sea, the Trent Outlet alternative seems more likely. In addition, the Ottawa River and the St. Lawrence River seem to possess several western species that are absent or very rare in Lake Ontario and Central New York (e.g. *Obovaria olivaria, Alasmidonta calceolus,* and *Elliptio dilatatus)* and it is quite possible that these species migrated to that region via the Trent or Ottawa River outlet stage.

Canals

The distribution of the unionids in Central New York has been further complicated by the extensive canal system throughout the state. On October 26, 1825, the Erie Barge Canal was opened to boat traffic between Buffalo and Albany. In the same year the Champlain Canal uniting the Hudson River and Lake Champlain was also finished (Whitford, 1921). Additional canals were soon constructed: the Oswego Canal, the Cayuga-Seneca Canal, the Black River-Mohawk River Canal, the Chemung Canal and several others, but among these only the Chemung Canal from Seneca Lake to the Chemung River at Elmira (1833) opened new regions to possible immigration by mussels.

The Erie Barge Canal has brought additional species to our region, e.g. *Crenodonta costata, Anodonta imbecilis, Fusconaia flava, Carunculina parva,* and *Lampsilis r. siliquoidea.* Most of these were immigrants from Lake Erie, but it is possible that *L. r. siliquoidea* and some other species

of the canal were also derived from the Genesee River. It has not been established whether any exchange of species has occurred by way of the now abandoned Chemung Canal.

Limnological factors

In central New York as elsewhere, limnological factors exert strong influences on the distribution of mussels. The Finger Lakes are unusually deep, Seneca and Cayuga being the deepest lakes, except for the Great Lakes, in the United States east of the Rocky Mountains. They have rocky basins with steep sides and only a minimum of shoals, and they are oligotrophic to mesotrophic in type, relatively poor in nutrients and plankton density. Thus both morphological and edaphic factors are unfavorable for mussels, and mussels are not abundant in these lakes. By contrast, Oneida Lake is remarkably shallow considering its great surface area (the largest lake entirely within the boundaries of New York State), and it is typically eutrophic or rich in nutrients and in the plankton organisms that mussels require for food. Since it has extensive sandy shoals in addition to these other favorable attributes, it is not surprising that Oneida Lake supports the heaviest population of mussels found in any lake included in this survey.

Pollution is an important limiting factor. Mussels are killed very quickly by the decrease in oxygen resulting from organic pollution, and their absence from sections of rivers below towns or manufacturing areas can usually be traced to present or recently existing organic pollution or to equally destructive chemical pollution. Below the effluent source, sewage and other organic pollution in heavy concentration typically produces first, a decomposition zone in which bacterial metabolism causes a reduction in dissolved oxygen, second, a septic zone characterized by complete absence of oxygen, third, a recovery zone where a gradual increase in oxygen occurs, and finally, a clean water zone (Bartsch and Churchill, 1949; Wurtz, 1955). Unionids are usually absent from the first three of these zones where the oxygen is significantly reduced. Occasionally a small amount of sewage may fertilize the water and increase the abundance of the gastropods *Physa* and *Campeloma,* and in rare instances even unionids seem to be more common after such mild fertilization.

The water at all collecting stations listed in tables 1 and 2 was shallow, turbulent, and well oxygenated. Although some deep lakes were visited, the collecting stations in them were in littoral regions, well above the thermocline. Since the dissolved oxygen at all stations was at or near saturation levels and since the minor differences observed in oxygen tension would have no limiting effects on the mussel fauna, values for dissolved oxygen are omitted from these tables.

Water hardness or alkalinity varies greatly in natural waters of central New York and exerts a strong influence on the distribution of unionids.

Table 1. **Limnological conditions and mussels found at representative lake stations**

Lake, locality, and map symbol	Area, depth	Lake type, substrate	Water hardness		No. of species	Abundance†	Dominant species
			Date	p.p.m.*			
Fayet. Green, Fayetteville (FGL)	67 acres 190 feet	meromictic marl, sand	XI-4-56	130–285	0	0	
Little York, Little York (LYL)	150 acres‡ 78 feet	eutrophic mud	XI-13-55	135	3	2	*Anodonta cataracta*
Cross, Jordan (CRL)	1,920 acres 65 feet	eutrophic gravel, sand, snail shells	V-27-56	117	1	1	*Lampsilis r. siliquoidea*
Conesus, Lakeville (COL)	3,328 acres 61 feet	eutrophic sand	XI-16-57	102	2	3	*Anodonta grandis* *L. r. siliquoidea*
Cayuga, King Ferry (CL)	42,520 acres (66.4 sq. mi.) 435 feet	oligotrophic-mesotrophic gravel	XI-11-55	99	3	2	*Lampsilis r. radiata*
Seneca, Dresden (SL)	43,330 acres (67.7 sq. mi.) 618 feet	oligotrophic-mesotrophic rocks, sand	VI-27-56	92	3	3	*L. r. radiata* *Elliptio complanatus* *A. grandis*
Oneida, Bridgeport (EB)	51,200 acres (80 sq. mi.) 55 feet	eutrophic sand	VIII-28-56	76	5	4	*E. complanatus* *L. r. radiata*
Dryden, Dryden (DRL)	106 acres‡ 14 feet	senescent mud	IX-30-55	62–87	1	1	*A. grandis*
Cayuta, Cayutaville (CTL)	367 acres 25 feet	eutrophic mud, sand	X-7-55	47–49	1	1	*A. grandis*
Canadice, Canadice (CNL)	642 acres 83 feet	mesotrophic sand, mud	XI-16-57	33	0	0	

*Bicarbonates plus carbonates, if present, in parts per million.
†Approximated on the following scale: 4 = unionids abundant, 3 = common, 2 = uncommon, 1 = rare, 0 = no unionids found.
‡Computed from geological survey maps.

To facilitate observation of these differences and of their effects on the mussel fauna, both tables are arranged in the order of decreasing water hardness.

Although limestone is typically abundant in central New York, it is by no means evenly distributed. Onondaga limestone outcrops in a belt running east to west across the northern ends of the Finger Lakes and beyond, and streams cutting through it are high in calcium carbonate and rich in mussels. For example, Honeoye Creek (186 p.p.m. $CaCO_3$ at Rush, November 16, 1957) and Chittenango Creek (175 p.p.m. $CaCO_3$ at Kirkville, August 28, 1956) cut through Onondaga limestone, and mussels are large and abundant in them. On the other hand, Black Creek (46 p.p.m. $CaCO_3$ at Cleveland, Oswego County, September 29, 1957) is north of the limestone belt and contains only the soft water species *Margaritana margaritifera;* and Canadice Lake (33 p.p.m. $CaCO_3$, November 16, 1957) is south of the limestone belt and has a small drainage and, although other conditions are favorable, the lake is apparently barren of

Table 2. **Limnological conditions and mussels found at representative stream and canal stations**

Stream, locality, and map symbol	Remarks	Substrate	Water hardness		No. of species	Abundance†	Dominant species
			Date	p.p.m.*			
Honeoye Creek, 2 miles west of Rush (HC)	shallow, width and current medium	rocks, gravel	XI-16-57	186	6	4	*L. o. ventricosa* *V. iris* *L. costata*
Chittenango Creek, Kirkville (CC)	shallow, width and current medium	gravel, sand	VIII-29-56	175	8	4	*E. complanatus* *L. r. siliquoidea* *L. costata*
Oatka Creek, Pavilion Center (OTC)	wide, shallow, slow	mud	XI-16-57	146	3	3	*A. grandis* *A. ferussacianus*
Sphaerium Brook, McLean (SPB)	small, shallow, moderate flow	gravel, mud	X-22-55	130	2	3	*L. compressa* *A. grandis*
Erie Barge Canal, 3½ miles west of Macedon (EBC)	drained, wide	mud	II-26-57	130	3	3	*A. grandis* *A. imbecilis*
Erie Barge Canal, Pittsford (BC)	drained, wide	gravel, mud	II-26-57	112	11	4	*A. grandis* *L. r. siliquoidea*
Black Creek, Cleveland (BLC)	shallow, width medium, rather fast current	gravel	IV-29-57	46	1	3	*M. margaritifera*

*Bicarbonates plus carbonates, if present, in parts per million.
†Approximated on the following scale: 4 = unionids abundant, 3 = common, 3 = uncommon, 1 = rare, 0 = no unionids found.

unionids. These are extreme examples of the well-known dependence of unionids on limestone, a relationship that is apparent throughout the whole region.

Siltation is another significant factor, although it is less commonly observed. Wherever the velocity of a stream is decreased, its carrying capacity is reduced, and fine sediments are deposited. Although certain light, thin-shelled species known as "floaters" (especially *Anodonta* spp.) sometimes manage to stay on top of such sediments, mussels in general are smothered by the rapid accumulation of silt that often results.

Solid rock bottoms are even less productive than those composed of materials too light and diffuse for optimum compaction. The foot must penetrate into the substrate to function effectively as a holdfast structure. It follows that very rocky bottoms are less desirable than bottoms of gravel or sand and that substrates of bed rock are almost completely barren of unionids.

Beyond these general factors limiting mussel distribution, individual species have requirements and ecological tolerance limits, considered below, that control their distribution. It is evident that no mussel species can thrive unless at least one of the fish species potentially useful as hosts of its glochidia is present. Mussels restricted to only one or two species of fish hosts often seem to be excluded from otherwise suitable situations by this requirement.

The natural processes of eutrophication may bring about significant changes in lakes within 50 years or less, and the species composition of a lake population will change as a consequence. For example, the C. J. Maury Collection at Cornell University contains many large specimens of *Lampsilis r. radiata* from Little York Lake, Little York, collected about 1910. The heavy shell of this species affords excellent protection against the severe molar action encountered on barren, wave-swept, sand or gravel shoals, but would cause rapid sinking and asphyxiation in mud or silt bottoms. Whether because of changes in the character of the bottom, in the plankton and/or fish species available, or because of a combination of these and altered physical-chemical conditions, *L. r. radiata* was not found alive in this lake in 1955. However, *Anodonta cataracta*, a species common to more evolved habitats, was abundant. Such cases are numerous, and old locality records cannot be relied upon to locate presently existing populations.

Classification of the Unionacea

The anatomically based classification of Ortmann (1911) which is used here has been followed by most North American workers. Recently Modell (1942, 1949) proposed new groupings, but his system, based so heavily on beak sculpture and employing an excessive number of family group names (43), has not been widely accepted.

Morrison (1955) concluded that *Unio* Retzius is related to the Anodontinae and not to the Unioninae of American authors, and therefore proposed that all American species previously assigned to Unioninae be removed to a new subfamily Ambleminae and that the species previously assigned to Anodontinae should be placed in the Unioninae. In addition, the newly constituted Unioninae would be raised to family status and subdivided into Unioninae, Alasmidontinae, and Anodontinae; and the subfamilies Ambleminae and Lampsilinae would be combined under the family Amblemidae.

The spined glochidia and pustulous beak sculpture of *Unio pictorum* Linné (the type species of *Unio*) link *Unio* to the *Anodonta* complex, but the well-developed lateral teeth and the short breeding season are very unlike the anodontines, and the reproductive anatomy of *U. pictorum* is not known in sufficient detail to establish relationships on that basis. It is therefore considered prudent to defer acceptance of this confusing change in family nomenclature until more compelling evidence is available. The subdivision of the Anodontinae into 2 groups for American species is desirable, but in the present system the tribe names, Alasmidontini and Anodontini are used.

Key to Northeastern Species of Unionacea

All adult Unionacea of Northeastern North America are more than one inch long and lined with iridescent nacre. Lateral teeth, if present, are posterior to the pseudocardinal teeth. The other group of fresh-water bivalves, the Sphaeriidae or fingernail clams, are usually less than one inch long. They are not lined with nacre, and there are lateral teeth both anterior and posterior to the pseudocardinal teeth.

The following key includes all unionid species known to occur in the St. Lawrence System from the mouth of the St. Lawrence River to Lake Ontario and its tributaries east of the Niagara River, and in the Atlantic Drainage from the St. Lawrence River south to, and including, the Susquehanna System, with the exception of a few rare or doubtful species treated under Addenda in the Systematic Section.

The key is artificial and based on shell characters only. Beak sculpture is often obliterated in adult specimens. Where it is visible, however, it is a valuable accessory character for positive species identification. Beak sculpture characters are therefore included where appropriate, but identification can usually be made without their use.

Mussels are quite variable and a few specimens may key out incorrectly. It is therefore advisable to confirm all identifications made with the key by reference to the text and the figures. It should also be borne in mind that except for some places in or close to the Erie Barge Canal, all localities in the Northeast containing mussels are likely to contain *Elliptio complanatus* and/or *Anodonta cataracta*. *Lampsilis radiata radiata* also occurs very frequently. Identifications that indicate the absence of these species together with the presence of other species should be rechecked.

1. Articulating hinge teeth absent or vestigial.* Posterior slope without ridges crossing lines of growth 2
   Articulating hinge teeth present. Posterior slope with or without ridges crossing lines of growth 9
2. Vestigial pseudocardinal teeth indicated by a more or less prominent depression and thickening just anterior to beak. Ridges of beak sculpture without a central sinuation 3
   Pseudocardinal teeth entirely absent. Ridges of beak sculpture with a central sinuation 4
3. Nacre usually with salmon or pink suffusions near the beak cavity. Shell thin but usually not cracking extensively on drying. Beak sculpture coarse; bars sharply angled on posterior ridge (fig. 11, 12). Adults often exceeding 75 mm. in length. St. Lawrence and Atlantic Drainages ..... *Strophitus undulatus* (p. 43)
   Nacre usually bluish white, without salmon or pink suffusions. Shell thin, often cracking extensively on drying. Beak sculpture fine; bars not sharply angled on posterior ridge (fig. 13, 14). Adults very seldom exceeding 75 mm. in length. St. Lawrence Drainage only ..... *Anodontoides ferussacianus* (p. 35)
4. Beaks flattened and not projecting above hinge line. Hinge line straight. Shell thin and fragile. Periostracum greenish and shiny. Beak sculpture interrupted..... *Anodonta imbecilis* (p. 41)
   Beaks inflated and projecting above hinge line 5

*A few specimens of *Strophitus undulatus* have a rather clearly developed pseudocardinal tooth.

5. Nacre salmon or copper colored. Shell prominently thickened anterior-ventrally. Ridges of beak sculpture with shallow sinuations and without nodules (fig. 16). Atlantic Drainage ..... *Anodonta implicata* (p. 40)
Shell not as above 6
6. Atlantic Drainage. Shell variable, fragile, periostracum usually greenish and shiny, sometimes brownish and not shiny. Beak sculpture ridges sinuous and without nodules (fig. 17) ..... *Anodonta cataracta* (p. 39)
St. Lawrence Drainage 7
7. Beak sculpture fine, concentric, oblique, not sinuous (fig. 13, 14). Hinge line slightly curved. Nacre bluish white. Adults very rarely exceeding 75 mm. in length ..... *Anodontoides ferussacianus* (p. 35)
Beak sculpture sinuous (fig. 15, 17, 18). Hinge line straight. Nacre silvery, white, or bluish white. Adults usually exceeding 75 mm. in length 8
8. Periostracum green or greenish and shiny. Beak sculpture not nodulous (fig. 17) ..... *Anodonta cataracta*† (p. 39)
Periostracum brown or brownish and not shiny. Beak sculpture usually nodulous (fig. 15, 18) ..... *Anodonta grandis*† (p. 36)
9. Shell sculptured on posterior slope by ridges crossing lines of growth 10
Shell not sculptured as above 13
10. Shell short (height/length $>$ .68), subrhomboid, massive, and thick anteriorly. Posterior two-thirds traversed by large and prominent ridges ..... *Crenodonta costata* (p. 20)
Shell more elongate (height/length $<$ .65). Sculpturing on posterior slope only 11
11. Shell relatively compressed (width/height $<$ .60). Posterior ridge low and rounded. Interdental tooth prominent. Shell usually not prominently and extensively rayed. Length often exceeding 100 mm. ..... *Lasmigona costata* (p. 33)
Shell relatively inflated (width/height $>$ .60). Posterior ridge inflated and prominent. Interdental tooth absent. Shell often prominently and extensively rayed. Length very rarely exceeding 100 mm. 12
12. Posterior ridge inflated and rather sharp. Adult specimens often exceeding 70 mm. in length. Shell sharply truncated. Periostracum extensively rayed, darker anteriorly and lighter posteriorly. St. Lawrence and Susquehanna Systems only ..... *Alasmidonta marginata* (p. 27)
Posterior ridge inflated and rounded. Adult specimens rarely exceeding 70 mm. in length. Shell not sharply truncated. Periostracum more or less extensively rayed, lighter anteriorly and darker posteriorly. St. Lawrence System east of Lake Ontario and Atlantic Drainage ..... *Alasmidonta varicosa* (p. 28)
13. Interdental tooth in left valve more or less well developed and articulating with interdental depression in right valve. Pseudocardinal teeth directed forward. Beak sculpture as in fig. 1 or 2. Nacre not purple 14
Shell not as above 15
14. Adults usually exceeding 70 mm. in length. Interdental tooth large and prominent. Specimens smaller than 70 mm. with a low, more or less prominent posterior wing. St. Lawrence System and upper Hudson River System ..... *Lasmigona compressa* (p. 31)
Adults not known to exceed 65 mm. in length. Interdental tooth small. Adult specimens without a posterior wing. Lake Ontario Drainage in New York, Erie Barge Canal, and Susquehanna System ..... *Lasmigona subviridis* (p. 32)
15. Articulating lateral teeth short, poorly developed, or absent 16
Articulating lateral teeth elongate and well developed 18
16. Adult length usually exceding 90 mm. Height/length usually $<$ .50. Valves often arcuate. Periostracum dark and rayless ..... *Margaritana margaritifera* (p. 17)
Adult length less than 90 mm. Height/length $>$ .50. Valves not arcuate. Periostracum often rayed 17
17. Valves ovate or triangular ovate, prominently thickened anteriorly, and with maximum inflation near middle of shell. Atlantic Drainage and St. Lawrence System ..... *Alasmidonta undulata* (p. 25)
Valves sub-rhomboid, not prominently thickened anteriorly, and with maximum inflation at posterior ridge. St. Lawrence System only ..... *Alasmidonta calceolus* (p. 29)
18. Adults small, not exceeding 50 mm. in length. Lateral teeth double in the right valve and single in the left.‡ Periostracum brown and without rays. Atlantic Drainage only ..... *Alasmidonta heterodon* (p. 24)
Lateral teeth single in the right valve and double in the left.‡ 19
19. Shell sub-ovate, compressed, comparatively thin, and medium to large, usually with a prominent dorsal wing 20
Shell without a prominent dorsal wing and not as above 21
20. Periostracum dark brown or nearly black; nacre purple to pink; pseudocardinal teeth compressed, strong, and well developed ..... *Proptera alata* (p. 45)
Periostracum yellowish or light brown; nacre silvery white, sometimes pinkish dorsally; pseudocardinal teeth thin, weak, and poorly developed ..... *Leptodea fragilis* (p. 46)
21. Shell elongate (height/length $<$ .48)§ and subcylindrical, (width/height $>$ .60)§, or both. Periostracum brownish-black to black and not extensively rayed 22
Shell less elongate (height/length $>$ .48) or more compressed (width/height $<$ .60), or both. Periostracum variable 23
22. Shell medium sized, less than 110 mm. long. Posterior end extended and bluntly pointed centrally. Nacre purple or white. Atlantic Drainage and St. Lawrence System ..... *Ligumia nasuta* (p. 51)
Shell large, usually more than 110 mm. long. Posterior end rounded and somewhat extended. Nacre white or tinged with purple dorsally. St. Lawrence System only ..... *Ligumia recta* (p. 52)
23. Shell regularly ovate or short elliptical, heavy, thick anteriorly, and with massive teeth. Beaks greatly swollen, pointed forward, and near or at the anterior end. Length less than 70 mm. St. Lawrence System only ..... *Obovaria olivaria* (p. 47)
Shell not as above 24
24. Nacre purple 25
Nacre white, pinkish, or orange 26
25. Shell variable, usually sub-rhomboid, discs flattened, posterior obliquely subtruncate. Shell rather compressed; if more inflated then broadest near posterior slope. Beaks not close to anterior end. Very common. Atlantic Drainage and St. Lawrence System ..... *Elliptio complanatus* (p. 21)
Shell variable, usually subelliptical, discs somewhat convex, posterior slightly extended and tapered. Shell broadest anteriorly. Beaks close to anterior end. Uncommon. St. Lawrence System only ..... *Elliptio dilatatus* (p. 23)
26. Shell very small, usually not exceeding 35 mm. Ovate, relatively thick and strong, and with well-developed hinge teeth. Periostracum usually blackish, without rays, and roughened by lines of growth. St. Lawrence Drainage only ..... *Carunculina parva* (p. 49)
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27. Shell relatively small (45 to 65 mm. long), subrhomboid, not ovate, relatively thin, and compressed, especially posterior-dorsally. Wavy, wide, irregular rays sometimes present. Hinge teeth rather delicate, not serrated. Young specimens with a low posterior wing. Beak sculpture double looped (fig. 2). Susquehanna System, Erie Barge Canal, and Lake Ontario Drainage ..... *Lasmigona subviridis* (p. 32)
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28. Beaks near anterior end. Posterior end tapered and somewhat extended. Shell somewhat elongate and subcylindrical. St. Lawrence System only 29
Beaks not near anterior end. Posterior end not tapered and extended. Shell not elongate or subcylindrical. St. Lawrence System and Atlantic Drainage 30
29. Periostracum with prominent green or brown rays alternating with yellow. Length usually less than 75 mm. Beak sculpture ridges distinctly double looped ..... *Villosa iris* (p. 53)
Periostracum brown and without rays. Length often exceeding 70 mm. Beak sculp-

†See Remarks under *A. grandis*, page 37.

‡Records of abnormal individuals are known, but such specimens are rare. See Van der Schalie, 1936.

§Occasional specimens are slightly outside these limits.

ture ridges straight or slightly sinuate centrally, not double looped ..... *Elliptio dilatatus* (p. 23)

30. Shell triangular-ovate, heavy, and with thick and ponderous hinge teeth. Height/length > .70. Posterior pointed basally. Periostracum without rays. St. Lawrence System ..... *Fusconaia flava* (p. 19)
Shell not as above 31

31. Shell variable, sub-rhomboid, posterior obliquely subtruncate. Posterior ridge present. Periostracum usually without rays. Beak sculpture concentric (fig. 6). Height/length usually < .60. Very common ..... *Elliptio complanatus* (p. 21)
Shell subelliptical or sub-ovate and either more or less rayed or with a shiny, yellowish periostracum. Posterior ridge nearly absent, or height/length > .60, or both. Beak sculpture often double looped 32

32. Shell heavy, elliptical, and with wide rays. Length often exceeding 120 mm. Sexual dimorphism not readily apparent. Rare. St. Lawrence Drainage only ..... *Actinonaias carinata* (p. 48)
Shell not as above 33

33. Shell medium or small (length usually less than 80 mm.), relatively thin, and only slightly thickened anteriorly. Pseudocardinal teeth and interdentum thin and compressed. Sexual dimorphism well marked. Atlantic Drainage only ..... *Lampsilis ochracea* (p. 57)
Shell larger (length more than 80 mm.) and substantially thicker anteriorly than posteriorly 34

34. Shell without rays or rays on posterior slope only. Periostracum yellowish and shiny. Atlantic Drainage and St. Lawrence System east of Lake Ontario ..... *Lampsilis cariosa* (p. 54)
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35. Shell sub-ovate and usually with more or less well developed narrow or wide rays generally distributed on a yellowish background. Height/length > .60 in both sexes. Sexual dimorphism well marked. Posterior ridge often well developed. St. Lawrence System only ..... *Lampsilis ovata ventricosa* (p. 55)
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36. Sexual dimorphism not prominent. Rays mostly wide. Periostracum not shiny. Nacre white or suffused with pink or orange. Atlantic Drainage and St. Lawrence System ..... *Lampsilis radiata radiata* (p. 58)
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Systematic Section

In the Systematic Section the synonymies have been abbreviated to include only citation to: 1) the original description of the nominate species, 2) the original introduction of the name being replaced, if any, and 3) equivalent names used in important works dealing with the unionids of Central New York or adjacent areas. In the latter category the works cited are: DeKay, 1843; Letson, 1905; and Baker, 1915 (all dealing with Central New York); Johnson, 1915 (New England); Ortmann, 1919 (Pennsylvania); Robertson and Blakeslee, 1948 (Western New York); and LaRocque, 1953 (Canada). Exhaustive synonymies are given in Simpson (1914) and the equivalent name(s) used in that work are cited also.

FAMILY MARGARITANIDAE[1]

Shells medium to large, sculpturing reduced or absent, and with incomplete hinge teeth. Beak sculpture concentric. Marsupia formed from all 4 gills. Interlamellar septa discontinuous or continuous, diagonal, not forming water tubes. Contains only 2 genera, *Margaritana* and *Cumberlandia*, and a few species. Widely, but discontinuously, distributed throughout the Northern Hemisphere.

Genus *Margaritana* Schumacher 1817[1]

Type species: *M. fluviatilis* Schum. (= *Mya margaritifera* Linné), by monotypy.

Margaritana margaritifera (Linné), Figs. 57, 58

Mya margaritifera Linné 1758, Syst. Nat., 10th ed.:671 (type locality: Europe).

Alasmodon arcuata Barnes: DeKay 1843:197.

Margaritana margaritifera (Linné): Letson 1905:92; Simpson 1914:513; Johnson 1915:28; Baker 1916:252 [error]; Ortmann 1919:2; LaRocque 1953:85.

Description: This species is characterized by its elongate and typically arcuate shape, blackish periostracum, strong pseudocardinal teeth, and usually obsolete or absent lateral teeth. The gill structure differs from that of all other mussels in this region in having the interlamellar septa scattered, diagonal, not continuous, and not forming water tubes.

Shell medium to large, elongate elliptical and often arcuate, moderately thick, strong, and somewhat inflated. Periostracum brown; black in old specimens and rather smooth but often heavily eroded. Beak sculpture consisting of a few coarse, parallel ridges following the lines of growth. Pseudocardinal teeth well developed, conical, single in the right valve and double in the left. Lateral teeth obsolete, usually absent. Nacre whitish or suffused with pink or purple, iridescent posteriorly.

Adult specimens commonly range from 90 to 150 mm. (3½ to 6 inches) and have H/L (height/length) ratios of .45 to .50 and W/H (width/height) ratios of .50 to .60.

Distribution: Circumboreal, recorded from Northern and Middle Europe, Northern Asia, Japan, Labrador to Pennsylvania in Eastern North America, Saskatchewan, and (subspecies *falcata* Gould) Alaska to New Mexico in Western North America. Except for the Saskatchewan record (Dall, 1905) which needs confirmation, it is unrecorded from Central North America. In Pennsylvania it occurs in one small area only, the headwaters of the Little Schuylkill River in Schuylkill County. For details of its distribution see Walker, 1910.

Records: Fish Creek, Lewis County (Walker, 1910); "Oneida" (DeKay,

[1]For discussions of this name see Bailey (1957) and McMichael (1956).

1843); Oneida Lake (Beauchamp, 1886); tributaries of Mohawk, Oneida County (Marshall, 1895); Black Creek at Cleveland, ½ mi. N. of Oneida Lake, Oneida County (this survey). Baker (1916) recorded the species from Oneida Lake, but later (Baker, 1918) stated that this was in error.

Biology and ecology: The anatomy of this species was discussed by Ortmann (1911:230). Conner (1909) gave June to August as the breeding season. The glochidia are very small (.018 mm. long), semicircular, globular, without true hooks, but with a number of small teeth on the ventral margin (Ortmann, 1911:232). Harms (1907:821) gave the common European minnow *(Phoxinus phoxinus* Linné (= *P. laevis* Agassiz) as a host of the glochidia in Europe. Murphy (1942:94) listed the brown trout, *Salmo trutta* Linné, and the rainbow trout, *S. gairdneri* Richardson, as hosts of *M. m. falcata* Gould. *S. trutta* also occurs in Black Creek at Cleveland, N. Y., where it is the probable host of *M. m. margaritifera*. Since both the brown and the rainbow trout were introduced into Eastern North America by man, it is probable that the native brook trout *Salvelinus fontinalis* (Mitchill), is also a host for this mussel.

Ortmann (1919:5) stated that this species is restricted to soft waters and usually associated with sandy shoals and pools in cold, clear, rather rapidly flowing, small to medium-sized streams. On September 27, 1957, a hardness of 46 p.p.m. $CaCO_3$ was found in Black Creek at Cleveland, New York. This is the softest stream water analysed in this survey, and it is also the only locality among those visited in Central New York that contains *M. margaritifera*. This species occurs alone or in association with *Elliptio complanatus* and a few additional species.

FAMILY UNIONIDAE

Shells small to large, sculpturing variable, and with hinge teeth complete, reduced, or absent. Beak sculpture variable. Marsupia formed by all 4 gills or 2 outer gills only. Interlamellar septa continuous and parallel to the gill filaments forming vertical water tubes. Containing many genera and species.

SUBFAMILY UNIONINAE

Shells usually large and solid; sculpturing well developed, moderate, or absent; hinge teeth complete and strong. Sexual dimorphism usually not apparent. Tachytictic, or short term breeders (females retaining the glochidia in the marsupia or gill pouches for only a few days or weeks during the summer). Marsupia formed by all 4 gills or 2 outer gills only but in either case the whole gill serving as the marsupium. Water tubes not divided in the gravid female. Glochidia subelliptical or subcircular and without hooks.

Genus *Fusconaia* Simpson 1900

Type species: *Unio trigonus* Lea, by original designation.

Fusconaia flava (Rafinesque), Fig. 24

Obliquaria flava Raf. 1820, Monographie:305 (type locality: small tributaries of Kentucky, Salt, and Green Rivers).
Quadrula undulatus (Barnes): Letson 1905:93.
Quadrula rubiginosa (Lea): Letson 1905:93; Simpson 1914:872 (in part).
Quadrula undata (Barnes): Simpson 1914:880 (in part).
Fusconaia flava trigona Lea: Ortmann 1919:19.
Fusconaia flava (Raf.) Robertson and Blakeslee 1948:93; LaRocque 1953:91.

Description: The sub-triangular, short, heavy, and unsculptured shell of this species renders it entirely distinct. Several rather similar species also occur in the Ohio-Mississippi Drainage, but *F. flava* is the only one that has penetrated into Central New York.

Shell medium-sized, triangular-ovate, rather heavy, strong, and somewhat inflated. Posterior ridge prominent. Periostracum brown or blackish, sometimes obscurely rayed, and with distinct growth lines. Beaks inflated and elevated and with sculpture consisting of 3 to 5 sub-concentric bars, slightly waved, and forming an angle on the posterior ridge. The fourth and fifth bars usually present only as nodular swellings on the posterior ridge. Unsculptured except on beaks, and with sculpturing often indistinct even there. Pseudo-cardinal teeth large, heavy, and irregular, 1 in the right valve and 2 in the left. Lateral teeth heavy, moderately long, 1 in the right valve and 2 in the left. Nacre white, sometimes suffused with salmon pink. All 4 gills serving as marsupia. Ovisacs and placentae (conglutinates) sub-cylindrical; placentae rather prominent and usually reddish.

Adult specimens commonly range from 60 to 95 mm. in length (2½ to 4 inches) with H/L ratios of .70 to .80 and W/H ratios of .62 to .68.

Distribution: Ohio-Mississippi System from Arkansas and Tennessee to North Dakota and Pennsylvania. Great Lakes System from Wisconsin to Central New York and Southern Ontario.

Records: ***Great Lakes System.*** Genesee River: Avon (this survey); Chili and Rochester (both Ortmann, 1919); South Park, Rochester (Baker, 1898). Honeoye Creek, 2 mi. W. of Rush (this survey). Erie Barge Canal: Clover Road, Pittsford; Monroe Avenue, Pittsford; ½ mi. E. of Fairport (all this survey); Onondaga County; Utica; Utica-Ilion; and Mohawk (all Marshall, 1895).

Biology and ecology: For anatomical details see Ortmann (1911:241) under *Fusconaia rubiginosa* (Lea). The species breeds from May to August. The glochidia are rather small, of sub-oval shape, without hooks, 0.15 mm. in length and height (Ortmann, *l.c.*). The host fish is unknown.

In Central New York *F. flava* is known to occur in a large creek, a rather large river, and a canal. In these localities the substrate varies from rocks and gravel to sand and mud. Ortmann (1919) stated that it usually occurs in smaller streams with bottoms of gravel and fine sand. Van der Schalie (1938) characterized it as a species of large creeks and rivers, living on gravel or sand. In New York it occurs with other species, especially *Lampsilis ovata ventricosa* and *L. radiata siliquoidea*.

Genus *Crenodonta* Schluter 1938

Type species: *Unio plicatus* Say, by subsequent designation, Simpson 1900.

It seems unfortunate to discard the familiar name *Amblema* Rafinesque in favor of *Crenodonta*. However, Clench and Turner (1956) pointed out that *Amblema* was originally proposed (Raf., 1819) as a monotypic genus based on *A. ovalis* Raf., a species that is unrecognizable. Since there are no specimens nor diagnostic descriptions of this species to serve as the standard for comparison with all other species placed in the genus, the correct application of *Amblema* cannot be determined. Attempts to validate the generic name by basing it on *Amblema* Raf. (1820) (type: *A. costata* Raf.) are unacceptable. If *Amblema* Raf. (1820) is interpreted as a proposal of a new generic name, it must be discarded as a junior homonym; if it is considered merely an extension of *Amblema* Raf. (1819), *ovalis* must be regarded as the generitype unless and until it is officially suppressed. There are 2 or 3 alternative solutions of this problem. In adopting *Crenodonta* in favor of *Amblema*, Clench and Turner *(op. cit.)* have already chosen one that may be as good as any other. In any event, we will create less confusion by accepting this solution than by taking any other course.

Crenodonta costata (Rafinesque), Fig. 25

Amblema costata Raf. 1820, Monographie:315, (type locality: Ohio River and small rivers of Kentucky) Robertson and Blakeslee 1948:94; LaRocque 1953:86.
Quadrula undulata (Barnes): Letson 1905:93; Simpson 1914:814.
Amblema plicata costata (Raf.): Ortmann 1919:28.

Description: This large, sub-ovate, thick-shelled, and heavily corrugated species is entirely distinct from all other local mussels.

Shell large, sub-ovate, thick and ponderous, heavily sculptured and somewhat compressed. Central part of each valve traversed by 3 to 5 large, rounded, irregular corrugations extending posterior-ventrally. Posterior slope often sculptured by similar, smaller corrugations. Periostracum brown or brownish black. Beak sculpture consisting of 3 to 5 ridges that are slightly angular and nodulous posteriorly. Only 3 or less ridges distinct, and all ridges disappearing anteriorly. Pseudocardinal teeth very large, erect, subtriangular and deeply serrate, 1 large and 1 small tooth in the right valve, 2 large teeth in the left. Lateral teeth long, elevated, nearly straight, single in the right valve and double in the left. Nacre white, iridescent posteriorly. All 4 gills serving as marsupia. Ovisacs and placentae (conglutinates) leaf-shaped, the latter rather poorly developed and usually white.

Adult specimens commonly range from 75 to 125 mm. (3 to 5 inches) in length and exhibit H/L ratios of .70 to .86 and W/H ratios of .45 to .60.

Distribution: Entire Ohio-Mississippi System. St. Lawrence System from Lake Huron and its drainage to the Erie Barge Canal in Central New York.

Records: *St. Lawrence System.* Erie Barge Canal: Clover Road, Pittsford; Ayrault Road, Pittsford; 2 mi. S.E. of Pittsford, 1½ mi. W.N.W. of Macedon (all this survey); and Onondaga County (Marshall, 1895).

Biology and ecology: The anatomy was discussed by Ortmann (1911:246) under *Crenodonta undulata* (Barnes). The breeding season is from May to July. The glochidia are sub-oval, without hooks. 0.21 mm. long and 0.22 mm. high (Ortmann, 1911:247). Coker, *et al.* (1921:153) listed several fish as hosts for the glochidia of the closely related (conspecific?) *C. plicata* Say, but omitted this species.

According to Ortmann (1919:32) *C. costata* occurs in large and medium-sized streams on gravel or sand bottoms, and it "avoids" mud. In the Erie Barge Canal at the stations where it was collected, the predominant substrate is mud. This is probably not indicative of the more natural ecology of the species. Here the most common associates are *Anodonta grandis* and *Lampsilis radiata siliquoidea*.

Genus *Elliptio* Rafinesque 1819

Type species: *Unio nigra* Rafinesque (= *Unio crassidens* Lamarck), by subsequent designation, Simpson 1900.

Elliptio complanatus (Solander), Figs. 26, 27, 28

Mya complanata Solander 1786, Portland Catalogue:11, lot 2190 (type locality: Maryland).
Unio complanatus Dillwyn: DeKay 1843:188; Letson 1905:92 Simpson 1914:651; Johnson 1915:27.
Elliptio complanatus (Dillwyn): Robertson and Blakeslee 1948:98; LaRocque 1953:27.
Unio complanatus mainensis Rich: Johnson 1915:27.
Unio roanokensis northamptonensis (Lea): Johnson 1915:27.
Elliptio violaceus (Spengler): Ortmann 1919:103.

Description: This species is exceedingly variable but is nevertheless quite easy to recognize. It is commonly rather compressed with flattened discs and an obliquely flattened posterodorsal margin. When more inflated, it is broader in the region of the posterior slope. This character and the sub-trapezoidal shape will usually distinguish it from *E. dilatatus* Rafinesque which is broader in the anterior region and is more regularly

tapered posteriorly. Also, the beaks are quite near the anterior end in *dilatatus* while in *complanatus* they are not.

Shell variable, medium to large, sub-elliptical to subrhomboid, of medium thickness, strong and often somewhat compressed. Periostracum yellowish brown to black and without rays except in some young specimens. Beak sculpture distinct, see Fig. 6. Pseudocardinal teeth prominent, erect, and serrate, single in the right valve and double in the left. Lateral teeth well-developed and slightly curved, also single in the right valve and double in the left. Nacre usually purple but variable, sometimes salmon, bluish, or white. Only the outer 2 gills serving as marsupia.

Adult specimens are usually between 70 and 115 mm. (3 to 4½ inches) in length and have H/L ratios of .50 to .60 and W/H ratios of .40 to .60.

Distribution: *E. complanatus* occurs on the Atlantic Coastal Plain from the Gulf of St. Lawrence to Georgia and inland to Lake Ontario and the Niagara River. It is also reported from Lake Huron and Lake Superior and their drainages, the Hudson Bay Drainage and eastern Lake Erie. Walker (1913) and Matteson (1948) discussed the distribution of this species. The records of Matteson (1948 b:718) from the Apalachicola and elsewhere in the Gulf of Mexico Drainage represent the closely related *E. strigosus* Lea.

Records: ***St. Lawrence System.*** Genesee River: Rochester (Ortmann, 1919); South Park, Rochester (Baker, 1898); Avon (this survey). Honeoye Creek: 2 mi. W. of Rush (this survey). Honeoye Lake (Marshall, 1895). Erie Barge Canal: Clover Road, Pittsford; Monroe Avenue, Pittsford; Route 252, S.E. of Pittsford (all this survey). South Street Brook, Auburn (Baker, 1899). Chittenango Creek: Bridgeport and Kirkville. Oneida Lake: Lakeport; Eagle Bay, Bridgeport; Shackelton Point; Muskrat Bay; Frenchman's Island; and Brewerton (all this survey). Oswego River and Mohawk River (both Marshall, 1895). Lake Ontario: Sodus Bay and Little Sodus Bay. St. Lawrence River: Waddington; and Sheek Island, Mille Roches, Ontario (all this survey).

Susquehanna System. Conhocton River, Steuben County (Marshall, 1895). Susquehanna River: Athens, Pennsylvania; Smithboro; Nineveh; Afton; and Otego. Cayuta Creek at Alpine. Catatonk Creek: near mouth, Owego; 2 mi. S.E. of Candor; 4½ mi. W. of Candor; and below Spencer Lake, Spencer. Tioughnioga River: Messengerville; Cortland; 5.5 mi. N. of Cortland; and Little York Lake, Little York. Otselic River: 1 mi. N. of Whitney Point; Upper Lisle; Willet; and Pitcher. Creek at Lincklaen, Chenango County. Chenango River: Chenango Forks and 2 mi. N.E. of Greene (all this survey).

Biology and ecology: For anatomical details see Ortmann (1911:269) and Reardon (1929:10). The breeding season is from April to July or August. The glochidia are white, sub-ovate, without hooks, 0.20 mm. long and 0.19 mm. high (Ortmann, *l.c.*). The yellow perch, *Perca flavescens* (Mitchill), serves as a host for this species (Lefevre and Curtis, 1912:168; Matteson, 1948 b:707).

This is the most common species in the Atlantic Drainage. It occurs in lakes, ponds, rivers, and small streams on nearly all kinds of substrate except very soft mud. It is often the only species in a particular locality, and when other species are present *E. complanatus* is usually more abundant than the others. In the Finger Lakes Region, however, it is often second in abundance to *Lampsilis radiata radiata*, which with *Anodonta cataracta* is its most usual associate throughout the Northeast.

Elliptio dilatatus (Rafinesque), Fig. 44

Unio dilatatus Rafinesque 1820, Monographie:297 (type locality: Ohio River).
Unio gibbosus Barnes: Letson 1905:92; Simpson 1914:597.
Elliptio dilatatus (Raf.): Ortmann 1919:95; Robertson and Blakeslee 1948:95; LaRocque 1953:91.

Description: *Elliptio dilatatus* is entirely distinct from other species in our area except *E. companatus*. For differential characters see under *E. complanatus*.

Shell medium to rather large, elongate-ovate, heavy, strong and subinflated. Periostracum brown to black, sometimes obscurely rayed with green in young specimens. Beak sculpture distinct, consisting of 4 to 5 rather heavy bars, the first 2 subconcentric, those following parallel to the lines of growth, nearly straight centrally or with a slight sinuation, and partially obliterated at the ends. Pseudocardinal teeth well developed, divergent, serrate, usually 1 in the right valve and 2 in the left. Lateral teeth long, slightly curved, 1 in the right valve and 2 in the left. Nacre purple or light pink to white or a combination of these colors. Only the outer two gills serving as marsupia.

Adult specimens usually measure between 65 and 125 mm. (2½ to 5 inches) in length and give H/L and W/H ratios of .48 to .58.

Distribution: Ohio-Mississippi Drainage, Gulf of Mexico Drainage, St. Lawrence Drainage in tributaries from Lake Michigan to Lake Ontario, also St. Lawrence River and Ottawa River. The subspecies *sterkii* Crier (1918, Nautilus, 32:9) occurs in large lakes from Lake Huron to Lake Erie, but this is probably only an ecotype.

Records: ***St. Lawrence System.*** Lake Ontario at Grand View Beach, Monroe County (Robertson and Blakeslee, 1948). Erie Canal (Baker, 1898; Letson, 1905). Pittsford, Monroe County (Marshall, 1895). Northeast of this region it occurs in the St. Lawrence River at Sheek Island, Mille Roches, Ontario (this survey and H.D. Athearn) and the Ottawa River (LaRocque, 1953). The record Lake Keuka (Marshall, 1895) is very doubtful.

Biology and ecology: Anatomically, *E. dilatatus* resembles *E. complanatus*

(Ortmann, 1911:271). Females retain the glochidia to August. The glochidia are rather small, sub-oval, without hooks, and measure 0.20 mm. in length and 0.22 mm. in height. The host fish is unknown.

E. dilatatus is very common throughout most of its range. It occurs in large and small rivers, in rapid or slow flowing sections, and in lakes on rocky, gravel, sand, or mud bottoms. "It is practically ubiquitous, and there are few streams which contain shells in which it is not found" (Ortmann, 1919:100). In Central New York and eastward it is at the edge of its range and is quite uncommon. In the St. Lawrence River it is associated with *Elliptio complanatus* and many other species.

SUBFAMILY ANODONTINAE

Shells small to large, usually not heavy, often thin, sculpturing variable; hinge teeth nearly always reduced or absent. Sexual dimorphism usually not apparent. Bradytictic or long term breeders (females retaining the glochidia in the marsupia at least from the fall to the following spring). Marsupia formed by outer gills in their whole length. Water tubes in the gravid female divided longitudinally into 3 tubes, only the middle one used as an ovisac. Glochidia semicircular or triangular and with a spine.

TRIBE ALASMIDONTINI

Shell of medium thickness, with or without sculpturing on the posterior slope. Pseudocardinal teeth present and often prominent, and lateral teeth present or absent.

Genus *Alasmidonta* Say 1818

Type species: *Monodonta undulata* Say, by monotypy.

Subgenus *Prolasmidonta* Ortmann 1914

Type species: *Unio heterodon* Lea, by monotypy.

Alasmidonta (Prolasmidonta) heterodon (Lea), Fig. 35

Unio heterodon Lea 1830, Trans. Amer. Philos. Soc. 3:428, pl. 8, fig. 11 (type locality: Schuylkill River and Derby Creek, Pa.).

Alasmidonta heterodon (Lea); Letson 1905: 91; Simpson 1914:499; Johnson 1915:26.

Alasmidonta (Prolasmidonta) heterodon (Lea): Ortmann 1919:173.

Description: The small size, inflated posterior ridge, and reversed lateral teeth of this species will differentiate it from all others in the Northeastern States.

Shell small, sub-ovate or sub-trapezoidal, rather thin and somewhat inflated. Posterior ridge rounded and slightly inflated. Periostracum olive brown to blackish brown, sometimes more or less rayed with blackish green. Beak sculpture consisting of about 3 or 4 moderately

heavy blunt bars, the first 2 concentric and simple, the following ones forming sharp angles on the posterior ridge, in front of which are more or less well-developed shallow sinuses. Pseudocardinal teeth well developed, rather narrow, 1 or 2 in the right valve and 2 in the left. Interdental tooth in left valve usually present and well defined. Lateral teeth present and extending posteriorly to the end of the ligament or a little beyond, and characteristically *2* in the right valve and *1* in the left, the reverse of all other northeastern species having lateral teeth. Nacre bluish or silvery white, iridescent posteriorly, and with pinkish or salmon suffusions in the beak cavities.

Adult specimens usually range from 30 to 45 mm. (1.2 to 1.8 inches) in length and give H/L and W/H ratios of .52 to .60.

Distribution: Atlantic Drainage from New Brunswick to Virginia, but discontinuous, and recorded only from 5 drainage areas: Petitcodiac River System, New Brunswick (Athearn, 1952); Connecticut River System, New England (Johnson, 1915, and others); Housatonic River (Johnson, 1915); Delaware River System in Pennsylvania; and Rappahannock River System in Virginia (both Ortmann, 1919). Lea's type locality (Schuylkill River, Pennsylvania) is in the Delaware River System.

Records: The only New York records of this species are from Marshall (1895): Eastern Part (of New York) "Anthony", and Southeastern Portion (of New York) "Beauchamp". The species may occur in the Delaware River Drainage of New York.

Biology and ecology: The anatomy was discussed by Ortmann (1911:295). The species is bradytictic but the limits of its time of breeding are not well known. Gravid females have been found in February and April. The glochidia are subtriangular, with strong hooks, and measure .30 mm. in length and .25 mm. in height. The host fish is unknown.

This is a rather rare and inconspicuous species. East of New York, *A. heterodon* occurs in medium or rather slow flowing rivers of varying size on gravel, sand, or muddy sand bottoms and sometimes among submersed aquatic plants. Ortmann (1919:173) found it in large numbers in a canal. In New England it occurs in association with *Elliptio complanatus* and *Strophitus undulatus.*

Subgenus *Alasmidonta* Say, s.s.

Alasmidonta (Alasmidonta) undulata (Say), Fig. 33

Monodonta undulata Say 1817, Nich. Ency., pl. 3, fig. 3 (type locality: Delaware and Schuylkill Rivers).

Alasmidonta undulata (Say): DeKay 1843:198; Letson 1905:90; Simpson 1914:494; Johnson 1915:26; Baker 1916:255; LaRocque 1953:86.

Alasmidonta (Alasmidonta) undulata (Say): Ortmann 1919:117.

Description: This species is well characterized by its shortened, subtri-

angular form, heavy beak sculpture, thickened anterior, and peculiar hinge.

Shell small, triangular-ovate, thickened anteriorly, thinner posteriorly, somewhat strong, inflated. Posterior ridge weak, posterior slope usually smooth. Periostracum yellowish, greenish, or reddish brown, or modified with black and with greenish or blackish rays which are partially obscured in older, blackened specimens. Beak sculpture usually very heavy, see fig. 11. Posterior ridge weak, posterior slope usually smooth. Pseudocardinal teeth stubby but well developed, 1 in the right valve and 2 in the left, the anterior one sometimes rudimentary. Lateral teeth nearly absent or absent. Nacre whitish anteriorly and bluish posteriorly, or modified with salmon, pink, or shades of red.

Adult specimens are commonly 60 to 75 mm. (2½ to 3 inches) in length and exhibit H/L ratios of .55 to .63 W/H ratios of .65 to .78.

Distribution: Atlantic Drainage from the Lower St. Lawrence System south to North Carolina.

Records: ***St. Lawrence System.*** Monroe County (Walton, 1892); Seneca Lake (Dewey, 1856); Erie Barge Canal, Onondaga County, (Beauchamp, 1886); Oneida Lake (Baker, 1916); St. Lawrence River at Sheek Island, Mille Roches, Ontario (this survey and H.D. Athearn).

Susquehanna System. Canisteo River, Steuben County; Cohocton River, Steuben County; Tioga River, Corning (all Marshall, 1895). Susquehanna River at Athens, Pennsylvania (this survey); and Oaksville, New York (H.D. Athearn). Catatonk Creek: Owego; 2 mi. S.E. of Candor, 4½ mi. W. of Candor; and just below Spencer Lake, Spencer. West Branch, Tioughnioga River, Little York. Otselic River near Upper Lisle. Creek, ½ mi. S. of Lincklaen, Chenango County. Chenango River at Chenango Forks (all this survey). Otsego Lake, 5 mi. N. of Cooperstown (H.D. Athearn).

Biology and ecology: The anatomy of *A. undulata* was discussed by Ortmann (1911:296). The species breeds from the middle of July until the middle of the following June. The glochidia are moderately large, with strong hooks, and measure 0.34 mm. in length and 0.36 mm. in height (Ortmann, *l.c.*). The host fish is unknown.

This species is rare in the St. Lawrence Drainage of New York but is relatively common in the Susquehanna and other coastal drainage systems. It occurs in moderately flowing streams varying in size from large rivers to small creeks. It is most abundant on gravel and sand bottoms and is usually absent in muddy areas. It is also found in lakes on sand or gravel bottoms, but seems to reach maximum size in outlet streams just below lakes. *Strophitus undulatus* and *Elliptio complanatus* are its most usual associates.

Subgenus *Decurambis* Rafinesque 1831

Type species: *Alasmidonta scriptum* Rafinesque (= *A. marginata* Say), by subsequent designation, Ortmann and Walker 1922.

Alasmidonta (Decurambis) marginata (Say), Fig. 32

Alasmidonta marginata Say 1819, Nich. Ency., pl. 3, fig. 5 (type locality: Scioto River Chillicothe, Ohio).

Alasmidonta marginata Say: Letson 1905:91; Simpson 1914:504; Johnson 1915:27; Robertson and Blakeslee 1948:101; LaRocque 1953:86.

Alasmidonta (Decurambis) marginata (Say): Ortmann 1919:181.

Alasmidonta (Decurambis) marginata susquehannae Ortmann 1919:187.

Description: The inflated posterior ridge, characteristic hinge teeth, sculpturing on the posterior slope, and sub-trapezoidal shape will distinguish *A. marginata* from all other species in our area except *Alasmidonta varicosa* (Lam.). In *A. varicosa* the posterior ridge is rather evenly rounded, the periostracum is usually lighter anteriorly and darker posteriorly, the shell is not sharply truncated, and the length does not normally exceed 70 mm. In *A. marginata* the posterior ridge is more inflated and is somewhat sharp, the periostracum is darker anteriorly and lighter posteriorly, the shell is sharply truncated, and the length may reach nearly 100 mm.

Shell medium in size, sub-trapezoidal, slightly thickened and moderately strong in the adult. Periostracum yellowish, greenish, brownish or blackish, lighter in color on the posterior slope, and usually prominently rayed. Posterior slope sculptured with grooves or wrinkles running toward the upper posterior margin; wrinkles seldom entirely obscure except occasionally on old shells. Posterior ridge much inflated and sharply rounded. Pseudocardinal teeth distinct, narrow, rather depressed, one in each valve. Left valve with a smaller, more or less developed interdental tooth. Lateral teeth absent. Nacre bluish white, sometimes discolored with gray or green, or with suffusions of very pale salmon; specimens from the Susquehanna Drainage often showing pinkish or reddish tints.

Adult specimens commonly range from 65 to 90 mm. (2½ to 3½ inches) in length and have H/L ratios of .48 to .62 and W/H ratios of .60 to .78. The distance from the beak to the anterior end commonly falls between 32 and 44 percent of the total length.

Remarks: Ortmann (1919) differentiated the Susquehanna Drainage form as variety *susquehannae*, but he wrote it as a trinomial, a combination reserved for subspecies. *A. m. susquehannae* was characterized as being somewhat smaller than *marginata* s.s., having a "peculiar, brighter" periostracum, and nacre which is often colored with salmon or reddish tints and is rarely bluish-white, the typical nacre color of *marginata*. Also, Ortmann's figures for the ratio derived by dividing the distance from beak to anterior end by total length indicate a range of .30–.35 for *marginata* and .29–.33 for *susquehannae*.

Thirty-eight percent of the specimens seen from the Susquehanna Drainage in this survey, supposedly all *susquehannae*, are larger than the largest *susquehannae* reported by Ortmann, and the largest specimen at hand (89 mm.) approaches rather closely the largest specimen of *margin-*

ata (96 mm.) reported by Ortmann from Western Pennsylvania. The ratios of distance between beak and anterior end divided by total length found in local specimens equal and exceed the ratios given by Ortmann for both *marginata* and *susquehannae*. Local specimens seen do not appear to be "brighter" than *marginata* s.s., and the meaning of "peculiar" is not clear. The only differential character with value seems to be nacre color; New York specimens from the Susquehanna Drainage often exhibit pinkish or reddish suffusions and those from the Ohio and St. Lawrence Drainages do not show this color except rarely. Such a difference might well be caused by a single gene. In any case, this is not of sufficient importance to justify subspecific status, and the Susquehanna form is here considered as *marginata* s.s.

Distribution: Ohio-Mississippi Drainage, St. Lawrence Drainage from Lake Huron to the Ottawa River, and Susquehanna River Drainage.

Records: ***St. Lawrence System.*** Genesee River: Avon (this survey); South Park, Rochester (Baker, 1898); and 2 mi. S.W. of Geneseo (H.D. Athearn). Honeoye Creek at Route 315; and Erie Barge Canal, Clover Road, Pittsford (both Robertson and Blakeslee, 1948). Canandaigua Lake and Seneca River (both Marshall, 1895). Chittenango Creek: Kirkville and 5 mi. S. of Bridgeport (both this survey). Oneida Creek, 1 mi. S.W. of Oneida Valley; and Little Salmon River, 2 mi. S. of Bombay, Franklin County (both H.D. Athearn). St. Lawrence River at Sheek Island, Mille Roches, Ontario (this survey, and H.D. Athearn).

Susquehanna System. Tioga River (Marshall, 1895). Susquehanna River: Athens, Pennsylvania; Smithboro; and Afton. Catatonk Creek: Oswego and 2 mi. S.E. of Candor. Tioughnioga River at Itaska. Otselic River near Upper Lisle. Chenango River: Chenango Forks and 3 mi. N.E. of Greene (all this survey).

Biology and ecology: The anatomy of *A. marginata* has been discussed by Ortmann (1911–297) and Lea (1863, Observations *10*:446). Time limits of its breeding period are not known, but records indicate that the period begins on or before the middle of July. The glochidia are rather large, with hooks, and have been reported as 0.33 mm. in length and 0.36 mm. in height by Ortmann *(l.c.)* and 0.35 and 0.38 mm. by Surber (1912, pl. 3, fig. 42). The host fish is unknown.

A. marginata is most common in rocky and gravel substrates of large and middle-sized streams, and especially in rapids or riffles. It is one of the very few species that are more abundant in such habitats than elsewhere. In the Susquehanna System it is associated with many species: *Lampsilis cariosa, Elliptio complanatus, Alasmidonta varicosa,* and others. In the St. Lawrence System it occurs with nearly all of the river species.

Alasmidonta (Decurambis) varicosa (Lamarck), Fig. 34

Unio varicosa Lam. 1819, Anim. sans Vertebres, 6:68 (type locality: Schuylkill River near Philadelphia, Pa.).

Alasmidon marginata Say: DeKay 1843:196.
Alasmidon marginata Say: Letson 1905:91 (in part); Johnson 1915:27.
Alasmidonta varicosa (Lam.): Simpson 1914:506.
Alasmidonta (Decurambis) varicosa (Lam.): Ortmann 1919:190.

Description: The inflated posterior ridge, corrugations on the posterior slope, hinge teeth, etc., distinguish this species from all others except *Alasmidonta marginata*. For differences between these species see under *A. marginata*.

Shell small to medium, sub-trapezoidal or sub-elliptical, somewhat thickened and strong in the adult, and inflated posteriorly. Periostracum yellowish, greenish, brownish or blackish, often lighter in color anteriorly and usually extensively rayed. Posterior slope sculptured with short, fine wrinkles and grooves which are interrupted by the lines of growth and perpendicular to them. Posterior ridge inflated and rounded or flattened centrally and apparently double. Beak sculpture as in *A. marginata* (fig. 9). Pseudocardinal teeth sometimes partially obscure but usually distinct, narrow, and depressed, one in each valve. Left valve often with a small interdental tooth. Lateral teeth absent. Nacre whitish or bluish white and often with suffusions of pink or salmon which may be widespread and rather intense.

Adult specimens usually are between 40 and 65 mm. (1½ to 2½ inches) in length and exhibit H/L ratios of .52 to .62 and W/H ratios of .68 to .80.

Distribution: Atlantic Drainage from the Lower St. Lawrence System to North Carolina.

Records: ***Susquehanna System.*** Catatonk Creek: Owego; 2 mi. S.E. of Candor; 4½ mi. W. of Candor; and below Spencer Lake, Spencer (all this survey). Tioughnioga River at Cortland (Ortmann 1919:193, also C. J. Maury Collection). West Branch Tioughnioga River, 5.5 mi. N. of Cortland. Otselic River: Whitney Point and near Upper Lisle. Chenango River, Chenango Forks (all this survey).

Biology and ecology: According to Ortmann (1919:191) the anatomy and glochidia of *A. varicosa* are identical with *A. marginata*. The species breeds from August to the following May. The fish host is unknown.

As in *A. marginata, A. varicosa* is usually found in rapids or riffles on rock and gravel substrates and also in sandy shoals. It is more abundant in small rivers and creeks, whereas *A. marginata* is more abundant in larger streams. The two species often occur together, however, and are readily separable. Other commonly associated species are *Strophitus undulatus* and *Elliptio complanatus*.

Subgenus *Pressodonta* Simpson 1900

Type species: *Unio calceolus* Lea, by original designation.

Alasmidonta (Pressodonta) calceolus (Lea), Fig. 30

Unio calceolus Lea 1830, Trans. Amer. Philos. Soc. 3:265, pl. 4, fig. 1 (type locality: Ohio).
Alasmidonta calceola (Lea): Letson 1905:91.
Alasmidonta calceolus (Lea): Simpson 1914:497; Robertson and Blakeslee 1948:100; LaRocque 1953:86.

Description: The small size, sub-rhomboid shape, inflated posterior ridge, and irregular and poorly defined lateral teeth are the primary diagnostic characters for this variable species. The other small species, *Carunculina parva* and *Alasmidonta heterodon*, are not truncate posteriorly and are quite different in many characters, especially the lateral teeth.

Shell small, sub-rhomboid, rather thin, somewhat strong, and inflated. Valves inflated principally in the region of the posterior ridge, which is prominently elevated. Periostracum dull, yellowish brown to greenish brown, and often with irregular greenish rays that may occupy most of the surface. Beak sculpture consisting of about 6 heavy, sub-concentric corrugations most prominent in middle and on posterior ridge. Corrugations either straight in center or double looped, sharply angled on posterior ridge, and obsolete posteriorly and anteriorly. Pseudocardinal teeth small, elevated, irregular, 1 in right valve and 1 bifurcate tooth in left valve. A second, smaller tooth sometimes present in left valve in front of larger tooth. Lateral teeth poorly defined and irregularly developed, 1 or 2 in right valve and 2 in left, but often reduced or nearly absent. Nacre white or bluish white.

Adult specimens commonly measure between 32 and 50 mm. (1¼ to 2 inches) in length and exhibit H/L ratios of .62 to .70 and W/H ratios of .58 to .68.

Distribution: Mississippi System from Ohio River Drainage to Tennessee River Drainage. Also reported from the St. Lawrence System from Lake Huron to Ottawa River (LaRocque and Oughton, 1937).

Records: ***St. Lawrence System.*** Old Erie Canal, Monroe County; and Mud Creek, Genesee County (both Marshall, 1895). Oriskany Creek, Oriskany Falls, Oneida County (H. D. Athearn). Specimens are occasionally, but positively, reported from the Niagara River (Robertson and Blakeslee, 1948:100, 150). LaRocque (1953:86) has recorded it from Lake Ontario and the Ottawa River and its tributaries.

Biology and ecology: The anatomy of *A. calceolus* is similar to *A. marginata* (Baker, 1928:186). The species is bradytictic, but the limits of its breeding season are not known. The glochidia are rather large (0.30 mm. long, 0.26 mm. high), sub-triangular, with a straight hinge line and a ventral spine. The central johnny darter, *Boleosoma nigrum* (Rafinesque), and northern muddler, *Cottus bairdii* Girard, are fish hosts for this species (J. P. E. Morrison, personal communication).

This species usually occurs in riffles or pools of creeks on a sand or gravel substrate (Van der Schalie, 1938:58), although it is sometimes found in muddy banks, backwater areas, or lakes.

Genus *Lasmigona* Rafinesque, 1831

Type species; *Alasmidonta costata* Rafinesque, by subsequent designation, Simpson 1900.

Subgenus *Platynaias* Walker 1918

Type species: *Symphynota compressa* Lea, original designation.

Lasmigona (Platynaias) compressa (Lea), Fig. 29

Symphynota compressa Lea 1829, Trans. Amer. Philos. Soc. 3:450. pl. 12, fig. 22 (type locality: Ohio and Norman's Kill, Albany, N. Y.); Letson 1905:89; Simpson 1914:481 Johnson 1915:25.
Unio compressus (Lea): DeKay 1843:191.
Symphynota compressa var. *plebius* (C. B. Adams): Letson 1905:90.
Symphynota compressa plebeia (C. B. Adams): Johnson 1915:25.
Lasmigona (Platynaias) viridis (Raf.): Ortmann 1919:116.
Lasmigona compressa (Lea): Robertson and Blakeslee 1948:98; LaRocque 1953:94.

Description: The color and shape, beak sculpture, and characteristic hinge teeth, especially the interdental projection, will usually differentiate this species from all others except *L. subviridis*. Young specimens of *compressa* resemble older specimens of *subviridis* but the former are more distinctly trapezoidal with posterior wing and interdental projection both well developed. Adults of *compressa* are much larger than those of *subviridis*.

Shell medium-sized or moderately large, sub-rhomboid or sub-trapezoid, slightly thickened, moderately strong, and rather compressed. Young specimens with a low wing. Periostracum yellowish-brown, greenish or blackish and usually extensively rayed. Posterior ridge low and rounded. Posterior slope compressed and usually without sculpturing. Beak sculpture distinct but somewhat variable, generally similar to fig. 1. Pseudocardinal teeth well developed, narrow, directed forward, 1 in the right valve and usually 2 in the left. Interdental projection in the left valve prominent and articulating with an interdental groove in the right valve. Lateral teeth long and rather thin, typically 1 in the right valve and 2 in the left, but often rudimentary near the beaks or almost entirely absent. Nacre silvery white or bluish, iridescent posteriorly, sometimes cream-colored or salmon near the beak cavities.

Adult specimens are usually from 70 to 100 mm. (3 or 4 inches) in length and give H/L ratios of .52 to .60 and W/H ratios of .50 to .64.

Distribution: Hudson Bay, Upper Mississippi, Ohio, and St. Lawrence Drainages from Saskatchewan and Nebraska to Vermont. Also Hudson River Drainage.

Records: ***St. Lawrence System.*** Oatka Creek: Pavilion Center (H. D. Athearn and this survey) and Le Roy (Robertson and Blakeslee, 1948). Genesee River, South Park, Rochester (Baker, 1898). Genesee Canal and Canandaigua Lake (both Marshall, 1895). Canandaigua Outlet, Phelps (H. D. Athearn). Penn Yan and Flint Creek, Yates County (both B. H. Wright [MCZ[1]]). West River, Yates County (Marshall, 1895). Seneca River (Beauchamp [MCZ]). Erie Barge Canal: Palmyra (Walker [MCZ]); Onondaga County; and Mohawk (both Marshall, 1895). Hydraulic Canal, Herkimer (Call [MCZ]). Brook 4 mi. N. of Auburn (Baker, 1899). Tompkins County: Fall Creek at McLean and Freeville; Sphaerium Brook, McLean (all this survey). The records Canisteo River, Steuben County; and Chemung River (both Marshall, 1895) are probably based on misidentifications of *L. subviridis.*

Biology and ecology: The anatomy of *L. compressa* was discussed by Ortmann (1911:281) under *Symphynota compressa* Lea. The breeding season is from August to the following June. Specimens with male gill structure are very seldom found. The glochidia are subtriangular, almost semicircular, with hooks, and measure 0.34 mm. in length and 0.28 mm. in height. The host fish is unknown.

L. compressa usually occurs in medium- or small-sized streams on a sand or gravel substrate. It is sometimes found in streams as narrow as 6 feet or less. Occasionally it occurs in muddy situations as at Oatka Creek (above) or in lakes (Lake Erie, Ortmann, 1919:120). It is often found alone, especially in small streams, or with *Elliptio complanatus, Strophitus undulatus,* and other species.

Lasmigona (Platynaias) subviridis (Conrad), Fig. 31

Unio subviridis Conrad 1835, New Fresh Water Shells, appendix, pl. 9, fig. 1 (type locality: Schuylkill River; Juniata River; creeks in Lancaster Co., Penn.).
Unio tappanianus Lea: DeKay 1843:194.
Symphynota viridis (Con.): Letson 1905:90; Simpson 1914:484.
Lasmigona (Platynaias) subviridis (Con.): Ortmann 1919:121.

Description: This species does not closely resemble any other except *L. compressa.* See under that species.

Shell rather small, sub-ovate, somewhat thin, fragile, and compressed. Young specimens with a low posterior wing. Periostracum yellowish brown, greenish, or blackish brown and often extensively rayed. Posterior ridge slightly inflated and rounded. Posterior slope not markedly compressed and not sculptured. Beak sculpture distinct, similar to *L. compressa* but with only about 4 bars, being somewhat stronger and more equal, not extending so far on the disc, and with the posterior loop not so sharply angled (fig. 2). Pseudocardinal teeth present, more or less well

[1]Records from specimens in the Museum of Comparative Zoology, Harvard University.

developed, relatively smaller than in *L. compressa,* directed forward, 1 in the right valve and 1 or 2 in the left. Interdental projection in left valve usually absent, sometimes rudimentary. Lateral teeth thin and weak, typically 1 in right valve and 2 in the left but often partially obliterated. Nacre white or bluish white, iridescent posteriorly, and often partly tinted with yellowish brown or salmon.

Adult specimens commonly range from 45 to 65 mm. (1¾ to 2½ inches) in length and show H/L ratios of .56 to .62 and W/H ratios of .50 to .66.

Distribution: Erie Barge Canal, Lake Ontario Drainage, and Susquehanna River Drainage in New York and south in the Atlantic Drainage to North Carolina. Also New River and Greenbrier River, Virginia (Ortmann, 1913:371).

Records: ***St. Lawrence System.*** Erie Barge Canal: Syracuse [MCZ] and Mohawk [MCZ]. Chittenango Creek, Kirkville (this survey).

Susquehanna System: Chemung River, Chemung (B. H. Wright [MCZ]). Susquehanna River: Athens, Pennsylvania; Nineveh; Afton; and Otego. Cayuta Creek at Alpine. Willseyville Creek, Willseyville. Catatonk Creek at Owego (all this survey).

Biology and ecology: The anatomy of *L. subviridis* is similar to that of *L. compressa* (Ortmann, 1911:283; Lea, 1874, Observations, 13:71). The breeding season lasts from August to the following June. Specimens with male gill structure have never been found. The glochidia are similar to those of *L. compressa:* sub-triangular, almost semicircular and with hooks, but measure 0.36 mm. in length and 0.30 mm. in height. The host fish is unknown.

This species is similar to *L. compressa* in ecology and usually occurs in medium or small streams on gravel or sand substrates. It also occurs in medium-sized rivers, and Ortmann (1919:124) reported it from canals and pond areas of streams. *L. subviridis* is usually found alone or in association with any of a number of stream species, e.g. *Lampsilis cariosa* and *Alasmidonta marginata.* We have not found it in association with *L. compressa,* but most of our records are from the Susquehanna System and *L. compressa* is not known to occur there.

Subgenus *Lasmigona* s.s.

Lasmigona (Lasmigona) costata (Rafinesque), Fig. 59

Alasmidonta costata Raf. 1820, Monographie: 318, pl. 82, figs. 15, 16 (type locality: Kentucky River).
Alasmodon rugosa Barnes: DeKay 1843:196.
Symphynota costata (Raf.): Letson 1905:90; Simpson 1914:488; Johnson 1915:26.
Lasmigona (Lasmigona) costata (Raf.): Ortmann 1919:125.
Lasmigona costata (Raf.): Robertson and Blakeslee 1948:98; LaRocque 1953:94.

Description: The large size and corrugated posterior slope will ordinarily make this species entirely distinct. In those relatively few instances where the specimens are smaller and the corrugations are absent, it resembles *L. compressa*. In such cases the development of the teeth and the beak sculpture, if visible, will usually differentiate the two species, and if a series can be examined intergrades between smooth and costate forms will probably occur. If soft parts are available the presence of appreciable numbers of males is diagnostic of *L. costata*.

Shell medium to large, sub-rhomboid or sub-trapezoid, rather thick, strong, corrugated posteriorly, and compressed. Periostracum yellowish, greenish, or brownish and with green rays which are obscure in old specimens. Posterior ridge low and often indistinct. Posterior slope corrugated, with approximately 10 to 20 broad ribs intersecting and perpendicular to the dorsal posterior margin. Ribs occasionally poorly defined or almost absent. Beak sculpture distinct, like that shown in fig. 10 or without the shallow sinus shown there. Pseudocardinal teeth moderately developed and often heavy in old shells, sub-conical or lamellar, 1 in the right valve and usually 2 in the left. Interdental projection prominent and sometimes heavy, articulating with an interdental groove in the right valve. Lateral teeth rudimentary or absent. Nacre white, usually bluish white and iridescent anteriorly, and sometimes suffused with pale salmon near the beak cavities. Dioecious.

Adult specimens from New York commonly measure 75 to 125 mm. (3 to 5 inches) in length and show H/L ratios of .50 to .58 and W/H ratios of .45 to .56.

Distribution: Entire Mississippi and Ohio River Drainages, Great Lakes Drainage from Lake Superior (Ortmann, 1919, p. 130) to Lake Champlain and the Ottawa River. It is also reported from the Hudson Bay Drainage and the Gulf of Mexico Drainage (both *ibid.*).

Records: ***St. Lawrence System.*** Genesee River: Avon (this survey); South Park, Rochester (Baker, 1898). Honeoye Creek, 2 mi. W. of Rush. Erie Barge Canal at Clover Road, Pittsford (both H.D. Athearn and this survey). Canandaigua Lake (Marshall, 1895). Canandaigua Outlet, Phelps (H. D. Athearn). Cayuga Lake, Cayuga (C. J. Maury Collection). Owasco Lake at foot of lake; and Owasco River near Auburn (both Baker, 1899). Onondaga Lake (Marshall, 1895). Chittenango Creek: Kirkville and 5 mi. S. of Bridgeport (both this survey). Mohawk River (Ortmann, 1919). St. Lawrence River at Sheek Island, Mille Roches, Ontario (this survey and H. D. Athearn).

Biology and ecology: Ortmann (1911:283) discussed the anatomy of this species under *Symphynota costata* (Raf.). The glochidia are rather large, triangular, and measure approximately 0.36 mm. in length and 0.38 mm. in height, with some variation (Ortmann, 1919:127). The breeding season lasts from the beginning of August to the middle of the following May. The host fish is unknown.

Lasmigona costata is found in large and small rivers, creeks, lakes, and canals, and on gravelly, sandy, and muddy bottoms. In streams it occurs in riffles and in pools. In our region, like many other species, it is most abundant in streams heavily charged with calcium carbonate. Commonly associated species include *Lampsilis radiata siliquoidea, L. ovata ventricosa, Alasmidonta marginata,* and *Elliptio complanatus.*

TRIBE ANODONTINI

Shell thin, often fragile, without sculpturing on posterior slope. Pseudocardinal teeth vestigial or absent, and without any trace of lateral teeth.

Genus *Anodontoides* Simpson 1898

Type species: *Anodonta ferussaciana* Lea, by subsequent designation, Simpson 1900.

Anodontoides ferussacianus (Lea), Fig. 39

Anodonta ferussaciana Lea 1834, Trans. Amer. Philos. Soc., 5:45, pl. 6, fig. 15 (type locality: Ohio River, Cincinnati, Ohio).
Anodon ferussaciana (Lea): DeKay 1843:200.
Anodon subcylindracea (Lea): DeKay 1843:200.
Anodontoides ferussacianus (Lea): Letson 1905:88; Simpson 1914:467; Johnson 1915:25, [error]; Ortmann 1919:165; Robertson and Blakeslee 1948:100.
Anodontoides ferussacianus var. *subcylindraceus* (Lea):Letson 1905:89.
Anodontoides ferussacianus var. *modestus* (Lea): Letson 1905:89.
Anodontoides ferussacianus var. *buchanensis* (Lea): Simpson 1914:469.

Description: This species is much like *Strophitus undulatus* and some species of *Anodonta* in general appearances. If the characteristically fine, subconcentric, and oblique beak sculpture is visible, *A. ferussacianus* is readily identified. Furthermore, in *Anodonta* there is no trace of pseudocardinal teeth, the hinge is straighter, and adult specimens are larger. In *Strophitus* the rudiments of the pseudocardinal teeth are more distinct; the shell is usually heavier; and nacre is inclined to be suffused with pink or salmon and to be less iridescent; and the ovisacs are subdivided into compartments, while in *A. ferussacianus* they are not. For additional anatomical differences see Ortmann (1911, 1912 a).

Shell small to medium, sub-elliptical, usually thin, rather fragile, and inflated. Periostracum light green, brown, or modified with black and often extensively rayed, especially in young specimens. Posterior ridge rounded, slightly inflated. Beak sculpture distinct and a most important character in this species (figs. 13, 14). Pseudocardinal teeth absent or indicated only by a slight swelling or incurving of the hinge line just in front of the beak. Lateral teeth entirely absent. Nacre bluish white, somewhat

iridescent, and often with greenish or cream tints near the beak cavities. Supra-anal opening about as long as united part of mantle margin which separates it from anal opening. Inner lamina of inner gills always free. Ovisacs not subdivided.

Adult specimens usually measure from 50 to 75 mm. (2 to 3 inches) in length and exhibit H/L ratios of .52 to .58 and W/H ratios of .62 to .80.

Distribution: Mississippi and Ohio Drainages, and St. Lawrence Drainage from Lake Michigan to the Ottawa River. Lake Champlain (H. D. Athearn, personal communication).

Records: It is impossible to determine which of the older records for this often difficult species are valid, but Marshall's (1895) records for the Susquehanna Drainage are almost certainly incorrect. Most of the old records are therefore omitted from the following list.

St. Lawrence System: Oatka Creek at Pavilion Center (H. D. Athearn and this survey). Erie Barge Canal, Pittsford (Robertson and Blakeslee, 1948). Conesus Lake Outlet, Lakeville; Canandaigua Outlet, Phelps; and branch of Seneca River, 1 mi. S.W. of Seneca Falls (all H. D. Athearn). Onondaga County (Beauchamp, 1880). South Street Brook, Auburn (Baker, 1899). St. Lawrence River: Grass Point State Park, Jefferson County; and Sheek Island, Mille Roches, Ontario (both H. D. Athearn).

Biology and ecology: According to Ortmann (1911:294), the anatomy of this species resembles that of *Anodonta*. Glochidia are retained in the female gill pouches from August until the following May. The glochidia are sub-triangular, with hooks, and measure 0.32 mm. in length and height. The rather widely distributed northern muddler, *Cottus bairdii* Girard, is a host fish for this species (J. P. E. Morrison, personal communication).

A. ferussacianus occurs in slow flowing streams, in backwater areas, and in lakes. It is often found in mud but has also been reported from sand and gravel. Its most common associate is *Anodonta grandis*.

Genus *Anodonta* Lamarck 1799

Type species: *Mytilus cygneus* Linne, by monotypy.

Subgenus *Anodonta* s.s.

Anodonta (Anodonta) grandis Say, Fig. 38

Anodonta grandis Say 1829, New Harmony Dissem., 2:341 (type locality: Fox River of the Wabash); Letson 1905:87; Simpson 1914:418; Baker 1916:255; Ortmann 1919:138; Robertson and Blakeslee 1948:99; LaRocque 1953:87.

Anodon plana Lea: DeKay 1845:201.

? *Anodonta marginata* Say: Letson 1905:86.

? *Anodonta kennicotii* Lea: Letson 1905:88.

? *Anodonta pipiniana* Lea: Letson 1905:88.

? *Anodonta grandis* var. *benedictensis* Lea: Letson 1905:88.

Anodonta grandis var. *gigantea* Lea: Letson 1905:87.

? *Anodonta grandis* var. *footiana* Lea: Letson 1905:87.

? *Anodonta grandis benedictensis* Lea: Johnson 1915:25; LaRocque 1953: 87.

? *Anodonta grandis footiana* Lea: Ortmann 1919:147; Robertson and Blakeslee 1948:99; LaRocque 1953:88.

Anodonta grandis gigantea Lea: Ortmann 1919:99; LaRocque 1953:88.

Description (of typical *grandis*)*:* Typical specimens of *grandis* may be recognized by their relatively high and short form and usually by the tuberculous beak sculpture.

Shell medium to large, sub-ovate or sub-elliptical, usually thin and fragile, and inflated. Posterior slope compressed dorsally and somewhat alate in young specimens. Periostracum greenish, brownish, or blackish, often shiny, sometimes obscurely rayed, and usually with concentric darker and lighter bands. Beaks elevated above hinge line. Beak sculpture usually distinct, variable, rather heavy, and commonly tuberculous. (The nontuberculous phase is shown in figs. 15 and 18.) Pseudocardinal and lateral teeth absent. Nacre variable, usually white or bluish white and iridescent, sometimes partly pinkish. Dioecious. Supra-anal opening much shorter than section of united mantle margins separating it from anal opening. Ovisacs not subdivided.

Adult specimens commonly range from 100 to 175 mm. (4 to 7 inches) in length and show H/L ratios of .45 to .55 and W/H ratios of .68 to .88.

Remarks: In addition to the typical *Anodonta grandis*, 3 subspecies of *grandis* and 3 closely related species are currently listed as present in our fauna (LaRocque, 1953:87–88). Simpson (1914), Ortmann (1919), and Van der Schalie (1938) elucidated these forms whose chief differential characteristics are length, relative height, and degree of inflation. Representing these characters as L, H/L, and W/H, and rearranging the measurements of Simpson and Ortmann, these forms may be roughly defined as follows:

	L(mm.)	H/L	W/H	N	Reference
A. grandis	91–128	.49–.58	.57–.71	6	Ortmann
A. g. benedictensis	92	.62	.65	1	Simpson
A. g. footiana (long form)	95–122	.50–.54	.73–.79	5	Ortmann
A. g. footiana (short form)	93–107	.57–.63	.64–.70	2	Ortmann
A. g. gigantea	93–149	.59–.62	.53–.71	6	Ortmann
A. kennicottii	80–107	.50–.59	.59–.66	2	Simpson
A. marginata	85–132	.46–.49	.66–.82	3	Simpson
A. pepiniana	55–65	.52–.58	.55–.59	2	Simpson

Ortmann (1919:140) pointed out that *gigantea* (type locality: Port Gibson, Miss.) is simply an ecotype of *grandis* which occurs in muddy pools and is in no sense a subspecies. *A. g. benedictensis* (type locality:

Lake Champlain) is a small form of *grandis* and is possibly a depauperate local race. *A. g. footiana* (type locality: Fort Winnebago [Lake Winnebago, Wisconsin]) is generally more inflated than *grandis,* particularly in the umbonal and anterior regions, usually more elongate, and has finer beak sculpture. Van der Schalie (1938:52) has shown this to be a common variation in *grandis* s.s. *A. kennicottii* (type locality: Fort Rae, Great Slave Lake; and north end of Lake Winnepeg), a variable form with an upcurved posterior ridge, is poorly understood but probably does not occur in the Great Lakes System. *A. marginata* (type locality not specified but presumably near Philadelphia) is a thin-shelled form with silvery or bluish-white nacre. Van der Schalie *(l.c.)* has shown that Michigan specimens of *"marginata"* are simply elongate, thin shelled forms of *grandis* which occur in lakes of low pH (and low calcium carbonate content). *A. pepiniana* (type locality: Lake Pepin, Portage County, Ohio) is a small, relatively compressed "species" without prominent differential characters. This taxon is also poorly understood, but it is probably an ecological form or a local race below the level of the subspecies.

According to Ortmann (1919), Van der Schalie (1938) and others, *Anodonta grandis* is excessively variable, morphologically responsive to ecological variations, and prone to develop local races. For convenience, all anodontas found in this survey in the St. Lawrence Drainage, except *imbecilis* and very characteristic specimens of *cataracta,* are here treated as *grandis* s.s. This problem should be investigated further.

Distribution: Entire Mississippi System, St. Lawrence System, Red River of the North, Lake Winnepeg, Manitoba, and Southwest Texas.

Records: ***St. Lawrence System:*** Genesee River: Avon (this survey); South Park, Rochester (Baker, 1898). Conesus Lake, Lakeville. Erie Barge Canal: Clover Road, Pittsford; Monroe Avenue, Pittsford; Ayrault Road, Pittsford; 2 mi. S. E. of Pittsford; Lynden Road, Fairport; 3½ mi. W. of Macedon; 1½ mi. W. N. W. of Macedon; and Macedon (all this survey). Canandaigua Lake and Keuka Lake (both Marshall, 1895). Seneca Lake: Geneva and Dresden. Cayuga Lake: Aurora, King Ferry, and Portland Point. Dryden Lake; Sphaerium Brook, McLean; Lake Como and Lake Como Outlet, Dresserville (all this survey). Onondaga Lake; and Beaver Lake, Onondaga County (both Marshall, 1895). Erie Barge Canal, Onondaga County (Beauchamp, 1886). Oneida Lake: Eagle Bay, Bridgeport; Muskrat Bay, Brewerton; and Brewerton. Lake Ontario: Sodus Bay and Little Sodus Bay (all this survey).

Biology and ecology: Ortmann (1911:292) discussed the anatomy of this species. The breeding season lasts from the first part of August to the following April or May. The glochidia are comparatively large and measure 0.36 mm. in length and 0.37 mm. in height. They are subtriangular and possess hooks. The following fish serve as hosts for this speciees: brook stickleback, *Eucalia inconstans* (Kirkland); bluegill, *Lepomis macrochirus* Rafinesque; white crappie, *Pomoxis annularis* Rafinesque; largemouth bass, *Micropterus salmoides* (Lacepede); northern carpsucker, *Carpiodes carpio carpio* (Rafinesque); central johnny darter, *Boleosoma nigrum* (Rafinesque); Iowa darter, *Poecilichthys exilis* (Girard); and a minnow, *Notropis* sp. (J. P. E. Morrison, personal communication).

A. grandis is found in rivers, creeks, lakes, ponds and canals in nearly all kinds of substrates. It becomes large and abundant in muddy situations and is the only species found in many muddy places. There is a great tendency to form local races and to vary considerably in response to ecological conditions. It is a very common species throughout its range. In Central New York its associated species usually include *Lampsilis radiata siliquoidea* or *L. r. radiata* and *Elliptio complanatus.*

Anodonta (Anodonta) cataracta Say, Fig. 46

Anodonta cataracta Say 1817: Nicholsons Encyclopedia, 1st ed., **2,** pl. 3, fig. 4 (type locality not specified); Letson 1905:86; Simpson 1914:386; Johnson 1915:24; Ortmann 1919:152.

Anodon fluviatilis Dillwyn: DeKay 1843:203.

Description: *A. cataracta* is close to *A. grandis* but is usually more elongate, more distinctly green, and more prominently rayed posteriorly. Also, the beak sculpture is without the tubercles which are typical of *grandis.*

Shell medium to large, elliptical, thin, fragile, and inflated. Periostracum smooth, shiny, and grass-green or modified with yellow, brown, or black, often with green rays, especially on the posterior slope. Beaks somewhat inflated and projecting above the hinge line. Beak sculpture distinct, double looped, and not nodulous (fig. 17). Hinge teeth absent. Nacre silvery or white, tinged with blue or yellow and iridescent. Dioecious. Supra-anal opening much shorter than section of united mantle margins separating it from anal opening. Ovisacs not subdivided.

Adult specimens are commonly between 75 and 150 mm. (3 to 6 inches) in length and have H/L ratios of .45 to .56 and W/H ratios of .62 to .76.

Distribution: This species occurs in the lower St. Lawrence Drainage and in the Atlantic Drainage from the Gulf of St. Lawrence to North Carolina. Specimens morphologically inseparable from *cataracta* also occur in Michigan, implying that this species may have migrated to that region along with *Elliptio complanatus* during Pleistocene deglaciation.

Records: ***St. Lawrence System.*** Oneida Lake: Muskrat Bay, and Eagle Bay, Bridgeport (both this survey). Seneca River, Onondaga County (Beauchamp, 1886). St. Lawrence River: Waddington; and Sheek Island, Mille Roches, Ontario (this survey).

Susquehanna System: West Mission, Steuben County (Marshall, 1895). Susquehanna River: Nineveh and Avon. Cayuta Lake, near Montour Falls. Catatonk Creek: Owego; 2 mi. S. E. of Candor; 4½ mi. W. of Candor; below Spencer Lake, Spencer. Spencer Lake, Spencer. Willseyville Creek: Willseyville and South Danby. Owego Creek, 3 mi. N. E. of

Speedsville. West Branch, Tioughnioga River, 5.5 mi. N. of Cortland. Otselic River: Whitney Point and Upper Lisle. Chenango River at Chenango Forks. Cincinnatus Lake, Willet (all this survey). Richfield, Otsego County (Marshall, 1895).

Biology and ecology: The anatomy of *A. cataracta* is similar to that of *A. grandis* (Ortmann, 1911:293). It has been further investigated by Reardon (1929:8). The breeding season lasts from the middle of July to the following April or May. The glochidia are similar to those of *A. grandis,* comparatively very large and measure 0.36 mm. in length and 0.37 mm. in height. They are subtriangular and possess hooks. The host fish is unknown.

A. cataracta is found in lakes and ponds and in streams varying in size from medium-sized rivers to small brooks. It is most abundant in mud or sand, but also occurs in gravel and in rocky areas. It is often the only species present in the soft mud of ponds and backwater areas of streams. Next to *Elliptio complanatus,* it is probably the most common species in the Atlantic Drainage. Its most usual associate is *E. complanatus.*

Anodonta (Anodonta) implicata Say, Fig. 42

Anodonta implicata Say: 1829, New Harmony Dissem., 2, no. 22:340 (type locality: Danvers, Mass.). Simpson 1914:391; Johnson 1915:24; Baker 1916:253 (probably incorrect); Ortmann 1919:159, pl. 11, fig. 2–3; LaRocque 1953:88.

Anodon implicata (Say): DeKay 1843:202.

Description: The most characteristic features of this species are the prominent thickening in the anterior-ventral portion of the shell, the dark and usually rayless periostracum, the usually salmon or copper colored nacre, the large size, and the high degree of inflation.

Shell large, elongate elliptical, thickened anteriorly and thinner posteriorly, relatively strong, and prominently inflated. Posterior ridge usually well defined and double. Periostracum usually heavy, yellowish, brownish, or black, and sometimes obscurely rayed with green in young specimens. Beaks inflated and somewhat elevated above the hinge line. Beak sculpture concentric and not tuberculous (fig. 16). Pseudocardinal and lateral teeth absent. Nacre usually salmon colored or pinkish, sometimes white or bluish. Dioecious.

Adult specimens from southeastern Massachusetts commonly measure from 100 to 165 mm. (4 to 6½ inches) in length and give H/L ratios of .46 to .58 and W/H ratios of .78 to .88.

Remarks: Johnson (1946) clarified the previously confused concept of this species and designated a neoholotype from a sandy stream, the Agawam River, Plymouth, Massachusetts. Say's type locality "Pond in Danvers, Massachusetts" could have been any of several ponds now included within the boundaries of Peabody, and although these areas are ecologically very different from the Agawam River the neoholotype is probably Say's

species. Johnson stated that all valid records of this species are from coastal streams and ponds frequented by the alewife, *"Pomolobus pseudoharengus,"* the fish host of *A. implicata.* The authors have seen no authentic specimens of *implicata* from the Great Lakes Drainage and all records for this mussel from that region may be invalid, but it should not be forgotten that the alewife also occurs in the Great Lakes and in the Finger Lakes of New York (Odell, 1934, and others).

Distribution: Atlantic Drainage from Nova Scotia to the District of Columbia (Johnson, 1946). Also, St. Lawrence Drainage and "Saskatchewan Basin" (LaRocque, 1953). The latter record is from Dall (1905:129). Examination of his specimens at the United States National Museum (USNM 128768, 128775) has shown them to be misidentified forms of *Anodonta grandis* Say.

Records: Charlotte, Lake Ontario; and Pittsford, New York (Baker, 1898). Oneida Lake (8 localities) (Baker, 1916). Western New York (Wesley Newcomb Collection). These records are all doubtful.

Biology and ecology: The anatomy of this species has not been investigated. The breeding season is reported to last from September to June. The glochidia are rather large, subtriangular, and with a spine at the tip of each valve (Johnson, 1946:112). The host fish is the alewife, *Alosa pseudoharengus* (Wilson).

A. implicata occurs with greatest abundance in ponds close to the coast that have an unobstructed outlet to the ocean, or in these outlets, or in portions of other streams near the coast. It usually occurs on sand or gravel, rarely on mud. Its most common associates are *Anodonta cataracta, Lampsilis r. radiata, L. ochracea,* and *Elliptio complanatus.*

Subgenus *Utterbackia* F. C. Baker 1927

Type species: *Anodonta imbecilis* Say, by original designation.

Anodonta (Utterbackia) imbecilis Say, Fig. 40

Anodonta imbecilis Say: 1829, New Harmony Dissem., 2, no. 23:355 (type locality: Wabash River). *Anodonta imbecilis* Say: Letson 1905:87, Simpson 1914:395; LaRocque 1953:88.

Anodonta ohiensis Raf.: Ortmann 1919:162.

Description: The flat, entirely unelevated beaks distinguish this species from all other anodontas in this area. Other outstanding characters are the green, shiny periostracum, the fragile shell, and the fine, interrupted beak sculpture.

Shell small to medium, sub-elliptical, rather elongate, thin, fragile, compressed in the young and more inflated in the adult. Shell compressed posterodorsally and somewhat alate. Periostracum green, smooth, and with more or less well-defined darker green rays. Two or 3 dark green or blackish rays present on posterior slope. Beaks depressed, not at all elevated above the hinge line. Beak sculpture fine, irregular, consisting of

4 to 6 subconcentric ridges which are somewhat expanded posteriorly, the earlier bars often broken centrally and the later ones slightly sinuate centrally. Bars disappearing anteriorly and posteriorly. Hinge entirely without teeth and forming a straight line. Nacre bluish white, silvery, and iridescent posteriorly. Males rare or absent in most populations.

Adult specimens commonly measure between 75 and 100 mm. (3 to 4 inches) in length and give H/L ratios of .48 to .55 and W/H ratios of .62 to .72.

Remarks: Say's original spelling was *imbecilis*, not *imbecillis*, and a return to the correct orthography seems desirable.

Distribution: Ohio-Mississippi System generally, Gulf of Mexico Drainage from Florida to Mexico, Atlantic Drainage from North Carolina to Georgia, and Great Lakes System from Wisconsin to Central New York.

Records: ***St. Lawrence System.*** Irondequoit Creek, Monroe County (Marshall, 1895). Erie Barge Canal: Clover Road, Pittsford; 3½ mi. W. of Macedon; 1½ mi. W. N. W. of Macedon; and Macedon (all this survey). Oswego Canal; and Beaver Lake, Onondaga County (both Marshall, 1895).

Biology and ecology: The anatomy of *A. imbecilis* was discussed by Lea (1863, Observations 10:449) and Utterback (1915:261). Ortmann (1911: 291) reported only females found in Pennsylvania, but Utterback *(l.c.)* indicated that males were also present among Missouri specimens. It seems to breed throughout the year. Howard (1914) reported that glochidia develop entirely within marsupia of the parent and do not become parasitic on fish. He also suggested that, since the juvenile shell is thin and buoyant, dispersal is accomplished by currents, a function usually performed in other species by the host fish.

On April 29, 1959, Dr. A. W. Eipper collected a living specimen of *Anodonta imbecilis* from an isolated farm pond 2 miles southwest of Cayuta, Schuyler Co., New York. This pond was built in 1953 and stocked in 1954 with 6 hatchery-raised bluegills *(Lepomis macrochirus macrochirus* Raf.) and about 30 wild-caught creek chubs *(Semotilus atromaculatus atromaculatus* (Mitchill)). The mussel had 4 well-marked growth rests on the shell and was apparently in the fifth year of life. It is nearly certain that it was attached as a glochidium to one of the fish introduced in 1954, and since the *L. m. macrochirus* were hatchery-raised and presumably glochidia-free, *S. a. atromaculatus* is indicated as the host fish. The habitat preference and known geographic range of this fish closely approximate the habitat and range of *A. imbecilis.*

In the Erie Barge Canal, *A. imbecilis* is found in soft, muddy banks. Ortmann (1919:164) also reported it from muddy or somewhat sandy banks and bottoms of ponds, creeks, and small rivers. Van der Schalie (1938:52) reported it from mud and sand bottoms and also from gravel areas of swift-flowing streams. In the New York region its most abundant associate is *Anodonta grandis.*

Genus *Strophitus* Rafinesque 1820

Type species: *Anodonta undulata* Say, by monotypy.

Strophitus undulatus (Say) Fig. 41

Anodonta undulata Say 1817: Nicholson's Encyclopedia, Philadelphia, 1st Ed., 2:20–21, pl. 3, fig. 6 (type locality not specified, but presumably near Philadelphia).
Anodon rugosus Swainson 1822: Zool. Illust., pl. 96.
Anodon edentula Say: DeKay 1843:201.
Anodon unadilla DeKay 1843:203.
Anodon pavonia Lea: DeKay 1843:201.
Strophitus edentulus (Say): Letson 1905:85; Simpson 1914:345; Johnson 1915:23; Ortmann 1919:197.
Strophitus edentulus var. *pavonius* (Lea): Letson 1905:85.
Strophitus undulatus (Say): Letson 1905:85; Simpson 1914:349; Johnson 1915:23; Ortmann 1919:195.
Strophitus rugosus (Swainson): Robertson and Blakeslee 1948:101; LaRocque 1953:99.

Description: In the Susquehanna System and elsewhere in the Atlantic Drainage, *S. undulatus* can easily be distinguished from other species by its dark periostracum, obsolete teeth, and characteristic nacre color. In the St. Lawrence System, it may be confused with *Anondontoides ferussacianus* Lea, but that species has a thinner shell, more uniform bluish white nacre, and much finer beak sculpture. If gravid females are at hand, the marsupial structure at once distinguishes *S. undulatus* from all others.

Shell variable, of medium size, sub-elliptical, thin when young and slightly thickened when adult, moderately strong, and sub-inflated. Periostracum relatively smooth and shiny and yellowish brown to black, rarely with narrow, green rays. Beak sculpture of rather coarse, oblique, curved bars (fig. 12). Hinge teeth absent or greatly reduced; pseudocardinal teeth usually indicated by slight swellings just anterior to the beaks, or occasionally present as a very low, rounded excrescence in each valve. Lateral teeth absent. Nacre bluish-white, with suffusions of yellow or salmon near the beaks and bordered with olive green or greenish brown. Ovisac of each water tube subdivided into a number of compartments, each containing a well-developed placentula placed transversely to the tube. Placentae persistent until they are discharged.

Adult specimens commonly measure 60 to 90 mm. (2½ to 3½ inches) in length and give H/L ratios of .52 to .64 and W/H ratios of .52 to .68.

Remarks: It is unfortunate that the well-known name *rugosus* must be discarded, but this seems to be the least objectionable course consistent with the International Rules of Nomenclature. Say gave no type locality, designated no type specimen, and provided a poor figure which represents a juvenile specimen. Recent authors have logically considered *undulatus*

Say (1817) as conspecific with *rugosus* Swainson (1822) or the synonymous name *edentulus* Say (1829). Ortmann (1919:195) stated that in his opinion *undulatus* was only a poorly defined variety of *edentulus*, "connected by intergrades," and that they were the same species. However, he formally retained the two as separate species, "thus avoiding. . . inconvenience." Frierson (1927:22) changed the name to *undulatus*, but this course was not followed by most of the subsequent workers.

It is quite clear that only one species of *Strophitus* occurs in the Atlantic Drainage, and since *undulatus* is the earliest name, it must be used. The alternative of considering *undulatus* as unidentifiable would demand that the name *Strophitus* be replaced, since *undulatus* is its type species by monotypy. This even less desirable course certainly is not justified.

Description: This species is more widely distributed in North America than any other. It occurs in the Atlantic Drainage from the Gulf of St. Lawrence to North Carolina; the St. Lawrence Drainage from Lake Huron eastward; and throughout the entire Ohio, Mississippi, and Missouri River Systems.

Records: ***St. Lawrence System.*** Genesee River at Avon (this survey). Long Pond, Monroe County (Walton, 1892). Creek near Kelly's Grove, Rochester (Baker, 1898). Outlet of Canadice Lake, Canadice (this survey). Honeoye Creek, Monroe County; Pittsford, Monroe County; Seneca River; and Onondaga County (all Marshall, 1895). N. end of Owasco Lake (Baker, 1899). Oneida Lake (Baker, 1916). Chittenango Creek: Kirkville and 5 mi. S. of Bridgeport. St. Lawrence River at Sheek Island, Mille Roches, Ontario (all this survey).

Susquehanna System. Canisteo River, Steuben County (Marshall, 1895). Susquehanna River: Nineveh and Afton. Catatonk Creek: Owego; 2 mi. S. E. of Candor; 4½ mi. W. of Candor; and below Spencer Lake, Spencer. West Branch, Tioughnioga River, Little York. Otselic River: Whitney Point, Upper Lisle, and Willet. Genegantslet Creek at Smithville Flats (all this survey). Unadilla River, Otsego County; and Little Lakes, Otsego County (both Marshall, 1895).

Biology and ecology: Ortmann (1911:299) discussed the anatomy of this species under *S. endentulus* (Say). The breeding season lasts from July to the following April or May. The glochidia are subtriangular, with hooks, and measure 0.36 mm. in length and 0.30 mm. in height. They may complete their development within the marsupia of the parent or they may metamorphose during a period of parasitism on fish. Under experimental conditions the glochidia completed their development attached to the fins and skin of the largemouth black bass, *Micropterus salmoides* (Lacepede) and the northern creek chub, *Semotilus atromaculatus* (Mitchill), (Baker, 1928:201), both of which are widely distributed in the Mississippi, St. Lawrence, and Atlantic Drainages.

S. undulatus is a common and widely distributed species. It usually occurs in small rivers and creeks on mud, sand, or fine gravel substrates. It is found more rarely in lakes and canals. Frequently associated species are *Elliptio complanatus* and *Alasmidonta undulata*.

SUBFAMILY LAMPSILINAE

Shells small to large, thickened or thin, sculpturing variable, hinge teeth usually well developed. Sexual demorphism often apparent. Bradytictic (females retaining the glochidia in the marsupia at least from fall to the following spring). Marsupia usually formed by the posterior part of the outer gill, rarely by the whole outer gill. Water tubes not divided in the gravid female. Glochidia semicircular or semielliptical and without a spine, except in *Proptera* where they are ax-shaped and with 2 spines on each valve.

Genus *Proptera* Rafinesque 1819

Type species: *Unio alatus* Say, by subsequent designation, Simpson 1900.

Proptera alata (Say), Fig. 23

Unio alatus Say: 1817, Nich. Ency., pl. 4, fig. 2 (type locality not specified); DeKay 1843:195.
Lampsilis alatus (Say): Letson 1905:84.
Lampsilis alata (Say): Simpson 1914:162.
Lampsilis (Proptera) alata (Say): Johnson 1915:23.
Proptera alata (Say): Ortmann 1919:252; Robertson and Blakeslee 1948: 105; LaRocque 1953:97.

Description: The high posterior wing, dark periostracum, ovate form, relatively thin shell, and purple or pink nacre make recognition of this species very easy.

Shell large, ovate and with a posterior wing, rather thin, but not as thin and fragile as the shell of *Leptodea fragilis*. Posterior wing triangular and high, occasionally lower in old shells. Periostracum greenish brown or brown in young specimens, brown or blackish in adults, sometimes obscurely rayed. Beak sculpture faint, consisting of 3 to 4 fine bars, the first sub-concentric, the others double-looped but nearly obliterated anteriorly. Pseudocardinal teeth conical, serrate, not large, 1 or 2 in the right valve, 2 in the left. Lateral teeth elongate, elevated, curved, single in the right valve and double in the left, though fused anteriorly. Nacre purple to pink and iridescent.

Adult specimens ordinarily measure from 90 to 150 mm. (3½ to 6 inches) in length and exhibit H/L ratios of .60 to .80 and W/H ratios of .36 to .56, depending largely on the degree of preservation of the wing.

Distribution: Ohio-Mississippi Drainage, St. Lawrence Drainage east to Lake Champlain and the Ottawa River, and Hudson Bay Drainage.

Records: ***St. Lawrence System.*** Genesee River at South Park, Rochester (Baker, 1898). Old Erie Canal, French Road, Pittsford (this survey). Erie Barge Canal, Cayuga County; Seneca River; and Oneida River (all Marshall, 1895).

Biology and ecology: The anatomy was discussed by Lea (1863, Observations *10*:403) and Ortmann (1911:333). It is very similar to that of *Leptodea fragilis*. *P. alata* breeds from about August to the following July. The glochidia are ax-head shaped, with 2 spines on each valve, and have been measured as 0.23 mm. in length and 0.41 mm. in height, and as 0.20 mm. and 0.38 mm. (Ortmann, *l.c.*). The fish host is unknown.

P. alata occurs in large rivers, in lakes, and in canals on mud, sand, or gravel bottoms. It is rare in small creeks. In Lake Champlain, where it is locally common, it occurs in protected, muddy, moderately vegetated areas. Associated species often include *Leptodea fragilis* and *Lampsilis ovata ventricosa*.

Genus *Leptodea* Rafinesque 1820

Type species: *Unio (Leptodea) fragilis* Rafinesque, by subsequent designation, Herrmannsen 1847.

Leptodea fragilis (Rafinesque), Fig. 22

Unio fragilis Raf. 1820, Monographie, p. 295 (type locality: Ohio River).
Lampsilis gracilis (Barnes): Letson 1905:84; Simpson 1914:181.
Lampsilis (Proptera) gracilis (Barnes): Johnson 1915:23.
Paraptera fragilis (Raf.): Ortmann 1919:247.
Leptodea fragilis (Raf.): Robertson and Blakeslee 1948:105; LaRocque 1953:94.

Description: This species is well characterized by its thin and fragile shell, high posterior wing, light-colored periostracum, white or pinkish nacre, and weak hinge teeth. Compare with *Proptera alata*.

Shell medium to large; ovate, compressed, with a posterior wing; thin and fragile but somewhat stronger when old. Posterior wing high, triangular, usually prominent but obliterated in most old shells. Periostracum light yellow to yellow-brown, sometimes with poorly defined, narrow, green rays; smooth, except in old shells; and with growth rests marked by brown, concentric bands. Beak sculpture faint, consisting of 3 or 4 fine bars, the first subconcentric, the others double-looped but anterior loops partly obliterated. Pseudocardinal teeth thin, weakly developed, single or nearly absent in the right valve and double, single, or nearly absent in the left valve. Lateral teeth elongate, thin, elevated and single in the right valve, less elevated and double in the left valve although fused anteriorly. Nacre silvery white and iridescent, sometimes pinkish, especially dorsally.

Adult specimens commonly range between 75 and 135 mm. (3 to 5½ inches) in length and show H/L ratios of .62 to .76 and W/H ratios of .40 to .56, depending largely on the degree of preservation of the wing.

Distribution: Entire Ohio-Mississippi Drainage, Gulf of Mexico Drainage from Alabama to Texas, and St. Lawrence Drainage from Lake St. Clair to the city of Quebec (Bousfield, 1955).

Records: *St. Lawrence System.* Erie Barge Canal: Clover Road, Pittsford; Monroe Avenue, Pittsford (both this survey); and Rochester (Marshall, 1895). Cross Lake, Onondaga County; and Onondaga Lake (both Marshall, 1895).

Biology and ecology: The anatomy of *L. fragilis* was discussed by Ortmann (1911:331) under the synonym *Paraptera gracilis* (Barnes). The species breeds from near the end of August to the following July. The glochidia are very small, sub-ovate, and measure approximately 0.08 mm. in length and 0.09 mm. in height. Howard (1912:3) gives the sheepshead *Aplodinotus grunniens* Raf. as a host fish for this species.

This species occurs in rivers of various size, lakes, and canals in mud, sand, or gravel. Ortmann (1919:251) has reported it from riffles in gravel. In the Erie Barge Canal and in Lake Champlain it occurs in quiet water in mud. Associated species often include *Proptera alata* and *Anodonta grandis*.

Genus *Obovaria* Rafinesque 1819

Type species: *Obovaria torsa* Rafinesque, by subsequent designation, Agassiz 1852.

Subgenus *Pseudoön* Simpson 1900

Type species: *Unio ellipsis* Lea, by original designation.

Obovaria (Pseudoön) olivaria (Rafinesque), Fig. 36

Amblema olivaria Raf. 1820, Monographie: 314 (type locality: Kentucky River).
Obovaria ellipsis (Lea): Letson 1905:85; Simpson 1914:299.
Obovaria (Pseudoön) olivaria (Raf.): Ortmann 1919:229.
Obovaria olivaria (Raf.): Robertson and Blakeslee 1948:104 LaRocque 1953:96.

Description: The ovate or nearly round shell, massive teeth, and swollen anterior beaks make this species entirely distinct from all others in northeastern North America.

Shell medium-sized, almost round or sub-ovate, thick, solid, and somewhat inflated. Posterior ridge indistinct. No apparent sexual dimorphism. Periostracum olive green or modified with yellow or brown, often with indistinct rays. Beaks near or at the anterior end, swollen, elevated, incurved, and directed forward. Beak sculpture rudimentary, consisting of 4 or 5 fine, centrally sinuate bars which disappear on the posterior slope. Bars sometimes obsolete even on specimens with well-preserved beaks. Pseudocardinal teeth heavy, thick, stubby, or slightly elongate, subparallel with the lateral teeth, 1 in the right valve and 2 in the left. Lateral teeth moderately elongate, heavy, slightly curved, 1 or 2 in the right valve and 2 in the left. Nacre silvery white. Inner edge of mantle without papillae or flaps.

Adults usually measure from 35 to 70 mm. (1½ to 2¾ inches) and have H/L ratios of .68 to .82 and W/H ratios of .60 to .84. Specimens from the vicinity of New York usually do not exceed 50 mm. (2 inches) in length.

Distribution: Ohio and Mississippi Rivers and major tributaries, Lakes Huron and Erie and their drainages, Lake Ontario drainage (?), St. Lawrence River, Ottawa River, and St. Francis River, Quebec.

Records: ***St. Lawrence System.*** Cayuga Lake (Marshall, 1895). Onondaga Lake (Beauchamp, 1886, as *O. leibi*). These are the only records from Central New York, and the Beauchamp record may be another species. West of this area it occurs in the Niagara River (Robertson and Blakeslee, 1948:101), and east of this region it is known from St. Lawrence River at Sheek Island, Mille Roches, Ontario (H. D. Athearn); between Three Rivers and St. Joachim and at Montmagny, Quebec (Bousfield, 1955); St. Francis River, Yamaska County, Quebec (Athearn, 1952); and Ottawa River, Duck Island, Russell County, Ontario (F. R. Latchford).

Biology and ecology: The anatomy of *O. olivaria* was discussed by Ortmann (1911:323) under *O. ellipsis* Lea. It breeds from August to the following June. The glochidia are sub-oval, without hooks, and measure 0.19 mm. in length and 0.22 mm. in height (Ortmann, *l.c.*). The sheepshead *Aplodinotus grunniens* Raf. is listed by Howard (1912:3) as a host fish for this species.

This species occurs primarily in large rivers in rather deep water and on sand or gravel bottoms. It is usually not found in lakes.

Genus *Actinonaias* Crosse and Fisher 1893

Type species: *Unio sapotalensis* Lea, by subsequent designation, Frierson 1917.

Actinonaias carinata (Barnes), Fig. 43

Unio carinatus Barnes 1823, Amer. J. of Sci. 6:259, pl. 11, fig. 10 (type locality: Fox River, Wisconsin).
Lampsilis ligamentina (Lam.): Simpson 1914:79.
Lampsilis ligamentina var. *nigrescens* Simpson 1914:82.
Actinonaias ligamentina (Lam.): Ortmann 1919:232.
Actinonaias carinata (Barnes): Robertson and Blakeslee 1948:104; LaRocque 1953:85.

Description: The regularly ovate shape, large and heavy shell, and broad rays will usually distinguish this species from others. Young specimens are somewhat similar to young *Lampsilis radiata siliquoidea* and *Villosa iris* but are less elongate and of a different color. If soft parts are available, the presence of papillae or flaps on the inner edge of the mantle in female *Lampsilis* and *Villosa* will distinguish them from *Actinonaias*.

Shell medium to large, sub-elliptical to sub-ovate, thick, strong, and somewhat inflated. Beaks not close to anterior end. Sexual dimorphism not apparent. Periostracum yellowish, greenish, or brownish and often with broad rays, especially in young specimens. Beak sculpture poorly developed, consisting of a few fine, indistinct bars, which are more or less double-looped. Pseudocardinal teeth well developed, strong, sub-triangular, usually 1 or 2 in the right valve and 2 in the left, not parallel to the lateral teeth. Lateral teeth long, heavy, 1 in the right valve and 2 in the left. Nacre white, or very rarely pinkish. Inner edge of mantle without papillae or flaps.

Adult specimens usually measure 100 to 150 mm. (4 to 6 inches) in length and give H/L ratios of .60 to .66 and W/H ratios of .56 to .68.

Distribution: Ohio-Mississippi Drainage from New York and Minnesota to Arkansas. St. Lawrence Drainage in tributaries from Lake Michigan to Lake Ontario. Hudson Bay Drainage in Manitoba.

Records: ***St. Lawrence System.*** Cross Lake, Onondaga County, "rare" (Beauchamp, 1886). Oneida Lake, northeast side of Frenchman's Island, "one specimen" (Baker, 1916). Lake Ontario (LaRocque and Oughton, 1937). Nearby records include: Niagara River (Letson, 1905); Allegheny River at Olean (H. D. Athearn); and Lake Erie tributaries (Goodrich and Van der Schalie, 1932).

Biology and ecology: According to Ortmann (1911:325), the anatomy of *A. carinata* is similar to that of *Obovaria*. It breeds from August to the following May. The glochidia are of medium size, sub-elliptical, with a short, undulate hinge line, without hooks, and measure approximately 0.22 mm. in length and 0.25 mm. in height. The following widely distributed fish serve as hosts for the glochidia of *A. carinata* (modified from data in Coker, *et al.*, 1921): green sunfish, *Lepomis cyanellus* Rafinesque; bluegill, *L. macrochirus* Rafinesque; white crappie, *Pomoxis annularis* Rafinesque; black crappie, *P. nigromaculatus* (LeSueur); largemouth bass, *Micropterus salmoides* (Lacepede); smallmouth bass, *M. dolomieui dolomieui* Lacepede; white bass, *Roccus chrysops* (Rafinesque); yellow perch, *Perca flavescens* (Mitchill); and easter sauger, *Stizostedion canadense* (Smith).

In the Ohio-Mississippi Drainage *A. carinata* is very common and often outnumbers all other species at any particular locality. It occurs there in large and medium-sized rivers usually in gravel or sand but sometimes in mud also. It is associated with many river species. In the St. Lawrence Drainage east of Lake Erie it is exceedingly rare.

Genus *Carunculina* (in Baker) Simpson 1898[2]

Type species: *Unio parvus* Barnes, by monotypy.

Carunculina parva (Barnes), Fig. 37

Unio parvus Barnes 1823, Am. J. Sci., 6, pl. 13, fig. 18 (type locality: Fox River).

[2]This generic name refers to the "caruncle" on the mantle of the type species. It was misspelled *Corunculina* in the original description, but in the index of that work it was corrected to *Carunculina*. The error was also cited and emended by Simpson (1900:563).

Lampsilis parvus (Barnes): Letson 1905:84.
Lampsilis parva (Barnes): Simpson 1919:151.
Toxolasma parvum (Barnes): Ortmann 1919:258.
Carunculina parva (Barnes): Robertson and Blakeslee 1948:106; LaRocque 1953:90.

Description: The small size, relatively robust, inflated, and elliptical shell, characteristic hinge teeth and beak sculpture, and absence of rays are sufficient to distinguish this species from all others in northeastern North America.

Shell small, sub-elliptical, moderately thick and solid, and rather inflated, especially in the female. Posterior ridge poorly defined. Sexual dimorphism distinct. Periostracum greenish brown to blackish and folded at lines of growth to give a velvety appearance. Beak sculpture pronounced, consisting of about 6 rather strong, subconcentric bars of which the later ones are subangular on the posterior ridge. Pseudocardinal teeth prominent, compressed, 1 or 2 in the right valve and 2 in the left. Lateral teeth well developed, nearly straight, 1 in the right valve and 2 in the left. Nacre silvery white, iridescent posteriorly. Inner edge of mantle with a caruncle, or crowded group of short papillae, in front of branchial opening.

Adult specimens usually measure between 26 and 34 mm. (1 to 1½ inches) in length and give H/L ratios of 153 to 160 and W/H ratios of .67 to .79.

Distribution: Ohio-Mississippi System; St. Lawrence System in Lake Erie, its tributaries, and the Erie Barge Canal in New York. It is replaced by several similar species in the south, and its southern limits are therefore not well established.

Records: ***St. Lawrence System.*** Erie Barge Canal: Clover Road, Pittsford (this survey, and Robertson and Blakeslee, 1948); 1½ mi. W. of Macedon (this survey); and Onondaga County (Beauchamp, 1886). Genesee Canal (Marshall, 1895).

Biology and ecology: The anatomy was discussed by Ortmann (1911:338), and Utterback (1916:396). It is probably bradytictic, but the time limits of its breeding season are unknown. Utterback (1916:397) and others have reported only specimens with female gill structure from many localities, but some specimens with male gill structure have been found with females at other locations. The glochidia are sub-elliptical, without hooks, with a straight hinge line, and measure approximately 0.18 mm. in length and 0.20 mm. in height. The host fish is unknown.

C. parva occurs in sluggish streams and canals on muddy bottoms. It is rare in the Erie Canal. Associated species include *Anodonta grandis* and *Lampsilis radiata siliquoidea.*

Genus *Ligumia* Swainson 1840

Type species: *Unio recta* Lamarck, by original designation.

Ligumia nasuta (Say), Fig. 54

Unio nasutus Say, 1817 Nich. Ency., pl. 4, fig. 1 (type locality: Delaware and Schuylkill Rivers); DeKay 1843:191.
Lampsilis nasutus (Say): Letson 1905:83.
Lampsilis nasuta (Say): Simpson 1914:97; Johnson 1915:22.
Eurynia (Eurynia) nasuta (Say): Ortmann 1919:271.
Ligumia nasuta (Say): Robertson and Blakeslee 1948:107; LaRocque 1953:95.

Description: The relatively elongate form, the centrally located, narrow posterior point, the small and compressed pseudocardinal teeth, and usually the purple nacre render this species easily distinguishable from all others in northeastern North America.

Shell of medium size, elongate-elliptical, pointed posteriorly, of medium thickness, strong, and somewhat compressed. Posterior end elongate, bluntly pointed, and subtending an angle of about 60°. Females slightly expanded post-basally. Periostracum typically brown to black, occasionally dark olive green, sometimes with narrow, green, more or less well-defined rays. Beak sculpture subconcentric and double-looped (fig. 5). Pseudocardinal teeth small, erect, compressed, and single or double in each valve. Lateral teeth narrow, elongate, single in the right valve and double in the left. Nacre purple, salmon, or more rarely silvery white. Inner edge of mantle having papillae in front of branchial opening.

Adults usually range between 80 and 105 mm. (3¼ to 4¼ inches) in length and give H/L ratios of .41 to .47 and W/H ratios of .62 to .72.

Distribution: St. Lawrence System and Atlantic Drainage south to North Carolina.

Records: Erie Barge Canal: Rochester (Marshall, 1895); Clover Road, Pittsford; 2 mi. S. E. of Pittsford; and Lynden Road, Fairport (all this survey). Old Erie Canal, Pittsford (Robertson and Blakeslee, 1948). St. Lawrence River: Grass Point State Park, Jefferson County (H. D. Athearn). Tributaries of Lake Ontario in New York (Ortmann, 1919).

Biology and ecology: The anatomy of *L. nasuta* was discussed by Ortmann (1911:343) and Reardon (1929:8). It breeds from August until the following June. The glochidia are sub-ovate, with an undulate hinge line, and measure 0.25 mm. in length and 0.29 mm. in height. The host fish is unknown.

This species occurs in protected areas in ponds and lakes, in slack water portions of streams, and in canals. It is found in sand and in mud. Frequently associated species include *Elliptio complanatus* and *Lampsilis r. radiata* or *L. r. siliquoidea.*

Ligumia recta (Lamarck), Fig. 60

Unio recta Lamarck, 1819, Anim. sans Vertebres, 6:74 (type locality: Lake Erie).
Unio latissima Rafinesque, 1820, Monographic, p. 297, pl. 80, figs. 14, 15 (type locality: Ohio River).
Lampsilis rectus (Lam.): DeKay 1843:195; Letson 1905:82.
Lampsilis recta (Lam.): Simpson 1914:95; Johnson 1915:22.
Eurynia (Eurynia) recta (Lam.): Ortmann 1919:276.
Ligumia recta (Lam.): Robertson and Blakeslee 1948:107; LaRocque 1953:95.

Description: *Ligumia recta* is easily recognized by its large size, lanceolate shape, complete hinge teeth, and almost black color. Young male specimens may resemble *Elliptio dilatatus* but are shiny and greenish black, whereas *E. dilatatus* is not shiny and is brownish black.

Shell large, elongate-elliptical, rather thick and heavy, strong, and slightly inflated. Females often expanded post-basally. Periostracum glossy, dark green, dark brown, or blackish. Rays dark green, usually obscure in adults. Beak sculpture faint and obsolete, consisting of 3 to 5 indistinct double-looped bars with a central sinus, bars disappearing on the posterior slope. Pseudocardinal teeth well developed, compressed, double in the left valve and single or double in the right valve. Lateral teeth erect, elongate, single in the right valve and double in the left. Nacre silvery white, often purple or pink centrally, in the beak cavity, and on the hinge teeth. Inner edge of mantle with papillae in front of branchial opening.

Adult specimens usually measure between 115 and 175 mm. (4½ to 7 inches) in length and give H/L ratios of .40 to .46 and W/H ratios of .60 to .68.

Distribution: Ohio-Mississippi System, St. Lawrence System east to Lake Champlain and the Ottawa River, Red River of the North, and Alabama River Drainage.

Records: ***St. Lawrence System.*** Erie Barge Canal, Clover Road, Pittsford (Robertson and Blakeslee, 1948). Seneca River and Oneida River (Marshall, 1895). Oneida Lake: ½ mi. E. N. E. of Lakeport; Eagle Bay, Bridgeport; Shackelton Point, Bridgeport (all this survey). Grass River, 1½ mi. S. W. of Chase Mills, St. Lawrence County (H. D. Athearn). St. Lawrence River, Sheek Island, Mille Roches, Ontario (this survey).

Biology and ecology: The anatomy of *L. recta* was discussed by Ortmann (1911:345) and Utterback (1916:440). The species breeds from August to the following July. The glochidia are sub-ovate, with an undulate hinge line, and measure approximately 0.22 mm. in length and 0.28 mm. in height. The widely distributed bluegill, *Lepomis macrochirus* Rafinesque, and white crappie, *Pomoxis annularis* Rafinesque, serve as host fish for the glochidia.

Ligumia recta is found in rivers of varying size, in creeks, and in lakes. It occurs on gravel and sand bottoms. Specimens are found in protected or unprotected portions of lakes, and in freely flowing areas of streams. Occasionally it is found in muddy situations and in canals. Frequently associated species include *Elliptio complanatus* and *Lampsilis radiata radiata* or *L. r. siliquoidea.*

Genus *Villosa* Frierson 1927

Type species: *Unio villosus* Wright, by original designation.

As Clench and Turner (1956) have pointed out, the familiar name *Micromya* Agassiz (1852) is preoccupied by *Micromya* Rondani (1840), a genus of Diptera. Even if we accept Agassiz's emendation of *Micromya* Rondani to *Micromyia,* the original usage still preoccupies, and under the Rules *Micromya* (Unionidae) is a homonym and cannot be used.

Villosa iris (Lea), new combination, Fig. 45

Unio iris (Lea) 1830, Trans. Amer. Philos. Soc., 3:439, pl. 11, fig. 18 (type locality: Ohio).
Unio novi-eboraci Lea: DeKay 1843:194 (not pl. 20, fig. 240).
Unio radiatus (Gm.): DeKay 1843, pl. 18, fig. 236.
Lampsilis iris (Lea): Letson 1905:83; Simpson 1914:113.
Eurynia (Micromya) iris (Lea): Ortmann 1919:265.
Eurynia (Micromya) iris novi-eboraci (Lea): Ortmann 1919:268.
Micromya iris (Lea): Robertson and Blakeslee 1948:107; LaRocque 1953:96.
Micromya iris novi-eboraci (Lea): LaRocque 1953:96.

Description: This species may be distinguished from others by its narrow form, small size, prominent rays, concentric bands of light color, anteriorly placed beaks, and iridescent nacre.

Shell small to medium, sub-elliptical or lanceolate, thickened anteriorly and thinner posteriorly, strong, and inflated. Sexual dimorphism distinct. Periostracum yellowish to light green, with dark rays over the whole surface or obsolete anteriorly, and often with concentric light colored bands. Beak sculpture consisting of 4 to 6 rather fine, distinct bars. First bar subconcentric, those following distinctly double looped, although often irregular. Pseudocardinal teeth well developed, elevated, and somewhat compressed, 1 in the right valve and 2 in the left. Lateral teeth long and narrow, 1 in the right valve and 2 in the left. Nacre silvery white, iridescent posteriorly. Inner edge of mantle with papillae in front of branchial opening.

Adult specimens commonly range between 40 and 65 mm. (1½ to 2½ inches) in length and have H/L ratios of .50 to .58 and W/H ratios of .58 to .75.

Remarks: The writers follow Simpson (1914) and Robertson and Blakeslee (1948) in considering *iris* and *novi-eboraci* synonymous. The character

of interrupted rays which distinguishes the latter form occurs throughout the whole range of *iris*, and although interrupted rays are said to occur more frequently in the St. Lawrence Drainage, both continuous-rayed and interrupted-rayed specimens are common. Such a difference is insufficient to qualify the St. Lawrence Drainage form as a separate subspecies.

Distribution: *Villosa iris* is recorded from the St. Lawrence System in the Lake Huron Drainage to the Lake Ontario Drainage and from the Ohio, Tennessee, and Upper Mississippi River Systems. Its southern limit is not well defined because of the presence of similar and poorly understood species in those areas.

Records: ***St. Lawrence System.*** Honeoye Creek, Route 15, 2 mi. W. of Rush (this survey, and H. D. Athearn). Erie Barge Canal: Rochester (Baker, 1898), Pittsford (Marshall, 1895), and Onondaga County (Beauchamp, 1886). Canandaigua Lake and Seneca River (Marshall, 1895). Cayuga Lake at King Ferry (E. J. Karlin). Chittenango Creek: Kirkville and 5 mi. S. of Bridgeport (both this survey). Oneida Lake: near Shaw Point, and Muskrat Bay (both Baker, 1916). Oneida River; and "Schenandoah Creek, Oneida Castle" (both Marshall, 1895). Oneida Creek, 1 mi. S. E. of Oneida Valley (H. D. Athearn).

Biology and ecology: The anatomy of this species was discussed and figured by Ortmann (1911:341). *V. iris* is probably bradytictic but time limits of its breeding season are not known. The glochidia are large, semi-elliptical, with a short hinge line, and measure approximately 0.23 mm. in length and 0.29 mm. in height. The fish host is unknown.

Villosa iris is found in sand or gravel in lakes and in medium-sized creeks. It also occurs in canals, but uncommonly. In Central New York it is rare at most localities, and we have found it common only in Honeoye Creek and Chittenango Creek, both of which are very high in dissolved calcium carbonate (measured as 186 p.p.m. and 175 p.p.m., respectively). At these localities it is associated with *Lampsilis ovata ventricosa, L. radiata siliquoidea, Lasmigona costata,* and other species.

Genus *Lampsilis* Rafinesque 1820

Type species: *Unio ovatus* Say, by subsequent designation, Simpson 1900.

Lampsilis cariosa (Say), Figs. 49, 50

Unio cariosus Say 1817, Nich. Ency., pl. 3, fig. 2 (type locality: Delaware and Schuylkill Rivers); not DeKay 1843, pl. 21, figs. 243, 244 (= *L. ovata ventricosa* (Bar.)).

Lampsilis cariosa (Say): Letson 1905:80; Simpson 1914:43; Johnson 1915: 21; Ortmann 1919:313; LaRocque 1953:92.

Description: *L. cariosa* resembles no other local species except *L. ovata ventricosa*. For distinguishing characters see that species.

Shell medium to somewhat large, sub-elliptical in the male, sub-ovate in the female, thickened anteriorly, thinner posteriorly, strong and sub-

inflated. Females typically much higher at the posterior termination of the ligament than at the beaks, males approximately equally high at these points. Periostracum smooth, usually bright straw yellow, yellow brown, or reddish brown and without rays or with narrow rays on the posterior slope only. Beak sculpture subconcentric (see fig. 5). Pseudocardinal teeth prominent, elevated, sub-conical, compressed and directed forward; 2 in each valve. Lateral teeth elevated, strong, straight or somewhat curved, 1 in the right valve and 2 in the left. Nacre white, often suffused with pink or orange near the beak cavities and posteriorly. Inner edge of mantle forming a ribbonlike flap in front of branchial opening that projects to anterior end.

Adults usually range between 75 and 130 mm. (3 to 5¼ inches) in length and give H/L ratios of .56 to .68 and W/H ratios of .58 to .76, females being proportionately higher posteriorly than males.

Distribution: Atlantic Drainage from the Lower St. Lawrence River to Georgia. Also recorded from stations in the Lake Ontario Drainage and the Ottawa River, but many of these records are probably incorrect (Johnson, 1947:149).

Records: ***St. Lawrence System.*** The records from Lake Ontario tributaries are probably based on misidentifications of *L. ovata ventricosa* (Johnson, 1947:149). The following records seem to be correct: Raquette River, Potsdam; Mohawk River, Mohawk (both Johnson, 1947); Grass River, 1½ mi. S. W. of Chase Mills (H. D. Athearn); and St. Lawrence River, Sheek Island, Mille Roches, Ontario (this survey).

Susquehanna System. Susquehanna River: Athens, Pennsylvania; Smithboro; Nineveh; and Afton. Tioughnioga River at Itaska. Otselic River: Whitney Point and Upper Lisle. Chenango River: Chenango Forks and 3 mi. N. E. of Greene (all this survey).

Biology and ecology: The anatomy of *L. cariosa* is said to be similar to that of *L. ovata ventricosa* (Ortmann, 1911, p. 353). The species is probably bradytictic, but time limits of its breeding season are unknown. The morphology of the glochidia has not been determined with accuracy, but they are reported to be sub-elliptical and to measure approximately 0.25 mm. in length and 0.29 mm. in height. The host fish is unknown.

L. cariosa occurs in large and medium-sized rivers. It is found in fairly swift currents, on shoals and riffles, in finer or coarser gravel, and very often in sand bars. It is also recorded from ponds near the seacoast, but here it does not attain the large size reached in rivers. Associated species often include *Elliptio complanatus, Lampsilis radiata radiata,* and *Alasmidonta marginata.*

Lampsilis ovata ventricosa (Barnes), Figs. 47, 48

Unio ventricosus Barnes 1823, Amer. J. Sci., 4:267, pl. 13, fig. 14 (type locality: Wisconsin River and Mississippi River at Prairie du Chien, Wisconsin).

Unio cariosus Say: DeKay 1843, pl. 21, figs. 243, 244.
Lampsilis ventricosa (Barnes): Simpson 1914:38; Johnson 1915:21; LaRocque 1953:93.
Lampsilis ventricosus (Barnes): Letson 1905:80.
Lampsilis ovata ventricosa (Barnes): Ortmann 1919:301; Robertson and Blakeslee 1948:111.
Lampsilis ovata canadensis (Lea): Robertson and Blakeslee 1948:111.
Lampsilis ventricosa canadensis (Lea): LaRocque 1953:94.

Description: *L. ovata ventricosa* is quite unlike all other species in our region except *L. cariosa*. *L. cariosa* is usually smaller and has a scarcely visible posterior ridge, while in *L. o. ventricosa* the posterior ridge is prominent. In addition, the periostracum of *cariosa* is more distinctly yellow, and if rays are present, they are limited to the posterior slope.

Shell medium to large, sub-elliptical (males) or sub-ovate (females), thickened anteriorly, thinner posteriorly, strong, and inflated. Sexual dimorphism distinct. Females typically much higher at the posterior termination of the ligament than at the beaks, males approximately equally high at these points. Periostracum yellowish, yellowish green or olive brown, somewhat shiny to dull, and with narrow or wide dark green rays generally distributed over the entire shell or on posterior slope only. Rays rarely completely absent. Beak sculpture consisting of about 6 rather coarse bars, invisible anteriorly and posteriorly. The first simple; the second to fourth straight in the middle or with a shallow sinus, causing them to be somewhat double looped; the outer two or three bars partially obscure. Pseudocardinal teeth prominent, elevated, somewhat conical, compressed, and directed forward; 2 in each valve. Lateral teeth elevated, strong, somewhat curved, 1 in the right valve and 2 in the left. Nacre bluish white or silvery white, sometimes suffused with pink. Inner edge female mantle forming a ribbon-like flap in front of branchial opening that projects to anterior end.

Adult specimens commonly measure between 100 and 160 mm. (4 to 6½ inches) in length and have H/L ratios of .62 to .68 and W/H ratios of .62 to .76.

Remarks: Ortmann (1919, p. 298, 303) pointed out that *ovata* s.s. occurs in large rivers and gradually gives way to *ovata ventricosa* in smaller rivers and streams, that numerous intergrades occur in intermediate areas, and that this is a general phenomenon and occurs in widely separated streams. Van der Schalie (1938, p. 70) discussed a similar change from the *ovata ventricosa* form to the *ovata canadensis* form which intergrades, as one goes from rivers into lakes. It is probable that *ventricosa* and *canadensis* are therefore only ecotypes of *ovata* and are not true subspecies, but insufficient evidence is available to decide this question with certainty.

Distribution: Ohio-Mississippi Drainage, St. Lawrence Drainage from Lake Superior to the Ottawa River and Lake Champlain, and Hudson Bay Drainage.

Records: ***St. Lawrence System.*** Genesee River: Rochester (Ortmann, 1919), Avon (this survey); and Mt. Morris (Robertson and Blakeslee, 1948). Honeoye Creek, 2 mi. W. of Rush (this survey). Erie Barge Canal: Clover Road, Pittsford (this survey), and Rochester (Baker, 1898). Seneca River, Onondaga County; and Oswego River (both Marshall, 1895). Sodus Bay, Lake Ontario; and St. Lawrence River, Sheek Island, Mille Roches, Ontario (both this survey).

Biology and ecology: The anatomy of *L. o. ventricosa* was discussed by Ortmann (1911:351). Glochidia are retained in the female gill pouches from the end of July to near the beginning of the following July. The glochidia are sub-elliptical, with a straight hinge line, without hooks, and measure 0.25 mm. in length and 0.29 mm. in height. Coker, *et al.* (1921:153) reported the following fish as hosts: bluegill, *Lepomis macrochirus* Rafinesque; white crappie, *Pomoxis annularis* Rafinesque; largemouth bass, *Micropterus salmoides* (Lacepede); smallmouth bass, *M. dolomieui dolomieui* Lacepede; yellow perch, *Perca flavescens* (Mitchill); and yellow pikeperch, *Stizostedion vitreum* (Mitchill).

L. o. ventricosa occurs in rivers and creeks on gravel, sand, or even mud bottoms. The lake form, considered as *L. ovata canadensis* by many authors (see Remarks), usually occurs on sand or gravel bottoms in exposed or protected situations. Commonly associated species include *Lampsilis radiata siliquoidea*, *Lasmigona costata*, and *Elliptio complanatus*.

Lampsilis ochracea (Say), Figs. 55, 56

Unio ochraceus Say 1817, Nich Ency. 2, pl. 3, fig. 8 (type locality: Delaware and Schuylkill Rivers); not DeKay 1843, pl. 19, figs. 237, 238 (probably = *L. r. radiata*).
Lampsilis ochraceus (Say): Letson 1905:81.
Lampsilis ochracea (Say): Simpson 1914:40; Johnson 1915:21; Ortmann 1919:318; LaRocque 1953:92

Description: *L. ochracea* does not resemble any other local species except occasionally *L. cariosa* and *L. radiata radiata*. *L. cariosa* has a relatively large, thickened shell with thickened hinge teeth, usually a yellow, shiny periostracum, and when rays are present they are confined to the posterior slope. In contrast, *L. ochracea* has a relatively small, thin shell with delicate hinge teeth, usually a brownish, mostly dull periostracum, and when rays are present they are generally distributed. *L. r. radiata* usually has a relatively large and thick shell and exhibits no marked sexual dimorphism. *L. ochracea* is smaller and thinner and exhibits prominent sexual dimorphism. Also the interdentum is thin and compressed, but in *L. cariosa* and *L. r. radiata* it is relatively thick and heavy. The three species also differ in beak sculpture (see figures).

Shell small to small-medium, sub-ovate, thin, somewhat strong, and sub-inflated. Females typically much higher at the posterior termination of the ligament than at the beaks, males approximately equally high at these points. Periostracum smooth or somewhat wrinkled, especially near the ventral and posterior margins, brownish or modified with greenish, reddish, or yellowish shades. Rays usually absent, but when present are widespread, narrow, green, and usually rather obscure. Beak sculpture subconcentric (see fig. 7) but seldom preserved in this species. Pseudocardinal teeth narrow, compressed, pointed forward, 2 in each valve, or rarely 3 in the left valve. Laterals thin, slightly curved, 1 in the right valve and 2 in the left. Nacre white, bluish white, or tinted with pink or salmon. Inner edge of mantle in the female forming a ribbon-like flap in front of branchial opening that projects to anterior end.

Adult specimens commonly measure between 60 and 90 mm. (2½ to 3½ inches) in length and have H/L ratios of .60 to .70 and W/H ratios of .62 to .70.

Distribution: Atlantic Drainage from the Lower St. Lawrence Drainage to the Ogeechee River, Georgia.

Records: Mohawk River at Mohawk, Herkimer County (Marshall, 1895); Champlain Canal (C. B. Adams [MCZ]); Hudson River at Heath, Ulster County (W. S. Teator [MCZ]); and Troy [MCZ]. It has not been recorded from Central New York. The record from St. Lawrence River, Waddington, St. Lawrence County (Clarke, 1958) was based on thin shelled specimens of *Lampsilis radiata radiata* with unusually compressed pseudocardinal teeth.

Biology and ecology: The anatomy was thoroughly investigated by Reardon (1929:1). The glochidia, the fish host, and limits of the breeding season apparently are not known (Johnson, 1947:153; and Ortmann, 1919:319).

L. ochracea occurs in ponds, canals, and slow-flowing portions of rivers on sandy or muddy substrates. It is often abundant in ponds near the seacoast. Associated species include *Elliptio complanatus* and *Lampsilis radiata radiata*.

Lampsilis radiata radiata (Gmelin), Fig. 53

Mya radiata Gmelin 1792, Systema Naturae, 13th ed., p. 3200 (type locality Virginia).

Unio radiatus (Gmelin): DeKay 1843:189, not pl. 18, fig. 236 (= *Villosa iris* (Lea)).

Lampsilis radiata (Gmelin): Simpson 1914:64; Johnson 1915:22; Ortmann 1919:292.

Unio resaceus DeKay 1843:192, pl. 39, figs. 355, 356; pl. 40, fig. 357.

Lampsilis luteola var. *rosacea* (DeKay): Simpson 1914: 62 (in part).

Lampsilis luteola rosacea (DeKay): Johnson 1915:22; Ortmann 1919:289 (in part).

Lampsilis silquoidea rosacea (DeKay): Robertson and Blakeslee 1948:110 (in part); LaRocque 1953:53 (in part).

Lampsilis borealis Gray 1882, Trans. Ottawa Field Nat. Club:53 & pl.; Simpson 1914:63; Baker 1916:257.

Lampsilis radiata borealis (Gray): LaRocque and Oughton 1937:148; LaRocque 1953:93 (in part ?).

Lampsilis radiata oneidensis F. C. Baker 1916, The Nautilus, 30:74–75.

Description: This common species is well characterized by its general shape, wide, generally distributed rays, somewhat rough periostracum, well-developed hinge teeth, and characteristic beak sculpture. In New York a wide band of intergradation exists between this and *L. radiata siliquoidea*, and the abundant intergrades may be called *L. radiata* or given the name of the subspecies they resemble the most after consideration of all available characters. (See below.)

Shell medium to rather large, sub-elliptical, thickened anteriorly and thinner posteriorly, strong, and somewhat inflated. Females only slightly swollen posteriorly and usually indistinguishable from males. Periostracum yellowish, greenish, brownish or blackish and not smooth, but roughened by close concentric wrinkles. Rays dark green or blackish, mostly wide, and generally distributed but not sharply defined except in young or light-colored individuals. Beak sculpture double looped, (see fig. 4). Pseudocardinal teeth medium in size, erect, pyramidal, serrate, 2 in each valve. Anterior tooth in right valve small. Lateral teeth well developed, straight or slightly curved, narrow, 1 in the right valve and 2 in the left. Nacre white, bluish white, tinted with pink or salmon, or entirely pink or salmon. Inner edge of mantle in the female forming a ribbon-like flap in front of branchial opening that projects to anterior end.

Adult specimens usually measure between 75 and 100 mm. (3 to 4½ inches) in length and have H/L ratios of .50 to .59 and W/H ratios of .60 to .66.

Remarks: Many authors, e.g. Beauchamp, (1886, p. 7), Marshall (1895, p. 78), Simpson (1914, p. 66), Baker (1916, pp. 256–257), Ortmann (1919, p. 297), Frierson (1927, p. 72), and Blakeslee (1946, pp. 109–113) have pointed out the great difficulty in separating some specimens of *L. radiata* from *L. siliquoidea* in New York or have emphasized from this or similar evidence the close relationship of these "species". Observations by the present writers suggest that gene exchange has occurred in the Lower St. Lawrence Drainage and the Erie Barge Canal between these taxons. Thirteen lots of specimens randomly collected from stations on the Barge Canal and in the Lower St. Lawrence System ranging from the Niagara River to Lake Memphramagog, Vermont, were analyzed for sexual dimorphism, index of obesity, ray width, and nacre color. All lots were intermediate in these characters between *siliquoidea* from Lake Erie and *radiata* from the Susquehanna River. Hybrid indices indicated that in

the Barge Canal and the Lower St. Lawrence Drainage, the influence of *siliquoidea* decreased and the influence of *radiata* increased from west to east. See appendix for numerical results.

In view of the width of the zone of intergradation, it is necessary to reduce *L. siliquoidea* to the subspecies *L. radiata siliquoidea*. Also, the former subspecies *L. siliquoidea rosacea* (DeKay) (Seneca Lake) and *L. radiata oneidensis* Baker (Oneida Lake) must be reduced to infrasubspecies of *L. radiata radiata* or abandoned, since they represent only stages in a continuum. Examination of the lectotype and the paratype series of *Lampsilis borealis* Gray from Duck Island, Ottawa River, Canada, at the Museum of Comparative Zoology has revealed them to be inflated *radiata-siliquoidea* intergrades, similar to specimens of *L. radiata radiata* recently collected in the St. Lawrence River at Sheek Island, Ontario. This form must also be reduced to an infrasubspecies of *L. radiata radiata* or be abandoned.

Distribution: Lake Ontario and Lower St. Lawrence Drainage, and in the Atlantic Drainage south to North Carolina.

Records: ***St. Lawrence System.*** Seneca Lake: Dresden and Geneva. Owasco Outlet at Auburn. Lake Ontario: Sodus Bay. St. Lawrence River: Waddington; and Sheek Island, Mille Roches, Ontario (all this survey).

Susquehanna System. Tioga River, Steuben County (Marshall, 1895). Susquehanna River: Nineveh and Afton. Cayuta Lake, Cayutaville. Tioughnioga River at Messengerville. Little York Lake, Little York. Otselic River: Whitney Point, 1 mi. N. of Whitney Point, and Willet. Chenango River: Chenango Forks and 3 mi. N. E. of Greene (all this survey).

Biology and ecology: According to Ortmann (1911:349), the anatomy of *L. radiata radiata* agrees "in all essential respects" with that of *L. r. siliquoidea*. Meager evidence indicates tha the breeding season begins in August and ends the following August. The glochidia are rather large, sub-oval, without hooks, and measure 0.22 to 0.23 mm. in length and 0.27 to 0.28 mm. in height. The host fish are unknown, but probably many of the fish serving as hosts for *L. r. siliquoidea* are hosts for *L. r. radiata* also.

L. r. radiata ranks next in abundance to *Elliptio complanatus* and *Anodonta cataracta* in the Atlantic Drainage, and is usually associated with these species. It occurs in rivers and lakes of all sizes, usually on gravel or sand bottoms, and occasionally on mud. It is usually absent from the smaller creeks and ponds.

Lampsilis radiata siliquoidea (Barnes), new combination, Figs. 51, 52

Unio siliquoideus Barnes 1823, Amer. J. of Sci., 4:269, pl. 13, fig. 150 (type locality: Wisconsin River).

Unio luteolus Lam.: DeKay 1843:190, pl. 20, fig. 241.

Lampsilis luteola (Lam.): Simpson 1914:60; Ortmann 1919:283.

Lampsilis luteola rosacea (DeKay): Ortmann 1919:289 (in part).

Lampsilis siliquoidea (Barnes): Robertson and Blakeslee 1948:110; LaRocque 1953:93.

Lampsilis siliquoidea rosacea (DeKay): Robertson and Blakeslee 1948:110 (in part); LaRocque 1953:93 (in part).

Description: This subspecies cannot be confused with any other species or subspecies except *L. r. radiata*, with which it intergrades completely in the Lower St. Lawrence Drainage of New York. Typically *L. r. siliquoidea* differs from *L. r. radiata* in that it is prominently swollen posterior-ventrally in the female; exhibits a smooth, shiny periostracum with numerous, narrow rays; has compressed pseudocardinal teeth; and never has pink or salmon-colored nacre. See Remarks under *L. r. radiata;* also see appendix.

Shell medium to large, sub-elliptical, swollen posteriorly in the female, thicker anteriorly and thinner posteriorly, strong, and somewhat inflated. Females swollen posterior-ventrally causing the shell to be much higher at the posterior termination of the ligament than at the beaks; males not swollen posteriorly, height at posterior termination of ligament nearly the same as height at the beaks. Periostracum yellowish, greenish, or brownish, smooth, hard, and shiny. Rays green or blackish, mostly narrow, generally distributed, and usually sharply defined. Beak sculpture similar to *L. radiatus radiatus* but with some differences (see fig. 3). Pseudocardinal teeth medium in size, variable in shape but typically compressed, elevated, and directed forward, 1 or 2 in the right valve, 2 in the left. Anterior tooth in right valve and posterior tooth in left valve both small. Lateral teeth well developed, straight or slightly curved, narrow, 1 in the right valve and 2 in the left. Nacre white or bluish white and iridescent posteriorly. Inner edge of mantle in the female forming a ribbonlike flap in front of branchial opening that projects to anterior end.

Adult specimens usually range between 85 and 125 mm. (3½ to 5 inches) in length and give H/L ratios of .50 to .62 and W/H ratios of .64 to .72.

Distribution: Mississippi Drainage generally, except the Cumberland and Tennessee River Systems (Ortmann, 1919, p. 289). St. Lawrence System from Lake Superior to the Lake Ontario Drainage.

Records: It is uncertain which of the records in the literature (chiefly Marshall, 1895) were based on specimens of this subspecies and which referred to *L. r. radiata*. Therefore, the only records presented here are from this survey.

St. Lawrence System: Genesee River at Avon; Conesus Lake at Lakeville; and Honeoye Creek, 2 mi. W. of Rush. Erie Barge Canal: Clover Road, Pittsford; Monroe Avenue, Pittsford; Ayrault Road, Pittsford; 2 mi. S. E. of Pittsford; ½ mi. E. of Fairport; 3½ mi. W. of Macedon; 1½ mi. W. of Macedon; and Macedon. Cross Lake, Jordan; Chittenango Creek, at Kirkville. Oneida Lake: Lakeport, Eagle Bay, Shackleton Point,

Muskrat Bay, and Frenchman's Island. Cayuga Lake: Portland Point, King Ferry, and Aurora. Lake Ontario at Little Sodus Bay.

Biology and ecology: The anatomy of *L. r. siliquoidea* was discussed by Ortmann (1911:348) under *L. luteola* (Lam.). Glochidia are retained in the marsupia from the first of August to the middle of the following July. The glochidia are rather large, sub-oval, without hooks, and measure 0.23 mm. in length and 0.28 mm. in height. Coker, *et. al.* (1921:153) listed several widely distributed species of fish as hosts: bluegill, *Lepomis macrochirus* Rafinesque; white crappie, *Pomoxis annularis* Rafinesque; black crappie, *P. nigromaculatus* (LeSueur); largemouth bass, *Micropterus salmoides* (Lacepede); smallmouth bass, *M. dolomieui dolomieui* Lacepede; white bass, *Roccus chrysops* (Rafinesque); yellow perch, *Perca flavescens* (Mitchill); eastern sauger, *Stizostedion canadense* (Smith); and yellow pikeperch, *S. vitreum* (Mitchill).

Abundant throughout its range, this subspecies occurs most frequently in slow-flowing portions of rivers, in lakes, and in canals. The usual substrate is fine gravel, sand, or mud. It is ordinarily absent from brooks and very small creeks, and from riffles in larger streams. Associated species often include *Lampsilis ovata ventricosa* and *Anodonta grandis*.

Addenda

Elliptio fisherianus Lea has been reported by Gabb (Ortmann, 1919: 114) from the lower Schuylkill River in Pennsylvania. This record has never been confirmed, and the most northern recent records are from the Potomac River Drainage in Adams County, Pennsylvania (Athearn, 1953: 9). It probably does not occur in the Susquehanna System or north of it.

Lampsilis fasciola Rafinesque was listed by Marshall (1895, as *L. multiradiatus* Lea) from Butternut Creek, Otsego County; Genesee River, Monroe County; and Medina, Orleans County. It has not been recorded from New York since then. This is an Ohio-Mississippi System species, and the New York records were probably based on misidentified specimens of *L. cariosa* and *L. ovata ventricosa*.

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Appendix

The data derived from 13 lots of *Lampsilis "radiata"* and *L. "siliquoidea," (sensu lato)* are summarized in table 3. The characters analyzed are posterior inflation, ray width, and nacre color. Posterior inflation is expressed as B/A, where A is the height taken at a point one-third of the distance from anterior to posterior, and B is the height taken at a point two-thirds of the distance from anterior to posterior. Ray width is expressed on a scale of 0 to 7, where 0 = rays absent; 1 = rays very narrow; 2, 3, 4, 5, and 6 = rays of progressively greater width; and 7 = very wide rays. Nacre color is expressed on a scale of 1 to 6, where 1 = white or bluish white (no pink); 2 = very faint pink suffusions; 3, 4, and 5 = pink progressively darker and more general; and 6 = orange nacre.

Other characters were studied also: length (L), the ratio B/L, periostracum ground color, degree of periostracum lustre, and shape of pseudocardinal teeth, but all were found to be either excessively susceptible to ecological variation or difficult to classify numerically and therefore not revealing.

The following abbreviations for localities are used in tables 3, 4, and 5 and (except for the 3 not in New York State) also on the map in the introductory section.
GR—Genesee River, Avon, Livingston County, N. Y.
HC—Honeoye Creek, 2 mi. W. of Rush, Monroe Co., N. Y.
BC—Erie Barge Canal, Pittsford, Monroe Co., N. Y.
CC—Chittenango Creek, Kirkville, Onondaga Co., N. Y.
EB—Eagle Bay, Oneida Lake, Bridgeport, Madison Co., N. Y.
SB—Sodus Bay, Lake Ontario, Wayne Co., N. Y.
LS—Little Sodus Bay, Lake Ontario, Cayuga Co., N. Y.
SL—Seneca Lake, Dresden, Yates Co., N. Y.
CL—Cayuga Lake, King Ferry, Cayuga Co., N. Y.
MR—St. Lawrence River, Sheek I., Mille Roches, Stormont Co., Ontario
LC—Sand Bar State Park, Lake Champlain, Vermont
LM—Lake Memphramagog at Clyde River, Newport, Vermont
SR—Susquehanna River, Nineveh, Broome Co., N. Y.

Subspecies *siliquoidea* differs from *radiata* particularly in that the females of *siliquoidea* are posteriorly inflated (B/A > 1.14) and the females of *radiata* are not (B/A < 1.14); the nacre in *siliquoidea* is usually white (class 1) and in *radiata* it is largely pink (classes 2 to 6); the rays in *siliquoidea* are not wide (largely classes 0–4) and in *radiata* they are often wide. The percentage of specimens in each lot having *siliquoidea* characters as thus defined are given in table 4.

Table 3. Index of posterior inflation (B/A), ray class, and nacre class of subspecies *radiata* and *siliquoidea*

	GR	HC	BC	CC	EB	SB	LS	SL	CL	MR	LC	LM	SR
.95	–	–	–	–	–	–	–	–	–	–	–	–	–
.96	–	–	–	–	–	1	–	–	–	1	–	–	–
.97	–	–	–	–	–	–	–	–	–	1	–	–	2
.98	–	–	–	–	–	–	–	–	–	–	–	–	–
.99	–	–	–	–	–	3	3	–	–	4	–	–	2
1.00	3	–	1	2	–	–	–	–	–	–	–	–	–
1.01	–	–	–	–	–	2	–	13	7	11	2	1	3
1.02	3	–	2	2	2	–	–	–	–	–	–	–	–
1.03	7	–	2	–	2	–	–	1	1	1	2	1	4
1.04	1	–	6	–	1	2	–	2	2	–	–	–	–
1.05	1	–	3	–	5	2	2	8	1	9	2	2	3
1.06	1	1	1	–	2	–	–	3	3	–	3	1	1
1.07	1	–	3	–	7	2	–	3	1	3	–	1	2
1.08	1	2	–	–	2	2	–	2	–	2	1	1	–
1.09	4	1	3	–	6	1	1	4	2	–	–	4	1
1.10	–	–	–	–	3	2	–	1	1	3	–	3	2
1.11	–	1	2	–	2	–	1	4	2	–	–	2	–
1.12	3	1	2	–	5	1	–	4	1	1	1	–	–
1.13	2	1	1	2	4	1	–	1	–	–	–	3	–
1.14	–	1	3	–	4	–	–	3	–	–	–	–	–
1.15	1	–	3	1	4	–	–	–	1	–	–	–	–
1.16	2	1	1	–	–	–	–	–	–	–	–	–	–
1.17	–	1	2	–	1	–	–	–	–	–	–	–	–
1.18	1	–	1	–	3	–	–	1	1	–	–	1	–
1.19	–	–	–	–	1	–	1	–	–	–	–	1	–
1.20	–	–	–	–	3	1	–	–	–	–	–	–	–
1.21	–	1	1	–	–	–	–	–	–	–	–	–	–
1.22	–	–	1	–	1	–	–	–	–	–	–	1	–
1.23	–	–	–	–	–	–	–	–	–	–	–	–	–
1.24	–	2	–	–	–	–	–	–	–	–	–	–	–
1.25	–	–	–	–	–	–	–	–	–	–	–	–	–
1.26	–	–	1	–	–	–	–	–	–	–	–	–	–
N	31	13	38	8	58	21	9	51	24	37	11	24	21
	Ray class												
0	5	–	3	1	8	1	1	5	3	3	–	–	–
1	11	6	11	4	11	4	4	7	3	11	1	–	–
2	7	5	7	1	12	6	2	8	4	8	1	1	–
3	1	1	4	2	7	3	2	7	3	13	4	5	–
4	2	–	7	–	10	1	–	7	–	11	3	2	2
5	–	1	3	–	5	3	–	7	3	18	2	6	6
6	–	–	2	–	2	–	–	3	2	9	–	–	7
7	–	–	–	–	3	–	–	1	–	3	–	–	6
N	26	13	37	8	58	18	9	45	18	76	11	14	21
	Nacre class												
1	31	13	38	7	40	7	9	18	19	25	1	9	4
2	–	–	–	1	16	11	–	8	4	17	1	12	10
3	–	–	–	–	2	5	–	11	1	16	4	3	4
4	–	–	–	–	–	1	–	5	–	6	3	–	1
5	–	–	–	–	–	–	–	6	–	11	2	–	–
6	–	–	–	–	–	–	–	–	–	1	–	–	2
N	31	13	38	8	58	24	9	48	24	76	11	24	21

Table 4. **Percentage of specimens having characters typical of subspecies *siliquoidea***

	GR	HC	BC	CC	EB	SB	LS	SL	CL	MR	LC	LM	SR
% B/A > 1.14	13	38	24	25	22	5	11	2	8	0	0	12	0
% in ray classes 0–4	100	92	87	100	83	83	100	75	72	61	82	57	10
% in nacre class 1	100	100	100	88	69	29	100	38	79	33	9	37	19

Finally hybrid indices were computed for these 13 lots of specimens. The values observed for each of the three characters in the specimens from Honeoye Creek (the most nearly typical *siliquoidea)* were set arbitrarily as equal to 10. The values for each character in the lot from the Susquehanna River (the most nearly typical *radiata)* were set equal to 0. Relative values for each character in each lot were computed on the arbitrary scale thus obtained and the values given for each lot were summed to get the hybrid indices given in table 5.

Table 5. **Hybrid indices computed after setting Honeoye Creek *(siliquoidea)* characters equal to 10 and Susquehanna River *(radiata)* characters equal to 0**

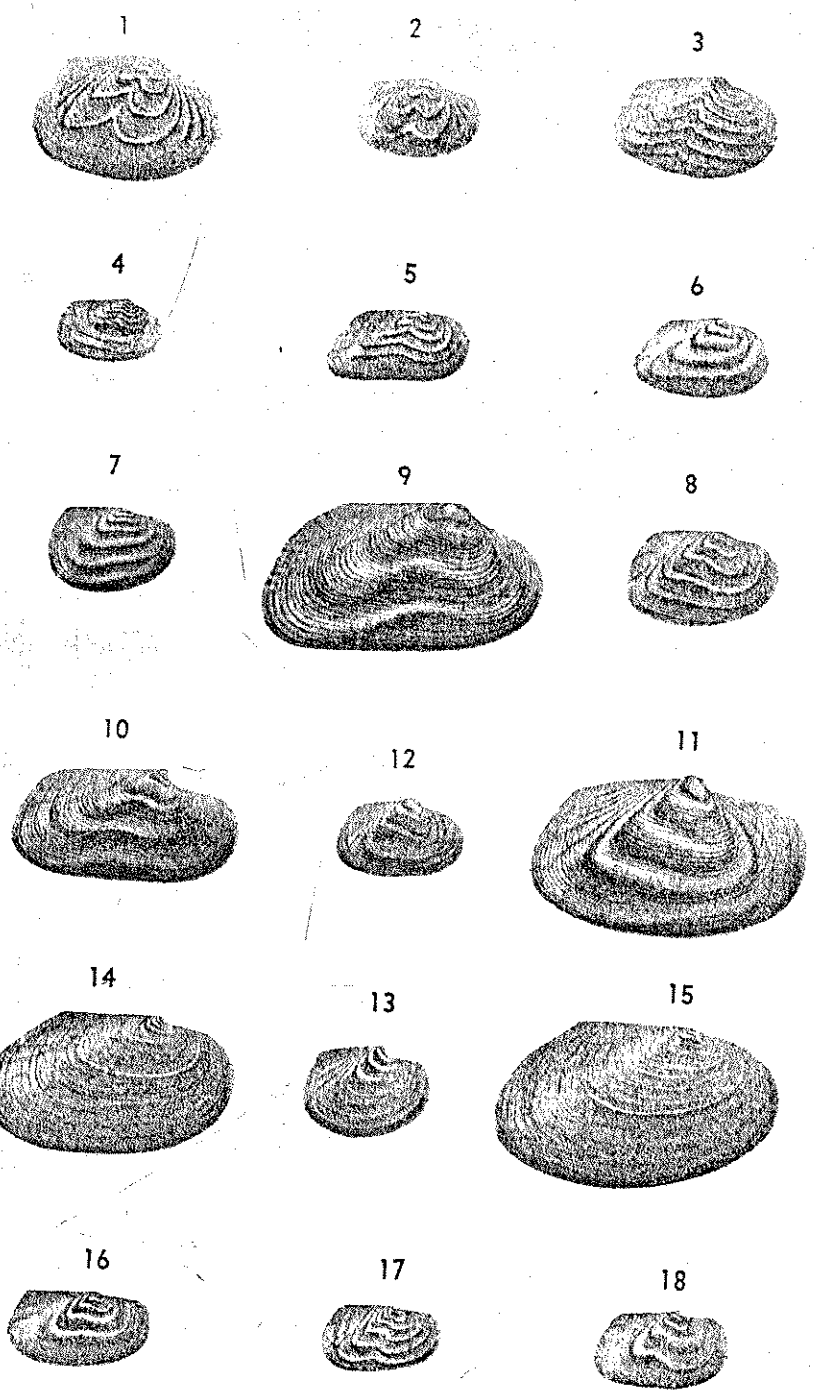
	HC	GR	BC	CC	EB	SB	LS	SL	CL	MR	LC	LM	SR
B/A > 1.14	10.0	3.4	6.3	6.6	5.8	1.3	2.9	0.5	2.1	0.0	0.0	3.2	0.0
Ray classes 0–4	10.0	11.0	9.4	11.0	8.9	8.9	11.0	7.9	7.5	6.2	8.8	5.7	0.0
Nacre class 1	10.0	10.0	10.0	8.5	6.2	1.2	10.0	2.3	7.4	1.7	−1.2	2.2	0.0
Hybrid index	30.0	24.4	25.7	26.1	20.9	11.4	23.9	10.7	17.0	7.9	7.6	11.1	0.0

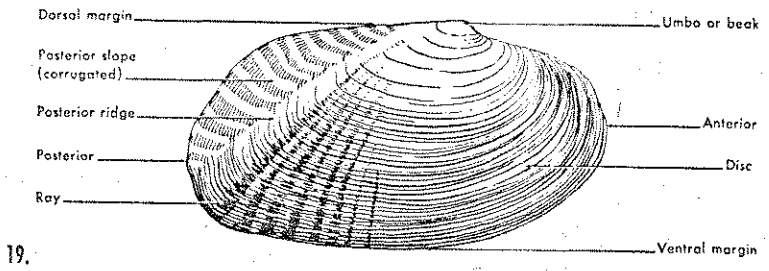
If the stations are arranged in order of decreasing hybrid index (HC, CC, BC, GR, LS, EB, CL, SB, LM, SL, MR, LC, SR), a general west to east trend is apparent. With the exception of LS, all 7 of the highest values are stations on the Erie Barge Canal or associated with it. The observed uneven trend should be expected from the irregularity of the drainage patterns and the several immigration routes of *siliquoidea* and *radiata* into the St. Lawrence System. But the essential point can be made that the fauna of the St. Lawrence System in Central New York and eastward is intermediate between *siliquoidea* (s.s.) and *radiata* (s.s.) and widespread gene flow between these taxa is indicated. This justifies the conclusion that there is no effective reproductive isolation between them and that they are best considered as subspecies of the same species *(radiata).*

Plate 1. ***(opposite page).*** **Beak sculpture of fresh-water mussels.**

Fig. 1. *Lasmigona compressa.*
Fig. 2. *Lasmigona subviridis.*
Fig. 3. *Lampsilis radiata siliquoidea.*
Fig. 4. *Lampsilis radiata radiata.*
Fig. 5. *Ligumia nasuta.*
Fig. 6. *Elliptio complanatus.*
Fig. 7. *Lampsilis ochracea.*
Fig. 8. *Lampsilis cariosa.*
Fig. 9. *Alasmidonta marginata.*
Fig. 10. *Lasmigona costata.*
Fig. 11. *Alasmidonta undulata.*
Fig. 12. *Strophitus undulatus.*
Fig. 13. *Anodontoides ferussacianus.*
Fig. 14. *Anodontoides ferussacianus.*
Fig. 15. *Anodonta grandis.*
Fig. 16. *Anodonta implicata.*
Fig. 17. *Anodonta cataracta.*
Fig. 18. *Anodonta grandis.*

(From W. B. Marshall, 1890: Beaks of Unionidae. N. Y. State Museum Bul. 2, no. 9. Courtesy New York State Museum).





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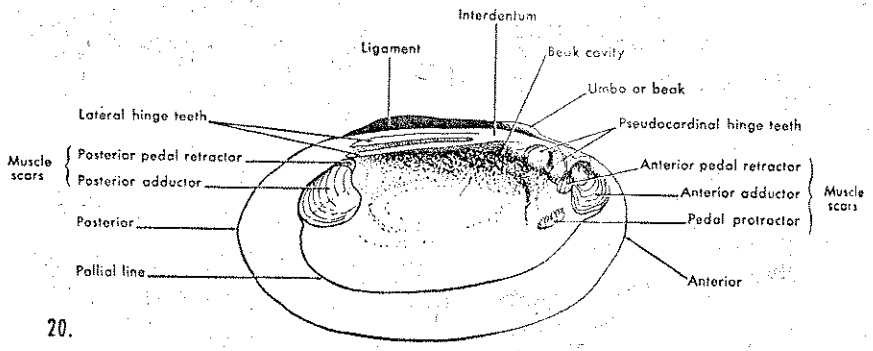

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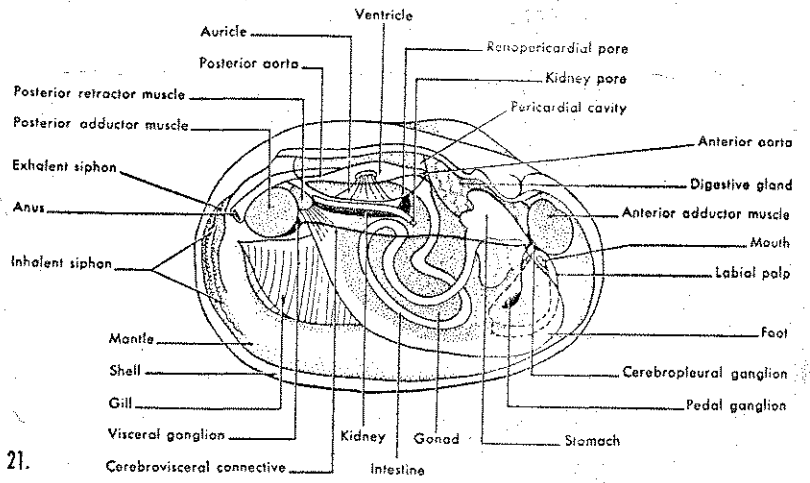

21.

Plate II. Morphology of fresh-water mussels.

Fig. 19. External aspect of shell (schematic): right valve of *Lasmigona costata.*
Fig. 20. Internal aspect of shell: left valve of *Lampsilis radiata radiata.*
Fig. 21. Gross anatomy of a typical *Lampsilis* (*after* Hegner and Stiles, 1951: College zoology, 6th ed., p. 357).

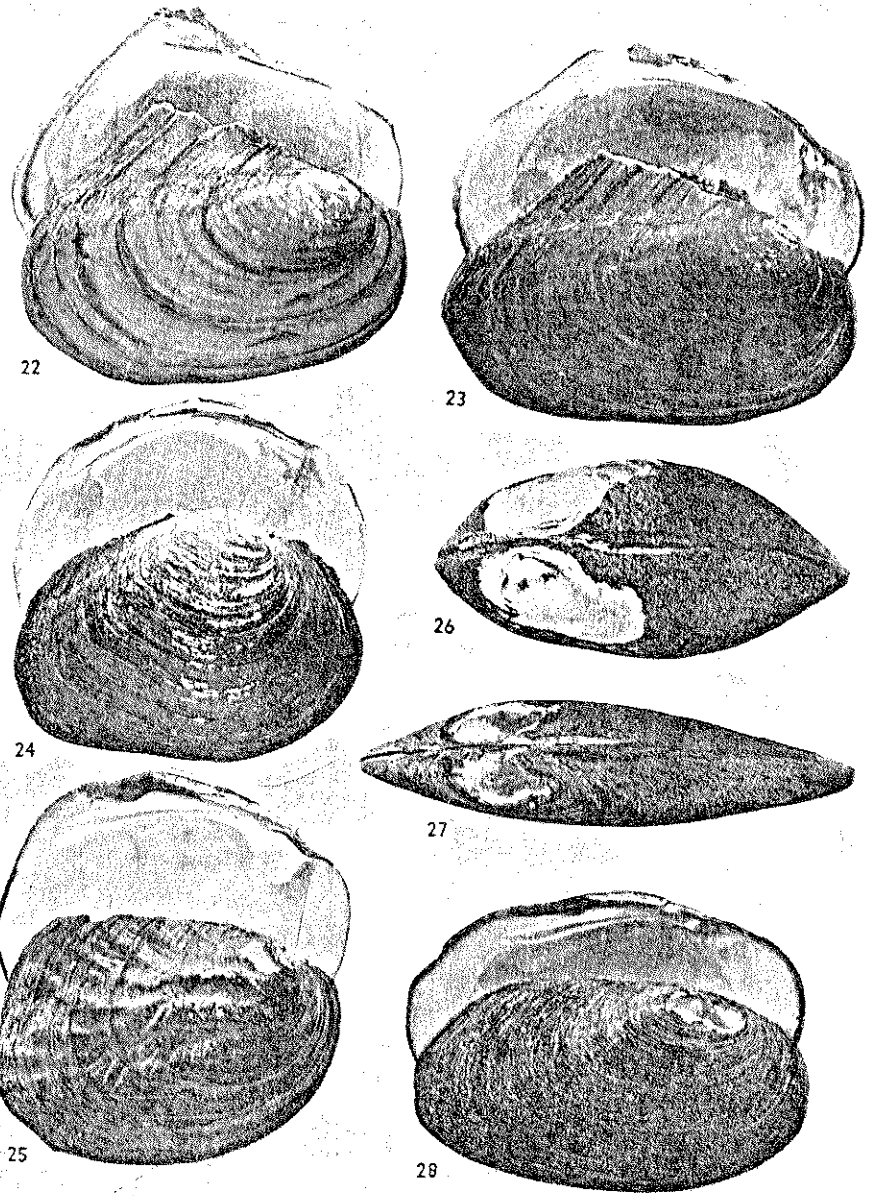

Plate III. Shells of fresh-water mussels.

Fig. 22. *Leptodea fragilis.*
Fig. 23. *Proptera alata.*
Fig. 24. *Fusconaia flava.*
Fig. 25. *Crenodonta costata.*
Fig. 26. *Elliptio complanatus:* dorsal view of inflated specimen.
Fig. 27. *Elliptio complanatus:* dorsal view of compressed specimen.
Fig. 28. *Elliptio complanatus:* lateral view.

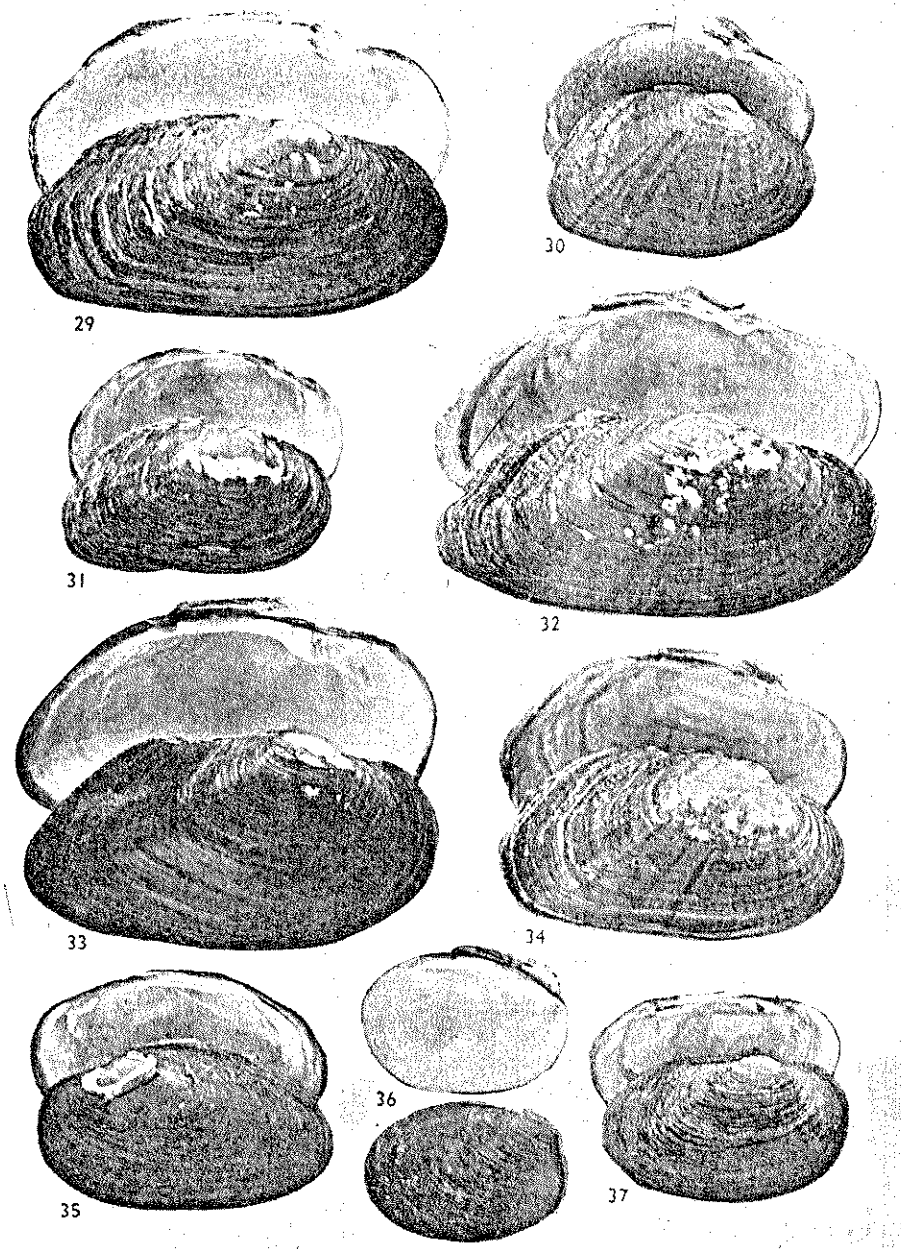

Plate IV. Shells of fresh-water mussels.

Fig. 29. *Lasmigona compressa.*
Fig. 30. *Alasmidonta calceolus.*
Fig. 31. *Lasmigona subviridis.*
Fig. 32. *Alasmidonta marginata.*
Fig. 33. *Alasmidonta undulata.*
Fig. 34. *Alasmidonta varicosa.*
Fig. 35. *Alasmidonta heterodon.*
Fig. 36. *Obovaria olivaria.*
Fig. 37. *Carunculina parva.*

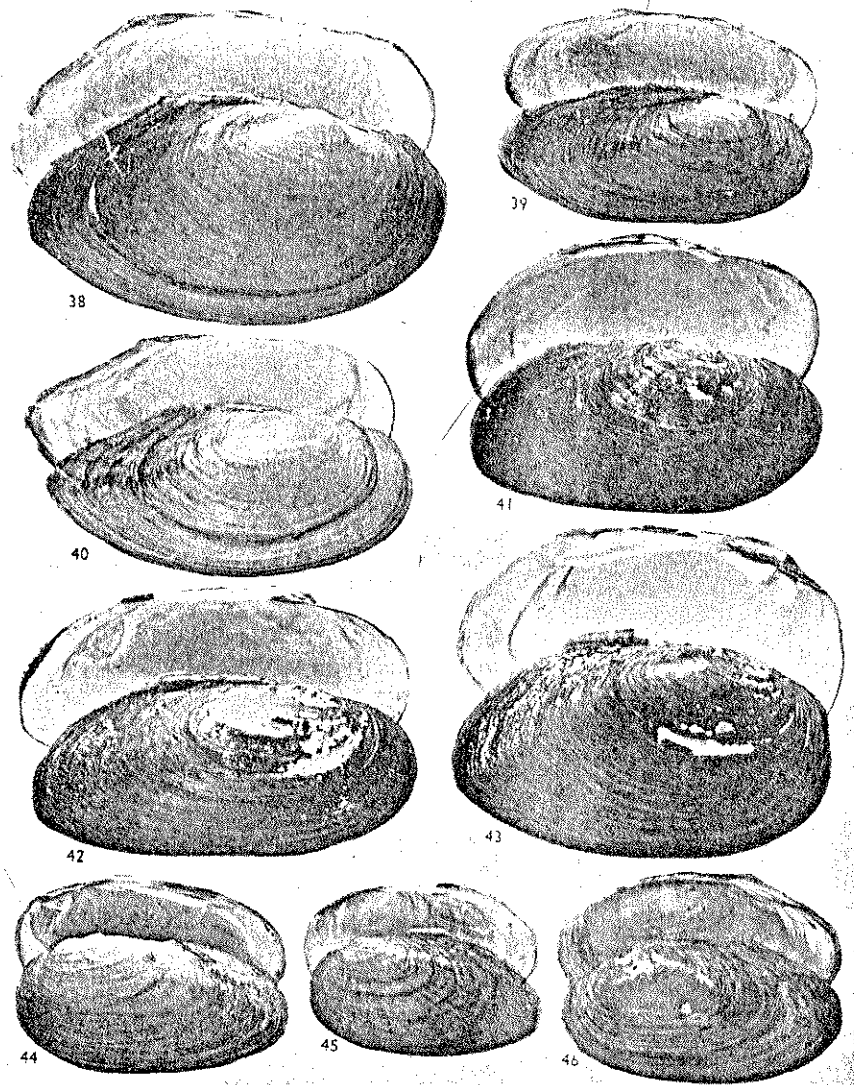

Plate V. Shells of fresh-water mussels.

Fig. 38. *Anodonta grandis.*
Fig. 39. *Anodontoides ferussacianus.*
Fig. 40. *Anodonta imbecilis.*
Fig. 41. *Strophitus undulatus.*
Fig. 42. *Anodonta implicata.*
Fig. 43. *Actinonaias carinata.*
Fig. 44. *Elliptio dilatus.*
Fig. 45. *Villosa iris.*
Fig. 46. *Anodonta cataracta.*

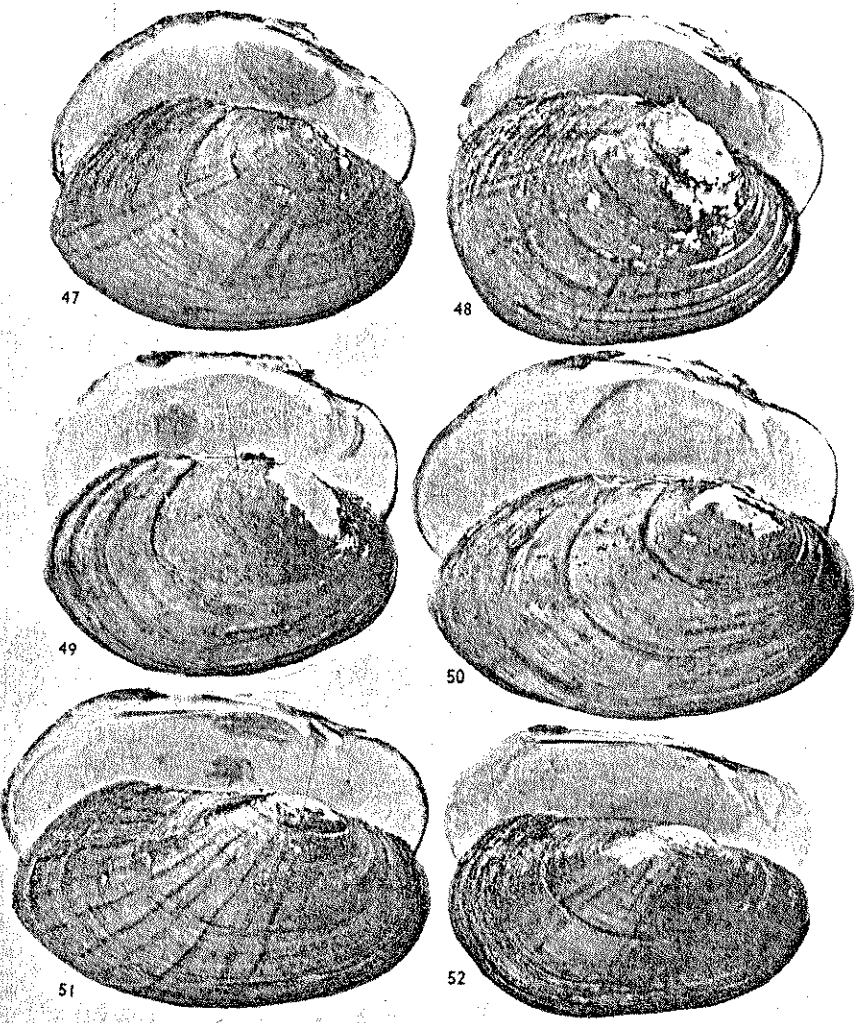

Plate VI. Shells of fresh-water mussels.

Fig. 47. *Lampsilis ovata ventricosa* ♂.
Fig. 48. *Lampsilis ovata ventricosa* ♀.
Fig. 49. *Lampsilis cariosa* ♀.
Fig. 50. *Lampsilis cariosa* ♂.
Fig. 51. *Lampsilis radiata siliquoidea* ♂.
Fig. 52. *Lampsilis radiata siliquoidea* ♀.

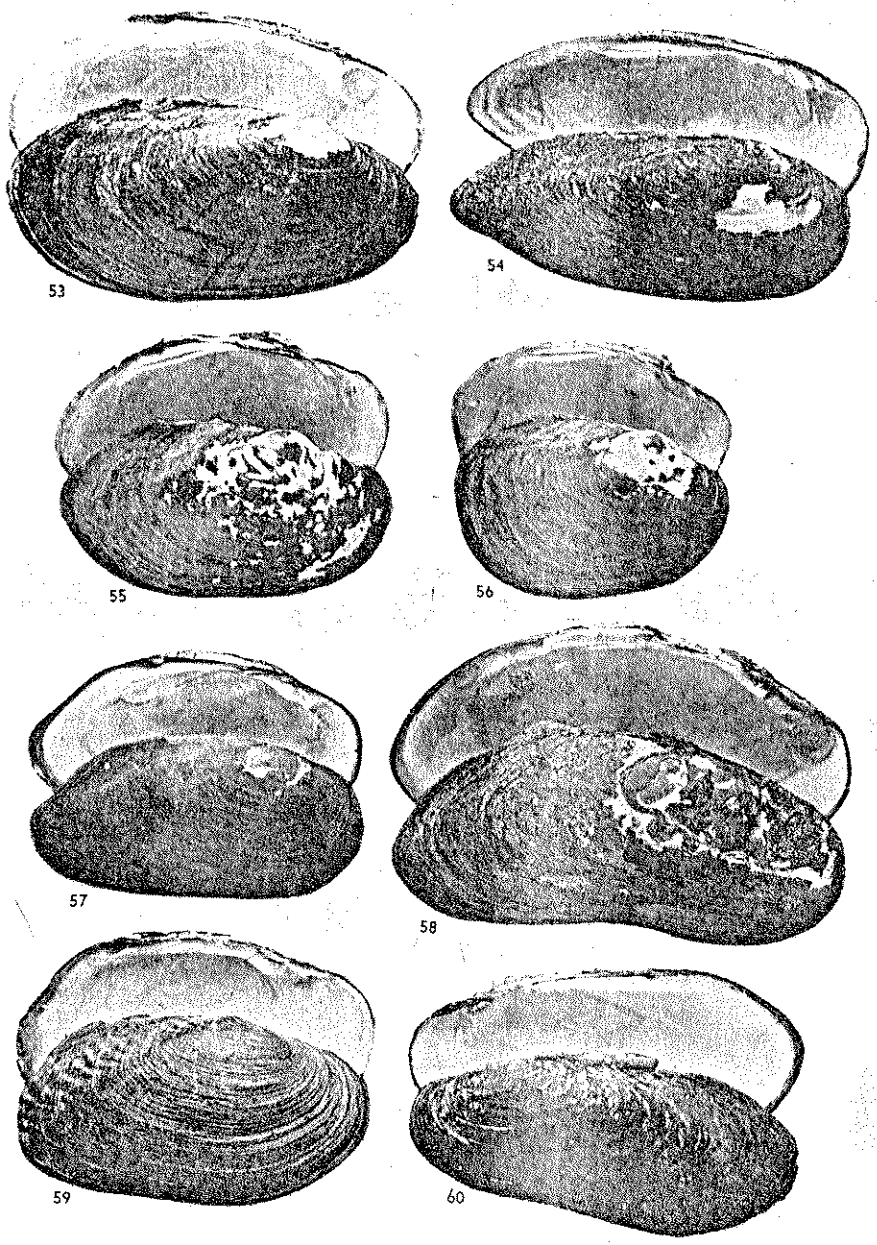

Plate VII. Shells of fresh-water mussels.

Fig. 53. *Lampsilis radiata radiata.*
Fig. 54. *Ligumia nasuta.*
Fig. 55. *Lampsilis ochracea* ♂.
Fig. 56. *Lampsilis ochracea* ♀.
Fig. 57. *Margaritana margaritifera* (immature).
Fig. 58. *Margaritana margaritifera* (mature).
Fig. 59. *Lasmigona costata.*
Fig. 60. *Ligumia recta.*