

THE FRESH WATER MOLLUSCA OF WISCONSIN

PART II. PELECYPODA

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FOREWORD

This volume constitutes the second part of a report on the aquatic mollusca of Wisconsin. The first part, including the Gastropoda, is in the press and will be promptly issued.

Three organizations, supported in whole or in part by the State of Wisconsin, have cooperated in preparing and publishing this report: The Wisconsin Geological and Natural History Survey, The University of Wisconsin, and the Wisconsin Academy of Sciences, Arts, and Letters.

An important part of the work of the Wisconsin Survey has been the preparation of reports on the aquatic plants and animals of the state. A report on the phytoplankton of the lakes by G. M. Smith has been issued in two parts (Bull. 57, parts I and II); a report on the rotifera by H. K. Harring and F. J. Myers is in process of publication, four parts having appeared in the Transactions of the Wisconsin Academy (Vols. XX, XXI, XXII, XXIII); field work for a report on the fishes is in active progress; and the present report on the mollusks covers one of the largest groups of animals and one of the most important, whether regarded from the scientific or the economic point of view.

The cost of preparing these reports has been borne by the Survey and other institutions have cooperated in publishing them, in accordance with the provisions of Sec. 36.26 of the Wisconsin Statutes. In the present case the University of Wisconsin contributes the publication of part II, including the Pelecypoda, and the Wisconsin Academy that of part I, the Gastropoda. The present volume, therefore, constitutes Bulletin 1527 of the University of Wisconsin and also Bulletin 70, part II of the Wisconsin Survey.

The business arrangements among the three institutions concerned in issuing this report made it necessary to print Part II before Part I. The numbers of the figures and the plates run consecutively through the entire report but the paging of Part II is necessarily independent.

Each of the three institutions concerned in issuing this report has made about the same financial contribution. The cor-

dial thanks of the Survey are extended to the University and to the Wisconsin Academy, whose aid has made it possible to prepare and publish a report so large and so adequately illustrated.

E. A. BIRGE.

*Natural History Division,
Wisconsin Geological Survey,
May 7, 1928*

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Class PELECYPODA Goldfuss

(LAMELLIBRANCHIATA Blainville)

"Aquatic, bilaterally symmetrical, acephalous mollusks, protected by a pair of shelly valves, which are secreted by the lateral portions of the mantle, connected by a ligament, and moved by the contraction of muscles attached to the inner faces of the valves; feeding by ciliary action and destitute of a radula or jaw; breathing by lateral gills; imperfectly sensible to light and rarely provided with peripheral visual organs; possessing olfactory organs (osphradia), auditory and equilibrating organs (otocysts), tactile papillae, and a nervous system composed of ganglia united by nerves, but without a pedovisceral commissure; provided with an extensile, tactile, or locomotor organ (foot); a circulatory system containing haemolymph, and operated by a single or paired cardinal ventricle and two auricles; a more or less convoluted intestinal canal, with its oral and anal extremities at opposite ends of the body; a stomach; paired nephridia, connected with the pericardium, and discharging independently of the rectum; reproducing without copulation, by eggs and spermatozoa; monoecious or dioecious; development external to the ovary; the post-larval stage protected by a prodissoconch, and sometimes exhibiting a special nepionic stage" (Dall, in Zittel).

Order PRIONODESMACEA Dall

"Pelecypods having the lobes of the mantle generally separated, or, when caught together, with imperfectly developed siphons; the soft parts in general diversely specialized for particular environments; the shell structure nacreous and prismatic, rarely porcellaneous; the dorsal area amphidetic* or obscure, rarely divided into lunule and escutcheon, and when so divided, having an amphidetic ligament; ligament variable, rarely opisthodontic; nepionic stage usually with a taxodont provinculum; permanent armature of the hinge characterized

* See the glossary at the end of the volume.

by a repetition of similar teeth upon the hinge line, or by amorphous schizodont dentition; habits active, sessile, or nestling, not burrowing; monoecious or dioecious" (Dall. in Zittel).

MORPHOLOGY, GROSS ANATOMY, REPRODUCTION, ETC.

Before proceeding to discuss the particular genera and species of Unionidae inhabiting Wisconsin, it may be of interest and value to briefly consider the general structural characteristics, methods of reproduction, ecology, and commercial importance of this group of animals.

THE SHELL

All Unionidae are covered by a bivalve shell which varies in form, thickness, size, and color. The outer surface is covered with a heavy epidermis or periostracum, which protects the limy part of the shell (composed of calcium carbonate) from injury by the carbon dioxide which is found in most bodies of water. When the epidermis becomes thin or is removed from any cause the limy shell thus exposed quickly becomes eroded or may be entirely removed in spots. The colors vary from light yellowish, through dark green to black or brown. The nacre varies from pure silvery white, through pink to dark purple (see Grier, 1920b, 1920c, for investigations concerning changes in color in both epidermis and nacre). The surface may be marked only by lines of growth or there may be knobs, pustules, wrinkles, folds, or other corrugations. In many species the surface is smooth and beautifully rayed. The terms used in the diagnosis of the different species are shown on Plate XXX.

The shell of a river mussel is composed of four distinct layers: the outer is the horny epidermis or periostracum (rarely composed of two separate layers); beneath this is a very thin calcareous layer composed of vertical prisms of calcium carbonate; beneath this, and composing the greater substance of the shell, is the nacreous or mother-of-pearl layer, which is composed of very thin laminae or plates lying one upon another, parallel to the surface of the shell; the fourth layer is called the hypostracum, which is closely connected with the nacre and is

secreted by the muscles. Growth is effected by the addition of very thin films of shelly matter to each of the above layers, each kind of material being deposited by certain cells on the edge of the mantle set apart for this purpose. The periostracum is secreted only by the edge of the mantle, but the nacreous layer may be secreted by almost any part of the mantle. Breaks in the younger part of the shell are easily repaired for the nacreous layers, but the periostracum is not represented.

THE SOFT BODY OR ANIMAL

The general relation and position of the organs of the water mussel are indicated in fig. 1, pl. LVII. The mantle is appressed to all parts of the inner side of the shell, and the siphon has been formed by it. A muscular band is formed by the attachment of the mantle above the ventral border of the shell and is attached to the latter by strong muscles at the place called the pallial line. This attachment forms a barrier normally preventing all foreign matter from getting in between the mantle and shell. Pin head pearls, blisters, and other marks, are more frequent on the area between the pallial line and the edge of the shell than inside this attachment, showing that it forms a very effective barrier to mud as well as to some parasites. A thin film of horny material connects the edge of the mantle with the outer edge of the shell. This film forms the horny periostracum or epidermis. The border of the mantle is very contractile and when touched will quickly retract a short distance within the edge of the shell. When the mussel is alive and active, the mantle edge extends from between the valves of the shell as a whitish roll of flesh.

The function of the mantle is to secrete the shell, assist the gills in respiration, and as a sensory organ. At the posterior end the mantle edge is modified to form three openings, the supra-anal, which is smooth, the anal, which may be smooth or have small crenulations, and the branchial, which is distinctly papillose. The edge of the mantle anterior to the branchial opening or siphon is modified in some species to form finger-like digitations (see pl. XXIX, fig. 2).

Two series of muscles are conspicuous, the larger adductor muscles, one at each end, which close the shell, and the two smaller retractor muscles of the foot lying above or near the adductors.

Just in front of the posterior adductor muscle lies the heart,

which may plainly be seen pulsating through the translucent membrane. Near the anterior adductor muscle the greenish liver or digestive gland may be seen surrounding the stomach; the rectum of the intestine is seen to pass through the heart. It discharges just above the posterior adductor muscle. The so-called kidney, or organ of Bojanus, a brownish mass, may be seen just below the heart (see figs. 203, 204).

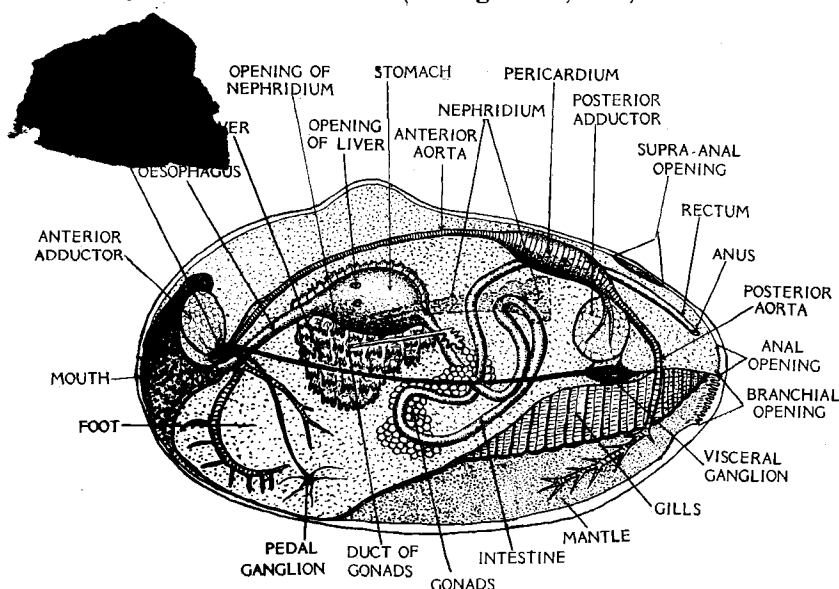


Fig. 203. Diagrammatic longitudinal section of *Anodonta* showing relation and position of different organs of the body.

Turning back the mantle the most conspicuous organ is the muscular foot, a brownish-white mass of flesh which is highly retractile. Near the anterior end of the animal are situated the four large organs called the labial palpi, two on each side of and surrounding the small mouth (fig. 1, pl. XXIX). The large folds occupying the greater portion of the space between the palpi and the posterior end of the animal are the two pairs of gills, the inner being slightly the larger. The outer gill is connected above and on the outside to the mantle, while the inner gill is attached on the inner side to the body and posteriorly to the inner gill of the opposite side of the animal.

Each gill is composed of two lamellae which are united below but are open above, forming a V-shaped figure in section.

The cavity between the lamellae is subdivided by vertical partitions into many narrow chambers or water tubes, closed below but opening above into a space along the dorsal portion of the gill called the suprabranchial chamber. The outer surface

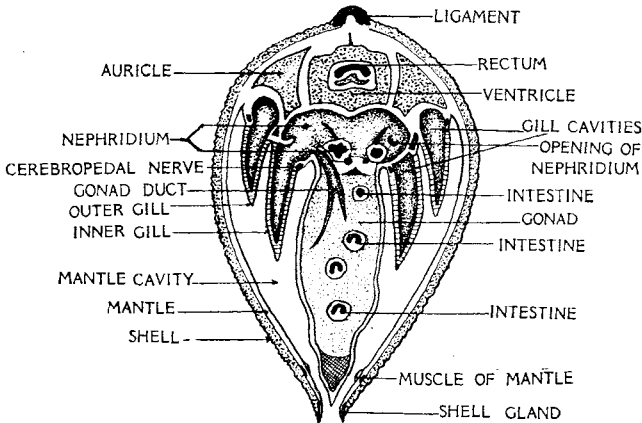


Fig. 204. Diagrammatic cross section through heart, kidney, gills, and foot of *Anodonta*.

of the gill filament is perforated with many minute holes (ostia see fig. 205) and is covered with many minute hair-like paddles or cilia. These cilia drive the water through the ostia into the water tubes, whence it passes into the suprabranchial cavity, and then outward through the anal opening. There are thus two currents of water constantly passing through the mussel,

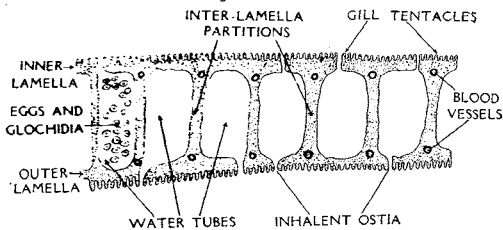


Fig. 205. Diagrammatic horizontal section through gravid gill of *Anodonta* to show character of marsupial gill.

an inhalent by way of the branchial cavity, thence through the pores into the gills; and an exhalent from the water tubes outward through the anal cavity. The gills are primarily breathing organs, providing fresh water filled with oxygen for puri-

fying the blood. They are also related to both feeding and reproduction, features which are described in a later section of this chapter (see Bush, 1922; Ortmann, 1911, 1912a; Allen, 1921).

The other organs of the body are similar to those of other members of this class. There is a mouth with a short oesophagus, leading into a stomach, which is surrounded by the brown liver or digestive gland, and a rather long, coiled intestine, which passes through the heart as a rectum and opens just above the posterior adductor muscle. A peculiar, long, slender rod of gelatinous material (the crystalline style) in the intestine is thought to separate food from foreign particles and also to store enzymes or ferments to aid digestion. A Bojanus organ surrounding the heart acts as a kidney.

There is a heart with connecting arteries and veins. The blood is colorless. Circulation consists of passing the blood from the heart through the arteries to many small vessels which ramify through the body, returning through a large vein to the Bojanus organ, thence to the gills, where oxygen is added, and thence back to the heart. The blood that passes to the mantle returns directly to the heart, being oxygenated in the mantle.

The nervous system consists of three pairs of nerve centers or ganglia connected by long nerve cords; one pair lies near the mouth on each side of the oesophagus; a second pair in the foot; and a third pair beneath the posterior adductor muscle. Fine nerves extend into the tissue from these centers. There are no eyes or ears, but several special sense organs, one (osphradium) near the posterior adductor muscle is believed to test the purity of the water, while another, called the otocyst, is believed to be a balancing organ indicating when the animal is in a vertical or normal position. Other sense organs are located along the posterior edge of the mantle and surrounding the branchial and anal openings.

The reproductive organs (gonads) are located in a mass of tissue above the foot and in some species are brightly colored, orange or pinkish. The ova and sperm are discharged through small openings into the suprabranchial cavity above the gills, the sperm to be discharged through the anal opening into the surrounding water and the ova into the water tubes of the gills. The development of the young larva or glochidium is discussed in a later section.

REPRODUCTION AND DEVELOPMENT OF MUSSELS

The development of fresh water mussels is unique among fresh water animals and the metamorphoses or changes of the young clam are quite as wonderful as are those of the butterfly or beetle. For many years the young of clams, called glochidia, have been known, but their relation to river mussels has not, until comparatively recent years (about 1866) been fully understood. The gills of female mussels have a peculiar function other than for respiration, that of the care of the eggs and developing young, or glochidia, in the water tubes, during the early period of their development, thus forming a true marsupium. A section through the gill of a male mussel is shown in fig. 206. A non-marsupial gill of a female is the same.

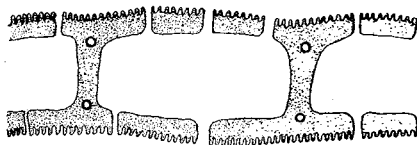


Fig. 206. Diagrammatic horizontal section through gill of *Anodonta* to show character of water tubes in male mussel and in gill of female not used as a marsupium (as inner gill).

In the female mussel the eggs are fertilized by the sperm which is taken in with the water through the inhalent or lower (branchial) siphon, the eggs having previously been discharged from the ovaries into the suprabranchial cavity and thence to the water tubes of the part of the gills destined to serve as brood pouches or marsupia. After the lapse of a certain period of time the embryos become purse-shaped and the gills become swollen and distended by the mass of glochidia present (fig. 207). After another lapse of time, the length varying in different groups of mussels, the young glochidia are discharged into the water and fall to the bottom where they lie with their two shell valves widely open. Unless the proper host, which is nearly always a fish, appears and presents a favorable opportunity for fastening upon the gills, tail, or fins, the glochidia die. The next stage is passed on this host where they become encysted by the outgrowth of the skin of the fish which entirely covers the mussel embryo. After the lapse of another period of time (varying from 9 to 74 days in different species),

the embryo, having completed its transformation by the growth of internal organs, breaks the cyst and falls to the bottom. There are, therefore, four distinct stages in the growth of a mussel: 1, the fertilized egg; 2, the glochidium in the marsupium (gill) of the mother mussel; 3, the parasitic stage in a fish or salamander; and 4, the post-glochidial stage with fully formed shell. Subsequent growth is in size.

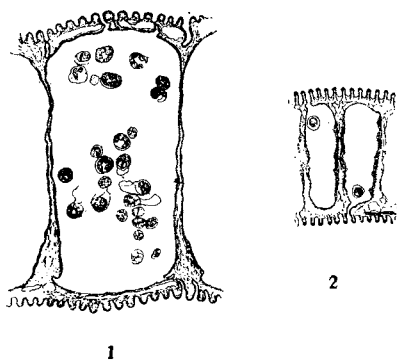


Fig. 207. Cross sections of marsupial gills. 1. Transverse section of single water tube of the marsupium of *Proptera alata megaptera* showing several embryos in early cleavage stage. 2. Transverse section of two water tubes of gravid outer gill of *Fusconaia ebena* showing glandular epithelium on the interlamellar junctions, and two embryos in early stages. Both drawn to same size. Lefevre and Curtis, 1910, Pl. 4, Figs. 30, 31.

Few authors have described the methods by which the glochidia are discharged from the marsupial gills of the female clam. Ortmann (1910b, p. 94) has given a very succinct account, which may be briefly indicated as follows: in certain groups of species (as *Amblema costata*, *Pleurobema coccineum*, *Strophitus rugosus*, and *Anodontoides ferussacianus*) the glochidia pass from the water tubes (ovisacs) into the supra-branchial canal, from this into the cloacal chamber, and thence leave the shell by way of the anal opening. The placentae are discharged whole in some species (as *Pleurobema coccineum*), in others (as *Strophitus rugosus*) the glochidia may become free before being extruded, and in still others (as *Lasmigona costata*) the glochidia are rather loose from the placentae when discharged. This method is found in the two subfamilies Unioninae and Anodontinae. In the Lampsilinae the

glochidia do not leave the marsupium in the natural way but break through the walls of the gills, at the edge of the marsupium, by small holes formed for this purpose, which close again after the discharge. Each ovisac (water tube) has one hole at its distal end, and the glochidia are generally discharged in irregular masses, rather loosely connected, without preserving the shape of the placentae. In only one case, *Ptychobranhus*, are the placentae discharged whole. Through these holes the glochidia are discharged into the branchial chamber, and enter the water through the branchial opening.

Unless the young mussel falls in a favorable locality on the bottom of the lake or stream it will not long survive. Young mussels less than 20–25 mm. in length are seldom found. Those described by Isely (1911) were found attached to rocks and pebbles by a byssus or adhesive thread. They were from 2.9 to 22.5 mm. in length. Not all young mussels have this byssus. Isely found his material on a stony shore and remarks that "this kind of an environment gives a constant supply of oxygen, and sufficient food, is frequented by suitable fish; and is free from shifting sand and silt accumulation. Those mussels that drop from the fish in these favorable situations develop in large numbers, while the less fortunate, that drop in shifting sand or silt, die early" (1911, p. 79).

This outline of the metamorphosis of a mussel is typical of many species. Yet each species has its own peculiar life history which may differ more or less from all others. Some species require a certain species of fish and can develop on no other. Two species (*Utterbackia imbecillis* and *Strophitus edentulus*) are known to develop without parasitism, glochidial development taking place in a cord in the gill which forms a sort of placenta or nutritive body (Lefevre, 1911, p. 863; 1912b, p. 171; Howard, 1914b, p. 353). The latter species (*edentulus*) is able also to develop on a fish in the usual way (Howard, 1914b) and *imbecillis* has recently been shown to develop in the normal manner.

Breeding in mussels begins early, in some species the first summer after leaving the host (*Proptera laevis*). *Utterbackia imbecillis* and *Truncilla donaciformis* apparently breed the second summer. *Fusconaia undata* breeds at four and five years; *Megalonia giganta* at eight years. *Lampsilis siliquoidea* from Lake Pepin may breed the third year. These

naiads indicate some variability in the age at which breeding begins (see Coker, Shira, etc., 1921, p. 137).

The formation of the gills into brood pouches has already been described. In some species (*Fusconaia undata*, *Pleurobema coccineum*) the marsupium appears red when filled with eggs, the color being due to redness of the eggs. In other species (*Lampsilis ventricosa*, *L. siliquoidea*) the lower part of the marsupium is marked by dark bands, due to pigment in the outer walls of the ovisacs. Not all gills are used as marsupia nor are all parts of each gill used. This difference is shown in the following table, in which the marsupium occupies:

All four gills (*Fusconaia ebena*)

Entire outer gills (*Lasmigona complanata*)

Entire outer gills, but egg masses lying transversely in the gill (*Strophitus rugosus*)

Only posterior end of outer gills (*Ligumia recta*)

Specialized portion of middle region of outer gills (*Obliquaria reflexa*)

Entire lower border of outer gills in form of folds (*Ptychobranchus phaseolus*)

Lower border only of outer gills, not folded (*Dromus dromus*)

It is noteworthy that those species in which all four gills or only the outer gills are used as marsupia have the male and female shell practically alike; while in those species in which only a portion of the gill is specialized for this purpose the male and female shells are clearly distinguishable externally. The eggs or glochidia in the water tubes may be embedded in a mucilaginous material, attached to each other by their adhesive membranes, or lie freely in the chamber not attached to each other, as in *Anodonta*, *Alasmidonta*, and *Lasmigona*. The masses of agglutinated eggs or embryos are molded into the exact shape of the water tube, of which each mass forms a cast. Each cast has been given the name of conglutinate (Lefevre & Curtis, 1910, p. 90; see pl. LXII, figs 8-11). When fully ripe, all are easily separable. Disturbance of the female mussel when gravid usually results in the abortion of the eggs.

It has been ascertained that there is a long and a short period of gravidity or reproduction. In the long period the eggs are fertilized from the middle of July to the middle of August, and the glochidia are carried in the marsupium until the following spring or summer (winter breeders-*bradytictic*). In the short period the entire breeding season is confined to about four

months, extending from the end of April to the middle of August, and the glochidia are discharged as soon as they are fully developed (summer breeders-tachytictic). Such genera as *Fusconaia*, *Pleurobema*, *Amblema*, *Elliptio*, and *Margaritana* belong to this group. Nearly all others belong to the long-term group. The short-term breeders are considerably more primitive, in both breeding habits and structure, while the more specialized long-term breeders are of later development in time, the gill being modified to provide better water circulation and hence more oxygen for the embryos (Ortmann, 1911, p. 303; Coker, Shira, etc., 1921, p. 140).

THE GLOCHIDIUM

The glochidium or larva of the mussel before extrusion from the marsupium of the parent is more or less rounded or oval in form. There are two valves of a thin but firm shell, hinged at one end, held together by an adductor muscle. The surface of each side of the body also bears two pair of clusters of hairs, of a sensory character, believed to be connected with the closing of the shell when in contact with some part of a fish. In a few genera of American mussels (*Elliptio dilatatus*, *Anodonta corpulenta*, *Amblema peruviana*) there is a long larval thread of unknown function. When ready to leave the parent, the glochidium has the rudiments of mouth, heart, foot, and intestine, which will not be fully developed for use until the end of the parasitic period. Each female mussel bears a very large number of glochidia, thus insuring the perpetuation of the species by sheer force of numbers, even though a large proportion fail to pass through the parasitic period. In a specimen of *Leptodea fragilis* about three inches (7.4 cm.) long there were computed to be 2,225,000 glochidia; *Lampsilis siliquoidea* from Lake Pepin contained 79,000 in a mussel 6.1 cm. long; 74,000 in one 7 cm. long; and 129,000 in one 8.5 cm. long (Coker, et al, 1921, p. 144).

The glochidia may be divided into two main types, one with a simple, rounded shell, the other with a tooth or hinged hook on the ventral part of the shell. There is a third type, known as the axe-head type, hooked, which is found only in a few species of mussels. The hooked type is usually larger than in the other types and includes *Anodonta*, *Strophitus*, and *Lasmigona*. The hook is believed to assist in securing an attachment to fish,

this type being usually found on the fins or tail of the host (see pl. XXXIV, figs. 1, 2). The hookless type (pl. XXXIV, figs. 3-5) are rounded in form, usually smaller than the first type, and are gill parasites (excepting *Megalonaia gigantea* which has been found on both gills and fins). They range in size from that of *Margaritana monodonta* (0.05 x 0.052 mm.) to that of *Cyclonaias granifera* (0.290 x 0.355 mm.) The axe-head type (pl. XXXIV, figs. 6, 7) are related to the hookless rather than the hooked type, the spines on the angle of the shell not being comparable to the hinged hook in the first type. This form is found only in the genus *Proptera*. Various forms of glochidia are figured on plates XXXI and XXXII.

PARASITIC STAGE

When the glochidium is fully developed and ready to leave the marsupial pouch, it is very active, and when liberated will rapidly snap its valves by the contraction of the adductor muscle. After being expelled into the water it must come in contact with the gills or fins of a suitable fish and become attached to its involuntary host (pl. XXXIII, figs. 1, 2). Failure to accomplish this means early death. This attachment is accomplished by firmly clasping the tissue of the fish between the valves of the shell, the hooks assisting when it is a hooked type to be attached to a fin. After successful attachment the tissue of the fish gradually covers the glochidium until it is completely encased in a cyst. The portion of the fish tissue enclosed within the shell of the glochidium is consumed as food. The process of encystment may be completed in from 24 to 36 hours (pl. XXXIII, fig. 3). During the parasitic period in which the glochidium is encysted on the fish, the larva changes in form, though not in size (excepting *Proptera laevissima*), the internal organs of the adult mussel are formed, and the young clam, when it breaks the cyst, falls to the bottom ready to lead an independent life.

The parasitic period varies with the season of the year and with other conditions not yet fully understood. Temperature of the water, vitality of the host, and long or short period of incubation in the glochidial pouch are factors governing the length of development in the host. Experiments at the Fairport Laboratory of the United States Bureau of Fisheries indicate extremes of six (*Quadrula pustulosa* on *Ameiurus melas*)

to 193 (*Megalonaias giganteus* on *Aplodinotus grunniens*) days. The more common periods are 10 to 20 days (Coker, et al, 1921, p. 150).

FISH HOSTS OF MUSSELS

It has been ascertained that each mussel glochidium reacts to certain species of fish and will not complete the metamorphosis on others. Likewise certain species of fish may serve as host for several species of mussels. If a glochidium by chance becomes attached to a wrong fish it sooner or later becomes sloughed off, even if encystment has begun, and the glochidium is lost. Our knowledge of the number of species of host fishes is limited at the present time. Observations and experiments made at the Biological Laboratory at Fairport, Iowa, have given us about all of the information at present available. During one year, 3,671 fish of 46 species were examined and only 324, or 8.8 per cent were found to be infected. The fishes infected with commercial mussels belonged to 12 species and the glochidia represented 20 species. The number of glochidia of a given species on infected fish ran from one to 416; but examples of the niggerhead mussel (*Fusconaia ebena*) ranged from 1,895 to 3,740 glochidia on the river herring. The number of hosts for individual mussel species ranged from one to 13, and in several cases a single fish was observed to be host for as many as six species of mussels. One mussel (*Simpsoniconcha ambigua*) is now known to develop on an amphibian host, *Necturus*.

When we consider that only a relatively small number of species of fish are susceptible to infection by glochidia, it becomes evident that there must be a definite ecological relation between the fish and the parent mussel, i. e., both must frequent the kind of environment at the period when the glochidia are ready to be discharged. The environment must be one that attracts the fish in its search for food, so that it may become infected as it browses on the bottom. In one case at least, *Lampsilis ventricosa*, the female is provided with a peculiar flap on the edge of the mantle, anterior to the branchial siphon, which waves about when the mussel is discharging glochidia. The black bass, perch, and other fish that act as host, evidently mistake this waving flap for an insect and nibble at it, thus making easy the process of infection. A few fish, as the sheepshead (*Aplodinotus grunniens*) and the catfish (*Ictalurus punc-*

tatus) feed on mussels, and are thus easily infected. The sheepshead is almost always heavily infected with glochidia. As far as is known at the present time, the parasitism of glochidia causes little drain on the vitality of the fish, excepting, perhaps, where there may be cases of overabundant infection, or of the few species that increase in size during the glochidial period of parasitism.

It has recently been shown that certain fish may acquire immunity against repeated infections. Experiments indicate that very large fish (as bass) become immune after one heavy infection (probably having been previously infected), while small bass require several artificial infections before becoming immune. When immunity has been acquired the fish cannot be successfully infected with the glochidia of any species of mussel (see Coker, Shira, etc., 1921, p. 156).

Wilson (1916) has made some very significant discoveries which have an important bearing on the conditions surrounding the glochidial infection of the host. Coker, Shira, et al (1921, p. 156) thus summarize these observations. "His observations and experiments showed that the fish which are most susceptible to glochidia are those which are subject to parasitic copepods (fish lice); that there is a definite connection or fellowship of copepods and mussel parasites, so that knowing the species of mussel for which a given species of fish serves as host, one may often predict what species of copepod that fish will carry; and finally that the presence of glochidia on an individual fish renders that species practically or completely immune to the attacks of the fish lice, and vice versa. These conclusions may be stated in another way: while glochidia and copepods have essentially identical taste in fish hosts, the presence of one is antagonistic to the other". Glochidial infection, therefore, is highly beneficial to a fish, giving immunity from attacks by a more serious parasite. Thus the sheepshead, which is always heavily infected with glochidia, is never infected with copepod parasites.

JUVENILE STAGE

When the glochidium breaks its cyst in the fish and falls to the bottom of the water body it enters another stage, intermediate in character between the glochidium and the adult form, during which time the siphons, labial palpi, outer gills, sex

glands, etc., are developed. This stage has been aptly called the juvenile stage (pl. XXXIII, fig. 5). It measures about 1/100 of an inch in length. The adult shell lies beneath the glochidial shell, has but little lime, is transparent, and develops the ridges or knobs which are later called beak sculpture. This sculpture appears to be characteristic, each species having a more or less different pattern.

The organs are conspicuous in the young mussel. . The long, slender foot covered with cilia, having the power to adhere to even smooth surfaces, thus providing a means of locomotion. The cilia are in rapid motion when the foot is protruded. This organ changes to the normal foot during the first month. The second organ is the byssus, a long, sticky, hyaline thread secreted by the byssus gland which is situated in the posterior part of the foot. The function of the byssus is not yet clearly known, but it is believed to serve at least one purpose, an anchor for attachment to foreign objects. This organ is particularly characteristic of the subfamily Lampsilinae, but is also found in some *Amblema* and *Fusconia*. After shedding the byssus the young mussels often bury themselves deeply in the bottom.

Young mussels are exceedingly difficult to find. They occur in Wisconsin waters more often on gravel or coarse sand, although some have been found in fine sand. At this period they are very active and travel about constantly. When the young mussel begins to breed the juvenile stage is ended and adult life has begun. In some species this occurs the third summer while in others it does not take place until the mussel is eight years old. *Proptera laevissima*, however, has been observed to breed at one year of age.

Growth of young mussels is relatively rapid, considering the small size of the glochidium. Coker, Shira, et al (1921, p. 159) present a table showing growth of the Lake Pepin mucket (*Lampsilis siliquoidea pepinensis*), which is, perhaps, characteristic (pl. XXXIII, fig. 5).

Age	Length
Beginning of juvenile stage -----	0.25 mm.—0.01 inches
15 days -----	0.5 mm.—0.02 "
38 days -----	4.2 mm.—0.17 "
68 days -----	13.0 mm.—0.51 "
5 months -----	32.0 mm.—1.27 "
End of second growing season -----	58.3 mm.—2.30 "

GROWTH OF THE SHELL

The large, heavy, black lines on the surface of a river mussel are called rest periods and are believed to indicate the resting stage of winter, of low water, or of some physical disturbance. In many cases these rings are seasonal and the age of a mussel may be known by counting these rings. This is not always true, because any great fluctuation in the water level will react on the mussel and a more or less distinct line will be formed. In some lake shells, on which the seasonal marks are very strongly impressed, it seems quite safe to call these rest marks annual rings of growth. It depends largely upon the character of the environment (see Grier, 1922b, pp. 139-148).

Experiments carried on by careful biologists indicate that any disturbance of the shell, such as removal for measurement, will produce a reaction and a line will be formed on the periost-
racum. This disturbance causes growth to cease for a time, and when resumed the new layer is started a short distance inside of the last layer. Experiments by Isely (1914), Lefevre and Curtis (1912) and Coker (1921) show that *Lampsilis ventricosa* doubled in size in two years (45-81 mm.); *Lampsilis siliquoidea* doubled in size in four seasons (43-84 mm.); *Leptodea fragilis* increased nearly twice (190 per cent) in one year. It was observed in the experiments that the thick-shelled species (*Quadrula*) grew much more slowly, and increased only from three to 24 per cent in about ten months. Isely's experiments with tagged mussels (1914), mostly *Quadrula*, indicated an average increase in length of 2.7 to 7.5 mm., and in weight of from 11.4 to 30.8 grams in one year. He believes that the thin shells, *Leptodea*, etc., grow much faster than the heavy *Quadrula*. These experiments were not all under natural conditions and the growth would probably be greater under normal conditions. The works cited should be consulted for a full understanding of the subject of growth.

GENERAL ECOLOGY OF MUSSELS

In life, the mussels are wholly or partly buried in the sand or mud of the bottom of the river, pond, or lake. Some mussels, as *Lampsilis siliquoidea* (fig. 208) are usually but partly buried, the anterior portion being embedded in the sand while the posterior part, bearing the siphons, is elevated above the bottom.

Some, like *Lampsilis ventricosa occidentis* (fig. 209), have the entire shell buried from sight only the siphons appearing above the bottom. In most species the normal position is with the shell buried in a vertical or partly horizontal position, the posterior end pointed upstream, the two siphons fully distended, the lower (branchial) taking in fresh water and food and the upper (anal) discharging waste products and impure water (pl. LXX, figs. 8, 9). The two edges of the mantle are tightly appressed, completely closing the mantle cavity.

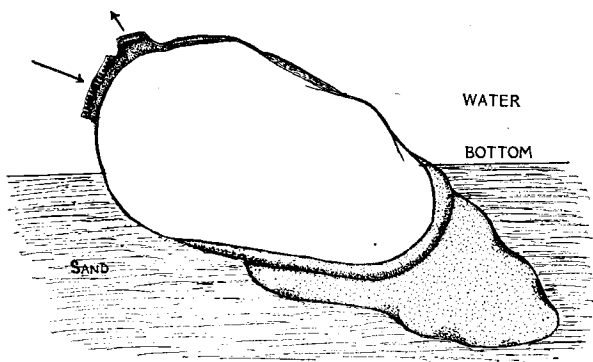


Fig. 208. *Lampsilis siliquioidea* (Barnes). Female in natural position when living in bottom of river. Arrows indicate flow of water currents through animal.

Locomotion in the river mussels is on the whole limited in adult life. Young mussels are usually quite active. The heavy clams, such as *Quadrula*, *Amblema*, *Fusconaia*, and *Pleurobema*, are less active than the lighter species of *Lampsilis*, *Ligumia*, and *Proptera*. In some localities mussels have been observed to be quite active, *Ligumia recta*, *Lampsilis siliquioidea*, and *Actinonaias carinata* have been seen in active locomotion on a sand bottom in Red Cedar River, Lake Winnebago, and in creeks near Green Lake and Kilbourn. A distinct, trough-like mark is left in the sand. In a few cases these tracks may vary from 18 inches to 10 feet in length (fig. 210). Locomotion is accomplished by pushing the foot well into the sand and then pulling the shell forward. By this process a mussel may move a number of feet in a few hours. What stimuli cause the mussel to move is not clearly known. Extreme shallowness will cause them to migrate to deeper water, a feature seen

many times in both Wisconsin and Illinois streams. Possibly the heat of the sun provides a sufficient stimulus. They will also move from stagnant to running water if the lowering of the water body produces such an environment. When rivers are in flood some mussels move to the sandy bars or shoreward.

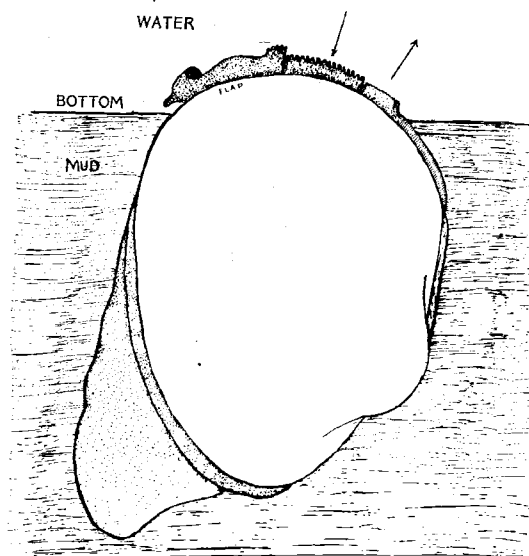


Fig. 209. *Lampsilis ventricosa occidentalis* (Lea). Female in natural position in bottom of stream. The special mantle flap is shown below the branchial siphon.

Isely (1914) while conducting experiments in growth, planted many tagged mussels in shallow water. He observed that those heavy shells (*Quadrula*) placed in three feet of water moved very little, while those placed in one foot of water moved to deeper water. It seems certain that mussels can change their environment, voluntarily, in but a slight degree when conditions become unfavorable and must either adapt themselves to the changed environment (which they do to a remarkable degree) or perish. The group is, therefore, of value in determining the condition of polluted streams.

Density of Population. Mussels are scattered over the bottom in varying degrees of density. There are no cases known of mussel beds piled several feet deep, as mussels live normally

only on or but slightly buried in the bottom of the water body, as has already been stated (see figs. 208, 209). Clark and Wilson (1912, p. 20) record a density of 81 specimens of eight species in one meter, or an average of $7\frac{1}{2}$ per sq. foot. Coker, Shira, (1921, p. 84) record that J. F. Boepple estimated a population of 66 mussels of ten species in an area estimated to be four square feet, or $16\frac{1}{2}$ per sq. ft. Baker (1918b, p. 113) found



Fig. 210. Tracks in sand made by naiades. 1. *Lampsilis ventricosa* *occidens*, 10 feet. 2, same, 18 inches. 3. *Lasmigona complanata*, 6 feet, deflected by log obstruction. 4, same, 6 feet. 5, same about 7 feet. 6. *Lampsilis siliquioidea*, 5 feet.

the mussel population of Oneida Lake to range from one to 20 per sq. yd. This average is about that observed in Sturgeon Bay, although in spots the population increased to as much as 10 per sq. ft. The density of population in rivers greatly exceeds that of lakes.

General Habitats. Some fresh water mussels are found in all kinds of habitats, rivers, creeks, sloughs, canals, ponds, swamps, and lakes. Each type of habitat, however, usually has its peculiar type of mussel group, which usually differs from types in other kinds of habitats. Young mussels require a different type of environment than adult mussels and usually

cannot live in the adult habitat. Quiet ponds or pond-like stretches of river have one kind of naiad fauna while rivers and creeks with rapid current have another kind, the character of the environment usually being reflected in the mussel fauna inhabiting it.

River mussels attain their greatest development both in variety and number, in streams with good currents and it is probable that this was their original habitat, since the center of dispersal is in the south where lakes do not occur. The lake-dwelling mussels were evidently evolved during or after the Glacial Period, which produced lakes and ponds in the north. It is probable that lake species existed during the interglacial intervals, particularly the Sangamon Interval. The river species are usually larger and heavier than lake species, due possibly to a more abundant food supply which is made more accessible by the river currents which are absent in lakes. River mussels also develop a heavier type of hinge teeth, due possibly to the greater danger of twisting valves in a rapid current. Thick shells and hinge teeth are also found in lake species which inhabit open shores subject to heavy surf.

It has been observed by several biologists that in most rivers there is a succession of types from source to mouth. In this succession it has been noted that as one descends a stream from the headwaters toward the mouth, the number of species increases rapidly, and in some persistent species the form of the shell changes, becoming heavier and of greater diameter. In a stream in Illinois, the Big Vermilion River (Baker, 1922d, p. 22), the number of species increased from three to 28 in a distance of 27 miles. The relation of length to width in one species (*Fusconaia flava*) increased from 39 to 50 percent in a distance of 30 miles. Ortmann (1920) has made extensive studies of the naiades of the streams of Ohio and Tennessee and finds that certain forms become more compressed as they pass up-stream, that with the decrease in obesity there is often an increase in size, and that in a few tubercular species the tubercles become small or are lost (p. 311). We do not know just why these changes take place, but one factor is believed to be the change in the size of the stream. All species, however, do not observe this law. Ortmann suggests that because these genera (*Fusconaia*, *Amblesma*, *Quadrula*, *Pleurobema*, *Lexingtonia*) are of the most primitive type of American naiad-

des they are subject to this law, which has not been observed so commonly among the higher naiades, such as *Lampsilis* (see also Baker, 1927d, for a study of the naiades of the Rock River system).

Other investigators have observed this law of distribution. Wilson and Clark (1914) found the mussels of the Cumberland River system to be large and inflated in the larger part of the stream and to be smaller and more compressed in the smaller tributaries. Grier (1919) found the mussels of Lake Erie to vary in a definite manner from the nearly related species or varieties in the Ohio and its tributaries. Grier also made studies on the correlation of nacreous color and station (1920b), morphology and sex (1920a), and epidermal color and station (1920c.). For sex he found that the female shells were on the whole more inflated and higher with a greater length of the anterior hinge line. For the variation in nacreous color, Grier found that it became lighter and more bluish going downstream, and that the lake shells have a greater proportion of blues than the shells of the rivers Maumee and upper Ohio. He concludes that each system of drainage has a peculiar kind of nacre and that this also varies in certain local areas. Similar results were secured as regarded epidermal coloring. In the shells of Wisconsin quite the contrary results would be obtained by a statistical study of some of the river mussels. This indicates that there is great variability in the coloring, form, and ornamentation of river mussels and that no law has yet been found that does not have a number of exceptions.

Recently, Ball (1922) has made statistical studies of the variation in fresh water mussels, especially as regards the change in form as correlated with size of stream. He compared stream flow with size, etc., and his mathematical studies are the most exhaustive that have yet been made. Eight species were considered, *Amblema peruviana*, *Amblema perplicata*, *Cyclonaias tuberculata*, *Ptychobranhus occidentale*, *P. greenii*, *Lampsilis orbiculata*, *Dysnomia torulosa*, and *D. rangiana*. Ball's conclusions are as follows:

1. Shells of the same species often change in shape according to the size of the stream in which they occur. Shells of smaller streams are less swollen than those of larger streams.
2. Certain groups of shells show this correlation much more strongly than do others; in some cases there is apparently no relation between the size of the stream and the degree of obesity.

3. Other factors in addition to size of stream apparently enter into the determination of the degree of obesity.

4. For most species considered, young shells are more swollen than older ones.

5. There is frequently a correlation between the sex and obesity; either the male or the female shell may be the more swollen.

6. In some cases the development of the tubercles is greatest in the large-stream forms; in other cases tubercle development is the same throughout the stream.

7. Usually the flattest and the most swollen forms are connected by a complete series of intergrades.

These conclusions, while significant and applying well to certain species, do not apply to all species, and many forms in Wisconsin do not agree with the types of variation cited. Some of these are discussed under the different species. Intergrades are not present in many cases, at least in Wisconsin, and a study of the mussels of this state, without comparison with those of other parts of the range, might lead to different conclusions from those expressed above. As Ball states under section 3, other factors enter into this variation besides size of stream or flow of water. It is probable that the inherent tendency to vary, possessed by all animals and plants, has as much to do with these variations as anything else, and that the different animals do not respond to this tendency to vary in the same degree, and that the environment, as a stimulus, acts differently on different forms.

The distribution of mussels in a stream is not uniform. Habitats may be quite unsuited for mussel development and maintenance, as the shifting sand on the bottom of the Missouri River which renders that stream practically barren for several hundred miles above its mouth, and this condition also prevails in the Mississippi River for a considerable distance below the mouth of the Missouri. Falls or dams also check the distribution of mussels by preventing the glochidial fish host from ascending the stream. Thus, the Falls of St. Anthony in the Mississippi River have apparently prevented species of the genus *Quadrula* from ascending the river beyond the falls (Wilson & Danglade, 1914). In the Wisconsin River, the Naiad fauna below the power dam at Kilbourn is far richer in species than in the river above this dam.

Mussels appear to be restricted to an area near the shore in many streams. Coker and Shira (1921, p. 97) give a cross

section of the Mississippi River in Andalusia Chute, where the river is about 1000 feet wide. Mussels were found not farther than 85 feet from the shore on the right bank and 60 feet on the left bank, leaving a stretch fully 850 feet wide in the middle of the river which was barren of mussels. Depth did not appear to be a governing factor, but nearness to shore. Recent dredging by the writer in the Wisconsin River below the Dells at Kilbourn gave similar results. When sand or gravel bars are present, or when the stream is narrow and shallow, distribution usually occurs from one bank to the other.

Lake Habitats. In Wisconsin, lake habitats are of two kinds: expansions of rivers, as Lake Pepin in the Mississippi River, Lake Wisconsin in the Wisconsin River, lakes Winnebago and Butte des Morts in the Fox River; and true lakes which are isolated from rivers but may have small connecting streams. Green Lake, Tomahawk Lake, and many others in southeastern and northeastern Wisconsin are of this character. The first type have a larger fauna which is characteristically of the river type, including the same or nearly related species or varieties. Lake Pepin is one of the best examples of this kind, supporting a fauna of 32 species which are confined to the shore lines and flats (Shira). The richness of the fauna of this type of lake is due, largely, to the great quantity of food which is brought to the mussels by the currents, in addition to the fact that the mussels are typically river species and are naturally more numerous than in lakes.

In this connection it is interesting to note that in northwestern Wisconsin, many of the lakes are but enlargements of rivers, caused by artificially damming the stream for lumbering operations. Such conditions were recently found to exist in connection with Lake Chetek, in Barron County, where a 16 foot dam built some 60 years ago impounds the waters of Chetek River, a tributary of Red Cedar River, forming three lakes of good size, Chetek, Prairie, and Pokegoma. The fauna in these lakes is fluvial not lacustrine, with the exception of two species, *Anodonta marginata* and *Anodonta grandis footiana*. The latter has been modified from the *grandis* stock (which is common in tributaries of the lake and in the Red Cedar River) in the space of 60 years. Some individuals are near the *grandis* form while others are typical *footiana*. This is an excellent example of the effect of a changed environment

on a species, a change from river to lake conditions. The Lake Winnebago species show similar changes, but produced by natural changes since the last Glacial Period (see Grier and Mueller, 1926, for recent studies of correlation of shape and station).

The fauna of the thousands of small lakes is usually poorly represented in species which are generally smaller than the related river species. This is probably due to less easily procured food and also, perhaps, to a lake shore environment where there is more or less pounding by the waves. The beds of clams usually border the shore in comparatively shallow water. In the larger lakes—Michigan, Superior—mussels are found only in shallow bays. Small ponds of quiet type support a small fauna in number of species, but the shells may attain large size, as *Anodonta grandis*, which occurs in pond-like stretches of the Fox River, and elsewhere.

Bottom. The character of bottom plays a considerable part in the distribution of naiades. All mussels, with few exceptions, are partly or wholly buried in the substratum of the bottom, and this material must not be too hard or too soft. In time of drought many species 'dig in' to a depth of a foot or more and thus hibernate over the dry period (*Unio merus tetralasmus*, for example). In some lakes and rivers the mussels may be seen protruding from the bottom with their siphons expanded. In other places the mussels lie buried in the bottom to a depth of 6–8 inches. In one part of the Red Cedar River very few mussels could be seen on the surface of the bottom, but by digging into the sand bars they were found in abundance at depths of 3–6 inches below the surface.

A shifting bottom is usually devoid of mussels, whether it be of mud or sand. Fine silt is always avoided and it is doubtful if mussels could live in this kind of an environment. Mussels are usually rare or wanting where great quantities of silt are discharged by small streams from fields.

Generally speaking, mussels are found on four kinds of bottom: gravel, sand, mud, clay. They are common or abundant in the first three and rare in the last. The smaller rivers are made up, usually, of alternating stretches of quiet places with mud bottom and swift current over gravel or sand (riffles). Mussels are common in both places but seem more abundant in the quieter places with mud bottom. In the Big

Vermilion River in Illinois, Baker (1922d, p. 22) found 28 species on a mud bottom and 23 species on a sand and gravel bottom. In Oneida Lake (Baker, 1918b, p. 117) the greatest number of species was found on a sandy clay bottom, the next largest on a mud bottom, and the least number on a boulder and gravel bottom. In lakes there is a definite sorting process, the larger boulders being near shore, the gravel, sand, mud, clay, and silt following in the order named, toward deeper water. In Green Lake the naiades occurred most abundantly on a sand bottom. In Sturgeon Bay on a sand and sandy clay bottom. In Fox River on a sand bottom, in Lake Winnebago on a rock or gravel bottom, and in Red Cedar River on both a stony, gravel, and sand bottom. No very definite classification according to kind of bottom can be made, because a single species may be found in all kinds of bottom under different circumstances. However, thin-shelled species do not usually live on stony bottoms and thick-shelled species do not usually live on a soft bottom. The large Anodontas are able to live in soft mud because the large size of the shell prevents them from sinking too deeply and becoming smothered. The kind of bottom, in addition to other ecological factors, influences the same species in different ways, sometimes producing distinct ecological varieties.

Current. Observation will quickly show that river mussels are more numerous in species as well as in individuals where there is a good current, i. e., in rivers and streams as against ponds, lakes, and sloughs. This is due, probably, to the better distribution of dissolved salts and gasses, as they diffuse too slowly normally to cause even distribution, to the greater quantity of oxygen (the water of streams is supersaturated with oxygen, Birge and Juday, 1911), and to the larger food supply which the currents constantly bring to the mussels. In rivers and streams the current is always bringing fresh oxygen and carrying away waste products of metabolism. In lakes the currents may be from several directions or there may be no current and the mussels must depend for food upon such organisms as drift or swim within reach of their siphons. On lake shores, however, there are almost always large or small waves and the undertow causes a most efficient circulation of the water.

In Wisconsin, as well as in Illinois, many species of mussels

are found in water with a swift current. In the Red Cedar River mussels were abundant in water 1-2 feet deep in a current so swift that one could hardly stand against it. The same was true, though in a lesser degree, in Gilmore Creek (Toma-hawk Lake), the outlet of Green Lake, and in Dell Creek (Kilbourn). These streams have a relatively steep descent which causes the rapid current. Mussels were observed with their siphons extended their full length, apparently enjoying the rush of cool waters.

Depth. Depth influences mussels, affecting the degree of light, temperature, and amount of dissolved gasses. In lakes, especially, the effect of wave action is largely influenced by depth. The great majority of naiades live in comparatively shallow water—from a foot to six feet in depth. More rarely they descend to depths as great as 25 feet. In the small streams of Wisconsin, mussels are abundant in water from one to four feet deep. In Fox River they were found at a depth of 8½ feet. In the Wisconsin River, near the Dells at Kilbourn, they were common at six feet and were not found in deeper water. In Lake Winnebago clams occurred at depths from eight to 15 feet. In Sturgeon Bay from two to seven feet.

In the larger rivers, and in some lakes, mussels occur at greater depths. In Lake Pepin, they range from eight to 20 feet, the optimum being at 12-18 feet. The greater number of mussels, however, are found at depths not greater than 12-15 feet. In Oneida Lake (Baker, 1918b, p. 107) a mussel, *Elliptio complanatus*, occurs abundantly in 18 feet of water on a mud bottom. Muttkowski (1918, p. 474) records *Anodonta* and *Lampsilis* from depths of 5-7 meters (16-23 feet). Records of depths of fresh water mussels from greater depths than 25 feet are to be viewed with suspicion.

Light. Studies of mussels in relation to light have not been carried on to any extent. That they are affected by light conditions seems evident. It has been frequently reported, and also personally observed, that mussels will close their shells when disturbed by a distinct shadow. On dark days they are less active than on sunny days. A sand flat in clear water on a bright, sunny morning may be covered with mussels, all of which may have the siphons fully extended. Let a boat slowly drift over them and many will close their shells. It may be

that the depth distribution of mussels is largely influenced by light, as the deeper dwellers are in more or less clear water. Lake Pepin, where mussels reach their deepest station, is a clear water body, permitting light to reach this depth in good quantity. In Oneida Lake light descends to a considerable depth, a white disc disappearing at 10 feet (Baker, 1918b, p. 41).

Vegetation. Mussels are usually found in areas free from vegetation or where plant life is but sparingly developed. There are numerous exceptions to this rule, however. Wilson and Danglade (1914, p. 15) record a most unusual condition in a section of Minnesota.

"The bottom of the river where the shells are obtained is covered with algae and water weeds to the depth of 12 or 18 inches, and the thicker the vegetation the more plentiful the mussels beneath it. Two men were actively working the Shell River at Twin Lakes near Menahga at the time of our visit, and we watched them rake off the algae and weeds and then dig into the underlying gravel and sand for the mussels. The latter are often buried to a depth of a foot or more. This is, at the least, a novel condition and one which, so far as is known, has not been reported from any other locality".

In Sturgeon Bay, *Lampsilis siliquoidea rosacea* and *Anodonta grandis footiana* are found in rather dense vegetation, *Potamogeton*, *Elodea*, *Vallisneria*, with a covering of *Chara* over the sandy clay (often marly clay). The mussels, however, were in the small bare spots between the plants, in 4-5 feet of water. *Chara* was noted as an abundant plant on the bottom of this bay and mussels and other mollusks lived near and in it.

Condition of Water. The character of the water in which mussels live profoundly influences them for good or ill. It may be filled with suspended particles, brought in from land drainage, from shore washings, and may consist of mud, organic debris of plants and animals, or minute animals and plants—the plankton. Most of this is beneficial bringing in food to the more or less sedentary mussels, excepting that if the mud be of too great a quantity the mussels will be smothered. Streams of great turbidity, like the Missouri, are usually devoid of naiad life. Mineral matter in solution of value to the mussel consists principally of calcium carbonate (comprising about 90 per cent of the shell); silica, manganese, iron, alumina, and phosphoric acid are also present. Hard water

supports a large naiad fauna while soft water streams contain few species of light-shelled forms.

Of the dissolved gasses in the water, oxygen is the most important and mussels cannot live in streams in which the dissolved oxygen is low. Falls, rapids, and waves stir up the water and accelerate the absorption of oxygen which is carried to different parts of the stream by currents. Carbon dioxide (CO_2), or carbonic acid gas, the product of decomposition of animal and vegetable matter, is harmful if in too great quantity. When the water contains a large amount of free carbon dioxide, it causes erosion of the shells where they are not protected by the horny covering or epidermis.

UNFAVORABLE INFLUENCES

Among unfavorable influences, other than those mentioned in the last section, the most significant at the present time is stream pollution by sewage and manufacturing wastes. While raw or undiluted sewage in small quantities is not inimical, but rather beneficial to aquatic life, when this amount becomes great the excess of organic material reduces the amount of oxygen in the water and thus renders it unfit for normal clean-water life. Manufacturing wastes, particularly coal tar and oils, quickly make a stream totally unfit for any kind of animal life, producing in time a desert. Studies by Ortmann (1909) show that whole stretches of the Allegheny, Ohio, and Monongahela rivers have been made deserts by the large amount of poisonous substances discharged into these streams by mines, oil industries, and chemical and other manufactories that border these rivers.

Forbes and Richardson (1919, p. 145) have shown that the sewage from Chicago has affected the Illinois River as far as Peoria, a distance of 120 miles (Richardson, 1925). Wilson and Clark (1912, p. 34) describe the Desplaines where it joins the Kankakee River as simply an immense sewer which has killed off all of the river mussels. In the Maumee River, Wilson and Clark (1912, pp. 26, 28) found that refuse from gas works near St. Mary's and St. Joseph's rivers, Indiana, had killed many mussels. The water at these places was observed to be covered with an oily scum. Baker (1920c) studied the Genesee River, at Rochester, N. Y., for a period of 27 years and observed its fauna gradually die off and disappear and later become restored (in two years) when septic conditions had been

removed. A more recent study of the Big Vermilion River in Illinois (Baker, 1922d, pp. 72–89) showed that the mussel fauna for a distance of 14 miles below the sewage entrance at Urbana had been completely killed and that a normal fauna was not encountered until a distance of 20 miles had been traversed.

In Wisconsin, serious pollution was observed in the Fox River at Oshkosh, where the sewage empties into Lake Winnebago, a very shallow lake (20 feet maximum depth), and from which the water supply of this city is taken. Sooner or later conditions similar to those at Chicago in 1895–1900, will prevail at Oshkosh unless better means of sewage disposal are provided. Sewage enters the Fond du Lac River and is discharged into the upper part of Lake Winnebago. Manufacturing wastes also enter the lake from both Oshkosh and Fond du Lac. Lake Michigan receives sewage from Milwaukee, Kenosha, and other cities. The Mississippi and Wisconsin rivers also receive sewage from cities along their banks, but no serious damage has been observed in these streams. As a whole, the small streams and lakes of Wisconsin are free from harmful pollution and the fauna and flora is very rich in species and individuals.

ENEMIES

The enemies of fresh water mussels are principally of two kinds, parasitic and predatory. Of the latter may be included the muskrat, whose depredations on mussel beds have become classic. Mink and otter, raccoon, and some birds, also use them as food (see Baker, 1916, p. 236). Aboriginal man used the naiades as food, but civilized man has never acquired a taste for these mussels, although they are largely used for the manufacture of pearl buttons. Fish use mussels as food to a very limited degree, the catfishes and sheepshead feeding almost exclusively on the softer shelled species (Forbes, 1888, p. 481; Adams, 1892, p. 127).

In Wisconsin, muskrat piles have been observed on the shores of Lake Winnebago and vicinity, Fox River, Wisconsin River, Tomahawk Lake and vicinity, as well as in other places. Often, rare species occur among these piles which cannot be gathered by any other means.

Fresh water mussels suffer from the presence of a number

of parasites and commensals. Chief among the latter are the water mites (Hydracarina) of the genus *Unionicola* (Atax). These animals infest the gill cavity and the whole of the mantle cavity. Their eggs are laid in the flesh of the gills, foot, and mantle. A number of species are known, mostly of reddish or blackish color. A common form has a Y-shaped white mark on its back on a black background.

Infestation with mites may be heavy or it may be very light or absent. Many Wisconsin naiades were observed to be thus infested and in a few cases accurate record was kept of the number found in each mussel. These are shown below.

Anodonta kennicotti, Green Lake. Eleven specimens, seven infested as follows: 5, 20, 25, 26, 30, 75, 100. From Outlet to Green Lake: Six infested, four free: 1, 1, 1, 1, 3, 5. *Lampsilis siliquoidea*, Lake Chetek. Ten specimens, six infested: 1, 1, 2, 2, 3, 3. *Lampsilis siliquoidea rosacea*, Green Lake. Eleven specimens, all infested: 1, 1, 1, 1, 2, 2, 3, 3, 3, 5, 6.

Seven or more species have been identified as living in mussels. A single species infested one to 11 species of mussels, and one species, not identified, was observed in 35 species of mussels (Kelly, pp. 407-409).

Leeches are sometimes found on the mantle edge or between the margin and the pallial attachment. These are probably accidental intrusions and may have come to feed on the mucus of the mussel.

Of true parasites a number are known to infest the fresh water mussels. Two larval flukes, *Cotylaspis insignis*, and *Aspidogaster conchicolor*, infest respectively the branchial and pericardial cavity. *Cotylaspis* infests 24 species and *Aspidogaster* 37 species. Of the first a dozen or more occurred in one mussel (Kelly, pp. 404, 405). Distomids of several species occur in the muscular parts of the body. They have also been observed in the pericardium and ovary. One free distomid has been recorded in 14 species. The free distomids are common in the flesh near the hinge line. Sporocysts of distomids are common in some groups, as *Quadrula*. The majority of these parasites appear to be harmless, their presence being shown by small irregular pearls and blisters, especially along the hinge line where baroque pearls are formed. One species, however, may occur in such numbers as to completely destroy the repro-

ductive organs (Kelly, p. 407). Several Protozoa of the genus *Conchophthirus* occur in mussels.

The discoloration in many Anodontas is caused by several species of distomids. These discolorations are brick-red, purplish, or steel-blue. Small blisters or pimples on the inside of the shell are caused by larval *Unionicola* which have migrated into the space between the mantle and shell and have been covered with pearly matter.

FOOD OF MUSSELS

A fresh water mussel when active has a stream of water constantly flowing through the body, entering through the branchial siphon and leaving through the anal siphon. About a liter of water is siphoned in 42 minutes. This water is laden with particles of material much of which is of food value. The filaments of the gills, as well as the lining of the branchial chamber and all organs coming in contact with the water, are lined with cilia which are constantly in motion. The material in the water becomes entangled in the mucus of the animal and is passed on to the anterior part of the animal where the small mouth is situated, just behind the anterior adductor muscle. The upper lip of the mouth is continuous with the outer right and left labial palp, and the lower lip with the inner right and left palp. These palps decide what is desirable or undesirable food, and pass on to the mouth or reject the food particle by a curious arrangement of cilia which move toward or away from the mouth. There are four regions in the mussel where choice of food material is made: The incurrent siphon, the labial palps at the upper margin, the palps on the furrowed surface, and the mouth (see Allen, 1914).

Blegvad (1915, pp. 41-78), a Danish biologist, sums up his investigations on the food of the invertebrate animals of Danish waters in the following words: "Detritus forms the principal food of nearly all invertebrate animals of the sea bottom, next in order of importance being plant food from fresh benthos plants. The value of live phytoplankton in this connection is absolutely minimal, amounting in any case to nothing more than an indirect significance through the medium of plankton copepods" (see also Baker, 1918, p. 204).

All observations on the food of fresh water mussels lead to the same conclusion concerning the food. The stomach and in-

testine are filled with the same material as that of the bottom of the water body. It is known that this upper layer of bottom material is made up of dead organic material—fragments of plants, skins or skeletons of worms and crustaceans, shells of small mollusks, and all of the organic debris that is constantly falling to the bottom of a river, lake, or pond. The observations of Schrader (Coker & Shira, 1921, pp. 88–90) point to a very large use of this debris and but little use of plankton. It was noted that only about half of the green algae and diatoms was attacked to any degree by the digestive process, the green algae often retaining their green color after this process. The detritus, composed largely of vegetable matter, was on the contrary greatly changed by the process of digestion.

Clark (1912, pp. 57–61) observes that mussels include anything in the water that is not too large. Clark also noted the presence of great masses of mud in the stomach and intestine—the detritus of the bottom. Such members of the plankton as diatoms, desmids, green algae, flagellate Protozoa, rotifers, and small Entomostraca, were present in large numbers in some mussels. Like Schrader, Clark observed that much of the green algae was living when expelled from the alimentary canal and also retained its green color (see Evermann and Clark, 1920, pp. 47–72).

It may be said, in brief, that any habitat having a bottom with a good covering of detritus, all other factors being favorable, will support a fauna of mussels. The formation of the shell is not so much due to food as to the mineral elements in the water, mainly calcium carbonate (see Allen, 1914, p. 137, where the function of the crystalline style in regard to digestion is described; also 1921).

ABNORMALITIES

Deformed or pathologic mussel shells (pl. XXXV) are of frequent occurrence. They may be due largely to mechanical injuries, but are also frequently the result of infestation by parasitic worms (flukes). Distomids cause rusty stains, as has already been described, as well as blisters, and pearls. A parasite causes atrophy of the sexual organs. Deformities are frequently caused by a parasitic worm which inhibits the growth of the shell in one place and does not affect it in an-

other. Mud frequently gets in between the shell and the mantle and the latter secretes a thin film of shelly matter over the mud, forming a blister on the interior of the shell. This may sometimes cover the entire area of one valve (see Baker, 1901b; 1922d, pl. x, xi; Coker, Shira, 1921, p. 133).

COMMERCIAL IMPORTANCE

The manufacture of buttons from fresh water mussel shells began in America in 1891. The industry has grown in extent and value until in 1912 there were upwards of 196 separate plants employing mussel shells for button manufacture. Of these, 153 plants were devoted only to cutting blanks, while 36 factories finished and graded their material. There were 34 shell-crushing plants, of which 32 were connected with button factories, and there were six novelty works. These establishments were located in 20 different states, including Wisconsin. The pearl button product from fresh water mussels amounted to \$6,173,486 in 1912. Pearls to the value of \$364,000 yearly are obtained in connection with shelling, as a by-product. Button material from fresh water mussels ranks first among all material for the manufacture of buttons (see Coker, 1919, for a most comprehensive account of the mussel industries of the United States).

Of the 500 or more species of mussels in the rivers and streams or lakes, of the United States, only about 40 are useful to the button manufacturer and but 17 are considered of first importance. The value of this raw material—the shells—now ranges from about \$800,000 to \$1,000,000, consisting of 40,000 to 60,000 tons, averaging \$14 to \$20 per ton in different parts of the fishing area. The 17 species which are considered of greatest value, most of which occur in Wisconsin, are known under the following names: Niggerhead, Hickory-nut, Pimple-back, Maple-leaf, Monkey-face, Pig-toe, Ohio River Pig-toe, Blue-point, Three-ridge, Washboard, Mucket, Southern Mucket, Lake Pepin Mucket, Butterfly, Pocketbook, Yellow Sand Shell, Black Sand Shell.

Depletion of Fishing Grounds. Continued and indiscriminate shelling has seriously depleted the mussel beds in many rivers. Universal conservation laws are badly needed, and a few states have already enacted protective legislation. Depleted streams should be closed for several seasons to permit

them to regain their normal condition. Artificial propagation or cultivation, as practiced at the Fairport Laboratory, will doubtless greatly aid in bringing many of the old beds back to a productive condition.

Methods of Collecting Mussel Shells. The common apparatus in use on most large rivers is the crowfoot dredge, which consists of many four-pronged hooks attached to a long iron bar by heavy cord. These are dragged along the bottom from a flat-bottomed "John" boat. When the hook enters between the open valves of the mussel the animal closes upon it and the clam is dragged from its burrow. A mussel bar of one inch gas pipe may be from 12 to 20 feet in length and have 100 to 200 hooks. A "mule" or underwater sail of cloth attached to a wooden frame (sometimes with wooden top and metal bottom frame, i. e., a roll mule) aids propulsion of the boat, the current pushing against the mule and overcoming the effect of the hooks, which is normally to anchor the boat. (pl. XXXVII, fig. 2). More than 100 mussels can be taken at one trip with this apparatus. The crowfoot bars are raised on high cleats on the side of the boat when not in use (pl. XXXVII, fig. 1).

Another method of collecting is with the dip net bag, attached to a stout rake, which holds the clams as they are raked from the bottom. Rake-like tongs, shoulder rakes, many-pronged forks, and various forms of dredges are also used in collecting mussels. In many shallow streams hand picking is found successful. About 70 per cent. of all mussels, however, are secured with the crowfoot dredge. In Winnebago Lake, a crowfoot is used with wheels at either end of the bar, a feature made necessary by the rocky character of the bottom in this part of the lake.

The mussels are killed by steaming in a cooker about five feet long and two feet wide, and 12 to 18 inches deep. The cooker is made of wood with a metal bottom. The mussels are steamed about 20 minutes and then shoveled to a sorting table, (pl. XXXVI, fig. 1) where the shells are roughly sorted and the meat examined for pearls. The shells are sold to traveling buyers or direct to the factories, when these are near the fishing grounds.

The mussel fisherman does not discriminate between sizes of shells and there is a large amount of material wasted that should be returned to the stream to reach a size suitable for

commercial use. Some states have enacted laws covering the size of mussels to be taken for button manufacture, but more and better laws, uniformly passed by all interested states, are badly needed.

Mussel fishing for the button industry is carried on at the following places in Wisconsin (and probably in others not recorded or observed): Prairie du Chien, Lake Pepin, Mississippi River; Prairie du Sac, Wisconsin River; Hudson, St. Croix River; Omro and Princeton, Fox River; Wolf River; Lake Winnebago; Fort Atkinson, and other places, Rock River (pl. XXXVII, fig. 2); Fox River of Illinois. The mussels of Lake Pepin are of the first quality and active fishing is in progress in this section of the Mississippi River. The Lake Pepin mucket (*Lampsilis siliquioidea pepinensis*) comprises about 60 percent of the mussels fished in this lake. The mussel industry in Wisconsin is of considerable importance and should be adequately protected by state laws, governing open seasons and admitting of the possibility of closing certain streams for fishing when they have become partly depleted.

The manufacture of buttons need not be discussed here, since an exhaustive paper (Coker, 1919, pp. 64–89) is available. An interesting account of the pearl fisheries of the United States may be found in Kunz, 1893 and 1898.

MUSSEL CULTURE AND PROPAGATION

Continued fishing of the mussels for the button industry has greatly depleted the more productive beds and exhausted the more limited ones. To remedy this condition the United States Bureau of Fisheries has for a decade conducted experiments, at the Biological Laboratory at Fairport, Iowa, and elsewhere, and methods have been devised by which the old beds may be restocked with mussels. These methods are by propagation and by mussel culture.

Briefly stated, the propagation consists in bringing the ripe glochidia in contact with the proper fish hosts, which are confined for a short period in large tanks until infection has taken place and then the fish are liberated and nature is left to complete the life history of the mussels. This propagation of mussels differs from that of fish propagation in that the young mussels or glochidia have already been fertilized and it only remains to provide a means for the safe and certain attach-

ment to the fins or gills of a suitable fish. Infection is effected in from five to 25 minutes.

The degree of infection varies. "That degree of infection which employs the fish to the best advantage in mussel propagation, without doing appreciable injury to the host, is termed the 'optimum infection.' It varies with the species of mussel and with the kind and the size of the fish." This is illustrated in the following table (after Coker and Shira, 1921, p. 162) :

OPTIMUM INFECTION FOR CERTAIN SPECIES OF MUSSEL ON SEVERAL SPECIES OF FISH.

Species of mussel.		Fish host.		Number of glochidia on fish
Scientific name	Common name	Species	Size in inches	
<i>Lampsilis siliquoidea pepinensis</i>	Lake Pepin mucket.....	Black bass.....	8	2,000
Do.....	do.....	White bass.....	8	2,000
Do.....	do.....	Wall-eyed pike.....	8	2,500
Do.....	do.....	Bluegill.....	5	500
Do.....	do.....	Crappie.....	5	400
Do.....	do.....	Yellow perch.....	6	1,500
<i>Lampsilis anodontoides</i>	Yellow sand-shell.....	Gar.....	16	2,000
<i>Actinonaias ligamentina</i>	Mucket.....	Black bass.....	8	2,000
<i>Quadrula pustulosa</i>	Pimple-back.....	Channel catfish.....	14	1,200

The operations of mussel propagation serve to carry the young mussels through the most critical stage of their life history—to give the thousands the chance for life that would ordinarily fall to dozens. Natural infections on fish are few and the number of glochidia limited. Artificial infection thus provides for a larger supply of mussels than would be obtained by nature herself. It is probable that great mortality may occur among the young mussels as they are liberated from the host, but this mortality is relatively less among the propagated individuals.

Mussel Culture. Going a step farther, the Fairport Laboratory has successfully reared young mussels in tanks and ponds. The Lake Pepin mucket was reared in crates anchored and floating in the Mississippi River to the age of 2½ years when they had attained a length of 70 to 80 mm. (about three inches) or to a size from which button blanks could be cut. In the floating crate method over 8 per cent. of the juvenile mussels survived (Howard, 1922, pp. 68–72, 85).

Experiments have also been made with cement-lined and earthy ponds and several species of mussels planted, but re-

sults, excepting in a few cases, were unsatisfactory. In one case *Quadrula pustulosa* was kept alive for four years in a concrete-lined pond, the largest size attained being 24.2 mm. (about an inch). The only successful mussels for this type of artificial environment seems to be the pond-inhabiting species. The true river mussels cannot adapt themselves to this kind of habitat. Twenty species of mussels, all juveniles, have been found in the artificial ponds at Fairport, giving the hope that when difficulties are overcome it will be possible to control the culture of desirable species, (see Coker, Shira, etc., 1921, pp. 160-166; Howard, 1914, 1922; Coker, 1914; Surber, 1912, 1915; for data concerning the propagation and culture of fresh water mussels).

ORIGIN OF THE WISCONSIN NAIAD FAUNA

The naiades, as well as some other fresh water molusks, first appear in the Triassic period of Texas. Later, they occur in various Cretaceous beds of the western and southwestern part of the United States and Canada. By migration, principally by fish hosts, if the peculiar development of this group began as early as this, geologically, the species were scattered over the eastern and northeastern part of the country, as land was lifted above the sea and fresh waters became available. The great Cumberland divide, extending from the eastern states southwest into Texas, separated the drainages of this ancient country into a north and a south system, the waters of the former draining northward and those of the latter southward into the Atlantic Ocean and the Gulf of Mexico. Later, the Mississippi embayment was formed which caused many of the groups of naiades to be isolated on either side of this great inland sea. Continued changes of land areas, principally by uplift and separation of drainage areas, caused farther isolation, which resulted in the formation of a very complex fauna, similar, perhaps, to that living in the south today.

What the fauna may have been during preglacial times we do not know, but we believe that it was largely a river fauna, as there were, probably, but few lakes, if, indeed, there were any. The glacial period is believed to have either killed or driven south all life in the area covered by the great ice sheets. In Wisconsin, there is an area known as the "Driftless Area"

which was untouched by any of the ice invasions and it is thought that perhaps some of the fresh water fauna may have been preserved in the icy streams of this region. At any rate, the fauna as a whole was driven south and when the ice receded and laid bare the State it was very different from its preglacial condition. In place of river valleys with regular systems of erosion, as may now be seen in parts of the driftless area bordering the Mississippi River in the southwestern part of the State, there were many lakes and ponds, such as are now to be seen in parts of the State. This changed environment has resulted in the evolution of a number of races which are characteristic of lakes and ponds.

The naiad fauna of the State has been influenced by migrations from several parts of the United States. There are two very distinct elements in the naiad fauna, derived from different sources. Of these elements, Walker says: "The fauna of the Mississippi Valley, from one end to the other, is a substantially homogeneous fauna, varying simply in the number of species in different parts of its extent. But on examining the Unionidae of the Great Lakes, we find that, while the fauna of Lake Superior, at the western extremity of the system is similar to that of the Lower St. Lawrence, and the New England States, there is in the center of the system, with Lake Erie as its metropolis, an entirely different fauna, which extends eastward as far as the Ottawa River and Montreal, and westward to the Saginaw Valley, and even perhaps as far as Mackinac. The relations of this fauna are entirely with that of the Ohio and Mississippi valleys." (1913, p. 18). This Lake fauna is, also, somewhat different from the river fauna of the Mississippi Valley.

These faunal characteristics described by Walker are not as marked in Wisconsin as they are in Michigan, the eastern migration being represented by but one species, *Elliptio complanatus*, which is now found to extend its range to the western end of Lake Superior. Other eastern species found in Michigan are absent from Wisconsin. Of the Lake Erie fauna, there appear to be representatives in Lake Winnebago and Green Bay, which may have arrived via the glacial connection between Lake Chicago and Lake Warren, the Grand River outlet. The Lake Erie fauna probably reached its location by way of the Wabash-Maunee River connection.

It is more probable, however, that the great bulk of Wisconsin naiades found their way to the State by way of the Mississippi River and thence up the smaller streams. There were doubtless stream connections in the southeastern part of the State by which many species crossed from one drainage into another. The old post-glacial outlet at Portage, Wisconsin River enabled many species to enter the Fox River Valley. It is also very likely that many species found their way to the small streams bordering Lake Michigan shore by way of the outlet at Chicago, the Desplaines River. It is known that a large fauna, differing from that now inhabiting the Chicago area, took possession of old Wilmette Bay of Glacial Lake Chicago, and fish may have carried this fauna northward into Wisconsin. (See Baker, 1920d). Once spread over the State, the naiad fauna has increased in size and has taken possession of nearly all bodies of water, large and small. (See Walker, 1913; 1917c).

CLASSIFICATION OF THE NAIADS

Early classifications of the fresh water mussels were based largely on shell characters. Three genera, *Unio*, *Anodonta*, and *Margaritana*, constituted the entire grouping of the American species. Lea prepared a synopsis in 1836, followed by other editions in 1838, 1852, and 1870, in which he divided the species into two great groups or genera, *Margaron* and *Platiris*, with many subgenera and smaller groups, founded on the presence or absence of a dorsal wing, and on the form and sculpture of the shell. This classification was highly artificial and was so regarded by Dr. Lea.

In 1900, Mr. Charles T. Simpson, then of the United States National Museum, published a new synopsis based on characters of the animal, principally the modification of the gill in its use as a marsupium. This classification has been strengthened by Sterki (1903) and augmented by Ortmann (1911, 1912a, 1919). In 1914, Walker published Simpson's Catalog of the Species of Naiades, in which the later classification and its modifications are set forth. The nearly 500 recognized species of North American mussels have been grouped into many genera, based on characters of shell and animal, including glochidia, and on the whole this system seems very comprehensible (see Walker, 1918).

NOMENCLATURE

The nomenclature of the naiades has been in a state of confusion during the past ten or fifteen years. Lea's use of names, set forth in the Observations, had been followed with little deviation for many years and were familiar to all students and teachers of biology and zoology. Later zoologists, Ortmann, Walker, Sterki, Frierson, and others, have applied more strictly the law of priority, and certain names of the eccentric French naturalist, Rafinesque, have been found to be recognizable and have been adopted (see Ortmann and Walker, 1922). Also certain names of Conrad, published prior to those of Lea, have been given precedence. As they now stand, the names in current use seem stable and can reasonably be depended upon. The decisions of Pilsbry, Ortmann, and Walker so carefully made and stated, should be followed by all students of the naiades.

In the matter of varietal names, the writer believes that any form which can be distinguished from another should bear a name. Names are but handles to use in descriptive work and the trinomial system lends itself clearly to the designation of varieties. These varieties may be geographical or ecological. In the Wisconsin field work it was frequently noted that the mussels of smaller streams differed in a more or less marked degree from those of the same species living in the larger rivers. Lake forms, also, differed in many cases from river and creek forms. These ecological differences can best be expressed in a varietal sense, thus, *Proptera alata* is a lake form, while *Proptera alata megaptera* is a river form. Many other examples could be cited but are found in the body of this work. Several new varieties of this character are described in the following pages.

Ortmann has established the differences between many species by a system of measurements which give a varying percentage formula, obtained by dividing the width by the length, hence the formula is an expression of the relative percentage of width to length. This has been found very useful in dividing many varieties, although it is not infallible, and there are many exceptional specimens which have measurements above or below the normal figures given. These percentages follow the measurements of many species described in this monograph.

Superfamily NAIADACEA Menke

Shell of varied form, normally equivalve, inequipartite, and dimyarian; rarely alate; shell substance nacreous and prismatic, with a conspicuous epidermis; hinge area obscure or amphidetic; ligament parivincular, usually opisthodontic and external; pallial lobes usually free, except for an anal siphon, the pallial line simple; foot normally long, compressed, keeled; byssus obsolete; young usually with a distinct nepionic stage; station usually fluviatile or lacustrine (Dall).

KEY FOR IDENTIFICATION OF WISCONSIN NAIADES

This key is very artificial and is based on such obvious characters as a student not well acquainted with the group might easily grasp. As most identifications will be made from the shell alone, no reference to the animal is included. It is not possible to make a key that will include all variations in so large and homogeneous a group as the fresh water mussels, but it is believed that the key will be a valuable aid, and in connection with the descriptions and figures will reasonably insure the correct identification of most individuals of each species. The terms used are indicated on plate XXX.

1. a. Surface with pustules, knobs, or ridges	2
b. Surface without pustules or ridges	23
2. a. Surface with pustules or knobs which do not extend over the anterior end	3
b. Surface with pustules extending well over the anterior end	15
c. Surface with ridges or flutings	16
3. a. Curve of side of valve evenly rounded, without a sulcus or median depression	4
b. Curve of side of valve interrupted by a median sulcus or depression	11
4. a. Nacre white	5
b. Nacre purple or coppery	8
5. a. Surface with few large knobs or tubercles	6
b. Surface with many tubercles or pustules covering the pos- terior third of the valve	7
6. a. Posterior dorsal margin alate, usually pustulose, surface with 2 or 3 longitudinal rows of large, elongated tubercles	<i>nodulata</i>
b. Posterior dorsal margin not alate or pustulose; surface with 2 or 3 large, elongated knobs arranged in a vertical row on the center of the valve	<i>reflexa</i>

7. a. Shell inflated, width more than 55% of length ----- *pustulosa*
 b. Shell compressed, width less than 50% of length ----- *prasina*
8. Nacre purple or coppery ----- 9
9. a. Umbones depressed, placed near the anterior end (15% or less from anterior margin); shell compressed, somewhat oblique, nacre purple ----- *tuberculata*
 b. Umbones elevated, inflated, placed near the center of the dorsal margin (20% or more from the anterior margin); shell wider and more orbicular, nacre more coppery ----- *granifera*
11. Curve of side of valve interrupted by a median sulcus or depression ----- 12
12. a. Umbones depressed, flattened, not much raised above the lunule ----- 13
 b. Umbones elevated, rounded, raised considerably above the lunule ----- 14
13. a. Shell rounded, somewhat inflated, many small tubercles or pustules mostly anterior of the sulcus ----- *quadrula*
 b. Shell elongated, compressed, tubercles less numerous and more elongated ----- *bullocki*
14. a. Tubercles usually in a row on each side of the median sulcus; posterior ridge sharper than in 13 ----- *fragosa*
 b. Tubercles few in number, forming large knobs on the angular posterior ridge, with a few smaller pustules anterior to this ridge ----- *metanevra*
15. Surface with pustules extending well over the anterior end; shell greatly elongated and compressed laterally; dorsal margin with small flutings ----- *verrucosa*
16. Surface with flutings or diagonal ridges on the posterior part of the shell ----- 17
17. a. Small flutings or undulations confined to the postero-dorsal margin, shell compressed laterally ----- 18
 b. Large undulations arranged diagonally, shell inflated ----- 19
18. a. Flutings distinct on postero-dorsal margin ----- *costata*
 b. Flutings obsolete or nearly so, shell heavier and wider than *costata* ----- *nuda*
19. a. Surface with large diagonal undulations or ridges; postero-dorsal margin usually without small flutings ----- 20
 b. Surface with undulations; postero-dorsal margin with many small flutings or plications, turned upward ----- 21
20. a. Shell very wide, umbones elevated, swollen, turned forward, placed near the anterior end (about 12% from end); outline ovate ----- *peruviana*
 b. Shell compressed laterally, umbones flattened and not conspicuously turned forward, placed within 20% or more of anterior margin; outline quadrate ----- *raripectata*
21. a. Postero-dorsal margin with small flutings, lateral teeth well-developed ----- 22
 b. Lateral teeth represented by thickening of the hinge line; plications on umbonal slope raised to form two nodulous ridges ----- *confragosa*

22. a. Umbonal region without ornamentation excepting the beginning of the diagonal plications ----- *costata*
 b. Umbonal region densely covered with small zigzag undulations which extend half way to the ventral border ---- *gigantea*
23. a. Hinge with well-developed pseudocardinal and lateral teeth; surface without pustules or ridges ----- 24
 b. Hinge with laterals or pseudocardinals or both missing ---- 60
24. a. Epidermis black or brown, rayless when adult, faintly rayed when young ----- 25
 b. Epidermis yellowish or greenish smooth or polished with more or less distinct rays; rarely yellowish and rayless-- 38
25. a. Adult shell more than 50 mm. in length, teeth massive, interdentum more or less wide ----- 26
 b. Adult shell never more than 50 mm. in length; hinge very slight, no interdentum ----- *parva*
26. a. Nacre usually white, height of shell 70% or more of length 27
 b. Nacre usually violet or purple, height of shell 60% or less of length, hinge less massive and interdentum narrower 35
27. a. Posterior ridge angled with a slight depression or sulcus in front ----- 28
 b. Posterior ridge not angled, evenly rounded, no distinct sulcus or depression ----- 30
28. a. Umbones depressed, near center of dorsal margin, diameter about 55% of length more or less ----- 29
 b. Umbones greatly inflated and elevated, shell strongly trigonal, diameter 75% of length ----- *wagneri*
29. a. Diameter less than 55% of length ----- *flava*
 b. Diameter 55% or more of length, umbones more elevated than *flava* ----- *undata*
 c. Shell about two-thirds size of *undata*, more trigonal ---- *parvula*
30. a. Posterior ridge not angled; interdentum very wide ----- 31
 b. Posterior ridge not angled; interdentum very narrow ---- 33
31. a. Shell almost circular, umbones elevated and turned forward ----- *ebena*
 b. Shell squarish or very oblique with sharply truncated posterior margin ----- 32
32. a. Umbones slightly anterior of the center of the dorsal margin; diameter 66% or less of length ----- *catillus*
 b. Umbones greatly elevated, placed near the anterior margin; shell very oblique; diameter 70% or more of length ---- *solida*
33. a. Pseudocardinals heavy, pyramidal, triangular; width about 50% of length ----- 34
 b. Pseudocardinals narrow, slight, lamellar, parallel with hinge line; width about 93% of length ----- *capar*
34. a. Shell evenly ovate or elliptical, umbones very broad; pseudocardinals heavy, parallel with lateral teeth; center of valve smooth ----- *olivaria*

- b. Shell elongate-quadrate, posterior end sharply truncated; pseudocardinals divergent with lateral teeth; center of valve smooth ----- *coccineum*
- c. Shell elongate-ovate, posterior end sharply pointed; center of valve from umbones to ventral margin with a rounded swelling on which the growth lines may develop into raised ridges ----- *cyphus*
35. a. Hinge teeth large, massive, lateral teeth short, wide; shell very thick, heavy ----- 36
- b. Hinge teeth small, delicate; lateral teeth long, very narrow; shell thin, umbones flush with hinge line ----- 37
36. a. Umbones near center of dorsal margin, slightly elevated above hinge line; height about 60% of length ----- *crassidens*
- b. Umbones near anterior margin, depressed, scarcely raised above hinge line; height 53% of length ----- *dilatatus**
- c. Shell similar to last, but much smaller, about $\frac{1}{2}$, with more delicate hinge ----- *sterkii*
37. a. Height 55% of length, shell quadrangular ----- *complanatus*
- b. Height 45% of length, shell lanceolate ----- *delicatus**
38. a. Shell rayed; posterior ridge producing a sharp angle ----- 39
- b. Posterior ridge not angled, rounded or absent ----- 41
39. a. Rays broken up into spots like vertical dashes; interdentum very wide, flat; teeth massive ----- *securis*
- b. Rays forming V-shaped markings, especially on the umbonal region; interdentum absent; teeth delicate ----- *triquetra*
- c. Rays extending from umbones to ventral margin in an unbroken line ----- 40
40. a. Rays composed of simple straight lines; height 85% of length; a small interdentum present ----- *truncata*
- b. Rays as in last, shell smaller, ridge less sharp, no interdentum ----- *lacustris*
- c. Rays supplemented by more or less distinct zigzag lines; height 65% of length; no interdentum ----- *donaciformis*
41. a. Posterior dorsal margin not alate ----- 42
- b. Posterior dorsal margin alate ----- 56
42. a. Shell solid, thick; hinge with large, triangular pseudocardinal teeth; width more than 30% of length ----- 43
- b. Shell thin to fragile; hinge weak; pseudocardinal teeth reduced to remnant; width less than 30% of length ----- 55
43. a. Height 46% or less of length; shell lanceolate ----- 44
- b. Height more than 55% of length; shell elliptical ----- 45
44. a. Epidermis black or green with many dark rays; nacre pink or salmon ----- *latissima*
- b. Shell with brownish epidermis, smaller than last, with fewer rays ----- *recta*
- c. Epidermis plain yellow, usually without rays; height 42% of length ----- *anodontoides*

* These shells sometimes have white nacre, which may be tinged with pink.

- d. Epidermis yellowish with many fine rays; height 46% of length ----- *fallaciosa*
45. a. Beak sculpture of fine, wavy, concentric lines; epidermis dark green or yellowish green with dark green rays more or less distinct ----- 46
- b. Beak sculpture of strong double-looped ridges; epidermis yellowish green or reddish, rays well developed, or feeble, rarely absent ----- 47
46. a. Shell broadly elliptical, rounded before and behind; rays straight ----- *carinata*
- b. Shell elongate-ovate, rounded before, pointed behind, smaller than last; rays wavy ----- *ellipsiformis*
47. a. Height less than 65% of length ----- 48
- b. Height more than 65% of length ----- 51
48. a. Epidermis yellowish with green rays ----- 49
- b. Epidermis with strong tinge of red or brown ----- 50
49. a. Width less than 40% of length ----- *siliquoides*
- b. Width more than 45% of length ----- *pepinensis*
50. a. Width 40% or less of length ----- *rosacea*
- b. Width 45% or more of length ----- *chadwicki*
51. a. Pseudocardinal teeth lamellar, parallel with hinge margin, rather slight; distance from umbones to anterior margin 28% or more of length; shell not thick ----- 52
- b. Pseudocardinal teeth divergent with hinge margin, massive; distance from umbones to anterior margin 25% or less, shell thick ----- *higginsii*
52. a. Epidermis yellowish with dark green rays ----- 53
- b. Epidermis yellowish or reddish with light green rays which may be feeble or absent ----- 54
53. a. Width 46% or less of length ----- *ventricosa*
- b. Width 50% or more of length ----- *occidens*
54. a. Width less than 44% of length ----- *burida*
- b. Width more than 44% of length, smaller than last, with more distinct rays ----- *winnebagoensis*
55. a. Pseudocardinal teeth well-defined, triangular; umbones slightly elevated above hinge line; beak sculpture of coarse, double-looped ridges; rays distinct, more or less interrupted; nacre silvery white ----- *novi-eboraci*
- b. Pseudocardinal teeth reduced to inconspicuous elevations; beak sculpture of fine, faintly double-looped ridges; rays fine uninterrupted; nacre pinkish ----- *leptodon*
56. Posterior dorsal margin alate (very old individuals lose the alate appearance); shell compressed, thin to fragile; epidermis yellowish, greenish, or brownish; height 64% of length ----- 57
57. a. Nacre pinkish, rarely pure silvery white; epidermis yellowish with or without rays; teeth very fine, parallel with hinge margin ----- 58

- b. Nacre purplish or salmon; epidermis greenish or blackish; teeth heavier than last ----- 59
58. a. Alate wing extending well above umbones which appear to lie in a depression between two wings (old females sometimes without well-marked wings) ----- *laevissima*
- b. Alate wing forming a straight line with the umbones, the hinge margin being an unbroken line; alae not well-developed in old shells ----- *fragilis*
- c. Smaller than last, yellowish without green rays ----- *lacustris*
59. a. Nacre purplish or salmon; shell large; epidermis greenish or black ----- *megaptera*
- b. Shell smaller than last, epidermis brownish ----- *alata*
60. Hinge with laterals or pseudocardinals or both missing ---- 61
61. a. Hinge edentulous without thickening indicating position of hinge teeth; shell usually thin and fragile ----- 62
- b. Hinge line thickened, pseudocardinal area represented by small tubercular thickening ----- 67
- c. Hinge with well-developed (though slight) lateral teeth, but with pseudocardinals reduced to mere tubercles ---- *compressa*
- d. Hinge without distinct lateral teeth but with pseudo-cardinals well-developed ----- 69
62. a. Beak markings of distinct double-looped ridges ----- 63
- b. Beak markings consisting of subconcentric bars more or less diagonal to the hinge line ----- 65
63. a. Height less than 65% of length ----- 64
- b. Height more than 65% of length; umbones much swollen, giving a mammae-like appearance to this part of shell ----- *corpulenta*
64. a. Shell slightly thickened, umbones prominent, often inflated; epidermis greenish, yellowish, brownish or pinkish; nacre white with more or less red, salmon, or pink ----- *gigantea, grandis* and var.
- b. Shell thin, paper-like, umbones flush with hinge line; nacre a peculiar bluish silvery color; epidermis reddish or chestnut ----- *marginata*
- c. Shell very thin; umbonal swelling entirely absent, hinge line perfectly straight; umbonal markings very fine; epidermis bright green with rays ----- *imbecillis*
65. a. Posterior ridge rounded ----- 66
- b. Posterior ridge forming a distinct ridge or angle, the posterior dorsal margin slightly excavated ----- *birgei*
66. a. Shell long-elliptical, posterior end pointed ----- *ferussacianus*
- b. Shell subcylindrical, posterior end rounded ---- *subcylindraceus*
67. a. Shell more than 50 mm. in length, very thick ----- 68
- b. Shell less than 40 mm. in length, very thin, fragile; pseudocardinal represented by thin, long tubercle; no swellings for lateral teeth ----- *ambigua*

68. a. Hinge line thickened, pseudocardinal area represented by small tubercular thickening; height less than 40% and width less than 25% of length; anterior abductor scars much roughened ----- *monodonta*
 b. Hinge line thickened, pseudocardinal area represented by small tubercular thickening; height more than 55% and width more than 40% of length ----- *rugosus* and vars.
69. a. Shell more than 50 mm. in length ----- 70
 b. Shell less than 50 mm. in length, height 60% of length, posterior end sharply truncated ----- *calceolus*
70. a. Pseudocardinals represented by elevated, lamellar tubercles; hinge plate with thin elevated ridges representing lateral teeth; epidermis greenish, brownish or black; height more than 65% and width less than 35% of length ----- *complanata* and var.
 b. Pseudocardinals represented by lamellar tubercles, lateral teeth by thickenings of the hinge line; epidermis greenish or yellowish (sometimes reddish) with many green rays; height less than 65% and width more than 55% of length ----- *marginata* and var.

Family MARGARITANIDAE Ortmann

Diaphragm incomplete, formed by the gills; posteriorly the outer lamina of the outer gills not connected with the mantle for a considerable distance; anterior end of the inner gills separated from the palpi by a gap; branchial and anal openings ill-defined, and the latter not closed above; no supra-anal developed; gills without watertubes or with incomplete tubes, and with scattered interlamellar connections, which in certain places form irregular diagonal rows; marsupium formed by all four gills; larva a small, semicircular glochidium, without distinct hooks; shell elongated; sculpture of the beak concentric; hinge-teeth imperfect; epidermis blackish (Ortmann, 1911, p. 334).

Genus MARGARITANA Schumacher, 1817*

Shell elongated, usually arcuate, rounded in front, almost lacking a posterior ridge; beaks rather low, sculpture consisting of a few coarse, parallel ridges which follow the growth lines; epidermis concentrically striate, brownish or blackish; hinge-teeth generally imperfect or not fully developed, two

*For generic references to the Naiades the reader is referred to the Catalog of Simpson and the papers by Ortmann listed in the Bibliography.

more or less perfect pseudocardinals in the left valve and one in the right, often reduced to mere tubercles; laterals short, imperfect or wholly wanting; cavity of the beaks rather shallow (Walker).

Subgenus MARGARITANA Sensus stricto

Animal having the gills without water-tubes and with scattered interlamellar connections which in some places form irregular rows, running obliquely forwards. Type: *Mya margaritifera* Linn. Not found in Wisconsin.

Subgenus CUMBERLANDIA Ortmann, 1912

Animal having the gills with incomplete water-tubes and with continuous septa, running obliquely forwards. Type: *Unio monodonta* Say.

MARGARITANA MONODONTA (Say). Spectacle-Case

Plate XXXI, figures 1, 2

Unio monodonta SAY, New Harm. Dissem., II, p. 293, 1829; Amer. Conch., I, pl. iv, 1830.

Margaritana monodonta ORTMANN, Ann. Carnegie Museum, VIII, p. 233, 1912.

Margaritana monodonta SIMPSON, Cat., p. 521, 1914.

Cumberlandia monodonta ORTMANN, Nautilus, XXVI, p. 13, 1912.

TYPE LOCALITY: Falls of the Ohio and Wabash River (Say).

WISCONSIN RECORDS

1905c. *Margaritana monodonta* BAKER, p. 255. Prairie du Chien.

SHELL: Elongated, arcuate, compressed, strikingly inequilateral, rather solid; beaks but slightly elevated, not inflated, their sculpture of heavy ridges parallel with the growth lines; anterior end broadly rounded, posterior end rounded; ventral margin broadly concave, dorsal margin broadly convex; posterior ridge curved, broadly rounded; surface with heavy growth lines somewhat raised; rest periods often accentuated; epidermis greenish or brownish in young shells, black in old individuals; pseudocardinals greatly reduced, a single tubercular tooth in the right valve fitting into a depression in the left valve in old specimens, in which also the laterals become indistinct and merge into the hinge line; in young individuals there is a well-marked pseudocardinal in each valve and two laterals in the left valve and one in the right valve; anterior ad-

ductor muscle scar deeply impressed and roughened, posterior scar well-marked, elliptical; dorsal muscle scars in the shallow beak cavity; pallial line well-impressed; nacre white, more or less granular and pitted, iridescent posteriorly.

Length, 153; height, 61; diameter 32 mm. Prairie du Chien. C. A. S. 20275.

" 147; " 56; " 33 mm. Prairie du Chien. C. A. S. 20275.

ANIMAL: (Fig. 211). Margins of mantle free all around from the anterior to the posterior end and with no tendency to unite anywhere: Branchial opening indistinctly separated from anal, a horizontal ridge running from the posterior insertion of the outer lamina of the outer gill to the margin of the mantle, but the margins of the mantle are not held together by the diaphragm; anal opening not closed above, and no supra-anal formed; branchial opening ill-defined anteriorly, on the inner edge with strong papillae, which disappear anteriorly, and then the inner edge of the mantle is smooth; inner edge of anal opening almost smooth; palpi large, subcalci-form, drawn out and pointed behind, their posterior margins connected for about one-third of their length.

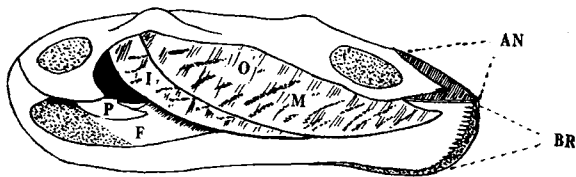


*Fig. 211. Animal of *Margaritana monodonta*, after Ortmann.

* All abbreviations on figures of animals have the following significance: AN, anal opening; BR, branchial opening; F, foot; I, inner gill; O, outer gill; P, labial palpi; M, marsupium; SA, supra-anal opening; PP, papillae on mantle margin; MF, flap on mantle margin.

Gills rather long, the inner the wider, chiefly so anteriorly; outer lamina of outer gill not entirely connected with the mantle; posteriorly a part of it is free for about one-seventh or more; inner lamina of inner gill free from the abdominal sac with exception of its anterior end; behind the foot, the two inner laminae of the inner gills are connected; thus the diaphragm (separation of branchial and suprabranchial-cloacal cavities) is formed only by the gills, and it is incomplete posteriorly, and does not reach the margin of the mantle, although the medially united free ends of the gills project to near the margins of the mantle (Ortmann).

While in other species of the genus *Margaritana* the inter-laminar connections of the gills are scattered, and irregularly distributed, or fall into more or less distinct oblique rows, in the present species these irregular, interrupted rows are developed as continuous septa, which run obliquely forwards. In the middle of the gills, these septa are well developed and quite continuous, but rather distant from each other. Toward the ends of the gills they are more irregular, shorter, and chiefly at the posterior end they are somewhat interrupted, and thus it is clearly seen that they represent a further development of the oblique, interrupted rows present in other species of *Margaritana*. The septa of *monodonta* have nothing to do with the family Unionidae, for in the latter they run parallel to the gill-filaments while here they cross them obliquely (Ortmann, 1912b, p. 13).

All four gills are gravid, the inner gill containing many more glochidia than the outer gill (Howard, 1915, p. 6).

Color of soft parts whitish, edge of mantle blackish all round, but chiefly at the anal and branchial openings; gills transparent, but not blackish; foot grayish-white in its distal part, this gray color marked off in sharp contrast from the basal white part.

BREEDING SEASON: Specimens were collected near Moline, Ill., on May 2, 1913 by A. D. Howard. The glochidia (pl. XXXI, fig. 1) are very small, 0.050 x 0.052 mm., semielliptical in shape, ventral margin somewhat acutely rounded; hinge line long, straight. This minute size of the glochidium suggests *Tritogonia tuberculata* in general shape, but it has a less proportionate depth, with longer hinge line. Host unknown (Surber, 1915, p. 7). Howard states that there are probably two broods produced in a season (1915, p. 6).

GENERAL DISTRIBUTION: Ohio; Cumberland and Tennessee river systems; Illinois; eastern Iowa; Nebraska? (Simpson).

DISTRIBUTION IN WISCONSIN: Prairie du Chien, Crawford Co. (Baker).

ECOLOGY: *Monodonta* has been collected from various kinds of bottom, including sand, gravel, and mud. In the Mississippi, at Prairie du Chien, it occurs in a mud bottom deeply buried. In Illinois it is found on a gravel or sand bottom, usually well below the surface. The long, slender foot enables this naiad to dig deeply and remain firmly fixed. It requires a fairly good

current. Its habitat is in the larger rivers and, unlike its relative, *Margaritana margaritifera* of the eastern states, it does not inhabit the small brooks and streams.

REMARKS: *Margaritana monodonta* is different from all other species of Wisconsin mollusks, at once recognized by its greatly elongated, compressed shell, peculiar hinge structure, and black epidermis. It is the only representative of the Family Margaritanidae in the State as well as in the Mississippi Valley. Baker's citation (1905c, p. 255) is the only record of the species in the State. Shimek (1921) also records it from McGregor, Iowa. These records seem to mark the northern distribution of this species in the Mississippi River and are the first from Wisconsin (See Walker, 1910b, p. 138). In Illinois it is rather widely distributed, being found in the Kankakee, Illinois, and Mississippi rivers (Baker, 1906b, p. 76). *Monodonta* is rare in the Mississippi at both Prairie du Chien and McGregor, only a few specimens being found among thousands obtained by the mussel fishermen.

The metropolis of this species is the rivers of Tennessee and Kentucky, and it is believed that the original point of dispersal was in the head waters of the Tennessee River system, from whence it migrated by old preglacial river systems, now extinct (see Walker, 1911, p. 57). Its presence in the Mississippi River in southwestern Wisconsin may be due to post-glacial migration or it may have been among those species that found refuge in the driftless area during the Wisconsin ice invasion.

Family UNIONIDAE (d'Orbigny) Ortmann, 1911

Diaphragm complete, formed by the gills; posteriorly the outer lamina of the outer gill connected with the mantle to its posterior end; anterior end of the inner gills separated from the palpi by a gap; branchial and anal openings sharply separated from one another by the diaphragm; anal opening generally closed and with a supra-anal opening (which very rarely may be obliterated); gills with water-tubes and distinct continuous interlamellar septa, running parallel to the filaments. Marsupium in all four gills, or only in the outer gills; larva a glochidium. Shell of very variable shape; sculpture of the beak more or less reduced, of various types, but originally of

the concentric or zigzag pattern; hinge-teeth perfect or imperfect; epidermis plain or with color-markings (Ortmann).

KEY TO THE SUBFAMILIES OF UNIONIDAE

1. a. Water-tubes simple in the gravid female 2
- b. Water-tubes in the gravid female divided into three tubes,
 of which only the center one is used as an ovisac...*Anodontinae*
2. a. Male and female shells usually alike; edge of the gravid
 marsupium always sharp and not distending*Unioninae*
- b. Male and female shells usually different; edge of the gravid
 marsupium distending and bulging out beyond the orig-
 inal edge of gill*Lampsilinae*

Subfamily UNIONINAE (Swainson, 1840) Ortmann, 1910

"Inner lamina of the inner gills generally free from the abdominal sac (sometimes, in extralimital forms, connected); supra-anal opening sometimes not separated from the anal, normally present, the closed part rather short; branchial opening well-defined, no papillae nor flaps on the edge of mantle in front; marsupium formed by all four gills or by the outer gills only; edge of marsupium always sharp and not distended; water tubes not divided in the gravid female; glochidium semi-elliptic or semicircular, without spines; shell generally heavy and solid, rounded to elongated, mostly with dull-colored epidermis; sculpture of the beak generally rather indistinct, concentric or pustulous or with indications of double loops or zigzag bars; hinge always complete, with rather strong teeth; generally no difference of sex shown in the shell" (Ortmann).

KEY TO GENERA OF UNIONINAE

1. a. All four gills serving as marsupia 2
- b. Outer gills only serving as marsupia 5
2. a. Male and female shells alike 3
- b. Male and female shells different*Tritogonia*
3. a. Surface plicate 4
- b. Surface pustulose*Quadrula*
- c. Surface smooth*Fusconaia*
4. a. Beaks sculptured with coarse, concentric or somewhat double-
 looped ridges, which do not extend over the surface...*Amblema*
- b. Beaks sculptured with strong, zig-zag ridges extending over
 the upper surface*Megalonaias*
5. a. Surface tuberculous 6
- b. Surface smooth 7

6. a. Nacre deep purple ----- *Cyclonaias*
 b. Nacre white or tinged with pink ----- *Plethobasus*
 7. a. Shell short, rounded, quadrate or oblique, beak sculpture
 coarse, inclined to be more or less double-looped --- *Pleurobema*
 b. Shell (usually) elongate and straight, beak sculpture run-
 ning parallel with the growth lines and angled on the
 posterior slope ----- *Elliptio*

Genus FUSCONAIA Simpson, 1900

Shell round, rhomboid, triangular or short elliptical, with a moderate posterior ridge; beaks high and full, curved inward and forward, sculpture with a few coarse, parallel ridges, which curve upward behind; epidermis dark; surface not sculptured; hinge plate of moderate width; pseudocardinals strong; nacre white, salmon or purple (Walker). TYPE: *Unio trigonus* Lea.

FUSCONAIA FLAVA (Rafinesque). Wabash Pig-Toe

Plate XXXIX, figures 6-9; plate XL, figure 7

Obliquaria flava RAF., Mon., p. 305, pl. lxxxi, figs. 13, 14, 1820.

Quadrula rubiginosa SIMPSON, Cat., p. 872, 1914.

Fusconaia flava ORTMANN, Mem. Carnegie Mus., VIII, p. 14, pl. ii, fig. 3, 1919.

Unio rubiginosus LEA, Trans. Amer. Phil. Soc., III, p. 427, pl. viii, fig. 10, 1829; Obs., I, p. 41, pl. viii, fig. 10, 1834.

Fusconaia flava ORTMANN and WALKER, Oc. Papers, U. of M., p. 5, 1922.

TYPE LOCALITY: *Flava*, small rivers (tributaries) of Kentucky, Salt River and Green River (Raf.); *rubiginosa*, Ohio.

WISCONSIN RECORDS:

1860. *Unio trigona* LAPHAM, p. 156, Milwaukee.

1885. *Unio rubiginosus* CALL, p. 47, Wisconsin.

1906. *Quadrula rubiginosa* CHADWICK, p. 96. Milwaukee River, Menomonee River, and Mud Creek, Milwaukee Co.; Two Rivers, Manitowoc Co.; Clear Water Lake, Oneida Co.

1922b. *Fusconaia rubiginosa* BAKER, p. 19, Fox River, Winnebago Co.

1924. *Fusconaia flava* BAKER, p. 133. Fox River, Omro.

1927d. *Fusconaia flava* BAKER, p. 107. Bark River, Dousman; Rock River, Ashippun to Ixonia; Crawfish River, Aztalan; Rock River, Jefferson to Fort Atkinson.

SHELL. Elongate-quadrate, thin to rather solid, inequipartite to equipartite, compressed to rather inflated; beaks not much elevated, somewhat inflated, turned forward, their sculpture of 3 to 5 subconcentric bars, forming an angle on the pos-

terior ridge; anterior end rounded, truncated above, meeting the dorsal line at a sharp angle; posterior end obliquely truncated; dorsal margin slightly curved or straight; basal margin straight, slightly curved, or with a slight emargination; posterior ridge conspicuous, roundly angled, with a more or less distinct depression in front, usually ending in a point at the basal margin; surface marked only by growth lines, usually rather rough and even raised to form slight ridges; epidermis brownish or reddish with a tinge of green, faintly rayed in juvenile and young shells, but dark uniform brown in old individuals, with a satin-like gloss.

Two pseudocardinals in left valve, almost parallel with hinge line, elevated, triangular, elongated, serrated; one large triangular, elevated pseudocardinal in right valve; laterals long, lamellar, elevated, inclined to double in right valve; interdentum slight, narrow, or absent; anterior scar deeply impressed, posterior scar well marked; beak cavities deep, broad; nacre whitish, frequently tinged with salmon, iridescent posteriorly.

L. 99; H. 64; D. 32 mm. 33%	Waukesha (Dudley, 405).
L. 81; H. 58; D. 46 mm. 56%	Wisconsin (U. of W. 1883).
L. 80; H. 52; D. 35 mm. 43%	Princeton (U. of W. 792)
L. 72; H. 53; D. 37 mm. 51%	Fort Atkinson (U. of W., 793).
L. 72; H. 50; D. 35 mm. 45%	Princeton (U. of W., 794).
L. 75; H. 62; D. 43 mm. 57%	Menomonee R. (U. of I., Z5438).
L. 68; H. 49; D. 25 mm. 36%	Wyocena (U. of W., 795).
L. 60; H. 46; D. 26 mm. 43%	Omro (U. of W., 796).
L. 48; H. 37; D. 23 mm. 48%	Omro (U. of W., 797).

ANIMAL: (Fig. 212). Supra-anal opening very large, separated from anal by a short mantle-connection (sometimes absent); anal and branchial siphons separated by short mantle-connection; branchial opening papillose, anal opening with small papillae; labial palpi subcalciform, connected on posterior margins for third to half of length; gills short, wide, the inner the larger; "outer gill attached at its anterior end at the highest point of the attachment line of the mantle, far above the palpi; inner gill with its anterior end slightly in front and below that of the outer gill, widely separated from the palpi; outer lamina of outer gills entirely connected with the mantle; inner lamina of inner gill free from the abdominal sac, except at its anterior end; behind the foot, the two inner laminae of the inner gills are connected up to their posterior end; thus a

complete gill diaphragm is formed, which reaches backward close to the posterior margin of the mantle" (Ortmann, 1912a, p. 242).

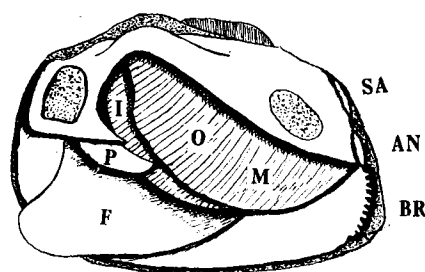


Fig. 212. Animal of *Fusconia flava*. Red Cedar River, near Chetek. Aug. 11, 1921.

Both gills possess well-developed septa and water-tubes, which are better developed, thicker, and generally longer in the female than in the male. All four gills are marsupial in function. The marsupia when filled with ovisacs do not become greatly distended, as in many other species. The ova are red in color and are contained in ovisacs forming placenta, which are subcylindrical in form and are discharged whole through the anal opening. The glochidia are small, suboval in shape, and hookless. They measure about 0.15 mm. in both height and length.

The color of the animal is striking, though variable. The gills are yellowish or brownish (orange-brown in the female when gravid), the mantle margin, the extremity of the foot, and the adductor muscles are deep orange or salmon. The rest of the animal is yellowish or light salmon.

BREEDING SEASON: Typically tachytictic, breeding from May to August. Ortmann suggests that in the case of single individuals it may be much shorter. Gravid females have been observed in Wisconsin in July and August.

HOST: Not at present known.

GENERAL DISTRIBUTION: *Flava* (as *rubiginosa*) has been recorded from western New York west to Kansas and Nebraska, and from the Red River of the North south to Kentucky and West Virginia. How much farther south the typical form may range appears uncertain.

DISTRIBUTION IN WISCONSIN: *Flava* is found in the tributaries of the Chippewa, Rock, and Wisconsin rivers. It is the only *Fusconaia* in the Fox River and also in the small streams emptying into Lake Michigan.

ECOLOGY: As noted by Ortmann and others, *flava* is characteristically a species of the smaller rivers and creeks. It prefers a bottom of fine hard gravel, but also occurs in sand. Its normal habitat, in Wisconsin, appears to be in quiet places just below riffles. Shells from small tributaries are usually more compressed than those from larger streams, which are more inclined to be quadrate. Wisconsin ecological preferences are as follows: Outlet of Green Lake, on sand bottom in water .3-.6m. deep; Moose Ear Creek, on sand and gravel bottom in riffles, water .3-.6m. deep; Red Cedar River, sand bottom, water .3m. deep, buried from sight in sand; Bark River, near Dousman, gravel bottom, .3m deep, considerable current.

REMARKS: *Flava* is a characteristic though variable species. It may be either compressed or quite inflated (compare figs. 3-5, pl. XXXIX); almost quadrate or markedly elongate-quadrate; thin or quite solid. But with all of this variation its general features are so characteristic as to readily separate it from any other Wisconsin mussel. In all its various forms it preserves a distinct squarish outline with strongly truncated posterior end, partly truncated anterior end, and almost parallel dorsal and ventral borders. The sides are also distinctly flattened or compressed and there is a more or less distinct depression in front of the posterior ridge.

Two other species may be confounded with it: *undata*, which (in Wisconsin) has more elevated umbones and a more triangular outline, the pseudocardinals are much more massive and the laterals are curved toward the base of the shell. Young individuals are more likely to be mistaken for *undata*, the shape of both often being greatly similar (compare fig. 9, pl. XXXIX with fig. 6, pl. XL). The juvenile forms of the two species are quite different, as may be seen by the following measurements: *flava*, 20 x 14 x 7 mm.; *undata*, 21.5 x 13 x 12.2 mm. *Undata* is much wider than *flava*. A form from the Menomonee River is strikingly like *undata* in outline but the texture of the shell and the form of the hinge is like *flava*. (pl. XL, fig. 7).

The second species is *Pleurobema coccineum*, which is in

some respects more like *flava* than *undata*. In this species the posterior ridge is reduced to a rounded swelling or may be totally wanting. The whole shell is, also, more roundly oblique, and the umbones are not as elevated. The pseudocardinals are more massive, less elevated, and lack the sharp serrations of the more acutely pyramidal pseudocardinals of *flava*. The laterals are strongly curved downward in *coccineum* while they are almost straight in *flava*.

There seems no doubt that this shell is the form called *flava* by Rafinesque, the figure and description, poor and inadequate as they are, clearly indicating this form of shell. Fig. 13 of Rafinesque is one of the best of that excentric author. A study of Lea's figure of *rubiginosa* (Obs. I, pl. viii, fig. 10) together with specimens from Illinois in the Hinkley collection of the University of Illinois, seem to indicate that *flava* and *rubiginosa* are not completely synonymous. The Ohio River shell is heavier, more rounded, not as flatly compressed in the middle of the valves, and the dorsal and ventral margins are not as parallel as in *flava*. Lea's figure shows a rather massive hinge with heavily sulcated pseudocardinals, quite divergent, and a wide interdentum. In typical *flava*, the pseudocardinals are not divergent but almost parallel with the hinge line and they are not as deeply sulcated, and the laterals are longer and more delicate. The interdentum is so narrow as to be almost lacking. *Rubiginosa* has the heavy hinge structure of *undata* and is closely related to that species, while *flava* differs from both of these forms. *Rubiginosa* is possibly the large river form of *flava* and might be included as a variety of that species. As far as my Kentucky material goes, the *flava* is like the small stream form in Wisconsin.

In Illinois, typical *flava* is common in the smaller streams while the more robust *rubiginosa* occurs in the larger streams. This seems another example of the law noted by Ortmann and others that a species increases in obesity and solidity toward the lower reaches of the rivers. Material from Salt Fork, a tributary of the Big Vermilion River in Illinois, are exactly like the specimens from Wisconsin. None of the *rubiginosa*-like shells have been noted among Wisconsin shells.

FUSCONAIA FLAVA PARVULA Grier. Little Pig-Toe

Plate XXXIX, figures 1-5

Fusconaia flava var. *parvula* GRIER, Nautilus, XXXII, p. 11, 1918;
Ann. Carnegie Mus., XII, p. 168, 1919.

Fusconaia flava parvula ORTMANN, Mem. Carnegie Mus., VIII, p. 21,
pl. ii, fig. 2, 1919.

TYPE LOCALITY: Lake Erie, Presque Isle Bay, Erie Co., Penn.

WISCONSIN RECORDS:

1922b. *Fusconaia rubiginosa parvula*, BAKER, p. 19. Winnebago Lake.

1924. *Fusconaia flava parvula* BAKER, p. 133. Winnebago Lake.

SHELL: Differing from *flava* in being smaller, more triangular, and wider in proportion to its length; hinge heavier and more like that of *undata*, the pseudocardinals divergent and heavily sulcated, with a rather wide interdentum; epidermis brownish or dark chestnut, the rest periods very distinctly marked; only faint rays are to be seen on Wisconsin specimens; some individuals are somewhat flattened or compressed, while others are inflated; old specimens are drawn out posteriorly and are somewhat oblique; some specimens have a faint pink nacre.

L. 60; H. 49; D. 34 mm. 56%	Brown Co. (U. of W., 151) ¹	Marston.
L. 55; H. 42; D. 29 mm. 53%	Brown Co. (U. of W., 148) ²	"
L. 55; H. 45; D. 30 mm. 30%	Lake Winnebago (U. of W., 799).	
L. 41; H. 34; D. 22 mm. 53%	"	(" 800).
L. 38; H. 31; D. 20 mm. 52%	"	(" 801).
L. 35; H. 33; D. 24 mm. 68%	"	(" 802).

ANIMAL: Similar to that of *flava*. Ortmann reports the glochidia as similar to those of *flava* and that gravid females were found from early to late July (24th). Winnebago Lake specimens collected on August 26 were not gravid.

ECOLOGY: In Lake Winnebago this mussel occurred on gravel and stone bottoms in water 2-3 m. deep.

GENERAL DISTRIBUTION: According to Ortmann (1919, p. 23) *parvula* is found in the western part of Lake Erie and in Winona Lake, Indiana. With the Wisconsin localities, a wide range is indicated, coincident, almost, with that of *flava*. It also occurs in Lake St. Clair (Smith).

¹ Trigona-like form.

² Flava-like form.

DISTRIBUTION IN WISCONSIN: *Parvula* has been found only in Lake Winnebago and in the lower part of Fox River in Brown Co.

REMARKS: *Parvula* is a lake form of *flava*, seeming to hold much the same relation to that species that *rosacea* and *canadensis* hold to *Lampsilis siliquioidea* and *ventricosa*. The form living in Lake Winnebago is similar to the Lake Erie form described by Grier and has probably been produced by the same circumstances of a lake environment. That the Lake Winnebago form is related to *flava* rather than to *undata* is indicated by the fact that *flava* is the only form living in the Fox River above Lake Winnebago. Yet the general form of the shell and the hinge structure are more like *undata* in some individuals, while in others the hinge and general form are more like *flava*. Typical *flava* is common at Omro and in other parts of the Fox River, about five miles above Lake Butte des Morts, which lies west of Lake Winnebago. The lake shells would seem to be migrants from Fox River, having adapted themselves to the changed conditions and produced the form called *parvula*—a physiographic or ecologic form.

In the lower part of the Fox River, in Brown County, this form occurs and is very variable, individuals resembling both *flava* and *undata*. It would seem that the lake form is here endeavoring to change again into the river form in response to physiographic agencies. Specimens in the Marston collection in the University of Wisconsin were labelled both *rubiginosa* (*flava*) and *trigona* (*undata*).

FUSCONAIA UNDATA (Barnes). Pig-Toe

Plate XL, figures 4-6

Unio undatus BARNES, Amer. Jour. Sci., VI, p. 121, pl. iv, fig. 4, 1823.

Unio undatus WALKER, Nautilus, XXIV, pp. 6-10, 16-24, pl. i, figs. 1-3, 1910.

Quadrula undata SIMPSON, Cat., p. 880, 1914.

Fusconaia undata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 6, 1922.

TYPE LOCALITY: Wisconsin and Fox Rivers (Barnes).

WISCONSIN RECORDS:

1823. *Unio undata* BARNES, p. 121. Wisconsin River.

1852. *Unio trigonus* and *undatus*, LAPHAM, p. 369. No locality.

1897. *Unio trigona* WISWALL, p. 47. Southern Wisconsin.

1906. *Quadrula trigona* CHADWICK, p. 96. Sugar River at Brodhead.

1910a. *Unio undatus* WALKER, p. 23. Wisconsin, Sauk Co.

1914. *Quadrula undata* SIMPSON, p. 880. Wisconsin and Fox Rivers.
 1919. *Fusconaia flava trigona* ORTMANN, p. 21. Wisconsin River, Sauk Co.
 1922. *Fusconaia undata* ORTMANN and WALKER, p. 6. Wisconsin and Fox Rivers.
 1927d. *Fusconaia undata* BAKER, p. 107. Rock River, Rock Co.

SHELL: More or less triangular, solid, inflated, nearly equi-partite; beaks high, swollen, turned forward, their sculpture of several ridges which turn up behind; there are several fine thread-like lines behind the ridges; anterior end rounded below, squarely truncated above where it meets the dorsal margin at a sharp angle; posterior end sharply, obliquely truncated; dorsal margin curved downward forming an angle at the posterior end; ventral margin rounded, more or less sinused at the posterior third; posterior ridge usually well-developed, forming a sharp angle near the umbones with a depression behind, and usually a broad depression in front; the widest and highest part of the shell is just in front of this depression where the base is rounded; surface marked only by growth lines, with sometimes a few radial striae on the anterior part; epidermis yellowish, greenish, or brownish, green in the young shell which is often distinctly rayed, dark brown or black in old shells.

Pseudocardinals wide, heavy, divergent, very ragged or serrated, the two in the left valve usually united to form an elevated, triangular, continuous ridge with a triangular depression or pit in front and below; one pseudocardinal in right valve, massive, triangular, strongly serrated, with a deep pit above and behind; laterals usually strongly directed toward the ventral margin, partly double in right valve, wide and thick; interdentum present but narrow; muscle scars deeply excavated or impressed and pallial line distinctly marked; beak cavities deep; nacre whitish frequently salmon-colored, especially on the ventral margin; iridescent posteriorly.

L. 92; H. 75; D. 53 mm. 61%	Kilbourn (U. of W., 803).
L. 68; H. 58; D. 41 mm. 69%	Sauk Co. (U. of I., Z5483).
L. 66; H. 51; D. 39 mm. 59%	" (" Z5483).
L. 62; H. 52; D. 38 mm. 61%	Kilbourn (U. of W., 804).
L. 65; H. 52; D. 40 mm. 64%	Osceola (U. of W., 805).
L. 48; H. 40; D. 31 mm. 64%	Sauk Co. (U. of I., Z5483).
L. 42; H. 35; D. 25 mm. 59%	Kilbourn (U. of W., 806).
L. 36; H. 29; D. 20 mm. 64%	" (" 807).
L. 23; H. 19; D. 13 mm. 56%	" (" 808).

ANIMAL: (Fig. 213). *Undata* agrees in all respects with *flava* in its general anatomical features. Color; mantle yellowish-white, openings edged with brown, foot salmon or pinkish, gills brownish or yellowish when not gravid. Gravid females have the gills rosy pink, the tubes being filled with rosy-colored eggs. Under a low power all four gills seem to be made up of red bands separated by white spaces. There are 44 septa in Wisconsin examples. Glochidia (pl. XXXI, fig. 2) similar to those of *flava*, measuring 0.15 by 0.16 mm., as recorded by Ortmann. Howard gives height 0.136 to 0.149 mm., length 0.136 to 0.153 mm.

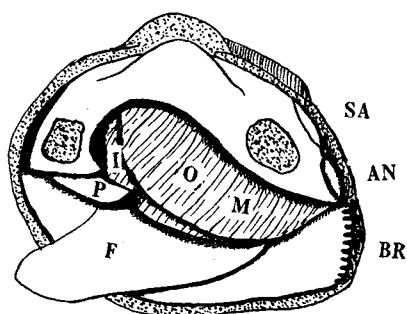


Fig. 213. Animal of *Fusconaia undata* (Barnes). Lower Dells of Wisconsin River, Kilbourn. Gravid female. July 22, 1922.

BREEDING SEASON: Tachytictic, June to September 10 (Howard, 1914a, p. 23). Gravid females both with eggs and glochidia were found during the entire month of July in the Wisconsin River at Kilbourn.

HOST: Not certainly known, but believed to be the sunfish (*Pomoxis annularis*) and black crappie (*Pomoxis sparoides*).

ECOLOGY: Inhabits the larger rivers where it lives on a mud bottom in rather deep water (1-2 m., Wisconsin River). Young and juvenile mussels are usually found on sand bars in gravel or coarse sand. Such were common below Kilbourn. At this locality, the river is very swift, the current often being as much as eight miles per hour during periods of high water.

GENERAL DISTRIBUTION: The general distribution includes Minnesota, east to southwestern New York and western Pennsylvania and south to Arkansas, Kentucky, Alabama, and

Louisiana. In Wisconsin, Illinois, and Indiana it is a most abundant species.

DISTRIBUTION IN WISCONSIN: *Undata* is confined to the Mississippi Drainage, including the large tributary streams Wisconsin and Rock. Its presence in the Fox River at Portage is entirely due to the Fox-Wisconsin canal through which the species has migrated into the deepened Fox River. A ditch was dug about 1766 to connect these streams, then about half a mile apart, and in 1849 the government canal was started and completed about 1851. *Undata* is confined to the vicinity of Portage, true *flava* being found exclusively above the canal and at some distance below the canal.

In the Wisconsin River, *undata* ascends to the vicinity of Kilbourn, but has not been seen from the river above the Upper Dells. In the lower part of Rock River it is common (Marston coll.) In the Mississippi it is replaced by another form which may be recognized as an ecological variety. Above Lake Pepin *undata* again appears and is said to extend well into Minnesota. Chadwick's reference from the Milwaukee River at Lindwurm is very doubtful. The single valve is an undoubted *trigona*, but no others have been found and the record is probably a case of mixed labels.

REMARKS: *Undata* is an abundant mollusk in the larger rivers of Wisconsin. Normally it is very distinct and easily distinguished by its heavy trigonal shell and high, swollen umbones, sharp posterior ridge with its radial depression in front, and by the peculiar rounded swelling of the margin in the antero-ventral region. It may be known from *flava* by its more massive shell and the characters noted above, and particularly by the shape of the pseudocardinals which are strongly divergent, widely triangular and deeply sulcated. The laterals are heavier and more sharply directed toward the ventral margin. The interdentum is also wider than in *flava*.

Large and old individuals of *flava parvula* resemble *undata* in the general shape of the shell, but the hinge teeth are not as heavy, and the posterior end is more elongated. Some of the shells, however, are strikingly like *undata* and if seen apart from the normal form, and without understanding the nature of the environment, might be referred to that species.

Undata also resembles *solida*, but that form has a less trigonal shell, the pseudocardinals are heavier, with a wider inter-

dentum, the posterior ridge, so sharply defined in *undata*, is rounded in *solida*, and there is (usually) a total absence of the median sulcus in front of the posterior ridge. *Solida* is also included in another genus (*Pleurobema*).

We cannot agree with Ortmann (1919, p. 19) in making *undata* a variety of *flava*. Some forms of *flava* somewhat resemble certain forms of *undata* but the hinge is different. There is in Wisconsin no evidence of intergrades between the two species, each inhabiting a different environment, *undata* the larger rivers and *flava* the smaller rivers and creeks. The index of 55% established by Ortmann will usually separate the two forms (though not always, *flava* sometimes exceeding this percentage). The mathematical method does not always work and cannot be invariably depended upon. Walker truly says, "The possibility that *trigonus* (*undata*) and *rubiginosus* can be specifically identical may consequently most emphatically be answered in the negative" (1910a, p. 21). With this statement the author is in full accord after examining a large collection from near the type localities of the forms involved.

. FUSCONAIA UNDATA TRIGONA (Lea)

Plate XLVIII, figures 5, 6

Unio trigonus LEA, Trans. Amer. Phil. Soc., IV, p. 110, pl. xvi, fig. 40, 1831; Obs., I, p. 120, pl. xvi, fig. 40, 1834.

Unio undatus and *trigonus* of authors generally.

TYPE LOCALITY: Ohio River, Cincinnati and Louisville.

WISCONSIN RECORDS:

1834. *Unio trigona* COOPER, p. 155. Prairie du Chien.

1905c. *Quadrula trigona* BAKER, p. 256. Prairie du Chien.

1926. *Fusconaia flava undata* GRIER and MUELLER, pp. 16, 32, etc. (part). Mississippi River below Lake Pepin.

SHELL: Differs from typical *undata* in being more trigonal, the diameter greater in comparison with the length, the posterior end shorter, not drawn out into a point, the umbones higher and the posterior ridge sharper.

L. 61.0; H. 59.0; D. 42.5 mm. Fairport, Iowa (U. of I., Z19681).

L. 62.0; H. 58.0; D. 38.5 mm. " "

L. 53.0; H. 52.5; D. 39.5 mm. " "

ANIMAL, BREEDING SEASON, etc.: Same as *undata*.

ECOLOGY: Inhabits the largest rivers, as the Ohio and Mississippi, on gravel, sand, and mud bottoms, in fairly deep water.

GENERAL DISTRIBUTION: This probably includes Wisconsin, Minnesota, Illinois and Ohio, as well as all the states bordering the Mississippi and Ohio rivers.

DISTRIBUTION IN WISCONSIN: Apparently confined to the Mississippi River below Lake Pepin; possibly inhabits the lower reaches of the Wisconsin River.

Mississippi Drainage: Prairie du Chien, Crawford Co. (Baker, Cooper) Mississippi River below Lake Pepin (Grier and Mueller).

REMARKS: Though Walker has shown that *trigona* is probably a synonym of *undata* (Walker, 1910a, p. 6) there are reasons for separating Lea's form as an ecological variety. Though the original figures are of little value in separating the two forms and the description of one will fit the other equally well, there are tangible differences in the two groups which are recognizable when the two habitats are considered. *Trigona* is another example of the law of stream distribution in which the species tends to become more inflated and shorter, the beaks higher and the whole shell smaller. *Undata* is the type of the species as it occurs in rivers of medium size, like the Wisconsin; *trigona* is the form of large rivers, like the Ohio and Mississippi. There are, of course, intermediate forms between the type localities, but this is to be expected. If one were to descend a river there would be every gradation between the forms of the upper part and those of the large lower part. As we cannot recognize all of the variations we can only formally christen the most obvious variations as they correlate with distinct ecological conditions. *Trigona* and *undata* are purely ecological variations but as such they should be recognized by separate designations.

FUSCONAIA UNDATA WAGNERI Nov. Var. Wagner's Pig-Toe

Plate XL, figures 1-3

Fusconaia undata GRIER, Amer. Mid. Nat., VIII, pp. 11-31, 1922 (part).

Fusconaia flava undata GRIER, Bull. Wagner Free Inst., I, p. 16, 1926 (part).

TYPE LOCALITY: Lake Pepin, near Lake City, Minn., collected by Professor Geo. Wagner.

WISCONSIN RECORDS:

1922a. *Fusconaia undata* GRIER, pp. 11-31. Pierce and Pepin Cos.

1922b. *Fusconaia undata* GRIER, p. 48. Lake Pepin.

1926. *Fusconaia flava undata* GRIER and MUELLER, pp. 16, 23. Lake Pepin.

SHELL: Differing from *trigona* in being more trigonal, usually very oblique, with higher umbones which are more conspicuously directed forward; a sharper posterior ridge and a deeper median sulcus; the lunule is usually larger and wider than in *trigona* or *undata*; the pseudocardinals are heavier and more deeply sulcated and the laterals are wider and more massive; the interdentum is wider; the umbones are very much nearer the anterior margin than in *trigona*.

L. 61.0; H. 59.0; D. 43.0 mm. 70% Lake Pepin (U. of W., 344b, type).

L. 58.0; H. 57.0; D. 44.0 mm. 76% " (" 344c, paratype).

L. 66.0; H. 58.0; D. 44.0 mm. 66% " (" 344d, paratype).

L. 60.0; H. 56.0; D. 42.0 mm. 70% " (U. of I., Z14016 paratype).

L. 53.0; H. 52.0; D. 39.0 mm. 73% " (" Z14017 paratype).

L. 51.0; H. 56.0; D. 43.0 mm. 84% " (" Z14018).

L. 65.0; H. 59.0; D. 43.0 mm. 66% Hudson (U. of W., 809).

L. 49.0; H. 52.0; D. 44.0 mm. 89% " (" 810).

ANIMAL: In all respects as in *trigona* and *undata*.

ECOLOGY: In water $\frac{1}{2}$ -3 m. deep, on gravel, sand, and mud bottom in a moderate to rapid current.

DISTRIBUTION IN WISCONSIN: As far as known this variety lives in Lake Pepin and in the Mississippi River immediately north of this lake-like expansion of the river, as well as in the St. Croix River.

Lake Pepin and vicinity (Bullock, Grier, Wagner); Hudson, St. Croix River, St. Croix Co. (Bullock).

REMARKS: The extreme forms of this variety of *trigona* are so different from the typical form as to give it almost specific distinctness. The chief features of differentiation have already been indicated. It can be confused with but one other form, *solida*, which lacks the posterior ridge and median sulcus, besides having more massive and differently shaped pseudocardinals and a very wide interdentum. It has been mistaken for *obliquum*, and certain individuals do in a general way resemble this species, but the resemblance is but superficial, true *obliquum* being quite a different species and not found in any part of Wisconsin. *Wagneri* marks the extreme limit of variation

of the *undata* group in the elevation of the umbones, the trigonal shape of the shell, and the great height as compared with length.

Grier (1926, p. 23) compares the Lake Pepin shells with his variety *parvula* from Lake Erie, but the writer can see no particular resemblance of this variety to the high-umboned, short and high *wagneri* from Lake Pepin. *Parvula* is a variant of the flatter *flava* while *wagneri* is a lake form of the large river type of *undata*, namely, *trigona*. Lake Pepin is not of the same character as Lake Erie or even Lake Winnebago, the latter being so large (30 by 10 miles) that it has the true characteristics of a lake, though in reality a widened out Fox River. Lake Pepin is a widened out large river, and is quite different from Lake Winnebago.

Wagneri extends up the St. Croix River as far as Hudson, St. Croix Co., where specimens are the same as the Lake Pepin form. A few miles farther up this river the form is true *undata*, not *trigona*, as might be expected.

FUSCONAIA EBENUS (Lea). Niggerhead

Plate XLI, figures 1-3

Unio ebenus LEA, Trans. Amer. Phil. Soc., IV, p. 84, pl. ix, fig. 14, 1831; Obs. I, p. 94, pl. ix, fig. 14, 1834.

Quadrula ebena SIMPSON, Cat., p. 897, 1914.

Fusconaia ebenus ORTMANN and WALKER, Oc. Papers, 112, p. 4, 1922.

TYPE LOCALITY: Ohio River (Lea)

WISCONSIN RECORDS:

1897. *Unio ebenus* WISWALL, p. 48. Southern Wisconsin.

1905c. *Quadrula ebena* BAKER, p. 256. Prairie du Chien.

1906. *Quadrula ebena* CHADWICK, p. 97. Between Prairie du Chien and De Soto.

1922a. *Fusconaia ebena* GRIER, pp. 11-31. Mississippi R., Pierce, Pepin, Buffalo Co.

1926. *Fusconaia ebenus* GRIER and MUELLER, p. 16. Lake Pepin and Mississippi River.

SHELL: Suborbicular to subelliptical, inflated, solid, decidedly inequipartite; anterior end usually squarely or obliquely truncated below the beaks; posterior end usually broadly rounded; ventral margin broadly rounded; dorsal margin evenly curved; posterior ridge not well developed, sometimes faintly double; beaks high, full, turned forward and inward over the

rather small lunule; sculpture a few feeble corrugations; surface with many concentric ridges indicating rest periods; epidermis reddish-brown to black, without rays.

Pseudocardinals massive, somewhat radial, the two in the left valve forming an inverted-V, joined above, which receives the large, ragged triangular tooth of the right valve, which seems to rise out of a deep pit; laterals curved, massive, wide, the larger one in the right valve usually double; interdentum very wide, smooth, flat; beak cavities deep, somewhat compressed; anterior muscle scar very deep, much roughened; nacre pearly white, iridescent posteriorly.

L. 95; H. 75; D. 58 mm.	Prairie du Chien (Dudley).
L. 76; H. 70; D. 46 mm.	Kilbourn (U. of W., 811).
L. 75; H. 68; D. 46 mm.	Wisconsin R. (U. of I., Z5536).
L. 65; H. 61; D. 43 mm.	Prairie du Chien (U. of W., 812).
L. 48; H. 47; D. 33 mm.	" " (" 813).
L. 52; H. 48; D. 32 mm.	" " (" 814).

ANIMAL: The animal of *ebenus* (pl. XXIX, fig. 1) is similar to that of *undata*; the anal opening has fine crenulations; the mantle connections separating the anal and supra-anal openings varies as in *undata*. The animal is dimorphic in color, one type having deep orange on the foot, adductor muscles, and mantle margin, the gills and other parts being brownish; in the other type the orange-colored organs are whitish or yellowish-white. The gonads are purplish or whitish in color.

The eggs are pink, causing the gills to appear of that color as in *undata* and *flava*. The glochidia are uncolored, suborbicular or subsemicircular as seen in side view. Height 0.148 to 0.15, length 0.153 to 0.16, (pl. XXXI, fig. 3). "The dimensions of this shell are so near those of *trigona* and *solida* that one is obliged to rely chiefly on the form to distinguish them (Howard, 1914a, p. 18).

BREEDING SEASON: Tachytictic, last of May to Sept. 3 (Howard, Surber).

HOST: The natural host of this species is the blue herring or Skipjack (*Pomolobus chrysochloris*), a fish inhabiting both salt and fresh water. Infection is heavy (1895 to 3740 in a single fish) and the number of infected fish is large (see Surber, 1913, p. 110; Howard, 1914, p. 18).

ECOLOGY: *Ebenus* is common in the large rivers where there is a rather swift current, on a mud bottom in rather deep water. In Lake Pepin it occurs on gravel, sand, and mud bottom in 1-3 m. or more of water. At Kilbourn it was found on a sandy-mud bottom in six ft. of water.

GENERAL DISTRIBUTION: Mississippi drainage generally; Alabama and Tombigbee rivers.

DISTRIBUTION IN WISCONSIN: *Ebenus* occurs in Wisconsin only in the Mississippi and Wisconsin rivers. In the former it ascends as far as Lake Pepin, where it is rare; in the Wisconsin it is found as far as Kilbourn, where it is rare.

REMARKS: *Ebenus* is one of the most abundant shells in parts of the Mississippi River. Among Wisconsin mollusks it is easily known by its almost circular shape and the high umbones which are placed near the anterior end and project over the lunule. In young shells the epidermis is yellowish on the umbones followed by bright green and brown. Young shells are more or less pyramidal in form, half-grown shells are almost circular, and old shells become quite oblique. Old specimens from the Mississippi River are relatively longer and of less height than those from the Wisconsin, Illinois, and Rock rivers, which are rounder (pl. LXI, fig. 1). In the Illinois River, at Havana, the shells are smaller and notably oblique. From the Rock River, near Lyndon, they are very large and roundly oblique.

Ebenus is one of the most valued shells to the button manufacturer and thousands of tons have been used for this industry. In some parts of the Mississippi River the niggerhead forms 80 per cent of the mussel beds. Its commercial value has made it the standard of comparison for all species as regards quality.

Genus MEGALONAIAS Utterback, 1915

Shell large, heavy, obovate or rhomboid, alate post-dorsally, disk obliquely folded; beaks sculptured with coarse, double-looped corrugations, which extend over the upper surface of the disk as nodulous plications; epidermis dark-brown or blackish; beak cavities narrow and deep; anterior muscle scars deep and filled with a nacreous deposit, posterior scars large and indistinct (Walker).

TYPE: *Unio heros* Say (*gigantea* Barnes).

MEGALONAIAS GIGANTEA (Barnes). Washboard

Plate XLVII, figures 3-4

Unio giganteus BARNES, Amer. Jour. Sci., VI, p. 119, 1823 (as variety of *U. crassus* (Say)).

Unio undulatus BARNES, Op. Cit., p. 120, pl. 2, fig. 2, 1823.

Unio heros SAY, New Harm. Dissem., II, No. 19, p. 291, 1829.

Unio multiplicatus LEA, Trans. Amer. Phil. Soc., IV, p. 70, pl. iv, fig. 2, 1831; Obs., I, p. 80, pl. iv, fig. 2, 1834.

Quadrula heros SIMPSON, Cat., p. 825, 1914.

Unio giganteus FRIERSON, Nautilus, XXX, p. 61, 1916.

Megaloniaias heros UTTERBACK, Naiades of Missouri, p. 43, 1916.

Megaloniaias gigantea ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 7, 1922.

TYPE LOCALITY: Mississippi River, Prairie du Chien (*gigantea*; Ohio (*undulatus*); Fox River, tributary of the Wabash, Ind. (*heros*); Tennessee and Ohio rivers (*multiplicatus*).

WISCONSIN RECORDS:

1823. *Unio giganteus* BARNES, p. 119. Prairie du Chien.

1905c. *Quadrula heros* BAKER, p. 255. Prairie du Chien.

1906. *Quadrula heros* CHADWICK, p. 96. Between Prairie du Chien and De Soto.

1916. *Unio giganteus* FRIERSON, p. 63. Prairie du Chien.

1922a. *Megaloniaias heros* GRIER, pp. 11-31. Pepin, Pierce, Buffalo Cos.

1922. *Megaloniaias gigantea* ORTMANN and WALKER, p. 7. Prairie du Chien.

1922. *Megaloniaias gigantea* GRIER and MUELLER, p. 48. Rare in Lake Pepin and more plentiful above than below it.

SHELL: Elongate-quadrate, very solid, heavy, inequipartite, moderately inflated; anterior end rounded, forming an angle with the nearly straight dorsal margin; posterior end slightly obliquely truncated, angled above; ventral margin usually slightly curved; posterior ridge rounded, merging more or less in the undulations or folds of the surface; beaks full, depressed, the sculpture consisting of heavy, double-looped ridges, which become nodulous on the posterior ridge; surface with several broad, rounded oblique undulations or folds confined to the posterior half of the shell; below the beaks the surface is heavily tuberculated, this condition extending well down on the side; young and immature individuals have the shell heavily covered with folds and nodules which are chevron-shaped on the anterior and central parts of the valve; the postero-dorsal end or wing is marked by several rounded folds, curved upward; in mature and old shells the ventral half or two-thirds of the sur-

ANIMAL: (Fig. 214). Supra-anal opening very large, separated from anal opening by a short mantle connection; branchial opening large, with few small, branched papillae; anal opening of good size with fine crenulations; gills large, long and wide, inner gill much wider than outer gill; the inner gill is usually free from the abdominal sac, but may also be connected for its entire length; labial palpi very large connected for nearly their whole length at their base; color for the most part flesh, the branchial opening edged with brown and yellowish.

The gills, all four of which are marsupial, are purplish and greatly swollen when gravid. "Ovisacs simple, undivided, some filled with rusty-brown mucus next to the laminae, thus giving the marsupium a spotted appearance; conglutinates shape of an insole, rather solid, usually discharged whole, edges with brownish-red pigment, rather thick, with no thin transparent portions." (Utterback 1916a, p. 44). There is no sexual difference in the shell.

Glochidia (p. XXXI, fig. 5): Large, hinge line long, almost straight, ventral margin obliquely rounded, no spines present. Height 0.316 to 0.340 mm., length 0.250 to 0.260 mm. The right valve contains a large and conspicuous thread gland; this is in the form of a spiral rod tapering at each end, and having about two turns about the adductor muscle. As compared with this gland in *Anodonta*, it is more conspicuous because of its greater width and its being possibly more highly reflective to light. The inconspicuous tapering extremities lie near the ventral side of the adductor muscle and one of them opens to the mantle cavity; from this opening the larval thread extends. The latter is of considerable length and lies coiled in the mantle chamber. It consists of a delicate hyaline thread which becomes readily extended when the glochidia are extruded from the gills (Howard, 1914a, p. 30).

BREEDING SEASON: Utterback says (1916a, p. 47) "gravid with ova of early embryos in fall and early winter, with late embryos and immature glochidia in midwinter, and with mature larvae in late winter, but barren from April to August. Ovulation has been observed for the latter part of August and unfertilized ova have been found in the ovaries on August 19." Howard records as follows the months in which this species was found carrying glochidia: Sept., Oct., Nov.

NATURAL HOST: Glochidia have been found on the following fish: Fins of gizzard shad (*Dorosoma cepedianum*) and white crappie (*Pomoxis annularis*); gills of white bass (*Roccus chrysops*), dog-fish (*Amia calva*), and mud-cat (*Leptops olivaris*). Infections were noted on the salamander (*Necturus maculosus*) but they were not encysted and it is believed that this mussel is incapable of development on this host. The most heavily infected fish was the gizzard shad. The productivity of this species is very large, a single individual carrying from 280,000 to 3,000,000 glochidia.

ECOLOGY: In the large rivers in deep water on a muddy bottom in quiet places. Sometimes found on a gravelly bottom. Young and adult occupying the same habitat.

GENERAL DISTRIBUTION: Simpson says, "Mississippi River system generally; Red River of the North; Tombigbee River, Alabama; southwest to Neo Leon, Mexico."

DISTRIBUTION IN WISCONSIN: In this State, *gigantea* has not been found outside of the Mississippi River, where it extends above Lake Pepin.

REMARKS: This large, heavy mussel is distinguished from all Wisconsin naiads by the pustulose character of the early shell growth in connection with its elongate-quadrate shape, this feature readily separating it from any *Amblema*. In young shells the interior of the valves is white and pearly, or tinged with pink or salmon, but in older shells the interior becomes dull and marked by blotches of brown. In very old shells the hinge teeth become very heavy and large and the anterior adductor muscle scar becomes deeply impressed and roughened.

Gigantea is an abundant species in the Mississippi where it is the largest and heaviest of river mussels, single individuals weighing as much as four pounds and measuring 11 inches in length. No such dimensions have been noted among Wisconsin specimens, the largest individuals having been noted among Illinois and Kentucky shells. In the button industry this shell is valued on account of its large size and good color, providing material for cutting the largest buttons.

Genus AMBLEMA Rafinesque, 1819

Shell more or less alate; beaks prominent, sculptured with coarse, concentric or somewhat double-looped ridges which do

not extend over the surface of the shell; surface of the valves usually sculptured with oblique folds; posterior slope generally having small radial plications, which curve upwards behind; epidermis brownish or blackish; anterior muscle scars large, distinct, the anterior edge smooth, the rest apparently filled with roughened shelly matter; posterior scars large, indistinct; escutcheon large and dark. Marsupium occupying all four gills (Walker).

TYPE: *Amblesma costata* Raf.

AMBLEMA PERUVIANA (Lamarck). Blue-Point

Plate XLI, figures 4-5

Unio peruviana LAMARCK, An. sans Vert., VI, p. 71, 1819.

Unio peruviana DESHAYES, Encyc. Méth., pl. 248, fig. 7; pl. 249, fig. 1, 1827.

Quadrula plicata SIMPSON (not Say), Cat., p. 814, 1914 (part).

Quadrula plicata of authors generally.

Amblesma peruviana ORTMANN and WALKER, Oc. Papers, 112, p. 13, 1922.

TYPE LOCALITY: Erroneously given as Peru.

WISCONSIN RECORDS:

1823. *Unio plicatus* BARNES, p. 120. Wisconsin.

1834. *Unio plicatus* COOPER, p. 155. Prairie du Chien.

1897. *Unio plicatus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Quadrula plicata* BAKER, p. 255. Prairie du Chien.

1906. *Quadrula plicata* CHADWICK, p. 95. Between Prairie du Chien and De Soto.

1914. *Quadrula plicata* WILSON and DANGLADE, p. 20. Lake Pepin.

1922a. *Amblesma peruviana* GRIER, pp. 11-31. Pierce, Pepin, and Buffalo Cos.

1922. *Amblesma peruviana* GRIER and MUELLER, p. 48. St. Croix drainage.

1926. *Amblesma peruviana* GRIER and MUELLER, p. 16. Lake Pepin and Mississippi River.

SHELL: subquadrate, inflated, solid, inequipartite; beaks elevated, inflated, turned forward, their sculpture of several irregular, heavy ridges somewhat nodulous on the posterior slope; posterior ridge rounded, not prominent, with a shallow depression above it; anterior end rounded; posterior end almost squarely truncated; ventral margin slightly rounded; dorsal margin almost straight, produced into a wing posteriorly; surface with several oblique folds or plications, usually parallel with the posterior ridge; plications usually absent from the

wing-like area above the ridge; growth lines coarse; epidermis light greenish with faint rays in the young shell, becoming brown or black in old specimens.

Two strong triangular, divergent, pseudocardinals in the left valve, very rough, sometimes split into radial sulci; a large triangular, radially sulcate pseudocardinal in the right valve, with a small triangular sulcated tooth in front; posteriorly the narrow interdentum is more or less heavily sulcated; two almost straight laterals in the left valve, one in the right, sometimes double posteriorly; beak cavities deep; anterior muscle scars deeply impressed, sulcate, the pallial line also impressed and sulcate anteriorly; nacre white, iridescent posteriorly; interior often marked with dark spots.

L. 95; H. 68; D. 56 mm. 59% Wisconsin River (U. of W., 195).

L. 77; H. 63; D. 45 mm. 53% Lake Pepin (U. of W., 717).

L. 90; H. 68; D. 49 mm. 54% Lake Pepin (U. of W., 718).

L. 29; H. 23; D. 17 mm. 59% Rock River (U. of W., 66).

ANIMAL: Similar to that of *Amblema rariplicata* in general anatomical features. Glochidia (pl. XXXI, fig. 4) semicircular, nearly as long as high, spineless, white in color. Thread gland and larval thread present. This is somewhat different from that of *Megaloniaias gigantea* and may be thus described: The turns or loops of the spiral are of about the same number, but a small portion of what may be designated the distal end, becomes abruptly two or three times broader than the remainder. This larger portion begins at the posterior end of the hinge line and on reaching the anterior side of the adductor muscle curves in close to its ventral and posterior side. The contents of this enlarged portion is the coiled hyaline thread secreted by the gland, in a less condensed state than at the time of its emergence from the external pore, which lies at the posterior side of the adductor muscle (Howard, 1914a, p. 26). The dimensions of the glochidium are, length, 0.195 to 0.215, mm. width, 0.185 to 0.200 mm.

BREEDING SEASON: June, July, August (tachytictic).

NATURAL HOST: White and black crappies (*Pomoxis annularis* and *sparoides*). Glochidia thought to be this species have been found on the sauger (*Stizostedion canadense*) and black bass (*Micropterus salmoides*). Observed during June, July, and August. Successfully artificially infected on the above

fish, as well as on some others (see Howard, 1914a, pp. 26, 27). Period of parasitism 8–11 days.

ECOLOGY: In the larger rivers, in rather deep water (1–8 m.) generally on a mud bottom. It thrives in a good current.

GENERAL DISTRIBUTION: Said by Simpson to range from upper Mississippi drainage south to the Tennessee and Arkansas rivers. This range also includes, probably, *rariplicata*. The northern records (Red River of the North; Saskatchewan River, etc.) are doubtful. Typical *peruviana* is known only from the Mississippi and its larger tributaries.

DISTRIBUTION IN WISCONSIN: *Peruviana* has been authentically reported only from the Mississippi River.

REMARKS: *Peruviana* may be known by its elevated, swollen umbones; this character is not variable to any degree in Wisconsin material. It is most liable to be confused with *rariplicata*, but the umbones of that species are more depressed and are not full as in *peruviana*. When observed from the inside of the valve, the umbones of *peruviana* extend above the lunule as a large globular swelling, while in *rariplicata* and *costata* the umbones are but slightly raised above the lunule as a flattened swelling. Viewed from the front the beaks of *peruviana* are incurved over a wide lunule giving the outline a distinct cordate shape, which is absent in both *costata* and *rariplicata*. The plications vary in size and number.

Ortmann (1912a, p. 246) has shown that the name *plicata* should be used for the plicate mussel found in Lake Erie (= *hippopaeus* Lea), and that the heavy shell usually called *plicata* should bear the name of *peruviana*.

Typical *peruviana* appears to be confined principally to the Mississippi River in Wisconsin and Illinois. Material from the smaller rivers in the State (Wisconsin, Rock) is referable to *rariplicata*. The same may be said of mussels from the Illinois, Kaskaskia, and Wabash rivers in Illinois. Shells from the Ohio River at Golconda are *rariplicata* and not *peruviana*.

Peruviana is the common plicate mussel of the Mississippi River and is largely used for button material. Many tons have been fished from this stream in Illinois, Iowa, and Wisconsin.

AMBLEMA RARIPLICATA (Lamarck). Blue-Point

Plate XLI, figure 6; plate XLII, figures 1-3

Unio rariplicata LAM., An. sans Vert., VI, p. 71, 1819; ed. 2, VI, p. 533, 1835.*Unio rariplicata* DESHAYES, Encyc. Méth., II, p. 578, 1830.*Quadrula plicata* SIMPSON, Cat., p. 814, 1914 (part).*Quadrula rariplicata* WALKER, Synopsis, p. 168, 1918.

TYPE LOCALITY: Ohio River (type preserved in Museum at Geneva, Switzerland (Walker)).

WISCONSIN RECORDS:

1823. *Unio plicatus* BARNES, p. 120 (part). Wisconsin.1838. *Unio plicatus* CONRAD, p. 116. Wisconsin.1852. *Plectomerus plicatus* LAPHAM, p. 369. Wisconsin.1960. *Unio plicatus* LAPHAM, p. 155. Rock and Wisconsin Rivers.1927d. *Amblesma rariplicata* BAKER, p. 107. Neosho mill pond, Rubicon River; Rock River, Ashippun to Rock Co.

SHELL: Quadrate to elongate-quadrate, thick, solid, moderately inflated; beaks slightly elevated, somewhat inflated, the sculpture as in *peruviana*; posterior ridge rounded; dorsal margin slightly curved; ventral margin more or less rounded; anterior end rounded; posterior end usually sharply truncated; surface with several rounded ridges or folds more or less oblique to the dorsal margin; usually no radial ridges on the posterior wing; epidermis brownish in young shells, black in old shells.

Two massive, divergent, radially sulcated pseudocardinals in the left valve; one large sulcated pseudocardinal in the right valve, with usually a sharp, erect, denticle in front of it; interdendum narrow; laterals as in *costata* but heavier; anterior muscle scar deeply sulcated and impressed; beak cavities rather deep; nacre white, iridescent posteriorly; edge of valves frequently edged with purple.

L. 162; H. 115; D. 64 mm. 39%	Kilbourn (U. of W., 819).
L. 130; H. 98; D. 58 mm. 44%	" (" 820).
L. 122; H. 95; D. 57 mm. 46%	" (" 821).
L. 110; H. 96; D. 61 mm. 55%	Aztalan (U. of W., 822).
L. 109; H. 78; D. 49 mm. 45%	Osceola (U. of W., 823).
L. 105; H. 78; D. 55 mm. 52%	" (" 824).
L. 89; H. 65; D. 44 mm. 49%	Sugar R. (U. of W., 95).
L. 46; H. 34; D. 20 mm. 42%	Kilbourn (U. of W., 825).

ANIMAL: (Fig. 215). Similar to *costata*. Supra-anal separated from anal by very short mantle connection. Anal

less than half as long as supra-anal. Color whitish, siphons and mantle edged with dark brown; gills brownish. Glochidia not seen. No gravid females seen, all specimens examined in July being sterile.

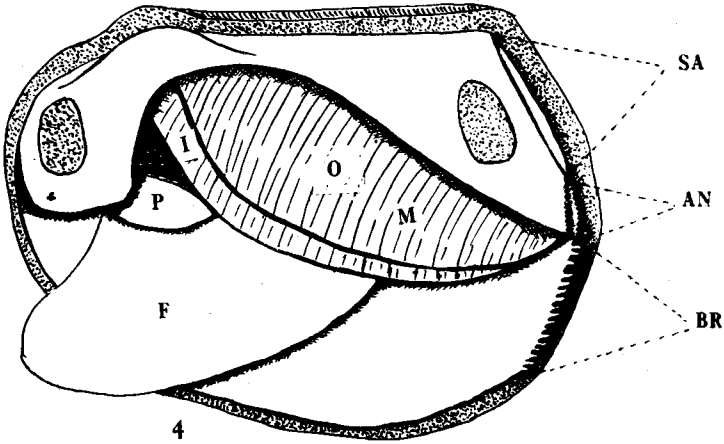


Fig. 215. *Amblema rariplicata* (Lam.). Lower Dells of the Wisconsin River, Kilbourn. Aug. 11, 1921.

NATURAL HOST: Unknown. Perhaps the same as for *peruviana*.

BREEDING SEASON: Probably same as in *peruviana* and *costata*.

ECOLOGY: In Wisconsin, *rariplicata* lives on a mud bottom, in water 1–2 m. deep, in swift current, 6–8 miles per hour; Rock River, in riffles.

GENERAL DISTRIBUTION: Not accurately known. It occurs in the Ohio River, as well as in the Illinois and Wabash rivers.

DISTRIBUTION IN WISCONSIN: *Rariplicata* occurs in the St. Croix river, the Wisconsin and the Rock river systems. No authentic specimens have been seen from other parts of the State.

St. Croix Drainage: Osceola, Polk Co. (Bullock); North of Grantsburg, Burnett Co. (Bullock).

Wisconsin Drainage: Prairie du Sac, Sauk Co. (U. of Wis.); Kilbourn, Columbia Co. (Baker); Baraboo River, Sauk Co. (Wiswall).

Rock Drainage: One mile west of Ashippun, Dodge Co.; Crawfish River, Aztalan; Lake Koshkonong, Jefferson Co. (Cahn); Aztalan, (Bullock, Cahn).

REMARKS: The Wisconsin plicate naiades naturally divide into three groups; one is the shell known as *peruviana*, with large inflated umbones; a second is the more compressed shell called *undulata* (= *costata*) with depressed umbones almost flush with the hinge line; a third type is perhaps midway between these two extremes and seems to be the *rariplicata* of Lamarck. Of this type of shell Walker says, "This species, which has been referred to *plicata*, Say, by Simpson and authors generally, is neither typical *peruviana* (Lam.) nor typical *plicata* (Say)" (Walker, 1918, p. 168). The Wisconsin shells seem related to *costata* and some specimens would be difficult to satisfactorily place if seen apart from typical examples.

Rariplicata has higher and more inflated beaks than *costata*, which are sometimes placed nearer the center of the dorsal margin, the beak cavities are deeper (they are more compressed in *costata*), and the surface is usually less plicate than in *costata*. It also has usually a greater diameter in comparison with the length. *Peruviana* has much more swollen umbones which are placed nearer the anterior end, and the shell is much wider.

This species bears a close relationship to Say's *plicata* of Lake Erie and that species is possibly a dwarfed lake variety of *rariplicata*. Walker (1918, p. 168) believes that it may be the *costata* of Rafinesque rather than the *undulata* of Barnes, as determined by Ortmann (1919, p. 28). *Rariplicata* is the common *plicata* of authors from the Ohio River. In their paper on the nomenclature of certain naiades, Ortmann and Walker (1922, p. 12) state that the *costata* of Rafinesque is the same as the *undulata* of authors, but there is reason, as stated by Walker in the earlier citation, to believe that it may be the same as the *rariplicata*. The figures of Rafinesque (figs. 13-14) indicate a shell with high umbones and not with depressed umbones as in the *undulata* of authors. The localities given by Rafinesque, Ohio River and small rivers of Kentucky, indicate that he included both the *undulata* and *rariplicata* types in his *costata*. The term "aplati" (flattened or compressed) might apply equally well to *rariplicata* as to *undulata* when compared with the wider *peruviana* of the Mississippi. The *undulata* type in Wisconsin is a small river form and is not found in the larger rivers. For example, it is common in the Fox River from Portage to Lake Butte des Morts, but is not found in the

Wisconsin River, north and west from Portage, the form found here being the *rariplicata*. As Rafinesque evidently included the form found in the smaller rivers and mentions the compressed shell, his name should be used for the *undulata* type, as indicated by Ortmann and Walker. The name *costata* should be restricted to the smaller river type which is abundant in Kentucky. This is typically a compressed shell with distinct costae on the postero-dorsal margin and the umbones are flattened and placed well forward.

The three plicate naiades, *peruviana*, *rariplicata*, and *costata*, appear to inhabit three ecological situations. The first inhabits the large Mississippi and its larger tributary streams (lower Wisconsin and Rock); *rariplicata* is the shell of moderate sized rivers and is found in the upper Wisconsin, St. Croix, and Rock rivers. *Costata* is the plicate form inhabiting the smaller rivers and is found in the Fox, Red Cedar, and other small streams.

Most of the mussels identified as *plicata* from Illinois are *rariplicata*. Shells from the Illinois, Kaskaskia, Ohio at Golconda, Spoon River, Wabash, and other streams in the Hinkley collection of the University of Illinois are *rariplicata*. *Costata* has been seen from the smaller streams, such as the upper parts of the Big Vermilion. *Peruviana* in Illinois has been seen only from the Mississippi River. In the upper part of the Rock River, near Ashippun, Dodge Co., the variation is toward *costata*, the umbones being flatter and the posterior flutings more numerous. In the lower part of Crawfish River and in the Rock River above Fort Atkinson and Jefferson there is an overlapping of the two species, good examples of both occurring.

Juvenile forms of the two species are quite different, as may be seen in the following measurements; small stream form, *costata*, from Salt Fork of the Big Vermilion River, Ill., 25 x 19.5 x 9 mm.; large stream form, *rariplicata*, from Little Wabash River, Wayne Co., Ind., 26 x 22 x 15 mm. The first has a ratio of 36% of width to length and the latter a ratio of 60%.

A study of all available specimens of this plicate group seems to point to the suggestion that they may be varieties of one type. *Plicata*, the lake type; *rariplicata*, the large river type; *costata* the small river type. If this be true we must write these three forms as follows:

Ambblema plicata (SAY). Lake Erie form.

Ambblema plicata rariplicata (LAMARCK). River form.

Ambblema plicata costata (RAFINESQUE). Small river and creek form.

AMBLEMA COSTATA Rafinesque. Three-Ridge

Plate XLIII, figures 1-5

Ambblema costata RAF., Ann. Gen. Sci. Phys. Brux., V, p. 315, pl. lxxxii, figs. 13, 14, 1820.

Quadrula undulata SIMPSON (not Barnes), Cat., p. 819, 1914.

Ambblema costata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 12, 1922.

Unio and *Quadrula undulata* of authors generally.

TYPE LOCALITY: Ohio River (rare); small rivers of Kentucky, common (Raf.).

WISCONSIN RECORDS:

1852. *Unio heros* JAY, Cat., p. 60. Fox River (?).

1897. *Unio undulatus* WISWALL, p. 47. Southern Wisconsin.

1906. *Quadrula undulata* CHADWICK, p. 96. Fox River, near Big Bend, Waukesha Co.; ancient shell heaps at Winneconne, Winnebago Co.; Two Rivers, Manitowoc Co.; Clear Water Lake, Oneida Co.

1911a. *Quadrula undulata* BAKER, p. 232. Wisconsin River, Oneida Co.

1924. *Ambblema costata* BAKER, p. 133. Omro, Fox River; L. Butte des Morts.

1917d. *Ambblema costata* BAKER, p. 107. Rock River, Jefferson to Ft. Atkinson.

SHELL: Elongate-quadrate, solid, inequipartite, subinflated to compressed; beaks depressed or but slightly elevated, not much inflated, the sculpture a few well-marked ridges; posterior ridge broad, rounded, not conspicuous; dorsal margin straight or slightly curved; basal margin broadly rounded to straight; anterior end rounded; posterior end rather sharply truncated, rounded into base posteriorly; surface with rounded ridges or folds parallel with the posterior ridge; there are usually a few small radial ridges on the posterior wing (or it may be smooth); frequently a few elongated pustules are present on the posterior half of the valve; epidermis greenish or yellowish-green in young shells, sometimes with slight indications of rays; in old shells the epidermis becomes dark brown or black.

Pseudocardinals, two in left valve, large, triangular, elevated, radially sulcated; one large triangular sulcated tooth in the right valve, with a small lamellar, divergent ridge in

front; a third subobsolete tooth may (rarely) be developed posteriorly: two long, almost straight laterals in left valve, one in right; interdentum narrow; anterior muscle scars deeply impressed, roughened by addition of shelly matter; posterior scars wide, distinct but not impressed; pallial line deeply impressed anteriorly; beak cavities compressed, deep; nacre white, iridescent posteriorly; dark brown blotches are frequently noted on the nacre of the shell; occasionally the entire valve or only the posterior margin may be dark purple, or it may be tinged with pinkish.

- L. 130; H. 87; D. 57 mm. 43% Blanchardville (U. of W., 827).
- L. 108; H. 77; D. 42 mm. 38% Jefferson (U. of W., 528).
- L. 123; H. 86; D. 55 mm. 44% Princeton (U. of W., 829).
- L. 104; H. 72; D. 44 mm. 42% Omro (U. of W., 830).
- L. 103; H. 63; D. 38 mm. 37% Omro (U. of W., 831).
- L. 88; H. 61; D. 43 mm. 48% Brown Co. (U. of W., 144).
- L. 87; H. 65; D. 40 mm. 47% Princeton (U. of W., 832).

ANIMAL: Anal and supra-anal openings separated by a very short mantle connection; branchial opening large, with heavy papillae; anal opening with fine crenulations or small papillae; labial palpi large, elongated, their posterior margins connected at the base or for one-third of the length; gills short, broad, the inner gill the wider, the inner lamina of the inner gills united to the abdominal sac only at the anterior end. Of the marsupial structures Ortmann says (1912a, p. 247): "Gills with well-developed septa and water-tubes, as usual. In the female, marsupial structure is observed in all four gills, the septa being better developed, with folded epithelium, closer together and the water-tubes being narrower. Yet in the outer gill the water-tubes are somewhat narrower than in the inner gill, which is chiefly noticeable at the base of the gills. In the gravid female, the gills swell moderately, so that the ovisacs assume a lanceolate, leaf-like shape, while the edges of the gills remain sharp and do not distend. Eggs whitish, filling the ovisac in rather poorly connected masses, although a placenta-like cohesion is seen. But later on this placenta structure is lost, and the glochidia are discharged in rather loose, irregular masses". Glochidia of suboval shape, without hooks. Length, 0.21; height, 0.22 mm. The animal is whitish in color, with the mantle margins, gills, and foot brown-

ish or yellowish-brown. There is no sexual difference in the shape of the shells.

BREEDING SEASON: Typically tachytictic, breeding from May to July.

NATURAL HOST: Not recorded.

ECOLOGY: A species of small rivers and tributaries of large rivers. Common on a sand or gravel bottom in comparatively shallow water (.3-1 m.). Also rarer on a mud bottom. Not very deeply buried in the bottom.

GENERAL DISTRIBUTION: Simpson gives Mississippi basin generally: St. Lawrence drainage; Red River of the North; Lake Winnipèg; Alabama River system. This distribution covers a wide area, but it is probable that in many places it has been confused with *rariplicata*. Its distribution in the south is imperfectly known.

DISTRIBUTION IN WISCONSIN: *Costata* is found in many small streams in the State. It is the only *Amblema* in the Fox River drainage. In the Wisconsin drainage it is found in the headwaters and in the Baraboo tributary. In the Rock River it is the first *Amblema* to appear, followed by *rariplicata* and *peruviana*. In the Sugar and Pecatonica rivers it is the only *Amblema*. The same may be said of the small streams flowing into Lake Michigan.

REMARKS: *Costata* is a variable shell in both form and sculpture. Its nearest relative is *Amblema rariplicata*, which is normally quite distinct, having more elevated and fuller umbones, a more inflated shell, and fewer and smoother plications. *Costata* varies from compressed to moderately inflated, from plicate to almost smooth, and the umbones from decidedly compressed and depressed to elevated and slightly swollen. When viewed from the anterior end the umbones are seen to be more depressed, almost flush with the hinge line, and not to have the forward, incurved direction seen in *rariplicata* and *peruviana*. The plications on the dorsal wing are usually larger and more conspicuous than in *rariplicata*, in which this area is usually smooth. However, there are specimens of true *costata* in which this area is quite as smooth as any *rariplicata* (see figs. 2, 3).

In some specimens the lower posterior portion of the shell is elongated and drawn out into a thin, rounded point and in these shells the umbones are placed nearer the anterior end (as

in fig. 3). Small pearl blisters are more or less common on the posterior end, usually between the pallial line and the lower margin of the valve. The *costata* from Wisconsin are less plicate and more inflated, on the whole, than the same species from the rivers of Illinois, the latter sometimes approaching *latecostata* Lea. Old individuals have the wide shell of *rariplata* but the umbones are small and flat as in the more compressed forms. The shell does not attain the dimensions in Wisconsin that it does in Illinois.

Amblema costata has been reported from Lake Pepin by both Grier (1922a, pp. 11–31) and Wilson and Dangle (1914, p. 20). Grier reports it as common, associated with *peruviana*. Later (1922, p. 48) he says common in Mississippi drainage generally. "Believed by Clark to be another tributary stream species". Efforts to obtain specimens of this *costata* from the Mississippi River have been unavailing none being in the collection of the Fairport Laboratory. Specimens sent have all been *peruviana*. Not even a specimen of *rariplata* was among them although this species occurs in the St. Croix River and is in the Bullock collection. The shells of *undulata* mentioned by Wilson and Dangle were taken from piles of shells of fishermen and were not personally collected. They might have come from the St. Croix River, if they were other than *peruviana*. It is not recorded in the 1926 paper of Grier and Mueller.

This species, long known under the familiar name of *undulata*, has been shown to be the *costata* of Rafinesque. The *undulata* of Barnes is synonymous with Say's *heros* (*giganteus*, which see).

Genus QUADRULA Rafinesque, 1820

Theliderma SWAINSON, 1840; *Theliderma* (Swainson) Simpson, 1900, 1914.

Quadrula AGASSIZ, 1852.

Shell triangular, quadrate or rhomboid; solid, inflated with rather coarse prominent beaks, which are generally sculptured with a few coarse, irregular, subparallel ridges that are inflated where they cross the posterior ridge; posterior ridge ordinarily well developed; disk sculptured or smooth; epidermis usually dull-colored, dark and rayless or feebly rayed; hinge plate heavy, wide, flattened; pseudocardinals solid, direct, ragged;

laterals double in the left and single in the right valve; cavity of the beaks deep and compressed. Marsupium occupying all four of the gills throughout, the whole smooth and pad-like (Walker).

TYPE: *Obliquaria (Quadrula) quadrula* Rafinesque.

KEY TO SECTIONS OF QUADRULA

Posterior slope with a radial furrow above the posterior ridge-----*Orthonymus*
 -----*Quadrula*
 No radial furrow above posterior ridge -----

Section QUADRULA sensu stricto

Shell rounded, quadrate to rhomboid, solid, pustulous; beaks rather prominent, sculpture consisting of a few rather coarse, subparallel ridges, anterior end rounded, base often arcuate, posterior end truncate, high and angled behind the ligament; epidermis rarely rayed, never as in *Orthonymus*. Type: *Quadrula quadrula* Rafinesque.

QUADRULA QUADRULA Raf. Maple-Leaf

Plate XLVI, figure 4; Plate XLVIII, figures 2-4

Obliquaria (Quadrula) quadrula RAF., Ann. Gen. Sci., Brux., V, p. 307, 1820.

Unio lachrymosus LEA, Trans. Amer. Phil. Soc., III, p. 272, pl. vi, fig. 8, 1828; Obs., I, p. 14, pl. vi, fig. 8, 1834 (young shell).

Unio asperrimus LEA, Trans. Amer. Phil. Soc., IV, p. 71, pl. v, fig. 3, 1831; Obs., I, p. 81, pl. v, fig. 3, 1834 (very old shell).

Quadrula lachrymosa SIMPSON, Cat., p. 841, 1914.

Quadrula quadrula ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 16, 1922.

Unio rugosus BARNES, Amer. Jour. Sci., VI, p. 126, pl. 8, fig. 9, 1823.

TYPE LOCALITY: Ohio River for all names cited.

WISCONSIN REFERENCES:

1905c. *Quadrula lachrymosa* BAKER, p. 255. Prairie du Chien.

1922a. *Quadrula quadrula* GRIER, pp. 11-31. Pierce, Pepin, Buffalo Co.

SHELL: Somewhat quadrate in outline, more or less compressed, inequipartite, solid; beaks elevated, moderately inflated, the sculpture consisting of double-loops or zigzag bars with radiating threads behind them; posterior ridge usually well developed, sometimes double toward the lower part of the shell, causing a slight biangulation at the posterior end; ante-

rior end rounded; posterior end usually sharply truncated; basal margin with a wide sinus in the middle causing the ventral border to be arcuate; there is a central depression in front of the posterior ridge which separates the valve into two parts, ending at the central sulcus; sculpture consisting of lachrymous or elongated tubercles arranged in three series, one on a swelling in front of the median sulcus (a continuation of the anterior loop of beak sculpture), one on the umbonal ridge, and the third on the dorsal margin of the posterior wing, near the ligament, more or less radial; the tubercles near the umbones are small, rounded or elongated and somewhat crowded; lower down on the valve the pustules become elongated with the lines of growth; the surface varies from almost smooth to decidedly pustulous on the areas indicated; in old shells the lower margin may be free from pustules; epidermis yellowish-green in the young and immature individuals, often very feebly rayed; in old specimens it is brownish or black.

Two pseudocardinals in left valve, roughly triangular, frequently joined above, sulcated and roughened; a single large pseudocardinal in right valve, triangular, sulcated, with a small denticle near the lunule and another behind on the interdentum, which is fairly wide and flat in most specimens; laterals rather long, slightly curved, that in the right valve frequently double; anterior muscle scars deeply impressed, posterior scars distinct; beak cavities deep, compressed; nacre white, more or less pearly.

L. 71; H. 63; D. 38 mm. 53%	Lake Pepin (U. of W., 343).
L. 80; H. 69; D. 44 mm. 55%	Ohio R., Ill. (U. of I., Z5341).
L. 53; H. 47; D. 33 mm. 62%	" " (U. of I., ").
L. 88; H. 69; D. 45 mm. 51%	Lake Pepin (U. of I., Z18029).
L. 84; H. 73; D. 51 mm. 60%	" (U. of I., Z18028).

ANIMAL: Supra-anal opening very large, the mantle-connection between it and the anal opening very short; branchial opening large with branched papillae, anal opening small, its inner edge slightly and irregularly crenulated, in places smooth; palpi long, the posterior margins connected for half to two-thirds their length; inner lamina of inner gills free from the abdominal sac; the gills are long and somewhat narrow, the inner somewhat larger; all four gills used as marsupia. The general color of the animal is pearly-white tinged with flesh.

Glochidia (pl. XXXI, fig. 8), not fully matured, were semi-

elliptical in shape, the ventral margin rounded, hinge line rather short, usually depressed, but sometimes straight. Measurements: height 0.085, length 0.078 mm. The glochidia are the smallest of the *Quadrula* group (Surber, 1915, p. 8).

BREEDING SEASON: May to August (tachytictic). Eggs were observed the middle of June; they were white in color and occupied all four gills. Early embryos of this species were found in four out of five specimens examined June 27. According to the observations, mature glochidia would be found during July in this region. Mature glochidia were obtained in August, 1912, from a tributary of Fall River, Glenwood Co., Kans., and also June 12, 1913, at Fairport, Iowa (Howard, 1914a, p. 16).

NATURAL HOST: Not recorded.

GENERAL DISTRIBUTION: Entire Mississippi River drainage; various localities in the St. Lawrence basin; Red River of the North; southwest into eastern Texas (Simpson). Some of this distribution may include recognizable varieties.

DISTRIBUTION IN WISCONSIN: Typical *quadrula* has been found only in the Mississippi River where it extends northward into Minnesota.

Prairie du Chien, Crawford Co. (Baker); Lake Pepin (Wagner); Pierce, Pepin, and Buffalo Cos. (Grier). Upper Mississippi (U. S. Bu. Fish.).

ECOLOGY: *Quadrula* occurs on a mud or sand bottom in fairly deep water.

REMARKS: Typical *quadrula* can be confused with but one other naiad, *fragosa*. It is less quadrate than that species, is more compressed and the umbones are not as inflated. Viewed anteriorly the beaks of *fragosa* are elevated and turned forward over the wide lunule, a feature absent in *quadrula* which, as a rule, has flatter, more compressed umbones. The postero-dorsal margin in *fragosa* is more compressed or alate than in *quadrula*. The immature shells of the two species are rather widely different, *fragosa* having a higher, shorter, and wider shell than *quadrula*. This feature is well shown in the following measurements: *fragosa*, Wisconsin river, length 36, height 36, diameter 22.5 mm.; *quadrula*, Posey Co., Ind., length 35, height 30, diameter 18.5 mm. (see pl. XLVIII, figs. 1-2).

Typical *quadrula* is not widely distributed in Wisconsin and appears to be confined to the Mississippi River. Its absence

from collections made in other parts of the state is noteworthy. A more compressed form is found in the Fox River, but no form of the species has as yet been found in the Rock River or its tributaries in Wisconsin. In Illinois and Indiana the typical form is common, the small-stream form being somewhat compressed, becoming wider and higher in the larger parts of the streams, as at New Harmony, Indiana, and in the lower Ohio, and in the Mississippi, especially in Lake Pepin, assuming a form resembling *fragosa*, for which it has been at times taken. (pl. XLVI, fig. 4).

QUADRULA QUADRULA BULLOCKI Nov. Var. Bullock's Maple-Leaf
Plate XLVI, figures 1-3

TYPE LOCALITY: Fox River near DePere, Wisconsin (Marston coll.).

WISCONSIN REFERENCES:

1924. *Quadrula quadrula* BAKER, p. 133. Omro, Fox River.

SHELL: Differing from *quadrula* in being more elongated and compressed with a deep ventral sulcus and a wider median depression, ending posteriorly in a wider biangulation; posterior ridge wider and more elevated; tubercles few or absent; dorsal marginal and lateral teeth not as much curved; pseudocardinals less massive and interdentum narrower.

L. 78; H. 57; D. 33 mm. 42% De Pere. Paratype (U. of W., 166).

L. 73; H. 55; D. 35 mm. 45% De Pere. Type (U. of W., 163).

L. 70; H. 51; D. 28 mm. 40% Omro (U. of W., 836).

L. 49; H. 39; D. 22 mm. 45% " (" 837).

L. 66; H. 50; D. 34 mm. 51% De Pere. Paratype (U. of W., 167).

ANIMAL: As in *quadrula*. Glochidia: Not examined.

NATURAL HOST: Not known. Possibly same as *quadrula*.

GENERAL DISTRIBUTION: Uncertainly known. Typical examples of the variety have not been seen outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: Apparently confined to the Fox River Drainage. Omro, Winnebago Co. (Baker, Bullock); DePere, Brown Co. (Marston).

ECOLOGY: In small rivers and streams on a mud or sand bottom in shallow water.

REMARKS: *Bullocki* differs from *quadrula* in being more elongated and compressed, and usually less pustulous, and with more depressed umbones. It appears to be the form of small

ivers and streams while *quadrula* is confined to the larger rivers. It appears to bear the same relation to *quadrula* that *prasina* bears to *pustulosa*. It is a common mussel in the Fox River drainage and does not show much variation toward the more quadrate and inflated form called *quadrula*. The name chosen for this variety is that of a Wisconsin gentleman who has done much to work out the distribution of the mollusks of the State by his careful data attached to a representative collection of State mollusks.

Lea's *asperrimus* was thought at first to be the same as this elongated form, his figure indicating an elongated shell with few tubercles. However, this shell is from the large Ohio River and appears to be a large, old specimen of the more quadrate form. Similar forms are frequent among any series of *quadrula* and have been seen in several collections from Illinois streams (Big Muddy and Kaskaskia rivers, Hinkley collection). *Bullocki* appears to be a true ecological or physiographic variety. A form with compressed shell and with few tubercles occurs in Lake Erie (vide Sterki and Ortmann).

QUADRULA FRAGOSA (Conrad). Hickory Nut Shell

Plate XLVI, figures 5, 6; Plate XLVII, figure 1; Plate XLVIII, figure 1

Unio fragosus CONRAD, Monog., II, p. 12, pl. vi, fig. 2, 1836.

Quadrula fragosa SIMPSON, Cat., p. 843, 1914.

TYPE LOCALITY: Scioto River, Ohio (Conrad).

WISCONSIN RECORDS:

1897. *Unio fragosus* WISWALL, p. 47. Southern Wisconsin.

1906. *Quadrula fragosa* CHADWICK, p. 96. Wisconsin River.

SHELL: Differing from *quadrula* in being more inflated, roundly quadrate in outline, the umbones more elevated and distinctly turned forward over the lunule above which they are distinctly raised; this feature is not as apparent in *quadrula*; the anterior swelling of the umbonal slope is also usually more pustulose; the postero-dorsal area is wider and more alate than in *quadrula*.

L. 102; H. 84; D. 53 mm. 52%	Kilbourn (U. of W., 838).
L. 94; H. 83; D. 50 mm. 53%	Wisconsin River (U. of I., Z5338).
L. 88; H. 80; D. 44 mm. 50%	Wisconsin River (U. of W., 206).
L. 74; H. 70; D. 45 mm. 60%	Kilbourn (U. of I., Z5338).
L. 55; H. 47; D. 37 mm. 67%	Kilbourn (U. of W., 840).
L. 60; H. 53; D. 38 mm. 63%	Wisconsin River (U. of W., 15).

ANIMAL: Similar to that of *quadrula*.

BREEDING SEASON: Not stated, but probably same as *quadrula*. No gravid specimens have been seen. Glochidia not described.

NATURAL HOST: Not recorded.

ECOLOGY: In the larger rivers on a mud bottom in water 2 m. or more in depth.

GENERAL DISTRIBUTION: Simpson gives the distribution as follows: Ohio, Cumberland, and Tennessee river systems; westward probably to Minnesota, Nebraska, and Kansas. It is quoted in state lists from Illinois (Baker, 1906b); Ohio (Sterki, 1907); Indiana (Call, 1900); Kansas (Scammon, 1906); and Missouri (Utterback, 1916a).

DISTRIBUTION IN WISCONSIN: In this state, *fragosa* appears to be confined to the Wisconsin River drainage.

Wisconsin River (Marston, Hinkley); Kilbourn, Columbia Co. (Baker); Baraboo River, Sauk Co. (Wiswall).

REMARKS: *Fragosa* is likely to be confused with but one other form, namely *quadrula* (= *lachrymosa*), the differential characteristics of which have been given above. There is some degree of variation as would be expected in a closely related species, the pustules being fewer in number and less conspicuous in older individuals. There is also some variation in shape. Old shells become elongated with a very rough surface and few pustules. The material from Kilbourn corresponds closely with Conrad's figure and may be considered typical.

A study of the *quadrula-fragosa* groups indicates that, while the two forms are closely related, they should be regarded as species and not variations of one type. Conrad's shell is always distinguishable from *quadrula*, the juvenile and immature shells being quite unlike as noted on a previous page. Shells from Mississippi, especially in Lake Pepin, simulate *fragosa*, but the young are of the *quadrula* type and the adult shells are more elongated. Among specimens from the lower Wabash River, near New Harmony, Indiana, there occur individuals with wide shells which approach *fragosa*, but these are variants of the true *quadrula* type. *Fragosa* appears rare in Wisconsin and Illinois, the Wisconsin River being the only locality in Wisconsin. The nearest approach in Illinois is found among specimens from Spoon River. When eliminated

from the swollen varieties of *quadrula*, *fragosa* appears to be a characteristic species, quite distinct from the more abundant *quadrula*.

QUADRULA PUSTULOSA (Lea). Pimple-Back

Plate XLIV, figures 1-6

Unio pustulosus LEA, Trans. Amer. Phil. Soc., IV, p. 76, pl. vii, fig. 7, 1831; Obs., I, p. 86, pl. vii, fig. 7, 1834.

Quadrula pustulosus SIMPSON, Cat., p. 848, 1914.

Unio dorfeuillianus LEA, Trans. Amer. Phil. Soc., VI, p. 73, pl. xvii, fig. 54, 1838; Obs., II, p. 73, pl. xvii, fig. 54, 1838.

Quadrula pustulosa ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 15, 1922.

TYPE LOCALITY: Ohio for both names.

WISCONSIN RECORDS:

1852. *Unio bullatus* LAPHAM, p. 369. No locality.

1860. *Unio pustulosus* LAPHAM, p. 155. Rock and Wisconsin rivers.

1897. *Unio pustulosus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Quadrula pustulosa* BAKER, p. 255. Prairie du Chien.

1906. *Quadrula pustulosa* CHADWICK, p. 96. Between Prairie du Chien and De Soto.

1911. *Quadrula pustulosa* WILSON and DANGLADE, p. 20. Lake Pepin.

1922a. *Quadrula pustulosa* GRIER, pp. 11-31. Pierce, Pepin, Buffalo Co.

1927d. *Quadrula pustulosa* BAKER, p. 107. Rock River, Ashippun to Rock Co.

SHELL: subquadrate, subrhomboid or suborbicular, more or less inflated, solid, inequipartite; beaks high, swollen, turned forward, sculptured with three or four coarse ridges; lunule broad, deep; anterior end rounded; posterior end sharply truncated; basal margin straight or slightly rounded; dorsal margin rounded; posterior ridge rounded but usually conspicuous in the typical form; posterior two-thirds of surface more or less covered with lachrymose or rounded tubercles, rarely entirely smooth; a few radial ridges or tubercles on the posterior wing; epidermis brownish or yellowish-green in young shells, usually with a broad, broken green ray extending from umbones toward base of shell; old shells are dark brownish or black.

Two pseudocardinals in left valve, divergent, sharply pyramidal in section, elongated, roughened, almost meeting above to form an inverted V; in right valve one large, broadly triangular pseudocardinal, sulcated, with a small denticle anteriorly and posteriorly; interdentum rather broad and flat; lat-

erals straight, heavy, short, slightly sulcated; muscle scars excavated anteriorly, distinct posteriorly; beak cavities deep, somewhat compressed; nacre white, more or less iridescent, often blotched on different parts of the valve.

L. 89; H. 81; D. 50 mm. 56%	Kilbourn (U. of W., 839).
L. 77; H. 70; D. 46 mm. 59%	Prairie du Chien (U. of W., 841).
L. 76; H. 61; D. 43 mm. 56%	Fort Atkinson (U. of W., 842).
L. 63; H. 63; D. 46 mm. 73%	Fox River (U. of W., 8).
L. 46; H. 46; D. 28 mm. 61%	Wisconsin R. (U. of W., 60).
L. 23; H. 19; D. 12 mm. 52%	Kilbourn (U. of W., 843).
L. 16; H. 13; D. 8 mm. 50%	" (" 844).

ANIMAL: (Fig. 216). Anal and supra-anal opening separated by a short mantle connection, which is uniformly present; branchial opening large with small blackish papillae; anal opening small without papillae, but with crenulations; palpi short, wide, ovate, the basal margins connected for a third of their length; gills rather broad, length varying with length of shell, inner gill larger; inner lamina of inner gills attached to

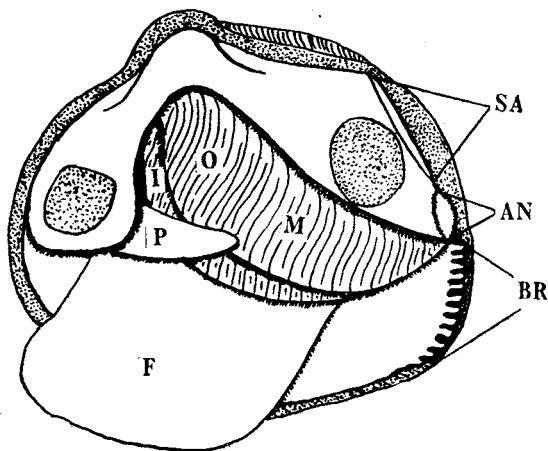


Fig. 216. *Quadrula pustulosa* (Lea). Gravid female, Lower Dells, Wisconsin River, Kilbourn. July 24, 1922.

abdominal sac only at anterior end; septa of gills well developed. All four gills in female used as marsupia, the septa close together and the water-tubes narrow; in the inner gill the septa are somewhat less crowded near the base. Color, mantle yellowish-brown, somewhat salmon-tinted, edged with black; foot

whitish, tinged yellowish or salmon. No sexual difference in form of shell.

Glochidia (pl. XXXI, fig. 6) of hookless type, rather purse-shaped. Dimensions: Length 0.23, height 0.32 mm. (Lefevre & Curtis, 1910, p. 97); L. 0.23, H., 0.29 mm. (Surber, 1912, p. 9); L. 0.22 to 0.23 mm, H. 0.28 to 0.30 mm. (Howard, 1914a, p. 9). There is frequently some growth beyond the embryonic shell before the cyst is broken

BREEDING SEASON: Tachytictic. Gravid from June 12 to Aug. 23 (Howard, 1912, p. 9); May 19 to July 19 (Ortmann, 1919, p. 35).

NATURAL HOST: Channel Cat (*Ictalurus punctatus*) on gill filaments.

GENERAL DISTRIBUTION: Simpson gives entire Mississippi drainage; Michigan; Lake Erie. It is widely distributed.

DISTRIBUTION IN WISCONSIN: Typical *pustulosa* is confined in the State to the larger rivers, Mississippi, Wisconsin, Rock. At Portage it has migrated into the Fox River through the government canal. In the smaller part of Fox River and in the smaller streams it is represented by the variety *prasina*.

ECOLOGY: This species occurs in rivers and large streams, in water from .3 to 3 m. or more in depth, and on sand, gravel, and mud bottom. In the Wisconsin at Kilbourn it is found on a mud bottom in 1-2 m. of water, in a swift current. Young shells are usually found on gravel bars in shallow water.

REMARKS: This common naiad may easily be distinguished by its suborbicular shell, prominent beaks, and pustulose surface. The material from Wisconsin divides into two groups, one the somewhat orbicular typical form and the other a more compressed, quadrate form which is referred to Conrad's *prasina*. In the typical form the surface varies greatly in ornamentation, from smooth to very pustulose, the pustules being rounded or elongated in the direction of the lines of growth. Sometimes a specimen occurs (as from Ft. Atkinson, pl. XLIV, fig. 4) in which the earlier half of the valve is pustulose and the later part is marked only by lines of growth. The growth lines are often accentuated at the rest periods into slight ridges. The height and shape of the beaks varies somewhat from depressed to quite elevated.

The form called *dorfeuillianus* by Lea (pl. XLIV, fig. 1) can-

not be separated from typical *pustulosa* (fig. 5) in a large series. Young shells are marked by a broad dark green stripe across the center of the shell. *Pustulosa* is a valuable shell for the button manufacturers and is largely fished by the mussel fishermen.

Pustulosa responds to the river law of variation as has been noted in the other species described. The small stream form, *prasina*, is reasonably distinct and easily determined. There is less difference between the medium sized and large river forms, however, and it does not seem possible to separate the form of the Mississippi and Ohio rivers from that of the medium sized rivers, as the Wisconsin, Illinois, and Wabash. The Mississippi River type (pl. XLIV, fig. 5) is usually smaller, has a greater diameter in comparison with its length, and the umbones are larger and somewhat more elevated. The variation is not as striking, however, as in the case of the other species mentioned. In the Rock River, Dodge County, Wisconsin, the *pustulosa* are the largest seen and combine characteristics of both small and medium sized streams, being much elongated and varying in the degree of pustulosity. In the lower part of the Rock River, in Illinois, the variation is between the medium sized and the large river form, much pustulose and round, with elevated umbones.

QUADRULA PUSTULOSA PRASINA (Conrad). Flat Pimple-Back

Plate XLV, figures 3, 5-8

Unio prasinus CONRAD, New Fresh Water Shells, p. 44, pl. iii, fig., 1834 (May); Monog., IX, p. 79, pl. xlv, fig. 2, 1837.

Unio schoolcraftensis LEA, Trans. Amer. Phil. Soc., V, p. 37, pl. iii, fig. 9, 1834 (September); Obs., I, p. 149, pl. iii, fig. 9, 1834.

Quadrula pustulosa var. *schoolcraftensis* SIMPSON, Cat., p. 850, 1914.

Quadrula pustulosa prasina ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 16, 1922.

TYPE LOCALITY: Fox River at Green Bay (Conrad).

WISCONSIN RECORDS:

1834. *Unio prasinus* CONRAD, p. 44. Fox River of Green Bay.

1837. *Unio prasinus* CONRAD, p. 79. Fox River.

1834. *Unio schoolcraftensis* LEA, p. 37; (Obs., p. 149). Green Bay.

1852. *Unio prasinus* LAPHAM, p. 169. No locality.

1845. *Unio schoolcraftensis* WHEATLEY, p. 12. Fox River.

1860. *Unio schoolcraftensis* LAPHAM, p. 155. Fox River.

1885. *Unio schoolcrafti* CALL, p. 48. Wisconsin.

1906. *Quadrula pustulosa* CHADWICK, p. 96. Ancient shell heaps at Winneconne.

SHELL: More quadrate and compressed than the typical form, the umbones less full, more depressed; posterior two-thirds of surface varying from smooth (rarely) to densely pustulose; the posterior ridge is usually well developed and behind this the shell is produced into a compressed wing; the pustules are often very large and elongated in the direction of lines of growth.

L. 68; H. 55; D. 33 mm. 53%	Omro (U. of W., 846).
L. 66; H. 55; D. 33 mm. 50%	" (" 847).
L. 63; H. 51; D. 27 mm. 43%	" (" 848).
L. 57; H. 49; D. 28 mm. 49%	" (" 849).
L. 41; H. 36; D. 22 mm. 53%	" (" 850).
L. 30; H. 25; D. 15 mm. 50%	" (" 851).

ANIMAL: Similar to the typical form. Glochidia not recorded.

BREEDING SEASON: Probably the same as *pustulosa*. Utterback (1916a, p. 52) gives June and July in Missouri.

GENERAL DISTRIBUTION: Simpson records it from the Mississippi Valley. It is reported from Erie Co., Penn (Ortmann); parts of Ohio (Sterki, Ortmann); Illinois (Baker); Indiana (Daniels); Missouri (Utterback); Arkansas (Call); Michigan (Walker); Iowa (Sterki, Walker). As it has been confused with *pustulosa* it may occur in other states.

DISTRIBUTION IN WISCONSIN: *Prasina* is a form of the smaller rivers. As far as the records show it has not been found in this State outside of the Fox River drainage.

ECOLOGY: In quiet rivers on a mud, gravel or sand bottom, in shallow water. More abundant on a mud bottom.

REMARKS: In Wisconsin a large part of the *pustulosa* examined were referable to the compressed *prasina* type, and there has been little intergrading material observed. The surface varies from almost smooth to a condition in which the posterior two-thirds of the shell is heavily covered with rounded or elongated pustules. In some individuals the tubercles may form two vertical series, leaving a narrow smooth space between. In some individuals the tubercles on the valve become quite massive. In outline the shells vary from almost orbicular to elongate-quadrate, the posterior part behind the umbones being longer than the anterior part. As far as Wisconsin material is concerned the compressed type of shell exhibits little intergrading. Pin-head pearls were observed on the posterior

areas outside of the pallial line and also discolored areas in the same region, in specimens from Omro.

Schoolcraftensis and *prasina* were founded on the same type specimen, *prasina* being published a few months earlier. This form is characteristic of the smaller rivers while typical *pustulosa* is confined to the larger rivers. The same ecological relation has been observed in the *pustulosa* of Illinois, although the small stream form is not as compressed and shows a greater tendency to intergrade with the typical form than in Wisconsin specimens. At Portage, typical *pustulosa* occurs in the part of the Fox River immediately adjacent to the government canal, to which location it has doubtless migrated from the Wisconsin River, where it is abundant (pl. vii, fig. 6). All other Fox River specimens are referable to typical *prasina*. In the upper Rock River, near Ashippun, a form of *prasina* occurs which is very large, compressed, with tubercles on the upper part of the valves, though occasional specimens occur which are quite pustulous all over the posterior region. These are beginning to show variation toward the *pustulosa* type, the river increasing in size at this point. Farther down, true *pustulosa* occur. Several specimens measure as follows: L. 97; H. 77; D. 48 mm.; L. 96; H. 76; D. 47 mm. (U. of I., Z17316).

QUADRULA NODULATA Raf. Warty-Back

Plate XLV, figures 1, 2, 4

Obovaria (Quadrula) nodulata RAF., Ann. Gen. Sci. Phys., Brux., V, p. 307, pl. lxxxi, figs. 17, 18, 1820.

Unio pustulata LEA, Trans. Amer. Phil. Soc., IV, p. 79, pl. vii, fig. 19, 1834; Obs., I, p. 89, pl. vii, fig. 19, 1834.

Quadrula pustulata SIMPSON, Cat., p. 856, 1914.

Quadrula nodulata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 17, 1922.

TYPE LOCALITY: Kentucky River (Raf., for *nodulata*); Ohio and Tennessee, (Lea, for *pustulata*).

WISCONSIN RECORDS:

1905c. *Quadrula pustulata* BAKER, p. 256. Prairie du Chien.

SHELL: Subquadrate, more or less inflated, solid, nearly equipartite; beaks elevated, swollen, turned forward of a wide lunule, sculptured with one or two coarse corrugations which continue down the disk of the shell in two diverging lines of

widely separated tubercles; anterior end sharply rounded; posterior end sharply truncated, slightly winged or alate, with a sinus in the middle indicating termination of a posterior furrow; ventral margin curved; dorsal margin almost straight; posterior ridge well developed, roundly angled; surface with two rows of widely spaced tubercles on the postero-central part of the valve, and a group of small tubercles on the dorso-posterior part of the alate portion, these varying in number from one to 12; in some individuals these may be absent; epidermis yellowish-green or brownish-green, smooth and shining to rather rough, rarely feebly rayed.

Two pseudocardinals in left valve, divergent, pyramidal, roughened; one large pseudocardinal in right valve, sulcated, with a small denticle above anteriorly and posteriorly; laterals slightly curved, not heavy, with sometimes a second lamina in the right valve; interdentum narrow; beak cavities deep; anterior adductor muscle scars deeply excavated, anterior muscle scars, faintly impressed; nacre white, iridescent posteriorly.

L. 57; H. 50; D. 37 mm.	Prairie du Chien	(C. A. S., 20277).
L. 51; H. 49; D. 38 mm.	" "	(" ").
L. 47; H. 41; D. 30 mm.	" "	(" ").
L. 35; H. 33; D. 25 mm.	" "	(" ").
L. 27; H. 23; D. 18 mm.	" "	(" ").

ANIMAL: Similar in all essential respects to *pustulosa*. Glochidia (pl. XXXI, fig. 7) similar in form to those of *pustulosa*, but slightly smaller. Measurements, height 0.25, length 0.20 mm. (Surber, 1912, p. 9).

BREEDING SEASON: Tachytictic, from June to July.

NATURAL HOST: Surber (1913, p. 113) found one specimen on *Pomoxis annularis* with the gills infected with glochidia of this species. Howard (1914a, p. 15) succeeded in artificially infecting *Pomoxis sparoides*, *Micropterus salmoides*, and *Lepomis pallidus* with glochidia of *nodulata*, but the fish died before the glochidia reached full development.

ECOLOGY: *Nodulata* is a species of the large rivers where it usually lives on a mud bottom; rare on gravel bottom. Juvenile shells are abundant on sand bars, rare in mud or gravel.

GENERAL DISTRIBUTION: Simpson gives the range as "Ohio, Cumberland and Tennessee river systems, Mississippi River and tributaries from eastern Iowa south to Louisiana." It is a

species of southern distribution, the Wisconsin locality marking its most northern range.

DISTRIBUTION IN WISCONSIN: Recorded only from the Mississippi River near Prairie du Chien, Crawford Co. (Baker).

REMARKS: *Nodulata* may be distinguished from *pustulosa* by its more quadrate form, slightly alate posterior margin, sometimes pustulose, and by the double row of large, laterally elongated tubercles, which are much less numerous than in *pustulosa*. It seems quite distinct from *pustulosa*, no intergrades having been seen in Wisconsin or other states. It is not common in Wisconsin.

The familiar name *pustulata* of Lea must give way to the equally appropriate name of *nodulata* of Rafinesque, this author's figure and description being adequate for its identification.

Section ORTHONYMUS Agassiz, 1852

See Ortmann and Walker, 1922, p. 15.

Shell quadrate or rhomboid; surface pustulous, with a high, rounded or sharp posterior ridge, above which, on the posterior slope, is a decided radial furrow; umbonal region high; epidermis shining, usually painted with a beautiful pattern of triangular spots or chevron-shaped lines (Walker). Type: *Unio cylindricus* Say.

QUADRULA METANEVRA Rafinesque. Monkey-Face

Plate XLVIII, figure 2; Plate XLIX, figures 1-3

Obliquaria (Quadrula) metanevra RAF., Ann. Gen. Sci., Brux., V, p. 305, pl. lxxxii, figs. 15, 16, 1820.

Quadrula metanevra SIMPSON, Cat., p. 834, 1914.

Quadrula metanevra ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 17, 1922.

Unio nodosus BARNES, Amer. Jour. Sci., VI, p. 124, pl. vi, figs. 7, 7a, 7b, 1823.

TYPE LOCALITY: Kentucky River (*metanevra*); Wisconsin (*nodosus*).

WISCONSIN REFERENCES:

1823. *Unio nodosus* BARNES, p. 124. Wisconsin.

1852. *Unio metanevra* LAPHAM, p. 369. Wisconsin.

1860. *Unio metanevrus* LAPHAM, p. 155. Wisconsin River.

1885. *Unio metanevra* CALL, p. 37. Lake Pepin.

1897. *Unio metanevrus* WISWALL, p. 47. Southern Wisconsin.

- 1905c. *Quadrula metanevra* BAKER, p. 255. Prairie du Chien.
1906. *Quadrula metanevra* CHADWICK, p. 96. Wisconsin.
1919. *Quadrula metanevra* ORTMANN, p. 52. Wisconsin River.
1922a. *Quadrula metanevra* GRIER, pp. 11-31. Pepin, Pierce, Buffalo Cos.

SHELL: solid, inequipartite, inflated, roughly rhomboid; beaks high inflated, directed forward, sculptured with small irregular ridges which are nodulous on the posterior part; lunule narrow; anterior end rounded; posterior end sharply truncated with a striking sinus above the ridge; a strong, wide, elevated ridge extends obliquely from the umbones to the posterior angle of the shell; there is usually a depression or radial furrow behind this ridge; base slightly rounded or incurved behind the middle of the shell; surface of posterior two-thirds of shell more or less covered with rounded or lacrymous tubercles, those on the posterior ridge being larger and often forming elongated knobs; epidermis yellowish-green or brownish, with many irregular, triangular or chevron-shaped markings of dark green; surface slightly shining.

Pseudocardinals, two in left valve, divergent, heavy, triangular, sulcated; one in right valve, triangular, sulcated, with a small denticle in front, and one behind on the wide interdentum; laterals short, straight, heavy, sulcated, with sometimes a small accessory tooth on the right lateral; anterior muscle scars deeply excavated; posterior scars distinct but not heavily impressed; beak cavities not very deep; nacre white, sometimes slightly pinkish; the shell is greatly thickened at the anterior base and very thin at the posterior base; no sexual differences in the shell.

- L. 88; H. 72; D. 47 mm. Wisconsin River (U. of I., Z5290).
L. 84; H. 67; D. 50 mm. Kilbourn (U. of Wis., 833).
L. 72; H. 60; D. 39 mm. Wisconsin R. (U. of W., 50).
L. 67; H. 64; D. 47 mm. Prairie du Chien (U. of W., 834).
L. 57; H. 50; D. 42 mm. Prairie du Chien (U. of W., 835).
L. 33; H. 28; D. 22 mm. Mississippi R. (U. of W., 308a).

ANIMAL: Anal and supra-anal openings always separated by a short mantle-connection; supra-anal opening very large; branchial opening very large with short but well developed papillae; anal opening small, smooth or with irregular crenulations; palpi long, rather pointed, the posterior or basal margins connected for about a third of their length; gills short,

wide, the inner laminae of the inner gills attached to the abdominal sac only at anterior end; the septa and water-tubes well developed. All four gills in the female are used as marsupia, the water-tubes and septa being as in other members of the genus. Color of animal whitish, mantle and openings edged with black or brown; gills grayish or brownish-white; foot same color; posterior part of abdominal sac sometimes blackish.

Glochidia (pl. XXXI, fig. 9) measuring, length 0.18, height 0.19 mm. (Lefevre & Curtis, 1910, p. 97). Howard (1914a, p. 17) gives height 0.185 to 0.2 mm; length 0.17 to 0.176 mm. In form they are somewhat elliptical with rounded ventral margin. A form of the purse-shaped type with narrow hinge line.

BREEDING SEASON: Tachytictic, May to July.

NATURAL HOST: On gills of sunfish (*Lepomis pallidus*, June 24) and sauger (*Stizostedion canadense*, July 26).

ECOLOGY: *Metanevra* is a species of both large and small rivers where it lives in the channel on a gravel bottom in deep water, where there is a good current. The young are usually found on gravel bars in shallow water. Rare on a mud bottom.

GENERAL DISTRIBUTION: Mississippi drainage area except its southern portion, extending to the Tennessee and Arkansas rivers (Simpson).

DISTRIBUTION IN WISCONSIN: *Metanevra* is confined to the Mississippi and Wisconsin rivers, as far as the records show.

REMARKS: *Metanevra* is a common species in the larger rivers of the State. The shell exhibits considerable variation in both shape and ornamentation and this variation may occur in shells from the same locality (as at Prairie du Chien and Kilbourn). The outline varies from rhomboid to almost circular, the variation being mostly confined to the elongation of the anterior end, which may be broadly rounded or more acutely rounded. The posterior end also varies in the amount of elongation, in some individuals bringing the umbones near the center of the dorsal margin. The surface varies from almost smooth, with three or four prominent knobs on the umbonal ridge, to a condition in which all but the anterior fifth of the surface is covered with lacrymous tubercles. The umbonal ridge is usually present in Wisconsin specimens and has always two or more prominent tubercles. The lateral teeth also vary

in massiveness. The prominent posterior ridge with its depressed wing-like area behind and with its radial groove, will usually easily distinguish this species.

Metanевра exhibits a form of stream variation similar to that of other species. In the creeks and small rivers, it is small, somewhat compressed, and often without tubercles. This form in Ohio and Iowa has been called *wardii* Lea (Obs. IX, p. 9, pl. 24, fig. 257, 1863) and a similar form, more tuberculous, occurs in the Salt Fork of the Big Vermilion River in Illinois. The large river form (*metanевра*), in the Wisconsin and Rock rivers, and in the Rock in Illinois, is very large and somewhat elongated. In the Mississippi River, and in the lower Wabash and Illinois rivers, the form becomes smaller and more quadrate. None of the *wardii* form has as yet been found in Wisconsin. A specimen of *wardii* from Coon River, Dallas Co., Iowa, measures, length 74; height 58, and width 31 mm. or 42% ratio (U. of I., Z25304).

Genus TRITOGONIA Agassiz, 1852

Shell solid, elongate, rhomboid, having a strong, irregular posterior ridge; obliquely truncated behind in the male, in the female this region is somewhat compressed and expanded into a broad wing; base curved; whole surface, except the rounded wing of the female, covered with pustules; beaks rather low, incurved and turned forward over the well developed lunule; beak sculpture strong, consisting of irregular, sub-parallel ridges which are curved upwards behind and fine radiating ridges in front of and behind them; epidermis dark olive; hinge plate rather narrow; pseudocardinals strong, ragged; laterals long and straight, near to the pseudocardinals; cavity of beaks rather deep, compressed; female shell more compressed than that of the male. Marsupium occupying all four gills (Walker). Type: *Unio tuberculatus* Barnes (= *verrucosa* Raf.).

TRITOGONIA VERRUCOSA (Raf.). Buckhorn

Plate L, figures 1-4

Obliquaria verrucosa RAF., Ann. Gen. Sci., Phys., Brux., V, p. 304, pl. lxxxix, figs. 10-12, 1820.

Unio tuberculatus BARNES, Amer. Jour. Sci., VI, p. 125, pl. vii, figs. 8a, 8b, 1823.

Quadrula tuberculata SIMPSON, Cat., p. 318, 1914.

Quadrula verrucosa ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 18, 1922.

TYPE LOCALITY: Ohio River (*verrucosa*); Wisconsin (*tuberculata*).

WISCONSIN RECORDS:

1823. *Unio tuberculatus* BARNES, p. 135. Wisconsin.

1852. *Unio verrucosus* LAPHAM, p. 369. Wisconsin.

1860. *Unio tuberculatus* LAPHAM, p. 155. Wisconsin River.

1897. *Unio tuberculatus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Tritogonia tuberculata* BAKER, p. 254. Prairie du Chien.

1906. *Tritogonia tuberculata* CHADWICK, p. 93. Sugar River, Brodhead, Green Co.; between Prairie du Chien and De Soto.

1914. *Tritogonia tuberculata* SIMPSON, p. 319. Wisconsin.

1919. *Quadrula verrucosa* ORTMANN, p. 43. Wisconsin.

1922a. *Quadrula verrucosa* GRIER, pp. 11-31. Pierce, Pepin, Buffalo Co.

1926. *Quadrula verrucosa* GRIER and MUELLER, p. 16. Lake Pepin and Mississippi River.

SHELL: As in the generic description.

L. 166; H. 85; D. 45 mm. Baraboo R. (Dudley coll). Female.

L. 150; H. 77; D. 44 mm. Kilbourn (U. of W., 852). Female.

L. 140; H. 80; D. 43 mm. " (" 853). Male.

L. 118; H. 60; D. 33 mm. Omro (U. of W., 854). Female.

L. 102; H. 64; D. 34 mm. " (" 855). Male.

L. 106; H. 59; D. 28 mm. Portage (U. of W., 856). Female.

L. 87; H. 53; D. 28 mm. Prairie du Chien (U. of W., 857). Male.

ANIMAL: (Fig. 217). Anal and supra-anal openings usually connected by a short mantle margin; supra-anal very long; branchial about two-thirds length of supra-anal; anal about one-half length of branchial; branchial opening with numerous well developed, branched papillae; anal opening with small crenulations which may in some individuals resemble minute papillae; gills long and rather wide, the inner gill the broader, connected with abdominal sac only at its anterior end; palpi elongated, their posterior margins connected for half their length or more; septa of gills well developed, widely spaced in the male, crowded in all four gills of the female, the water tubes narrow. Four gills used as marsupia. Soft parts greyish or yellowish; gills brownish; foot light salmon; mantle and openings edged with black or dark brown.

Glochidia (pl. XXXI, fig. 10) usually small, hinge line

straight, length 0.085 mm., height 0.100 mm. (Surber, 1912, p. 9).

BREEDING SEASON: Tachytictic, April to June (Surber); July to August (Utterback). None were gravid in July in the Wisconsin River at Kilbourn (Baker). The placentae are white; gravid marsupia are colored brown by the egg masses.

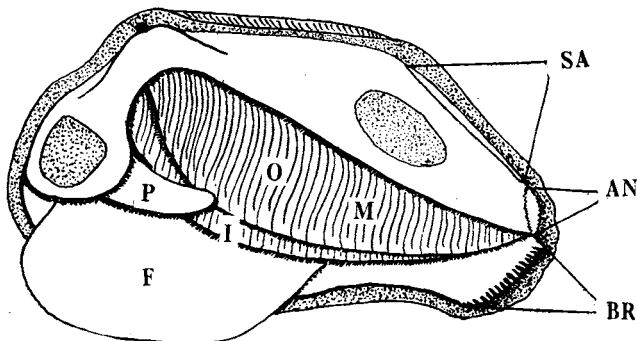


Fig. 217. *Tritogonia verrucosa* (Raf.). Lower Dells, Wisconsin River, Kilbourn, July 25, 1922. Female, not gravid.

NATURAL HOST: Unknown.

ECOLOGY: In fairly deep water on a sand or mud bottom. Common on riffles, in shallow water (3-1 m.) in smaller streams. This is especially true in Illinois streams. Usually not deeply buried in riffles but deeper in mud. Young shells are common on sand bars. One of the few species living in both large and small streams and showing little ecological or physiographic variation.

GENERAL DISTRIBUTION: Mississippi drainage generally; streams falling into the Gulf of Mexico from the Alabama system west to central Texas (Simpson).

DISTRIBUTION IN WISCONSIN: *Verrucosa* is found in the drainage of four rivers, the Mississippi, the Wisconsin, the Fox, and the Sugar. Its absence from the main branch of the Rock River is noteworthy. It is one of the few species of mussels common to the Wisconsin and Fox rivers.

REMARKS: No other Wisconsin shell is comparable with *verrucosa*, the elongate-quadrate outline, heavy shell, densely pustulose surface, and pinched-out appearance of the posterior end, especially in the female, at once distinguishing it. There is some variation, particularly in the degree of pustulosity, but

on the whole the species is very uniform. Young shells, 1–2 inches in length, are heavily, regularly pustulose and the valves are much compressed.

The species attains large dimensions in all habitats, especially in the larger rivers. At Kilbourn, specimens seven inches in length were collected. The advisability of separating this species from *Quadrula* as a genus has been questioned by Ortmann (1919, p. 44) and there seems little difference in the characters of the soft parts. Yet the shape of the shell, and particularly the difference in shape between the two sexes mark it as more than specifically different from the other *Quadrula*. It is, therefore, placed in this genus as defined by Walker and Simpson.

Genus CYCLONAIAS Pilsbry, 1922

Rotundaria SIMPSON, 1900, p. 794; 1914, p. 80.

Shell rounded; slightly truncated above in front; posterior ridge low, beaks prominent, curved inward and forward over a strongly marked lunule; beak sculpture consisting of numerous, fine, irregular, broken, somewhat concentric corrugations; posterior three-fourths of the shell tuberculate; epidermis brown; nacre purple. Only the outer gills serve as marsupia. Type: *Obliquaria tuberculata* Raf. (See Ortmann and Walker, 1922, p. 18).

CYCLONAIAS TUBERCULATA Raf. Purple Pimple-Back

Plate LI, figures 1, 2, 5

Obliquaria (Rotundaria) tuberculata RAF., Ann. Gen. Sci. Phys., Brux., V, p. 308, 1820.

Unio tuberculatus CONRAD, Mon. p. 43, pl. xxii, 1836.

Unio verrucosus BARNES, Amer. Jour. Sci., VI, p. 123, pl. v, fig. 6, 1823.

Quadrula tuberculata SIMPSON, Cat., p. 903, 1914.

Rotundaria tuberculata ORTMANN, Ann. Carnegie Mus., VIII, p. 57, 1919.

TYPE LOCALITY: Ohio and its tributaries (Raf., *tuberculata*); Wisconsin River (Barnes, *verrucosus*).

WISCONSIN RECORDS:

1823. *Unio verrucosus* BARNES, p. 123. Wisconsin River.

1836. *Unio tuberculata* CONRAD, p. 43. Wisconsin.

1852. *Unio tuberculata* LAPHAM, p. 369. Wisconsin.

1860. *Unio verrucosus* LAPHAM, p. 155. Rock River.

1897. *Unio verrucosus* WISWALL, p. 47. Southern Wisconsin.

1919. *Rotundaria tuberculata* ORTMANN, p. 60. Mississippi, Rock, St. Croix and Wisconsin rivers (part).
1924. *Quadrula verrucosa* BAKER, p. 133. Omro, Fox River.

SHELL: subrotund, subquadrate, or suborbicular in outline, compressed or but slightly inflated, solid, heavy; anterior end rounded or slightly truncated; posterior end obliquely, roundly truncated, with a distinct furrow above the posterior ridge; ventral border broadly rounded; dorsal margin slightly convex; posterior ridge not conspicuous, depressed; there is a rather wide, wing-like radial depression above the ridge ending posteriorly in an inconspicuous sinus; beaks rather prominent, somewhat compressed, inclined forward over a distinct lunule; beak sculpture consisting of many fine, irregular, broken ridges, each ridge made up of zigzag bars, then several loops, and then more zigzag bars, the double loops being confined to the middle of the umbone; this beak sculpture is continued down the valve until the nodules appear; center and posterior portion of valve more or less covered with tubercles elongated parallel with the lines of growth, which are usually sharp or even raised to form ridges; tubercles variable in number, form, and size, but the anterior third of the valve is always free from tuberculation; a few riblets are sometimes developed on the posterior wing; epidermis varying from light to dark brown, sometimes with traces of greenish rays, especially in young shells.

Two rather narrow, divergent pseudocardinals in the left valve, forming an inverted V, almost meeting above, with deep sulcations between and on the teeth; in right valve, one pseudocardinal, massive, obscurely triangular, heavily sulcated, with a small denticle on either side, forming a broad bow above the pseudocardinal; interdentum broad and flat, smooth; laterals short, massive, almost straight, with a second lateral usually developed in the right valve; beak cavities deep, compressed; dorsal muscle scars on hinge plate; anterior adductor scars deeply excavated, roughened; posterior scars very distinct; nacre brownish-purple or coppery, iridescent on the posterior part of valve; no sexual difference in the shell.

- L. 109; H. 96; D. 51 mm. Baraboo River (U. of W., 230).
L. 80; H. 70; D. 41 mm. Rock River (U. of W., 104).
L. 69; H. 63; D. 34 mm. Fox River (U. of W., 21).
L. 39; H. 38; D. 24 mm. Rock River (U. of W., 225).
L. 79; H. 76; D. 40 mm. Barnes' measurements.
L. 49; H. 43; D. 22.5 mm. " "

ANIMAL: (Fig. 218) Anal opening very large, not closed above, thus preventing the formation of a supra-anal opening; branchial opening very large, with papillae on the inner edge; anal opening with smooth inner edge; palpi elongated, subtriangular, united along their posterior margins for one-third to one-half their length; gills short, wide, the diaphragm complete; inner lamina of inner gills attached to the abdominal sac only at the anterior end. The outer gills only are used as marsupia, where the septa are crowded and the water-tubes narrower than in the inner gills or in the male gills. Color of animal whitish or brownish white, brownish or mantle margin, deep black or brown near the anal and branchial openings.

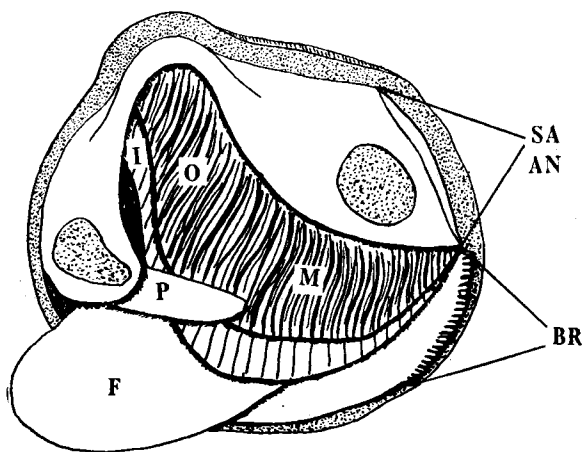


Fig. 218. *Cyclonaias tuberculata compressa* F. C. Baker. Salt Fork, Vermilion River, below Urbana, Ill. Sterile female. July 21, 1920.

Utterback describes the reproductive structure as follows (1916, p. 69): Only outer gills marsupial, septa closely crowded, when charged distended very little even in median-longitudinal line, ventral edge not blunt, ovisacs rather narrow; conglutinates white, narrowly lanceolate, not solid; glochidia large, spineless, ventral margin rounded, hinge line short, straight, or nearly so; measurements: length 0.267, height 0.325 mm.

BREEDING SEASON: Gravid females were collected by Utterback August 11, 1913, in the Osage River, Bagnell, Mo.; he states that the species is gravid from June to the middle of

August, bearing ripe glochidia mostly about the middle of June. Ortmann gives the season from late May to middle of August. A tachytictic form.

NATURAL HOST: Not recorded.

ECOLOGY: Found usually on a mud bottom in fairly deep water, .1-2 m. Ortmann records it from riffles in coarse gravel. This may include the flat form of small rivers, mentioned below.

GENERAL DISTRIBUTION: *Tuberculata (verrucosa)* is said to occupy the Mississippi drainage generally (Simpson). Some of the references to the Tennessee and other southern rivers may include forms not strictly referable to typical *tuberculata*. Specimens referable to the typical form have been seen from Rock River (Wisconsin and Illinois), Ohio River, and Wabash River.

DISTRIBUTION IN WISCONSIN: *Tuberculata* is confined, apparently, to the rivers of medium size, the Rock and the Wisconsin, and the lower Fox. Although the Wisconsin River is cited by Barnes as the type locality for his *verrucosa*, none were found in the neighborhood of Portage or Kilbourn. It does occur in the Baraboo River, and possibly in the Wisconsin below the points examined.

REMARKS: This distinctive naiad is subject to considerable variation and may be confused with several other species. It is usually easily known by its peculiar copper-colored nacre and the very broad interdentum. The shell varies considerably in outline from almost circular to elongate-quadrate, the posterior end being drawn out, forming an oblique truncation. Old shells are usually always very oblique, and the tubercular portion may be so eroded as to entirely obliterate the pustules. The nacre varies from uniform copper-color to a condition in which the copper color is confined to the area between the outer margin and the pallial line, the balance of the interior, including the hinge, being light mauve. *Tuberculata* is at once separated from the pustulose *Quadrula* by its purple or copper-colored nacre.

Under the names *tuberculata* and *granifera* several recognizable forms are included. It is probable that Rafinesque in his *tuberculata* included the wider form later described as *granifera* by Lea. In fact, his description fits this form better than the Wisconsin *verrucosa* of Barnes. As Conrad, Say,

and other early authors, as well as later students, Simpson, Walker, and Ortmann, have fixed the name *tuberculata* for the tuberculate form in the Ohio and its tributaries, it is best not to reopen the question. *Tuberculata* is the form living in medium sized rivers while *granifera*, the more corpulent form, seems to be restricted to the large rivers, as the Mississippi, lower Ohio and Wabash rivers.

In Illinois, Indiana, and Michigan (probably also in other states) there is a much compressed, very elongate form, heavily pustulose, especially on the flattened alate portion posteriorly, with a remote pallial line, which lives in the smaller tributaries; in Illinois this form is found in shallow water on a gravel bottom, in riffles. This compressed form has not been seen from Wisconsin. For the compressed variety I propose the varietal name *compressa*, the type locality being Middle Fork at mouth, Vermilion River, Vermilion Co., Ill. (U. of I., No. Z11672, pl. LXXV, figs. 1, 2. Two specimens measure as follows: L. 98 mm. H. 82 mm., D. 40 mm. (type). L. 83 mm. H. 71 mm. D. 35 mm. (paratype). The same variety is in the Hinkley collection from Huron River, Ann Arbor, Mich. It has not been seen from Wisconsin. Typical *tuberculata* occurs in the Rock River, Illinois, in Winnebago Co., indicating that this form extends down the river toward the Mississippi. In Kentucky and Tennessee a small variety occurs, the *pusilla* of Simpson (Cat. p. 906).

CYCLONAIAS TUBERCULATA GRANIFERA (Lea). Purple Warty-Back
Plate LI, figures 3, 4

Unio graniferus LEA, Trans. Amer. Phil. Soc., VI, p. 69, pl. xix, fig. 60, 1838; Obs., II, p. 69, pl. xix, fig. 60, 1838.

Quadrula granifera SIMPSON, Cat., p. 905, 1914.

TYPE LOCALITY: Ohio River, near Cincinnati (Lea).

WISCONSIN RECORDS:

1905c. *Quadrula granifera* BAKER, p. 256. Prairie du Chien.

1922a. *Rotundaria granifera* GRIER, pp. 11-31. Pepin, Pierce Co.

1922. *Cyclonaias granifera* GRIER and MUELLER, p. 48. Lake Pepin to Fairport.

SHELL: Orbicular in outline, inflated, solid; anterior margin rounded or slightly truncated; posterior margin truncated with a slight sinus terminating a furrow above the rounded posterior ridge; ventral margin well rounded; dorsal margin

rounded; beaks high, inflated, inclined forward over a distinct lunule; sculpture as in *tuberculata*, but the zigzag bars and loops coarser and the bars forming connected wavy lines anteriorly; tubercles larger and usually more numerous than in *tuberculata*; epidermis greenish-brown or olive, sometimes chestnut colored; hinge teeth as in *tuberculata*; nacre purplish or mauve, more coppery on the region outside the pallial line.

L. 85; H. 77; D. 50 mm. Hudson (U. of W., 858).

L. 69; H. 68; D. 42 mm. Prairie du Chien (U. of W., 859).

ANIMAL: Essentially the same as that of *tuberculata*. The glochidia (pl. XXXI, fig. 11), are of large size, with the following dimensions: height 0.355, length 0.29 mm. (Howard, 1914a, p. 16; Surber, 1912, p. 9). These are larger than those of *tuberculata*.

BREEDING SEASON: Tachytictic, probably the same as *tuberculata*.

NATURAL HOST: Not recorded.

ECOLOGY: *Granifera* is found in the larger rivers on a mud bottom in fairly deep water.

GENERAL DISTRIBUTION: Ohio, Cumberland, and Tennessee river systems; northwest to Iowa (Simpson). Typical *granifera* has been seen personally only from the Mississippi, lower Ohio and Wabash rivers. In the Tennessee river the specimens are smaller and more compressed than those from the larger rivers and bear almost the same relation to *granifera* that the compressed form of Illinois and other places bears to *tuberculata*. It appears to be an ecological variety.

DISTRIBUTION IN WISCONSIN: Apparently confined to the Mississippi River, where it is known from the Illinois River northward to Hudson, St. Croix River.

REMARKS: *Granifera* may be known from *tuberculata* by its more inflated shell, more inflated and elevated umbones, rounder outline (length and height nearly equal) and by the dark purple color of the nacre which is not brownish purple nor as coppery as in *tuberculata*. While obviously closely related, the two forms seem easily separable when the points indicated are closely followed. No difficulty has been met in separating the rather large series of specimens in the various collections at hand, covering the majority of the area inhabited by *Cyclonaias*.

The Wisconsin *granifera* are not quite as pustulose as are specimens from the Ohio and Wabash rivers, and they are also somewhat rounder in outline with a less developed posterior wing. The purple nacre of this species, as well as *tuberculata*, renders the shell unfit for the manufacture of pearl buttons, excepting novelty forms.

The various groups of species or varieties of *Cyclonaias* conform to the law of river distribution as has already been noted for other species. Beginning with the flat, compressed shell herein called *compressa*, which inhabits the small streams, we pass to the wider, more elongated form called *tuberculata*, which inhabits the medium sized rivers like the Upper Ohio, Illinois, Rock, Wabash, Wisconsin, etc.; finally, in the large rivers, as the Mississippi and the lower parts of the Ohio, Wabash, Illinois, and Wisconsin, the form changes to the smaller, wider *granifera*, with high umbones and corpulent shell. The relationship of these three forms is obvious. It is the writer's opinion that *granifera* should be included under *tuberculata*, and *verrucosa* Barnes applied to the flatter form found in the medium sized rivers. Rafinesque's description fits the *granifera* form and it is this form that is common in the lower Ohio at Cincinnati and farther down. It is very probable that Rafinesque included both flat and corpulent forms in his *tuberculata*.

Genus PLETHOBASUS Simpson, 1900

Shell large, irregularly oval, inflated, solid, somewhat suddenly swollen at the posterior base; posterior ridge low and rounded; beaks rather high, near the anterior end, having a few strong ridges, which are curved upwards behind; a row of low, irregular tubercles extends from near the beaks to post-basal part of valves; epidermis tawny yellow to dark brown; hinge plate solid, not flattened; pseudocardinals triangular, rough; cavity of the beaks not deep; front part of the shell very heavy, thinner behind. Outer gills only serving as Marsupia (Walker). Type: *Unio aesopus* Green.

PLETHOBASUS CYPHYUS (Rafinesque). Bullhead

Plate XLIX, figures 4-6

Obliquaria cyphya RAF., Ann. Gen. Sci. Phys., Brux., V, p. 305, 1820.*Unio aesopus* GREEN, Cont. Mac. Lyceum, I, No. 2, p. 46, fig. 3, 1827.*Pleurobema aesopus* SIMPSON, Cat., p. 806, 1912.*Plethobasus cyphus* ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 19, 1922.

TYPE LOCALITY: *Cyphus*, Falls of Ohio, at Louisville, Ky. (Raf.); *aesopus*, Pittsburg, Penn. (Green).

WISCONSIN RECORDS:

1897. *Unio aesopus* WISWALL, p. 47. Southern Wisconsin.1905c. *Pleurobema aesopus* BAKER, p. 255. Prairie du Chien.1906. *Pleurobema aesopus* CHADWICK, p. 95. Wisconsin.1922a. *Plethobasus cyphus* GRIER, pp. 11-31. Pierce, Pepin, Buffalo Co.1922. *Plethobasus cyphus* GRIER and MUELLER, p. 49. Foot of Lake Pepin.1926. *Plethobasus cyphus* GRIER and MUELLER, p. 16. Below Lake Pepin.

SHELL: Elongated ovate, inflated, solid, oblique; anterior end acutely rounded; posterior end long, pointed; ventral margin rounded anteriorly, with a straight or slightly incurved line posterior of a swelling midway of the margin caused by a thick rib extending toward the ventral margin in an oblique direction; this rib is swollen in the center, giving the outline of the shell a convex appearance; posterior ridge rounded, ending in a blunt point, with a furrow-like depression above; there is usually a row of large tubercular swellings on the center of the valve extending down the rib from near the umbones to the ventral margin; beaks rather full, high, placed near the anterior margin, their sculpture of a few concentric ridges confined to the apex of the umbones; there is a wide radial depression behind the row of tubercles; epidermis yellowish or brownish, the rest periods darker; there are no rays. Anterior adductor muscle scar deeply excavated.

Two large, more or less triangular, divergent, sulcated pseudocardinals in the left valve; a large triangular, sulcated pseudocardinal in the right valve, with a small denticle on either side; interdentum narrow or absent; laterals heavy, sulcated, usually double in the right valve; beak cavities shallow; nacre pearly white, slightly iridescent posteriorly. No sexual differ-

ence in the shells. The anterior part of the shell is much thicker than the posterior part.

- L. 100; H. 70; D. 53 mm. Kilbourn (U. of W., 826).
 L. 94; H. 64; D. 47 mm. " (" 860).
 L. 83; H. 61; D. 46 mm. Prairie du Sac (Dudley).
 L. 76; H. 59; D. 43 mm. Sauk Co. (U. of I., Z5186).
 L. 63; H. 49; D. 35 mm. Mississippi R., Ill. (U. of W., 327).
 L. 50; H. 39; D. 27 mm. Kilbourn (U. of W., 861).
 L. 31; H. 25; D. 17 mm. " (" 862).

ANIMAL: (Fig. 219). Supra-anal opening larger than anal opening, separated by a very short mantle connection which is rarely absent; branchial opening with many papillae varying in size; anal opening with very fine papillae; palpi short and wide, the posterior margins connected a third of their length; gills rather long, broad; inner lamina of inner gills free from the abdominal sac; septa and water tubes well developed, in the male and the inner gill of the female the septa are more widely separated; only the outer gills used as marsupia. When gravid the ovisacs swell moderately only in the middle causing the placentae to become lanceolate in form; they are discharged whole. The eggs and placentae are pinkish or red in color. Color of animal generally pale orange; abdominal sac whitish, gills and palpi light brownish, often suffused with orange; foot, mantle margins and adductor muscles dark orange.

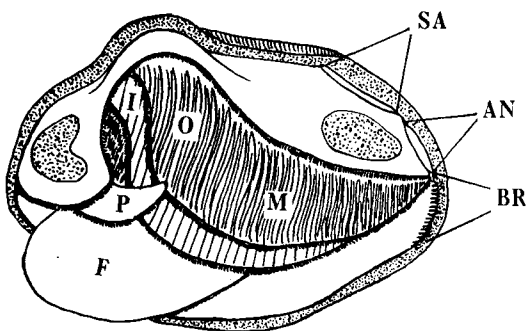


Fig. 219. *Plethobasus cyphus* (Raf.). Lower Dells of Wisconsin River, Kilbourn. Sterile female. July 24, 1922.

Glochidia (pl. XXXI, fig. 12) semioval or semicircular, ventral margin rounded, hinge line rather long, straight or slightly curved. Length 0.22, height 0.20 mm. (Surber, 1912, p. 10). Ortmann gives dimensions of 0.21 by 0.20 mm.

BREEDING SEASON: Tachytictic, May to July.

NATURAL HOST: Believed to be the sauger (*Stizostedion canadense*.) An infected fish was taken July 20, 1911, holding 17 glochidia of this mussel on its gills (Surber, 1913, p. 110).

ECOLOGY: In Wisconsin *cyphus* is a species of the large rivers where it lives on a mud bottom in water 1-2 m. deep, in a rapid current (Wisconsin River). In Lake Pepin found on mud, gravel, and sand bottom in deep water in a good current. In Pennsylvania it seems to prefer riffles with coarse gravel and strong current (Ortmann, 1919, p. 68).

GENERAL DISTRIBUTION: In the Ohio, Cumberland, and Tennessee river system. In the Mississippi Valley it ascends to Minnesota and Missouri (Simpson).

DISTRIBUTION IN WISCONSIN: Apparently confined to the Mississippi and the lower part of the Wisconsin rivers. Not reported above the dam at Kilbourn, Columbia Co. Extends the whole length of the Mississippi.

REMARKS: *Cyphus* is unlike any other Wisconsin naiad and may be at once distinguished by the row of irregular nodules extending down the middle of the shell and producing the pronounced post-basal swelling, and also its peculiar oblique outline. There is considerable variation in length as compared with height, old specimens becoming much elongated. The tubercles on the disk may or may not be developed, but the post-basal swelling is always present. Old specimens have, usually, a darker epidermis than young or immature individuals. It is quite common in certain parts of the State.

This species, commonly known as bullhead and sheepnose among the fishermen, while possessing a fine pearly lustre, is so hard in texture that it is very difficult to cut and often causes injury to the saws. When cut the blanks take a good polish and make fine buttons. It is not considered one of the most desirable button shells.

The familiar name of *aesopus* must give way to *cyphus* of Rafinesque, the description of which is sufficient for its identification (see Ortmann & Walker, p. 19). The name *cyphus*, however, was given to the short, heavy, smaller form of the Ohio, while *aesopus* is founded on the larger, longer, more elongated form of the medium sized rivers.

Genus PLEUROBEMA (Raf., 1820) Agassiz

Shell, solid, triangular to rhomboid, usually with a prominent umbonal region; beaks at or near the anterior end of the shell, incurved and pointed forward over a small, but well developed lunule; beak sculpture coarse, consisting of a few, often broken, ridges, which curve upward posteriorly; posterior ridge present, but low and rounded; epidermis showing the rest periods plainly, tawny to olive, often ornamented with rays which show a tendency to break into square spots; hinge rather strong, plate generally narrow; pseudocardinals double in both valves. Cavity of the beaks shallow. Outer gills only serving as marsupia (Walker). Type: *Pleurobema mytiloides* Raf. = *Unio clava* Lam.

PLEUROBEMA COCCINEUM (Conrad). Pink Niggerhead

Plate LIV

Unio coccineus CONRAD, Monog., III, p. 29, pl. xiii, fig. 1, 1836.

Unio coccineus LEA, Trans. Amer. Phil. Soc., VI, p. 12, pl. v, fig. 12, 1838; Obs., II, p. 12, pl. v, fig. 12, 1838.

Quadrula coccinea SIMPSON, Cat., p. 883, 1914.

Pleurobema obliquum coccineum ORTMANN, Mem. Carnegie Mus., VIII, p. 78, pl. vii, figs. 3-5, 1919.

TYPE LOCALITY: Mahoning River near Pittsburg, Pa. (Conrad); more exactly at Mahoningtown, Lawrence Co. (vide Ortmann).

WISCONSIN RECORDS:

1885. *Unio kirtlandianus* CALL, p. 33. Waukesha.

1900. *Quadrula kirtlandiana* SIMPSON, p. 791. 'North to Wisconsin'.

1906. *Quadrula coccinea* CHADWICK, p. 97. 'North to Wisconsin'.

1914. *Quadrula kirtlandiana* SIMPSON, p. 891. 'North to Wisconsin'.

1924. *Pleurobema coccineum* BAKER, p. 133. Omro, Fox River.

1927d. *Pleurobema coccineum* BAKER, p. 107. Rock River, Ashippun to Ft. Jefferson.

SHELL: Flattened laterally, compressed, solid, subquadrangular; beaks but slightly elevated, compressed, turned forward, their sculpture consisting of a few coarse, irregular ridges, curving upward behind; anterior end rather well rounded, slightly truncated above where it joins the dorsal margin; posterior end rather squarely truncated; posterior ridge rounded ending below in a rounded point; there is a slight depression above this ridge which may be called a radial fur-

row; surface marked only by roughened growth lines, which are especially conspicuous at resting periods; epidermis yellowish brown or chestnut, often pinkish, faintly rayed in young specimens, the rays sometimes retained on the umbones in old specimens.

Pseudocardinals rather heavy, triangular, divergent, coarsely radially sulcated, two in left valve forming an inverted V; a large, triangular, sulcated pseudocardinal in right valve, with two accessory denticles near the hinge line; interdentum rather wide, flat; laterals short, straight or very slightly curved, thick, solid, wide; muscle scars and pallial line well impressed or excavated; cavity of the beaks shallow, compressed; nacre white or pinkish, more or less iridescent; no sexual difference in shape of shells.

- L. 56; H. 42; D. 25 mm. 44% Mahoning River, Pa. (U. of I., Z5497; like Conrad's fig.).
 L. 74; H. 54; D. 33 mm. 44% " " " (U. of I., Z5497)
 L. 59; H. 47; D. 26 mm. 44% Omro (U. of W., 873).
 L. 78; H. 53; D. 36 mm. 46% Red Cedar River (U. of W., 871).
 L. 94; H. 70; D. 37 mm. 39% Princeton (U. of W., 870).
 L. 86; H. 62; D. 30 mm. 34% Rock River (U. of W., 25).
 L. 128; H. 83; D. 43 mm. 33% Rock River (U. of I., Z17319a).

ANIMAL: (Fig. 220). Supra-anal and anal openings separated by a short mantle connection, rarely absent; branchial opening with well marked papillae; anal opening with numer-

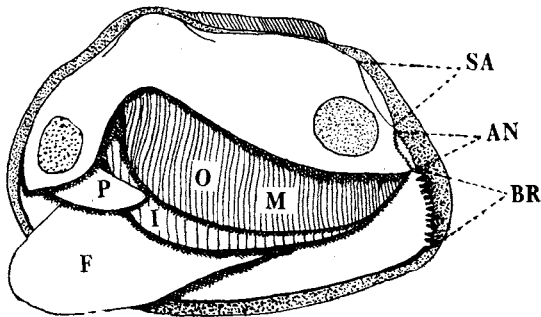


Fig. 220. *Pleurobema coccineum* (Conrad). Red Cedar River, near Chetek. Sterile female. Aug. 23, 1921.

ous crenulations that approach papillae in form and size; palpi rather long, connected at their bases for about half their length (sometimes a longer connection); inner gills larger than

outer gills with the inner lamina free from the abdominal sac; outer gills only marsupial, the ovisacs of the same lanceolate form as in *Plethobasus*, and discharged whole. The anatomical characters are similar to those of *catillus*.

Glochidia (pl. XXXI, fig. 14) rather small, subovate, without spines, length 0.15, height 0.15 mm. (Ortmann). Surber gives 0.16 x 0.16 mm.

BREEDING SEASON: Early May to late July. Glochidia discharged from last half of June. A tachyticyic form.

NATURAL HOST: Not recorded.

ECOLOGY: *Coccineum* is typically a species of small streams and creeks. In Red Cedar River, west of Chetek, it occurred in shallow water in riffles, the shells being buried deeply in sand bars. Lower down the river, found in gravel and sand in riffles, shallow water, the shells buried in sand bars. At Omro found on sand bottom in shallow water, along the edge of the shore. In Illinois, this variety is found in shallow streams, on a gravel or sand bottom (rarely mud) in riffles.

GENERAL DISTRIBUTION: Credited by Simpson to the Upper Mississippi drainage and St. Lawrence drainage. Its range is apparently bounded by western New York on the east, Iowa and Kansas on the west, Michigan and Wisconsin on the north, and Alabama and Arkansas on the south.

DISTRIBUTION IN WISCONSIN: *Coccineum* is found in the head waters of the Chippewa, Fox, and Rock rivers. Near Portage it has entered the Wisconsin River by way of the government canal between the Fox and Wisconsin rivers. It is also found in the upper Dells.

REMARKS: *Coccineum* is typically the most compressed member of the *obliquum* group of naiades, the average diameter being about 40% of the length while in *solida* and *catillus* the diameter is 50% or more. The hinge teeth are less massive than either of the forms mentioned and the interdentum is narrower. The umbones are also much more depressed and compressed and the shell is notably flattened in the middle of the valve. *Coccineum* is the most variable member of the *catillus* group. Typically, as it appears in the type locality, the Mahoning River in Ohio, and in the streams in Illinois and Indiana, it is easily separable from both *catillus* and *solida*. These shells are all flatter, compressed, and elongated. But when series are examined from some of the larger rivers, interme-

diates in size between the creeks and large rivers, the form shows great variation toward *catillus* and in some cases, as in a lot from the Wabash River at Lafayette, Ind., there is every gradation between typical *coccineum* (flat) and *catillus* (wider, elevated umbones). Specimens from Joliet and the Kankakee River, in the Hinkley collection, show the same variation.

Following Ortmann (1919, p. 78) *coccineum* is here considered a variation of the *catillus* type of mussel. As *coccineum* has page priority it must take precedence over *catillus* as the leading species and the races must be considered varieties of the flat form. I see no evidence, however, that this group should be united with *obliquum*, the hinge structure in that species being different.

The *coccineum* of the smaller streams divide into two groups; one the typical form, with rather wide interdentum and short, thick lateral teeth, and the other with a narrow interdentum and long, narrow lateral teeth. The former live in larger streams than the latter, which are usually more compressed, having a ratio of 33%–35%. This form is also found in the Rock River near Ashippun, Dodge Co. In Illinois it is abundant in the Salt Fork of the Big Vermilion River, Champaign Co. The type has a deep pink nacre, but the Rock River specimens are mostly white, and attain a large size.

No specimens from Wisconsin have been seen that are exactly like Conrad's figure of *coccineum* and like specimens from the Mahoning River. In the Rock River the narrow interdentum-type occurs as far down as the vicinity of Ashippun. At Ixonia the shell shows a widening of the interdentum, and at Ft. Atkinson the shell is typical *catillus*. Specimens from the Upper Dells, Kilbourn, Wisconsin River, have the narrow interdentum. Individuals from Red Cedar River have a rather wide interdentum. In the Kankakee River, Ill., the typical *coccineum* occurs. It would appear that, in Wisconsin, the transition from the narrow interdentum to the wide *catillus* type of interdentum is very abrupt. The majority of the Wisconsin *coccineum* are referable to the compressed type of shell.

Kirtlandiana has been reported from Wisconsin, but this reference is erroneous as noted doubtfully by Simpson (1914, p. 891) and positively by Ortmann (1919, p. 14). Call's record is without doubt founded on *coccineum*. A specimen labelled *kirtlandiana* in the Marston collection is a good example of the

compressed form of *coccineum* (see pl. LIV, fig. 4). It is perfectly evident that *kirtlandiana* does not inhabit Wisconsin.

PLEUROBEMA COCCINEUM CATILLUS (Conrad). Small Niggerhead

Plate LV, figures 1-3

Unio catillus CONRAD, Monog., p. 30, pl. xiii, fig. 2, 1836.

Quadrula solida SIMPSON, Cat., p. 885, 1914 (part).

Pleurobema obliquum catillus ORTMANN, Mem. Carnegie Mus., VIII, p. 75, pl. vi, fig. 6, 1919.

Pleurobema catillus ORTMANN and WALKER, Oc. Papers, Univ. Mich., 112, p. 23, 1922.

TYPE LOCALITY: Scioto River, Ohio (Conrad).

WISCONSIN RECORDS:

1860. *Unio mytiloides* LAPHAM, p. 156. Rock River.

SHELL: Differing from *coccineum* in being shorter and more rounded in outline, the anterior end more rounded, the posterior end more pointed ventrally, the whole shell more inflated with higher umbones more inclined to be directed forward; the anterior dorsal margin in front of the umbones is shorter and rounder; interdentum wider, pseudocardinals more massive, laterals shorter, thicker and more directly curved downward toward the base of the shell; the whole shell (in Wisconsin specimens) is much more oblique than in *coccineum*.

L. 60; H. 49; D. 30 mm. 50%	Conrad's figure in Monog.
L. 62; H. 51; D. 31 mm. 50%	Rock River, Ill. (U. of I., 5496a).
L. 84; H. 69; D. 42 mm. 50%	Fort Atkinson (U. of W., 866).
L. 76; H. 60; D. 38 mm. 50%	" (U. of W., 867).
L. 81; H. 70; D. 45 mm. 55%	" (U. of W., 868).
L. 62; H. 50; D. 33 mm. 53%	Rock River, Wis. (U. of W., 26).
L. 66; H. 52; D. 42 mm. 63%	" " " (U. of W., 13).
L. 54; H. 44; D. 29 mm. 53%	" " " (U. of W., 43).

ANIMAL: Similar to *coccineum*. See also under *solida*.

ECOLOGY: A species of rivers of small to medium size, where it is found on a sand, gravel or mud bottom, water .5 to 2. m. or more in depth, in more or less rapid current.

GENERAL DISTRIBUTION: Typical *catillus* is known from Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, Iowa; specimens from other states referred to this form seem more nearly related to *solida*.

DISTRIBUTION IN WISCONSIN: Typical *catillus* has been seen only from the Rock River drainage.

Fort Atkinson, Jefferson Co. (Bullock); Rock River (Marston); Rock River, Winnebago Co., Ill. (Hinkley); Rock River, between Fort Atkinson and Jefferson; Crawfish River, Aztalan, Jefferson Co. (Cahn).

REMARKS: As remarked by Ortmann (1919, p. 75) this mussel has been misunderstood by most authors. Simpson made it a synonym of *coccineum* with which it is indeed closely related. Call's figure of *coccineum* (1900, pl. 56) represents *catillus* better than it does *coccineum*. Ortmann's figure 6 appears to be typical and very near the original figure of Conrad.

Catillus is a modification of the *coccineum* type of shell and it is not surprising that authors have been perplexed over its true position and relationship. It appears like a shortened-up, wider *coccineum*, which it probably is. In the Rock River in Wisconsin there is an almost perfect gradation from the flat *compressum* type to the wider *catillus* type. From *solida*, into which it also grades, it is separated by its less inflated umbones, more compressed and more elongated shell. The Rock River form is peculiar in the exaggerated elongation of the posterior end which causes the umbones to appear to almost overhang the anterior edge of the shell in old specimens (see fig. 1, pl. LV). Material from Crawfish River, as well as from Rock River, contain a small number of *solida*-like individuals. Young shells are like Conrad's figure and dimensions.

PLEUROBEMA COCCINEUM SOLIDA (Lea). Small Niggerhead

Plate LII; Plate LIII, figure 6

Unio solidus LEA, Trans. Amer. Phil. Soc., VI, p. 13, pl. v, fig. 13, 1838; Obs., II, p. 13, pl. v, fig. 13, 1838.

Quadrula solida SIMPSON, Cat., p. 885, 1914 (part).

Pleurobema obliquum catillus ORTMANN, Mem. Carnegie Mus., VIII, p. 75, 1919 (part).

TYPE LOCALITY: Ohio River at Cincinnati; Mahoning River, Ohio (Lea).

WISCONSIN RECORDS:

1860. *Unio obliquus* LAPHAM, p. 156. Wisconsin River.

1900. *Quadrula solida* SIMPSON, p. 789 (part). Wisconsin.

1900. *Quadrula pyramidata* SIMPSON, p. 790 (part). North in the Mississippi to Wisconsin.

1905c. *Quadrula obliqua* BAKER, p. 256. Prairie du Chien.

1906. *Quadrula pyramidata* CHADWICK, p. 97. North in the Mississippi to Wisconsin.

1906. *Quadrula solida* CHADWICK, p. 96. Wisconsin River.
 1914. *Quadrula solida* SIMPSON, p. 885. Wisconsin.
 1914. *Quadrula pyramidatum* SIMPSON, p. 889. Prairie du Chien.
 1919. *Pleurobema obliquum* ORTMANN, p. 73 (part). Wisconsin.

SHELL: Differing from *catillus* in being more inflated, with higher and more inflated umbones, the shell squarish or roundly oblique, the anterior end rounded, the posterior end squarely truncated; there is sometimes an indication of a radial furrow in front of the posterior ridge; young shells rayed and adult specimens sometimes rayed on the umbones; hinge much more massive than *catillus*, the interdentum wider, the pseudocardinals more massive and ragged, the laterals shorter, wider, more massive, slightly curved or straight and more directly bent toward the base of the shell than in *catillus*; whole shell massive and heavy; old specimens have the posterior end much elongated, producing a striking oblique appearance.

- L. 103; H. 78; D. 51 mm. 49% Kilbourn (U. of W., 863).
 L. 95; H. 72; D. 46 mm. 48% Wisconsin River (U. of W., 51).
 L. 81; H. 73; D. 51 mm. 63% Sauk Co. (U. of I., Z5512).
 L. 75; H. 68; D. 43 mm. 57% " (").
 L. 62; H. 60; D. 43 mm. 69% Kilbourn (U. of W., 864).
 L. 35; H. 36; D. 25 mm. 71% " (" 865).
 L. 77; H. 64; D. 46 mm. 59% Prairie du Chien (Chi. Acad. Sci., 20279).

ANIMAL (Fig. 221): Supra-anal larger than anal opening, separated by a small mantle connection which was not found absent in Wisconsin specimens; branchial opening with papillae; anal opening with crenulations which are very much like papillae; palpi rather short, the posterior margins connected for half their length or more. Gills long, broad, inner lamina of inner gills free from the abdominal sac; outer gills only marsupial, the marsupium swelling but little when gravid. Ovisacs compressed, lanceolate. The white placentae are well developed and leaf-like in shape. They are permanent and discharged whole. Color of animal grayish or yellowish-white, the openings edged with brown, gills brownish and foot flesh color.

Glochidia (of *solida*, pl. XXXI, fig. 13) resembling *Fusconaia ebena*, semi-circular in form, hinge line long and nearly straight. Length 0.16, height 0.16 mm. (Surber, 1912, p. 10); 0.145 to 0.155 by 0.155 to 0.160 mm. (Howard, 1914a, p. 23).

BREEDING SEASON: May (Surber, 1912, p. 7); May, June. White River, Arkansas, specimens contained eggs on August 2 and 5, 1914 (Ortmann, 1919, p. 75). None found gravid in Wisconsin in July.

NATURAL HOST (*solida*): Sunfish (*Lepomis pallidus*) gill infection (Surber, 1913, p. 113.

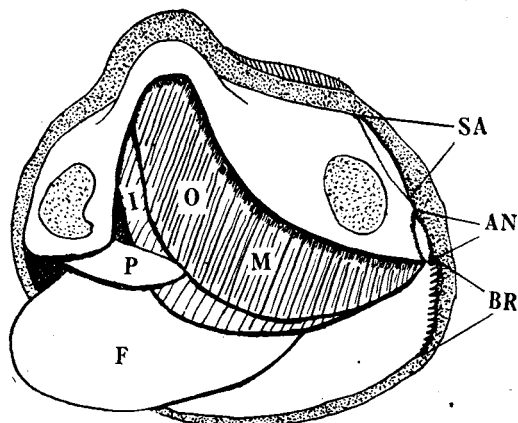


Fig. 221. *Pleurobema coccineum solida* (Lea). Lower Dells of Wisconsin River, Kilbourn. Sterile female. July 18, 1922.

ECOLOGY: *Solida* is a naiad of medium sized rivers and is found usually in rather deep water (1-3 m.) on a sand, gravel or mud bottom. In the Wisconsin River it occurred in water 2 m. deep on a sandy-mud bottom.

GENERAL DISTRIBUTION: This variety has been seen from the states bordering the Mississippi and Ohio rivers; also in the Wisconsin, Illinois, Rock and Iowa rivers, and smaller tributary streams near the larger streams. Specimens from Arkansas and other parts of the southwestern states appear somewhat different (smaller with prominent umbones) and should probably be separated as a local variety.

DISTRIBUTION IN WISCONSIN: *Solida* has been found only in the Wisconsin and Mississippi rivers.

REMARKS: In the Wisconsin River the *solida* are likely to be confused with *undata*, but may be at once distinguished by the much heavier hinge and wide interdentum, the whole hinge-plate being different; the shell is also rounder and more oblique. Lea also noted this resemblance in his original descrip-

tion of *solida*. There is great variation in *solida*, from the more quadrate type resembling *catillus* to the most pronounced oblique form which resembles *obliquum*. The Wisconsin River specimens are the largest seen, old specimens being more than double the size of Lea's specimen figured, which was probably not fully mature.

We cannot agree, with Ortmann that *solida* is completely synonymous with *catillus*. It is a heavier, wider, usually more oblique shell, with the umbones usually placed nearer the anterior end, and the umbonal region is more globose. Other differences have been pointed out in the diagnosis. Conrad's and Lea's shells represent two types of mussels, apparently ecological, and they should be recognized as such. The Wisconsin River shells vary toward *catillus*, not being as oblique as the form which is found nearer the Mississippi and also in that stream. The young and immature specimens more nearly resemble *solida*. Two color forms have been noted in the Wisconsin River; one with chestnut-colored epidermis with rather distinct rays, especially notable in young individuals; and the other glossy black or very dark brown without rays. The first live on gravel and sand and the latter on mud bottom. Very old specimens of *solida* from Sauk Co., Wisconsin River, have a slight radial furrow in front of the posterior ridge and these resemble somewhat Barnes' *undata* which lives in association with *solida*.

PLEUROBEMA COCCINEUM MISSISSIPPIENSIS Var. Nov.

Plate LIII, figures 1-5

TYPE LOCALITY: Lake Pepin, Mississippi River.

WISCONSIN RECORDS:

- 1922a. *Pleurobema catillus* GRIER, pp. 11-31. Lake Pepin and Mississippi River.
1922. *Pleurobema pyramidatum* GRIER and MUELLER, pp. 23, 96. Lake Pepin.

SHELL: Differing from *solida* in being markedly trigonal, inequiptartite, and oblique, with higher, narrower, more pointed umbones which are strongly directed forward and incurved over the lunule, and are so near the anterior margin as to be parallel with it in the most typical forms; anterior margin sharply truncated, rounding into the convex basal margin; posterior margin pointed, plough-shaped; there is a slight in-

dication of a radial furrow in front of the more or less distinct posterior ridge and also one posterior of this in a few specimens; hinge more massive than *solida*, the interdentum very wide and flat, the laterals short, thick, and sharply directed toward the base of the shell; cavity of the beaks entirely obliterated.

L. 62; H. 66; D. 47 mm. 75%	Lake Pepin (U. of I., Z14019) Type.
L. 53; H. 55; D. 37 mm. 69%	" (" Z14023) Paratype.
L. 55; H. 56; D. 39 mm. 71%	" (" Z14020) Male.
L. 52; H. 52; D. 36 mm. 69%	" (" Z14021) Female.
L. 48; H. 48; D. 33 mm. 68%	" (" Z14022) Male.
L. 36; H. 38; D. 22 mm. 61%	" (U. of W., 726) Immature.

ANIMAL: Not examined. Probably the same as *catillus* and *solida*.

ECOLOGY: In the largest rivers on sand, gravel, and mud bottoms, in fairly deep water with good current.

GENERAL DISTRIBUTION: Upper Mississippi River and Lake Pepin.

DISTRIBUTION IN WISCONSIN. Not known outside of the Mississippi River.

REMARKS: The variety herein named *mississippiensis* is liable to be confused with *Fusconaia undata wagneri*, both being of about the same size and general shape and both living in Lake Pepin. *Wagneri*, however, has less massive hinge teeth which are of a different shape and there is a more distinct furrow in front of the posterior ridge.

This variety marks the culmination of variation in *coccineum*, the shell being reduced in size, greatly increased in height as compared with length, the umbones reduced in size, pointed, and markedly directed forward; it is also very oblique and the umbones have migrated toward the anterior margin. The hinge has also increased notably in massiveness. The Lake Pepin shells vary greatly among themselves, some specimens greatly resembling immature forms of *solida* (pl. LIII, fig. 5). The typical form (pl. LIII, fig. 1) greatly resembles *pyramidatum* and these were so identified by Grier (1922a, p. 23). The Fairport Laboratory kindly submitted these shells for study (pl. LIII, figs. 1, 2, 3, 5). They had been identified at the Laboratory as *solida*, which they most nearly resemble. Other references to *pyramidatum* and *obliquum* from the Mississippi may have been founded on this type of shell. A shell in the

Hinkley collection (U. of I., Z5510) is in a measure intermediate between *mississippiensis* and *solida*, resembling fig. 2 on pl. LIII (L. 61; H. 63; D. 41 mm. 67%), though nearer the former than the latter. This specimen indicates that the change in form begins before Lake Pepin is reached. The *solida* collected near Prairie du Chien are referable to the typical form and not *mississippiensis* (pl. LIII, fig. 6). These latter, however, begin to show the lengthening of the posterior lower angle so characteristic of the new variety.

A small form of *solida* occurs in Arkansas which might be distinguished as a geographic race. It is smaller than the form herein called *solida*, the umbones are very large and high and the shell is slightly trigonal. This variation was collected abundantly by Hinkley at Cotter, Ark. Many specimens are intermediate between *catillus* and *solida*.

The naiad group herein assembled under the species name *coccineum* is one of the best examples of the law of river distribution as well as of the law of evolutionary development as influenced by environment. There is a perfect and unbroken range of variation from the small creeks to the great rivers. This may be summarized as follows:

Small creeks and streams. 35% *Coccineum*, compressed. Mukwonago River.

Small rivers. 40% *Coccineum*. Kankakee River.

Medium sized rivers. 53% *Coccineum catillus*. Rock R. Jefferson Co.

Large rivers. 60% *Coccineum solida*. Wisconsin River and Mississippi River.

Largest river and lake. 70% *Coccineum mississippiensis*. Lake Pepin.

The course of evolution from the small to the large stream is seen to be a relative increase in diameter, a shortening of the shell and an increase in height, an increase in size and elevation of the umbones, and an increase in size and massiveness of the hinge. There is a size curve beginning with the small flat form, passing to the large *solida* of the Wisconsin River, and returning to a small size in the upper Mississippi River.

Genus ELLIPTIO Rafinesque, 1819

SHELL inequipartite, ovate or elongated, rounded in front and pointed or biangulate behind, with a more or less developed posterior ridge, often becoming slightly arcuate when old;

beaks only moderately full, generally sculptured with coarse ridges, which run parallel with the growth lines or are somewhat double looped, sometimes broken and showing fine radiating lines behind; surface smooth, slightly concentrically ridged or pustulous; epidermis generally rather dull colored, rayless or fully rayed; hinge-plate narrow, two pseudocardinals and two laterals in the left valve and one pseudocardinal and one lateral in the right valve, with rarely a vestige of a second lateral; cavity of the beaks not deep or compressed. Marsupium occupying the whole length of the outer gills only, forming a thick, smooth pad when filled with young. (Walker).

Section ELLIPTIO sensu stricto

SHELL elongated, rhomboid or oval, usually more or less biangulate behind; beak sculpture consisting of a few rather strong ridges, which are nearly parallel with the lines of growth or slightly double looped; the surface smooth or feebly corrugated (Walker). Type: *Unio crassidens* Lam.

ELLIPTIO DILATATUS (Raf.). Spike; Lady-Finger

Plate LV, figures 4, 5

Unio dilatata RAF., Ann. Gen. Sci., Phys., Brux., V, p. 297, 1820.

Unio gibbosus BARNES, Amer. Jour. Sci., VI, p. 262, pl. xi, fig. 12, 1823.

Unio mucronatus BARNES, Amer. Jour. Sci., VI, p. 266, pl. 13, fig. 13, 1823.

Unio gibbosus SIMPSON, Cat., p. 597, 1914.

Elliptio dilatatus ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 30, 1922.

TYPE LOCALITY: Ohio River (Raf., *dilatatus*); inhabits the Wisconsin (Barnes, *mucronatus*); Wisconsin (Barnes, *gibbosus*).

WISCONSIN RECORDS:

1823. *Unio gibbosus* BARNES, p. 262. Wisconsin.

1823. *Unio mucronatus* BARNES, p. 266. Wisconsin River.

1852. *Unio dilatatus* LAPHAM, p. 51. Wisconsin.

1860. *Unio gibbosus* LAPHAM, p. 156. Milwaukee.

1897. *Unio gibbosus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Unio gibbosus* BAKER, p. 255. Prairie du Chien.

1906. *Unio gibbosus* CHADWICK, p. 95. Milwaukee; Two Rivers and mill pond at Hika, Manitowoc Co.; Prairie du Chien and De Soto, Crawford Co.

1914. *Unio gibbosus* SIMPSON, p. 597. Wisconsin.

1914. *Unio gibbosus* WILSON and DANGLADE, p. 20. Lake Pepin.
 1922a. *Elliptio dilatatus* GRIER, pp. 11-31. Pierce, Pepin, Buffalo Co.
 1922. *Elliptio dilatatus* GRIER and MUELLER, p. 97. Lake Pepin.
 1926. *Elliptio dilatatus* GRIER and MUELLER, pp. 16, 23. Lake Pepin and Mississippi River.
 1927d. *Elliptio dilatatus* BAKER, p. 107. Rock Co.

SHELL: Elongated, heavy, thick, usually compressed, sometimes slightly inflated, markedly inequipartite; beaks depressed, flattened, turned slightly forward over a conspicuous lunule; beak sculpture of 4-5 well developed bars, running parallel with the growth lines, the earlier ones somewhat double looped; anterior end broadly rounded; posterior end sharply pointed and often compressed; ventral margin broadly convex in young shells, straight or arcuate in older shells; dorsal margin slightly curved, descending abruptly posteriorly and ending in a sharp biangulation; posterior ridge strongly developed, more or less angular; it is sometimes double, accentuating the post-basal biangulation; surface roughened by concentric growth lines, more or less uneven; epidermis black or brown in old specimens, greenish or yellowish-green in young specimens, often slightly rayed.

Pseudocardinals triangular, compressed, sulcated; right valve with two additional cusps above the pseudocardinals; laterals heavy, wide, rough, the single right lateral sometimes double; interdentum narrow, smooth; beak cavities shallow, often scarcely indicated; dorsal scars distinct, in beak cavities; adductor scars impressed at both ends of shell; pallial line impressed; nacre varying from white, through salmon, to deep purple, iridescent posteriorly. No sexual difference in form of shell.

- L. 122; H. 57; D. 39 mm. Kilbourn (U. of W., 875).
 L. 115; H. 51; D. 33 mm. Prairie du Chien (U. of W., 876).
 L. 97; H. 50; D. 31 mm. Hudson (U. of W., 877).
 L. 97; H. 53; D. 35 mm. Lake Pepin (U. of W., 352c).
 L. 84; H. 44; D. 28 mm. Rock River (U. of W., 14).
 L. 72; H. 38; D. 24 mm. Lake Pepin (U. of W., 352n).
 L. 62; H. 36; D. 23 mm. Lake Pepin (U. of W., 353).
 L. 53; H. 25; D. 13 mm. Kilbourn (U. of W., 878).
 L. 37; H. 16; D. 7.5 mm. Kilbourn (U. of W., 879).

ANIMAL: (Fig. 222, of *delicatus*). Not differing essentially from *crassidens*. The narrow mantle connection between anal and supra-anal openings is absent in rare cases;

the anal opening is distinctly papillose; palpi short and wide, connected at their bases for about two-thirds of their length; color of animal whitish or grayish, the mantle edged with black on the posterior portion; pericardium reddish brown. Only the outer gills act as marsupia, the eggs and glochidia being white in color.

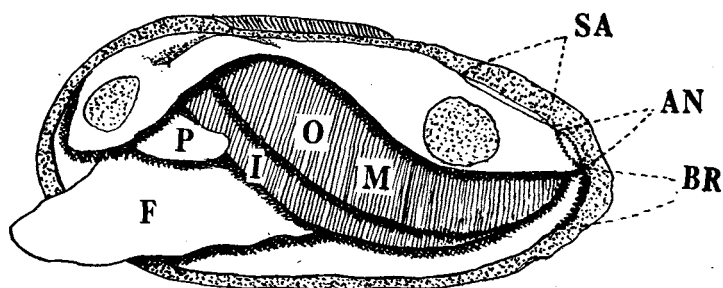


Fig. 222. *Elliptio dilatatus delicatus* (Simpson). Omro, Fox River. Sterile female. Aug. 3, 1920.

Glochidia (pl. XXXI, fig. 15), small, suboval or semicircular; hinge line long and nearly straight. Length 0.200, height 0.215 mm. (Surber). Ortmann's measurements are 0.20 by 0.22 mm.

BREEDING SEASON: Middle of May to August (Ortmann, 1919, p. 96). Tachytictic.

NATURAL HOST: Not observed.

ECOLOGY: A species with a wide range of habitats. In the Wisconsin River at Kilbourn it occurred on a mud and sand bottom; Lake Pepin, gravel, sand, and mud bottom. Depth varies from .3–2 m. at Kilbourn and even deeper water in Lake Pepin. Current sluggish to seven or eight miles per hour.

GENERAL DISTRIBUTION: Entire Mississippi drainage; St. Lawrence and its tributaries; Alabama River system; Southeast into Florida; Southwest to the Guadalupe River, Texas (Simpson). A wide range, including, however, several races in the south.

DISTRIBUTION IN WISCONSIN: Typical *dilatatus* has a wide range in Wisconsin, though it is mostly confined to the large rivers. It has crossed over into the Lake Michigan drainage in several places. Its presence in the small streams in the

southeastern part of the State is noteworthy, and may be due to the old Chicago outlet (see Baker 1920d).

REMARKS: This mussel, long known as *gibbosus* Barnes and now changed by the law of priority to *dilatatus* Raf., is one of the most abundant and widely distributed naiads in the State. It may easily be distinguished by its elongated shape and purple nacre. It might be confounded with *Ligumia recta latissima*, if care is not taken to compare the pseudocardinals which are not as heavy and are of different shape in *latissima*. The general shape and color of the two species is quite different.

Dilatatus is variable in form, young shells having a rounded ventral margin while old shells are usually arcuate ventrally. The nacre varies from white often tinged with pink, to very dark purple, and this variation may occur in the same habitat. Immature specimens are more or less distinctly rayed. On account of the purple nacre, these shells are of little commercial value to the button manufacturers. The texture of the shell is excellent, rendering cutting easy, but the color offsets this favorable quality. It is used, however, for making smoked buttons and for novelties.

Dilatatus conforms to the law of stream distribution in the same manner as recorded for *undata*, *costata*, *catillus*, etc. The typical form, common in the Ohio, Mississippi, and lower parts of the Wabash, Illinois, and Rock rivers, is very thick and heavy, particularly swollen in the umbonal region, and with the umbones placed rather near the anterior end; the adult shell is also nearly always arcuate. Another form, which is characteristic of the medium sized rivers, Wisconsin, Rock, Illinois, etc., is more elongated, the posterior end is more pointed and the hinge is not as massive. This is the *gibbosus* of Barnes, the type of which came from the Wisconsin River. The third variety is the delicate form called *delicatus* by Simpson. The lake form, *sterkii*, adds a fourth variety. We believe the variations of this species might be distinguished as follows:

Large river form, *Elliptio dilatatus* (Raf.).

Medium river form, *Elliptio dilatatus gibbosus* (Barnes).

Creek form, *Elliptio dilatatus delicatus* (Simpson).

Lake form, *Elliptio dilatatus sterkii* Grier.

The *dilatatus* from the streams flowing into Lake Michigan are not referable to the creek form, as would be supposed, but

to the large river form. The presence of these typical *dilatatus* in the small streams in eastern Wisconsin is to be accounted for by their post-Glacial migration from old Wilmette Bay, Glacial Lake Chicago, whence the form had migrated from the Illinois via the old Desplaines outlet. (See Baker, 1920d). These *dilatatus* are not as heavy as the Mississippi River form, resembling more closely the specimens from the Wisconsin River. The original specimens on which the records were based have been examined.

ELLIPTIO DILATATUS DELICATUS (Simpson). Delicate Spike

Plate LVI, figures 7, 8; plate LVII, figures 1, 2

Unio gibbosus var. *delicatus* SIMPSON, Syn., p. 704, 1900; Cat., p. 600, 1914.

TYPE LOCALITY: Greenway, Clay Co., Arkansas (Simpson).

WISCONSIN RECORDS:

1906. *Unio gibbosus delicatus* CHADWICK, p. 95. Fox River, near Big Bend, Waukesha Co.; Beasley Brook, She-she-pe-comeo Park, Waupaca Co.

1924. *Elliptio dilatatus* BAKER, p. 133. Omro, Fox River.

1924. *Elliptio dilatatus delicatus* BAKER, p. 133. Omro, Fox River.

1927d. *Elliptio dilatatus delicatus* BAKER, p. 107. Bark River, Dousman; Rock River, Ashippun to Ft. Atkinson.

SHELL: Simpson (1914, p. 600) diagnoses this variety as "shell subsolid or rather thin, subcompressed or compressed, subrhomboid or almost evenly elliptical, never arcuate. More delicate than the type."

L. 98; H. 43; D. 32 mm. Crawfish River (U. of W., 1884).

L. 86; H. 38; D. 21 mm. Princeton (U. of W., 744).

L. 78; H. 40; D. 22 mm. Red Cedar River (U. of W., 880).

L. 79; H. 36; D. 20 mm. Racine (U. of W., 45).

L. 75; H. 35; D. 22 mm. Omro (U. of W., 881).

L. 64; H. 29; D. 16 mm. Marinette (U. of W., 778).

L. 48; H. 22; D. 11 mm. Marinette (U. of W., 780).

ANIMAL: See *dilatatus*.

ECOLOGY: A form of the smaller rivers. Found under following conditions, in places mentioned. Omro, Fox River, 3 m. deep, gravel bottom in channel, also mud bottom in shallow water near shore; outlet creek, Green Lake, sand bottom, water .3-.6 m. deep, in riffles; Moose Ear Creek, Barron Co., sand and gravel bottom, riffles, shallow water, shells in sand

bars; Red Cedar River, west of Chetek, in riffles on sand and gravel bottom, shallow water, buried deeply in sand bars. Difficult to dig from bottom with hands. In Mukwonago River on gravel bottom, swift current, water .3–.6 m. deep.

GENERAL DISTRIBUTION: Widely distributed in the Mississippi Valley and into Michigan (Simpson). It is probably coincident with *dilatatus* in range.

DISTRIBUTION IN WISCONSIN: This form is a mussel of shallow rivers. It is widely distributed in the Chippewa, Fox, Rock, Menomonee, and some of the other smaller rivers. It seems equally common in both the Mississippi and St. Lawrence drainages.

REMARKS: The *dilatatus* of Wisconsin divide naturally into two groups. One, the typical form, has a heavy, more or less arcuate shell, with massive hinge teeth, in which the laterals bend somewhat ventrally, and with a rather wide interdentum. The other, named *delicatus* by Simpson, has a delicate shell usually compressed or flattened on the sides, is seldom arcuate, and the hinge teeth are delicate, the laterals nearly straight or parallel with the dorsal margin, and the interdentum is reduced to a mere remnant or is absent. While there are some intermediate stages, as would be expected in a variety, this form on the whole is quite consistent and easily recognized. Ecologically, the heavy form is characteristic of the large rivers while the delicate form inhabits the smaller rivers and creeks. It is the delicate type that is often confused with *Ligumia recta*, having the same general shape, but differing altogether in the form of the hinge and in the umbonal markings. The nacre is usually shades of purple, but occasional specimens occur which are white tinged with purple or salmon. Sometimes the nacre is of a dull copper color. While the majority of *delicatus* have a pointed posterior end, not a few occur which are slightly arcuate, though not as much so as in the typical form. The epidermis is rarely faintly rayed.

Specimens from Crawfish Creek, near Aztalan, Jefferson Co., are very cylindrical and not compressed as in typical *delicatus*, the nacre is whitish with light lavender suffused about the posterior end. These specimens greatly resemble *Ligumia recta latissima*, differing, however, in the form of hinge and markings of the umbones (pl. XIX, figs. 1, 2). In Rock River, be-

low Jefferson, some forms resemble typical *dilatatus*, showing the influence of the increased size of the river.

Delicatus from the vicinity of Chetek, Barron Co., in the Red Cedar River, and other places near by, show great variation, although clearly the delicate form and not the heavy river form. The shells vary from cylindrical to compressed, in some cases much elongated with a long, pointed posterior end. The color ranges from white tinged with pinkish to deep purple. Young specimens are distinctly rayed. Barnes' figure of the exterior of his *gibbosus* (1823, pl. 11, fig. 12) well illustrates this elongated cylindrical form, which has an extended anterior end. The interior figure, however, shows the heavy hinge structure and not the light hinge of *delicatus*, and his description (p. 262) is undoubtedly of the heavy, large river form. See, however, under *dilatatus*.

ELLIPTIO DILATATUS STERKII Grier. Sterki's Spike

Plate LVI, figures 3-6

Elliptio dilatatus var. *sterkii* GRIER, Nautilus, XXXII, p. 9, 1918.

Elliptio dilatatus sterkii ORTMANN, Mem. Carnegie Mus., VIII, p. 101, pl. viii, fig. 3, 1919.

Elliptio dilatatus sterkii GRIER, Ann. Carnegie Mus., XIII, p. 169, 1919.

TYPE LOCALITY: Lake Erie, Presque Isle Bay, Lake Erie Co., Pa. (Grier).

WISCONSIN RECORDS:

1922. *Elliptio gibbosus sterkii* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

1924. *Elliptio dilatatus sterkii* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: *Sterkii* may be distinguished from the typical form by its smaller size, rather swollen shell as compared with its length, ventral and dorsal margins nearly straight, umbones placed nearer the anterior end, epidermis smooth, almost polished, olive green or yellowish to reddish-brown, rarely black. The nacre is usually lavender, reddish-purple or light bluish. Hinge very delicate.

L. 66; H. 29; D. 19 mm. Winnebago Lake (U. of W., 882).

L. 54; H. 25; D. 17 mm. " " (" 883).

L. 56; H. 30; D. 20 mm. " " (" 884).

L. 57; H. 33; D. 18 mm. " " (" 885).

L. 47; H. 28; D. 20 mm. " " (" 886).

ANIMAL: As in *dilatatus*. Gravid (eggs) in July and August in Lake Winnebago.

ECOLOGY: Off Stony Point and Roe Point, 2-3 meters, gravel and cobble bottom; off Far Rockaway Point, 3 meters, gravel bottom, three-fourths mile from shore; one-fourth mile east of mouth of Fox River, 3 meters, gravel and sand bottom.

GENERAL DISTRIBUTION: Lake Erie, Lake St. Clair, and Lake Winnebago.

DISTRIBUTION IN WISCONSIN: Whole of Lake Winnebago (Baker) and lower Fox River (Marston).

REMARKS: *Sterkii* is a recognizable variety of *dilatatus*, produced by lake conditions, hence an ecological form. The Winnebago Lake specimens do not differ materially from the Lake Erie specimens. A study of the *dilatatus* material from Wisconsin would seem to indicate that *sterkii* is an offshoot of the form called *delicatus*. The *dilatatus* of the Fox River are all of the compressed, delicate type, and not the heavy river type. Hence the Lake Winnebago form must have descended from the Fox River type, as this stream empties directly into Lake Winnebago. The Lake shells have a tendency to assume the arcuate form of typical *dilatatus*, only in a much reduced size. These are old shells. The *dilatatus* from Lake Pepin bear a superficial resemblance to *sterkii*, as noted by Grier (1926, p. 23). The Mississippi River form, however, is distinct from *sterkii*, and is typical *dilatatus*.

ELLIPTIO CRASSIDENS (Lamareck). Elephant's Ear

Plate LVII, figures 3-5

Unio crassidens var. b, LAM., An. sans Vert., VI, p. 71, 1819.

Unio crassidens HANLEY, Biv. Shells, p. 184, pl. xx, fig. 46, 1843.

Unio crassidens SIMPSON, Cat., p. 606, 1914.

Elliptio crassidens ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 28, 1922.

Unio cuneatus BARNES, Amer. Jour. Sci., VI, p. 263, 1823.

TYPE LOCALITY: Erroneously given as "Lake Erie" (Lamareck, *crassidens*); Inhabits the Ohio (Barnes, *cuneatus*).

WISCONSIN RECORDS:

1905. *Unio crassidens* WAGNER, p. 97. Fossil at Green Bay.

1905c. *Unio crassidens* BAKER, p. 255. Prairie du Chien.

1906. *Unio crassidens* CHADWICK, p. 95. Between Prairie du Chien and De Soto; fossil at Green Bay.

1922a. *Elliptio niger* GRIER, pp. 11-31. Pierce, Trempealeau Co.

SHELL: Very heavy, solid, thick, convex, somewhat compressed in the center of the valve, subrhomboid; umbones flatly depressed, only slightly elevated above the hinge line, their sculpture of 2-3 coarse ridges parallel with the growth lines; anterior end sharply rounded; posterior end obliquely truncated; basal margin convex in young specimens, almost straight or incurved in old specimens; dorsal margin slightly curved; posterior ridge prominent, often sharply angular, ending at the posterior end in a distinct biangulation or even a sharp point; surface with heavily marked growth lines giving the shell a rough aspect, sometimes wrinkled posteriorly; the young shells are smooth and polished; epidermis thick, reddish-brown or chestnut to black; young shells are yellowish-green with many green rays.

Pseudocardinals divergent, triangular, heavy, tubercular rather than serrated; laterals large, heavy almost straight, serrated; adductor muscle and other scars well impressed; pallial line impressed, roughened or crenate; nacre salmon, purplish, rarely white or pale violet. No sexual difference in shells.

L. 112; H. 70; D. 45 mm. Prairie du Chien (Bullock, U. of W., 887).

L. 82; H. 49; D. 30 mm. " " " (Dudley).

ANIMAL: (Fig. 223). Anal and supra-anal openings separated by a small mantle connection; branchial opening large with numerous rather small papillae; anal opening also large

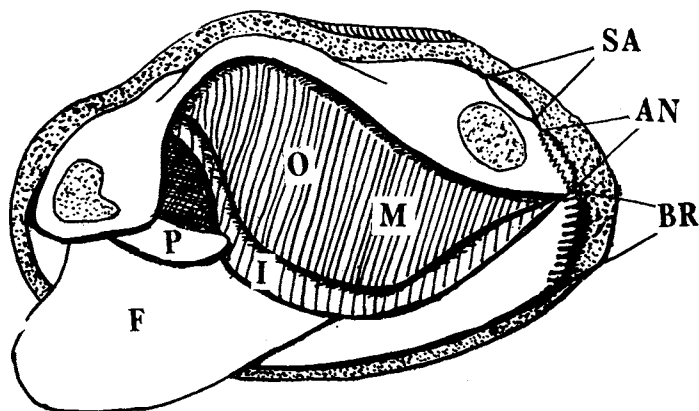


Fig. 223. *Elliptio crassidens* (Lam.). Prairie du Chien. Sterile female.

with many short papillae; palpi rather small, the posterior margins connected for but a short distance; gills large, the inner lamina of inner gill free from the abdominal sac; outer gills only marsupial, moderately distended when gravid, the placenta lanceolate as in *Plethobasus*. General color of animal whitish, the mantle edges at the siphonal openings black or brown; gills brownish.

Glochidia (pl. XXXI, fig. 16) subtriangular, ventral margin pointed; hinge line long, evenly curved; depth greater than length. Length 0.150, height 0.160 mm. (Surber).

BREEDING SEASON: June and July, tachytictic (Ortmann, Surber).

NATURAL HOST: Not recorded.

ECOLOGY: A species of large rivers where it is found on a gravel, stony, or shell bottom in rapid current, in rather deep water, 2 m. or more.

GENERAL DISTRIBUTION: Mississippi drainage generally; Alabama and Tombigbee rivers; southeast to Chattahoochee River (Simpson).

DISTRIBUTION IN WISCONSIN: Confined, apparently, to the Mississippi River. Possibly ascends the lower part of the Wisconsin River.

REMARKS: *Crassidens* is easily known by its heavy, subrhomboid shell, massive hinge teeth and purplish color of nacre. Its nearest relative is *Elliptio dilatatus* which has a more elongated shell of quite different shape with a dark purple nacre, rarely white in Wisconsin specimens. As in the case of *dilatatus*, *crassidens* is of little value as a button shell on account of its colored nacre.

A specimen referred to *crassidens* was found in Pleistocene deposits in Green Bay City (see Wagner, 1905, p. 97) during excavations for the city reservoir. It was found 15 feet below the surface. It is rather less elongated and higher than most Mississippi River specimens, the single left valve measuring length 91 mm., height 70 mm. (U. of W., 248; see pl. XXXV, fig. 4). This species possibly migrated up the Wisconsin-Fox rivers to Green Bay during an early stage of Glacial Lake Chicago, possibly the Bowmanville Stage (see Baker, Life of Pleistocene, p. 118). *Crassidens* is also found in the Wilmette Bay deposits of Glacial Lake Chicago, and these specimens resemble the Green Bay shell more than do the recent speci-

mens from the Mississippi River. It is possible that the Wisconsin fossil found its way to Green Bay by way of Lake Michigan instead of the Wisconsin-Fox outlet, by means of fish during the glochidial stage. The species does not now live in either the Fox or Wisconsin rivers. The Green Bay deposits should be given careful study to ascertain the character of the other mollusks (or fauna) present.

ELLIPTIO COMPLANATUS (Dillwyn)

Plate LVI, figures 1, 2

Mya complanata SOLANDER, Manuscript (no date); Dillwyn, Cat., I, p. 51, 1817.

Unio complanatus SIMPSON, Cat., p. 651, 1914.

Elliptio complanatus ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 30, 1922.

TYPE LOCALITY: Maryland and New Jersey.

WISCONSIN RECORDS: None.

SHELL: rhomboidal or subtrapezoidal, rather solid, about twice as long as high, rather compressed; anterior end rounded; posterior end obliquely truncated, pointed near the basal margin which is straight or slightly convex; dorsal margin straight, usually forming a sharp angle with the posterior margin; posterior ridge more or less sharply developed, ending below in a distinct biangulation; beaks depressed or only slightly raised above the hinge line, their sculpture of 5-6 ridges, the first 2-3 of which are subconcentric, the others being subparallel with the growth lines, curving up in front and behind; surface marked only by growth lines which may be very rough in old shells; epidermis yellowish or greenish in young shells, which are often rayed, brown or black in old shells.

Hinge well developed but not strong; pseudocardinals rather small, but massive, divergent, flatly pyramidal, sulcated, the pseudocardinals in right valve the larger; laterals long, slight, usually straight or but slightly curved; interdentum very narrow or absent; beak cavities very shallow, containing dorsal muscle scars; adductor and other scars well impressed; nacre varying from white, through pink or salmon to bluish or purple, sometimes with coppery iridescence. No sexual difference in the shell.

- L. 95; H. 52; D. 29 mm. Lake Superior (U. of W., 10).
L. 60; H. 33; D. 16 mm. Red Cliff Creek (U. of W., 888).
L. 58; H. 32; D. 17 mm. Red Cliff Creek (U. of W., 889).

ANIMAL: Anal and supra-anal openings separated by a connection shorter than the anal opening; branchial opening with large papillae; anal opening with fine papillae; posterior margins of palpi connected but a short distance; inner gill wider than outer gill; inner lamina of inner gill attached only at anterior end; septa and water tubes well developed, wider in the male. Outer gills of female marsupial, the septa crowded. In the gravid condition the gills swell but slightly, the edge is sharp, and the ovisacs and placentae become leaf-like in form. Soft parts grayish-white, foot and gills of a darker hue; gills slightly black posteriorly; openings edged with dark brown or black.

Glochidia always white, hookless, longer than high, subovate, and rather small. They resemble *Elliptio dilatatus* in form. Length 0.20 mm., height 0.19 mm. (Ortmann).

BREEDING SEASON: Last of April to middle of May.

NATURAL HOST: Not recorded.

ECOLOGY: In Wisconsin, in creeks and small rivers on a mud bottom in comparatively shallow water. In other places in quiet or running water and on sand, gravel, and mud bottom. A species, apparently, that has no ecological preferences. It is not, however, a species of large rivers.

GENERAL DISTRIBUTION: Atlantic drainage from St. Lawrence to Georgia. West in British Provinces to Manitoba (Simpson).

DISTRIBUTION IN WISCONSIN: Found only in the Lake Superior Region. Red Cliff Creek, Bayfield Co. (Baker); Duluth, Minn. (Walker); Lake Superior (Marston coll).

REMARKS: *Complanatus* is not easily confused with any other Wisconsin mussel. It is more rhomboid or subtrapezoidal than *Elliptio dilatatus*, is more compressed, and the hinge is lighter. The nacre is also very different. Specimens might be confused with *Lasmigona costata* or *compressa*, but the presence of lateral and pseudocardinal teeth will at once separate the present species from any member of *Lasmigona*.

This species is very rare in Wisconsin, being known definitely from but two places in the west end of Lake Superior. The distribution of *complanatus* is one of the most interesting of

our fresh water species. It is an eastern species that has migrated in post-glacial time into Georgian Bay and Lake Huron by way of the old Trent outlet during the Algonquin Stage of the Great Lakes (see Baker, 1920d, pl. 52). It has gradually spread westward until it is now found in Georgian Bay, Lake Huron, and the full length of Lake Superior (Walker, 1913, p. 30, map). It has but recently been found in the western part of Lake Superior. It is common in places in the northern peninsula of Michigan.

The Wisconsin specimens collected are very small as compared with the normal size as found in New York State and elsewhere in the east. Not enough material is at hand to determine whether this small size is a small variety or whether the specimens collected are immature. Much more material is desirable. At the Bayfield locality, Red Cliff Creek, the species was very rare, but two individuals being found in a day's search in this creek. A specimen of normal size is in the Marton collection labelled Lake Superior.

UNIONINAE ERRONEOUSLY REFERRED TO WISCONSIN

There are several species of Unioninae that have been listed from the State that have been based on misidentifications. These are mentioned below.

FUSCONAIA KIRTLANDIANA. (Lea)

Quadrula kirtlandiana SIMPSON, Cat., p. 891, 1914. See under *coccineum*, ante p. 113.

PLEUROBEMA OBLIQUUM (Lamarck). = CORDATUM Raf.

Quadrula obliqua SIMPSON, Cat., p. 881, 1914.

All references to this species by Baker, Ortmann, Simpson, and Shimek, from near Prairie du Chien, refer to *Pleurobema coccineum solida*. The same is true of Lapham's record from the Wisconsin River, which see, ante, p. 118. Coker (1919, p. 25) says of this species, "Ohio River pig-toe, *Quadrula obliqua*, is the commonest mussel in the Ohio River. It is found throughout its entire length as far as mussel beds extend. It often forms 80 per cent of the mussels in a bed. In some

places in the Cumberland River this is the most common mussel, and the shells from the Cumberland are superior to those of the Ohio. It is found also in the Illinois River, but is rarely, if ever, seen in the Mississippi." In the Daniels collection it is represented from the Wabash and in the Hinkley collection it is present from the Ohio and Wabash rivers. None have been seen from the Illinois River in these collections.

PLEUROBEMA PYRAMIDATUM (Lea)

Quadrula pyramidata SIMPSON, Cat., p. 888, 1914.

References by Grier, Shimek, and Simpson to this species are all based on variations of *Pleurobema solida*, which see p. 118. Call's reference (1885, p. 46, Rock River), is probably based on *Pleurobema coccineum catillus*.

PLEUROBEMA CLAVA (Lamarck)

Pleurobema clava SIMPSON, Cat., p. 735, 1914.

The reference in Lapham's 1852 list (p. 369) is erroneous, no specimens of this species having been found in the State. It is a common species in Illinois.

UNIOMERUS TETRALASMUS SAYI (Ward)

Unio tetralasmus var. *sayi* SIMPSON, Cat., p. 709, 1914.

Wheatley's reference to this mussel (1845, p. 12) has not been substantiated. The original localities are Walnut Creek and Ohio Canal, Circleville, Ohio. A form of the Ohio drainage.

Subfamily ANODONTINAE Ortmann, 1912

"Inner lamina of inner gill free from the abdominal sac, or more or less connected with it, rarely entirely connected; supra-anal opening well separated from the anal, sometimes the connection of the mantle separating it from the anal is very long and the supra-anal is quite short; branchial opening well defined, no papillae or flaps in front of it on the edge of the mantle; marsupium formed by the outer gills in their length, distending, when charged, and the thickened tissue at the edge capable of stretching out in a direction transverse to the gill, but not beyond the edge (or only slightly so); water-tubes in the gravid female divided longitudinally into three tubes, with

only the one in the middle used as an ovisac, and closed at the base of the gill; glochidium semicircular or triangular, with a spine (hook), in the middle of the ventral margin of each valve; shell generally very heavy, often thin, never round, but more or less elongated; color of epidermis generally bright and with color markings; sculpture of the beak double-looped or concentric, in the latter case often extremely heavy; hinge rarely complete, and, if so, of peculiar structure; generally there is a distinct tendency toward the reduction of the hinge-teeth, and often they are completely absent; sexual differences in the shell very rarely present" (Ortmann).

KEY TO GENERA OF ANODONTINAE

1. a. Beak sculpture concentric ----- 2
- b. Beak sculpture double-looped ----- 4
2. a. Beak sculpture fine ----- *Anodontoides*
- b. Beak sculpture coarse ----- 3
3. a. Pseudocardinals well developed ----- *Alasmidonta*
- b. Pseudocardinals rudimentary ----- *Strophitus*
4. a. Hinge wholly edentulous ----- *Anodonta*
- b. Hinge teeth more or less developed ----- 5
5. a. Beak sculpture tubercular; surface tubercular or folded -----
- *Arcidens*
- b. Beak sculpture not tubercular; surface smooth except on
 posterior slope ----- 6
6. a. Beak sculpture double-looped; pseudocardinals fully devel-
 oped ----- *Lasmigona*
- b. Beak sculpture open behind; a single pseudocardinal in each
 valve ----- *Simpsoniconcha*

Genus LASMIGONA Rafinesque, 1831

Shell elliptic-rhomboid, compressed; beaks low, their sculpture consisting of strong bars; one pseudocardinal in the right valve and two in the left, the hinder somewhat V-shaped, cutting of the hinge-plate in the right valve; laterals generally imperfect. Marsupium thick, pad-like, filling the outer gills (Walker). Type: *Alasmidonta costata* Raf.

KEY TO SUBGENERA OF LASMIGONA

1. a. Shell corrugated on posterior slope ----- *Lasmigona* s. s.
- b. Shell smooth ----- 2
2. a. Hinge teeth delicate ----- *Platynaias*
- b. Hinge teeth very heavy ----- *Pterosygna*

Subgenus PLATYNAIAS Walker, 1917

Shell smooth, subsolid, shining, rayed; beak sculpture sharply double-looped; teeth delicate; laterals compressed, moderately developed (Walker). TYPE: *Symphynota compressa* Lea.

LASMIGONA COMPRESSA (Lea)

Plate LVIII, figures 1-4

Unio pressus LEA, Proc. Amer. Phil. Soc., II, p. 237, 1843.

Symphynota compressa LEA, Trans. Amer. Phil. Soc., p. 450, pl. xii, fig. 22, 1829; Obs., I, p. 64, pl. xii, fig. 22, 1834.

Symphynota compressa SIMPSON, Cat., p. 481, 1914.

Lasmigona compressa ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 34, 1922.

TYPE LOCALITY: Ohio and Norman's Kill, Albany, N. Y. (Lea).

WISCONSIN RECORDS:

1852. *Complanaria compressa* LAPHAM, p. 370. Wisconsin.

1860. *Unio pressus* LAPHAM, p. 155. Milwaukee.

1885. *Unio pressus* CALL, p. 44. Wisconsin.

1897. *Unio pressus* WISWALL, p. 47. Southern Wisconsin.

1906. *Symphynota compressa* CHADWICK, p. 94. Jumbo Creek, Manitowoc Co.

1911a. *Symphynota compressa* BAKER, p. 231. Gilmore Creek.

1914. *Symphynota compressa* SIMPSON, p. 482. Wisconsin.

1919. *Lasmigona viridis* ORTMANN, p. 121. Wisconsin.

SHELL: Subrhomboid, compressed, longer than high; usually not very solid; anterior end rounded; posterior end diagonally truncated, biangulate; dorsal margin straight; ventral margin straight, slightly rounded, or even slightly arcuate; posterior dorsal angle with a well marked wing, especially evident in young shells; beaks not elevated, anterior of the center of the dorsal margin; beak sculpture conspicuous, consisting of 5-8 bars, the first one or two concentric, the next three distinctly double-looped, the outer ones either double-looped or broken up into wavy ridges; posterior ridge rounded, ending in a biangulation; surface sculpture of growth lines only; epidermis yellowish with many wide dark green rays in young shells; older shells are greenish yellow; very old shells become dark brown, black and rayless; rest periods sometimes marked by ridges and of a dark color.

Pseudocardinals long, thin, and delicate, slightly diagonal

with margin of hinge plate; laterals long, thin, delicate, almost parallel with hinge margin; interdentum of left valve forming a small projection that fits into a depression in the right valve; beak cavities very shallow, carrying dorsal muscle scars; anterior adductor scar impressed, posterior scar faint; nacre white, often tinged with cream or salmon, near the beak cavity, iridescent posteriorly.

L. 93; H. 53; D. 30 mm.	Green Lake Outlet (Baker, U. of W., 890).
L. 92; H. 55; D. 32 mm.	" " " (" " 891).
L. 87; H. 49; D. 28 mm.	" " " (" " 892).
L. 79; H. 46; D. 25 mm.	" " " (" " 893).
L. 79; H. 51; D. 26 mm.	Rockland (Marston, U. of W., 156).
L. 78; H. 45; D. 23 mm.	Tigerton (Bullock, U. of W., 894).
L. 60; H. 36; D. 16 mm.	Racine (Marston, U. of W., 89).

ANIMAL: (Similar to *costata*, fig. 224). Supra-anal and anal openings separated by a mantle connection that is shorter than anal opening; branchial opening with papillae, anal opening with distinct crenulations on the inner edge; palpi small, subtriangular, united at the base for about half their length; gills broad, the inner lamina of inner gill connected to abdominal sac only at anterior end.

Of the reproduction organs Ortmann says: "This species being normally hermaphroditic, the gills have always (with extremely rare exceptions) the female structure, that is to say, in the inner gill the septa are rather distant, and the water-tubes are wider, and the outer gill is marsupial. When sterile, the septa are crowded, with marsupial epithelium, and the water-tubes are narrow. When gravid this gill swells considerably, and at the edge the tissue distends, so as to render the edge rounded off or truncated. Within this gill, each water-tube develops the characteristic lateral, or secondary, water-tubes, while the middle portion forms the ovisac, which is also closed at the base of the gill. The eggs fill the ovisacs in densely crowded masses, and in certain places a placenta-like cohesion may be observed. But when the glochidia are mature they are perfectly free, and no indications of placentae are seen (1912a, p. 281).

Color of animal whitish; mantle edged with black, especially near the siphonal openings; gills grayish-white; foot yellowish-brown; marsupium whitish in sterile, brownish or orange in gravid specimens.

Glochidia (pl. XXXI, fig. 17) large, subtriangular, longer than deep, with a spine at tip of each valve. Hinge line nearly straight. Length 0.353 mm., height 0.313 mm. (Surber, 1912, p. 8); Ortmann gives, length 0.34 mm., height 0.28 mm.

BREEDING SEASON: Bradytictic. August to May or June.

NATURAL HOST: Not recorded.

ECOLOGY: *Compressa* is a species of creeks and small streams, extending far up into the headwaters of rivers. It prefers quiet water in fine gravel, sand, or mud bottom. It is not usually found in riffles, but below them in small pools, .3–1 m. deep, on fine sand or mud bottom. More rarely on gravel bottom, swift current, water .3–6 m. deep.

GENERAL DISTRIBUTION: New York west to Nebraska, north to Minnesota and Wisconsin, south to Ohio and Kentucky. Areas south and west of these states need verification.

DISTRIBUTION IN WISCONSIN: *Compressa* is widely distributed in the state, both in the Mississippi Valley and in the Great Lakes drainage. It is confined to the smaller tributary streams and creeks.

REMARKS: A species not readily confused with any other Wisconsin naiad, excepting, perhaps, *Lasmigona costata*, which has a far heavier hinge without distinct laterals. Young shells of *compressa* are beautifully marked with broad, grass-green rays. There is not much variation in the form of the shell, excepting with age, as noted in the specific diagnosis. The laterals are uniformly present and will at once distinguish the species. It is of no economic value on account of its thin shell.

Subgenus LASMIGONA sensu stricto

Shell subrhomboid, compressed, corrugated behind; beaks low, their sculpture consisting of several coarse ridges, which generally fall into two slight loops, and often with radiating ridges in front and behind; epidermis shining; laterals partly developed, consisting of blurred ridges, which slope diagonally downward and backward on the hinge-plate; cavity of the beaks shallow (Walker). Type: *Alasmodonta costata* Raf.

LASMIGONA COSTATA Rafinesque. Fluted Shell

Plate LVIII, figures 5, 6; Plate LIX, figure 7

Alasmodonta costata RAF., Ann. Gen. Sci. Phys. Brux., V, p. 318, pl. lxxxii, figs. 15, 16, 1820.

Alasmodonta rugosa BARNES, Amer. Jour. Sci., VI, p. 278, pl. xiii, fig. 21, 1823.

Symphynota costata SIMPSON, Cat., p. 488, 1914.

Lasmigona costata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 36, 1922.

TYPE LOCALITY: Kentucky River (*costata*, Raf.); Wisconsin, Fox River (*rugosa*, Barnes).

WISCONSIN RECORDS:

1823. *Alasmodonta rugosa* BARNES, p. 278. Fox River.

1852. *Complanaria costata* LAPHAM, p. 370. Wisconsin.

1860. *Margaritana rugosa* LAPHAM, p. 156. Wisconsin River.

1885. *Margaritana rugosa* CALL, p. 17. Wisconsin.

1897. *Margaritana rugosa* WISWALL, p. 48. Southern Wisconsin.

1905. *Symphynota costata* BAKER, p. 255. Prairie du Chien.

1906. *Symphynota costata* CHADWICK, p. 94. Milwaukee River; between Prairie du Chien and De Soto.

1911a. *Symphynota costata* BAKER, p. 231. Gilmore Creek, Oneida Co.

1920. *Lasmigona costata* ORTMANN, p. 131. Wisconsin.

1922b. *Lasmigona costata eriganensis* BAKER, p. 133. Long Point Island. Lake Winnebago.

1924. *Lasmigona costata* BAKER, p. 133. Omro, Fox River.

1927d. *Lasmigona costata* BAKER, p. 107. Rock River, Ashippun and Rock Co.

SHELL: subrhomboid, more or less compressed, usually solid but not heavy; anterior end somewhat acutely rounded; posterior end obliquely truncated, biangulate at the lower part; ventral margin straight or slightly convex, sometimes a trifle concave, especially in old specimens; the height behind the umbones is greater than the height in front of the umbones; posterior ridge usually well developed, rounded; beaks depressed, scarcely rising above the general level of the dorsal margin; beak sculpture consisting of 3-4 heavy bars, the first curved, the others more or less double-looped; these bars are strongly developed and are parallel with the hinge line; surface sculpture of coarse lines of growth, the rest periods being marked off by heavy, raised, concentric ridges, edged with black; the postero-dorsal margin is more or less heavily marked by corrugations or flutings, usually turning upward; epidermis yellowish with many grass-green rays in young shells; older shells may be horny, yellowish, brownish, or black, more or less distinctly rayed; very large old shells are black and rayless.

Pseudocardinals generally heavy in old shells, somewhat elevated, pyramidal, not much corrugated, and directed forward; the teeth in the left valve are fused into one, forming a

long, somewhat lamellar ridge; laterals represented only by rudimentary thickenings of the hinge line; interdentum very narrow or absent; muscle scars and pallial line well marked; beak cavity shallow; nacre white, cream-colored, or salmon, the valves frequently bordered by a narrow violet-colored band; iridescent posteriorly.

There is little difference in the shell between the sexes. Females are usually rather more swollen in front of the posterior ridge. This is only observed in old specimens. In young shells there is no external difference to be seen.

- L. 154; H. 83; D. 52 mm. Prairie du Sac (U. of W., 338).
- L. 128; H. 75; D. 43 mm. " " (" 335).
- L. 107; H. 54; D. 29 mm. Omro (U. of W., 895).
- L. 103; H. 55; D. 25 mm. Racine (U. of W., 49).
- L. 95; H. 51; D. 26 mm. Omro (U. of W., 896).
- L. 92; H. 53; D. 29 mm. Lake Winnebago (U. of W., Male 899).
- L. 85; H. 48; D. 22 mm. Omro (U. of W., 897).
- L. 73; H. 40; D. 21 mm. West De Pere (U. of W., 111).
- L. 66; H. 37; D. 17 mm. Chippewa Falls (U. of W., 898).

ANIMAL: (Fig. 223, var. *nuda*). Not differing materially from that of *compressa*. The anal opening is very large, the mantle connection between anal and supra-anal being shorter than anal opening; the anal is minutely crenulated on the inner margin. Color yellowish or deep orange, sometimes salmon; edge of mantle black, gills brown. *Costata* is not hermaphroditic.

Glochidia (pl. XXXI, fig. 18) very large, triangular, higher than wide, hinge line irregular, undulate. Length 0.385, height 0.390 mm. (Surber); 0.34 by 0.37 (Ortmann); 0.35 by 0.39 (Lefevre and Curtis).

BREEDING SEASON: Bradyctictic. Beginning in August, glochidia being present in September. These are carried through the winter and discharged about the middle of May. No gravid females seen in June or July, which forms a resting period.

NATURAL HOST: Not recorded.

ECOLOGY: Abundant in situations of various kinds, in large as well as in small rivers. Prefers gravel on riffles, but also found in sand and fine gravel in quiet waters. Rare in mud.

GENERAL DISTRIBUTION: *Costata* has been recorded from a large area in the United States and Canada. From New York

it extends westward to Iowa, southward to Alabama and Mississippi, and northward to Manitoba. It is found eastward to Ottawa, Canada.

DISTRIBUTION IN WISCONSIN: *Costata* is widely distributed in the State in both the Mississippi and Great Lake drainages, and in all of the other important river drainages. It has not yet been recorded from the Lake Superior drainage.

REMARKS: *Costata* may at once be distinguished, usually, by the rugose posterior margin and peculiar hinge structure. Its nearest relative is *Lasmigona compressa* which differs in the hinge structure as well as in surface ornamentation. Among Wisconsin specimens variation is chiefly in the degree of inflation, of convexity of the ventral margin, and in the complexity of the rugose markings of the posterior wing. Some shells, which in several instances have been females, have a greater diameter behind the center of the shell. This, however, is not always true as regards sex. The shells vary greatly in thickness and the hinge in massiveness, the latter increasing with age. The color is also variable, from greenish to yellowish-brown, the young shells being usually beautifully rayed. The flutings on the posterior margin are better developed in shells living in quiet waters. It seems to be equally at home in the large as well as the small rivers and streams.

Baker's reference to *costata eriganensis* is erroneous and the form should be placed under typical *costata* (1922b, p. 133). The specimens from Lake Winnebago appeared at first to represent this lake variety, and while they are somewhat different from the typical form as found in the Fox River, they lack the peculiarities of the post-dorsal margin, as well as the elongated form, of *eriganensis*, (see pl. LIX, fig. 7). Specimens from the Mukwonago River are more compressed, with more anteriorly-placed umbones and with fewer flutings on the posterior end.

LASMIGONA COSTATA PEPINENSIS Nov. Var.

Plate LIX, figures 1, 2

TYPE LOCALITY: Lake Pepin.

WISCONSIN RECORDS:

1922a. *Lasmigona costata* GRIER, pp. 17, 19. Lake Pepin.

1922. *Lasmigona costata* GRIER and MUELLER, p. 97. Above Lake Pepin.

SHELL: Differing from typical *costata* in being heavier, with a thicker shell, of greater diameter, of smaller size, with finer posterior corrugations on the wing, the umbones wider and broader, the whole shell more cylindrical. Color yellowish with many dark green rays. Nacre white suffused with cream. Hinge very strong, with wide, solid plate.

L. 100; H. 54; D. 35 mm. Lake Pepin (U. of W., 357). Type.

L. 92; H. 50; D. 37 mm. " " (" 358). Paratype.

ANIMAL: Not examined.

ECOLOGY: Apparently a large river form.

GENERAL DISTRIBUTION: Only known at present from the upper Mississippi River.

DISTRIBUTION IN WISCONSIN: Apparently confined to Lake Pepin.

REMARKS: The shells from Lake Pepin are quite as different from typical *costata* as are the shells from Lake Erie called *eriganensis* by Grier. In fact, the Lake Pepin shells vary from *costata* by much the same characteristics that the Lake Erie form does (see Ortmann, 1919, p. 131), though these are smaller and more arched on the dorsal margin. *Pepinensis* is doubtless an ecological variety produced by a change from smaller to larger river conditions. The Lake Pepin shells are different from those found in the other parts of the Mississippi River, which are here referred to *costata*. The wide, heavy hinge plate is characteristic of *pepinensis*.

Costata follows the same ecological variation as noted for the other river species, though not to the same extent as some of the latter. The small stream or creek form is usually flatter and more elongated and of smaller size than the form found in the rivers of medium size, as the Rock, Wisconsin, Illinois, etc., where size reaches its maximum. The form of the large rivers (Ohio and Mississippi) is smaller than that of the rivers of medium size. The difference between the creek form and the variety of medium sized rivers is not great enough to apply a varietal name, though it is present to a noticeable degree.

LASMIGONA COSTATA NUDA Var. Nov.

Plate LIX, figures 3-6

TYPE LOCALITY: Red Cedar River, west of Chetek, Barron Co.

WISCONSIN RECORDS: None.

SHELL: Smaller than typical *costata*, of greater diameter, more rhomboid in shape, umbones wider, posterior end strongly biangulate, posterior ridge conspicuous, broadly rounded; posterior wing usually free from corrugations in the adult shell, though these are present in young specimens; color brownish or olive, rayless, excepting in young shells which may be faintly rayed; epidermis with roughened growth lines, marked off by rest periods; nacre white on the border between margin and pallial line, salmon, cream, or light purple in interior; in many specimens there is a border of rich purple or mauve entirely circling the edge of the valve. There is no difference in the shell between male and female, either may be inflated or compressed.

L. 92; H. 49; D. 31 mm.	Red Cedar River (U. of W., 900).	Male.	Type.
L. 93; H. 51; D. 35 mm.	" " " (" 901).	Female.	
Paratype.			
L. 100; H. 54; D. 32 mm.	" " " (" 902).	"	
Paratype.			
L. 76; H. 41; D. 22 mm.	" " " (" 903).	"	
Paratype.			
L. 51; H. 27; D. 13 mm.	" " " (" 904).	Juv.	

ANIMAL: As in *costata* in general anatomy. Foot bright reddish-salmon, edge of mantle salmon, openings edged with dark brown, gills and palpi yellowish-brown, adductor muscles

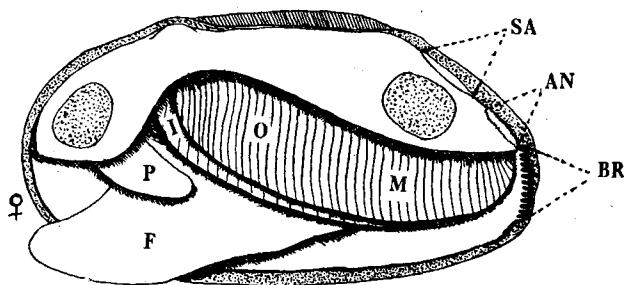


Fig. 224. *Lasmigona costata nuda* Baker. Red Cedar River, near Chetek. Gravid female. Aug. 12, 1921.

salmon or pink. In August, 75% were gravid, the gills being easily ruptured. Glochidia not observed, gills being filled with eggs on August 23, 1921 (see fig. 224).

BREEDING SEASON: Bradytictic, probably the same as *costata*.

NATURAL HOST: Unknown.

ECOLOGY: Apparently a species of small, shallow, swift-flowing streams. In Red Cedar River, the type locality, it was found in shallow water (few cm. to .6m.) on a gravel or sand bottom, frequently in sand bars in riffles.

DISTRIBUTION IN WISCONSIN: Apparently confined to the upper waters of the Chippewa River. Not known outside the State.

Red Cedar River, west of Chetek; outlet of Lake Chetek; Moose Ear Creek; all Barron Co. (Baker).

REMARKS: *Nuda* is a variation of the *costata* type in which the shell is more cylindrical, wider, and lacks the posterior flutings in mature shells. The variety is very uniform, only occasional specimens showing indications of flutings, which are present, however, in young specimens. Females outnumber the males two to one in the Red Cedar River. In the Wisconsin River, at Kilbourn, certain half-grown individuals of *costata* somewhat resemble *nuda* in form, but all have the posterior corrugations well developed; the variety is always smaller than the Wisconsin River shells.

Nuda is apparently another ecological or physiographic variety, seeming to be coexistent with a cold, shallow stream, rapidly flowing, with a stony or coarse sand bottom. In Illinois, the small stream *costata* are of the typical form, heavily fluted, and are common on mud, sand, and rare on gravel bottom. It is possible that *nuda* is a northern race as well as an ecological one. It seems quite distinguishable from typical *costata*, all of the fifty odd specimens at hand being of the type indicated.

Subgenus **PTEROSYGNA** Rafinesque, 1831

Shell large, ovate rhomboid, inflated in the post-basal region; beaks much compressed; their sculpture sharply and strongly doubly looped; epidermis dark, scarcely rayed; teeth very heavy. Type: *Alasmodonta complanata* Barnes (Walker).

LASMIGONA COMPLANATA (Barnes). White Heel-Splitter

Plate LX, figures 1, 2

Alasmodonta complanata BARNES, Amer. Jour. Sci., VI, p. 278, pl. xiii, fig. 21, 1823.

Symphynota complanata SIMPSON, Cat., p. 490, 1914.

TYPE LOCALITY: Fox River, Wisconsin (Barnes).

WISCONSIN RECORDS:

- 1823. *Alasmodonta complanata* BARNES, p. 278. Fox River.
- 1830. *Symphynota complanata* LEA, p. 448. Fox River (Obs. p. 62).
- 1852. *Complanaria complanata* LAPHAM, p. 370. Wisconsin.
- 1860. *Margaritana complanata* LAPHAM, p. 156. Milwaukee.
- 1897. *Margaritana complanata* WISWALL, p. 48. Southern Wisconsin.
- 1905c. *Symphynota complanata* BAKER, p. 255. Prairie du Chien.
- 1906. *Symphynota complanata* CHADWICK, p. 94. Milwaukee; Two Rivers, Manitowoc Co.
- 1914. *Symphynota complanata* SIMPSON, p. 491. Fox River.
- 1922a. *Lasmigona complanata* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.
- 1924. *Lasmigona complanata* BAKER, p. 133. Omro, Fox River.
- 1926. *Lasmigona complanata* GRIER and MUELLER, pp. 17, 23. Lake Pepin and Mississippi River.
- 1927d. *Lasmigona complanata* BAKER, p. 107. Neosho mill pond, Rubicon River; Rock River, Ashippun to Rock Co.

SHELL: Large, rather solid when adult, thin when young; broadly ovate, subrhomboid or irregularly elliptical in outline, almost as high as long; anterior end rounded; posterior end obliquely truncated, biangulate at the lower margin; ventral margin rounded; dorsal margin straight, ascending posteriorly to form a distinct wing which is symphynote at the upper margin; posterior ridge flatly rounded; beaks depressed, not elevated above the general dorsal margin; beak sculpture consisting of 4-5 heavy bars, the first two simple bars, the others strongly double-looped, the anterior loop round and wider than the posterior loop; sculpture of shell of coarse growth lines, elevated at rest periods; the posterior slope is sometimes marked by irregular ridges, extending toward the posterior margin, simulating, feebly, the rugose margin of *Lasmigona costata*; epidermis yellowish or greenish in the young shell, indistinctly rayed; older shells become brownish or blackish.

Pseudocardinals rather massive, of variable shape, usually a single somewhat fan-shaped tooth in the right valve fits in between two irregular teeth in the left valve, all teeth cut into the hinge-plate; these teeth may be almost smooth or quite rough; laterals absent or represented by lamellar thickenings of the hinge line; interdentum very narrow; anterior adductor scars well marked; posterior adductor scars very faint; beak cavities shallow, containing dorsal muscle scars; nacre white and irides-

cent, sometimes pinkish or cream colored near the anterior part of the shell and the beak cavity. There is no difference in shells as regards sex. Young shells are flat, wine colored, with bright green rays.

- L. 193; H. 143; D. 55 mm. Ashippun, Dodge Co. (Cahn, U. of I., Z17312).
 L. 175; H. 120; D. 65 mm. Grand River (U. of W., 905).
 L. 163; H. 120; D. 51 mm. Aztalan (Bullock, U. of W., 908).
 L. 148; H. 98; D. 44 mm. Princeton (Bullock, U. of W., 906).
 L. 147; H. 101; D. 45 mm. Jefferson (Bullock, U. of W., 907).
 L. 112; H. 81; D. 34 mm. Omro (Bullock, U. of W., 909).
 L. 92; H. 67; D. 25 mm. Fox River (Marston, U. of W., 102).

ANIMAL: (Fig. 225). Similar in general details to the other members of the genus. The mantle connection between the anal and the supra-anal is about as long as the anal opening, the supra-anal opening being slightly longer than the anal. Color whitish in young specimens; in mature individuals the foot, gills, and abdominal sac are brownish or yellowish; when gravid the gills are brownish.

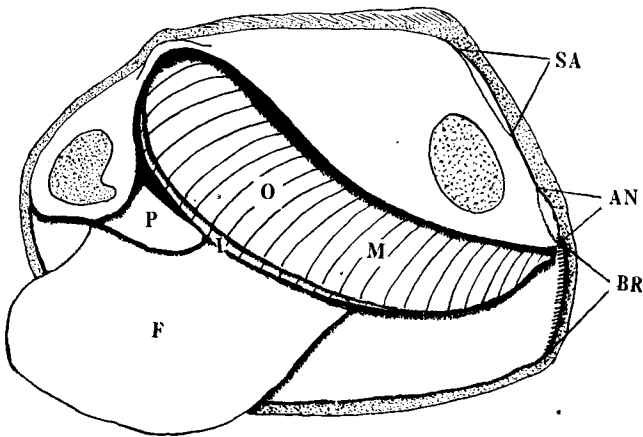


Fig. 225. *Lasmigona complanata* (Barnes). Lower Dells, Wisconsin River, Kilbourn. Sterile female. July 20, 1922.

Glochidia (pl. XXXI, fig. 19) large, triangular, hinge line undulate, ventral part of valve hooked. Measurements variable: 0.310 by 0.320 mm. (Surber, 1912, p. 9); 0.29 by 0.30 mm. (Lefevre & Curtis, 1910, p. 97); length and height 0.34 mm. (Ortmann, 1912a, p. 283); 0.31 by 0.32 mm. (Utterback, 1916a,

p. 99). Ortmann's measurements are of the smaller stream form while those of Surber, and Lefevre and Curtis, are of the large stream form.

Utterback (1916a, p. 100) states that this species is hermaphroditic, but no other author has observed this phenomenon. Specimens examined by the writer from Salt Fork, Vermilion River, Ill., were bisexual, as were also specimens from Wisconsin. *Lasmigona compressa* is the only member known to be hermaphroditic.

BREEDING SEASON: Bradytictic. September to April or May. Barren interrem in July and August.

NATURAL HOST: Not recorded.

ECOLOGY: *Complanata* is usually found on a mud bottom in quiet water, in depth from a few cm. to a meter. It seems equally abundant in both large and small rivers and creeks. Rarely it is found in sand and fine gravel.

GENERAL DISTRIBUTION: Pennsylvania and Ohio to Iowa and Arkansas south to Alabama and north to Lake Winnipeg and Nelson River.

DISTRIBUTION IN WISCONSIN: *Complanata* is widely, though irregularly distributed in the State. Its absence from all of the localities in the northern part of the State is noteworthy. The records indicate a wide range in the southeastern part and in the Mississippi River, but a large part of the State is not represented.

REMARKS: *Lasmigona complanata* may be recognized by its large, disk-like shell and well marked umbonal markings. It resembles in outline *Proptera alata megaptera*, but may be at once distinguished from that species by the absence of lateral teeth, white nacre (purple in *alata*), and the different markings of the umbones. There is some variation in the general form of the shell; the ventral border may be quite convex or slightly rounded, the wing may be quite alate or reduced to a simple projection. The hinge teeth also vary in complexity. The greatest variation is in the diameter of the shell, which may differ 30 or 40 per cent in shells of the same size. This has been thought to be a sexual characteristic, the female having the wider shell, but examinations of living material show that this does not hold true.

Unlike many other species having so wide a range, *complanata* seems to be very uniform and but one race has been de-

veloped (see below). The large and small stream forms do not differ materially, though the Mississippi form is smaller than the creek form which attains the greatest size. See Grier & Mueller, however, for Lake Pepin variation. When of large size and thickness, the heel splitter is of value for buttons. Its chief fault is its brittleness, the shell often splitting when the blanks are being cut.

LASMIGONA COMPLANATA KATHERINAE (Lea)

Plate LX, figures 3, 4

Unio katherinae LEA., Syn., p. 35, 1838; Trans. Amer. Phil. Soc., VI, p. 143, 1839.

Symphynota complanata katherinae SIMPSON, Cat., p. 492, 1914.

TYPE LOCALITY: Lake Superior (Lea).

WISCONSIN RECORDS: None.

SHELLS differing from *complanata* in being smaller, more regularly elliptical or obovate; the dorsal wing is usually not as well developed as in the typical form; the epidermis is brownish in old shells and shellac-colored in young shells; growth lines very rough, accentuated at rest periods; hinge rather slighter than in *complanata*.

L. 90; H. 66; D. 27 mm. Red Cliff Creek (U. of W., 910).

L. 90; H. 62; D. 27 mm. " " " (" 911).

L. 74; H. 58; D. 20 mm. " " " (" 912a).

ANIMAL: Not examined; probably same as *complanata*.

ECOLOGY: In Wisconsin, inhabits a small shallow creek, with sandy mud bottom.

GENERAL DISTRIBUTION: Lake Winnipeg; Saginaw Bay (Simpson). Probably a northern race inhabiting the northern region about Lake Superior and the northern part of Minnesota, Michigan, and parts of Ontario.

DISTRIBUTION IN WISCONSIN: Lake Superior Drainage. Red Cliff Creek, Bayfield Co. (Baker).

REMARKS: *Katherinae* is apparently a dwarf form of *complanata* inhabiting the northern part of the range of the species. It has the most northern range in the State. It is possible that some of the northern records of *complanata* may include *katherinae*. No specimens are at hand for comparison. At the Red Cliff locality it was common, specimens being seen in muskrat piles.

Genus ANODONTA Lamarck, 1799

Shell elliptical, thin, inflated, often slightly winged posteriorly; beak sculpture consisting of rather numerous, more or less parallel ridges, usually somewhat doubly-looped and becoming slightly nodulous on the loops; surface generally smooth, shining; hinge edentulous, reduced to a mere line, regularly curved; nacre dull. Marsupium occupying the whole outer gills, when filled forming a smooth, very thick, liver-colored pad. Type: *Mytilus cygneus* L. (Walker).

ANODONTA GRANDIS Say. Floater

Plate LXII, figure 5

Anodonta grandis SAY, New Harm. Dissem., II, p. 341, 1829.*Anodonta grandis* SIMPSON, Cat., p. 410, 1914.

TYPE LOCALITY: Fox River of Wabash River, Ind.

WISCONSIN RECORDS:

1860. *Anodonta plana* LAPHAM, p. 156. Wisconsin River.1860. *Anodonta fluviatilis* LAPHAM, p. 156. Milwaukee.1897. *Anodonta opalina* WISWALL, p. 48. Southern Wisconsin.1906. *Anodonta grandis gigantea* CHADWICK, p. 94. Milwaukee.1924. *Anodonta grandis gigantea* BAKER, p. 132. Omro, Fox River.

SHELL: Subovate, swollen in the middle near the beaks, usually large, thin to somewhat thickened near the hinge line; anterior end broadly rounded; posterior end rather pointed with rounded extremity; dorsal margin straight, ventral margin straight or slightly curved; the dorsal margin forms a sharp angle with the posterior end; posterior slope rounded; postero-dorsal margin compressed, sometimes alate, especially in young shells; beaks swollen and slightly elevated above hinge line; beak sculpture consisting of 4-5 heavy bars, the first two concentric, the others strongly double-looped, with a strong sinus between the loops; the posterior loop often forms a distinct tubercle, but this characteristic may be variable and there may be several strong tubercles or they may be very feeble, or absent; epidermis yellowish, greenish, or brownish, black in some very old shells; rays are feebly present in young or immature individuals and the epidermis may be marked off by several dark, or light, concentric bands, which indicate rest periods; there are frequently a number of wavy rays on the

anterior slope, which are seen to be chevron-shaped wrinkles under a magnifying glass.

Hinge edentulous, with a slight thickening under the beaks; beak cavities shallow; dorsal scars and adductor muscle scars more or less distinctly marked; nacre white more or less pearly and iridescent; salmon, cream, or pinkish in many individuals; a reddish or salmon stain is due to the presence of parasitic worms. There is but slight difference in the shape of the shell as regards sex. In some large females the shell is more swollen posterior to the umbones and in front of the posterior ridge, which gives the shell a greater diameter. This character is quite unreliable, however, females of the same size differing markedly in this respect.

L. 190; H. 127; mm. (Say's specimen, 7.5 by about 5 inches).

L. 130; H. 79; D. 58 mm. Lake Wingra (U. of W., 402).

L. 166; H. 98; D. 62 mm. Mirror Lake (U. of W., 917a). Male.

L. 127; H. 71; D. 48 mm. " (" 917b). "

L. 155; H. 92; D. 60 mm. " (" 917c). Female.

L. 67; H. 40; D. 26 mm. " (" 917d).

ANIMAL (Fig. 226): Anal and supra-anal openings separated by a very long mantle connection; branchial opening with distinct papillae, the inner edge in front smooth; anal opening crenulated on the inner edge; palpi connected poste-

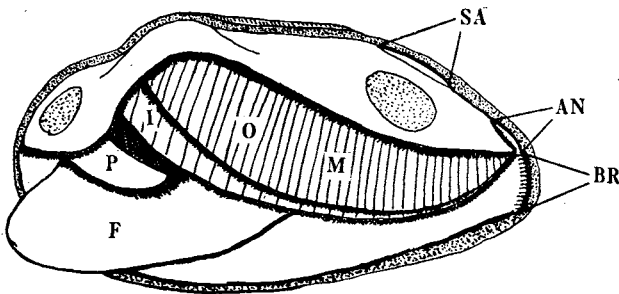


Fig. 226. *Anodonta grandis plana* Lea. Red Cedar River, near Chetek. Gravid female. Aug. 12, 1921.

riorly one-third to one half their length; gills long and rather narrow, the inner extending beyond the outer gill, its anterior edge being between the palpi and the inner gill; inner lamina of inner gills attached to abdominal mass only at anterior end;

outer gills only marsupial; lateral water tubes developed; the ova are contained in the central ovisacs which are not divided; placentae not present, the glochidia discharged in loose, irregular masses. Color of animal generally whitish, orange or yellowish on foot; palpi and gills brown; mantle edged with brown and black. When filled with eggs the marsupium is white which usually changes to brown when the glochidia have developed.

GLOCHIDIA: Similar in shape to those of *Anodonta gigantea*, but smaller, measuring 0.36 by 0.37 mm. (Ortmann).

BREEDING SEASON: Bradytictic, extending from August to April or May. Glochidia discharged very early. Gravid females were observed in Mirror Lake on July 29.

NATURAL HOST: Not recorded for *grandis*. See under *gigantea*.

ECOLOGY: Typical *grandis* is a species of medium-sized rivers, ponds, and pond-like extensions of rivers. Quiet stretches of rivers, where the water is fairly deep are favorite places for this species. In Mirror Lake, near Kilbourn, *grandis* occurs along shore, partly buried in a sandy-mud bottom in water a few cm. to 2 m. deep. In the Wisconsin River it occurs on a mud bottom in water 1-2 m. deep. At Omro, Fox River, this species lives on a sandy-mud bottom along shore, in water .6 to 1m. deep. It occurs in similar situations in Illinois.

GENERAL DISTRIBUTION: Entire Mississippi system and upper St. Lawrence drainage; Red River of the North; Lake Winnipeg, Manitoba; southwest to Texas (Simpson). The boundaries of distribution are not well understood in some directions.

DISTRIBUTION IN WISCONSIN: Apparently confined to the Wisconsin, Fox, and Rock drainages.

REMARKS: *Anodonta grandis* is a very variable shell in Wisconsin, as elsewhere throughout its range. A number of species have been made of these variations some of which may be recognized as ecological races. Some forms, as *salmonea*, seem to have been founded upon a pathologic condition, the salmon color of the nacre being due to the presence of parasitic worms which discolor the shell and cause the formation of pin-head pearls and other blister-like conditions.

Ortmann has taken the creek form of *grandis* as typical, but

in this he was in error, Say's type being a very large example of the form found in rivers of medium size, and by many confused with *gigantea*. Compared with the creek form, which appears to be referable to *plana*, *grandis* has a relation of height to length of 58 to 70 per cent., while *plana* has a 52–57 per cent ratio. *Grandis* is most likely to be confused with *gigantea* which is usually a more solid shell, more compressed, particularly near the umbones which are not usually as swollen as in *grandis*. The large river *gigantea* is also usually higher than *grandis*. The glochidia of *gigantea* are much larger than those of *grandis*.

In Lake Koshkonong, a widening of the Rock River, the large *Anodonta* appears to be *grandis* and not *gigantea*, although true *gigantea* occurs in the Rock River above the lake. This is an interesting result of response to environmental conditions, showing that *gigantea* is a true river form. The *grandis* of this lake are very large (165 mm.), of a beautiful grass-green color, the umbones very high and swollen, and the posterior margin somewhat alate. They somewhat resemble *Anodonta corpulenta* but lack the peculiar mammae-form middle portion of the valve which is so characteristic of that species.

ANODONTA GRANDIS PLANA Lea. Floater

Plate LX, figure 5, plate LXI, figures 3–6

Anodonta plana (err. typ. for *plana*) LEA, Trans. Amer. Phil. Soc., V, p. 48, pl. vii, fig. 18, 1834; Obs., I, p. 160, pl. vii, fig. 18, 1834.

Anodonta ovata LEA, Op. Cit., VI, p. 2, pl. ii, fig. 2, 1838; Obs., II, p. 2, pl. ii, fig. 2, 1838.

Anodonta salmonea LEA, Op. Cit., VI, p. 45, pl. xiv, fig. 41, 1838; Obs., II, p. 45, pl. xiv, fig. 41, 1838.

TYPE LOCALITY: Bear Grass Creek, near Louisville, Ky. (*plana*); near Marietta, Ohio (*ovata*); near Poland, Ohio (*salmonea*).

WISCONSIN RECORDS:

1852. *Anodonta declivis* LAPHAM, p. 370. Wisconsin.

1885. *Anodonta ovata* CALL, p. 12. Wisconsin.

1906. *Anodonta implicata* CHADWICK, p. 94. Honey Creek, Baraboo R.

1911a. *Anodonta implicata* BAKER, p. 218, 231. Gilmore Creek.

1911a. *Anodonta grandis footiana* (part) BAKER, p. 218, 231. Gilmore Creek.

1927d. *Anodonta grandis* BAKER, p. 107. Neosho mill pond; Rock River, Ashippun to Ixonia; Bark River, Dousman.

SHELL: Differing from *grandis* in being smaller, more elongated and cylindrical, of greater diameter compared with height, thicker shell and hinge, a more arcuate dorsal margin, with the umbones placed nearer the anterior margin. The posterior end is more distinctly pointed and the antero-posterior angle is not alate in mature forms. Color varying from grass green to dark brown; nacre from silvery white to salmon or pink.

L. 145; H. 80; D. 59 mm.	Fall River (U. of W., 913).
L. 112; H. 66; D. 44 mm.	Outlet Green Lake (U. of W., 914a).
L. 105; H. 55; D. 43 mm.	" " (" 914b).
L. 106; H. 55; D. 37 mm.	Red Cedar River (U. of W., 915a). Female.
L. 109; H. 60; D. 56 mm.	" " (" 915b). Male.
L. 100; H. 57; D. 41 mm.	" " (" 915c). Female.
L. 88; H. 49; D. 28 mm.	" " (" 915d). Female.
L. 58; H. 32; D. 18 mm.	" " (" 915e). Immature.

ANIMAL: As in *grandis*.

GLOCHIDIA: As in *grandis*.

BREEDING SEASON: Probably as in *grandis*. Gravid females were observed in Red Cedar River from Aug. 6 to Aug. 23, 75 per cent. being gravid (with eggs).

NATURAL HOST: Not recorded.

ECOLOGY: Variety *plana* is a mussel of small streams where it occurs in quieter places on a sand or mud bottom, seldom by choice occupying shallow water where there are riffles on a gravel bottom or coarse sand bottom. It is not found in the large rivers. Material personally collected in large quantities was found in small streams which are shallow in the fall, the mussels living in water .3-1m. deep on a sand or mud bottom. In one or two places, as near Lake Chetek (outlet creek), the mussels were found on a stony bottom in sand between rocks. In Red Cedar River they occurred in mud and fine sand in water .6-1m. deep.

GENERAL DISTRIBUTION: Probably coincident with *grandis*.

DISTRIBUTION IN WISCONSIN: *Anodonta grandis plana* is abundant in small streams and creeks over much of the State; where it occurs in the upper waters of the larger streams.

REMARKS: A careful study of Say's description of *Anodonta grandis* shows that the shell he gave this name is not the small creek form but the large river form, as already indicated above. The small, cylindrical form so abundant in creeks and

very small rivers appears to be the *plana* of Lea. The creek form is more variable than the larger river form (typical *grandis*) and appears to include Lea's *ovata* and *salmonia*, all forms characterized by a cylindrical shell of rather small size. In many Illinois creeks the shells are much elongated and very cylindrical and this is also true of much of the Wisconsin material. In the larger rivers, the form gradually changes to the higher, flatter form of typical *grandis*.

The shells of *plana* are not as greatly affected by parasitic worms on the average as *grandis*. In Red Cedar River the animals were observed to be but slightly infested with *Unionicola*, less than 45 per cent. being affected, the number of mites varying from one to five in each specimen.

ANODONTA GRANDIS FOOTIANA Lea

Plate LXI, figures 1, 2; Plate LXII, figures 1-3

Anodonta footiana LEA, Proc. Amer. Phil. Soc., I, p. 289, 1840; Trans. Amer. Phil. Soc., VIII, p. 225, pl. xx, fig. 44, 1842; Obs., III, p. 63, pl. xx, fig. 44, 1842.

Anodonta marryattana LEA, Trans. Amer. Phil. Soc., VIII, p. 226, pl. xx, fig. 45, 1842; Obs., III, p. 64, pl. xx, fig. 45, 1842.

Anodonta grandis footiana SIMPSON, Cat., p. 422, 1914.

TYPE LOCALITY: Lake Winnebago. Old Fort Winnebago, now the State Insane Asylum, for both species mentioned.

WISCONSIN RECORDS:

1840. *Anodonta footiana* LEA, p. 289. Fort Winnebago.

1842. *Anodonta footiana* LEA, p. 225. Fort Winnebago.

1842. *Anodonta marryattana* LEA, p. 226. Fort Winnebago.

1885. *Anodonta footiana* CALL, p. 11. Wisconsin.

1897. *Anodonta footiana* WISWALL, p. 48. Southern Wisconsin.

1906. *Anodonta grandis* CHADWICK, p. 94. Winnebago Lake at Menasha and west of High Cliff.

1906. *Anodonta grandis footiana* CHADWICK, p. 94. Wisconsin.

1911a. *Anodonta grandis footiana* BAKER, p. 231. Tomahawk Lake.

1919. *Anodonta grandis footiana* ORTMANN, p. 151. Winnebago.

1924. *Anodonta grandis footiana* BAKER, p. 132. Lakes Winnebago and Butte des Morts.

1927d. *Anodonta grandis footiana* BAKER, p. 107. Small lakes in Waukesha Co.

SHELL: Differing from typical *grandis* in being much smaller, more elongated, with thicker shell and hinge, less inflated in the umbonal region, the umbonal markings usually

finer and four in number, although the number varies to five or six in some individuals. The color is usually yellowish-green or greenish, but often straw-colored and pinkish. The posterior end is distinctly plough-shaped without the alate postero-dorsal margin so characteristic of typical *grandis*. Rest periods are strongly marked by black or brown concentric rings. *Footiana* differs from variety *plana*, which it most nearly resembles, in being less elongated, higher in proportion to its length, more compressed laterally, with the umbones placed nearer the center of the dorsal margin. The posterior end is usually more sharply truncated and less distinctly pointed than in *plana*. The shell is usually thicker and the colors of the epidermis are more mixed with reddish and yellowish than in *plana*.

L. 115; H. 70; D. 50 mm.	Lake Winnebago	(U. of W., 918).
L. 85; H. 50; D. 33 mm.	" "	(" 919a).
L. 88; H. 57; D. 40 mm.	" "	(" 919b).
L. 77; H. 48; D. 32 mm.	" "	(" 920a).
L. 52; H. 32; D. 19 mm.	" "	(" 920b).
L. 23; H. 13; D. 7 mm.	" "	(" 920c).
L. 87; H. 51; D. 33 mm.	Butte des Morts	(" 921a).
L. 87; H. 49; D. 34 mm.	" " "	(" 921b).

ANIMAL: As in *grandis*. Mantle connection between anal and supra-anal openings sometimes shorter than anal. Glochidia as in *grandis*.

BREEDING SEASON: Probably the same as *grandis*. Gravid females were collected from Fahney Point and Long Point Island, Lake Winnebago, Aug. 16 to Aug. 26. None observed gravid in July or before Aug. 16. Specimens collected on Aug. 7 were not gravid.

NATURAL HOST: Not recorded.

ECOLOGY: *Anodonta* referred to *footiana* were collected under the following conditions at the places named. Small Island in Lower Asylum Bay (type locality), rock bottom, water .3m. deep; Long Point Island, sand and gravel bottom, water .2-.6 m. deep; Plummerts Point, Lake Butte des Morts, sand bottom, water .6-1 m. deep; Green Lake, sandy-clay bottom, water 1 m. deep; Lake Chetek and Prairie Lake, sand and mud bottom, water 1-1.1 m. deep; Sturgeon Bay, on hard sandy clay bottom, water 1-2 m. deep, with *Chara*.

GENERAL DISTRIBUTION: The general distribution of this variety is not well known, owing to misconception of the form.

It may prove to be a northern form as suggested by Ortmann. It has been seen from lakes in Wisconsin and Michigan.

DISTRIBUTION IN WISCONSIN: *Footiana* appears to be a common mussel in certain bodies of water in the Lake Michigan drainage, its metropolis being in Green Bay and Lake Winnebago. Outside this area the variety occurs but scatteringly.

Wisconsin Drainage: Tomahawk Lake, Oneida Co. (Baker); Found Lake, Vilas Co. (Cahn).

Fox Drainage: Lake Winnebago and Lake Butte des Morts, Winnebago Co. (Baker, Lea); Little Rapids, Lower Fox River, Brown Co. (Marston); Green Lake, Green Lake Co. (Baker); Menasha and West of High Cliff, Lake Winnebago (Chadwick); Shawano Lake, Shawano Co. (C. E. Brown).

Lake Michigan: Detroit Harbor, Washington Island, Door Co. (Bullock); Sturgeon Bay, Door Co. (Baker); Lake Noque Bay, near Crivitz, Marinette Co.; Green Bay, at Marinette, Marinette Co. (Bullock).

Fox (Illinois) Drainage: Lake Geneva (Baker); Lake Delavan (Woodruff); Lake Beulah (Baker, Cahn). All Walworth Co.

Rock Drainage: Lake Mendota, Kane Co. (Dudley); Dutchmans Lake, Ashippun Lake, Oconomowoc and Golden lakes, Lake la Belle, Little Silver Lake, Keesus Lake, Eagle Lake, Pewaukee Lake, Waukesha Co. (Cahn).

REMARKS: *Footiana* is a lake manifestation of *grandis*, modified to fit the environment of the rough waters of a lake. The shell varies in length and width as well as in thickness, the thinner shells being confined to the quieter portion of lakes while the heavy forms are characteristic of exposed situations in larger lakes. The Butte des Morts specimens have a much swollen umbonal region, resembling small *grandis*, and the shell is rather thin. This form approaches the large form which lives in the Fox River above Butte des Morts. The Lake Winnebago specimens usually have a more flattened umbonal region, and the shell is thick and solid. In some specimens there is a pronounced posterior ridge, somewhat angled. In color the shells vary from rather dark green through olive to brown and yellow.

Footiana has been a most puzzling form and has been made to include almost any small *Anodonta* found in lakes. A very large collection from the original locality of Old Fort Winnebago, now the State Asylum for the Insane, and from other parts of Winnebago Lake, indicates that this form has been misunderstood by most authors. It is typically not the small,

rusty brown shell so frequently referred to as *footiana*, but a larger shell appearing almost like a small edition of *grandis*, but with a more squarish shell and less mammae-like umbones. Lake Winnebago *footiana* would appear to be a modification of the *grandis* form, that form living in Fox River. Lake Butte des Morts specimens combine characteristics of both forms and it is possible that Lea's original specimens of *marryattana* came from this lake, just west of Winnebago, because the *Anodonta* of this lake is like the figure of *marryattana*. The shell is thinner and more elongated posteriorly and with swollen umbones. Lea's figure of the dorsal aspect of this form is probably somewhat exaggerated, because no shells of this nature could be found in any of the Lake Winnebago material.

This type of shell is found in many lakes. In Green Lake the color is more inclined toward yellow and greenish-yellow than in the Winnebago shells. In Lake Chetek and Prairie Lake, this form is found and is of special interest, because these lakes were formerly (some 60 years ago) small creeks or streams inhabited by *Anodonta grandis plana* which now occurs in the inlets and outlets (see under *plana*). The change from a creek to a lake has changed the shell from a *plana* to a *footiana*. The color and texture of the shell is brownish like the creek form. There are some intermediate forms but the majority are exactly like the Winnebago Lake shells. Specimens from Sturgeon Bay are similar to the Lake Winnebago form excepting in color, red and yellow largely replacing the green of the latter. In Brown County (exact locality not stated) a form occurs in which the umbonal region is quite swollen, this feature being exaggerated in some individuals, causing the shell to resemble typical *grandis*; it would appear that these shells in a river environment (the lower Fox River) are changing back to the original *grandis* form.

The series of variations of *Anodonta grandis* is another example of the changes due to differences in environments acting on such plastic animals as river mussels. The series, including the large river *gigantea*, stand as follows:

footiana, lake form.

plana, small river and creek form.

grandis, form of medium-sized rivers.

gigantea, form of very large rivers.

ANODONTA GIGANTEA Lea. Floater

Plate LXII, figure 4; plate LXV, figure 3

Anodonta gigantea LEA, Trans. Amer. Phil. Soc., V, p. 1, pl. i, fig. 1, 1834; Obs., II, p. 1, pl. i, fig. 1, 1838.

Anodonta grandis var. *gigantea* SIMPSON, Cat., p. 420, 1914.

TYPE LOCALITY: Port Gibson, Clairborne Co., Mississippi; possibly in Bayou Pierre.

WISCONSIN RECORDS:

1905a. *Anodonta grandis gigantea* BAKER, p. 254. Prairie du Chien.

1906a. *Anodonta grandis* BAKER, p. 254. Prairie du Chien.

1922a. *Anodonta grandis* GRIER, pp. 11-31. Lake Pepin.

1927d. *Anodonta grandis gigantea* BAKER, p. 107. Crawfish River, Aztalan; Rock River, Jefferson and Rock Co.

SHELL: In general form like *Anodonta grandis* but rather more quadrate, the umbones placed near the center of the dorsal margin and usually not as much inflated, often much compressed, the valves flattened ventrally and compressed both anteriorly and posteriorly; the anterior end of the dorsal margin is longer and straighter than in *grandis*; umbonal markings heavier and more nodulous than in *grandis*, the double loop strongly marked; the posterior end in *gigantea* is much more sharply truncated than in *grandis*.

L. 201; H. 123; D. 87 mm. Lea's specimen.

L. 176; H. 108; D. 82 mm. Yalabusha River, Grenada, Miss. (U. of I., 5198).

L. 166; H. 106; D. 68 mm. Mississippi River, Fairport, Iowa (U. of I., Z19675).

L. 159; H. 115; D. 53 mm. Jefferson, Rock River (U. of W., 916).

L. 85; H. 57; D. 32 mm. Prairie du Chien (Dudley).

ANIMAL: As in *grandis*.

GLOCHIDIA (Pl. XXXI, fig. 20): Very large, length and height about equal, somewhat triangular in form, hooked, hinge line nearly straight. Length 0.410, height 0.420 mm. (Surber).

BREEDING SEASON: Bradytictic, from August to April or May.

NATURAL HOST: Roach (*Abramis crysoleucas*), German carp (*Cyprinus carpio*), yellow perch (*Perca flavescens*), blue-gill sunfish (*Lepomis pallidus*), rock bass (*Ambloplites rupe-*

tris), and crappie (*Pomoxis annularis*) (see LeFevre and Curtis, 1910, p. 103).

ECOLOGY: In the large rivers in quieter localities on mud bottom. No data are at hand concerning range in depth.

GENERAL DISTRIBUTION: Mississippi River, lower part of Wisconsin and Rock Rivers. Also probably lower Ohio, Illinois and Wabash rivers.

DISTRIBUTION IN WISCONSIN: Confined to the Mississippi River and the lower parts of the Wisconsin and Rock rivers, in the latter extending as far up as Jefferson Co., above which the form is *grandis*.

Mississippi Drainage: Prairie du Chien, Crawford Co. (Baker, Dudley); Lake Pepin and Mississippi below (Grier, Wagner).

Wisconsin Drainage: Lone Rock, Iowa Co. (Dudley).

Rock Drainage: Jefferson, Jefferson Co. (Bullock); between Jefferson and Ft. Atkinson; Crawfish River, Aztalan, Jefferson Co. (Cahn).

REMARKS: *Anodonta gigantea* appears to be a distinct species of the genus and not a variety of *grandis*. The discrepancy between the measurements of Surber and Ortmann indicate that two species are involved. Surber's specimens came from the Mississippi River and the glochidia measure 0.410 by 0.420. Ortmann's specimens came from a small river or creek and measure 0.36 by 0.37. Recently, Miss Mary E. Tucker, a graduate student at the University of Illinois, measured the glochidia of typical *grandis* from Lake Decatur, an artificial lake made by damming the Sangamon River, and found them to agree essentially with Ortmann's measurements but to be much smaller than those described and figured by Surber. The differences in shells are not so great but that of the glochidia appear conclusive. Such differences as are apparent have been indicated in the diagnosis of the species.

The distribution of this species is somewhat peculiar. It occurs in the Mississippi, probably throughout its entire length as far up as Lake Pepin. In the lower Wisconsin it has been seen as far up as Lone Rock. In the Rock River it occurs in the lower part in Illinois but none have been seen from the upper part. In Wisconsin, this form occurs in the Rock River in Jefferson Co. and apparently ascends the lower part of the Crawfish River. In Lake Koshkonong, which is a widening of the Rock River, an *Anodonta* occurs which is apparently referable to *grandis*, having the high umbones and thin shell of that

species. Apparently *gigantea* does not occur in this lake, for it is found above Lake Koshkonong. These somewhat resemble *corpulenta*, but lack the peculiar mammaeform appearance near the beaks. Unfortunately, the animal has not been examined and the glochidia are not known. No specimens of *gigantea* have been seen from the Illinois River, although the species should be found in the lower part near the Mississippi, as in the case of the Rock River. Apparently the only sure way of separating *grandis* from *gigantea* is by an examination of the glochidia.

ANODONTA KENNICOTTII Lea

Plate LXIII, figures 1-3

Anodonta kennicottii LEA, Proc. Phil. Acad. Sci., V, p. 56, 1861; Journ. Phil. Acad., p. 214, pl. xxxiii, fig. 283, 1862; Obs., IX, p. 36, pl. xxxiii, fig. 283, 1863.

Anodonta kennicottii SIMPSON, Cat., p. 435, 1914.

Anodonta simpsoniana LEA, Proc. Phil. Acad., V, p. 36, 1861; Obs., IX, p. 34, pl. XXXII, fig. 281, 1863.

TYPE LOCALITY: North end of Lake Winnipeg and Fort Rae, Great Slave Lake (*kennicottii*); Fort Rae, Great Slave Lake (*simpsoniana*).

WISCONSIN RECORDS: None.

SHELL: elongated, elliptical, subrhomboid, inequipartite, quite convex, rather solid; anterior end rounded; posterior end sharply rounded; ventral border straight or but slightly rounded; dorsal margin nearly straight; posterior ridge subangular or rounded, curving upward somewhat in the middle, ending in a bluntly rounded point at the posterior end, which may be somewhat biangular; there is a slight wing-like expansion of the posterior dorsal margin above the ridge; umbones swollen but beaks somewhat compressed, not much elevated above the dorsal margin; beak sculpture consisting of wavy, double-looped, nodulous ridges, similar to those of *grandis* and *footiana* but smaller; epidermis yellowish, brownish, or slightly pinkish, the resting periods showing as distinct, brownish bands, five or six being visible in mature shells; surface somewhat imbricated or roughened by the growth lines.

Hinge edentulous, rather thickened along the margin behind the beaks; beak cavities rather deep; muscle scars well marked; nacre white or pinkish, more or less iridescent.

- L. 63; H. 39; D. 25 mm. Green Lake (U. of W., 923a).
 L. 72; H. 44; D. 30 mm. " " (" 923b).
 L. 74; H. 44; D. 29 mm. " " (" 924a).
 L. 59; H. 33; D. 25 mm. " " (" 924b).
 L. 56; H. 31; D. 20 mm. Grantsburg (U. of W., 922).
 L. 90; H. 49; D. 32 mm. Lake Ellen (U. of W., 235).

ANIMAL: Similar to *footiana*. Mantle connection between anal and supra-anal not as long as anal opening. Supra-anal as large as anal and mantle connection combined. Gills brown, the balance of the animal colored as in *footiana*. Glochidia not observed (Green Lake specimens).

BREEDING SEASON: Not ascertained; none gravid in July in Wisconsin.

NATURAL HOST: Not recorded.

ECOLOGY: In Green Lake this species was found on an open shore of the lake, on a sand bottom, in water from few cm. to 3 m. Exceptionally, they occurred as deep as 6 meters. Not found in any number on a mud bottom (see Juday, 1924, p. 360). *Kennicotti* were found in deeper water than *footiana* which also lives in Green Lake.

GENERAL DISTRIBUTION: "Upper and middle St. Lawrence River System; northwest into the Mackenzie drainage" (Simpson).

DISTRIBUTION IN WISCONSIN: At present recorded from the Mississippi and Fox drainages. Probably much more widely distributed than the specimens at hand would indicate.

Mississippi Drainage: Mud. Hen Lake, Grantsburg, Burnett Co. Bullock).

Fox Drainage: Green Lake, Green Lake Co. (Baker, Juday).

REMARKS: *Kennicottii* is a species of northern distribution, apparently. It may be known from *footiana*, which it greatly resembles, by being shorter, more rhomboidal in form, more compressed and flatter on the sides, the posterior ridge placed higher up and the shell more swollen in this region, and by the posterior end which is rounded in *kennicottii* while it is pointed in *footiana*. The posterior end also bends downward, forming a somewhat plough-shaped projection. The color is always different from typical *footiana*, being rusty, yellowish, or pinkish while *footiana* is usually green. Some *footiana*, however, may be rusty in color.

This form of *Anodonta* was at first thought to be referable to the *imbricata* of Anthony (Amer. Journ. Conch., I, p. 159), but an examination of specimens of *imbricata* from the Anthony collection in the Mus. Comp. Zool., Harvard University, kindly loaned by Dr. Samuel Henshaw, shows that this approximation is not correct, *imbricata* having finer umbonal markings like those of *Anodonta marginata*, to which species *imbricata* is related rather than to the *grandis* group. Dr. Bryant Walker has suggested that the Wisconsin mussel is *kennicottii* and it agrees with the description and figure of Lea.

While usually *footiana* and *kennicottii* are easily separated, there are some forms of the former living in Sturgeon Bay that resemble the short *kennicottii* form and but for the presence of undoubted *footiana* might be referred to the northern species. In Green Lake, some specimens show a tendency to lengthen the posterior end which becomes rather pointed. A specimen from Lake Ellen carries this variation to an extreme, but the shell appears to be referable to *kennicottii*.

ANODONTA MARGINATA Say. Paper-Shell Floater

Plate LXIV, figures 1-4

Anodonta marginata SAY, Nich. Encyc., II, pl. iii, fig. 5, 1917.

Anodonta fragilis LAM., An. sans. Vert., VI, p. 85, 1919.

Anodonta marginata SIMPSON, Cat., p. 388, 1914.

Anodonta lacustris LEA, Pr. Acad. Nat. Sci., Phil., I, p. 84, 1857;
Jour. of same, p. 363, pl. lxii, fig. 188, 1860; Obs., VIII, p. 45, pl. lxii,
fig. 188, 1860.

Anodon irisans ANTHONY, Amer. Jour. Conch., I, p. 163, pl. xvi, fig. 2,
1865.

TYPE LOCALITY: Not given for *marginata* (Say); Crooked Lake and Little Lakes, New York (*lacustris*, Lea); Bostwick's Lake, Michigan, (*irisans*, Anthony).

WISCONSIN RECORDS:

1897. *Anodonta lacustris* WISWALL, p. 48. Southern Wisconsin.

1911a. *Anodonta marginata* BAKER, p. 231. Tomahawk Lake.

1906. *Anodonta cataracta* CHADWICK, p. 93. Golden Lake, Waukesha Co., Maple Lake, Oneida Co.

1927d. *Anodonta marginata* BAKER, p. 107. Small lakes in Waukesha Co.

SHELL: Long-ovate or elongate-elliptical, moderately inflated, usually with thin valves; anterior end rounded; posterior

end elongated, pointed, biangulate; ventral margin slightly rounded; dorsal margin straight, slightly sloping at the extremities; beaks slightly raised above the dorsal margin, rather full in some specimens, slightly compressed in others; beak sculpture consisting of 4-5 (rarely 6), somewhat irregularly looped bars, of which the posterior loop is short and v-shaped, and the anterior loop is long and broadly rounded; posterior ridge rounded, faintly double, ending in a rather bluntly biangulate point, which is midway of the posterior margin, the dorsal and ventral margins declining and inclining to meet it; surface with raised growth lines which are more conspicuous on the posterior end, and which are larger and edged with black at rest periods; epidermis olive greenish, brownish, sometimes blotched with reddish-brown on the anterior slope, or the shell may have a brownish cast over a yellowish-green background; region of umbones sometimes of a rich golden color; green rays are more or less distinct on the surface; nacre usually a peculiar dull, silvery tint, iridescent at the posterior end, frequently stained with salmon near the beak cavities, which are shallow. Hinge edentulous.

L. 120; H. 68; D. 39 mm.	Yahara, above Kegonsa (Dudley).
L. 120; H. 62; D. 41 mm.	Lake Mendota (Dudley).
L. 100; H. 53; D. 31 mm.	Fish Lake (Chi. Acad. Sci., 14823).
L. 81; H. 43; D. 27 mm.	" " (" " " 14823).
L. 75; H. 44; D. 25 mm.	Brown Co. (U. of W., 131b).
L. 98; H. 48; D. 31 mm.	Chetek Lake (U. of W., 925a).
L. 65; H. 34; D. 21 mm.	" " (" 925b).
L. 49; H. 29; D. 16 mm.	" " (" 925c).
L. 30; H. 16; D. 9 mm.	" " (" 925d).

ANIMAL: Not differing materially from *Anodonta grandis*. Mantle connection between anal and supra-anal much wider than anal opening, and longer than supra-anal opening. Glochidia not examined.

BREEDING SEASON: Not recorded. Probably similar to that of *Anodonta grandis*. None gravid in July or August.

NATURAL HOST: Not recorded.

ECOLOGY: Shallow, quiet lakes in mud bottom. Lake Chetek, sand and mud bottom, water .6-1 m. deep, near shore; Sturgeon Bay, near canal, in fine sand, in 1.1 m. of water. This species is for the most part a mussel of lakes and is seldom found in rivers.

GENERAL DISTRIBUTION: "St. Lawrence drainage" (Simpson). Specimens from Lake Chetek and lakes in the Wisconsin and Rock drainage indicate that this species also inhabits the Mississippi drainage.

DISTRIBUTION IN WISCONSIN: *Marginata* is widely distributed in the State, occurring in the Mississippi, Wisconsin, Rock, and Fox drainages.

REMARKS: *Anodonta marginata* may be distinguished from *grandis* by its thinner shell, more pointed and elongated posterior end, less elevated and more compressed umbones, peculiar silvery nacre, and the umbonal markings which are finer than *grandis*, differently looped (anterior much longer than posterior), and not nodulous. These differences are slight, but sufficiently differentiate the two forms. *Grandis* usually has a larger and differently shaped shell. Some forms of *grandis footiana* somewhat resemble *marginata* in the elongation of the posterior end, which may be distinctly biangulate, but the umbones in *footiana* are more elevated, the umbonal region more swollen, and the umbonal markings different. In the *grandis* group the dorso-anterior margin forms a sharp angle with the rounded anterior end, while in the *marginata* from Wisconsin this feature is wholly lacking or only slightly developed. The shell of *marginata* is usually very thin and fragile, but occasional specimens are rather solid.

There is some variation in the shell of this species. Normally, the shell is rather compressed and the umbonal slope of the valve flatly rounded. Specimens from Lake Mendota (pl. LXIV, fig. 1) vary from this form by having the umbonal slope rather swollen, giving the shell greater diameter. Lake Chetek specimens are cylindrical with a great length as compared with width and height. Specimens from this locality vary from flatly elongated to cylindrically elongated. Occasional species resemble *Anodonta cataracta*, differing in having a thinner shell, the peculiar silvery nacre, and differently shaped beak markings. Specimens with swollen umbones from Sturgeon Bay more nearly resemble this *cataracta*-like form. Chadwick's reference to *cataracta* is based on such forms. Like the *Anodonta* group in general, this species has no commercial value other than as food for fish or other animals.

ANODONTA CORPULENTA Cooper. Stout Floater

Plate LXVI

Anodonta corpulenta COOPER, App. Narrative Exp. Miss. to Itasca Lake, p. 154, 1834.

Anodonta corpulenta SIMPSON, Cat., p. 430, 1912.

TYPE LOCALITY: Upper Missouri River (Cooper).

WISCONSIN RECORDS:

1905c. *Anodonta corpulenta* BAKER, p. 254. Prairie du Chien.

1922a. *Anodonta corpulenta* GRIER, pp. 11-31. Pierce, Buffalo, Trempealeau Co.

1926. *Anodonta corpulenta* GRIER and MUELLER, p. 17. Upper Mississippi River.

SHELL: Large, subrhomboid, inflated, slightly inequipartite, thin to strong; anterior end rounded; posterior end diagonally truncated above, rounded below; ventral margin usually quite convex; dorsal margin straight, meeting both anterior and posterior ends at a sharp angle, and winged or alate on both sides of the umbones; beaks full, high, recurved, extending much above the dorsal margin of the valves; the umbonal swelling extends well down to the center of the valves; beak sculpture consisting of about four very irregular corrugations, which are irregularly double-looped, and often represented only by raised nodules; posterior ridge low, rounded, ending in a slight biangulation; surface with irregular growth lines more or less raised to form concentric ridges, which may or may not be coincident with rest periods; epidermis olive, yellowish-brown, reddish-brown, greenish-black in old specimens, slightly rayed in immature and young specimens; nacre whitish, purplish, or rich salmon, especially near the beak cavities, iridescent posteriorly; beak cavities deep; hinge edentulous. No sexual differences in the shells.

L. 112; H. 77; D. 46 mm. Prairie du Chien (Dudley).

L. 103; H. 76; D. 47 mm. " " " "

L. 153; H. 103; D. 70 mm. Henderson Co., Ill. (U. of I., 3825).

L. 128; H. 88; D. 53 mm. Lake Pepin (U. of W., 342c).

L. 107; H. 73; D. 21 mm. " " (" 342b).

ANIMAL: Similar in anatomical details to *Anodonta grandis*. Glochidia (pl. XXXI, fig. 21) smaller than *grandis*, length and width equal, hinge line irregular, undulate. Length 0.350, height 0.350 mm. (Surber).

BREEDING SEASON: Bradyctic. October to April (Surber, 1912, p. 7).

NATURAL HOST: Fin parasite upon same host as *Fusconaia ebena*, the skipjack (*Pomolobus chrysocharis*), occurring on the caudal, ventral, and pectoral fins. A young fish (three inches long) had 24 glochidia on Nov. 10, 1910 (Surber, 1913, p. 106).

ECOLOGY: Found only in the larger rivers, usually on a mud or sandy mud bottom, in water .3–2 m. or more in depth.

GENERAL DISTRIBUTION: Missouri River; upper Mississippi River drainage; east to Indiana (Simpson). The distribution in the south and east is not well defined. Specimens are in the Hinkley collection from pond near Shreveport, Louisiana, and Cadda Lake, Texas. These do not differ materially from the Mississippi River *corpulenta*. In Illinois this large *Anodonta* is common.

DISTRIBUTION IN WISCONSIN: As far as available records show, *corpulenta* is found only in the Mississippi River.

REMARKS: This *Anodonta* may be at once known from *grandis gigantea*, which it most nearly resembles, by its large corpulent shell, alate dorsal margin, on both sides of the umbones, its swollen umbones, and its nodulous beak sculpture. It is a squarish shell, the height being almost equal to the length. The glochidia are also different, which fact alone establishes its right to specific recognition. It is common in the Mississippi River where the fishermen call it the floater, because when dead it rises to the surface and floats upon the water. It is of no value commercially, but affords food for catfishes and possibly other fish.

The *corpulenta* of Lake Pepin are somewhat more compressed and have more depressed umbones than the typical form from other parts of the Mississippi River. The specimens at hand were collected by Mr. George Wagner near Lake City, Minn. (pl. LXVI, figs. 3, 4). They are also more solid than *corpulenta*. As intergrades occur and as Grier did not find any great difference between the Lake Pepin shells and those from the river below the lake, it does not appear that they have formed a stable ecologic variety. The influence of the lake environment, however, is plainly manifest, indicating that this law affects all species to some degree.

Genus UTTERBACKIA F. C. Baker, 1927

Lastena Utterback (non Raf.), Naiades of Missouri, p. 104, 1916.

Utterbackia F. C. Baker, Amer. Mid. Nat., p. 221, Jan. 1927.

Shell thin, subalated, smooth on disk; beaks flat, sculptured with four or five faintly double-looped ridges; epidermis smooth, polished, rayed in green on the region of the post-umbonal ridge; hinge teeth absent; muscle scars faint, confluent; nacre bluish.

Animal with branchial opening narrow, upcurved, papillose, anal opening smooth, supra-anal opening short, widely separated from anal; gills long, tapering posteriorly, outer and inner gills of about the same size; inner laminae of inner gills free from visceral mass; palpi subfalcate; color of most exposed soft parts orange, rest of soft parts tan-colored and soiled white; marsupia rusty color when charged, ventral edges distended, water canals present; no specialized structure of mantle edge anterior to branchial opening; (Utterback, 1916a, p. 104). Type: *Anodonta imbecillis* Say.

Utterback included *Anodonta imbecillis* (listed as *Lastena ohioensis* Raf.) and *A. suborbiculata* in Rafinesque's genus *Lastena*. Ortmann (1919, p. 162) and Walker and Ortmann (1922, p. 37) have shown that this name cannot be used for this species, the name *Lastena* having been correctly diagnosed and a type fixed by Simpson (1900, p. 654), the *Anodonta* (*Lastena*) *lata* of Rafinesque.

As indicated by Utterback, however, *Anodonta imbecillis* differs in several particulars from the other members of the genus *Anodonta* and should receive group distinction. The shell is different from all other American *Anodonta* in having pronounced flattened beaks. The animal is hermaphroditic and the parasitic stage in the development of the glochidium is often omitted, the process taking place in the marsupium and the young mussel discharged into the water when ready to begin independent life. These characteristics differentiate *imbecillis* from all other *Anodontae* at present known. *Anodonta suborbiculata* is a true *Anodonta*, is not hermaphroditic, and its glochidium develops regularly on a fish host. (see Utterback, 1916a, p. 108).

Sterki (1898d, p. 87) was the first observer to record *imbecillis* as hermaphroditic. Ortmann and Utterback also attest

this fact. Howard (1914b, p. 353), described the young mussels and made additional observations on their development. In abstract he says: "Gravid mussels were collected in November. Upon examining the contents of the marsupium of one individual I found that what at first glance appeared to be mature glochidia were instead juvenile mussels with organs developed to the stage usually seen at the end of the parasitic period when the young mussel escapes from its host. These young mussels lie crowded in the marsupial gill of the parent without apparently any matrix or conglomerate structure whatever. Among the six lots of marsupial juveniles collected the degree of development varied slightly in the amount of shell growth, otherwise there seemed to be little difference. This growth consists of a narrow rim only, around the edge of the glochidial shell. The hooks of the glochidium are still much in evidence but are much weaker than in parasitic forms. Between the gaping valves can be seen the ciliated foot, two adductor mussels, the mantle, on each side the gill papillae, etc., indicating a development equal to that of other young Naiades at the end of parasitism."

Howard tested the reaction of the glochidia to fish and obtained strong evidence that they do not respond as other known parasitic forms. Experiments showed no reaction on the fish while the glochidia of *Lasmigona complanata* showed perfect attachment. In a later experiment encystment was effected but metamorphosis did not ensue for this species, while it was complete for *Strophitus rugosus*. Howard further states that "From these observations I think we are warranted in concluding that this mussel passes through its metamorphosis in the entire absence of parasitism".

Recent experiments by Miss Mary E. Tucker, a graduate student at the University of Illinois, indicate beyond doubt that *imbecillis* does develop in the glochidial stage on a fish host as in the case of other Anodontae. From the data already presented by the several observers, it would appear that *imbecillis*, like *Strophitus*, may develop either with or without metamorphosis on a fish host. Additional observations on this will be of interest.

UTTERBACKIA IMBECILLIS (Say). Paper Pond Shell

Plate LXVIII, figures 6-8

Anodonta imbecillis SAY, N. Harm. Diss., II, No. 23, p. 355, 1829.*Anodonta imbecillis* SIMPSON, Cat., p. 395, 1914.*Anodonta ohioensis* ORTMANN, Mem. Carnegie Mus., VIII, p. 162, 1919.*Anodonta imbecillis* ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 37, 1922.

TYPE LOCALITY: Wabash River.

WISCONSIN RECORDS:

1852. *Anodonta imbecilis* LAPHAM, p. 370. Wisconsin.1860. *Anodonta imbecilis* LAPHAM, p. 156. Milwaukee.1897. *Anodonta imbecilis* WISWALL, p. 48. Southern Wisconsin.1919. *Anodonta ohioensis* ORTMANN, p. 165. Milwaukee.1922a. *Anodonta imbecillis* GRIER, pp. 11-31. Pierce, Pepin, Buffalo Co.1924. *Anodonta imbecillis* BAKER, p. 132. Omro, Fox River.

SHELL: Usually very thin and fragile, inequipartite, rounded anteriorly, somewhat pointed posteriorly; dorsal margin nearly straight, ventral margin slightly rounded; beak flattened, flush with the hinge line, sloping toward the center of the valve in young specimens, horizontal in old shells; beak sculpture fine, consisting of 5-6 irregular, often broken, sub-concentric ridges, which are somewhat wavy and inclined to form a feeble double loop, the anterior loop much the larger; posterior ridge low, rounded; posterior dorsal margin forming a compressed wing; epidermis grass-green, lighter or darker in individuals, sometimes horn colored, brownish, or yellowish in the region of the beaks, with many dark green rays, two or more of which are frequently heavily marked on the posterior slope; the rest periods are usually marked by distinct ridges of growth lines, edged with black; hinge line edentulous; beak cavities shallow, containing dorsal muscle scars; adductor muscle scars very faintly marked; nacre bluish-white, silvery, iridescent posteriorly; the beak cavities cream or yellowish-brown.

L. 77; H. 36; D. 25 mm. Ogle Co., Ill. (U. of I., Z3815).

L. 73; H. 34; D. 24 mm. " " (" Z3815).

L. 40; H. 20; D. 10 mm. Omro (U. of W., 926).

ANIMAL: (Fig. 227). Anal and supra-anal openings separated by mantle connection about as long as anal opening;

branchial opening with papillae, anal opening but slightly crenulated, almost smooth; outer and inner gills of about equal size; inner laminae of inner gills free from abdominal sac; palpi subfalcate, united at their anterior end for about two-thirds of their length; marsupium occupying only outer gill which becomes pad-like as in *Anodonta*. The entire length of the gill is affected. Specimens from Omro contained 40 septa. The species being hermaphroditic there is no difference in the shells as regards sex.

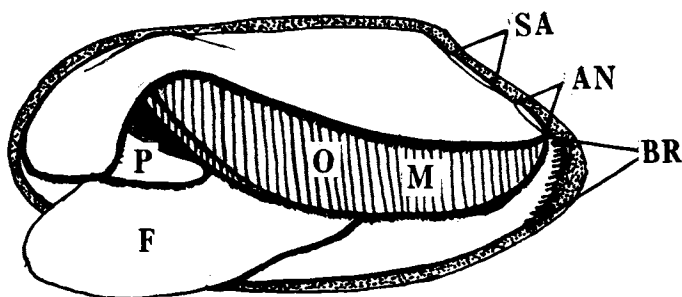


Fig. 227. *Utterbackia imbecillis* (Say). Omro, Fox River. Gravid female. Aug. 3, 1920.

Glochidia (pl. XXXII, fig. 1) of medium size, very broad, higher than wide; the hinge line straight, ventral margin with hook. Height 0.31, length 0.29 mm. (Surber, 1912, p. 8); height 0.31, length 0.30 mm. (Ortmann, 1919, p. 163).

BREEDING SEASON: Gravid individuals have been noted in March, May, June, July, August, September, October, November and February. Ortmann says: "This is undoubtedly a bradytictic form, and according to the above dates is apparently 'all the year round', i. e., the succeeding breeding seasons overlap in June and July, but probably not in the same individual." Specimens from Omro collected on August third were gravid, the glochidia in an advanced stage of development. Howard found glochidia in May and July, early embryos in February and November, late embryos and glochidia in November, and a specimen not gravid in September 24. Juveniles were observed on November 7. The presence of juveniles in the marsupia during November in a majority of the specimens examined indicates that the metamorphosis may be completed in the fall.

HOST: See under generic description. The buoyancy of the young mussel enables it to be carried for long distances by currents before it settles to the bottom, and this buoyancy is believed to take the place of distribution by fish host.

ECOLOGY: Small rivers and ponds in shallow, quiet water along shore on a fine sand or mud bottom (Wisconsin, Fox River; Illinois, Vermilion River). Ecology of the Mississippi River form not specifically stated.

GENERAL DISTRIBUTION: Found in both the Mississippi Valley and Great Lakes drainages, more common in the latter. Simpson says: "Entire Mississippi drainage area; southern Michigan; North Carolina to Georgia; southwest to Matamoras, Mexico." Its eastern limit is apparently Herkimer Co., N. Y., and its western limit Kansas and Oklahoma.

DISTRIBUTION IN WISCONSIN: Rather widely scattered in the Mississippi and Great Lakes drainages. It is apparently rare as it appears in but few of the rather numerous collections from the State.

Mississippi Drainage: Pierce, Pepin, Buffalo Co. (Grier).

Fox Drainage: Omro, Fox River, Winnebago Co. (Baker).

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Chadwick, Latham).

REMARKS: *Utterbackia imbecillis* is one of the most easily distinguished of American naiades, the peculiar flattened beaks and umbones, cylindrical shape, and grass-green color being distinguishing characteristics quite unmistakable. There is little variation, except that due to age, this resulting in greatly increased diameter and flattening of the umbonal region. Young shells are quite compressed. Omro specimens are green with rather faint rays. There is little variation in the rather abundant material from Illinois, Indiana, Michigan and Wisconsin. The species appears to be rare in Wisconsin.

It is probable that when the various types of shell referred to this genus are critically examined from all parts of its range, there will be found differences of specific or varietal importance. A form of *imbecillis* from Alabama may be a variety, but not enough material is at hand to determine this question. *Anodonta henryana* Lea, described from Matamoras and Tamaulipas, Mexico, is a member of the genus *Utterbackia* and probably a distinct species. It is in the Hinkley collection of the University of Illinois from San Rafael, Texas.

UTTERBACKIA IMBECILLIS FUSCA F. C. Baker

Plate CIII, figures 12-14

Utterbackia imbecillis fusca F. C. BAKER, Amer. Mid. Nat., X, p. 222, 1927.

TYPE LOCALITY: Sturgeon Bay, Door Co., Wis.

WISCONSIN RECORDS: Op. Cit. and locality as above.

SHELL: Differing from typical *imbecillis* in being smaller, more cylindrical, shorter in relation to height, valve less swollen in the center of the disk, and color shades of brown with rarely yellowish rays on an olive background.

L. 48; H. 25; D. 14 mm. Sturgeon Bay (U. of W., 927a). Holotype.
 L. 43; H. 21; D. 11 mm. " " (" 927b). Paratype.
 L. 24; H. 11; D. 3 mm. " " (" 927c).

ANIMAL: Not examined.

ECOLOGY: Shore of an open bay with sandy-clay-marl bottom.

DISTRIBUTION IN WISCONSIN: Apparently confined to the type locality. Sturgeon Bay, Door Co. (Baker).

REMARKS: This small, thin mussel appears to be a dwarf form of *imbecillis* occupying a habitat in a turbulent bay. Its small size and peculiar color will readily differentiate it from *imbecillis* of the rivers and ponds, which is always grass-green and much larger. It is apparently an ecological variety.

Genus ANODONTOIDES Simpson, 1898

Shell elliptical, inflated, thin, with a faint posterior ridge, sometimes constricted at the center of the base; beaks rather full, with a few, not very coarse, subparallel, concentric ridges, which are curved up rather suddenly behind and back of these are fine radiating ridges; epidermis smooth and shining, often rayed; hinge line slightly incurved in front of the beaks, edentulous or bearing the merest rudiments of teeth; nacre bluish-white. Marsupium occupying the outer gills only (Walker). Type: *Anodonta ferussaciana* Lea.

ANODONTOIDES FERUSSACIANUS (Lea). Cylindrical Paper-Shell

Plate LXVII, figures 3, 4, 7; plate LXXV, figures 3-5

Anodonta ferussaciana LEA, Trans. Amer. Phil. Soc., V, p. 45, pl. vi, fig. 15, 1834; Obs., I, p. 157, pl. vi, fig. 15, 1834.*Anodontoides ferussacianus* SIMPSON, Cat., p. 467, 1914.*Anodonta buechanensis* LEA, Op. cit., VI, p. 47, pl. xiv, fig. 43, 1838; Obs., II, p. 47, pl. xiv, fig. 43, 1838.

TYPE LOCALITY: Ohio River, near Cincinnati, Ohio (*ferussacianus*); Buck Creek, Ohio (*buchanensis*).

WISCONSIN RECORDS:

1852. *Anodonta ferussaciana* LAPHAM, p. 370. Wisconsin?
 1860. *Anodonta ferussaciana* LAPHAM, p. 156. Milwaukee.
 1897. *Anodonta ferussaciana* WISWALL, p. 48. Southern Wisconsin.
 1906. *Anodontoides ferussacianus* CHADWICK, p. 94. Milwaukee.
 Jumbo Creek, Manitowoc Co.
 1919. *Anodontoides ferussacianus* ORTMANN, p. 170. Wisconsin?
 1927d. *Anodontoides subcylindraceus* BAKER, p. 107. Neosho mill pond.

SHELL: Long-elliptical, thin, inequipartite, somewhat inflated; anterior end rounded; posterior end more or less biangulate, pointed; ventral margin slightly rounded; dorsal margin straight or slightly curved, forming a slight angle with the posterior margin; a wing is rarely developed posteriorly; beaks convex, slightly raised above the hinge line, more swollen in some individuals; beak sculpture consisting of 3-4 very fine, sharp, subconcentric ridges, the first two oblique to the hinge line, the others forming a distinct angle, all bent up sharply behind; there are usually several additional (5-7) very faint, diagonal, bars on the posterior slope; the beak sculpture is not double-looped, as in *Anodonta*; posterior ridge rounded, faintly biangulate; young shells are compressed, older ones more swollen, especially in the region of the posterior ridge; epidermis light green, olive, or yellowish-brown, lighter on the beaks, the rest periods marked by black, concentric bands; surface with many dark green rays, more marked on the posterior slope; these disappear in old specimens.

Hinge edentulous, but beneath the beaks the dorsal margin is incurved and is marked by several irregular swellings, which are rudimentary pseudocardinal teeth; beak cavity shallow; all muscle scars faint; nacre bluish-white, silvery, iridescent at posterior end, cream or salmon tinted in the vicinity of the beak cavity. Shells of male and female slightly different, the latter swollen in front of the posterior ridge and with a greater height in this region than in the male. This feature, however, is not always present.

- L. 88; H. 42.0; D. 36.0 mm. Outlet of Green Lake (Baker, U. of W., 928).
 L. 62; H. 33.0; D. 24.0 mm. Green Lake (Baker, U. of W., 929a). Male.
 L. 70; H. 35.0; D. 28.5 mm. Mukwonago River (U. of I., Z17325).
 L. 68; H. 37.0; D. 27.0 mm. Salt Fork, Ill. (U. of I., Z11212). Male.
 L. 63; H. 32.5; D. 27.0 mm. Salt Fork, Ill. (U. of I., Z11702). Male.

ANIMAL: Similar to that of *Anodonta*. The mantle connection between anal and supra-anal openings shorter than in *Anodonta*, being about as long as the anal opening; the branchial opening is papillose, the anal opening is fringed on the inner edge with fine papillae; palpi connected at their base for but a short distance; inner gills larger than outer gills, the inner laminae of inner gills not attached to the abdominal sac; outer gills only marsupial, distended at edges when filled with glochidia; secondary water tubes formed, but ovisacs are not subdivided and placentae are not formed. Color of animal light flesh or whitish, mantle and siphon openings edged with black or brown; outer gills brownish when filled with glochidia.

Glochidia (pl. XXXII, fig. 4) large, subtriangular in shape, length and height about equal, hinge line nearly straight, valves hooked. Length 0.32, height 0.32 mm. (Ortmann, 1912a, 294). Surber's measurements are 0.33 by 0.33 mm. (*buchanensis*).

BREEDING SEASON: Bradytictic. August to May. None found gravid in Green Lake in July.

NATURAL HOST: Not recorded.

ECOLOGY: A species of small, quiet creeks where it lives on a sandy bottom in shallow water. In Green Lake it occurs at the mouth of Silver Creek on a hard sand bottom in .6 m. of water. In the outlet to Green Lake it is found in shallow water on a sand bottom in quiet pools below riffles. It is rare at this locality. Mukwonago River, on gravel bottom, swift current, water .2-.7 m. deep. In Stony Creek, south of Muncie, Champaign Co., Ill., *ferussacianus* occurs in pools below riffles on a mud bottom, in water a few inches to half a meter in depth.

GENERAL DISTRIBUTION: Mississippi and St. Lawrence drainages. Eastern New York west to Colorado, Red River of the North south to Kentucky and Tennessee.

DISTRIBUTION IN WISCONSIN: Apparently confined to the eastern part of the state, as far as the records show.

Fox Drainage: Green Lake at outlet of Silver Creek and outlet of Green Lake, Green Lake Co. (Baker); Beasley Brook, Waupaca Co. (C. E. Brown).

Rock Drainage: Neosho mill pond, Dodge Co. (Cahn).

Lake Michigan Drainage: Jumbo Creek, Manitowoc Co. (Chadwick). Milwaukee, Milwaukee Co. (Chadwick).

REMARKS: This neat species, while greatly resembling a small *Anodonta*, may be distinguished at once by the beak

markings which are peculiar to the genus. Its general cylindrical shape will also aid in its recognition. Some individuals approach *Strophitus rugosus* in general shape, and also in color, but the difference in umbonal markings, as well as in the hinge, which is thicker in *Strophitus*, will easily distinguish *ferussacianus*. The nacre of the two species is also different.

Typical *ferussacianus* appears to be rare in Wisconsin. In Illinois it is very common in many places, and is on the whole more typical in form than the Wisconsin material, which approaches more nearly the *buchanensis* type. A study of all available material leads to the conclusion that *buchanensis* is a female *ferussacianus*. In all large lots of *ferussacianus* several specimens occur which have the enlarged post-basal swelling shown in Lea's figure. *Ferussacianus*, also is as much a creek form as is *buchanensis*. It is found in the Big Vermilion River and its tributaries from the smallest branch to the large river phase (Baker, 1922, p. 44), in Kent Creek, at Rockford, and in the Kishwaukee River, Ill. In all of these places the two forms, *ferussacianus* and *buchanensis*, are associated, the latter form, however, never being as abundant as the former. The color of these shells is usually rather bright greenish, but brownish forms occur. The two forms are figured on plate LXXV, figs. 4, 5. Grier states (1922, p. 98) his opinion that *buchanensis* is an old female of *ferussacianus*, and I agree that this form represents the female shell. No gravid specimens have been personally examined. Material thus far examined have been males with rather pointed posterior end and straight ventral margin (pl. LXXV, figs. 3, 4). Surber may have had the subcylindrical form in studying the glochidia.

ANODONTOIDES FERUSSACIANUS SUBCYLINDRACEUS (Lea)

Plate LXVII, figures 5, 6; plate LXVIII, figure 5

Anodonta subcylindracea LEA, Trans. Amer. Phil. Soc., VI, p. 106, pl. xxiv, fig. 117, 1838; Obs., II, p. 106, pl. xxiv, fig. 117, 1838.

TYPE LOCALITY: Oak Orchard Creek, Orleans Co., N. Y.

WISCONSIN RECORDS: None.

SHELL: Smaller and more cylindrical and elongated than *ferussacianus*, more inflated post-basally, the dorsal margin more convex, the posterior end usually more sharply rounded,

not distinctly biangulate, the anterior dorsal margin not straight but sharply descending, causing the shell to appear slightly oblique; color brownish usually without rays.

L. 48; H. 26; D. 18 mm. Creek near Green Bay (U. of W., 234).

L. 50; H. 27; D. 22 mm. " " " " (" 184).

L. 41; H. 23; D. 15 mm. " " " " (" 182).

ANIMAL: Similar to *ferussacianus*. Glochidia of the small form not examined.

BREEDING SEASON: Probably the same as for *ferussacianus*.

NATURAL HOST: Not recorded.

ECOLOGY: *Subcylindraceus* is a form of creeks and probably occupies the same relative habitats as the creek specimens of *ferussacianus*.

GENERAL DISTRIBUTION: Said to occur from New York west to Wisconsin, south to Ohio. Specimens believed to be referable to this form have been seen from Wisconsin, Michigan, Ohio, Illinois, and Indiana.

DISTRIBUTION IN WISCONSIN: At present known only from the Fox River drainages in Illinois and Wisconsin.

Fox Drainage (Illinois): Mukwonago River, Mukwonago, Waukesha Co. (Cahn).

Fox Drainage: Creek east of Green Bay (Marston).

REMARKS: *Subcylindraceus* appears to be separable from *ferussacianus* and might be considered a distinct species. The specimens figured on the plate are certainly different from any forms of *ferussacianus*, and resemble the figures of Lea. Both *ferussacianus* and *buchanensis* occur in creeks and small rivers. In the Kishwaukee River, in Winnebago Co., Illinois, two forms of *Anodontoides* occur. One is very cylindrical, large, wide, inflated over the umbones, the dorsal margin in front of the umbones is straight and the anterior end is broadly rounded. This form is referred to *ferussacianus*. (U. of I., Z3827).

A second form is smaller, a little more compressed, with a noticeable posterior ridge, the dorsal margin in front of the umbones descends rather abruptly toward the sharply rounded anterior end, and the umbonal region is somewhat compressed, not inflated. This form agrees perfectly with the figure of Lea's *subcylindraceus*, which appears to be an adult shell. (U. of I., Z14863). The first form is greenish, the latter, brownish.

Forms of this type are in the University collection from Bessey Creek and Maple River, near Douglas Lake, Mich., collected by Dr. Frank Smith, and these appear quite typical and are certainly different from *ferussacianus*.

Subcylindraceus somewhat resembles *birgei*, the lake form of *Anodontoides*, but the umbones are not as swollen, are placed nearer the anterior end, and the beak sculpture is large like typical *ferussacianus* and not fine as in *birgei*. *Birgei* resembles the Michigan *modesta* in its beak sculpture. Ortmann (1919, p. 171) records this variety from beach pools in Lake Erie, but these do not appear like the creek form but similar to *birgei*, a form of which they may possibly be. An abundance of material of the *ferussacianus-buchanensis* group is needed for study, that the limit of variation, as well as the geographic distribution, of the two forms may be more clearly known. The status of *buchanensis* and *subcylindraceus* should be determined by the study of material from different localities. As far as the material at my command is concerned, *buchanensis* appears to be a female of *ferussacianus*, while the smaller *subcylindraceus* appears to be a variety.

ANODONTOIDES BIRGEI F. C. Baker

Plate LXVIII, figures 1-4

Anodontoides birgei F. C. BAKER, Nautilus, XXXVI, p. 123, 1923.

TYPE LOCALITY: Sturgeon Bay, Door Co., below railroad bridge.

WISCONSIN RECORDS:

1923. *Anodontoides birgei* BAKER, p. 123. Sturgeon Bay.

SHELL: Rather solid, elongated, cylindrical, inequipartite, inflated; anterior end broadly rounded, posterior end pointed, distinctly biangulate; ventral margin straight or somewhat concave; dorsal margin straight, forming an angle with the posterior end; postero-dorsal margin developing a small but well marked wing; beaks swollen, elevated above hinge line; beak sculpture as in *ferussacianus* but finer, with the bars closer together, and with a tendency to become double-looped; posterior ridge sharply rounded, very distinct, with a postero-dorsal excavated area; the shell is greatly inflated anterior to this ridge; epidermis yellowish-horn or olive, the rest periods show-

ing as brown concentric bands; surface rayless; hinge edentulous, but reinforced beneath the beaks by swellings representing rudimentary pseudocardinal teeth; the shell beneath the ligament is also thickened; beak cavities shallow; muscle scars faintly impressed; nacre bluish-white, silvery tinged with salmon or pinkish, especially below the beak cavities. Female shell not as much incurved ventrally as male shell, otherwise there is no difference between the sexes.

L. 61; H. 30; D. 26 mm.	Sturgeon Bay (U. of W., 930a).	Type. Female.
L. 58; H. 29; D. 23 mm.	" " (" 980b).	Paratype.
L. 29; H. 17; D. 10 mm.	" " (" 930c).	Paratype.
L. 56; H. 28; D. 25 mm.	" " (" 930d).	Male.
L. 44; H. 24; D. 17 mm.	" " (" 930e).	
L. 82; H. 37; D. --	" " (" 930f).	Half valve.

ANIMAL: (Fig. 228). Similar to that of *ferussacianus*. Mantle connection between anal and supra-anal openings much shorter than anal; anal opening fringed with fine papillae on the inner edge; palpi connected at base as in *ferussacianus*; inner gills larger than outer gills, especially anteriorly; inner laminae of inner gills free from abdominal sac as in *ferussacianus*; outer gills marsupial. Mantle purplish-white, openings edged with brown; gills whitish, foot and abdomen creamy-white. Glochidia similar to those of *ferussacianus*, but a trifle smaller; length and width 0.28 mm.

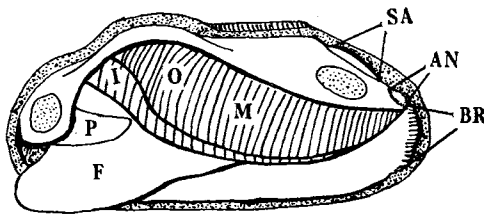


Fig. 228. *Anodontooides birgei* Baker. Sturgeon Bay. Gravid female. Aug. 25, 1922.

BREEDING SEASON: Probably same as *ferussacianus*. Gravid specimens examined in middle of August.

NATURAL HOST: Unknown.

ECOLOGY: On a bay shore exposed to the forces of waves, buried in sandy-clay or marly-clay bottom, at depths of from .6-.2 m.

DISTRIBUTION IN WISCONSIN: Sturgeon Bay (Baker); Inhabits Michigan (Walker).

REMARKS: *Birgei* is related to *modesta*, having the same type of beak sculpture, which is finer, with the bars closer together than in *ferussacianus*. It differs markedly, however, in the shape of the shell, being more cylindrical and more inflated, with a well-marked posterior ridge and with the beaks longer. The swelling of the beaks extends downward on the side of the shell, giving it a greatly swollen appearance when viewed from the dorsal margin. Comparisons have been made with *modesta* from Long Lake, near Kalamazoo, Mich.

This *Anodontoidea* occurs in great abundance on the shores of Sturgeon Bay and has evidently been produced by a lake environment. There is some variation in the form of the shell and in the degree of development of the posterior ridge. All have the cylindrical shape when mature, but young and immature individuals are more compressed and have a rounded posterior ridge. A small form of *Anodontoidea* occurs in a creek six miles east of Green Bay, which somewhat resembles *birgei*, but this form has the beak sculpture of *ferussacianus* and is referred to variety *subcylindraceus* of that species. The new species is dedicated to Dr. Edward A. Birge, President Emeritus of the University of Wisconsin, and former Director of the State Geological and Natural History Survey.

The *Anodontoidea* of Wisconsin divide into three groups: the large shell with green rays and heavy umbonal markings (*ferussacianus*); the smaller, cylindrical shell brown in color and rayless or but faintly rayed, also with coarse umbonal markings (*subcylindraceus*); and the larger, cylindrical shell, brown or horn colored, with marked umbonal ridge, and fine umbonal markings, the space between the bars being about half that in the two forms previously mentioned (*birgei*). All are measurably distinct and easily separable, at least in Wisconsin, and also in the material at hand from other states. It is possible that the *buchanensis* listed by Ortmann as living in beach pools in Lake Erie may readily be a form of *birgei*.

Genus SIMPSONICONCHA Frierson, 1914

Hemilastena SIMPSON (non Agassiz), Syn. 1900, p. 673; Desc. Cat., 1914, p. 323.

Shell small, elongate elliptical, rounded in front and behind, often slightly incurved at the central base; beak rather sharp, but not full; sculpture consisting of fine parallel ridges which

are looped up in the middle and open behind; epidermis brownish, rayless; teeth imperfect, a single irregular, compressed tooth in each valve; laterals nearly or quite wanting; anterior end of shell much thickened; nacre dull whitish or purplish, especially near the shallow beak cavities. Marsupium occupying the whole of the outer gills (Walker). Type: *Alasmodonta ambigua* Say.

SIMPSONICONCHA AMBIGUA (Say)

Plate LXX, figures 1-3

Alasmodonta ambigua SAY, Jour. Acad. Nat. Sci. Phil., V, p. 131, 1825.

Unio hildrethianus LEA, Trans. Amer. Phil. Soc., V, p. 36, pl. iii, fig. 8, 1834; Obs., I, p. 48, pl. iii, fig. 8, 1834.

Hemilastena ambigua SIMPSON, Cat., p. 325, 1914.

Simpsoniconcha ambigua ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 38, 1922.

TYPE LOCALITY: Northwest Territory (*ambigua*); Ohio, near Marietta (*hildrethianus*).

WISCONSIN RECORDS: None.

SHELL: As in generic diagnosis. The male shell is less inflated, the female being swollen behind near the posterior ridge. Females greatly outnumber the males according to Simpson.

L. 49; H. 25; D. 17 mm. Iowa City, Iowa (U. of I., Z4845).

L. 34; H. 17; D. 10 mm. Kilbourn (U. of W., 931a).

L. 30; H. 15; D. 9 mm. " (" 931b).

ANIMAL: "Marsupium filling the entire outer gills and forming enormously thickened pads, the upper part finely, vertically striate, the lower part of different texture, lighter colored, wrinkled and granular on the surface; embryos very large; outer and inner gills nearly alike in size, the latter free from the abdominal sac, all united to the mantle to their posterior ends; palpi elongated, granular; mantle straight below, thickened on the border; branchial opening large, with numerous light colored papillae with dark lines; anal opening black, without papillae, separated from the small supra-anal opening by a long bridge; hinder part of the mantle, branchial and anal openings widely separated by the very thick marsupia (Simpson, 1914, p. 324). This anatomical description is far from being satisfactory.

Glochidia clear white, of triangular type, with well developed hooks. Height 0.265 to 0.274 mm., length 0.247 to 0.555 mm. (Howard, 1915, p. 8).

BREEDING SEASON: Not well known. Probably bradytictic.

NATURAL HOST: The amphibian, *Necturus maculosus*. Deeply embedded in the external gills; parasitic period extending from Oct. 17th to May, or over seven months. The host was kept alive in the Fairport laboratory during this entire parasitic period, and the mussels carried through to the juvenile stage (Howard, 1915, p. 7).

ECOLOGY: "It is sometimes found in mud and on gravel bars, but in greatest numbers and perfection hidden in the mud under flat stones; more than 200 have been taken from under a single flat rock about one square foot area (Call, 1900, p. 527). In Wisconsin, at Kilbourn, dead shells were found on a gravel bar on the edge of the river in about .3 m. of water. No living shells could be found, though search was carried on during several days. Howard (op. cit.) found *Necturus* in the particular habitat of this mussel, another example of the agreement of mussel and host in ecological conditions. Both occurred under flat stones.

GENERAL DISTRIBUTION: Ohio River system; north to Michigan; west to Iowa; south to Arkansas; east to Tennessee (Simpson, 1914, p. 325).

DISTRIBUTION IN WISCONSIN: At present known only from the Wisconsin River at Kilbourn, Columbia Co. (Baker coll.).

REMARKS: *Ambigua* resembles *Carunculina parva* but may be easily distinguished by the difference in hinge structure, *parva* having distinct pseudocardinals and laterals. There is no variation among the few dead shells found. It seems to be rare in Wisconsin where it fails to attain the dimensions of the localities farther south. Kilbourn is the most northern locality yet reported. The peculiarities of shell structure and particularly the unique host of the glochidial stage, an amphibian, render this species of unusual interest.

Genus ALASMIDONTA Say, 1818

Shell generally rhomboid, inflated, with a well developed posterior ridge, which ends in a point when it is single or a biangulation when double; beaks full and high, with coarse, concen-

tric or slightly doubly looped bars; epidermis rayed, shining; hinge with two pseudocardinals in the left valve and one in the right; laterals usually wanting or imperfect, present in *Prolasmidonta*, cavity of the beaks deep; nacre bluish. Marsupium occupying the entire outer gills (Walker).

TYPE: *Monodonta undulata* Say.

Subgenus PRESSODONTA Simpson, 1900

Shell small, decidedly rhomboid, surface generally painted with unbroken rays; beak sculpture slightly corrugated; teeth compressed. (Walker).

TYPE: *Unio calceolus* Lea.

ALASMIDONTA CALCEOLUS (Lea). Slipper-Shell

Plate LXIX, figure 1; plate LXXII, figures 1-7

Unio calceolus LEA, Trans. Amer. Phil. Soc., III, p. 265, pl. iv, fig. 1, 1830; Obs., I, p. 7, pl. iii, fig. 1, 1834.

Alasmidonta calceolus SIMPSON, Cat., p. 496, 1914.

Margaritana deltoidea LEA, Trans. Amer. Phil. Soc., VI, p. 43, pl. xiii, fig. 38, 1838; Obs., II, p. 43, pl. xiii, fig. 38, 1838.

TYPE LOCALITY: *Calceolus*, Ohio; *deltoidea*, Ohio River, near Cincinnati, Ohio; Scioto River.

WISCONSIN RECORDS:

1852. *Strophitus calceolus* LAPHAM, p. 370. Wisconsin.

1860. *Margaritana calceola* LAPHAM, p. 156. Milwaukee.

1897. *Margaritana deltoidea* WISWALL, p. 48. Southern Wisconsin.

1906. *Alasmodonta calceolus* CHADWICK, p. 95. Lake Michigan shore, Milwaukee; Jumbo Creek, Manitowoc Co.; Beasley Creek, She-she-pe-comeo Park, Waupaca Co.

1922. *Alasmidonta calceola* GRIER and MUELLER, p. 98. Fountain City.

1927d. *Alasmidonta calceolus* BAKER, p. 107. Ashippun River.

SHELL: Small, rhomboid, moderately inflated, more or less solid; anterior end rounded; posterior end roundly, obliquely truncated; ventral margin straight or slightly incurved; dorsal margin slightly convex, rounding into the truncated posterior margin; posterior ridge high, rounded, usually terminating in a rounded point at the base of the shell, which is often biangulate; beaks swollen, but not much elevated above the hinge line; sculpture consisting of 5-6 irregular, heavy bars, the first one or two diagonal to the hinge line, the others more or less concentric; the bars form more or less of an angle be-

hind and extend forward in a series of wavy bars, corrugations, or nodules, which sometimes assume a looped aspect; surface with uneven lines of growth, raised into dark lined ridges at rest periods; epidermis greenish or yellowish, sometimes pinkish, with many, more or less wavy, green rays of varying width.

Pseudocardinals more or less rudimentary; left valve with a small denticle beneath the beak and another, more indistinct, in front; right valve with one elevated, triangular tooth beneath the beak with a slight swelling of the hinge behind; laterals represented by slight elevation of the hinge line; cavity of beaks not very deep; adductor muscle scars well marked, but not much impressed; nacre whitish, frequently tinged with pink or salmon, more or less iridescent. Female shell swollen in the region of the posterior ridge, male more compressed.

ANIMAL: Similar in general form to *marginata*. Mantle connection between anal and supra-anal shorter than anal; color generally as in the larger species.

Glochidia (pl. XXXII, fig. 5). Large, subtriangular, longer than high, hinge line straight, with ventral spine. Length 0.300 mm., height 0.255 m. (Surber, 1912, p. 8).

BREEDING SEASON: Probably bradytictic, with mature glochidia in the fall (September).

NATURAL HOST: Not recorded.

ECOLOGY: Usually burrowing in streams on a sand bottom in shallow water. Also on lake shores on a sand bottom. In Sturgeon Bay on a sandy-clay bottom in 1-1.1 m. of water.

GENERAL DISTRIBUTION: Simpson gives the range as Upper Mississippi drainage; Ohio, Cumberland, and Tennessee rivers; lower and middle St. Lawrence systems. It is listed from the following states: Illinois (Baker), Indiana (Call), Ohio (Sterki), Michigan (Walker), New York (Letson), Missouri (Utterback), Arkansas (Utterback). Specimens are in the Hinkley collection from Kentucky.

DISTRIBUTION IN WISCONSIN: *Calceolus* is widely distributed in Wisconsin. Its peculiar rhomboid shape, coarse beak markings, and simply armed hinge plate will easily distinguish it from all other species. A study of the *calceolus* from its range, contained in the available collections, indicates that there are several distinguishable varieties that should be recognized, mostly for ecological reasons. These are indicated below:

ALASMIDONTA CALCEOLUS (Lea)

Plate LXIX, figure 1; plate LXXII, figures 1-6

Typical *calceolus* has a heavy shell, rather wide, with rather heavy pseudocardinal teeth, the female shell very wide posteriorly, with a large, rounded or subangulated posterior ridge, which frequently has a median sulcus behind it.

L. 42; H. 25; D. 17 mm. 40% Joliet, Ill. (U. of I., Z11801). Male.

L. 35; H. 22; D. 19 mm. 54% Kishwaukee R., Ill. (U. of I., Z14907). Female.

L. 30; H. 19; D. 15 mm. 50% Rock River, Wis. (U. of W., 80). Female.

DISTRIBUTION IN WISCONSIN: The larger rivers.

Mississippi Drainage: Fountain City, Buffalo Co. (Grier). *Rock Drainage*: Rock River, southern Wis. (Marston);

REMARKS: *Calceolus*, as here understood, is the form of large and medium sized rivers, with a wide, heavy shell, the female being notably wide posteriorly. There is no way of knowing what kind of habitat Lea's *calceolus* came from, his locality being simply Ohio. The figure appears to be of a large male shell of the large river type. His *deltoidea*, while said to be smaller and more flattened than *calceolus*, seems referable to the large river type on account of the type locality—Ohio River near Cincinnati and Scioto River. This form is found in the Illinois River, in the larger rivers of Winnebago Co., and in other other places in Illinois.

ALASMIDONTA CALCEOLUS DANIELSI Nov. Var.

Plate LXIX, figure 2; plate LXXII, figures 7-11

TYPE LOCALITY: Moots Creek, White Co., Ind.

This variety is the creek form of *calceolus*, differing from the type in being more compressed laterally, more delicate in every way, including hinge structure, and the female shell is not as wide, relatively, as in *calceolus*. It is usually a smaller shell than the type form.

L. 34; H. 21; D. 12 mm. 35% Moots Creek, Indiana (U. of I., Z14301a).

Male. Type.

L. 31; H. 19; D. 14 mm. 45% " " " (" Z14301c).

Female. Paratype.

L. 34; H. 22; D. 16 mm. 47% Ashippun R., Wis. (U. of I., Z17324). Female.

ECOLOGY: Mukwonago River, gravel and sand bottom, swift current, water .2-.7 m. deep; Bark River, Rome, coarse sand bottom, water shallow; Oconomowoc Lake specimens are yellowish and somewhat reddish, and are found on a pebble bottom in shallow water. The usual habitat is in sand buried from sight (Cahn).

DISTRIBUTION: Probably in Wisconsin, Illinois, Michigan.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the state.

Rock Drainage: Ashippun River, east of Mapleton; Lisbon and Summit Townships, in Bark River; Oconomowoc River, Waukesha Co.; Bark River, Rome, Jefferson Co. (Cahn).

Fox Drainage: Beasley Creek, She-she-pe-comeo Park, Waupaca Co. (Brown, Chadwick).

Lake Michigan Drainage: Jumbo Creek, Manitowoc Co. (Chadwick).

Fox Drainage (Illinois): Mukwonago River, Mukwonago; Mukwonago Creek, west of Howitt Lake, Waukesha Co. (Cahn).

REMARKS: *Danielsi* is the creek form of *calceolus*, and, following the law of stream development, is smaller, more compressed, and of a more delicate type. Intermediate individuals occur, as would be expected, specimens from Ashippun River and Bark River being of this character (see measurements).

The females show the greatest difference, *calceolus* having the ratio of 50-54% and *danielsi* the ratio 45-47%. The greatest difference is in the female shell, which is much more swollen and has a more decided posterior ridge in *calceolus*. The more compressed type has been seen from Illinois (Kents Creek near Rockford, Winnebago Co., especially), Indiana, Ohio, and several places in Michigan. It was at first thought that Lea's *deltoidea* could be used for this form, but that appears to have been founded on the large stream form.

ALASMIDONTA CALCEOLUS MAGNALACUSTRIS Var. Nov.

Plate LXXII, figures 12-16; plate LXIX, figure 3

TYPE LOCALITY: Sturgeon Bay, Door Co., Wis.

SHELL: Smaller than either *calceolus* or *danielsi*, more compressed than *danielsi*, the female shell shorter as compared with length, beak sculpture somewhat finer, hinge weaker, especially the pseudocardinals, which are reduced to narrow tubercles; color yellowish or rusty, with brownish stripes. No greenish specimens seen.

- L. 26; H. 17; D. 12 mm. 46% Sturgeon Bay (U. of W., 933a).
 Type. Female.
 L. 25; H. 16; D. 12 mm. 48% " " (U. of I., Z18056).
 Paratype. Female.
 L. 20; H. 13; D. 8 mm. 40% " " (U. of W., 933b).
 Paratype. Immature female.
 L. 25; H. 16; D. 9 mm. 36% Lake Noque Bay (U. of W., 932).
 Male.

DISTRIBUTION IN WISCONSIN: A lake form, abundant in Lake Michigan and its bays, on a sandy bottom in water .6 to 1 m. deep. Also found in smaller lakes.

Sturgeon Bay, Door Co., below bridge (Baker); Lake Noque Bay, near Crivitz, Marquette Co. (Bullock); Lake Michigan shore near Milwaukee (Chadwick); Oconomowoc Lake, Waukesha Co. (Cahn). Also in Burt Lake, Douglas Co., Mich. (F. Smith).

REMARKS: As would be expected, the lake form of *calceolus* differs from both the river and creek forms, being more compressed than the creek type. The percentage ratios given show that these are not in all cases reliable, the lake and creek forms being almost identical mathematically, while they differ more in form than do the creek-rivers forms which have a different mathematical ratio. *Calceolus* is seen to follow the same law of variation as do so many other species of the naiades.

Subgenus DECURAMBIS Rafinesque, 1831

Rugifera SIMPSON, 1900.

Shell elongated, rhomboid, inflated, surface brilliantly painted with radiations which often break into dappled or splashed pattern of color; posterior slope slightly corrugated; teeth very imperfect; laterals wanting (Walker). Type: *Alasmodon (Decurambis) scriptum* Raf. (= *Alasmidonta marginata* Say.)

ALASMIDONTA MARGINATA Say. Nigger-Toe; Elk-Toe

Plate LXXI, figures 1-5

Alasmodonta marginata SAY, Nich. Encyc., No. 1, 1819; Jour. Acad. Nat. Sci., Phil., I, p. 459, 1819.

Alasmodon (Decurambis) scriptum RAF., Con. Mon., p. 4, 1831.

Alasmodonta marginata SIMPSON, Cat., p. 504, 1914.

Alasmidonta marginata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 38, 1922.

TYPE LOCALITY: Scioto River, Chillicothe, Ohio (Say).

WISCONSIN RECORDS:

1852. *Alasmodonta marginata* LAPHAM, p. 370. Wisconsin.
1860. *Margaritana marginata* LAPHAM, p. 156. Milwaukee.
1897. *Margaritana marginata* WISWALL, p. 48. Southern Wisconsin.
1906. *Alasmodonta marginata* CHADWICK, p. 95. Milwaukee River;
Junction Lake, Waupaca Co.
1927d. *Alasmodonta marginata* BAKER, p. 107. Bark River, Dousman.

SHELL: Long-rhomboid or subtrapezoidal, nearly equipartite, thin when young, thick and solid when old, more or less inflated; anterior end sharply rounded; ventral margin straight or slightly convex; dorsal margin straight or but slightly convex, forming a sharp angle with the obliquely truncated posterior end, which is pointed below; beaks large, inflated, elevated above hinge line, usually placed a little in front of the middle of the dorsal margin; beak sculpture very coarse, heavy, consisting of 3-4 rounded bars, which may be double-looped in some individuals; the second and third bars are somewhat angular on the posterior side; the fourth bar is usually indistinct and rudimentary; on the posterior slope there are many fine, radial ridges, extending upward toward the posterior margin, and extending to the basal portion of the posterior end in even the oldest shells; these ridges are never absent but may vary in number, size, and the extent of the surface covered; posterior ridge elevated, rounded, but very distinct, in old shells inclined to be double; in old shells there is a depression in the flat, truncated posterior end, bounded by the posterior ridge and an elevated part of the posterior margin of the valve; epidermis yellowish-brown or greenish with many greenish or blackish rays of variable width; there are also many darker spots on the shell which are formed in connection with the rays, and may be found over a part or the whole of the surface, but are rarely absent.

Hinge margin thickened, with a single lamellar, elongated pseudocardinal in each valve, the left valve with an additional interdental projection, which may be separate or united to the pseudocardinal; laterals absent, but hinge thickened; beak cavities moderately deep containing the dorsal muscle scars, which are also placed on the hinge plate; adductor scars distinct; nacre bluish-white, silvery, or with different shades of pink,

more or less iridescent; in old shells there is a wide band of gray bordering the valve. No distinction of sex in the shell.

- L. 80; H. 44; D. 34 mm.* A. E. 29 mm. 36% Homer Park, Ill.
(U. of I., Z14054). Male.
L. 78; H. 45; D. 33 mm. A. E. 30 mm. 38% Homer Park, Ill.
U. of I., Z14054). Female.
L. 60; H. 34; D. 22 mm. A. E. 20 mm. 33% Homer Park, Ill.
(U. of I., Z14054). Male.
L. 75; H. 44; D. 29 mm. A. E. 27 mm. 36% Homer Park, Ill.
U. of I., Z14054). Male.
L. 71; H. 38; D. 27 mm. A. E. 22 mm. 31% Bark River, Wis.
U. of I., Z17345).
L. 72; H. 39; D. 31 mm. A. E. 24 mm. 33% Bark River, Wis.
(U. of I., Z17345).

ANIMAL (see fig. 229): Supra-anal and anal openings separated by mantle connection shorter than anal opening; branchial opening with numerous papillae; anal opening crenulated; palpi very long, united for one half, or less, of their length; inner gills wider than outer gills; inner laminae of inner gills invariably entirely connected with the abdominal sac. Only outer gills marsupial. Marsupium when distended with

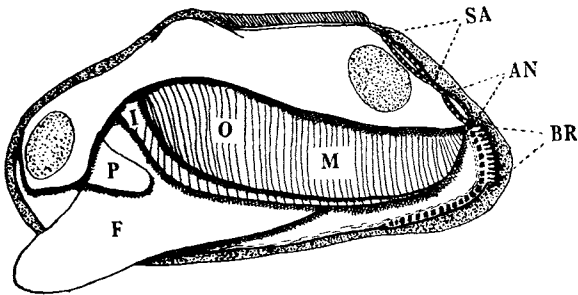


Fig. 229. *Alasmidonta marginata variabilis* Baker. Red Cedar River, near Chetek. Gravid female. Aug. 12, 1921.

eggs or embryos, with swollen edges; secondary water tubes are formed and the ovisacs are undivided. General color whitish; foot and palpi often orange-brown; gills light brownish or orange; mantle grayish, the edges darker and mottled with black spots; all organs may be more or less tinged with orange; when filled with eggs the marsupium is light yellowish; when filled with glochidia it is brownish.

* Distance of beaks from anterior end and percentage of length.

Glochidia (pl. XXXII, fig. 3) large, higher than long, with strong hooks; hinge line slightly undulate. Length 0.35, height 0.38 mm. (Surber, 1912, p. 9); 0.33 by 0.36 mm. (Ortmann, 1919, p. 183).

BREEDING SEASON: Bradytictic. Middle of July to middle of June. Ortmann found eggs from July 19 to Oct. 23. Glochidia were observed on Sept. 2 (1919, p. 183).

NATURAL HOST: Not recorded.

ECOLOGY: Typical *marginata* inhabits the small streams and creeks, usually on a gravel or sand bottom, in water .2 to 1 m. deep. Prefers a location with good current. Rare on mud bottom. In Bark River it occurs on a gravel-sand bottom in water .5 m. deep.

GENERAL DISTRIBUTION: Western New York and Pennsylvania west to Iowa and Missouri, south to Arkansas, and northward to Minnesota, Michigan, and Ontario.

DISTRIBUTION IN WISCONSIN: Typical *marginata* has been seen from the Rock and Fox river systems. It probably occurs in other small rivers and creeks.

REMARKS: *Marginata* cannot be confused with any other species found in the waters of Wisconsin. The peculiar shape of the shell, with its flattened posterior end, its large beak markings, and its conspicuous coloring are distinctive features. The typical form of this species is an inhabitant of creeks and small rivers and is smaller and more cylindrical than the form occurring in the large and medium-sized rivers. In the typical form the distance from anterior end to umbones varies from 31 to 36 per cent., while in the large river form it varies from 33 to 47 per cent. The ventral border is usually straight in mature shells.

In Bark River this species is dimorphic in color, about 75 per cent. having a beautiful mauve nacre. There are no intermediate colors, all shells being either white or colored.

ALASMIDONTA MARGINATA TRUNCATA (B. H. Wright)

Plate LXV, figures 1, 2; plate LXXI, figures 6, 7

Margaritana marginata var. *truncata*, B. H. WRIGHT, Nautilus, XI, p. 124, 1898.

TYPE LOCALITY: Not defined.

WISCONSIN RECORDS:

1906. *Alasmidonta marginata* CHADWICK, p. 95. Between Prairie du Chien and De Soto.

- 1922a. *Alasmidonta marginata* GRIER, pp. 25, 29, 31. Buffalo and Trempealeau Cos.
 1927d. *Alasmidonta marginata* BAKER, p. 107. Rock River, Ashippun, Rock Co.; Crawfish River, Aztalan.

SHELL: Differing from typical *marginata* in being much larger, with higher, more swollen umbones, which are placed nearer the center of the dorsal margin, the distance from the umbones to the anterior margin being relatively greater than in *marginata* (33–47%). The posterior end is more sharply truncated with a sharper posterior ridge and the ventral border is more usually convex than straight. The shell is thicker and heavier.

L. 126; H. 72; D. 53 mm. A. E. 52 mm. 41%	Lone Rock (Dudley).
L. 100; H. 63; D. 51 mm. A. E. 45 mm. 45%	Jefferson Co. (U. of W., 1885).
L. 82; H. 49; D. 39 mm. A. E. 31 mm. 37%	" " (" 934).
L. 59; H. 33; D. 26 mm. A. E. 20 mm. 33%	Rock River (U. of W., 82).
L. 119; H. 80; D. 52 mm. A. E. 55 mm. 46%	Ashippun (U. of I., Z17344).
L. 112; H. 67; D. 51 mm. A. E. 45 mm. 41%	" (" "
L. 103; H. 61; D. 52 mm. A. E. 42 mm. 47%	" (" "

ANIMAL: As in the typical form.

ECOLOGY: In Wisconsin, *truncata* is an inhabitant of the larger rivers, occurring on a sand, gravel, or mud bottom, in water .3–2 m. deep, or more, in a good current. The foot of this form, as well as of the typical form, is large and well developed. When fully extended and the animal has been able to get a good hold on a gravel bottom of the stream, it requires a great effort to dislodge it.

GENERAL DISTRIBUTION: *Truncata* has been observed in the states of Wisconsin, Illinois, Iowa, Indiana and Ohio. It may occur in other places.

DISTRIBUTION IN WISCONSIN: *Truncata* has its greatest development in the Mississippi, Wisconsin, and Rock Rivers. It extends northward in the Mississippi to Lake Pepin and up the Wisconsin to Lone Rock, or possibly farther. In the Rock River it ascends as far as Jefferson County.

REMARKS: Variety *truncata* differs from typical *marginata* by being less cylindrical, of greater height as compared with length, larger and more swollen umbones, a more squarely truncated posterior end, and by the greater distance between

umbones and anterior end. This end increases in length with age. This is the large-stream form, always of greater size than typical *marginata*. The nacre is usually white, but in Rock River near Ashippun it is of a beautiful rose color, though white-nacred forms occur with the rose color.

Wright's *truncata* appears to fit this variety, although that author did not give a type locality. The statement that it is larger and more produced in front, and abruptly truncated behind definitely fixes the variation. The typical form in Wisconsin is found in the smaller streams, Bark River, Mukwonago River, etc. In the Rock River, the variety apparently begins to appear near Ashippun, Dodge Co., and increases in size and weight toward the Illinois line. In the lower Wisconsin River and in the Mississippi River it increases in thickness, though the shell is much too thin for commercial purposes.

ALASMIDONTA MARGINATA VARIABILIS Nov. Var.

Plate LXIX, figures 4-9

TYPE LOCALITY: Red Cedar River, near Chetek, Barron Co. (Baker).

WISCONSIN RECORDS: None.

SHELL: Smaller than typical *marginata*, comparatively more elongated, the posterior slope not as flat and less rugose; epidermis reddish-brown, with many dark green rays of variable width (though mostly fine), which are broken up into dark spots of varying intensity, forming parallel zones near rest marks; posterior slope without rays and usually lighter than the rest of the shell; nacre whitish with usually a tinge of pink or salmon, no individuals having this color wholly absent; absolutely no difference between male and female shells.

- L. 78; H. 44; D. 33 mm. A. E. 27 mm. Type (U. of W., 935a). Female.
- L. 71; H. 43; D. 30 mm. A. E. 30 mm. Type (" 935b). Male.
- L. 69; H. 39; D. 28 mm. A. E. 24 mm. Paratype (U. of W., 935c). Male.
- L. 50; H. 27; D. 19 mm. A. E. 18 mm. Paratype (" 935d). Male.
- L. 39; H. 22; D. 17 mm. A. E. 13 mm. Paratype (" 935e). Female.
- L. 72; H. 41; D. 32 mm. A. E. 29 mm. Paratype (U. of I., Z18031). Female.
- L. 48; H. 29; D. 21 mm. A. E. 17 mm. Paratype (" Z18031). Female.

ANIMAL: (Fig. 229). As in typical *marginata*. Mantle with short connection between anal and supra-anal openings.

Dark spots on mantle edge near openings very conspicuous. Foot and adductor muscles pink or salmon; gills brown; rest of body whitish. Glochidia as in typical *marginata*.

BREEDING SEASON: Bradytictic. Red Cedar River specimens were gravid during August. Females more numerous than males.

NATURAL HOST: Unknown.

ECOLOGY: In shallow water on riffles buried in fine sand to the depth of several inches. Not found in a gravel bottom. Common on sand bars in Red Cedar River.

GENERAL DISTRIBUTION: Not known outside of Wisconsin. Small individuals of a form of *marginata* occur in some of the tributary streams in Illinois (Salt Fork of Vermilion River, for example) which have the general shape of *variabilis*, but the epidermis is more greenish and the nacre is silvery, not reddish or salmon, as in *variabilis*. The posterior ridge is also more angular than in the Wisconsin variety. In Alabama and Tennessee there are small forms of *marginata*, but these probably belong to other varieties. Ortmann's variety *susquehannae* is similar in form but probably belongs elsewhere.

DISTRIBUTION IN WISCONSIN: Known only from Red Cedar River, near Chetek, Barron Co., in the Chippewa Drainage. (Baker).

REMARKS: This small variety of *marginata* is quite characteristic and easily distinguished. The posterior end is not as sharply truncated as in typical *marginata* and the umbones are somewhat nearer the anterior end. The nacre is always of a pinkish tinge and not bluish white as in *marginata*. The surface markings are peculiar and striking. The posterior margin is not as rugose as in *marginata*.

Variabilis resembles in color the shell called *susquehannae* by Ortmann (1919, p. 187) as a variety of the *marginata* of western Pennsylvania. There is reason to believe, however, that *susquehannae* is a variety of the eastern *varicosa* and not of the western *marginata*. Ortmann's map (p. 189) shows that the variety occupies the upper waters of the streams in which *varicosa* occurs in abundance and none are found in the waters containing *marginata* (see map, p. 183). *Variabilis* is very abundant in the Red Cedar River. It is evident that this form is an ecological variety, living in a small river with rapid current, which has developed a different shell from the form

of the more sluggish rivers of greater size. In the Red Cedar River, the current is so rapid in the portion of the stream occupied by the variety, that it is difficult to walk against it. The shells were buried far from sight in sand bars in the middle of the stream where the current was strongest. It is possible that *variabilis* is a northern form or race and that it will be found in other streams in northern Wisconsin, Minnesota, and Michigan.

Genus *ARCIDENS* Simpson, 1900

Shell subsolid, inflated, subrhomboidal, with full high beaks; beak sculpture very strong, consisting of irregular corrugations, which fall into two loops, at the base of which the ridges are swollen into knobs that continue out in two radiating rows on to the disk of the shell; in front of and behind the beaks are many fine, radial wrinkles, the posterior ones being zigzagged; surface of the shell covered with oblique folds and wrinkles; epidermis dark olive, shining; left valve with two elongated, compressed pseudocardinals, the posterior under the beak and curved upwards, cutting off the hinge plate in the right valve, which has a single, compressed pseudocardinal in front; laterals numerous, short, blurred; nacre white. Marsupium occupying the outer gills (Walker). Type: *Alasmodonta confragosa* Say.

ARCIDENS CONFRAGOSUS (Say). Rock Pocketbook

Plate LXIII, figures 4-7

Alasmodonta confragosa SAY, New Harm. Diss., II, p. 339, 1829; Amer. Conch, I, Pl. xxi, 1830.

Arcidens confragosa SIMPSON, Cat., p. 475, 1914.

TYPE LOCALITY: New Orleans, La. (Say).

WISCONSIN RECORDS:

1905c. *Arcidens confragosa* BAKER, p. 254. Prairie du Chien.

1922a. *Arcidens confragosa* GRIER, pp. 15, 23. Mississippi River, off Pierce and Pepin Co.

SHELL: As in generic description, *confragosa* being the only species in the genus.

L. 104; H. 79; D. 57 mm. Miss. R., Ill. (U. of W., 311).

L. 88; H. 68; D. 44 mm. Prairie du Chien (Dudley).

L. 41; H. 32; D. 21 mm. Miss. R., Ill. (U. of W., 311a).

L. 106; H. 71; D. 50 mm. Prairie du Chien (U. of W., 936).

ANIMAL: (Fig. 230). Anal and supra-anal openings separated by a mantle connection that is shorter than the anal opening; supra-anal opening long; branchial opening with papillae on the inner edge; anal opening crenulated on inner edge; diaphragm complete; palpi connected for about half their length; inner gills wider than outer gills, the inner laminae of inner gills attached to abdominal sac only at the anterior end. Animal generally white or yellowish white; gills and palpi brown.

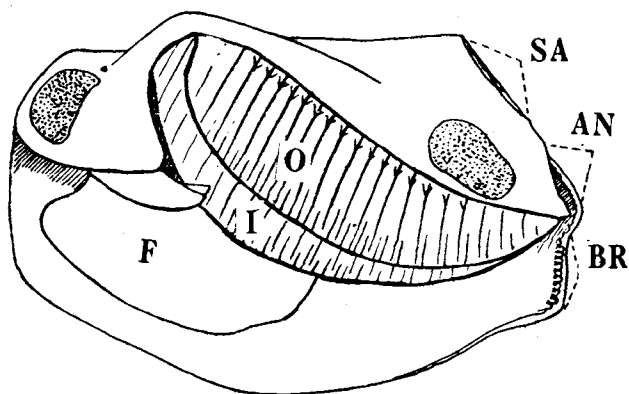


Fig. 230. *Arcidens confragosus* (Say). Male from Bayou Pierre, De Soto Parish, La. Ortmann's Fig. 12 (1912).

Glochidia (pl. XXXII, fig. 2) large, subtriangular, length and height about equal, hinge line undulate, ventral spine of valve present. Dimensions 0.355 by 0.350 mm. (Surber, 1912, p. 8).

BREEDING SEASON: Bradytic, probably from September to June. "Gravid with active glochidia the latter part of January and with late embryos in the middle of March. Sterile in July and August (Utterback, 1916a, p. 104).

NATURAL HOST: Not recorded.

ECOLOGY: On a sand or mud bottom in water a few feet deep. Current rapid.

GENERAL DISTRIBUTION: "Mississippi River and states adjoining; Ohio River drainage; southwest to Colorado River, Texas; Bayou Teche, Louisiana (Simpson).

DISTRIBUTION IN WISCONSIN. Known only from the Mississippi River, as far as recorded.

REMARKS: *Arcidens confragosus* is at once known by the peculiar sculpture of its beaks and shell, no other Wisconsin mussel being at all like it. It exhibits very little variation. In the Mississippi River it is fairly common near Prairie du Chien, but is apparently rarer in the upper river. In Illinois this species is found in the smaller streams and rivers (the Sangamon at Mahomet, for example) but in Wisconsin it has not been reported from streams other than the one mentioned. The small stream form is more compressed, thus conforming to the law of stream variation.

The rock pocketbook or bastard shell is not of great value commercially on account of its thin shell, though the nacre is good.

Genus *STROPHITUS* Rafinesque, 1820

Shell elliptical to rhomboid, inflated, subsolid, pointed or biangulate behind, with a low posterior ridge, which is sometimes double; beaks full, sculpture consisting of a few, strong, concentric ridges, which curve sharply upwards behind; epidermis rayed or rayless, shining; hinge line incurved in front of the beaks; teeth rudimentary, a vestigial, compressed tooth in each valve, and sometimes a secondary tooth; laterals rarely present. Marsupium occupying the whole of the outer gills, consisting of short, horizontal ovisacs, which run directly across the gills. (Walker). Type: *Anodonta undulata* Say.

STROPHITUS RUGOSUS (Swainson). Squaw Foot

Plate LXXIII, figures 6, 7

Anodon rugosus SWAINSON, Zool. Ill., Ser. I, II, Pl. 96, 1822.

Alasmodonta edentula SAY, New Harm. Diss., II, No. 22, p. 340, 1829.

Anodonta wardiana LEA, Trans. Amer. Phil. Soc., VI, p. 46, pl. xiv, fig. 42, 1838; Obs., II, p. 46, pl. xiv, fig. 42, 1838.

Strophitus edentulus SIMPSON, Cat., p. 345, 1914.

Strophitus rugosus ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 40, 1922.

TYPE LOCALITY: *rugosus*, United States (Swainson); *edentula*, Wabash River, Ind. (Say); *wardiana*, near Chilicothe, Ohio (Lea).

WISCONSIN RECORDS:

1852. *Strophitus edentulus* LAPHAM, p. 370. Wisconsin.

1897. *Anodonta edentula* WISWALL, p. 48. Southern Wisconsin.

- 1905c. *Strophitus edentulus* BAKER, p. 254. Prairie du Chien.
 1922a. *Strophitus edentulus* GRIER, pp. 11–31. Upper Mississippi.
 1926. *Strophitus edentulus* GRIER and MUELLER, p. 17. Above and below Lake Pepin.
 1927d. *Strophitus rugosus* BAKER, p. 107. Rock River, Ashippun to Rock Co.; Crawfish River, Aztalan.

SHELL: Subelliptical or subovate, thick and rather solid, when adult more or less inflated, moderately inequipartite; anterior end rounded; posterior end rounded or obliquely truncated, distinctly biangulate; ventral margin slightly convex, straight or sometimes concave in the middle; dorsal margin slightly convex, forming an angle with the oblique posterior margin; beaks depressed, not much elevated above the hinge line; beak sculpture heavy, consisting of four concentric bars, somewhat oblique to the hinge line, rounded anteriorly and forming an angle posteriorly; there are several additional radiating ridges on the posterior slope; posterior ridge broadly rounded, indistinct in some individuals, distinct and even acute in others; the posterior slope is compressed in many specimens and the shell may be compressed or quite inflated; epidermis yellowish or greenish, brownish and black in old specimens, more or less marked by greenish or black rays of variable size and character; concentric bands are sometimes present at rest periods.

Hinge plate thickened but laterals absent and pseudocardinals indicated by several swellings or tubercles below and in front of the beaks, where the hinge line is somewhat bent inward; beak cavity moderately deep containing the dorsal muscle scars; adductor scars distinct, the anterior deeply impressed; nacre white, cream-colored or salmon in the center, sometimes pinkish, bluish-white and iridescent on the border of the valve. Practically no difference between male and female shells.

- L. 100; H. 56; D. 37 mm. A. E. 38 mm. 38% Jefferson, Rock R. U. of W., 937).
 L. 104; H. 63; D. 47 mm. A. E. 39 mm. 38% Ashippun, Rock R. (U. of I., Z17346).
 L. 102; H. 65; D. 37 mm. A. E. 38 mm. 37% Ashippun, Rock R. (U. of I., Z17346).
 L. 103; H. 64; D. 39 mm. A. E. 44 mm. 42% Rock Falls, Ill. (U. of I., Z19713).
 L. 97; H. 59; D. 39 mm. A. E. 37 mm. 38% Lyndon, Rock R., Ill. (U. of I., Z19761).

L. 99; H. 54; D. 41 mm. A. E. 35 mm. 35% Prairie du Chien U. of W., 938).

L. 91; H. 57; D. 7 mm. A. E. 35 mm. 38% Posey Co., Wabash R. (U. of I., Z14952).

ANIMAL: (Fig. 231). Supra-anal and anal openings separated by a mantle connection shorter than anal opening; branchial opening papillose; anal opening crenulated on inner edge; palpi united nearly to their tips; inner laminae of inner gills connected from half to entire length, this feature being very variable; outer gill only marsupial, the septa much more crowded than in inner gills; the ovisacs are at first simple but soon become divided into compartments or swollen sacs which are arranged crosswise, and in which are situated small white placentae, containing ova and larvae (2-10); when gravid the gills are greatly distended at the edges and lateral water tubes are formed.

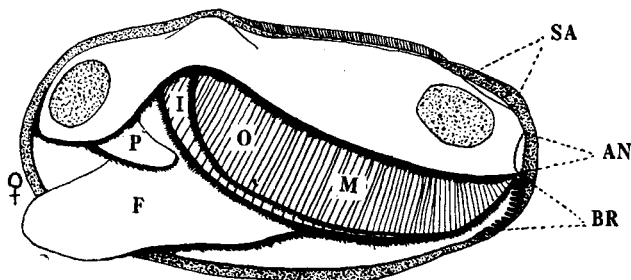


Fig. 231. *Strophitus rugosus pavonius* (Lea). Red Cedar River, near Chetek. Gravid female. Aug. 12, 1921.

Color variable, the foot, palpi and adductor muscles being orange, often very bright; the mantle edge blackish, with orange and black spots at intervals; young specimens are more uniformly yellowish-white or grayish.

Glochidia (pl. XXXII, fig. 6) large, subtriangular, longer than high, hinge slightly undulated, ventral spine present. Length 0.350, height 0.285 mm. (Surber, 1912, p. 8); 0.36 by 0.30 mm. (Ortmann, 1912a, p. 300).

BREEDING SEASON: Bradyctictic. July to April and May. Interim from end of May to middle of July. Ellis and Kein (*Nautilus*, 32, p. 17) found a form of *rugosa* gravid on Dec. 6, 1917, in St. Vrain Creek, near Longmont, Col. The glochidia were fully developed and active.

NATURAL HOST: *Rugosus* shares the distinction with *Utterbackia imbecillis* of being the second case of metamorphosis without parasitism. Like *imbecillis*, *rugosus* may complete its growth either with or without parasitism. In the latter case the placenta, or gelatinous cords, are discharged into the water a few at a time. These are believed to have a nutritive function. The wide distribution of *rugosus* is possibly due to the buoyancy of these placenta (see Lefevre and Curtis, 1911, 1912; Howard, 1914b, p. 353).

Dr. Howard carried the glochidia of *rugosus* through their metamorphosis on the black bass (*Micropterus salmoides*) and on the chub (*Semotilus atromaculatus*). The infection was on the fins and skin, but not on the gills (R. L. Barney, in letter).

ECOLOGY: In the larger and medium sized rivers, *rugosus* lives on a mud or sand (rarely gravel) bottom in fairly deep water (.6–3 m.), the current rapid to slow, the water murky for the most part.

GENERAL DISTRIBUTION: The typical form is confined to the larger streams and occurs from Ohio west to Iowa, and from Wisconsin south to the states bordering the Ohio river in its lower part, and the Mississippi. Also in the Wabash, Illinois, and Rock rivers, ascending well up toward the headwaters.

DISTRIBUTION IN WISCONSIN: Confined to the Mississippi, Rock, Wisconsin, and perhaps the lower part of other rivers, as the Chippewa, Black, St. Croix.

REMARKS: *Strophitis rugosus*, though a very variable species in general form, may be recognized by the large umbonal markings, elliptical shape, and thickened but almost edentulous hinge plate. It is most easily confused with *Anodontoides ferussacianus*, the chief differences being the thinner shell and finer beak markings of the latter (see pl. LXVII, fig. 2). *Rugosus* is very variable in Wisconsin waters, the shell varying from elliptical to rhomboid; the ventral margin from convex to concave; the shell from rather thin to very solid; the epidermis from yellowish with more or less distinct rays, to black and rayless; the hinge from almost smooth to the development of a distinct tubercle just beneath the beak; and the nacre from almost pure white to deep salmon with a marginal border of purple.

Typical *rugosus* should be restricted to the large stream or medium-sized stream form which has the umbones near the cen-

ter of the shell with an index of the relation of the anterior end to the whole length of 35-42%. This form is usually large and heavy, with rounded ventral margin and the height is usually greater than in the form from the small creeks. The latter has an index of from 27-32%. In many specimens, however, the ventral margin may be straight or slightly incurved. Say's specimens probably came from Posey Co., Indiana, from the Wabash. A specimen from this locality, in the Hinkley collection, is measured above. This should be considered the type form as we do not know where Swainson's specimens came from. *Rugosus* ascends the rivers to near the headwaters, where there is great variation in the ratio of length between beak and anterior end. Such specimens occur in the Kishwaukee River, Winnebago Co., Ill., near Rock River. In Kent Creek, near by, the form is undoubtedly *pavonius* and Rock River shells are *rugosus*. Mississippi River specimens are somewhat more swollen near the umbones and have a greater relative diameter, but are otherwise similar.

STROPHITUS RUGOSUS PAVONIUS (Lea)

Plate LXXIII, figures 1-5; plate LXXIV, figures 7, 9, 10; plate LXVII, figures 1, 2

Anodonta pavonia LEA, Trans. Amer. Phil. Soc., VI, p. 78, pl. xxi, fig. 65, 1836; Obs., II, p. 78, pl. xxi, fig. 65, 1838.

TYPE LOCALITY: Headwaters of the Little Beaver Creek, Ohio.

WISCONSIN RECORDS:

1860. *Anodonta edentula* LAPHAM, p. 156. Milwaukee.

1906. *Strophitus edentulus* CHADWICK, p. 93. Milwaukee River, Kinnickinnick River, Milwaukee Co.; Mill pond at Hika, Manitowoc Co.; Beasley Brook, She-she-pe-comeo Park, Waupaca Co.

1911a. *Strophitus edentulus* BAKER, p. 231. Gilmore Creek.

1924. *Strophitus rugosus* BAKER, p. 132. Omro, Fox River.

1927d. *Strophitus rugosus* BAKER, p. 107. Bark River, Dousman.

SHELL: Differing from *rugosus* in being smaller, thinner, the hinge more delicate and but slightly thickened (*rugosus* is heavy, massive, with thickened hinge and well-marked evidences of pseudocardinals); the umbones are situated nearer the anterior margin (in *rugosus* they are almost centrally located); and the height is not usually as great as in *rugosus*; nacre white slightly tinged with cream or salmon; epidermis

yellowish with bright green rays, varying to brownish or black, more or less rayed with dark green.

- L. 70; H. 39; D. 22 mm. A. E. 19 mm. 27% Racine (U. of W., 84).
 L. 73; H. 39; D. 22 mm. A. E. 22 mm. 30% " (U. of W., 93).
 L. 73; H. 39; D. 24 mm. A. E. 22 mm. 30%. Moose Ear Creek) U. of W., 940a). Male.
 L. 63; H. 37; D. 25 mm. A. E. 18 mm. 29% Moose Ear Creek (U. of W., 940b). Female.
 L. 65; H. 46; D. 32 mm. A. E. 21 mm. 32% Red Cedar River (U. of W., 941). Pathologic.
 L. 77; H. 44; D. 30 mm. A. E. 21 mm. 27% Omro, Fox River (U. of W., 942).
 L. 90; H. 47; D. 38 mm. A. E. 24 mm. 29% Princeton, Fox R. (U. of W., 937).

ANIMAL: As in *rugosus*.

ECOLOGY: In creeks and small rivers, usually in shallow water on sand or gravel bottom. A few specific habitats are listed below:

Outlet of Green Lake, shallow water (.3-.6 m.), sand bottom, swift current, clear water; Gilmore Creek, shallow water, sand bottom, swift current, clear water. Red Cedar River, Chetek, shallow water (.2-.5 m.) sand and gravel bottom, swift, clear, cold water; Omro, Fox River, gravel bottom, water 2.6 m. deep, murky, current slow. In Illinois (Salt Fork) it is found on gravel bottom, in water .3-.6 m. deep, which is clear in fair weather (Baker). Bark River, sand and gravel bottom, water shallow (Cahn).

GENERAL DISTRIBUTION: Probably more widely distributed than *rugosus*, as it is found in the small tributaries of many streams. Specimens have been seen from Wisconsin, Michigan, Illinois, Indiana, Ohio, New York, and Arkansas.

DISTRIBUTION IN WISCONSIN: *Pavonius* is widely distributed in the state occurring in all of the drainage areas excepting that of Lake Superior. Its presence in the Fox River and in small streams bordering Lake Michigan is to be accounted for by the old Post-Glacial outlets via Portage (Wisconsin River), and Glacial Lake Chicago via the Des Plaines River.

REMARKS: Though listed as a synonym of *rugosus* (*eden-tulus*) by many recent students, *pavonius* is a well defined variety. It is the small stream or creek form and its characteristics are moderately uniform wherever the habitat is normal for the variety. Its chief characteristic is perhaps the position

of the umbones which cause the anterior end to be shorter or longer. In *pavonius* the portion of the anterior end in front of the umbones is 32% or less, while in *rugosus* it is 35% or more. This differentiation is paralleled by the variation between the varieties of *Alasmidonta marginata* in this respect. Other differences have been noted in the diagnosis. In color the epidermis varies from brightly rayed to black, as in *rugosus*. A pathologic specimen was found in a lot from the outlet of Green Lake, which had assumed the shape of *Fusconaia flava* (pl. LXXIV, fig. 7).

Ortmann (1919, p. 205) says that *edentulus* is characteristic of smaller streams, and avoids large rivers. He was evidently unacquainted with the large forms of the western rivers, and his descriptions are mostly of the form herein called *pavonius*. The statement on the same page that the creek form avoids riffles and strong currents is not borne out by its presence in Wisconsin and Illinois. The form figured by Ortmann is the small river form, *pavonius*.

Clark and Wilson (1912, p. 48) have stated their belief that the better development of rays in *pavonius* and other forms of *rugosus* is correlated with clearness of water, and Ortmann (1919, p. 199) agrees with this hypothesis. The *rugosus* of Wisconsin, in many instances, indicate quite the reverse, the specimens with the black rayless epidermis coming from the clearest streams (as Red Cedar River). In Illinois streams rayed and black rayless forms inhabit the same locality, clear on riffles and murky in deeper places. As a rule, the rayed forms are young or immature, the black, rayless condition being correlated with age.

STROPHITUS RUGOSUS PEPINENSIS Var. Nov.

Plate LXXIV, figure 8

TYPE LOCALITY: Lake Pepin, near Lake City, Minn.

WISCONSIN RECORDS:

- 1914. *Strophitus edentulus* WILSON and DANGLADE, p. 20. Lake Pepin.
- 1922a. *Strophitus edentulus* GRIER, pp. 11-31 (part). Lake Pepin.
- 1926. *Strophitus edentulus* GRIER and MUELLER, pp. 17, 22. Lake Pepin.

SHELL: Differing from the usual form of the Mississippi River in being smaller, of greater relative diameter and height,

and with the ratio of anterior portion in front of umbones to length of 30% or less.

L. 68; H. 40; D. 28 mm. A. E. 21 mm. 31% Lake Pepin (U. of W., 362f). Type.

GENERAL DISTRIBUTION: Wisconsin and Minnesota.

DISTRIBUTION IN WISCONSIN: Not known outside of Lake Pepin. Recorded by Grier & Mueller, Wagner, Wilson & Dangle.

REMARKS: This widely distributed naiad reacts in a characteristic manner to the law of river distribution and it is not surprising that the Lake Pepin specimens should be quite markedly different from those of the river above and below. The principal difference is in the reduction in size and the migration of the umbones toward the anterior end, in this respect varying toward the race *pavonius*. Grier and Mueller, in their study of the shape and station of the shells of the upper Mississippi, note this difference, finding also a greater obesity and height (1926, p. 22). The interpolated river-lake environment has here been a potent factor in developing a striking ecological variety.

Pepinensis is similar in size and form to the small *Strophitus* found in Lake Winnebago, though these differ in other respects and the form is a true lake variety.

STROPHITUS RUGOSUS WINNEBAGOENSIS Var. Nov.

Plate LXXIV, figures 1-6

TYPE LOCALITY: Long Point Island, Lake Winnebago.

WISCONSIN RECORDS:

1922a. *Strophitus edentulus rhombicus* BAKER, p. 132. Lakes Butte des Morts and Winnebago.

1924. *Strophitus rugosus*, var. BAKER, p. 132, Lakes Winnebago and Butte des Morts.

SHELL: Differing from variety *pavonius* in being smaller and more cylindrical, of greater diameter, the umbones more depressed; epidermis dark brown with few rays in young shells; nacre salmon or pinkish under umbones; surface more or less imbricated by the growth lines; posterior end more squarely truncated, not elongated and pointed; beaks in most cases placed somewhat nearer the center of the shell; hinge more solid, with well developed rudiments of pseudocardinals.

L. 57; H. 35; D. 24 mm. A. E. 18 mm. 31%	Long Point Island (U. of W., 943a). Type.
L. 56; H. 31; D. 22 mm. A. E. 16 mm. 29%	Long Point Island (U. of W., 943b). Paratype.
L. 55; H. 34; D. 23 mm. A. E. 20 mm. 36%	Long Point Island (U. of I., Z12292). Paratype.
L. 66; H. 40; D. 26 mm. A. E. 21 mm. 32%	Brown Co. (U. of W., 133).
L. 44; H. 28; D. 20 mm. A. E. 14 mm. 32%	De Pere (U. of W., 181).
L. 51; H. 28; D. 20 mm.	Lake Erie (Ortmann, 1919, p. 200).

ANIMAL: As in *pavonius*.

BREEDING SEASON: Not known.

ECOLOGY: In Lake Winnebago, on wave-beaten shore in shallow water, on a rocky or sand bottom, in .3–1.5 m. depth of water.

GENERAL DISTRIBUTION: Unknown. It is possible that the *rugosus* of Lake Erie, mentioned by Ortmann (1919, p. 200) as being smaller than the river form, is referable to this variety, in which case the distribution would be from Lake Erie to Lake Winnebago.

DISTRIBUTION IN WISCONSIN: Known only from eastern Wisconsin.

Fox Drainage: Winnebago Lake and Lake Butte des Morts (Baker); lower Fox River (Marston) all Winnebago Co.; Sturgeon Bay, Door Co. (Baker).

REMARKS: The *rugosus* of Winnebago Lake and the lower Fox River differ markedly from the large form so abundant in creeks and rivers. They are much smaller and more cylindrical and generally more solid. They are evidently a variation of the *pavonius* type not of the large river type, *pavonius* being the common form in the Fox River above Lake Butte des Morts. As Lake Winnebago is but a widening-out of the Fox River it is the creek and small river form that has varied to form *winnebagoensis*. A small form occurs in Lake Pepin, which is a similar widening of the Mississippi River, but this variant is from the large river type or typical *rugosus*, and differs notably from the smaller Lake Winnebago form, which is much more cylindrical. From *lacustris* it differs in its more cylindrical shape.

Two specimens of a small *Strophitus* were found in Sturgeon Bay which are provisionally referred to *winnebagoensis*. They are thinner, more quadrate, and of lighter color, but not

enough material is at hand for forming a decisive opinion. As the Winnebago Lake form is found in the lower part of Fox River it may have migrated up Green Bay to Sturgeon Bay. They strongly resemble some forms of *winnebagoensis* (see pl. LXXIV, figs. 4, 5).

STROPHITUS RUGOSUS LACUSTRIS Var. Nov.

Plate LXXV, figures 6-8

TYPE LOCALITY: Oconomowoc Lake, Waukesha Co., Wis.

WISCONSIN RECORDS: None.

SHELL: Quadrate or rhombic in form, thin to rather thick, compressed, inequipartite; anterior end rounded; posterior end broadly rounded, usually ending in a squarish, biangulate point, slightly pointing downward in many specimens; ventral border straight or slightly incurved; dorsal margin nearly straight; umbones but slightly elevated above dorsal margin, compressed; sculpture as in *pavonius*; posterior ridge rounded or but slightly angled; epidermis yellowish, olivaceous, or reddish, sometimes faintly rayed; surface smooth or quite rough, growth lines well marked, accentuated at rest periods by black bands; hinge plate as in *pavonius*, but rather heavier; beak cavity very shallow; muscle scars distinct; nacre tinged with salmon or pink, rarely white.

L. 65; H. 38; D. 23 mm. A. E. 17 mm. 26% Oconomowoc Lake
(U. of I., Z22073). Type.

L. 50; H. 30; D. 19 mm. A. E. 15 mm. 30% Oconomowoc Lake
(U. of I., Z22073). Paratype.

L. 71; H. 37; D. 23.5 mm. A. E. 21 mm. 30%. Silver Lake (U. of I., Z22074).

ANIMAL: Not examined.

ECOLOGY: On sand bar east of outlet of Oconomowoc Lake, pebble bottom, shallow water to .5 m. deep, also along shore; Silver Lake, clear sand without vegetation, packed quite hard, shallow water, the water clear to depth of 3.7 m. (Cahn).

GENERAL DISTRIBUTION: Wisconsin, and perhaps Indiana and Michigan. The beak sculpture of these lake forms varies greatly.

DISTRIBUTION IN WISCONSIN: Probably confined to the inland smaller lakes; known at present from Waukesha Co., only.

REMARKS: *Lacustris* differs from variety *pavonius*, to which it is related, by its squarish shell, greater height as compared with length, and heavier hinge structure. It is usually of a more reddish color. This form was at first thought to be the same as *rhombicus* Anthony (Amer. Journ. Conch., I, p. 158, pl. 12, fig. 5, 1865). Comparison with Anthony's original specimens in the Museum of Comparative Zoology, by Mr. Wm. J. Clench, Curator of Mollusca, shows that it is not that form, the beak markings of *rhombicus* being much finer and differently shaped, placed closer together and forming quadrangular loops curving upward both before and behind the beaks; there are also three or four fine riblets radiating from each side of the beaks near the hinge line. Specimens of apparently true *rhombicus* have been personally collected from White Lake, Oakland Co., Mich., which agree with Anthony's type. A lake form living in Lake Maxinkuckee, Indiana, is similar to the Wisconsin form in beak sculpture, though the shape of the shell is slightly different.

Lacustris in Waukesha County is a direct offshoot of *pavonius*, that variety being common in the small streams near these lakes. In Bark River near Dousman, a form of *pavonius* occurs which has the red color of *lacustris* and the form of *pavonius*, indicating the relationship. A specimen from Silver Lake has the elongated form of the creek type but has a rather distinct posterior ridge (fig. 8).

The northern *Strophitus rugosus* appears to be one of the most plastic of species in responding to changes of environment, five more or less distinct variants being specially noted. These are shown below:

Strophitus rugosus. Large and medium sized rivers.

Strophitus rugosus pavonius. Creek form.

Strophitus rugosus pepinensis. River-lake form (from *rugosus*).

Strophitus rugosus winnebagoensis. Small river-lake form (from *pavonius*).

Strophitus rugosus lacustris. Small lake form (from *pavonius*).

The finer-beaked form, *rhombicus*, should probably be considered a distinct species and not a variety of *rugosus*. It would be interesting to compare all the small lake forms of this genus to ascertain the range of variation of the size and form of the beak markings.

Subfamily LAMPSILINAE Ortmann, 1912

"Inner lamina of inner gills rarely more or less free from the abdominal sac, generally connected with it throughout; supra-anal opening separated from the anal, rarely entirely closed; branchial openings well defined; edge of the mantle in front of the branchial opening smooth to crenulated or with peculiar papillae or a flap; marsupium rarely formed by the whole outer gill, generally only by or within the posterior part of the outer gill; edge of marsupium, when charged, distending and bulging out beyond the original edge of the gill, generally assuming a beaded appearance; water-tubes simple in the gravid female; glochidium semicircular or semi-elliptic, without spine, rarely celt-shaped and with two spines; shell heavy or lighter, rounded or oval to elongate; color of the epidermis rarely dull, mostly bright, with color markings; sculpture of the beak generally double-looped, but often obsolete, more rarely concentric; hinge generally complete, with well developed teeth, which only in rare cases show a tendency to become reduced; sexual difference more or less noticeable in the shell, often very strongly expressed". (Ortmann).

KEY TO GENERA OF LAMPSILINAE

1. a. Male and female shells alike ----- *Obliquaria*
- b. Male and female shells different ----- 2
2. a. Female shell more or less expanded in the post-basal region; dorsal margin winged ----- 3
- b. Dorsal margin not winged ----- 4
3. a. Pseudocardinals perfect; glochidium celt-shaped, with two spines ----- *Proptera*
- b. Pseudocardinals rudimentary; glochidium semicircular, without spines ----- *Leptodea*
4. a. Pseudocardinals well developed, complete; shell with a distinct posterior ridge, dorsal slope smooth ----- 5
- b. Shell usually without a distinct posterior ridge, or when distinct, dorsal-slope radially sculptured ----- 6
5. a. Hinge heavy and strong; hinge plate wide, flat ----- *Plagiola*
- b. Hinge delicate; hinge-plate narrow ----- *Truncilla*
6. a. Marsupial expansion of the female shell of the same texture as the rest of the shell ----- 7
- b. Marsupial expansion of the female shell of different texture from the rest of the shell and usually radiately sculptured ----- *Dysnomia*

7. a. Inner edge of the mantle in front of the branchial opening differentiated with papillae or flaps	8
b. Inner edge of mantle in front of branchial opening without papillae or flaps	10
8. a. Shell smooth; beak sculpture double-looped	9
b. Beak sculpture concentric	<i>Carunculina</i>
9. a. Inner edge of mantle in front of branchial opening in female distinctly papillate	<i>Ligumia</i>
b. Inner edge of mantle in front of branchial opening in female with a ribbon-like flap	<i>Lampsilis</i>
10. a. Shell inflated, usually higher than long	<i>Obovaria</i>
b. Shell subcompressed, longer than high	<i>Actionaias</i>

Genus OBLIQUARIA Rafinesque, 1820

Shell inflated, solid, oval, ending in a tolerable sharp point behind, having a row of large, compressed, longitudinal knobs running from the beaks to the center of the base, those of one valve alternating with the knobs of the other, and a well developed posterior ridge; the space between the ridge and the knobs somewhat excavated; posterior slope and sometimes the entire shell more or less corrugately sculptured; beaks prominent, incurved and pointed slightly forward toward a fairly well developed lunule; beak sculpture strong, consisting of four or five heavy, parallel ridges, which fall low in front, but are curved upwards behind; epidermis smooth, generally shining, painted with numerous, delicate, wavy, darker, broken rays; pseudo-cardinals strong, distinct and ragged; laterals short, nearly straight; front part of the shell very solid, suddenly becoming rather thin, just behind the knobs. Marsupium consisting of a few distinctly marked ovisacs (4 to 7), occupying a position just behind the centre of the outer gills, projecting far below the branchiae, their bases rounded (Walker). Type: *Obliquaria reflexa* Raf.

OBLIQUARIA REFLEXA Raf. Three-Horned Warty-Back

Plate LXXVI, figures 1-3

Obliquaria (Quadrula) reflexa RAF., An. Gen. Sci. Phys., Brux., V, p. 306, 1820.

Unio cornutus BARNES, Amer. Jour. Sci., VI, p. 122, pl. iv, figs. 5, a, b, c, 1823.

Obliquaria reflexa SIMPSON, Cat., p. 330, 1914.

Obliquaria reflexa ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 42, 1922.

TYPE LOCALITY: Kentucky River, and Letart Falls, Meigs Co., Ohio (*reflexa*); Fox River, Wisconsin (*cornutus*).

WISCONSIN RECORDS:

1823. *Unio cornutus* BARNES, p. 122. Fox River.
1852. *Unio reflexus* LAPHAM, p. 369. Wisconsin.
1860. *Unio cornutus* LAPHAM, p. 155. Fox River.
1897. *Unio cornutus* WISWALL, p. 47. Southern Wisconsin.
1905c. *Obliquaria reflexa* BAKER, p. 254. Prairie du Chien.
1914. *Obovaria reflexa* WILSON and DANGLADE, p. 20. Lake Pepin.
1919. *Obliquaria reflexa* ORTMANN, p. 217. Fox River.
1922a. *Obliquaria reflexa* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Cos.
1926. *Obliquaria reflexa* GRIER and MUELLER, p. 17. Lake Pepin and Mississippi River.
1927d. *Obliquaria reflexa* BAKER, p. 107. Rock River, Jefferson to Ft. Atkinson.

SHELL: As in generic description, *reflexa* being the only species. Sexual differences in shell slight. The females are usually more swollen and lack the emargination of the posterior lower margin while the radial furrow is indistinct.

- L. 59; H. 52; D. 42 mm. Wisconsin River (U. of W., 128).
L. 63; H. 53; D. 40 mm. Fort Atkinson (U. of W., 946).
L. 48; H. 40; D. 31 mm. Prairie du Chien (U. of W., 947).
L. 35; H. 32; D. 26 mm. Lake Pepin (U. of W., 725).
L. 45; H. 37; D. 30 mm. Illinois (U. of W., 323a).

ANIMAL: (Pl. XXIX, fig. 3). Supra-anal and anal openings separated by mantle connection shorter than anal opening; branchial opening rather large with papillae; anal opening about half as long as branchial, crenulated; palpi small, rather wide, their posterior margins connected only at the base; gills short, very broad, the inner gills wider at the anterior half; inner laminae of inner gills attached to abdominal sac only a short distance at the anterior end; outer gills only marsupial; when gravid the marsupium forms a heavy, pad-like structure, extending beyond the normal edge of the gill, each ovisac, of which there may be 4 to 8 in number, being subcylindrical in form and curved backward. The ova and glochidia are encased in solid placentae, packed close together. These placentae are believed to be discharged whole. Color of animal whitish, mantle edge brownish, especially near the anal and branchial openings. Marsupium white.

Glochidia (pl. XXXII, fig. 7) of medium size, semicircular in

form, hinge line short, with gradual curve. Length 0.225, height 0.230 mm. (Lefevre & Curtis); 0.225 by 0.235 mm. (Surber); 0.22 by 0.22 (Ortmann). These figures indicate a certain range of variation.

BREEDING SEASON: A tachytictic species. Lefevre and Curtis, and Surber, indicate the breeding season to be from May to August, embryos being present from the end of May to July 9, and glochidia from June 20 to Aug. 8.

NATURAL HOST: Not known. May possibly be absence of parasitism, as in *Strophitus rugosus* (Howard, 1914a, p. 44).

ECOLOGY: Inhabits the large rivers, where it is found on a sand, gravel, or mud bottom in water .3-2 m. or more deep, in a more or less rapid current.

GENERAL DISTRIBUTION: Western Pennsylvania west to Iowa, Kansas, and Oklahoma, south to Louisiana, Texas, and Georgia, and northward to Michigan and Minnesota.

DISTRIBUTION IN WISCONSIN: The records indicate that this species inhabits the Mississippi, Wisconsin, Fox, and Rock rivers. No exact locality is given for the Fox River by Barnes and others and it was not found in personal collections in that river. The Rock River record needs confirmation, as Cahn did not find it above Lake Koshkonong. It occurs in Rock River, Winnebago Co., Ill.

Mississippi Drainage: Lake Pepin (Pearse); Pierce and Pepin Co. (Wilson and Danglade); Pierce, Pepin, Buffalo, Trempealeau Co. (Grier); Prairie du Chien, Crawford Co. (Baker, Bullock, Dudley).

Wisconsin Drainage: Wisconsin River (Marston, Wiswall).

Fox Drainage: Fox River (Barnes).

Rock Drainage: Fort Atkinson, Jefferson Co. (Bullock).

REMARKS: *Obliquaria reflexa* cannot be mistaken for any other Wisconsin mussel, the presence of the peculiar transverse, knob-like tubercles at once identifying it. When the shell is viewed from the anterior or posterior end the tubercles are seen to be placed alternately on each valve. The shell varies in shape, the posterior end sloping sharply upward to meet the truncated posterior margin, or projecting downward, forming a plow-shaped posterior end. The tubercles also vary in size and shape and they may be placed regularly from beak to base, or they may be concentrated near the upper part of the shell leaving the lower half with simple growth lines.

The color also varies from light yellowish-brown to dark green, heavily rayed; some specimens may be almost black. The species as found in the smaller streams, as the Wisconsin, Illinois, and Rock rivers, is somewhat more elongated and compressed than when living in the Mississippi and Ohio rivers. A small difference in shape was observed by Grier and Mueller between shells from the Mississippi and Lake Pepin. This variation is so gradual and the differences so slight that no varietal distinctions can be drawn. In Wisconsin it is common only in the Mississippi River, apparently. Not of great commercial value.

In the south, several forms occur, more especially in Alabama, which should probably receive ecological designation. The immature shell of all variations is compressed, the variation apparently taking place as the animal becomes mature.

Genus OBOVARIA Rafinesque, 1819

Shell short, oval, rounded or retuse, solid, inflated, thick in front, thinner behind, with high beaks, which are sculptured with very faint, irregular, often broken and slightly nodulous ridges, which show a tendency to fall into two loops, the posterior often open behind; epidermis dull, brownish, silky or cloth-like, rarely rayed, rays indistinct; female shell but slightly inflated in the post basal region, commonly having a shallow furrow or a flattened area at the posterior end; pseudocardinals solid, stumpy; laterals short, club-shaped. Marsupium kidney-shaped, projecting far below the edge of the gill and occupying the posterior portion of the outer gills. (Walker). Type: *Unio retusa* Lamarck.

Subgenus PSEUDOON Simpson, 1900

Shell elliptical, inflated, solid; that of the male slightly pointed at the upper posterior part; epidermis brownish or blackish, rayless or very feebly rayed; beaks anterior; pseudocardinals solid, stumpy or slightly elongate in age, and showing a tendency toward being parallel with the laterals; nacre silvery, iridescent posteriorly. Marsupium kidney-shaped, not reaching to the posterior end of the outer gill, though extending quite well forward. Type: *Unio ellipsis* Lea.

OBOVARIA OLIVARIA (RAF). Hickory-Nut

Plate LXXVI, figures 4-8; plate LXXVII, figures 1-2

Amblema olivaria RAF., An. Gen. Sci. Phys., Brux., V, p. 314, 1820.*Unio ellipsis* LEA, Trans. Amer. Phil. Soc., III, p. 268, pl. iv, fig. 4, 1828; Obs., I, p. 10, pl. iv, fig. 4, 1834.*Obovaria ellipsis* SIMPSON, Cat., p. 299, 1914.*Obovaria olivaria* ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 46, 1922.TYPE LOCALITY: Kentucky River (*olivaria*) Ohio (*ellipsis*).

WISCONSIN RECORDS:

1852. *Unio olivarius* LAPHAM, p. 369. Wisconsin.1860. *Unio ellipsis* LAPHAM, p. 156. Wisconsin River.1897. *Unio ellipsis* WISWALL, p. 47. Southern Wisconsin.1905c. *Obovaria ellipsis* BAKER, p. 254. Prairie du Chien.1906. *Obovaria ellipsis* CHADWICK, p. 93. Wisconsin.1919. *Obovaria olivaria* ORTMANN, p. 223. Southern Wisconsin.1922a. *Obovaria olivaria* GRIER, pp. 11-31. Pierce, Buffalo, Trempealeau Co.1922. *Obovaria olivaria* GRIER and MUELLER, p. 100. Rare in Lake Pepin.1926. *Obovaria olivaria* GRIER and MUELLER, p. 18. Lake Pepin and Mississippi River.

SHELL: Ovate or elliptical, very oblique (consequently markedly inequiptartite), thick, solid, inflated; anterior end broadly rounded; posterior end roundly pointed in the male, broadly rounded in the female; ventral margin convex; dorsal margin slightly convex, passing into the posterior margin without sharp angle; posterior ridge feeble or absent; beaks swollen, incurved and directed obliquely forwards, elevated slightly or considerably above the hinge line; beak sculpture consisting of 4-5 delicate bars, having a sinus in the middle, giving a double looped aspect to the bars; the posterior part of each bar becomes indistinct and disappears on the posterior slope; surface marked by heavy concentric growth lines which are dark colored and raised into slight ridges at rest periods; epidermis olive-green, becoming dark brown in old shells; young shells are more or less distinctly rayed with fine green lines.

Pseudocardinals heavy, solid, one in right, two in left valve, slightly elongated, often serrated or with small tubercles, in old shells becoming subparallel with laterals; laterals rather long, heavy, thick, triangular in cross section; interdentum slightly developed; beak cavities rather shallow, containing dorsal mus-

cle scars; anterior adductor muscle scar very deeply excavated, roughened; posterior scar well marked; nacre silvery white, markedly iridescent posteriorly; there is sometimes a slight tinge of pinkish or cream in the center of the valve. Sexual difference in the shell strongly marked in some specimens, the female being more broadly rounded posteriorly, while the male is more or less sharply pointed and the ventral margin is quite convex. The male shell is usually larger than the female shell (pl. XXXV, figs. 4, 5).

L. 79; H. 64; D. 43 mm.	Sauk Co. (U. of I., Z4471).	Male.
L. 61; H. 49; D. 37 mm.	" " (" Z4471).	Female.
L. 101; H. 76; D. 53 mm.	" " (" Z4471).	Male.
L. 64; H. 50; D. 37 mm.	" " (" Z4471).	Male.
L. 65; H. 52; D. 43 mm.	Wis. R. (U. of W., 130).	Male.
L. 64; H. 48; D. 30 mm.	Omro (U. of W., 948).	Female.
L. 70; H. 55; D. 34 mm.	Portage (U. of W., 949).	Male.
L. 33; H. 25; D. 16 mm.	Juv. Omro (U. of W., 948b).	

ANIMAL (Fig. 232): Anal and supra-anal openings but slightly separated by mantle connection; supra-anal opening large, slightly crenulated; branchial opening with papillae; anal opening crenulated; in the female, the inner edge of the mantle immediately in front of the branchial opening is finely

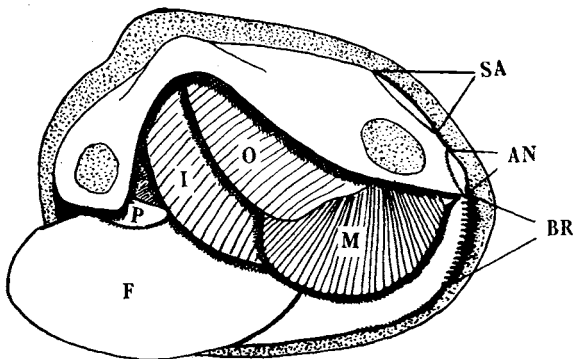


Fig. 232. *Obovaria olivaria* Raf. Wisconsin River, Lower Dells, Kilbourn. Gravid female. July 12, 1922.

crenulated to about the posterior third of the lower margin; palpi connected only at their posterior margins; gills wide, the anterior part of the inner gill wider than the anterior part of the outer gill; inner laminae of inner gills entirely connected with abdominal sac. The marsupium occupies the posterior

half of the outer gills and is semicircular or kidney-shaped, and made up of 30-40 or more ovisacs; when gravid this part of the gill is pad-like and extends far below the edge of the outer gill and somewhat below the edge of the inner gill. Placentae white, the glochidia discharged in loose masses. Color of animal whitish, edge of mantle blackish, especially about openings. In the female, the marsupium is pigmented with purplish-gray on the edge.

Glochidia (pl. XXXII, fig. 8) of medium size, elliptical, ventral margin rounded, hinge line curved, short. Length 0.19, height, 0.22 mm. (Ortmann, 1919, p. 230); 0.210 by 0.265 mm. (Surber, 1912, p. 9).

BREEDING SEASON: Bradyctictic, from August to June.

NATURAL HOST: Not known. Two species have been artificially infected, *Aplodinotus grunniens* and *Ictalurus punctatus*, but the experiment was unsuccessful (see Coker, Shira, et al, 1921, p. 152).

ECOLOGY: *Olivaria* is usually found on a sand or gravel bottom in rather deep water (1-2.5 m. or more) where there is a good current. In smaller rivers it may be found at low water in shallow places.

GENERAL DISTRIBUTION: From western Pennsylvania and western New York west to Missouri, Iowa, and Kansas, south to Arkansas, Kentucky, and northern Alabama, and north to Minnesota, Michigan, and Quebec.

DISTRIBUTION IN WISCONSIN: *Olivaria* is found in the Mississippi, Wisconsin, Chippewa, and Fox Rivers. Its migration has been by way of the Mississippi and thence up the Chippewa and Wisconsin rivers. It doubtless entered the Fox River by way of the Post-glacial connection at Portage.

REMARKS: *Obovaria olivaria* is usually easily recognized (at least in Wisconsin) by its subovate or ovate outline, oblique shape, anteriorly placed umbones, smooth surface (silky or cloth-like) and characteristic hinge armature. There is considerable variation in the position of the beaks, in old shells these being placed far forward, almost overhanging the anterior margin. In the Mississippi and Wisconsin rivers the shells are large and quite globose with anteriorly-placed umbones.

In some smaller rivers, as the Fox, the shells are more compressed, more oblique, with a very widely rounded posterior end. The hinge is also more delicate and the umbones more depressed.

This form occurs at Omro and Princeton and appears to be the small river representative of *olivaria*, paralleling the differences in size and delicacy observed in other species (pl. LXXVI, figs. 5, 8). The compressed forms, curiously enough, are all females, no males being represented. In the lower Fox, in Brown Co., the shells are like the Wisconsin River form, large and of good diameter. Not enough material is at hand to determine whether the small river form is constantly different; if so, it would form an ecological variety, comparable to the other small varieties of other species. The *olivaria* from the Chipewewa River are like the Wisconsin River shells, though this is a small river. The females are not always with broadly rounded posterior end, a female from the Wisconsin River would have been declared a male from the shell alone. It is similar in form to fig. 1, pl. LXXVII.

The *olivaria* in the Mississippi River, and in the lower Wabash River, are smaller than the specimens from the Wisconsin River in Sauk and Columbia counties and are more circular and less oblique. There appears to be a size and length curve, as noted in other species, beginning with the small, compressed form in the Fox River, swelling to the large, wide, more oblique form in the Wisconsin River and in the lower Rock River in Illinois, and culminating in the smaller, more globular shell of the Mississippi and lower Wabash rivers in Illinois. The variations in these streams, however, are not distinct enough for special designation, although the compressed form in the Fox River may form an ecological variety when more abundant material is available for study.

Genus ACTINONAIAS Fischer and Crosse, 1893

"Shell ovate or subelliptical, distinctly longer than high, compressed or slightly inflated, without, or with, indistinct posterior ridge. Disk not sculptured. Beaks moderately anterior, never in middle of the shell and never very near the anterior end. Beak sculpture poorly developed, consisting of a few faint bars, which have a tendency to become double-looped, with the central part between the loops obliterated. Epidermis yellowish to greenish, generally with distinct rays. Male and female shells differing in shape, but the difference often hardly noticeable. Soft parts agreeing with those of *Obovaria* in every

respect; the glochidia also of the same type." (Ortmann).
Type: *Unio sapotalensis* Lea.

ACTINONAIAS CARINATA (Barnes). Mucket

Plate LXXVII, figures 3-6

Unio carinatus BARNES, Amer. Jour. Sci., VI, p. 259, pl. xiii, fig. 10, 1823.

Unio ellipticus BARNES, Op. Cit., p. 259, pl. xiii, fig. 19, 1823.

Unio crassus SAY, Nich. Encyc., II, pl. i, fig. 8, 1817 (not *Unio crassus* Retzius, 1778).

Unio ligamentinus LAM., Simpson, Cat., p. 79, 1914.

Actinonaias carinata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 47, 1922.

TYPE LOCALITY: Fox River, Wisconsin (*carinatus*, *ellipticus*); Ohio (*crassus*).

WISCONSIN RECORDS:

1823. *Unio carinatus* BARNES, p. 259. Fox River.

1823. *Unio ellipticus* BARNES, p. 259. Fox River.

1852. *Unio fasciatus* LAPHAM, p. 369. Wisconsin.

1860. *Unio ligamentinus* LAPHAM, p. 156. Milwaukee.

1885. *Unio ligamentinus* CALL, p. 35. Racine.

1897. *Unio ligamentinus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Lampsilis ligamentina* BAKER, p. 253. Prairie du Chien.

1906. *Lampsilis ligamentina* CHADWICK, p. 91. Milwaukee River; Fox River, near Big Bend, Waukesha Co.; Clear Water Lake Creek, Oneida Co.; Sugar River, Brodhead, Green Co.; Honey Creek, towns Wauwatosa and Greenfield; between Prairie du Chien and De Soto.

1904. *Lampsilis ligamentina* BAKER, p. 103. Kilbourn.

1911a. *Lampsilis ligamentina* BAKER, p. 231. Wisconsin River and Gilmore Creek.

1919. *Actinonaias ligamentina* ORTMANN, p. 237. Racine, Racine Co.; Milwaukee.

1922a. *Actinonaias carinata* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.

1922. *Actinonaias carinata* GRIER and MUELLER, p. 100. Throughout upper Mississippi drainage but rare in Lake Pepin.

1924. *Actinonaias carinata* BAKER, p. 132. Omro, Fox River; Lake Butte des Morts.

1927d. *Actinonaias carinata* BAKER, p. 107. Neosho mill pond; Rock River, Ashippun to Rock Co.

SHELL: Thick, heavy, of large size when adult, subovate or subelliptical, inequipartite; anterior end rounded; posterior end pointed; ventral margin broadly rounded; dorsal margin almost straight; posterior ridge rounded, very faint or absent;

the shell is usually not much inflated, young individuals being quite compressed; beaks somewhat swollen, not much elevated above the dorsal margin; beak sculpture consisting of a few delicate, more or less distinct bars, which are more or less double-looped; surface without sculpture, the growth lines sometimes exaggerated at rest periods and dark bordered; epidermis yellowish, greenish, olive or brownish-yellow, with many broad green rays which gradually increase in width from the umbones; old individuals are usually rayless and become brown or blackish; rarely concentric bands of color are present, especially in half-grown shells.

Pseudocardinals subtriangular, elevated, heavy, serrated, divergent, two large teeth in left valve, one in right valve, with one small, somewhat cone-shaped anterior tooth and sometimes a third posterior tooth; laterals long, elevated, strong, heavy, somewhat roughened, two in left, one in right valve; interdentum long, narrow, frequently absent; beak cavity moderately deep; dorsal muscle scars in beak cavity and on hinge plate; anterior adductor muscle scar deeply excavated, sulcated; posterior scar distinct; nacre silvery white, often faintly pink or cream colored, iridescent posteriorly. In the female shell the post-basal region is slightly more rounded than in the male shell, causing the height of the shell to be greater in the female.

- L. 148; H. 90; D. 58 mm. Ashippun (U. of I., Z17349).
- L. 136; H. 86; D. 49 mm. Baraboo River (Dudley).
- L. 130; H. 75; D. 69 mm. Jefferson (U. of W., 950).
- L. 138; H. 78; D. 53 mm. Princeton (U. of W., 951).
- L. 110; H. 64; D. 36 mm. Omro (U. of W., 952a). Male.
- L. 92; H. 58; D. 36 mm. Omro (U. of W., 925b). Male.
- L. 83; H. 53; D. 35 mm. St. Croix R. (U. of W., 953). Female.
- L. 60; H. 36; D. 24 mm. Prairie du Chien (Dudley). Juv.

ANIMAL (Fig. 233): Similar to that of *Obovaria olivaria*. There is a short mantle connection between anal and supra-anal openings, the latter being very large. Marsupium when gravid large and swollen, and made up of 30 to 60 ovisacs. Placentae distinguishable when eggs are present but the cohesion is lost when glochidia are formed. Mantle of female slightly lamellated or crenulated in front of the branchial opening.

Glochidia (pl. XXXII, fig. 9) of medium size, semielliptical, ventral margin rounded, hinge line short, undulate. Length

0.220, height 0.260 mm. (Surber, 1912, p. 9) ; 0.22 by 0.24 mm. (Ortmann, 1919, p. 234).

BREEDING SEASON: Bradytictic, August to May, sterile in June and July. Surber (1912, p. 7) gives the interim in August, with glochidia present from September to July. In the Wisconsin River, at Kilbourn, gravid females were collected from July 8 to July 24, many of the marsupia being partly filled with glochidia in late July.

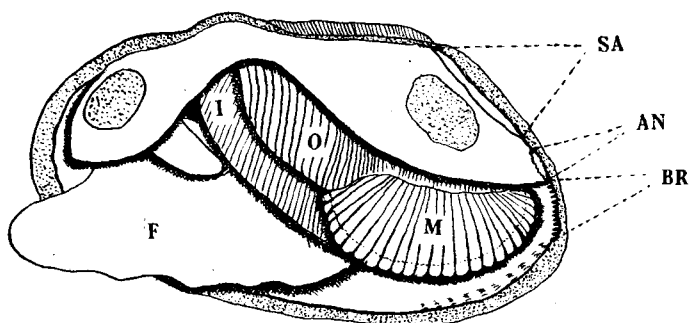


Fig. 233. *Actinonaias carinata* (Barnes). Fox River, Omro. Gravid female. Aug. 3, 1920.

NATURAL HOST: Glochidia of the mucket are found on the gills of the following fish:

<i>Lepomis cyanellus</i>	Blue-spotted Sunfish
<i>Lepomis pallidus</i>	Bluegill
<i>Micropterus dolomieu</i>	Small-mouth Black Bass
* <i>Micropterus salmoides</i>	Large-mouth Black Bass
* <i>Perca flavescens</i>	Yellow Perch
* <i>Pomoxis annularis</i>	White Crappie
* <i>Roccus chrysops</i>	Striped Bass

Successful artificial infection was secured on those above marked by an asterisk, and also on gills of *Stizostedion canadense*, sauger, and *Pomoxis sparoides*, black crappie.

ECOLOGY: *Carinata* is typically a species of the large rivers, but is also found in smaller rivers. In parts of Wisconsin and Illinois it is abundant in shallow rivers of less than 30 feet width on riffles, in sand and gravel bottom. Occasionally it is found on a hard stony bottom, wedged in between large boulders, almost buried from sight. Sand and gravel bars are its favorite places, in water .3-1.6 m. deep. Rarely is it found on

a mud bottom in deeper water. Its best habitat is in a rather swift current, 2-7 miles per hour.

In Gilmore Creek, *carinata* was found in clean, firm sand, in swift water, buried almost from sight. At Kilbourn, in the Wisconsin River, it occurred on a sand or gravel bottom in 1-2 m. of water. Here it also occurred sparingly on a mud bottom. In the Fox River, at Omro, it was found on a sand bottom in shallow water.

GENERAL DISTRIBUTION: Mississippi River drainage generally; southern Michigan; western New York; Manitoba; Ontario (Simpson). It has been reported from Missouri (Utterback, 1916a) and Arkansas (Call, 1895), but in the south the variety *gibba* appears to take the place of the typical *carinata*.

DISTRIBUTION IN WISCONSIN: *Carinata* is widely distributed in the State, being found in all of the important drainage areas excepting that of Lake Superior. It ascends the Mississippi well up the St. Croix River, also into the head waters of the Wisconsin. It crossed the divide at Portage and has become well established in the Fox River system. It is common in the Rock River and its tributaries, and has migrated into southeastern Illinois (Lake drainage) by way of the Fox River of Illinois. It may also have migrated to Racine by way of Glacial Lake Chicago, the species being common in the post-glacial deposits in old Wilmette Bay (Baker, Life of Pleistocene, p. 23).

REMARKS: *Carinata* is an abundant and widespread species in Wisconsin. Usually it is easily distinguished from all other species by its subovate or elliptical outline, fine umbonal markings, and heavy hinge plate. Very old specimens of this species and *Lampsilis siliquoidea* are sometimes difficult to distinguish when the beak markings are obliterated. The lighter hinge structure and usually thinner shell, besides the different shaped outline (*siliquodea* being more elongated with sharper posterior end) will usually distinguish *siliquoidea* from *carinata*. In young shells of equal size, *carinata* is more compressed or flattened laterally, is not as pointed, has wider rays, and differs markedly in beak sculpture as well as in hinge structure.

The mucket varies considerably in coloration, though moderately uniform in shape. Young shells are brightly rayed, but old shells lose these markings and become uniform brown or dark chestnut. The hinge also varies somewhat in massiveness. The nacre may be pure silvery white or deep pink or

rose, the last color being common among the shells in the Mississippi River at Prairie du Chien. Often this bright tint suffuses the whole interior of the shell, including the teeth. Increased age usually thickens the shell until it becomes very solid and heavy. A specimen from Jefferson, Rock River, is almost as wide as high and the shell valves are a fourth of an inch thick. A specimen from Rock River, in the Marston collection, is strongly "humped" resembling the variety *gibba* of Simpson from the Southern States. A specimen (female) from Princeton has a blister in the right valve covering 50 per cent. of the area and enclosing a space 9 mm. deep.

Though inhabiting all types of river and creek environment, this species shows little active variation. The creek forms are somewhat smaller and more compressed than the forms of the medium sized rivers, and these in turn are somewhat larger than specimens from the lower Ohio and Mississippi rivers. The largest and heaviest specimens appear to inhabit such streams as the Rock River in Dodge County and the Spoon River near the Illinois. The widest specimens seen came from the lower Rock River in Illinois. There appears to be a swelling of the width or diameter curve in the lower part of the medium sized rivers with a flat form in the creeks and a smaller, narrower form in the Mississippi River. *Carinata* is one of the least variable of Wisconsin naiades.

The mucket is widely used commercially but is of varying quality, this feature depending upon the locality from which the shells are collected. The muckets of the Mississippi have not been highly esteemed by button manufacturers. The heavy end or "butt" is considered too chalky and the posterior end is usually too thin. In many shells the nacre is pink (as at Prairie du Chien) and this lessens its value. Some of the best shells come from smaller streams, where the nacre may be white and the shell not as brittle as in the larger rivers. Good shells for commercial purposes have been found in Indiana and Kentucky. In 1919 muckets were worth \$45 per ton. The muckets of the Wisconsin River near Kilbourn, where they are very abundant, have good nacre, free from color, the shells are thick, and appear not to be very brittle. In Illinois, the best muckets have been found (by the writer) in the Big Vermilion River, on a rocky bottom in very shallow water. These are of good size, nacre, and thickness of shell.

Geiser (1911) has shown that in certain species of mussels, particularly *Actinonaias carinata*, a third pseudocardinal may be present in the right valve. This third tooth is almost universally present in *carinata*, more or less distinct; the large pseudocardinal usually has a second denticle anteriorly, overhanging the anterior adductor muscle scar, and a third on the edge of the interdentum, which is better developed in some specimens than in others and when exaggerated, becomes a third pseudocardinal, especially in old shells.

The nomenclature of this species is somewhat involved. It was first described as *crassus* by Say in 1817 (name preoccupied by the European *crassus* of Retzius), and later as *ellipticus* and *carinatus* by Barnes in 1823 (*ellipticus* preoccupied by Rafinesque in 1820). Rafinesque's *fasciata* has been thought to be this species. In 1834, Lea, after examining the type of Lamarck's *ligamentina*, declared it to be that species, which was described in 1819. This name, however, cannot be recognized with any degree of certainty, and it has been shown by Ortmann and Walker (1922, p. 48) that the first valid name for the mussel so long known as *ligamentina* is *carinatus*. It is a satisfaction to Wisconsin students of the Mollusca to have this common species bear the name given by one of our earlier students, who was among the first to study the fauna of the State.

Genus TRUNCILLA Rafinesque, 1819

Shell inflated, decidedly truncate at the posterior slope; surface slightly concentrically sculptured; posterior ridge sharp and well defined; epidermis shining, sometimes wrinkled, looped and painted with a beautiful pattern of broken or arrow-marked rays; area of the beaks flattened off in the direction of the axis of the shell, but not compressed; beak sculpture delicate, sometimes broken and doubly looped, the anterior loop rounded, the posterior sharp below, the ribs fading out where they cross the posterior ridge; hinge delicate; pseudocardinals rather compressed, high and ragged; hinge plate narrow; female shell very slightly swollen at the post-base. Marsupium consisting of numerous distinct ovisacs and having a well marked sulcus extending around it at some distance above its base. Type: *Truncilla truncata* Raf. (Walker). *Truncilla* takes the place of the name *Amygdaloniaias* of Crosse and

Fischer, 1893, type *Unio cognatus* Lea, which is congeneric with *Unio elegans* Lea (= *truncata* Raf.). See Ortmann and Walker, 1922, p. 49.

TRUNCILLA TRUNCATA Raf. Deer-Toe

Plate LXXVIII, figures 3-9

Truncilla truncata RAF., An. Gen. Sci. Phys., Brux., V, p. 301, 1820.

Unio elegans LEA, Trans. Amer. Phil. Soc., IV, p. 83, pl. ix, fig. 13, 1831; Obs., I, p. 93, pl. ix, fig. 13, 1834.

Plagiola elegans, SIMPSON, Cat., p. 306, 1914.

Amygdaloniaias truncata, ORTMANN, Mem. Carnegie Mus., VIII, p. 238, pl. xiv, fig. 7, 1919.

Truncilla truncata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 50, 1922.

TYPE LOCALITY: Ohio River, *truncata* (Raf.); Falls of the Ohio (Vanatta); Ohio, *elegans*.

WISCONSIN RECORDS:

1852. *Unio truncatus* LAPHAM, p. 369. Wisconsin.

1860. *Unio elegans* LAPHAM, p. 155. Wisconsin River.

1897. *Unio elegans* WISWALL, p. 47. Southern Wisconsin.

1905a. *Plagiola elegans* BAKER, p. 254. Prairie du Chien.

1906. *Plagiola elegans* CHADWICK, p. 93. Wisconsin.

1919. *Amygdaloniaias truncata* ORTMANN, p. 241. Wisconsin.

1922a. *Amygdaloniaias truncata* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.

1924. *Truncilla truncata* BAKER, p. 132. Omro, Fox River; Lake Butte des Morts.

1926. *Truncilla truncata* GRIER and MUELLER, p. 17. Lake Pepin and upper Mississippi River.

SHELL: of medium size, subtrigonal, thick, solid, more or less compressed; anterior end rounded; posterior end obliquely truncated, joining the short, slightly rounded dorsal margin at a more or less sharp angle; ventral margin convex, curved upwards into the posterior margin, producing a sharp posterior end, which is sometimes biangulate; posterior ridge sharp, with an excavated area behind it and a slight radial furrow in front; the shell when viewed posteriorly is seen to be flatly truncated; the postero-ventral border has a wide sinus more or less well developed; beaks elevated, slightly incurved; beak sculpture consisting of several (3-4) fine bars, the first nearly concentric, the others double-looped, the posterior loop being triangularly pointed, the ascending bar being obscure or obliterated; epider-

mis greenish, yellowish, or yellowish-brown, usually with distinct rays of varying width, which are frequently marked with dark green spots which may form a zigzag pattern; in old specimens the rays often disappear and the shell becomes uniformly brownish.

Pseudocardinals triangular, compressed, elevated, subparallel, strongly serrated, two in left valve one in right valve with a small denticle in front and above; in very old specimens a third denticle may be developed near the short, narrow interdentum; laterals short, elevated, compressed, roughened, directed ventrally but almost straight; beak cavities rather shallow, containing dorsal muscle scars; anterior adductor muscle scar deeply excavated, posterior scar distinct; nacre silvery white, sometimes slightly pinkish, iridescent posteriorly. Sexual difference in shell not well marked, the males usually have a shallow furrow in front of the posterior ridge with a corresponding concave region on the posterior-ventral border, the females having an evenly rounded ventral border. This feature, however, is not always present.

L. 55; H. 43; D. 28 mm.	Prairie du Chien (Dudley).	Female.
L. 62; H. 53; D. 43 mm.	Sauk Co. (U. of I., Z4519).	Male.
L. 55; H. 47; D. 38 mm.	" " (" Z4519).	Male.
L. 51; H. 39; D. 26 mm.	Lake Pepin (U. of W., 724).	Male.
L. 29; H. 25; D. 18 mm.	Lake Pepin (U. of W., 349).	
L. 60; H. 45; D. 34 mm.	Princeton (U. of W., 954).	Male.
L. 55; H. 40; D. 24 mm.	" (" 955).	Female.
L. 56; H. 41; D. 26 mm.	Omro (U. of W., 956a).	Female.
L. 45; H. 33; D. 20 mm.	" (" 956b).	Male.
L. 48; H. 32; D. 21 mm.	" (" 957).	Female.

ANIMAL (Fig. 234): Anal and supra-anal openings separated by mantle connection about as long as anal opening; branchial opening with numerous papillae; anal opening finely crenulated; palpi rather small, their basal margins connected for about one-third their length; the inner edge of the mantle, in the female, is lamellar with fine crenulations in front of the branchial opening, this condition extending to about the middle of the lower margin; inner laminae of inner gills either entirely connected with the abdominal sac or free for as great a distance as one-fourth the length of the abdominal sac. Marsupium of female occupying the posterior half (or more) of the outer gill. The numerous ovisacs (30 or more) extend below the sterile edge of the gill. Color of animal whitish, with

mantle edge blackish, the region of the branchial and anal openings mottled black and white.

Glochidia (pl. XXXII, fig. 10) very small, semicircular, ventral margin rounded, hinge line short, evenly curved, spineless. Length 0.060, height 0.070 mm. (Surber, 1912, p. 9) ; 0.075 by 0.090 (Ortmann, 1919, p. 239). This discrepancy in measurements would indicate either that the species is very variable or that two forms are included.

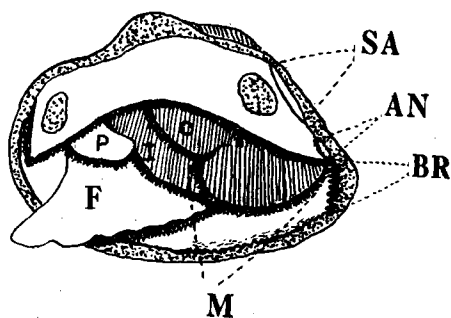


Fig. 234. *Truncilla truncata* (Raf.). Omro, Fox River. Gravid female. Aug. 3, 1920.

BREEDING SEASON: Bradytictic. Gravid in May and July (Surber, 1912, p. 6). Lefevre and Curtis list this species among bradytictic forms (1912, p. 141). Ortmann found gravid females on May 25, 1914. Gravid specimens were found at Omro, Fox River, on August 3, 1920, and at Kilbourn, in the Wisconsin River, the last of July, 1922.

NATURAL HOST: Not recorded.

GENERAL DISTRIBUTION: Mississippi drainage generally. Western Pennsylvania west to Iowa and Kansas, north to Minnesota and Michigan, and south to northern Alabama, Tennessee, Louisiana, and Texas.

DISTRIBUTION IN WISCONSIN: *Truncata* is widely distributed in three rivers, the Mississippi, Wisconsin, and Fox. The Fox distribution is probably due to the old post-glacial connection at Portage. It seems rare in the southeastern portion of the State, as but a single record is available from this region. Its metropolis is in the Mississippi and Wisconsin rivers.

ECOLOGY: In Wisconsin River in water 1-2 m. deep, on a sand or mud bottom; in Fox River at Omro, on a sandy mud

bottom in .3-.6 m. of water, usually along shore; in Lake Butte des Morts, on a mud bottom in water 11 feet deep.

REMARKS: *Truncilla truncata* is easily recognized by its trigonal shape and strong, almost keel-like posterior ridge. The posterior end is both truncated and peculiarly flattened. It bears some resemblance to *Truncilla donaciformis*, but this species is always a smaller shell with a pointed, not truncated, posterior end and a rounded posterior ridge. *Truncata* cannot be mistaken for any other Wisconsin shell.

This species varies with the size and general characteristics of the stream as do others already mentioned. The creek form, or small river form, is more elongated and more compressed than the form of larger rivers. The percentage of height to length being 67 to 75% while the ratio of diameter to length is 43 to 56%. In the medium sized rivers, as in the Wisconsin, Sauk Co., the diameter ratio is 60 to 70%, while the height ratio is about 85%. In the Mississippi, near Prairie du Chien, the diameter ratio is about 50% while the height ratio is 75 to 80%. In Lake Pepin the diameter ratio is 50 to 62% and the height ratio is 77 to 86%. The range of variation appears to be elongated and compressed in the small rivers, obese and shortened, with greater height, in the rivers of medium size, and then a return to compressed and lengthened in the large rivers, as the Mississippi and lower Ohio rivers. No distinct ecological forms can be clearly recognized in this variation.

Lea's *elegans* is apparently completely synonymous with *truncata*, an earlier name of Rafinesque. See Ortmann and Walker, 1922, p. 50.

TRUNCILLA TRUNCATA LACUSTRIS Var. Nov.

Plate LXXVIII, figures 1, 2

Truncilla truncata, Var. BAKER, Trans. Wis. Acad. Sci. Arts, Lett., XXI, p. 132, 1924.

TYPE LOCALITY: Long Point Island, Lake Winnebago.

WISCONSIN RECORDS: As above.

SHELL: Differing from typical *truncata* in being smaller, more compressed, with more depressed umbones, a less angular posterior ridge, the posterior face not deeply excavated and without a trace of a radial furrow in front of the ridge. The

pseudocardinal and lateral teeth are finer, more lamellar and the whole hinge much weaker; surface light brownish without distinct rays; nacre inclined to pinkish.

L. 42; H. 32; D. 20 mm. Female. Lake Winnebago (Baker, U. of W., 958). Type.

L. 38; H. 28; D. 18 mm. Male. Lake Winnebago (Baker, U. of W., 959). Paratype.

ANIMAL: Not examined. Probably same as *truncata*.

ECOLOGY: Open shore of large lake. Only dead shells found on points and shores of Long Point Island and eastern part of lake.

DISTRIBUTION IN WISCONSIN: Known only from Lake Winnebago. Possibly the form from Lake Erie, mentioned by Ortmann, may belong to *lacustris*.

REMARKS: The Winnebago Lake form of *truncata* is constantly distinguishable from the river form, the depressed umbones, rounder and less angular posterior ridge, smaller and more compressed shell being features which seem constant. The flattened shell of the Fox River above Lake Butte des Morts seems to have readily responded to the lake environment. In the lower Fox River, Brown Co., the *truncata* are small and compressed and differ from lake specimens principally in the more developed posterior ridge and more elevated umbones. In a measure they are transitional forms. The lower Fox River is wide and in many places lake-like and the development of these shells seems to be in response to this kind of an environment. These individuals, however, are more like the typical form than the lake form designated as *lacustris*.

It is possible that the smaller and lighter form mentioned by Ortmann as occurring in Lake Erie may also be referable to *lacustris*. (see 1919, p. 239).

TRUNCILLA DONACIFORMIS (Lea). Fawn's Foot

Plate LXXIX, figures 1-3

Unio donaciformis LEA, Trans. Amer. Phil. Soc., III, p. 267, pl. iv, fig. 3, 1828; Obs., I, p. 9, pl. iv, fig. 3, 1834.

Plagiola donaciformis SIMPSON, Cat., p. 308, 1914.

Unio zigzag LEA, Trans. Amer. Phil. Soc., III, p. 440, pl. xii, fig. 19, 1829; Obs., I, p. 54; pl. xii, fig. 19, 1834.

Truncilla donaciformis ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 50, 1922.

TYPE LOCALITY: Ohio for both names.

WISCONSIN RECORDS:

- 1852. *Unio nervosus* LAPHAM, p. 369. Wisconsin.
- 1860. *Unio donaciformis* LAPHAM, p. 155. Wisconsin.
- 1860. *Unio zigzag* LAPHAM, p. 156. Wisconsin River.
- 1885. *Unio donaciformis* CALL, p. 27. Wisconsin.
- 1885. *Unio zigzag* CALL, p. 56. Wisconsin.
- 1897. *Unio donaciformis* WISWALL, p. 47. Southern Wisconsin.
- 1906. *Plagiola donaciformis* CHADWICK, p. 93. Milwaukee.
- 1922a. *Amygdalonaias donaciformis* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.

SHELL: Small, ovate or elongate-ovate, inequipartite, strong but not solid; anterior end rounded; ventral margin strongly convex, curving up sharply posteriorly; dorsal margin slightly convex, gently curving with the sloping posterior end which forms a more or less sharply biangulate point; beaks full, slightly elevated above the dorsal margin; beak sculpture similar to that of *truncata*; posterior ridge well rounded, seldom angular, with a slight posterior depression, but no anterior radial furrow; epidermis greenish or yellowish with many dark green rays which are usually broken up into zigzag or arrow-head lines, often forming a very striking pattern; the growth lines are sometimes roughened on the posterior slope; the shell, "gapes" rather widely anteriorly, where the valves fail to meet.

Hinge light; pseudocardinals compressed, slightly divergent, triangular, serrated; there is frequently a vestige of a second tooth in the right valve; laterals elevated, straight, somewhat lamellar, slightly roughened; beak cavity shallow; muscle scars distinct, the anterior somewhat deeply excavated; nacre silvery white. The male shell is usually more sharply pointed than the female shell, though this distinction does not always hold true.

- L. 43; H. 28; D. 21 mm. Sauk Co. (U. of I., Z4532). Male.
- L. 33; H. 22; D. 16 mm. Illinois (U. of W., 241). Female.
- L. 45; H. 29; D. 26 mm. Kilbourn (U. of W., 960a). Male.
- L. 34; H. 23; D. 19 mm. " (" 960b). Female.
- L. 55; H. 34; D. 25 mm. Rock R., Ill. (U. of I., Z1970). Male.

ANIMAL: Not differing from *truncata* in essential details. Marsupium of female formed by 25-30 ovisacs. Glochidia very small, similar to those of *truncata*, measuring length 0.060,

height 0.063 mm. (Surber, 1912, p. 9); 0.05 by 0.06 (Ortmann, 1914, p. 67).

BREEDING SEASON: Not clear. Probably similar to *truncata*. Gravid females have been noted on the following dates: latter part of July (Surber, 1913, p. 109); Aug. 18 (Ortmann, 1919, p. 242); June 19 (Utterback, 1916a, p. 148); May and June (Utterback, 1916b, p. 3).

NATURAL HOST: Surber (1913, p. 109) found the Sheepshead (*Aplodinotus grunniens*) the almost exclusive host of this species, on the gills. It was rare on the sauger (*Stizostedion canadense*). Surber found that this species increased 7 times in length and about $3\frac{1}{2}$ times in depth during parasitic stage. It is not known whether this development is very rapid, from July glochidium to October development in the fish host, or whether it is from infection of previous summer and the development slow (Surber, p. 109).

ECOLOGY: More usual in large rivers on a sand or mud bottom in water .3-1 m. or more in depth.

GENERAL DISTRIBUTION: Western Pennsylvania west to Kansas, north to Minnesota, south to eastern Texas and Alabama.

DISTRIBUTION IN WISCONSIN: The distribution of this species seems quite erratic. It appears to be found in both large and small rivers and is common to both the Mississippi and Great Lakes drainages.

Mississippi Drainage: Pierce, Pepin, Buffalo, Trempealeau Co. (Grier).

Wisconsin Drainage: Sauk Co. (Hinkley); Kilbourn, Columbia Co. (Baker); Baraboo River, Sauk Co. (Wiswall); Wisconsin River (Lapham).

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Chadwick, Lapham); Kenosha, Kenosha Co. (Wiswall).

REMARKS: *Truncilla donaciformis* is clearly related to *truncata*, but seems quite distinguishable. It is a smaller shell, more elongated, with a rounded, not angular, posterior ridge. The color markings are distinctive and different, usually, from those of *truncata*. Shells from the Wisconsin River are very much wider than those from any other locality at hand (about 30 lots from Wisconsin to Alabama) and the color markings are not as brilliant, many shells being brownish without markings. The finest specimens seen are from the Wabash River,

Indiana (Daniels collection). The same relative variation recorded under *truncata* also occurs in *donaciformis*.

Neither *truncata* or *donaciformis* are of value as button shells, never reaching a size that would profitably make button blanks.

Genus **PLAGIOLA** (Rafinesque, 1819) Agassiz

Shell solid, surface irregularly, concentrically ridged; epidermis smoothish, but here and there wrinkled; painted with larger and smaller scattered rays, which are generally broken into irregular lunate or squarish blotches; hinge heavy and strong; hinge plate wide and flat, female shell smaller than the male, more inflated and swollen at the post basal region. Marsupium large, projecting far below the inner gills (Walker). Type: *Unio securis* Lea (= *Obliquaria lineolata* Raf.).

PLAGIOLA LINEOLATA Raf. Butterfly

Plate LXXIX, figures 4-8

Obliquaria (Plagiola) depressa RAF., An. Gen. Sci. Phys., Brux, V, p. 302, pl. 81, figs. 5-7, 1820.

Obliquaria (Plagiola) lineolata RAF., Op. Cit., p. 303, 1820.

Obliquaria (Ellipsaria) ellipsaria RAF., Op. Cit., p. 303, 1820.

Unio securis LEA, Trans. Amer. Phil. Soc., II, p. 437, pl. xi, fig. 17, 1829; Obs., I, p. 51, pl. xi, fig. 17, 1834.

Plagiola securis SIMPSON, Cat., p. 304, 1914.

Plagiola lineolata ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 51, 1922.

TYPE LOCALITY: Falls of the Ohio, at Louisville, Ky. (*lineolata*); Evansville, Ind. (*depressa*); Kentucky River (*ellipsaria*); Ohio (*securis*).

WISCONSIN RECORDS:

1897. *Unio securis* WISWALL, p. 47. Southern Wisconsin.

1885. *Unio securis* CALL, p. 48. Wisconsin.

1905c. *Plagiola securis* BAKER, p. 254. Prairie du Chien.

1906. *Plagiola securis* CHADWICK, p. 93. Between Prairie du Chien and De Soto.

1922a. *Plagiola lineolata* GRIER, 11-31. Pierce, Buffalo, Trempealeau Co.

SHELL: *Plagiola* is a monotypic genus and the generic description is practically sufficient to identify this peculiar species. The sharp posterior ridge, peculiarly painted epidermis,

squarish or elongated spots, compressed shell, wide interdentum of hinge plate, and very low umbones are characteristics that will readily identify this beautiful species.

- L. 65; H. 50; D. 20 mm. Prairie du Chien (Dudley). Male.
L. 47; H. 34; D. 16 mm. Wisconsin River (U. of W., 67). Male.
L. 51; H. 40; D. 24 mm. Kaskaskia River (U. of I., Z4492). Female.
L. 100; H. 75; D. 45 mm. " " (" Z4492). Male.

ANIMAL: Resembling *Truncilla* in form and general anatomy. Anal and supra-anal openings with medium sized mantle connection; branchial opening small with many papillae; anal opening crenulated; palpi large, the posterior margins connected for one-fourth their length; in the female the inner edge of the mantle in front of the branchial opening is lamellar with fine teeth, but not papillose; inner laminae of inner gills attached to the abdominal sac for only about a quarter of their length. Marsupium usually filling the posterior half of the outer gills, the ovisacs, which are compressed and lanceolate, very numerous (about 30), the placentae not well formed. Color whitish, edge of mantle black, especially on the siphonal openings. The gills are sometimes brownish and the general color flesh or tan.

Glochidia (pl. XXXII, fig. 13) large, semielliptical, ventral margin rounded, hinge line short, almost straight, anterior and posterior margins distinctly gaping. Length 0.230, height 0.330 mm. (Surber, 1912, p. 9); 0.26 by 0.35 mm. (Ortmann, 1919, p. 245); 0.23 by 0.31 mm. (Lefevre and Curtis, 1910, p. 97. These measurements indicate some degree of variation.

BREEDING SEASON: Bradytictic. Gravid August to June or July (Ortmann, 1919, p. 245). Interim includes part of July and August.

NATURAL HOST: On gills of *Aplodinotus grunniens*, Sheepshead. One glochidium found on sunfish (*Apomotis cyanellus*) in 1912. No development indicated (Surber, 1913, p. 110).

ECOLOGY: A species of larger rivers. Found on sand, gravel, and mud bottom, especially bars. Call (1190, p. 471) says that it buries itself deeply in sand bars. In the Mississippi River it occurs on sand, gravel, and mud bottom in water .6–2 m. or more feet deep.

GENERAL DISTRIBUTION: Western Pennsylvania west to Iowa, north to Minnesota, south to Kansas, Oklahoma, and Alabama.

DISTRIBUTION IN WISCONSIN: Apparently largely confined to the Mississippi River. It probably ascends the Wisconsin River for some distance but no definite records are at hand. A specimen in the Marston collection is labelled Wisconsin River, without other location. Its apparent absence from Lake Pepin is interesting.

REMARKS: *Plagiola lineolata* is easily distinguished among Wisconsin naiades. The female shell is smaller than that of the male, and is more inflated, reducing the sharpness of the posterior ridge. (Compare figures 4 and 8 on pl. LXXIX). Young and half-grown shells are very brightly colored, with yellowish surface covered with dark green or black rays, broken into squarish, elongated, or arrow-head-shaped spots and dashes. In old specimens, however, the shell becomes dark brown, the markings are obliterated, and the posterior end becomes elongated and plow-shaped. Lea's familiar name *securis* must give way to the earlier one of Rafinesque, as indicated many years ago by Conrad, and more recently by Ortmann & Walker (1922, p. 51).

The butterfly is considered a valuable button shell, having a white color and good luster. The males are the best shells, having better luster and not too thick a shell. The shells are not numerous enough to be obtained in large quantities and a lot of 100 pounds is considered a good catch, and when mixed with other shells adds much value.

Genus LEPTODEA Rafinesque, 1820

Shell large, thin, elliptical or slightly obovate, more or less compressed, winged on the dorsal margin; beaks low; epidermis rather smooth, often feebly rayed, dull colored, but usually glossy; teeth compressed, pseudocardinals but feebly and often imperfectly developed; nacre purplish. Male and female shells nearly alike, the latter slightly swollen at post-basal region.

Marsupium kidney-shaped, swollen, consisting of many ovisacs occupying the posterior part of the outer gill; mantle edge of female slightly lamellar in front of the branchial opening,

with crenulations, but not with papillae. Glochidia very small, of suboval shape. Type: *Unio (Leptodea) fragilis* Raf. *Paraptera* of Ortmann (1911, p. 368), having the same type, becomes a synonym of *Leptodea*. (Walker).

LEPTODEA FRAGILIS Raf. Fragile Paper Shell

Plate LXXX, figures 1-4

Unio (Leptodea) fragilis RAF., An. Gen. Sci. Phys., Brux., V, p. 295, 1820.

Unio gracilis BARNES, Amer. Jour. Sci., VI, p. 274, 1823.

Lampsilis gracilis SIMPSON, Cat., p. 181, 1914.

Leptodea fragilis ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 53, 1922.

Unio planus BARNES, Op. Cit., p. 272, fig. 16, 1823.

TYPE LOCALITY: Ohio River (*fragilis*); Wisconsin River and "The Lakes" (*gracilis*); Wisconsin River (*planus*).

WISCONSIN RECORDS:

1823. *Unio gracilis* BARNES, p. 274. Wisconsin River and The Lakes.

1823. *Unio planus* BARNES, p. 272. Wisconsin River.

1830. *Symphynota gracilis* LEA, p. 452. Wisconsin.

1836. *Unio fragilis* CONRAD, p. 53. Fox River.

1852. *Metaptera fragilis* LAPHAM, p. 369. Wisconsin.

1852. *Unio fragilis* var. *fragilis* JAY, p. 59. Fox River.

1852. *Unio leptodon* var. *planus* JAY, p. 61. Wisconsin.

1860. *Unio gracilis* LAPHAM, p. 155. Milwaukee.(?)

1897. *Unio gracilis* WISWALL, p. 48. Southern Wisconsin.

1904c. *Lampsilis gracilis* BAKER, p. 103. Kilbourn.

1905c. *Lampsilis gracilis* BAKER, p. 253. Prairie du Chien.

1906. *Lampsilis gracilis* CHADWICK, p. 93. Milwaukee?

1914. *Lampsilis gracilis* SIMPSON, p. 182. Wisconsin River and the lakes.

1919. *Paraptera fragilis* ORTMANN, p. 252. Wisconsin.

1922a. *Leptodea fragilis* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.

1922b. *Paraptera fragilis* BAKER, p. 131. Omro, Fox River.

1924. *Leptodea fragilis* BAKER, p. 132. Omro and other places on Fox River.

1926. *Leptodea fragilis* GRIER and MUELLER, p. 17. Lake Pepin and upper Mississippi River.

SHELL: Large, usually thin and brittle, subovate or subelliptical; anterior end rounded, ventral margin broadly convex, curved upward into the obliquely truncated posterior margin; dorsal margin straight, forming a slight wing anteriorly and a marked, more or less symphynote wing posteriorly; this wing

becomes more or less obliterated in old shells; posterior ridge almost obliterated, the valves compressed posteriorly, and when the wing is developed even excavated below the wing; beaks but slightly elevated above the dorsal margin; beak sculpture faintly developed, consisting of 3–4 bars of which the first is almost concentric, the others double looped, the posterior loop only being distinct; epidermis smooth, surface marked by concentric growth lines at rest periods; color yellowish or pale greenish yellow, or light brownish; rayed or rayless, the rays when present being straight, wide or narrow, sometimes ill defined and confined to different parts of the shell; yellow, rayless shells are common.

Pseudocardinals small, compressed, parallel with the hinge line, more or less lamellar, two in left and one in right valve; laterals long, thin, compressed, the lower one in the left valve frequently feebly developed; no interdentum; beak cavity shallow; dorsal muscle scars forming an oblique row in beak cavity; anterior adductor scar well impressed; posterior scar less so; nacre silvery white with pink suffusion in posterior part of valve; frequently the whole interior pinkish.

The female shell has an expanded post-basal region which is absent in the male shell; the greatest height of the male shell is near the middle while in the female shell it is near the posterior end.

L. 148; H. 93; D. 43 mm.	Baraboo River (Dudley).	Male.
L. 110; H. 72; D. 37 mm.	Prairie du Chien (Dudley).	Male.
L. 100; H. 67; D. 35 mm.	Omro (U. of W., 961a).	Male.
L. 84; H. 58; D. 28 mm.	" (" 961b).	Female.
L. 136; H. 83; D. 42 mm.	Kilbourn (U. of W., 962a).	Male.
L. 40; H. 26; D. 10 mm.	" (" 962b).	Juv.
L. 24; H. 15; D. 6 mm.	" (" 962c).	Juv.

ANIMAL (See fig. 235): In all respects like that of *Prop-tera alata*, excepting that the mantle-connection between anal and supra-anal is somewhat longer than the anal opening, hence longer than in *alata*. The marsupium occupies the posterior part of the outer gill, the ovisacs are 30–40 in number and lanceolate in form.

Glochidia (pl. XXXII, fig. 12) distributed throughout the placental mass, very small, suboval in shape. Length 0.08, height 0.09 mm. (Ortmann); 0.070 by 0.095 (Surber).

BREEDING SEASON: Bradytictic. From end of August to about middle of July (Ortmann). Surber found glochidia in July and August, showing that the seasons overlap in August. Gravid in Fox River and Wisconsin River in July and August.

NATURAL HOST: Not recorded.

ECOLOGY: Omro, Fox River, in .3-.6 m. of water, on sandy mud bottom; Kilbourn, in water 1-2 m. deep, on a sand and mud bottom, in a rapid current. The same habitat in the Mississippi River. Ortmann found the species chiefly in riffles in Pennsylvania.

GENERAL DISTRIBUTION: Eastern New York and the Ottawa River west to Iowa and Kansas, north to Red River of the North, and south to Texas, Mississippi, and Alabama. A very wide geographic range.

DISTRIBUTION IN WISCONSIN: *Fragilis* is confined to the Mississippi, Wisconsin, and Fox rivers. The Fox River extension was probably by way of the old Post-glacial connection at Portage.

REMARKS: *Leptodea fragilis* is a common shell in parts of Wisconsin. Its thin, fragile valves, subovate outline, weak hinge, and yellowish color will easily distinguish it from other Wisconsin naiades. Young shells somewhat resemble *Proptera alata*, but in that species the posterior wing is elevated higher above the posterior ridge, the shell is shorter, has a greater diameter, and is usually greenish in color. In older shells the color of the nacre of *alata* will at once distinguish it, as well as the difference in the wing, hinge teeth, etc. Lapham (op. cit.) has listed this species from Milwaukee, but Chadwick (1906, p. 93) doubts the citation, as no specimens could be found in the river or vicinity. It is possible that specimens of *alata*, which occur in the Milwaukee River, have been mistaken for *gracilis* (*fragilis*). It cannot be admitted as inhabiting the small Lake Michigan streams until authentic specimens have been found.

Fragilis exhibits to some degree the law of variation coincident with stream size. The form as found in the creeks and small streams is small, about 100 mm. in length, and is flattened somewhat on the valves. In the larger rivers of medium size, as the Wisconsin, Rock, Illinois, the form increases greatly in size (length 145 mm.) and the shell is more inflated. In the Mississippi River, the form is again somewhat smaller. The

largest and finest specimens occur in the Wisconsin and Baraboo rivers in Sauk Co., in Wisconsin, and in the lower Rock River in Illinois. The thin shell renders this species of no commercial value as a button shell.

Ortmann (1919, p. 252) states that *fragilis* avoids small rivers and creeks. While this may be true for Pennsylvania, it is decidedly not the case in Wisconsin and Illinois, the form being abundant in the Fox River in Wisconsin and in the small rivers of southern Illinois.

LEPTODEA FRAGILIS LACUSTRIS Baker. Paper Shell

Plate LXXX, figures 5-7; plate LXXXI, figures 1, 2

Paraptera gracilis lacustris BAKER, Nautilus, XXXV, p. 131, 1922.

TYPE LOCALITY: Lake Butte des Morts, off Plummers Point.

WISCONSIN RECORDS:

1906. *Lampsilis gracilis* CHADWICK, p. 93. Winnebago Lake, near High Cliff, Calumet Co.; Menasha, N. Branch Fox River.

1922b. *Paraptera gracilis lacustris* BAKER, p. 131. Lake Butte des Morts.

1924. *Leptodea fragilis lacustris* BAKER, p. 132. Lakes Winnebago and Butte des Morts.

SHELL: Differing from *fragilis* in being somewhat rounder, higher in proportion to length, the dorsal margin more strikingly alate in immature males, shell more compressed, color straw-yellow with few or no radiating lines, and rest periods distinctly marked and equally spaced. Other characters as in *fragilis*.

L. 100; H. 60; D. 29 mm. Male. Doemel Pt. (Baker, U. of W., 963).

L. 94; H. 61; D. 30 mm. Male. Lake Butte des Morts (U. of W., 964a). Type.

L. 70; H. 48; D. 24 mm. Female. Lake Butte Des Morts (U. of W., 964b). Type.

L. 90; H. 55; D. 33 mm. Male. Lake Butte des Morts (U. of W., 964c). Paratype.

L. 84; H. 59; D. 25 mm. Male. Lake Butte des Morts (U. of W., 964d). Paratype.

L. 52; H. 35; D. 16 mm. Female. Lake Butte des Morts (U. of W., 964e). Paratype.

L. 35; H. 21; D. 11 mm. Juv. Off Roe Pt. (U. of W., 965a).

L. 15; H. 10; D. 5 mm. Juv. " " (" 965b).

ANIMAL (Fig. 235): As in *fragilis*. Mantle connection between anal and supra-anal openings longer than anal and longer

than in *fragilis*. Color yellowish white, mantle pearly white, openings edged with brown. Marsupium with 35-39 ovisacs, forming a thick pad. Glochidia of same form as *fragilis*. Length 0.07, height 0.09 mm.

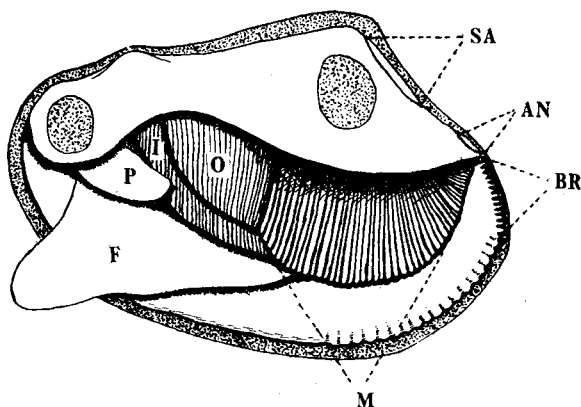


Fig. 235. *Leptodea fragilis lacustris* Baker. Doemel Point, Lake Winnebago. Gravid female. July 1, 1920. Type.

BREEDING SEASON: Probably same as *fragilis*. Gravid females collected on July 1 and July 24.

NATURAL HOST: Unknown.

ECOLOGY: Plummers Point, Lake Butte des Morts, gravel bottom, water one foot deep; Lake Winnebago at the following places: Lower Asylum Bay, gravel and stony bottom, water .3-1 m. deep; south of Roe Point, sand with boulders, water .3-.6 m. deep; cove below Stony Point, sand bottom, water .3-.6 m. deep; off Stony Point, gravel and cobble bottom, water 2.5-3 m. deep.

GENERAL DISTRIBUTION: The Lake Erie *fragilis* referred to by Ortmann (1919, p. 249) may be referable to this race, though it approaches closely to the river form of the west. Lake St. Clair, Michigan, specimens are *lacustris* (coll. Frank Smith).

DISTRIBUTION IN WISCONSIN: At present known only from Lakes Winnebago and Butte des Morts. Collected at the following places: Plummers Point, Lake Butte des Morts (type locality); Long Point Island, Doemel Point, Miller Bay,

Asylum Point, Lower Asylum Bay, Fahney Bay, Mansur Point, Roe Point, off Stony Beach, and near Oshkosh, Winnebago Lake (Baker); near High Cliff, Calumet Co.; North branch Fox River, at Menasha, Winnebago Co. (Chadwick). Probably inhabits all of Winnebago Lake and a large part of Lake Butte des Morts.

REMARKS: As in *Proptera* and *Lampsilis*, the lake environment has produced a shell somewhat different from typical *fragilis* of the rivers. The Lake Winnebago and Butte des Morts shells are constantly separable from the *fragilis* of the Fox River at Omro and other places. It is always smaller, the *lacustris* being but two-thirds the size of the *fragilis* in the Wisconsin and Baraboo rivers, as well as of the Mississippi River. *Lacustris* is more compressed and the males have a much larger and particularly symphynote posterior wing. The females are smaller than those of *fragilis* and have a more marked post-basal extension. The rest period marks are almost metamERICALLY placed. There is some variation in the elongation of the shell, old males becoming lengthened and losing the symphynote wing to a large degree.

Lacustris is an abundant mussel in the two lakes mentioned. In many places on the shores of Lake Winnebago, as at Long Point Island, Doemel Point, and in Asylum Bay, the beach debris is largely made up of the shells of this naiad. Males outnumber females about five to one. As in other cases, this variety is a striking example of the effect of a change of environment from a river to a lake habitat.

LEPTODEA LEPTODON Raf.

Plate LXXXV, figures 5-7

Unio (leptodea) leptodon RAF., An. Gen. Sci. Phys., Brux., V, p. 295, pl. 80, figs. 5-7, 1820.

Unio velum SAY, New Harm. Dissem., II, p. 293, Sept. 23, 1829.

Symphynota tenuissima LEA, Trans. Amer. Phil. Soc., III, p. 453, pl. xi, fig. 21, 1829; Obs., I, p. 67, pl. xi, fig. 21, 1834.

Lampsilis leptodon SIMPSON, Cat., p. 188, 1914.

Leptodea leptodon ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 52, 1922.

TYPE LOCALITY: Lower Ohio River (*leptodon*); Kentucky River (*velum*); Ohio (*tenuissima*).

WISCONSIN RECORDS:

1852. *Alasmodonta leptodon* LAPHAM, p. 370. Wisconsin.

1836. *Unio leptodon* CONRAD, p. 58. Wisconsin.

1860. *Unio tenuissimus* LAPHAM, p. 156. Milwaukee?

SHELL: Long-ovate, greatly inequipartite, compressed, usually thin; anterior end rounded; posterior end bluntly pointed; dorsal margin straight, ventral margin slightly convex; posterior ridge rounded, not conspicuous; young shells slightly winged, the wing disappearing in older shells; valves gaping at both ends, especially at the posterior base; beaks compressed, small, inconspicuous, their sculpture consisting of 4-5 very fine doubly-looped ridges; surface with heavy, almost sulcate growth lines; epidermis not shining, greenish or olive green with many wide, faint, green rays.

Pseudocardinals reduced to a low, inconspicuous tubercle under or a little in front of the beaks; this varies in development; two faintly marked laterals in the left valve, a single stronger lateral in the right valve; these are long and lamellar; beak cavity very shallow, containing a row of large, irregular, well marked dorsal scars; adductor muscle scars large, well marked; nacre purplish or salmon colored, area outside the well marked pallial line highly iridescent; sex differences slight, the female having a slightly rounder base, the posterior pointed end being higher than in the male.

L. 90; H. 44; D. 26 mm. Duck R., Tenn. (U. of I., Z4391).

L. 58; H. 28; D. 13 mm. New Boston, Ill. (U. of I., Z4399).

ANIMAL: Not examined. Recorded as similar to that of *fragilis*.

BREEDING SEASON: Probably Bradyctic.

ECOLOGY: Call states that "it is found in muddy bottoms in the Ohio and Wabash rivers" (1900, p. 463).

GENERAL DISTRIBUTION: Upper Mississippi River drainage and south to the Tennessee River; Buffalo, N. Y.; southern Michigan: Souris River, Manitoba (Simpson).

DISTRIBUTION IN WISCONSIN: In this State known only from the Mississippi River near McGregor, Iowa. No actual records are known from Wisconsin waters, but its presence on the Iowa shore is conclusive evidence that it also lives on the Wisconsin shore between the Wisconsin River and the Illinois line.

REMARKS: *Leptodon* may be known by its thin, elongate-ovate shell, which is always twisted to right or left when viewed from above or below. The shell also gapes at both ends, an unusual condition in a naiad. The pseudocardinals, also, are reduced to mere rudiments and the laterals are feebly developed.

This is apparently a rare species in most places. It occurs on the Illinois shore of the Mississippi at Savanna, Carrol Co., and will in all probability be found on the Wisconsin shore to the north of this locality. Lapham's record "Milwaukee" has never been substantiated and it is very doubtful that this species should be found in the southeastern part of Wisconsin, as it is absolutely unknown in northeastern Illinois. (= *tenuissimus* of Lapham's list). Just what species could have been mistaken for *leptodon* is not clear.

Genus PROPTERA Rafinesque, 1819

Shell usually large, gaping at anterior edge and edge of dorsal slope, winged along the dorsal region when young and often when adult; beak sculpture feeble, consisting, when developed, of an anterior and posterior loop, the former often wanting; epidermis generally brown, often cloth-like when fresh, rayless or feebly rayed; teeth rather compressed, pseudocardinals frequently imperfect or nearly wanting; laterals remote. Marsupium kidney-shaped, consisting of numerous ovisacs occupying the posterior part of the outer gill; edge of mantle in female slightly lamellar in front of the branchial opening with granulations, but without papillae. Glochidia celt-shaped, with two spines, one at each end of the ventral corners (Walker). Type: *Unio alatus* Say.

PROPTERA ALATA (Say). Pink Heel-Splitter

Plate LXXXI, figures 3-6

Unio alatus SAY, Nich. Encyc., II, pl. iv, fig. 2, 1817.

Lampsilis alata SIMPSON, Cat. p. 102, 1914 (part).

Proptera alata ORTMANN, Mem. Carnegie Mus., VIII, p. 252, 1919 (part).

TYPE LOCALITY: Lake Erie.

WISCONSIN RECORDS:

1906. *Lampsilis alata* CHADWICK, p. 92. Winnebago Lake at Menasha and west of High Cliff, Calumet Co.

1924. *Proptera alata* BAKER, p. 132. Lakes Winnebago and Butte des Morts.

SHELL: Of medium size, rather thick, subovate, roughly subtriangular; anterior end sharply rounded; ventral margin slightly convex; dorsal margin straight, strongly alate or symphynote posteriorly; posterior margin obliquely truncated, meeting the dorsal wing at a sharp angle, but rounding into the ventral margin; the alate border is sometimes slightly concave; region of the posterior ridge rounded, with one or two elevated, radiating lines, mostly feeble in young shells and sometimes absent in old shells; valves more or less compressed, somewhat flattened on the sides; beaks but little elevated above the hinge line; beak sculpture consisting of 3-4 fine bars, the first subconcentric, the rest double looped, with sometimes indications of a fifth loop; the anterior loop varies in distinctness, being fully formed in some individuals and feebly indicated in others; epidermis dark brownish-green in young specimens, becoming brownish or black in old specimens; young specimens are usually rayed, the rays being more or less distinct, straight, and better developed on the posterior end; in old individuals the rays disappear and the surface becomes roughened by elevated growth lines; rest periods are conspicuously marked.

Pseudocardinals strong, flatly triangular, subparallel with the hinge line, serrated, two in left, one in right valve; there may be a second anterior tooth in the right valve; laterals long, almost straight, thin or lamellar; no interdentum; beak cavity shallow, containing dorsal muscle scars in an almost straight row; adductor muscle scars well marked; nacre pearly white suffused with pink in young shells, always purple, rose, or salmon in adult and well grown shells, iridescent posteriorly.

Differences in the shell due to sex fairly distinguishable; the female is more broadly rounded in the post-basal region and is also more swollen in front of the posterior ridge; the female does not reach the dimensions of the male.

L. 103; H. 71; D. 36 mm.	Lower Asylum Bay (U. of W., 966).	Male.
L. 92; H. 64; D. 30 mm.	Long Point Island (U. of W., 967a).	Male.
L. 68; H. 56; D. 25 mm.	" " " (" 967b).	Female.
L. 50; H. 42; D. 15 mm.	" " " (" 967c).	Juv.
L. 88; H. 65; D. 31 mm.	" " " (" 967d).	Male.
L. 76; H. 61; D. 33 mm.	" " " (" 967e).	Female.

ANIMAL: As in the river form (which see). Glochidia not examined.

BREEDING SEASON: Not clearly observed for the lake shells. Ortmann found discharged females in May and early July. The beginning of the breeding season has not been observed in the lake shells. No gravid shells seen in Lake Winnebago.

NATURAL HOST: Unknown.

ECOLOGY: *Alata* is found on open shores where it receives the full force of the waves. It is most abundant in from .3–.6 m. of water and on a gravel or rocky bottom. Ortmann (1919, p. 256) says that the Lake Erie *alata* is found in the sand of the north shore of Presque Isle Bay, in from two to three feet of water, and seems to prefer the open shores (not covered and fringed with rushes). This is about the same as the Lake Winnebago habitats, excepting that the shores are rocky.

GENERAL DISTRIBUTION: At present known from Lake Erie, Lake St. Clair, and Lake Winnebago.

DISTRIBUTION IN WISCONSIN: Common in most parts of Lake Winnebago (Baker); Menasha and west of High Cliff, Calumet Co. (Chadwick).

REMARKS: Although subject to some variation in outline, diameter, and wing expansion, *alata* may easily be known by its strongly alate posterior wing and its rich purple nacre. Female shells are smaller and more obese than male shells, and when this feature is exaggerated it strongly suggests *Proptera purpurata*. Flat forms (males) resemble *Lasmigona complanata*, but, of course, differ in the structure of the hinge. The male shells may be much rounded post-basally. The female shells vary in diameter, in some examples being evenly swollen over the center of the disk, while others have a large central swelling. The symphynote wing also varies, being most largely developed in young shells, and almost disappearing in old shells, appearing almost as if broken off.

Say's shells came from Lake Erie and are the small form characteristic of lakes. They differ from the large river form in being smaller, slightly more swollen on the average, of a darker brown, the nacre is lighter, and the resting stage marks are more evenly marked, especially in the Winnebago Lake shells, though this feature is said by Ortmann not to be so well marked in Lake Erie shells. There is less variation among the lake shells than among the river shells. That the shells of Lake Erie should be duplicated in Lake Winnebago is another

interesting case of distribution observed among the naiads in this lake.

PROPTERA ALATA MEGAPTERA (RAF.). Pink Heel-Splitter

Plate LXXXII, figures 1-4

Metaptera megaptera RAF., An. Gen. Sci. Phys., Brux., V, p. 300, pl. 80, fig. 20-22, 1820.

Proptera alata ORTMANN, Mem. Carnegie Mus., VIII, p. 252, 1919 (part).

Lampsilis alata SIMPSON, Cat., p. 162, 1914 (part).

TYPE LOCALITY: Ohio River.

WISCONSIN RECORDS:

- 1823. *Unio alatus* BARNES, p. 260. Fox River.
- 1836. *Unio alatus* CONRAD, p. 56. Wisconsin.
- 1852. *Unio alatus* JAY, p. 54. Fox River.
- 1853. *Metaptera alata* LAPHAM, p. 369. Wisconsin.
- 1860. *Unio alatus* LAPHAM, p. 155. Milwaukee.
- 1897. *Unio alatus* WISWALL, p. 47. Southern Wisconsin.
- 1904c. *Lampsilis alata* BAKER, p. 103. Kilbourn.
- 1905c. *Lampsilis alata* BAKER, p. 253. Prairie du Chien.
- 1906. *Lampsilis alata* CHADWICK, p. 92. Two Rivers, Manitowoc Co.; Milwaukee River; between Prairie du Chien and De Soto.
- 1914. *Lampsilis alata* WILSON and DANGLADE, p. 20. Lake Pepin.
- 1922a. *Proptera alata* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.
- 1924. *Proptera alata megaptera* BAKER, p. 132. Fox River.
- 1926. *Proptera alata* GRIER and MUELLER, p. 18. Lake Pepin and Mississippi River.
- 1927d. *Proptera alata megaptera* BAKER, p. 107. Rock River, Ashipun and Rock Co.

SHELL: Differing from *alata* in being larger, a little less inflated on the average, with a lighter brown or black epidermis, a darker nacre, and a heavier hinge structure. The female shell is more elongated and not as much produced in the post-basal region.

- L. 189; H. 132; D. 61 mm. Baraboo River (Dudley). Male.
- L. 125; H. 97; D. 42 mm. " " (U. of W., 202). Male.
- L. 132; H. 87; D. 36 mm. Prairie du Chien (U. of W., 968). Male.
- L. 118; H. 94; D. 45 mm. Lake Pepin (U. of W., 345b). Male.
- L. 110; H. 80; D. 47 mm. Princeton (U. of W., 969a). Female.
- L. 98; H. 75; D. 45 mm. " (" 969b). Female.
- L. 74; H. 54; D. 26 mm. Omro (U. of W., 970). Male.
- L. 100; H. 76; D. 37 mm. Racine (U. of W., 73). Female.

ANIMAL: (Fig. 236): Supra-anal opening large (over twice as long as anal), separated from anal by a short mantle connection; branchial opening large, somewhat tubular, curved upward, with many papillae; anal opening small, somewhat tubular, smooth; palpi large, width and length about equal, the bases attached for about half their length; inner laminae of inner gills completely connected with abdominal sac. Marsupium large, filling the posterior half of the outer gill; ovisacs large, extending somewhat beyond the margin of the sterile gill; the gravid marsupium is crenulated; placentae large, the ova and glochidia scattered throughout. Color generally flesh color, mantle edges blackish.

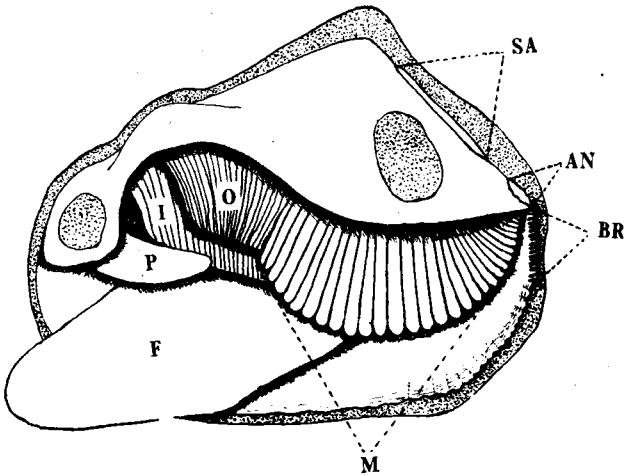


Fig. 236. *Proptera alata megaptera* Raf. Omro, Fox River. Gravid female. Aug. 3, 1920.

Glochidia (pl. XXXII fig. 14; pl. LXII, figs. 6, 7) of axe-head type, large, with two spines on each shell, at the ventral angles of the valve. Length 0.23, height, 0.41 mm. (Lefevre and Curtis); 0.20 by 0.38 mm. (Ortmann); 0.22 by 0.38 mm. (Surber).

BREEDING SEASON: Bradyctictic, August to June. The breeding season appears to overlap in June and July, discharging mussels being observed in July. It probably breeds all the year round (Ortmann, for Ohio form). Gravid specimens observed in Fox River, Omro, Aug. 30, 1920.

NATURAL HOST: Not recorded.

ECOLOGY: *Megaptera* is an inhabitant of rivers of fair size. In those rivers like the Mississippi and Wisconsin it attains

large dimensions, but is usually smaller in the smaller rivers, as the Fox. Usually found in places where the current is strong. At Omro it was collected from a sand and mud bottom in water a few cm. to .6 m. deep. In the Wisconsin River, at Kilbourn, it was found on a sandy or mud bottom in 2 m. of water, in strong current (4-6 miles per hour). Pearse dredged it from 8 meters in Lake Pepin. Reported on riffles on coarse gravel in several places (Ortmann, 1919, p. 256), but not found in this kind of a habitat in Wisconsin.

GENERAL DISTRIBUTION: Widely distributed in the Ohio and Mississippi valleys. Its range extends from Eastern New York and Ottawa west to eastern Kansas, north to Red River of the North, and south to Tennessee and Northern Alabama.

DISTRIBUTION IN WISCONSIN: *Megaptera* is a wide-spread species in the Mississippi, Wisconsin, and Fox rivers. The old Post-glacial connection at Portage opened the way for its migration into the Fox River. It is common in the lower part of the Rock River and has entered several Lake Michigan drainage rivers, possibly by way of the old Lake Chicago of Pleistocene days.

REMARKS: In this case, the principal form of the species, the river variety, becomes the variety by law of priority, Say's name for the lake form having been given three years earlier. The river shells vary more than the lake shells, this variation being in the length and development of the posterior end, which may be greatly bent downward even in male shells. Old shells become almost oval in shape and the wing is reduced to a very small size. The only shell likely to be confused with *megaptera* is *Lasmigona complanata*, which has an entirely different kind of hinge.

The river form of *alata* passes through the same variation as that recorded for *Leptodea gracilis*. The largest and finest specimens observed came from the Baraboo River, a male shell measuring 185 mm. in length. Mississippi River shells are somewhat smaller than those from the Wisconsin and Rock rivers.

This mussel is subject to infestation by parasitic worms, and pin-head pearls, blisters, and other growths and malformations are frequent. The pink heel-splitter is of no value to the button manufacturers on account of its purple color. It is used, however, for the production of novelties in pearl.

PROPTERA LAEVISSIMA (Lea). Fragile Heel-Splitter

Plate LXXXIII, figures 1-3

Symphynota laevisissima LEA, Trans. Amer. Phil. Soc., III, p. 444, pl. xiii, fig. 23, 1830; Obs., I, p. 58, pl. xiii, fig. 23, 1834.*Lampsilis laevisissima* SIMPSON, Cat., p. 183, 1914.

TYPE LOCALITY: Ohio.

WISCONSIN RECORDS:1922a. *Proptera laevisissima* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.1921. *Lampsilis laevisissima* SHIMEK. McGregor, Mississippi R.

SHELL: Elliptical in outline, wider posteriorly, thin, compressed ventrally, inflated near the umbones, with a high, triangular, thin posterior wing, often turned to one side, and a small anterior wing; the valves gape at both ends, markedly posteriorly; beaks compressed, flattened, not raised above the hinge line, marked with several small, nodulous, slightly looped, broken ridges; anterior and posterior ends of shell rounded, ventral margin convex, dorsal margin straight, exclusive of the wings; posterior ridge rounded; surface with irregular growth lines which are usually raised into ridges at rest periods, the whole surface often sculptured with delicate, radiating, impressed lines; epidermis olive-green or yellowish-green, yellowish near the beaks, polished; some specimens show fine rays.

Pseudocardinals feeble, thin, somewhat lamellar, diagonal to the dorsal margin, slightly roughened, one or two in each valve; laterals well marked, long, thin, elevated, somewhat truncated at end; no interdentum; beak cavities shallow, containing row of dorsal muscle scars. Adductor muscle scars not deeply marked; nacre rich mauve, lighter in young shells. Sexual differences in shell slight, the female being a trifle fuller along the base than in the male.

L. 96; H. 62; D. 25 mm. Below Lake Pepin (U. of I., Z14026).

L. 120; H. 83; D. 36 mm. Wabash River. (U. of I., Z4395).

L. 46; H. 30; D. 13 mm. Meredosia, Ill. (U. of I., Z4396).

ANIMAL: Similar to *P. alata megaptera*, especially the short mantle connection between anal and supra-anal openings; anal and branchial openings tubular in form, directed away from each other.

Glochidia (pl. XXXII, fig. 16) axe-head type, small, without ventral spines; ventral border broad, convex. Length 0.100, height, 0.155 mm. (Surber, 1912, p. 9); 0.12 by 0.18 (Ortmann, 1912a, p. 334).

BREEDING SEASON: Bradytictic: Surber records specimens as gravid in April, June, and September (1912, p. 7).

NATURAL HOST: Sheepshead (*Aplodinotus grunniens*), 112 to 850 glochidia being found on gills of a single specimen; Crappie (*Pomoxis annularis*), 112 to 210 found on gills of one fish (Surber, 1913, p. 107; see also for peculiar metamorphosis in which glochidial shell remains as saddle on post-glochidial shell).

ECOLOGY: In large rivers associated with *Proptera alata megaptera*, on sand and mud bottoms in good current, water 1-2 m. or more in depth. Common on sand bars (Grier).

GENERAL DISTRIBUTION: "Mississippi drainage generally; eastern Texas; southern Michigan; western New York (Simpson). It is recorded in the following state lists: Western New York (Letson); Ohio (Sterki); So. Michigan (Walker); Indiana (Call); Illinois (Baker); Arkansas (Call); Missouri (Utterback); Texas (Singley).

DISTRIBUTION IN WISCONSIN: Known only from the Mississippi River, where it extends northward into the St. Croix River.

REMARKS: *Proptera laevissima* greatly resembles *Leptodea fragilis*, from which it may be distinguished by its less elongate shell, more polished surface, feeble radial sculpture, and, usually, the greater development of the wings, there being no anterior wing in *fragilis*. The glochidia differ widely. In juvenile individuals (fig. 1) the beaks are placed between two strongly developed wings, and this condition may be retained in fully mature specimens. There is little variation in form, the color varying from light olive to greenish-brown. Females are not usually as alate as males. This species is apparently not common in Wisconsin, but in Illinois it is fairly common in many streams.

PROPTERA CAPAX (Green). Fat Pocketbook

Plate LXXXIV, figures 1-4

Unio capax GREEN, Cab. Nat. Hist., II, p. 290, 1832.

Symphynota globosa LEA, Trans. Amer. Phil. Soc., V, p. 41, pl. iv, fig. 12, 1832; Obs., I, p. 153, pl. iv, fig. 12, 1834.

Lampsilis capax SIMPSON, Cat., p. 47, 1914.

TYPE LOCALITY: Falls of St. Anthony; Bayou Teche (*capax*); Ohio River, 150 miles below Louisville (*globosa*).

WISCONSIN RECORDS: None.

SHELL: Greatly inflated, obovate, subsolid, gaping at both ends; anterior end sharply rounded; much less in height than the broadly rounded posterior end; dorsal margin curved; ventral margin straight, curving sharply into the ends; umbones elevated, much inflated, the beak sculpture of a few faint, oblique ridges; posterior ridge full, rounded, with a flattened or excavated area posteriorly; anteriorly the shell is distinctly alate; ligament long, passing forward under the beaks and forming a long lunule; surface smooth and more or less shining; epidermis yellowish or reddish-brown, sometimes olive, more or less smoky, rayless; rest marks often very distinct.

Hinge line with a double curve; pseudocardinals of left valve more or less double, thin, compressed, elevated, sulcated, situated in front of the beaks; pseudocardinals of right valve double, erect, compressed; all pseudocardinals parallel with hinge line; laterals short, erect, curved, double in left, single in right valve; beak cavities wide and deep; adductor muscle scars well marked anteriorly, very faint posteriorly; nacre bluish-white, tinged with salmon. The female shell is a trifle more inflated in the post-basal region than the male.

L. 99; H. 75; D. 68 mm. Wabash River (U. of I., Z4016). Female.

L. 90; H. 66; D. 55 mm. " " (" Z4016). Male.

ANIMAL: Supra-anal opening large, mantle connection between it and anal opening slightly longer than anal opening, the latter finely crenulated; branchial opening with reddish papillae. In the female, the inner edge of the mantle in front of the branchial opening is slightly lamellar, with few remote, fine crenulations, which resemble minute papillae near the branchial opening, and pass gradually into the smooth anterior mantle edge; posterior margins of palpi connected for about two-thirds or one-half their length; inner laminae of inner gills entirely connected with abdominal sac. Marsupium occupying posterior part of outer gills, kidney-shaped, consisting of many (about 50) ovisacs. Color of animal yellowish or tan, the mantle edges darker brown (see Ortmann, 1914, p. 68).

Glochidia (pl. XXXII, fig. 17) celt-shaped or axe-shaped,

rather small, with spines at ventral corners. Length 0.105, height 0.185 mm. (Surber, 1912, p. 9); 0.09 by 0.18 mm. (Ortmann, 1914, p. 68).

BREEDING SEASON: Reported gravid in June, July, August, and Oct. (Surber and Ortmann). Duration of season not indicated. Possibly bradytictic.

NATURAL HOST: Not recorded.

ECOLOGY: Not well recorded. In Mississippi found on a mud bottom.

GENERAL DISTRIBUTION: Lower Ohio River drainage; southwest to St. Francis River, Arkansas; north to eastern Iowa (Simpson). A species of more southern distribution.

DISTRIBUTION IN WISCONSIN: Though the type locality for this species is Falls of St. Anthony, Minnesota, the species is rare above Davenport, Iowa. It is reported from the vicinity of McGregor, Iowa, and probably occurs on the Wisconsin side of the Mississippi. Shimek's records are the only ones referable to Wisconsin.

REMARKS: *Capax* is at once known among Wisconsin naiades by its globose shell and peculiar shape, its full high beaks and curved hinge line. The shell also gapes greatly both before and behind. The species is only locally abundant in the Mississippi River and at present is not found north of McGregor. The fat pocketbook is not suitable for the button manufacturers on account of its thin shell.

Genus *CARUNCULINA* Simpson, 1898

Shell small, inflated, obovate, rather solid, with a thick dark epidermis, which is rayless or only feebly rayed; beak sculpture consisting of rather strong, concentric ridges, which form, as a general thing, only a single rounded loop in front and are strongly curved upward behind. Pseudocardinals compressed, smooth on the side, generally reflected upward, somewhat torn on the edges. Shell quite commonly pointed posteriorly, that of the female truncated obliquely on the post-base. Marsupium kidney-shaped, formed by a few large ovisacs; projecting beyond the gill; female having a well developed caruncle on the inner edge of the mantle in front of the branchial opening (Walker). Type: *Unio parvus* Barnes.

The use of the name *TOXOLASMA* Raf., by Ortmann (1919,

p. 257; Frierson, 1914, p. 7) is untenable because the type species, *lividus*, is not recognizable. See Ortmann & Walker, 1922, pp. 54, 55.

CARUNCULINA PARVA (Barnes). Lilliput Shell

Plate LXXXVI, figures 1-4

Unio parvus BARNES, Amer. Jour. Sci., VI, p. 274, pl. xiii, fig. 18, 1923.

Lampsilis parva SIMPSON, Cat., p. 151, 1914.

Toxolasma parvum ORTMANN, Mem. Carnegie Mus., VIII, p. 258, pl. xvi, fig. 3, 1919.

TYPE LOCALITY: Fox River, Wisconsin.

WISCONSIN RECORDS:

1823. *Unio parvus* BARNES, p. 274. Fox River.

1860. *Unio parvus* LAPHAM, p. 156. Fox River.

1885. *Unio parvus* CALL, p. 41. Lake Pepin.

1897. *Unio parvus* WISWALL, p. 47. Southern Wisconsin.

1919. *Toxolasma parvum* ORTMANN, p. 260. Fox River.

1922a. *Carunculina parva* GRIER, pp. 11-31. Lake Pepin.

1922. *Carunculina parva* GRIER and MUELLER, p. 100. Lake Pepin.

SHELL: Small, rather solid, subelliptical, somewhat inflated, especially in the female; anterior and posterior ends rounded; ventral margin straight or slightly convex, dorsal margin straight, almost parallel with ventral margin; posterior ridge absent, the posterior slope somewhat flattened and compressed; beaks slightly elevated above the hinge line, somewhat inflated, their sculpture consisting of 5-6 distinct bars, sub-concentric, the last 3-4 forming a blunt angle posteriorly; epidermis very thick, usually dark brown or black, rayless, the growth lines usually coarse and slightly elevated.

Pseudocardinals triangular, compressed, erect, subparallel with dorsal margin, rough, two in left, one in right valve; laterals straight, rather strong, erect, rough; no interdentum; beak cavities deep, containing dorsal muscle scars in a diagonal row, pointed anteriorly; anterior adductor muscle scar deeply impressed, posterior scar not very distinct; nacre silvery white, more or less iridescent; sometimes there is a tinge of pinkish-yellow near the beak cavities.

Sex differences in the shell marked in the adult, the female being more cylindrical and swollen with the greatest height at the posterior end where the shell is more broadly rounded than in the male shell.

L. 23; H. 12; D. 9 mm.	Wyocena (U. of W., 971).	Male.
L. 25; H. 15; D. 11 mm.	Edwards Co. Ill. (U. of W., 266).	Female.
L. 24; H. 15; D. 10 mm.	" " " (" 266).	Female.
L. 24; H. 14; D. 11 mm.	" " " (" 266).	Female.

ANIMAL (Fig. 237): Supra-anal opening very small, separated from anal opening by a small mantle connection (supra-anal opening sometimes closed); branchial opening small with few large papillae; anal opening with fine crenulations; both openings are directed upward; inner edge of mantle, in front of branchial opening, with crowded papillae which occupy but a small area and terminate in a knobbed caruncle in the female; this caruncle may be cylindro-conical, pyramidal, semi-globular, or somewhat divided; the caruncle is absent in the male but there is a group of papillae present; palpi rather large connected only at base; inner laminae of inner gills attached to abdominal sac for less than half their length. Marsupium kidney-shaped, filling posterior half of outer gills; ovisacs 11-20 in number, projecting beyond margin of sterile gill; placentae white, club-shaped, discharged whole. Color of animal whitish or yellowish, the openings edged with brownish; mantle papillae brownish or blackish, the base with a black mark, caruncle white or brownish (see Ortmann, Nautilus, XXVIII, p. 130).

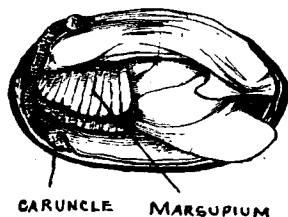


Fig. 237. *Carunculina parva* (Barnes). Gravid female. Walker, Synopsis, Fig. 209.

Glochidia (pl. XXXII, fig. 18) of medium size, subelliptical, hinge line straight, spineless. Length 0.170, height 0.200 mm. (Surber, 1915, p. 5); 0.180 by 0.200 mm. (Ortmann, 1919, p. 259).

BREEDING SEASON: Probably bradytictic. Glochidia have been observed on May 19, June 17, 26, July 20, Aug. 9 (eggs). The records indicate that much is still to be learned concerning

the breeding season of this tiny species. Said to be locally hermaphroditic (Utterback, 1916a, p. 165).

NATURAL HOST: Not recorded.

ECOLOGY: Usually in small streams where the current is sluggish on a mud bottom, in a few cm. to a meter or more of water.

GENERAL DISTRIBUTION: Western New York west to Iowa, Missouri, and Kansas, north to Minnesota, Michigan, and southern Canada, south to Oklahoma and Texas.

DISTRIBUTION IN WISCONSIN: *Parva* seems to be of limited distribution and very rare in this State, as the three records below would indicate. It did not occur in any of the localities personally studied.

Mississippi Drainage: Lake Pepin, Pierce and Pepin Co. (Grier); Lake Pepin (Call).

Fox Drainage: Fox River (Barnes, Lapham).

Wisconsin Drainage: Wyocena, Columbia Co. (Bullock).

REMARKS: This, the smallest of Wisconsin naiades, is easily recognized by its subparallel outline and brown or black, rayless shell, and also by its beak sculpture. There is little variation in the form of the shell excepting that due to sex. It appears to be a rare species in the streams of the State. It is a very common shell in Illinois.

Parva appears to be normally a creek or small stream species and its presence in Lake Pepin is of extreme interest (see Grier, 1922a). No specimens from this locality are at hand for comparison.

CARUNCULINA PARVA CAHNI F. C. Baker

Plate CV, figures 14-18

Carunculina parva cahni BAKER, Amer. Mid. Nat., X, p. 222, 1927.

WISCONSIN RECORDS:

1927d. *Carunculina parva* BAKER, p. 107. Neosha mill pond.

SHELL: Differing from typical *parva* in being larger, more inflated, with heavier hinge teeth. It is well rounded at both ends and there is not the distinct difference due to sex shown in *parva*. The beak sculpture is very heavy.

L. 45.5; H. 25.5; D. 25.0 mm. Type (U. of I., Z17341).

L. 41.0; H. 24.0; D. 22.0 mm. Paratype (U. of I., Z17342).

L. 44.0; H. 26.0; D. 24.0 mm. " (").

L. 36.0; H. 21.0; D. 18.5 mm. " (").

L. 22.5; H. 12.6; D. 9.0 mm. " (").

TYPE LOCALITY: Neosho mill pond, Dodge Co., Wisconsin.

ANIMAL: Not differing from *parva*.

DISTRIBUTION: Not seen outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: At present known only from the southeastern part of the state. *Rock Drainage*; Neosho mill pond, Dodge Co.; Lake Koshkonong, Jefferson Co. (Cahn).

ECOLOGY: Apparently a pond or lake form; living in deep, sticky clay bottom (Cahn).

REMARKS: This form of *parva* is so distinct from the usual small, more or less compressed form of the species, as found in Wisconsin and Illinois, that it should be designated as a variety. Typical *parva* has a width index of 40–45% while *cahni* has an index of 50–55%. It appears to be a pond or lake form, typical *parva* being a river form, so that the distinction is largely an ecological one. The specimens were collected by Dr. Alvin R. Cahn, of the Department of Zoology, University of Illinois, to whom the variety is dedicated.

Genus LIGUMIA Swainson, 1840

Shell oval to oblong; surface smooth; beak sculpture delicate, double-looped; female shell more or less expanded or swollen in the post-basal region. Inner edge of the mantle in the female distinctly papillate; Marsupium kidney-shaped, occupying the posterior part of the outer gill (Walker).

First given the name of *Eurynia* by Rafinesque (1820, p. 297) who, however, indicated no type. The first designation of a type for *Eurynia* was that of *Unio dilatata* Raf., by Herrmannsen (in 1847), and thus *Eurynia* becomes a synonym of *Elliptio* with the same type. This opens the way for the admission of *Ligumia* Swainson with the same type as *Eurynia* of Simpson and Agassiz (see Ortmann & Walker, 1922, p. 59).

Subgenus LIGUMIA sensu stricto

Shell usually of good size, subelliptical, elongated, more or less pointed behind; beak sculpture double-looped, the posterior loop often open behind. Inner edge of mantle in the female in front of the branchial opening with a long row of quite regular, uniform, subequal papillae, reaching to about the middle of the lower margin (Walker). Type: *Unio recta* Lam.

LIGUMIA RECTA (Lamarek). Black Sand Shell

Plate LXXXVII, figures 4, 5

Unio recta LAM., An. sans Vert., VI, p. 74, 1819.*Ligumia recta* ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 59, 1922.*Unio sageri* CONRAD, Monog., VI, p. 53, pl. xxix, fig. 1, 1836.*Lampsilis recta* var. *sageri* SIMPSON, Cat., p. 96, 1914.TYPE LOCALITY: Lake Erie (*recta*) Detroit River, Mich. (*sageri*).**WISCONSIN RECORDS:**1922b. *Lampsilis recta* BAKER, p. 131. Lake Winnebago.1924. *Ligumia recta* BAKER, p. 132. Lake Winnebago.

SHELL: Of good size, heavy, solid, elongated, subelliptical, sometimes lanceolate, especially in the young shell, much longer than high, valves flattened on the side; anterior end rounded, ventral margin straight or slightly convex; dorsal margin straight or but slightly convex, like the ventral margin passing gently into the pointed posterior end; posterior slope faintly indicated near the beaks, rounded and obliterated below, but the posterior slope is flattened above the ridge near the beaks. In specimens from the Detroit River, Michigan, the posterior ridge is rather sharp and distinct; beaks low, scarcely raised above the hinge line, their sculpture consisting of 3-5 faint, subobsolete bars, which are double-looped, the bars ending abruptly on the posterior slope of the umbo; epidermis more or less shining, dark green, brown or blackish with or without distinct rays; in the young shell the rays are usually quite distinct; rest periods are sometimes marked by color bands of dark green or black and the shell may be raised into ridges at these places.

Pseudocardinals irregular, compressed, serrated, somewhat triangular, two in left one in right valve; laterals long, straight, elevated, crenulated; no interdentum; cavity of the beaks shallow, containing dorsal muscle scars well under the hinge line; anterior adductor muscle scar well excavated, posterior scar faintly impressed; pallial line impressed anteriorly; nacre usually deep purple, mauve, or white, iridescent posteriorly; female shell produced in the post-basal region.

L. 102; H. 46; D. 29 mm.	Lake Winnebago (U. of W., 972).	Male.
L. 94; H. 44; D. 28 mm.	" " (" 927b).	Female.
L. 120; H. 56; D. 35 mm.	" " (" 973a).	Female.
L. 105; H. 49; D. 35 mm.	" " (" 973b).	Male.

ANIMAL: In every respect as in variety *latissima*. Marsupium with 34 ovisacs (fig. 238).

GLOCHIDIA as in *latissima*. Length 0.220, height 0.280 mm. (Doemel Point specimens).

BREEDING SEASON: Probably as in *latissima*. Gravid females examined July 1, from Winnebago Lake.

NATURAL HOST: Not recorded.

ECOLOGY: In Lake Winnebago, *recta* occurs on a stony bottom in water a few cm. to half a meter or more in depth. Ortmann describes the Lake Erie form as living on a sand or gravel shore in protected situations, and in beach pools in sandy-mud bottom, in quiet waters. The Lake Winnebago form lives where it receives the full pounding of the heavy surf in times of storm.

GENERAL DISTRIBUTION: Typical *recta* is common in Lake Erie and extends into the Detroit River and Lake St. Clair. The Lake Winnebago *recta* are similar in form.

DISTRIBUTION IN WISCONSIN: Known only from Lake Winnebago. It occurs in the following localities: Miller Bay, Doemel Point, Long Point Island, Lower Asylum Bay, Asylum Point, Lighthouse Point, Oshkosh, Fahney Bay (Baker).

REMARKS: *Ligumia recta* can be confused with but one other species. Young male specimens resemble *Elliptio dilatatus*, but may be distinguished by the following characters: *dilatatus* has a dull black epidermis with fine rays; *recta* a shining greenish or brownish epidermis with more or less distinct rays; *dilatatus* has darker purple nacre, the posterior end is not as pointed and the hinge teeth are very differently shaped, while the beak sculpture is larger and coarser. Anatomically the two species are widely different.

The Lake Winnebago *recta* are notably uniform in shape, varying principally in the color of the nacre, which ranges from white to dark mauve. It can scarcely be called purple. White-nacred specimens are apparently rarer in Wisconsin than in Lake Erie. Sand blisters and pearly growths are common in this species.

Lamarck's specimens came from Lake Erie and this small

form, and not the river form, must bear this name. It is not surprising to find that the Lake Winnebago *recta* is the same as the Lake Erie shell, because so many of the Winnebago shells have had the lake characteristics. The *recta* from this locality are very abundant and differ uniformly from the river form in their smaller size, reddish-brown epidermis, greater width and hence more cylindrical shape, and paler nacre.

The Detroit River form described as *Unio sageri* by Conrad (Monog., VI, p. 53, 1836) is not exactly like either the Lake Erie or Lake Winnebago shells, having a more pronounced posterior ridge near the umbones, this feature not being distinctly marked in the lake shells. This is probably a local feature as it has not been observed in any other shells from the lake drainage.

LIGUMIA RECTA LATISSIMA (RaC). Black Sand Shell

Plate LXXXVII, figures 1-8; plate LXXXVI, figs. 13, 14

Unio latissima RAF., An. Gen. Sci. Phys., Brux., V, p. 297, pl. xxx, figs. 14, 15, 1820.

Unio praelongus BARNES, Amer. Jour. Sci., VI, p. 261, pl. xiii, fig. 11, 1823.

Eurynia recta SIMPSON, Cat., p. 95, 1914.

Ligumia recta latissima ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 59, 1922.

TYPE LOCALITY: Ohio River (*latissima*); Fox River (*praelongus*).

WISCONSIN RECORDS:

1823. *Unio praelongus* BARNES, p. 261. Fox River.

1852. *Unio rectus* LAPHAM, p. 369. Wisconsin.

1860. *Unio rectus* LAPHAM, p. 156. Wisconsin and Rock rivers.

1897. *Unio rectus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Lampsilis recta* BAKER, p. 253. Prairie du Chien.

1906. *Lampsilis recta* CHADWICK, p. 92. Fox River, near Big Bend, Waukesha Co.; La Crosse, La Crosse Co.; between Prairie du Chien and De Soto.

1911a. *Lampsilis recta* BAKER, p. 230. Wisconsin River, Oneida Co.

1914. *Lampsilis recta* WILSON and DANGLADE, p. 120. Lake Pepin.

1922a. *Eurynia recta* GRIER, pp. 11-31. Pierce, Pepin, Buffalo, Trempealeau Co.

1924. *Ligumia recta latissima* BAKER, p. 132. Omro, Fox River.

1926. *Ligumia recta latissima* GRIER and MUELLER, p. 18. Lake Pepin and upper Mississippi River.

1927d. *Ligumia recta latissima* BAKER, p. 107. Crawfish River, Aztalan; Rock River; Ashippun to Rock Co.

SHELL: Differing from typical *recta* in being larger, more compressed laterally, with the posterior ridge near the beaks less conspicuous, with darker brown or black epidermis, more vivid nacre, and less distinctly marked growth lines. Female shells decidedly modified in the post-basal region.

- L. 187; H. 85; D. 47 mm. Ashippun (U. of I., Z17336a). Female.
 L. 167; H. 68; D. 48 mm. Jefferson U. of W., 974). Female.
 L. 164; H. 70; D. 52 mm. Wisconsin River (U. of W., 185). Male.
 L. 146; H. 67; D. 39 mm. Princeton (U. of W., 975). Female.
 L. 146; H. 64; D. 45 mm. Jefferson U. of W., 4401). Male.
 L. 132; H. 56; D. 34 mm. Baraboo River (U. of W., 187). Male.
 L. 123; H. 51; D. 34 mm. Prairie du Chien (U. of W., 4402). Male.
 L. 65; H. 28; D. 16 mm. Menominee River (U. of W., 781). Male.
 L. 54; H. 22; D. 13 mm. Racine (U. of W., 92). Juv.
 L. 36; H. 14; D. 8 mm. Wisconsin River (U. of W., 4403). Juv.

ANIMAL (Fig. 238): Anal and supra-anal openings separated by mantle connection about half as long as supra-anal opening; anal opening smaller than supra-anal, finely crenulated; branchial opening smaller than anal, with numerous papillae; the inner edge of the mantle, in the female, from the branchial opening forward to about the middle of the body is

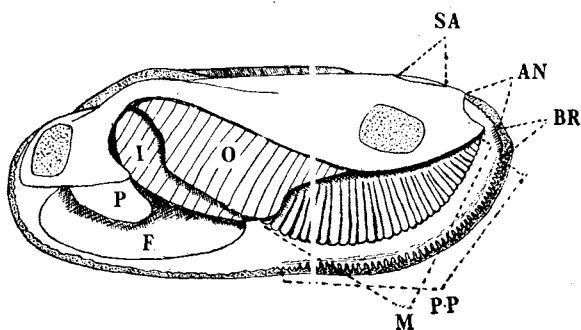


Fig. 238. *Ligumia recta* Doemel Point, Lake Winnebago. Gravid female. July 1, 1920.

provided with a row of subequal, large, somewhat conical papillae, which are more or less crowded; they end abruptly on the mantle margin; the papillae are blackish at their bases and white at their tips, and there is a black streak on the mantle just above the papillae; inner laminae of inner gills attached to abdominal sac throughout their length; palpi wide, short, attached for only a short distance at their bases; marsupium

occupying posterior half of outer gill, a portion at the posterior end being non-marsupial in function; ovisacs 15 to 30 (Ortmann), 50 (Utterback). When gravid the marsupium becomes thick and pad-like and extends below the edge of the non-gravid portion; ova and glochidia in irregular masses. Color of animal generally grayish, openings brownish.

Glochidia (pl. XXXII, fig. 19) large, semielliptical, ventral margin rounded, hinge line short, undulate. Length 0.220, height 0.280 mm. (Surber, 1912, p. 9); 0.20 by 0.24 mm. (Lefevre & Curtis, 1921, p. 146).

BREEDING SEASON: Bradytictic. Middle of August to end of July (Ortmann). Interval longer for individuals. Specimens in Red Cedar River gravid in August, 1921.

NATURAL HOST: Gill parasite of Bluegill (*Lepomis pallidus*) July (Surber, 1913, p. 109). White crappie (*Promoxis annularis*) on gills (Coker, Shira, et al, 1912, p. 153).

ECOLOGY: *Recta latissima* is typically a form of the larger rivers but also enters the smaller streams. It is usually found on a gravelly bottom in strong current and in riffles in gravel. In the Red Cedar River it occurred in sand and gravel, in riffles, water .3–.6 m. deep, often almost buried from sight in the sand bars. In the Wisconsin River near Kilbourn it was common on a sandy bottom in about 2 m. of water. Common in Lake Pepin in deep water and also near shore.

GENERAL DISTRIBUTION: Western New York and Pennsylvania west to Iowa and Kansas, north to Minnesota, Winnipeg, Michigan, Quebec, and Montreal, and south to Alabama, Georgia, and Arkansas. A species of very wide distribution.

DISTRIBUTION IN WISCONSIN: *Latissima* is widely distributed in Wisconsin, occurring in all of the drainage areas excepting that of Lake Superior. Its metropolis, judging from the records, centers in the Mississippi and Wisconsin rivers. It probably occurs in nearly all of the rivers and their tributaries.

REMARKS: The river form of *recta*, *latissima*, is distributed over all Wisconsin, where it is markedly uniform, the principal variation being in the color of the nacre, which ranges from white, through salmon, pink, to mauve, some specimens being suffused with all of these colors. The post-basal expansion in the female is more marked in the river form than in the lake specimens. Young individuals of *latissima* are flatly com-

pressed, the shells becoming more cylindrical with age. Young shells are also beautifully rayed with fine diagonal lines on a light greenish background. Immature specimens have a brownish-red epidermis, but old specimens become black and are usually somewhat eroded at the beaks. The largest specimens occur in the Rock and Wisconsin rivers.

The black sand shell is commercially valuable when the nacre is white and the shell not too brittle. It has a peculiarly good luster and pearly iridescence that is often very striking. The colored specimens are used for novelties.

Subgenus *MICROMYA* Agassiz, 1852

Shell small or of medium size, suboval or subelliptical, not very long and not much pointed behind; beak sculpture distinctly double-looped, but often obsolete, the posterior loop often showing a tendency to be open. Inner edge of the mantle of the female in front of the branchial opening with a shorter or longer row of rather irregular, larger and smaller papillae, reaching not quite to the middle of the lower margin (Walker). Type: *Unio fabalis* Lea.

LIGUMIA IRIS NOVIEBORACI (Lea). Rainbow-Shell

Plate LXXXVI, figures 8-12

Unio novieboraci LEA, Trans. Amer. Phil. Soc., VI, p. 104, pl. xxiv, fig. 114, 1838; Obs., II, p. 104, pl. xxiv, fig. 114, 1838.

Lampsilis iris SIMPSON, Cat., p. 116, 1914 (part).

Eurynia iris novieboraci ORTMANN, Mem. Carnegie Mus., VHI, p. 268, 1919; pl. xvi, figs. 8, 9.

TYPE LOCALITY: Oak Orchard Creek, Orleans Co., N. Y.

WISCONSIN RECORDS:

1860. *Unio iris* ? LAPHAM, p. 156. No locality.

1885. *Unio novieboraci* CALL, p. 39. Wisconsin.

1906. *Lampsilis iris* CHADWICK, p. 92. Milwaukee River at Lindworm.

1914. *Lampsilis iris* SIMPSON, p. 115. Wisconsin.

1919. *Eurynia iris* ORTMANN, p. 268. Wisconsin?

1919. *Eurynia iris novieboraci* ORTMANN, p. 270. Wisconsin.

SHELL: Subelliptical or subovate, elongated, compressed laterally, thicker anteriorly than posteriorly; anterior end rounded; posterior end roundly pointed, bluntly biangulate in many individuals; dorsal margin slightly convex or almost

straight, lower margin similar; posterior ridge not developed; beaks but slightly elevated above hinge line, their sculpture consisting of 4–6 fine, more or less distinct bars, the first concentric, the others distinctly or irregularly double-looped; epidermis yellowish or greenish-yellow with wide dark green rays, which are usually straight, sharply defined, and interrupted, forming in many cases squarish spots of elongated form; the rest periods are indicated by dark bands of color or by a regular interruption of the rays, especially on the posterior part of the shell, where the rays are often wider than on the anterior part.

Pseudocardinals triangular, somewhat compressed, parallel with the hinge line, roughened, two in left, one in right valve; laterals long, straight thin; beak cavities shallow, containing dorsal muscle scars; anterior adductor muscle scar well impressed, anterior scar faintly indicated; nacre silvery-white, iridescent. Sexual differences not always well-marked; female more expanded in the post-dorsal region and hence more broadly rounded; male shell rather sharply pointed.

L. 42; H. 21; D. 11.5 mm. Milwaukee (Marston, U. of W., 100). Female.

L. 56; H. 29; D. 15 mm. Racine (Marston, U. of W., 91). Male.

L. 54; H. 28; D. 14 mm. Racine (Chi. Acad. Sci.).

ANIMAL: (Fig. 239, of *iris*): anal and supra-anal openings separated by mantle connection shorter than anal opening; anal opening about as long as branchial opening, finely crenulated; branchial opening densely papillose; the mantle edge of

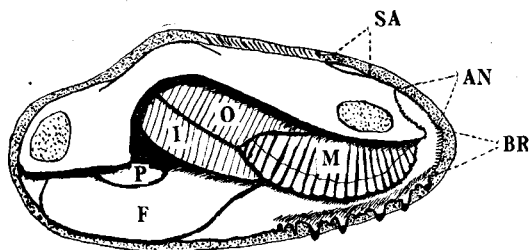


Fig. 239. *Ligumia iris* (Lea). Little Beaver Creek, Enon Valley, Lawrence Co., Pa. Gravid female. Ortmann, 1912, p. 341, Fig. 23.

the female in front of the branchial opening with a varying number (3–10) of large, conical papillae, spaced somewhat distantly, and frequently with smaller papillae between the larger ones; these papillae disappear before reaching the cen-

ter of the mantle margin; inner laminae of inner gills attached to visceral sac; inner gills wider than outer gills; palpi somewhat sickle-shaped, attached for about half their length basally; marsupium occupying the posterior half of the outer gill, with a very small non-marsupial portion at the posterior end; there are 13 to 22 ovisacs; color of soft parts tan or salmon; posterior part of gills and mantle blackish.

Glochidia (pl. XXXII, fig. 20) large, semielliptical, ventral margin rounded; hinge line short, undulate. Length 0.240, height 0.300 mm. (Surber, 1912, p. 9); 0.22 by 0.28 mm. (Ortmann, 1919, p. 266).

BREEDING SEASON: Bradytictic. Glochidia have been observed in May, July, August, and September (Ortmann, Surber, Wilson and Clark). Probably the season extends from late July to early May.

NATURAL HOST: Not recorded.

ECOLOGY: A mussel of small streams, living below riffles on a sandy or mud bottom. Also in riffles on a gravel bottom in less than a meter of water.

GENERAL DISTRIBUTION: Western New York and Pennsylvania west to Wisconsin, north to Ontario and North Dakota, and south to Illinois and Ohio.

DISTRIBUTION IN WISCONSIN: Apparently restricted to the southeastern part of the State. A migrant, possibly, from Glacial Lake Chicago.

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Chadwick, Marston); Racine, Racine Co. (Marston).

Fox Drainage (Illinois): Mukwonago River, Mukwonago; Mukwonago Creek, west of Howitt Lake, Waukesha Co. (Cahn).

REMARKS: *Ligumia iris novieboraci* may be known by its beautifully rayed shell with laterally compressed valves. Young specimens of *Lampsilis siliquoidea* somewhat resemble this species, which may be distinguished by its more compressed shell, wider and less distinct rays, less distinctly double-looped beak sculpture, and more highly iridescent nacre, which is less brilliant in *siliquoidea*.

An examination of material from Indiana and Illinois casts some doubt upon the standing of *novieboraci* as a distinct northern race or variety. There are two forms, typically quite distinct, one with continuous, rather faint rays (*iris*), the other with distinct, more or less interrupted rays which may be

broken up into squarish or elongated dots or spots (*novieboraci*). In the material in the Hinkley collection there are specimens from several localities that can be referred to both variations (Baldwinsville, N. Y.; Kalamazoo River, Mich.; Muncie, Ind.; Stillwater River, Ohio; Cook Co., Ill.). In a large majority of cases the rays show a tendency to become broken up, and while the extremes of variation are quite striking and distinct, there are many intermediate forms. Specimens from the southern part of the range of *iris* show this interruption of the rays less than those from more northern localities.

All of the Wisconsin material is referable to the *novieboraci* type, no typical *iris* having been seen from the State. It seems apparent that the variety is characteristic of the northern range of *iris*, integrading with the latter and becoming typical *iris* toward the south. It is a rare shell in Wisconsin. The Milwaukee specimens are nearer the typical form in coloration.

LIGUMIA ELLIPSIFORMIS (Conrad). Ellipse

Plate LXXXV, figures 1-4

Unio ellipsiformis CONRAD, Monog., VIII, p. 60, pl. xxxiv, fig. 1, 1836.

Lampsilis ellipsiformis SIMPSON, Cat., p. 128, 1914.

Unio spatulatus LEA, Pr. Amer. Phil. Soc., IV, p. 164, 1845; Trans., X, p. 80, pl. viii, fig. 22, 1848; Obs., IV, p. 54, pl. viii, fig. 22, 1848.

TYPE LOCALITY: Michigan (*ellipsiformis*); Rock River, Wis. (*spatulatus*).

WISCONSIN RECORDS:

1845. *Unio spatulatus* LEA, p. 164. Rock River.

1848. *Unio spatulatus* LEA, p. 54, p. 80. Rock River.

1885. *Unio spatulatus* CALL, p. 49. Wisconsin.

1897. *Unio spatulatus* WISWALL, p. 48. Southern Wisconsin.

1906. *Lampsilis ellipsiformis* CHADWICK, p. 92. Milwaukee River; Fox River near Big Bend, Waukesha Co.; mill pond at Hika, Manitowoc Co.

1927d. *Ligumia ellipsiformis* BAKER, p. 107. Bark River, Dousman.

SHELL: Long-elliptical or long-ovate, solid, not much inflated; anterior end rounded; posterior end produced into a more or less biangulate point; ventral margin slightly convex or nearly straight in some specimens, sometimes a trifle concave in front of the posterior end; dorsal margin slightly convex; posterior ridge rounded, with a flattened area behind;

beaks not much elevated above hinge line, their sculpture consisting of about four feeble bars which are faintly double-looped; epidermis greenish-yellow with numerous more or less wavy, continuous rays of dark green; growth lines heavy, sometimes forming concentric ridges, especially at rest periods; the surface may also be clouded greenish with indistinct rays.

Pseudocardinals thick, massive, triangular, corrugated, divergent, two in left, one in right valve with sometimes a second denticle anteriorly and a swelling on the very narrow interdentum; laterals straight, heavy, thick, roughened, not very long; cavity of the beaks shallow, containing dorsal muscle scars; adductor muscle scars well excavated; there is a radial furrow in the posterior part of the valve, below the lateral teeth; nacre bluish-white, sometimes slightly flesh-colored, iridescent. Sex differences not marked. The female shell is slightly more produced in the post-basal region.

L. 46; H. 26; D. 16 mm. Chippewa Falls (U. of W., 4404).

L. 78; H. 45; D. 32 mm. Winnebago Co., Ill. (U. of I., Z3791).

L. 71; H. 42; D. 28 mm. " " " (" Z3791).

ANIMAL: Anal and supra-anal openings separated by small mantle connection; branchial opening with many yellowish papillae; anal opening with fine crenulations; supra-anal opening small; inner laminae of inner gills entirely connected with visceral sac. Marsupium occupying posterior half of outer gills, consisting of about 20 ovisacs; when gravid extending below edge of sterile gill; mantle edge anterior to branchial opening with papillae which extend to about the center of the mantle margin, terminating in fine crenulations; conglomerates not described. Glochidia not described.

BREEDING SEASON: The published records indicate that this species is bradytictic, the interim occurring in July and August.

NATURAL HOST: Not recorded.

ECOLOGY: Sand and gravel bottom, commonly on riffles in swift current, shallow water. Rare in mud bottom. Scammon (1906, p. 297) says: "its favorite habitat is strictly mud banks". Mukwonago River, gravel bottom, swift current, shallow. In Bark River on sand and gravel bottom (Cahn). In Illinois its observed habitat is sand and gravel. A species of the smaller rivers and streams.

GENERAL DISTRIBUTION: "Upper Mississippi Valley generally; south to about latitude 38°; western New York, southern

Michigan, Southern Canada, Red River of the North." Simpson. *Ellipsiformis* is listed from the following states: Western New York (Letson); Ohio (Sterki); Southern Michigan (Walker); Indiana (Call); Illinois (Baker); Iowa (Call); Minnesota (Call); Kansas (Scammon); Missouri (Utterback).

DISTRIBUTION IN WISCONSIN: *Ellipsiformis* appears to be a rare shell in Wisconsin. It appears to be more abundant in the southeastern part of the State.

REMARKS: *Ellipsiformis* may be known by its somewhat compressed shell, long-elliptical outline, numerous green rays, which are slightly wavy, especially near the ventral border of the shell, solid shell with heavy teeth, fine beak sculpture, and the radial furrow in the interior of the valve, just below the lateral teeth. Care will easily separate it from either *iris noviboraci* or *Lampsilis siliquoides*, both of which it somewhat resembles. Utterback classifies this species with *Actinonaias carinata* (1919a, p. 141), but it seems more logically related to *Ligumia*. Owing to its size it has no commercial importance. Figures are given of typical Illinois specimens from the Kaskaskia River, Ill.

Genus LAMPSILIS Rafinesque, 1820

Shell oval to elliptical, smooth or slightly, concentrically sculptured, usually without a posterior ridge; epidermis generally smooth and shining, often rayed; beak sculpture consisting of double-looped, parallel ridges; sometimes the posterior loop is open behind or the sculpture is obsolete; hinge with one or two pseudocardinals and one lateral in right valve, and two pseudocardinals and two laterals in the left; female shell having a strong inflation of the shell and dilatation in the post-basal region, producing a distinct posterior truncation of the shell. Marsupium kidney-shaped, occupying the posterior part of the outer gills; edge of the mantle of the female in front of the branchial opening developed into a ribbon-like flap, generally produced anteriorly into a full, projecting lobe, which has a lacerated appearance (Walker). Type: *Unio ovatus* Say.

LAMPSILIS ANODONTOIDES (Lea). Yellow Sand-Shell

Plate LXXXVIII, figures 1-3

Unio anodontoides LEA, Trans. Amer. Phil. Soc., IV, p. 81, pl. viii, fig. 11, 1834; Obs., I, p. 91, pl. viii, fig. 11, 1834.*Lampsilis anodontoides* SIMPSON, Cat., p. 90, 1914.*Lampsilis anodontoides* ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 60, 1922.

TYPE LOCALITY: Mississippi, Alabama, and Ohio Rivers.

WISCONSIN RECORDS:1905c. *Lampsilis anodontoides* BAKER, p. 253. Prairie du Chien.1906. *Lampsilis anodontoides* CHADWICK, p. 92. Between Prairie du Chien and De Soto.1922a. *Lampsilis anodontoides* GRIER, pp. 11-31. Pierce, Buffalo, Trempealeau Co.

SHELL: Large, thick, solid, elongated, somewhat inflated; gaping at both ends, more or less; anterior end rounded; posterior end pointed; dorsal and ventral margins straight, nearly parallel; posterior ridge rounded, low; beaks full but not much elevated above the hinge margin; beak sculpture consisting of about 8-10 distinct ridges which are looped in the middle and continuing anteriorly, but open posteriorly, and sometimes somewhat wavy; epidermis smooth and shining, greenish-yellow or straw-colored, with a few faint rays, usually most distinctly marked on the posterior part of the shell; growth lines, particularly rest marks, are usually distinct, brownish in color; the region of the beaks is often reddish or brownish.

Pseudocardinals somewhat compressed, two in each valve, the anterior tooth elongated and compressed, the posterior tooth more elevated, both serrated; laterals long, lamellar, nearly straight, roughened; no interdentum; beak cavities not deep, containing dorsal muscle scars; adductor muscle scars well marked, especially the anterior scar; old shells are much roughened in the vicinity of the pallial line, especially anteriorly; nacre silvery white, sometimes cream-colored or pinkish toward the beak cavities, iridescent posteriorly; the shell is thicker in the anterior part.

Sexual differences in the shell are well marked, the female having a conspicuous swelling behind the center of the ventral border.

- L. 156; H. 75; D. 63 mm. Prairie du Chien (Dudley). Female.
 L. 130; H. 65; D. 51 mm. " " " (U. of W., 4405a). Female.
 L. 125; H. 63; D. 47 mm. " " " (" 4405b). Male.

ANIMAL: anal and supra-anal openings of about equal length, the mantle connection very much shorter than either; branchial opening rather large, papillose; anal opening finely crenulated; the inner edge of the mantle in the female, anterior to the branchial opening, forms a long, ribbon-like expansion of a blackish or brownish color, covered with crenulations, but without papillae; this flap extends less than a third the length of the ventral margin; inner laminae of inner gills connected their entire length to abdominal sac; palpi wide, connected for about one-fourth their length at the base; marsupium kidney-shaped, occupying more than half of the posterior part of the outer gill, when gravid forming a thick, pad-like structure of upwards of 30 ovisacs; margin of marsupium marked with blackish; placentae white; color of soft parts whitish, mantle edged with blackish.

Glochidia (pl. XXXII, fig. 21) of medium size, semielliptical, ventral margin rounded, hinge line short and slightly undulate. Length, 0.185, height 0.210 mm. (Surber, 1912, p. 9).

BREEDING SEASON: Bradytictic.

NATURAL HOST: Found on gills of long-nosed gar (*Lepisosteus osseus*). The following fish have carried the development through after artificial infection: Long-nosed gar, short-nosed gar (*Lepisosteus platosyomus*), and alligator gar (*Lepisosteus tristoechus*).

The following fish have been found naturally infected but the occurrence is of doubtful significance: Blue-spotted sunfish (*Lepomis cyanellus*); orange-spotted sunfish (*Lepomis humilis*); large-mouth black bass (*Micropterus salmoides*); white crappie (*Pomoxis annularis*); and black crappie (*Pomoxis sparoides*). See Coker, Shira, et al, 1921, p. 152.

ECOLOGY: Larger rivers on sandy bottom in a rather swift current, water a meter or more in depth. Also found on muddy bottoms in quieter habitats.

GENERAL DISTRIBUTION: Entire Mississippi River drainage except (probably) the upper Missouri. All the Gulf drainage from Withlacoochee River, Florida, to the Rio Grande, and into Mexico (Simpson). This includes *fallaciosa*.

DISTRIBUTION IN WISCONSIN. *Anodontoides* appears to be confined to the Mississippi River, no records being available outside this area. It is surprising that it has not been found in the Wisconsin River, as this stream seems ecologically well

suited for the species. This species is said not to inhabit Lake Pepin, its place being taken by *fallaciosa*. Specimens examined from this body of water are *fallaciosa*.

REMARKS: *Anodontooides* is readily known by its elongated shell and yellowish color, without rays. There is no other species, excepting *fallaciosa*, with which it can be confused, excepting, possibly, yellow specimens of *siliquoidea*, but this species is not as long as *anodontooides* and the umbonal markings are different. *Anodontooides* differs from *fallaciosa* in being larger and less cylindrical, with a greater height as compared with length, and with a yellowish, usually rayless epidermis.

The yellow sand shell is the most highly prized of all commercial shells, its luster and pearly qualities being almost if not quite equal to the marine shells, its texture is smooth and firm, the shape of the shell is such that knife handles and novelties may be cut, and the uniformity of thickness makes the shell yield the best return in proportion to its weight. It is not used for domestic button manufacture but is exported to France and Germany, prices as high as \$92.50 per ton, f. o. b. New York, being offered (see Coker, 1919, p. 31).

LAMPSILIS FALLACIOSA (Smith) Simpson. Slough Sand Shell

Plate LXXXIX, figures 1-4

Lampsilis fallaciosus SMITH, Bull. Fish. Com., p. 291, pl. lxxix, 1899.

No description.

Lampsilis fallaciosus SIMPSON, Pr. Acad. Nat. Sci. Phil., p. 74, pl. ii, fig. 5, 1900.

Lampsilis fallaciosa SIMPSON, Cat., p. 92, 1914.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1905c. *Lampsilis fallaciosa* BAKER, p. 253. Prairie du Chien.

1914. *Lampsilis fallaciosa* WILSON and DANGLADE, p. 20. Lake Pepin.

1922a. *Lampsilis fallaciosa* GRIER, pp. 11-31. Pierce, Pepin, Trempealeau Co.

1922. *Lampsilis fallaciosa* GRIER and MUELLER, p. 101. Lake Pepin.

1926. *Lampsilis anodontooides fallaciosa* GRIER and MUELLER, p. 18. Lake Pepin and upper Mississippi River.

SHELL: of medium size, not very thick, much elongated, somewhat inflated, cylindrical; anterior end rounded, posterior end pointed, dorsal and ventral margins almost parallel; pos-

terior ridge rounded; beaks depressed and sculpture as in *anodontoides*; epidermis smooth and shining, greenish-yellow with many dark green rays covering the greater part of the surface; young shells are bright greenish-yellow with grass-green rays; hinge as in *anodontoides*; nacre the same.

L. 96; H. 43; D. 34 mm. Prairie du Chien (Chi. Acad. Sci., 20258). Male.

L. 79; H. 36; D. 29 mm. Prairie du Chien (Chi. Acad. Sci., 20258). Female.

L. 72; H. 32; D. 25 mm. Prairie du Chien (Chi. Acad. Sci., 20258). Male.

L. 85; H. 40; D. 29 mm. Lake Pepin (U. of W., 351). Female.

L. 63; H. 29; D. 21 mm. Rock River (U. of W., 94). Female.

L. 125; H. 57; D. 48 mm. Big Vermilion R., Ill. (U. of I., 11147). Male.

ANIMAL: As in *anodontoides*. Glochidia (pl. XXXII, fig. 22) larger and more ovoid than those of *anodontoides*, hinge line comparatively shorter. Length 0.200, height 0.240 mm. (Surber, 1912, p. 5, 7).

BREEDING SEASON: Bradytictic as in *anodontoides*. Surber noted gravid specimens in November.

NATURAL HOST: Gill infections on white crappie (*Pomoxis annularis*) and sturgeon (*Scaphirhynchus platyrhynchus*). Infections noted in Oct. and Nov. (Surber, 1913, p. 107). Also on short-nosed gar (*Lepisosteus platostomus*) on gill filaments (Coker, Shira, et al., 1921, p. 153).

ECOLOGY: *Fallaciosa* is an inhabitant of muddy sloughs or in pond-like "cut-offs" of the river, where there is little current. Also, in Illinois, in small streams on mud bottom in shallow water.

GENERAL DISTRIBUTION: Upper Mississippi drainage; south to the Cumberland River, Tennessee, and to Arkansas; Red River of the North? (Simpson).

DISTRIBUTION IN WISCONSIN: With the exception of a Rock River record, this species is confined to the Mississippi River. As it occurs in the Pecatonica and other tributaries of the Rock River in Winnebago Co., Ill., it probably also occurs in the lower waters of the Rock River in Wisconsin.

REMARKS: *Fallaciosa* differs from *anodontoides* in its smaller and more elongated shell, its more cylindrical shape, and particularly by its epidermis which is smooth and usually densely rayed. Young *fallaciosa* 30 mm. long are closely

marked with grass-green rays, while the young of *anodontoides* are yellowish with few if any rays. Ortmann and others have thought that *fallaciosa* might be but a form of *anodontoides*, but its occurrence in the same stream (though not in the same ecological habitat), as well as the fact that the glochidia are considerably larger than those of *anodontoides*, seem to warrant the belief that the two types represent different species. *Fallaciosa* has a height index of 45% or less while *andontoides* has an index of over 50%.

Fallaciosa not only inhabits the Mississippi River but, in Illinois, ascends the smaller rivers and is found in such small streams as the Salt Fork of the Big Vermilion River, the Little Muddy River, and the Pecatonica River. Similar distribution occurs in Indiana. Throughout its distribution it exhibits little variation, excepting in size, those from the Big Vermilion River being the largest seen.

On account of its thinner shell and general scarcity the slough sand shell is not of much commercial value to the button industry.

LAMPSILIS SILIQUOIDEA (Barnes). Fat Mucket

Plate LXXXIX, figures 5-8; plate XC, figure 1

Unio siliquoides BARNES, Amer. Jour. Sci., VI, p. 269, pl. xiii, fig. 15, 1823.

Unio inflatus BARNES, Op. Cit., p. 266, 1823.

Lampsilis luteola SIMPSON, Cat., p. 61, 1914.

Lampsilis siliquoides ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 61, 1922.

TYPE LOCALITY: Wisconsin River for both species.

WISCONSIN RECORDS:

1823. *Unio siliquoides* BARNES, p. 269. Wisconsin River.

1823. *Unio inflatus* BARNES, p. 266. Wisconsin River.

1852. *Unio luteolus* LAPHAM, p. 369. Wisconsin.

1860. *Unio luteolus* LAPHAM, p. 156. Milwaukee.

1885. *Unio luteolus* CALL, p. 36. Wisconsin.

1891. *Unio luteolus* SIMPSON, p. 88. Wisconsin.

1897. *Unio luteolus* WISWALL, p. 47. Southern Wisconsin.

1905c. *Lampsilis luteola* BAKER, p. 253. Prairie du Chien.

1906. *Lampsilis luteola* CHADWICK, p. 91. Milwaukee River above Lindwurm; Two Rivers, Manitowoc Co.; Clear Water Creek, Oneida Co.; Fox River, near Big Bend, Waukesha Co.; Beasley Brook, She-she-po-comeo Park, Waupaca Co.

1906. *Lampsilis borealis* CHADWICK, p. 91. Wisconsin.

- 1911a. *Lampsilis luteola* BAKER, p. 230. Wisconsin River and Gilmore Creek, Oneida Co.
1924. *Lampsilis siliquoidea* BAKER, p. 132. Omro, Fox River.
1924. *Lampsilis siliquoidea rosacea* BAKER, p. 132. Lake Butte des Morts.
1927d. *Lampsilis siliquoidea* BAKER, p. 107. Ashippun River; Neosho mill pond; Crawfish River, Aztalan; Rock River, Ashippun to Ft. Atkinson.

SHELL: Attaining large size, rather thick, sometimes very solid, subelliptical, subovate or ovate; somewhat compressed in young and male specimens but more swollen in old and female specimens; anterior end rounded, posterior end obliquely truncated, meeting the almost straight dorsal and ventral margins in a bluntly rounded point; posterior ridge indistinct, rounded, the shell somewhat flattened above; beaks not much elevated above hinge line, flattened, their sculpture consisting of 6–10 fine, wavy, double-looped bars, which become indistinct on the posterior slope; epidermis yellowish-green, sometimes brownish, smooth and shining, usually with many dark green rays, usually of varying width, which may cover all of the surface; the rays may be crowded or widely separated, or the larger rays may be made up of several finer rays grouped together; shells may also be of uniform yellow color, or uniform brownish, especially in old individuals; growth lines often distinct, especially at rest periods.

Pseudocardinals variable, more or less triangular, erect, strong, laterally compressed, roughened, two in left valve, one large and sometimes a second smaller tooth in right valve; laterals long, straight or slightly curved, thin; no interdentum; beak cavities shallow containing dorsal muscle scars; anterior adductor scar excavated, posterior scar not well marked; nacre silvery or milky-white, iridescent posteriorly.

Sexual differences well marked, the female shell having a strong post-basal enlargement which becomes swollen in old shells; the female shell is also wider posteriorly and the posterior margin becomes broadly truncated. The female shell is usually smaller than the male shell, on the average.

- L. 129; H. 72; D. 51 mm. Princeton (U. of W., 740). Male.
L. 103; H. 51; D. 38 mm. " (" 4406). Male.
L. 104; H. 58; D. 48 mm. Aztalan (U. of W., 1887). Male.
L. 94; H. 60; D. 57 mm. Princeton (U. of W., 735). Female.
L. 105; H. 55; D. 40 mm. Omro (U. of W., 4407a). Male.

- L. 92; H. 50; D. 34 mm. Omro (U. of W., 4407b). Male.
 L. 78; H. 47; D. 35 mm. " (" 4407c). Female.
 L. 75; H. 48; D. 33 mm. " (" 4407d). Female.
 L. 66; H. 39; D. 21 mm. Chippewa Falls (U. of W., 4408). Male.

ANIMAL: (Fig. 240): Anal opening separated from supra-anal opening by mantle connection shorter than anal opening; branchial opening large, papillose; anal opening finely crenulated; in the female there is in front of the branchial opening, on the inner edge of the mantle, a ribbon-like flap, provided

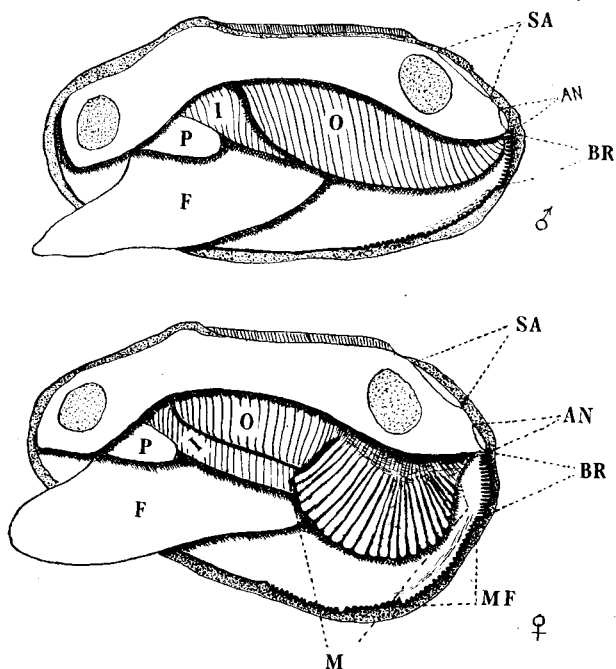


Fig. 240. *Lampsilis siliquioidea* (Barnes). Omro, Fox River. Upper Fig. male. Lower Fig. Gravid female. Aug. 3, 1920.

with irregular, tooth-like projections; the flap covers about a third of the margin of the mantle; a few crenulations occur on the edge of the mantle in front of this flap; inner laminae of inner gills entirely connected with the abdominal sac; palpi short and wide, connected for about a fourth of their length at base; Marsupium kidney-shaped, occupying posterior half of outer gills, with very small non-marsupial portion at posterior end; ovisacs numerous (15-40 or more).

Color of soft parts whitish, yellowish on foot, gills sometimes brownish; margin of mantle blackish on posterior portion; there is a black streak on the inner side of the eye spot on the mantle, inconspicuous.

Glochidia (pl. XXXII, fig. 15) large, semielliptical, hinge line short and evenly curved, ventral margin rounded. Length 0.250, height 0.290 mm. (Surber, 1912, p. 9). Ortmann gives 0.23 by 0.28 mm. Surber (1912, p. 4) states that glochidia from different localities may differ in size.

BREEDING SEASON: Bradyctictic. August to July. There is a short interim in July but gravid and discharged females have been observed in this month. As a species it may be said to be gravid throughout the year. Found gravid in Wisconsin in August in Red Cedar River, Omro, Fox River, Kilbourn, Wisconsin River. None gravid in July. Specimens from Red Cliff Creek were gravid on July 23, 1921.

NATURAL HOST: Bluegill (*Lepomis pallidus*), Yellow perch (*Perca flavescens*), wall-eyed pike (*Stizostedion vitreum*). Artificial infection has been carried through on gills of the following fish: *Lepomis pallidus*, *Micropterus dolomieu*, *M. salmoides*, *Perca flavescens*, *Pomoxis annularis*, *P. sparoides*, *Stizostedion canadense*, *S. vitreum*.

ECOLOGY: *Siliquoidea* is usually described as a mussel frequenting quiet water on a mud bottom and that it avoids riffles and large rivers. In Wisconsin it has been found in all of these situations. Some of these are noted below:

Outlet of Green Lake, a small creek, on sand bottom, water clear, with rapid flow, .3–.6 m. deep; Red Cedar River, in riffles, on gravel and sand bottom, water swift, .3–.6 m. deep; Prairie and Chetek lakes, sand bottom near shore, water .3–.6 m. deep (many specimens dark reddish, assuming characteristics of *rosacea* form). Lake Chetek, as well as Prairie Lake, are artificial, formed by damming Chetek River at the town of Chetek. The river form of *siliquoidea* is becoming the lake form as in the case of *Anodonta grandis* and *footiana*. Moose Ear Creek, near Chetek, shallow water, riffles, sand and gravel bottom. Shells much eroded and discolored. Fox River, at Omro, quiet water, mud or sand bottom, water .2–.3 m. deep. Kilbourn, Wisconsin River, mud or sand bottom, water 1–2 m. deep.

GENERAL DISTRIBUTION: Mohawk River, N. Y., west to Iowa, Kansas, and Missouri, north to Ontario, Michigan, and Minnesota, south to Kentucky, Oklahoma, and West Virginia.

DISTRIBUTION IN WISCONSIN: *Siliquoidea* is the most widely distributed mussel in the state, occurring in all of the drainage areas, including that of Lake Superior.

REMARKS: *Lampsilis siliquoidea* is the most abundant and widely distributed of Wisconsin Naiades. It is also one of the most variable in form, yet there are few species with which it can be confused. Its elongate-ovate shape, bright surface, distinct rays, and marked umbonal sculpture will usually readily identify it. Young individuals of *Actinonaias carinata* somewhat resemble young *siliquoidea*, but differ in being more elliptical in shape, in having a much heavier hinge plate, swollen umbones, and different umbonal markings. *Ligumia iris* is somewhat similar in form to young *siliquoidea*, differing in its more elongated shape, more compressed shell, feebler hinge teeth, and coarser and differently shaped beak markings.

The color and rays are variable, shells from the same habitat (as at Omro) varying from yellow to reddish, and from no rays to heavily or densely rayed. There is also much variation in the compression of the valves, some individuals being quite compressed while others are wider and more cylindrical. Occasional specimens are very high and resemble *Actinonaias carinata*. Old specimens become heavy, lose their rays and bright surface, becoming yellowish or brownish with feeble rays, and also becoming very much swollen.

Siliquoidea varies in size and diameter in the different river systems as has been noted in other species. The larger river specimens (Wisconsin, Rock) are larger and more swollen than the specimens from the smaller rivers and creeks, as Fox River, Red Cedar River, and St. Croix River. Some specimens have intense green rays on a polished surface and these have been referred to *radiatus* by several authors (Lapham, Jay, Chadwick, see extralimital species at end of this subfamily). Nothing approaching the true *radiata* of New York has been seen from this State. The same may be said of *borealis*. Shells from the Bayfield Peninsula, in streams flowing into Lake Superior, are not *Lampsilis superiorenensis*, as might be supposed, but are quite typical *siliquoidea*. No true *superiorenensis*

(of which specimens from the original locality are in the Hinkley collection) have been seen from Wisconsin.

The fat mucket is a very valuable shell for the button manufacturers and thousands of tons have been fished for this purpose. Certain varieties are of more value than others. The commercial value is discussed under the following variety.

The name *luteola* of Lamarck has for years been used for this species of mussel, but recently, Ortmann & Walker have shown that this name cannot be certainly identified with the present form. *Fasciata* of Rafinesque has been thought to be identifiable, but this has been shown to be unrecognizable from the description. The *siliquoides* of Barnes is clearly this species and was so decided by Lea (1829) and Conrad (1836). (See Ortmann and Walker, 1922, p. 61).

Siliquoidea differs somewhat from the typical form in the small streams and creeks, being more compressed and elongated. This variation soon disappears, however, as soon as the stream becomes of some size and the variation, apparently, cannot be recognized as in the case of some of the other species already discussed.

LAMPSILIS SILIQUOIDEA PEPINENSIS F. C. Baker. Lake Pepin Mucket
Plate XC, figures 2-5

Lampsilis siliquoidea pepinensis BAKER, Amer. Mid. Nat., X, p. 223, 1927.

TYPE LOCALITY: Lake Pepin, Lake City, Minn. (coll. Wagner).

WISCONSIN RECORDS:

1914. *Lampsilis luteola* WILSON and DANGLADE, p. 20. Lake Pepin.

1922a. *Lampsilis siliquoidea* GRIER, pp. 11-33. Pierce, Pepin, Buffalo, Trempealeau Co.

1922. *Lampsilis siliquoidea* GRIER and MUELLER, p. 101. Lake Pepin.

SHELL: Differing from typical *siliquoidea* in being comparatively shorter and higher, of much greater diameter with a more marked posterior slope, a thicker, heavier shell and more massive pseudocardinal teeth. The surface is usually marked with bright green rays of great intensity.

L. 94; H. 58; D. 39 mm. Lake Pepin (Male, U. of W., 354f). Paratype.

L. 77; H. 52; D. 48 mm. " " (Female, " 355p). Type.

L. 87; H. 52; D. 38 mm. " " (Male, " 355e). Type.

L. 74; H. 48; D. 34 mm. " " (Female, " 256).

L. 87; H. 55; D. 45 mm. " " (Male, U. of I., Z22075). Paratype.

L. 92; H. 60; D. 51 mm. " " (Female, " Z22075). Paratype.

ANIMAL: Not examined. Probably same as *siliquoidea*.

GENERAL DISTRIBUTION: Mississippi River and the lower part of the St. Croix River.

DISTRIBUTION IN WISCONSIN: Same as above.

ECOLOGY: In Lake Pepin found at depth of 8 meters (Pearse). Also found on sand and mud bottom in shallow water.

REMARKS: The *siliquoidea* from Lake Pepin are peculiar in having the valves of the shell very thick and heavy and in being greatly inflated, the female shell often being almost globular in extreme forms. The width index (diameter-length) of *pepinensis* 41 to 51% for males and 46 to 62% females. This form has long been known under the common name of "Lake Pepin mucket" and it seems quite appropriate that a scientific name should be given to so marked a variety. The extreme variation is found only in Lake Pepin, but the *siliquoidea* of the St. Croix River are also referable to *pepinensis* at least as far up as Osceola. Above Grantsburg, in Burnett Co., the shells begin to resemble the more typical form, but are more nearly like the lake variety. There is little variation among the large series of specimens examined from Lake Pepin. In Quiver Lake, Illinois River, near Havana, the *siliquoidea* are somewhat similar to the Lake Pepin form but material from the Illinois River at this locality is like the large river form of *siliquoidea*. These specimens were collected before sewage conditions became so bad.

The Lake Pepin mucket is considered one of the best of button shells. The Lake and St. Croix River yield a very distinct type of mucket, which is remarkably even in thickness, with a surface relatively flat in males, and even in females much less curved than usual. Practically the whole surface can be cut into blanks which are of suitable thickness. No other shell of any species cuts with as little waste, either as to the proportionate weight of the shell that is thrown away after cutting the blanks or as to the small amount to be ground from the blanks in reducing them to a proper thickness for buttons. The Lake Pepin mucket brought in 1914 and 1919, respectively, about \$20 and \$35 per ton (Coker).

The rate of growth is relatively rapid. At the Fairport station mussels of this species have grown to a length of more than one inch within six months after the date of infection

upon the fish. These were in floating crates in the river. The age of commercial shells can not yet be positively stated but it is probably from 4 to 6 years. Its fish hosts are the common game fishes, such as basses, crappies, sunfishes, perches, and pikes. The Lake Pepin mucket lends itself to methods of propagation better than any other species.

LAMPSILIS SILIQUOIDEA ROSACEA (De Kay). Lake Mucket

Plate XCI, figures 1-4

Unio rosaceus DEKAY, Zool. N. Y., V, p. 192, pl. xxxix, figs. 355, 356; pl. xl, fig. 357, 1843.

Lampsilis luteola var. *rosacea* SIMPSON, Cat., p. 62, 1914.

TYPE LOCALITY: Seneca Lake, N. Y.

WISCONSIN RECORDS:

1906. *Lampsilis luteola* CHADWICK, p. 91. Golden Lake and Ballard's Cottage, Okauchee Lake, Waukesha Co.;

1911a. *Lampsilis luteola* BAKER, p. 230 (part). Tomahawk Lake, Oneida Co.

1919. *Lampsilis luteola rosacea* ORTMANN, p. 292. Off Kenosha, in Lake Mich.

1927d. *Lampsilis siliquoides rosacea* BAKER, p. 107. Small lakes of Waukesha Co.

SHELL: Smaller than the typical *siliquoides*, the epidermis much lighter, usually yellowish, brownish, sometimes dark rusty red, the lines of growth at resting stages more clearly defined, forming distinct concentric rings of dark color; rays less distinct and often entirely absent; nacre white or pinkish; hinge frequently much weaker.

L. 90; H. 53; D. 38 mm. Green Lake (U. of W., 4409a). Male.

L. 71; H. 45; D. 29 mm. " " (" 4409b). Female.

L. 62; H. 38; D. 26 mm. " " (" 4409c). Male.

L. 59; H. 38; D. 31 mm. " " (" 4409d). Female.

L. 95; H. 51; D. 35 mm. Lake Monona (U. of W., 4411a). Male.

L. 77; H. 48; D. 34 mm. " " (" 4411b). Female.

ANIMAL: As in *siliquoides*. Glochidia identical.

BREEDING SEASON: Bradytictic like the river form. Specimens in Green Lake were not gravid in July.

ECOLOGY: *Rosacea* is a naiad of lakes, where it is very abundant on rocky or sand bottom in water from a few cm. to 2 m. or more in depth. Characteristic habitats: Green

Lake, sand, gravel, and sandy-clay bottom, water few cm. to 3 m. in depth; Sturgeon Bay, sandy-clay bottom, often with Chara, in water .6-2 m. deep. Of the Lake Erie *rosacea* Ortmann says: "In Presque Isle Bay in Lake Erie, where it is a common shell, it is found everywhere on the sandy and gravelly shores, in shallow water, and down to a depth of about fifteen feet in sand and mud. It also is found in the beach pools of Presque Isle, upon sandy-muddy bottom, and is one of the few shells existing in the open lake, being frequently thrown out alive by the surf". (1919, p. 292).

GENERAL DISTRIBUTION: New York west to N. Dakota, north to Minnesota, Moose River, and N. shore of Lake Superior, south to N. Illinois, N. Indiana, and N. Ohio.

DISTRIBUTION IN WISCONSIN: *Rosacea* appears to be confined principally to the eastern part of the State, judging by the records at hand. It is common on parts of the Lake Michigan shore and also in the group of small lakes in the eastern and southeastern part of Wisconsin. It is known from lakes in the headwaters of the Chippewa, Wisconsin, and Rock rivers. Curiously enough it has not been recorded from the lakes in the northwestern part of the State.

REMARKS: *Rosacea* appears to be a recognizable variety of *siliquoidea*. It is a mussel of the lakes, usually smaller than the typical form, with a reddish or yellowish shell, the rays more or less feeble. Many specimens from Lake Mendota, Green Lake, and Green Bay are of a rich, rusty red color, very intense toward the umbones and the anterior end. Shells from Lake Butte des Morts are somewhat different from typical *siliquoidea* and approach *rosacea*, but the males having a more pointed posterior end and the epidermis being dark brownish-green or brown, with distinct rays on many individuals. These shells are nearer typical *siliquoidea*, however, and show the influence of the Fox River, where the typical form is abundant. The *rosacea* from Green Lake are very uniform and typical of the variety, the epidermis being yellowish, suffused with more or less rusty red or pink. The nacre is usually silvery white though a few individuals occur with rosy nacre, as first described by DeKay.

LAMPSILIS SILIQUOIDEA CHADWICKI Var. Nov.

Plate XCI, figures 5-8

TYPE LOCALITY: Doemel Point, Lake Winnebago, near Oshkosh.

WISCONSIN RECORDS:

1906. *Lampsilis luteola* CHADWICK, p. 91. Lake Winnebago, near High Cliff.

1924. *Lampsilis siliquoides rosacea* BAKER (part), p. 132. Lake Winnebago.

SHELL: Differing from *rosacea* in being thicker and more solid, more inflated and cylindrical, umbones flatter and broader, hinge heavier with stumpier and more massive teeth, and with a deeper beak cavity; the color is yellowish or yellowish green with few or many dark green rays; surface dull, not shining as in *rosacea*; smaller than *siliquoides*, much more swollen, shorter in comparison with width and height; nacre not clear white, blotched and spotted with brown marks.

L. 75; H. 44; D. 30 mm. Doemel Point (Male, U. of W., 4413a). Type.

L. 67; H. 40; D. 37 mm. " " (Female, " 4413b). Type.

L. 78; H. 48; D. 36 mm. " (Male, U. of I., Z22076). Paratype.

L. 76; H. 48; D. 36 mm. " (Female, " Z22076). Paratype.

ANIMAL: As in *rosacea* and *siliquoides*. Glochidia not examined.

BREEDING SEASON: Probably same as *siliquoides*. None found gravid in July (specimens collected from July 1 to 28). Several gravid (eggs) in August (26).

NATURAL HOST: Unknown.

ECOLOGY: *Chadwicki* is a naiad of rock and gravel shores in water .3-3.5 m. deep. Off Doemel Point, 11 feet, gravel bottom; Lower Asylum Bay, stone and gravel bottom, .3-.6 m. deep; Long Point Island, 1.6 m. deep, cobble bottom. None found living on any but a stony bottom.

DISTRIBUTION IN WISCONSIN: Lake Winnebago, west of High Cliff (Chadwick); collected from the following places in Lake Winnebago: Long Point Island, Doemel Point, Libby Point, Roe Point, Asylum Point, Mansur Bay. Probably occurs on all shores in the lake (Baker).

REMARKS: The form herein diagnosed as *chadwicki* bears somewhat the same relation to *siliquoides* that *pepinensis* does,

the large lake environment producing a heavy, more or less swollen shell. All of the Lake Winnebago Lake shells are referable to *chadwicki*, but in Lake Butte des Morts, *siliquoidea* occurs. The inflated form of Lake Winnebago recalls both *borealis* and *hydianus*, being more like the latter. Comparison with *hydiana*, however, shows that the lake shells are a variation of the *rosacea* type, not having the same epidermis or rayed surface of *hydiana*, which is a more southern shell. *Borealis* is another form related to *radiata* and quite different from the present variety. The Winnebago shells might be included in *rosacea* as a marked variety but it seems better to distinguish them as a local variety of *siliquoidea*. Some specimens resemble individuals of *rosacea* from Sturgeon Bay, but the majority are different from this variety and would be quickly observed if mixed with typical *rosacea*. Their chief distinguishing characteristic is the striking cylindrical form produced by the increase in diameter. It seems another example of the result of response to a somewhat unfavorable environment. This interesting form is named in honor of Professor George H. Chadwick, of the University of Rochester, who some years ago prepared a very good catalog of the Mollusca of Wisconsin (see 1906).

Chadwicki is largely fished for button material in Winnebago Lake, especially in the vicinity of Long Point Island, where a crowfoot dredge supported with wheels at either end is used. This is made necessary because of the stony character of the environment, the usual form of dredge being quite useless on such a bottom. When not in use the dredge rope is attached to a large log which marks the place for later work. Some of the best specimens from the lake were obtained with this dredge, which the author borrowed without the owner's consent.

Lampsilis siliquoidea is a striking example of the correlation of shape and station in the naiades, though belonging to a group (the Lampsilinae) in which the species of diverse habitats show little variation. Beginning with the creeks and small rivers the shell is elongated, compressed or flattened laterally, rather high and yellowish in color with few or many light green rays. As the streams increase in size, the shell becomes larger and rather more cylindrical; this feature is strongly emphasized in the Mississippi, the large river, when the shell becomes some-

what smaller, notably cylindrical, with the umbones a trifle nearer the center than in the typical form; the color also becomes more greenish with many dark green rays; in Lake Pepin, and for some distance up the Mississippi and St. Croix rivers, another variation takes place, in which the shell becomes strikingly solid, much shortened and very globose; this is *pepinensis*, a variation of the large river form. In Lake Winnebago another variation occurs in which the shell becomes small, cylindrical, and of greater obesity; this is *chadwicki*, a variation of the small river or creek form; finally, the true lake variety, *rosacea*, a form with rosy or pinkish shell, shortened and obese, occurs in the smaller lakes and in Lake Michigan and its bays. These four variations are direct responses to a change of environment, two of which have developed in a lake lying between two extremities of a river. This variation is parallel by *Strophitus rugosus* in the *Anodontinae*, and *Fusconaia flava* and *undata* in the *Unioninae*, indicating that in each of these sub-families certain species occur in which the law of stream variation is more active than in others.

LAMPSILIS VENTRICOSA (Barnes). Pocketbook

Plate XLVIII, figure 7

Unio ventricosus BARNES, Amer. Journ. Sci., VI, p. 267, pl. xiii, fig. 14, 1923.

Lampsilis ventricosa SIMPSON, Cat., p. 38, 1914.

Lampsilis ventricosa ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 63, 1922.

TYPE LOCALITY: Wisconsin and Mississippi rivers, Prairie du Chien, Wisconsin.

WISCONSIN RECORDS:

- 1823. *Unio ventricosus* BARNES, p. 267. Prairie du Chien, Wisconsin and Mississippi rivers.
- 1834. *Unio occidentalis* COOPER, p. 155. Wisconsin River. (?)
- 1905c. *Lampsilis ventricosa* BAKER, p. 252. Prairie du Chien.
- 1906. *Lampsilis ventricosa* CHADWICK, p. 90. Between Prairie du Chien and De Soto.
- 1914. *Lampsilis ventricosa* SIMPSON, p. 39. Prairie du Chien.
- 1922a. *Lampsilis ventricosa* GRIER, pp. 11-31. Mississippi River.
- 1926. *Lampsilis ovata ventricosa* GRIER and MUELLER, p. 18. Upper Mississippi River.

SHELL: Large and ponderous when old, rather solid when mature, thin when young, subovate to subelliptical, in many

cases almost as high as long, especially in the female shell; anterior end sharply rounded; ventral margin curved; dorsal margin straight or slightly convex; posterior end ending in a blunt point formed by the meeting of dorsal and ventral margins upward and downward, the posterior dorsal junction often forming a distinct angle, especially in young shells; anterior region in front of umbones sometimes inclined to be slightly alate with a pinched appearance; beaks swollen, elevated above the hinge line; beak sculpture very coarse, of 4 or 5 bars, of which the 2-3 may be slightly double-looped, the 4-5 quite indistinct; none of the bars appear on the posterior slope; posterior ridge rounded, sometimes distinct near the umbones, better developed in young shells; the dorsal area is sometimes a little excavated behind the ridge; posterior slope flat or slightly convex; epidermis smooth and shining, yellowish-green, or green, with dark green rays which vary greatly in width; the rays may be almost absent, or cover only a part of the surface; lines of growth more or less distinct and sometimes elevated into small ridges in old shells, particularly at rest periods; the rays may also be arranged to form indistinct bands of color.

Pseudocardinals heavy, more or less triangular, compressed in young and immature specimens, squarish or stumpy in old individuals, parallel with hinge line, all serrated; left valve with two teeth, right valve with a second, small pseudocardinal in front just below the lunule; this becomes a mere tubercle in old specimens; laterals lamellar, high, straight, the single right lateral abruptly truncated at the posterior end; interdentum very narrow, but usually present; cavity of the beaks deep, containing dorsal muscle scars; anterior adductor muscle scar deeply excavated, posterior scar distinct; nacre silvery-white, more or less iridescent, sometimes suffused with pink which may in some cases become dark pink and cover the entire valve, especially in young shells from certain localities.

Sexual differences well marked, the male shell being elongate-ovate with more or less pointed posterior end, the female more inflated with the post-basal region expanded to form a large swelling, causing the posterior end to have a truncated appearance.

- L. 132; H. 94; D. 71 mm. Lone Rock, Wis. R. (Dudley coll.). Male.
 L. 105; H. 69; D. 55 mm. Prairie du Chien (U. of I., Z22390). Male.
 L. 121; H. 83; D. 67 mm. " " " (Dudley coll.). Female.
 L. 106; H. 75; D. 53 mm. " " " (U. of W., 4420). Female.

ANIMAL (Fig. 241): Mantle connection between anal and supra-anal opening about half the length of supra-anal; branchial opening large, papillose; anal opening small, crenulated; the mantle edge, in front of the branchial opening has a short, wide flap, which extends well beyond the border of the mantle; the anterior termination of the flap is toothed; an eye spot is developed at the end near the branchial opening; this lobe is very large and much expanded when the animal is living; inner laminae of inner gills usually entirely connected with abdominal sac; palpi connected basally for about a third of their length; marsupium large, pad-like, occupying more than half the outer gill, consisting of upwards of 30 ovisacs; the edge of

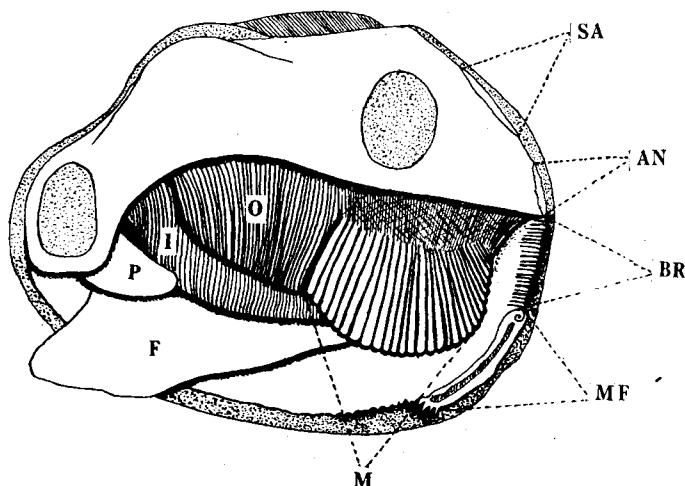


Fig. 241. *Lampsilis ventricosa occidens* (Lea). Omro, Fox River. Gravid female. Aug. 3, 1920.

the marsupium is marked with pigment; placentae discharged in unbroken masses. Color of soft parts grayish-white, gills brownish, foot yellowish or blackish; marsupium white with black margin; edge of mantle mottled with brownish or blackish.

Glochidia (pl. XXXII, fig. 24) of medium size, semielliptical, hinge line short, evenly curved, ventral margin rounded.

Length 0.205, height 0.255 mm. (Surber, 1912, p. 9); 0.25 by 0.29 mm. (Ortmann, 1919, p. 302). This wide discrepancy may be due to the confusion of two varieties, Surber's specimens being the Mississippi River form (*ventricosa*) while Ortmann's being the smaller river form (*occidens*).

BREEDING SEASON: Bradyctictic. Early August to early July. Interim in July when females have discharged glochidia. Females are more numerous than males, sometimes having the ratio of 2 to 1, as in Red Cedar River. Gravid females were observed in Red Cedar River August 11 to 23; in Fox River, at Omro, females were sterile on July 1. The same condition was observed in the Wisconsin River, at Kilbourn, in July.

NATURAL HOST: Natural infection observed on gills of white crappie (*Pomoxis annularis*) and sauger (*Stizostedion canadense*). Artificial infection has been successfully induced on gills of bluegill (*Lepomis pallidus*), small mouth black bass and large mouth black bass (*Micropterus dolomieu* and *salmoides*), yellow perch (*Perca flavescens*), and white crappie (*Pomoxis annularis*). Coker, Shira, et al, 1921, p. 153.

ECOLOGY: On sand and gravel bottom, more rarely in mud, in water 1-4 m. deep.

GENERAL DISTRIBUTION: In the larger rivers, Mississippi, lower Ohio and Wisconsin; probably also in lower part of Illinois, Wabash, and Rock rivers.

DISTRIBUTION IN WISCONSIN: Confined to the Mississippi River and the lower part of the Wisconsin River (as far up as Lone Rock, Iowa Co.).

REMARKS: *Lampsilis ventricosa* is readily recognized by its ovate outline and large shell with bright green rays on a yellowish or greenish background. It varies greatly, however, in color and thickness, but is rather uniform in shape. The nacre varies from bluish-white to pink and the epidermis from yellowish with faint rays to greenish with many wide, dark green rays. Female shells are much higher postbasally than male shells. The female also somewhat resembles *Proptera capax*, which is much smaller and uniformly brownish or olive without the bright green rays of *ventricosa*.

The type form of *ventricosa* is from the Mississippi and Wisconsin rivers near Prairie du Chien. Though Barnes probably included all forms of the *ventricosa* type in his species, the form

with the wide, almost centrally-placed, swollen umbones must be taken as the typical *ventricosa*, as it occurs at Prairie du Chien. This form differs greatly from the more compressed shells of the smaller rivers, in which the umbones are placed nearer the anterior end and are more depressed. Transition forms are abundantly represented in material from the lower parts of the Illinois, Rock, Wabash, and Ohio rivers. Specimens from Posey County, Indiana, are of this character. Though Barnes' figures are of small specimens, they plainly indicate the form with high, centrally-placed, swollen umbones. Typical *ventricosa* is rather a deep water form while the shell of smaller streams is characteristic of shallow water.

LAMPASILIS VENTRICOSA PERGLOBOSA Var. Nov.

Plate XCH, figures 1-4

TYPE LOCALITY: Lake Pepin, near Lake City, Minn.

WISCONSIN RECORDS:

1922a. *Lampsilis ventricosa* GRIER, pp. 11-31. Lake Pepin.

1926. *Lampsilis ovata ventricosa* GRIER and MUELLER, p. 18. Lake Pepin.

SHELL: Differing from *ventricosa* in being smaller, more globose, the umbones relatively more inflated and higher, especially in the female shell; the shell is relatively shorter and higher; color very light yellowish or slightly pinkish with very dark, grass-green rays.

L. 94; H. 63; D. 46 mm. Lake Pepin (U. of W., 354a). Male. Type.

L. 79; H. 59; D. 48 mm. " " (U. of W., 354g). Female. Paratype.

L. 76; H. 55; D. 45 mm. " " (U. of W., 255). Female. Paratype.

ANIMAL: Not examined.

ECOLOGY: Lake Pepin, 4.5 m. in channel (Pearse).

GENERAL DISTRIBUTION: Lake Pepin.

DISTRIBUTION IN WISCONSIN: Not known outside of Lake Pepin (Grier & Mueller, Pearse, Wagner).

REMARKS: As in the case of *Fusconia undata*, *Strophitus rugosus*, and *Lampsilis siliquoidea*, the Lake Pepin form of *Lampsilis ventricosa* is strikingly different from the Mississippi River form as well as from the more compressed form as it occurs in the smaller rivers. The small, globose shell of the female is so characteristic as to raise the question of its relationship to *ventricosa* without the presence of intermediate

forms. *Perglobosa* is common in Lake Pepin and the specimens seen show little variation among themselves. Grier noted the greater diameter of the Lake Pepin shells as well as their greater height. Just how far up or down the Mississippi River this variety extends is not known, no material being at hand for comparison.

LAMPSILIS VENTRICOSA OCCIDENS (Lea). Pocketbook

Plate XCII

Unio occidens LEA, Trans. Amer. Phil. Soc., II, p. 435, pl. x, fig. 16, 1829; Obs. I, p. 49, pl. x, fig. 16, 1834.

Unio subovatus LEA, Op. Cit., IV, p. 118, pl. xviii, fig. 46, 1831; Obs. I, p. 128, pl. xviii, fig. 46, 1834.

Lampsilis ventricosa STIMPSON, Cat., p. 38, 1914 (part).

Lampsilis ventricosa of authors generally.

TYPE LOCALITY: Ohio (*occidens*); Ohio River (*subovatus*).

WISCONSIN RECORDS:

1852. *Unio cardium* LAPHAM, p. 369. Wisconsin.

1860. *Unio occidens* LEA, p. 51. Wisconsin.

1860. *Unio ventricosus* LAPHAM, p. 156. Wisconsin River.

1885. *Unio ventricosus* CALL, p. 55. Wisconsin.

1897. *Unio ventricosus* WISWALL, p. 47. Southern Wisconsin.

1906. *Lampsilis ventricosa* CHADWICK, p. 90 (part). Milwaukee River; Clear Water Lake Creek, Oneida Co.; Dodgeville, Iowa Co.; Wisconsin River.

1906. *Lampsilis occidens* CHADWICK, p. 91. Nashotah, Waukesha Co.

1911a. *Lampsilis ventricosa* BAKER, p. 230. Wisconsin River and Gilmore Creek.

1919. *Lampsilis ovata ventricosa* ORTMANN, p. 306. Wisconsin.

1924. *Lampsilis ventricosa* BAKER, p. 132. Omro, Fox River.

1927d. *Lampsilis ventricosa* BAKER, p. 107. Rock River, Ashippun to Rock Co.

SHELL: Differing from *ventricosa* by being relatively more compressed, especially in the male, the anterior end longer and more narrowly rounded (ratios of anterior length to umbones, males 22 to 32 per cent., females 29-32 per cent. for *occidens*; males 38-39 per cent., females the same for *ventricosa*); the umbonal region in *occidens* is more depressed and compressed; the color is more often yellowish with faintly marked rays, though these are more marked in young shells; the hinge in *occidens* becomes much heavier in old shells, the pseudocardinals becoming thick and solid; the shell also grows to a larger size in *occidens*.

L. 176; H. 130; D. 81 mm.	Ashippun (U. of I., Z17374a).	Male.
L. 163; H. 135; D. 82 mm.	" (" Z17375a).	Female.
L. 144; H. 94; D. 60 mm.	Dell Creek (U. of W., 4419a).	Male.
L. 128; H. 99; D. 62 mm.	" " (" 4419b).	Female.
L. 102; H. 67; D. 42 mm.	Princeton (U. of W., 4414).	Male.
L. 156; H. 96; D. 59 mm.	" (" 4416a).	Male.
L. 114; H. 80; D. 65 mm.	" (" 4416b).	Female.
L. 99; H. 73; D. 45 mm.	Red Cedar River (U. of W., 4415).	Female.
L. 55; H. 34; D. 25 mm.	Portage (U. of W., 774).	Male.

ANIMAL: As in *ventricosa*. The discrepancy in size between the glochidial measurements of Surber and Ortmann are probably due to the fact that they represent the two varieties of mussels here indicated, as noted below: *Ventricosa*, Mississippi River, size 0.205 by 0.255. Surber, 1912, p. 9. *Occidens*, smaller streams, size 0.25 by 0.29. Ortmann, 1919, p. 302.

BREEDING SEASON: See under *ventricosa*.

NATURAL HOST: Probably much the same as for *ventricosa*. It is probable, however, that in the creeks and smaller rivers there may be other species of host involved.

ECOLOGY: Commonly distributed in the smaller and medium sized rivers, under varying habitat conditions. The following are typical for Wisconsin: Red Cedar River, in riffles among gravel and coarse sand buried deeply, only the tip of the shell exposed above the bottom, in shallow water (.3-.6 m.); outlet of Lake Chetek, on a rock bottom in water .3-.6 m. deep, in riffles, and on a hard, firm, sand bottom. In both rivers the current is very swift. Fox River at Omro, on a sandy-mud bottom along the edge of the river, in water .3-1 m. deep, in a steady, strong current; Wisconsin River at Kilbourn, on a sand and gravel bottom (rarely mud) in water about 2 m. deep, current very rapid. Red Cedar specimens are dark red in color.

Female specimens of *occidens* have been observed, both in Illinois and Wisconsin, in the act of discharging glochidia. This feature was most clearly observed in the Big Vermilion River in Illinois on Sept. 26, 1918 (Baker, 1922d, p. 55). The shells were buried in the sand, only the tips of the siphons showing above the general level of the bottom of the stream. The bright yellow mantle flap, which is enlarged during the period of mature gravidity, was observed to wave about with a graceful, undulatory motion. The movements were more or less intermittent, a waving period being followed by a resting stage. The mussels had well formed glochidia and were evi-

dently discharging embryos from the marsupia. These glochidia are of the hookless type and develop on the gills of the fish host and the undulatory motions probably attract these fish which may be thus more easily infected with the glochidia, as suggested by Wilson and Clark (1912, pp. 13, 14). This undulatory motion of the mantle flap is so striking that it at once attracts the attention of an observer, even if this person is not interested in the study of these animals. The habit of burying itself deeply in the sand bottom (10-180 cm.) renders this species extremely difficult to collect, especially if the sand be packed rather hard and the water is half a meter or more deep as frequently occurs in the fall of the year, when *ventricosa* may be hand collected in the smaller streams.

Ortmann's observations on the ecology of *ventricosa* do not entirely agree with the conditions as found in Illinois and Wisconsin. He records it as not favoring rough bottoms and currents, but rather quiet pools and eddies above and below riffles. It has been found in these situations in both states mentioned but also in the other kinds of habitats listed.

GENERAL DISTRIBUTION: Western New York west to Iowa and Missouri, north to Minnesota, south to Kentucky and Oklahoma.

DISTRIBUTION IN WISCONSIN: *Occidens* will probably be found to inhabit all of the stream drainages of the State, excepting, perhaps, the Lake Superior drainage. It is abundant wherever found, but is chiefly characteristic of small and medium sized rivers. It occurs in both the Mississippi and Great Lakes drainages. Curiously enough, it has not been reported from north of Milwaukee in the Lake Michigan drainage, nor from the rivers draining into Green Bay (the Menominee drainage).

REMARKS: The variety *occidens* is normally readily recognized by its ovate outline and large shell with green rays on a yellowish or greenish background. It varies greatly, however, in color and thickness. Wisconsin specimens are usually rather uniform in shape. Young and immature specimens are usually well colored, but old individuals become brown or blackish and lose their rays, besides increasing greatly in thickness. The epidermis may vary from plain yellow to yellow with green rays in the same locality. The nacre varies from bluish-white to pinkish. Male shells are more or less compressed while

female shells are usually much inflated. In old females the shell develops a great height, as much as two-thirds of the length, and the umbones become more inflated.

Occidens may be confused with several other species. *Siliquoidea* has a more elongated shell, less inflated beaks, and wavy or interrupted rays, which are also narrower. Old *occidens* which are elongated may be confused with *Actinonaias carinata*, but the inflation of the umbones and the different hinge structure will usually distinguish these. In old *occidens* the pseudocardinals also become very heavy and somewhat resemble those of *carinata* (*ligamentina*).

Shells from the Chippewa drainage, both Chippewa River and the outlet of Lake Chetek, have very dark red or chestnut epidermis and are wider than the shells from other places, even the shells of the Red Cedar River nearby being more like the typical *occidens* in color.

Lea's *occidens* and *subovatus* are founded on a more compressed and otherwise somewhat different form of shell from typical *ventricosa* as found in the Mississippi River, and the variety should be recognized. *Occidens* is the female shell and *subovatus* the male shell. Ortmann's figures of *ventricosa* (1919) are all of the *occidens* type. We cannot agree with Ortmann that *ventricosa* is a race of *ovata*, which seems more nearly related to *excavata*, both having the same form of posterior ridge and umbones.

The pocketbook does not rank high as a button shell, the males being better, however, than the females. The *occidens* of the smaller rivers are considered better than the typical *ventricosa* form, the shells being larger and thicker, the males having a flatter, broader surface for cutting large blanks.

LAMPSILIS VENTRICOSA LURIDA Simpson. Lurid Pocketbook

Plate XCIII, figure 5; plate XCIV, figures 5, 6

Lampsilis ventricosa var. *lurida* SIMPSON, Cat., p. 41, 1914.

TYPE LOCALITY: Not specifically given. St. Lawrence drainage (Simpson).

WISCONSIN RECORDS:

1906. *Lampsilis ventricosa* CHADWICK, p. 90. Clam Lake, Waupaca Co.

1860. *Unio cariosus* LAPHAM, p. 156. Silver Lake.

1891. *Unio canadensis* BROWN, p. 81. Lake Ellen.

1927d. *Lampsilis ventricosa canadensis* BAKER, p. 107. Small lakes, Waukesha Co.

SHELL: Differing from *ventricosa occidentis* in being generally smaller, the epidermis light yellowish or yellowish-green, or grayish-yellow, with a few widely separated rays, or rayless, often much lighter in color on the posterior slope. Many individuals are reddish or brownish, especially on the disk and near the beaks. Old males are longer in proportion to height than are the males of *occidens*. Hinge not as massive as *occidens*.

- L. 138; H. 83; D. 65 mm. Lake la Belle (U. of I., Z17360). Male.
 L. 95; H. 65; D. 39 mm. Lake Ellen (U. of I., Z3995). Male.
 L. 87; H. 60; D. 39 mm. " " (" "). Female.
 L. 95; H. 59; D. 40 mm. Lake Noquebay (U. of W., 4421). Male.
 L. 103; H. 65; D. 45 mm. Sturgeon Bay (U. of W., 3322a). Male.
 L. 84; H. 65; D. 41 mm. " " (U. of W., 4422b). Female.

ANIMAL: As in *occidens*. Glochidia not observed.

BREEDING SEASON: Gravid females have been seen in May. July specimens were sterile. Season probably same as *occidens*.

NATURAL HOST: Not recorded.

ECOLOGY: On more or less exposed shores of small lakes. In the small lakes of Waukesha Co. in shallow water near shore in gravel or sand bottom. On a sand or rock bottom in water 1-2 m. deep in Sturgeon Bay.

GENERAL DISTRIBUTION: *Lurida* is largely confined to the St. Lawrence basin drainage. It is known from New York, Michigan, and Wisconsin. Since it has been confused with *ventricosa* and *canadensis* the exact limits of its range are not clear. It probably extends northward in Canada as well as farther west in Wisconsin. It is common in large as well as small lakes.

DISTRIBUTION IN WISCONSIN: This species is largely restricted to the lakes in the Lake Michigan drainage. Several records in Waukesha Co. are in lakes draining into the Rock River and thus belong to the Mississippi drainage. These would seem to be migrants from the eastern part of the St. Lawrence system.

Menominee Drainage: Lake Noquebay, near Crivitz, Marinette Co. (Bullock).

Green Bay: Sturgeon Bay, Door Co. (Baker); Brown Co. (Marston).

Fox Drainage: Clam Lake, Waupaca Co. (C. E. Brown, Chadwick).

Rock Drainage: Silver Lake, Waukesha Co. (Lapham); Oconomowoc, Little Silver, La Belle, Golden, Lower Genessee, Beulah lakes, Waukesha Co. (Cahn).

REMARKS: *Lurida* is a lake form of *ventricosa occidentis* and bears much the same relation to *ventricosa* that *rosacea* bears to *siliquoides*, both being smaller than the typical species, and both having the same brownish or yellowish epidermis and reddish beak regions. They both appear to be dwarfed forms characteristic of more northern regions. Old males of *lurida* are comparatively more elongated than are the males of the river form and the posterior end has a tendency to become more pointed (pl. XCIII, fig. 5). The reddish color of the umbonal region is not confined to *lurida*, for in specimens of *occidentis* from Chetek River and also Fox River the shells are so marked.

Western references to *Lampsilis cariosa* all seem founded on forms of *lurida*. We agree with Simpson that *canadensis* and *lurida* are not the same form. *Canadensis* would seem to be the small form characteristic of the great lakes, being smaller than *lurida* with the posterior slope rather more flattened than *lurida* and with the posterior end peculiarly drawn out in the male. The same type is found in Lake Erie, Lake St. Clair, and the Detroit River. It is also found in Lake Huron. Ortmann (1919, p. 307) correctly restricts this form to the large lake type. As far as observed, the *canadensis* type is seldom as lurid as *lurida*. True *canadensis* has not been observed in Wisconsin.

LAMPSILIS VENTRICOSA WINNEBAGOENSIS Var. Nov.

Plate XCIV, figures 1-4

TYPE LOCALITY: Winnebago Lake, near Oshkosh, Wis.

WISCONSIN RECORDS:

1906. *Lampsilis ventricosa* CHADWICK, p. 90. Lake Winnebago, near High Cliff, Calumet Co.
1924. *Lampsilis ventricosa canadensis* BAKER, p. 132. Lakes Winnebago and Butte des Morts.

SHELL: Differing from *lurida* in being smaller, the males more cylindrical, the females rounder, shorter, of relatively greater diameter, with a less marked post-basal expansion; color yellowish with more or less well marked dark green rays; the umbones are placed relatively nearer the center of the shell.

- L. 77; H. 47; D. 34 mm. Lake Winnebago (U. of W., 4423a). Male. Type.
L. 70; H. 52; D. 34 mm. Lake Winnebago (U. of W., 4423b). Female. Paratype.
L. 77; H. 51; D. 38 mm. Lake Winnebago (U. of I., Z12244a). Male. Paratype.
L. 80; H. 60; D. 39 mm. Lake Winnebago (U. of I., Z12244b). Female. Paratype.

BREEDING SEASON: Probably in May. No gravid specimens seen in July or August.

ECOLOGY: Long Point Island, sand and gravel bottom, water .3-.6 m. deep; Lower Asylum Bay, gravel and stony bottom, water .3-.6 m. deep; off Long Point Island, cobble bottom, water 1.5 m. deep; Lake Butte des Morts, off Plummers Point, sand bottom, water 1 m. deep.

DISTRIBUTION: Not known outside of the State.

DISTRIBUTION IN WISCONSIN: As far as known confined to Lakes Winnebago and Butte des Morts (Baker, Chadwick).

REMARKS: A form of *ventricosa* abundant in Winnebago Lake is so different from typical *lurida* as to require separate designation. The more cylindrical shape of the male and the rounder outline of the female will readily distinguish it from *lurida*, besides which it never attains the dimensions of that variety. The color is nearer *occidens*, the rays being of the same dark green color, and more numerous than in *lurida*. The shell never has the elongated posterior end of the latter. *Winnebagoensis* is a variation of the *occidens* type produced by a lake environment, a dwarf form, probably. The *occidens* of the upper Fox River, near Omro and Princeton, are very large, the males much compressed and the females greatly inflated, as much so as the females of the *ventricosa* in the Mississippi River. The variation is paralleled by the small form of *ventricosa* found in Lake Pepin, which is a river-formed lake. The two variations are, however, entirely different. The several hundred specimens examined of the Winnebago Lake form show very little variation among themselves, being more uniform in this respect than either *lurida* or *occidens*. All of the naiades in Lake Winnebago are different from the river forms as noted in Fox River.

Lampsilis ventricosa parallels the same variation observed in *Lampsilis siliquidea*, which inhabits the same territory and ecological situations. The law of stream development is beau-

tifully shown by these two species. *Ventricosa* responds to environmental changes as follows:

Typical *ventricosa*. Large stream form. Mississippi River.

Perglobosa. Lake-river form. Lake Pepin.

Occidens. Smaller river form. Wisconsin, Ohio, Rock rivers.

Lurida. Form of small inland lakes.

Winnebagoensis. Form variant from *occidens* of the river to a river-lake environment.

Canadensis. Great Lake variant.

LAMPSILIS HIGGINSII (Lea). Higgin's Fye

Plate XCV

Unio higginsii LEA, Proc. Acad. Nat. Sci. Phil., IX, p. 84, 1857; Jour. of same, V, p. 188, pl. xxiv, fig. 258, 1862; Obs., IX, p. 10, pl. xxiv, fig. 258, 1863.

Lampsilis higginsii SIMPSON, Cat., p. 78, 1914.

Lampsilis higginsii var. *grandis* SIMPSON, Cat., p. 78, 1914.

TYPE LOCALITY: Muscatine, Iowa.

WISCONSIN RECORDS:

1905c. *Lampsilis orbiculata* BAKER, p. 253. McGregor, Iowa.

1921. *Lampsilis orbiculata* and *higginsii* SHIMEK, McGregor, Iowa.

1922a. *Lampsilis higginsii* GRIER, pp. 11-31. Pierce, Buffalo, Trempealeau Co.

1922. *Lampsilis higginsii* GRIER and MUELLER, p. 101. Lake Pepin.

SHELL: Oval or elliptical, somewhat inflated, solid, with gaping anterior base; beaks placed forward of the center of the dorsal margin, much elevated, swollen, their sculpture consisting of a few feeble ridges slightly looped; anterior end broadly rounded; posterior end truncated in the female, bluntly pointed in the male; ventral and dorsal margins slightly curved, almost parallel; posterior ridge rounded but well marked; surface shining, marked by irregular growth lines which are better developed at rest periods where they are usually dark colored; epidermis olive or yellowish-green with faint green rays.

Hinge massive; pseudocardinals erect, triangular or pyramidal, divergent, serrated, two in the left and one in the right valve, with sometimes indications of additional denticles on either side of the single right pseudocardinal; interdentum narrow, flat; laterals short, thick, slightly curved, almost smooth; cavity of the beaks deep, containing the dorsal muscle scars; anterior adductor scar deeply excavated, posterior scar distinct; nacre silvery-white, iridescent, often tinged with pink.

Sex differences in the shell strongly marked. In the male the posterior end is roundly pointed; in the female it is sharply truncated, and there is a decided post-basal swelling.

L. 68; H. 49; D. 38 mm. Lake Pepin (U. of I., Z14027). Female.

L. 85; H. 60; D. 43 mm. Mississippi River, Ill. (U. of I., Z7364). Male.

L. 90; H. 70; D. 50 mm. " " " (" "). Female.

ANIMAL: Similar to *orbiculata* and other *Lampsilis*. Ortmann says of *orbiculata*, "This flap (the mantle flap) has numerous teeth along its edge, and projects at the anterior end in a free lobe. It also has black pigment on the inside. An eye spot has not been seen, but this may be obscured on account of the contracted condition of my specimens. All the rest of the soft parts are like those of the foregoing species (of *Lampsilis*). See Ortmann, 1912a, p. 353.

Glochidia (pl. XXXII, fig. 23) of medium size, semielliptical ventral margin rounded, hinge line short, undulate. Length 0.210, height 0.260 mm. (Surber, 1912, p. 9).

BREEDING SEASON: Bradytictic. Gravid in May and September (Surber, p. 7).

NATURAL HOST: On gills of *Stizostedion canadense*. A specimen of this fish contained 600 glochidia on Oct. 4, 1912 (Surber, 1913, p. 107).

ECOLOGY: Not well recorded. Apparently a species of the larger rivers.

GENERAL DISTRIBUTION: Mississippi river. *Higginsii* has been confused with *orbiculata* and its range is not clear. It is known certainly from the Mississippi River, from Fairport to Lake Pepin, and from the Illinois River as far as Havana. Reported from parts of Illinois, Indiana, and other states but some of these are the *orbiculata*.

DISTRIBUTION IN WISCONSIN: Not known outside of the Mississippi River, where it occurs from the State line to Lake Pepin, more or less sparingly in some localities.

REMARKS: *Lampsilis higginsii* can be confused with but one other species in Wisconsin, *Obovaria olivaria*, which, however, has a different hinge structure and the outline is more regularly ovate. Small specimens somewhat resemble *Actionaias carinata*. The valves of *higginsii* are very thick. There appears to be very little variation in the shape of the shell in Wisconsin specimens. *Lampsilis orbiculata*, a related species with a

rounder outline and less inflated umbones, has been recorded from the Mississippi River near Prairie du Chien, but all material examined from the Mississippi River has been clearly referable to *higginsii*. It has been suggested that *higginsii* is the large-stream form of *orbiculata* Hildreth, and an index of comparative obesity has been established, *orbiculata* having 55 per cent. or less and *higginsii* more than 55 per cent. (Ball, 1922, p. 113). However, my material from the Mississippi River is all 55 percent or under, none exceeding this percentage, and they would fall under *orbiculata* according to this arbitrary standard. The two forms, as represented by typical material from the Mississippi and the Ohio and southern rivers, indicate that they may well be separated as distinct species. The umbonal peculiarities (depressed and elevated) are characteristic and easily separate any specimen I have seen among the rather ample material at hand. Lake Pepin shells average somewhat smaller than those from the Mississippi River.

Ortmann found two sizes of glochidia on his slides, measuring as follows: 0.19 by 0.21 mm. and 0.20 by 0.25 mm. His specimens came from the Ohio River in Beaver Co., Penn., and are thus typical *orbiculata*. (1912, p. 353). Surber's measurements of Mississippi *higginsii* are 0.210 by 0.260 mm. It is possible that the larger measurements are of the *higginsii* form and the smaller of the *orbiculata*. A species does not usually vary as much as this in the size of its glochidia. Additional information is needed to settle the status of these forms. In the Tennessee River in Alabama *orbiculata* occurs in abundance and is quite distinct from the shells of the Mississippi.

Higginsii is considered a good button shell when the nacre is white and the texture and thickness of the desired quality.

Genus DYSNOMIA Agassiz, 1852

Shell rounded, oval or subtriangular, solid, inflated, generally smooth and rayed; beak sculpture delicate, often obsolete, double-looped; female shell very different from that of the male, having a very decided inflation in the post-basal region, which is thinner than the rest of the shell, of different texture, often toothed and usually radially sculptured.

The inner edge of the mantle in the female in front of the branchial opening is not parallel to the outer edge, but is more

or less remote from it, often quite distant from it and has finer or coarser papillae. The mantle between the two edges is peculiarly spongy. Marsupium swollen, kidney-shaped, formed by many ovisacs, occupying the posterior portion of the outer gill (Walker). Type: *Unio foliatus* Hild. = *Obliquaria flexuosa* Raf.

Since the type of *Truncilla* has been designated by Herrmannsen as *Tr. truncata* Raf., this name takes the place of *Amygdalonia*. The next available name for this genus is *Dysnomia* Agassiz, the type of which has been fixed by Simpson. (Ortmann & Walker, 1922, p. 65).

Subgenus TRUNCILLOPSIS Ortmann & Walker, 1922

Shell covered with broken rays, somewhat triangular and without a wide, radiate, posterior furrow. Type: *Truncilla triquetra* Raf.

DYSNOMIA TRIQUETRA (Raf.)

Plate LXXXVI, figures 5-7; plate LXX, figures 4-7

Truncilla triquetra RAF., An. Gen. Sci. Phys. Brux., V, p. 300, pl. lxxxi, figs. 1-4, 1820.

Truncilla triquetra SIMPSON, Cat., p. 6, 1914.

Dysnomia (Truncillopsis) triquetra ORTMANN and WALKER, Oc. Papers, Mich., 112, p. 65, 1922.

TYPE LOCALITY: Falls of the Ohio.

WISCONSIN RECORDS:

1922b. *Truncilla triquetra* BAKER, p. 131. Omro, Fox River.

1924. *Dysnomia triquetra* BAKER, p. 132. Omro, Fox River.

SHELL: rather small, valves thickened, outline subovate, depressed, triangular or somewhat trapezoidal; anterior end rounded; posterior end truncated; ventral margin straight or slightly curved, slightly emarginate posteriorly; dorsal margin short, slightly curved in young specimens, forming an angle with the sharply truncated posterior margin, but in old specimens this angle is bluntly rounded; posterior ridge sharply defined, behind which the shell is widely flattened, especially in the female; beaks swollen, somewhat elevated above the hinge line; beak sculpture consisting of 3-4 faint bars, more or less double-looped; the valves are swollen but flattened on the sides; epidermis yellowish or yellowish-green with many dark green rays which cover all but the flattened posterior slope behind the posterior ridge; the rays are usually broken up into squarish,

triangular, or chevron-shaped spots of color, which sometimes resolve themselves into concentric bands by the regularity of the interruption of the rays; in old specimens the rays are absent from the lower third of the surface and in very old specimens they may disappear altogether.

Hinge well developed; pseudocardinals two in each valve (the upper denticle in right valve smaller), strong, high, a little longer than wide, and very ragged; laterals short, strong, serrated, elevated, roughened; no interdentum; cavity of the beaks rather deep; adductor scars distinct; dorsal muscle scars in beak cavity; nacre silvery-white.

Sex differences strongly marked, in the shell of the female the posterior ridge is much swollen, the portion of the shell posterior to this ridge is widely flattened, and the ridge is continued beyond the ventral margin where it forms a wide expansion; the ridge and the posterior flattened area are marked by strong, wavy, radial ribs which denticulate the posterior margin of the shell; the width of the female is greatest across this ridge; the female is always smaller than the male.

L. 67; H. 43; D. 33 mm. Duck River, Tenn. (U. of I., Z3976). Male.

L. 46; H. 27; D. 34 mm. " " " (" Z3976). Female.

L. 22; H. 17; D. 12.5 mm. Omro (Baker, U. of W., 4424). Juv.

ANIMAL (Fig. 242): Anal and supra-anal openings separated by a mantle connection of medium length, but shorter than the anal. Anal with fine crenulations, branchial with

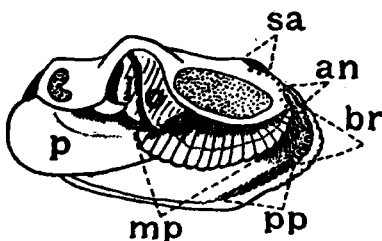


Fig. 242. *Dysnomia triquetra* (Raf.). Allegheny River, Alladin, Armstrong Co., Pa. Gravid female. Ortmann, 1912, p. 356, Fig. 27. Sept. 18, 1908.

papillae, which stand somewhat remote from the outer edge. The latter is, corresponding to the teeth on the margin of the shell, toothed or scalloped. In the female, the inner edge of the mantle in front of the branchial opening is also somewhat distant from the toothed edge, and bears four to ten, rather dis-

tant, subconical, small papillae, which are smaller than the papillae of the branchial, and decrease in size forward. Along this part of the edge runs a black streak, and the papillae also are black or brown. The space between the two edges is blackish-brown, lighter toward the outer edge. Before the middle of the lower margin is reached; the two edges approach each other, and thence forward are normal, the inner one smooth. In the male, the two edges are subparallel and close together, as is normal, and there are only a few small papillae in front of the branchial opening.

Posterior margins of palpi connected at base only. Gills and diaphragm of normal structure. Inner lamina of inner gills entirely connected with abdominal sac. Marsupium formed by over half of the posterior part of the outer gill, with hardly any non-marsupial part behind, greatly swollen, kidney-shaped, higher in front than behind, and slightly deformed to suit the shape of the shell, presenting a broad face outwardly and downwardly, and having a blunt edge toward the median line of the animal, where the two marsupia come into contact. Margin of marsupium without pigment. Ovisacs numerous, 30-40.

Color of soft parts whitish. Margin of the mantle with black spots in the posterior part, black inside of the branchial opening, and with black streak in front of the latter, farther in front brown." (Ortmann, 1912a, p. 355). Glochidia of medium size, almost semicircular; length and height 0.21 mm. (Ortmann).

BREEDING SEASON: Bradytictic. Gravid females have been observed in Sept. and Oct., and in May. Earliest date Sept. 5. Glochidia observed Sept. 17. Discharging females May 23. The interim appears to be in June, July, and August. (Ortmann, 1919, p. 327).

NATURAL HOST: Not recorded.

ECOLOGY: Omro, Fox River, gravel bottom, water $2\frac{1}{2}$ m. deep. Common in other places in riffles with stony and sandy bottom and in swift currents. Usually found deeply buried in sand.

GENERAL DISTRIBUTION: Western New York west to Nebraska and Kansas, south to West Virginia, Tennessee and northern Alabama, and north to Wisconsin and Michigan.

DISTRIBUTION IN WISCONSIN: Only two records are known from the State, one in the Fox River and one in the Wisconsin

River. It may be a migrant up the Wisconsin and into the Fox by way of Portage, or it may have reached the Fox by means of fish hosts from Glacial Lake Chicago.

Wisconsin Drainage: Wisconsin River, Sauk Co. (Walker coll., ex Wright). *Fox Drainage:* Omro, Fox River (Baker).

REMARKS: *Dysnomia triquetra* can be confused with but two other species of naiades, *Truncilla truncata* and *Alasmidonta marginata*. The former is more triangular with a sharper posterior ridge and with the posterior part of the shell excavated. *Marginata* differs by the lack of distinct pseudocardinal and lateral teeth and by the strong umbonal sculpture.

This species has not before been reported from Wisconsin. The single specimen found in the Fox River is typical and was collected alive. The specimens from Sauk Co., Wisconsin River, were in the Wright collection, acquired by Dr. Bryant Walker of Detroit, Mich. They were with specimens of *Truncilla donaciformis*, and with two labels, one reading "*U. donaciformis*, Wis. R. Sauk Co., Wis.," the other "*U. donaciformis*, Miss. River", with the remark "perfect" on the back of the label. The *donaciformis* from the Mississippi River are large and fine and it is assumed that these are the ones referred to. The *triquetra* from Sauk Co. (assuming that these are the ones referred to) are not large, but are typical males. The record is not absolute and is listed here for the benefit of future collectors, so that the species may be established on a firmer basis by the finding of additional material. The Fox River shell is the first actual record without question. One of the Sauk Co. shells is figured.

The records of Grier (1922a, and 1922, p. 102) are open to question. No specimens are deposited in the Fairport Laboratory from this area. Mr. Clark of the Laboratory says: "We have seen no *Truncilla triquetra* from the Mississippi farther north than here (Fairport), where it is apparently now extinct. A few old dead valves were found. We know of no basis for Grier's identification of this species." In the Nautilus, (1922, p. 102) Grier and Mueller report two specimens from Lake Pepin. They remark that this probably represents the most northerly record. Additional information is needed before the species can be said to inhabit the upper waters of the Mississippi.

ANODONTINAE AND LAMPSILINAE ERRONEOUSLY REFERRED TO WISCONSIN

ANODONTINAE

ANODONTA CATARACTA Say

1906. *Anodonta cataracta* CHADWICK, p. 93. Golden Lake, Waukesha Co.; Maple Lake, Oneida Co.

The specimens upon which these records are based have been examined and are good examples of *Anodonta marginata* Say. They are similar to specimens from Sturgeon Bay, Door Co., and also to specimens from lakes in Kent Co., Mich. In these the umbones are more elevated than in many forms of *marginata*, in this respect resembling certain forms of *cataracta* from New York. The two species, however, are quite different. There are no authentic records of *cataracta* from Wisconsin.

ANODONTA IMPLICATA Say

1906. *Anodonta implicata* CHADWICK, p. 94. Baraboo River, Wis.; Honey Creek, Towns Greenfield and Wauwatosa.

These records are based on specimens of *Anodonta grandis* Say. The original specimens have been examined. *Implicata* has not been authentically reported from Wisconsin.

LAMPSILINAE

PTYCHOBANCHUS FASCIOLARE (Radlfsque) = P. PHASEOLUS (Hildreth)

1852. *Unio fasciolaris* LAPHAM, p. 369. Wisconsin.
1860. *Unio phaseolus* LAPHAM, p. 156. Wisconsin River.

Ortmann (1919, p. 213) says "Two records from Wisconsin and Minnesota are undoubtedly erroneous and have been dropped by Simpson". No shells of this species have been seen from Wisconsin and it is quite certain that the species does not inhabit the State.

LIGUMIA SUBROSTRATA (Say)

1852. *Unio subrostratus* LAPHAM, p. 369. Wisconsin.
1922a. *Eurynia subrostrata* GRIER, p. 27, 31. Upper Mississippi River.
1922. *Ligumia subrostrata* GRIER and MUELLER, p. 100. Near Fountain City, Wis.

Grier records this species from two places in the Mississippi River, Straight Slough (1 spec.), and near Homer, Minn., (3 spec.). In 1922, it is recorded from near Fountain City. No specimens have been available for examination, the specimens upon which the identifications were made not having been preserved. Dr. Grier has been unable to add any information. Mr. Clark, of the Fairport Biological Laboratory in answer to a letter of inquiry says: "We have not seen any examples of *Eurynia subrostrata* in the Grier collection; in fact we have no examples above Fairport, and have seen them from as far north only as Davenport. The species was once fairly common here in the sloughs, represented by a very large form (*mississippiensis*), resembling a dark thin shelled *Lampsilis fallaciosa*." The species is not listed by Shimek in his list of McGregor mollusks (1921). The identification may have been based on a dark form of *fallaciosa*. At any rate, the species cannot be admitted until additional authentic material has been collected and examined.

LAMPSILIS CARIOSUS (Say)

- 1852. *Unio cariosus* LAPHAM, p. 369. Wisconsin.
- 1894. *Unio cariosus* SIMPSON, p. 123. Nashotah, Wis.
- 1906. *Unio cariosus* CHADWICK, p. 91. Nashotah, Wis.

All references to *cariosa* are based on a small form of *ventricosa*, probably variety *lurida*. *Cariosa* does not occur in Wisconsin.

LAMPSILIS RADIATUS (Gmelin)

- 1836. *Unio radiatus* CONRAD, p. 24. Wisconsin.
- 1852. *Unio radiatus* JAY, p. 61. Wisconsin.
- 1852. *Unio radiatus* LAPHAM, p. 369. Wisconsin.
- 1860. *Unio radiatus* LAPHAM, p. 156. Milwaukee.
- 1895. *Unio radiatus* SIMPSON, p. 332. St. Croix River, Wis.
- 1900. *Lampsilis radiatus* SIMPSON, p. 536. Northwest boundary of Wis.
- 1906. *Lampsilis radiata* CHADWICK, p. 91. Northwest boundary of Wis.

"There is a shell in the U. S. National Museum from the northwest boundary of Wisconsin, which is probably this species" (Simpson, p. 536). This statement is repeated in the Catalog, p. 66. No specimens have been seen that are referable to *radiata*. Most references are based on variations of *Lampsilis siliquioidea*. Specimens from the St. Croix River are all

siliquioidea or *pepinensis*. The presence of this species in Michigan is also doubtful, according to Walker. The species may safely be omitted from the list of Wisconsin mussels.

LAMPSILIS BOREALIS A. F. Gray

1891. *Unio borealis* SIMPSON, p. 88. Wisconsin.

1906. *Lampsilis (Eurynia) borealis* CHADWICK, p. 91. Wisconsin.

The references of this species to Wisconsin are quite erroneous, the specimens being small, heavy examples of *siliquioidea*, not at all like the real *borealis*, a number of specimens of which are in the U. of I. collection from the original locality, Duck Island, Ottawa River.

LAMPSILIS SUPERIORENSIS (Marsh)

1906. *Lampsilis (Eurynia) superioensis* CHADWICK, p. 91. Two Rivers, Manitowoc Co.

The original specimen upon which Chadwick based his determination of *superioensis* cannot be found in the collection of the Milwaukee Museum. However, no mussels from any part of Wisconsin have been seen that are at all like this species (or variety). Specimens from the original locality are in the Hinkley collection of the U. of I.

Order TELEODESMACEA Dall

Pelecypods with reticulate gills, the ventricle of the heart embracing the rectum; having the mantle lobes more or less connected and usually possessing developed siphons; the adductors practically equal; the shell structure cellulo-crystalline (porcellaneous) or obscurely prismatic, never nacreous; the dorsal area, when present, always prosodetic or divided into lunule and escutcheon; ligament opistodetic, with or without separate resilium; without a lithodesma, rarely with external accessory shelly pieces; nepionic stage usually without a taxodont provinculum; permanent armature of the hinge characterized by separation of the hinge teeth into distinct cardinals and laterals; the posterior laterals, when present, placed behind the ligament; the animals active or nestling, sometimes sessile, but rarely sedentary burrowers, rarely inequivalve, usually possessing a hinge plate and a pallial sinus; sexes usually separate (Dall).

Superfamily CYRENACEA Tryon

Cypricardians which have become specialized for fresh water or brackish water conditions, and, as usual in such cases, have developed variability of character (Dall).

Family SPHAERIIDAE Dall, 1895

Shell small and thin, ligament feeble, short; pallial line simple; no hinge plate; cardinal teeth usually two in each valve; laterals four in the right valve, two anterior and two posterior, and two in the left valve, one anterior and one posterior; foot long, narrow, grooved, byssiferous when young; monoecious; the young incubated in a marsupium formed by the inner gill (Walker).

GENERAL MORPHOLOGY AND REPRODUCTION OF SPHAERIIDAE

In America, little attention has been given to the morphology of these small clams. The paper by Drew (1896, p. 173) and a later publication by Gilmore (1917, p. 16) constitute about all of the available information on this subject. The latter is very comprehensive and should be consulted by all interested in these small mollusks.

The general anatomy is similar to all Pelecypods, the principal organs being much the same as in the Unionidae, varying in form, shape, and position. A comparison of the figure of *Anodonta* (figs. 203, 204) with those of *Sphaerium* and *Musculium* (figs. 243-245) will indicate the principal differences better than pages of description.

Like the Unionidae, the Sphaeriidae carry the young in a marsupium, formed by the gill, but the general method of reproduction is different. This may be briefly described as follows, the information being all taken from the paper by Gilmore.

The animal is hermaphroditic, the reproductive organs being situated beneath the pericardium and behind the stomach. They consist of a pair of racemose glands, the anterior part

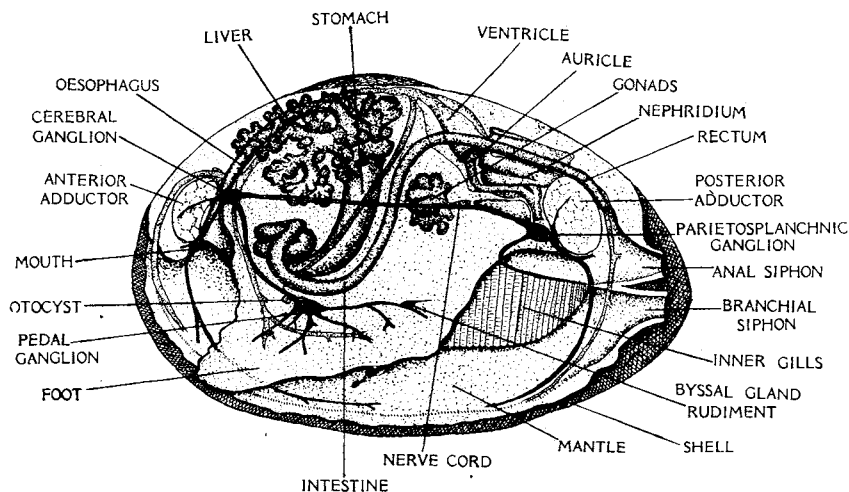


Fig. 243. Diagrammatic longitudinal section of *Sphaerium simile*, showing relation and position of the different organs of the body. (Drew, 1896, Pl. viii).

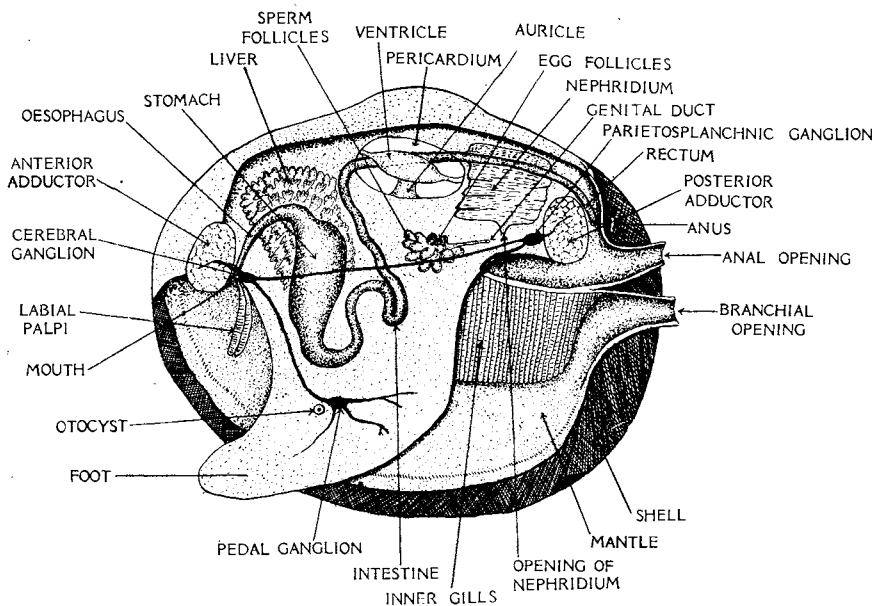


Fig. 244. Diagrammatic longitudinal section of *Musculium truncatum* showing relation of the different organs (Gilmore, 1917, Pl. iv, Fig. 1).

producing sperm and the posterior part eggs (see the figures). A common genital duct continues backward, opening into the cloacal chamber of the inner gill near the opening of the kidney. Eggs develop by the enlargement of certain cells of the lining of the egg follicle, and when a developing egg has grown to four or five times the size of the neighboring cells it is pushed out of its position by a pedestal-like growth of the basement of the membrane. Thus projected into the lumen of the follicle,

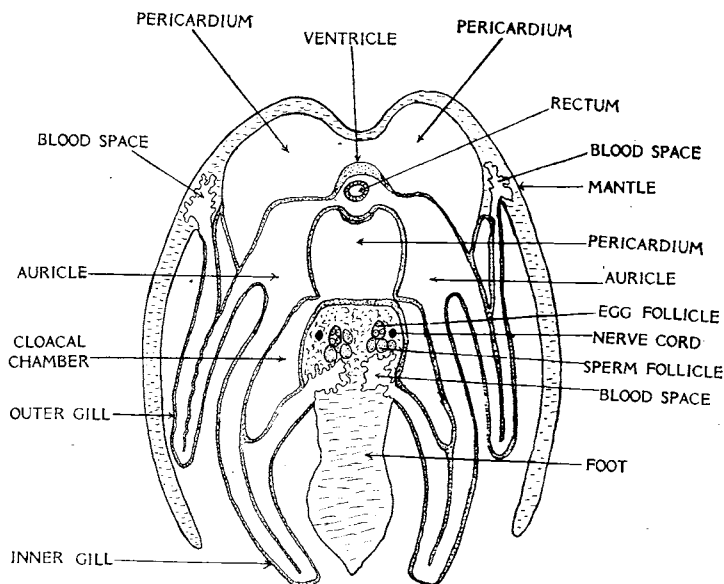


Fig. 245. Diagrammatic cross section through the region of the reproductive organs (*Musculium truncatum*). Showing reproductive follicles, position of brood pouch, etc. (Gilmore, 1917, Pl. v, Fig. 5).

it continues to develop until mature, when it drops off. The sperm follicles are irregularly spherical and are arranged about their common duct like the parts of a raspberry. Each follicle is made up of a mass of sperm mother cells about its outer part with younger cells in the inner part. The center of the follicle is hollow and communicates with the common sperm duct, which extends a short distance backward where it receives the product of the egg follicle, continuing from this point as a common genital duct.

Fertilization is believed to be as follows: when an egg drops from the follicle and falls into the duct joining the sperm duct it is immediately surrounded by a mass of fully formed sperm, and fertilization takes place at this point, although another author asserts that it occurs in the gill chamber.

The gills of *Sphaerium* are four in number, an outer and an inner pair, the outer being smaller than the inner. Each gill is made up of two lamellae, the outer lamella of the outer gill being attached to the mantle, the inner lamella of the outer gill and the outer lamella of the inner gill are attached to each other, and the inner lamella of the inner gill is attached to the body. It is the outer lamella of the inner gill which contains the brood pouches or marsupium (see fig. 245). The lamellae are made up of gill filaments separated by interlamellar partitions, and in places supported by fibrous chitin, ribbon-like bands. Each filament is a hollow tube which, bent upon itself, forms a Y-like figure, the upper part of the Y forming the cloacal chamber. All water entering the animal and passing between the filaments must pass through this chamber. The chief function of the gills, as in the Unionidae, is to purify the blood. The brood pouches are thus admirably situated to form marsupia, the freshly aerated blood passing through them from the alimentary tract.

The brood pouch formed by the cloacal chamber may contain but one embryo or it may include several embryos; and the pouch may involve only two filaments or it may be constructed of several filaments. The inner wall of such a pouch is thrown into folds which divide it into communicating chambers. Just how the pouch originates is still an open question, the general consensus of opinion being that it is a modification of the gill filaments.

No method has been discovered for determining the age of young or the period of incubation in the pouch. It is thought that young in *Musculium* may be carried for a year or more. In a pond under observation for a period of over a year, adults were found in April to contain fully formed young. This pond was dry from July of the year preceding until it became filled by melting snow in March. It had no inlet or outlet and received no overflow floods from nearby ponds or streams.

The number of young produced varies greatly in individuals. Gilmore states that it may vary from 10 to 20 in *Musculium*

and from 2 to 4 in *Sphaerium*. Specimens of *Sphaerium striatinum* collected at Omro, Fox River in early August contained the following number and sizes of young:

	Adult	Young	Total
1.	11.5	3.75; 2.1; 2. 1 mm. -----	3
2.	11.5	4.5; 2.7; 2.1; 2.0 mm. -----	4
3.	6.5	-----	0
4.	10.7	1.7; 1.6; 1.6 mm. -----	3
5.	10.0	1.2 mm. -----	1
6.	9.1	-----	0
7.	13.0	3.5; 3.0; 1.5; 1.5; 0.7 mm. -----	5
8.	10.0	1.4; 1.0 mm. -----	2
9.	11.1	1.4; 1.2; 1.2 mm. -----	3
10.	12.0	1.2 mm. -----	1
11.	12.0	1.2; 1.2 mm. -----	2

Other Sphaeriidae contained young as follows:

Sphaerium torsum. Adult 10.5 mm. One young 3.2 mm.

Sphaerium acuminatum. Adult 9 mm. One young 5 mm.

Sphaerium rhomboideum. Seven specimens contained 5, 6, 2, 3, 5, 9, 5, young.

Musculium partumeium. Adult 7.5 mm. Three young 1.6 mm. each.

It will be observed that no specimens under 7 mm. bore young. Gilmore presents several tables indicating number of young borne by Sphaeria; 401 specimens were examined. Of these 138 were under 12 mm. in length and bore no young (34 per cent.). The ratio of young increased as follows: 13 mm. long, 6.6 per cent. bore young; 15 mm. long, 46.8 per cent. bore young; 16 mm. long, 80 per cent.; and 18, 19 mm. long, 100 per cent. bore young. In another place 267 young were taken from 400 adults. The ratio of young is nothing like as large as in the Unionidae. This is according to a well established law that the greater the chance of mortality, the larger the number of young, thus insuring the perpetuation of the species by sheer numbers. In the case of the Sphaeriidae, the young are cared for by the mother until ready for independent life, hence reducing the danger of extermination by enemies to a minimum.

BREEDING SEASON: The breeding season of the Sphaeriidae probably continues through the greater part of the year. Gilmore found animals taken in November and December to contain, in newly formed brood pouches, eggs some of which were unsegmented and others in very early cleavage stages. Information on this point is very meager.

AGE IN SPHAERIUM: Gilmore examined a large number of *Sphaerium* in the belief that the distinctness of growth rings might determine the age by the number of rings present. His results are not conclusive, but suggestive. He found no individuals over 19 mm. long and none had more than 8 growth rings. The averages showed an increase of about 2 mm. between each ring. The growth of individuals seemed to be irregular and suggested that the rings might not indicate seasons. This is probably true, because, as has been found in Unionidae, any disturbance of the animal, either by deficiency of water or by temporary removal from the habitat, caused a halting of the formation of shelly matter, and a rest ring was formed. As the streams in which many Sphaeriidae live are subject to more or less fluctuation in water content, it is highly probable that these rings cannot be depended upon to accurately gauge the age of these animals.

GENERAL ECOLOGY: The Sphaeriidae inhabit all kinds of habitats—large lakes, small lakes, ponds, pools, rivers, creeks, and, in fact any kind of water body. Many of them live in ponds or pools that dry up for a large part of the year, being full of water only in the spring. In these places most of the animals die during the dry interval, a few surviving by burrowing deeply in the mud bottom. All kinds of bottom are used, gravel, sand, mud, clay. The Pisidia often occur among vegetation. They are formed in the shallowest of water and in the lower depths of the deepest lakes.

While the adults usually bury themselves in the bottom, the young may be very active, crawling over plants and even suspending themselves from plants by their byssal threads. It is thought that the Musculia are rather short-lived and are either annuals or biannuals. In many cases, when pools dry up, only the young survive, growing to maturity during spring and early summer. There is much need for more accurate data on the ecology of these small clams, as well as upon their age, reproduction, and general habits. The food is believed to be mainly diatoms. It is also probable that the universal food of many invertebrates, the detritus of the bottom, is also largely used.

As in the naiades, the *Sphaeriidae* are subject to attack by parasitic worms, which, in some instances, modify the form of the shell. Sterki (1906a, p. 11) records a probable instance

of parasitism causing pathological conditions in *Sphaerium solidulum* from Des Moines, Iowa. The shells were considerably smaller than the average, almost globular, with large beaks. At the anterior margin of the shell there was a more or less marked scar, near the anterior adductor muscle and the lateral teeth. Sterki believes that this scar was caused by a parasite affecting the mantle edges. He also states that this condition has been noted in other *Sphaeria* as well as some *Pisidia*.

DISTRIBUTION: The family is of world-wide distribution. In America, some member of the family is found in almost every condition of habitat—high mountains, deep lakes, shallow rivers, creeks, pools, and woodland ponds of more or less temporary character. Wherever fresh water is found, unless the conditions are unusually unfavorable, *Sphaeriidae* of one form or another are sure to be found.

ECONOMIC VALUE: Unlike the *Unionidae*, these small mussels have no economic importance in the way of supplying man with buttons or other material. More remotely, yet directly, they have a real value in forming a large part of the food of many valuable fish, both food and game. The gizzard shad (*Dorosoma cepedianum*) eats *Sphaerium*; the common white fish (*Coregonus clupeaformis*) consumes 26 per cent of molluscan food, including *Sphaerium striatinum* and several *Pisidium*, which forms upwards of 60 per cent. of the molluscan food in some cases; the red-mouth buffalo (*Ictiobus cyprinella*) consumes as much as 25 per cent. of *Sphaerium* in its average food; the mongrel buffalo (*Ictiobus urus*) and the quillback buffalo (*Ictiobus bubalus*) feed on these small clams. The spotted sucker (*Minytrema melanops*) feeds on *Sphaeriidae*. The common sucker (*Catostomus commersonii*) has been found to feed on *Pisidium henslowanum* and *Sphaerium vermontanum*, in some cases 20 per cent of its food was of these clams. The following fish are known to eat more or less of this molluscan food: Common red horse (*Moxostoma aureolum*), short-headed red horse (*Moxostoma breviceps*), sucker (*Placopharynx duquesneri*), common bullhead (*Ameiurus nebulosus*), bluegill (*Lepomis pallidus*), pumpkinseed (*Eupomotis gibbosus*), yellow perch (*Perca flavescens*), and sheepshead (*Aplodinotus grunniens*).

Many of the game fishes, such as the black bass (*Micropterus dolomieu* and *M. salmoides*) and pickerel (*Esox recticularis*),

feed on smaller fish or other animals which are mollusk eaters and so are to be considered in measuring the economic value of the small clams (see Baker, 1916, pp. 153-223).

The flat oval form of *Sphaerium* and *Musculium* has suggested the name "finger-nail clams" for these small Pelecypods.

MONOGRAPHS OF SPHAERIIDAE

Since the time of Temple Prime, no monographic account of the American species has been published. Clessin (1879) published a monograph of the group in Martini-Chemnitz, but this included species of the world and is unsatisfactory from the American standpoint. Some years ago, Dr. V. Sterki, of New Philadelphia, Ohio, began the study of these small and interesting forms and has made a comparatively exhaustive study of the many species. His Preliminary Catalog (1916, p. 429) brings the matter down to the present time, listing the majority of species published.

Of the Sphaeriidae Dr. Sterki says: "The study of this intricate group of mollusks is rendered especially difficult and particularly interesting by the great, and in some species apparently endless, variation which occurs. It may be in order to state in this connection that injudicious and haphazard "lumping" has done more to bring difficulties than has been caused by minute discrimination between forms. The careful differentiation of forms alone enables us to determine their natural interrelations and affinities. Some forms of distinct species may resemble each other closely; while on the other hand forms of one species may be so different from each other, that at first glance they appear to belong to widely different species". (op. cit., p. 429).

Dr. Sterki has very kindly examined all of the Wisconsin material so that every species described and figured has been passed upon and is authentic. There are many forms not yet determined, which will be added to the Sphaeriidae fauna in the course of time. The list of species of the three genera, *Sphaerium*, *Musculium*, and *Pisidium*, recorded from Wisconsin bears out Sterki's statement that the metropolis of the Nearctic Sphaeriidae is the region of the Great Lakes. Michigan alone contains a greater number of species.

SUBGROUPS OF SPHAERIIDAE: Clessin and others have divided the genera of Sphaeriidae into several subgenera or sections. For the most part these groups are exceedingly artificial and in some cases are separated on characters which have been shown to be erroneous. In a group where it is difficult to draw specific lines, it seems unwise to build up groups of lesser rank than genera. The three genera *Sphaerium*, *Musculium*, and *Pisidium* are well characterized. Smaller groups may well be ignored until more is known concerning the range of variation and especially the characteristics of the animals of the different species.

KEYS TO SPHAERIIDAE: A number of attempts have been made to formulate workable keys for the identification of the species of these groups, but without success. It may be possible to make keys that will help the beginner to separate the different species and varieties of this difficult family, but in a group where many of the varieties simulate in both form and sculpture other remotely related species, the powers of descriptive differentiation seem totally inadequate to make intelligible aids to identification in the form of keys. It is believed, however, that the descriptions and figures are accurate enough to identify at least the great majority of species. The large number of species of the group found in Wisconsin has made the matter of keys especially difficult.

KEY TO SUBFAMILIES OF SPHAERIIDAE

1. A distinct anal and branchial siphon; anterior end shorter than posterior end *Sphaeriinae*
2. Only the anal siphon developed, the branchial siphon being represented by the mantle cleft; anterior end longer than posterior end *Pisidiinae*

Subfamily SPHAERIINAE F. C. Baker, 1927

Sphaeriinae F. C. BAKER, Amer. Mid. Nat., X, p. 220, 1927.

This subfamily includes *Sphaerium*, *Musculium*, and *Eupera*. It is characterized principally by the presence of distinct anal and branchial siphons. The general anatomy, etc., is discussed in the descriptions of *Sphaerium* and *Musculium*.

In 1895, Dall called attention to the difference in siphonal arrangement between *Sphaerium* and *Pisidium*, and said "If

this is found by more extensive observation to be constant within the genera the family might be divided into two subfamilies" (p. 540). As this has been found to be constant in all American species examined, the suggestion is here accepted and the family accordingly divided into two subfamilies on the basis of the differences in siphonal structure.

KEY TO GENERA OF SPHAERIIDAE

1. a. Shell nearly equipartite; beaks subcentral ----- 2
 b. Shell inequipartite; beaks terminal ----- *Pisidium*
2. a. Nepionic valves not distinctly separated from the subsequent
 growth of the shell ----- *Sphaerium*
 b. Nepionic valves inflated, usually separated from the adult
 growth by a distinct sulcus ----- *Musculium*

Genus SPHAERIUM Scopoli, 1777

Sphaerium SCOPOLI, Intr. ad Hist. Nat., p. 397, 1777. Type: *Tellina cornea* Linn.

Cyclas LAMARCK, Prodome, p. 84, 1799. Type: *Tellina cornea* Linn.

Cornea MEGELE v. MÜHLFELD, Mag. Gesell. Naturf. Freunde, Berlin, V, p. 56, 1811. Type: *Cornea communis* Megele (= *Tellina cornea* Linn.).

Corneocyclas (Ferussac in litt.) BLAINVILLE, Dict. Sci. Nat., XII, p. 278, 1818.

No type cited; new name for *Cornea* Megele (vide Blainville).

Pilsbry, (Amer. Mus. Nat. H., Bull., LIII, p. 347, 1927), type by designation, *Cyclas cornea* Drap.

Amesoda RAFINESQUE, Ann. Gen. des Sci. Phys., Bruxelles, V, p. 319, 1820. Type: *Cyclas similis* SAY.

Shell thin, oval, more or less inflated; subequipartite, beaks subcentral; surface smooth or concentrically striate; teeth small, cardinals one in the right, two in the left valve; laterals double in the right, single in the left valve; nepionic shell passing into adult without any distinct demarcation.

ANIMAL (Figs. 246, 247). Mantle open below, united posteriorly to form the siphons, and anteriorly and over the back; mantle edge with muscular ridge extending from the anterior to the posterior adductor muscle; siphons united at base but separated for their greater extent, smooth, without papillae or crenulations, the lower (branchial) siphon flat, large, with wide opening, the upper (anal) siphon rounded with small opening; when active the two siphons are directed away from

each other; foot cylindrical, capable of considerable extension; gills four in number, the inner gill larger than the outer gill; outer lamella of outer gill attached to the mantle lobes, inner lamella of outer gill and outer lamella of inner gill attached to each other, inner lamella of inner gill attached to the abdominal

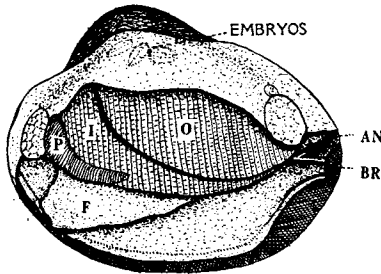


Fig. 246. Animal of *Sphaerium striatinum* Lam. Omro, Fox River, Aug. 3, 1920.

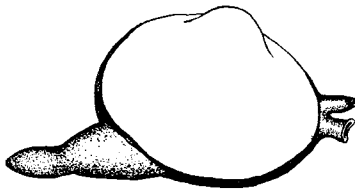


Fig. 247. Animal of *Sphaerium striatinum* Lam. Showing siphons and foot extended.

sac anteriorly and to its fellow posteriorly, forming a complete diaphragm; inner gills alone marsupial in character; palpi long, curved, narrow, connected at base to each other and to the body surrounding the mouth.

SPHAERIUM SIMILE (Say)

Plate XCVI, figures 4-7

Cyclas similis SAY, Nich. Encyc., 1st Amer. Ed., II, pl. i, fig. 9, 1816 or 1817; 2nd Ed., IV, pl. i, fig. 9, 1818; 3rd Ed., IV, pl. i, fig. 9, 1919.

Cyclas sulcata LAM., An. sans Vert., V, p. 560, 1818.

Sphaerium sulcatum PRIME, Mon., p. 33, 1865.

Sphaerium simile PRIME, Cat., p. 158, 1869.

Sphaerium sulcatum STERKI, Cat., p. 431, 1916.

TYPE LOCALITY: Lake George, N. Y. (*sulcata*). Delaware River (*similis*).

WISCONSIN RECORDS:

1852. *Cyclas similis* LAPHAM, p. 370. Wisconsin.
 1865. *Sphaerium sulcatum* PRIME, p. 34. Wisconsin.
 1897. *Sphaerium sulcatum* WISWALL, p. 48. Southern Wisconsin.
 1906. *Sphaerium simile* CHADWICK, p. 98. Milwaukee; Calumet Co.; Manitowoc Co.; Kenosha.
 1911a. *Sphaerium simile* BAKER, p. 232. Tomahawk Lake.
 1920. *Sphaerium simile* BAKER, p. 119, 120. Wauwatosa (fossil).
 1920. *Sphaerium sulcatum* BAKER, p. 121. Kenosha (fossil).

SHELL: Large, transversely oval, inflated, almost equipartite, rather solid; dorsal and ventral margins convex; anterior and posterior ends rounded, similar in shape; umbones depressed, inflated, placed a trifle forward of the center of the dorsal margin; beak markings of fine concentric ridges, fol-

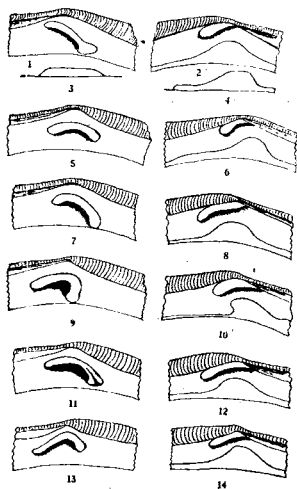


Fig. 248. Cardinal teeth of *Sphaerium simile* Say. Right and left valves. 1, 2. Loyal. 3. Profile of cardinal of right valve (1); 4. Profile of lower tooth of left valve. 5, 6. From Brown Co. 7, 8. Brown Co. 13, 14 Hancock. 9-12. Variety *planatum* Sterki. Winnebago Lake. Greatly magnified.

lowed by rather coarse concentric ridges; umbonal slopes rounded; surface shining, sculpture of heavy growth lines raised into rather evenly spaced ridges; color light to dark horn, chestnut in very old specimens; scutum and scutellum well marked.

Hinge strong, regularly curved; cardinals very small (fig. 248, 1-8, 13, 14), a long, elevated, arched tooth in the right valve and two teeth in the left valve, the upper long and arched, the lower tooth large, heavy, pyramidal; laterals double in the right, single in the left valve, short, lamellar, pyramidal, nearly straight; muscle scars and pallial line faintly impressed; nacre bluish-white; cavity of beaks rather deep.

L. 16.0; H. 12.0; D. 8.2 mm.	De Pere (U. of W., 411).
L. 14.0; H. 10.5; D. 7.3 mm.	" "
L. 18.0; H. 13.0; D. 9.2 mm.	Menomonee River (U. of I., Z22250).
L. 19.0; H. 13.0; D. 9.5 mm.	" "
L. 18.0; H. 12.7; D. 9.0 mm.	" "

BREEDING SEASON: Young, fully formed, found in marsupium in July and August. Young shell ovate-quadrate, compressed, scutellum with very fine concentric lines, scutum with coarse concentric ridges 17-29 in number. The young when ready to leave the parent are about 30-35 per cent as large as the adult.

L. 6.0; H. 4.5; D. 2.4 mm.	Scutum with 18 ridges.
L. 6.1; H. 4.8; D. 2.6 mm.	" " 21 "
L. 7.0; H. 5.5; D. 3.2 mm.	" " 29 "

ECOLOGY: Red Cedar River, sand bottom, .3-1 m. deep; Silver Creek, mud bottom, 1.3 m. deep (Baker). Bark River, gravel-sand bottom, shallow, good current; Mukwonago River, shallow, gravel bottom, swift current (Cahn).

GENERAL DISTRIBUTION: East of the Rocky Mountains, rare in the south (Sterki). Very common in Mich., Wis., Ill., Ind., Ohio, Penn., and N. Y.

DISTRIBUTION IN WISCONSIN: Widely distributed in the State. It probably occurs in all of the drainage areas.

REMARKS: *Simile* is the largest *Sphaerium* in Wisconsin, easily known by its size and centrally-placed umbones. There is some variation in shape, many specimens being more cylindrical, longer in comparison with height, than in typical *simile*. Young shells are much compressed laterally with an almost straight dorsal margin (pl. XCVI, fig. 7). The color varies all the way from light yellowish to very dark chestnut, older specimens usually having the darker color. Reversed hinges (those in which teeth of the right valve have the characteristics of the

left valve) are rare in the *similis* of Wisconsin. This *Sphaerium* is the most abundant finger-nail shell in many parts of Wisconsin. The cardinal teeth vary greatly in shape, especially in the right valve. Some of these are shown in fig. 248.

The specific name of this *Sphaerium* seems to be somewhat involved. Prime (1865) gives the species to Lamarck who described his *sulcata* in 1818. Sterki (1916) follows Prime. Say described and figured (poorly) his *Cyclas similis* in the first edition of the Nich. Encyc., which, according to Binney (Biblio., p. 254) was published in 1816. This description is repeated in the second edition (1818) and third edition (1819). Prime, in his Catalog of the Family (1869, p. 158) gives the species to Say, quoting the edition as 1817. I have not been able to find that the name *similis* had been used before Say's description, and if Binney and Prime (1869) are right in the dates of the first edition of Nicholson's Encyclopedia, I cannot see why Say's name should not be used. Dall (1905, p. 134) uses Say's name, giving the date of the first edition of Nich. Enc. as 1817. All of the evidence shows that Say's name has priority.

In the lakes in the northern part of the state there is a large *Sphaerium* of the *simile* type which is different from either the river form or *planatum*. It is very large, very corpulent, especially over the umbones, somewhat cylindrical, dorsal and ventral margins somewhat curved, ends rounded or but slightly truncated. In some respects this form resembles Sterki's *insigne* (Cat. p. 432) but differs in color and somewhat in form. As the variation of *insigne* appears not to be definitely known the form is not especially characterized. Sterki identified the material as "*S. sulcatum*, large". Measurements of some of these forms are given below.

L. 18.0; H. 14.0; D. 9.5 mm. Hancock (U. of W., 4428).

L. 18.5; H. 14.5; D. 11.0 mm. " "

L. 21.0; H. 14.0; D. 12.5 mm. Vilas Co. (U. of I., Z22253).

L. 19.0; H. 14.0; D. 11.5 mm. " "

L. 23.0; H. 17.0; D. 14.0 mm. Meechs Lake, Ont. (U. of I., Z20139).

Specimens are in the Wisconsin and Illinois collections from Hancock, Waushara Co. (Bullock); Lake Nixon, Vilas Co. (Cahn); Meechs Lake, Ontario (Latchford). The Hancock form is figured on pl. XCVI, figs. 1-3.

SPHAERIUM SIMILE PLANATUM Sterki

Plate XCVI, figures 8-10; plate XCVIII, figures 29-33

Sphaerium sulcatum planatum STERKI, Cat., p. 432, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1924. *Sphaerium sulcatum* BAKER, p. 133. Lakes Winnebago and Butte des Morts.1924. *Sphaerium sulcatum planatum* BAKER, p. 133. Lake Winnebago.

SHELL: Smaller than common, or typical, *sulcatum*, more inequiptartite, the beaks being markedly anterior; less inflated, especially flattened over the lower parts of the valves, more truncate anteriorly and posteriorly, inferior margin less curved; beaks narrower and little elevated; surface striae slighter; shell and hinge slighter. Extreme forms are so different as to appear distinct, but there are intermediates (Sterki).

L. 13.0; H. 9.7; D. 7.0 mm. Lake Winnebago (U. of W., 4430).

L. 11.9; H. 9.0; D. 6.6 mm.

"

"

L. 14.1; H. 10.2; D. 7.5 mm.

"

(U. of I., Z13435).

L. 15.5; H. 11.1; D. 8.0 mm.

"

"

L. 14.0; H. 10.0; D. 7.2 mm. Dutchmans Lake (U. of I., Z22251).

ECOLOGY: Lake Winnebago, .5 m. deep, boulder bottom; 2.2 m. to 3.1 m., sand and gravel bottom; 1.5 m. sandy mud bottom; 3.4 to 5.5 m.; Lake Butte des Morts, sand and mud bottom 0.5 to 1.2 m. deep. Lake Chetek, sand and mud bottom, 1.3 to 1 m. deep (Baker). Oconomowoc Lake, water 3-5 m. deep, among vegetation; Golden Lake, bottom pure sand, water 1 m. deep (Cahn).

GENERAL DISTRIBUTION: Ohio, Indiana, Illinois, Michigan, Wisconsin Ontario.

DISTRIBUTION IN WISCONSIN: Apparently as widely distributed as the typical form.

REMARKS: The more anterior umbones and smaller, more cylindrical shell will usually distinguish this variety. The cardinal teeth of the hinge are very variable, two being shown in fig. 248 (9-12). A study of the Wisconsin *simile* indicates a division of the material into two groups, the large, heavy, squarish river form (which is typical) and the more cylindrical, slighter lake form. These two forms are ecological and reflect differences in the environment. The lake form corresponds

to the diagnosis of *planatum*, though there are various forms which vary toward *simile* and others that are still different from anything described, but all appear to be referable to the *planatum* form. The material from the small lakes in Waukesha county is slightly different from the Lake Winnebago specimens.

It is possible that all lake forms should be called variety *sulcatum*, Lamarck's type being from Lake George, N. Y., and if so the variety should be called *simile sulcatum* with *planatum* as a synonym. It is apparent that in the *Sphaeriidae* great allowance must be made for individual variation and the species can best be separated into varieties on the basis of ecological habits.

SPHAERIUM CRASSUM Sterki

Plate XCVI, figures 11-13

Sphaerium crassum STERKI, Nautilus, p. 140, 1901.

Sphaerium crassum STERKI, Cat., p. 432, 1916.

TYPE LOCALITY: Carp Lake, near Mackinaw City, Mich.

WISCONSIN RECORDS: None.

SHELL: Large, strongly inflated, almost equipartite, somewhat rhomboidal in perpendicular outline; beaks a little anterior, large and full, slightly flattened on top, prominent over the hinge line; superior margin rather strongly, inferior moderately curved; scutum and scutellum distinct with slight projecting, rounded angles at their terminations, the one at the scutum being less marked in full-grown specimens; anterior and posterior ends almost equally, obliquely truncated, especially in specimens not quite mature, while in the adult the posterior end forms a more regular curve from the beaks down to the rather low-situated rounded end; surface with sharp, fine and crowded sulcations, usually somewhat coarser on the beaks, dull or with a slight gloss; a few strongly marked lines of growth; color grayish or whitish-brown in the young and the same in slightly marked marginal zones of older specimens, plumbeous in half grown, and reddish or brownish, or smoky-brown, in the adult, with narrow, darker zones on the lines of growth; shell thick, muscle insertions distinct, nacre white, almost porcellaneous, with bluish zones corresponding with the lines of growth.

Hinge strong, plate rather broad, cardinal teeth comparatively large (fig. 249), the right strongly curved, emarginate at the free edge, its posterior part thick, slightly to deeply grooved; the inferior in the left valve short, curved, the superior shorter to longer than the inferior, moderately posterior, oblique, little curved; lateral teeth strong, those of the left valve with very high pointed cusps; ligament rather large, covered (Sterki).

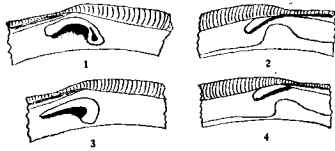


Fig. 249. Cardinal teeth of *Sphaerium crassum* Sterki. Pokegoma Lake.

L. 15.0; H. 11.5; D. 9.5 mm. Type, after Sterki. Carp Lake.

L. 16.0; H. 12.0; D. 9.5 mm. Phillips (U. of W., 4431a).

L. 15.0; H. 12.0; D. 9.0 mm. " (" 4431b).

L. 13.2; H. 10.4; D. 8.0 mm. " (" 0031c).

ECOLOGY: Lake Pokegoma, mud bottom, .5 to 1.5 m. of water. Sturgeon Bay, shallow water near shore, marly-clay bottom.

GENERAL DISTRIBUTION: Northern New York, Quebec, Ontario, northern Michigan, Wisconsin.

DISTRIBUTION IN WISCONSIN: Rather widely scattered. It has probably been mixed with *stamineum* and *simile* by previous writers.

Chippewa Drainage: Phillips, Big Elk River, Price Co. (Bullock); between Chetek and Prairie Lakes, near Chetek, Barron Co. (Baker).

Rock Drainage: Yahara River, near Madison, Dane Co. (Juday).

Lake Michigan Drainage: Brown Co. (Marston); Sturgeon Bay, above town, Door Co. (Baker).

REMARKS: "This is a remarkable *Sphaerium*. It stands near some large forms of *stamineum*, yet by its shape, large diameter and very large beaks, is different; *S. solidulum* is more rounded in its outlines, less inflated, its beaks are smaller, and the sulcation is coarser. In its surface appearance, sulcation and color, our species resembles *S. simile*, but is much shorter, comparatively, its beaks are higher, the hinge margin is more curved, and the hinge very much stronger (Sterki, p. 141).

Most examples are larger, more elongate, and more inequipartite than the original types from Michigan (Sterki, 1916, p. 432).

Crassum seems rare in Wisconsin, occurring in but few lots of *Sphaerium*. The specimens from Sturgeon Bay are, according to Sterki, like the types from Carp Lake, Mich. It is a neat species and seems sufficiently distinct from the related species of the genus.

SPHAERIUM AUREUM DECLIVE Sterki

Plate XCVI, figures 14-17

Sphaerium declive STERKI, Ann. Carnegie Mus., XIII, p. 438, 1922.

TYPE LOCALITY: Cheyenne River, near Tolina, N. Dakota.

WISCONSIN RECORDS: None.

SHELL: "The mussel is less elongate than *aureum*, the supero-anterior slope is more marked and steeper, the posterior margin is truncate or subtruncate at nearly right angles; both ends are more angular (old specimens are often of more rounded outlines) and more ventral; the beaks are somewhat anterior and inclined forward, and markedly narrow in the center, as is especially noticeable in half-grown and adolescent mussels, moderately large, somewhat broad, and not so greatly prominent in full-grown; the sulci are somewhat coarse and rather irregular to slight and almost obsolete; the color is lighter or darker grayish corneous.

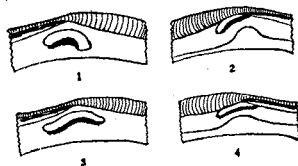


Fig. 250. Cardinal teeth of *Sphaerium declive* Sterki. Bayfield.

"The hinge (fig. 250) is somewhat more curved, the posterior laminae being at a noticeable angle to the plate. It should be added that mussels taken for *aureum* are regularly and evenly rounded-inflated, while in *declive* the disks—i. e., the middle part of the valves—are somewhat flattened" (Sterki).

L. 14.5; H. 11.5; D. 8.8 mm.	Sterki's types.
L. 13.0; H. 11.3; D. 8.6 mm.	Red Cliff Creek (U. of W., 4432a).
L. 11.5; H. 9.5; D. 7.0 mm.	" " " (" 4432b).
L. 10.0; H. 8.0; D. 6.1 mm.	" " " (" 4432c).

ECOLOGY: Red Cliff Creek, sand bottom, water .6 m. deep.

GENERAL DISTRIBUTION: North and South Dakota to Wisconsin; south to Missouri, Arkansas, and Kansas.

DISTRIBUTION IN WISCONSIN: Lake Superior drainage. Found only in Red Cliff Creek, north of Bayfield, Bayfield Co. (Baker).

REMARKS: "In the Preliminary Catalog of North American Sphaeriidae, p. 433, it is stated that a form of *Sphaerium* was doubtfully referred to *aureum* Prime. With more material coming in, it became evident that the form was at least a well-marked subspecies, which I have named *declive*. A large number of good specimens from the Cheyenne River, North Dakota, collected by members of the University of Michigan in the summer of 1919, are evidently the same, and showed conclusively that this *Sphaerium* is different and distinct from *aureum*" (Sterki).

This mussel, which seems to be an extreme form of *aureum*, was found in Wisconsin only in Bayfield County, on Lake Superior. Prime's *aureum* is believed to have come from Lake Superior, but Sterki's *declive* appears to be different from Prime's description and figure in Mon. Corb., p. 35, fig. 26. Individuals were not common.

SPHAERIUM LINEATUM Sterki

Plate XCVI, figures 18-21

Sphaerium lineatum STERKI, Nautilus, XXIII, p. 142, 1910.

Sphaerium lineatum STERKI, Cat., p. 433, 1916.

TYPE LOCALITY: Turkey Lake, Kosciusko Co., Ind.

WISCONSIN RECORDS:

1924. *Sphaerium lineatum* BAKER, p. 133. Doemel Point, Lake Winnebago.

SHELL: "Mussel somewhat elongate, inequipartite, well inflated; beaks somewhat anterior, rather large, full, rounded, projecting over the hinge margin; dorsal and ventral margins moderately and regularly curved, anterior and posterior ends subtruncate-rounded, oblique; scutum and scutellum distinctly

marked, narrow; surface dullish with a slight silky gloss, with the concentric striae (sulci) fine, sharp, crowded, regular, and several (3 or 4 to 7) strongly marked, dark lines of growth; color grayish-horn to reddish, the latter prevalent on the beaks and upper part of older specimens; shell rather thin.

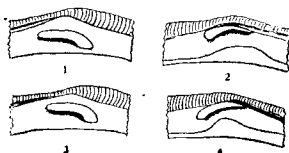


Fig. 251. Cardinal teeth of *Sphaerium lineatum* Sterki. Lake Winnebago.

"Hinge (fig. 251) slight, long, plate narrow; cardinal teeth small, slight, short, the right curved or angular, emarginate, its posterior part bifid, the left anterior rudimentary or wanting in some specimens; ligament long, slight, covered" (Sterki).

L. 15.5; H. 11.5; D. 8 mm. Turkey Lake. Type (Sterki).

L. 13.0; H. 11.5; D. 8 mm. Winnebago Lake (U. of W., 4433).

ECOLOGY: Winnebago Lake, boulder bottom, water 0.6 m. deep.

GENERAL DISTRIBUTION: Indiana, Illinois, Michigan, Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from Winnebago Lake, where it is rare.

REMARKS: This is a rare species in Wisconsin. The Winnebago Lake specimens are smaller and relatively wider than the Turkey Lake specimens and the umbones are not quite as prominent. There are four of the peculiar dark lines that give the mussel its name. These appear to be rest growth lines, and the lake mussels would seem to mark periods when shell growth ceased, as in the Unionidae. The Daniels collection of the University of Illinois contains many specimens of the original lot collected by L. E. Daniels, and the Winnebago Lake specimens are very much like them.

"It appears that the comparatively numerous, strong, mostly dark lines of growth and the fine (as compared with those of other species) sharp, crowded striae are characteristic and, combined with surface appearance and color, let specimens be recognized at a glance" (Sterki).

SPHAERIUM SOLIDULUM (Prime)

Plate XCVII, figures 1-3; plate XCVIII, figures 26-28

Cyclas solidula PRIME, Proc. Bost. Soc. N. H., p. 158, 1851.*Sphaerium solidulum* PRIME, Mon. Corb., p. 36, 1865.*Sphaerium solidulum* STERKI, Cat., p. 433, 1916.**TYPE LOCALITY:** Ohio.**WISCONSIN RECORDS:**1865. *Sphaerium solidulum* PRIME, p. 36. Wisconsin.1906. *Sphaerium solidulum* CHADWICK, p. 97. Kenosha.

SHELL: Elongate-ovate, slightly inequipartite, moderately inflated; beaks usually placed near the center of the dorsal margin, but often a trifle nearer the anterior end, of good size, rounded, projecting considerably above the hinge line; dorsal margin short, moderately curved; ventral margin broadly convex; anterior and posterior ends rounded, a trifle oblique in some specimens; scutum and scutellum well marked; surface dull in most specimens, with a silky gloss in more perfect specimens; sculpture of coarse concentric ridges, widely separated, with fine growth lines between; ridges especially coarse on the umbones, where they are erect and widely spaced; color light yellowish, smoky, horn; shell rather heavy, the valves thick.

Hinge rather strong, slightly curved, plate rather wide; cardinals small, that in the right valve rather long, usually curved, placed near the ligament or below it, near the ventral margin of the plate; in left valve, upper tooth rather long, narrow, lower tooth more or less pyramidal, thick; laterals short, thick, compressed-pyramidal; cavity of beaks deep; nacre bluish-white.

L. 13.0; H. 10.0; D. 7.0 mm. Near Joliet, Ill. (U. of I., Z13871).

L. 10.2; H. 8.6; D. 6.5 mm. Mukwonago River (U. of I., Z22254).

L. 9.1; H. 7.0; D. 5.0 mm. " " " "

L. 9.0; H. 8.0; D. 6.0 mm. " " " "

ECOLOGY: Shallow water, bottom gravel with sand, good current, water clear (Bark River, Rome); shallow water, clear and cold, gravel-sand bottom (Mukwonago River near Eagle Lake); shallow water, gravel bottom, swift current, some vegetation (Mukwonago). Cahn.

GENERAL DISTRIBUTION: Mississippi Valley eastward. Typical forms occur in Ohio, Indiana, Illinois, Michigan, and

Kentucky. From Ohio eastward it is represented by smaller forms, some of them rarely recognizable. Westward (Iowa) and southward (Alabama) there are found other different, yet apparently conspecific forms, more elongate, with fine striae, and slighter shells and hinges (Sterki, 1916, p. 433).

DISTRIBUTION IN WISCONSIN: At present known only from southeastern Wisconsin in the Rock, Fox, and Lake Michigan drainages.

REMARKS: *Solidulum* resembles *stamineum*, but is a more solid shell, of a more trigonal form, with stronger and coarser beak sculpture and heavier lateral teeth. It is found in both the rivers and lakes of southeastern Wisconsin and exhibits little variation in the two habitats. All of the Wisconsin forms, however, are smaller and more swollen about the umbonal region than material from the rivers of Illinois (compare figures on pl. XCVII and XCVIII).

SPHAERIUM SOLIDULUM WINNEBAGOENSE Var. Nov.

Plate XCVII, figures 4, 5

SHELL: Differing from the river form of *solidulum* in being smaller, more delicate, relatively more corpulent, more elongated, and cylindrical, with more swollen umbones, anterior and posterior ends more rounded, lines of growth more irregular; hinge weaker (fig. 252).

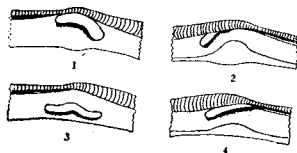


Fig. 252. Cardinal teeth of *Sphaerium solidulum* (Prime). Lake Winnebago.

L. 9.0; H. 7.4; D. 5.0 mm. Lake Butte des Morts (U. of W., 4435). Type.
L. 8.5; H. 6.7; D. 6.0 mm. " " " " (" 4435). Paratype.

TYPE LOCALITY: Lake Butte des Morts, Fox River channel, 3.4 m.

WISCONSIN RECORDS:

1865. *Sphaerium solidulum* PRIME, p. 36 (?). Wisconsin.
1906. *Sphaerium solidulum* CHADWICK, p. 97 (?). Wisconsin.

1906. *Sphaerium vermontanum* CHADWICK, p. 97. N. shore Lake Winnebago, west of High Cliff.
1924. *Sphaerium solidulum* BAKER, p. 133. Lake Winnebago and Butte des Morts.

ECOLOGY: Lake Butte des Morts, Fox River channel, 3.4 m., mud bottom; wild rice zone, .8 m., hard sand bottom. Lake Winnebago, off Morely Pt., 2.8 m., sand and gravel; off Long Island, 1.6 m., sand & gravel.

DISTRIBUTION IN WISCONSIN: Known from the Winnebago Lake region, where it seems widely distributed.

REMARKS: The Winnebago Lake region *solidulum* appears to be an ecological form, characterized by a smaller, more cylindrical shell. As far as material is at hand, this variety or ecological race includes no integrades with the river form, as found in Illinois (compare figures 4, 5 with figs. 1–3 on plate XCVII). The form seems to be rare in this State. The citation of Chadwick (1906, p. 97) from Kenosha needs confirmation, but no specimens are at hand for comparison. The variety is evidently the result of the same influences that produced the peculiar lake naiads, such as *Ligumia recta* and *Leptodea fragilis lacustris*.

SPHAERIUM STAMINEUM (Conrad)

Plate XCVII, figures 6–9

Cyclas staminea CONRAD, Amer. Jour. Sci., XXV, p. 342, pl. i, fig. 5, 1834.

Sphaerium stamineum PRIME, Mon. Corb., p. 38, 1865.

Sphaerium stamineum STERKI, Cat., p. 433, 1916.

TYPE LOCALITY: South Alabama.

WISCONSIN RECORDS:

1906. *Sphaerium stamineum* CHADWICK, p. 97. N. Branch Milwaukee River at Lindworm; Mud Creek, half-mile east of Teutonia Ave.; Kinnickinnic River, near Eleventh Ave.
1922a. *Sphaerium stamineum* GRIER, p. 28. Mississippi River, Trempealeau Co.
1924. *Sphaerium stamineum* BAKER, p. 133. Lake Winnebago and Fox River.

SHELL: Trigonal or roundly ovate, inequipartite, much inflated; beaks slightly anterior, of good size, swollen, greatly elevated above the hinge line; dorsal margin short, slightly convex; ventral margin more broadly rounded; anterior margin

rounded or slightly truncated; posterior margin similar; scutum and scutellum well marked, surface dull, with silky gloss, sculpture of coarse concentric ridges with fine lines between, coarse on the umbones; color brownish or chestnut, rarely yellow; shell rather heavy, thick.

Hinge strongly curved, plate wide, thick; cardinals small, a single massive, thick, straight or slightly curved cusp in the right valve, and two cusps in the left valve, the upper thick, straight, the lower short, erect, pyramidal (fig. 253); laterals short, broadly pyramidal, laterally compressed, not much elevated above the hinge line; cavity of beaks deep; nacre bluish, more or less purplish.

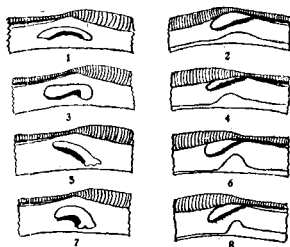


Fig. 253. Cardinal teeth of *Sphaerium stamineum* (Conrad). Red Cedar River.

L. 10.4; H. 8.9; D. 6.5 mm. Red Cedar River (U. of W., 4436).

L. 9.5; H. 8.5; D. 6.4 mm. " " (" 4436).

L. 11.5; H. 9.1; D. 7.0 mm. Outlet Lake Chetek (U. of W., 4437).

ECOLOGY: Omro, Fox River, mud bottom, .7 m. and .9 m.; outlet of Lake Chetek, sand bottom, .3 to 1 m.; Red Cedar River, sand bottom, .3 to 1 m.; Green Lake, marly-clay bottom, 3 m.

GENERAL DISTRIBUTION: Mississippi Valley and eastward (rare east of the Appalachians); Manitoba. Recorded from Michigan, Ohio, Indiana, Illinois, Iowa, Minnesota, etc. As the type locality is Alabama, it must occur in the drainage areas of that state.

DISTRIBUTION IN WISCONSIN: Rather widely distributed, but the distribution is not clear in many places. It should be found well scattered over the State.

REMARKS: Sterki says of this species: "Very variable, more so than any other species, and several extreme forms appear to be distinct. It is rather a 'form-cycle' than a species

in the current sense". In Wisconsin, *stamineum* may be separated from *solidulum*, its nearest ally, by its more trigonal form, more elevated beaks, more curved hinge line, and usually more corpulent shell. It does not appear to be common, judging by the paucity of specimens in all streams studied. Wisconsin specimens are darker than Illinois specimens, on the average. Reversed hinges occurred in specimens from Brown Co., though rarely. Specimens from Sturgeon Bay are near var. *wisconsinense*, but seem more logically referred to *stamineum*. They are more rounded and evenly inflated than *wisconsinense*.

SPHAERIUM STAMINEUM WISCONSINENSE Sterki

Plate XCVII, figures 10-12

Sphaerium stamineum wisconsinense STERKI, Ann. Carnegie Mus., X, p. 434, 1916.

TYPE LOCALITY: Not given, but probably from Fox River, Brown Co.

WISCONSIN RECORDS: None, other than Sterki's record "Wisconsin" in the original description.

SHELL: Smaller than the average *stamineum*, not so high, less inflated, superior margin less curved; surface sculpture moderately coarse to obsolete; color light corneous to grayish; shell and hinge slighter (Sterki, 1916, p. 434).

L. 7.2; H. 6.5; D. 4.6 mm. Brown Co. (U. of W., 4438).

L. 7.5; H. 7.0; D. 5.0 mm. " " (" 4438).

L. 8.5; H. 7.1; D. 5.1 mm. " " (" 4438).

ECOLOGY: Not recorded.

GENERAL DISTRIBUTION: Wisconsin, Michigan; fossil in Illinois (Chicago deposits).

DISTRIBUTION IN WISCONSIN: Known only from the lower Fox River, in Brown Co., mostly from four miles south of De Pere. (Marston coll.).

REMARKS: Apparently a well marked variety of *stamineum*, characterized as noted in the diagnosis of Sterki. It is the most abundant *Sphaerium* in Wisconsin, judging by the number of specimens in the collection. Whether this is an ecological or geographic variety is not clear. It is not a lake form because it does not occur in Winnebago Lake, the form there

being the typical *stamineum*. The lower Fox River is peculiar in being very wide and lake-like and it may be a response to this kind of an environment. It may also be a northern race of the typical form. The hinge (cardinal teeth) is slighter than *stamineum*, at least the cusps in the left valve are slighter, the right cardinal does not differ much (fig. 254; compare with fig. 253). The laterals are shorter, but still rather massive. The difference in size and shape of the shell is well shown on the plate (pl. XCVII, figs. 6-12). On the whole it

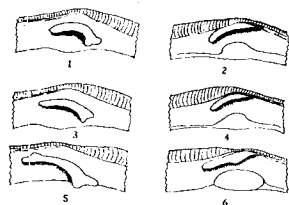


Fig. 254. Cardinal teeth of *Sphaerium stamineum wisconsinense* Sterki. Fox River.

is rounder and less elongated than the typical form. Specimens from Sturgeon Bay are referred to this variety by Sterki, with a query; they are more elongated than *wisconsinense*, more rounded and evenly inflated, with the slight shell of the variety. They seem to be an intermediate form and best referred to *stamineum*, at least until more material is available for study. They are not at all like the specimens from the Fox River.

SPHAERIUM EMARGINATUM (Prime)

Plate XCVII, figures 19-22

Cyclas emarginata PRIME, Proc. Bost. Soc. N. H., IV, p. 156, 1851.

Sphaerium emarginatum PRIME, Mon. Corb., p. 43, 1865.

Sphaerium emarginatum STERKI, Cat., p. 434, 1916.

TYPE LOCALITY: In the region of Lake Superior.

WISCONSIN RECORDS: None.

SHELL: Solid, thick, trigonal, nearly equipartite, inflated; anterior and posterior ends roundly truncated; dorsal margin much curved; ventral margin broadly convex; beaks almost centrally placed, distinctly elevated above the dorsal margin, rounded, sculpture of very fine lines; scutellum and scutum well

marked; surface dull, sculpture of more or less regularly spaced sulcations, with fine growth lines between; color dark brown in adult, yellowish-brown in young and immature shells.

Hinge rather weak, narrow; cardinal teeth elongated, narrow, slightly curved, the single cusp in the right valve with a swelling at the lower part, which is sometimes bifid; upper cardinal in left valve narrow, straight or but slightly curved; lower cardinal larger, short, pyramidal (fig. 255); laterals short, straight, extending well above the edge of the valve, pyramidal, compressed; nacre bluish-white; cavity of beaks deep.

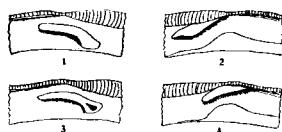


Fig. 255. Cardinal teeth of *Sphaerium emarginatum* (Prime). Red Cedar River.

L. 11.4; H. 9.2; D. 7.0 mm.	Red Cedar River	(U. of W., 4439).
L. 10.0; H. 8.1; D. 6.5 mm.	" "	(" 4439).
L. 9.0; H. 8.5; D. 6.5 mm.	" "	(" 4439).
L. 9.0; H. 7.5; D. 5.9 mm.	" "	(" 4439).
L. 7.0; H. 5.2; D. 4.4 mm.	" "	(" 4439).

ECOLOGY: Red Cedar River, sand bottom, depth .3 to 1 m.

GENERAL DISTRIBUTION: Maine to Lake Superior, Winnipeg, Keewatin (Sterki). It is in the Daniels collection of the University of Illinois from Pine Lake, and Lake Michigan shore, Indiana, and from various places on the Lake Michigan shore in Illinois.

DISTRIBUTION IN WISCONSIN: Known only from Red Cedar River, near Chetek, Barron Co. (Baker).

REMARKS: *Emarginatum* is a rather distinct species, related, however, to *stamineum*, with which it is associated in the Red Cedar River. Sterki says of these specimens "although some examples of these are much alike, the two are apparently distinct. The prevalence of one or the other at different places of that river seems of interest" (in letter). As both occur in the same habitat, it seems evident that they are separate species. The shell of *emarginatum* is not as heavily sulcated as that of *stamineum*, the whole shell is more trigonal, the umbones are not as heavily sulcated, and the hinge line is more

convex. Its nearest relative seems to be *S. torsum*, which is more inequiptartite, more inflated, especially near the umbones, and more heavily sulcated. *Emarginatum* is the most abundant *Sphaerium* in the Red Cedar River, but appears to be absent from other parts of the State.

SPHAERIUM TORSUM Sterki

Plate XCVII, figures 22-24

Sphaerium torsum STERKI, Ann. Carnegie Mus., X, p. 434, 1916.

TYPE LOCALITY: Quebec, Ontario, along the Ottawa River, near Hull and Ottawa. Moores Creek (vide Latchford).

WISCONSIN RECORDS:

1916. *Sphaerium torsum* STERKI, p. 434. Wisconsin.

SHELL: "Inequiptartite, oblique, well inflated, posterior part higher, and much more voluminous than the anterior; dorso-ventral axis curved and oblique; beaks strongly inclined forward, large, prominent, rounded, not, or slightly, mamillar; superior margin curved, not, or barely, bounded by angles; scutellum and scutum well marked; anterior and posterior ends rounded, inferior margin moderately curved; surface with fine, slight, irregular or subregular concentric striae and a few lines of growth, shining; yellow, straw-colored in younger specimens; shell moderately strong.

"Hinge long for the shape and size of the mussel, almost regularly curved, rather slight; cardinal teeth small, the left posterior tooth vestigial in some specimens; laminae (laterals)

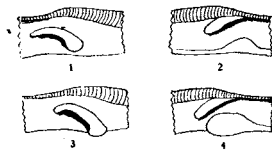


Fig. 256. Cardinal teeth of *Sphaerium torsum* Sterki. Moores Creek, Canada.

rather slight, at almost a right angle to each other; ligament covered, resilium moderately strong." (Sterki, 1916, p. 434). The cardinal in the right valve is strong, curved, enlarged at the lower part; the upper cardinal in left valve is almost straight, wide; the lower cardinal varies in size from a mere

swelling of the hinge line to a large, wide, pyramidal cusp (fig. 256). There is a deep pit below the cardinal in the right valve.

L. 11.0; H. 9.0; D. 7.0 mm. Sterki's type.

L. 10.5; H. 8.4; D. 6.5 mm. Moores Creek (U. of I., Z11347).

L. 10.0; H. 8.5; D. 6.4 mm. " " (" Z11347).

ECOLOGY: Not recorded.

GENERAL DISTRIBUTION: Quebec, Ontario and Wisconsin. Fossil in Goat Island gravels, N. Y.

DISTRIBUTION IN WISCONSIN: Known from but one locality at present, Noquebay Lake, near Crivitz, Marinette Co. (Sterki, Walker).

REMARKS: "*Sphaerium torsum* appears to range near *emarginatum* of the same region, but is more oblique, of more rounded outlines, more evenly inflated. The beaks are less elevated, less mamillar, and more inclined forward, and the hinge is much slighter" (Sterki). This species is closely related to *emarginatum*, but the characters indicated by Sterki will easily separate it from that species. A single specimen of *torsum* contained one young in the inner gill, 3.2 mm. long, the adult specimen being 10.5 mm. long.

SPHAERIUM ACUMINATUM (Prime)

Plate XCVII, figures 23-26

Cyelas acuminata PRIME, Proc. Bost. Soc. N. H., IV, p. 155, 1851.

Sphaerium acuminatum PRIME, Mon. Corb., p. 37, 1865 (syn. of *striatum*).

Sphaerium acuminatum STERKI, Cat., p. 435, 1916.

TYPE LOCALITY: Lake Superior.

WISCONSIN RECORDS:

1906. *Sphaerium vermontanum* CHADWICK, p. 97. Lake Michigan at Milwaukee.

SHELL: Trigonal, somewhat rounded, but slightly inequipartite, not much inflated; beaks a trifle anterior, not much inflated, almost flush with the hinge line in some specimens; dorsal margin strongly arched; ventral margin broadly convex; anterior and posterior ends roundly truncated; scutum and scutellum well marked; surface glossy or silky, growth lines rather coarse with fine lines between; color corneous, sometimes with indistinct rays extending from umbones to ventral

margin; there are usually several zones of dark color, mostly concentric, on the surface; shell rather thick.

Hinge line rather strong, wide arched; cardinal of right valve large, heavy, strongly arched, often enlarged and bifid at the lower end; cardinals of left valve, upper long, thin, almost straight; lower high, thick, pyramidal, does not show much variation (fig. 257); laterals rather massive, short, wide, not much elevated above the edge of the valve; cavity of the beaks fairly deep; nacre bluish-white often tinged with pinkish.

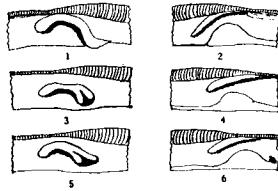


Fig. 257. Cardinal teeth of *Sphaerium acuminatum* (Prime). Lake Michigan.

L. 11.0; H. 9.0; D. 6.0 mm.	Lake Michigan (U. of I., Z14028).
L. 10.0; H. 8.1; D. 5.7 mm.	" " (" Z14028).
L. 9.0; H. 7.5; D. 5.7 mm.	" " (" Z14028).
L. 8.9; H. 7.5; D. 5.0 mm.	" " (" Z14028).

ECOLOGY: Golden Lake, pure sand, no vegetation, water about 1 m. deep; Oconomowoc Lake, sand-clay bottom, 2.5 m. deep (Cahn). The Lake Michigan specimens must live on a more or less wave-beaten shore. Chadwick records sand bottom at Milwaukee.

GENERAL DISTRIBUTION: Region of the Great Lakes.

DISTRIBUTION IN WISCONSIN: Known in living condition only from Lake Michigan and Green Bay.

Green Bay: Marinette, Marinette Co. (Bullock); Sturgeon Bay, Door Co. (Baker).

Lake Michigan: Sandy beach of Lake Michigan at Milwaukee, Milwaukee Co. (Chadwick); Lake shore from Illinois line northward (Baker).

Fox River Drainage: Spring Lake, Green Bay Co., near Green Lake, Pleistocene fossil (Baker).

Rock Drainage: Oconomowoc, Genessee, Golden, La Belle lakes, Waukesha Co. (Cahn). Lower Nashotah Lake, Waukesha Co., fossil (Cahn).

REMARKS: The strongly trigonal shell, with depressed umbones, placed fairly near the center of the dorsal margin, and the somewhat "pinched" appearance of the ventral part of the valves, will help to distinguish this species. The sculpture is finer than that of *solidulum*, with which it has been confused. *Striatinum* is longer and more inequipartite. This species, long considered a synonym of *striatinum*, is very distinct and easily recognized. Sterki examined the original specimens of *acuminatum* (1913, p. 139) and was at once convinced of their distinctness from that species. Should *albula* Prime, be definitely ranked as a synonym of *acuminatum*, it would have to be used for the species, it having precedence on the page.

Acuminatum is one of the most abundant shells on the shore of Lake Michigan between Indiana and Wisconsin, the beach in many places in both Illinois and Indiana being fairly paved with the separated valves. It probably inhabits the shore somewhat north of Milwaukee, but details are not available. It is not found on the shore of the Door Co. Peninsula, this region being personally examined for a distance of several miles east of Sturgeon Bay.

One adult *acuminatum*, 9 mm. long, contained one young, the shell of which was 5 mm. long.

SPHAERIUM BAKERI Sterki

Plate XCVII, figures 30-32

TYPE LOCALITY: Green Lake, Green Lake Co., Wis.

WISCONSIN RECORDS: None.

SHELL: The diagnosis of this species has not been published by Dr. Sterki. See under remarks.

L. 9.0; H. 7.5; D. 5.8 mm. Green Lake (U. of W., 4450).

L. 9.0; H. 8.0; D. 6.0 mm. " " (" 4450).

ECOLOGY: Off west shore Green Lake, 1.5 m., sand bottom; Sturgeon Bay, west of City, sand bottom, 2 m. deep. Evidently a lake species.

DISTRIBUTION IN WISCONSIN: Known only from the Fox River and Green Bay drainage.

Fox Drainage: West end Green Lake, Green Lake Co.

Green Bay Drainage: Sturgeon Bay, west of city, Door Co. (Baker).

REMARKS: *Bakeri* is evidently related to *acuminatum*, another species of the Great Lakes; it may be known from this species by its more corpulent, rounder shell, with more elevated and mammae-like umbones, those of *acuminatum* being almost flush with the dorsal margin. The outline of the shell of *acu-*

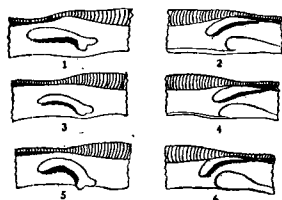


Fig. 258. Cardinal teeth of *Sphaerium bakeri* Sterki. West end Green Lake.

minatum is scarcely interrupted by the umbones, while in *bakeri* they form a distinct, rounded projection on the dorsal margin. Specimens from Green Lake are rounder than those from Sturgeon Bay, the latter having a pointed and somewhat truncated posterior end, which is longer than in the Green Lake specimens. The more rounded form also occurs among individuals from Sturgeon Bay.

SPHAERIUM STRIATINUM (Lamarek)

Plate XCVIII, figures 1-5

Cyclas striatina LAM., An. sans Vert., V, p. 560, 1818.

Sphaerium striatinum PRIME, Mon. Corb., p. 37, 1865 (excepting synonyms).

Sphaerium striatinum STERKI, Cat., p. 435, 1916.

TYPE LOCALITY: Lake George, N. Y.

WISCONSIN RECORDS:

1906. *Sphaerium striatinum* CHADWICK, p. 97. Mud Creek, half-mile east of Teutonia Ave.; cement mills, Lindwurm, Milwaukee Co.

1911a. *Sphaerium striatinum* BAKER, p. 232. Wisconsin River.

1924. *Sphaerium striatinum* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Elongate-oval, inequipartite, not much inflated; beaks placed anterior of the center of the dorsal margin, not much inflated, raised a trifle above dorsal margin, rather full, mammae-form; dorsal margin slightly arched; ventral margin

broadly rounded, in some specimens almost straight; anterior and posterior ends roundly truncated, the posterior end usually more pointed and distinctly truncated; scutum and scutellum well marked; sculpture usually of rather feeble concentric ridges with fine lines between, but ridges on umbonal slope may be heavier in some specimens; color corneous, dark in some specimens and with dark spots or blotches on different parts of the shell; shell of medium thickness, sometimes rather thin.

Hinge not very wide; cardinals small, that in the right valve curved, lower end swollen and sometimes bifid, with a deep pit beneath; upper cardinal of left valve small, straight or slightly curved; lower cardinal pyramidal, erect, of variable size; all cardinals are variable as to shape and size (fig. 259 p. 1-4); laterals rather short, somewhat curved, extending considerably above the margin of the valve; the posterior laterals are longer and narrower than the anterior laterals; cavity of beaks deep; nacre purplish or bluish-white; the pallial line is very wide and irregularly serrated.

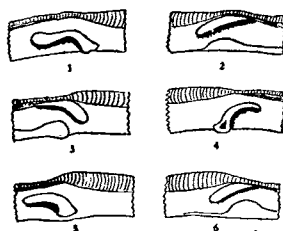


Fig. 259. Cardinal teeth of *Sphaerium striatinum* (Lam). 1, 4. Taber Lake, near Chetek. 3, 4. Reversed hinges. 5, 6. Var. *corpulentum* Sterki. Omro, Fox River.

L. 11.3; H. 8.8; D. 6.1 mm.	Lake Butte des Morts (U. of W., 4440).
L. 10.9; H. 8.1; D. 6.0 mm.	" " " " (" 4440).
L. 9.5; H. 7.6; D. 5.5 mm.	" " " " (" 4440).
L. 9.0; H. 7.0; D. 5.0 mm.	" " " " (" 4440).
L. 12.0; H. 9.0; D. 6.7 mm.	Lake Winnebago (U. of W., 4441).

ECOLOGY: Lake Butte des Morts, sand bottom, .8 to 3.4 m.; mud bottom, 3-3.4 m.; Lake Winnebago, sand and gravel bottom, 2.6 m.; Wisconsin River, Oneida Co., shallow water along shore, sand bottom.

GENERAL DISTRIBUTION: East of the Rocky Mountains. The center of distribution appears to be in the Middle States,

Ohio, Michigan, Indiana, and Illinois. Typical or near-typical forms have not been seen from the South.

DISTRIBUTION IN WISCONSIN: Rather widely distributed in the State in both lakes and rivers. It is found in both the Mississippi Valley and Great Lakes drainages.

REMARKS: "Very variable, and still difficult to define as a species" (Sterki). Wisconsin *striatinum* may usually be known by its elongate-ovate shape, depressed umbones, and usually by its delicate sculpture, as compared with other *Sphaeria*.

Striatinum is one of the most variable species of the genus and it is often difficult to place satisfactorily some of the mutations. Specimens from Taber Lake, near Chetek, are similar to typical forms from Illinois and Indiana. In the Wisconsin River, above Kilbourn, a form occurs which is much elongated, very cylindrical, with depressed umbones and a very delicate hinge. These may constitute a variety when more material is available, according to Sterki. A few shells were dredged in Lake Winnebago at a depth of .9 m., on a sand bottom, which have a beautifully polished shell like some *striatinum* from Illinois and Indiana, but it is larger with a more pointed posterior end and higher umbones. It is probably a mutation of the typical form (see fig. 5, pl. XCVIII). Reversed hinges are rare in Wisconsin material (see fig. 259, 3, 4).

SPHAERIUM STRIATINUM CORPULENTUM Sterki

Plate XCVIII, figures 6-9

Sphaerium striatinum corpulentum STERKI, Ann. Carnegie Mus., X, p. 435, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS: None.

SHELL: Large, high; well inflated, the surface often having rather coarse striae; shell and hinge rather strong (Sterki).

L. 14.0; H. 11.5; D. 8.3 mm.	Fox River (U. of W., 4442).
L. 12.0; H. 9.9; D. 7.0 mm.	" " (" 4442).
L. 12.0; H. 9.0; D. 6.5 mm.	" " (" 4442).
L. 9.0; H. 7.0; D. 5.0 mm.	" " (" 4442).
L. 5.5; H. 4.5; D. 3.1 mm.	" " (" 4442).
L. 12.0; H. 9.1; D. 6.6 mm.	De Pere, Fox R. (U. of W., 444).

ECOLOGY: Omro, Fox River, .9 to 2.9 m., mud and gravel bottom, more common in the former. The normal habitat of this variety appears to be along the margin of the river, in water .9 m. deep, on a mud bottom; in this habitat it is very common, dozens being brought up in a dipper at one time.

GENERAL DISTRIBUTION: Michigan, Ohio, Illinois, mostly in creeks.

DISTRIBUTION IN WISCONSIN: Widely distributed, but the records few and scattering. It is probably found in many places but has been called by some other name.

St. Croix Drainage: Near Grantsburg, Burnett Co. (Bullock).

Fox River Drainage: Omro, Winnebago Co. (Baker); De Pere, and four miles south of De Pere, Brown Co. (Marston); Fox River, Portage, Columbia Co. (Baker).

Lake Michigan Drainage: Marinette, Marinette Co. (Bullock).

REMARKS: The *striatinum* of Wisconsin divide into two quite distinct forms or varieties. One, typical *striatinum*, has an elongate-ovate shell, low umbones, and fine sculpture; the other is more or less trigonal, with high, swollen umbones, and heavy sculpture, especially near the beaks. The typical form seems to be more characteristic of lakes or streams with moving water, while the variety is characteristic of creeks or slow moving bodies of water. There are many intermediate forms, however, connecting these two extremes. Thus in Lakes Winnebago and Butte des Morts, a form occurs which has the form of *striatinum* with the sculpture of *corpulentum*. These two extremes are figured on the plate. The hinge of the variety is a trifle heavier, and the cardinals are stouter (Fig. 259, 5, 6).

Of this variety Sterki remarks: "This appears to be the really typical form, rather than the small eastern mussel described by Prime in his Monograph. Prime's figure does not agree with the description nor with any specimens" (op. cit., p. 436).

A number of specimens of this variety were examined and some interesting notes obtained on the size and number of young found in adult mussels. A table of the results will be found in the introduction to Sphaeriidae.

SPHAERIUM STRIATINUM LILYCASHENSE Baker

Plate XCVIII, figures 10-12

Sphaerium lilycashense BAKER, Nautilus, XII, p. 65, 1898.*Sphaerium lilycashense* BAKER, Moll. Chi. Area, p. 395, text fig. 137, 1902.*Sphaerium lilycashense* STERKI, Ann. Carnegie Mus., X, p. 436, 1916.

TYPE LOCALITY: Lilycash Creek, near Joliet, Ill.

WISCONSIN RECORDS:

1924. *Sphaerium lilycashense* BAKER, p. 133. Fox River.

SHELL: Differing from the typical *striatinum* in being higher, more regularly ovate, with the anterior and posterior ends equally rounded and not truncated as in *striatinum* and *corpulentum*; umbones elevated as in *corpulentum* and a trifle more mammae-form, placed near the center of the dorsal margin; the lower part of the valves is more compressed in *striatinum* than in either *lilycashense* or *corpulentum*; the surface sculpture is much finer than in either the typical form or *corpulentum*; the luster may be shiny or dull, and the color is dark corneous with darker zones.

The hinge is not quite as strong as *corpulentum* or *striatinum*; cardinals (Fig. 260) more variable than the typical form or the variety, the single cusp in the right valve much curved, heavy, wide; the upper cardinal in left valve not as heavy is in either of the forms mentioned; the lower tooth about as the other forms; a single reversed hinge had a strongly bifid cardinal in the left valve and two very narrow, lamellar teeth in the right valve (Fig. 260, 5, 6). Grantsburg specimen.

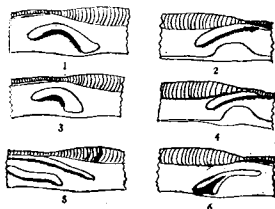


Fig. 260. Cardinal teeth of *Sphaerium striatinum lilycashense* Baker.
1, 2. Lake Butte des Morts. 3-6. Grantsburg. 5, 6. Reversed hinges.

L. 13.0; H. 10.0; D. 8.0 mm.	Joliet (Type specimen).
L. 13.0; H. 10.0; D. 7.7 mm.	Butte des Morts (U. of W., 4443).
L. 11.2; H. 9.1; D. 7.0 mm.	Grantsburg (U. of W., 4444).
L. 10.7; H. 8.7; D. 6.2 mm.	" (" 4444).
L. 10.1; H. 8.0; D. 6.0 mm.	" (" 4444).
L. 8.0; H. 6.5; D. 4.4 mm.	" (" 4444).

ECOLOGY: In small creek in soft mud (original locality); Lake Butte des Morts, mud bottom, 3.4 m. deep; Upper Dells, Wisconsin River, Kilbourn, mud bottom, shallow water near shore.

GENERAL DISTRIBUTION: Lilycash Creek, near Joliet; Chicago River, near Chicago, Illinois. Charlevoix, Mich. Wisconsin references.

DISTRIBUTION IN WISCONSIN: Widely distributed, but in scattered localities. Probably uniformly distributed over much of the State.

Fox Drainage: Lake Butte des Morts, Winnebago Co. (Baker).

Wisconsin Drainage: Upper Dells, Kilbourn (Baker).

St. Croix Drainage: Grantsburg, Burnett Co. (Bullock).

Rock Drainage: Bark River, Rome, Jefferson Co. (Cahn).

REMARKS: *Lilycashense* appears to be a variety of *striatinum* and not a distinct species. The differences pointed out in the diagnosis will usually separate the variety, but there are specimens from several places that are intermediate between it and either *corpulentum* or the typical form. Such occur in the Fox River at Portage, as well as in the Wisconsin in the Upper Dells at Kilbourn. Some specimens (as at Kilbourn) are much elongated, with depressed beaks and fine sculpture, but they are evidently but a mutation of the *lilycashense* type.

The three varieties of shell described—*striatinum*, *corpulentum*, *lilycashense*—appear to be variations of the same type of shell, more or less well connected by integrades. Some of the variations seem to be ecological, others well marked mutations. Typical *striatinum* was described from a lake habitat, while the other two forms occupy river and creek habitats. There might be a division on the basis of ecological station.

SPHAERIUM NOTATUM Sterki

Plate XCVII, figures 13, 14, 18

Sphaerium notatum STERKI, Nautilus, XLI, p. 55, 1927.

TYPE LOCALITY: Camp Creek, Dickinson County, Kansas.

WISCONSIN RECORDS: None.

SHELL: "Somewhat elongate, subequipartite, medium inflated; beaks slightly or barely anterior, moderately projecting, rounded and slightly mammillar; dorsal margin rather short,

moderately curved, bounded by slightly marked angles, ventral margin moderately and regularly curved; anterior and posterior slopes slightly marked, anterior end well rounded, posterior somewhat angular; surface dull to dullish, microscopically rugulose, with the striae rather fine, crowded, sharp, irregular to subirregular; color of the adult corneous to drab or grayish, mostly with a narrow marginal lighter zone, of the young straw to light yellowish; shell rather thin, opaque or subtranslucent; hinge moderately curved, of the same formation as in *striatinum*, etc., plate quite narrow, cardinals small (see fig. 261).

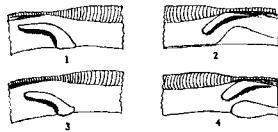


Fig. 261. Cardinal teeth of *Sphaerium notatum* Sterki. Outlet of Green Lake.

- L. 15.0; H. 11.5; D. 8.3 mm. Type.
 L. 12.0; H. 9.2; D. -- mm. Creek, W. end Green Lake (U. of W., 4445).
 L. 10.0; H. 8.1; D. 6.0 mm. Outlet Creek, Green Lake (U. of W., 4446).
 L. 9.0; H. 7.0; D. 5.8 mm. " " " " (" 4446).

ECOLOGY: Outlet creek, Green Lake, below six foot dam, shallow water, rapid current, rock bottom. A *Goniobasis* habitat. Dead shell off mouth of creek west end of lake, 2 m. Sterki says, "rivers and creeks, occasionally ponds."

GENERAL DISTRIBUTION: At present known from Wisconsin south to Texas and west to North Dakota, Arkansas, and Oklahoma (Sterki).

DISTRIBUTION IN WISCONSIN: As far as known confined to the creeks near Green Lake, either outlet or draining into the lake.

REMARKS: "This *Sphaerium* had been known for many years and regarded as probably a distinct species. It is of the same group as *striatinum* and apparently takes its place westward, but their areas are somewhat overlapping, e. g. in Illinois and Wisconsin. The mussels are larger, more equipartite with the dorsal margin somewhat shorter, somewhat less and more evenly inflated. The surface is more markedly rugulose, more dull, and decidedly less variable as to station."

SPHAERIUM OHIOENSE Sterki

Plate XCVII, figures 15–17, 33–35

Sphaerium ohioense STERKI, Nautilus, XXVI, p. 139, 1913.*Sphaerium ohioense* STERKI, Cat., p. 436, 1916.

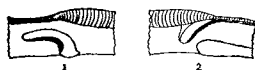
TYPE LOCALITY: Ohio River at Cannelton, Ind.

WISCONSIN RECORDS:

1924. *Sphaerium ohioense* BAKER, p. 133. Lake Winnebago.

SHELL: Transversely elongated, inequipartite, moderately inflated, the valves rather flat toward the margins; shell not solid, valves rather thin; dorsal and ventral margins slightly rounded; anterior end rounded; posterior end obliquely truncate to subtruncate, rounded below; umbones not much elevated, beaks small, placed just anterior of the center of the dorsal margin; scutum and scutellum rather long, narrow; surface dull, with irregularly placed ridges or sulci with fine lines of growth between; color straw to corneous, old specimens smoky-horn, sometimes with dark blotches.

Hinge slight, plate narrow; cardinals small, right tooth curved, rather thick, lower part swollen or thickened, sometimes nearly cubical; left upper cardinal thick, slightly curved, lower tooth elevated, elongated, not pyramidal; cardinals very uniform (fig. 262); laterals short, slight, not much elevated above edge of valve; cavity of beaks broad, not very deep; ligament and resilium rather long, slight; nacre bluish-white.

Fig. 262. Cardinal teeth of *Sphaerium ohioense* Sterki. Portage.

L. 14.0; H. 10.5; D. 7.0 mm. Portage (U. of W., 4447).

L. 13.5; H. 9.5; D. 7.0 mm. " (" 4447).

L. 13.0; H. 9.0; D. 7.0 mm. Winnebago Lake (U. of W., 4448).

L. 10.0; H. 8.0; D. 5.5 mm. " " (" 4448).

ECOLOGY: Winnebago Lake, mud bottom, 1.2 m. deep.

GENERAL DISTRIBUTION: Ohio River in Ohio and Indiana; Elk River, West Virginia; Wisconsin; Joliet, Ill.

DISTRIBUTION IN WISCONSIN: Known only from the Wisconsin and Fox rivers. The old Glacial connection at Portage may be responsible for the Lake Winnebago specimens.

Fox Drainage: Lake Winnebago, Winnebago Co. (Baker).

Wisconsin Drainage: Portage, Wisconsin River, Columbia Co. (Bullock).

REMARKS: *Ohioense* is a rather distinct species, related in a way to the variety *lilycashense* of *striatinum*, having much the same general shape. Its very elongate shell, almost centrally placed umbones, delicate sculpture and somewhat thin shell will differentiate it from the forms named. It is found in company with both *striatinum* and *stamineum*, from both of which it is easily distinguished. It is abundant in parts of Wisconsin, but seems confined to the Wisconsin-Fox drainages. The shells are very uniform in Wisconsin but differ somewhat from Indiana specimens in the Daniels collection, which are not as cylindrical as the Winnebago Lake and Portage forms, and the sculpture is finer. Otherwise they are similar.

A form of *Sphaerium* occurs in the Wisconsin River, below Kilbourn, which is somewhat different from typical *ohioense*. It is of less diameter, with flattened umbones, is more elongated, and with a much thinner shell. Dr. Sterki states that, while somewhat different from typical *ohioense*, these shells seem not to be distinct enough for a separate designation, merging more or less with the typical form (see pl. XCVII, figs. 33-35). Three specimens measure as follows:

L. 11.0; H. 7.5; D. 5.0 mm.	Wisconsin River (U. of W., 4449).
L. 11.0; H. 7.9; D. 4.9 mm.	" " (" 4449).
L. 9.5; H. 6.1; D. 4.0 mm.	" " (" 4449).

They may live in deep water in the river. None was found living, but dead shells were common on the shore of bars and points about a mile below Kilbourn.

SPHAERIUM FLAVUM (Prime)

Plate XCVIII, figures 18-21

Cyclas flavum PRIME, Proc. Bost. Soc. N. H., IV, p. 155, 1851.

Sphaerium flavum PRIME, Mon. Corb., p. 43, 1865.

Sphaerium fabale BAKER, Moll. Chi. Area, p. 118, 1898.

Sphaerium flavum STERKI, Cat., p. 436, 1916.

TYPE LOCALITY: Sault St. Marie, Lake Superior.

WISCONSIN RECORDS:

1906. *Sphaerium fabale* CHADWICK, p. 98. Honey Creek, near Layton Park, Milwaukee.

SHELL: Transversely oval, somewhat compressed, almost equipartite, thin and fragile to quite solid; dorsal margin short, almost straight; ventral margin straight or slightly rounded, curved upward at the ends; anterior and posterior ends roundly truncated, the posterior end somewhat pointed; umbones depressed, raised just a trifle above the dorsal margin; scutellum and scutum well marked; umbonal slopes gently rounded; surface usually shining, dull in old shells; growth lines fine but distinct, ridges not conspicuous; color light greenish or corneous, frequently with a dark chestnut concentric band near the base of the shell.

Hinge narrow, rather slight; cardinal in right valve rather large, thick, much curved, enlarged at lower part and somewhat emarginate on lower end; upper cardinal of left valve thick, straight; lower cardinal large, very erect, pyramidal (fig. 263, 1-4); laterals rather long, slight, straight; cavity of beaks shallow; nacre whitish with a tinge of blue.

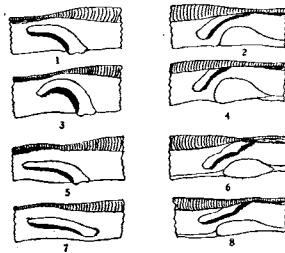


Fig. 263. Cardinal teeth of *Sphaerium flavum* and *foxense*. 1-4. Lake Michigan. 5-8. Lake Butte des Morts.

L. 10.0; H. 7.6; D. 5.0 mm.	Lake Michigan	(U. of W., 4451).
L. 9.3; H. 7.6; D. 5.0 mm.	" "	(" 4451).
L. 8.5; H. 7.0; D. 4.2 mm.	" "	(" 4451).
L. 7.5; H. 5.8; D. 3.4 mm.	" "	(" 4451).

ECOLOGY: Found on the sandy beach of Lake Michigan, depth of water not known definitely, but observed in .5 m.

GENERAL DISTRIBUTION: Region of the Great Lakes.

DISTRIBUTION IN WISCONSIN: Known only from the shore of Lake Michigan; Lake shore near Illinois-Wisconsin Line (Baker); Honey Creek, near Layton Park, Milwaukee, Milwaukee Co. (Chadwick).

REMARKS: *Flavum* may be known by its depressed umbones which are placed near the center of the dorsal margin, by its

compressed shell, and truncated ends. It is variable in its sculpture, specimens being coarser or finer in this respect in the same locality. It has a more polished shell than *striatinum*, the umbones are more depressed, and the whole shell is more compressed and evenly elongate-ovate. The Lake Michigan specimens are strikingly uniform in shape and diameter. On some beaches, at certain seasons of the year, this species, with *acuminatum*, occurs by thousands. The Lake Michigan specimens correspond with Prime's description and figure better than some from creeks in Indiana.

SPHAERIUM FLAVUM FOXENSE Nov. Var.

Plate XCVII, figures 27-29

TYPE LOCALITY: Lake Butte des Morts, near Plummer's Point.

WISCONSIN RECORDS:

1924. *Sphaerium flavum* BAKER, p. 133. Lake Butte des Morts.

SHELL: Differing from *flavum* in being of greater diameter, with a more trigonal shell, the umbonal region more swollen, the shell slightly inequipartite, umbones elevated, and sculpture much coarser, the umbonal region frequently having heavy, concentric ridges. The shell is slightly heavier.

L. 9.5; H. 7.5; D. 5.5 mm.	Butte des Morts (U. of W., 4452).	Type.
L. 8.6; H. 7.0; D. 5.6 mm.	" " " (" 4452).	Paratype.
L. 5.6; H. 4.9; D. 3.5 mm.	" " " (" 4452).	"

ECOLOGY: Lake Butte des Morts, .5 m., boulder bottom.

GENERAL DISTRIBUTION: Possibly inhabits the rivers or small lakes of the Great Lakes Region. Specimens from Deer Creek, Carroll Co., Ind., and Cannon Lake, Rice Co., Minn., are more like the *foxense* type than the typical *flavum* type from Lake Michigan.

DISTRIBUTION IN WISCONSIN: Known only from Lake Butte des Morts at the present time.

REMARKS: The form here separated from *flavum* as variety *foxense* is so uniformly different from the compressed Lake Michigan specimens that it should be distinguished as a variety. It is probable that the typical form is like the Lake Michigan specimens, judging by the description and figure of Prime, and also from the fact that the original specimens came from the

Great Lakes. *Foxense* would seem to be the river variety, characterized by a more corpulent shell and higher umbones, besides more pronounced sculpture of the surface. All of the river forms should probably be referred to variety *foxense*. The cardinal teeth of the variety are not as rugged nor as curved as in typical *flavum* (see fig. 263, 5–8).

SPHAERIUM RHOMBOIDEUM (Say)

Plate XCVIII, figures 13–17

Cyclas rhomboidea SAY, Jour. Acad. Nat. Sci. Phil., p. 380, 1822.

Sphaerium rhomboideum PRIME, Mon. Corb., p. 39, fig. 31, 1865.

Sphaerium rhomboideum STERKI, Cat., p. 438, 1916.

TYPE LOCALITY: Lake Champlain.

WISCONSIN RECORDS:

1906. *Sphaerium rhomboideum* CHADWICK, p. 97. Mud Creek, east of Teutonia Ave. bridge, and Honey Creek near Layton Park, Milwaukee.

1916. *Sphaerium rhomboideum* STERKI, p. 438. Wisconsin.

1920. *Sphaerium rhomboideum* BAKER, p. 119. Wauwatosa (fossil).

SHELL: subquadrate or rhombic, equipartite, inflated, convex at the beaks; dorsal margin slightly curved; ventral margin but slightly convex; anterior and posterior ends roundly truncated, the latter slightly angular; beaks depressed, not much raised above the hinge line; scutellum and scutum rather faint;

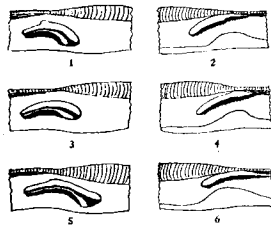


Fig. 264. Cardinal teeth of *Sphaerium rhomboideum* (Say). Brown Co.

surface dull with a satiny sheen; sculpture of close-set lines of growth with a few ridges in some individuals; color olive-green or dark corneous, with one or more straw-colored zones near the basal margin.

Hinge plate curved, thin, fragile, narrow; cardinal of right valve rather long, wide, slightly curved, erect, triangular in

section, the crest acute; the anterior end of the cusp may be narrower than the larger posterior end; cardinals in left valve small, the upper narrow, erect, long, not much curved; the lower cusp larger, pyramidal, erect (fig. 264); laterals rather long, strong, pyramidal, compressed, not, or little, elevated above the edge of the shell margin, straight or but slightly curved; cavity of beaks deep, large; nacre bluish or purple.

- L. 10.5; H. 8.1; D. 5.9 mm. Brown Co. (U. of W., 457).
 L. 8.7; H. 7.0; D. 6.0 mm. " " (" 457).
 L. 10.0; H. 8.0; D. 6.0 mm. Green Lake (U. of W., 4453).
 L. 9.0; H. 7.5; D. 5.0 mm. " " (" 4453).
 L. 12.5; H. 9.9; D. 7.7 mm. Wisconsin R. (U. of W., 4454).
 L. 12.0; H. 9.0; D. 8.1 mm. " " (" 4454).

ECOLOGY: West Creek, Green Lake, inside bridge, mud bottom, water .6 m. deep. Wisconsin River, Lower Dells, Kilbourn, mud bottom, water 1-2 m. deep. Dead shells were dredged off Sherwood Forest Hotel, in water 13.5 m. deep on a marly-clay bottom; these were probably washed down from shallower water, possibly from one of the creek habitats. Bark River, Rome, shallow water, gravel and coarse sand.

GENERAL DISTRIBUTION: New England and New York, west to Wisconsin; Ontario, Manitoba, Alaska. Doubtfully recorded from British Columbia and Nevada.

DISTRIBUTION IN WISCONSIN: Widely distributed in the State, but actually obtained from but few localities.

REMARKS: *Rhomboideum* cannot be mistaken for any other Wisconsin *Sphaerium*, its peculiar rhombic form, centrally placed umbones, and yellow zones easily distinguishing it. There is little variation in the form of the shell, but the color may be light corneous or almost dark red or chestnut. The light zones are also variable, being wide, narrow, or absent. Seven specimens from Lily Lake, Indiana, contained the following number of young: 5, 6, 2, 3, 5, 9, 5.

This is a widely distributed shell in America and should be found in nearly all parts of the State. It has failed, however, to be present in collections from many places where it should, apparently, occur. The records from Illinois are equally scattered and few in number. In Wisconsin, this species is as much at home in rivers as in lakes.

SPHAERIUM OCCIDENTALE Prime

Plate XCIX, figures 1-3

Cyclas ovalis PRIME, Proc. Bost. Soc. N. H., p. 276, 1852 (preoccupied).*Sphaerium occidentale* PRIME, Proc. Acad. Nat. Sci. Phil., p. 295, 1860.

Mon. Corb., p. 41, 1865.

Sphaerium occidentale STERKI, Cat., p. 438, 1916.

TYPE LOCALITY: Oswego and Greenwich, N. Y.; Columbus, Ohio.

WISCONSIN RECORDS:

1865. *Sphaerium occidentale* PRIME, p. 41. Wisconsin.1897. *Sphaerium occidentale* WISWALL, p. 48. Southern Wisconsin.1906. *Sphaerium occidentale* CHADWICK, p. 98. Kenosha?; overflow pond, of Milwaukee River, at Lindworm, Milwaukee.1911a. *Sphaerium occidentale* BAKER, p. 232. Swamp bordering Wisconsin River, Oneida Co.

SHELL: Suborbicular, inflated, fragile, nearly equipartite; all margins rounded; beaks large, rounded, raised from the shell in the form of a plate; scutum and scutellum not very well marked; surface with very fine lines of growth, with usually several rough concentric lines indicating rest periods; color horn or yellowish brown, with sometimes several lighter areas or zones.

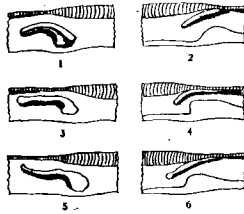


Fig. 265. Cardinal teeth of *Sphaerium occidentale* and *amphibium*. 1-4. *occidentale*, Green Lake in swale. 5, 6. *amphibium*, Lake Butte des Morts.

Hinge plate fragile, narrow; cardinal of right valve (fig. 265) wide or narrow, curved little or much, or sometimes straight, lower end always enlarged and of several shapes, in section acutely triangular (pyramidal) or more or less rounded; cardinals of left valve, upper rather long and narrow, thin, almost straight or much curved; lower cusp large, pyramidal, erect; laterals short, straight, pyramidal, compressed, not much,

if any, raised above the margin of the shell; cavity of the beaks rather deep; nacre purplish or corneous.

- L. 6.1; H. 5.1; D. 3.8 mm. Swamp, Green Lake (U. of W., 4455).
L. 6.0; H. 5.2; D. 3.8 mm. " " " (" 4455).
L. 6.6; H. 6.0; D. 4.0 mm. Pond, Brown Co. (U. of W., 459).

ANIMAL: Transparent, whitish, reddish-brown near the umbones; mantle white; the organization is similar to that of *simile*; the gills are wide and united above, the palpi long and narrow, the foot large, transparent and usually protruded from the center of the base of the shell. The shell is so transparent that the organs may be seen through it when held between the light and the observer, in this respect resembling the *Musculia*.

ECOLOGY: A species of quiet waters, as ditches, ponds, swamps, etc. Swamp near Green Lake, in pool dry in summer. Swale near Shell Lake.

GENERAL DISTRIBUTION: Widely distributed over the continent, but as yet of doubtful occurrence in the southwestern states; apparently rare in the south (Sterki).

DISTRIBUTION IN WISCONSIN: Only a few widely-scattered records are known. It probably lives over much of the area in the State.

REMARKS: This small, fragile *Sphaerium* is easily recognized by its globular shell and peculiar cup-like umbones. It is usually very abundant and the surface of a pool or swampy tract may be paved with the shells of this mussel in midsummer. It would appear that full growth must be attained in one season, as some of the ponds in which they live dry up and the majority of the mussels die. A few old ones probably survive and bear young for the following season. Living mussels may often be found in these ponds by digging into the bottom a foot or so, or exploring the bottom of the sun cracks.

SPHAERIUM OCCIDENTALE AMPHIBIUM Sterki

Plate XCIX, figures 4, 5

Sphaerium occidentale amphibium STERKI, Proc. Ohio Acad. Sci., p. 395, 1907; Cat., p. 438, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1924. *Sphaerium occidentale amphibium* BAKER, p. 133. Plummers Point, Lake Butte des Morts.

SHELL: Smaller than the typical form, and of somewhat different shape and appearance (Sterki). It is more elongated and not as round as *occidentale*.

L. 6.1; H. 5.6; D. 4.2 mm.	Butte des Morts (U. of W., 4456).
L. 6.0; H. 5.0; D. 3.9 mm.	" " " (" 4456).
L. 6.0; H. 5.0; D. 4.0 mm.	" " " (" 4456).

ECOLOGY: "Living on damp ground, under leaves, etc. (Sterki). Plummer's Point woods, under leaves and debris; ground baked hard and dry in July and August and shells present by thousands. In spring and late winter this locality is a large pond in the woods with water varying from a few inches to nearly two feet in depth.

GENERAL DISTRIBUTION: Extends over the same area as the preceding (*occidentale*), but is apparently more northern in distribution (Sterki).

DISTRIBUTION IN WISCONSIN: Apparently not common in the State and known from but one locality. *Fox Drainage*: Woods on Plummer's Point, Lake Butte des Morts, Winnebago Co. (Baker).

REMARKS: *Amphibium* is the common small clam found in the woods in depressions under leaves, although the typical form is sometimes found under similar situations. It is usually associated with *Aplaxa hypnorum*, and *Galba caperata*, all inhabitants of areas wet in winter and spring, but dry in summer and fall. The shell is somewhat longer than the typical form and not as round. The cardinal of the right valve is usually less massive and sometimes peculiarly curved; the left cardinals are also lighter in form (see fig. 265, 5, 6).

Genus MUSCULIUM Link, 1907

Musculium Link, Besch. Natural. Samml. Univ. Rostock, III, p. 152, 1807. Type: *Tellina lacustris* Müller.

Phymesoda Rafinesque, Ann. Gen. des Sci. Phys., Bruxelles, V, p. 319, 1820. Type: *Cyclas lacustris* Müller.

Calyculina Clessin, Mal. Blätt., XIX, p. 159, 1872. Type: *Cyclas calyculata* Drap. (= *Cyclas lacustris* Müller).

Shell thin, suborbicular or oblong, smooth, shining, striae very fine and delicate; beaks calyculate (usually); cardinal teeth minute, sometimes obsolete.

Animal (figs. 244, 245) similar in general form to *Sphaerium*. Siphons united for the greater part of their length, capable of great extension; anal siphon with small, round opening, branchial siphon larger, with opening higher than wide (fig. 266). Gills usually wider than in *Sphaerium*, not as much pointed, posteriorly, otherwise similar.

Phymesoda of Rafinesque has been united with *Corneocyclas* and *Pisidium* by Dall, but the first species designated as type is *Cyclas lacustris* to which he adds *Cyclas dubia* Say, which is a synonym of *Pisidium virginicum*. The description of Rafinesque fits *lacustris* but not exactly *dubia*. Rafinesque frankly states under the genus *Cyclas* that this group is in need of revision notwithstanding the works of Megele and Ferussac. He forthwith proceeds to divide the genus *Cyclas* into four genera, which include the modern groups *Cyrena*, *Musculium*, *Sphaerium*, and *Corbicula*. I cannot see that he indicates anything concerning the genus *Pisidium* which was later instituted by Pfeiffer. The three names *Musculium*, *Phymesoda*, and *Calyculina* each have the same type species and refer to the same form of mussel.

Musculium occupies about the same habitats as *Sphaerium*; some species are characteristic of shallow, small ponds, or even temporary pools, while others are found in the larger lakes. In Wisconsin the genus is widely distributed, some member being found in nearly all streams or lakes. The shells differ markedly from those of *Sphaerium* in being very thin and fragile, almost or quite transparent, and usually with cap-like or calyculate beaks. Of the 16 species and races living in the Middle West, 8 have been definitely found in Wisconsin. Others will probably ultimately be added when the territory is more thoroughly explored.

KEY TO SPECIES OF MUSCULIUM

1. a. Height 70 per cent of length ----- *transversum*
- b. Height 80 per cent or more of length ----- 2
2. a. Umbones in center of dorsal margin, shell of same height
 both anterior and posterior of umbones ----- 3
- b. Umbones nearer anterior end of shell, posterior part higher
 than anterior ----- 4
3. a. Shell large, over 10 mm. in length, ends truncated ----- *jayense*
- b. Shell small, 6 mm. or less in length, ends rounded ----- *rosaceum*
4. a. Shell rhombic-orbicular, umbones near center of shell, diameter 50 per cent of length, posterior end not much
 higher than anterior end ----- 5

- b. Shell orbicular-triangular, umbones near anterior end, diameter 57 per cent or more of length, posterior end markedly higher than anterior end ----- 6
5. a. Beaks depressed, comparatively, flattened, posterior end rounded, outline roundly orbicular ----- *partumeium*
- b. Beaks elevated, swollen, outline rhombic, posterior end truncated, shell more inflated than *partumeium* ----- *truncatum*
6. a. Shell distinctly trigonal, beaks elevated and mammaeform, anterior end acutely rounded ----- *ryckholti*
- b. Shell more or less orbicular, beaks not as elevated as in *ryckholti*, not distinctly mammaeform, anterior end broadly rounded ----- 7
7. a. Outline orbicular, proportionately higher than *sphaericum* ----- *securis*
- b. Outline elongate-ovate, proportionally less in height than *securis* ----- *sphaericum*

MUSCULIUM TRANSVERSUM (Say)

Plate XCVIII, figures 22-28

Cyclas transversa SAY, New Harm. Dissem., II, p. 356, 1829.*Sphaerium transversum* PRIME, Mon. Corb., p. 48, fig. 45, 1865.*Sphaerium transversum* STERKI, Cat., p. 440, 1916.

TYPE LOCALITY: Kentucky.

WISCONSIN RECORDS:

1906. *Calymene transversa* CHADWICK, p. 98. Mud Creek, half mile east of Teutonia Ave., Milwaukee.1924. *Musculium transversum* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Transversely elongated, thin, fragile, slightly inequipartite, somewhat inflated; dorsal and ventral margins almost straight, the latter slightly convex, especially in imma-

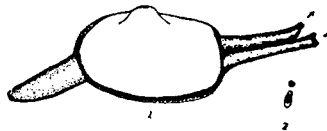


Fig. 266. Animal of *Musculium transversum* (Say). Omro, Fox River.
2. End view of two siphons, upper anal, lower, branchial.

ture specimens; anterior end rounded; posterior end more or less truncated; beaks placed slightly anterior of the center of the dorsal margin, calyculate, well elevated above the dorsal margin; scutum and scutellum well marked; sculpture of very

fine lines of growth, rather dull; color corneous, greenish-yellow or light yellowish.

Hinge plate long, arched, narrow, fragile; cardinal of right valve very long, narrow, curved, erect, enlarged slightly at the posterior end; in some specimens the cardinal is arched below and curved upward at each end (fig. 267, 1); upper cardinal of left valve short, narrow, slightly curved; lower cardinal erect, high, more or less pyramidal, but compressed (fig. 267): laterals rather long, narrow, lamellar, not much elevated above the margin of the shell; cavity of the beaks shallow; nacre bluish or light bluish white.

L. 12.0; H. 8.0; D. 5.4 mm. Omro (U. of W., 4457).

L. 12.0; H. 7.7; D. 6.5 mm. " (" 4457).

L. 10.0; H. 6.8; D. 4.6 mm. " (" 4457).

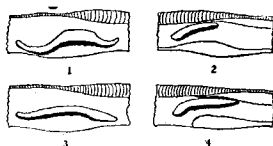


Fig. 267. Cardinal teeth of *Musculium transversum* (Say). Omro, Fox River.

ANIMAL: Whitish, greenish about the liver; most organs appear translucent; siphons long, united for the greater part of their length; anal opening small, round, the end of the siphon turned upward when extended; branchial opening larger, compressed laterally during extension (fig. 266); foot long, cylindrical, capable of great extension; other organs as in the group.

ECOLOGY: In rivers, ponds and lakes, usually in soft mud, on the surface or buried at different depths. Lake Butte des Morts, mud bottom, 1.9 to 3.4 m.; sand bottom, .8 m.; sandy-mud bottom, 1 m. Lake Winnebago, sand and gravel bottom, 1.5 to 2.8 m. Omro, Fox River, mud bottom, .5 to 1 m. Yellow River, Spooner, mud bottom, .3 to 1 m. Sturgeon Bay, mud bottom, 3.5 m. Rock River, Pipersville, gravel and sand bottom, shallow.

GENERAL DISTRIBUTION: The continent to Mexico (Sterki).

DISTRIBUTION IN WISCONSIN: Widely distributed in scattered localities. It is doubtless found pretty well over the State.

REMARKS: *Transversum* is the largest *Musculium* in Wisconsin. Its elongated shape, as well as large size, will usually distinguish it. This species is common in places, but seems not to have been observed over a very wide area. That this fragile mussel should be found in such diverse habitats—river, pond, lake—and under such varying ecological conditions—mud, sand, gravel bottoms—without showing any marked ecological variation is noteworthy. Specimens from Sturgeon Bay and Lake Winnebago do not differ from those in Fox River.

A specimen of *transversum* from Sturgeon Bay contained six young, 1.6 to 2.5 mm. long, the parent being 8 mm. long.

MUSCULIUM JAYENSE (Prime)

Plate XCIX, figures 27, 28

Cyclas jayensis PRIME, Proc. Bost. Soc. N. H., IV, p. 157, 1851.

Sphaerium jayanum PRIME, Mon. Corb., p. 46, 1 fig. 43, 1865.

Sphaerium jayense STERKI, Cat., p. 440, 1916.

TYPE LOCALITY: Lake Superior.

WISCONSIN RECORDS:

1897. *Sphaerium jayanum* WISWALL, p. 48. Southern Wisconsin.

1902b. *Calyculina jayensis* STERKI, p. 92. Wisconsin.

1906. *Calyculina jayensis* CHADWICK, p. 98. Kenosha (?).

1924. *Musculium jayense* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Rhombic, nearly equipartite, inflated, thin, fragile; dorsal margin short, but slightly curved; ventral margin convex; anterior and posterior ends squarely truncated, angled above, rounded below; umbones conspicuously elevated above dorsal margin, strongly calyculate; scutum and scutellum well

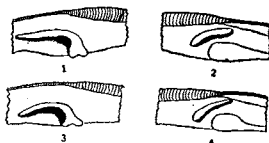


Fig. 268. Cardinal teeth of *Musculium jayense* (Prime). De Pere.

marked; surface sculpture of very fine lines of growth; epidermis dull to shining; color corneous with sometimes a zone of yellowish bordering the valves.

Hinge margin thin, narrow, slightly curved; cardinal in right valve rather large, curved acutely at the lower (posterior) end,

which forms a club-shaped swelling, strongly emarginate on the base; upper cardinal of left valve short, slightly curved, narrow, erect; lower cardinal pyramidal, high, somewhat massive (Fig. 268); laterals long, curved, lamellar, not much raised above shell margin; cavity of beaks shallow; nacre bluish or bluish-white.

L. 9.7; H. 8.5; D. 6.4 mm. De Pere (U. of W., 446).

L. 6.5; H. 6.0; D. 4.0 mm. " " (" 431).

ECOLOGY: Lake Butte des Morts, near Plummer's Point, sandy-mud bottom, water 1 m. deep; also 1.5 m. deep near west end of lake. Silver Lake, pure sand packed hard.

GENERAL DISTRIBUTION: Ohio to Dakota, Ontario, Manitoba, Alberta (Sterki).

DISTRIBUTION IN WISCONSIN: *Jayense* has not been recorded outside of the Fox, Rock and Lake Michigan drainages.

Fox Drainage: Lakes Butte des Morts and Winnebago, Winnebago Co. (Baker); four miles south of De Pere, Fox River, Brown Co. (Marston). Fox River, near Portage, Columbia Co. (Baker).

Rock Drainage: Silver Lake, Waukesha Co. (Cahn).

Lake Michigan Drainage: Kenosha, Kenosha Co. (Chadwick, Wisconsin).

REMARKS: *Jayense* is one of the handsomest of the Wisconsin *Musculium*, its large, rhombic shell with truncated ends and centrally placed umbones readily distinguishing it. It seems as rare in individuals as recorded by Prime, 60 years ago, only one or two specimens being found at one place, usually. The hinge structure is markedly different from that of *transversum*. This species resembles both *truncatum* and *partumeium*; it is larger than either, more inflated and with more sharply truncated ends. It is also higher in relation to length, usually. Lake forms are somewhat smaller and more delicate than river forms.

MUSCULIUM PARTUMEIUM (Say)

Plate XCIX, figures 24-26

Cyclas partumeia SAY, Jour. Acad. Nat. Sci. Phil., II, p. 380, 1822.

Sphaerium partumeium PRIME, Mon. Corb., p. 45, fig. 42, 1865.

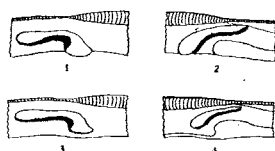
Sphaerium partumeium STERKI, Cat., p. 441, 1916.

TYPE LOCALITY: Germantown, near Philadelphia, Penn.

WISCONSIN RECORDS:

1865. *Sphaerium partumeium* PRIME, p. 46. Wisconsin.1906. *Calymene partumeia* CHADWICK, p. 98. Kenosha.1911a. *Musculium partumeium* BAKER, p. 232. Wisconsin R., Oneida Co.

SHELL: Subquadrate or roundly-ovate, thin, fragile, nearly equipartite, not much inflated; dorsal margin nearly straight; ventral margin slightly convex; anterior end rounded; posterior end truncated, roundly angled above, rounded below; the height is slightly greater posterior than anterior of the umbones; umbones elevated, calyculate; scutellum and scutum rather well marked; sculpture very fine, surface more or less shining; color light corneous or greenish-yellow.

Fig. 269. Cardinal teeth of *Musculium partumeium* (Say). Indiana.

Hinge slightly curved, narrow, fragile; cardinal of right valve rather large, massive, anterior end straight, posterior end curved toward lower edge of hinge, enlarged but not emarginate at end, a deep pit below the cusp (fig. 269, 1, 3); upper cardinal of left valve long, swollen and club-shaped at posterior end; lower cardinal larger, thick, pyramidal, erect; laterals long, almost straight, lamellar, erect; cavity of beaks shallow; nacre bluish or whitish.

L. 8.0; H. 6.9; D. 4.2 mm. Kosciusko Co., Ind. (U. of I., Z13853).

L. 8.1; H. 7.0; D. 4.3 mm. " " " (" Z13853).

ANIMAL: The siphons are pink, the rest of the animal whitish or with a shade of pinkish.

ECOLOGY: Its natural habitat appears to be in ponds in black mud, shallow water.

GENERAL DISTRIBUTION: East of the Rocky Mountains, commoner in the northeast (Sterki).

DISTRIBUTION IN WISCONSIN: Only a few scattered records are known from the State. It doubtless occurs in many places.

Wisconsin Drainage: Small ponds, Wisconsin River, Oneida Co. (Baker).

Fox Drainage: Pond near Bay Settlement, Brown Co. (Marston).

Lake Michigan Drainage: Kenosha, Kenosha Co. (Chadwick, Wiswall).

REMARKS: *Partumeium* resembles *jayense*. It is smaller, less inflated, the ends are more distinctly rounded, not as acutely truncated as in *jayense*, and the calyculate beaks are not as high. The cardinal teeth are also heavier and not emarginate. As in Illinois, this species seems to be characteristic of small ponds that are liable to dry up in the summer or fall. It is apparently not common in Wisconsin. An adult 7.5 mm. long contained three young 1.6 mm. long.

MUSCULIUM TRUNCATUM (Linsley)

Plate XCIX, figures 21-23

Cyclas truncata LINSLEY, Amer. Jour. Sci., VI, p. 234, fig. 3, 1848.

Cyclas pellucida PRIME, Proc. Bost. Soc. N. H., IV, p. 277, 1851.

Sphaerium truncatum PRIME, Mon. Corb., p. 51, fig. 50, 1865.

Musculium truncatum STERKI, Cat., p. 441, 1916.

TYPE LOCALITY: Connecticut (*truncata*); Vermont, Maine (*pellucida*).

WISCONSIN RECORDS:

1865. *Sphaerium truncatum* PRIME, p. 51. Wisconsin.

1906. *Calyculina truncata* CHADWICK, p. 98. Mud Creek, east of Teutonia Ave. bridge; pool in Johnson's woods; Honey Creek, near Layton Park, Milwaukee.

1924. *Musculium truncatum* BAKER, p. 133. Lake Butte des Morts.

SHELL: Rhombic-orbicular, thin, fragile, somewhat inflated, inequipartite, pellucid; dorsal margin nearly straight; ventral margin slightly convex; anterior end rounded, angled above; posterior end sharply, obliquely truncated; beaks well raised above the dorsal margin, calyculate; surface with many close-set, fine lines of growth; color light greenish horn; scutum and scutellum well marked.

Hinge line but slightly curved, narrow, slight; cardinal of right valve heavy, anterior part thin, straight in some specimens, curved and enlarged in others; the lower part of the cusp is enlarged and often emarginate; there is a deep pit below the cusp; in section, the postero-ventral part of the cardinal is higher than the antero-dorsal part (fig. 270, 5); upper cardinal in left valve, long, narrow, high, slightly curved, and

sometimes enlarged at the lower end; cardinal in lower part pyramidal, thick, erect; laterals rather long, straight, lamellar; cavity of beaks shallow; nacre light blue.

L. 8.0; H. 6.5; D. 4.4 mm. Green Lake (U. of W., 4458).

L. 7.0; H. 6.0; D. 3.8 mm. " " (" 4458).

L. 6.5; H. 5.6; D. 4.1 mm. " " (" 4458).

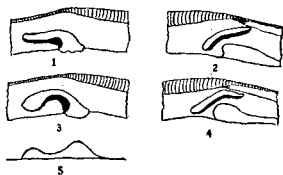


Fig. 270. Cardinal teeth of *Musculium truncatum* (Linsley).
Green Lake.

ECOLOGY: Prime gives the habitat as in running streams under stones (1851, p. 277). In Wisconsin it has been found in the following habitats: Lake Butte des Morts, mud bottom, 1.2 to 2.2 m.; Silver Creek, Green Lake, sandy-mud and mud bottom, .5 to 1 m.; small stream flowing into Sandstone Bay, mud bottom, 1 m.; pond at west end of lake, hard bottom, .3-.5 m.; ditch near Upper Dells, Wisconsin River, Kilbourn, mud bottom, .3 m.; swale in Upper Dells, dry in summer; Wisconsin River above Kilbourn, mud bottom, 1 m. (Baker). Oconomowoc Lake, 3-5 m. among vegetation; 12 m., sand bottom; Cooks and Dutchmans lakes, soft mud bottom, shallow water (Cahn).

GENERAL DISTRIBUTION: East of the Rocky Mountains, occurring most commonly from New York to Illinois. It is apparently rare, if occurring at all, in the south (Sterki).

DISTRIBUTION IN WISCONSIN: The records would indicate that this species is confined to the southeastern part of the State. Occurs as a Pleistocene fossil in marl bed in Lower Nemahbim Lake, Waukesha Co. (Cahn).

REMARKS: *Truncatum* may be confused with several species of *Musculium*. It is smaller than *jayense* with a more rounded anterior end and with the umbones nearer the anterior end. It is more corpulent than *partumeium*, not as orbicular, and the anterior end is not as high. Attention to these details will usually distinguish these three species. The cardinal teeth of *partumeium* and *truncatum* are somewhat similar, but are different from *jayense*. This species is very com-

mon in parts of Wisconsin, as in Illinois and Indiana, the dry shore being paved with these shells in some ponds. Specimens from a swale in the Upper Dells, near Kilbourn, are the largest observed in the State, measuring 12.7 mm. long and 11.5 mm. high.

MUSCULIUM ROSACEUM (Prime)

Plate XCIX, figures 19, 20

Cyclas rosacea PRIME, Proc. Bost. Soc. N. H., IV, p. 155, 1851.

Sphaerium rosaceum PRIME, Mon. Corb., p. 50, fig. 48, 1865.

Musculium rosaceum STERKI, Cat., p. 442, 1916.

TYPE LOCALITY: Schuylkill River, Penn.

WISCONSIN RECORDS: None.

SHELL: Rather small, roundly-oval, thin, fragile, almost equipartite, inflated; dorsal and ventral margins slightly rounded; anterior and posterior margins roundly truncated, obscurely angled above, rounded below; beaks well elevated above the dorsal margin, placed near the center, mammae-like, approximate, calyculate; sculpture of fine lines of growth; color reddish horn.

Hinge very thin and fragile, narrow; cardinal of right valve small, club-shaped at the lower, posterior end, placed on the edge of the lower part of the hinge plate; upper cardinal of left valve short, straight, lower cardinal erect, pyramidal; the cardinals and laterals are similar to those of *ryckholti* (see fig. 271); cavity of the beaks deep; nacre bluish white.

L. 5.7; H. 5.0; D. 3.6 mm. Upper Dells (U. of W., 4459).

ECOLOGY: The single specimen from the Upper Dells was found in a shallow pond-like embayment of the river where the bottom is soft mud (Baker). Mud Lake, soft mud with decomposing vegetation, shallow water (Cahn).

GENERAL DISTRIBUTION: Maine to Virginia, Ontario, Ohio, Illinois.

DISTRIBUTION IN WISCONSIN: Known only from the Wisconsin River, Upper Dells, above Kilbourn, Columbia Co. (Baker); and Mud and Genesee lakes, Waukesha Co. (Cahn).

REMARKS: *Rosaceum* is most likely to be confused with *ryckholti*, from which it may be known by its reddish color, and particularly by the difference in the ends which are slightly

truncated in *rosaceum* and the height of the shell is about the same on both sides of the umbones; in *ryckholti* the ends are rounded and the posterior end is higher than the anterior end. The umbones are also distinctly calyculate in *ryckholti* while they are *scarcely* so in *rosaceum*.

The species appears to be a rare shell in Wisconsin, but one specimen occurring among many hundred *Musculia* examined by Dr. Sterki.

MUSCULIUM RYCKHOLTI (Normand)

Plate XCIX, figures 6-9

Cyclas ryckholti NORMAND, Notes sur Quelques Nouvelles Cyclades, p. 7, figs. 5, 6, 1844.

Calyculina ryckholti CLESSIN, Mon. Cycladeen, in Martini-Chemnitz, p. 257, pl. 40, figs. 20-27, 1897.

Musculium ryckholti STERKI, Cat., p. 443, 1916.

TYPE LOCALITY: Europe.

WISCONSIN RECORDS:

1911a. *Musculium rosaceum* BAKER, p. 232. Small pools, Tomahawk Lake.

SHELL: Small, trigonal, short, slightly inequipartite, calyculate, inflated; dorsal and ventral margins curved; anterior and posterior margins rounded, the latter rather roundly truncated; scutum and scutellum distinctly marked; the region in front of the umbones is much less in height than the region behind the umbones; beaks elevated, swollen; rather wide, not approximate; surface shining, sculpture of fine lines of growth; color smoky grayish or corneous.

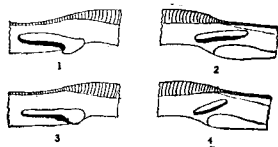


Fig. 271. Cardinal teeth of *Musculium ryckholti* (Normand). Bayfield.

Hinge narrow, fragile; cardinal in right valve heavy, thick, anterior part straight, posterior end with knob-like termination, directed toward lower part of hinge plate (fig. 271); upper cardinal in left valve short, straight, narrow; lower cardinal large, thick, pyramidal; laterals short, slightly curved; cavity of beaks deep; nacre smoky or grayish.

L. 5.5; H. 5.0; D. 3.1 mm. Green Lake (U. of W., 4460).

L. 5.5; H. 5.0; D. 3.0 mm. Bayfield (U. of W., 4461).

L. 5.0; H. 4.0; D. 2.9 mm. " (" 4461).

ECOLOGY: Small pond near Bayfield, fine deep mud bottom, water .6 m. deep (common); pond west end of Green Lake, hard clay bottom, water .3-.6 m. deep (rare); pool behind beach, near Sandstone Camp, Green Lake, mud bottom, water .5 m. deep; Silver Creek, behind bar, marly-clay bottom, water .5 m. deep; Madeline Island, near Bayfield, in swale, clay bottom, dry in summer; Chetek Lake, mud bottom, water .6-1 m. deep.

GENERAL DISTRIBUTION: Palaearctic and Nearctic regions. In America, Maine, Connecticut, Ontario, Michigan, Iowa, S. Dakota, Montana, Colorado, Wisconsin, Idaho, and probably far northward (Sterki).

DISTRIBUTION IN WISCONSIN: Found well over the State. It probably occurs in many other places.

REMARKS: This is a distinct little mussel related to both *truncatum* and *securis*, and also to *rosaceum*. From the first it may be known by its more trigonal shape and elevated umbones, the calyculate beaks standing up like mammal glands. It is more closely related to *securis* from which it may be known by its more trigonal, less rounded outline, and particularly by the form of the posterior end, which is greater in height and more broadly rounded in *ryckholti*, which has a rather sharply truncated posterior margin. *Ryckholti* is elongated, somewhat, while *securis* is more rounded.

Ryckholti is a common *Musculium* in many localities in the State, apparently replacing *securis* and *truncatum*. It has probably been confused with both of these species. A specimen 8 mm. in length had five young in the shell 1 mm. in length. This species is very variable and many varieties have been distinguished in Europe, some of which may also occur in America.

MUSCULIUM SECURIS (Prime)

Plate XCIX, figures 10-13

Cyclas securis PRIME, Proc. Bost. Soc. N. H., p. 160, 1851.

Sphaerium securis PRIME, Mon. Corb., p. 49, 1865.

Musculium securis STERKI, Cat., p. 444, 1916.

TYPE LOCALITY: Fresh Pond and Cambridge meadows, Cambridge, Mass.

WISCONSIN RECORDS:

1911. *Musculium securis* BAKER, p. 232. Tomahawk Lake.

SHELL: Small, rhombic-orbicular, well inflated, slightly inequipartite, thin; dorsal margin slightly curved; ventral margin well rounded; anterior and posterior ends rounded, the latter higher than the former, and forming a rather sharp angle with the dorsal margin; beaks long, wide, elevated considerably above dorsal margin, calyculate; scutum and scutellum distinctly marked; sculpture of rather coarse, regular growth lines, surface shining; color yellowish or greenish-horn.

Hinge narrow, fragile; cardinal of right valve narrow, curved, enlarged at lower end, which may be emarginate or bifid (fig. 272); upper cardinal short, narrow, straight; lower

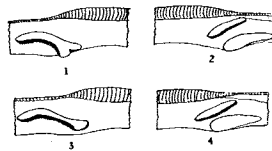


Fig. 272. Cardinal teeth of *Musculium securis* (Prime). Swale near Oshkosh.

cardinal pyramidal, erect; laterals narrow, straight, pyramidal, slightly raised above the shell margin; cavity of beaks shallow; nacre yellowish or corneous.

L. 5.5; H. 4.4; D. 3.2 mm. La Porte, Ind. (U. of I., Z13857).

L. 5.5; H. 4.8; D. 3.6 mm. " " " (" Z13857).

L. 5.1; H. 4.5; D. 3.5 mm. " " " (" Z13857).

ECOLOGY: Swale near Oshkosh, water few inches deep, mud bottom; Lake Butte des Morts, mud bottom, water 2 m. deep (Baker); Oconomowoc Lake, in water plants, 3–5 m. deep (Cahn).

GENERAL DISTRIBUTION: East of the Rocky Mountains, but apparently rare in the South and wanting in the Gulf States; common in the Northeast; South Carolina (Sterki).

DISTRIBUTION IN WISCONSIN: Widely distributed but of scattered occurrence.

REMARKS: One of most abundant and widely distributed species of the genus. It is about the size of *ryckholti*, from which it is separated by its higher and more truncated posterior margin, more rounded ventral border, and the pinched

character of the dorsal margin on either side of the beaks, a feature absent in *ryckholti*. *Truncatum* is less inflated, the beaks are not as much elevated above the dorsal margin, and the shell is more regularly rounded—not rhombic.

Two specimens were observed with young, one 5.5 mm. long had five young 1.5 mm. long. Another of about the same size also had five young.

MUSCULIUM SECURIS SPHAERICUM (Anthony)

Plate XCIX, figures 14-18

Cyclas sphaerica ANTHONY, Proc. Bost. Soc. N. H., IV, p. 275, 1852.

Sphaerium sphaericum PRIME, Mon. Corb., p. 50, 1865.

Musculium sphaericum STERKI, Cat., p. 444, 1916.

TYPE LOCALITY: Loraine Co., Ohio.

WISCONSIN RECORDS: None.

SHELL: Differing from *securis* in being oval, the anterior and posterior margins rounded; not truncated, dorsal margin rounding into ends without notable angle. It is also usually larger than *securis*. The "aestivale" forms have rounded beaks which are much lower than the calyculate beaks of the normal form, giving the shell a more regularly oval shape.

L. 6.0; H. 5.0; D. 3.5 mm. Prairie Lake (U. of W., 4463).

L. 5.6; H. 4.6; D. 3.5 mm. " " (" 4463).

L. 5.4; H. 4.5; D. 3.2 mm. " " (" 4463).

ECOLOGY: Small pool near Prairie Lake, mud bottom, water .6 m. deep; pool near Shell Lake, mud bottom, shallow water (Baker). Bark River, gravel and coarse sand bottom, shallow water (Cahn).

GENERAL DISTRIBUTION: Western Ohio, Indiana, Michigan, New York, and New England, more common in the western part of the area (Sterki).

DISTRIBUTION IN WISCONSIN: Probably same as that of *securis*.

Rock Drainage: Bark River, Rome, Jefferson Co. (Cahn).

St. Croix Drainage: Pool near Shell Lake, Washburn Co. (Baker).

Chippewa Drainage: Pool near Prairie Lake, Barron Co. (Baker).

Wisconsin Drainage: Pond in Dell Creek near Delton, Sauk Co. (Baker).

REMARKS: *Sphaericum*, as suggested by Sterki, seems no more than a variety of *securis*: "It appears that *M. sphaeri-*

cum is not specifically distinct from *M. securis* Prime, although typical forms are noticeably different from each other, they are inseparably and intricately connected by intermediate forms. Both are decidedly variable, yet the specimens from each habitat are fairly uniform; of both there are forms with calyculate and with plain rounded beaks, "aestivale". The summer forms "aestivale", are notably different, and might be taken for distinct species. Only the calyculate form has been noted in Wisconsin collections. The hinge teeth are similar to those of *securis*. The Bark River specimen is in an unusual habitat for *Sphaerium* in Wisconsin; this is usually a pool with mud bottom.

Specimens from Indiana are somewhat larger than those from Wisconsin but are otherwise similar. In Illinois, this form is known only from Fulton Co.*

Subfamily PISIDIINAE Baker, 1927

Pisidiinae BAKER, Amer. Mid. Nat., X, p. 220, 1927.

There is a distinct anal siphon capable of considerable extension, although not as much as in either *Sphaerium* or *Musculium*; there is no branchial siphon, the inhalent orifice being represented only by the mantle cleft through which the foot is protruded. The posterior end of the shell is shorter than the anterior end. Other characters as in the genus *Pisidium*.

Hannibal (1912, p. 133) has instituted a family Corneocycladidae following Dall's use of the name for the shells referred to *Pisidium*. This name is open to objection for the same reason as that given under the genus. The characters named are of the shell only and do not sufficiently differentiate the group from *Sphaerium* and its allies.

Genus PISIDIUM C. Pfeiffer, 1821

Pisidium C. PFEIFFER, Syst. Anordn. u. Beschreib. Deutsch. Land-u. Wasser-Schnecken, pp. 17 and 123, 1821. Type by designation of Herrmannsen (Ind. Gen. Malac., II, p. 274, 1847), *Tellina amnica* O. F. Müller.

Corneocyclas DALL (non Fér.), Wagner, Free Inst. Sci., III, vi, p. 1459, 1903.

Corneocyclas HANNIBAL (non Fér.), Proc. Mal. Soc., X, p. 134, 1912.

*As this portion of the monograph is passing through the press, a valuable paper on the anatomy of *Sphaerium* has been published by Mr. Cecil R. Monk, a graduate student of the University of Illinois. See Monk, 1928.

Shell small, rounded, oval or obliquely cuneiform; inequipartite, the anterior side longer; beaks terminal; cardinal teeth situated under the beaks, one in right and two in left valve; laterals elongated, lamelliform, one in the left two in the right valve; ligament on the short (posterior) side, internal.

Animal similar in general structure to *Sphaerium* and *Musculium*. The foot is large for the size of the animal and is distinctly tongue-shaped, in some respects resembling that of *Cardium*; palpi elongated, triangular; gills rather broad; there is a complete diaphragm and the mantle is closed above. The greatest difference, which has been thought of subfamily rank, is in the siphonal openings, which are very different from any genus of the family. The anal siphon is small and directed either upward or straight behind; but there is no branchial siphon, the incurrent water entering directly from the outside through the mantle cleft beneath the anal siphon, as indicated in fig. 273. Most authors in America have described the posterior openings as "short, simple, united to the end", but an examination of the posterior end of the living animal shows but one siphon (anal) and the currents of water entering the cleft of the mantle from which the foot is extended.

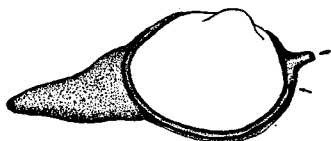


Fig. 273. Animal of *Pisidium politum decorum* Sterki, with foot and siphon fully extended. Note the absence of a branchial siphon, the water entering the cleft of the mantle as indicated by the arrow. Bayfield.

The foot differs from that organ in the *Sphaeriinae*, being larger in proportion to the size of the animal, more tongue-shaped, and capable of great extension. It is used for burrowing in the sand or mud of the bottom or for crawling over vegetation or debris on the bottom.

The cardinal teeth of *Pisidium* have been described as double in both valves "sometimes united" (Prime, Tyron, Walker); but this is not true, there being but one cardinal as in the other members of the *Sphaeriidae*. There is often a constriction in the upper part of the cardinal, which, when the shell is old, may cause the tooth to appear double (see ante, fig. 270, 5). This

occurs, however, in both *Sphaerium* and *Musculium*, as well as in *Pisidium*. Sterki indicated this error in 1911 (p. 2). The cardinals of *Pisidium* are relatively heavier and the whole hinge is relatively stouter than in the *Sphaeriinae*. The teeth vary greatly in form, size, and massiveness, and in some cases these characteristics are of value in separating species. The young have more clearly formed cardinals than the older specimens, especially in the right valve, in which there is no doubt of the singleness of this tooth. The laterals also vary in massiveness and size (see Sterki, 1922b, for an extended discussion of this subject).

In habits, *Pisidium* resembles the other members of the family, as a whole. They are relatively more active, frequently being observed crawling about in vegetation. A haul of the dipper in vegetation (algae, *Potamogeton*, *Elodea*) will frequently be largely composed of this genus. They also burrow in the mud or other material of the bottom. They are more widely distributed than the other members of the family as regards depth, *Pisidium* extending deeper than any other group. In Lake Mendota they occur at 5–7 m.; Devils Lake about 12 m.; Green Lake 39 m.; off High Island Harbor, Lake Michigan, 25 m. They also occur abundantly in shallow water. Their small size and rounded form suggests the common name of "pill-clams".

They are widely distributed over the State, occurring in large lakes, small lakes, ponds, pools, creeks, rivers, and streams of all sizes. They may be very abundant or rare in certain localities. Economically, they are of value as affording food for many valuable food and game fishes (see ante, p. 309).

Dall (1903, p. 77; 1903, p. 1459) has used the name *Corneocyclas* of Ferussac in place of *Pisidium*. Some other American students have followed him (Hannibal, 1912, p. 133), but most American students, including Sterki and Walker, have retained the name *Pisidium*. Woodward, commenting upon Dall's treatment of the genus, says (1903, p. 367) "Since, however, De Blainville admits that *Corneocyclas* is a synonym for *Cornea* Megele (1811), which Dall rightly makes a synonym for *Sphaerium*, while of the species cited the majority are referable to *Sphaerium*, *Corneocyclas* must be regarded as a synonym of *Sphaerium*. Moreover, since De Blainville no-

where cites *Tellina pusilla* Müller under it and there is no proof that the *Cyclas fontinalis* Drap, which he does cite is the same species, it is hardly permissible to arbitrarily select *pusillum* as the type of *Corneocyclas* to-day and ignore the prior claim of *Pisidium*, already founded to include *inter alia* the *Cyclas fontinalis* of Drap."

As De Blainville himself considered it a synonym of *Cornea*, which is a synonym of *Sphaerium*, and as all subsequent authors, American and European, excepting Dall, have so considered it, there appears to be little reason for arbitrarily forcing the name to replace the well-characterized *Pisidium*, the type of which is well known. In the Catalog of Non-marine Mollusca (1926) recently issued by the British Museum and prepared by Kennard and Woodward, this course has been taken. The name *Phymesoda* of Rafinesque, suggested as an alternative by Dall, cannot be used, apparently, as it is an absolute synonym of *Musculium* in both description and type. See also Pilsbry, 1927, p. 347.

No attempt has been made to divide the species into groups or sections, as has been proposed by Clessin and others. Some of these are founded on mistaken characteristics (as *Fluminina*, characterized by "two cardinal teeth in the right valve") and others on totally inadequate characters. Among the American forms there seems to be but one significant difference in the cardinal teeth, those of *virginicum* which are heavier and differently formed than any other species examined (compare the figures in the specific descriptions). The genus appears to be quite homogeneous, and division seems quite unwarranted, unless based on characters which have not yet been discovered.

This is a very difficult group, only one student having the courage, evidently, to study the species analytically. Dr. Sterki has made a life-long study of the family and to him we owe our present knowledge of the various species. Many of these are founded on what might seem trivial characters but an examination of the whole group indicates that in most cases the forms are well characterized. A few may ultimately be reduced to varieties of related species. All of the Wisconsin material has been examined by Dr. Sterki, and only those so examined have been figured. Most figures of this group have been unsatisfactory. These here presented are photographic enlargements

retouched to bring out the characteristics of form and hinge. The latter (cardinals) are shown by diagrams in the text, they being too small to show with the whole shell. It is hoped that these figures will help materially in the identification of the different species. For the same reasons as given under *Sphaerium*, no key to the species is given. All attempts have met with failure. It is to be hoped that Dr. Sterki may find some method of making a key that will help in this direction, when he monographs the entire family.

PISIDIUM VIRGINICUM (Gmelin)

Plate C, figures 4-6

Tellina virginica GMELIN, Syst. Nat., VI, p. 3236, 1772.

Pisidium virginicum PRIME, Mon. Corb., p. 61, fig. 61, 1865.

Pisidium virginicum STERKI, Cat., p. 446, 1916.

Cyclas dubia SAY, Nichol. Encycl., ed. 2, IV, pl. i, fig. 10, 1817.

TYPE LOCALITY: Not ascertained. (*virginica*); Delaware River (*dubia*).

WISCONSIN RECORDS:

1865. *Pisidium virginicum* PRIME, p. 62. Wisconsin.

1906. *Pisidium virginicum* CHADWICK, p. 99. Wisconsin.

1911. *Pisidium virginicum* BAKER, p. 233. Wisconsin River, Oneida Co.

1924. *Pisidium virginicum* BAKER, p. 133. Lake Butte des Morts.

SHELL: Large, thick, not greatly inflated, very oblique; umbones not much elevated, prominent, full, placed near the posterior end of the shell; dorsal margin curved; ventral margin rounded; anterior end broadly rounded; posterior end roundly truncated; umbonal slopes rounded, sometimes somewhat angular on the anterior side; scutum faint, scutellum well marked; surface shining, marked by heavy growth lines which are heavier near the ventral margin; color dark horn in old specimens, lighter in younger individuals, and sometimes zoned with light yellowish near the ventral margin.

Hinge rather solid, wide; cardinal of right valve in form of an inverted V, with both ends enlarged and club-shaped, or fan-shaped, with a deep pit between the two angles of the Δ ; there is frequently a depression between the two angles, at the point of meeting of the Δ , which has led to the statement that there are two cardinals; an examination shows that there is but one cardinal (fig. 274, 1, 3, 5); upper cardinal of left valve long,

narrow, straight or slightly curved, reaching to the base of the hinge plate; lower cardinal pyramidal, erect, with a deep pit on either side into which the two arms of the Δ -shaped cardinal of the right valve fit; laterals short, curved, strong, triangular, raised considerably above the margin of the shell; the hinge plate near the anterior lateral is much widened and thickened; cavity of the beaks deep; nacre rather dark bluish-white.

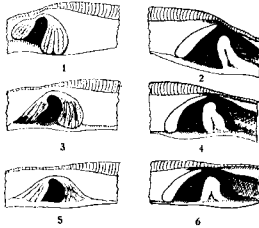


Fig. 274. Cardinal teeth of *Pisidium virginicum* (Gmelin). Fox River, Brown Co.

L. 7.0; H. 5.5; D. 4.2 mm. Fox River (U. of W., 412).

L. 6.0; H. 4.6; D. 3.5 mm. " " (" 412).

L. 6.8; H. 5.1; D. 4.1 mm. " " (" 412).

ECOLOGY: Common in the sandy shore of the Wisconsin River, in shallow water, associated with *Sphaerium striatinum*, *Campelema*, and *Lampsilis siliquoidea*; Lake Butte des Morts, sand bottom, 1.2 m. deep (Baker). Bark River, sand-gravel bottom, with vegetation, water .2-.5 m. deep (Cahn).

GENERAL DISTRIBUTION: East of the Rocky Mountains, north to Yukon and Alaska (Sterki).

DISTRIBUTION IN WISCONSIN: At present known only from the Wisconsin, Fox and Rock drainages.

REMARKS: Next to *Pisidium idahoense*, *virginicum* is the largest *Pisidium* in the State. It is easily recognized by its large size, very oblique shell, and particularly by the peculiar form of the cardinal teeth, which are different from any other Wisconsin member of the genus. The shell varies somewhat in outline, certain individuals being more oblique than others. The cardinals are somewhat variable, also the single arched tooth in the right valve varying from dumb-bell-shaped to simply arched, sometimes with an indication of emargination on the lower edge of the posterior angle. The cardinals of the left valve are more uniform in the specimens examined.

PISIDIUM IDAHOENSE Roper

Plate C, figures 1-3

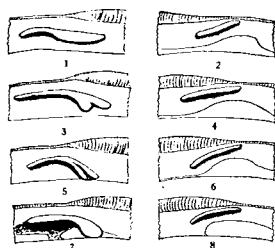
Pisidium idahoense ROPER, Nautilus, IV, p. 85, 1890.*Pisidium idahoense* STERKI, Cat., p. 446, 1916.

TYPE LOCALITY: Near Old Mission, Northern Idaho.

WISCONSIN RECORDS:

1922. *Pisidium idahoense* JUDAY, p. 467. Lake Mendota.

SHELL: Large, subovate, oblique, inequipartite; dorsal and ventral margins curved; posterior end short, broadly rounded; anterior end long, more acutely rounded or pointed; beaks full, high, somewhat raised above the dorsal margin; scutum and scutellum well marked; sculpture of well marked growth lines, usually marked off by regularly spaced darker rest marks; color yellowish in young and immature specimens, brownish in older shells, sometimes smoky-horn colored.

Fig. 275. Cardinal teeth of *Pisidium idahoense* Roper. Fish Lake.

Hinge plate wide but not very strong; cardinal (fig. 275) of right valve long, thin, the posterior, lower part usually widened out, club-shaped, emarginate, or even bifid; anterior part thin, straight or slightly curved, parallel with hinge line; upper cardinal of left valve small, thin, straight or but slightly curved, not reaching to the base of the hinge plate; lower cardinal larger, thick, more or less pyramidal; laterals long, thin, triangular, somewhat elevated above the margin of the shell; cavity of the beaks deep; nacre bluish or smoky-horn.

L. 7.6; H. 7.1; D. 5.0 mm. Fish Lake (U. of W., 4464).

L. 7.1; H. 6.1; D. 3.8 mm. " " (" 4464).

L. 6.0; H. 5.7; D. 3.1 mm. " " (" 4464).

ECOLOGY: The original specimens came from a muddy slough. In Lake Mendota this species lives on a mud bottom in water from 5 to 20 m. depth (Juday).

GENERAL DISTRIBUTION: Idaho, Washington to Yukon, Lake Michigan, Prince Edward Island (Sterki).

DISTRIBUTION IN WISCONSIN: The distribution in the State is not well known, specimens being at hand from but three localities.

Lake Superior Drainage: Fish Lake, Bayfield Co. (U. of W.).

Fox Drainage (Illinois): Lake Geneva, Walworth Co. (Baker).

Rock Drainage: Lake Mendota, Dane Co. (Juday).

REMARKS: *Idahoënsis* is the largest *Pisidium* in Wisconsin and is easily separated from *virginicum* by its size and shape, as well as by its quite different cardinal teeth. It appears to be rare in the State, but should occur in the northern lakes. That it should be absent from most of the collections made during the past few years is surprising.

PISIDIUM COMPRESSUM Prime

Plate C, figures 9-13

Pisidium compressum PRIME, Proc. Bost. Soc. N. H., IV, p. 164, 1851; Mon. Corb., p. 64, fig. 67, 1865.

Pisidium compressum STERKI, Cat., p. 447, 1916.

TYPE LOCALITY: Massachusetts, in Fresh Pond, near Cambridge.

WISCONSIN RECORDS:

1906. *Pisidium compressum* CHADWICK, p. 99. Mud creek, N. Milwaukee.

1924. *Pisidium compressum* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Small, solid, inflated, very inequipartite, oblique, trigonal; anterior end rounded; posterior end roundly truncated; dorsal and ventral margins curved; scutum and scutellum not well marked; beaks elevated, compressed, placed near the posterior end, with well marked appendages, umbonal slopes rounded; surface shining, with well marked lines of growth; color yellowish, darker in older specimens.

Hinge plate rather solid, wide; cardinal (fig. 276) in right valve narrow, curved, slightly enlarged at both ends in some specimens, and in all at the lower posterior end near the base

of the hinge plate; upper cardinal in left valve narrow, long, curved; lower cardinal very large, rounded, usually occupying the greater part of the cardinal area; the pits between and below the cardinals are very deep; laterals rather strong, elevated, somewhat curved, rather short; cavity of the beaks deep; nacre bluish, sometimes with a white zone bordering the valve.

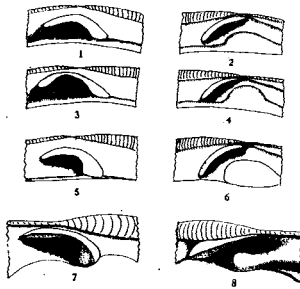


Fig. 276. Cardinal teeth of *Pisidium compressum* Prime (1-4, Medford), *Pisidium compressum limnicolum* Sterki (5, 6, Winnebago Lake), and *P. cruciatum* Sterki (7, 8, Bark River).

L. 3.5; H. 3.5; D. 2.5 mm. Medford (U. of W., 4465).

L. 3.1; H. 3.0; D. 2.3 mm. " (" 4465).

ECOLOGY: The typical form of *compressum* is confined principally to creeks and rivers. No exact notes on its ecology have been observed. Fox River near Portage, mud bottom, rather deep water; Mirror Lake, mud bottom, water 2 m. deep; Sturgeon Bay, 6.3 m., clay bottom.

GENERAL DISTRIBUTION: Distributed over the continent, more common in the East than in the West (Sterki).

DISTRIBUTION IN WISCONSIN: Scattered over the State but apparently more common in the eastern part, as far as the records show.

REMARKS: *Compressum* is very variable and not always easy to identify. Usually its very trigonal form and elevated beaks will distinguish it; but this form is not constant in any considerable lot of specimens. In some individuals the posterior outline from beaks to ventral margin is almost straight, while in others it is interrupted by a short projection of the dorsal margin. The elevation of the beaks also varies.

Sterki remarks: "As typical is accepted the common river and creek form: beaks high, narrow, with well developed appendages, above which there are small flattened or even im-

pressed smoothish areas, usually with more or less distinct radial lines; balance of the surface with rather coarse, sharp, regular, concentric striae, dull, with microscopic wrinkles, color whitish to grayish, and often there are marginal zones of straw to yellow color, with more shallow, irregular striae, more or less shining; shell and hinge stout, with whitish nacre" (1905, p. 81).

The Green Lake specimens vary toward variety *pellucidum* as do also the Sturgeon Bay individuals. Dr. Sterki, however, refers them to the typical form. The Green Lake specimens are mostly dead shells and may have been washed in from surrounding creeks. The typical form seems rare in the State.

PISIDIUM COMPRESSUM PELLUCIDUM Sterki

Plate C, figures 18-21

Pisidium compressum pellucidum STERKI, Cat., p. 447, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1924. *Pisidium compressum pellucidum* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Smaller, less elevated, beaks less pointed, with the ridges slight or vestigial; surface with the striae slighter, more or less glossy, shell translucent (Sterki). Hinge similar to *compressum*, but right cardinal heavier, enlarged at posterior end.

L. 3.4; H. 2.9; D. 1.9 mm. Brown Co. (U. of W., 4468).

L. 3.1; H. 2.8; D. 2.0 mm. " " (" 507).

L. 3.5; H. 2.9; D. 2.1 mm. Butte des Morts (U. of W., 4467).

L. 3.5; H. 3.0; D. 2.1 mm. " " " (" 4467).

ECOLOGY: Lake Butte des Morts, sand and mud bottom, water .9 to 3.4 m. deep; Lake Winnebago, mud bottom, 3.1 to 5.5 m.; sand bottom, .6 to 1.5 m.; sand and gravel bottom, 2.5 to 2.8 m.; gravel bottom, .3 to 3.1 m.; Prairie Lake, mud bottom, 1 m.; Chicago Creek, Bayfield, mud bottom, 1 m. (Baker). Oconomowoc Lake, 3-5 m. in vegetation; 12 m., sand bottom; Golden Lake, 1 m., sand (Cahn).

GENERAL DISTRIBUTION: Ontario, northern New York, Michigan and Wisconsin.

DISTRIBUTION IN WISCONSIN: *Pellucidum* is more widely distributed than the typical form, though more common in the eastern part of the State.

Lake Superior Drainage: North side Madeline Island, Apostle Group; mouth of Chicago Creek, near Bayfield, Bayfield Co. (Baker).

Chippewa Drainage: Lakes Chetek and Prairie, Barron Co. (Baker).

Rock Drainage: Genesee, Oconomowoc, Ashippun, Silver lakes; fossil in Lower Nemahbin Lake, Waukesha Co. (Cahn).

Fox Drainage: Lakes Butte des Morts and Winnebago, Winnebago Co. (Baker); Fox River, Brown Co. (Marston).

REMARKS: Variety *pellucidum* is the form of *compressum* usually found in lakes. It seems sufficiently distinct from the typical river form, which has higher, more compressed beaks, and a shorter hinge line. In the Fox River specimens there is a strong tendency to vary toward the typical form, some individuals having high, somewhat compressed beaks, and heavy hinges. Normally, *pellucidum* has rather slight hinges. In the lakes of Waukesha County, which are largely expansions of rivers, *pellucidum* varies toward typical *compressum*.

Three specimens were observed with young, the adults and young having the following dimensions: (1), with 3 young 1 mm. long, adult 3.5 mm. long; (2), with 2 young, 1 mm. long, adult 2.5 mm. long; (3); with 2 young .7 mm. long, adult 2.7 mm. long.

PISIDIUM COMPRESSUM LIMNICOLUM Sterki

Plate C, figures 14-17

Pisidium compressum var. *limnicolum* STERKI, Nautilus, XIX, p. 81, 1905.

Pisidium compressum var. *arrosum* STERKI, Nautilus, XIX, p. 82, 1905.

Pisidium compressum arrosum STERKI, Cat., p. 447, 1916.

TYPE LOCALITY: Fox River, Brown Co. (*limnicolum*); Grand Rapids, Blue Lake, Allegan Co.; Brooks Lake, Newago Co.; Green Creek, Allegan Co. (*arrosum*).

WISCONSIN RECORDS:

1905. *Pisidium compressum* var. *limnicolum* STERKI, p. 82. Fox River, Brown Co.

1916. *Pisidium arrosum* STERKI, p. 447. Wisconsin.

1918. *Pisidium compressum limnicolum* WALKER, p. 189. Fox River.

SHELL: Near *laevigatum*, but much smaller, some specimens have ridges or well formed appendages on the beaks; shell and hinge slight, cardinal teeth well formed. A form of deeper, quiet waters, lakes, etc. (*limnicolum*).

"Rather small and low, not very oblique, outlines somewhat angular, moderately inflated, beaks not much elevated, narrow,

rounded or slightly flattened on top, without appendages, and with barely any radial lines; surface with very fine striae above, becoming somewhat more distant and irregular towards the margins, slightly shining, color pale to yellowish or reddish-horn, shell thin, somewhat translucent, hinge slight" (Sterki, 1905, p. 82). Cardinal of right valve curved, enlarged at posterior end (fig. 276, 5, 6).

- L. 2.3; H. 2.0; D. 1.2 mm. Brown Co. (U. of W., 4466).
 L. 2.4; H. 2.0; D. 1.2 mm. " " (" 4466).
 L. 3.4; H. 2.9; D. 1.9 mm. Winnebago Lake (U. of W., 4469).
 L. 2.8; H. 2.2; D. 1.5 mm. " " (" 4469).

ECOLOGY: Winnebago Lake, sand and gravel bottom, water .3 to 2.8 m. deep.

GENERAL DISTRIBUTION: Michigan, Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the Fox River region. Fox River, Brown Co. (Marston); Winnebago Lake, Winnebago Co. (Baker).

REMARKS: This small variety of *compressum* seems quite distinct. It is more angular than *compressum* or *pellucidum*, more elongated, with a longer posterior end; the beaks are not as much compressed and the hinge is slighter.

Limnicolum and *arrosus* appear to be the same thing, the description of the latter absolutely agreeing with specimens of *limnicolum* from the original locality, named by Sterki. Sterki does not list *limnicolum* in his catalog, but does mention *arrosus*, giving both Michigan and Wisconsin as localities. He says of it "A small, slight, lacustrine and deep-water form." The form here described and figured appears to represent both of these forms of *compressum*. The differences between the three varieties of this species are well shown on Plate C.

PISIDIUM FALLAX Sterki

Plate CII, figures 1-4

Pisidium fallax STERKI, Nautilus, X, p. 20, 1896.

Pisidium fallax STERKI, Cat., p. 449, 1916.

TYPE LOCALITY: Tuscarawas River and Sugar Creek, Ohio.

WISCONSIN RECORDS:

1902a. *Pisidium fallax* BAKER, p. 401. Wisconsin.

1906. *Pisidium fallax* CHADWICK, p. 99. Wisconsin.

1924. *Pisidium fallax* BAKER, p. 133. Lake Winnebago.

SHELL: Mussel rather small; it is of the same type with *P. compressum* Prime, but smaller, more rounded in outline, the upper margin is less strongly curved, not angular, the ridges on the beaks are comparatively larger and situated less high up; the striation is finer, crowded, somewhat irregular and sharp; the color commonly greenish or yellowish-horn in the younger, more yellow in older specimens; the hinge is strong, more regularly curved than in *compressum*, the hinge plate broad, the cardinal tooth of the right valve more oblique, the lateral teeth strongly projecting inward; nacre more glassy-whitish; ligament strong (Sterki).

L. 2.9; H. 2.5; D. 1.6 mm. Winnebago Lake (U. of W., 4470).

L. 2.0; H. 1.6; D. 1.4 mm. " " (" 4470).

L. 3.2; H. 2.9; D. 2.1 mm. Sterki's type.

ECOLOGY: Winnebago Lake, boulder bottom, .6 m. deep.

GENERAL DISTRIBUTION: New Jersey to South Dakota, Ohio River, Lake Erie (Sterki).

DISTRIBUTION IN WISCONSIN: Apparently of limited distribution. Winnebago Lake, Winnebago Co. (Baker); Rock River, Pipersville Rapids, Jefferson Co. (Cahn).

REMARKS: "It is decidedly and constantly distinct, not a variety or depauperate form of *Pisidium compressum*." (Sterki). In the type locality it is associated with *compressum*, *cruciatum*, and *punctatum*. In form *fallax* resembles some specimens of *compressum pellucidum*, but is rounder, less angular, and has ridged beaks similar to those of *compressum* but larger. It is quite unlike typical *compressum* or variety *limnicolum*. Found in the stomach of the Buffalo Sucker with *Pisidium cruciatum* and other molluscan shells (Sterki). This species will probably be found in collections labelled *compressum*.

PISIDIUM FALLAX PRESSUM Sterki

Plate CV, figures 9-11

A smaller, rounder, more compressed, less triangular shell, with rounded, not ridged beaks, has been named variety *pressum* by Sterki. The figures indicate the differences in the shells. The cardinal teeth, which are slighter, are figured for comparison (fig. 277). The variety has not yet been published by Sterki.

L. 3.0; H. 2.7; D. 1.8 mm. Mukwonago River (U. of I., Z22387).

L. 2.5; H. 2.3; D. 1.5 mm. " "

L. 2.2; H. 2.0; D. 1.0 mm. " "

ECOLOGY: Mukwonago River, few cm. to .7 m. deep, gravel bottom, swift current, some vegetation (Cahn).

GENERAL DISTRIBUTION: Wisconsin.

DISTRIBUTION IN WISCONSIN: Mukwonago River, at Mukwonago, Waukesha Co., Fox River of Illinois drainage (Cahn).

PISIDIUM CRUCIATUM Sterki

Plate CV, figures 4-6

Pisidium cruciatum STERKI, Nautilus, VIII, p. 97, pl. ii, figs. 1-6, 13, 1895.

Pisidium cruciatum STERKI, Cat., p. 449, 1916.

TYPE LOCALITY: Tuscarawas River, New Philadelphia, Ohio.

WISCONSIN RECORDS: None.

SHELL: Minute, inequiptartite, oblique, subtriangular in outline, high, ventricose, regularly and comparatively coarsely striated, straw colored; anterior part moderately long with an oblique, nearly straight edge above and the end rounded; posterior part short, the end somewhat obliquely truncate, superior margin rather strongly curved, scutum scarcely, scutellum little marked, the latter forming a rather distinct angle; inferior part moderately curved; beaks prominent, each with two ridges diverging at nearly right angles, together forming a cross on the upper aspect of shell, each of the ridges ending in a nodule of which the posterior is larger and more prominent; nacre rather thick, whitish; hinge very stout, list strong; cardinal teeth rather large, and strongly projecting inward from the hinge list; in the right valve one, strongly curved, posterior part thick, anterior thin, lamellar, the ends united by a lamella so as to form a deep groove into which the posterior tooth of the left valve articulates; in the left valve two, the posterior (inferior) stout, massive, the other, superior and a little anterior, rather short, fine lamellar, oblique, little curved (fig. 276, 7, 8); lateral teeth large, high and pointed in the left, strongly projecting inward in the right valve, the latter with no (or only traces of) outer teeth, and a deep groove; between the cardinal and the lateral teeth the hinge list is rather deeply excavated,

so that all teeth are markedly isolated; muscle insertions visible; ligament short, strong (Sterki).

L. 1.9; H. 1.9; D. 1.4 mm. Type.

L. 1.0; H. 1.0; D. 0.8 mm. Bark River (U. of I., Z22389).

ECOLOGY: "They live in mud among aquatic plants and dead leaves, and, as a rule, are covered with a black or brown coat, sometimes so thick that they appear to be globules of dirt" (Sterki). Bark River, Wis., on sand and gravel bottom, in shallow water, among vegetation. Specimens very clean (Cahn).

GENERAL DISTRIBUTION: Ohio, Michigan, Illinois, Wisconsin, Missouri, Arkansas, Alabama.

DISTRIBUTION IN WISCONSIN: Known only from the southeastern part of the state. *Rock Drainage*: Crawfish River, Aztalan, Jefferson Co.; Bark River, at Highway 67, Waukesha Co. (Cahn).

REMARKS: "The singular shape of the umbones is so characteristic that this species will be recognized at once, and cannot be mistaken for any other. And also in the formation of the hinge it is quite unlike any other *Pisidium*, so that it holds a peculiar position in the genus. Our species is rather variable, even so that all specimens from one place in the river are different in size and shape from those of another place scarcely half a mile distant. It measures from 1.6 to 2.1 mm., 1.9 mm. being the average; the margins may be rather obtuse or somewhat acute, the beaks more or less prominent, and the anterior nodule more or less marked. The cardinal teeth vary, also" (Sterki).

Wisconsin specimens conform rather closely to the diagnosis and figures of the original description. It is apparently rare in Wisconsin. When once distinguished it should be found widely distributed in other places.

PISIDIUM PUNCTATUM Sterki

Plate CV, figures 1-3

Pisidium punctatum STERKI, Nautilus, VIII, p. 99, pl. ii, figs. 7-12, 14, 1895.

Pisidium punctatum STERKI, Cat., p. 451, 1916.

TYPE LOCALITY: Tuscarawas River, Ohio.

SHELL: Minute, inequipartite, high, oblique, strongly ventricose, almost globular, regularly and sharply striated, micro-

scopically rugulose, whitish; anterior part moderately long, the edge above oblique, almost straight, end slightly angled, rather inferior; posterior part short, truncate, slightly angular above, rounded below; superior and inferior margins moderately curved, the former rather short, the latter long; scutum little, scutellum moderately marked, both forming slight angles; vertical section heart-shaped, horizontal, short, lanceolate-rhombic; margins very slightly acute; beaks moderately full and prominent, with a longitudinal, slightly oblique ridge (sometimes obsolete) below the culmination; nacre moderately thick, whitish, with crowded, small pits, from which it appears as if dotted.

Hinge moderately strong; cardinal teeth fine, in the left valve two, lamellar, longitudinal, about equally long, a little curved, almost parallel, the upper little anterior; in the right valve one, longitudinal, little curved, lamellar, the posterior end slightly thickened; lateral teeth rather small and thin, in the left valve one, pointed, in the right valve two, the outer quite small; hinge list fine, rather regularly formed; ligament rather long and fine (Sterki, 1895a, p. 99).

L. 1.8 mm. H. 1.6 mm. D. 1.3 mm. Type.

Differs from *compressum* in being smaller, with the appendages on the outside below the culmination of the beaks while in *compressum* they are rather on top of the beak.

The typical form has not yet been found in Wisconsin but a variety, described below, has been noted in two localities.

PISIDIUM PUNCTATUM SIMPLEX Sterki

Plate CII, figure 27

Pisidium punctatum var. *simplex* STERKI, Nautilus, XIX, p. 34, 1905.

Pisidium punctatum simplex STERKI, Cat., p. 451, 1916.

TYPE LOCALITY: Joliet, Ill.; Carp Lake near Mackinac, Mich.; Fox River, Wis.

WISCONSIN RECORDS: As noted above.

1924. *Pisidium punctatum simplex* BAKER, p. 133. Lake Winnebago.

SHELL: Beaks without appendages, rounded or slightly flattened on top; striation slighter; mussel sometimes smaller than the typical form (Sterki). Cardinal of right valve long, lamellar, slightly thickened on posterior end, placed on lower

margin of hinge plate; cardinals of left valve rather thick, the upper slightly curved, the lower straight, placed on the lower margin of the hinge plate (fig. 277).

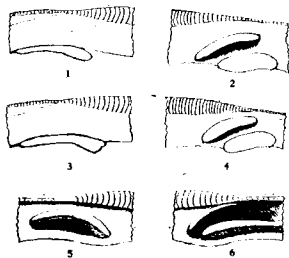


Fig. 277. Cardinal teeth of *Pisidium punctatum simplex* Sterki, (Fox River, Brown Co.) and *P. fallax pressum* Sterki (Mukwonago River).

L. 1.6; H. 1.5; D. 1.0 mm. Fox River (U. of W., 4471).

L. 1.6; H. 1.4; D. 1.0 mm. " " (" 4471).

ECOLOGY: Winnebago Lake, gravel and mud bottom, 1.5 m. deep.

GENERAL DISTRIBUTION: New England to Ohio, Indiana, Illinois, Wisconsin, Michigan, Missouri (Sterki).

DISTRIBUTION IN WISCONSIN: Known only from eastern Wisconsin.

Fox Drainage: Fox River, Brown Co. (Marston, type locality); Winnebago Lake, Winnebago Co. (Baker). **Rock Drainage:** Oconomowoc Lake, Waukesha Co. (Cahn).

REMARKS: *Punctatum simplex* is one of the smallest of Wisconsin Pisidia. Though ranging from Maine to Minnesota, the typical form has not yet been found in the State. The variety is rare and seems confined to the eastern part of the State. Its small size has probably caused it to be overlooked among larger Pisidia.

PISIDIUM PERALTUM Sterki

Plate C, figures 7, 8

Pisidium peraltum STERKI, Nautilus, XIV, p. 5, 1900 (partim).

Pisidium fraudulentum peraltum STERKI, Cat., p. 451, 1916.

TYPE LOCALITY: Crystal Lake, Benzie Co., Mich.

WISCONSIN RECORDS. None.

SHELL: Mussel of moderate size, somewhat oblique, very high, much inflated, beaks large, full and prominent; hinge

margin strongly curved; posterior part, behind the beaks, very short, the margin high, slightly to distinctly truncated, passing into the well rounded inferior with a wide, regular curve; antero-superior margin slightly curved in a steep slope to the slightly angular, rounded anterior end; color light yellowish horn in the young and a zone along the margins in older specimens, in which the upper parts usually are grayish; surface slightly shining, finely and irregularly striated, with some deeper lines of growth usually of darker color; shell rather strong, nacre whitish to grayish, muscle insertions distinct.

Hinge stout, strongly curved, plate moderately broad; cardinal teeth short, the one in the right valve curved, its posterior part thick, and usually grooved; the anterior of the left valve short, stout, triangular, abrupt, with a deep groove, posterior short, oblique, curved; lateral teeth short, stout, high, pointed, the outer ones in the right valve quite small; ligament short, moderately strong (Sterki).

L. 3.8; H. 3.8; D. 2.8 mm. Type.

L. 3.0; H. 3.0; D. 3.0 mm. Green Lake (U. of W., 4472).

ECOLOGY: Not recorded.

GENERAL DISTRIBUTION: Michigan, Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from Green Lake, Green Lake Co. (Baker).

REMARKS: "Typical specimens are easily distinguished from all other species—except an extreme form of *P. compressum* Pr., from the same place, having rounded beaks without ridges. Yet they are quite distinct. *P. peraltum* is somewhat variable; in some specimens there are small but distinct projecting angles at the scutum, or scutellum, or both. Others are less high, and the beaks are not so full and prominent" (Sterki). *Peraltum* may be distinguished from Wisconsin *Pisidia* by its more rounded trigonal form, rounder beaks and higher and narrower shell, the height and length being usually equal. It is also more globular than *compressum*.

Sterki (Cat. p. 451). makes *peraltum* a variety of *fraudulentum*. If the two species are conspecific, as indicated, the name *peraltum* must take precedence, it having twelve years priority. This is unfortunate, for Sterki says that *fraudulentum* is really the typical form and *peraltum* a variety. However, the rules of nomenclature forbid the combination as listed

in the catalog. *Peraltum* is very rare in Wisconsin, but two specimens being found among thousands examined by Dr. Sterki.

PISIDIUM VARIABLE Prime

Plate CI, figures 1–4

Pisidium variable PRIME, Proc. Bost. Soc., N. H., IV, p. 163, 1851;
Mon. Corb., p. 66, fig. 69, 1865.

Pisidium variable STERKI, Cat., p. 453, 1916.

TYPE LOCALITY: Fresh Pond, near Cambridge, Mass.

WISCONSIN RECORDS:

1924. *Pisidium variable* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Large for the genus, solid, inflated, oblique; umbones elevated, full, rounded; all margins rounded, the anterior end rather pointed; scutellum and scutum not well marked; surface shining, marked by rather heavy, regular growth lines; color varying from light yellow or straw color to greenish or brownish, with a zone of lighter color near the ventral margin; in some specimens several zones may be present, while in others the zone is hardly visible.

Hinge rather narrow, moderately strong; cardinal of right valve varying from long, narrow to wide, distinctly curved, enlarged, usually at both ends; the anterior end may be almost

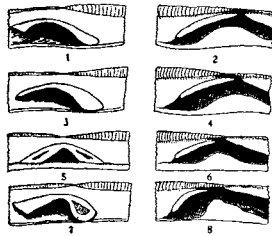


Fig. 278. Cardinal teeth of *Pisidium variable* Prime. Fox River, Brown Co.

parallel with the hinge plate or it may be bent downward to near the ventral margin of the plate; the tooth may be simply and regularly curved (fig. 278, 1) or it may be markedly arched (fig. 278, 5); there is a deep pit beneath the cardinal; upper cardinal of left valve, long, almost straight or, rarely, curved,

reaching to near the base of the plate; lower cardinal large, pyramidal or rounded, with a deep pit above it; laterals thin, not much elevated, the anterior rather long, the posterior short; cavity of the beaks deep; nacre bluish-white.

L. 3.8; H. 3.2; D. 2.5 mm. Brown Co. (U. of W., 4473).

L. 3.9; H. 3.1; D. 2.5 mm. " " (" 4473).

L. 3.5; H. 3.0; D. 2.5 mm. " " (" 4473).

ECOLOGY: Lake Winnebago, mud bottom, 3.7 to 6.1 m.; sand and gravel bottom, .3 to 3.1 m.; Lake Butte des Morts, mud bottom, 1.2 to 3.4 m.; Lake Chetek, mud bottom, 2.5 m.; Green Lake, marly clay bottom, .5 to 10 m.; Bayfield, mud bottom, small pool behind beach, .3 m.; Devils Lake, mud bottom, 8.5 to 13.5 m. (Baker). Bark River, sand bottom, with gravel and some silt, matted vegetation, shallow water, considerable current; Ashippun River, gravel and silt bottom, shallow to 1 m. deep; Oconomowoc Lake, water 3-5 m. deep in vegetation; Mud Lake, soft mud bottom, shallow water; Oconomowoc Lake, 12 m. deep, sand bottom (Cahn).

GENERAL DISTRIBUTION: Widely distributed over the continent, except, apparently, in the South; common in the northeast, ranging from New England and New York to Michigan (Sterki).

DISTRIBUTION IN WISCONSIN: Well distributed over the State but at present known from scattered localities. It seems to inhabit all of the great drainage systems.

REMARKS: The shape of *variabile* will help to distinguish it; the beaks are placed nearer the center of the dorsal margin than in most species of *Pisidium*, and the shape is more oval than oblique. It is larger than *P. compressum pellucidum*, which it much resembles, and it is usually of a darker color, smoother and more shiny. In Wisconsin, *variabile* seems rather constant in form. The specimens from Devils Lake are said by Dr. Sterki to be rather small and slight. This lake has no outlet or inlet and its waters are cold and deep. Its molluscan fauna is somewhat peculiar. None of the races of *variabile* has as yet been found in Wisconsin. The lake form is on the average smaller than the river form, with less elevated umbones.

PISIDIUM MINUSCULUM Sterki

Plate CII, figures 5-8

Pisidium minusculum STERKI, Nautilus, XX, p. 17, 1906; Cat., p. 453, 1916.

TYPE LOCALITY: Fox River, Brown Co.

WISCONSIN RECORDS:

1906. *Pisidium minusculum* STERKI, p. 17. Fox River.

1924. *Pisidium minusculum* BAKER, p. 134. Lake Butte des Morts.

SHELL: Minute, slightly oblique, medium inflated; superior margin short, moderately curved, bounded by slightly projecting angles; supero-anterior and posterior slopes little curved or straight, posterior end rounded, anterior a rounded angle situated much below the median longitudinal line, inferior margin rather well curved; beaks slightly posterior, rather large, rounded or somewhat flattened, moderately projecting over the hinge margin; surface with very fine, slight striae, somewhat shining, color pale horn, shell translucent.

Hinge rather stout, cardinal teeth; the right strongly curved, its posterior part much thicker and grooved, left anterior rather short, well curved, the posterior larger, oblique, curved; laterals strong, the outer ones in the right valve well formed; ligament short, thick (Sterki).

L. 2.2; H. 1.8; D. 1.5 mm. Type.

L. 2.5; H. 2.2; D. 1.6 mm. Butte des Morts (U. of W., 4474).

L. 2.7; H. 2.3; D. 1.7 mm. " " " (" 4474).

ECOLOGY: Lake Butte des Morts, sand and mud bottom, 1.2 to 2.2 m.

GENERAL DISTRIBUTION: Wisconsin, Ohio.

DISTRIBUTION IN WISCONSIN: Known only from the Fox River drainage. Fox River, Brown Co. (Marston); Lake Butte des Morts, Winnebago Co. (Baker).

REMARKS: This small species resembles *compressum pelucidum*, from the same type locality, but is smaller, less oblique on the whole, with finer striae, and with the beaks placed farther forward. It is also proportionately wider and the hinge line is not as much curved (compare figs. 5-8, Pl. CII, with figs. 18-21, Pl. C). It is apparently rare in Wisconsin.

PISIDIUM GLABELLUM Sterki

Plate CII, figures 9-11

Pisidium glabellum STERKI, Nautilus, XXVI, p. 137, 1913; Cat., p. 454, 1916.

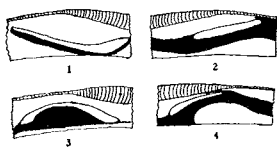
TYPE LOCALITY: Hess Lake, Newaygo Co., Mich.

WISCONSIN RECORDS:

1924. *Pisidium glabellum* BAKER, p. 133. Lake Butte des Morts.

SHELL: Small, somewhat oblique, rather well inflated; superior margin nearly straight, bounded by angles in front and behind, supero-anterior slope nearly straight, anterior end rounded, posterior and inferior margins forming one curve; beaks slightly posterior, rounded or somewhat flattened on top, moderately prominent; surface polished, with very fine, slight striae, color corneous, occasionally with a reddish tinge, to clear amber, shell transparent to translucent.

Hinge stout, plate rather broad; right cardinal curved, its posterior part thicker, left anterior with apex pointed, posterior rather short, oblique, well curved; ligament and resilium short, strong (Sterki).

Fig. 279. Cardinal teeth of *Pisidium glabellum* Sterki. Chetek Lake.

The cardinal teeth are peculiar, the right cardinal being very long and thin, curved, and enlarged at one or both ends; in one specimen the cardinal curved upward and was very long (Fig. 279, 1); the upper cardinal of left valve may be straight or curved, but is usually thin; the lower cardinal is larger, rounded, rather thick (Lake Chetek specimens).

L. 2.2; H. 1.9; D. 1.4 mm. Type.

L. 2.3; H. 2.0; D. 1.5 mm. Butte des Morts (U. of W., 4475).

L. 2.3; H. 2.0; D. 1.2 mm. " " " (" 4475).

ECOLOGY: Lake Butte des Morts, sand bottom, .8 m. deep.

GENERAL DISTRIBUTION: New England, New Jersey, Pennsylvania to Ontario, Minnesota, and Manitoba (Sterki).

DISTRIBUTION IN WISCONSIN: The records indicate a wide range, though intermediate localities are at present lacking.

Chippewa Drainage: Lake Chetek, Barron Co. (Baker).

Fox Drainage: Lake Butte des Morts, Winnebago Co. (Baker).

REMARKS: *P. glabellum* has some resemblance to small forms of *P. splendidulum*; the latter is widely distributed, common and very variable, but from all its forms, *glabellum* proved distinct. The hinge is markedly strong and somewhat like that of *P. variabile* and *compressum*; the mussel is somewhat like a miniature *P. variabile*, and it appears to range with that group (Sterki, 1913, p. 138).

As remarked by Sterki, this species bears some resemblance to *variabile* but is a much smaller shell with polished surface. Sterki describes the shell as rather well inflated, but the specimens from Wisconsin would be better described as rather compressed or flattened on the side. The specimens from some places are quite variable and it is believed that more than one form may be represented.

PISIDIUM ADAMSI Prime

Plate CI, figures 7-9, 19

Cyclas nitida MIGHELS (non Hanley), Proc. Boston Soc. N. Hist., I, p. 48, 1841.

Pisidium adamsi (PRIME) STIMPSON, Moll. New Eng., p. 16, 1851; Cat., p. 63, fig. 63, 1865.

Pisidium affine STERKI, Nautilus, XV, p. 66, 1901; Cat., p. 454, 1916.

TYPE LOCALITY: Great Lakes region, Michigan to New York (*affine*), Norway, Me., Holly, Oakland Co., Mich. (*adamsi*).

WISCONSIN RECORDS:

1924. *Pisidium adamsi affine* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Rather large, well inflated, slightly oblique, beaks somewhat posterior, large and prominent in full-grown, broad and quite low in young specimens, rounded or slightly flattened on top; superior and inferior margins moderately curved, posterior sub-truncate, with slightly marked angles above and below, supero-anterior forming one regular curve from the beaks to the anterior end, which is low-situated and well rounded; surface distinctly and somewhat irregularly striated, with some coarser lines of growth, dull or somewhat shining; color lighter

or darker grayish-horn to plumbeous or brownish with a few irregular darker zones corresponding with the lines of growth, and often with fine darker mottlings, usually with a broad lighter zone along the margins; the young are pale horn or straw-colored; shell moderately thick, nacre whitish (Sterki).

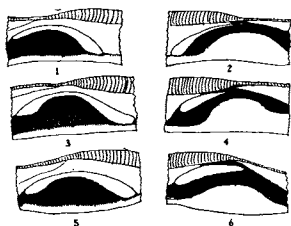


Fig. 280. Cardinal teeth of *Pisidium adamsi* Prime. Chetek Lake.

Hinge rather stout, plate rather broad; (fig. 280) cardinal of right valve long, thin, much curved, slightly enlarged at the posterior end, and sometimes at the anterior end; sometimes grooved; upper cardinal of left valve long or short, straight or slightly curved, usually enlarged at the lower (posterior) end; lower cardinal large, rounded, sometimes somewhat overlapping the upper cardinal; laterals long, pointed, rather thick, of good size; cavity of the beaks deep.

L. 6.0; H. 5.0; D. 4.0 mm. Type. Average.

L. 5.5; H. 4.5; D. 3.9 mm. Taber Lake (U. of W., 4476).

L. 5.2; H. 4.8; D. 3.9 mm. Yellow River (U. of W., 4477).

ECOLOGY: Winnebago Lake, mud bottom, 3.4 m. deep; Lake Butte des Morts, mud bottom, 1.2 to 2.2 m. deep; Green Lake, mud and marly-clay bottom, 1 to 13.5 m.; Lake Chetek, mud bottom, .6 m.; Taber Lake, mud bottom, .3 m. "It seems to prefer quiet water, small lakes and slow-running streams" (Sterki). Its presence in Lake Winnebago indicates that it also lives in the larger lakes (Baker). Oconomowoc Lake, pebble bottom, shallow water; 3-5 m. deep with vegetation; Mud Lake, soft mud bottom, with decomposing vegetation, shallow water (Cahn).

GENERAL DISTRIBUTION: Maine to Virginia and Minnesota.

DISTRIBUTION IN WISCONSIN: The records indicate a wide distribution in the State, though the localities known are greatly separated.

REMARKS: "*Pisidium affine* is related with *noveboracense* Pr. and with *sargenti* St. From the former, it differs by the following characters: it averages larger, its beaks are larger, broader, as especially noticeable in the young, the whole mussel is more full, the hinge margin is less curved, the supero-anterior, as mentioned, forms one long, unbroken curve, the anterior part is larger, the end situated nearer the 'base' and more rounded. *P. noveboracense* retains its light, yellowish horn color, and the surface is rather shining, while older specimens of *affine* usually are light to dark grayish, and the surface is more dull" (Sterki). *Affine* is also much more swollen than *noveboracense*, as may be seen by comparing the figures on plate CI. The young are quite different in shape from the adult, as described by Sterki (see fig. 9 of plate). The species is quite variable and it requires some experience, as remarked by Sterki, to distinguish some of these from the species mentioned.

Sterki states that *affine* is the common, widely distributed, most characteristic form; while *adamsi* is a somewhat extreme local form, as shown by specimens in the Prime collection. Having priority, the species must bear the name *adamsi*.

PISIDIUM SARGENTI Sterki

Plate CI, figures 5, 6, 18

Pisidium sargenti STERKI, Nautilus, XV, p. 67, 1901; Cat., p. 454, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1906. *Pisidium sargenti* CHADWICK, p. 99. Mud Creek, N. Milwaukee.

1924. *Pisidium sargenti* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Of medium size, somewhat oblique, medium inflated; beaks not much posterior, rounded or slightly flattened on top, well prominent over the hinge margin; the latter slightly curved in the adult, almost straight in the young and half-grown, with projecting, not or hardly rounded angles at the scutum and scutellum, which are slightly to well marked, narrow; posterior margin subtruncate above, passing into the well rounded inferior with an interrupted curve, or with a slightly marked, rounded angle, more so in the young; supero-anterior margin little to moderately curved, sloping from the

projecting angle at the scutellum to the rounded anterior end; surface regularly and rather coarsely striated, dull, rarely somewhat shining in older specimens; epiconch thin and often worn off, pale horn colored in the young, lighter to darker grayish to brownish in older specimens, usually with a lighter zone along the margins; shell moderately thick, nacre glassy, colorless to white or bluish, muscle insertions distinct (Sterki).

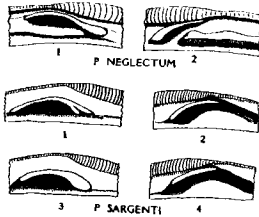


Fig. 281. Cardinal teeth of *Pisidium sargenti* Sterki. Winnebago Lake. *P. neglectum* Sterki, Oconomowoc Lake.

Hinge stout, with broad plate; cardinal of right valve long, thin to rather thick, the posterior end thickened and frequently grooved; upper cardinal of left valve thin, long, almost straight to rather curved; lower cardinal larger, thick, rounded; laterals short, thick, the plate widened, and the cusps widely separated in the right valve (fig. 281).

L. 5.0; H. 4.4; D. 3.4 mm. Type.

L. 3.8; H. 3.0; D. 2.0 mm. Winnebago Lake (U. of W., 4479).

L. 4.9; H. 4.0; D. 4.0 mm. Butte des Morts (U. of W., 4480).

ECOLOGY: Lake Winnebago, mud bottom, .3 m.; mud with gravel, 1.5 to 5.4 m.; mud and gravel, 2.8 m.; Lake Butte des Morts, mud bottom, 1.2 m.

GENERAL DISTRIBUTION: New York and Pennsylvania to Iowa, Missouri, and Arkansas.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern side of the State.

Fox Drainage: Lakes Butte des Morts and Winnebago, Winnebago Co. (Baker).

Lake Michigan Drainage: Mud Creek at N. Milwaukee, Milwaukee Co. (Chadwick).

REMARKS: "Well formed specimens are easily recognized by the oblique shape, the rather short, slightly curved hinge

margin with the projecting angles at both ends, the regular striation and the dull, often roughish appearance of the surface; by the latter features it may be discerned from some of *P. scutellatum* which are of similar shape; but it is more nearly related to *P. noveboracense* and *affine*; and some full-grown, well-inflated specimens, in which the scutar and scutellar angles are sometimes less marked, might be mistaken for one or the other. But a lot of mussels at different stages of growth are always recognizable at once; the projecting angles, especially marked in half-grown specimens, in connection with the peculiarly dull surface are well marked characters, and so is the color, which turns to grayish while the mussels are much younger and smaller than in *P. affine*. In the latter species the hinge-teeth, especially the cardinals, are longer" (Sterki).

Sargenti is rare in Wisconsin, occurring in but one region of those examined by the writer.

PISIDIUM NEGLECTUM Sterki

Plate CV, figures 7, 8

Pisidium neglectum STERKI, Nautilus, XX, p. 87, 1906; Cat., p. 456, 1916.

TYPE LOCALITY: Krumroy, Summit Co., Ohio.

WISCONSIN RECORDS: None.

SHELL: "Mussel of small size, slightly to scarcely oblique, rather rounded in outlines, moderately to rather well inflated; superior margin slightly curved or nearly straight, with more or less marked angles where passing into the anterior and posterior; supero-anterior slope generally marked, slightly curved, anterior end rounded angular, posterior part subtruncate, inferior margin moderately curved; beaks slightly posterior, rather narrow, rounded or somewhat flattened on top, moderately projecting over the superior margin; surface with fine, subregular to regular, crowded, concentric striae, microscopically rugulose, dullish or somewhat shining; over the beaks there are much finer concentric striae to the center, and the surface is not rugulose, more shining; color light to yellowish-horn to whitish, shell translucent to rather opaque, rather thin; hinge rather slight, well formed, plate comparatively broad; right cardinal tooth rather short, strongly curved, not reaching the lower edge of the plate, its posterior end much thicker, deeply grooved or bifid; there is an impressed groove

between it and the edge of the plate; left anterior strongly curved to sharply angular and bent upward, the posterior oblique, curved; lateral teeth moderately stout, the outer ones of the right valve distinct, the anterior left cusp pointed, abrupt, the surfaces of all the cusps rugulose; ligament rather strong" (Sterki). Cardinal teeth fig. 281.

L. 3.0; H. 2.6; D. 1.8 mm. Type. Ohio.

L. 2.5; H. 2.2; D. 1.5 mm. Oconomowoc Lake (U. of I., Z22385).

L. 2.5; H. 2.3; D. 1.5 mm. " " (" Z22386).

L. 2.5; H. 2.3; D. 1.5 mm. " " (" Z22386).

ECOLOGY: "Living in all kinds of water" (Sterki). Oconomowoc Lake, 12 m., very fine sand bottom, shell fragments abundant (Cahn).

GENERAL DISTRIBUTION: East of Rocky Mountains, apparently rare in the South (Sterki).

DISTRIBUTION IN WISCONSIN: At present known only from Oconomowoc Lake, Waukesha Co. (Cahn).

REMARKS: "This *Pisidium* was regarded as probably distinct years ago; since then the material has been looked over and compared dozens of times. It seems to be a central form of a group which is one of the most difficult to deal with of all our *Pisidia*. There are a host of forms ranging under it or near it, really or apparently, and if only a few specimens from various places were on hand, they might well be regarded as distinct. But among the thousands seen, there are more or less plainly intermediate forms. Some of them have a slight resemblance to some forms of the polymorphous "*abditum* Hald", others to small forms of *noveboracense*. It may also be said that the more typical specimens resemble *Pisidium pusillum* Gmel. more than any other of our *Pisidia* do" (Sterki). The Wisconsin specimens are somewhat smaller than the type from Ohio.

PISIDIUM NOVEBORACENSE Prime

Plate CI, figures 10-12, 20

Pisidium noveboracense PRIME, Ann. N. Y. Lyc., VI, p. 66, pl. i, fig. 3, 1853; Mon. Corb., p. 67, fig. 71, 1865.

Pisidium noveboracense STERKI, Cat., p. 454, 1916.

TYPE LOCALITY: Greenwich and Mohawk, N. Y.

WISCONSIN RECORDS:

1906. *Pisidium noveboracense* CHADWICK, p. 99. Mud Creek, N. Milwaukee.

SHELL: Large for the genus, ovate somewhat oblique, not much inflated; dorsal margin short, slightly curved; posterior end sub-truncated, rounding into the broadly curved ventral margin; anterior margin regularly curved, pointed below; scutum and scutellum fairly well marked; beaks large, inflated, rounded or flattened on top, placed nearer the posterior end; sculpture of rather coarse striae; color slight horn to dark brownish.



Fig. 282. Cardinal teeth of *Pisidium noveboracense* Prime. Green Lake.

Hinge wide, stout; cardinal (fig. 282) of right valve narrow, much curved, enlarged at the posterior end; upper cardinal of left valve very fine, curved; lower cardinal much larger, thick, rounded; laterals moderately long, thick, straight; cavity of beaks deep; nacre bluish or whitish.

L. 5.5; H. 4.6; D. 3.4 mm. Fox River (U. of W., 506).

L. 5.0; H. 4.2; D. 3.1 mm. " " (" 506).

L. 4.0; H. 3.4; D. 2.5 mm. " " (" 4481).

ECOLOGY: Especially characteristic of spring brooks (Sterki).

GENERAL DISTRIBUTION: East of the Mississippi River; New England and New York to Illinois (the more typical form).

DISTRIBUTION IN WISCONSIN: Known only from the eastern part of the State.

REMARKS: A rather large species characterized by an oblique shape with a rather well-truncated posterior end. It is related to both *sargenti* and *affine*, but differs in outline, diameter, and in the form of the cardinal teeth. See under the species mentioned for comparative remarks. This species is not common in Wisconsin, judging by the small number of specimens found. None of the numerous varieties of this species have as yet been recorded from the State.

PISIDIUM SCUTELLATUM Sterki

Plate CI, figures 14-17

Pisidium scutellatum STERKI, Nautilus, X, p. 66, 1896; Cat., p. 457, 1916.

TYPE LOCALITY: Not specifically given. Pine Lake, Mich., and Lake Michigan, off New York Point.

WISCONSIN RECORDS:

1927a. *Pisidium scutellatum* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Of medium size, rather high, oblique, markedly protracted downward in its anterior part, well rounded, rather strongly inflated; beaks much posterior, rather large, prominent, rounded; superior margin short, little curved, or almost straight, scutum and scutellum well marked, forming project-

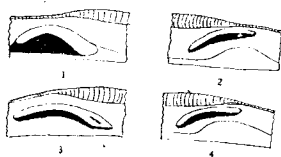


Fig. 283. Cardinal teeth of *Pisidium scutellatum* Sterki. Winnebago Lake.

ing angles; the other margins well curved, or the posterior very slightly truncated, anterior end well rounded, or with a slight indication of an angle; surface polished, with irregular striae and some coarse lines of growth; shell thin, transparent, of a yellowish-horn to amber color, often grayish or brownish-horn in old specimens, and whitish on the beaks; nacre glassy, inner surface microscopically rugulose (Sterki).

Hinge rather fine, of medium width; cardinal of right valve rather long, curved, enlarged at the posterior end, sometimes grooved; upper cardinal of left valve lamellar, curved, the lower cardinal larger, thick (fig. 283); laterals short, thin, triangular, not much raised above the shell margin; cavity of the beaks rather deep.

L. 4.0; H. 3.6; D. 3.8 mm. Type.

L. 3.3; H. 2.8; D. 2.4 mm. Deep water form (Sterki).

L. 4.0; H. 3.3; D. 2.4 mm. Winnebago Lake (U. of W., 4482).

L. 3.4; H. 3.1; D. 2.4 mm. " " (" 4482).

L. 3.5; H. 3.0; D. 2.3 mm. Green Lake (U. of W., 4483).

L. 3.0; H. 2.5; D. 2.0 mm. Off Racine (U. of W., 482).

ECOLOGY: Lake Winnebago, mud bottom, 3.4 m.; sand bottom, .8 m. to 1.7 m.; sand-gravel bottom, 1.5 m. to 2.8 m.; gravel bottom, 1.6 m. to 3.1 m.; boulder bottom, .4 m. to .6 m. Lake Butte des Morts, sand bottom, .8 m. to 1.2 m. Green Lake, sand bottom, 1.5 m.; marly clay bottom, 13.5 m. Devils Lake, mud bottom, 9 m. to 13.5 m. Sterki cites several places from which it has been dredged: Pine Lake, Mich., 5–11 m. Lake Michigan, off New York Point, 23 m. (Baker). Oconomowoc Lake, water 12 m. deep, bottom sand; water 17.5 m., black mud bottom; 2.5 m., sand and clay bottom (Cahn).

GENERAL DISTRIBUTION: Lake Champlain, Vermont; region of the Great Lakes and as far west as Montana; Yukon Territory (Sterki).

DISTRIBUTION IN WISCONSIN: More common in the eastern part of the State. It probably inhabits much of the western part, as specimens were found in Barron Co.

REMARKS: "This is one of our most characteristic *Pisidia*, distinguished, beside its surface features, color, and the configuration of the hinge, by its oblique shape and the much larger anterior part. This character it has in common with *P. virginicum* and *walkeri*; the former of these is out of the question; the latter species is much more elongated, its beaks are much smaller, the outline is more angular, and the surface dull, from microscopic lamellae, but even" (Sterki). A single specimen, from stomach of *Leucichthys hoyi*, has elongate beaks, and somewhat resembles a miniature *Musculium*.

This seems to be a characteristic species, the well marked scutum and scutellum being among its distinguishing characters, and also its great height as compared with length. It is said by Sterki to be very variable and that there are several well-marked varieties. It seems to be a species of lakes, not occurring in Wisconsin in rivers or streams. This species is eaten by the Cisco, *Leucichthys hoyi*.

PISIDIUM SCUTELLATUM CRISTATUM Sterki

Plate CI, figure 13

TYPE LOCALITY: Not ascertained.

WISCONSIN RECORDS:

1924. *Pisidium scutellatum cristatum* BAKER, p. 134. Lake Butte des Morts.

SHELL: With coarser sculpture than that of typical *scutellatum*, somewhat smaller, anterior end not as pointed, beaks nearer the center, scutellum and scutum not as prominent.

L. 3.0; H. 2.7; D. 2.0 mm. Lake Winnebago (U. of W., 4485).

GENERAL DISTRIBUTION: Not ascertained.

DISTRIBUTION IN WISCONSIN: Widely distributed, but records scattered.

Chippewa Drainage: Lake Chetek, Barron Co. (Baker).

Fox Drainage: Lake Winnebago, Winnebago Co. (Baker).

ECOLOGY: Lake Winnebago, sand and gravel bottom, 1.5 to 2.6 m. Lake Chetek, sand and mud bottom, 1 m.

REMARKS: *Cristatum* appears to be a local variation of *scutellatum* rather than a geographic race, being found, at least in Wisconsin, in the same habitats associated with the type form, though it is not as abundant. It is perhaps an accentuation of individual variation so common in other aquatic forms of life.

PISIDIUM WALKERI Sterki

Plate CII, figures 12-14

Pisidium walkeri STERKI, Nautilus, IX, p. 75, 1895; Cat., p. 457, 1916.

TYPE LOCALITY: Kent County, Mich.

WISCONSIN RECORDS:

1906. *Pisidium walkeri* CHADWICK, p. 99. Mud Creek, Milwaukee.

1924. *Pisidium walkeri* BAKER, p. 134. Lake Winnebago.

SHELL: Of medium size, elongated, not much inflated, resembling *P. abditum*, but is smaller than good sized examples of that species; it is also more elongated, and the smaller and moderately prominent beaks are more posterior; thus the anterior part is comparatively very long, with the end rounded, the posterior quite short, truncated at the end; scutum and scutellum well marked; the shell is very thin, translucent, the surface very finely, and sharply striated, often somewhat scaly, dullish, or with a silky gloss; color grayish, along the margin more or less yellowish-horn.

Hinge moderately strong, of the same type as in *P. abditum*; cardinal of right valve large, heavy, curved, enlarged and grooved at the lower, posterior end; there is a deep pit beneath the cardinal; upper cardinal of left valve large, thick, curved;

lower cardinal thick rounded, cavity of beaks rather deep; nacre whitish or bluish-white (modified from Sterki).

L. 4.5; H. 3.7; D. 2.8 mm. Type.

L. 3.5; H. 3.0; D. 1.9 mm. Winnebago Lake (U. of W., 4486).

L. 3.4; H. 2.9; D. 1.9 mm. " " (" 4486).

L. 3.4; H. 2.9; D. 1.9 mm. " " (" 4486).

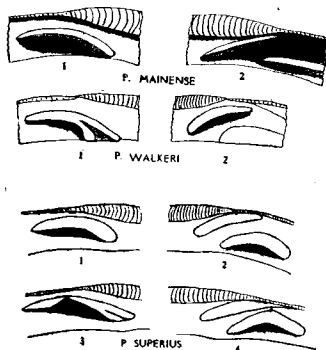


Fig. 284. Cardinal teeth of *Pisidium mainense* Sterki. Golden Lake. Cardinal teeth of *Pisidium walkeri* Sterki. Winnebago Lake. Cardinal teeth of *P. superius* St. 1, 2, Lake Geneva; 3, 4, Michigan.

ECOLOGY: Winnebago Lake; mud bottom, 4.9 m. to 6.1 m.; sand and boulder bottom, .6 and .8 m. Green Lake, marly-clay bottom, .6 m. to 1.3 m.

GENERAL DISTRIBUTION: Maine to Virginia and Ontario, Missouri, S. Dakota (Sterki).

DISTRIBUTION IN WISCONSIN: Reported only from the eastern part of the State.

Fox Drainage: Winnebago Lake, Winnebago Co.; Green Lake, Green Lake Co. (Baker); Brown Co.; Green Bay, near Hurlberts office, Brown Co. (Marston).

Rock Drainage: Battle Creek, Waukesha Co.; Crawfish River, Aztalan, Jefferson Co. (Cahn).

Lake Michigan Drainage: Mud Creek, N. Milwaukee, Milwaukee Co. (Chadwick).

REMARKS: "*Pisidium walkeri* is quite a characteristic and beautiful species which cannot be mistaken for any other. In outline, our species has some resemblance with *P. virginicum*, by its elongate shape, the beaks situated posteriorly, the long and below somewhat sacciform anterior part. But it is much

smaller, its shell quite thin, the hinge finer, the striation finer and the beaks are much smaller." (Sterki).

As stated by Sterki, *walkeri* somewhat resembles *virginicum*, but differs greatly in size, less inflated shell, and widely different hinge teeth, especially the cardinals. It seems rare, both as regards occurrence and number of specimens. This species inhabits both lakes and rivers.

PISIDIUM MAINENSE Sterki

Plate CV, figures 12, 13

Pisidium walkeri var. *mainense* STERKI, Nautilus, XII, p. 79, 1898; Cat., p. 457, 1916.

TYPE LOCALITY: Caribou, Aroostook Co., Maine.

WISCONSIN RECORDS: None.

SHELL: Differs from *walkeri* by being smaller, shorter, especially the anterior part, and less saccate. But it resembles *walkeri* by the small beaks situated near the very short and truncated posterior end, the surface sculpture and color, and the thin shell. Placed side by side with typical specimens, which, in outline, have a marked resemblance with *P. virginicum*, it would hardly be ranged under the same species (Sterki). In the Catalog Sterki says "this is a distinct species." The hinge is certainly different, the cardinal teeth being longer and narrower, and less solid (see fig. 284).

L. 3.0; H. 2.5; D. 1.6 mm. Golden Lake (U. of I., Z22388).

L. 2.8; H. 2.3; D. 1.6 mm. " "

ECOLOGY: Golden Lake, bottom pure sand, no vegetation, water about 1 m. deep (Cahn).

GENERAL DISTRIBUTION: Maine, Mass., Ohio, Michigan, Illinois, Indiana, Wisconsin, Ontario.

DISTRIBUTION IN WISCONSIN: Golden Lake, Waukesha Co. (Cahn).

REMARKS: *Mainense* is a neat little species without any very distinctive characteristics. It is clearly related to *walkeri*, but the hinge is different, especially the cardinal teeth. Dr. Sterki reports that the Golden Lake specimens are not typical but seem to be a form of this species. It is not common in this lake.

PISIDIUM SUPERIUS Sterki

Plate XIII, figures 27-30

Pisidium superius STERKI, Nautilus, XX, p. 98, 1907.

TYPE LOCALITY: Mountain Lake, Marquette Co., Mich.

WISCONSIN RECORDS: None.

SHELL: "Rather small, well inflated, ovoid in outlines, rounded or subangular; beaks rather posterior, broad, rounded or somewhat flattened on top, projecting over the superior margin which is slightly curved, with slightly projecting, rounded angles at the scutum and scutellum, the latter often covered in lateral aspect, in full-grown mussels; supero-anterior slope well marked, slightly curved to nearly straight, posterior part subtruncate to rounded; young specimens are generally more angular in outlines than adults; surface with very fine, crowded, concentric striae and generally a few well marked lines of growth, somewhat shining; color light to deeper horn, generally with lighter zones along the margins; shell rather thin more or less translucent.

"Hinge (fig. 284) slight, well formed, plate narrow, right cardinal moderately to strongly curved, its posterior part thick and grooved; a deep, impressed groove in the plate between its inferior edge and the cardinal tooth; left anterior strongly curved, posterior oblique, slightly curved to nearly straight; 'lateral teeth' with short, slight, thin cusps, the left ones and the right anterior pointed, the outer anterior of the right valve distinct, the posterior quite small; ligament rather slight" (Sterki).

L. 3.2; H. 2.8; D. 2.2 mm. Type.

L. 3.5; H. 3.0; D. 2.4 mm. Type lot (U. of I., Z19468).

L. 2.5; H. 2.0; D. 1.4 mm. Lake Geneva (U. of W., 4736).

ECOLOGY: Not specifically recorded but evidently largely a lake form.

GENERAL DISTRIBUTION: Northern Michigan, Wisconsin, Lake Nipissing, Ont.

DISTRIBUTION IN WISCONSIN: At present known only from Lake Geneva, Walworth Co. Fox River drainage, Illinois (Pearse).

REMARKS: *Superius* is rather a distinct little mussel, not particularly resembling any other Wisconsin species. The

ovoid outline scarcely interrupted by the lateral angles will help to distinguish it. The specimens from Lake Geneva (from stomach of Cisco) are smaller than the type form from Michigan and lack the posterior angle at the hinge line so notable in the type lot.

PISIDIUM OVERI Sterki

Plate CII, figures 15, 16

Pisidium overi STERKI, Nautilus, XXVI, p. 136, 1913; Cat., p. 457, 1916.

TYPE LOCALITY: Clear Lake, Deuel Co., S. Dakota.

WISCONSIN RECORDS: None.

SHELL: "Rather small, oblique, with the anterior part somewhat longer, medium to well inflated; superior margin short, nearly straight; posterior subtruncate to rounded, inferior curved; supero-anterior slope beginning with an angle, close to beaks, rather long, straight to slightly curved; anterior end situated well below the median line, rounded angular; beaks rather small, rounded; surface dullish to somewhat glossy, with very fine subregular striae; shell thin, translucent, nearly colorless to pale corneous.

"Hinge medium stout, plate narrow; cardinal teeth rather long, moderately curved to nearly straight, the right not, or little thicker in its posterior part, left anterior with its apex rounded to somewhat pointed in old specimens; ligament and resilium rather short and slight."

L. 3.5; H. 3.0; D. 2.4 mm. Type.

L. 3.3; H. 3.0; D. 2.2 mm. Green Lake (U. of W., 4487).

L. 3.2; H. 3.0; D. 2.2 mm. " " (" 4487).

ECOLOGY: Silver Creek, Green Lake, marly-clay bottom, 1.5 m.

GENERAL DISTRIBUTION: South Dakota, Iowa, Minnesota, Wisconsin.

DISTRIBUTION IN WISCONSIN: At present known only from Green Lake, Green Lake Co. (Baker).

REMARKS: "*Pisidium overi* somewhat resembles *walkeri* in shape and appearance, but is smaller, the anterior part of the mussel is much smaller, and the cardinal teeth are markedly different, as seen in quite a number of specimens." (Sterki). The chief characteristics seem to be the longer posterior end,

the very distinct scutum and scutellum, the almost straight, diagonal anterior slope to the end, and the greater height as compared with length. The cardinal teeth are much finer than those of *walkeri* and are not (or little) enlarged at the posterior end, which is the case very markedly in *walkeri*, in which the posterior end is grooved. The cardinals are more like those of *roperi*. *Overi* is apparently rare in Wisconsin.

PISIDIUM ROPERI Sterki

Plate CII, figures 23–25

Pisidium roperi STERKI, Nautilus, XII, p. 77, 1898; Cat., p. 458, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1911a. *Pisidium roperi* BAKER, p. 232. Pools near Tomahawk Lake.

SHELL: Rather large, strongly inflated when mature, very little so when young; oblong to ovoid in outline, margins regularly curved, with no projecting angles (in the adult); scutum and scutellum scarcely marked; beaks moderately posterior, very broad; surface somewhat glossy, with irregular, not sharp, striae and some strongly marked lines of growth; color of the dry shell straw to yellowish-horn, often with one to several fine, concentric lines of purple; shell rather thin, nacre whitish, muscle insertions scarcely marked." (Sterki).

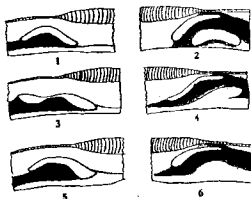


Fig. 285. Cardinal teeth of *Pisidium roperi* Sterki. Bayfield.

Hinge rather fine, not very broad; cardinal of right valve usually rather short, curved, slightly or not thickened at the posterior end; (fig. 285) upper cardinal of left valve fine, curved, variable in size; lower cardinal larger, somewhat angular to rounded, erect above hinge margin; laterals small, short, triangular, projecting but little above the margin of the valve. In one example, the right cardinal was doubly curved and en-

larged at both ends, the upper cardinal of the left valve being thin, doubly curved, and the lower cardinal bifid at the anterior end (see 285, 3. 4).

L. 5.5; H. 4.4; D. 3.8 mm.	Type.
L. 5.0; H. 4.0; D. 2.5 mm.	Bayfield (U. of W., 4488).
L. 4.6; H. 3.9; D. 2.4 mm.	" (" 4488).
L. 5.0; H. 4.0; D. 2.6 mm.	" (" 4488).

ANIMAL: Soft parts pink, especially so the foot and mantle edges; the living mussel appears pale red; but the color soon fades away after the death of the animal; it is also very pale, scarcely noticeable in the young, becoming more intense with the age of the animal (Sterki). Specimens from Bayfield were as described by Sterki.

ECOLOGY: Swale on Madeline Island, near Bayfield. Small pool west of Prairie Lake, near Chetek.

GENERAL DISTRIBUTION: New England to Illinois, Minnesota, Ontario, Manitoba, Alberta, Montana.

DISTRIBUTION IN WISCONSIN: Known only from the northern and northwestern part of the State.

Lake Superior Drainage: Madeline Island, near Bayfield, Bayfield Co. (Baker).

Wisconsin Drainage: Pools near Tomahawk Lake, Oneida Co. (Baker).

Chippewa Drainage: Swale near Prairie Lake, near Chetek, Barron Co. (Baker).

REMARKS: "*Pisidium roperi* cannot be mistaken for any other species except some forms of *abditum*, but is at once distinguished from the latter species by its comparatively very broad beaks, the more elongated and more regular outline, the different appearance of its surface, usually the lighter color, the comparatively finer and shorter hinge, and, in the living animal, by the pink color of the soft parts, shining through the shell. It is the only species in which that color has been noticed so far, yet it remains to ascertain whether this be a constant character. But however that may be, the species is valid. From several places specimens were obtained in company with *P. abditum*, and at once recognized as distinct." (Sterki).

Certain specimens resemble *abditum* but may be distinguished by comparing the figures on pl. CIII, fig. 1-4, with those of *roperi*. The species was quite common in the Made-

line Island habitat. Wisconsin specimens have all been found in pools which dry up in the summer.

PISIDIUM COMPLANATUM Sterki

Plate CIII, figures 9-11

Pisidium complanatum STERKI, Nautilus, XVII, p. 79, 1903; Cat., p. 458, 1916.

Pisidium fragillimum STERKI, Nautilus, XX, p. 18, 1906.

TYPE LOCALITY: Little Black Creek, and lakes in Muskegon Co., Mich. (*complanatum*); Lake Geneva, Wisconsin (*fragillimum*).

WISCONSIN RECORDS:

1906b. *Pisidium fragillimum* STERKI, p. 18. Lake Geneva.

SHELL: Inequipartite, slightly oblique, moderately to well inflated; superior margin short, somewhat curved, with rounded, more or less projecting angles at the scutum and scutellum; posterior part short, truncate, passing with a rounded angle in the inferior margin, which rises in a strong curve to the rounded-angular anterior end; supero-anterior slope not well marked, slightly curved; beaks rather posterior, projecting over the hinge margin, slightly bulging anteriorly and posteriorly, flattened laterally; surface with very fine, almost regular striae and a few faint lines of growth, with a slight, silky gloss; color light to brownish-horn; shell scarcely translucent; nacre thin, with the muscle insertions visible but not impressed.

Hinge slight to moderately stout, plate rather narrow; right cardinal tooth curved, occupying the whole width of the plate, its anterior end abruptly thick and grooved or bifid, its ends are connected by the sharp, inferior edge of the plate, thus forming a groove (or pit); left anterior cardinal tooth short, curved or angular, the posterior quite short, small, oblique; lateral teeth moderately stout, with short, pointed cusps, the outer ones of the right valve quite small but distinct; ligament short, comparatively stout (Sterki).

L. 3.2; H. 2.8; D. 1.8 mm. Type *complanatum*.

L. 2.7; H. 2.4; D. 1.6 mm. Type *complanatum*.

L. 3.0; H. 2.6; D. 1.8 mm. Type *fragillimum*.

ECOLOGY: Not recorded.

GENERAL DISTRIBUTION: Michigan, Wisconsin, Iowa.

DISTRIBUTION IN WISCONSIN: Known only from the southeastern part of the State. *Fox River (Illinois)*: Lake Geneva, Walworth Co. (Baker).

REMARKS: This species was first described as *complanatum*, and later *fragillimum* was found to be synonymous. Of the first species Sterki says: "This species is different and distinct from all other *Pisidia*. It somewhat resembles *P. ultramontanum* Prime, but is much smaller, its beaks are narrower, of different shape and more prominent. Some of the specimens from the creek are higher over the beaks and in the posterior part, and thus the mussel is of a rather different shape. In others, the beaks are less flattened, laterally (1903, p. 80).

The Wisconsin specimens were described as *fragillimum* (1906b, p. 18), and of this species Sterki says: "Although only ten specimens were seen, this *Pisidium* is quite distinct by its shape and the formation of the hinge; the shell is the thinnest and most fragile yet seen in *Pisidia*. The mussel has some resemblance in shape with *P. walkeri* St., but is much smaller, shorter, especially its anterior part, the surface sculpture is finer and slighter, and the hinge is quite different. Its closer affinities are yet unknown."

PISIDIUM STRENGI Sterki

Plate CII, figures 17, 18

Pisidium strengi STERKI, Nautilus, XV, p. 126, 1902; Cat., p. 458, 1916.

TYPE LOCALITY: Perch Lake, Mich.

WISCONSIN RECORDS:

1924. *Pisidium strengi* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Of moderate size, regularly inflated, rather short; beaks slightly posterior, small, narrow, approximate, somewhat projecting over the hinge margin; superior and inferior margins well curved, the supero-anterior slightly so and forming a steep slope to the somewhat angled anterior end; the posterior end subtruncate; scutum and scutellum indistinct; angles in front of and behind the beaks slight, rounded; shell rather thin, translucent; surface very finely striate, appearing smooth, with very fine, irregular lines of growth, and with a slight, dull gloss; color pale horn shading into grayish, whitish or yellowish; nacre almost glassy, muscle scars very slight.

Hinge fine, plate narrow; cardinal teeth small, thin; the right one curved, its posterior end deeply cleft; the left anterior curved or almost straight, the posterior short, oblique (fig. 286); lateral teeth small, somewhat pointed, the outer ones of the right valve quite small but distinct; ligament small (Sterki).



Fig. 286. Cardinal teeth of *Pisidium strengi* Sterki. Winnebago Lake.

L. 4.0; H. 3.7; D. 2.6 mm. Type.

L. 4.0; H. 3.3; D. 2.5 mm. Winnebago Lake (U. of W., 4489).

L. 3.7; H. 3.1; D. 2.2 mm. " " (" 4489).

ECOLOGY: Winnebago Lake, sand bottom, .3 to .9 m. deep.

GENERAL DISTRIBUTION: Region of Great Lakes; Ohio (also in the drainage of the Ohio River); Maine, Maryland (Sterki).

DISTRIBUTION IN WISCONSIN: Known only from the Lake Winnebago region, Winnebago Co. (Baker).

REMARKS: "*Pisidium strengi* has a resemblance to some smaller forms of *P. additum* Hald., *novoboracense* Pr., and *politum* St., but can be recognized by its high form, the small, approximate beaks, especially noticeable in front (or rear) aspect, the peculiar, dull gloss of the surface, and the strongly cleft posterior end of the right cardinal tooth. The latter feature was found constant in normal specimens from widely distant places; but it may be added that the species appears to be particularly inclined to abnormal, and even monstrous formation of the cardinal teeth. As to size, shape and general appearance, the mussel does not vary greatly, so far as seen" (Sterki).

This species seems rare in Wisconsin.

PISIDIUM POLITUM Sterki

Plate CII, figure 19

Pisidium politum STERKI, Nautilus, IX, p. 75, 1895; Cat., p. 458, 1916.

TYPE LOCALITY: New Philadelphia, Ohio.

WISCONSIN RECORDS: None.

SHELL: Of medium size, well inflated, rather high, beaks slightly posterior, rather high and prominent, not full but well

rounded; scutum and scutellum slightly marked; superior margin rather short, rather strongly curved; inferior well curved, more so in front than behind; posterior margin distinctly truncated, with a well marked angle where joining the superior, and a less marked, rounded angle where joining the inferior margin; anterior end forming a slight but distinct angle situated rather high up; surface very finely, irregular striated, polished; color whitish or straw-colored, often leaden-grayish on the beaks, or even all over; shell moderately thick; nacre whitish; muscular insertions very distinct (Sterki).

Hinge resembling that of *abditum*; plate rather wide; cardinal of right valve large, thick, curved, enlarged at posterior end; upper cardinal of left valve narrow, long, curved; lower cardinal large, thick, rounded; laterals rather long, narrow, the outer ones smaller in right valve.

L. 4.0; H. 3.4; D. 2.4 mm. Type.

L. 4.7; H. 4.0; D. 2.9 mm. Type.

L. 4.0; H. 3.5; D. 2.9 mm. Prairie Lake (U. of W., 4490).

ECOLOGY: Prairie Lake, shore debris. No ecological data available in Wisconsin. Sterki found the type specimens in the outlet of a small peaty swamp.

GENERAL DISTRIBUTION: New York, Pennsylvania, Ohio, Ontario to Illinois and Minnesota.

DISTRIBUTION IN WISCONSIN: Known only from Prairie Lake, near Chetek, Barron Co. (Baker); and upper Dells, Kilbourn, Columbia Co. (Baker).

REMARKS: "*Pisidium politum* is rather variable in size, and more so in color as noted above, but so markedly constant in its several habitats that a number of different local forms, or varieties, could be described. It has some resemblance with *Pisidium abditum* Hald., and *Pisidium variabile* Pr.; from the former it is different by its being somewhat smaller, comparatively shorter and higher, the beaks being less full, the surface finer striated and more polished; from the latter it is distinguished by its smaller size, the beaks being less full, the antero-superior margin less straight, and the angle at the anterior end being situated higher up; the shell is thinner and the hinge less strong, the coloration different. With all these differences appearing only gradual, our *Pisidium* is a good species beyond a doubt and will always be recognized (Sterki).

As but few specimens have been found in Wisconsin, it is to be considered very rare. A variety, described below, is more common.

PISIDIUM POLITUM DECORUM Sterki

Plate CII, figures 20–22

Pisidium politum decorum STERKI, Cat., p. 458, 1916.

TYPE LOCALITY: Not given.

WISCONSIN RECORDS:

1924. *Pisidium decorum* BAKER, p. 134. Lake Butte des Morts.

SHELL: Smaller, slighter; shell more translucent to transparent, pale corneous to nearly colorless (Sterki).

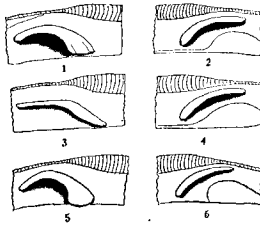


Fig. 287. Cardinal teeth of *Pisidium politum decorum* Sterki. Tyrrell's sand pit pond.

Hinge rather wide and strong; cardinal of right valve thick, very much curved, enlarged and sometimes slightly cleft at the posterior end; upper cardinal of left valve narrow, long, curved; lower cardinal large, thick, rounded (fig. 287); the right cardinal of one specimen was much elongated, narrow, with a straight anterior end, the posterior end being bent downward at almost a right angle (fig. 287 1, 3).

L. 3.0; H. 2.5; D. 2.0 mm. Bayfield (U. of W., 4491).

L. 3.4; H. 3.0; D. 2.0 mm. Butte des Morts (U. of W., 4492).

ECOLOGY: Small pond behind beach, Bayfield, mud bottom, .5 m. deep. Lake Butte des Morts, mud bottom, 1.2 m. Artificial pond Tyrrell's sand pit, sand bottom, .6 m. deep.

GENERAL DISTRIBUTION: Ohio, Indiana, Michigan, Illinois, Wisconsin.

DISTRIBUTION IN WISCONSIN: The widely separated localities indicate a rather wide distribution in the State. It will probably be found in many places.

Lake Superior Drainage: Bayfield, Bayfield Co. (Baker).

Fox Drainage: Lake Butte des Morts and Tyrells sand pit pond, Winnebago Co. (Baker).

REMARKS: The small variety of *politum* is more common than the type form. It differs somewhat in shape as well as size, the anterior end being longer and more pointed without an angle at the point as in *politum*. The diameter, also, seems less. It is closely related to *abditum*, but differs in the more elevated umbones and in the general shape of the shell (compare the figures on pl. CIII with those of *decorum* on pl. CII).

PISIDIUM ABDITUM Haldeman

Plate CIII, figures 1-5

Pisidium abditum HALDEMAN, Proc. Acad. Nat. Sci., Phil., I, p. 53, 1841.

Pisidium abditum PRIME, Mon. Corb., p. 6, 1865.

Pisidium abditum STERKI, Nautilus, XXVI, p. 6, 1912; Cat., p. 459, 1916.

TYPE LOCALITY: Lancaster Co. Penn.

WISCONSIN RECORDS:

1911. *Pisidium abditum* BAKER, p. 232. Tomahawk Lake and Wisconsin River pools.

SHELL: Of good size, well inflated rather high, beaks slightly posterior, prominent but not much elevated, well rounded; scutum and scutellum well marked; dorsal margin rather long, curved; ventral margin broadly curved; anterior margin long, rounded, the end about midway of the margin; posterior end roundly truncated but without angles to the dorsal or ventral margins; surface finely irregularly striated, not polished, but shining; color corneous or grayish, rarely yellowish, often rosy or pinkish; shell moderately thick; nacre whitish.

Hinge rather stout, plate wide; cardinal of right valve large, thick, usually curved, enlarged at the posterior end, where it may also be deeply cleft, emarginate, or simply rounded; the anterior end may also be enlarged; upper cardinal of left valve large, thick, slightly curved, reaching to the base of the hinge plate; lower cardinal very thick, rounded, usually rather short

(fig. 288); laterals small, short, not much elevated; cavity of beaks not very deep.

L. 3.0; H. 2.4; D. 1.9 mm. Green Lake (U. of W., 4493).

L. 3.1; H. 2.9; D. 2.0 mm. " " (" 4493).

L. 3.5; H. 3.0; D. 2.1 mm. Indiana (U. of I., Z13919).

L. 3.0; H. 2.4; D. 1.9 mm. " (" Z13919).

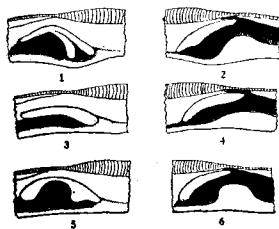


Fig. 288. Cardinal teeth of *Pisidium abditum* Haldeman. 1, 2, Green Lake. 3-6, Steuben Co., Indiana.

ECOLOGY: Small pond near Green Lake, hard clay bottom, 0.5 m. Pond near Chetek, clay bottom, 0.3 m.

GENERAL DISTRIBUTION: East of the Rocky Mountains; common in the Northeast; apparently scarce west of Ohio; not seen from the Southwest and the Gulf States (Sterki).

DISTRIBUTION IN WISCONSIN: Rather widely distributed but the records scattered.

REMARKS: This species is very variable, and, as remarked by Sterki, has been made a dumping ground for any unknown form of the genus. The types were recently examined by Sterki and found to be of a characteristic species, somewhat different from the figure and description of Prime, who included too many species in the synonymy. The general rounded or roundly-oval form with the depressed beaks and the rather heavy hinge teeth (cardinal) will help to distinguish this variable species.

Abditum greatly resembles the European *Pisidium fontinale* Pfr., and the two species are very closely related if not identical, in which case the species would be like others in fresh water genera-circumboreal as in some of the Lymnaeas. However, for convenience it is better left under the American name, particularly as to change it would cause confusion in an already difficult enough group.

PISIDIUM SUBROTUNDUM Sterki

Plate CI, figures 21-23

Pisidium subrotundum STERKI, Nautilus, XX, p. 19, 1906; Cat., p. 459, 1916.

TYPE LOCALITY: Albany River, Ont.; Isle Royale, Mich.

WISCONSIN RECORDS:

1911. *Pisidium subrotundum* BAKER, p. 233. Wisconsin River, swampy places, Oneida Co.

SHELL: Small, moderately and regularly to rather well inflated; outlines oval to short oblong, to nearly circular; superior margin straight or nearly so, as especially noticeable in young specimens; beaks slightly posterior, rather broad (in most forms), moderately projecting over the hinge margin, thus completing the round outlines, except for the slight projecting angles at the scutum and scutellum; surface with very fine, subregular to irregular striae and usually a few well marked lines of growth, dullish to somewhat shining; color horn or light amber to straw to whitish; shell translucent (in the horn colored) to opaque (in the light colored specimens), thin (Sterki).

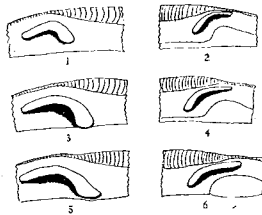


Fig. 289. Cardinal teeth of *Pisidium subrotundum* Sterki. 1, 2, Bayfield. 3-6, Prentice.

Hinge rather slight, plate narrow; cardinal of right valve small, curved, slightly enlarged at the posterior end; upper cardinal of left valve very small, narrow, curved; lower cardinal larger, thick, rounded; laterals as in *abditum* (fig. 289).

- L. 3.2; H. 2.7; D. 1.8 mm. Average, type.
 L. 3.6; H. 3.0; D. 2.3 mm. Albany River type.
 L. 3.5; H. 3.0; D. 1.8 mm. Prentice (U. of W., 4494).
 L. 3.2; H. 2.5; D. 1.6 mm. " (" 4494).

ECOLOGY: Winnebago Lake, mud bottom, 5.2 m. Bayfield, in swampy pool, shallow water, mud bottom. Bayfield, in small brook at edge of forest, shallow, sandy-mud bottom. Drainage ditch near Portage, mud bottom, shallow water. Devils Lake, mud bottom, 10–11 m.

GENERAL DISTRIBUTION: New England and New York to Ohio, Indiana, Ontario, Michigan, Minnesota. Montana and Oregon(?). Sterki.

DISTRIBUTION IN WISCONSIN: Widely distributed over the State, in the drainage areas of both Great Lakes and the Mississippi River.

REMARKS: Sterki says: "Near *P. abditum*, but is probably distinct. In over a hundred lots in the collection every specimen is plainly *P. subrotundum*. Moreover the two forms have repeatedly been found associated and always easily separable. *P. subrotundum* is generally more northern and appears to be more ancient." The shell is rounder and less inflated than *abditum*, and the cardinal teeth are very different, much more delicate (compare fig. 289 with 290). This species seems more abundant in Wisconsin than *abditum*. The fact that it inhabits both shallow pools and deep lakes is of interest, indicating a wide range of ecological characteristics.

PISIDIUM SUBROTUNDUM PUMILUM Sterki

Plate CII, figure 26

Pisidium subrotundum pumilum STERKI, Cat., p. 460, 1916.

TYPE LOCALITY: Danvers, Mass.

WISCONSIN RECORDS: None.

SHELL: Rather small, variable in size, 2–3.5 mm. long. Rather high, moderately inflated; superior margin nearly straight, bounded by angles; the remainder of the outline short-elliptical to almost circular; beaks not much behind the middle; surface with rather coarse, irregular striae; color pale corneous, shell less translucent (Sterki).

The cardinal teeth are similar to those of *subrotundum*, differing somewhat in shape; as a whole they are somewhat slighter in form. (fig. 290).

L. 3.0; H. 2.4; D. 1.8 mm. Marinette (U. of W., 4496).

L. 2.9; H. 2.4; D. 1.7 mm. " (" 4496).

ECOLOGY: The original specimens came from a water-hole in a cemetery.

GENERAL DISTRIBUTION: Massachusetts, Pennsylvania, Michigan, Wisconsin.

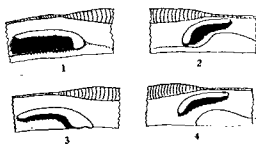


Fig. 290. Cardinal teeth of *Pisidium subrotundum pumilum* Sterki. Marinette.

DISTRIBUTION IN WISCONSIN: Known from but one locality in the State. Marinette, Marinette Co. (Bullock).

REMARKS: *Pumilum* seems very close to *subrotundum* and would be difficult to separate except by one having large experience with this group. It is smaller than the typical form and somewhat rounder, the umbones being placed nearer the center of the shell than in the typical form. The specimens collected by Mr. Bullock are very uniform and compare well with the description of the Massachusetts shells.

PISIDIUM SPLENDIDULUM Sterki

Plate CII, figures 28-30

Pisidium splendidulum STERKI, Nautilus, XI, p. 113, 1898; Cat., p. 461, 1916.

TYPE LOCALITY: Caribou, Maine.

WISCONSIN RECORDS:

1924. *Pisidium splendidulum* BAKER, p. 134. Lake Winnebago.

SHELL: Small, well inflated, rather ovoid in outline, scutum and scutellum rather well marked, the former often prominent; beaks slightly posterior, somewhat prominent, moderately large, rounded; color pale to deep horn, surface polished, with very fine, somewhat irregular striae; shell thin, transparent.

Hinge rather fine but well formed, plate narrow; cardinal teeth longitudinal, lamellar, the right one rather long, slightly curved, most so at both ends, more or less thickened at the posterior end, and often with a groove; the two in the left valve nearly equal, parallel, little curved, the superior is anterior for

about one-third of its length; lateral teeth comparatively strong, all projecting into the interior of the mussel, pointed; ligament rather long (Sterki).

Several specimens of the Lake Winnebago lot have a somewhat spindle-shaped right cardinal, bent upward at the anterior end and downward at the posterior end; the upper left cardinal

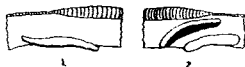


Fig. 291. Cardinal teeth of *Pisidium splendidulum* Sterki.
Winnebago Lake.

is narrow and curved, and the lower cardinal is thicker and but slightly curved (fig. 291).

L. 2.8; H. 2.4; D. 1.7 mm. Type.

L. 3.2; H. 2.6; D. 2.0 mm. Winnebago Lake (U. of W., 4497).

L. 2.9; H. 2.2; D. 1.6 mm. " " (" 4497).

ECOLOGY: Winnebago Lake, mud bottom, 5.5 m. (Baker); Ashippun Lake, soft sand bottom, shallow water (Cahn).

GENERAL DISTRIBUTION: Maine to Virginia and Minnesota.

DISTRIBUTION IN WISCONSIN: Known from but few places in the state. It is a common species in many places and should be found abundantly in Wisconsin.

Fox Drainage: Lake Winnebago, Winnebago Co. (Baker).

Rock Drainage: Ashippun and Oconomowoc Lake, Waukesha Co.; fossil in Lower Nashotah Lake (Cahn).

Green Bay Drainage: Sturgeon Bay, canal, Door Co. (Baker).

REMARKS: "Our species cannot be mistaken for any other *Pisidium*. In shape it has some resemblance with *P. abditum* and *P. politum*; but its small size, the color and transparency of the shell, the shape of the cardinal teeth, will readily distinguish it. In size, color, and transparency of the shell, and the polished surface, it resembles *P. ventricosum* and *vesiculare*, but both the latter are much more inflated, their beaks are quite posterior and larger. It is, however, rather variable in size and coloration, and the striation of the surface" (Sterki).

The species is very variable and several varieties have been named, none of which are at present known from Wisconsin.

PISIDIUM GRISEOLUM Sterki

Plate CIV, figures 25, 26

Pisidium griseolum STERKI, Ann. Carnegie Mus., XIII, p. 432, 1922.

TYPE LOCALITY: Lake Winnecook, Unity, Maine.

WISCONSIN RECORDS:1924. *Pisidium griseolum* BAKER, p. 134. Lake Winnebago.

SHELL: Small, subequipartite, slightly elongate, moderately inflated; superior margin nearly straight, bounded by an angle posteriorly and a more obtuse angle anteriorly; supero-anterior slope somewhat marked, moderately oblique; posterior margin truncate or subtruncate at nearly right angles, inferior moderately curved; beaks barely behind the middle, rather small, rounded, or slightly flattened on top, not very prominent; surface dull glossy, with very fine, somewhat irregular striae; color pale corneous to light grayish; shell thin, translucent.

Hinge rather long and stout, plate rather broad; cardinals short, rather well up on the plate, the right angular in the middle, its posterior part thicker and grooved, left both of about the same size, the anterior angular, its edge sharply pointed, slightly curved; laminae (laterals) somewhat massive, the right anterior with its cusp about median, pointed, not abrupt, posterior with cusp somewhat distal, abrupt distally, outer teeth rather large, about half as long as their principals; left tooth with cusps about median, pointed, not very abrupt; ligament rather short and thick.

L. 2.8; H. 2.3; D. 1.5 mm. Type.

L. 2.6; H. 2.1; D. 1.6 mm. Winnebago Lake (U. of W., 4512).

ECOLOGY: Winnebago Lake, mud bottom, 4.3 m.**GENERAL DISTRIBUTION:** Maine to Wisconsin.**DISTRIBUTION IN WISCONSIN:** Known only from Lake Winnebago, Winnebago Co. (Baker).

REMARKS: "This modest and rather inconspicuous *Pisidium* can not be referred to any of the described species, and can not be mistaken for any other. Similar specimens have been seen before and set aside with a query—e. g., some from Lynnfield, Massachusetts, collected by H. W. Winkley in 1910. The color of these is yellowish corneous and the hinge is slightly different" (Sterki).

This species of *Pisidium* is very rare in Wisconsin, only a few specimens being found in a summer's work on Lake Winnebago. It was found only in the deeper parts of the lake, some distance from shore.

PISIDIUM MILIUM Held

Plate CIV, figures 23, 24

Pisidium milium HELD, Isis, p. 280, 1836.

Pisidium milium CLESSIN, Monog. Cycladeen, in Martini-Chemnitz, p. 20, pl. ii, figs. 4-7; pl. v, figs. 16-17 (the figures show the outlines too angular).

Pisidium milium STERKI, Cat., p. 462, 1916.

TYPE LOCALITY: European.

WISCONSIN RECORDS:

1924. *Pisidium milium* BAKER, p. 134. Lake Winnebago.

SHELL: Small, somewhat inflated, long-ovate in outline; beaks posterior of the center of the dorsal margin, rather full, not much raised above the shell margin; dorsal and ventral margins but slightly curved; anterior margin sub-truncate, rounding below into the ventral margin without an angle, but there is a more or less distinct angle at the postero-dorsal margin; anterior end slightly below the median longitudinal line; surface polished, with very fine to rather coarse striae; color bluish-white to dark horn; shell rather thin.

Hinge plate well formed, rather wide and strong; cardinal of right valve rather narrow, curved, enlarged at the posterior end; upper cardinal of left valve small, narrow, curved; lower cardinal thick, rounded; laterals rather strong, thick, projecting somewhat into the shell cavity; nacre bluish white.

L. 2.5; H. 2.1; D. 1.6 mm. Winnebago Lake (U. of W., 4498).

L. 2.1; H. 1.6; D. 1.5 mm. Lake Chetek (U. of W., 4500).

ECOLOGY: Winnebago Lake, mud bottom, 5.6 m.; Green Lake, Silver Creek, behind lake bar, marly-clay bottom, 1.5 m. Lake Chetek, mud bottom, 2 m. (Baker); Oconomowoc Lake, 3-5 m. deep, among vegetation; 12 m. sand bottom (Cahn).

GENERAL DISTRIBUTION: Palearctic and Nearctic regions; Maine, New York, Ontario, Michigan, Minnesota, Manitoba, (Sterki).

DISTRIBUTION IN WISCONSIN: Distributed in widely separated localities. Probably occurs in places between these extremes.

Chippewa Drainage: Lake Chetek, Barron Co. (Baker).

Rock Drainage: Oconomowoc Lake, Waukesha Co. (Cahn).

Fox Drainage: Lake Winnebago, Winnebago Co.; mouth of Silver Creek, Green Lake, Green Lake Co. (Baker).

REMARKS: *Milium* resembles some forms of *abditum*, but is smaller with a more elongated shell, and different cardinal teeth. The whole hinge plate is heavier than most species of the *abditum* group.

Like other *Pisidia*, *milium* occurs in both shallow water and deeper habitats. The Wisconsin habitats are all lakes. It is apparently very rare in Wisconsin, only a single specimen having been found in each of the three localities cited. The Winnebago specimen is very dark horn; the Lake Chetek specimen is very beautiful and perfect, with a glossy, whitish-corneous surface with regular, strong lines of growth. This specimen is rather well inflated, with the beaks widely separated, and rounded. It is almost as wide as the figure of *rotundatum* (pl. CIV, fig. 14).

PISIDIUM CONTORTUM Prime

Plate C, figures 26, 27

Pisidium contortum PRIME, Ann. N. Y. Lyc., VI, p. 65, pl. i, fig. 2, 1853; Mon. Corb., p. 83, 1865.

Pisidium contortum STERKI, Cat., p. 462, 1916.

TYPE LOCALITY: Pittsfield, Mass. Post-pliocene formation.

WISCONSIN RECORDS: None.

SHELL: Small, subrhomboid in outline, well inflated; beaks placed posterior of the center of the dorsal margin, rather high, full, rounded; dorsal margin somewhat rounded; scutum and scutellum not well marked; ventral margin well rounded, curving upward posteriorly to meet the slight angle at the postero-dorsal margin; and curving upward anteriorly to meet the somewhat pointed anterior end, which is slightly rounded, and which meets the antero-dorsal margin at a more or less distinct angle; surface shining, striae fine, but well marked; color yellowish-horn.

Hinge rather solid, wide, strong; cardinal of right valve long, narrow, curved, more or less enlarged at the posterior end and sometimes emarginate; no cleft cardinals seen; upper cardinal of left valve, narrow, rather long, curved; lower cardinal large,

rounded, elongated; (fig. 292); laterals short, rather massive, triangular, well extended into the shell cavity.

L. 3.2; H. 2.8; D. 2.1 mm. Green Lake (U. of W., 4501).

L. 3.0; H. 2.5; D. 1.7 mm. " " (" 4501).

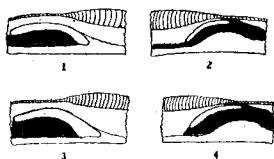


Fig. 292. Cardinal teeth of *Pisidium contortum* Prime. Green Lake.

ECOLOGY: Green Lake, sand bottom, 1.5 m.

GENERAL DISTRIBUTION: Maine, Ontario, Michigan, Massachusetts, Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from Green Lake, Green Lake Co. (Baker).

REMARKS: *Contortum* was originally described from Pleistocene specimens. Since that time, living material has been found in several states. It resembles *subrotundum*, but the shell is smaller and more elongated, the anterior end more pointed, and the hinge very much heavier and wider. The outlines are somewhat more angular in the postero-dorsal and antero-dorsal region. The color is a peculiar light, pale yellowish-white and the surface is bright and shining. It seems rare in the State.

PISIDIUM ABYSSORUM (Stimpson) Sterki

Plate CIV, figures 16-20

Pisidium abyssomus HOY, Trans. Wis. Acad. Sci., I, p. 100, 1870.

Pisidium abditum var. *abyssorum* STIMPSON, S. I. Smith, in Rep. U. S. Fish Com. for. 1872-3, p. 704, 1874.

Pisidium abyssorum (STIMPSON) STERKI, Nautilus, XI, p. 124, 1898; Cat., p. 463, 1916.

TYPE LOCALITY: Off Racine, Wis., in Lake Michigan.

WISCONSIN RECORDS:

1871. *Pisidium abyssomus* HOY, p. 448. Off Racine.

1874. *Pisidium abditum* var. *abyssorum* SMITH, p. 704. Off Racine.

1898. *Pisidium abyssorum* STERKI, p. 125. Off Racine, Lake Michigan.

1906. *Pisidium abyssorum* CHADWICK, p. 98. Off Racine.

SHELL: Small, moderately inflated, somewhat elongated and oblique (most specimens somewhat rhombic), superior and inferior margins moderately curved; scutellum slightly, scutum rather well marked; posterior end rounded or slightly truncated above, obliquely in postero-anterior direction, merging into the inferior margin with one continuous curve; anterior end a rounded angle situated rather inferiorly; beaks slightly posterior, rather low, comparatively broad; color whitish to pale horn; surface polished, with fine, irregular striae; shell very thin, translucent (Sterki).

Hinge very fine, plate very narrow; cardinal of right valve rather long, thin, lamellar, little curved, enlarged at the posterior end and sometimes emarginate, placed on the lower edge of the hinge plate, with the posterior end projecting below the ventral margin of the plate; upper cardinal of left valve short, thick, diagonal; lower cardinal short, thick, straight; the left cardinals are rather small (fig. 293); laterals very thin, rather short, not very high, the outer teeth of the right valve very small.

L. 2.4; H. 2.0; D. 1.2 mm. Type (Sterki).

L. 2.2; H. 2.0; D. 1.2 mm. Off Racine (U. of W., 4502).

L. 2.0; H. 1.9; D. 1.1 mm. " " (" 4502).

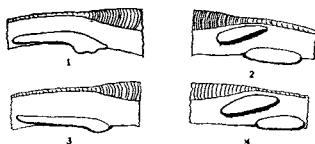


Fig. 293. Cardinal teeth of *Pisidium abyssorum* (Stimpson) Sterki. Lake Michigan, off Racine.

ECOLOGY: Off Racine in Lake Michigan in 40-50 fms. On the Michigan side from a depth of 24 meters.

A *Pisidium*, possibly this species, is listed by Smith as from 159 fms. in Lake Superior.

GENERAL DISTRIBUTION: Lake Michigan. Pine Lake, Michigan.

DISTRIBUTION IN WISCONSIN: Known only from the original locality (Hoy, Marston, Stimpson, Smith).

REMARKS: "This form comes nearest *Pisidium splendidulum* in size, and shape; but it is less inflated, the beaks are less prominent, the color is much paler (whitish), the shell

thinner, and the hinge much finer and, as mentioned, partly defective (Sterki).

Since it was first listed by Smith, this species has been practically unknown until republished by Sterki. It was first collected by a party of scientists, including the eminent western naturalist, William Stimpson, who were studying the food of the whitefish of the lakes. These *Pisidia* were found in the stomach of several fish and were also dredged in Lake Michigan. It is apparently a very common species in the lake in certain localities.

PISIDIUM ABYSSORUM LEVISSIMUM Sterki

Plate CIV, figures 1, 2

Pisidium levissimum STERKI, Nautilus, XX, p. 18, 1906; Cat., p. 463, 1916.

TYPE LOCALITY: Elk Rapids, Mich.

WISCONSIN RECORDS:

1898. *Pisidium abyssorum* STERKI, p. 125. Green Lake.

1905. *Corneocyclas abyssorum* DALL, p. 143. Green Lake.

1906. *Pisidium abyssorum* CHADWICK, p. 98. Green Lake.

SHELL: Small, somewhat elongate, slightly oblique, moderately inflated; superior margin moderately curved, posterior rounded, sometimes with a slightly projecting, rounded angle at the scutum; inferior slightly curved, supero-anterior slope, at some distance from the beaks, in some specimens straight or nearly so, in others obsolete; beaks rather broad, rounded or slightly flattened, little prominent over the upper margin; surface with very fine, slight, irregular striae, shining; color pale horn to light amber, shell translucent to transparent.

Hinge very slight, long, curved, plate narrow; cardinal teeth: the right rather long, straight or slightly curved, longitudinal, its posterior end more elevated, slightly thicker and projecting downward over the hinge plate, the left ones rather long, nearly longitudinal and parallel, lamellar, the posterior (upper) slightly curved; lateral teeth: the posterior much longer than the anterior, slight, curved, the right not raised in a cusp, the left with a slight cusp, the right anterior with a rounded, the left with a sharp and abrupt cusp, outer ones in the right valve wanting, or a mere trace of the anterior; ligament short"

(Sterki). The cardinal teeth are similar to those of *abyssorum* (see fig. 293).

L. 2.5; H. 2.0; D. 1.4 mm. Type.

L. 2.0; H. 2.0; D. 1.1 mm. Green Lake (U. of W., 4503).

L. 2.1; H. 1.5; D. 1.1 mm. " " (" 4503).

ECOLOGY: Green Lake, 39.5 and 47.5 meters, marly-clay bottom.

GENERAL DISTRIBUTION: Elk Rapids, Mich.; Green Lake, Wis.

DISTRIBUTION IN WISCONSIN: Eastern Wisconsin, Green Lake, Green Lake Co. (Baker, Chadwick, Sterki, Walker); Green Bay, Little Harbor Co. in stomach of *Leucichthys hoyi*, taken at 28 m. depth (Pearse).

REMARKS: "In shape and appearance, this *Pisidium* resembles a form of *tenuissimum*, but is much smaller and slighter, and the formation of the hinge is radically different, as ascertained on quite a number of specimens of both species. In fact, the "lateral teeth" are quite different from those of all other *Pisidia* seen" (Sterki).

In the Catalog of Sphaeriidae, Sterki places *levissimum* under *abyssorum* with the remark, "somewhat resembles *P. abyssorum* in size and shape, but may be distinct." The specimens are certainly somewhat different from *abyssorum* and it seems entitled to varietal distinction at least. *Levissimum* is more elongated, not as rounded anteriorly, and the hinge is very much weaker, the lateral teeth in many specimens being reduced in size and form. The Green Lake specimens are nearly all separated valves, bleached, but a few were living, indicating that this form is also a deep water *Pisidium*. These fragmentary specimens were very abundant. Used as food by cisco, *Leucichthys hoyi*.

PISIDIUM TENUISSIMUM Sterki

Plate CIV, figures 29-33

Pisidium tenuissimum STERKI, Nautilus, XIV, p. 99, 1901; Cat., p. 463, 1916.

TYPE LOCALITY: Straits and Orchard lakes, Oakland Co., Mich.

WISCONSIN RECORDS:

1924. *Pisidium tenuissimum* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Small, little to strongly oblique, moderately to rather well inflated, with the edge usually acutish, elongated or rather short, rhomboid to oblong-ovoid in outline, hinge margin little, inferior moderately curved, posterior end rounded or sub-truncate obliquely in a postero-anterior direction with a rounded angle above; anterior more or less curved, truncate obliquely with the rounded-angular end inferiorly, or the whole anterior part rather regularly parabolic, with the end in the longitudinal median line; beaks slightly posterior, somewhat broad, moderately elevated over the hinge line, somewhat mammillar; surface very finely, almost regularly striated, highly polished; color horn to smoky, or to greenish, or to light grayish; shell very thin, translucent (Sterki).

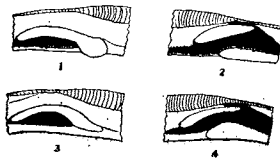


Fig. 294. Cardinal teeth of *Pisidium tenuissimum* Sterki. Winnebago Lake.

Hinge narrow, rather fine; cardinal of right valve rather long, slightly or little curved, enlarged or simple at the posterior end, on the lower margin of the hinge plate, which it somewhat overhangs, or placed some distance above it; upper cardinal of left valve short, wide or narrow, slightly or not at all curved; lower cardinal short, thick (fig. 294); laterals somewhat long, straight, thin, the cusps not much elevated.

L. 3.4; H. 2.8; D. 2.1 mm. Type.

L. 3.3; H. 2.9; D. 1.8 mm. Winnebago Lake (U. of W., 4504).

L. 3.1; H. 2.5; D. 1.9 mm. " " (" 4504).

L. 3.2; H. 2.5; D. 1.9 mm. " " (" 4504).

ECOLOGY: Winnebago Lake; Mud bottom, 1.2 to 6.1 m.; sand bottom, .3 to .8 m.; gravel bottom, 2.5 to 5.4 m.; boulder bottom, .6 m.; Green Lake, 66 m. (Baker). Ashippun Lake, soft sand bottom, shallow; Silver Lake, clear sand (Cahn).

GENERAL DISTRIBUTION: Region of the Great Lakes; Ohio (occurring in the Ohio River drainage area). Sterki.

DISTRIBUTION IN WISCONSIN: Known only from the Rock and Fox River drainages. Winnebago Lake, Winnebago Co.;

Spring Lake near Green Lake, Green Lake Co. (Baker); Green Lake, Green Lake Co. (Pearse); Genesee, Ashippun, Silver, La Belle, and Oconomowoc lakes, Waukesha Co. (Cahn).

REMARKS: "As pointed out in the description, the species is very variable in shape, and extreme forms, if found separate, might be taken for different species. One form from Pine Lake, Mich., has the beaks narrower and more elevated; the anterior part of the mussel is more rapidly and directly tapering to a rounded point, the color is light grayish with concentric, irregular, narrow zones of a darker shade. Some forms have resemblance with *P. splendidulum*, the more rhombic ones, with a corresponding form of *P. pauperculum*, but in case of doubt, the thin shell and very fine hinge with the markedly straight, slender lateral teeth will distinguish our species" (Sterki).

Tenuissimum is very common in Lake Winnebago and also very variable. It is very abundant in many fossil deposits, showing that it has been common in the past. Some of the fossils differ considerably from recent specimens. It is common in the deposit of ancient Wilmette Bay, of Glacial Lake Chicago, and may have reached the Winnebago Lake locality from this source.

PISIDIUM PAUPERCULUM Sterki

Plate C, figures 22-25

Pisidium pauperculum STERKI, Nautilus, X, p. 64, 1896; Cat., p. 463, 1916.

TYPE LOCALITY: Not specifically given.

WISCONSIN RECORDS:

1896. *Pisidium pauperculum* STERKI, p. 65. Fox River.

1906. *Pisidium pauperculum* CHADWICK, p. 99. Fox River.

1926. *Pisidium pauperculum* BAKER, p. 133. Lakes Winnebago and Butte des Morts.

SHELL: Of moderate size, rather oblique, moderately to rather strongly inflated; beaks slightly posterior, moderately large and prominent, rounded; scutum and scutellum slightly marked, edges acute or acutish, not pinched; superior and inferior margins moderately curved, posterior well rounded or slightly truncated, joining the inferior without any marked angle; antero-superior margin sloping, oblique, slightly curved, meeting the inferior at an angle situated rather inferior, more

distant in the adult than in younger examples; surface very finely striated, polished; color pale or yellowish to greenish-horn, sometimes whitish or straw in old specimens; shell thin, translucent. (Sterki).

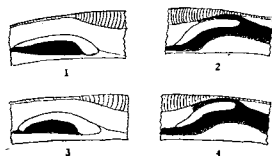


Fig. 295. Cardinal teeth of *Pisidium pauperculum* Sterki. Winnebago Lake.

Hinge moderately strong; cardinal of right valve more or less curved, enlarged at the posterior end, placed about the center of the hinge plate; upper cardinal of left valve rather long, curved more or less, rather thin; lower cardinal thicker, long; (fig. 295); laterals strong, the posterior ones curved, the anterior almost straight.

L. 3.2; H. 2.7; D. 1.9 mm. Average of type.

L. 3.1; H. 3.0; D. 2.2 mm. Winnebago Lake (U. of W., 4505).

L. 2.5; H. 2.1; D. 1.5 mm. " " (" 4505).

L. 3.0; H. 2.6; D. 1.9 mm. " " (" 4505).

ECOLOGY: Winnebago Lake; mud bottom, 1.5 m.; sand and gravel bottom, 1.5 to 1.7 m. Lake Butte des Morts; mud bottom, 1.2 to 3.4 m.; sandy-mud bottom, 1 m. Bleached shells were found in Green Lake, on a marly-clay bottom, at the following depths: 10, 12.5, 39.5 m.

GENERAL DISTRIBUTION: New England and New York to Ohio, Ontario, and Minnesota.

DISTRIBUTION IN WISCONSIN: Known only living from the Fox River Drainage. Winnebago and Butte des Morts lakes, Winnebago Co.; Green Lake, Green Lake Co. (Baker); Fox River, Brown Co. (Chadwick, Marston). Fossil in Lower Nashotah Lake, Waukesha Co. in Rock drainage (Cahn).

REMARKS: "Our species is one of modest appearance, and yet somewhat unique. Being so common, it has evidently been overlooked, or taken for younger specimens of some others, owing to its want of striking features; hence the name given to it. Almost always the mussel is more or less coated with a blackish or rusty substance in a rather characteristic way,

especially over the beaks and upper part, even when found in company with other *Pisidia* not thus coated, so that this is a feature of the species, usually independent of the habitat. Yet sometimes all specimens in a place are found clean.

"The species is variable, though being more constant in each place. There are marked differences in size and shape, prominence of the beaks and color. Especially notable is a form from Michigan, with less curved superior and inferior margins, the posterior end more abrupt, obliquely, so that the outline of the mussel resembles an oblique parallelogram; others, from Michigan and Minnesota, are very high, the altitude equalling or even exceeding the length. Some of these local forms may prove to be true varieties (Sterki).

The truncated anterior end, prominent beaks, and strong hinge will help to distinguish the Wisconsin specimens of this species. The cardinal teeth are quite different from those of *tenuissimum*. Many specimens have a light zone near the base of the valve, which seems characteristic of Winnebago Lake specimens.

PISIDIUM ROTUNDATUM Prime

Plate CIV, figures 11-15

Pisidium rotundatum PRIME, Proc. Bost. Soc. N. H., IV, p. 164, 1851; Mon. Corb., p. 72, 1865.

Pisidium rotundatum STERKI, Cat., p. 465, 1916.

TYPE LOCALITY: Lake Superior.

WISCONSIN RECORDS: None.

SHELL: Small, globose, somewhat oblique, rounded-oval in outline; dorsal margin almost straight to slightly rounded; anterior, posterior, and ventral margins forming a continuous, graceful curve from one end to the other; anterior end in the



Fig. 296. Cardinal teeth of *Pisidium rotundatum* Prime. Prentice.

median line or a trifle below in some specimens; beaks placed near posterior end, rather well elevated above hinge line, rounded; sometimes a trifle calyculate in some specimens; surface glossy, shining, striae distinct, fairly regular; color yellowish or brownish-horn, or whitish horn.

Hinge plate rather wide, strong; cardinal of right valve rather large, straight to curved, enlarged at the posterior end, and sometimes cleft; it may be situated about midway of the plate, or overhang the lower border (fig. 296); upper cardinal small, curved, short, situated high up on the hinge plate; lower cardinal short, thick, rounded; laterals short, slightly curved.

L. 2.5; H. 1.7; D. 2.0 mm. Type.

L. 2.0; H. 1.6; D. 1.9 mm. Prentice (U. of W., 4506).

ECOLOGY: Devils Lake, marly-clay bottom, 9.5 to 11 m. 9.5 to 11 m.

GENERAL DISTRIBUTION: New England and New York to Ontario, Ohio, Minnesota, Manitoba, Montana (Pacific drainage). It seems to occur also in Europe (Sterki).

DISTRIBUTION IN WISCONSIN: Known from two widely separated localities. As in other species, additional records will doubtless show that this species is found well over the State.

Chippewa Drainage: Prentice, Price Co. (Bullock).

Devils Lake: Sauk Co. Several localities (Baker).

REMARKS: This small, globular species is rare in Wisconsin. It can be mistaken for but one species, *vesiculare*, which is more ventricose, with a decided postero-dorsal angle and a more pointed anterior end. When perfect, *rotundatum* is a very handsome *Pisidium*.

PISIDIUM VESICULARE Sterki

Plate CIV, figures 6-10

Pisidium vesiculare STERKI, Nautilus, X, p. 21, 1896; Cat., p. 466, 1916.

TYPE LOCALITY: Grand Rapids, Mich.

WISCONSIN RECORDS:

1924. *Pisidium vesiculare* BAKER, p. 134. Lake Winnebago.

SHELL: Small, ovoid, very inequipartite, somewhat oblique, strongly inflated; beaks very posterior, moderately prominent; margins all well rounded, or the scutum forming a very slight angular projection; color yellowish to brownish-horn; surface slightly striated, polished, often with a few coarser lines of growth; shell thin, translucent; nacre rather glassy, colorless (Sterki).

Hinge rather small, markedly short; cardinal of right valve thick, slightly curved with its posterior end thicker and often emarginate; upper cardinal of left valve short, narrow, curved; lower cardinal thick, rounded; groove and pit below and between cardinals deep; laterals placed close to the cardinal area, short, somewhat abrupt, high (fig. 297).



Fig. 297. Cardinal teeth of *Pisidium vesiculare* Sterki. Winnebago Lake.

L. 2.3; H. 1.9; D. 1.7 mm. Type.

L. 2.4; H. 2.1; D. 1.8 mm. Winnebago Lake (U. of W., 4507).

L. 2.1; H. 2.0; D. 1.6 mm. " " (" 4507).

ECOLOGY: Winnebago Lake, mud bottom, 4.9 to 5.6 m.; gravel bottom, 1.6 m. Devils Lake, mud bottom, 9.5 m. (Baker). Oconomowoc Lake, 12 m., sand bottom, 2.5 m., sand and clay bottom (Cahn).

GENERAL DISTRIBUTION: Region of the Great Lakes.

DISTRIBUTION IN WISCONSIN: All records are from the eastern part of the State.

Rock Drainage: Oconomowoc Lake, Waukesha Co. (Cahn).

Fox Drainage: Winnebago Lake, Winnebago Co. (Baker); Spring Lake, near Green Lake, Green Lake Co. (Baker).

Devils Lake: Sauk Co. (Baker).

REMARKS: "*Pisidium vesiculare* can be mistaken only for *P. ventricosum* Pr., from which it differs by the following characters: it is longer, less oblique, more regular in form, being more regularly though less inflated, the beaks are much less prominent; the surface shows less coarse and irregular lines of growth. It is somewhat variable in size, measuring 2.1 to 2.7 mm. in length, and in being slightly more or less inflated" (Sterki).

Pisidium ventricosum has not yet been found in the State and it cannot, therefore, be confused with *vesiculare*. *Rotundatum* is somewhat similar in being inflated, but the beaks are situated nearer the posterior end and the whole shell is more oblique. The postero-dorsal margin is also somewhat angular in many specimens. This species is one of the most distinctive in the State and should be readily recognized.

PISIDIUM MEDIANUM Sterki

Plate CIII, figures 6-8

Pisidium medianum STERKI, Nautilus, XIII, p. 10, 1899; Cat., p. 466, 1916.

TYPE LOCALITY: Michigan, all over the state; lakes in Wisconsin.

WISCONSIN RECORDS:1899. *Pisidium medianum* STERKI, p. 11. Lakes in Wisconsin.1906. *Pisidium medianum* CHADWICK, p. 99. Lakes in Wisconsin.1924. *Pisidium medianum* BAKER, p. 134. Lake Winnebago.

SHELL: Of rather small size, elliptical in outline, much inflated, often of somewhat irregular growth; superior and inferior margins moderately curved, posterior well rounded, or with a slight angle above, anterior rounded or slightly truncated obliquely; beaks rather in the middle, slightly directed toward the posterior, rather high, prominent over the hinge margin; scutum and scutellum very slightly marked; surface with very fine, crowded striae, somewhat shining, light horn to yellowish or straw colored; shell thin; nacre colorless, muscle insertions barely perceptible (Sterki).

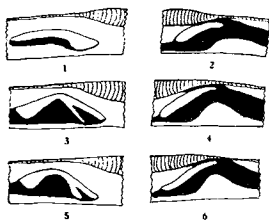


Fig. 298. Cardinal teeth of *Pisidium medianum* Sterki. Lake Winnebago. 1, 2. Young specimen. 3-6. Old specimens.

Hinge rather fine, plate narrow; cardinal of right valve almost straight or greatly curved, sometimes sharply angular, enlarged at the posterior end and frequently grooved or cleft, the tooth placed near the middle of the hinge plate; upper cardinal of left valve short, thin, straight or slightly curved; lower cardinal large, rounded or pyramidal; space between cardinals deep (fig. 298); laterals pointed, outer ones of right valve comparatively large.

L. 2.5; H. 2.0; D. 1.7 mm. Type.

L. 3.5; H. 2.8; D. 2.3 mm. Type.

L. 3.5; H. 2.5; D. 2.0 mm. Winnebago Lake (U. of W., 4509).

L. 3.0; H. 2.6; D. 2.0 mm. " " (" 4510).

ECOLOGY: Winnebago Lake; mud bottom, 4.9 to 6.1 m.; sand bottom, 0.8 to 2.8 m.; gravel and boulder bottom, 0.4 to 1.5 m. Silver Creek, Green Lake, marly-clay bottom, 1.5 m. Devils Lake, mud bottom, 8 to 13 m. (Baker). Dredged from 24 meters off New York Point, Lake Michigan (Walker). Oconomowoc Lake, 3-5 m., in vegetation, Ashippun Lake, sand bottom, shallow, Golden Lake, pure sand, 1 m. deep (Cahn).

GENERAL DISTRIBUTION: Region of the Great Lakes, common, especially in Michigan, which seems to be the center of distribution; Mohawk, N. Y., Ohio; also in Ohio River drainage (Sterki).

DISTRIBUTION IN WISCONSIN: All of known records are in the eastern part of the State.

Fox Drainage: Lake Winnebago, Winnebago Co.; Spring Lake and Silver Creek, Green Lake, Green Lake Co. (Baker).

Rock Drainage: Oconomowoc, Ashippun, Golden lakes, Waukesha Co. (Cahn).

Devils Lake: Sauk Co. (Baker).

REMARKS: *Pisidium medianum* is one of the best characterized of our species, not nearly related to or resembling any other *Pisidium*, except *P. ferrugineum* Pr., which is at once distinguished by the strong ridges on the beaks. *Pisidium medianum* is mainly characterized by its beaks being almost exactly in the middle of the mussel, its anterior part being sometimes even smaller than the posterior. Hence the name (Sterki).

This species has been taken from the stomach of the whitefish, indicating the usefulness of these small clams in affording food for this valuable food fish. In odd specimens the right cardinal becomes very heavy, much arched, enlarged at both ends, and strongly cleft (see fig. 298, 3).

PISIDIUM FERRUGINEUM Prime

Plate CIV, figures 3-5

Pisidium ferrugineum PRIME, Proc. Bost. Soc. N. H., IV, p. 162, 1851; Mon. Corb., p. 71, 1865.

Pisidium ferrugineum STERKI, Cat., p. 467, 1916.

TYPE LOCALITY: Cambridge, Mass.

WISCONSIN RECORDS:

1927a. *Pisidium ferrugineum* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Small, ovate or roundly-ovate, much inflated; dorsal margin nearly straight; ventral margin rounded, passing upward posteriorly and anteriorly in a regular, uninterrupted curve to meet the dorsal margin; the dorso-posterior margin is slightly angled in some specimens; anterior end rounded, a little below the median line; beaks placed but slightly posterior of the center of the dorsal margin, elevated above the hinge line, round, full, separated from the body of the shell by a marked ridge which causes the beaks to become tubercular; color yellowish or brownish, frequently covered with a ferruginous deposit; surface with well marked striae giving clean specimens a shining appearance.

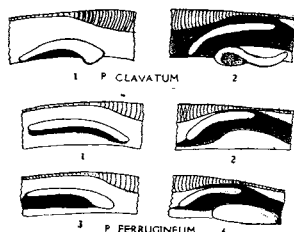


Fig. 299. Cardinal teeth of *Pisidium ferrugineum* Prime. Chetek Lake. 1, 2. Old specimen. 3, 4. Young specimen. Cardinal teeth of *Pisidium clavatum* Sterki. Lake Winnebago.

Hinge narrow, frail; cardinal of right valve but slightly curved, thin, lamellar, sometimes slightly enlarged at the posterior end, placed about the center of the hinge plate; upper cardinal of left valve long, narrow, curved; lower cardinal rounded, elongated, thick (fig. 299); laterals small, thin, placed near the cardinals, straight.

L. 2.8; H. 2.0; D. 1.5 mm. Chetek Lake (U. of W., 4511).

L. 2.0; H. 1.8; D. 1.3 mm. " " (" 4511).

ECOLOGY: Lake Chetek, mud bottom, 2 m.; between Chetek and Pokegoma lakes, mud bottom, 2.6 m.

GENERAL DISTRIBUTION: New England and Eastern New York west to Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from Northern Wisconsin.

Chippewa Drainage: Chetek (Bullock); Chetek and Pokegoma Lakes, Barron Co. (Baker).

Wisconsin Drainage: Little Arbor Vitae Lake, Vilas Co. (Winslow).

REMARKS: *Ferrugineum* greatly resembles *medianum*, especially in the nearly centrally placed beaks. It is a smaller shell and the beaks are tuberculate, a character not shared by *medianum* (a single specimen of *medianum* from Winnebago Lake had calyculate beaks). *Ferrugineum* is also rounder than *medianum*. The two species cannot be confused when the characters are once understood. The hinge of the two species is decidedly different, that of *medianum* being heavier with more curved cardinals, the one in the right valve being often cleft. (compare the figures). *Ferrugineum* is more common in the East than in the West.

PISIDIUM SUBTRUNCATUM Malm

Plate CIV, figures 21, 22

Pisidium subtruncatum MALM. Götheborgs K. Vet. & Witt. Samh. Handl., III, p. 92, figs., 1855.

Pisidium clavatum STERKI, Ms., Trans. Wis. Acad. Sci. Arts, Letters, XXI, p. 134, 1924.

TYPE LOCALITY: Europe.

WISCONSIN RECORDS:

1924. *Pisidium clavatum* BAKER, p. 134. Lake Winnebago.

SHELL: Small, oblique, inflated; beaks placed much posterior of the center of the dorsal margin, high, full, rounded, dorsal margin short, straight; scutum and scutellum well marked; ventral margin straight posteriorly and rounding upward anteriorly to meet the pointed end; posterior end broadly rounded; surface shining, lines of growth well marked; color light yellowish horn.

Hinge (fig. 299) rather strong; cardinal tooth of right valve long, curved, narrow at one end and enlarged at the other, the whole rather club-shaped, emarginate; upper cardinal of left valve long and narrow, curved ventrally at one end; lower cardinal of left valve much curved, elevated; laterals rather long, massive, triangular, extending well into the cavity of the shell.

L. 2.6; H. 2.2; D. 1.5 mm. Lake Winnebago (U. of W., 4513).

L. 3.0; H. 2.4; D. 2.0 mm. " " "

ECOLOGY: Lake Winnebago, mud bottom, 5.5 and 5.6 m.; sand bottom, .8 m.; gravel bottom, 1.6 to 3.1 m.

GENERAL DISTRIBUTION: Well distributed over England and northern Europe; distribution in America not definitely known.

Lake Nepigon, Ont. (Sterki) and Lake Winnebago, Wis. (Baker).

DISTRIBUTION IN WISCONSIN: Known only from Winnebago Lake, Winnebago Co.

REMARKS: The principal characteristic of the Winnebago specimens referred to *subtruncatum* are the high beaks and pointed anterior end. There is some variation in width and in the acuteness of the anterior end. It somewhat resembles *sargenti*, as well as *overi*, but in these species the posterior margin is sharply truncated while it is rounded in *subtruncatum*. Dr. Sterki at first thought this was a new species but later concluded that it was the same as the species so common in northern Europe.

PISIDIUM SPHAERICUM Sterki

Pisidium sphaericum STERKI, Nautilus, XXVI, p. 8, 1912.

In the description of this species, Sterki gives a citation from the Fox River, Wisconsin, supposed to have been collected by Geo. T. Marston, and submitted by E. W. Roper. Two specimens were sent by Mr. Roper, one an *abditum*, the other *sphaericum*. As no other specimens have turned up anywhere in the State or are found in the Marston collection of the University of Wisconsin, it seems evident that there has been a mixing of labels or specimens and the species is not included in the Wisconsin fauna. It is possible that it may be found later in some portion of the State, but as it is not listed from the west in the Catalog of Sphaeriidae (Maine to Virginia, Ontario) it seems hardly likely.

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GLOSSARY

In the following pages the technical and some other terms used in the body of this work are defined. Terms which are adequately explained in the text are not here included:

Abdominal sac. That portion of the Unionidae which contains the stomach and to which the gills are sometimes suspended.

Acephalous. Headless.

Acinose. Full of small bulgings; resembling the kernel in a nut.

Aculeate. Very sharply pointed, as the teeth on the radula of some snails.

Acuminate. Long and tapering, as the spire of some shells.

Admedian. Next to the central object, as the lateral teeth on the lingual membrane.

Afferent. To bring in; when relating to a vessel or duct, indicating that it brings in its contents.

Alate. Wing-like, as the dorsal part of some Unios.

Amoeboid. Shaped like an Amoeba, a small animalcule.

Amorphous. Without distinct form.

Amphibious. Inhabiting both land and water.

Amphidetic. With the ligament on both sides of the umbones.

Analogue. A likeness between two objects when otherwise they are totally different, as the wing of a bird and the wing of a butterfly.

Anastomosing. Coming together.

Annular. Made up of rings.

Approximate. Near together, as the umbones of some Unios.

Arborescent. Branching like a tree.

Arcti-spiral. Tightly coiled, as some spiral shells.

Arcuated. Bent in a bow or arched, as the ventral edge of some bivalves.

Assimilation. Act of converting one substance into another, as the changing of food-stuffs into living bodies.

Attenuate. Long and slender, as in some shells.

Biangulate. With two angles.

Bifurcated. Having two branches.

Bradytictic. Winter breeders.

Branchial. Referring to the lower or ventral siphons in Pelecypods.

Bulbous. Swollen.

Byssiferous. Attached by a byssus, as in some Unios.

Calcareous. Composed of carbonate of lime.

Callosity. A hardened and raised bunch, as the callus on the columella of some shells.

Callus. A deposit of shelly matter.

Calyculate. Cup-like, as the umbo when separated from the rest of the shell by a distinct mark, as in *Musculium*.

Campanulate. Formed like a bell.

Canaliculate. Resembling a canal, as the deep sutures in some shells.

Cancellated. Formed of cross-bars, as the longitudinal and spiral lines which cross in some shells.

Cardiac pouch. Containing the heart and placed near the umbones of the shell.

Carinate. Keeled.

Cartilaginous. Like cartilage.

Channeled. Grooved or formed like a channel.

Chitinous. Formed of chitin, as the radulae of snails.

Ciliary. By means of cilia.

Cilium (plural *cilia*). A lash; used to designate the hairs on the mantle, gills, etc.

Cirrated. Having movable hairs, as the siphons of *Unio*.

Clavate. Club-shaped.

Cloacal. Referring to the upper or dorsal siphon in pelecypods.

Coarctate. Pressed together, narrowed.

Compressed. Flattened out, pressed together, as some bivalves.

Concentric. From the same center, as the lines of growth on *Sphaerium*, which are parallel with the umbo.

Confluent. To run together, or into something else, as the muscle scars of some *Unios*.

Connective. A part connecting two other parts, as a muscle connecting two parts of the body, or a nerve connecting two ganglia.

Contractile. Capable of being contracted or drawn in, as the tentacle of a snail.

Convex. Bulged out, as the whole of some snails.

Corneous. Horn-like, as the opercula of some mollusks.

Corrugated. Roughened by wrinkles, as the shells of some *Unios*.

Costate. Having rib-like ridges.

Crenulate. Wrinkled on the edges.

Decollated. Cut off, as the apex of some shells.

Decussated. With spiral and longitudinal lines intersecting, as the sculpture of some shells.

Deflexed. Bent downward, as the last whorl in some snails.

Dentate. With points or nodules resembling teeth, as the aperture of some snails.

Denticulate. Finely dentate.

Depressed. Flattened, as the spire in some snails.

Dextral. Right-handed.

Diaphragm. Separation of branchial and subbranchial chambers in naiades.

Digitiform. Finger-like.

Dilated. Expanded in all directions, as the aperture of a shell.

Dimorphism. With two forms or conditions.

Dimyarian. Having two distinct abductor muscle impressions or scars, as in *Unio*.

Dioecious. Having the sexes in two individuals, one male and one female.

Distal. The farthest part from an object.

Discoidal. Shaped like a flat disk.

Diverging. Separating from each other, as the cardinal teeth in some *Unios*.

Diverticulum. A pouch or hole, as the pouch containing the radula, or that containing the dart in helices.

Dormant. In a state of torpor or sleep.

Dorsal. The back. In *bivalves* the hinge portion, and in *univalves* the opposite to the aperture.

Edentulous. Without teeth or folds, as the hinge plate in some *Unios*, and the aperture in some gastropods.

Efferent. Carrying out.

Emarginate. Bluntly notched.

Entire. With even, unbroken edges, as the aperture of some shells.

Epiphallus. A portion of the *vas deferens* which becomes modified into a tube-like organ and is continued beyond the apex of the penis; it frequently bears a blind duct, or flagellum. (*Pilsbry*).

Epithelium. All tissues bounding a free surface.

Equilibrating. Balancing equally.

Equidistant. Equally spaced, as the spiral lines on some snail shells.

Equipartite. Equal sided, as in *Unio* or *Sphaerium* when the umbones are placed in the center.

Equivalve. With both valves of the same size and shape.

Erosive. Capable of erosion.

Escutcheon. The region behind the umbones in *opisthodetic* *pelecypods*.

Excavated. Hollowed out, as the columella of some snails.

Excurrent. Referring to the siphon which carries out the waste matter of the body.

Exoskeleton. The outer skeleton; all shells are *exoskeletons*.

Exserted. Brought out.

Expanded. Spread out, as the lip of some shells.

Falcate. Scythe-shaped.

Fasciculus. A little bundle.

Flagellate. Animals with a flagellum or lash.

Flexuous. Formed in a series of curves or turnings, as the columella in some shells.

Flocculent. Clinging together in bunches. (See anatomical portion for the application of this word.)

Fluviatile. Living in running streams.

Fusiform. Thick in the middle and tapering at each end.

Gelatinous. Like jelly, as the eggs of some mollusks.

Gibbous. Very much rounded, as the whorls in some snails.

Granulated. Covered with little grains.

Gravid. A female mollusk (as Unio) with ovaries distended with young.

Gular. Relating to the windpipe or palate. In mollusks, referring to the innermost part of the aperture.

Habitat. Locality of a species.

Haemolymph. Molluscan blood.

Heliciform. In form like Helix.

Herbivorous. Subsisting upon vegetable food.

Hermaphrodite. Having the sexes united in the same individual.

Hibernation. The act of hibernating or going to sleep for the winter months.

Hirsute. Covered with hairs, as some snails.

Homologous. Having the same position or value, as the wing of a bird and of a bat.

Hyaline. Glassy.

Hypostracum. Fourth layer of shell next to the muscular mantle in Unionidae.

Imperforate. Not perforated or umbilicated.

Impressed. Marked by a furrow as the impressed spiral lines on some univalve shells.

Inequipartite. When one end of a shell is longer than the other, as the two ends in Pisidium.

Incrassate. Thickened.

Incurrent. The siphon in Unio which brings in the food-stuffs.

Incurved. Bent over, as the apex in some snails.

Inequivalve. When one valve is larger than the other.

Inflated. Swollen, as some bivalve shells.

Inflected. Turned in, as the teeth of some snails.

Inhalent. Same as incurrent.

Inoperculate. Without an operculum.

Intercostate. Between the ribs or ridges.

Invaginate. One part bending into another, as the tentacles of some land snails.

Invertible. Capable of being inverted, or drawn in, as the eye-peduncles of a land snail.

Keeled. With a more or less sharp projection at the periphery.

Labial. Pertaining to the lips, as the labial-palpi in Unio.

Lamellated. Covered with scales.

Lamelliform. Having the form of scales.

Laminated. Consisting of plates or scales laid over each other.

Lanceolate. Gradually tapering to a point.

Lenticular. Having the shape of a double convex lens, as some bivalves.

Lithodesma. An accessory shell plate near the umbones, in those shells having a "cartilage" or resiliium, as in *Mactra*.

Lobulate. Composed of lobes.

Lunate. Shaped like a half moon as the aperture in some shells.

Malleated. Appearing as though hammered.

Manducatory. Relating to the apparatus for masticating food. In snails, the jaws and radula.

Marsupium. A part of an animal used as a pouch to contain the young, as the gills of *Unio*.

Metabolism. The process of digestion.

Metamorphosis. Distinct changes in form of some animals during development, as the changes from glochidium to adult naiad, or as the change from caterpillar to butterfly.

Monoecius. Having the sexes united in the same individual.

Multifid. Made up of many lobes or projections, as the cusps on some radulae.

Multispiral. Consisting of many whorls, as some freshwater snails.

Nacreous. Pearly or iridescent, as the interior of some *Unios*.

Nave. The interior coating of *Pisidium* and *Sphaerium*.

Nepionic. The second stage of the embryonic shell, as the glochidium of *Unio*.

Nodulous. Provided with small knobs or projections, as the surface of some *Unios*.

Notched. Nicked or indented, as the anterior canal of some gastropods.

Nucleus. The first part or beginning, as the apex in a univalve and the umbo in bivalves.

Nucleated. Having a nucleus.

Obconic. In the form of a reversed cone.

Oblique. Slanting, as the aperture of some shells when not parallel to the longitudinal axis.

Oblong. Longer than high, as some *Unios*.

Obovate. Reversed ovate, as some shells when the diameter is greater near the upper than at the lower part.

Obtuse. Dull or blunt, as the apex of some univalves.

Opisthodontic. With the ligament behind the umbones.

Orbicular. Like an orb or disk, as some *Sphaeria*.

Ovately conic. Shaped like an egg, but with a somewhat conic apex, as some univalves.

Oviparous. Bringing forth young in an egg which is hatched after it is laid.

Ovisac. A pouch in which the eggs or embryos are contained.

Ovoviviparous. In this case the young are formed in an egg, but are hatched inside the parent.

Papillose. Covered with many little bulgings or pimples.

Parallel. Having the same relative distance in all parts, as when the spiral lines in univalve shells are the same distance apart all the way around.

Parivincular. A ligament "which may be compared to a cylinder split on one side, attached by the several edges, one edge to each valve." (Dall.)

Patelliform. Shaped like a flattened-out cone, as an *Ferrissia*.

Patulous. Open and spreading, as the aperture in some univalves.

Paucispiral. Only slightly spiral, as some opercula.

Pearly. Having a substance like pearl, as the interior of *Unio*.

Pectinate. Like the teeth of a comb, as the gills of some mollusks.

Pedunculated. Supported on a stem or stalk, as the eyes of land snails.

Pellucid. Transparent or clear, as the shells of some snails.

Penultimate. The whorl before the last in univalve shells.

Pericardium. The chamber containing the heart.

Periostracum. The epidermal covering of some shells.

Pervious. Very narrowly open, as the umbilicus in some snails.

Phytophagus. Vegetable-feeding.

Pilose. Covered with hairs.

Pinnate. Branched like a feather, as the gills of some mollusks.

Planorboid. Flat and orb-like, as some snails.

Pleurae. Relating to the side of a body.

Plexus. A network of vessels, as the form of the lungs in snails.

Porcellaneous. Like porcelain.

Post-basal. Beyond or near the base, as the postero-ventral part of *Lampsilis*.

Prodissoconch. The embryonic shell.

Prosodetic. A term applied to the area in opisthodetic ligaments, lying in front of the umbones and forming the lunule.

Protoconch. The embryonic shell.

Protractor pedis. The foot protractor muscle.

Proximal. The nearest end of an object.

Pseudocardinals. False cardinal teeth.

Pseudolaterals. False lateral teeth.

Pupiform. Like a pupa; one of the stages in the development of an insect.

Radiated. Extending from a common center, as the rays on some *Unios*.

Reflected. Bent backward, as the lip in some snails, or the cusps in the lingual membrane.

Renal. Relating to the kidneys.

Reticulated. Resembling a network, as when the longitudinal and spiral lines cross in a snail.

Retractile. Capable of being drawn in, as the eye peduncles in land snails.

Retractor pedis. Foot retractor muscle.

Rhomboid. Four-sided, but two of the sides being longer than the others.

Rimate. Provided with a very small hole or crack, as some snails in which the umbilicus is very narrowly open.

Rostriform. In the form of a rostrum.

Sacculated. Somewhat like a sac, or composed of sac-like parts.

Schizodont. With few teeth, consisting of one or two cardinals or laterals, as in *Unio*.

Scutellum. The projecting or pinched parts in front of the umbones in *Pisidium*.

Scutum. The pinched parts behind the ligament in *Pisidium*.

Secreted. Produced or deposited from the blood or glands, as the shell material in mollusks.

Sessile. Attached without a stem, as the eyes in some water snails.

Shouldered. Ridged, as the whorls in some snails.

Sigmoid. Shaped like the letter S.

Siliceous. Made up of silex.

Sinistral. Having the aperture on the left side.

Sinuous. Curved in and out, as the edge of some bivalves and the lips of some snails.

Spatulate. In the form of a spatula, a flat-bladed instrument used by druggists in pulverizing drugs.

Striated. Marked by lines or striae.

Subangulated. Moderately angled.

Subcarinated. Moderately carinated.

Subcentral. Not quite in the center.

Subcircular. Not quite circular.

Subconical. Moderately conical.

Subcylindrical. Moderately cylindrical.

Subequal. Not quite equal.

Subexcavated. A little excavated.

Subfusiform. Moderately fusiform.

Subglobose. Moderately globose.

Subglobular. Moderately globular.

Subhyaline. Moderately glassy.

Subimperforate. Not much perforated.

Suboblong. Moderately oblong.

Subobsolete. Almost disappearing.

Subovate. Nearly ovate.

Subparallel. Almost parallel.

Subquadrate. Almost four-sided.

Subreflected. Moderately turned back.

Subrotund. Moderately round.

Subspiral. Moderately spiral.

Subtriangulate. Moderately or almost triangular.

Subtrigonal. Moderately three-angled.

Subtruncate. Moderately cut off.

Subumbilicated. Moderately umbilicated.

Sulcated. Grooved.

Sulcus. A longitudinal furrow.

Superanal. Above the anus.

Supra-peripheral. Above the periphery.

Symphynote. Having the postero-dorsal portion of the shell flattened and produced, as in *Symphynota complanata*.

Tachytictic. Summer breeders.

Testaceous. Composed of shelly matter.

Torsion. A twisting around.

Tortuous. Twisted or winding.

Translucent. Not quite transparent; light is seen through the thin edges of the object.

Transparent. Objects may be seen through the substance.

Transverse. Referring to the form of a shell when it is wider than high.

Tripartite. Divided into three parts, as the foot of some snails.

Truncate. Having the end cut off squarely, as some Unios.

Tuberculate. Covered with tubercles or rounded knobs.

Turbinate. Having the form of a top.

Turriculated. Having the form of a tower.

Turreted. Having the form of a tower.

Umbilicated. Having an opening in the base of the shell.

Undulated. Having undulations or waves, as the surface of some Unios.

Univalve. Having the shell composed of a single piece, as a snail.

Vascular. Containing or made up of blood vessels.

Ventricose. Swollen or inflated on the ventral side.

Vibratile. Moving from side to side.

Vitreous. Resembling glass, as some snails.

EXPLANATION OF PLATES

PLATE XXIX

Fig. 1. *Fusconaia ebenus* (Lea). Marsupium occupying all four gills. Parts of animal indicated.

Fig. 2. *Ligumia recta latissima* (Raf.). Marsupium occupying only outer portion of outer gills.

Fig. 3. *Obliquaria reflexa* Raf. Marsupium occupying middle portion of outer gills.

Figures after Lefevre and Curtis, 1910, pl. I. 1 and 3 about natural size; Fig. 2 about one-half natural size.

PLATE XXX

Figures illustrating named parts of shell. Fig. 1. *Cyclonaias granifera* (Lea). Inside of valve. Fig. 2. Same species, outside of valve. Fig. 3. *Tritogonia verrucosa* (Raf.). Dorsal surface showing two valves in natural position. About two-thirds natural size.

PLATE XXXI

Glochidia of Naiades. Mostly from Surber, 1912, 1915
Relative size indicated by line at bottom of plate.

- Fig. 1. *Margaritana monodonta* (Say).
- Fig. 2. *Fusconaia undata* (Barnes).
- Fig. 3. *Fusconaia ebenus* (Lea).
- Fig. 4. *Amblesma peruviana* (Lam.).
- Fig. 5. *Megalonaias giganteus* (Barnes).
- Fig. 6. *Quadrula pustulosa* (Lea).
- Fig. 7. *Quadrula nodulata* Raf.
- Fig. 8. *Quadrula quadrula* Raf.
- Fig. 9. *Quadrula metanevra* Raf.
- Fig. 10. *Tritogonia verrucosa* (Raf.).
- Fig. 11. *Cyclonaias granifera* (Lea).
- Fig. 12. *Plethobasus cyphus* (Raf.).
- Fig. 13. *Pleurobema catillus* (Conrad).
- Fig. 14. *Pleurobema coccineum* (Conrad).
- Fig. 15. *Elliptio dilatatus* (Raf.).
- Fig. 16. *Elliptio crassidens* (Lam.).
- Fig. 17. *Lasmigona compressa* (Lea).
- Fig. 18. *Lasmigona costata* (Raf.).
- Fig. 19. *Lasmigona complanata* (Lea).
- Fig. 20. *Anodonta gigantea* Lea.
- Fig. 21. *Anodonta corpulenta* Cooper.

PLATE XXXII

Glochidia of Naiades. Mostly from Surber 1912, 1915
For size see scale at bottom of plate

- Fig. 1. *Utterbackia imbecillis* Say.
- Fig. 2. *Arcidens confragosus* (Say).
- Fig. 3. *Alasmidonta marginata* Say.
- Fig. 4. *Anodontoides ferussacianus buchanensis* (Lea).
- Fig. 5. *Alasmidonta calceolus* (Lea).
- Fig. 6. *Strophitus rugosus* (Swainson).
- Fig. 7. *Obliquaria reflexa* Raf.
- Fig. 8. *Obovaria olivaria* (Raf.).
- Fig. 9. *Actinonaias carinata* (Barnes).
- Fig. 10. *Truncilla truncata* Raf.
- Fig. 11. *Truncilla donaciformis* (Lea).
- Fig. 12. *Leptodea fragilis* (Raf.).
- Fig. 13. *Plagiola lineolata* Raf.
- Fig. 14. *Proptera alata megaptera* Raf.
- Fig. 15. *Lampsilis siliquoidea* (Barnes).
- Fig. 16. *Proptera laevissima* (Lea).
- Fig. 17. *Proptera capax* (Green).
- Fig. 18. *Carunculina parva* (Barnes).
- Fig. 19. *Ligumia recta latissima* (Raf.).
- Fig. 20. *Ligumia iris* (Lea).
- Fig. 21. *Lampsilis anodontoides* (Lea).
- Fig. 22. *Lampsilis fallaciosa* (Smith) Simpson.
- Fig. 23. *Lampsilis higginsii* (Lea).
- Fig. 24. *Lampsilis ventricosa* (Barnes).

PLATE XXXIII

Fig. 1. Anterior gill of a black bass infected with *Actinonaias carinata*, showing distribution upon the gill as a whole and appearance of the cysts.

Fig. 2. Portion of fig. 1 more highly magnified showing cysts of glochidia on gill filaments.

Fig. 3. Four stages in the formation of cyst surrounding glochidium of *Actinonaias carinata*. Taken at 15 minutes, 30 minutes, one hour, and three hours respectively, after infection.

Fig. 4. Young *Actinonaias carinata* one week after liberation from the fish, showing new growth of shell, cilia on foot, and positions assumed in crawling.

Fig. 5. Young Lake Pepin Mucket (*Lampsilis siliquoidea pepinensis*) at ages of 1, 2, 3, and 4 months, respectively. Natural size.

Figs. 1-4 from Lefevre and Curtis, 1910, greatly enlarged; fig. 5 from Coker, Shira, et al, fig. 6, pl. xv.

PLATE XXXIV

Figs. 1, 2. Hooked glochidium of *Lasmigona costata*.

Figs. 3-5. Hookless glochidium of *Ligumia subrostrata*.

Figs. 6, 7. Axe-head glochidium of *Proptera alata megaptera*. Side and end views of each; fig. 5, front view showing shell open with adductor muscle in center.

Fig. 8. Conglutinates (masses of glochidia) from *Obliquaria reflexa*.

Fig. 9. Portion of conglutinate of *Obliquaria reflexa*, magnified. Glochidia still within egg membranes which are closely pressed and adhering together.

Fig. 10. Conglutinates from the mucket (*Actinonaias carinata*).

Fig. 11. Portion of conglutinate of *Actinonaias carinata*, magnified. Glochidia inclosed in membranes embedded in a mucilaginous matrix.

All figures from Lefevre and Curtis, 1912.

PLATE XXXV

Fig. 1. *Actinonaias carinata* (Barnes). Fox River, Princeton. Blister caused by mud between mantle and shell. Bullock coll. U. of W., 4425.

Fig. 2. *Tritogonia verrucosa* (Raf.). Prairie du Chien. Twisted shell. Bullock coll. U. of W., 4426.

Fig. 3. *Actinonaias carinata* (Barnes). Shell abnormally compressed laterally, posteriorly. St. Croix River, above Grantsburg. U. of W., 4427.

Fig. 4. *Elliptio crassidens* (Lam.). Green Bay, in Pleistocene deposit. Marston coll. U. of W., 248.

Fig. 5. *Amblema rariplicata* (Lam.). Rock River near Old Ashippun. Posterior end deformed. U. of I., Z18436.

PLATE XXXVI

Fig. 1. Outfit for steaming clams to remove meat. Steaming stove in foreground; sorting table in background. Typical Mississippi River pearl and shell fishermen. Prairie du Chien. (Photograph by F. M. Woodruff.)

Fig. 2. Twenty-two tons of shells on Rock River west of Ashippun, Dodge Co., showing extent to which this stream is being clammed. (Photograph by Alvin R. Cahn).

PLATE XXXVII

Fig. 1. John boat on shore showing method of resting crowfoot dredge on uprights on side of boat when not in use. Note clams fastened to hooks; also number of dead clams on shore, mostly paper shells and clams too small for button purposes. Prairie du Chien. Photograph by F. M. Woodruff.

PLATE XXXVII—Continued

Fig. 2. John boat with 'mule' in front being pushed down stream by current, dragging crowfoot dredge behind. Mississippi River, near McGregor, Iowa, nearly opposite Prairie du Chien, Wis. (Photograph by F. M. Woodruff.)

PLATE XXXVIII

Figs. 1, 2. *Margaritana monodonta* (Say). Prairie du Chien, Crawford Co. Chicago Acad. Sci., 20245. About $\frac{3}{4}$ natural size.

PLATE XXXIX

Fig. 1. *Fusconaia flava parvula* Grier. Off Stony Beach, near Oshkosh, Lake Winnebago. U. of W., 799.

Figs. 2, 4. *Fusconaia flava parvula* Grier. Doemel point, Lake Winnebago. U. of W., 802.

Fig. 5. *Fusconaia flava parvula* Grier. Asylum Point, Lake Winnebago. U. of W., 800.

Fig. 6. *Fusconaia flava* (Raf.). Crawfish River, Aztalan, Jefferson Co. Specimen with great diameter. U. of W., 1883.

Fig. 7. *Fusconaia flava* (Raf.). Princeton, Fox River. Normal form. U. of W., 794.

Fig. 8. *Fusconaia flava* (Raf.). Princeton. Elongated form. U. of W., 792.

Fig. 9. *Fusconaia flava* (Raf.). Princeton. Immature specimen. U. of W., 798.

About natural size.

PLATE XL

Fig. 1. *Fusconaia undata wagneri* Baker. Hudson, St. Croix Co. U. of W., 810.

Figs. 2, 3. *Fusconaia undata wagneri* Baker. Lake Pepin, near Lake City, Minn. Type. U. of W., 344, b, c.

Fig. 4. *Fusconaia undata* (Barnes). Troutmere, Osceola, Polk Co. U. of W., 805.

Figs. 5, 6. *Fusconaia undata* (Barnes). Wisconsin River, Sauk Co. U. of I., Z5483.

Fig. 7. *Fusconaia flava* (Raf.). Menomonee River, Milwaukee Co. U. of I., Z5438. An unusual form resembling *undata*.

About natural size.

PLATE XLI

Fig. 1. *Fusconaia ebenus* (Lea). Prairie du Chien, Crawford Co. Dudley coll. Adult.

Fig. 2. *Fusconaia ebenus* (Lea). Wisconsin River. U. of I., Z5536.

Fig. 3. *Fusconaia ebenus* (Lea). Mississippi River, Illinois. U. of W., 814.

PLATE XLI—Continued

Fig. 4. *Amblesma peruviana* (Lam.). Wisconsin River. U. of W., 195.

Fig. 5. *Amblesma peruviana* (Lam.). Lake Pepin. U. of W., 718.

Fig. 6. *Amblesma rariplacata* (Lam.). Rock River. U. of W., 66.
About $\frac{3}{4}$ natural size.

PLATE XLII

Fig. 1. *Amblesma rariplacata* (Lam.). Crawfish River, Aztalan, Jefferson Co. U. of W., 822.

Figs. 2, 3. *Amblesma rariplacata* (Lam.). Osceola, Polk Co. U. of W., 823, 824.

About $\frac{3}{4}$ natural size.

PLATE XLIII

Fig. 1. *Amblesma costata* Raf. Edward's Creek, Ill. Young, compressed form. U. of W., 320b.

Fig. 2. *Amblesma costata* Raf. Fox River, Brown Co. Form without undulations. U. of W., 144.

Fig. 3. *Amblesma costata* Raf. Omro, Fox River. Form with produced posterior end and anterior umbones. U. of W., 831.

Figs. 4, 5. *Amblesma costata* Raf. Rock River, Jefferson Co. Normal form. U. of W., 828.

About $\frac{3}{4}$ natural size.

PLATE XLIV

Quadrula pustulosa (Lea)

Fig. 1. Wisconsin River. Form like *dorfeuilliana* (Lea) with few tubercles. U. of W., 127.

Fig. 2. Wisconsin River. U. of W., 60.

Fig. 3. Rock River. U. of W., 35.

Fig. 4. Fort Atkinson, Rock River. U. of W., 842.

Fig. 5. Prairie du Chien, Crawford Co. U. of W., 841.

Fig. 6. Fox River near Wisconsin River. U. of W., 8.

About $\frac{3}{4}$ natural size.

PLATE XLV

Quadrula nodulata Rafinesque

Figs. 1, 2, 4. Prairie du Chien. Chi. Acad. Sci., 20277, a, b.

Quadrula pustulosa prasina (Conrad)

Fig. 3. Omro, Fox River. U. of W., 848.

Fig. 5. Omro. Absence of tubercles. U. of W., 850.

Fig. 6. Omro. Compressed form. U. of W., 849.

Fig. 7. Omro. Pustulose. U. of W., 847.

Fig. 8. Princeton, Fox River. U. of W., 851.

About $\frac{3}{4}$ natural size.

PLATE XLVI

Fig. 1. *Quadrula quadrula bullocki* Baker. Fox River, near DePere, Brown Co. Holotype. U. of W., 163.

Fig. 2. *Quadrula quadrula bullocki* Baker. Omro, Fox River. U. of W., 836.

Fig. 3. *Quadrula quadrula bullocki* Baker. Omro, Fox River. Immature. U. of W., 837.

Fig. 4. *Quadrula quadrula* Raf. Lake Pepin. U. of W., 343.

Fig. 5. *Quadrula fragosa* (Conrad). Kilbourn, Wis. R. U. of W., 840.

Fig. 6. *Quadrula fragosa* (Conrad). Wisconsin R. U. of W., 15.

PLATE XLVII

Fig. 1. *Quadrula fragosa* (Conrad). Wisconsin River. Old specimen. U. of I., Z5338.

Fig. 2. *Quadrula metanevra* Rafinesque. Mississippi River, Ill. Immature specimen. U. of W., 308a.

Figs. 3, 4. *Megalonaias gigantea* (Barnes). Prairie du Chien. U. of W., 816, 817.

About $\frac{3}{4}$ natural size.

PLATE XLVIII

Fig. 1. *Quadrula fragosa* (Conrad). Wisconsin River, Sauk Co., Wis. Immature. U. of I., Z5338.

Fig. 2. *Quadrula quadrula* Raf. Wabash River. New Harmony, Posey Co., Ind. Immature. U. of I., Z14576.

Figs. 3-4. *Quadrula quadrula* Raf. New Harmony, Ind. Mature. U. of I., Z14576.

Figs. 5, 6. *Fusconaia undata trigona* (Lea). Mississippi River, Fairport, Iowa. U. of I., Z19681.

Fig. 7. *Lampsilis ventricosa* (Barnes). Prairie du Chien, Mississippi River, Wis. Type locality. Male shell. U. of I., Z22390.

Figures slightly reduced.

PLATE XLIX

Fig. 1. *Quadrula metanevra* Raf. Wisconsin River, Sauk Co. U. of I., Z5290.

Figs. 2, 3. *Quadrula metanevra* Raf. Prairie du Chien. U. of W., 834, 835.

Figs. 4, 5. *Plethobasus cyphus* (Raf.). Wisconsin River, Sauk Co. U. of I., Z5186.

Fig. 6. *Plethobasus cyphus* (Raf.). Mississippi River, Ill. U. of W., 327.

About $\frac{3}{4}$ natural size.

PLATE L

Tritogonia verrucosa (Raf.)

- Fig. 1. Prairie du Chien, Mississippi River. Male. U. of W., 857.
 Fig. 2. Omro, Fox River. Male. U. of W., 855.
 Fig. 3. Portage, Wis. R. Female. U. of W., 856.
 Fig. 4. Omro. Female. U. of W., 854.

About $\frac{3}{4}$ natural size.

PLATE LI

- Fig. 1. *Cyclonaias tuberculata* Raf. Fox River, near Wrightstown. U. of W., 104.
 Fig. 2. *Cyclonaias tuberculata* Raf. Rock R. U. of W., 21.
 Fig. 3. *Cyclonaias granifera* (Lea). Hudson, St. Croix R. U. of W., 858.
 Fig. 4. *Cyclonaias granifera* (Lea). Prairie du Chien. U. of W., 859.
 Fig. 5. *Cyclonaias tuberculata* Raf. Rock River. U. of W., 225.

PLATE LII

Pleurobema coccineum solida (Lea)

- Figs. 1-4. Wisconsin River, Sauk Co. U. of I., Z5512.
 Fig. 5. Wisconsin River. U. of W., 51.

About $\frac{1}{2}$ natural size.

PLATE LIII

Pleurobema coccineum mississippiensis var. nov.

- Fig. 1. Lake Pepin, Mississippi River. U. S. Fish Com., July 20, 1920. U. of I., Z14019. Type.
 Fig. 2, 3. Lake Pepin. June 17, 1918. Paratype. U. of I., Z14023.
 Fig. 4. Lake Pepin. Summer 1920. U. of W., 726.
 Fig. 5. Foot of Lake Pepin. July 22, 1920. U. of I., Z14021.

Pleurobema coccineum solida (Lea)

- Fig. 6. Prairie du Chien. Chi. Acad. Sci., 20279.

Slightly reduced in size.

PLATE LIV

Pleurobema coccineum (Conrad)

- Fig. 1. Omro, Fox River. Form with umbones placed anteriorly. U. of W., 869.
 Figs. 2, 3. Omro. Normal form. U. of W., 872.
 Fig. 4. Rock River. Form with anterior umbones, erroneously identified as *kirtlandiana*. U. of W., 25.
 Fig. 5. Princeton, Fox River. U. of W., 870.
 Fig. 6. Wisconsin River, below Kilbourn. U. of W., 874.

About $\frac{3}{4}$ natural size.

PLATE LV

Figs. 1, 2. *Pleurobema coccineum catillus* (Conrad). Fort Atkinson, Rock River. U. of W., 866, 867.

Fig. 3. *Pleurobema coccineum catillus* (Conrad). Rock River. U. of W., 43.

Fig. 4. *Elliptio dilatatus* (Raf.). Lake Pepin, Mississippi R. U. of W., 352c. Typical form.

Fig. 5. *Elliptio dilatatus* (Raf.). Hudson, St. Croix River. U. of W., 877.

About $\frac{3}{4}$ natural size.

PLATE LVI

Figs. 1, 2. *Elliptio complanatus* (Dillwyn). Red cliff Creek, Bayfield Co. U. of W., 888, 889.

Figs. 3, 4. *Elliptio dilatatus sterkii* Grier. Winnebago Lake, near Oshkosh. U. of W., 882, 883.

Fig. 5. *Elliptio dilatatus sterkii* Grier. Off Stony Beach, near Oshkosh, in 8 feet of water. U. of W., 884.

Fig. 6. *Elliptio dilatatus sterkii* Grier. Off Far Rockaway Point, 3 meters deep, gravel bottom, $\frac{3}{4}$ mile from shore. U. of W., 886.

Fig. 7, 8. *Elliptio dilatatus delicatus* (Simpson). Princeton, Fox River. U. of W., 744, 745.

About $\frac{3}{4}$ natural size.

PLATE LVII

Figs. 1, 2. *Elliptio dilatatus delicatus* (Simpson). Crawfish River, Aztalan, Jefferson Co. Wide ellongate form resembling *Ligumia recta latissima*. U. of W., 1884.

Fig. 3. *Elliptio crassidens* (Lam.). Prairie du Chien, Mississippi River. Immature. U. of W., 887.

Figs. 4, 5. *Elliptio crassidens* (Lam.). Prairie du Chien. Dudley coll.

About $\frac{3}{4}$ natural size.

PLATE LVIII

Figs. 1, 2. *Lasmigona compressa* (Lea). Rockland, Brown Co. U. of W., 156.

Figs. 3, 4. *Lasmigona compressa* (Lea). Outlet Creek, Green Lake. U. of W., 892.

Fig. 5. *Lasmigona costata* Raf. Racine. U. of W., 49.

Fig. 6. *Lasmigona costata* Raf. Omro, Fox River. U. of W., 897. Female.

Figs. 1-4 natural size; Figs. 5-6, $\frac{3}{4}$ natural size.

PLATE LIX

Figs. 1, 2. *Lasmigona costata pepinensis* Baker. Lake Pepin, near Lake City, Minn. U. of W., 357, 358. Type, Paratype.

Fig. 3. *Lasmigona costata nuda* Baker. Red Cedar River. U. of W., 900. Type. Male.

Figs. 4, 5. *Lasmigona costata nuda* Baker. Red Cedar River. U. of W., 901, 902. Paratypes. Female.

Fig. 6. *Lasmigona costata nuda* Baker. Red Cedar River. U. of W., 904. Immature.

Fig. 7. *Lasmigona costata* Raf. Long Point Island, Lake Winnebago. U. of W., 899.

About $\frac{3}{4}$ natural size.

PLATE LX

Fig. 1. *Lasmigona complanata* (Barnes). Omro, Fox River. U. of W., 909.

Fig. 2. *Lasmigona complanata* (Barnes). Fox River, Brown Co. U. of W., 101.

Figs. 3, 4. *Lasmigona complanata katherinae* (Lea). Red Cliff Creek, Bayfield Co. U. of W., 910, 911.

Fig. 5. *Anodonta grandis plana* Lea. Red Cedar River. U. of W., 915c. Immature.

About $\frac{3}{4}$ natural size.

PLATE LXI

Figs. 1, 2. *Anodonta grandis footiana* Lea. Lake Butte des Morts. U. of W., 921a, b. Like Lea's figure of *marryattana*.

Figs. 3, 4. *Anodonta grandis plana* Lea. Red Cedar River. U. of W., 915a, d. Females.

Figs. 5, 6. *Anodonta grandis plana* Lea. Red Cedar River. U. of W., 915b, c. Male and female.

About $\frac{3}{4}$ natural size.

PLATE LXII

Fig. 1, 2. *Anodonta grandis footiana* Lea. Lower Asylum Bay, Lake Winnebago. U. of W., 191c. Lea's original locality.

Fig. 3. *Anodonta grandis footiana* Lea. Lower Asylum Bay. U. of W., 191b. Like Lea's figure.

Fig. 4. *Anodonta gigantea* Lea. Prairie du Chien, Mississippi River. Dudley coll.

Fig. 5. *Anodonta grandis* Say. Lake Wingra, near Madison. U. of W., 402.

About $\frac{3}{4}$ natural size.

PLATE LXIII

- Fig. 1, 2. *Anodonta kennicotti* Lea. Green Lake. U. of W., 923a, b.
Fig. 3. *Anodonta kennicotti* Lea. Mud Hen Lake, Grantsburg. U. of W., 922.
Fig. 4, 5. *Arcidens confragosus* (Say). Prairie du Chien. Dudley coll.
Fig. 6, 7. *Arcidens confragosus* (Say). Mississippi River, Ill. U. of W., 311. Fig. 7 immature.
About $\frac{3}{4}$ natural size.

PLATE LXIV

Anodonta marginata Say

- Fig. 1. Lake Mendota. Dudley coll. Fig. 2, 3. Fish Lake. Chi. Acad. Sci., 14823. Fig. 4. Yahara River above Kegonsa. Dudley coll.
About $\frac{3}{4}$ natural size.

PLATE LXV

- Fig. 1, 2. *Alasmidonta marginata truncata* (B. H. Wright). Lone Rock, Wisconsin River. Dudley coll.
Fig. 3. *Anodonta gigantea* Lea. Jefferson, Rock River. U. of W., 916.
About $\frac{3}{4}$ natural size.

PLATE LXVI

- Figs. 1, 2. *Anodonta corpulenta* Cooper. Prairie du Chien. Dudley coll.
Figs. 3, 4. *Anodonta corpulenta* Cooper. Lake Pepin, near Lake City, Minn. U. of W., 342c, b.
About $\frac{3}{4}$ natural size.

PLATE LXVII

- Figs. 1-2. *Strophitus rugosus pavonius* (Lea). Silver Creek, Green Lake. Male. U. of W., 929a.
Figs. 3-4. *Anodontoides ferussacianus* (Lea). Silver Creek, Green Lake, July 1921. Female. U. of W., 929b.
Figs. 5, 6. *Anodontoides ferussacianus subcylindraceus* (Lea). Creek east of Green Bay. U. of W., 184.
Fig. 7. *Anodontoides ferussacianus* (Lea). Outlet of Green Lake. U. of W., 928.
Figures 1-4 natural size; 5-7, slightly enlarged,

PLATE LXVIII

Figs. 1-4. *Anodontoides birgei* Baker. Sturgeon Bay, below bridge. Aug. 1922. 930a, female; 930d, male. Types. 930c, e, immature.

Fig. 5. *Anodontoides ferussacianus subcylindraceus* (Lea). Creek east of Green Bay. U. of W., 182.

Figs. 6, 7. *Utterbackia imbecillis* (Say). Ogle Co., Ill. U. of I., Z3815. Fig. 8. Immature. Omro, Fox River. U. of W., 926.

Figures about natural size.

PLATE LXIX

Fig. 1. *Alasmidonta calceolus* (Lea). Kishwaukee River, Ill. Female. U. of I., Z3835.

Fig. 2. *Alasmidonta calceolus danieli* var. nov. Moots Creek, Ind. Female. U. of I., Z14301.

Fig. 3. *Alasmidonta calceolus magnalacustris* var. nov. Sturgeon Bay. U. of I., Z18056. Female.

Figs. 4-9. *Alasmidonta marginata variabilis* var. nov. Red Cedar River. Aug. 1921. U. of W. 935a; 935b-d, paratypes.

About $\frac{1}{2}$ natural size.

PLATE LXX

Figs. 1-3. *Simpsoniconcha ambigua* (Say). Wisconsin River, Kilbourn. U. of W., 931a, b.

Figs. 4, 5. *Dysnomia triquetra* (Raf.). Duck River, Tenn. U. of I., Z3976. Female.

Figs. 6, 7. *Dysnomia triquetra* (Raf.). Sauk Co., Wisconsin River. No. 44,307. Male. Walker collection.

Fig. 8. Rear view of yellow sand-shell (*Lampsilis anodontoides*) in natural position in bottom under water, showing the two siphonal openings, the gaping shell, and the apposed margins of the mantle (Bull. U. S. Fish. Com., XXXVII, pl. v, fig. 1).

Fig. 9. Rear view of *Anodonta corpulenta* showing siphonal openings. Note the smooth margins of the upper exhalent opening and the papillae or "feelers" surrounding the lower or inhalent opening (Op. cit., pl. v, fig. 2).

Figs. 1-7 natural size; 8, 9 slightly reduced.

PLATE LXXI

Alasmidonta marginata Say

Fig. 1, male; 2, female; 3, male; 4, male, immature; 5, female, immature. Homer Park, Salt Fork of Big Vermilion River, Ill. U. of I., Z14054.

Alasmidonta marginata truncata (B. H. Wright)

Fig. 6. Jefferson, Rock River, Wis. U. of W., 934; fig. 7, Rock River, Wis. Immature. U. of W., 82.

About natural size.

PLATE LXXII

Alasmidonta calceolus (Lea)

Fig. 1. Mercer Co., Ill., Z4824, male; fig. 2. Desplaines River, Joliet, Ill., Z11801, male; fig. 3. Kishwaukee River, Ill., Z11907, female; fig. 4. Kishwaukee River, Z3835, female; figs. 5, 6. Rock River, Wis. U. of W., 80, female.

Alasmidonta calceolus danielsi var. nov.

Fig. 7. Ashippun River, Wis., female, intermediate form, U. of I., Z17324; fig. 8. Moots Creek, Ind., male, U. of I., 14301, paratype; fig. 9. Moots Creek, male, Z14301a, male, type; fig. 10. Moots Creek, female, Z14301, paratype; fig. 11. Moots Creek, female, Z14301, paratype; fig. 11. Moots Creek, female, Z14301, paratype.

Alasmidonta calceolus magnalacustris var. nov.

Fig. 12. Lake Noque Bay, Wis., male, U. of W., 932; fig. 13. Sturgeon Bay, female, U. of W., 933b, paratype; fig. 14. Sturgeon Bay, female, U. of W., 933a, type; fig. 15. Sturgeon Bay, female, U. of I., Z18056, paratype; fig. 16. Onekama, Mich., male, U. of I., 14905.

Figures about natural size.

PLATE LXXIII

Strophitus rugosus pavonius (Lea)

Figs. 1-4. Moose Ear Creek. Aug. 1921. Figs. 1, 2, males U. of W., 940a; figs. 3, 4, females, 940b. Fig. 5. Fox River, Princeton. U. of W., 939.

Strophitus rugosus (Swainson)

Fig. 6. Rock River, Jefferson. U. of W., 937. Fig. 7. Prairie du Chien, U. of W., 938.

About $\frac{3}{4}$ natural size.

PLATE LXXIV

Strophitus rugosus winnebagoensis var. nov.

Fig. 1. Brown Co. U. of W., 181; figs. 2, 3. Doemel Point, Lake Winnebago. U. of W., 943b, paratype; fig. 6. Long Point Island. Lake Winnebago, U. of W., 943a, type.

Strophitus rugosus winnebagoensis var. nov.

Figs. 4, 5. Sturgeon Bay. U. of W., 944a, b.

Strophitus rugosus pavonius (Lea)

Fig. 7. Outlet of Lake Chetek. Pathologic shell. U. of W., 941.

Figs. 9, 10. Racine. Compressed form with bright rays. U. of W., 84, 93.

Strophitus rugosus pepinensis var. nov.

Fig. 8. Lake Pepin, near Lake City, Minn. Type. U. of W., 362f.

About natural size.

PLATE LXXV

Figs. 1, 2. *Cyclonaias tuberculata compressa* var. nov. Type, paratype. Big Vermilion River, Middle Fork, west of Danville, Ill. U. of I., Z11672.

Fig. 3. *Anodontoides ferussacianus* (Lea). Cylindrical form. Nesho mill pond, Dodge Co., Wis. U. of I., Z17325.

Fig. 4. *Anodontoides ferussacianus* (Lea). Male shell. Middle Fork, Big Vermilion River, west of Danville, Ill. Z11212.

Fig. 5. *Anodontoides ferussacianus* (Lea). Female shell. Salt Fork, Big Vermilion River, Muncie, Ill. U. of I., Z11702.

Figs. 6-8. *Strophitus rugosus lacustris* var. nov. Fig. 6, immature; fig. 7, type. Oconomowoc Lake, Waukesha Co., Wis. Z22073. Fig. 8, elongated form somewhat like creek form. Silver Lake, Waukesha Co. U. of I., Z22074.

Figures slightly reduced.

PLATE LXXVI

Figs. 1, 2. *Obliquaria reflexa* Raf. Wisconsin River. U. of W., 128.

Fig. 3. *Obliquaria reflexa* Raf. Mississippi River, Ill. U. of W., 323a, b.

Fig. 4. *Obovaria olivaria* (Raf.). Wisconsin River. U. of W., 130. Male with high beaks.

Figs. 5, 8. *Obovaria olivaria* (Raf.). Omro, Fox River. U. of W., 948a. Female shell, compressed.

Fig. 6. *Obovaria olivaria* (Raf.). Wisconsin River, Sauk Co. U. of I., Z4471a. Male.

Fig. 7. *Obovaria olivaria* (Raf.). Portage, Wisconsin River. U. of W., 949. Male.

About $\frac{3}{4}$ natural size.

PLATE LXXVII

Figs. 1, 2. *Obovaria olivaria* (Raf.). Wisconsin River, Sauk Co. U. of I., Z4471b. c. Male (1) and female (2).

Fig. 3. *Actinonaias carinata* (Barnes). Prairie du Chien. Dudley coll. Immature, with rays.

Fig. 4. *Actinonaias carinata* (Barnes). St. Croix River above Grantsburg. U. of W., 953. Female.

Figs. 5, 6. *Actinonaias carinata* (Barnes). Omro, Fox River. U. of W., 922a, b. Males.

About $\frac{3}{4}$ natural size.

PLATE LXXVIII

Figs. 1, 2. *Truncilla truncata lacustris* Baker. Long Point Island, Lake Winnebago. U. of W., 958. Holotype.

Fig. 3. *Truncilla truncata* Raf. Lake Pepin. U. of W., 349. Immature.

PLATE LXXVII—Continued

Figs. 4, 5. *Truncilla truncata* Raf. Fox River, Omro. U. of W., 957. Female.

Figs. 6, 7. *Truncilla truncata* Raf. Princeton, Fox River. U. of W., 954.

Figs. 8, 9. *Truncilla truncata* Raf. Sauk Co., Wisconsin River. U. of I., Z4519a. Male.

About $\frac{3}{4}$ natural size.

PLATE LXXIX

Figs. 1, 3. *Truncilla donaciformis* (Lea). Wisconsin River, Sauk Co. U. of I., Z4532. Male.

Fig. 2. *Truncilla donaciformis* (Lea). Illinois. U. of W., 341. Female.

Figs. 4, 5. *Plagiola lineolata* Raf. Prairie du Chien. Dudley coll. Male.

Figs. 6, 7. *Plagiola lineolata* Raf. Wisconsin River. U. of W., 67. Immature.

Fig. 8. *Plagiola lineolata* Raf. Kishwaukee River, Ill. U. of I., Z4492. Female.

About $\frac{4}{5}$ natural size.

PLATE LXXX

Figs. 1-4. *Leptodea fragilis* Raf. Omro, Fox River. U. of W., 961a, b. Figs. 1, 2, male; 3, 4, female.

Figs. 5-7. *Leptodea fragilis lacustris* (Baker). Off Plummers Point, Lake Butte des Morts. U. of W., 964. Figs. 5, 6. Female. Type. Fig. 7. Immature.

Figs. 1, 7. Slightly reduced; 2-6, natural size.

PLATE LXXXI

Figs. 1, 2. *Leptodea fragilis lacustris* (Baker). Plummers Point, Lake Butte des Morts. U. of W., 964c, d. Fig. 1, male; 2, female.

Figs. 3-6. *Proptera alata* (Say). Long Point Island, Lake Winnebago. U. of W., 967 c, d. Figs. 3, 4, Female; 5, 6, male.

$\frac{3}{4}$ natural size (5 about natural size)

PLATE LXXXII

Proptera alata megaptera Raf.

Figs. 1, 2. Princeton, Fox River. U. of W., 969a, b. Female.

Fig. 3. Prairie du Chien, Mississippi River. U. of W., 968. Male.

Fig. 4. Lake Pepin, Mississippi River. U. of W., 345b. Male.

About $\frac{3}{4}$ natural size.

PLATE LXXXIII

Proptera laevissima (Lea)

Fig. 1. Wabash River, White Co., Ind. U. of I., Z4396. Immature.

Figs. 2, 3. Wabash River, White Co., Indiana. U. of I., Z4395. Male.

Slightly reduced in size.

PLATE LXXXIV

Proptera capax (Green)

Wabash River, Posey Co., Ind. U. of I., Z4016. Figs. 1, 3, 4. Males; Fig. 2, Female.

About $\frac{3}{4}$ natural size.

PLATE LXXXV

Figs. 1-4. *Ligumia ellipsiformis* (Conrad). Kishwaukee River, Winnebago Co., Ill. U. of I., Z3791. Fig. 1, Female; 2, male; 3, female; 4, immature.

Figs. 5, 6. *Leptodea leptodon* Raf. New Boston, Mississippi River, Ill. U. of I., Z4399. Immature.

Fig. 6. *Leptodea leptodon* Raf. Duck River, Columbia, Tenn. U. of I., Z4391A. Male.

About natural size.

PLATE LXXXVI

Figs. 1, 2. *Carunculina parva* (Barnes). Edwards Co., Ill. U. of W., 266c. Female.

Figs. 3, 4. *Carunculina parva* (Barnes). Wyocena, Columbia Co., Wis. U. of W., 971. Male.

Figs. 5-7. *Dysnomia triquetra* (Raf.). Omro, Fox River. U. of W., 4424. Immature.

Figs. 8, 9. *Ligumia iris novieboraci* (Lea). Milwaukee, Wis. U. of W., 100. Female.

Figs. 10-11. *Ligumia iris novieboraci* (Lea). Racine, Wis. U. of W., 91. Male.

Fig. 12. *Ligumia iris novieboraci* (Lea). Racine, Wis. Male.

Fig. 13, 14. *Ligumia recta latissima* (Raf.). Racine, Wis. U. of W., 92. Immature.

Figs. 5-7, 10, slightly enlarged; others natural size.

PLATE LXXXVII

Figs. 1-3. *Ligumia recta latissima* (Raf.). Fig. 1. Princeton, Fox River. U. of W., 975. Female. Fig. 2. Prairie du Chien. U. of W., 4402. Male. Fig. 3. Fort Atkinson, Rock River. U. of W., 4401. Male.

Figs. 4, 5. *Ligumia recta* (Lam.). Doemel Point, Lake Winnebago. Fig. 4, female, U. of W., 972a. Fig. 5, male, 972b.

About $\frac{3}{4}$ natural size.

PLATE LXXXVIII

Lampsilis anodontoides (Lea)

Figs. 1, 2. Male, 4405a. Fig. 3. Female, 4405b. Prairie du Chien. U. of W.

About $\frac{3}{4}$ natural size.

PLATE LXXXIX

Figs. 1-4. *Lampsilis fallaciosa* (Smith) Simpson. Chic. Acad. Sci. 20258. Figs. 1, 2. Male. Figs. 3, 4. Female.

Figs. 5-8. *Lampsilis siliquoidea* (Barnes). U. of W., 4407, a, b, c, d. Figs. 5, 6. Male. Figs. 7, 8. Female.

About $\frac{3}{4}$ natural size.

PLATE XC

Fig. 1. *Lampsilis siliquoidea* (Barnes). Interior of valve. Omro, Fox River. U. of W., 4407e. Male.

Lampsilis siliquoidea pepinensis Baker. Lake Pepin, near Lake City, Minn. U. of W., 350, 355p. Figs. 2, 3. Male. Figs. 4, 5. Female. Types.

About $\frac{3}{4}$ natural size.

PLATE XCI

Figs. 1-4. *Lampsilis siliquoidea rosacea* (DeKay). Green Lake. 1, 2, male; 3, 4, female. U. of W., 4409.

Figs. 5-8. *Lampsilis siliquoidea chadwicki* var. nov. Doemel Point, Lake Winnebago: 5, 6, male; 7, 8, female. Types. U. of W., 4413a, b.

About natural size.

PLATE XCII

Lampsilis ventricosa occidentis (Lea)

Figs. 1, 2. Princeton, Fox River, Wis. Male. U. of W., 4414. Figs. 3, 4. Red Cedar River, Barron Co., Wis. Female. U. of W., 4415. Fig. 5. Portage, Wis. Immature. U. of W., 774.

About $\frac{3}{4}$ natural size.

PLATE XCIII

Figs. 1-4. *Lampsilis ventricosa perglobosa* var. nov. Lake Pepin. Type, paratype. Figs. 1, 2, female; 3, 4, male. U. of W., 354, g, a.

Fig. 5. *Lampsilis ventricosa lurida* Simpson. Lake Noquebay, near Crivitz, Marinette Co. Male. U. of W., 4421.

Figs. 1, 4, $\frac{3}{4}$ natural size; 2, 3, 5, slightly enlarged.

PLATE XCIV

Lampsilis ventricosa chadwicki var. nov. Figs. 1, 4, male; 2, 3, female. Type, paratype. Lake Winnebago, near Oshkosh. U. of W., 4423.

Figs. 5, 6. *Lampsilis ventricosa lurida* Simpson. Fig. 5, female, fig. 6, male. Lake Ellen, Wis. U. of I., Z3995.

About $\frac{3}{4}$ natural size.

PLATE XCV

Lampsilis higginsii (Lea)

Figs. 1-3. Lake Pepin. Female. U. of I., Z14027. Figs. 4, 5. Mississippi River, Ill. Male. U. of I., Z7364.

About $\frac{1}{2}$ natural size.

PLATE XCVI

Figs. 1-3. *Sphaerium simile* (Say). Hancock. U. of W., 4428a, b. Fully adult. Variety.

Figs. 4-7. *Sphaerium simile* (Say). New Richmond. U. of W., 4429. Young (7) and immature shells.

Figs. 8-10. *Sphaerium simile planatum* Sterki. Medford. U. of W., 4434.

Figs. 11-13. *Sphaerium crassum* Sterki. Phillips. U. of W., 4431.

Figs. 14-17. *Sphaerium aureum declive* Sterki. Red Cliff Creek, near Bayfield. U. of W., 4432.

Figs. 18-20. *Sphaerium lineatum* Sterki. Turkey Lake, Ind. Type locality. U. of I., Z13845.

Fig. 21. *Sphaerium lineatum* Sterki. Winnebago Lake. U. of W., 4433. Ends a trifle rounder.

Figs. 22-24. *Sphaerium torsum* Sterki. Moores Creek, Quebec, Canada. From type set, ex. coll. Latchford.

All figures enlarged two diameters.

PLATE XCVII

Figs. 1-3. *Sphaerium solidulum* (Prime). Lilycash Creek, near Joliet, Ill. U. of I., Z13871. Typical form.

Figs. 4, 5. *Sphaerium solidulum winnebagoense* Baker. Fox River channel, Lake Butte des Morts, 3.4m. deep. Types. U. of W., 4435.

Fig. 6. *Sphaerium stamineum* (Conrad). Outlet Lake Chetek. U. of W., 4437.

Figs. 7-9. *Sphaerium stamineum* (Conrad). Red Cedar River. U. of W., 4436.

Figs. 10-12. *Sphaerium stamineum wisconsinense* Sterki. Brown Co. U. of W., 4438. Type lot.

Figs. 13, 14. *Sphaerium notatum* Sterki. Outlet Green Lake, below dam. U. of W., 4446. A variation.

PLATE XCVII—Continued

Figs. 15, 17. *Sphaerium ohioense* Sterki. Winnebago Lake. U. of W., 4448.

Fig. 16. *Sphaerium ohioense* Sterki. Portage. U. of W., 4447.

Fig. 18. *Sphaerium notatum* Sterki. West end Green Lake, off mouth of creek. U. of W., 4445.

Figs. 19–22. *Sphaerium emarginatum* (Prime). Red Cedar River. U. of W., 4439.

Figs. 23–26. *Sphaerium acuminatum* (Prime). Lake Michigan shore north of Chicago. U. of I., Z14028.

Figs. 27–29. *Sphaerium flavum foxense* Baker. Lake Butte des Morts. U. of W., 4452.

Figs. 30–32. *Sphaerium bakeri* Sterki. West end Green Lake. U. of W., 4450. Types.

Figs. 33–35. *Sphaerium ohioense* Sterki, var. Wisconsin River, near Kilbourn. U. of W., 4449.

All figures enlarged about two diameters.

PLATE XCVIII

Figs. 1–4. *Sphaerium striatinum* (Lam.). Taber Lake, near Chetek. U. of W., 4440.

Fig. 5. *Sphaerium striatinum* (Lam.). Winnebago Lake. Variation. U. of W., 4441.

Figs. 6–9. *Sphaerium striatinum corpulentum* Sterki. Fox River, Omro. U. of W., 4442.

Fig. 10. *Sphaerium striatinum lilycashense* Baker. Lake Butte des Morts. U. of W., 4443.

Figs. 11, 12. *Sphaerium striatinum lilycashense* Baker. Grantsburg. U. of W., 4444.

Figs. 13, 14. *Sphaerium rhomboideum* (Say). West Creek, Green Lake. U. of W., 4453.

Figs. 15–17. *Sphaerium rhomboideum* (Say). La Porte, Ind. U. of I., Z13729.

Figs. 18–21. *Sphaerium flavum* (Prime). Lake Michigan, Millers, Ind. U. of W., 4451.

Figs. 22–24. *Musculium transversum* (Say). Omro, Fox River. U. of W., 4457.

Fig. 25. *Musculium transversum* (Say). Upper Dells, Kilbourn. U. of W., 4462.

Figs. 26–28. *Sphaerium solidulum* (Prime). Mukwonago River. U. of I., Z22254.

Fig. 29. *Sphaerium simile planatum* Sterki. Dutchmans Lake. U. of I., Z22251.

Figs. 30, 31. *Sphaerium simile planatum* Sterki. Near Oconomowoc Lake. U. of I., 22252.

Figs. 32, 33. *Sphaerium simile planatum* Sterki. Winnebago Lake. U. of I., Z13435.

All figures enlarged about two diameters.

PLATE XCIX

Figs. 1-3. *Sphaerium occidentale* (Prime). Kosciusko, Ind. U. of I., 13849.

Figs. 4, 5. *Sphaerium occidentale amphibium* Sterki. Plummers Point, Lake Butte des Morts. Pool in woods. U. of W., 4456.

Fig. 6. *Musculium ryckholti* (Normand). Pool behind beach, near Sandstone Bay, Green Lake. U. of W., 4460.

Figs. 7-8. *Musculium ryckholti* (Normand). Hays Creek, near Ward, Mont. U. of I., 13864.

Fig. 9. *Musculium ryckholti* (Normand). Pool behind beach, Bayfield. U. of W., 4461.

Figs. 10-13. *Musculium securis* (Prime). Clear Lake, La Porte, Ind. U. of I., 13857.

Fig. 14. *Musculium securis sphaericum* (Anthony). Pool near Prairie Lake, near Chetek. U. of W., 4463.

Figs. 15-17. *Musculium securus sphaericum* (Anthony). Pond near Camp Colfax, La Porte, Ind. U. of I., 13683.

Fig. 18. *Musculium securis sphaericum* (Anthony). Same location. Variation. U. of I., 13864.

Figs. 19, 20. *Musculium rosaceum* (Prime). Wisconsin River, above Kilbourn. U. of W., 4459.

Figs. 21-23. *Musculium truncatum* (Linsley). Small stream near Sandstone Bay, Green Lake. U. of W., 4458.

Figs. 24-26. *Musculium partumeium* (Prime). Kosciusko Co., Ind. U. of I., 13853.

Fig. 27. *Musculium jayense* (Prime). De Pere. U. of W., 431.

Fig. 28. *Musculium jayense* (Prime). Four Miles south of De Pere. U. of W., 446.

All figures enlarged slightly more than 3 diameters.

PLATE C

Figs. 1-3. *Pisidium idahoense* Roper. Fish Lake, Bayfield Co. U. of W., 4464.

Figs. 4-6. *Pisidium virginicum* (Gmelin). Four miles south of De Pere, Brown Co. U. of W., 412a. $\times 4$.

Figs. 7, 8. *Pisidium peraltum* Sterki. West end Green Lake. U. of W., 4472. $\times 6$.

Figs. 9, 10. *Pisidium compressum* Prime. Medford. U. of W., 4465. $\times 6$.

Figs. 11, 12. *Pisidium compressum* Prime. Galena, Mo. U. of I., 13818. $\times 6$.

Fig. 13. *Pisidium compressum* Prime. Galena, Mo. U. of I., 13817. $\times 6$.

Figs. 14, 15. *Pisidium compressum limnicolum* Sterki. Winnebago Lake. U. of W., 4469. $\times 6$.

Figs. 16, 17. *Pisidium compressum limnicolum* Sterki. Fox River, Brown Co. U. of W., 4466. From type lot. $\times 6$.

PLATE C—Continued

Figs. 18–20. *Pisidium compressum pellucidum* Sterki. Lake Butte des Morts. U. of W., 4467. $\times 6$.

Fig. 21. *Pisidium compressum pellucidum* Sterki. Fox River, Brown Co. U. of W., 4468. Beaks without appendages. $\times 6$.

Figs. 22–25. *Pisidium pauperculum* Sterki. Winnebago Lake. U. of W., 4505. $\times 7$.

Figs. 26, 27. *Pisidium contortum* Prime. Green Lake. U. of W., 4501. $\times 7$.

PLATE CI

Figs. 1–4. *Pisidium variabile* Prime. Brown Co. U. of W., 4473. $\times 7$.

Figs. 6, 18. *Pisidium sargenti* Sterki. Winnebago Lake. U. of W., 4479. Fig. 6, $\times 6$; Fig. 18, $\times 8$.

Fig. 5. *Pisidium sargenti* Sterki. Lake Butte des Morts. U. of W., 4480. $\times 6$.

Fig. 7. *Pisidium adamsi affine* Sterki. Yellow River, near Spooner. U. of W., 4477. $\times 5$.

Figs. 8, 19. *Pisidium adamsi affine* Sterki. Taber Lake, near Chetek. U. of W., 4476. Fig. 8, $\times 4$; Fig. 19, $\times 6$.

Fig. 9. *Pisidium adamsi affine* Sterki. Lake Butte des Morts. U. of W., 4478. Young shell. $\times 8$.

Figs. 10, 20. *Pisidium noveboracense* Prime. Fox River, Brown Co. U. of W., 506. Fig. 10, $\times 5$; Fig. 20, $\times 6$.

Fig. 11, 12. *Pisidium noveboracense* Prime. Green Bay, Brown Co. U. of W., 4481. $\times 5$.

Fig. 13. *Pisidium scutellatum cristatum* Sterki. Lake Chetek. U. of W., 4485. $\times 7$.

Figs. 14–16. *Pisidium scutellatum* Sterki. Lake Winnebago, Miller Bay. U. of W., 4482. $\times 5$.

Fig. 17. *Pisidium scutellatum* Sterki. Lake Butte des Morts. U. of W., 4484. $\times 6$.

Figs. 21–23. *Pisidium subrotundum* Sterki. Bayfield, in small pool. U. of W., 4493. $\times 7$.

PLATE CII

Figs. 1–4. *Pisidium fallax* Sterki. Winnebago Lake. U. of W., 4470. $\times 7$.

Figs. 5–8. *Pisidium minusculum* Sterki. Lake Butte des Morts. U. of W., 4474. $\times 7$.

Figs. 9–11. *Pisidium glabellum* Sterki. Lake Butte des Morts. U. of W., 4475. $\times 7$.

Figs. 12–14. *Pisidium walkeri* Sterki. Miller Bay, Lake Winnebago. U. of W., 4486. $\times 7$.

Figs. 15, 16. *Pisidium overi* Sterki. Silver Creek, Green Lake, behind bar. U. of W., 4487. $\times 7$.

PLATE CII—Continued

Figs. 17, 18. *Pisidium strengi* Sterki. Winnebago Lake. U. of W., 4489. $\times 6$.

Fig. 19. *Pisidium politum* Sterki. Prairie Lake, near Chetek. U. of W., 4490. $\times 6$.

Figs. 20, 21. *Pisidium politum decorum* Sterki. Tyrell's sand pit pond. U. of W., 4491. $\times 7$.

Fig. 22. *Pisidium politum decorum* Sterki. Pond behind beach, near Bayfield. U. of W., 4492. $\times 6$.

Figs. 23–25. *Pisidium roperi* Sterki. Small swale, Madeline Island, near Bayfield. U. of W., 4488. $\times 5$.

Fig. 26. *Pisidium subrotundum pumilum* Sterki. Marinette. U. of W., 4496. $\times 7$.

Fig. 27. *Pisidium punctatum simplex* Sterki. Fox River, Brown Co. U. of W., 4471. Type locality. $\times 8$.

Figs. 28–30. *Pisidium splendidulum* Sterki. Winnebago Lake. U. of W., 4497. $\times 7$.

PLATE CIII

Figs. 1–4. *Pisidium abditum* Haldeman. Steuben Co., Ind. U. of I., Z13919. From spring. $\times 7$.

Fig. 5. *Pisidium abditum* Haldeman. Small pond, west end Green Lake. U. of W., 4493. $\times 6$.

Fig. 6. *Pisidium medianum* Sterki. Winnebago Lake. U. of W., 4509. $\times 8$. Hinge of left valve.

Figs. 7, 8. *Pisidium medianum* Sterki. Winnebago Lake. U. of W., 4510. $\times 8$.

Figs. 9, 10. *Pisidium complanatum* Sterki. Hinge of left and right valves. Drawn by Mr. A. W. Stelfox. $\times 9$.

Fig. 11. *Pisidium complanatum* Sterki. Muskegon County lakes, Mich. Walker collection, cotype. $\times 9$.

Fig. 12–14. *Utterbackia imbecillis fusca* var. nov. Sturgeon Bay, Door Co. U. of W., 4732. 14, Holotype; 13, paratype. Enlarged.

PLATE CIV

Figs. 1, 2. *Pisidium abyssorum levissimum* Sterki. Off Sherwood Hotel, Green Lake, 47.5 m. U. of W., 4503. $\times 8$.

Figs. 3–5. *Pisidium ferrugineum* Prime. Lake Chetek. U. of W., 4511. $\times 7$.

Figs. 6–8. *Pisidium vesiculare* Sterki. Winnebago Lake. U. of W., 4507. $\times 7$.

Figs. 9–10. *Pisidium vesiculare* Sterki. Winnebago Lake. U. of W., 4508. $\times 7$.

Figs. 11–15. *Pisidium rotundatum* Prime. Skalkako Creek, Montana. U. of I., Z13902. $\times 7$.

PLATE CIV—Continued

Figs. 16–20. *Pisidium abyssorum* (Stimpson) Sterki. Off Racine, in deep water. U. of W., 4502. $\times 7$.

Figs. 21–22. *Pisidium subtruncatum* Malm. Miller Bay, Lake Winnebago. U. of W., 4513. $\times 7$.

Fig. 23. *Pisidium milium* Held. Silver Creek, Green Lake, behind bar. U. of W., 4499. $\times 7$.

Fig. 24. *Pisidium milium* Held. Lake Winnebago, 5.6 m. U. of W., 4498. $\times 7$.

Figs. 25, 26. *Pisidium griseolum* Sterki. Winnebago Lake. U. of W., 4512. $\times 7$.

Figs. 27, 28. *Pisidium punctatum* Sterki. Lilycash Creek, Ill. $\times 7$.

Figs. 29–33. *Pisidium tenuissimum* Sterki. Winnebago Lake. U. of W., 4504. $\times 7$.

PLATE CV

Figs. 1–3. *Pisidium punctatum* Sterki. Nautilus, VIII, pl. ii, figs. 1–3. $\times 12$.

Figs. 4–6. *Pisidium cruciatum* Sterki. Op. Cit., figs. 7–9. $\times 11$.

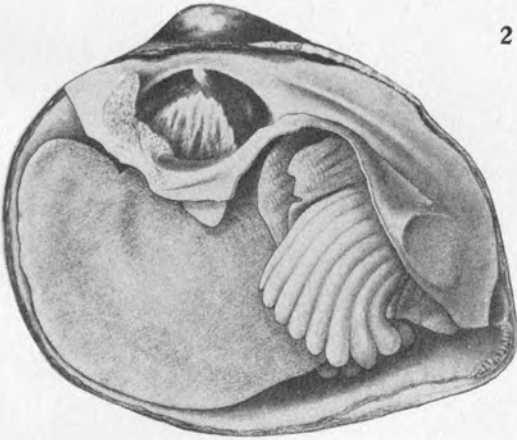
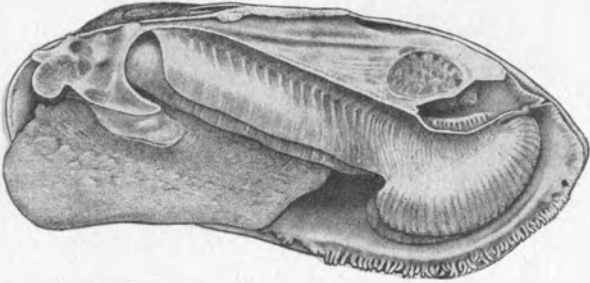
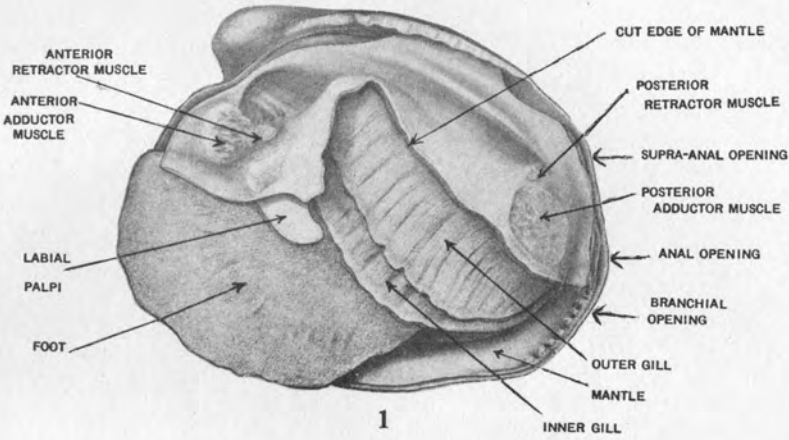
Figs. 7, 8. *Pisidium neglectum* Sterki. Okauchee Bay, Oconomowoc Lake. U. of I., Z22385. $\times 9$.

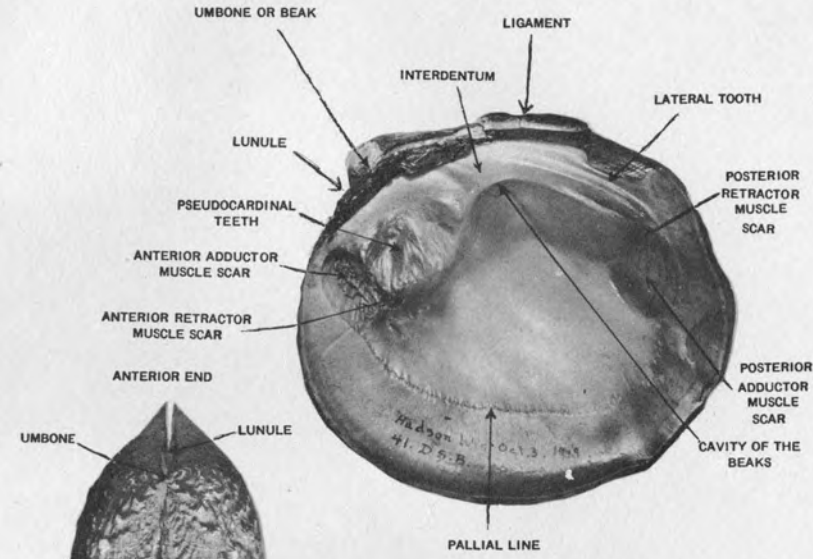
Figs. 9–11. *Pisidium fallax pressum* Sterki. Mukwonago River, Mukwonago. U. of I., Z22387. $\times 10$.

Figs. 12, 13. *Pisidium mainense* Sterki. Golden Lake. U. of I., Z22388. $\times 10$.

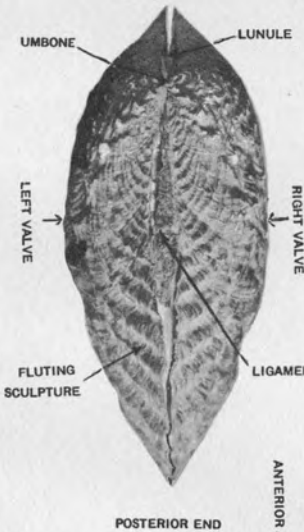
Fig. 14. *Carunculina parva cahni* F. C. Baker. Neosho mill pond. Type. U. of I., Z17341. Natural size.

Figs. 15–18. *Carunculina parva cahni* F. C. Baker. Paratypes. U. of I., Z17342. Natural size.

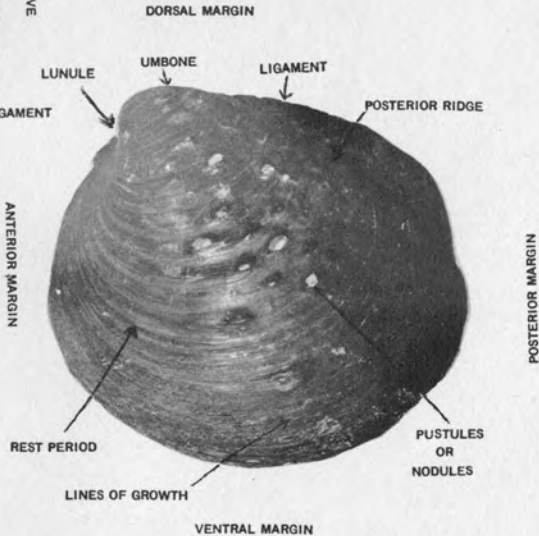




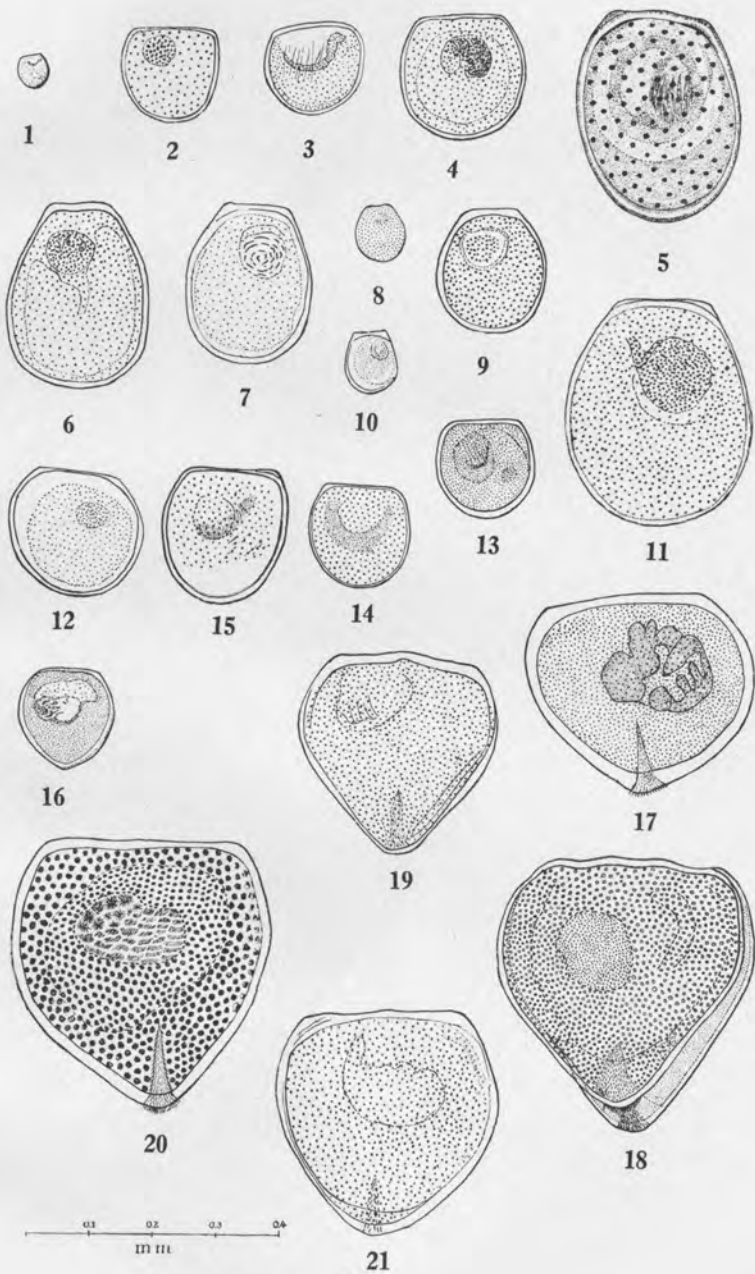
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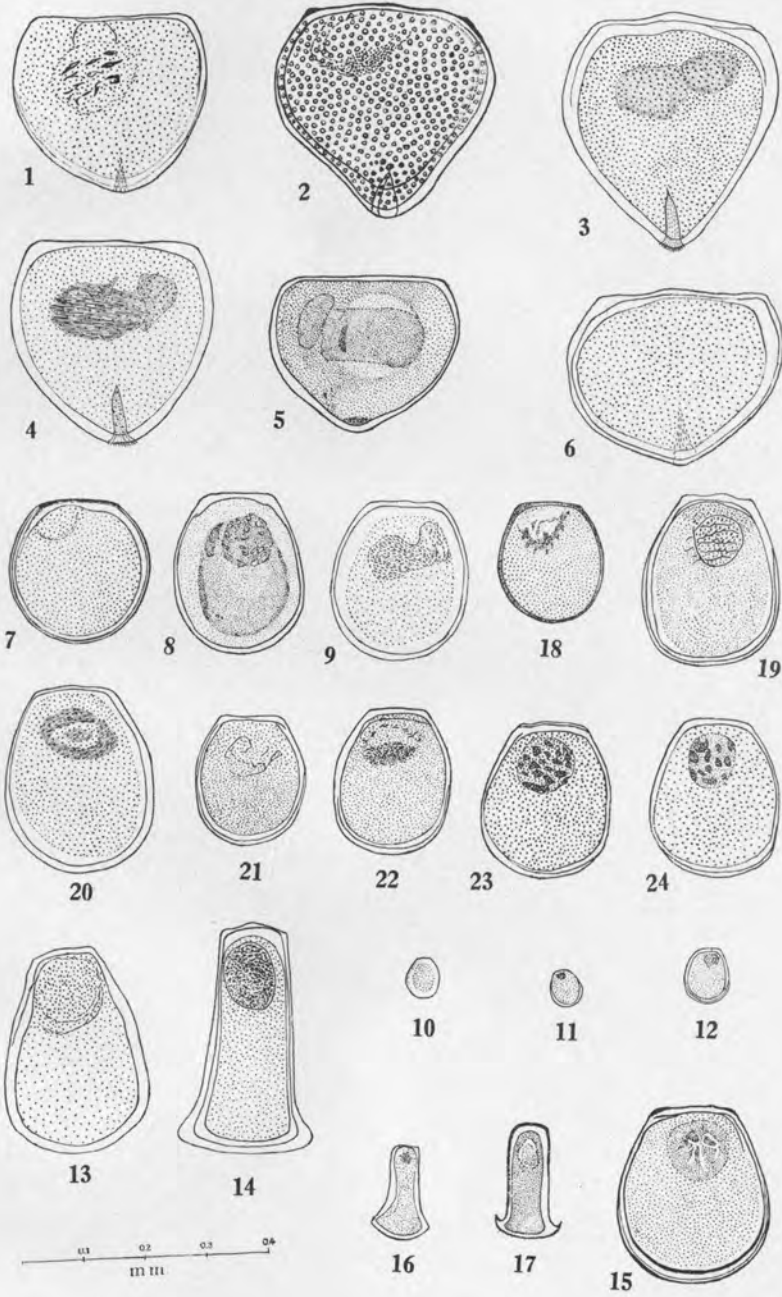


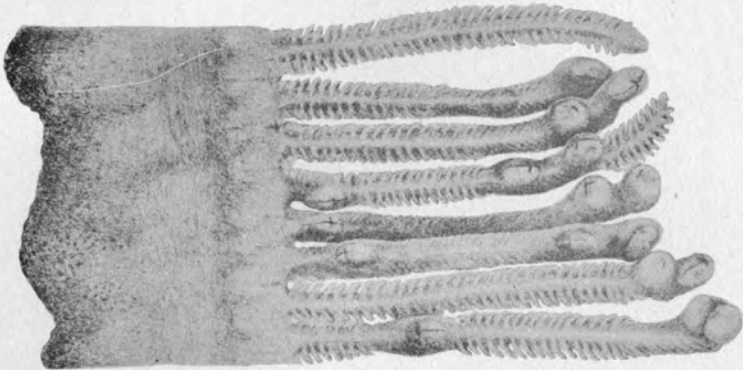
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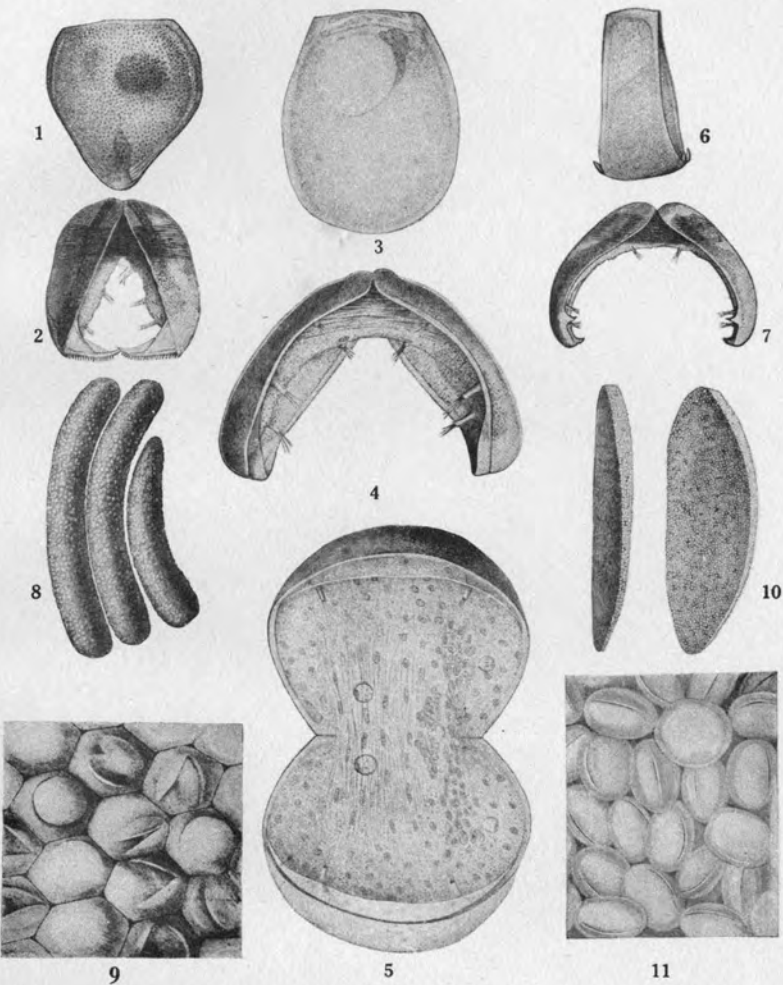
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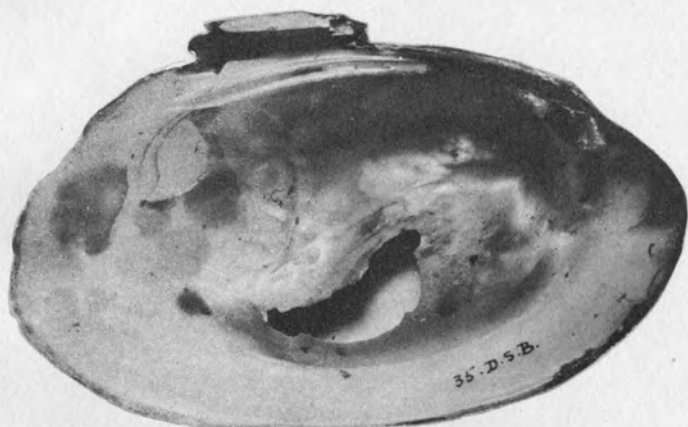


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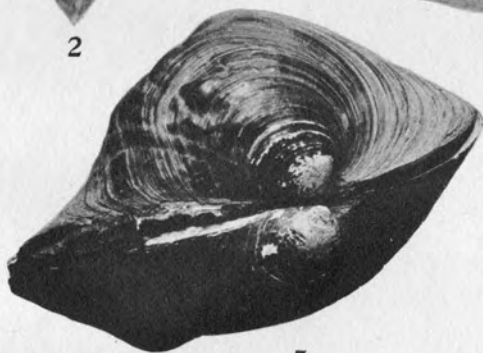
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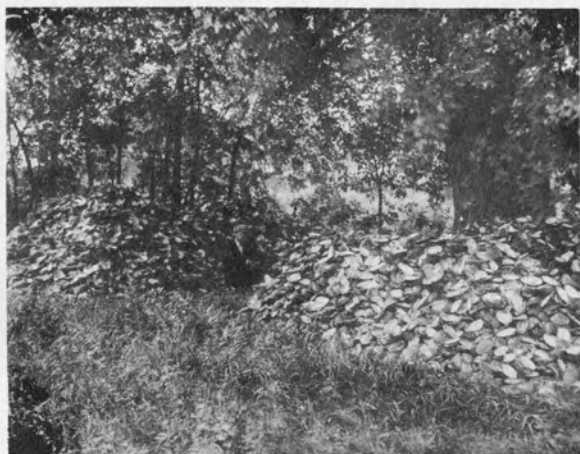
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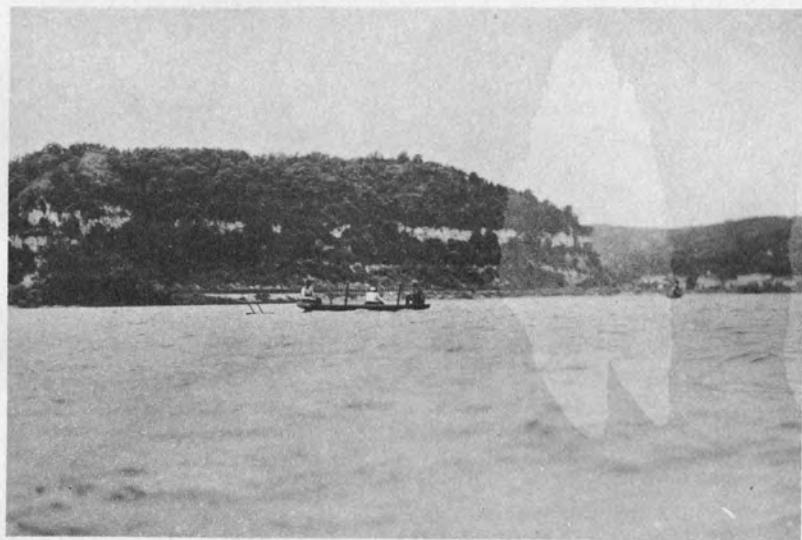


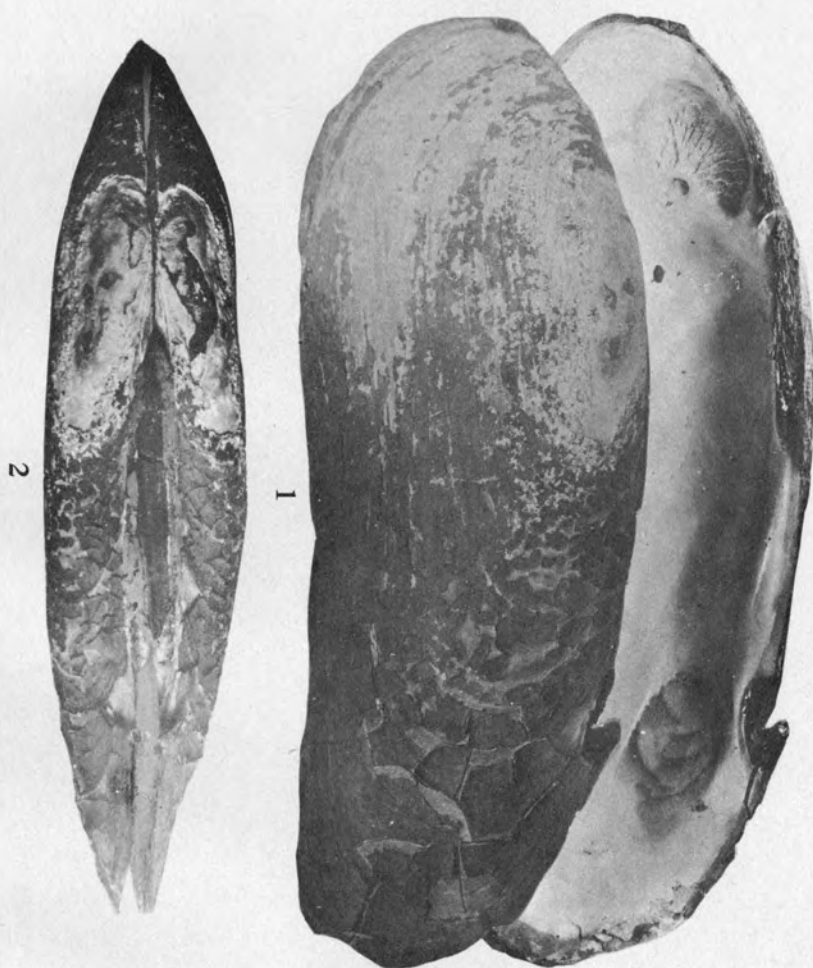
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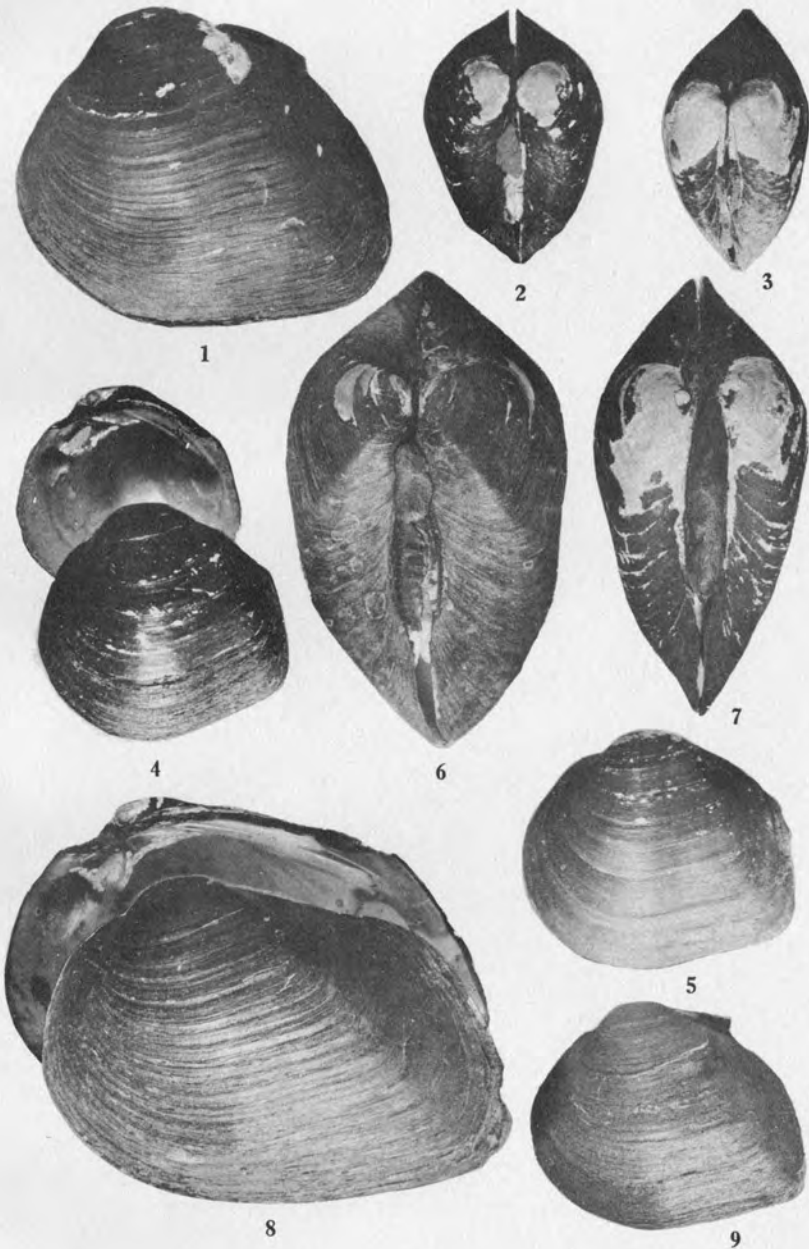


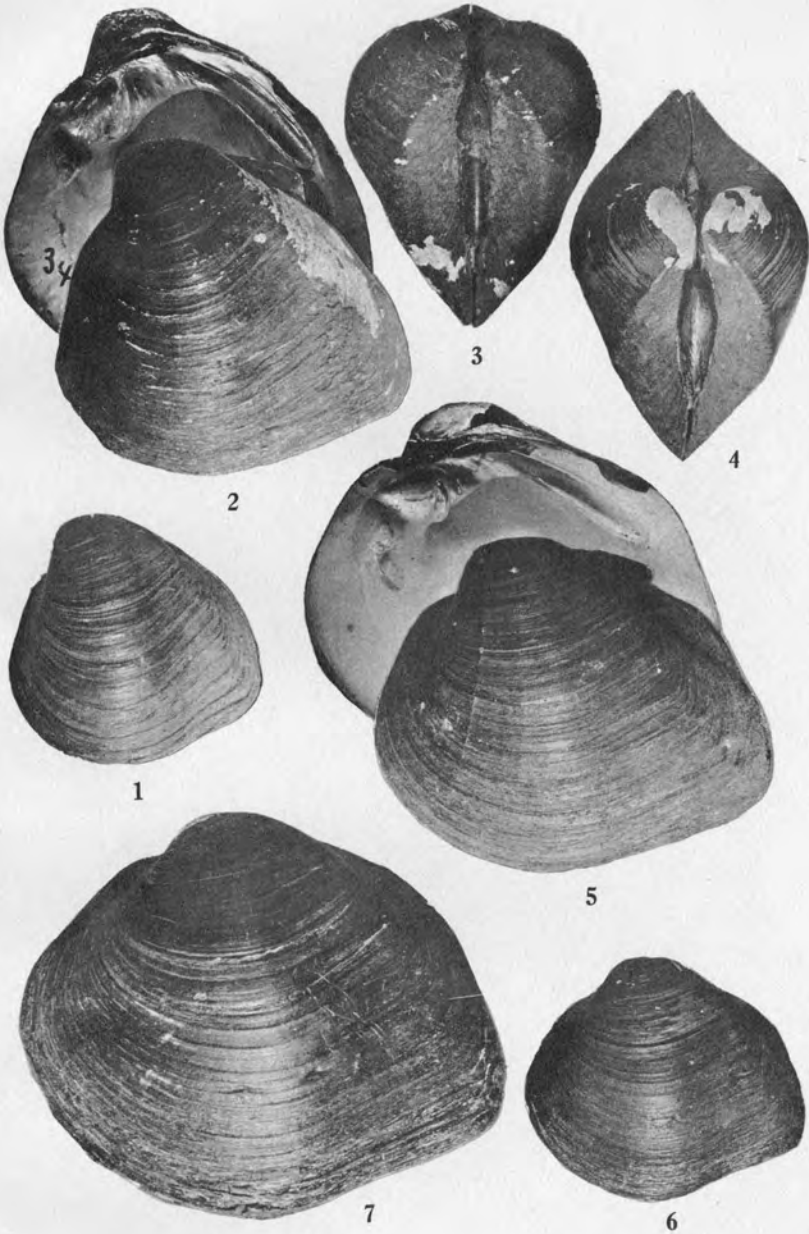
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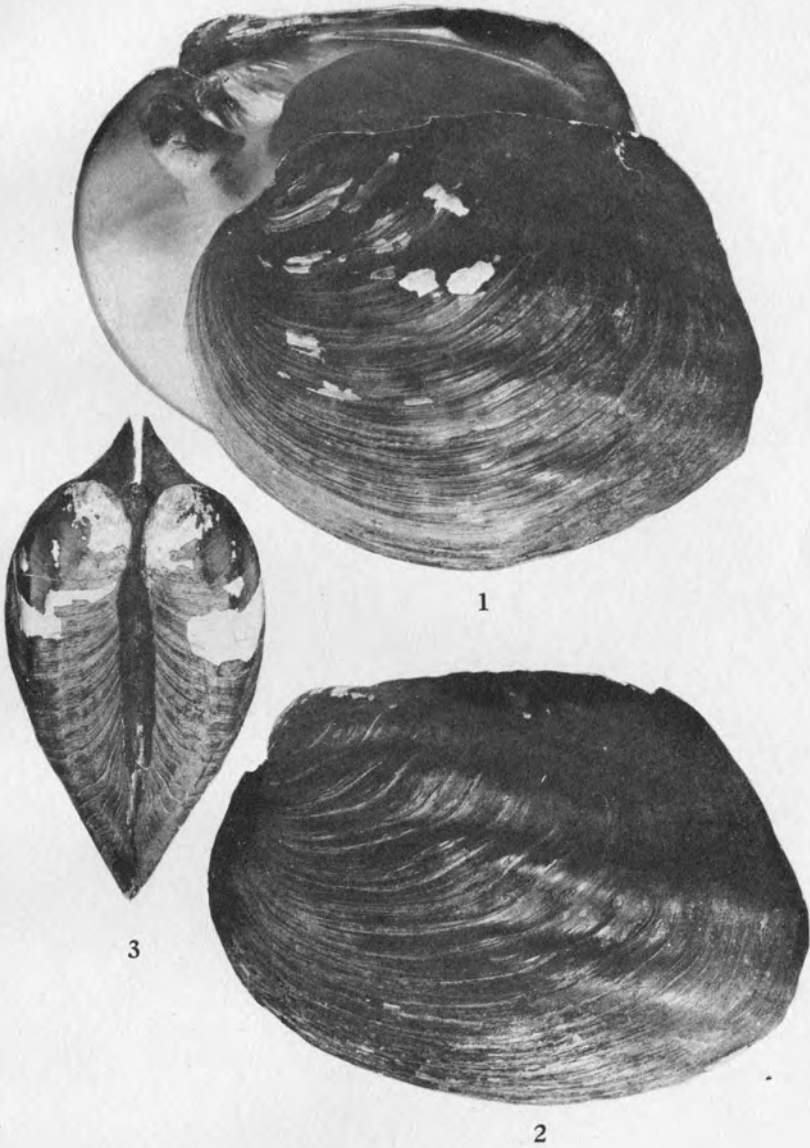
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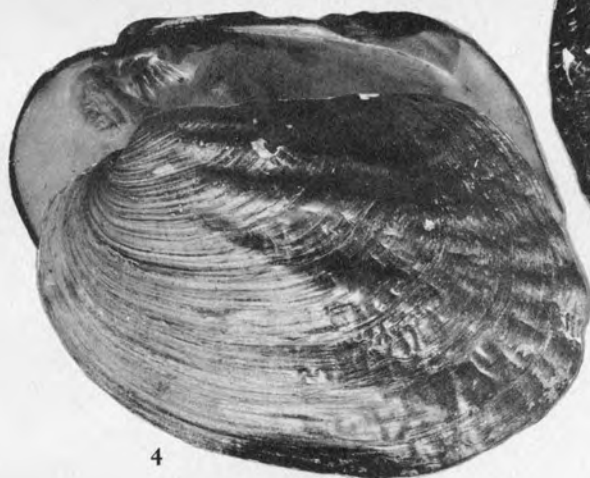


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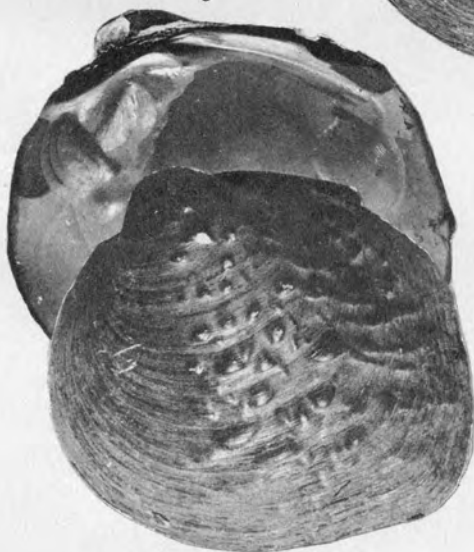
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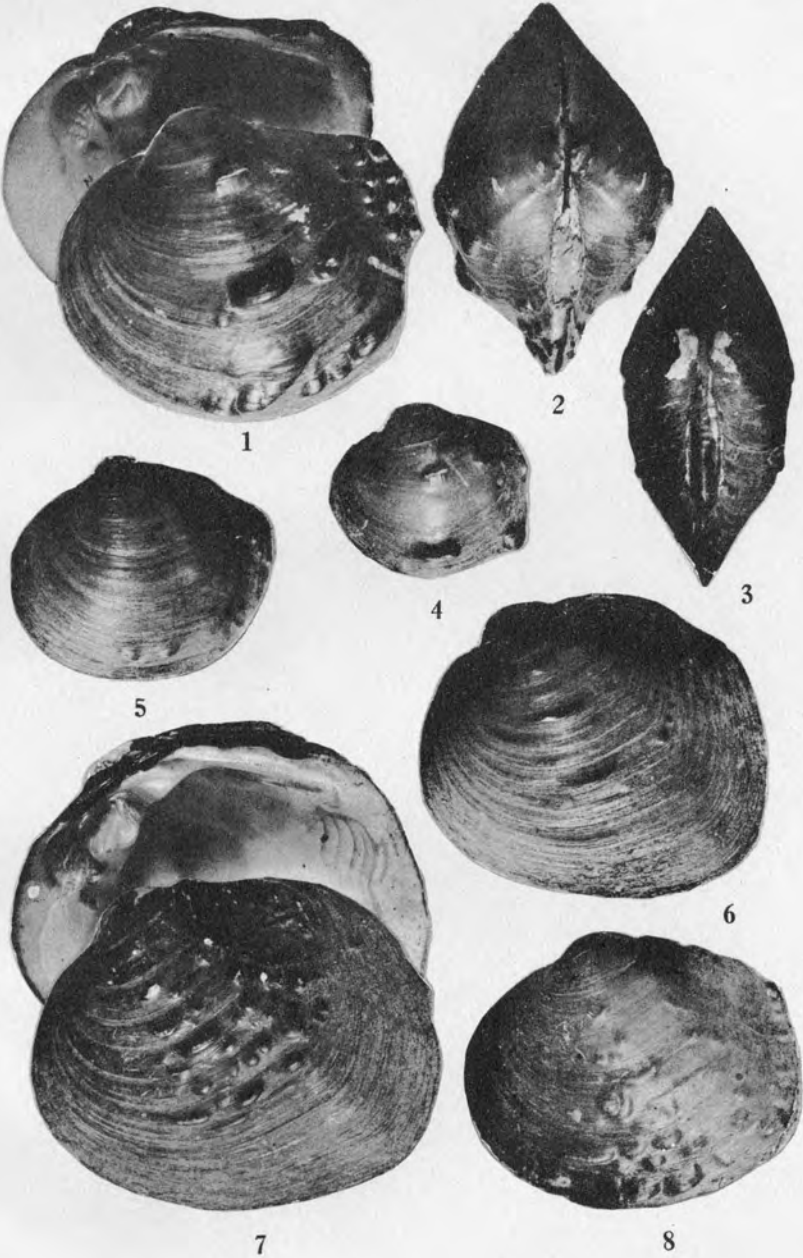
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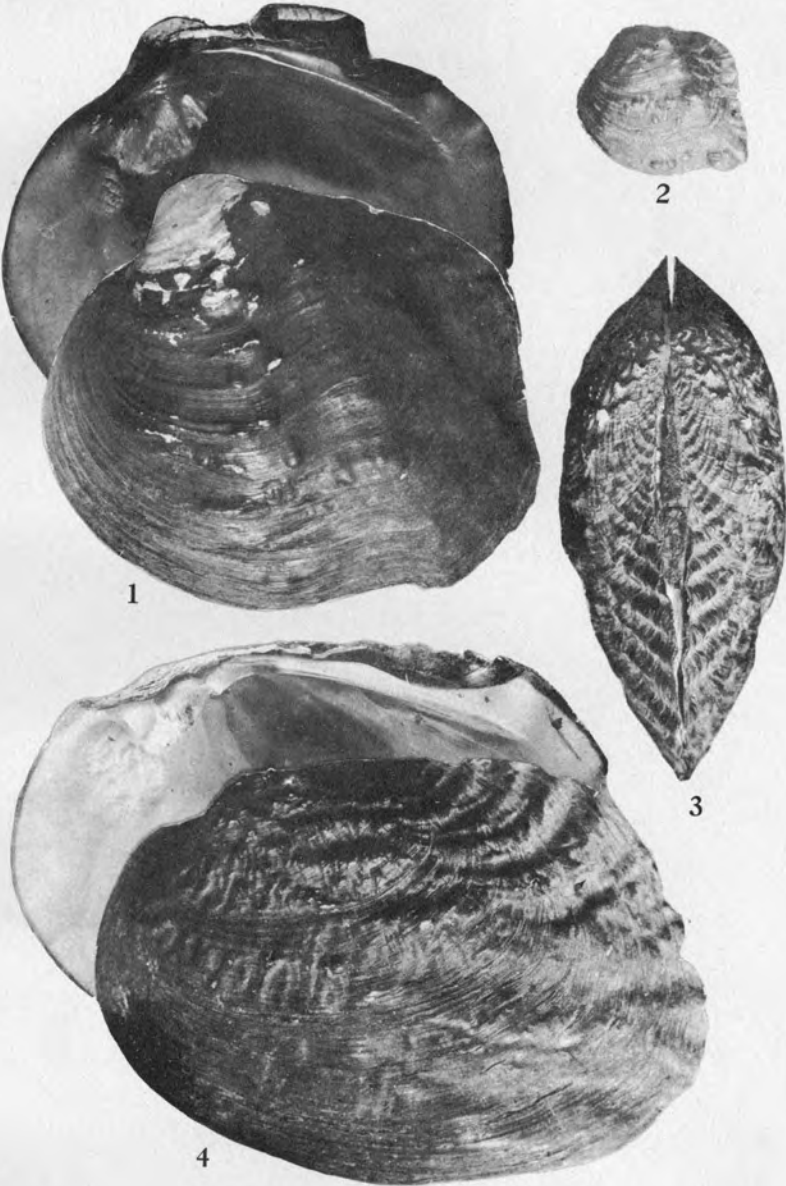
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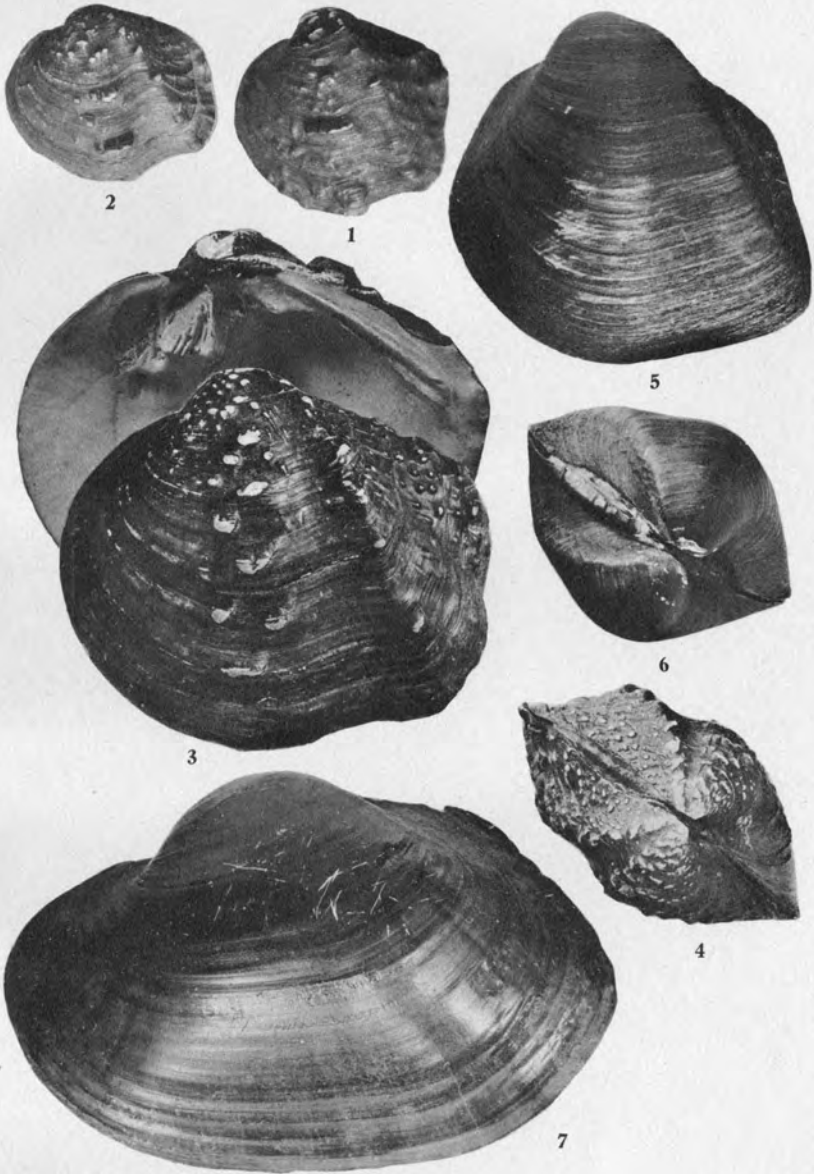


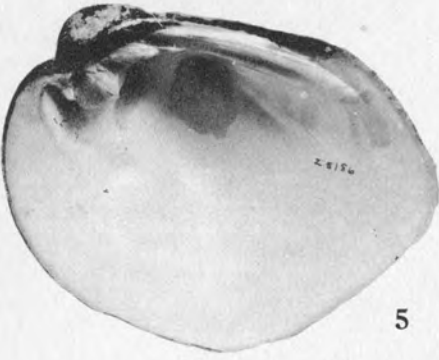
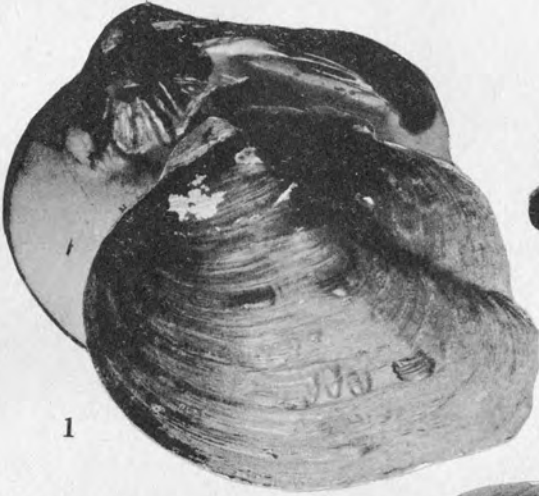
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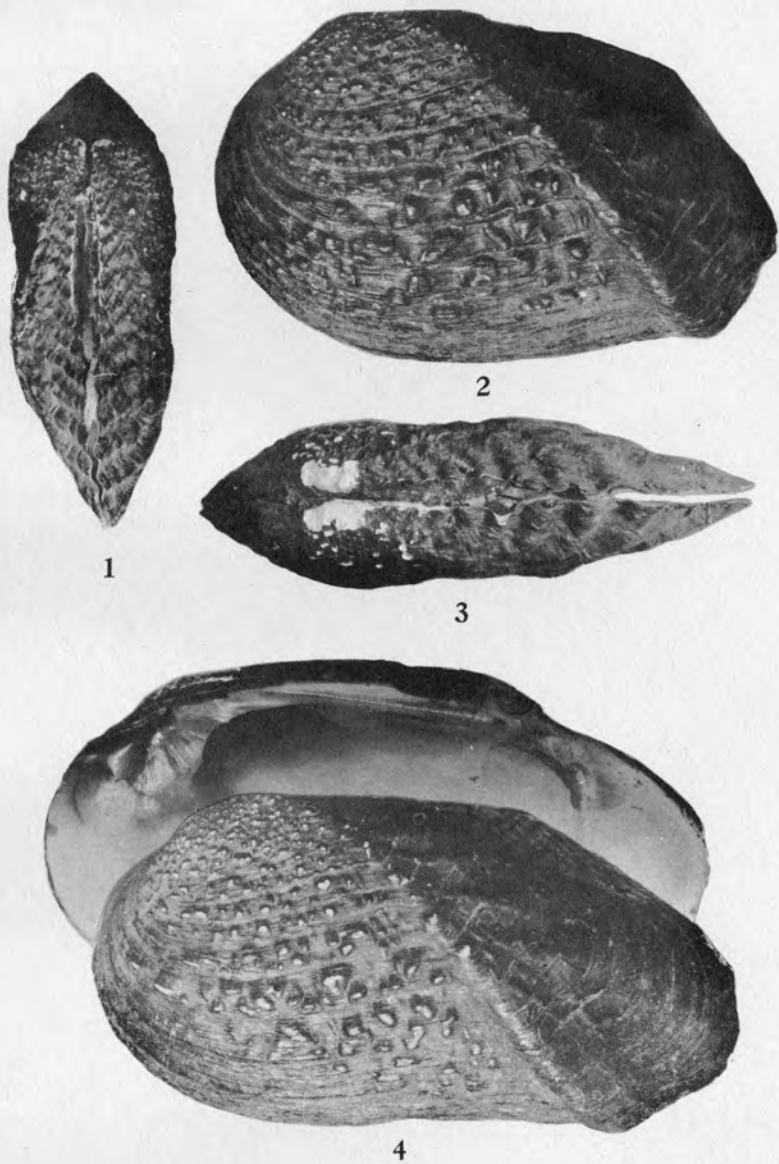


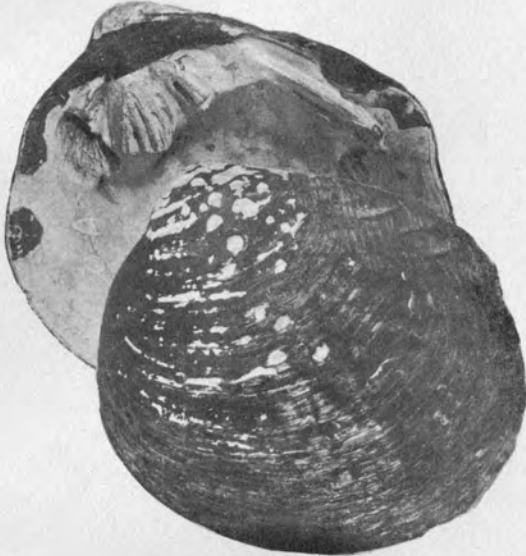
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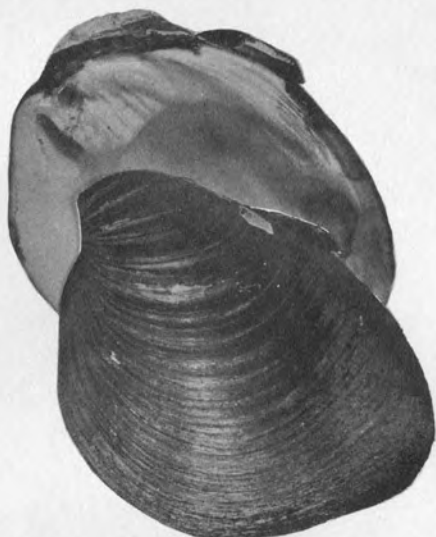
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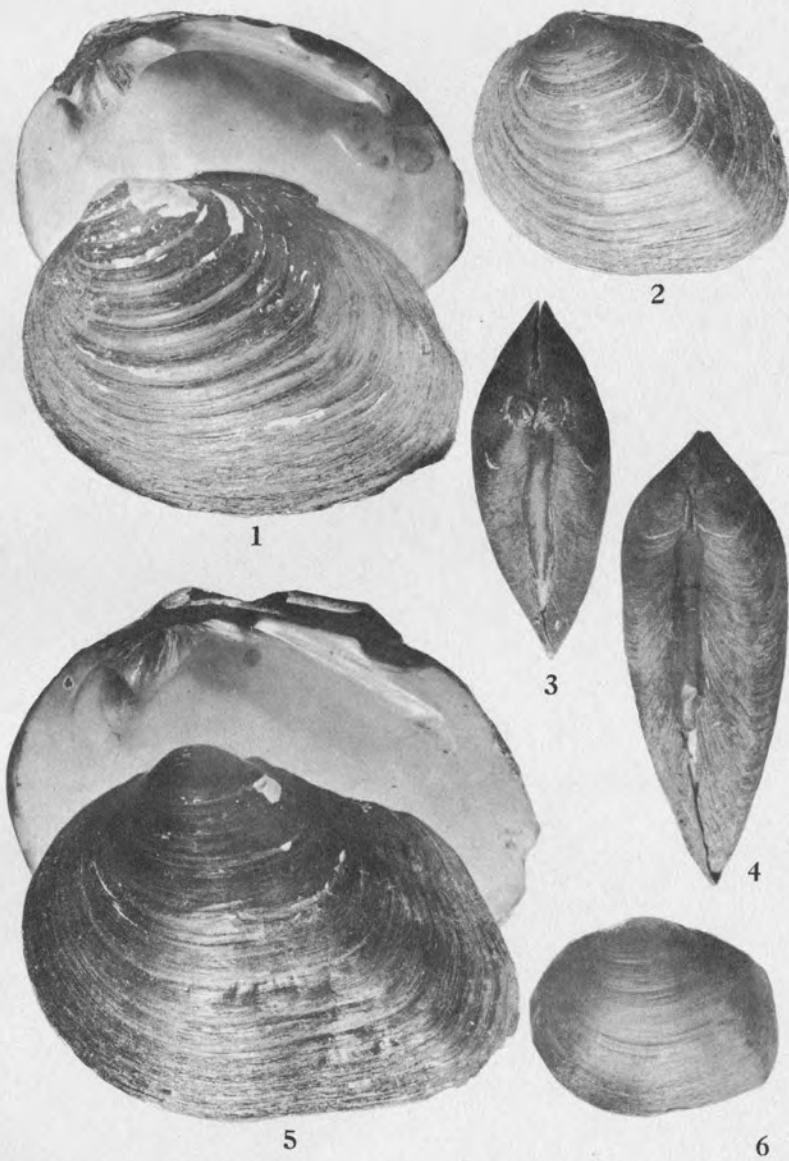
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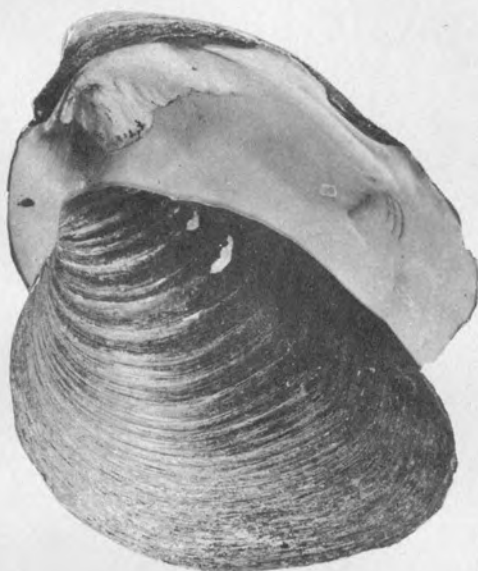


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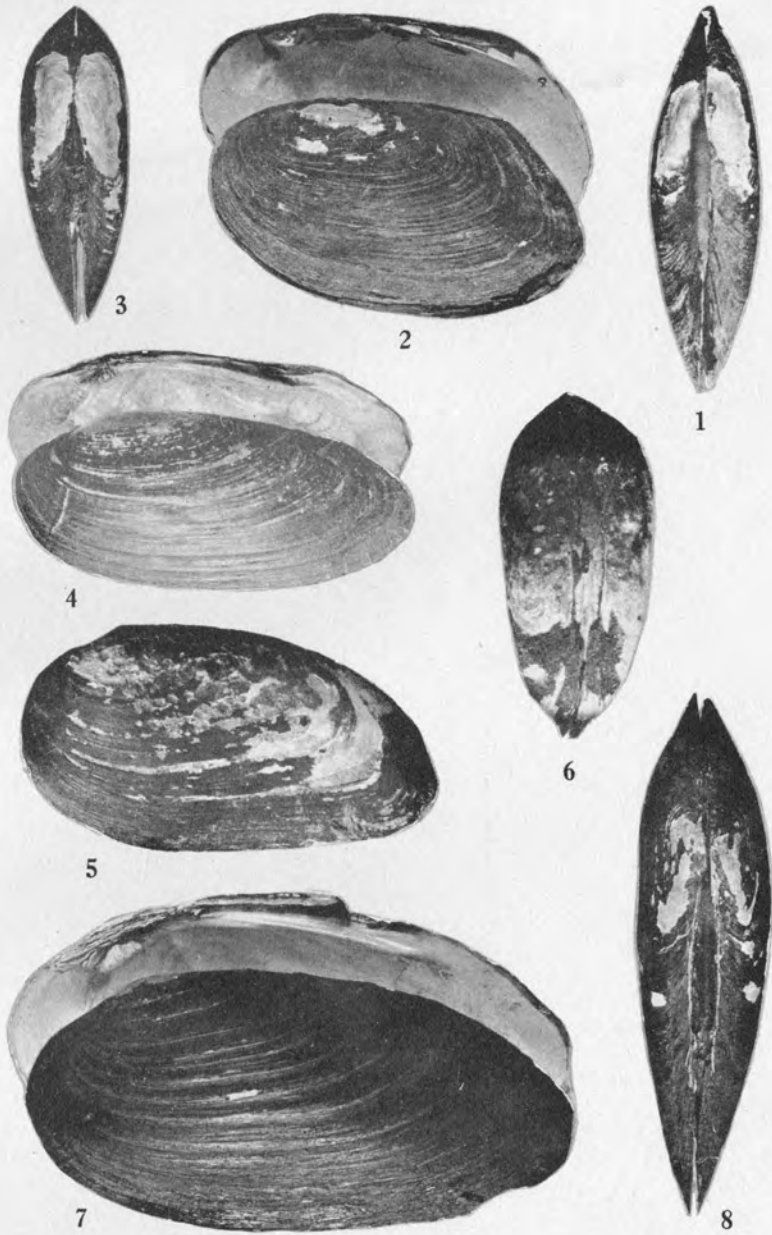
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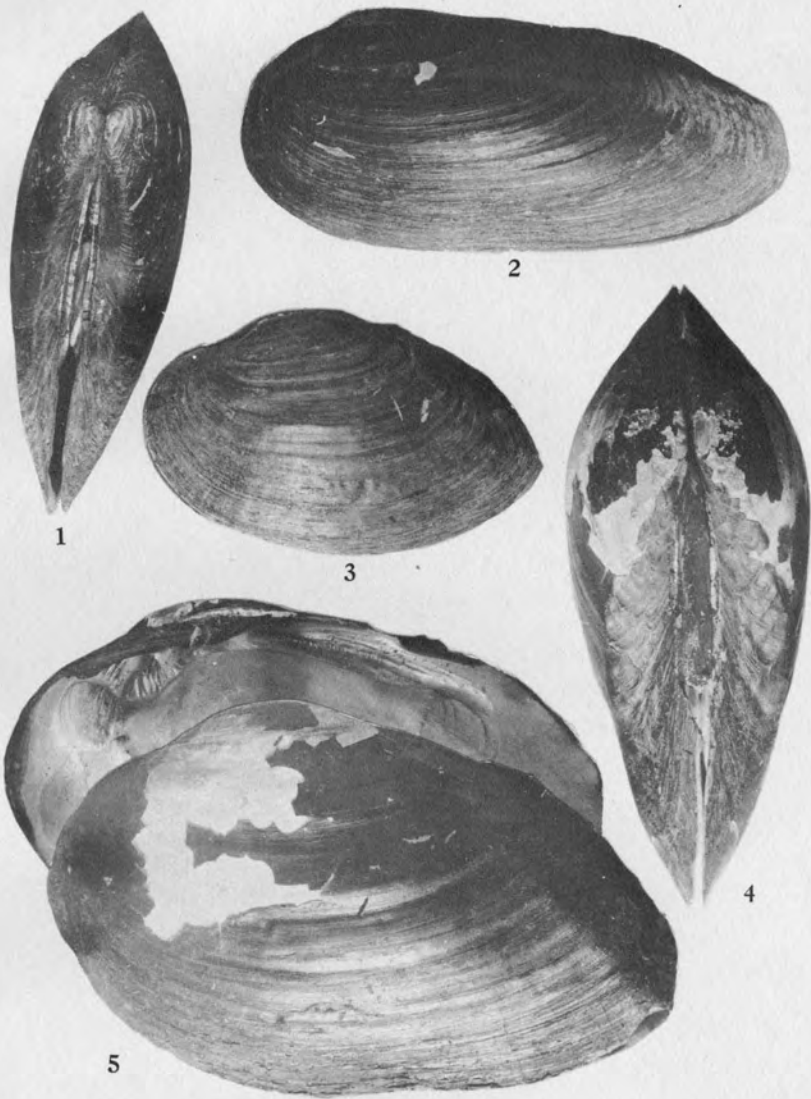


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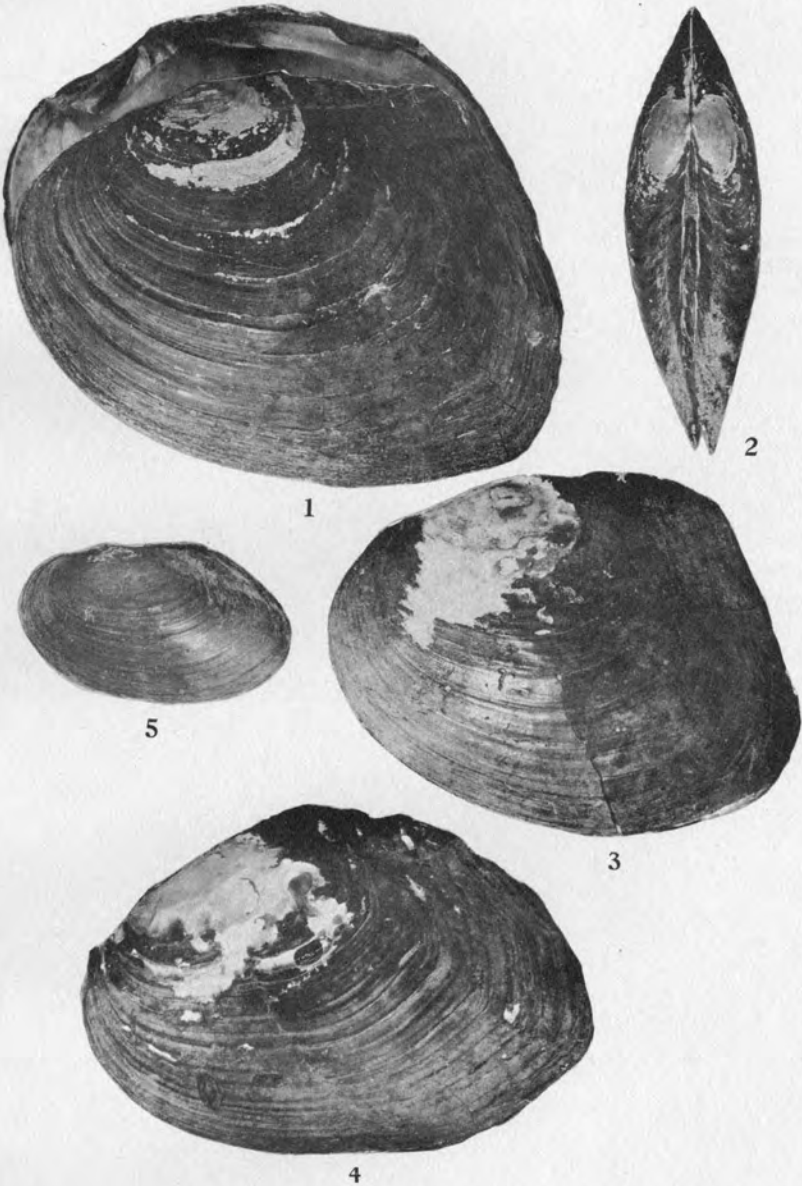
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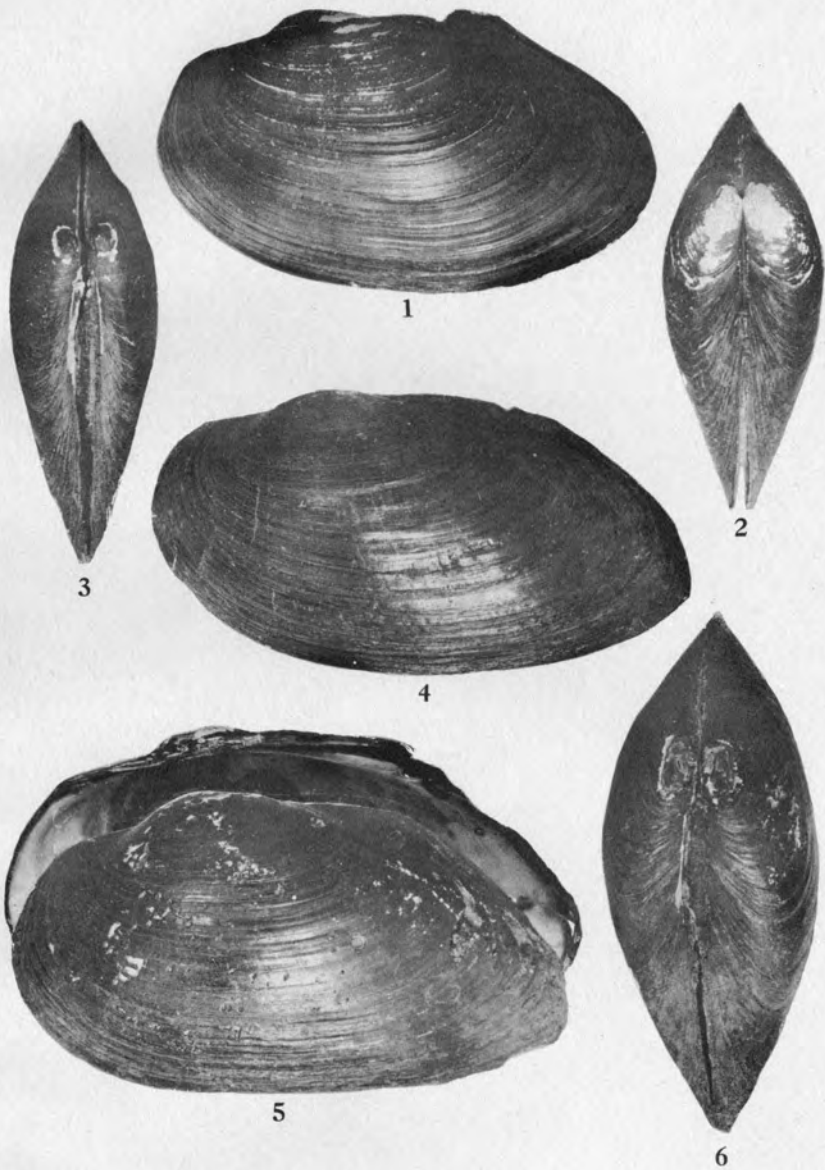


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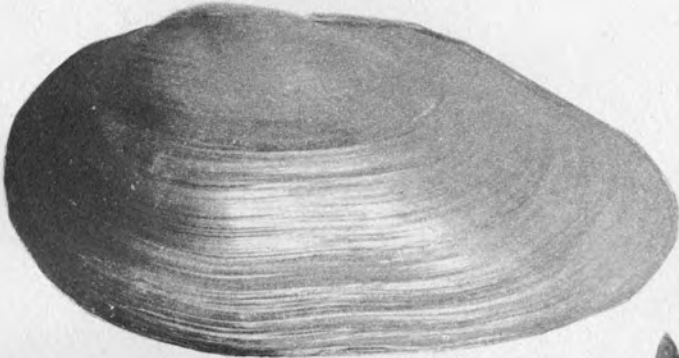
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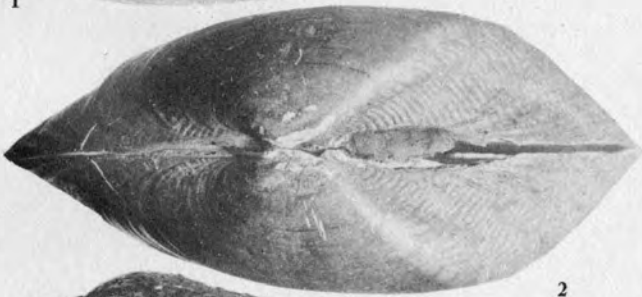
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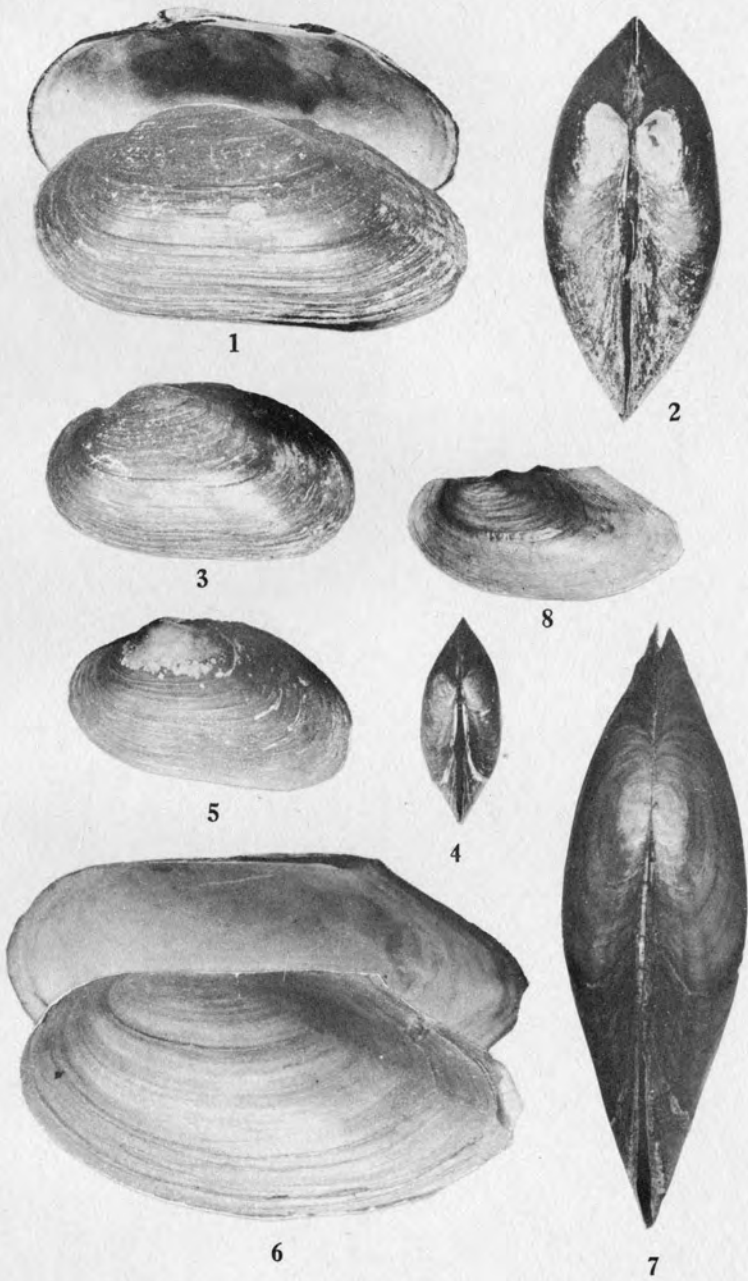
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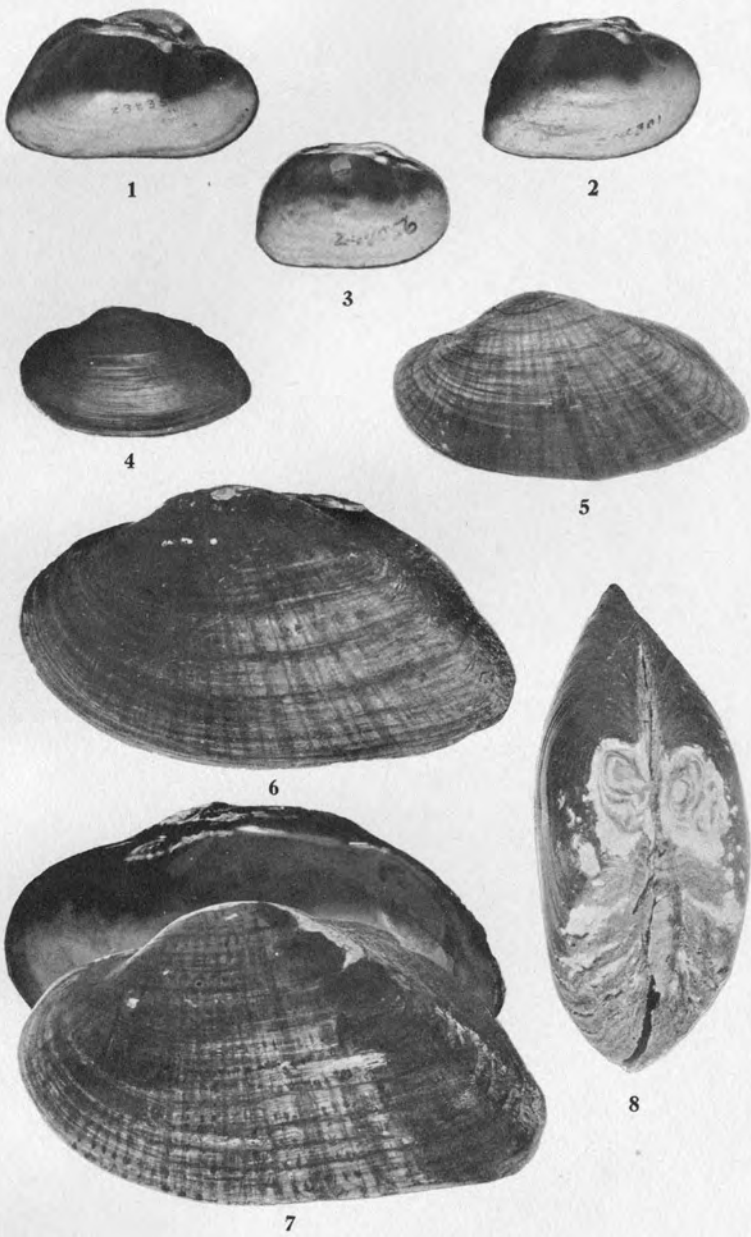


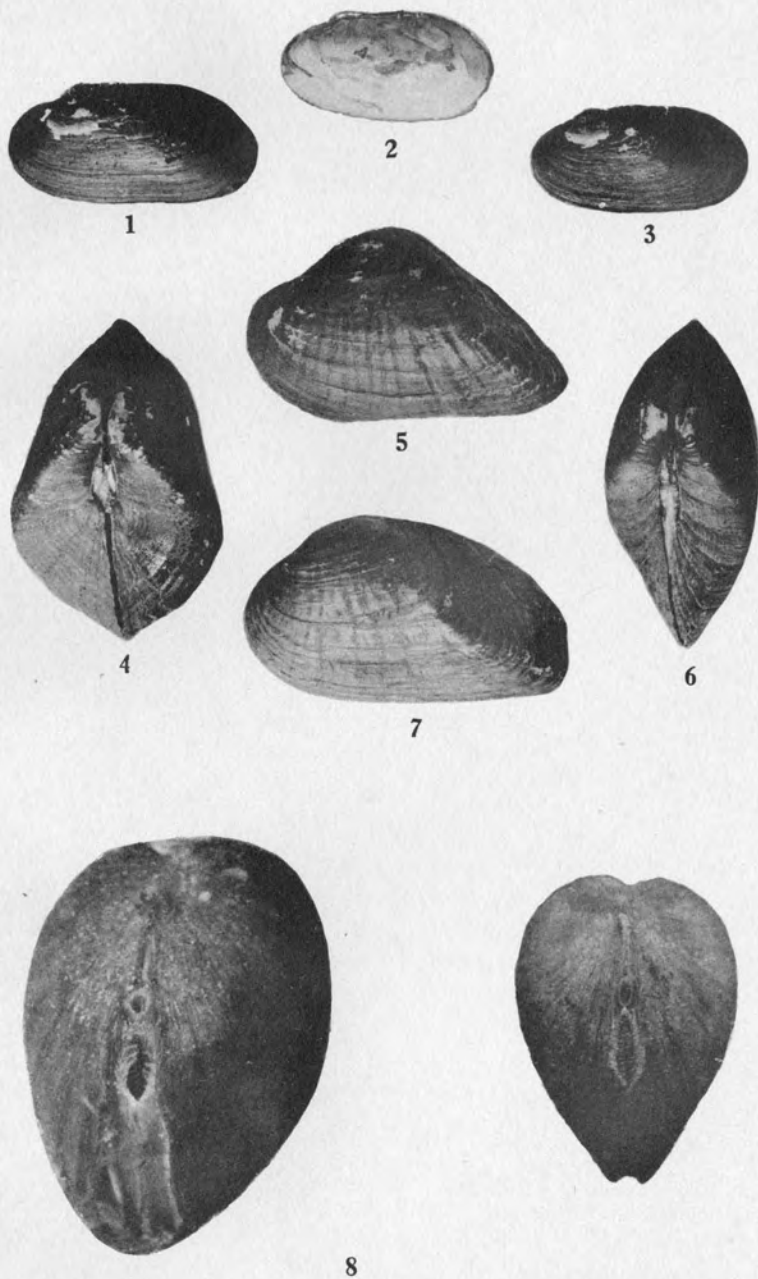
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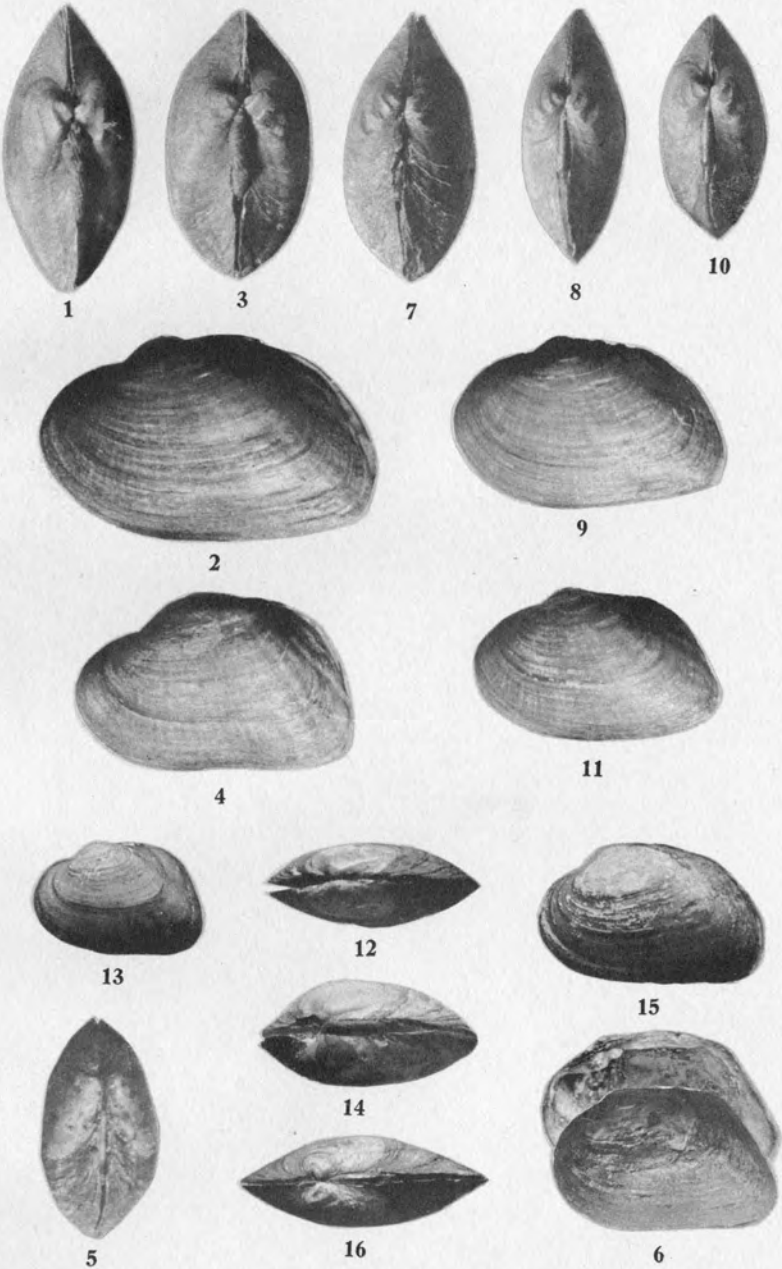
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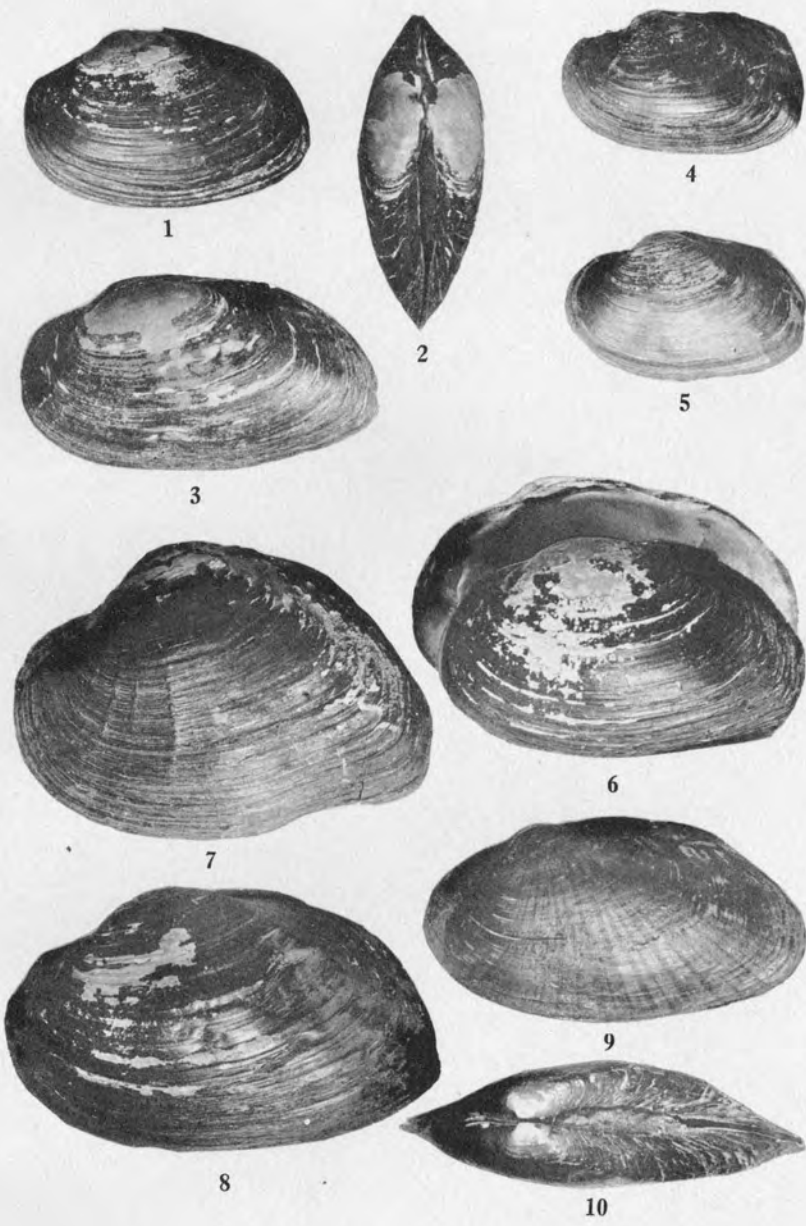
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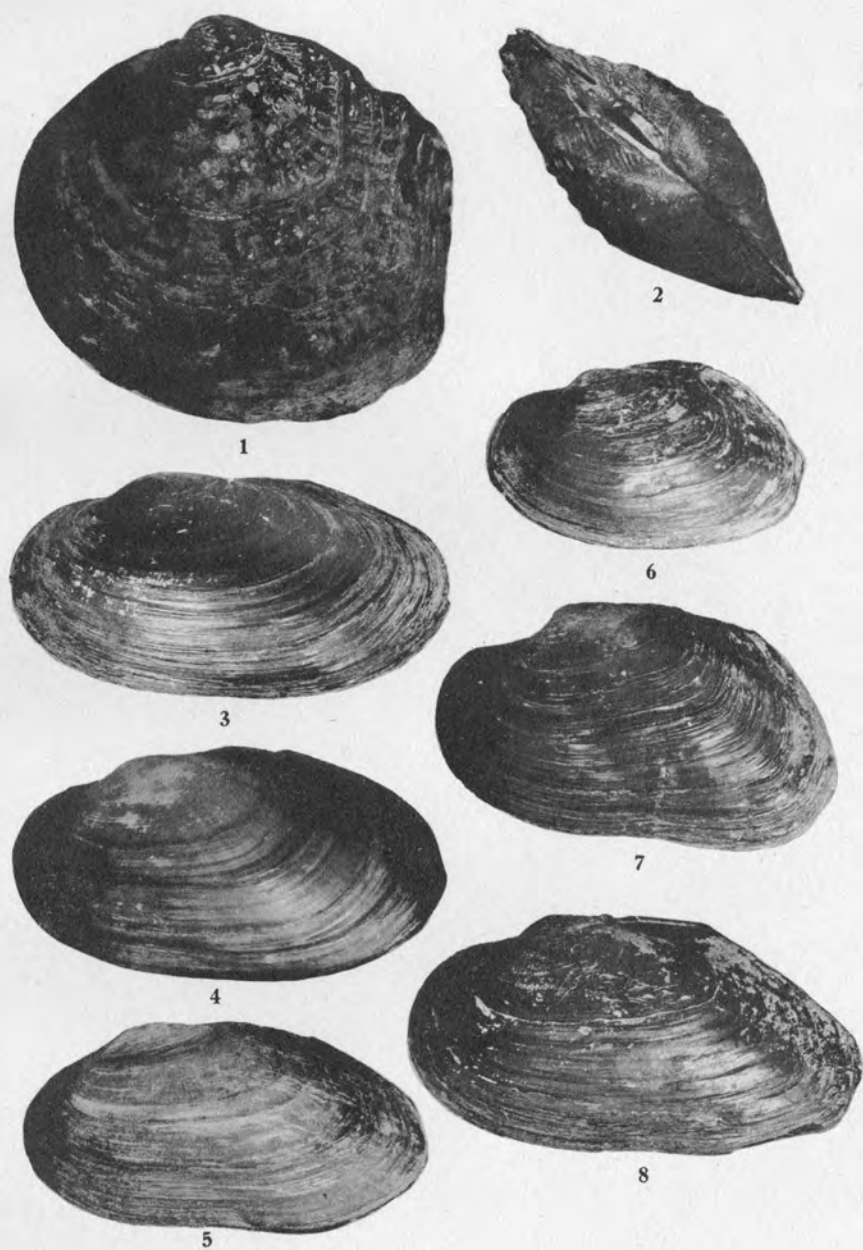


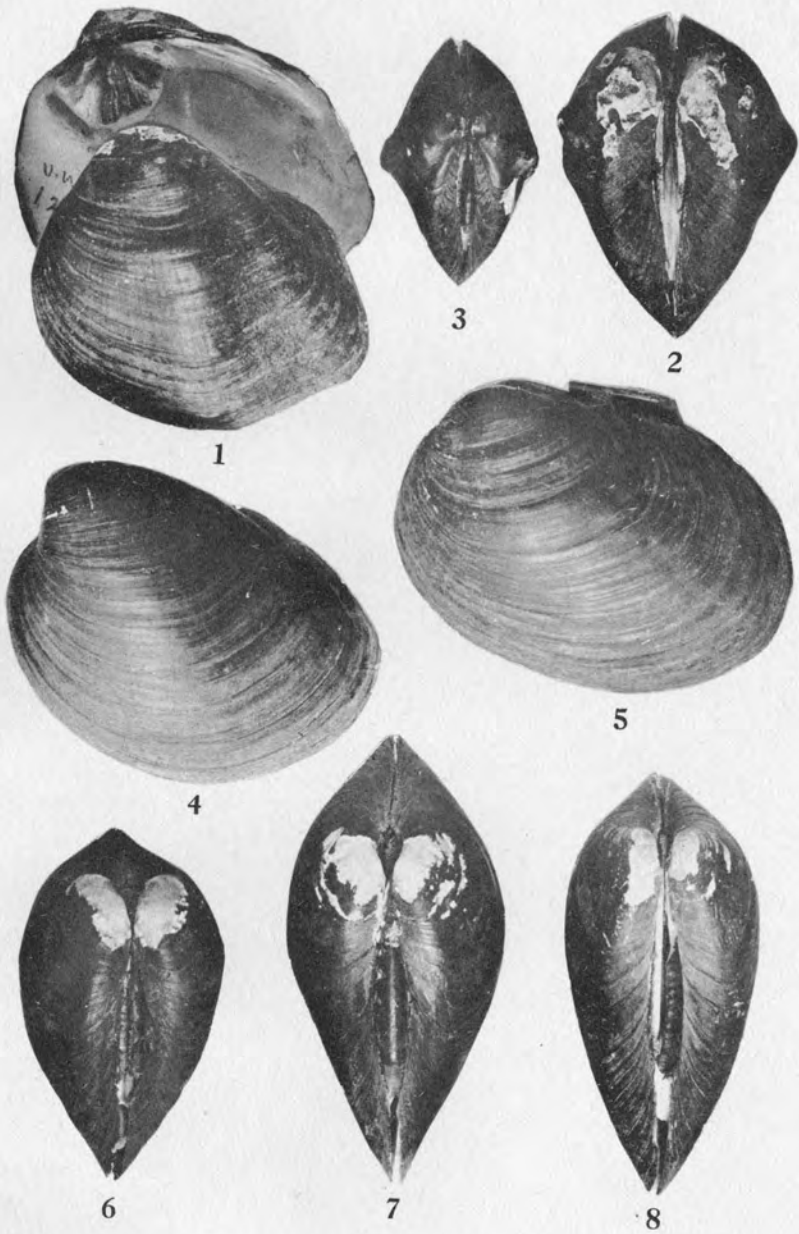
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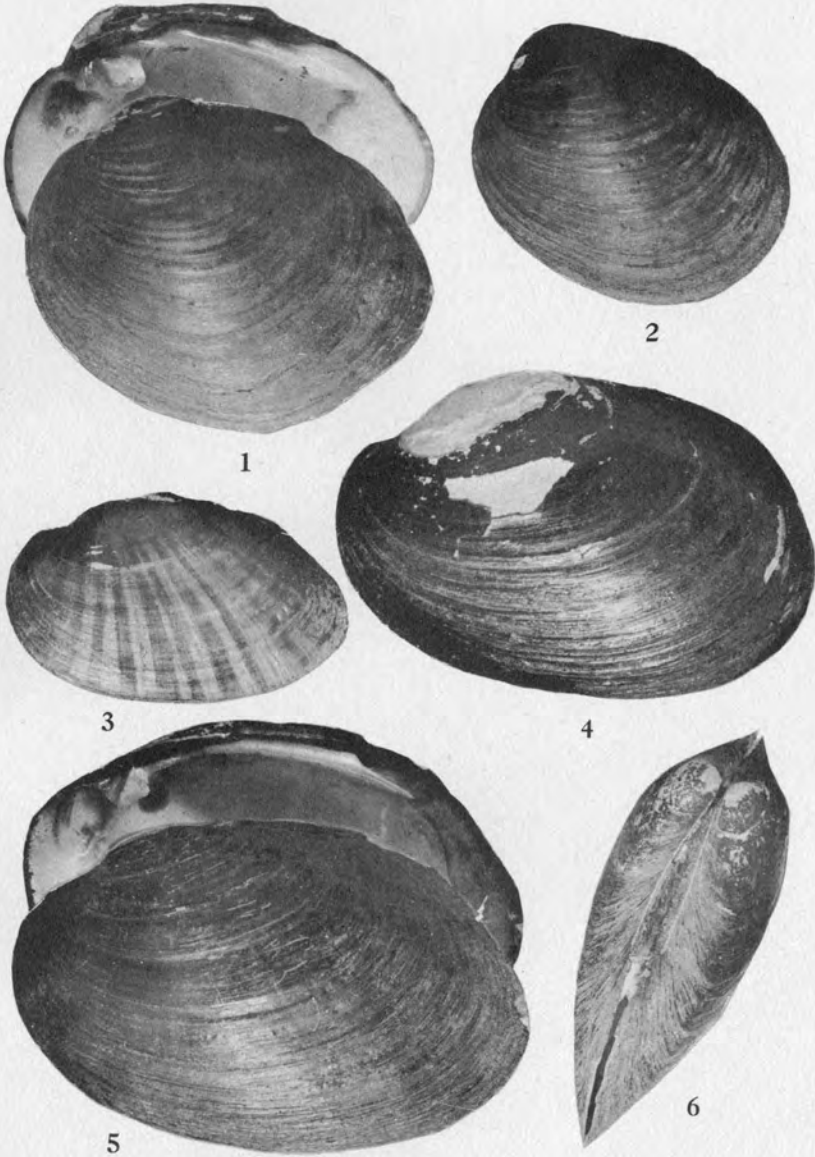


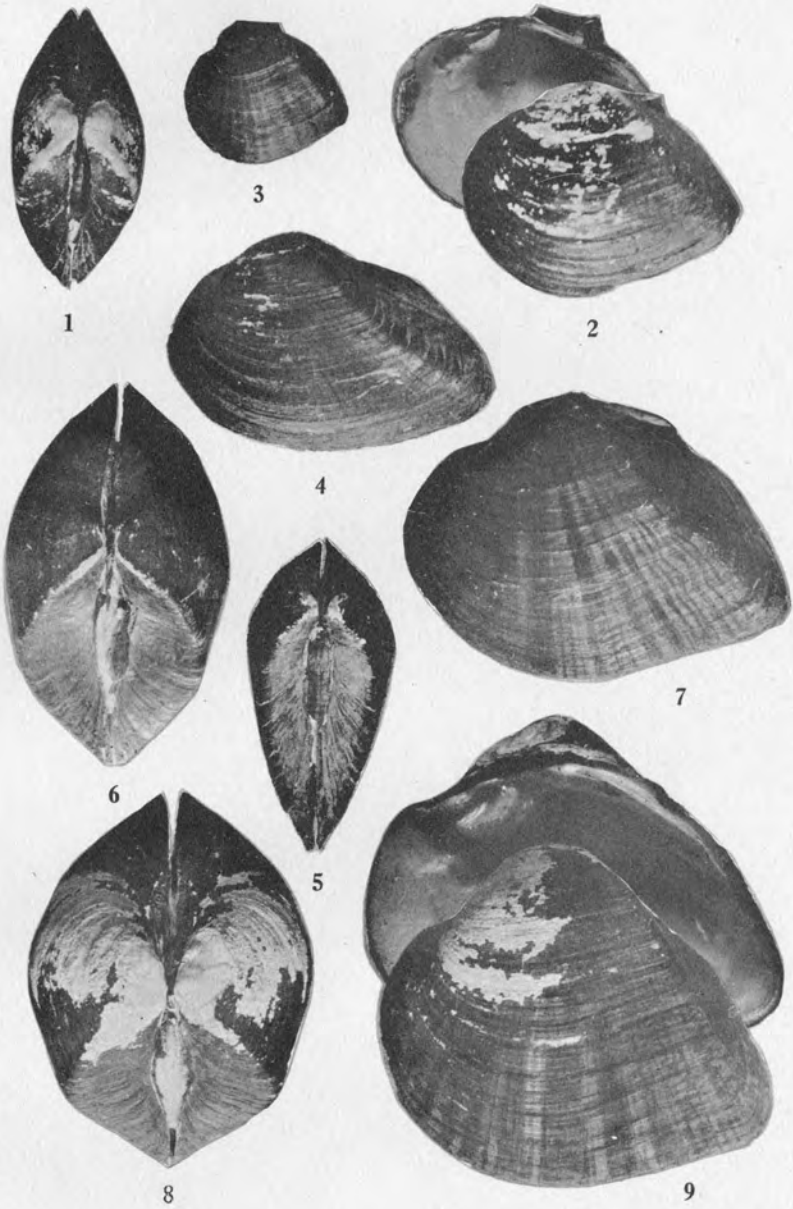
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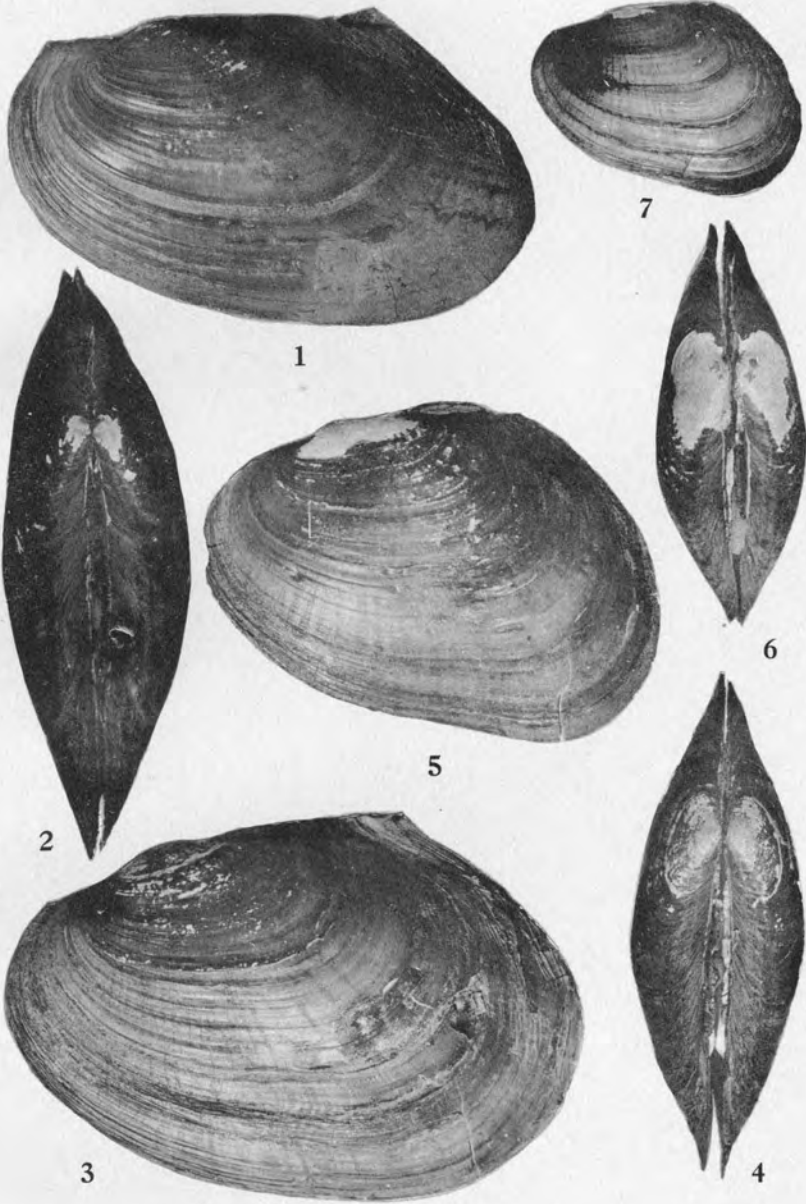
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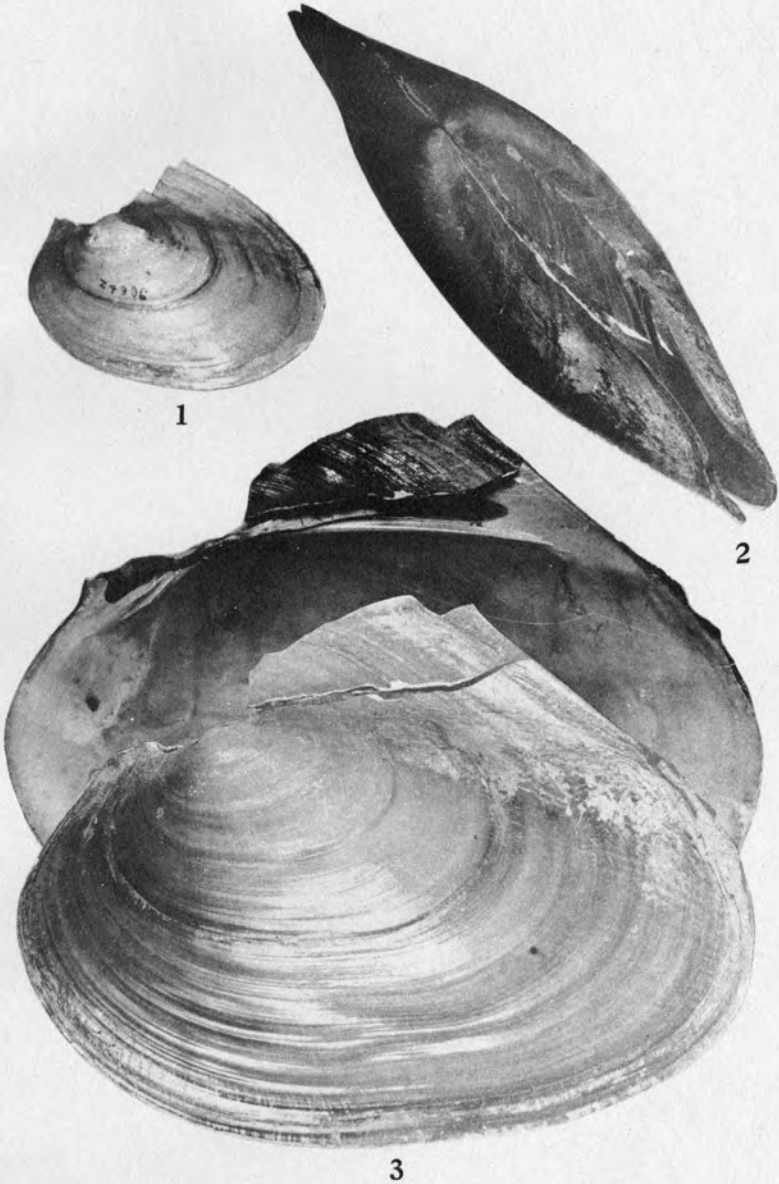
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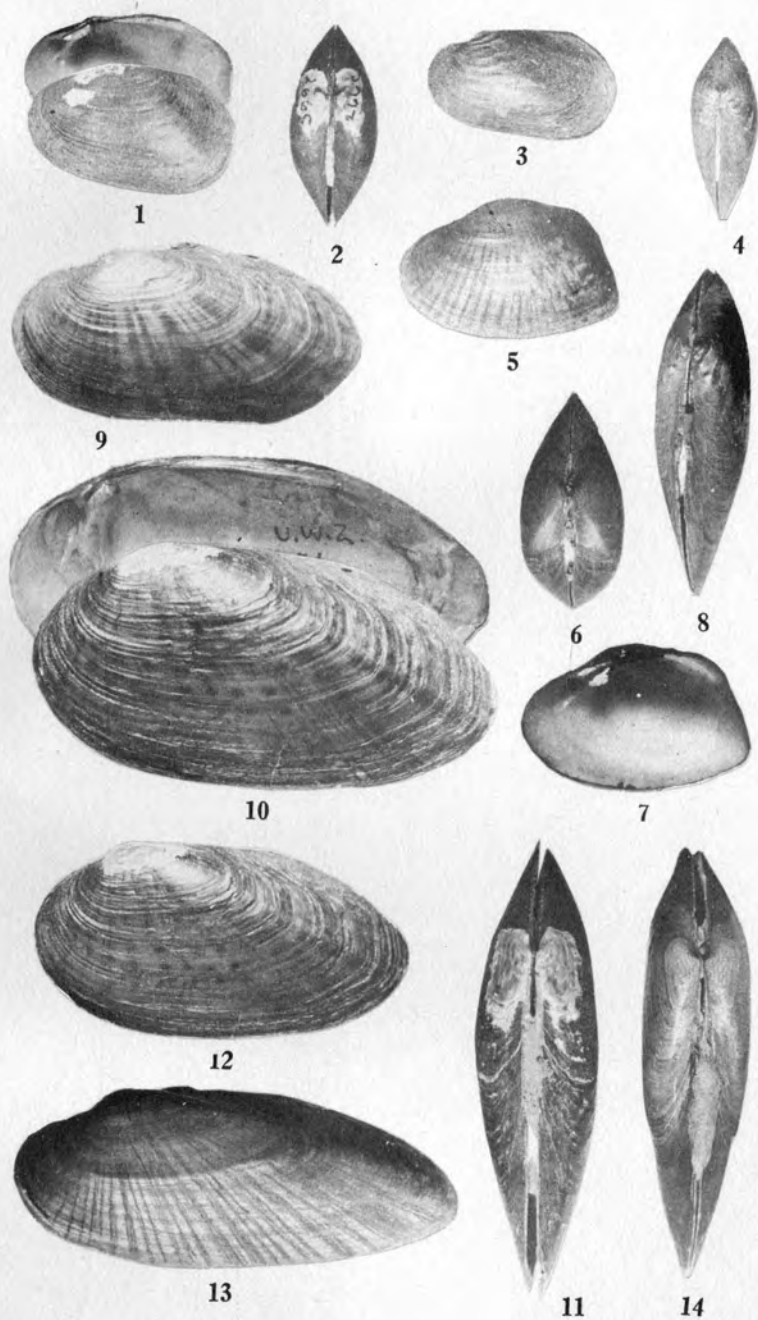
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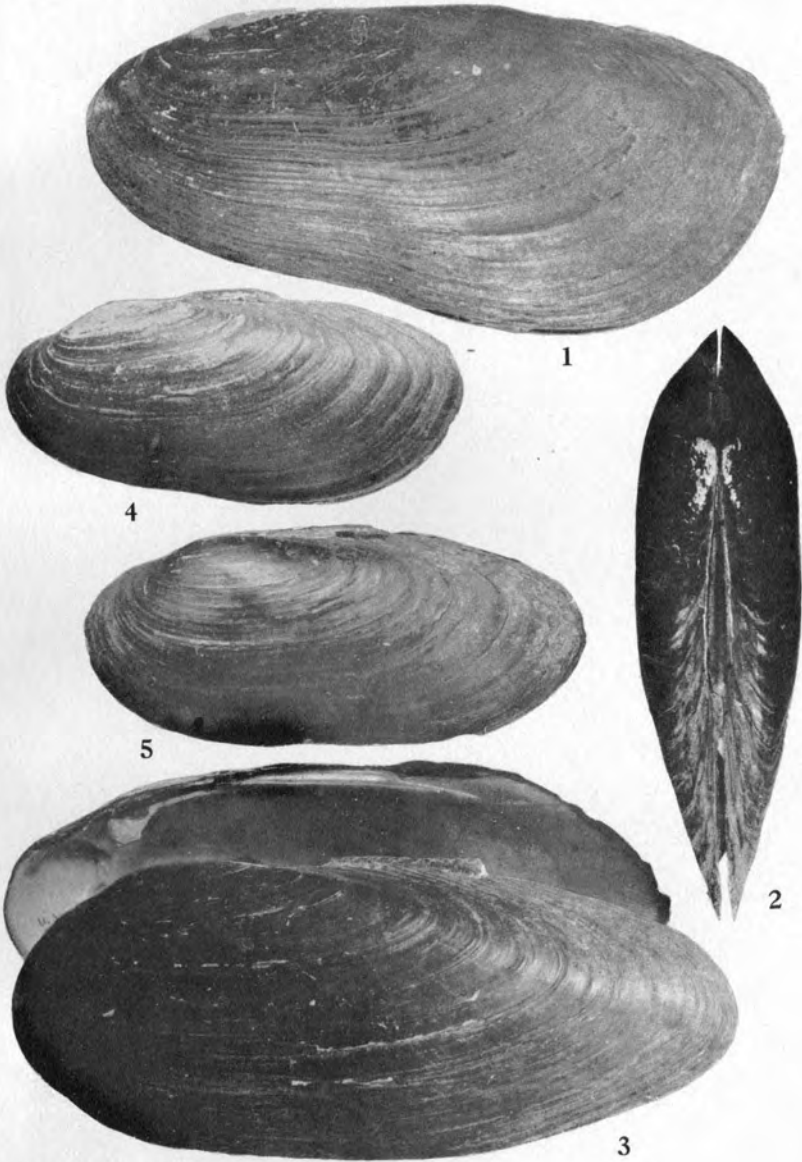


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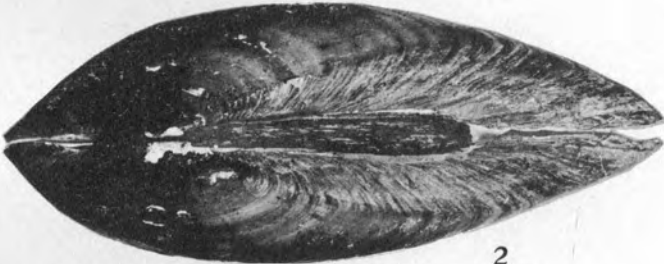
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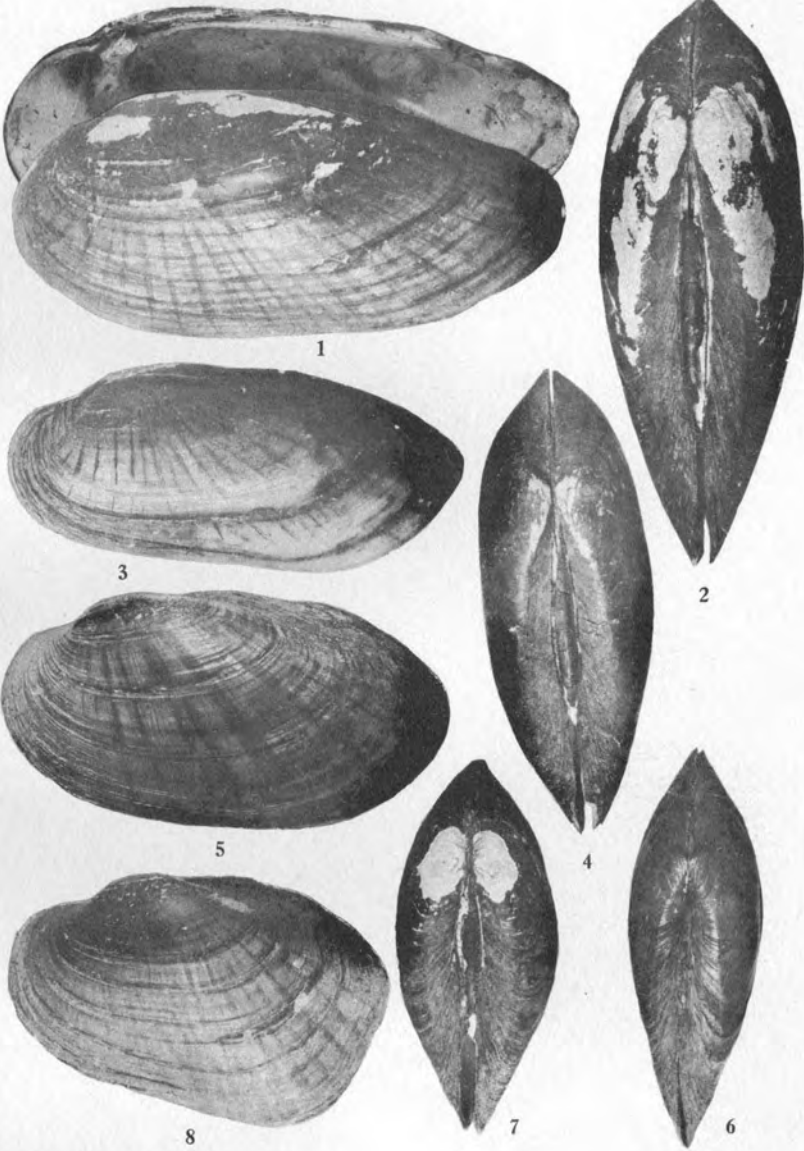
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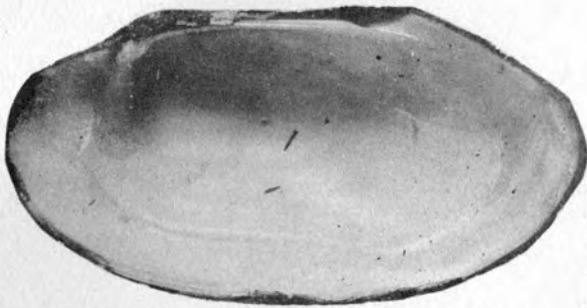


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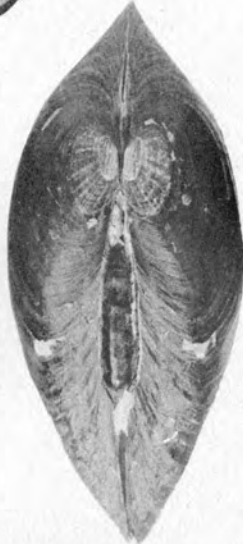




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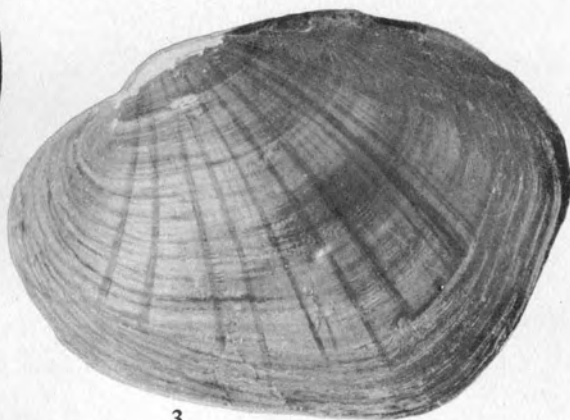
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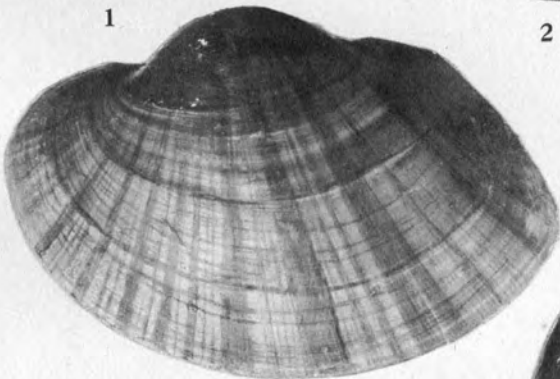
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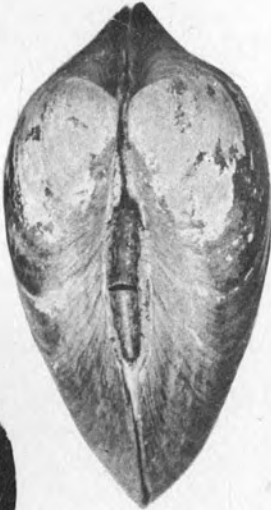
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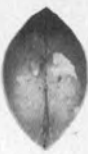
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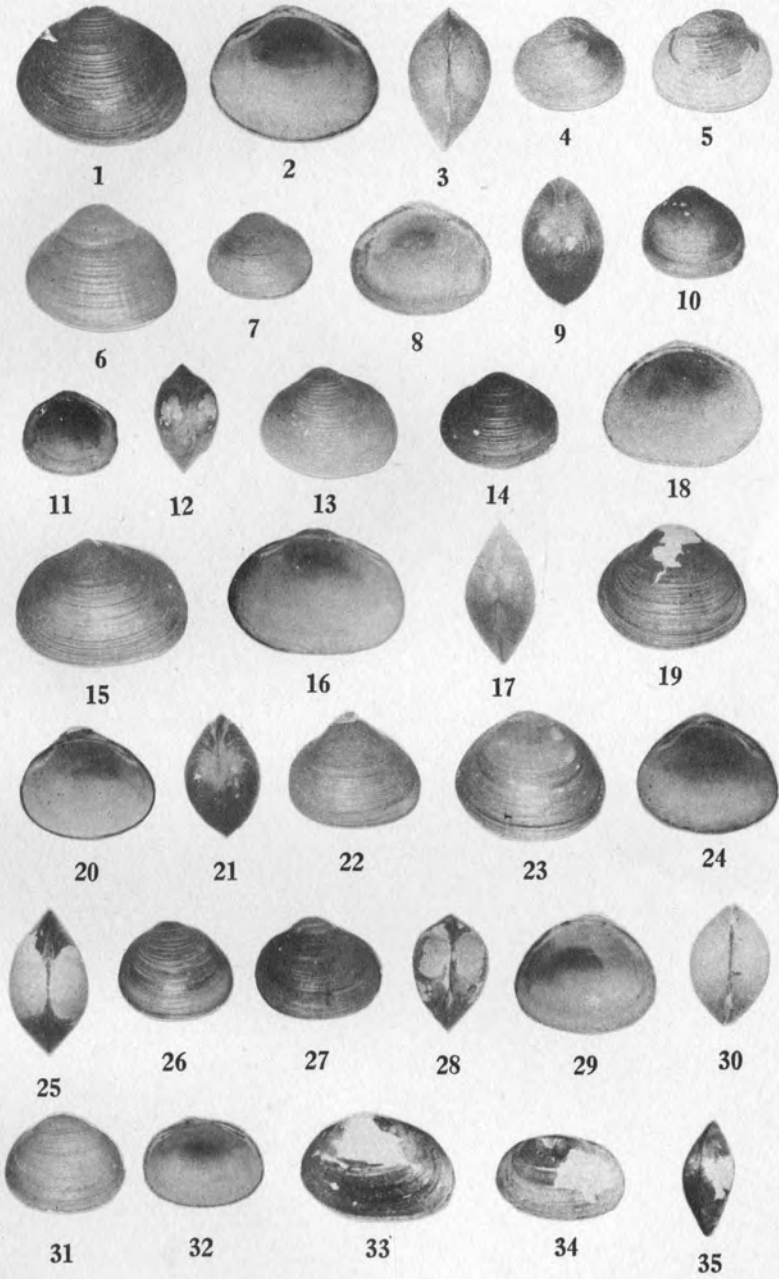
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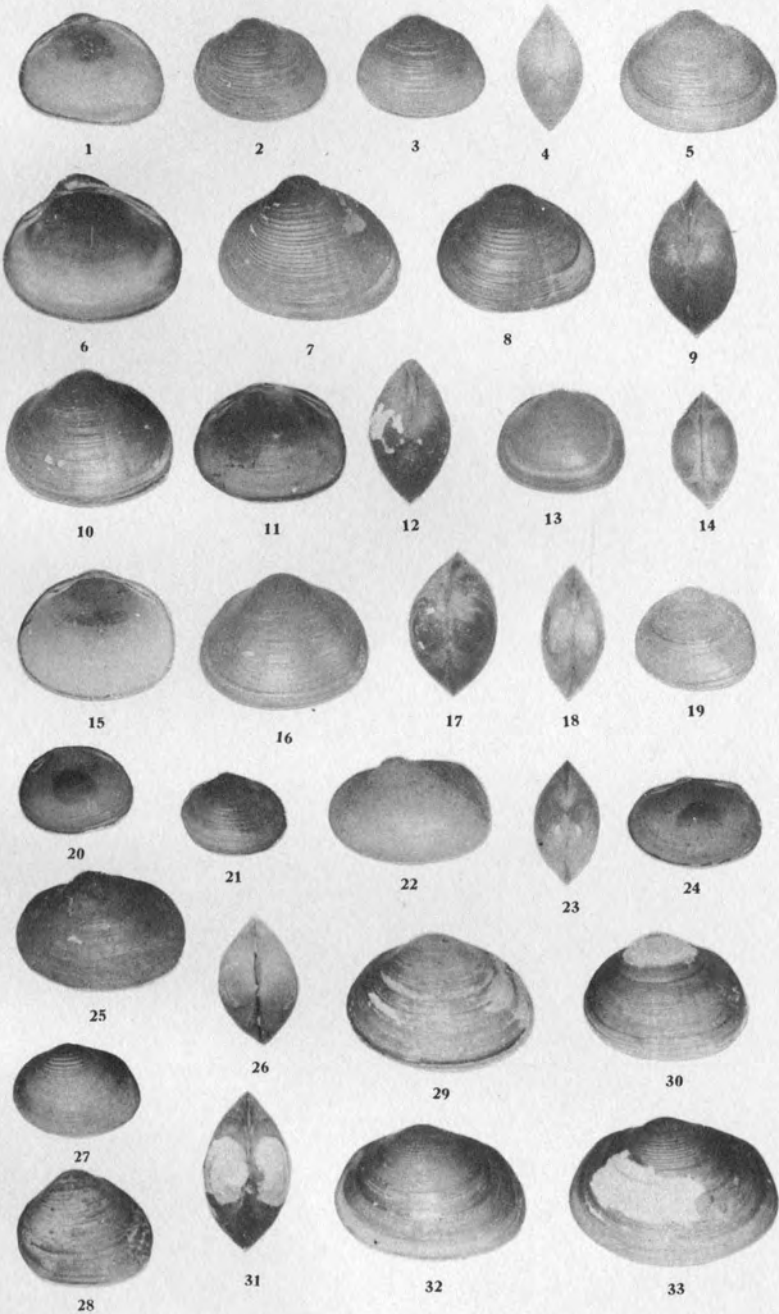


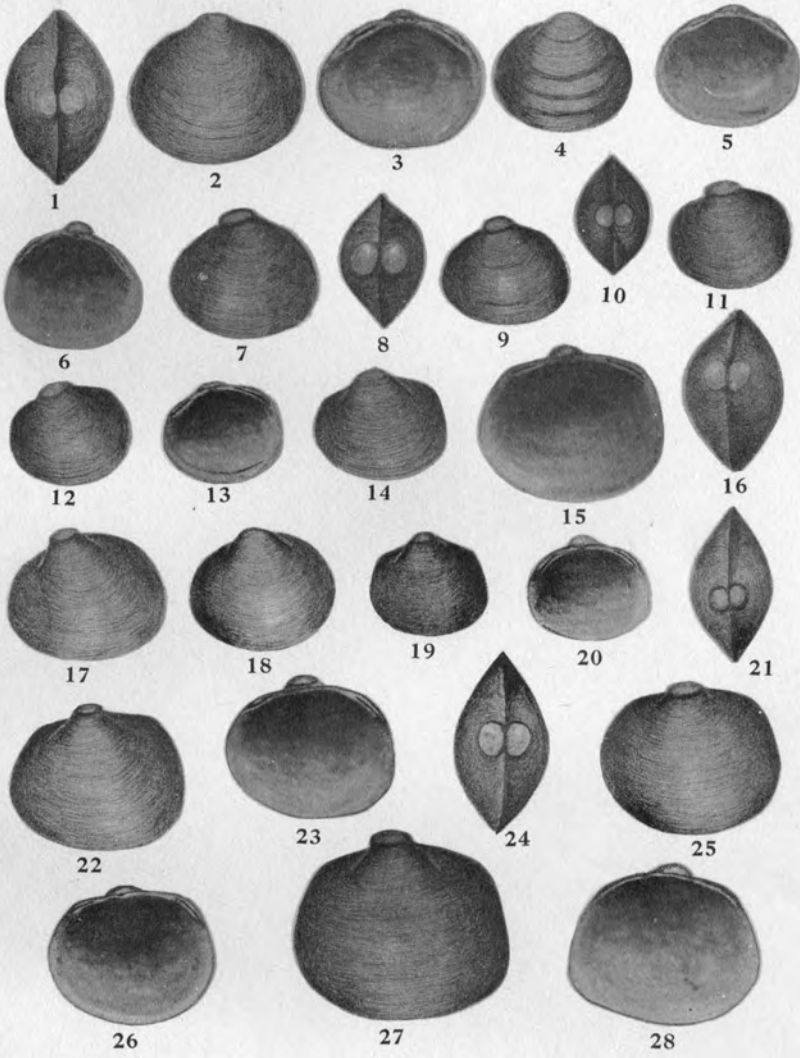
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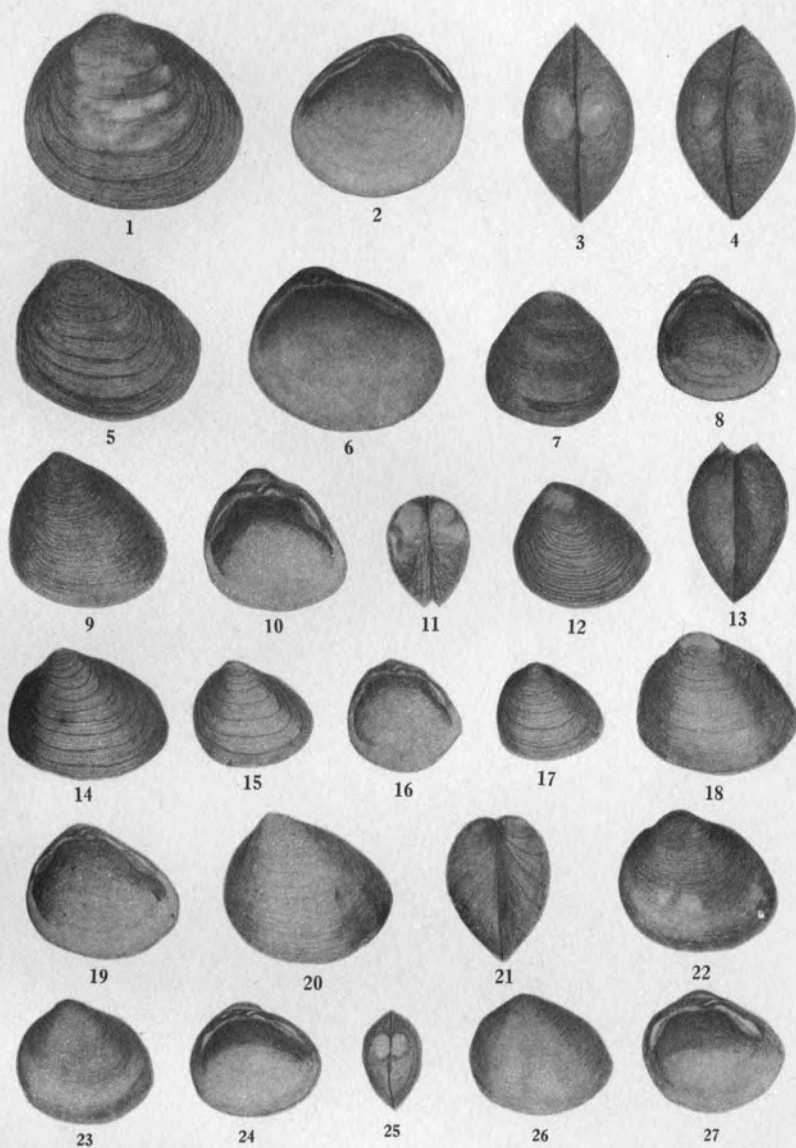


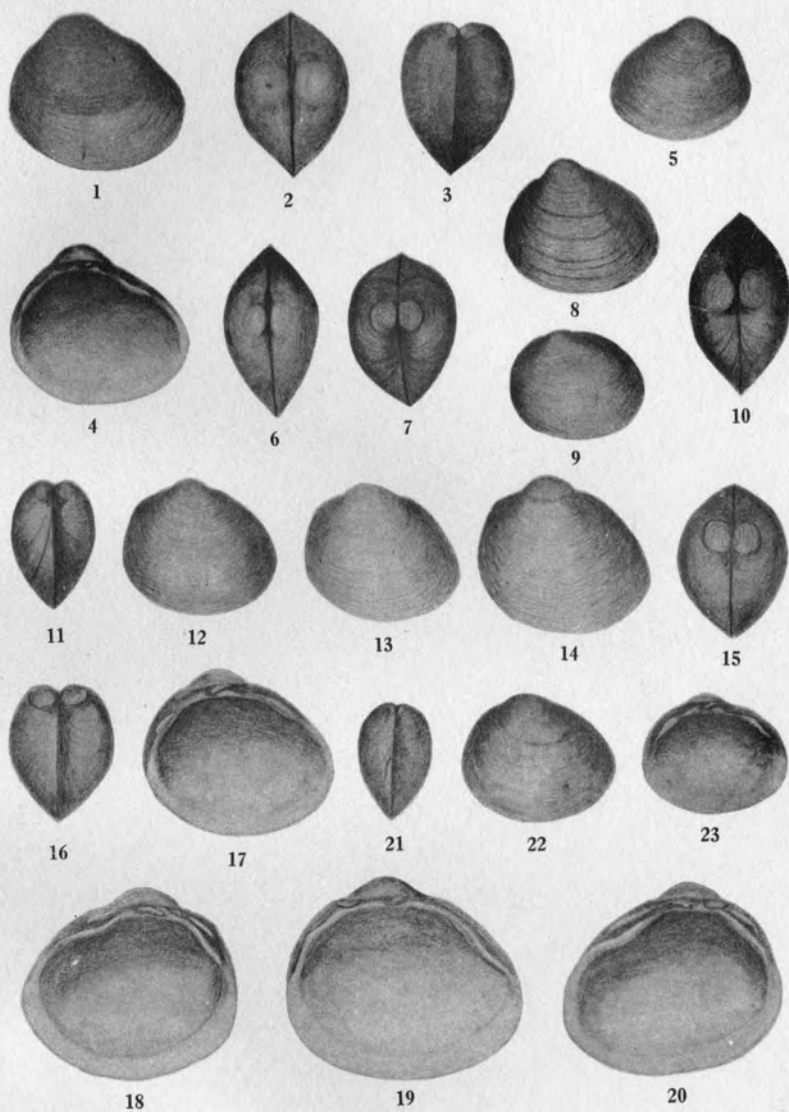
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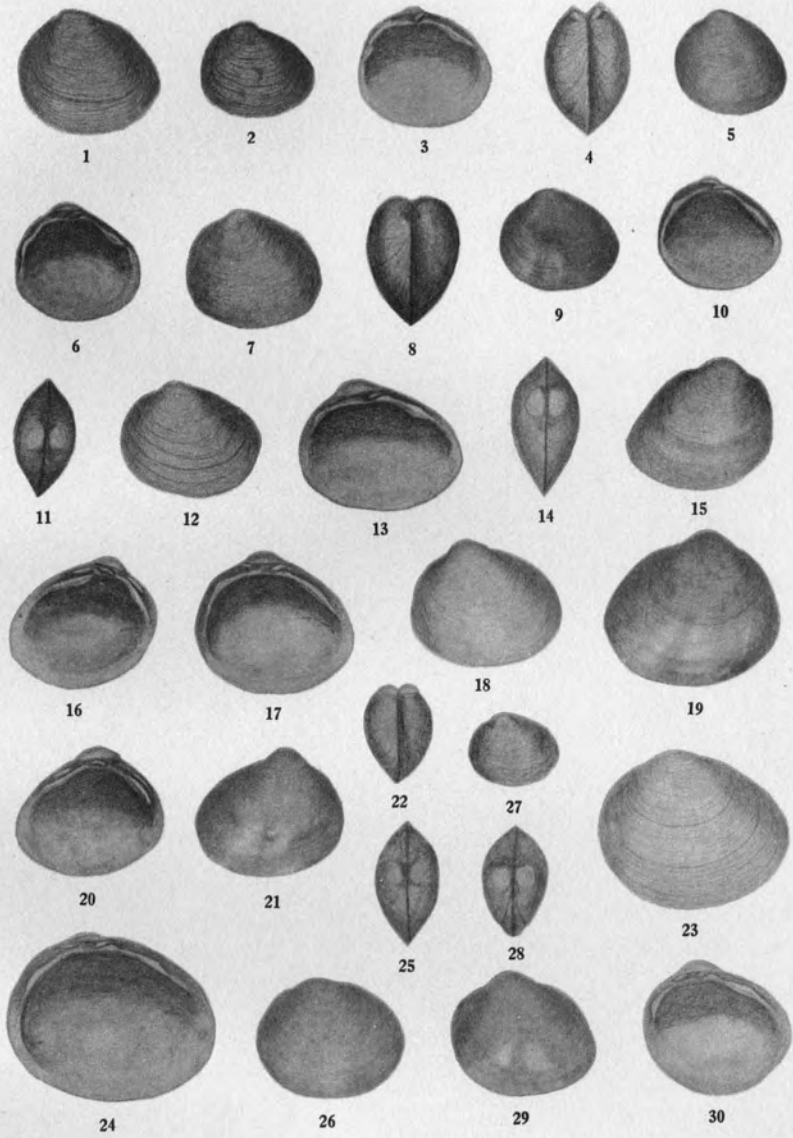


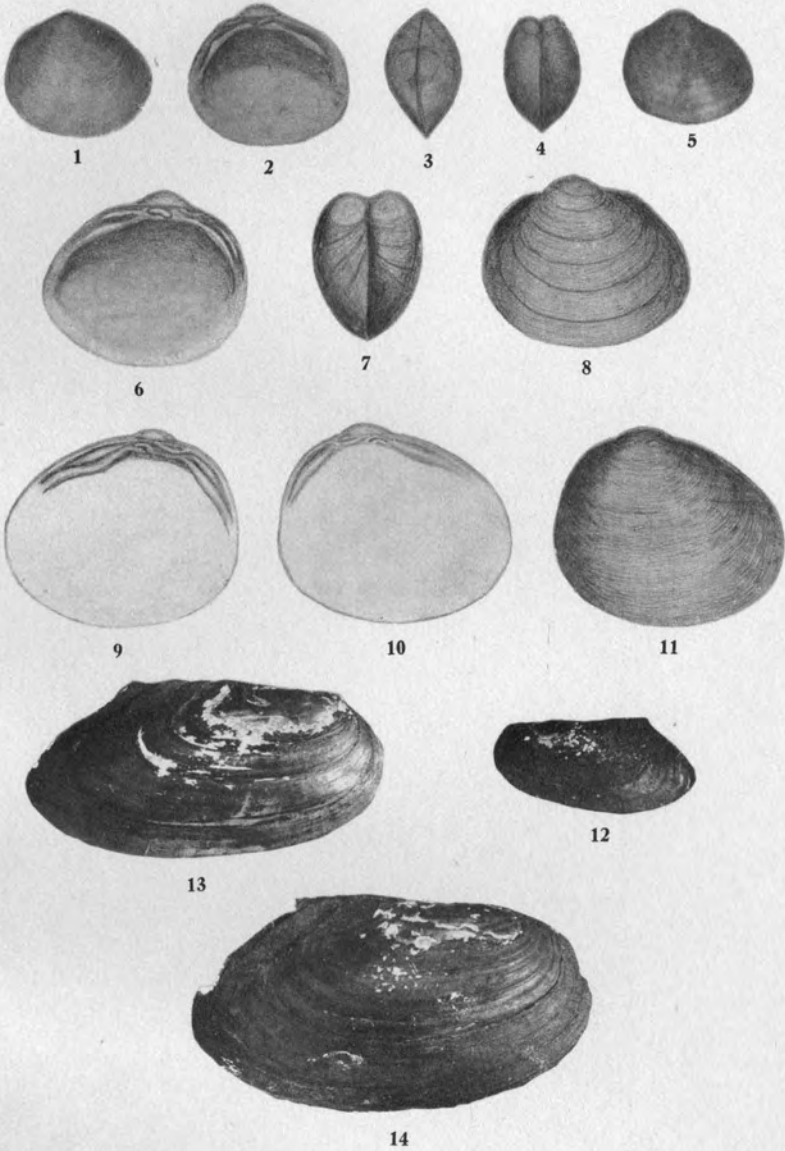


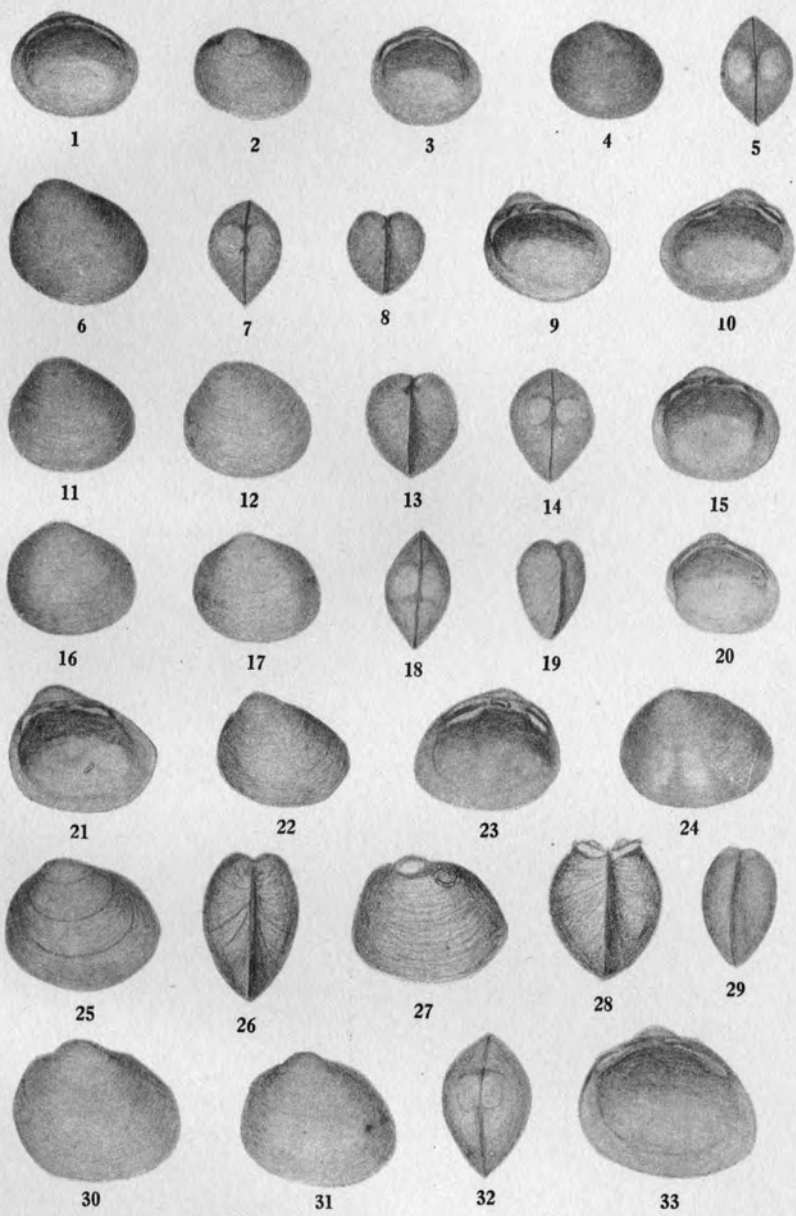


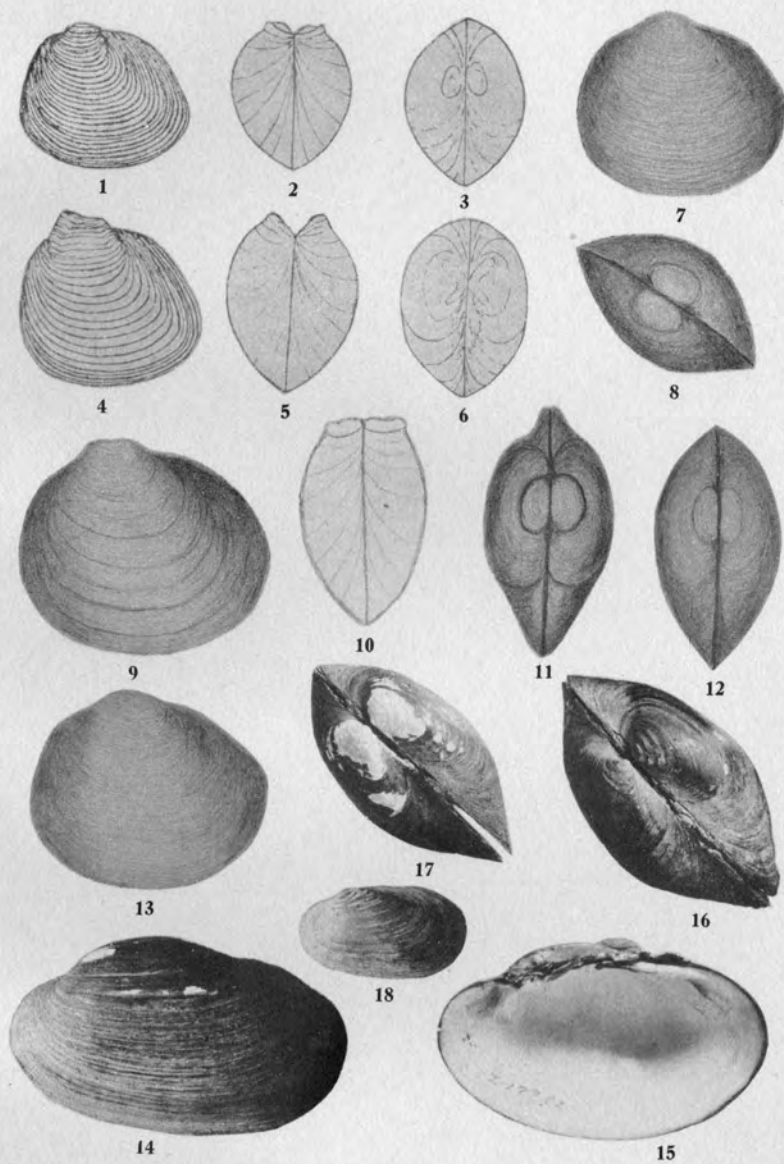












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