The Freshwater Bivalve Mollusca
(Unionidae, Sphaeriidae, Corbiculidae)
of the
Savannah River Plant, South Carolina

by
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THE FRESHWATER BIVALVE MOLLUSCA
(UNIONIDAE, SPHAERIIDAE, CORBICULIDAE)
OF THE SAVANNAH RIVER PLANT, SOUTH CAROLINA

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INTRODUCTION

This is the third in a series of guides to the fauna of the National Environmental Research Park of the Savannah River Plant. As with the former work, on the decapod crustaceans (Hobbs et al., 1976), the main purpose of the present paper is to aid investigators with the identification of a taxonomic group which is often difficult for inexperienced investigators to identify - in this case, the bivalve mollusks that can be expected to be found at the Savannah River Plant (SRP).

Within the last ten years, two important studies have been made of the unionid mussels of the southern Atlantic slope drainage. The first (Johnson, 1970) is monographic in scope and is an indispensable guide to the unionid shells from southern Georgia to Virginia and Maryland. The second paper (Fuller, 1971) is more restricted in scope, dealing primarily with mussels of the Savannah River system, but is important because of the emphasis upon the soft-part morphology of bivalves. The present paper is in no way intended to supplant either of these important studies. The reader is encouraged to have both papers readily available before any extensive research on the Bivalvia of this region is attempted. You will find here, however, a handy guide and reference to the more common and abundant bivalves in the waters of the SRP. A dichotomous taxonomic key is provided to common forms and to unreported species whose geographic distributions include nearby localities. Every species collected during field reconnaissance in the summer of 1977 is described, and a discussion of some aspects of its ecology, life history, larval hosts, and other pertinent information is provided.

STUDY AREA

The Savannah River Plant (SRP) occupies approximately 200,000 acres in southern South Carolina, occupying portions of Aiken, Barnwell and Allendale counties, near the cities of Augusta, Georgia, and Aiken, South Carolina. The SRP is located just below the Fall Line in the Atlantic Slope Coastal Plain. Five minor drainage systems flow from or through the SRP to the Savannah River, which courses for 22 miles along the southwestern border of the plant. A variety of terrestrial and aquatic habitats occur within the SRP boundaries. The former include lowland hardwood forests and cypress-gum swamps, turkey oak and longleaf pine sandhills, upland oak-hickory forests, and large old-field areas. The aquatic habitats include the Savannah River and adjacent swamps, several reservoirs including the 2,800-acre nuclear reactor cooling reservoir, Par Pond, various natural and thermally affected (by several nuclear production reactors) streams, and a number of Carolina bays, beaver-dam ponds, and abandoned farm ponds. Designated as the first National Environmental Research Park, the SRP is a unique protected outdoor laboratory where research can be conducted in both undisturbed and stressed ecosystems.

During May, June, and July 1977, one of us (JCB) spent several weeks surveying the various aquatic habitats on or near the SRP for bivalve mollusks. A total of 46 specific localities was visited, of which 26 proved to have at least one species of bivalve. Additional material was provided (by SLHP) from extensive collections made during numerous stream surveys for the Academy of Natural Sciences at Philadelphia (ANSP).

LIST OF BIVALVE MOLLUSKS AT THE SRP

There are several suprageneric classifications of the Unionacea, including those by Ortmann (1910, 1911, 1912, 1916, and 1919), Frierson (1927), Modell (1942, 1949, 1964), Haas (1969a, 1969b) and Heard and Guckert (1971). Following the similar treatments by Johnson (1970) and Fuller (1971), we employ the Ortmann system here. Three families, 14 genera, and 26 species are recognized with geographic ranges which include or are near the SRP. They are included in the following list. Twenty-three of these species were collected during the summer of 1977 and/or during ANSP/SRP surveillance since 1955. The remaining three species may occur within the boundary of the SRP and/or in the adjacent portions of the Savannah River. They are indicated by an asterisk in the list below and are included in the key. Otherwise, these three species are not given additional treatment herein.

SUPERFAMILY UNIONACEA Thiele 1934

FAMILY UNIONIDAE Fleming 1828

SUBFAMILY UNIONINAE Swainson 1840

GENUS Fusconaia Ortmann 1912
*Fusconaia masoni (Conrad 1834)

GENUS Uniomerus Conrad 1853
Uniomerus tetralasmus (Say 1831)

GENUS Elliptio Rafinesque 1819
Elliptio congaraea (Lea 1831)
E. complanata (Lightfoot 1786)
E. fraterna (Lea 1852)
E. lanceolata (Lea 1828)
E. icterina (Conrad, 1834)

SUBFAMILY ANODONTINAE Swainson 1840

GENUS Lasmigona Rafinesque 1831
*Lasmigona (Platynaias) subviridis (Conrad 1835)

GENUS Alasmidonta Say 1818
Alasmidonta (Alasmidonta) triangulata (Lea 1858)
*A. (Decurambis) varicosa (Lamarck 1819)
GENUS *Anodonta* (Lamarck 1799)
*Anodonta* (Utterbackia)
couperiana Lea 1840
A. (U.) imbecillisi Say 1829
A. (Pyganodon) cataracta Say 1817

GENUS *Strophiatus* Rafinesque 1820
*Strophiatus undulatus* (Say 1817)

SUBFAMILY LAMPSILINAE von Ihering 1901

GENUS *Carunculina* Baker 1898
*Carunculina pulla* (Conrad 1838)

GENUS *Villosa* Frierson 1927
*Villosa vibex* (Conrad 1834)
*V. delambis* (Conrad 1834)

GENUS *Lampsilis* Rafinesque 1820
*Lampsilis radiata splendidia* (Lea 1838)
*L. cariosa* (Say 1817)

SUPERFAMILY CORBICULACEA Gray 1847

FAMILY CORBICULIDAE Gray 1847

GENUS *Corbicula* von Mühlfeld 1811
*Corbicula* (*Corbicula*) *fluminea* (Müller 1774)

FAMILY PISIDIIDAE Gray 1857

GENUS *Pisidium* Pfeiffer 1821
*Pisidium americum* (Müller 1774)
*Pisidium casertanum* (Poli 1791)
*Pisidium compressum* Prime 1851
*Pisidium dubium* (Say 1834)

GENUS *Musculium*
*Musculium transversum* (Say 1829)

GENUS *Eupera* Bourguignat 1854
*Eupera cubensis* (Prime 1865)

1This is *Pleurobema masoni testa* Johnson (1790). See Fuller (1973) for extensive discussion.

ECOLOGICAL CONSIDERATIONS

Freshwater bivalve mollusks, especially the unionids, tend to be most abundant in flowing streams and rivers. The numbers of individuals and the species diversity usually diminish in the still waters of lakes or basins (e.g., Carolina Bays). Regardless of habitat, the distribution of bivalves is often patchy, clumped, or otherwise irregular. Large numbers of clams may be collected in one area, whereas in a similar environment only a few meters away, few or no specimens may be found. The irregular distribution of unionids may be related to the distribution patterns of freshwater fish which are employed by larval clams (glochidia) as hosts for dispersal (see later discussion). Freshwater mussels are often very abundant in substrates of shallow pools and protected coves or among reeds where various fish species may seek shelter.

There are some conditions where few if any clams or mussels should be expected. Ephemeral ponds or streams rarely harbor bivalves. Even the largest Carolina bays, which are never completely dry, may be devoid of clams. Permanent waters with poor circulation or flow rarely produce large clam populations. An abundance of individuals of certain species (e.g., *Anodonta imbecillusi*) may occur in Par Pond and other reservoirs at SRP but we have never found more than four or five bivalve species in these lakes. As sessile filter-feeders, most freshwater bivalves fare best when nutrient-laden waters flow continuously over them.

SRP streams are not especially rich in suspended particulate nutrients (Langley and Marter, 1973), hence the populations of bivalves in these waters are limited. Clean sand bars in the fast-flowing streams may harbor a few specimens, but most bivalves of SRP streams occur along banks or in stream eddies where nutrients tend to accumulate. The *Sphaeriidae* or fingernail clams are an exception. They can be found in the same localities as the stream Unionidae, but they are also particularly abundant in gravel substrates of stream riffles.

The river environment provides a greater nutrient load than that of smaller streams; as might be expected, the variety of bivalve populations is greater there. If one wishes to collect the rarer species of mussels in the vicinity of the SRP, localities in or near the Savannah River should be searched first. Mussels and clams are most abundant on semi-protected shoals or bars of the river where there is both adequate flow and protection against the catastrophic effects of flooding. They also occur in deeper parts of the river, but collecting in these areas is considerably more difficult.

The recent introduction of *Corbicula fluminea* into the Savannah River (or any waterway in this country) raises some concern about the effects that this expanding population may have on native bivalves. *C. fluminea* can reach exceptionally high densities just a few years after being introduced into an area (see below). Eventually, shell densities may become so great as to reduce the habitable space for other clams (e.g., Eng, 1977). Alternately, nutrient and/or chemical resources may be depleted or otherwise made unavailable to native species. The impact of *C. fluminea* on other clams is yet to be assessed, but one should be aware that a possible change in population densities may occur as a result of this invading bivalve.

In addition to nutrients, there are other aspects of water chemistry that may also influence the distribution of bivalves. Surface waters of southern South Carolina typically are slightly acidic and have low conductivity. Of the several ionic components which influence conductivity, calcium is one of the most important to mollusks. Calcium is required by bivalves for shell
formation. If it is in limited supply, the growth and/or abundance of bivalve species may be similarly limited. This becomes especially critical in slightly acidic waters. If calcium carbonate shells are exposed directly to acidity, they will undergo dissolution. Mollusks which live in acidic waters usually develop thick, organic periostracal layers to protect the underlying, inorganic carbonate from chemical breakdown—but mechanical abrasion can wear away the protective periostracum, thereby exposing the calcium carbonate shell to chemical dissolution. Thus, there is a series of interactions that ensure a turnover of calcium within the aquatic system. In flowing waters, the net effect will be a loss of calcium to the system if there are no local sites of replenishment.

In the vicinity of the SRP, several aquifers flow from calcium-rich groundwater sources to the surface and provide constant replenishment (Langley and Marter, 1973). Thus, although the calcium content of surface waters at the SRP seems low (generally less than 1.5 mg/l), this element is in constant supply from groundwater sources and is supplemented to a small degree by the dissolution of older and/or dead shells. The loss of shell material as a result of dissolution may be more critical to the individual mollusk. If a clam cannot replace shell material faster than it is being removed by mechanical abrasion or by chemical dissolution, eventually the shell will become perforated. One occasionally finds living specimens with a perforate umbo exposing the underlying mantle tissue to the external environment. More often, numerous unhinged dead valves with umbonal perforations are found, attesting to the frequency with which this process occurs. Although there are no relevant quantitative data, one wonders how important this process might be in limiting the bivalve populations and especially individual species in the SRP area.

All of the bivalves at the SRP are filter-feeding organisms. Waterborne food enters the mantle cavity through a posterior branchial aperture and circulates among the gill demibranchs, on whose surfaces particulate material is trapped. The water exits posteriorly through an anal aperture located dorsal to the branchial aperture. The branchial and anal apertures of Corbicula and some of the Sphaeriidae are siphonal. In most bivalves, the branchial aperture is papillate; the papillae are usually employed as a screen or filter for very large particles. The anal aperture may or may not be papillate, and the presence or absence of papillae here is a useful criterion for identification.

Food material and other particulate matter trapped by cilia of the gills are passed either toward the mouth by specific ciliary tracts or along rejection paths for elimination from the mantle cavity. Rejected material that does not pass into the digestive tract is eliminated as "pseudofeces" through the branchial aperture and between the mantle margins anterior of the incumbent aperture. (Bivalves held in aquaria frequently will eliminate considerable quantities of pseudofecal material). Additional details of the mechanics and physiology of the filter-feeding process can be found elsewhere (e.g., Owen, 1966). The similarities of habitat, feeding behavior, and numerous other traits are presumably responsible for a high degree of convergent evolution with respect to shell morphology within the Unionacea, Sphaeriidae, and Corbiculacea. There are numerous examples among the Unionacea of distinctly different soft-parts enclosed within superficially similar shells. Such is the case with many of the SRP unionaceans. At first glance, the shells of several SRP mussel species will appear almost identical. This makes the task of identification especially difficult for those working with the group for the first time. Johnson (1970) presented an extensive discussion of zoogeographical and phylogenetic relationships among Atlantic slope drainage unionids.

The life cycle of freshwater bivalves varies according to the taxonomic groups. All bivalves at the SRP brood larvae in gill marsupia. The Sphaeriidae and Corbiculidae produce brood chambers within the inner demibranchs of the gill. The former group restricts marsupia to the anterior portions of the demibranch, and the latter employs the entire demibranch. Members of both families release the larvae to the environment, where they undergo metamorphosis into juvenile clams. Heard (1977) discusses in considerable detail the reproductive biology of the Sphaeriidae, and additional remarks on the life cycle of Corbicula are presented below.

The Unionacea may brood larvae in all four demibranchs (e.g., Amblema, not found in this area), in only the outer demibranch (e.g., Elliptio), or in only specific portions of the outer demibranchs (e.g., Lampsis). Upon release from the brood chamber, the unionacean larva (glochidium) usually must undergo an obligatory parasitic encystment on gills or fins of freshwater fishes if development is to proceed. See the "Life History" section of Elliptio complanata for additional information on the reproductive behavior and the larvae of freshwater mussels.

COLLECTING TECHNIQUES

Clams and mussels are most easily collected during the drier months, when the water levels and flow rates of streams or rivers are low. Shoals or bars in large rivers become treacherous or deeply submerged during high water periods, this makes collecting difficult and even dangerous. In the drier seasons, the shoals often become partially exposed, easily worked, and often highly productive of mussels and clams. A particularly good river locality for mussels is in the lee of a sharp bend, i.e., along the shore opposite the cutting bank.

Mussels in smaller streams (such as the many at the SRP) may be found on mid-stream shoals, but more
frequently they lie partially buried in sand, mud or gravel along the stream bank. Sandy, sandy gravel, or sandy mud bottoms seem to be the most productive substrates, but some mussels are characteristically found in abundance among very fine, organically rich sediments trapped at the bases of tree roots or in calm areas of the stream. Rapidly shifting, transitory sand bars are usually unsuitable habitats, but one species in the Altamaha River basin of Georgia (Canthyria spinosa (Lea)) has spines on each valve, presumably to facilitate shell anchorage in this kind of habitat.

The Sphaeriidae, Corbicula, and some Unionidae commonly occur in the gravel substrates of stream riffle zones. This is a particularly good locality to search for fingernail clams.

If collecting is done during a period of low water and high air temperature, a word of caution is in order. Specimens collected for laboratory experiments should then be taken only if they were covered by at least several inches of water. Some clams (Corbicula fluminea, in particular) may suffer latent mortality several days or even weeks after air exposure or heat stress in temperatures above 37°C (Coldiron, 1975). On the other hand, if specimens are required for museum collections, locality records, or gross morphological studies, the more easily obtained exposed or semi-exposed individuals are preferred. The exposure has likely severely weakened many of these specimens, and collecting them instead of reproductive stocks from deeper waters will minimize depletion of the healthy bivalve populations.

There is no “best method” to collect bivalve mollusks. Many standard quantitative techniques (e.g., grab samplers) are ineffective with some bivalve groups, especially the Unionidae. Grab samplers will almost never collect large mussels in proportion to their actual abundance in a locality. These devices may be useful, however, for population estimates of Corbicula or the Sphaeriidae. The most reliable techniques for sampling bivalves are hand methods, despite numerous attempts by a variety of workers to develop other sampling procedures. There are several kinds of hand collecting techniques, all of which should be attempted at a given locality.

First and foremost, the most reliable of all methods to collect larger unionoids remains hand-sifting and searching the substrate. According to the preference of the collector, gloves may be worn to minimize abrasions and minor lacerations. One may “scan” a clear stream for larger specimens by walking along a bank or in the shallows and looking for the characteristic wedge-shaped posterior region projecting from the substrate in shallow water. The collector should always walk upstream, thereby ensuring that his view will be in clear, undisturbed water. In more turbid streams, or in low flow conditions, the scan technique may be impossible. The collector then must rely upon a blind search and

must use hands to sift along a sandy spit or among roots under a bank. A small rake may be useful in some localities but, if there is a large amount of rooted vegetation, it may become frequently tangled and prove ineffective.

If one is searching for Sphaeriidae or Corbicula, screening or sieving the substrate often is an efficient method of obtaining numerous specimens. Note, however, that screening rarely expedites the search for most of the larger mussels. Dip nets have been successfully employed at SRP for collecting bivalves, and they are especially well suited for obtaining fingernail clams and Corbicula. These clams almost always lie buried in the substrate, so a dip net should be raked through the streambed and then washed of its sediment burden before the net is searched. Look carefully among the organic debris for smaller specimens.

In shallow riffle zones, a Surber sampler or the PIBS (Portable Invertebrate Box Sampler) device can provide reasonably accurate quantitative estimates of the Sphaeriidae and/or Corbicula populations. Like other quantitative samplers, however, these devices are generally ineffective for quantitative sampling of unionids.

Most of the methods described above can be used along lake shores and in the shoals of larger rivers, as well as in the smaller stream localities of the SRP. For deeper lake or river waters, a shell dredge (e.g., Wildlife Supply Co., No. 175) may be useful. The effectiveness of dredging is highly dependent upon the nature of the substrate. Heavy vegetative cover, such as that frequently occurring on SRP lake bottoms, or the numerous snags or stumps that are common in the Savannah River, tend to reduce the effectiveness of the shell dredge as a bivalve collector. Nevertheless, during June, 1977, good results were obtained by dredging in some parts of Pond B and Par Pond in order to obtain Anodonta imbecillis and along deeper shoals in the Savannah River in order to obtain Corbicula fluminea.

Specimens have been collected by use of mask, snorkel, and fins in all localities sampled. The use of mask and snorkel along shoals in the Savannah River was especially productive. Diving with SCUBA gear was attempted in Par Pond, with only fair results. The low visibility and heavy plant growth on the bottom inhibited the diver’s collecting effectiveness considerably.

**PRESERVATION OF BIVALVE MOLLUSKS FOR IDENTIFICATION**

Shell features of bivalve mollusks are often used as the only criteria for identification. Indeed, it is far easier and inexpensive to prepare and maintain a collection of dry shells than a “wet collection.” Yet many Unionacea and Sphaeriidae are difficult or impossible to identify at the species level by using shell characters exclusively.
Hence, both “wet” and “dry” collections are recommended, especially if the purpose of the collection is to be for later reference. Techniques for both kinds of collections will be described.

Tissue preservation is achieved in 5-6% neutral or buffered formalin. It is recommended that specimens be “pegged” open to facilitate penetration of the preservative. This can be done by inserting small wooden wedges between the valves of a naturally gaping clam before it has an opportunity to close. Even with pegging, the soft tissues contract strongly upon exposure to the preservative. To avoid this response, clams and mussels can be relaxed in a dilute solution containing Nembutal® (sodium pentobarbital).

Place the specimens to be relaxed in a container just large enough to hold them without expanded soft parts touching with other specimens, but small enough to minimize fluid volumes. Add enough natural water to the container barely to cover the bivalves. Then add ten to twenty drops of Nembutal (stock solution containing 50 mg sodium pentobarbital per ml fluid carrier) to the water. Do not disturb the specimens for at least one hour. Then touch the extended foot of a clam with a probe. If it retracts quickly and/or if no specimens have exposed soft parts, add to the water a quantity of Nembutal equal to the first dose. Repeat this process, reducing the quantity of Nembutal you add as the response becomes progressively lethargic. Eventually, there will be little or no retraction upon tactile stimulation. At this point gradually begin to introduce small amounts of 5-6% formalin or 70% alcohol into the water. We have found alcohol more effective at this stage, as it acts as a further relaxing agent, particularly if it is added slowly. Eventually, however, the specimens should be transferred to 5-6% formalin solution for complete fixation.

A word of warning: The relaxation technique described above is a very tedious process and not always successful. Furthermore, it seems to work more effectively in some genera than in others. Be prepared for several repetitions, if necessary, before achieving satisfactory results. Fuller (1971) has figured specimens of *Lampsilis radiata splendida* and *L. r. siliquoidea* (Lea) that were relaxed by the Nembutal technique and are fine examples of excellent relaxation and preservation.

Specimens should remain in 5-6% buffered formalin for one to several weeks to ensure good penetration of the fixative. Eventually, however, they should be transferred to 70% ethanol (ethyl alcohol). Pigmented areas will rapidly fade in alcohol; so, if notes are to be made on pigmentation in tissues, this should be done shortly after fixation or, better still, in life before preservation.

Sometimes it is desirable to separate soft parts from shell material and to leave the shell dry and the soft parts in alcohol. The preserved tissue can be removed almost intact from the surrounding shell by careful dissection. If this is done, identification should be maintained between shell and soft parts. A fine wire with an identifying label can be affixed to the muscular foot tissue, and a similar identifying number can be written on the interior surfaces of both valves using a permanent ink.

If one intends to keep only shell material of some specimens, there are easier methods to obtain cleaned shells. The quickest procedure is to place living specimens in boiling water. Within a few minutes, the valves will gape noticeably. Remove the specimens from the boiling water and lift the soft parts away from the shells. Tissues should never be extracted for preservation using this method, for there is considerable and progressive shrinkage of the soft parts during boiling.

When freshwater shells are dried, there is usually a problem with cracking, peeling, or warping of periostracal layers. Sometimes this can be retarded by lightly coating the valves with mineral oil. Thin shells, such as those of *Anodonta*, are also plagued by cracking or fragmentation of carbonate layers when dried. Even the application of mineral oil may not prevent this kind of damage.

*Abbott Laboratories, North Chicago, Illinois. This barbituate is available only by prescription, and/or federal (FDA) permit for Class I proscribal substances.*

**KEY TO THE SPECIES OF BIVALVE MOLLUSKS OF THE SAVANNAH RIVER PLANT**

Two excellent keys to the Unionacea of this region have already appeared. Johnson (1970), treating the entire Unionacean fauna of the southern Atlantic slope region, relied exclusively upon shell morphology in his key. Fuller (1971) employed soft-part criteria (especially the nature of the mantle margin) in his key of the unionaceans of the Savannah River system. The key employed in this paper is more restrictive than either of the two previous efforts: only those species known or reported to occur in the vicinity of the SRP are included. Also, it is organized differently: some species “key out” in associations different from those in Johnson’s or Fuller’s works. This was done purposely in an attempt to enhance the value of all of the keys. Johnson has excellent plates of comparative shell material and types, which should be consulted. Fuller has numerous anatomical notes, which are also valuable aids in identification. There are some cases, however, in which the existing keys simply cannot be improved upon. The reader should not be surprised to find a few couplets similar or identical in all three works. A glossary is included at the end of this report in order to provide a ready reference to the more technical terms used in this key.
Some species not reported from the SRP are included below. They are indicated by an asterisk. No treatment of these species is given in the descriptive section that follows.

1a  Posterior portion of mantle fused to form one or two elongate siphons ........................................ 2
1b  Posterior mantle unfused ventral to position of anus; incurrent (branchial) and anal areas are unfused but differentiated apertures; mantle fusion may occur dorsal to position of anus ........................................... Unionacea 3
2a  Shell oval or trigonal; umbo usually central; deeply incised broadly spaced concentric rings present over entire surface of valve; three cardinal teeth in each valve (one in each valve is closely applied to dorsal surface of hinge plate) .......... (Corbiculidae) Corbicula fluminea
2b  Shell oval or trigonal; umbo usually anterior or posterior to middle; valves may have very fine concentric lines, but never deeply incised rings; two or fewer cardinal teeth in each valve .... Sphaeriidae (See separate section on page 20.)
3a  Hinge plate completely edentulous; anal aperture without papillae ........................................... 4
3b  Pseudocardinal teeth, lateral teeth, or both present on hinge plate although sometimes vestigial; anal aperture with or without papillae .. 6
4a  Umbo not elevated above dorsal margin; shell usually less than 120 mm in length ........... 5
4b  Umbo elevated above dorsal margin; shell often 120 mm or larger ........ Anodonta cataracta
5a  Ventral margin straight or slightly convex, subparallel with dorsal margin; length/height ratio usually greater than 2.0; periostracum with broad green rays .......... Anodonta imbecillis
5b  Ventral margin noticeably convex, divergent from plane of dorsal margin; length/height ratio usually less than 2.0; periostracum with narrow green rays .......... Anodonta cooperiana
6a  Mantle margin at anal aperture lacking distinct papillae (smooth or crenulate) .......... 7
6b  Mantle margin at anal aperture with distinct, well formed papillae ..................................... 11
7a  Lateral teeth present on hinge plate ........ 8
7b  Lateral teeth absent from hinge plate ........ 9
8a  Branchial papillae denticiform; periostracum with sati-like texture, unrayed; pseudocardinal teeth chunky, serrated; hinge plate lacking interdental projection in left valve .......... Uniomerus tetralasmus
8b  Branchial papillae simple (unbranched); periostracum may be smooth, shiny, or slightly roughened, but not with sati-like texture, often with distinct rays; pseudocardinal teeth thin, lamellate; hinge plate with interdental projection in left valve .......... "Lasmigona subvirdis
9a  Pseudocardinal teeth small, poorly formed, or vestigial; posterior ridge not sharply angular ........................................... 10
9b  A single, distinctly elevated pseudocardinal tooth in each valve; posterior ridge sharply angular .......... Alasmidonta triangulata
10a  Pseudocardinal teeth reduced to slight swellings on hinge plate anterior to umbo; posterior slope usually without radial wrinkles .... Strophitus undulatus
10b  Pseudocardinal teeth more distinctly formed, single in each valve; posterior slope with radial wrinkles .......... "Alasmidonta varicosa
11a  Mantle anterior to branchial aperture undifferentiated and smooth; marsupium formed along total length of outer demibranchs, inner demibranchs may or may not form marsupium9 shell lacking conspicuous sexual dimorphism ....... 12
11b  Mantle margin anterior to branchial aperture carunculate, papillose, and/or formed into flaps or thickened pads; marsupium restricted to posterior half of outer demibranchs, never formed within inner demibranchs; male and female shells usually sexually dimorphic ....... 17
12a  Soft tissues usually pigmented vividly red or orange; all four demibranchs form marsupium; rare in most localities ..... "Fusconaia masoni
12b  Not as above; marsupium restricted to outer demibranchs ........................................... 13
13a  Length/height ratio usually less than 1.8; shell subtriangular or subquadrate; periostracum usually centrally smooth, shiny .......... Elliptio congareae
13b  Length/height ratio usually greater than 1.8; shell lanceolate, rhomboidal, or trapezoidal; periostracum smooth or rough .......... 14
14a  Sculpture including weak plications traversing disk obliquely and weak subradial ridges on posterior slope .......... Elliptio fraterna
14b  Not as above; periostracum broadly oval ........................ Elliptio cocconeus
15a  Length/height ratio usually greater than 2.5; shell distinctly lanceolate .......... Elliptio lanceolata
15b  Length/height ratio usually less than 2.5; shell rhomboidal or trapezoidal .......... 16
16a  Shell distinctly trapezoidal; periostracum usually quite rough, rarely shiny anywhere on valve; egg masses in marsupium narrowly elongate, slightly broader ventrally ....... Elliptio complanata
16b  Shell subrhomboidal; periostracum often with slight sheen medially, but without gloss on anterior or posterior slopes; egg masses in marsupium broadly oval .......... Elliptio icterina
17a  Mantle margin anterior to branchial aperture carunculate in female; shell rarely exceeding 35 mm in length ........... Carunculina pulla
17b  Mantle margin anterior to branchial aperture
papillate, flap-like, or forming a thick pad, but not carunculate; shell frequently exceeding 35 mm in length ........................................18

18a Mantle margin anterior to branchial aperture papillate in female; shell rarely exceeding 70 mm in length .................................19

18b Mantle margin anterior to branchial aperture flap-like or formed into a thickened pad; shell often exceeding 70 mm in length ..............20

19a Periostracum with wide green rays occasionally interrupted by growth rests; sexual dimorphism weakly expressed ....................... *Villosa vibex*

19b Periostracum with narrow green rays often interrupted by broad yellowish background areas; sexual dimorphism well expressed ... *Villosa delumbis*

20a Adult shell large, heavy, subovate (female) to subtrigonal (male); periostracum smooth, yellowish, usually lacking rays; mantle anterior to branchial aperture flap-like .......... *Lampsilis cariosa*

20b Adult shell moderately large, moderately thickened, subrhomboidal; periostracum rough, somewhat satin-like, brownish or reddish, usually with faint rays; mantle anterior to branchial aperture forming a very darkly pigmented, thickened pad, and an anterior, ribbon-like flap .................... *Lampsilis radiata splendida*.

**TAXONOMIC CRITERIA**

Most of the terms employed in the descriptions below are defined in the glossary at the end of this paper and are illustrated in figures following the glossary. In each systematic description, two meristic shell ratios are given: length/height and height/inflation (= breadth). In order to standardize these values to facilitate comparison, the dimensions of length, height and inflation were measured at consistent locations on all shells (see Figures 2 and 4). Vernier calipers were used for measurements. Length was taken as the maximum anterioposterior elongation of the shell. Height and inflation were measured at the position of the umbo crest, immediately posterior to the umbo origin (see Figure 4). This does not always correspond with maximum height or inflation as can be seen in the figures. Hence, any future measurements must be taken exactly as indicated if comparisons with the present values are desired.

**DESCRIPTIONS OF THE BIVALVIA**

**SUPERFAMILY UNIONACEA Thiele 1934**

**FAMILY UNIONIDAE Fleming 1828**

**DIAGNOSIS:** Freshwater bivalves or clams with equivale shells usually larger than 1 cm in length; hinge edentulate, or with either pseudocardinal or lateral teeth or both; ligament opisthodetic and parviccular; periostracum usually conspicuous; a sheet of tissue almost completely separates excurrent and incumbent mantle cavity; gills with distinct interlamellar septa that parallel gill filaments and form watertubes, some or all of which become brood chambers (marsupia) for ova and larvae; larvae (glochidia) parasitic on vertebrates, usually fish.

**SUBFAMILY UNIONINAE Swainson 1840**

**DIAGNOSIS:** Marsupium occupying entire outer demibranchs; demibranchs only moderately distended when filled with ova and/or larvae; anal aperture papillate although papillae may be very short; pseudocardinal and lateral teeth present; glochidia oval to subovate, with or without hooks.

**GENUS Elliptio Rafinesque 1819**

**DIAGNOSIS:** Shell moderately to greatly elongated (length/height ratio) varying from 1.50 to at least 4.0); longitudinal axis generally straight. Beaks low, inequilateral, anterior, and prosogyrate. Ligament prominently elevated. Periostracum well developed and darkly colored in adults, often rayed in juveniles. Dentition consisting of 2 pseudocardinal teeth and 2 lateral teeth in left valve, 1 or 2 pseudocardinal teeth and 1 lateral tooth in right valve. Anal papillae present; simple branchial papillae usually dominant, but denticr branchial papillae sometimes present, occasionally numerous; papillae absent along mantle margin anterior to branchial aperture. Dorsal margins of inner lamellae of inner demibranchs not completely fused to visceral mass. Eggs white; glochidia without hooks, usually expelled from marsupium in compacted masses (oviscas).

**TYPE-SPECIES:** *Unio nigra* Rafinesque 1820 (= *Elliptio crassidens* (Lamarck 1819)).

*Elliptio complanata* (Lightfoot 1786)
(Plate I, Figure 1; Map 3)

**DIAGNOSIS:** Shell up to 140 mm in length; elongate, trapezoidal; mean length/height ratio 1.96 (N = 52, S.D. = 0.15, range 1.74 to 2.84); valves usually flattened or slightly inflated, sometimes moderately inflated; mean height/inflation ratio 1.68 (N = 39, S.D. = 0.17, range 1.3 to 2.1). Anterior end smoothly rounded; posterior end higher and trapezoidal, sometimes biangulate; ventral margin straight to noticeably arcuate; dorsal margin slightly arched but appearing parallel or subparallel to ventral margin, giving emphasis to trapezoidal shape of shell. Umbo low, uninflated, frequently eroded in larger specimens; beak sculpture when not eroded, of low concentric loops subparallel to growth lines. Posterior ridge faintly double. Periostracum in young specimens brownish, yellowish, or greenish, sometimes with faint rays over entire
surface; periostracum in adults brown to black, usually with strongly elevated growth lines over entire shell. Pseudocardinal teeth in left valve small, serrated; single right pseudocardinal serrated, but a vestigial tooth may occur slightly anterior to prominent pseudocardinal: lateral teeth with granulated surfaces. Paliial line often loops posteriad to posterior adductor muscle scar with posterial extension usually less than one-fourth total length of muscle scar. Nacre purple, copper orange, or pink, rarely salmon or iridescent white.

Branchial and anal papillae mostly unbranched, distinctly elevated, moderately to heavily pigmented. Glochidial masses in marsupium compacted into narrow elongate masses (ovisacs) along most of length and height of outer demibranch. Ovisacs may be expelled from marsupium intact as white narrow elongate wafers. Sexes separate, shell without sexual dimorphism.

**TYPE LOCALITY:** Restricted to Potomac River, Washington, D.C. by Johnson, 1976.


**DISTRIBUTION:** This is one of the most common of the Atlantic Slope unionids ranging from central Georgia to northern Canada and westward to Lake Superior. Matteson (1948a, 1948b) discusses the general distribution of the species.

**ECOLOGY:** *E. complanata* seems to prefer sandy or sandy-mud substrates in moderately to fast flowing streams. However, it can be found in almost any freshwater habitat from organically rich pond bottoms to clean sandy bars in sandy rivers. It has even been successfully introduced into new lentic habitats (see Smrchek, 1971, concerning the introduction of *E. complanata* in Douglas Lake, Michigan). It can be especially abundant in some parts of the Savannah River, where giant specimens in excess of 140 mm have been found. At SRP, *E. complanata* shares a common habitat with *E. icterina*, where the two species frequently coexist in approximately equal numbers. See also, Matteson (1948a, pp. 715-716).

**LIFE HISTORY:** Most of the information presented here is from Matteson (1948a), who describes the life history of *E. complanata* in considerable detail. The general pattern of development demonstrated by this species is very similar to that of many other unionids and can serve as a guide for the group. Hence, more information is presented here than in subsequent “Life History” sections. In the latter, those features which tend to differ from this species will receive the greatest attention.

Sexes are separate in *E. complanata* as is the typical case in the unionids. Matteson (1948a) found viable sperm present in the testes throughout the year, with the sperm count increasing during late spring. Males begin to release sperm into surrounding waters via the anal aperture in late April. Release continues through mid-June, with the peak sperm release occurring in mid-May. Sperm enter the female mantle cavity through the incurrent aperture. Simultaneously eggs are moved from the ovary via gonoducts to the supra-branchial chamber where fertilization normally occurs. Matteson (1948a) has observed fertilization in gill marsupia, and, in one instance, sperm “in the ovarian ducts leading to the suprabranchial chambers.” Fertilization occurs at the primary oocyte stage and eggs fertilized in the suprabranchial chambers are moved into water tubes of gill marsupia in the outer demibranchs of the gills.

Details of cleavage and pre-glochidial development are given by Matteson (1948a). Briefly, development from zygote to mature larvae requires approximately one month in the gill marsupium. Each water tube contains hundreds of developing larvae which are loosely bound together in white “ovisacs.” If female clams are disturbed during the brooding period by sudden temperature changes, toxic substances in the water, rough handling or other factors, they often release the ovisacs. The ovisac of *E. complanata* is distinctly shaped, being long, narrow and slightly broader ventrally. This is in direct contrast to the shorter, broader, more oval ovisac of an aberrant Mill Creek population of *Elliptio*, which we presently refer to as *E. icterina* (see below). The shape of the aborted ovisac reflects the shape of the water tube cavity and, according to Fuller (1971, 1972), the evolutionary history of the genus. Matteson (1948a) reports that expulsion of ovisacs represents abortion of larval stages rather than the primary mechanism of release. He shows that ovisacs contain larvae in various stages of development. Glochidia are brooded until “mature,” when they are released individually via the suprabranchial chamber and anal aperture. The actual mechanism of transport to the suprabranchial chamber is unknown. However, as glochidia are ejected from the anal aperture, they are accompanied by mucous strands which attach to whatever they contact in “cobweb” structures. Apparently this facilitates encounter with fish hosts.

An individual glochidium of *E. complanata* is a small, oval, bivalved, hookless larva approximately 200 μ in length and slightly less in height. Unionid glochidia usually must attach to a suitable fish host for development to proceed, although some species (e.g., *Anodonta imbecillis* *fide* van der Schalie, 1970) appear to be facultative parasites, which may develop directly without encystment. Obligatory parasitic glochidia such as those of *E. complanata* usually attach to and encyst on fish gills. Some species (e.g., *Anodonta* spp.) have hooks on the larval shell and can attach to the fins of fishes. Glochidia are apparently host specific, but host-glochidia relationships are far from being well known. There is considerable controversy concerning the “parasitic” period of the unionid life cycle, particularly whether the encysted glochidium actually derives nutrition from the host fish or merely uses the fish as a dispersal mechanism. Fuller (1974) reviews the
problem and presents a considerable bibliography. Those fish that serve as glochidial hosts of SRP mussels are listed in a separate section in each species discussion (see below).

Matteson (1948a) reports the encysted stage in *E. complanata* to be approximately 18 days. During the end of this period, the glochidia undergo a metamorphosis in which there is considerable alteration of internal anatomy. The clam then drops from the fish host to begin independent development. This period of the life cycle of most mussels including *E. complanata* is poorly understood. Matteson (1948a) was able to hold juvenile clams 35 days after the glochidial stage, with the shell increasing from 208 μ to 840 μ. Most information on the growth of unionids concerns specimens of at least 1 cm or more in length. Matteson (1948a) suggests that the greatest amount of growth in *E. complanata* occurs during the third growing season and the next greatest in the second growing season. The amount of shell material deposited diminishes with age with little appreciable growth of the shell occurring after the twelfth year (Matteson, 1948a). Sexual maturity is apparently reached in the second or third year.

**GLOCHIDIAL HOSTS:** The yellow perch, *Perca flavescens* has been reported to harbor glochidia of *E. complanata* (Lefevre and Curtis, 1912; Matteson, 1948a) as has the banded killifish, *Fundulus diaphanous* (Wiles, 1975). *P. flavescens* is known to occur commonly in waters throughout the SRP (McFarlane, 1976).

**ADDITIONAL REMARKS:** *Elliptio complanata* and *E. icterina* are the most common species of unionids encountered in this area. They are also frequently difficult to distinguish, especially on the basis of shell material alone. *E. icterina* tends to be somewhat smaller and more pointed and to have a smoother shell than *E. complanata.* The latter species usually possesses a rough periostracum and a more quadrate or rhomboidal shape. None of these differences is consistently reliable. The most positive means of identification is the nature of the marsupia and the contained ovisacs (see Life Cycle, above). Unfortunately, the ovisacs are formed only during summer months.

Fuller (1971) suggests that the pigmentation of anal and branchial apertures of *E. complanata* is darker than that of *E. icterina.* We have not found this to be a reliable criterion for differentiating the species. Although *E. complanata* tends to have more darkly pigmented apertural regions, there is considerable variability. Many *E. icterina,* including Mill Creek populations (see below) and those from other localities on and off the SRP have been observed with very darkly pigmented anal and branchial apertures.

Electrophoretic techniques can be employed to differentiate the species (M. Smith, J. Hagan and J. Britton, unpublished data). For example, when the enzyme system Phosphoglucomutase (PGM) is examined using starch gel electrophoresis on a tris-citrate buffer (pH 8.0), the two species distinctly separate with the homozygous product of *E. complanata* migrating consistently faster than the homozygous product of *E. icterina.* There are other differences that can also be shown by electrophoresis.

In summary, although *E. complanata* and *E. icterina* are the most abundant species of the SRP, their absolute identification often remains elusive, even for experts (cf. Fuller, 1971). Anyone requiring precise specific identification should always consult a knowledgeable malacologist for advice and assistance.

*Elliptio icterina* (Conrad 1834)  
(Plate 1, Figure 2; Map 2)

**DIAGNOSIS:** Shell reaching 86 mm in length; elongate, sub lanceolate to sub trapezoidal; mean length/height ratio 2.12 (N = 59, S.D. = 0.23, range 1.81 to 3.49); values moderately inflated; mean height/inflation ratio 1.49 (N = 59; S.D. = 0.15, range 1.00 to 1.81). Anterior end smoothly rounded; posterior end often pointed, sometimes biangulate; ventral margin slightly convex, rarely arcuate; dorsal margin straight to junction with posterior margin where the junction is often noticeably angulate; dorsal and ventral margins usually not parallel or subparallel for most of their lengths, so shell rarely presents rhomboidal shape. Umbos low, slightly inflated, frequently eroded in larger specimens; beak sculpture when not eroded, of several concentric elevated loops which are subparallel to growth lines and slightly tuberculate posteriorly. Posterior ridge slightly to distinctly double. Periostracum in young specimens as in *E. complanata*; adult periostracum often semi-polished on central shell, blackish or brownish black; infrequently with roughly formed and elevated growth lines. Hinge teeth typical of genus, left pseudocardinals small, equal in size; right pseudocardinals usually double with right anterior pseudocardinal almost vestigial; laterals with granulations. Pallial line often curves posteriad to posterior adductor scar, but rarely extends posterior more than one-half length of posterior adductor scar. Nacre iridescent white, pink, salmon orange, or purple.

Branchial and anal papillae mostly unbranched, very lightly to moderately pigmented. Glochidial masses in marsupium inflated and broadly oval in shape, may be expelled intact from marsupium as white broadly elliptical wafers. Sexes separate. shell without sexual dimorphism.

**TYPE-LOCALITY:** Muddy shore, Savannah River, opposite Augusta, Georgia.

**TYPE:** Holotype, Academy of Natural Sciences of Philadelphia, 41381 figured by Johnson, 1970, Plate 9, Figure 3.

**DISTRIBUTION:** From the Escambia River system of Alabama and Florida eastward through Florida and northward along the eastern Atlantic slope to the White Oak River, North Carolina.
ECOLOGY: In the region of sympatry (which includes the SRP), *E. icterina* and *E. complanata* frequently share similar habitats and can be collected side by side in streams, rivers, or lakes. Both species are usually most abundant in small fast-flowing streams where they generally lie partially buried along stream banks or on bars. Like *E. complanata*, *E. icterina* may be very abundant in some localities in the Savannah River, but rarely attains the size reached by some *E. complanata* there. The Mill Creek population (see Additional Remarks, below) occurs in a shallow, narrow stream that is only a few cm deep except in occasional “pools” (perhaps 30 cm in depth) close to its banks. Mill Creek is an upland SRP stream that drains a small watershed into Upper Three Runs. Its water presumably is acidic during much or all of the year, but this is the norm for higher-gradient creeks draining essentially coniferous watersheds in the Savannah River basin.

LIFE HISTORY: The life history of *E. icterina* is probably very similar to that described for *E. complanata* although there have been no detailed studies. Egg masses accumulate in the marsupium during June and July. The glochidium is hookless, oval and very similar in appearance to that of *E. complanata*. See the discussion under *E. complanata* for differences of marsupial structure and shape of ovisacs.

GLOCHIDIAL HOSTS: Unknown

ADDITIONAL REMARKS: The difficulty of distinguishing *E. icterina* from *E. complanata* has been discussed in the remarks of the latter species, which should be consulted by the reader.

The specimens of *E. icterina* inhabiting Mill Creek display some characteristics which may justify recognition of this population as (at least) a subspecies differing from the typical *icterina*. The marsupium of the Mill Creek *E. icterina* is far more obese than is characteristic for the species, and it is restricted primarily to the median one half of the outer demibranch.

Most students of Nearctic Naiades have agreed that Simpson (1900, 1914) and Ortmann (1910, 1911, 1912, 1916) were justified in interpreting marsupial type as the most important factor in unionid classification. Indeed, discovery of a novel kind of marsupium has regularly been taxonomically recognized by erection of a new genus. There is precedent, then, for also regarding the underscribed Mill Creek “Elliptio” as the type species of an undescribed genus, on account of the restriction of its marsupium to the median water tubes of the outer demibranchs. (This character is otherwise known only in the monotypic genus *Hemistena* of the naiad biogeographic Cumberlandian province (Ortmann, 1918; Neel and Allen, 1964; van der Schalie and van der Schalie, 1950). On the other hand, there is no reason to assume that *Elliptio* cannot be an exceptional case, where more than one marsupial type may have arisen within the same genus.

At any rate, introduction of new taxa is inappropriate in a handbook such as the present report. We have emphasized the peculiarities of “the Mill Creek ‘Elliptio’” simply in order to acquaint SRP scientists with this zoological curiosity in their midst and to encourage its further study and conservation.

This last point is of great importance. The Mill Creek *Elliptio* is proposed as a population of special concern in South Carolina. As long as the SRP remains a National Environmental Research Park, there will be little or no danger that the public will disturb this population. There is a very real potential danger, however, that SRP investigators themselves may unwittingly harm it. In an effort to forestall such mistakes, it would be well to survey SRP *Elliptio*, especially populations in the upper Three Runs drainage, where (at least in Mill Creek) more typical *E. icterina* populations are believed to be sympatric with the Mill Creek form.

Such an investigation would best be conducted in July, when the latter is known to be gravid. The valves can be pried apart, slowly and gently (with thumbnail or weak reverse pliers), just enough to reveal the charged marsupium (if, of course, the specimen in hand is a female). If the marsupium is fully charged and if it is obese and restricted the median halves of the outer demibranch, the specimen belongs to “the Mill Creek *Elliptio*”; if the specimen is a male or a barren female, this test cannot be performed, and field identification (i.e., without killing the animal) is not practicable unless, of course, shell characters will serve, as often is the case with *E. congareae* (Lea) and *E. complanata* (Lightfoot). Finally, such surveillance, conducted with utmost caution, would do much to clarify the taxonomic status (and thus the legal status, if any) of what we are calling “the Mill Creek *Elliptio*”.

We realize that this animal might well prove to be only a local aberration of *E. icterina*, but even in this case the surveillance would have been fruitful in providing knowledge of a creature that, under any circumstances, is highly unusual and requires conservation in the interest of further study and the genetic richness of the molluscan fauna.

The discussion of *E. icterina* by Fuller (1971) refers exclusively to the Mill Creek population. Hence, many of the statements attributed to *E. icterina* as a whole by Fuller (1971) are restricted exclusively to this single population, including figures of the marsupial structure.

Fuller (1972) described a new species, *Elliptio marsupiobesa* from the Cape Fear River, North Carolina, and suggested that this new species is closely related to *E. icterina*.

*Elliptio lanceolata* (Lea 1828)

(Plate I, Figure 4; Map 5)

DIAGNOSIS: Shell up to 140 mm in length; noticeably longer than high, mean length/height ratio 2.6 (N = 26, S.D. = 0.37, range 2.05 to 4.02); valves moderately inflated; mean height/inflation ratio 1.66 (N
There is a closely related species, *E. shepardiana* (Lea 1834), in the Altamaha River system where it is sympatric with *E. lanceolata*. Considering the large amount of variability in *E. lanceolata* in the Savannah River drainage, one must question whether *E. shepardiana* is a distinct species and not an ecotypic variation. Needless to say, *E. shepardiana* is quite singular with respect to shell elongation with a length/height ratio frequently exceeding 4 and approaching 6.

*Elliptio congaraea* (Lea 1831)
(Plate I, Figure 3; Map 3)

**DIAGNOSIS:** Shell up to 101 mm in length; slightly elongate, sub-triangular, mean length/height ratio 1.7 (N = 29, S.D. = 0.13, range 1.45 to 2.12); valves noticeably inflated; mean height/inflation ratio 1.5 (N = 29, S.D. = 0.11, range 1.06 to 1.64). Anterior end smoothly rounded to subangular; posterior end produced, pointed posteroventrally, ventral margin slightly convex; dorsal margin and ligament area short, slightly convex, not parallel with ventral margin. Posterior ridge prominent to subprominent, secondary ridge may occur; posterior slope frequently with short bars or ridges crossing growth lines. Umbos moderately elevated, frequently eroded in larger specimens, located in anterior third of shell. Periostracum smooth, yellowish or brownish and often with greenish rays in young specimens; becoming yellowish brown to chestnut in larger shells, polished to subpolished, sometimes with very fine radial crenulations on central shell area; thin elevated concentric growth lines more apparent at anterior end and on posterior slope. Right pseudocardinal teeth large, chunky, serrated, subequal; left posterior pseudocardinal large, serrated, more prominent than left anterior pseudocardinal which may sometimes appear vestigial; lateral teeth short, with granular surfaces. Pallial line usually not produced posterior to posterior adductor scar. Nacre white or salmon, slightly iridescent.

Simple and dendritic papillae produced at branchial aperture; anal papillae short, lightly to moderately pigmented. Nature of gravid marsupium unknown.

**TYPE-LOCALITY:** Congaree River, South Carolina.

**TYPE:** Holotype, National Museum of Natural History, 85693, figured in Johnson, 1970. Plate 5, Figure 1.

**DISTRIBUTION:** From the Ogeechee River system, Georgia to the Cape Fear River system, North Carolina.

**ECOLOGY:** Although *E. congaraea* has been collected from lower Three Runs Creek at Donora Station, the species is apparently best adapted for larger rivers. It is commonly found on sand bars along the Savannah River.

**LIFE HISTORY:** There is apparently no published information on the life history of *E. congaraea*. Many females were collected in June, 1977, during field work for this report, but none were found with larvae in the...
gills and only a few were found with eggs in the gonads. Ortmann (1912) reports larvae in the gills of a closely related species, *E. crassidens*, in mid-June. Possibly *E. congaraea* may hold larvae in the marsupium only a very short time before release.

**GLOCHIDIAL HOSTS:** Unknown

**REMARKS:** Patrick et al. (1966) report *E. incrassatus* from the Savannah River in the vicinity of the SRP. They are using this junior synonym of *E. crassidens* (Lamarck 1819) erroneously in reference to *E. congaraea*.

*E. congaraea* differs in several ways from the species of *Elliptio* discussed above, even though it presumably is a member of the same subgenus. For example, it has a more inflated, thicker shell. The reproductive period for this species apparently is not similar to that of *E. complanata*, *E. icterina*, or *E. lanceolata*. The species often displays at least some dendritic branchial papillae, despite Fuller's (1971) indication that dendritic papillae are absent. We believe that *E. congaraea* should receive further study, particularly comparative soft-part analysis with other *Elliptio* species. It and closely related congeners such as *E. crassidens* (which is the type species of *Elliptio*) may prove to be sufficiently distinct from the *complanata-icterina-lanceolata* group that the latter series might require subgeneric distinction.

*Elliptio fraterna* (Lea 1852)
(Figured by Johnson, 1970, Plate 7)

**DIAGNOSIS:** Shell moderately elongate and laterally compressed; sculpture consists of weak plications running obliquely across the disc and of weak subradial ridges on the posterior slope; periostracum is brownish yellow.

Incurrent papillae commonly are at least bifid, and dark pigment of mantle margin at incurrent aperture extends conspicuously for a short distance anterior. The posterior slope is well developed, clothlike, dark in adults, unrayed. Dentition consisting of 2 pseudocardinal teeth and 2 lateral teeth in left valve, and one pseudocardinal and one lateral tooth in right valve. Anal papillae short or appearing as crenulations but never completely absent; branchial papillae dendritic; papillae absent along mantle margin anterior to branchial aperture. Inner surface of inner demibranchs not fused to visceral mass; marsupium restricted to outer demibranchs. Glochidia without hooks, held in marsupium in narrow masses.

**TYPE:** The type specimen of *Unio fraternus* (*Elliptio fraterna*) is the holotype, NMNH 85396.

**DISTRIBUTION:** The known (or supposed) geographical distribution of *Elliptio fraterna* is confined to the Chattahoochee and Savannah Rivers of Georgia and/or South Carolina.

**ECOLOGY:** In the mainstem Savannah River, *Elliptio fraterna* has been taken only from sand bars beneath one or two feet of water.

**LIFE HISTORY:** Nothing is known about the life history of *Elliptio fraterna*.

**GLOCHIDIAL HOSTS:** Nothing is known about the larval host(s) of *Elliptio fraterna*.

**ADDITIONAL REMARKS:** The 1972 discovery by one of us (SLHF) of conchologically at least putative *Elliptio fraterna* in the Savannah River close to SRP is the cause of admitting this poorly understood species to the present report. If, as we believe, this record is authentic, it is the only recorded capture of living *E. fraterna* since the species' original description almost 130 years ago. These data are sufficient demonstration of this species' natural rarity in at least the Atlantic drainage.

**GENUS UNIOMERUS** Conrad 1853

**DIAGNOSIS:** Shell moderately elongate, rhomboidal, longitudinal axis generally straight. Beaks low, inequilateral, anterior, and prosogyrate. Ligament elongate, slightly to moderately elevated. Periostracum very well developed, clothlike, dark in adults, unrayed. Dentition consisting of 2 pseudocardinal teeth and 2 lateral teeth in left valve, and one pseudocardinal and one lateral tooth in right valve. Anal papillae short or appearing as crenulations but never completely absent; branchial papillae dendritic; papillae absent along mantle margin anterior to branchial aperture. Inner surface of inner demibranchs not fused to visceral mass; marsupium restricted to outer demibranchs. Glochidia without hooks, held in marsupium in narrow masses.

**TYPE-SPECIES:** *Unio tetralasmus* Say 1831, subsequent designation by Simpson (1900).

**REMARKS:** The genus is considered monotypic by Johnson (1970 and 1972) and Fuller (1971). There are marked morphological differences between Atlantic slope and Interior Basin populations which Johnson ascribes to ecophenotypic variation. Valentine and Stansbery (1971) have a more liberal interpretation of the number of species in this genus, stating that there are at least two and possibly more. Based upon differences in shell morphology, one is tempted to agree with the latter authors that at least two species can be recognized, with the populations of the Savannah River being atypical of the specimens from the Gulf Coastal drainages. Until a detailed examination of soft-part morphology is made, however, we are reluctant to differentiate the two shell forms as distinct species, and follow the more conservative positions of Fuller and Johnson.
**Uniomerus tetralsmus** (Say 1831)
(Plate I, Figure 6; Map 4)

**DIAGNOSIS:** Shell up to 114 mm in length, elongate, rhomboidal; mean length/height ratio 1.73 (N = 12, S.D. = 0.11, range 1.50 to 1.88); valves moderately inflated; mean height/inflation ratio 1.59 (N = 12, S.D. = 0.13, range 1.38 to 1.81). Anterior end smoothly rounded; posterior end high, trapezoidal, relatively straight from near termination of hinge teeth to subangular posteroventral margin; ventral margin slightly convex, usually not arcuate; dorsal margin almost straight to slightly curved, angular at junction with posterior margin. Umbos low, un inflated, frequently eroded in larger specimens; beak sculpture when present consisting of 6 to 8 low concentric loops oblique to growth lines on posterior slope. Posterior ridge broadly rounded; posterior slope wide with one or two radiating finely incised lines. Periostracum usually dark brown or black, heavy, often with a clothlike sheen. Pseudocardinal teeth in left valve serrated, subtriangular or triangular; single left pseudocardinal slightly larger, serrated; trace of a vestigial pseudocardinal may appear anterior to large left member; laterals typical of genus, sometimes faintly granulate. Pallial line extends slightly to distinctly posteriad to posterior adductor scar, from one-eighth to one-third length of scar. Nacre of valve interior white, bluish lavender, coppery purple, pink or purple.

Anal papillae short and crenulate; branchial papillae mostly dendritic, some simple; anal and branchial apertures moderately pigmented; papillae absent along ventral margin below and anterior to branchial aperture, mantle frequency exhibits a faint gray band along ventral margin. Glochidial masses in marsupium very narrow, elongate rods along most of length and height of outer demibranch. Sexes separate, sexual dimorphism not clearly indicated in shell.

**TYPE-LOCALITY:** Bayou St. John, Louisiana.
**TYPE:** Apparently lost, *fide* Johnson, 1970.
**DISTRIBUTION:** Central and southern United States from the base of the Rocky Mountains to the Atlantic slope drainages, generally below latitude 40 degrees. Johnson (1970) indicates this species is "noticeably scarce" in the Carolinas.

**ECOLOGY:** *U. tetralsmus* is not especially common in the waters of the SRP, but it does seem to be present in ponds as well as streams, and frequently in fine muds or silts. It has been taken in Upper Three Runs and Lower Three Runs Creeks, where it avoids the swifter waters over sand banks, preferring instead the fine organics and leaf debris traps created by slowly moving side eddies. It is also present in the muds of Par Pond.

*U. tetralsmus* is particularly well adapted for surviving drought or low water conditions for extended periods. This ability has prompted Fuller (1971) to describe the species as having an "enormous tenacity for life." If stranded by dropping water levels in drying streams or ponds, this mussel will bury itself deeply in the moist substrates to avoid dessication. One of us (ICB) has collected *U. tetralsmus* from a north Texas farm pond which had been drained at least one month prior to the date of collection. The surface of the drained pond was firm enough to walk upon without sinking into mud, yet numerous living specimens were found at the bottom of deep cracks caused by the drying substrate. Simpson (1893), Baker (1928), and others have published similar observations.

**LIFE HISTORY:** Only the outer demibranchs are marsupial in this species. Female marsupia were bare during June, 1977, lacking either eggs or larvae, but several females were collected with eggs in the gonads.

**GLOCHIDIAL HOSTS:** Unknown.

**REMARKS:** Valentine and Stansbery (1971) consider the South Carolina populations of *Uniomerus* to be *U. obesus* (Lea 1831). They consider this species a shorter, more inflated form which differs from the type-species, *U. tetralsmus*. Detailed examination of soft tissue morphology or cytochemistry may prove that *U. obesus* is a valid name.

**SUBFAMILY ANODONTINAE** Swainson 1840

**DIAGNOSIS:** Marsupia occupying entire outer demibranchs, demibranchs greatly distended when filled with ova and/or larvae; secondary partitioning of the water tubes present; anal aperture without papillae; lateral teeth, pseudocardinal teeth or both frequently reduced or absent; umbonal sculpture usually a series of raised double loops; glochidia ovate or subtriangular with hooks.

**GENUS Alasmidonta** Say 1818

**DIAGNOSIS:** Shell inequilateral, elliptical or rhomboidal, inflated moderately heavy posterior ridge usually prominent. Umbos inflated, anterior, and prosogyrate. Ligament short but prominently elevated. Periostracum thin to well developed, darkly colored in adults, often rayed. Pseudocardinal dentition always present; lateral dentition present, vestigial or absent; when present paired laterals may be in right valve. Inner surface of inner demibranchs may or may not fuse with visceral mass epithelium.

**TYPE-SPECIES:** *Unio heterodon* Lea 1830.

**Alasmidonta triangulata** (Lea 1858)
(Plate II, Figure 1, Map 4)

**DIAGNOSIS:** Shell elongate, subrhomboidal usually less than 60 mm in length; mean length/height ratio 1.49 (N = 4, S.D. = 0.04, range 1.44 to 1.51); valves thin to moderately thickened, inflated; mean height/inflation ratio 1.25 (N = 4, S.D. = 0.002, range 1.2 to 1.3). Anterior end rounded with most pronounced curvature along dorsal half of anterior margin; posterior end distinctly pointed at termination of posterior ridge.
angulate at margin of posterior slope; ventral margin gently curving; dorsal margin noticeably arched or sinuate, being most angulate just anterior to the umbo. Umbo prominent, inflated and elevated, crossed by several distinct, broadly spaced ridges that extend onto the uppermost eighth of the shell. Posterior ridge distinctly elevated, angular; secondary or tertiary ridges may occur on posterior slope and form marginal angulations at their termination. Periostracum relatively thin over most of shell exterior, but becoming slightly thickened on posterior slope, light green or yellow in young specimens, becoming brown, greenish brown or black in older animals; green rays often prominent on shell beneath periostracum. Left valve with a small, poorly elevated pseudocardinal tooth with a slight groove anterior to it and a slightly toothed interdental to the posterior; left lateral tooth almost absent.

**TYPE-LOCALITY:** Upper Chattahoochee River, Georgia.

**TYPE:** Holotype, NMNH, 86249, figures in Johnson, 1970, Plate 13, Figure 5.

**DISTRIBUTION:** Apalachicola River system to the south, and the Ogeechee, Savannah, and Santee-Cooper River systems on the Atlantic slope. The species is not common in any part of its range, and thus should perhaps be considered a threatened or endangered species.

**ECOLOGY:** *A. triangulata* is a rare species with little known about its ecology or life cycle. It is usually found in rivers or larger streams throughout its range, but never in abundance. During June, 1977, the species was found at only one locality on the Savannah River.

**GLOCHIDIAL HOSTS:** There have been no reports of host fish for the glochidia of *Alasmidonta triangulata*. Morrison (in Clarke and Berg, 1959) reports that glochidia of *A. calcicola* (Lea 1830) from the Mississippi system attach to a darter, *Etheostoma nigrum*, Johnson (1970) recognized two subgenera, *Pyganodon* Crosse and Fisher 1894 (including *A. cataracta*) and *Utterbackia* F. C. Baker 1927 (including *A. imbecillis* and *A. couperiana*) in the Savannah River drainage. The two groups can be differentiated in the Savannah drainage fauna by the nature of the umbo: *Utterbackia* has very low, almost flattened beaks; *Pyganodon* has inflated and elevated umbos.

**SUBGENUS Utterbackia F. C. Baker 1927**

**Anodonta imbecillis** Say 1829 (Plate 1, Figures 7 and 8; Map 3)

**DIAGNOSIS:** Shell elongate, subrhomboid, up to 80 mm in length; mean length/height ratio 2.27 (N = 30, S.D. = 0.18, range 2.02 to 3.08); valves very thin, fragile, moderately inflated; mean height/inflation ratio 1.51 (N = 30, S.D. = 0.12, range 1.28 to 1.75). Anterior end smoothly rounded; posterior end subpointed to angular with greatest distention in lower half; ventral margin slightly curving, subparallel to dorsal margin; dorsal margin almost straight, elongate. Umbos flat, not elevated or inflated; umboonal sculpture consisting of a series of distinctly raised double loops. Posterior ridge smoothly rounded; posterior slope somewhat flattened, sometimes raised into a slightly flaring wing. Periostracum relatively thin on all parts of shell, smooth and shiny medially, but slightly rougher on posterior slope; color tan: yellowish brown, greenish brown or green; broad greenish rays common. Hinge thin, narrow, edentulous, ligament thin, narrow, elongate. Nacre of shell interior bluish white to metallic steel blue.

Anal papillae absent, branchial papillae simple, unbranched, moderately pigmented. Monoecious, outer demibranchs greatly distended when charged with glochidia.

**TYPE-LOCALITY:** Wabash River, New Harmony, Indiana (restricted by Clench and Turner, 1956).

**TYPE:** Original type lost. Neotype, Senickenberg Museum 4301, selected by Haas, 1930.

**DISTRIBUTION:** From the eastern base of the Rocky Mountains to the Atlantic Slope.

**ECOLOGY:** *A. imbecillis* is a common pond or lake mussel, apparently preferring the quieter waters. It lives in sand, mud, or fine silts, but is usually absent from gravels or shifting sands in fast flowing streams. This is the most abundant species in Par Pond and other pooled basins of the SRP, being common from shore to depths of 8 to 10 m. The deeper water populations in Par Pond frequently produce a prominent "wing" or elevation of shell material posterior to the umbo (Plate I, Figure 7). *A. imbecillis* is very common and easily collected in the SRP lakes, where it cannot be confused with any other mussel. The only similar species, *A. couperiana*, may occasionally coexist with *A. imbecillis*. Patrick et al. (1966) report that both species were collected from a single station on the Savannah River near Johnson's Landing. The species can be distinguished in that the shell of *A. couperiana* is more inflated and the ventral margin is noticeably more convex than *A. imbecillis*, which has a more elongate, streamlined appearance.
**LIFE HISTORY:** The life history of *A. imbecillis* differs from that of other mussels in several ways. The species is almost always hermaphroditic (van der Schalie, 1970), although it is uncertain whether self-fertilization is possible in this species. It may also avoid the parasitic larval stage, with larvae developing directly in gill marsupia (see below). The larvae are brooded during the fall and winter months and may be held in the gills as late as mid-May (Ortmann, 1909). The glochidia bear hooks, which can be used to facilitate attachment to a fish host.

**GLOCHIDIAL HOSTS:** Clarke and Berg (1959) report that glochidia of *A. imbecillis* have been found in association with tissues of the cyprinid *Semothilus atromaculatus*, the Creek Chub. Tucker (1927, 1928) has shown that the centrarchid *Lepomis cyanellus*, the Green Sunfish, also harbor glochidia. Both fish species have been reported from SRP by McFarlane* (1976), but neither is reported from Par Pond, where *A. imbecillis* is very common. Thus, it is possible that additional fish species act as hosts for the larvae. On the other hand, there are reports that *A. imbecillis* glochidia are only facultative parasites and are capable of developing directly without the parasitic stage (e.g., Howard, 1914).

**REMARKS:** Clark and Berg (1959) present a discussion of the anatomy of this species.

**Anodonta cooperiana** Lea 1840

(see Johnson, 1970, Plate 16 and 17 for figures)

**DIAGNOSIS:** Similar to *A. imbecillis* except ventral margin noticeably convex and divergent from the plane of dorsal margin; length/height ratio usually less than 2.0; periostracum with narrow green rays; usually noticeably globose.

**TYPE-LOCALITY:** Hopeton, near Darien, McIntosh Co., Georgia.

**TYPE:** Lectotype, USNM 86673.

**DISTRIBUTION:** St. Marys River, Florida to Cape Fear River Drainage, North Carolina.

**ECOLOGY:** Johnson (1970) states that the species prefers sandy or muddy bottoms of ponds and sluggish streams.

**GLOCHIDIAL HOSTS:** Unknown.

**REMARKS:** This species was not collected in 1977, but it has been recorded in previous collections made by Fuller from the Savannah River.

**SUBGENUS Pyganodon** Crosse and Fisher 1894

*Anodonta cataracta* Say 1817

(Plate I, Figure 5; Map 2)

**DIAGNOSIS:** Shell elongate, subrhomboidal, large, up to 175 mm in length; mean length/height ratio 1.87 (N = 3, S.D. = 0.16, range 1.75 to 2.06); valves thin, light in younger specimens but becoming slightly thicker in older, larger shells; moderately well inflated; mean height/inflation ratio 1.28 (N = 3, S.D. = 0.07, range 1.20 to 1.35). Anterior end smoothly rounded; posterior end somewhat pointed or wedge-shaped; ventral margin almost straight or slightly and smoothly curving; dorsal margin straight, subparallel to ventral margin. Umbos slightly to moderately elevated above hinge line, somewhat inflated, beak sculpture having characteristic double-loop ridges of genus. Posterior ridge broadly rounded; posterior slope broad, slightly depressed. Periostracum smooth, shiny over median region of shell, becoming rough and laminate anteriorly and posteriorly, especially on posterior slope: color yellowish brown, yellowish green, or greenish; broad green rays common. Hinge endentulous, thin, narrow, except below ligament, where it becomes slightly thickened; ligament poorly elevated, thin, narrow, elongate. Nacre of shell interior white or bluish white, sometimes with a slight pinkish flush.

Anal papillae absent, branchial papillae simple, unbranched, moderately pigmented. Sexes separate.

**TYPE-LOCALITY:** Deep part of a mill dam near Philadelphia, Pennsylvania (locality restricted by Johnson, 1970).

**TYPE:** Original type lost. No neotype designated.

**DISTRIBUTION:** Alabama to the St. Lawrence River along coastal drainage systems and possibly westward along the St. Lawrence system to Michigan.

**ECOLOGY:** *A. cataracta* can be found in a variety of habitats. It is equally common in lakes, streams, and rivers, and in substrates from mud to sand. It generally avoids the swifter waters of streams, seeming to prefer more slowly moving currents in protected areas of streams. It has been found in the Savannah River near the mouth of Lower Three Runs Creek, at Donora Station, and in Pond B. It likely also occurs in Par Pond as well. It also seems to be rather abundant in the nearby Clark Hill Reservoir.

**LIFE HISTORY:** Like many of the Anodontinae, *A. cataracta* holds larvae in the marsupium for several months during the winter season, beginning in late September or October (Conner, 1909). Most specimens discharge the hooked glochidia in May, but Ortmann (1909) reports gravid females rarely can be found as late as mid-July.

**GLOCHIDIAL HOSTS:** Lefevre and Curtis (1910) report glochidia of this species from the cyprinid *Cyprinus carpio*, the carp, which is present at SRP (McFarlane, 1976).

**REMARKS:** This is *A. hallenbecki* Lea of Patrick *et al.* (1966).

**GENUS Strophitus** Rafinesque 1820

**DIAGNOSIS:** Shell elliptical to rhomboid moderately thickened, posterior end usually pointed, hinge teeth

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*McFarlane (personal communication) doesn’t believe Green Sunfish have been reliably reported from SRP. In the reference cited he cites Freeman for the record of this species presence in streams. McFarlane believes the record may very well be due to aberrant warmouth bass which he has seen here.*
rudimentary with usually at least one vestigial tooth in each valve.

*Strophitus undulatus* (Say 1817)
Figured in Johnson, 1970, Plate 17

**DIAGNOSIS:** Shell to 90 mm in length, rhomboid, valves moderately inflated, inequilateral; umbos well-expanded, vestiges of one pseudocardinal tooth in each valve anterior to umbo; lateral teeth absent; nacre bluish or pinkish.


**TYPE:** Original type lost. No neotype designated.

**DISTRIBUTION:** Savannah River, South Carolina to the St. Lawrence River, Canada and westward to the Mississippi and Ohio River drainages.

**LIFE HISTORY:** This is another species of Anodontinae which may complete metamorphosis from glochidium to adult without the need of a vertebrate host (Johnson, 1970).

**GLOCHIDIAL HOSTS:** The Largemouth Bass, *Micropterus salmoides* and the Northern Creek Chub, *Semotilus atromaculatus* have been identified by Baker (1928) as hosts for glochidia in this species.

**REMARKS:** This species has been collected only once in the vicinity of the SRP, on the Savannah River.

**GENUS Carunculina** Baker 1898

**DIAGNOSIS:** Marsupium usually restricted to posterior half or less of outer two demibranchs, this region usually becoming greatly distended when filled with ova and/or larvae; no secondary partitioning of water tubes; lateral teeth always present but sometimes weakly developed; pseudocardinal teeth usually present; glochidia subovate or hatchet-shaped, with or without hooks.

**REMARKS:** Fuller collected this species from the Savannah River. It was not collected in 1977.

**GENUS Villosa** Frierson 1927

**DIAGNOSIS:** Shell usually small or moderate in size, thin; greatest height always posterior to center; periostracum often distinctly rayed; umbos in anterior third of shell; beak sculpture distinctly of double-looped ridges; posterior ridge indistinct or broadly rounded; pseudocardinals and laterals present; usually narrow and compressed toward hinge line; mantle margin anterior to branchial aperture distinctly papillate, but not forming a pad or flap.

**REMARKS:** This is *Micromya* Agassiz 1852, of authors, a name preoccupied in the Insecta.

*Villosa delumbis* (Conrad 1834)

(Plate II, Figures 3 and 4; Map 5)

**DIAGNOSIS:** Shell with pronounced sexual dimorphism, relatively thin; length up to 70 mm; mean length/height ratio 1.93 (N = 13, S.D. = 0.09, range 1.80 to 2.12); valves moderately to greatly inflated, especially in females; mean height/inflation ratio 1.48 (N = 13, S.D. = 0.14, range 1.33 to 1.75). Anterior margin smoothly rounded; posterior half of shell considerably taller in females than in males; posterior margin of males subangulate with most acute curvature in posteroventral area; posterior margin of females subtruncate ventrally and produced dorsally with most acute curvature in dorsal third of posterior margin; posteroventral margin of females almost straight and oblique to anteroposterior axis of shell; ventral margin of male slightly curving; ventral margin of female descending almost straight to a point about two-thirds of the distance from anterior end, thence turning at an obtuse angle and passing almost straight to posterior termination; dorsal margin slightly curved with hinge plate quite thin. Ligament narrow but prominently elevated. Umbos elevated slightly above hinge line, moderately inflated, double loop sculpture distinct in those specimens without umbal shell erosion. Posterior ridge smoothly rounded, obscure, slightly more evident in male than female; marsupium imposes a distinctive bulge on female shell anteriad from posterior ridge; posterior slope may bear faint traces of radial lines. Periostracum thin, smooth, clothlike, sometimes shiny on medial surface, but often laminate on posterior slope; color yellowish or yellowish tan, becoming brown or chestnut in older specimens, shell always bearing narrow green rays which are usually interrupted along their length by non-pigmented areas. Left valve bearing two thin, erect almost triangular pseudocardinals, which are closely applied to hinge line; separated by a narrow interdentum from two thin,
closely spaced lateral teeth; right anterior pseudocardinal small, lying on hinge line; right posterior pseudocardinal larger, more projecting, and more distinctly separated from hinge line; narrow interdentum separates pseudocardinal area from a single right lateral tooth. Anterior adductor muscle scar moderately to deeply impressed: internal nacre white or bluish white, slightly iridescent.

Inner mantle fold anterior to branchial siphon distinctly papillate in female, but may be rudimentary or absent in male; mantle pigmentation moderately to weakly expressed.

**TYPE-LOCALITY:** Small stream near Cooper River, South Carolina.

**TYPE:** Apparently lost (Johnson, 1970).

**DISTRIBUTION:** From the Altamaha River system, Georgia, to the Neuse River system, North Carolina.

**ECOLOGY:** This species was almost always found in association with calm eddies in fast flowing streams where organic detritus and leaf debris tends to accumulate. The most reliable method of collecting *V. delumbis* in these areas is to sift the debris through one’s hands, searching for shells. *V. vibex, Elliptio complanata, E. icterina, and E. lanceolata* are common associates with *V. delumbis.*

**LIFE HISTORY:** Ortman (1912) discusses several *Micromya (= Villosa)* spp., suggesting that the period of brooding is during the winter. However, numerous gravid females of this and the following species were collected during June, 1977. As with all *Lampsilinae,* only the posterior portions of the outer demibranchs are marsupial.

**GLOCHIDIAL HOSTS:** Unknown.

**REMARKS:** Although male and female shells are distinctly and easily differentiated, the dimorphism is not evident in the various computed shell ratios (e.g., length/height) used in this study. This is largely due to the location on the shell where measurements are taken. If, for example, height were measured more posteriorly, the dimorphism would appear in all ratios employing the height dimension.

*Villosa vibex* (Conrad 1834)  
(Plate II, Figure 2; Map 5)

**DIAGNOSIS:** Shell weakly sexually dimorphic, thin; length up to 60 mm; mean length/height ratio 1.96 (N = 6, S.D. = 0.05, range 1.85 to 2.01); valves moderately inflated; mean height/inflation ratio 1.55 (N = 6, S.D. = 0.08, range 1.47 to 1.64). Anterior margin smoothly rounded; posterior margin somewhat pointed in males, but more broadly rounded and more elevated in females; ventral margin of males slightly convexly curved in males but almost straight or slightly arcuate in females; dorsal margin slightly curving, hinge plate very narrow. Ligament narrow and prominently elevated. Umbos slightly inflated and weakly elevated above hinge line, double-looped sculpture present in those specimens without umbonal shell erosion. Posterior ridge smoothly rounded, obscure; posterior slope may bear faint traces of thin, slightly elevated or incised radial lines. Periostracum thin, generally smooth, almost glossy on medial surfaces; color greenish yellow, yellowish, yellowish brown, or tan with broad green radial lines which usually are not interrupted along their length. Left anterior pseudocardinal thin, erect, triangular, spaced somewhat away from hinge plate; left posterior pseudocardinal vestigial, two thin, narrow, closely spaced left lateral teeth. Right anterior pseudocardinal larger, erect, triangular, distinctly projecting and separated from hinge plate; single, thin, relatively short right lateral tooth. Anterior adductor muscle scar slightly to weakly impressed; internal shell nacre bluish white or steel blue and iridescent.

Inner mantle fold anterior to branchial siphon distinctly papillate in female but may be rudimentary or absent in male; mantle rather darkly pigmented.

**TYPE-LOCALITY:** Black Warrior River, south of Blount’s Spring, Alabama.

**TYPE:** Holotype. ANSP. 56488a, figured by Johnson, 1970, Plate 17, Figure 10.

**DISTRIBUTION:** Pearl River drainage in Mississippi eastward along Gulf Coastal drainages to Florida, and from the Altamaha River system, Georgia, to the Cape Fear River, North Carolina.

**ECOLOGY:** Similar to that of *V. delumbis.*

**LIFE HISTORY:** See *V. delumbis.*

**GLOCHIDIAL HOSTS:** Unknown.

**GENUS** *Lampsilis* Rafinesque 1820

**DIAGNOSIS:** Shell moderate to large in size, solid, subovate to elongate; periostracum with or without rays; position of umbos variable; beak sculpture absent or of the double-looped type; sexual dimorphism usually prominent with female frequently more inflated and posteriorly truncate; pseudocardinals and laterals present. Narrow, lamellar: mantle margin extended in a prominent flap-like papillate fold or pad in female; “eyespot” near branchial aperture often present in female.

*Lampsilis curiosa* (Say 1817)  
(Plate II, Figures 5 and 6; Map 4)

**DIAGNOSIS:** Shell large, heavy with pronounced sexual dimorphism; length up to 140 mm in males, and 120 mm in females; mean length/height ratio of males 1.52 (N = 27, S.D. = 0.07, range 1.40 to 1.66); mean length/height ratio of females 1.47 (N = 8, S.D. = 0.10, range 1.36 to 1.67); valves greatly inflated, especially in females; mean height/inflation ratio of males 1.43 (N = 27, S.D. = 0.07, range 1.31 to 1.58); mean height/inflation ratio of females 1.28 (N = 8, S.D. = 0.06, range 1.22 to 1.38; mean length/inflation ratio of males 2.17 (N = 27, S.D. = 0.15, range 1.93 to 2.59); mean length/inflation ratio of females 1.89 (N = 8, S.D. = 0.20, range 1.73 to
2.30. Anterior end often bluntly pointed, sometimes slightly flaring, especially in the female, acute curvature of posterior margin more pronounced in dorsal half with ventral portion smoothly curving to join ventral margin; posterior margin extended and slightly to moderately pointed in male. more abrupt and almost truncated in female; ventral margin smoothly curving; dorsal margin arched, subangular with apex of arch located above interdeltum in left valve and near termination of right lateral tooth: ligament large, prominently elevated. Umbos inflated, raised above hinge line, frequently eroded in large specimens. Posterior ridge usually obscure, posterior slope delineated primarily by change in periostracal texture. Periostracum well developed, thick, shiny smooth on anterior and lateral shell surfaces, but becoming dull and distinctly laminate on posterior slope; color yellow, yellow brown, chestnut or reddish brown. Two serrated pseudocardinal teeth in left valve, anterior tooth usually larger, projecting anteriad, posterior tooth erect under umbo; broad interdeltum in left valve with hinge plate arched in posterior third of interdeltum; two relatively short left lateral teeth with lower lateral having a slightly granular face. Two serrated right pseudocardinal teeth with the ventral tooth larger and slightly posterior to the dorsal one, dorsal pseudocardinal sometimes sharply pointed; broad interdeltum in right valve; right lateral tooth short, prominently elevated, forming a distinct ledge on hinge plate. Pallial line usually does not extend beyond posterior termination of posterior adductor; anterior adductor scar distinctly impressed. Nacre of valve interior white or bluish white and frequently flushed with pink.

Distinct, large darkly pigmented “eyespot” on each mantle lobe of female just ventral to branchial aperture; mantle anterior to eyespot produced into a flap of tissue (not pad-like), lightly pigmented. Ventral margin of marsupium darkly pigmented.

**TYPE-LOCALITY:** Schuylkill River, near Philadelphia, Pennsylvania (restricted by Johnson, 1947a).

**TYPE:** Original type lost. Neotype, Harvard University Museum of Comparative Zoology. 178839, selected and figured by Johnson, 1947a, Plate 19, Figure 1.

**DISTRIBUTION:** Northern Georgia to Nova Scotia along the Atlantic slope drainages, and westward along the St. Lawrence River system.

**ECOLOGY:** *L. cariosa* is primarily a large river species, being particularly common along sand bars of the Savannah River. Its range apparently overlaps slightly with *L. ochracea*, a tide-water species common near river mouths. It cannot be confused with *L. ochracea* near SRP as that species apparently does not occur here. Johnson (1947a) has additional information on the ecology and systematics of both species. *L. cariosa* is only rarely found in smaller streams or creeks.

**LIFE HISTORY:** The life history of *L. cariosa* has never been studied in detail, but it is presumably similar to that of several other closely related Lampsilinae (e.g., *L. ventricosa*, *L. ovata*, etc.). Females of these species apparently employ the mantle flaps and “eyespots” on the mantle margin as fishlures, attracting host species of fish for the glochidia larvae. Kraemer (1970) presents a detailed discussion of this interesting behavior. The eyespots are not photoreceptors, but are pigmented areas which mimic the eyes of other organisms.

The species has been described as probably bradytictic (Ortmann, 1909; Conner, 1909). Almost all females collected in June, 1977, had glochidia or eggs in the marsupia.

**GLOCHIDIAL HOSTS:** Unknown.

**REMARKS:** *L. cariosa* is one of several closely related species, which include *L. ovata* (Say 1817), *L. dolabracenformis* (Lea 1857), and *L. satura* (Lea 1852). Admittedly, the species listed here cover a very broad geographic distribution, but certainly no more so than *Unio merus* *tetralasmus*, which is regarded by some (e.g., Johnson, 1970 and 1972; and Fuller, 1971) as conspecific throughout the range. In fact, *U. tetralasmus* displays at least as much variation as all of the above taken together.

For example, *L. dolabracenformis* is a species presumably endemic to the Altamaha River system and allopatric with *L. cariosa*, whose range extends southward only to the Ogeechee River system. Johnson (1971) frequently compares *L. dolabracenformis* to other species: 1) “is close to *L. cariosa*,” 2) “resembles *L. excavatus*,” 3) “resembles *L. binominatus*.” He points out that Simpson’s (1914) report of *L. dolabracenformis* from the Ogeechee and Savannah River systems are erroneous records of *L. cariosa*. In another section Johnson (1971) suggests that *L. cariosa* 1) “can be confused with *L. dolabracenformis*,” 2) “has been most often confused with *L. ochracea*,” and, with respect to *L. ovata*. 3) “while the two species are close, they are distinct.” It is not surprising that Cvancara (1963) concluded that three members of the *Lampsilis* complex from the central U.S., *L. ventricosa*, *L. ovata*, and *L. excavata* probably represent subspecific taxa. It is surprising, however, that subsequent workers (Johnson 1970; Fuller, 1971) do not formalize similar trends in the Atlantic slope Lampsilinae. We can follow Johnson (1970) and Fuller (1971) for the time being, accepting *L. cariosa* as the nominal designation for the large lampsilid of the Savannah River near the SRP, but we also suggest that a careful anatomical, cytochemical or biometric study be attempted on this large, widely distributed complex to resolve some of the problems encountered by a taxonomy based upon shell morphology alone.

*Lampsilis radiata splendida* (Lea 1838)

(Plate II, Figure 7; Map 5)

**DIAGNOSIS:** Shell moderately large, heavy, with slight sexual dimorphism; length up to 120 mm; mean
length/height ratio 1.89 (N = 21, S.D. =0.10, range 1.72 to 2.10); valves well inflated; mean height/inflation ratio 1.21 (N = 21, S.D. =0.10, range 0.98 to 1.42) with little difference in this ratio between males and females. Anterior end smoothly rounded or sometimes slightly angular in the dorsal portion; posterior margin bluntly pointed in males, smoothly rounded and less produced in females; ventral margin almost straight or slightly curved; dorsal margin slightly arched; ligament large, broad, elongate, prominently elevated. Umbos moderately inflated above hinge line, prominent. Posterior ridge rounded but distinctly formed; two or three additional radial lines may appear on posterior slope; posterior slope broad. Periostracum well developed, extensively laminate but shiny on medial surface, texture almost like satin, despite numerous lamellae; color reddish brown, yellowish, yellowish green or dark brown in older shells, frequently covered with numerous green rays which are irregularly spaced and varying in size from narrow to broad. Two elongate subequal serrated pseudocardinal teeth in left valve separated by a deep groove; anterior pseudocardinal small or vestigial, posterior tooth triangular, erect; right hinge plate with an elongate, narrow interdental; left lateral tooth single, straight, or slightly arched. Pallial line extends to or slightly beyond posterior termination of posterior adductor scar; anterior adductor scar deeply impressed with a distinct shell ridge immediately posterior to scar. Nacre of valve interior pink or reddish bronze, often white centrally.

Pad below the branchial aperture of female modified into a broad, darkly pigmented pad, less prominent in male. Marsupium typical of genus, darkly pigmented ventrally.

TYPE-LOCALITY: Altamaha River, McIntosh or Long County, Georgia.

TYPE: Holotype, NMNH, 84893, figured by Johnson, 1970, Plate 22, Figure 5.

DISTRIBUTION: From the Altamaha River system, Georgia, to the Santee-Cooper River system, South Carolina.

ECOLOGY: L. radiata splendida is usually found in fast-flowing streams and rivers where it occurs on sand or gravel. It is not particularly abundant in fine-grained substrates, but occasional specimens may be found in lakes (Johnson, 1970). It is most abundant in the larger creeks and river habitats near SRP.

LIFE HISTORY: This is another presumed bradytetic species in which almost all specimens collected during June, 1977, from the SRP and from the Ohooppee River, Georgia, had eggs in the marsupium.

GLOCHIDIAL HOSTS: Unknown.

REMARKS: Although one can detect slight sexual dimorphism in the shell morphology of L. radiata splendida, this could not be demonstrated at a statistically significant level for either of the basic shell dimension ratios (length/height and height/inflation) reported for specimens collected during this study. This is probably due to the use of a standard location for biometric measurements.

L. radiata splendida cannot be confused with any other freshwater mussel at SRP. It is distinctly lamelline and the very darkly pigmented pad before the branchial aperture of females is distinctive. This pad is present, but developed to a lesser degree in the male.

FAMILY CORBICULIDAE

DIAGNOSIS: Usually brackish to freshwater clams with oval to trigonal shells from 0.5 to 10 cm in length; hinge with well developed cardinal and lateral teeth; ligament opisthodetic and parivincular: periostracum conspicuous; sculpture of valves usually of very fine to coarse concentric bands.

GENUS Corbicula von Muhlfeld 1811

DIAGNOSIS: Shell with central or subcentral beaks, oval to trigonal shape; concentric sculpture usually well impressed on valves; lateral teeth usually elongate and serrate; inner demibranchs of gills form brood chamber for pediveliger larvae; some species viviparous but most discharge pediveliger larvae which develop directly without parasitic stage.

Corbicula fluminea (Müller 1774)

(Plate II. Figure 8; Map 2)

DIAGNOSIS: Shell to about 65 mm in length but usually less than about 40 mm: mean length/height ratio 1.13 (N = 200, S.D. = 0.07, range 1.00 to 1.30); valves moderately inflated; mean height/inflation ratio 1.48 (N = 200, S.D. = 0.31, range 0.94 to 3.21). Shell shape roughly equilateral suboval to trigonal; posteroventral margin sometimes slightly more produced than anteroventral margin; dorsal margin angular; hinge plate broad with well developed dentition. Ligament broad but very short, extending from beak to near origin of posterior lateral teeth. Umbos central, well elevated above hinge plate, not elongate, often with distinctive blue or purple blaze in shells less than 10 mm length; posterior ridge absent. Periostracum yellowish in young shells but becoming brown, reddish brown, or chestnut brown in larger specimens, fresh periostracum even in large shells often yellowish or light tan. Sculpture on valve exterior consists of well-impressed concentric rings with 6 to 10 rings per cm. Three cardinal teeth in each valve; left posterior cardinal almost vestigial, right anterior cardinal closely adjacent to upper hinge plate; one anterior and one posterior lateral tooth in left valve; two anterior and two posterior lateral teeth in right valve; lateral teeth serrate; thickened calcareous plate usually underlies ligament area. Pallial line not sinusoid near posterior adductor muscle scar; internal nacre white, lavender, or purple. Distinct anal and branchial siphons formed; inner demibranchs modified as
marsupia; animals monoecious and brood developmental stages (trocophore, and pediveliger larvae) in marsupia.

**TYPE-LOCALITY:** Unspecified locality in China.

**TYPE:** Universitets Zoologiske Museum, Copenhagen (no catalog number assigned), figured by Morton, 1977a, Plate I.

**DISTRIBUTION:** Originally from central and southeastern Asia, this clam was first discovered in the United States in 1938 in the Columbia River, Oregon. By the early 1950's, it had expanded the range along the west coast to southern California. It has since spread rapidly throughout the United States and occurs across the country from California to Pennsylvania, New Jersey and Delaware, primarily south of latitude 42°. It appeared in the Savannah River drainage between 1965 and 1973.

**ECOLOGY:** An extensive body of literature is developing on this potential pest species. *C. fluminea* has been responsible for clogging water cooling systems (e.g., cooling condensers) in a variety of industrial operations, impeding water flow in irrigation and water supply canals, spoiling gravel beds used for concrete aggregate, and perhaps crowding and competing for living space with native unionid mussels. Many of these problems are associated with the life cycle and high fecundity of this clam (see below). It is beyond the scope of the present paper to describe the numerous published ecological studies on this species. For the earlier literature, the reader is referred to Sinclair and Isom (1963) and Sinclair (1971). The Proceedings of the First International *Corbicula* Symposium (1979) contains additional literature and an extensive bibliography.

During field work at SRP in June, 1977, *C. fluminea* was found to be exceedingly abundant at every locality sampled in the Savannah River. Densities in excess of 2,000 living specimens/m² were measured. *C. fluminea* was also found in Beaver Dam Creek, but at no other upland stream locality at SRP. Apparently *C. fluminea* was recruited into Beaver Dam Creek via the intake water for the SRP 400 Production area, with specimens or larvae being transported through the system and deposited with the effluent entering Beaver Dam Creek. Other stream localities at the SRP should be closely monitored with the date of first occurrence noted. In view of the fact that there is exceedingly limited access to most SRP streams, an assessment of potential upstream migration by this species may be possible in this area.

**LIFE HISTORY:** *C. fluminea* in the United States appears to be a monoecious species, although Morton (1977a) suggests that a Hong Kong population in Plover Cove displays protandry. Larvae are brooded in the inner demibranchs. A glochidium is never formed, and *C. fluminea* never relies upon parasitism for dispersal. Rather, the larvae are released as free-living pediveligers. In most localities larvae are produced twice yearly, spring and fall. Aldridge and McMahon (1976) estimate the average individual daily fecundity of this species to be 387.0 veligers/clam and 319.8 veligers/clam for spring and fall reproductive periods, respectively. Brooded larvae have been known to die before release from the gill marsupium, stimulating a pathological tissue response (Morton, 1977b). Unreleased larva are surrounded by amoebocytes which proliferate to form a granuloma.

The metamorphosis to a juvenile clam apparently occurs shortly after release from the marsupium. Growth is exceedingly rapid during the first year, with shell lengths of 20 mm often being attained. Thereafter, the growth rate gradually diminishes (Britton, et al., 1979). The majority of a population apparently live two to three years, with some individuals surviving perhaps five or more years.

**REMARKS:** *C. fluminea* has been called *C. manilensis*, *C. leana*, and occasionally *C. fluminalis* in this country. Consult Britton and Morton (1979) for a justification of *C. fluminea* (Müller 1774) as the valid name for American *Corbicula* populations.

**FAMILY SPHAERIIDAE**

**DIAGNOSIS:** Shells thin, often translucent, small to minute, and oval to subtriangular in lateral outline. Ligament rarely external and, if so, usually partially to completely depressed. Cardinal and lateral teeth usually present: two or fewer cardinals in each valve. In all these respects, this family differs from the Unioniidae.

Organization of soft tissues in Sphaeriidae similar to that in Unioniidae (discussed above), but there is one difference readily useful in identification. In Unioniidae there is no fusion of the aperturing of the mantle margins in order to separate incipient and incipient mantle apertures, whereas this occurs in the Sphaeriidae, whose apertures are separate and sometimes provided with extensible mantle margin tissue so that true siphons are formed.

Again unlike the Unioniidae, the Sphaeriidae brood larvae and young in gills until early adulthood, when they are released from the parent into the external environment, where they pursue an independent existence without intervention of a metamorphic period of parasitism on another organism. The Sphaeriidae apparently can forego the parasitic period, which is the source of agility for the comparatively ponderous Unioniidae, because, as much smaller, lighter, and more active animals, they can depend upon mechanical transport for extending their geographic range.

**REMARKS:** We are confident that six species of Sphaeriidae (the pill, pea, and fingernail clams) have in recent years been identified with dependable accuracy from the SRP. These are *Pisidium amphicicum* (Müller 1774), *P. casertanum* (Foli 1791), *P. compressum* (Prime 1851), and *P. dubium* (Say 1834), plus *Musculum transversum* (Say 1829) and *Eupera cubensis* (Prime 1865).
Lawrence Tilly (SRL) contributed *Pisidium amnicum* from Upper Three Runs (Creek) and an indeterminate congener from Par Pond. One of us (JCB) found *P. amnicum* in a Tinker Creek riffle just below Kennedy Pond. The other (SLHF) and colleagues are responsible for the other records, which have accumulated during the about 25-year ANSP surveillance of SRP water quality, especially in Lower Three Runs (Creek) and the Savannah River.

Because of their small sizes, identification of spaerid clams is difficult, especially in the case of *Pisidium*, which, unfortunately, is much the most species-rich Nearctic sphaerid genus. On the other hand, at least on the SRP, identification of *Eupera cubensis* (because of its characteristic pigmentation of shell), *Musulium transversum* (which has a characteristic shape), any *Sphaerium* that might be encountered (they are few and refreshingly large), and *P. dubium* (also large, at least for a *Pisidium*, and thus easily visible!) is easy or relatively so. However, the problem of the minute pisidia remains. Comprehensive taxonomic keys (Herrington, 1962; Burch, 1972, 1975a) to Nearctic Sphaeriidae exist and assuredly are vastly superior to their predecessors. Nevertheless, identification of *Pisidium* species by shell criteria alone is hampered by the fact that they seem to be convergent among several subgenera of this genus. Consequently, a key whose initial couplets dealt with soft-tissue discriminants among the subgenera and that only then moved to shell characters could provide a new approach to *Pisidium* identification by markedly reducing (or perhaps even eliminating) the decisions between/among conchologically similar taxa. Indeed, such a project could be the objective of a worker on the staff of (or visiting) the SRP National Environmental Research Park. In any case, the need for improved aids in identifying *Pisidium* is evident and great.

Opportunities for studying *Pisidium* and other Sphaeriidae are prevalent at the SRP. These days, however, the interested investigator must search for them more assiduously than was required in the early seventies, when enormous beds of submerged aquatic vegetation in the Savannah River provided optional habitat for scores of macroinvertebrate species, including Sphaeriidae. During that period of obvious eutrophy, *P. casertanum* and *P. compressum* were abundant in the weed beds, and *Musulium transversum* was almost inconceivably plentiful; the mobility of these animals means that they could exploit a dependable habitat in the water column above their normal infaunal station. *Eupera cubensis* was rare in the weed beds, presumably because its usual habit of byssal attachment does not provide it adequate purchase in vegetation, but for many years of ANSP investigation at SRP this species has been varyingly common in bank-protection riprap along the mainstream Savannah. In recent years, however, probably in response to improved treatment of organic wastes in the upstream vicinity of Augusta, Georgia, the Savannah River has reverted to its earlier oligotrophy, and these extraordinary sphaerid populations have substantially abated with the weed beds, although all species can still be found.

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LITERATURE CITED


anal aperture - The dorsal posterior excurrent mantle opening or siphon through which water and feces exit the mantle cavity.

angulate - Having the tendency to form an angle, in contrast to being smoothly rounded.

arcuate - Curved or bent as in the shape of a bow.

beak - The umbo, or oldest portion of a bivalve shell.

Located on the dorsal surface, the beaks are frequently elevated above the surrounding shell material.

biangulate - Composed of two angular components.

bifid - Having two parts; usually applied to the description of hinge teeth.

bradytictic - Referring to freshwater mussels which retain ova and/or glochidia in gill marsupia for very long periods, usually during all seasons except summer.

branchial aperture - The ventral posterior incurrent opening or siphon through which water enters the mantle cavity. Water and pseudofeces can exit the mantle cavity through this aperture as a result of brief forceful contractions of various musculature.

cardinal teeth - Short, elevated triangular or slightly elongate toothlike lamella on the hinge plate immediately ventral to the umbo.

caruncle - A small fleshy protuberance on the inner edge of each side of the mantle, directly anterior to the branchial opening. Characteristic of members of the genus Carunculina.

clam - A common popular term for various members of the molluscan class Bivalvia. The term is not restricted to any particular group of bivalves, except by colloquial usage.

crenulate - With a wrinkled or minutely toothed margin.

dendritic - Finger-like branching.

demibranch - One half of a gill of a bivalve mollusk.

Bivalves possess one pair of gills. Each gill is reflected or folded upon itself; in cross-section it would appear much like the letter W. A demibranch is one V of the W. Upon dissection, bivalves appear to have two gills on each side of the body. Actually, these are two demibranchs of the same gill.

edentulous - Lacking hinge teeth, as in Anodonta.

elongate - The length dimension is noticeably greater than the height.

globose - Tending toward a spherical shape.

glochidium - The characteristic bivalved parasitic larval stage of the Unionacea.

gravid - When said of bivalves which brood larvae in gill marsupia, this term refers to the fact that the gills contain eggs, developmental stages, or larvae.

height - The distance between dorsal and ventral margins of the shell. See Figure 4, page 83.

height/inflation ratio - The height divided by inflation.

hinge plate - The opposing dorsal portions of the valves which include any lateral, pseudocardinal, or cardinal dentition and the interdentum.

inflation - The lateral thickness of a bivalve. See Figure 2, page 83.

interdentum - The space on the hinge plate between cardinal or pseudocardinal dentition and the lateral teeth.

lamellate (lamellar) - Formed in thin sheets or plates.

laminate - Formed of thin sheets or plates lying one upon another.

lanceolate - Elongate, lance-shaped.

lateral teeth - Elongate tooth-like lamellae on the posterior half of the hinge plate in Unionacea, or anterior and posterior to the cardinal teeth in other groups.

left valve - The shell half on the left side of the body when the shell is placed with the hinge up and the anterior end directed away from the observer.

length - The maximum anteroposterior dimension. See Figure 4, page 83.

length/height ratio - The shell length divided by shell height. See Figure 4, page 83.

ligament - The elastic organic structure which joins the two halves of a bivalve mollusk along the dorsal surface.

mantle - An epithelial extension of the dorsal body wall of mollusks which usually secretes the shell and encloses a mantle cavity.

marsupium - The pouch or brood chamber that contains ova, developmental stages, or larvae. In bivalves, the gills can serve as marsupia. The location and size of the marsupia are often useful taxonomic characteristics.

mussels - A common name of two general categories of bivalve mollusks, 1) members of the Unionacea, which are most often freshwater bivalves; or 2) members of the Mytilidae, which have numerous brackish water or marine representatives.

nacre - The white, pearly, or iridescent inner shell layer of bivalves. It may be variably colored in some bivalves.

naiad - A general term applying to the freshwater mussels of the Superfamily Unionacea.

obovate - Somewhat oval in outline, but one end narrower than the other.

opisthodetic - The condition in bivalve mollusks in which the hinge ligament is posterior to the umbo.

pallial line - An impressed line on the bivalve shell interior locating the position of attachment of mantle musculature.

papillate (papillosus) - Having numerous finger-like projections or papillae.

parvivincular - Ligament with long axis parallel to hinge line and lying posterior.

pediveliger - A form of shelled molluscan veliger larvac
which is adapted primarily for crawling rather than swimming.

*periostracum* - The organic covering on the exterior of bivalve shells.

*plication* - A fold or costa involving a major portion of the shell thickness.

*posterior ridge* - An external, slightly to sharply angulate ridge on the posterior portion of many bivalve shells extending from the umbo to the ventral margin. When the ridge is not easily differentiated by an angulation on the shell, its location may often be determined by a distinct change in external sculpture.

*posterior slope* - The area of a bivalve shell dorsal and posterior to the posterior ridge.

*prosogyrate* - The beaks of the umbo point anteriorly.

*protandry* - A hermaphroditic condition whereby the male gonad develops first, degenerates, and is followed by the development of the female gonads.

*pseudocardinal teeth* - In Unionacea bivalves, these structures lie on the hinge plate near or anterior to the umbo. They are compressed, often triangular or slightly elongate dentition that have embryonic affinities closest to anterior lateral dentition, but lie in the position normally occupied by cardinal teeth. Unionaceans lack true cardinal dentition.

*ray* - A streak or linearly pigmented area usually associated with the periostracum. It may be interrupted or continuous.

*right valve* - The valve opposite the left valve, see later.

*sinuate* - To bend up and down or in and out.

*subovate* - A shape approximating an oval, but slightly to moderately produced or elongated in at least one direction.

*subtrigonal* - Transitional between trigonal and ovate; or inequilaterally trigonal.

*tachytytic* - Bivalve mollusks which brood larvae in marsupia for relatively brief periods of time (i.e., usually during spring and/or summer months only).

*trigonal* - Shaped as a triangle; three cornered; usually equilateral.

*tuberculate* - Describing the presence of tubercules, pustules or small globular surface irregularities especially on the exterior of a bivalve shell.

*truncate* - Cut-off, abbreviated, more-or-less squarely shortened.

*umbo* - The oldest part of the bivalve shell, the beak. See latter.

*valve* - One of two opposing halves of the shell of a bivalve mollusk, which lie on the lateral surfaces of the body and are joined by a ligament.
ILLUSTRATIONS

2. *Elliptio complanata*, dorsal aspect with posterior end toward top of page. Solid bar across valves indicates location where inflation (I) is measured.
4. *Villosa vibex*, left valve exterior. Solid bars indicate locations where length (L) and height (H) were measured for this study; note that the position of measurement is not necessarily the position of greatest shell height (see “height” in Glossary).
5. Schematic representation of dendritic branchial papillae, as expressed in *Uniomerus tetralasmus*.

Legend: A, anterior end; AA, anterior adductor muscle scar; AN, anal aperture; BA, branchial (incurrent) aperture; D, dorsal margin; E, eyespot; H, height; I, inflation; ID, interdentum; L, length; LG, ligament; LT, lateral teeth; P, posterior end; PA, posterior adductor muscle scar; PL, pallial line; PR, posterior ridge; PS, pseudocardinal teeth; U, umbo or beak; V, ventral margin.
PLATE I

Figure 1. *Elliptio complanata*, male. Collected June 10, 1977, Pen Branch Creek at Highway C Bridge, SRP.
Figure 2. *Elliptio icterina*, male. Collected June 1, 1977, Mill Creek, SRP.
Figure 3. *Elliptio congaraea*, male. Collected June 11, 1977, on sand bar of Savannah River approximately 2 km upstream from Johnson's Landing.
Figure 4. *Elliptio lanceolata*, male. Collected June 2, 1977, Tinker Creek at Highway 8-11 crossing, SRP.
Figure 5. *Anodonta cataracta*. Collected June 15, 1977, Lower Three Runs Creek near Donora Station, SRP.
Figure 6. *Uniomerus tetralasmus*, female. Collected June 14, 1977, Lower Three Runs Creek near Donora Station, SRP.
Figure 7. *Anodonta imbecillis*. Collected June 9, 1977, Par Pond, SRP, water depth approximately 8 m.
Figure 8. *Anodonta imbecillis*. Collected June 9, 1977, Par Pond, SRP, water depth less than 1 m.
Figure 1. *Alasmidonta triangulata*. Collected June 11, 1977, on sand bar of Savannah River approximately 6 km upstream from Johnson’s Landing.

Figure 2. *Villosa vibex*, female. Collected June 6, 1977, Reedy Branch Creek near Road 8-1, SRP.

Figure 3. *Villosa delumbis*, female. Collected June 27, 1977, Tinker Creek just downstream from Kennedy Pond, SRP.

Figure 4. *Villosa delumbis*, male. Collected June 15, 1977, Lower Three Runs Creek about ½ km downstream from Donora Station, SRP.

Figure 5. *Lampsilis cariosa*, male. Collected June 21, 1977, on sand bar of Savannah River approximately 6 km upstream from Johnson’s Landing.

Figure 6. *Lampsilis cariosa*, female. Collected July 20, 1977, on sand bar of Savannah River approximately 2 km upstream from Johnson’s Landing.

Figure 7. *Lampsilis radiata splendida*, male. Collected June 15, 1977, Lower Three Runs Creek about ½ km downstream from Donora Station, SRP.

Figure 8. *Corbicula fluminea*. Collected June 3, 1977, Savannah River, mile 157, shore of midchannel island, SRP.
MAP LEGENDS

Map 1. The Savannah River Plant showing major drainage systems and sampling locations.
- Bivalve mollusks collected at these locations;
- Bivalve mollusks not collected or observed at these locations.

THE FOLLOWING ARE ACADEMY OF NATURAL SCIENCES AT PHILADELPHIA COLLECTING LOCALITIES WHERE ADDITIONAL BIVALVE MATERIAL HAS BEEN COLLECTED.

1 On Upper Three Runs about ¼ mi below SRP Road A, where *Elliptio icterina* has been collected.

2 On the Savannah River, where *Elliptio congaraea, E. icterina, E. complanata, E. lanceolata, Uniomerus tetralasmus, Anodonta imbecillis, A. cataracta, Villosa delumbis, Lampsilis cariosa,* and *Corbicula fluminea* have been collected.

3 On the Savannah River, where all species collected at Station 2 were also collected, plus *Alasmidonta triangulata, Andonta couperiana,* and *Strophitus undulatus*.

4 On the Savannah River, where all species collected at Station 3 except *Strophitus undulatus* were collected, plus *Carunculina pulla* and *Elliptio fraterna*.

BB On the Savannah River, where *Elliptio icterina* and *Lampsilis radiata splendida* were collected.

D Donora Station, where *Elliptio icterina, E. complanata, E. lanceolata, Uniomerus tetralasmus, Anodonta couperiana, Villosa delumbis,* and *Lampsilis cariosa* were collected.

L3R On Lower Three Runs Creek at SRP Road A, where *Elliptio icterina, E. lanceolata, Anodonta cataracta* and *Villosa vibex* were collected.

TCR On Lower Three Runs Creek at Tabernacle Road, where *Elliptio icterina, E. lanceolata* and *Villosa vibex* were collected.


Map 2. Collecting localities for *Elliptio icterina, Anodonta cataracta,* and *Corbicula fluminea*.

Map 3. Collecting localities for *Elliptio complanata, Elliptio congaraea,* and *Anodonta imbecillis*.

Map 4. Collecting localities for *Uniomerus tetralasmus, Lampsilis cariosa,* and *Alasmidonta triangulata*.

Map 5. Collecting localities for *Elliptio lanceolata, Lampsilis radiata splendida, Villosa vibex,* and *V. delumbis*.
- *Elliptio icterina*
- ▲ *Anodonta cataracta*
- ■ *Corbicula fluminea*
Uniomerus tetralasmus
Lampsilis cariosa
Alasmidonta triangulata
- *Elliptio lanceolata*
- *Lampsilis radiata splendida*
- *Villosa delumbis* and *V. vibex*