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Morphological variation in glochidia shells of six species of *Elliptio* from Gulf of Mexico and Atlantic Coast drainages in the southeastern United States

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Abstract.—The genus *Elliptio,* with 36 currently recognized species, is the largest genus in the family Unionidae in North America. The genus is represented by two species, *Elliptio crassidens* and *E. dilatata,* in the Interior Basin and 34 species in drainages of the eastern Gulf of Mexico and Atlantic Coast. The paucity and variation of conchological characters in the genus *Elliptio* makes it extremely difficult to define species and determine relationships. We examined glochidia from six species of *Elliptio* in an effort to determine if there are useful characteristics for species level identification and/or characters for identification of species groups. *Elliptio* species were selected to represent different morphological groups from four drainages in the southeastern United States. The glochidia from *E. crassidens, E. dariensis, E. hopetonensis, E. icterina, E. shepardiana,* and *E. mcmichaeli* were qualitatively compared, using scanning electron microscopy, with each other and with descriptions of these and other *Elliptio* glochidia described in the literature. Two groups were identified. The *crassidens* group, including *E. crassidens, E. dariensis,* and *E. mcmichaeli,* had subtriangular glochidia with a triangular styliform hook extending from the ventral margin of the valve and rough exterior valve sculpturing. Adults of this group had wrinkled or corrugated sculpturing on the posterior slope of the shell. The *complanata* group, including *E. hopetonensis, E. icterina,* and *E. shepardiana,* had subelliptical glochidia with a broad flange extending the entire ventral margin and loose-looped exterior valve sculpturing. Adults of this group lack sculpturing on the posterior slope of the shell. Differences in glochidial morphometrics were found, however, additional work is needed to determine if they are reliable for species level identification.

The genus *Elliptio,* with 36 currently recognized species, is the largest genus in the family Unionidae in North America (Turgeon et al. 1998). In the Interior Basin, this genus is represented by two species, *E. crassidens* and *E. dilatata.* The remaining 34 species are found in eastern Gulf of Mexico and Atlantic Coast drainages. These 34 species are characterized by extreme morphological variation ranging from compressed lanceolate forms (e.g., *E. shepardiana*) to those that are oval and highly inflated (e.g., *E. hopetonensis*) (Burch 1975). The paucity of conchological characters and the extreme morphological variation exhibited by most species makes it difficult to identify species and determine relationships.

Clench & Turner (1956) characterized the genus *Elliptio* as "more confusing than any other in the Unionidae of North America"—a statement which unfortunately remains true today. As the validity of some *Elliptio* species has been questioned, and some will probably be found to be synonyms, it is also likely there are valid species that are not currently being recognized. This uncertainty has resulted in reluctance on the part of conservation agencies and organizations to take appropriate actions to provide protection for some species. At least one species, the winged spike, *E. nigella,* is considered to be extinct (Brim Box & Williams 2000), and another 22 have been assigned a national conservation status of endangered, threatened, or special concern (Williams et al. 1993). While most recognized species of *Elliptio* have declined, it is still possible to protect much of the diversity represented in this genus if action is taken in the near future. Once discrete taxonomic entities are identified and their distribution accurately delineated only then can conservation and management plans be implemented.

The shells of *Elliptio* are usually moderately to greatly elongated, dark olive brown to black, often rayed in juveniles, and lack sculpturing with the exception of wrinkles or corrugations on the posterior slope and umbos of some species. Nacre color varies from white and highly iridescent to all shades of pink and red to deep purple and violet. Soft parts are whitish to flesh colored. The eggs are white. Branchial papillae are present and usually simple but dendritic papillae may be present; anal papillae are also present. The mantle margin lacks papillae anterior to branchial aperture. The glochidia are expelled from the marsupium in compacted masses called conglutinates. All species of *Elliptio* utilize only the outer gills as marsupia (Britton & Fuller 1980).

The genus *Elliptio* has been diagnosed as having hookless or spineless glochidia (Ortmann 1912, Britton & Fuller 1980). However, we found hook-like structures on the ventral margin of the glochidia of some *Elliptio* glochidia. This hook-like structure, "pseudohook," is not like those described as a diagnostic character of the subfamily Anodontinae (Clarke 1981, 1985). The pseudohook is an expansion of the flange on the ventral margin and is completely covered with microstylets of a near uniform size.

The paucity of information on *Elliptio* glochidial morphology (Hoggarth 1999) and host fish determinations (Watters 1994) is surprising considering the widespread distribution of the genus, high diversity (36 taxa), and the number of species with populations large enough to be utilized for study. Most of the work has been done on the two Interior Basin species, *E. crassidens* and *E. dilatata,* and one Atlantic Coast species, *E. complanata.* The difficulty in the identification and uncertainty surrounding their distributional limits has likely contributed to the lack of glochidial morphology and host fish research for the Atlantic Coast and eastern Gulf species.

We examined glochidia from six species of *Elliptio* in an effort to determine if there are characters useful in species and/or group identification. The *Elliptio* species were selected to represent different morphological groups from four drainages in the southeastern United States. The glochidial valve shape, lateral view, micropoints, microstyle, valve sculpturing, and hinge ligament length of *E. crassidens, E. dariensis, E. hopetonensis, E. icterina, E. shepardiana,* and *E. mcmichaeli* were compared qualitatively, using scanning electron microscopy (SEM). These species were then compared with other *Elliptio* glochidia described in published literature. Shells of adult *Elliptio* were also evaluated using museum specimens and published descriptions to determine if there were characteristics useful in identifying species groups within the genus *Elliptio.*

Materials and Methods

Gravid females representing six species of *Elliptio* were collected by hand and SCUBA. The valves were gently pried open 1 cm and the soft parts were visually inspected for swollen gills, which is usually indicative of eggs or glochidia. Three species, *E. dariensis, E. hopetonensis,* and *E. shepardiana* were collected from the Altamaha River, Appling County, Georgia, on 21 Apr 1996. A single gravid *E. crassidens* was collected from Cooleewahee Creek, Baker County, Georgia, on 2 Apr 1997, and a single gravid *E. icterina* was collected from Worthingon Springs, Dixie County, Florida, on 21 May 1996. Fifteen *E. mcmichaeli* were collected from the Choctawhatchee River on 5 May 1986.

The gravid mussels were transported in coolers with ambient temperature creek water to the U.S. Geological Survey, Center for Aquatic Resources Studies, Gainesville, Florida, where they were held in 4-liter jars until they released their glochidia. Female mussels released their glochidia within two weeks of their capture date. All of the glochidia were collected from females that released their glochidia in captivity, except for *E. mcmichaeli.* Glochidia of *Elliptio mcmichaeli* were removed from specimens that had been fixed in a 10% buffered solution of formalin and stored in 70% ethanol. Glochidia collected alive were determined viable when a snapping response was observed after a few salt crystals were added to a small subsample of 50 to 100 individual glochidia (Zale & Neves 1982). The viable glochidia were stored in 70% ethanol and were later used to describe glochidial morphology using *SEM.*

Tissue inside the glochidial shell was removed by soaking them in a 5% sodium hypochlorite solution for about 10 minutes. The shells were then rinsed several times with tap water and preserved in 70% ethanol (Kennedy et al. 1991). Several hundred preserved shells were mounted on a double-sided sticky carbon tape, air dried for 15 minutes, coated with gold, and examined using *SEM.* Photos were taken of the valve (250–500×), flange region (300–3,000×), hinge ligaments (500–1,000×), and shell sculpturing (15,000–30,000×) of the glochidia from the six *Elliptio* species. The flange is defined as a flattened area along the ventral margin of glochidial valve with microstylets, often referred to as micropoints (small tooth-like projections located along the flange). Measurements of the glochidia were determined by averaging the height (dorsal to ventral edge), length (anterior to posterior edge) and dorsal margin (long edge) length measurements of the glochidia under a stereo microscope with an ocular micrometer (10×). The number of glochidia used to determine average measurements varied because some of the glochidia samples collected were small.

Shells of adult *Elliptio* in the Florida Museum of Natural History collection were examined to determine the presence or absence of wrinkled sculpturing on the posterior slope. This character ranges in its development from the obvious to the obscure and may be absent in some individuals. It is often best developed on the upper portion of the slope nearest the umbo, which is often eroded, obscuring or removing any trace of the sculpturing. We examined lots of *E. congarea, E. crassidens, E. dilatata, E. hopetonensis, E. dariensis, E. fraterna, E. mcmichaeli,* and *E. shepardiana* to evaluate this character.

Results

Glochidial shell descriptions.—Elliptio crassidens (Lamarck, 1819). Glochidium subtriangular (Fig. 1a) with a length of 134 ± 2.8 μm (130–138 μm), a height of 150 ± 6.9 μm (141–160 μm), and a hinge length of 85 ± 4.5 μm (80–92 μm) (Table 1). A triangular, styliform flange (hook), covered with microstylets, extends from the ventral aspect of each valve (Fig. 1b, f). Microstylets are arranged in complete vertical rows. The microstylets are longer toward the middle and ventral margins of the valve and smaller toward the distal edge and the lateral margins of the valve. Valve outline is asymmetric with the anterior margin slightly more expanded than the posterior margin (Fig. 1a). Ventral margin produced into a nipple-like extension giving the valve

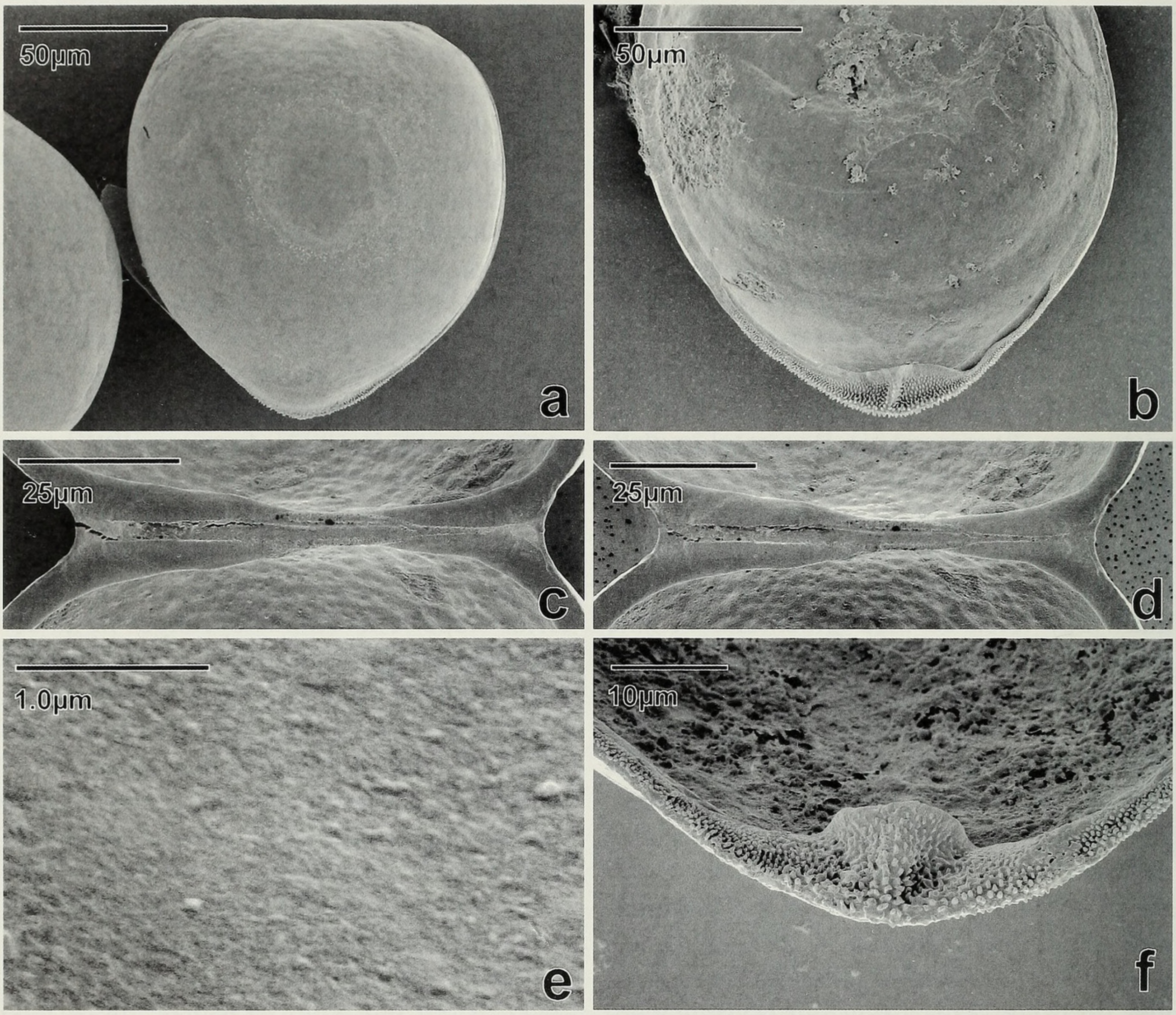

Fig. 1. *Elliptio crassidens.* Scanning electron micrographs (*SEM*) of glochidium. a, exterior valve; b, interior valve showing styliform hook; c, d, hinge; e, exterior valve sculpture; f, flange region with triangular styliform hook.

its triangular shape (Fig. 1a). The hinge ligament is located nearer the posterior margin (Fig. 1c, d) than the anterior margin and the valve is covered with rough exterior valve sculpturing (Fig. 1e).

Elliptio dariensis (Lea, 1842). Glochidium subtriangular (Fig. 2a) with a length of 142 ± 5.5 µm (135–151 µm), a height of 166 ± 6.4 µm (157–172 µm), and a hinge length of 88 ± 5.0 µm (81–95 µm) (Table 1). Anterior and posterior margins subequal with the anterior margin slightly more fully rounded than the posterior margin. Ventral margin produced into a nipple-like extension (Fig. 2a, e) giving the valve its triangular shape. A triangular, styliform flange extends from the ventral aspect of each valve to form a hook (Fig. 2b, e). Microstylets are arranged in complete vertical rows on the flange (Fig. 2b). They are larger toward the center of the flange and toward the proximate edge of the flange, and smaller near the distal edge of the hook and toward the lateral margins of the valve. The hinge ligament is slightly posterior of center (Fig. 2c) and the valve is covered with rough exterior valve sculpturing (Fig. 2d).

Elliptio mcmichaeli (Clench & Turner, 1956). Glochidium subtriangular (Fig. 3a) with a length of 146 ± 7.9 µm (130–157 µm), a height of 153 ± 5.8 µm (149–161 µm), and a hinge length of 90 ± 9.4 µm

Table 1.—The number of glochidia used to determine the measurements and standard deviation for six species of *Elliptio*.

Species	Number of glochidia	Number of females	Mean measurement ± *SD* Length	Height	Hinge
(Triangular shape)					
Elliptio crassidens	6	1	134 ± 3 (130–138 μm)	150 ± 7 (141–160 μm)	85 ± 5 (80–92 μm)
Elliptio dariensis	6	3	142 ± 6 (135–151 μm)	166 ± 6 (157–172 μm)	88 ± 5 (81–95 μm)
Elliptio mcmichaeli	10	5	146 ± 8 (130–157 μm)	153 ± 6 (149–161 μm)	90 ± 9 (80–110 μm)
(Subelliptical shape)					
Elliptio hopetonensis	10	4	206 ± 6 (197–215 μm)	226 ± 4 (222–231 μm)	137 ± 5 (130–145 μm)
Elliptio icterina	10	1	203 ± 6 (195–215 μm)	216 ± 11 (195–234 μm)	141 ± 9 (125–148 μm)
Elliptio shepardiana	10	2	241 ± 3 (238–245 μm)	284 ± 6 (279–295 μm)	148 ± 6 (140–160 μm)

(80–110 μm) (Table 1). Anterior and posterior margins subequal with the anterior margin slightly more fully rounded than the posterior margin. The ventral margin is produced into a nipple-like point (Fig. 3a–c) giving the valve a triangular appearance. Extending from the ventral margin of each valve is a triangular, styliform hook (collapsed in Fig. 3c). Microstylets cover the hook in complete vertical rows. The microstylets are longer near the center of the hook and become smaller laterally where they intergrade into micropoints (Fig. 3c). The hinge ligament is located slightly posterior of center (Fig. 3d) and the valve is covered with rough exterior valve sculpturing (Fig. 3c).

Elliptio hopetonensis (Lea, 1838). Glochidium depressed subelliptical (Fig. 4a) with a length of 206 ± 5.8 μm (197–215 μm), a height of 226 ± 3.9 μm (222–231 μm), and a hinge length of 137 ± 5.0 μm (130–145 μm) (Table 1). Anterior and posterior margins equal, but only slightly rounded to a more fully rounded ventral margin (Fig. 4a). A broad flange extends from the ventral margin (Fig. 4b). This flange is covered with microstylets in complete vertical rows (Fig. 4d). These microstylets are larger near the midpoint of the ventral margin and grade into micropoints laterally. The dorsal margin is straight, long, and the hinge ligament is located much nearer the posterior than the anterior margin (Fig. 4c). The surface of the valve is covered with loose-looped exterior valve sculpturing (Fig. 4e).

Elliptio icterina (Conrad, 1834). Glochidium depressed subelliptical (Fig. 5a) with a length of 203 ± 6.4 μm (195–215 μm), a height of 216 ± 10.5 μm (195–234 μm), and a hinge length of 141 ± 8.8 μm (125–148 μm) (Table 1). Anterior and posterior margins equally, but only slightly rounded to a more fully rounded ventral margin. A wide ventral flange extends from the margin (Fig. 5b). The flange is covered in microstylets, (Fig. 5b, d) which are longer near the midpoint of the flange and grade into micropoints laterally. The dorsal margin is straight with the hinge ligament located much nearer to the posterior margin of the valve (Fig. 5c). Loose-looped exterior valve sculpturing covers the exterior surface of each valve (Fig. 5e) and that sculpturing can even be seen extending onto the surface of the microstylets on the flange (Fig. 5d).

Elliptio shepardiana (Lea, 1834). Glochidium subelliptical (Fig. 6a) with a length

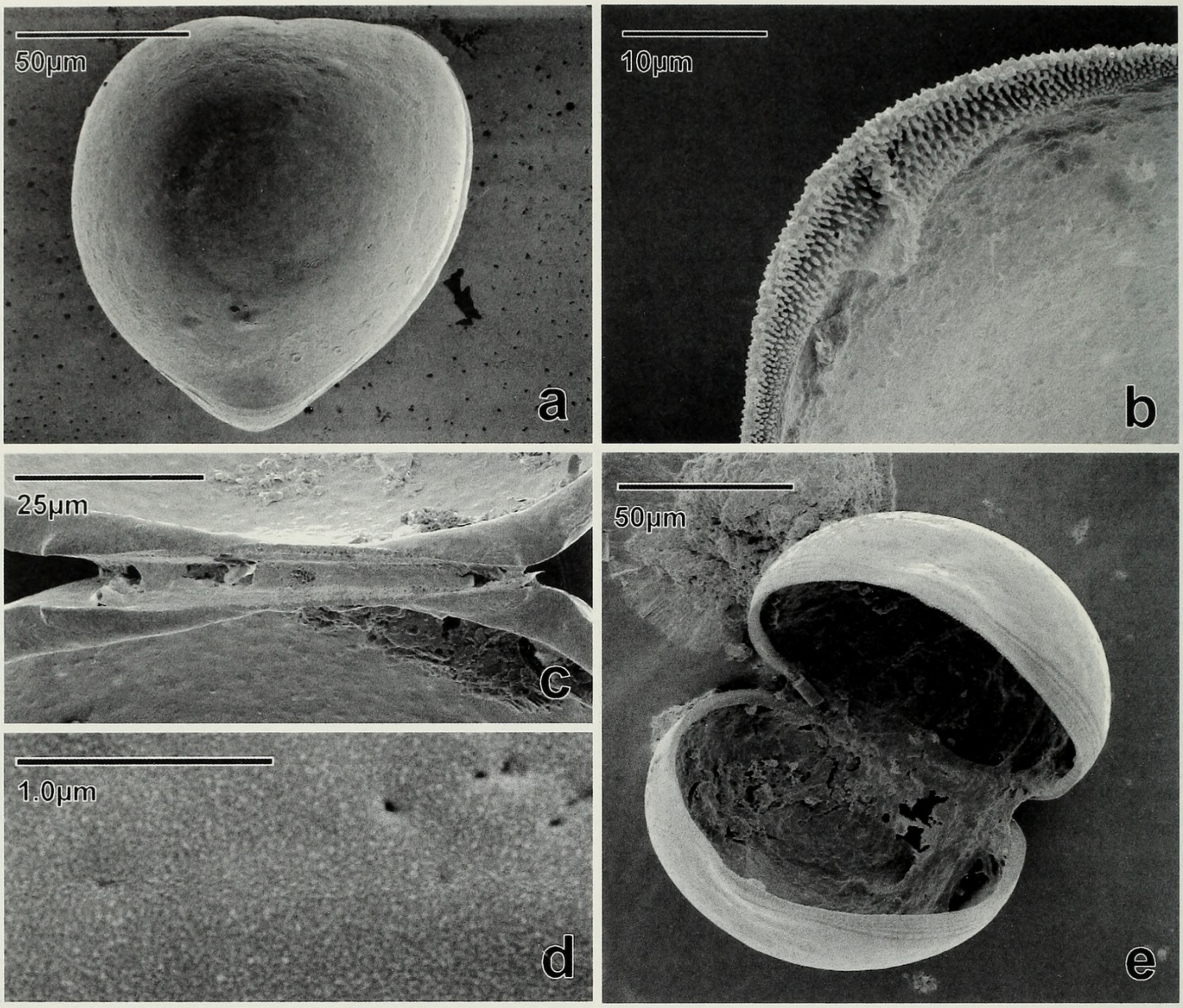

Fig. 2. *Elliptio dariensis. SEM* of glochidium. a, exterior valve; b, interior valve showing styliform hook; c, hinge; d, surface sculpturing; e, internal view.

of 241 ± 3.3 μm (238–245 μm), a height of 284 ± 5.8 μm (279–295 μm), and a hinge length of 148 ± 6.3 μm (140–160 μm) (Table 1). Anterior and posterior margins more or less equal and only slightly rounded. The ventral margin is strongly arched and supports a wide ventral flange (Fig. 6b). The ventral flange is widest near the middle of the ventral margin and tapers to both anterior and posterior margins. The flange supports numerous microstylets arranged in complete vertical rows which grade into micropoints distally on the flange and laterally toward the anterior and posterior margins of the flange (Fig. 6c, d). The hinge is straight and the hinge ligament is positioned nearest the posterior margin of the valve (Fig. 6c). Loose-looped valve sculpturing covers the exterior surface of each valve (Fig. 6e), and this sculpturing is seen extending onto the ventral flange and covering the microstylets (Fig. 6d).

Adult shell morphology.—Elliptio crassidens is widespread in the Interior Basin and eastward along the Gulf Coast from the Amite River in Louisiana to the Ochlockonee River drainage in Florida (Brim Box & Williams 2000). Populations in the Apalachicola and Ochlockonee have been referred to as a distinct subspecies, *E. incrassatus.* However, this taxon is generally not recognized as valid. *Elliptio crassidens* is large (length of 150 mm) and has a moderate to thick shell with a prominent pos-

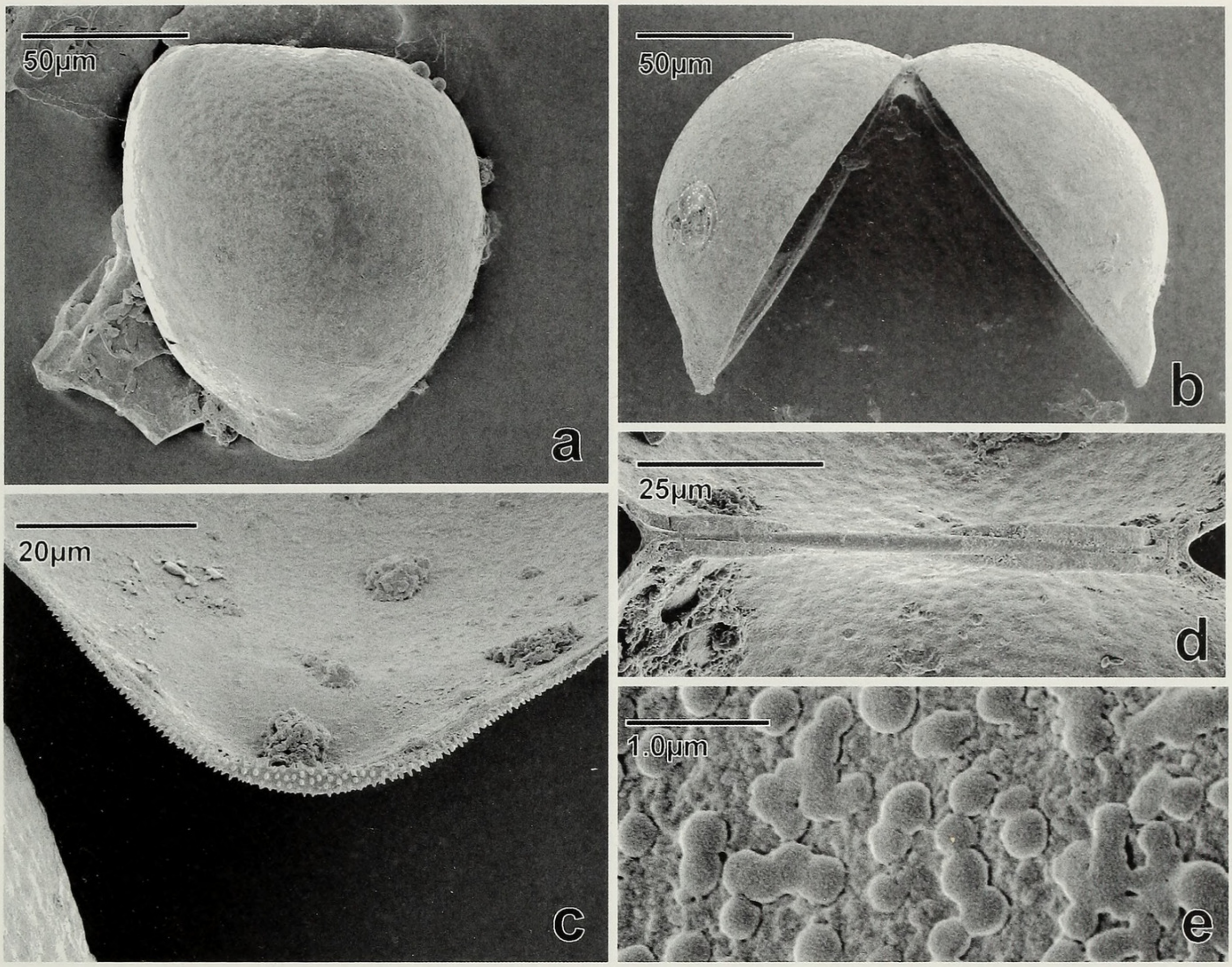

Fig. 3. *Elliptio mcmichaeli. SEM* of glochidium. a, exterior valve; b, side view of valve; c, flange; d, hinge; e, exterior valve sculpture.

terior ridge. It typically has sculpturing on the posterior slope consisting of distinct wrinkles or corrugations.

Elliptio dariensis is endemic to the Altamaha River drainage, including the Ohoopee and Ocmulgee rivers in Georgia. Johnson (1970, 1972) considered the distribution of this species to extend southward into the St. Johns River system in peninsular Florida. The shell is thin, large (length to 135 mm), and moderately inflated. The posterior ridge is well defined with a broad posterior slope. Similar to *E. crassidens,* the posterior slope typically has sculpturing in the form of numerous wrinkles.

Elliptio mcmichaeli is endemic to the Choctawhatchee River system (Gulf of Mexico drainage) in Alabama and Florida. The shell is thin, moderately large (>110 mm in length), with a poorly developed biangulated posterior ridge. The posterior slope is broad, somewhat concave, with sculpturing in the form of wrinkles that radiate from the posterior ridge across the slope to the dorsal margin.

Elliptio hopetonensis is endemic to the Altamaha River drainage in Georgia. The shell is moderately thin and large (155 mm in length). The posterior ridge is broad and rounded dorsally, but terminates in a biangulation near the ventral margin. The posterior slope is broad, somewhat concave, and lacks any wrinkled or corrugated sculpturing.

Elliptio icterina is found in coastal drainages from the Escambia River system in Alabama and Florida, east to peninsular Florida and north on the Atlantic Slope to

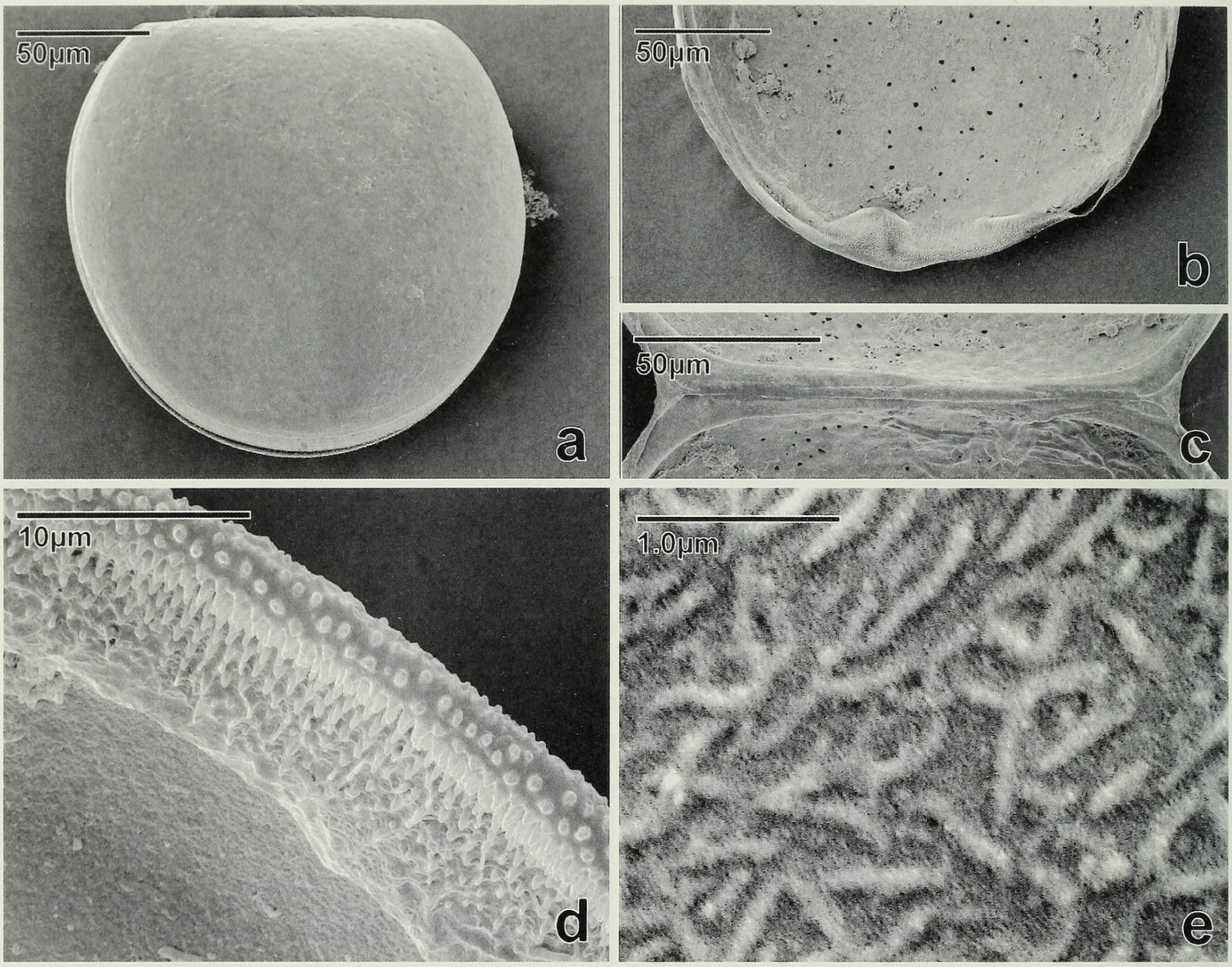

Fig. 4. *Elliptio hopetonensis. SEM* of glochidium. a, exterior valve; b, interior valve showing expanded flange of ventral margin; c, hinge; d, flange region showing rows of microstylets; e, exterior valve sculpture.

White Oak River in North Carolina (Johnson 1970). The shell of *E. icterina* is moderately compressed and small (length to approximately 85 mm). The posterior ridge is low, somewhat rounded, with a broad posterior slope. Wrinkled sculpturing is absent from the posterior slope.

Elliptio shepardiana is endemic to the Altamaha River system in Georgia, including the Ocmulgee, Oconee, and Ohoopee rivers. The shell is long (length to 190 mm), moderately compressed, rounded anteriorly, and somewhat pointed posteriorly. The posterior ridge is broadly rounded with a secondary ridge above it, which often results in a slight biangulation at the posterior end. The posterior slope is devoid of wrinkled sculpturing.

Discussion

Based on glochidial and adult shell morphology of the six species described above we have identified what appears to be two clades within the genus *Elliptio*. While the six species represent less than 20% of the genus, the nature and consistency of the characters would appear to be indicative of two distinct groups. As glochidia of the remaining 28 species of *Elliptio* are examined it should be easy to assign them to one of the two groups described above. It is also possible that one or more additional clades may be found in the remaining 26 species of Atlantic Coast and eastern Gulf of Mexico drainage *Elliptio*.

Elliptio crassidens *group.*—The glochidium of *Elliptio crassidens* was first figured

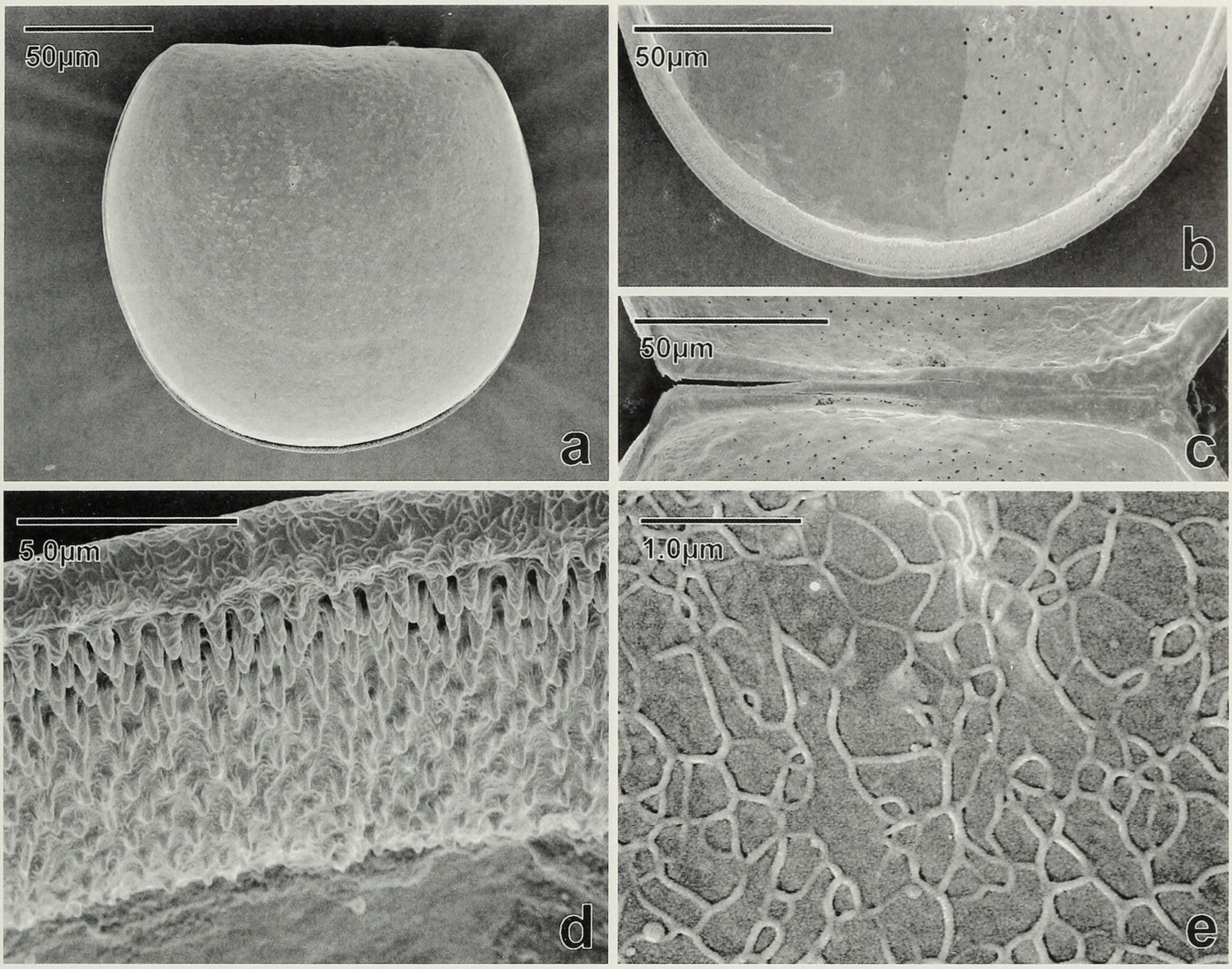

Fig. 5. *Elliptio icterina. SEM* of glochidium. a, exterior valve; b, interior valve; c, hinge; d, flange showing microstylets; e, exterior valve sculpture.

(Ortmann 1911) and subsequently described (Ortmann 1912) illustrating its subtriangular shape (Fig. 6, plate 89, page 346–347). Ortmann (1912) and Utterback (1915–1916) described the glochidium as small, suboval, without hooks. Ortmann and Utterback gave identical dimensions of 0.13 by 0.15 mm in length and height, respectively. Likewise, other reports (Surber 1912, 1915; Coker et al. 1921) generally describe the glochidium of *E. crassidens* (or its synonyms) as small, suboval, and spineless or hookless. Surber (1915) described the glochidium as subtriangular and somewhat intermediate between that of *Alasmidonata calceola* (= *viridis*) and *Quadrula* (= *Fusconaia*) *ebena.* He did not identify the glochidium of *E. crassidens* as having a hook on the ventral margin and he gave the size of this glochidium as larger, 0.15 by 0.16 mm.

We found the glochidium of *Elliptio crassidens* to be subtriangular with a definite hook-like structure at the terminus of the ventral margin. While our measurements generally agree with those of Ortmann and Utterback, their description does not mention the presence of a "hook." It is possible that they did not see the hook due to lack of magnification. The glochidial shells of the *crassidens* group were the only Lampsiline-Amblemine species observed to possess subtriangular glochidia (Hoggarth 1999).

The three species examined during this study which are assigned to the "*Elliptio crassidens*" group are *E. crassidens, E. dariensis,* and *E. mcmichaeli.* The glochidia

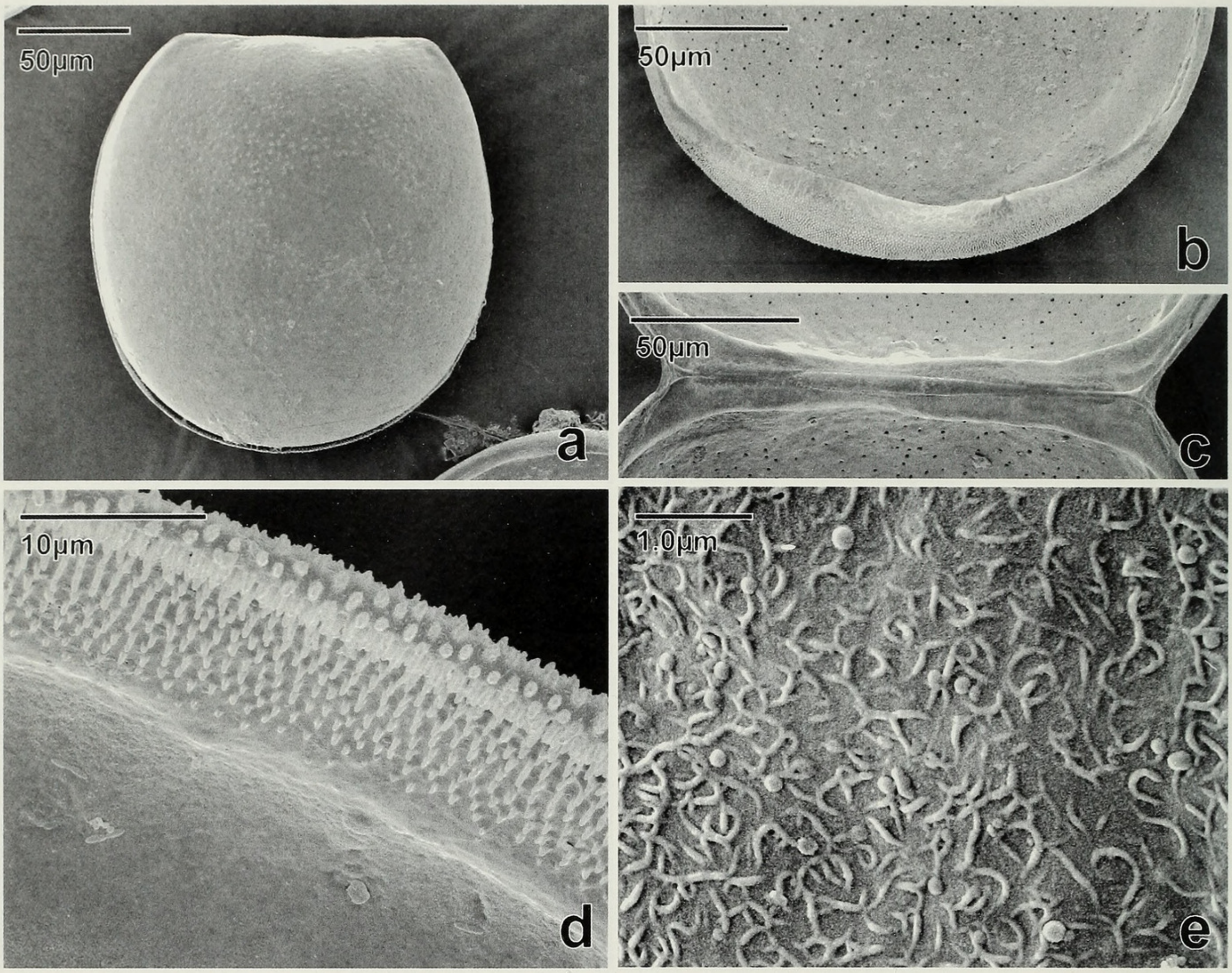

Fig. 6. *Elliptio shepardiana. SEM* of glochidium. a, exterior valve; b, interior valve showing wide ventral flange; c, hinge; d, flange region showing microstylets; e, exterior valve sculpture.

of these species share subtriangular valve shape, the presence of a small styliform hook at the terminus of the ventral margin, and rough exterior valve sculpturing. The shells of adults of this group also share the wrinkled or corrugated sculpturing on the posterior slope.

Elliptio complanata *group.*—The glochidium of *Elliptio dilatata* was first described by Lea (1863) (as *Unio gibbosus*). He described the glochidium as pouch-shaped, without hooks, and very much like that of *Ptychobranchus fasciolaris.* In fact, this glochidium is not similar to *fasciolaris,* except that both are subelliptical (Hoggarth 1999). Lefevre & Curtis (1910, 1912) provide the first measurements for this glochidium (0.22 by 0.19 mm in length and height) and Ortmann (1911, 1919) adds that the glochidium of *dilatata* is small, suboval, and without hooks.

Hoggarth (1999) described this glochidium as subelliptical with equal lateral margins and equal length and height (0.22 mm). He found that the glochidium was covered in loose-looped valve sculpturing and that lanceolate micropoints cover the narrow ventral flange. He noted that only Ortmann (1919) found the dimensions of this glochidium to be equal (0.20 mm), while Lefevre and Curtis (see above) described this glochidium as longer than high, and all other authors found this glochidium to have a length of 0.20 mm and a height of 0.22 mm (Ortmann 1912, Surber 1912, Utterback 1915–1916).

The light microscope photographs of the glochidia of *Elliptio complanata* in Matteson (1948) clearly show the shape to be subelliptical and hookless. The low magnification of the glochidial photographs is such that details of the sculpturing of the shell surface and micropoints are not visible. However, based on the subelliptical outline it appears to be identical to the glochidia of *E. dilatata, E. hopetonensis, E. icterina,* and *E. shepardiana.* These glochidia are all higher than long with *E. shepardiana* the largest and *E. icterina* and *E. hopetonensis* having almost identical dimensions with *E. complanata.* Furthermore, glochidia of all three species possess similar ventral margins (hookless and micropoint structure) and loose-looped external valve sculpturing, except for *E. complanata,* which is yet to be determined. These are characteristics they share with *E. dilatata* reported by Hoggarth (1999). Based on the subelliptical shape of the glochidia of *E. buckleyi* (D. S. Ruessler, pers. comm.), it also belongs to the *E. complanata* group. Adult shells of the species in the *E. complanata* group are characterized by the absence of sculpturing on the posterior slope.

Host fish.—Host fish data for most species of *Elliptio* is incomplete. Of the 36 currently recognized species in the genus, only five, *E. buckleyi, E. crassidens, E. complanata, E. dilatata* and *E. icterina,* have any published information on host fish (Watters 1994, Keller & Ruessler 1997). This may be explained in part by the fact that most species of *Elliptio* occur in Atlantic and eastern Gulf Coast streams where there are no commercially important species. The lack of economic interest resulted in very little research into the reproductive biology and host fish utilization by early mussel biologists, who concentrated their efforts on the commercially valuable Mississippi Basin species.

Howard (1914) reported finding *Elliptio crassidens* encysted on a skipjack herring, *Alosa chrysochloris.* This is the only host fish information available for *E. crassidens* (Watters 1994). The host fish for *E. dariensis* and *E. mcmichaeli* remain unknown. However, *E. dariensis* failed to produce juveniles when exposed to bluegill, *Lepomis macrochirus,* during a laboratory host fish experiment (C. O'Brien, pers. obs.). During the same laboratory host fish experiment, eastern mosquitofish, *Gambusia holbrooki,* and *L. macrochirus* were identified as host fishes for *E. hopetonensis,* but the largemouth bass, *Micropterus salmoides,* failed to produce juvenile mussels.

While the host for *Elliptio mcmichaeli* is unknown, there are data that suggest the host is a migratory fish. There are historic records of *E. mcmichaeli* from the upper Pea River, a tributary of the Choctawhatchee River, in southeast Alabama (Blalock-Herod, pers. comm.). The middle portion of the Pea River was impounded in the early 1900s, totally eliminating upstream access to native migratory fishes, including two migratory shads, Alabama shad, *Alosa alabamae,* and skipjack herring, *A. chryssoclorris.* During a recent survey of the entire watershed, *E. mcmichaeli* was found at numerous stations below the dam on the Pea River and elsewhere in the Choctawhatchee watershed, except it was absent in the Pea River above the dam (Blalock-Herod, pers. comm.). Since the Pea River above the dam currently supports a mussel community, which formerly included *E. mcmichaeli,* its absence today may be due to the lack of suitable migratory host fish that are blocked by the dam. Although circumstantial, we think this evidence strongly suggests a migratory host fish for *E. mcmichaeli.*

Matteson (1948) found yellow perch, *Perca flavescens,* as a host fish for *Elliptio complanata* via laboratory infestations and Wiles (1975) found *E. complanata* glochidia encysted on banded killifish, *Fundulus diaphanus.* Other fishes reported as hosts for *E. complanata* include green sunfish, *Lepomis cyanellus,* orangespotted sunfish, *L. humilis,* largemouth bass, *Micropterus salmoides,* and white crappie, *Pomoxis annularis* (Young 1911). Keller & Ruessler (1997) reported *L. machrochirus, M. salmoides,* and Florida gar, *Lepisosteus platy-*

rhincus as host fishes for *E. buckleyi.* They also identified *L. macrochirus* and *M. salmoides* as the host fishes for *E. icterina.* These were the only fish species tested with *E. icterina* during their study. The host fish for *E. shepardiana* remains unknown. Host fishes for the spike, *E. dilatata,* include six fishes representing four families: flathead catfish, *Pylodictus olivaris,* and sauger, *Stizostedion canadense* (Howard 1914); gizzard shad, *Dorosoma cepedianum,* and white crappie, *P. annularis* (Wilson 1916); black crappie, *P. nigromaculatus,* and yellow perch, *Perca flavescens* (Clarke 1981).

Based on host fish information available, it is not possible to make any definitive statements regarding possible association between species groups of *Elliptio* and particular host fish usage. However, based on glochidial shell morphology and host fish information presented above, this could be the case. It appears that species of the *crassidens* group, triangular-shaped glochidia, may only use the highly migratory fishes of the genus *Alosa* (family Clupeidae), while species of the *complanata* group, subelliptical-shaped glochidia, may use a variety of fishes, 12 species representing 6 families. None of the host fishes used by the *E. complanata* group are highly migratory. If future host fish research confirms this pattern this would provide an additional characteristic to distinguish these two species groups of *Elliptio.* It would also suggest a very early evolutionary divergence within the genus *Elliptio.*

Species level identification for many species of the genus *Elliptio* remains problematic and their evolutionary relationships remain a mystery. The proper identification of mussel species is a very important part of any management plan. However, conchological differences may not be the only tool needed to identify species of the complex *Elliptio* group. More research is needed to explore the genetic and host fish usage differences between these two *Elliptio* groups identified and any other groups that might become apparent.

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