

# A new species of freshwater mussel, *Anodonta hartfieldorum* (Bivalvia: Unionidae), from the Gulf Coastal Plain drainages of Alabama, Florida, Louisiana, and Mississippi, USA

**James D. Williams**

Florida Museum of Natural History,  
University of Florida  
Museum Road and Newell Drive  
Gainesville, FL 32611 USA  
fishwilliams@gmail.com

**Arthur E. Bogan**

North Carolina State  
Museum of Natural Sciences  
MSC 1626  
Raleigh, NC 27699-1626 USA  
arthur.bogan@ncdenr.gov

**Jeffrey T. Garner**

Alabama Division of Wildlife  
and Freshwater Fisheries  
350 County Road 275  
Florence, AL 35633 USA  
bleufer@aol.com

## ABSTRACT

A new species of unionid mussel, *Anodonta hartfieldorum*, is described from Coastal Plain streams of the eastern Gulf of Mexico drainages. It occurs in the Pearl River in Louisiana and Mississippi, Pascagoula River in Mississippi, Tombigbee River in Mississippi and possibly Alabama, Tensaw River in Alabama and the Escambia River drainage in Alabama and Florida. Based on shell morphology and presence of very thin green rays, it belongs to a species group within the genus *Anodonta* which includes *A. couperiana*, *A. heardi*, *A. implicata*, and *A. suborbiculata*. *Anodonta hartfieldorum* appears to be most closely related to *A. suborbiculata*, but differs in several aspects of shell morphology. *Anodonta suborbiculata* is widespread in the Mississippi Basin and has been widely introduced outside its native range. *Anodonta hartfieldorum* occurs in floodplain sloughs and oxbow lakes in silty sand to mud sediments. Its conservation status is unknown as its typical habitat is under-represented in most mussel sampling programs.

*Additional keywords:* Cypress Floater, new species, taxonomy, conservation, Alabama, Florida, Louisiana, Mississippi

species, *Anodonta cygnea* Linnaeus, 1758, is from western Europe. In North America, *Anodonta* occurs from Alaska and Canada to Mexico. Turgeon et al. (1998) recognized ten species in the genus. The number of *Anodonta* species worldwide is not clear due to poor delineation of taxa and varying interpretations of the species concept (e.g. Mock et al., 2004). Ortmann (1912) observed that "in Europe the species-making in this group has gone beyond all the bounds of reason." *Anodonta* Lamarck, 1799, is a *nomen conservatum* (ICZN, 1926: Opinion 94; 1959: Opinion 561). Hoeh (1990) used morphological and allozyme data to produce a phylogeny that divided North American *Anodonta*, along with the European type species *A. cygnea*, into three clades: *Anodonta*; *Pyganodon* Crosse and Fischer in Fischer and Crosse, 1894; and *Utterbackia* Baker, 1927. The latter two were elevated from subgeneric to generic status by Hoeh (1990).

## INTRODUCTION

Southeastern United States Unionidae have received considerable attention during the past half century. Thus, their taxonomy is well understood relative to some other groups of aquatic invertebrates (e.g. crayfishes) (Taylor et al., 2007). However, there are remaining undescribed unionid species (Williams et al., 2008). One undescribed species of *Anodonta* Lamarck, 1799, was first recognized in the Pascagoula River during the 1980s by Paul Hartfield, U.S. Fish and Wildlife Service, Jackson, Mississippi. Subsequent surveys revealed the presence of this species in Gulf Coast drainages from the Pearl River east to the Escambia River (Vidrine, 1993; Williams et al., 2008).

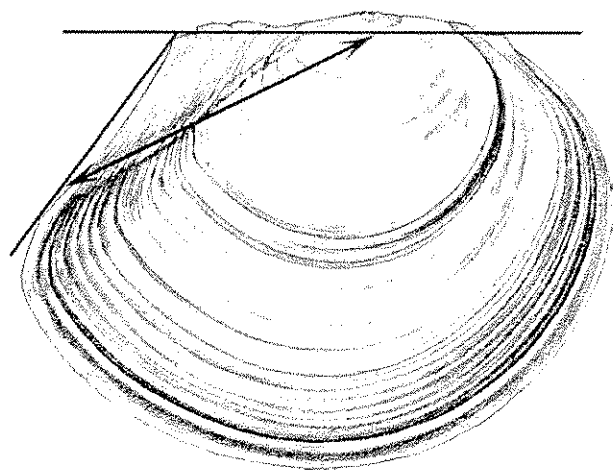
The genus *Anodonta*, as presently conceived, occurs in most of the Nearctic and Palearctic regions. The type

## MATERIALS AND METHODS

Comparative material of *Anodonta couperiana* Lea, 1840, *Anodonta hartfieldorum*, *Anodonta heardi* Gordon and Hoeh, 1995, and *Anodonta suborbiculata* Say, 1831, from several museums was utilized in this description. These institutions include Florida Museum of Natural History, University of Florida (UF), Gainesville, Florida; Mississippi Museum of Natural Science (MMNS), Jackson, Mississippi; Museum of Comparative Zoology (MCZ), Harvard University, Cambridge, Massachusetts; North Carolina State Museum of Natural Sciences (NCSM), Raleigh, North Carolina; Ohio State University Museum (OSUM), Columbus, Ohio; and National Museum of Natural History, Smithsonian Institution (USNM), Washington, DC. Additional material from the personal collection of Robert G. Howells, Kerrville, Texas, was also examined.

Shell measurements were made to the nearest millimeter using digital calipers and included total length,

height, width, hinge line length, and distance from umbo to posterior shell terminus. Total length is defined as distance between anterior and posterior margins, measured parallel to the hinge line. Shell height is distance between dorsal and ventral margins, measured near the midpoint of the hinge line, perpendicular to shell length. Shell width is maximum distance between the outer surfaces of the paired valves. Hinge line length is distance from its anterior terminus to the anterior end of the ligamental notch. Distance from the center of the umbo to the posterior shell terminus was measured in a straight line. The angle between dorsal margin and posterior margin was measured to the nearest five degrees using a protractor (Figure 1). Shell measurement data were analyzed using Excel spreadsheet scatter plots with linear regression. An ANOVA on the angle measurements was performed on the three species using SPSS v16.0. A post-hoc comparison using Tukey's test was performed to determine the significantly different groups. Gross anatomy of soft tissues was described from fresh and relaxed specimens fixed in 10% formalin and transferred to 70% ethanol. The anatomical descriptions follow methods described in Williams et al. (2008).



**Figure 1.** Illustration of how the angle between dorsal margin and posterior margin was measured. Image of *Anodonta suborbiculata* modified from Burch (1975).

*Anodonta hartfieldorum* new species

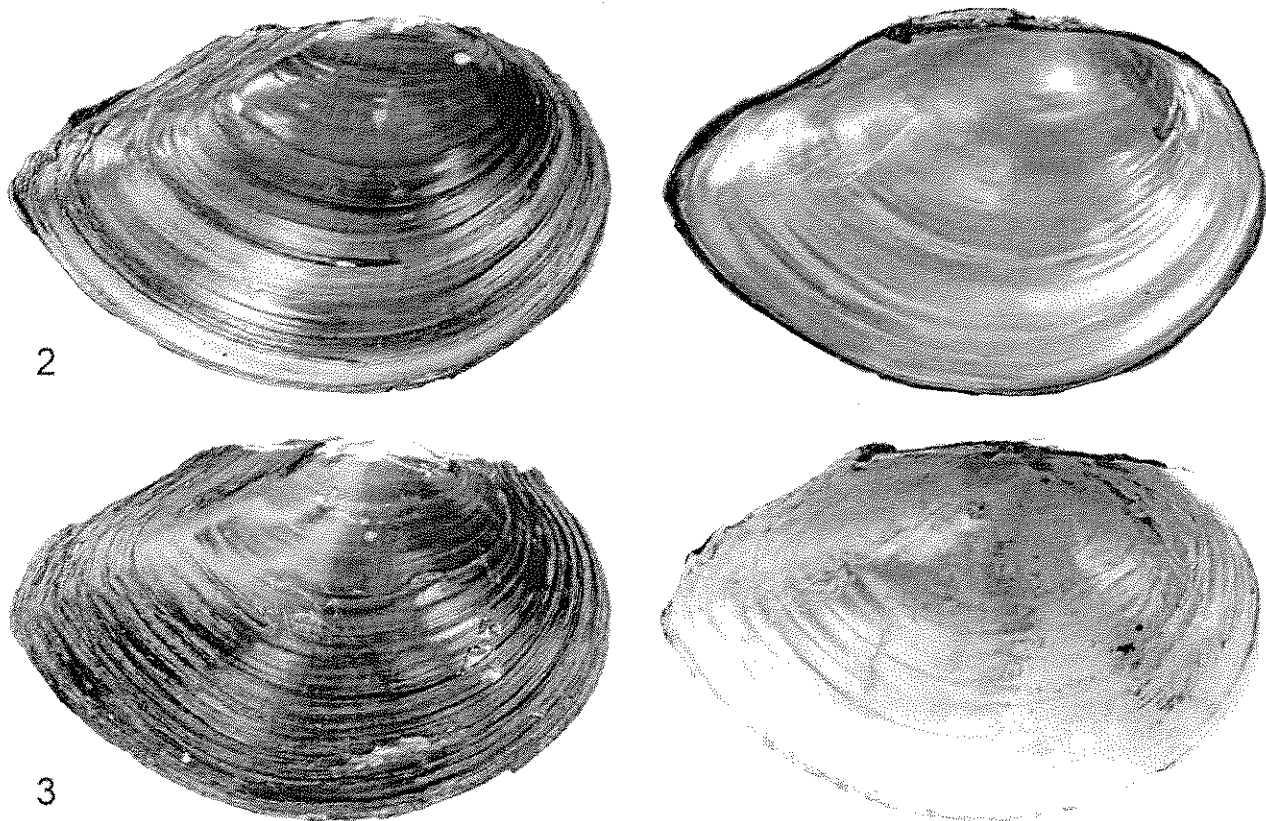
Cypress Floater  
(Figures 2, 3)

**Diagnosis:** *Anodonta hartfieldorum* is distinguished from other unionid species by a combination of the following characteristics: thin, compressed to inflated shell, elliptical to oval outline, ventral margin rounded; angle between dorsal margin and posterior margin usually  $140^{\circ}$  to  $150^{\circ}$ ; hinge teeth absent; periostracum smooth, tawny to olive or brown, typically with very thin green rays; umbo only slightly elevated above hinge line; umbo sculpture in the form of parallel bars in adults; inner lamellae of inner gills connected to visceral

mass only anteriorly; supra-anal aperture small, separated from excurrent aperture by wide mantle bridge (may be longer than either of the two apertures); outer gills marsupial; marsupium occupying entire gill, well padded when gravid; secondary water tubes present in gravid marsupia; glochidium with styloform hooks.

**Description:** Length to 120 mm; shell thin; moderately inflated; outline oval; posterior margin narrowly rounded to bluntly pointed; angle between dorsal margin and posterior margin  $140^{\circ}$  to  $155^{\circ}$  (mean =  $146^{\circ}$ ) (Table 1); anterior margin broadly rounded; dorsal margin straight; ventral margin convex; posterior margin low, rounded; posterior slope moderately steep, slightly concave, occasionally extending into a very low dorsal wing; umbo broad, moderately inflated, barely elevated above hinge line; umbo sculpture nodulous ridges in young and parallel bars in adults; periostracum tawny to olive or brown, typically with very thin, olive to greenish brown rays that often are obscure in adults. Pseudocardinal and lateral teeth absent; umbo cavity wide, shallow; nacre white, sometimes with salmon tint in umbo cavity (Figures 2, 3).

In life the mantle is creamy-white to tan or golden-tan, may be dull-orange external to pallial line, mantle outside of apertures dull-orange to grayish-brown; visceral mass creamy-white to tan, may be dull-orange adjacent to foot; foot dull-orange to creamy-white or tan. Gills gold to tan or brown; dorsal margin sinuato to concave, ventral margin convex; gill length 57–69% of shell length; gill height 31–53% of gill length; outer gill height 79–100% of inner gill height, outer gill height may be greater than inner gill height in gravid individuals; inner lamellae of inner gills only connected to visceral mass anteriorly. Outer gills marsupial; glochidia held across gill length; well padded when gravid; light-brown to brownish-orange. Labial palps tan, may have golden cast; straight to concave dorsally, convex ventrally, bluntly pointed distally; palp length 21–40% of gill length; palp height 46–67% of palp length; distal 27–58% of palps bifurcate. Incurrent aperture usually longer than excurrent and supra-anal apertures; supra-anal and incurrent apertures occasionally of similar length. Incurrent aperture length 8–12% of shell length; creamy-white to dull-orange within, sometimes grayish or rusty-brown basal to papillae; papillae in 2–3 rows, inner row usually larger, simple, short, thick; papillae tan to dull-orange, larger papillae often with black edges basally. Excurrent aperture length 5–8% of shell length; creamy-white to dull-orange within, marginal color band rusty-tan to dull-orange with black lines perpendicular to margin, generally with some lines converging proximally, some individuals with lines interconnected to form an irregular reticulated pattern; excurrent aperture margin smooth, may undulate. Supra-anal aperture length usually 5–8% of shell length, occasionally to 16% of shell length; creamy-white to tan within, usually without marginal coloration, occasionally with a thin, irregular tan band; supra-anal aperture margin smooth; mantle bridge separating supra-anal and excurrent apertures usu-



**Figures 2, 3.** *Anodonta hartfieldorum*. **2.** Holotype UF 375595, length 112 mm. Fish Lake, oxbow off Pascagoula River, 1 air mile [1.6 air kilometers] southeast of Highway 614 bridge, southwest of Wade, 30.6016°N; 88.6233°W, Jackson County, Mississippi, 27 Oct. 2000. © Richard T. Bryant. **3.** Non-type specimen UF 358657, length 114 mm. Slough and gravel pits adjacent to Escambia River, Mystic Springs boat ramp, 1 mile [1.6 kilometer] southeast of McDavid, Escambia County, Florida, 30.92656°N; 87.28597°W, 20 Sep. 1999. © Richard T. Bryant.

ally imperforate, of variable length, 67–480% of supra-anal length, occasional individuals with a short secondary mantle bridge anterior to primary bridge.

Minor soft anatomy differences were noted between *Anodonta hartfieldorum* specimens collected from the Pascagoula and Escambia River systems. Incurrent apertures of Pascagoula individuals (8–10% of shell length) were shorter than those of Escambia individuals (10–12% of shell length). Length of the mantle bridge separating excurrent and supra-anal apertures varied more widely in Pascagoula individuals (67–480% of supra-anal length) than in Escambia individuals (90–420% of supra-

anal length). Conversely, wider variation in labial palp size was observed in Escambia individuals (palp length/gill length 21–40%; palp height/palp length 47–67%) than Pascagoula individuals (palp length/gill length 25–29%; palp height/palp length 54–57%). Gill height in relation to gill length was greater in Escambia individuals (40–53%) than in Pascagoula individuals (31–38%). These differences are considered slight and could be an artifact of modest sample sizes ( $n = 6$  from each of the two drainages), so further comparisons are needed. No material from the Pearl River drainage or Mobile Basin was available for comparison.

**Table 1.** Frequency distribution of the angle measurement between dorsal margin and posterior margin of *Anodonta hartfieldorum*, *A. heardi* and *A. suborbiculata*. *Anodonta suborbiculata* was significantly different ( $p < 0.001$ ) from the other two species. There was no significant difference among the other two species ( $p = 0.534$ ).

Species	Angle between dorsal margin and posterior margin										N	Mean
	115°	120°	125°	130°	135°	140°	145°	150°	155°	160°		
<i>A. hartfieldorum</i>						18	25	19	7		69	146
<i>A. heardi</i>				1	1	1	5	6	2	2	18	147
<i>A. suborbiculata</i>	3	17	38	34	25	8	2				127	129

**Type Material: Holotype:** UF 375595, length 112 mm, Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), Jackson County, Mississippi, 27 Oct. 2000.

**Paratypes: Pascagoula River Drainage: Mississippi: Jackson County:** MCZ 361689, length 89–107 mm (3 dry shells), Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), 27 Oct. 2000. MMNS 6973, length 60–101 mm (6 dry shells), Pascagoula River at mouth of Dead River Lake (30.59236°N; 88.59761°W), 27 Aug. 1986. NCSM 29799, length 58–78 mm (2 alcohol preserved), Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), 27 Oct. 2000. NCSM 28212, length 57–101 mm (13 alcohol preserved), Dead River Lake (mouth) off Pascagoula River, [6 air km SSW center of Wade] (30.5944°N; 88.5979°W), 27 Aug. 1986. OSUM 80078, length 88–106 mm (3 dry shells), Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), 27 Oct. 2000. UF 428535 (6 in 95% alcohol preserved), Pascagoula River at Paper Mill Camp (30.63228°N; 88.65240°W), 21 Aug. 2008. UF 428536 (4 in 70% alcohol preserved), Pascagoula River at Paper Mill Camp (30.63228°N; 88.65240°W), 21 Aug. 2008. UF 428544, length 53–120 mm (9.5 dry shells), Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), 27 Oct. 2000. UMMZ 302000, length 90–105 mm (3 dry shells), Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), 27 Oct. 2000. USNM 1124163, length 79–99 mm (4 dry shells), Fish Lake, oxbow off Pascagoula River, 1 air mi. [1.6 air km] SE of Hwy 614 bridge, SW of Wade (30.6016°N; 88.6233°W), 27 Oct. 2000.

**Other Material Examined: Escambia River Drainage: Alabama: Covington County:** NCSM 45095 (16 alcohol preserved), Gantt Reservoir, Conecuh River, CR 86 [Dunn's Bridge Road], [3.2 air km NE center of Gantt] (31.42573°N; 86.4576°W), 5 Nov. 2006. NCSM 45145 (1 dry shell), Point A Reservoir [Conecuh River], SW corner, 1.77 km NW from intersection of CR 70 and US 84, (31.35953°N; 86.51628°W), 8 Nov. 2005; **Alabama: Escambia County:** UF 375317 (1 alcohol preserved), Old Faulkner Lake, oxbow lake of Conecuh River, 2 air mi. [3.2 air km] SE of Pollard, 0.5 air mi. [0.8 air km] N of Florida state line, 29 June 1995; **Florida: Escambia County:** UF 358657 (6 dry shells), slough and gravel pits adjacent to Escambia River, at Mystic Springs boat ramp, 1 mi. [1.6 km] SE of McDavid (30.92656°N; 87.28597°W), 20 Sep. 1999. UF 376605 (5 dry shells), slough and gravel pits adjacent to Escambia River, at Mystic Springs boat ramp, 1 mi. [1.6 km] SE of McDavid, 5 July 1992. UF 428537 (3 in 70% alcohol preserved), Escambia River at Bluff Springs boat ramp (30.92675°N; 87.28647°W), 19 Sep. 2007. UF 428538 (6 in 95% alcohol preserved), Escambia River at Bluff

Springs boat ramp (30.92675°N; 87.28647°W), 19 Sep. 2007. NCSM 28251 (16 alcohol preserved), Escambia River, abandoned gravel pits adjacent to Mystic Springs boat ramp, [point estimated 1.6 air km SSE center of] McDavid (30.85559°N; 87.31266°W), 9 Aug. 1992.

**Mobile Tensaw River Drainage: Alabama Baldwin County:** UF uncataloged (2 alcohol preserved), slough off Tensaw Lake about 1 air mi. [1.6 air km] SSW of Hubbard Fish Camp and Landing (31.049097°N; 87.871753°W), 18 Sep. 1999. These specimens were misplaced during a transfer from U.S. Geological Survey to the Florida Museum of Natural History.

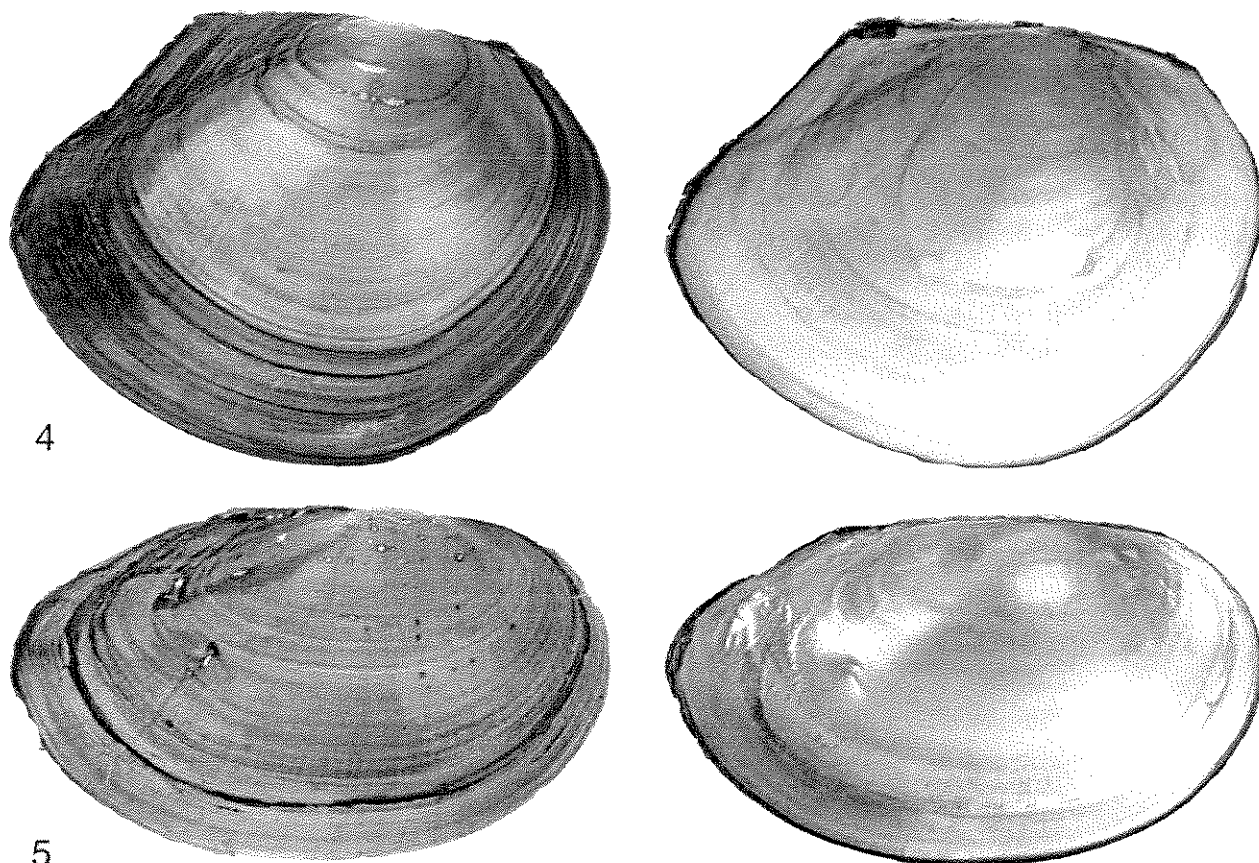
**Pascagoula River Drainage: Mississippi: George County:** MMNS 5503 (3 dry shells), McCrea Dead River E of Dale (30.83302°N; 88.74750°W), 29 May 2000.

**Pearl River Drainage: Louisiana: St. Tammany Parish:** MMNS 6444 (1 dry shell), Pearl River, Mississippi and Louisiana state line, at Walkiah Bluff, mouth of slough about 0.5 mi. [0.8 km] upstream of boat ramp, 18 Sep. 1986. Specimen was not examined; record based on a personal communication with Bob Jones, MMNS; **Mississippi: Marion County:** MMNS 2168 (1 dry shell), Pearl River, in vicinity of Columbia, 24 Apr. 1986.

**Comparison with Similar Species:** *Anodonta hartfieldorum* shells resemble those of *A. suborbiculata* (Figure 4) but are less round and usually more inflated, with a more inflated umbo that is elevated slightly above the hinge line. It also may resemble *Pyganodon grandis*, but that species has a much more inflated umbo that is considerably elevated above the hinge line. *Anodonta hartfieldorum* may vaguely resemble *Utterbackia imbecillis* and *Utterbackia peggyae* Johnson, 1965, but those species are more elongate and their umbos are not elevated above the hinge line. *Anodonta hartfieldorum* is similar in shell morphology to *A. heardi* (Figure 5), but the two species are allopatric, with *A. heardi* occurring only in the Apalachicola Basin and eastward in the Ochlockonee River (Gordon and Hoeh, 1995; Brim Box and Williams, 2000).

Shell proportions of *Anodonta hartfieldorum* differ from those of *A. suborbiculata* and *A. heardi*. The most notable differences are in the relative proportions of shell height and length, as well as the angle between dorsal margin and posterior margin. *Anodonta hartfieldorum* shell height, relative to length, is greater than that of *A. heardi* but less than that of *A. suborbiculata* (Figure 6). The angle between dorsal margin and posterior margin is about equal in *A. hartfieldorum* (mean = 146°, N = 68) and *A. heardi* (mean = 147°, N = 19) but is greater than that of *A. suborbiculata* (mean = 129°, N = 127). Frequency distributions of these angles are presented in Table 1.

**Distribution:** *Anodonta hartfieldorum* occurs from the Escambia River drainage in Florida and Alabama west to the Pearl River drainage in Louisiana and Mississippi (Figure 7). It is known from the Escambia River,



**Figures 4, 5.** *Anodonta* species. 4. *A. suborbiculata*. UF 376151, length 124 mm. Coosa River, Weiss Reservoir, mouth of Big Cedar Creek, about 2 air miles [3.2 air kilometers] east of Alabama and Georgia state line, Coosa River Mile 258, 34.18473°N; 85.40549°W, Floyd County, Georgia, 20 Aug. 1997. © Richard T. Bryant. 5. *A. heardi*. UF 358656, length 113 mm. Harrison Creek, north side of first 180° bend, above confluence of Brothers River, 29.873019°N; 85.037933°W, Franklin County, Florida, 7 Sep. 1991. © Richard T. Bryant.

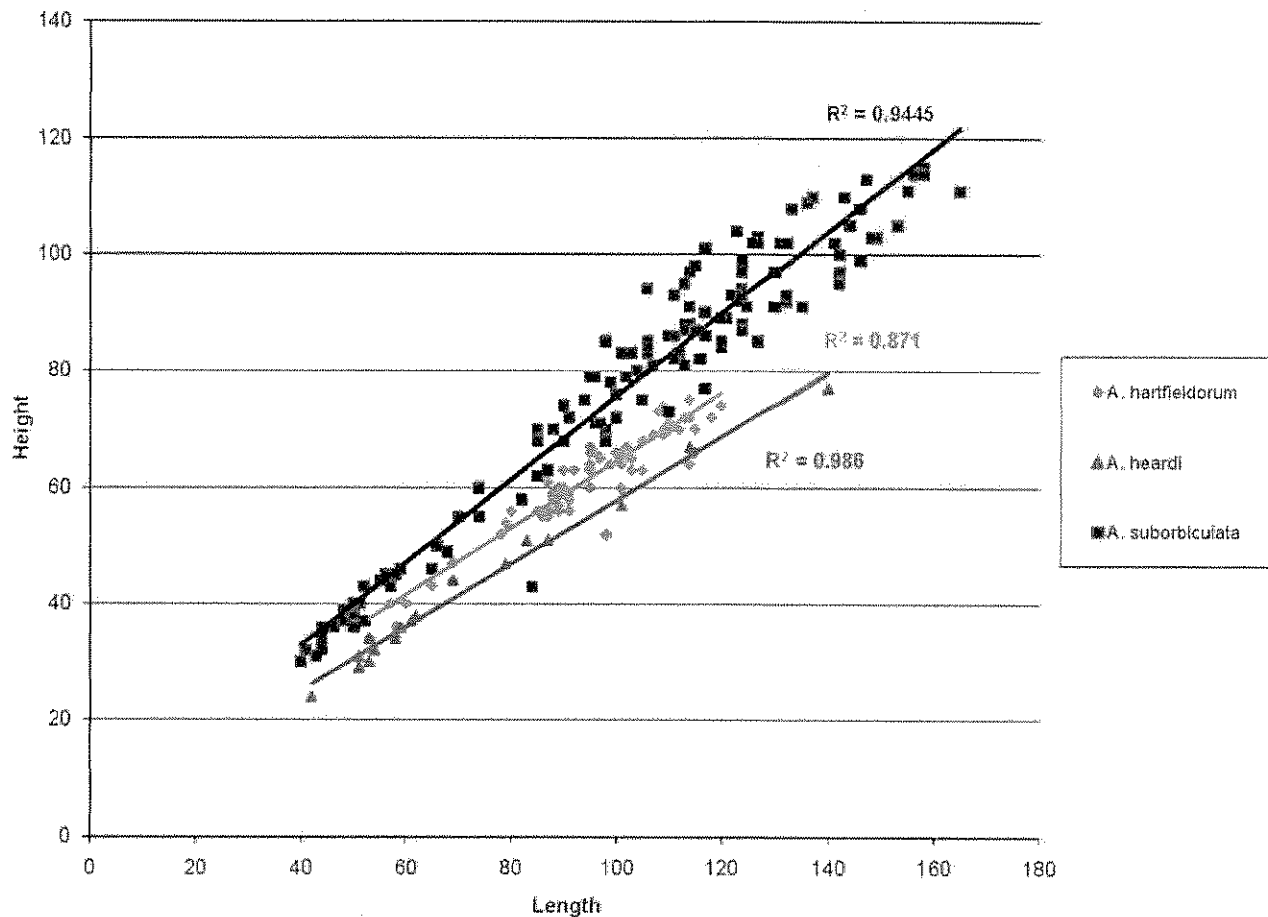
Escambia and Santa Rosa counties, Florida, upstream to Gantt Reservoir; on Conecuh River, Covington County, Alabama. In the Mobile Basin, it is known from the Tombigbee River drainage in Lowndes County, Mississippi, and a single site on the Tensaw River, Baldwin County, Alabama. *Anodonta hartfieldorum* is found in lower reaches of the Pascagoula River drainage in George and Jackson counties, Mississippi, and has been reported from Pearl River in Mississippi (Vidrine, 1993; Jones et al., 2005) and in Louisiana where the Pearl River forms a common border between the two states.

**Habitat and Biology:** *Anodonta hartfieldorum* occurs in water with little or no current such as oxbow lakes and sloughs. It has colonized Gantt and Point A reservoirs. Substrates in these habitats are typically composed of mud or muddy sand, often with detritus.

*Anodonta hartfieldorum* is a long-term brooder, presumably gravid from late summer or autumn to the following spring or summer. Gravid individuals brooding mature glochidia have been observed in late October and early November in Pascagoula River and Gantt

Reservoir, Conecuh River, respectively. Glochidial hosts of this species are unknown.

**Discussion:** *Anodonta hartfieldorum* appears to belong to a species group that includes *A. suborbiculata*, *A. couperiana*, *A. heardi*, and *Anodonta implicata* Say, 1829. A common morphological feature shared among these species is umbo sculpture that consists of parallel bars in adults. Juveniles of this group typically have fine green rays radiating from the umbo, but this feature is often obscure in adults with a darker periostracum. Molecular genetic data supports the relationship of this group, which is confined to the eastern United States (Zanatta et al., 2007). *Anodonta suborbiculata* is native to the Mississippi Basin and some central Gulf Coast drainages, *A. hartfieldorum* and *A. heardi* occur in eastern Gulf Coast drainages, and *A. couperiana* and *A. implicata* in Atlantic Coast drainages. There are populations of *A. suborbiculata* in the Brazos, Neches, and Sabine River drainages, east Texas, that differ somewhat in shell morphology (Howells et al., 1996). They are slightly more inflated than typical *A. suborbiculata*.



**Figure 6.** Scatter plot of the relationship between shell height and shell length (mm) in *Anodonta hartfieldorum*, *A. heardi*, and *A. suborbiculata*.

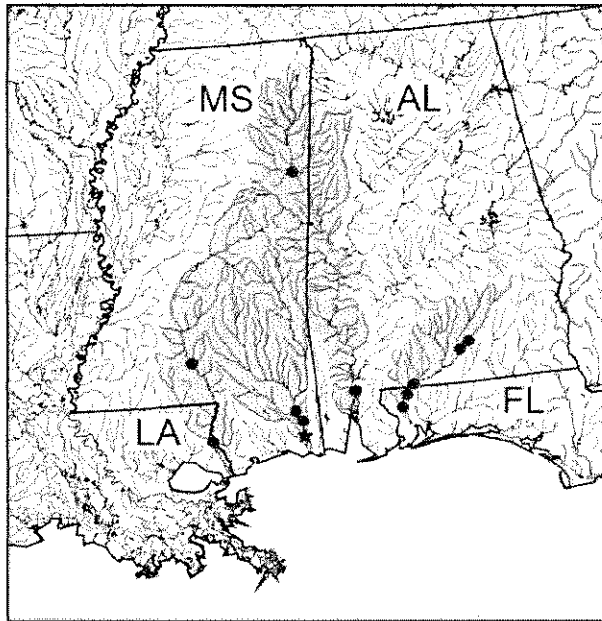
However, additional research is needed to resolve the relationships of these populations.

There have been several reports of *Anodonta suborbiculata* in the Escambia River drainage in Alabama and Florida. The first known Escambia drainage specimen of *Anodonta* was collected in 1917 by C. A. Burke, from Chunuckla Springs, Santa Rosa County, Florida. This specimen (UMMZ 101375) was reported as *A. suborbiculata* by Butler (1990) on the basis of a personal communication from William H. Heard, but it is most likely based on *A. hartfieldorum* (this specimen could not be located to confirm identification). Clench and Turner (1956) did not encounter *A. suborbiculata* in their survey of freshwater mollusks of Florida and southern Alabama. The report of *A. suborbiculata* from Gantt Lake, Covington County, Alabama (MCZ 267518), by Johnson (1969) is based on *A. hartfieldorum*. In the identification manual of freshwater clams of Florida, Heard (1979) reported and illustrated *A. suborbiculata* from the Escambia River drainage but locality data for the illustrated specimen were not given. A single juvenile (48 mm; UF 134930) *A. suborbiculata* from the Escambia River, Florida, was reported and illustrated by Williams

and Butler (1994). *Anodonta suborbiculata* appears to be a recent colonizer of the Escambia drainage, with the first confirmed records from the 1980s. The two species occur syntopically in Gantt and Point A reservoirs, Conecuh River, Alabama.

The natural oxbow and slough habitats of *Anodonta hartfieldorum* are often overlooked or avoided during mussel surveys, and these habitats have been greatly reduced due to channelization and impoundment of large rivers. These factors probably contributed to the dearth of records and museum material. A systematic survey of Gulf Coast floodplain lakes and reservoirs is required to determine the current conservation status of *A. hartfieldorum*. Additional comparative analyses of soft anatomy and molecular genetics are also needed to firmly resolve taxonomic relationships within the genus *Anodonta*.

**Conservation Status:** The fact that *Anodonta hartfieldorum* has not been previously recognized has precluded its inclusion in conservation status reviews. However, this species does not appear to be imminently imperiled. It can be locally abundant, but may have declined in some floodplain lakes and sloughs that have been negatively



**Figure 7.** Known range of *Anodonta hartfieldorum* (shaded area) in Alabama, Florida, Louisiana and Mississippi. Solid circles represent specific localities of *A. hartfieldorum*. Type locality of *A. hartfieldorum* is indicated by the star.

affected by channel incision following channelization of adjacent rivers. *Anodonta hartfieldorum* conservation status will remain unresolved until a systematic survey of appropriate habitat is conducted.

**Etymology:** The species name *hartfieldorum* is in honor of Paul D. and Elizabeth A. Hartfield in recognition of their significant contributions to conservation and natural history in the southeastern United States. Paul is a biologist in the endangered species program, U.S. Fish and Wildlife Service, Jackson, Mississippi, field office, and has been instrumental in protection and recovery of aquatic species. Elizabeth (Libby) is director of the Mississippi Museum of Natural Science, Jackson, Mississippi, where she presided over the enhancement of the institution, which is now one of the premier museums in the southeast. She has also played an integral role in conservation and environmental education. The common name, Cypress Floater, is in reference to the Cypress tree which is common along the flood plain sloughs and backwater oxbow lakes where *Anodonta hartfieldorum* is found.

#### COMPARATIVE MATERIAL EXAMINED:

##### *ANODONTA HEARDI*

**Apalachicola River Drainage: Florida: Franklin County:** UF 358656 (1 dry shell), Harrison Creek, [tributary of Apalachicola River] at first 180° turn, N side of bend (29.873019°N; 85.037933°W), 7 Sep. 1991.

**Florida: Gulf County:** NCSM 30334 (1 alcohol preserved), Chipola River, Florida Hwy 22 [CR 22/Lakegrove Road], [2.8 air km NE] of Wewahitchka (30.12766°N; 85.17638°W), 6 Aug. 1988. UF 375520 (1 dry shell), Apalachicola River at river mile 45.3, at the Wewahitchka Boat Ramp, about 5 air mi. [8 air km] NE of Wewahitchka, 1 Sep. 1999. UF 428532 (11 dry shells), Apalachicola River Mile 46.8, along right descending bank of river (30.1819°N; 85.1344°W), 7 Aug. 2006.

**Florida: Jackson County:** UF 1915 (1 dry shell), Tanvat Pond, 3 mi. [4.8 km] N of Sneads, 1 Apr. 1955.

**Florida: Leon County:** MCZ 267515 (1 dry shell), Ochlockonee River at US Hwy 27, 11 mi. [17.7 km] NW of Tallahassee.

**Florida: Liberty County:** UF 381286 (1 dry shell), Florida River, from downstream near SW edge of Acorn Lake to point downstream of head of feeder slough into Everett Slough, 4 June 2002.

**Georgia: Crisp County:** NCSM 28259 (1 alcohol preserved), Lake Blackshear, 0.3 mi. [0.5 km] S of US 280 bridge at edge of Georgia Veteran's Memorial State Park, [point estimated 6.2 air km E center of Cobb] (31.9624°N; 83.9224°W), Sep. 1992. UF 376024 (2 dry shells), Lake Blackshear, US Hwy 280 crossing (E side) middle of Lake Bridge, June 1995.

**Ochlockonee River Drainage: Florida: Leon County:** UF 370608 (4 alcohol preserved), Ochlockonee River about 3.5 air mi. [5.6 air km] S [SW] of Rt. 20 bridge (30.34804°N; 84.69356°W), 19 July 1993.

##### *ANODONTA SUBORBICULATA*

**Arkansas River Drainage: Arkansas: Crawford County:** USNM 124422 (2 dry shells), [Arkansas River,] Van Buren.

**Atchafalaya River Drainage: Louisiana: St. Martin Parish:** OSUM 76142 (1 dry shell), 4 mi. [6.4 km] SE of Henderson [6.4 km SE of Henderson, 4.8 km W of Butte La Rose] (30.28140°N; 91.73600°W), 27 Sep. 1975.

**Escambia River Drainage: Alabama: Covington County:** MCZ 267518 (1 dry shell), Clearview, on Conecuh River, Gantt Lake at US Hwy 29. NCSM 35282 (1 alcohol preserved), Point A Reservoir, [point estimated 2.3 air km NE center of River Falls] (31.36796°N; 86.52074°W), 2005. NCSM 48025 (3 dry shells), Point A Reservoir [Conecuh River], SW corner, 1.77 km NW from intersection of CR 70 and US 84, [2.3 air km NE center of River Falls] (31.35953°N; 86.51628°W), 8 Nov. 2005. UF 375318 (1 alcohol preserved) Patsaliga Creek, slough on impounded lower end, about 0.7 air mi. [1.1 air km] N of CR 59 bridge (31.382518°N; 86.522834°W), 24 July 1995.

**Florida: Escambia County:** UF 134930 (1 alcohol preserved) Escambia River, Rt. 4 crossing, 2.8 km E of Century, 13 km NNE of McDavid, 7.8 km W of Jay, 3 June 1998.

**Mississippi River Drainage: Illinois: Carroll County:** UF 225860 (4 dry shells), Thomson Lake.

**Tennessee: Shelby County:** MCZ 152833 (7 dry shells), Mississippi River, Presidents Island, near Memphis.

**Mobile Basin Drainage: Alabama: Cherokee County:** UF 374082 (1 dry shell), Coosa River at island, about 0.8 mi. [1.3 km] upstream of Hwy 20 bridge (Garrett Bridge), 7 Aug. 2000. UF 374282 (3 dry shells), Coosa River at Large Island, about 1 mi. [1.6 km] downstream from Maple Grove, 7 Aug. 2000.

**Alabama: Monroe County:** UF 374748 (10 dry shells), slough off Alabama River, about 1 mi. [1.6 km] upstream of Claiborne Lock & Dam, on west bank, 17 Sep. 1999.

**Alabama: Tallapoosa County:** UF 376505 (2 dry shells), Lake Martin at Wind Creek State Park, about 6 mi. [9.7 km] S of Alexander City, 28 Jan. 2004.

**Alabama: Walker County:** OSUM 58673 (1.5 dry shells), Bullbarn Creek, [6.1 km S of Jasper] (33.77000°N; 87.25888°W), 14 Aug. 1993. OSUM 59644 (1 dry shell), Bullbarn Creek, [6.1 km S of Jasper] (33.77000°N; 87.25888°W), 24 Feb. 1997.

**Alabama: Wilcox County:** UF 244013 (2 dry shells), Millers Ferry, 9 mi. [14.5 km] NW of Camden, 200 m N of Rt. 28 bridge over Alabama River, East Bank Park, 24 Sep. 1988. UF 374742 (1 dry shell), slough off Alabama River, about 1 mi. [1.6 km] upstream of Claiborne Lock & Dam, on west bank, 17 Sep. 1999. UF 376590 (1 dry shell), impoundment of Alabama River, East Bank Park at Millers Ferry, just NE of Hwy 28 bridge, about 7 mi. [11.3 km] W of Camden, 10 Sep. 1988. UF 376593 (1 dry shell), Coosa River at Large Island, about 1 mi. [1.6 km] downstream from Maple Grove.

**Georgia: Floyd County:** UF 376151 (1 dry shell), Coosa River (Weiss Reservoir), at mouth of Big Cedar Creek, about 2 air mi. [3.2 air km] due E of Alabama and Georgia state line (Coosa River Mile 258) (34.18473°N; 85.40549°W), 20 Aug. 1997.

**Mississippi: Prentiss County:** MMNS 9072 (2 dry shells), Tombigbee River, borrow pits at Natchez Trace at Brown Bottom, 12 mi. [19.3 km] ESE of Baldwin (34.46835°N; 88.42968°W), 23 Oct. 1999.

**Neches River Drainage: Texas: Nacogdoches County:** NCSM 30546 (3 dry shells), Sam Rayburn Reservoir, Shirley Creek Park, [point estimated at end of CR 496 (Sowell Bridge Road) in park, 9.7 air km WNW of Broadus] (31.31503°N; 94.37306°W), 12 Dec. 1995.

**Texas: San Augustine County:** MMNS 7477 (2 dry shells), Sam Rayburn Reservoir on the Angelina River, 5 Nov. 1995. Robert G. Howells (6 dry shells, 2 alcohol preserved), Sam Rayburn Reservoir, Ayish Creek arm at CR 2923, 12 Dec. 1995.

**Texas: Tyler County:** Robert G. Howells (1 dry shell), B.A. Steinhagen Reservoir, 29 Dec. 1993.

**Ouachita River Drainage: Arkansas: Clark County:** UF 64057 (3 dry shells), Old River, Arkadelphia.

**Pearl River Drainage: Mississippi: Madison County:** MMNS 6263 (1 alcohol preserved), Pearl River, left ascending bank, 0.5 mi. [0.8 km] below Lowhead Dam, above Coal Bluff Water Park (32.61559°N; 89.75558°W), 1 Oct. 1987.

**Mississippi: Pearl River County:** MMNS 6444 (2 dry shells), Pearl River at Walkiah Bluff, mouth of oxbow 0.5 mi. [0.8 km] upstream from boat launch (30.56513°N; 89.79114°W), 18 Sep. 1986.

**Red River Drainage: Louisiana: Bienville Parish:** USNM 119969 (1 dry shell), Mount Lebanon.

**Louisiana: DeSoto Parish:** USNM 133381 (4 dry shells), Frierson Mill.

**Louisiana: Rapides Parish:** USNM 86699 (1 valve of shell), Red River, Alexandria.

**Louisiana: Webster Parish:** OSUM 76518 (4 dry shells), Cypress Swamp, [6.7 km E of Doyline, 3.5 km W of Sibley] (32.53757°N; 93.33049°W).

**Texas: Marion County:** NCSM 33214 (2 dry shells), Lake O' The Pines (Big Cypress Bayou), [point estimated 9 air km WSW center of Kellyville] (32.81322°N; 94.69791°W), 9 July 1996.

**Texas: Camp/Titus counties:** Robert G. Howells (5 dry shells), Bob Sandlin Reservoir, 10 July 1996.

**Tennessee River Drainage: Alabama: Lauderdale County:** NCSM 43448 (16 dry shells), Pickwick Lake, Tennessee River, behind small islands 8.8 air km E [center] of Waterloo [Wright Quad] (34.89613°N; 87.96736°W), 6 Feb. 2009. NCSM 43449 (4 dry shells), Pickwick Lake, Second Creek Embayment, 2.9 km NE of Waterloo [Waterloo Quad] (34.93369°N; 88.03724°W), 6 Feb. 2009. UF 294002 (1 dry shell), Elk River, Wheeler Lake, above Hwy 72 bridge, 1 mi. [1.6 km] E of Rogersville, 1 mi. [1.6 km] above confluence with Tennessee River, above launch ramp, 23 Oct. 1998.

**Alabama: Limestone County:** NCSM 6187 (2 dry shells), Tennessee River Mile 306, Decatur Boat Harbor, [point estimated 1.8 air km E center of Decatur] (34.60472°N; 86.9625°W), 2 Feb. 2000. NCSM 30439 (4 dry shells), Elk River backwaters, [point estimated 5.2 air km NW center of Cartwright] (34.90416°N; 87.10517°W), 7 Nov. 1976.

**Alabama: Madison County:** NCSM 33215 (2 dry shell), Redstone Arsenal, unnamed tributary that flows into Tennessee River, 22–23 July 1993.

**Mississippi: Tishomingo County:** UF 376595 (1 dry shell), Yellow Creek downstream of junction with Pickwick Lake on Mississippi Hwy 25, about 1 mi. [1.6 km] SE of North Crossroads, 1 Mar. 1973.

**Tennessee: Humphreys County:** NCSM 6710 (2 dry shells), Tennessee River at Cuba Landing, I-40 crossing, [point estimated 10.7 air km NE center of Sugar Tree] (35.87826°N; 87.93317°W), 5 Feb. 1977.

**Tennessee: Meigs County:** UF 365491 (2 dry shells), Sugar Creek embayment of Hiwassee River, Chickamauga Reservoir on CR 306, about 2 mi. [3.2 km] E of junction 306 and 58, 21 Feb. 1998.



**Trinity River Drainage: Texas: Liberty County:** MCZ 227966 (2 dry shells), Wards Prairie Lake near Romayor (30.40965°N; 94.78743°W).

**Texas: Trinity County:** Robert G. Howells (2 dry shells), Lake Livingston, Aug. 1996. Robert G. Howells (1 dry shell), Lake Livingston, 30 July 1996.

**White River Drainage: Arkansas: Lawrence County:** MCZ (3 dry shells), Black River at Black Rock.

#### ACKNOWLEDGMENTS

Richard Bryant provided the outstanding photographs of specimens herein illustrated. We also extend our appreciation to the following people and their institutions for the loan of material in their care: Adam Baldinger (MCZ), Robert Hershler, Paul Greenhall, and Linda Ward (USNM), Robert Jones and Todd Slack (MMNS), Diarmaid O'Foighil and Taehwan Lee (UMMZ), John Slapcinsky and Gustav Paulay (UF), Jamie Smith (NCSM), and Tom Watters (OSUM). We also thank Robert G. Howells for the loan of material from his personal collection and for information on *Anodonta* populations in Texas and Louisiana. John B. Burch provided permission to use his illustration of *Anodonta suborbiculata*. Nathan Johnson and Jennifer Bernatis provided statistical support. Sherry Bostick provided technical assistance with manuscript review and layout. Cindy Bogan and Jamie Smith commented on a draft of this manuscript, as did two anonymous reviewers.

#### LITERATURE CITED

- Brim Box, J. and J.D. Williams. 2000. Unionid mollusks of the Apalachicola Basin in Alabama, Florida, and Georgia. Alabama Museum of Natural History Bulletin 21: 1–143.
- Burch, J.B. 1975. Freshwater Sphaeriacean Clams (Mollusca: Pelecypoda) of North America. Malacological Publications, Hamburg (Michigan), 96 pp.
- Butler, R.S. 1990. Distributional records for freshwater mussels (Bivalvia: Unionidae) in Florida and south Alabama, with zoogeographic and taxonomic notes. *Walkerana* (for 1989) 3: 239–261.
- Clench, W.J. and R.D. Turner. 1956. Freshwater mollusks of Alabama, Georgia, and Florida from the Escambia to the Suwannee River. Bulletin of the Florida State Museum, Biological Sciences 1: 97–239.
- Gordon, M.E. and W.R. Hoeh. 1995. *Anodonta heardi*, a new species of freshwater mussel (Bivalvia: Unionidae) from the Apalachicola River system of the southeastern United States. *Walkerana* 7: 265–273.
- Hoeh, W.H. 1979. Identification manual of the freshwater clams of Florida. Florida Department of Environmental Regulation, Technical Series 4, 83 pp.
- Hoeh, W.R. 1990. Phylogenetic relationships among eastern North American *Anodonta* (Bivalvia: Unionidae). *Malacological Review* 23: 63–82.
- Howells, R.G., R.W. Neck, and H.D. Murray. 1996. Freshwater Mussels of Texas. Texas Parks and Wildlife Department, Inland Fisheries Division, Austin, Texas, 218 pp.
- Johnson, R.I. 1969. Further additions to the unionid fauna of the Gulf drainage of Alabama, Georgia and Florida. *The Nautilus* 83: 34–35.
- Jones, R.L., W.T. Slack, and P.D. Hartfield. 2005. The freshwater mussels (Mollusca: Bivalvia: Unionidae) of Mississippi. *Southeastern Naturalist* 4: 77–92.
- Mock, K.E., J.C. Brim-Box, M.P. Miller, M.E. Downing, and W.R. Hoeh. 2004. Genetic diversity and divergence among freshwater mussel (*Anodonta*) populations in the Bonneville Basin of Utah. *Molecular Ecology* 13: 1085–1098.
- Ortmann, A.E. 1912. Notes upon the families and genera of the najades. *Annals of the Carnegie Museum* 8: 222–365, pls. 18–20.
- Taylor, C.A., G.A. Schuster, J.E. Cooper, R.J. DiStefano, A.C. Eversole, P. Hamr, H.H. Hobbs, III, H.W. Robison, C.E. Skelton, and R.F. Thomas. 2007. A reassessment of the conservation status of crayfishes of the United States and Canada after 10+ years of increased awareness. *Fisheries* 32: 376–389.
- Turgeon, D.D., J.F. Quinn, A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltama, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Mollusks. Second Edition. American Fisheries Society, Special Publication 26, 526 pp.
- Vidrine, M.F. 1993. The Historical Distributions of Freshwater Mussels in Louisiana. Gail Q. Vidrine Collectibles, Eunice, Louisiana, 225 pp.
- Williams, J.D. and R.S. Butler. 1994. Freshwater bivalves. In: Deyrup, M. and R. Franz (Eds.). Rare and Endangered Biota of Florida. Volume IV. University Press of Florida, Gainesville, pp. 53–128.
- Williams, J.D., A.E. Bogan, and J.T. Garner. 2008. Freshwater Mussels of Alabama and the Mobile Basin in Georgia, Mississippi and Tennessee. The University of Alabama Press, Tuscaloosa, 908 pp.
- Zanatta, D.T., A. Ngo, and J. Lindell. 2007. Reassessment of the phylogenetic relationships among *Anodonta*, *Pyganodon*, and *Utterbackia* (Bivalvia: Unionidae) using mutation coding of allozyme data. *Proceedings of the Academy of Natural Sciences of Philadelphia* 156: 211–216.