**Literature Cited**

Beaudet A. 2006. *Étude de la dynamique des populations de moules d'eau douce (Bivalvia : Unionidea) de deux rivières côtières de l'Est du Nouveau-Brunswick, la rivière Kouchibouguac et la rivière Kouchibouguacis*. Mémoires de Maîtrise, UQAR.

Clarke A.H. 1981. *The Freshwater Molluscs of Canada*. National Museum of Natural Science/National Museums of Canada: Ottawa, Canada. 446 pp.

Conner C.H. 1905. Glochidia of Unio on fishes. *Nautilus* 1905:142-143.

Cyr F. 2007. *Caractérisation de la biodiversité à l'aide d'une analyse génétique chez les moules d'eau douce du genre Pyganodon (Unionidae) dans le nord est de l'Amérique du Nord*. M. Sc. thesis, Département des Sciences biologique, Université de Montréal, Montréal, QC.

Cyr F., Paquet A., A.L. Martel, A. Bernard. 2007. Cryptic lineages and hybridization in freshwater mussels of the genus Pyganodon (Unionidae) in northeastern North America. *Canadian Journal of Zoology*, 85(12):1216–1227.

Eads C.B, M.E. Raley, E.K. Schubert, A.E. Bogan, J.F. Levine J.F. 2007. *Propagation and culture of freshwater mussels for release into North Carolina waters*. Final report submitted to North Carolina Department of Transportation. 87 pp.

Gray E.S., W.A. Lellis, J.C. Cole, C.S. Johnson. 1999. Hosts of Pyganodon cataracta (eastern floater) and Strophitus undulatus (squawfoot) from the Upper Susquehanna River Basin, Pennsylvania. Triannual Unionid Report 18.

Hoeh W. R. 1990. Phylogenetic relationships among eastern North American Anodonta (Bivalvia: Unionidae). *MalacoL Rev*. 23:63-82.

Hoggarth M. A. 1992. An examination of the glochidia-host relationships reported in the literature for North American species of Unionacea (Mollusca: Bivalvia). *Malacology Data Net* 3:1–30.

Lefevre G., W.C. Curtis. 1910. Experiments in the artificial propagation of fresh-water mussels. *Journal of Experimental Zoology*. 1910:79-116.

Martel A.L., D.F. McAlpine, J.B. Madill, D.L. Sabine, A. Paquet, M.D. Pulsifer, M.F. Elderkin 2010. Freshwater mussels (Bivalvia: Margaritiferidae, Unionidae) of the Atlantic Maritime Ecozone. Pages 551–598 In: *Assessment of Species Diversity in the Atlantic Maritime Ecozone*. Edited by: D.F. McAlpine & I.M. Smith. NRC Research Press, Ottawa, Canada.

Stanton L.M. 2008. Population genetics and taxonomic evaluation of two closely related freshwater mussel species, the eastern floater, Pyganodon cataracta, and the Newfoundland floater, P. fragilis, in Atlantic Canada. M.Sc. thesis, Department of Biology, Acadia University, Wolfville, NS.

Threlfall W. 1986. Seasonal occurrence of Anodonta cataracta Say 1817, glochidia on three-spined sticklebacks, Gasterosteus aculeatus (Linneaus). *Veliger* 29:231–234.

Watters G.T. 1994. *Annotated bibliography of the reproductive and propagation of the Unionoidea (primarily of North America)*. Ohio Biological Survey Miscellaneous Contributions, 1:1–159.

Wiles M. 1975. The glochidia of certain Unionidae (Mollusca) in Nova Scotia and their fish hosts. *Canadian Journal of Zoology*. 53:33–41.

## Taxonomic Status of Pigtoe Unionids in Texas

**Robert G. Howells[a], Charles R. Randklev[b],** and **Neil B. Ford[c]**

[a] BioStudies, Kerrville, Texas, biostudies@hctc.net; [b] Texas A&M University, College Station, Texas, crandklev@tamu.ag.edu; [c] University of Texas-Tyler, NFord@uttyler.edu.

Among the pigtoes, three *Fusconaia* and one *Pleurobema* have generally been considered to occur in Texas. Texas Pigtoe (*F. askewi*), Wabash Pigtoe (*F. flava*), and Louisiana Pigtoe (*P. riddellii*) have been historically reported from the San Jacinto drainage to the Red River system (Howells et al. 1996; Howells 2010a, b, c) and Triangle Pigtoe (*F. lananensis*) restricted to the Angelina River-Attoyac Bayou and Village Creek waters of the Neches-Angelina drainage (Howells et al. 1996; Howells 2010a, d). The fusconaid, *F. chunii*, has been treated by nearly all recent authorities as a synonym of the Wabash Pigtoe, but without genetic confirmation. Louisiana Pigtoe is morphologically and biochemically unique and easily distinguishable from *Fusconaia* species; identification is only a concern outside Texas where

other members of the genus occur. However, identification and distribution of Texas *Fusconaia* has been, and remains, confused.

Physical descriptions alone often fail to fully address the degree of variation in these species. The Wabash Pigtoe, *F. flava*, (Figure 1) is widely recognized as having many forms, ranging from thinner-shelled, oval smaller stream morphs to heavy-shelled, triangular, big-river types; externally it may have a yellowish tint and nacre ranges from white to pink throughout.


Figure 1. Wabash Pigtoe (*Fusconaia flava*) morphs from small-stream to big-river forms in the Mississippi River Basin. No biochemical genetic studies to data have confirmed that this species occurs in Texas.

Texas Pigtoe, *F. askewi*, (Figure 2) may be oval to subtriangular or sub-rectangular, external coloration is reddish-chestnut brown to black, nacre is often white with pink tints exterior to the pallial line, but can be completely white, pink, or orange. The pink coloration exterior to the pallial line in some Texas Pigtoe is not diagnostic; indeed, other unionid species in eastern Texas may show this same trait (Figure 3).


Figure 2. Texas Pigtoe (*Fusconaia askewi*) from Texas. Nacre color may be white with a pink tint exterior to the pallial line or completely white or pink. It may also have yellowish Tulberg-layer blotches or pearly bumps on the nacre like those that can occur in any unionid species.


Figure 3. Rock Pocketbook (*Arcidens confragosus*) and several other unionids from eastern Texas can show the same pink tints exterior to the pallial line that is sometimes seen in Texas Pigtoe (*Fusconaia askewi*).

Triangle Pigtoe, *F. lananensis*, (Figure 4) is usually sub-rectangular (despite its common name), chestnut brown to black externally, and with nacre that is pink to white, usually with yellowish blotches and pearly bumps. The yellow-tinted external coloration in some pigtoes from Texas, some of which have been identified as *F. chunii* in the past, suggests they may be forms of Wabash Pigtoe (Figures 5

and 6). The pearly "excrescences" and yellowish blotches reported in the description of Triangle Pigtoe are little more than the same flaws seen at times in virtually any unionid (Howells 2010d). These are not taxonomically diagnostic, but have been the source of some confusion.


Figure 4. Triangle Pigtoe (*Fusconaia lananensis*) from the Neches-Angelina drainage, Texas. Most show yellowish blotches on a pinkish nacre and have pearly bumps, but can be nearly white and free from physical or coloration flaws.


Figure 5. Fusconaid pigtoes from the San Jacinto River, Texas. These have been variously considered to be *F. flava* (*F. chunii*), *F. askewi*, and *F. lananensis*, but have not been subjected to biochemical genetic analysis. Some are similar to certain morphs of *F. flava*, none closely resemble *F. lananensis*, and it is possible all are only forms of *F. askewi*.

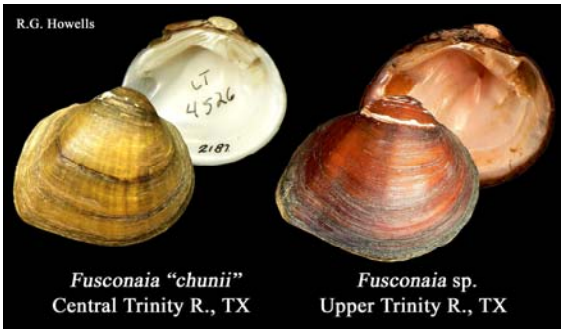


Figure 6. Fusconaid pigtoes from the Trinity River, Texas, that have been considered to be *F. flava*, *F. chuni*, and *F. askewi*, but without biochemical confirmation. The example above left is nearly identical to the type of *C. chunii* and both differ from classic examples of *F. flava* and *F. askewi*.

Electrophoretic analysis of Texas Pigtoe (Sabine River), Triangle Pigtoe (Attoyac Bayou), Wabash Pigtoe (Ohio R., Indiana), and Gulf Pigtoe (*F. cerena*; Pascagoula R., Mississippi) (Howells 1995) and subsequently with additional Texas, Triangle, and Wabash pigtoes from other locations (unpublished, but noted in Howells 2010b, d) found that Texas-Triangle pigtoes were easily distinguished from Wabash and Gulf pigtoes, but with no significant differences found between Texas and Triangle forms. Christian et al. (2008) employed DNA analysis to demonstrate a clear difference between Texas Pigtoe from the Sabine River and Wabash Pigtoe. In an expanded DNA analysis of these same species and others, Hayes (2010) found Texas-Triangle types to be distinctly different from Wabash and Gulf pigtoes, but with very little genetic difference between them. Neither Howells nor Hayes found any confirmation of Wabash Pigtoe in tissue samples from Texas, but neither appears to have had examples of the Texas *flava-chunii* morphs; however, these have been found in the Trinity, Big Cypress, and Sulphur drainages in recent surveys (Ford, pers. obs.). All three found Louisiana Pigtoe (Figure 7) to be a unique taxon as well, and recent surveys have found it in several Texas drainages.


Figure 7. Louisiana Pigtoe (*Pleurobema riddellii*) is the only pleurobemid present in Texas. It has white, rarely peach, nacre. High beaks; a distinct posterior ridge; and more-massive pseudocardinal teeth, along with white soft tissues, readily distinguish it from fusconaids in Texas.

Burlakova et al. (2012) repeated these DNA studies with specimens identified as Texas and Triangle pigtoes. They, too, found no significant biochemical differences between these two species and, like prior work, found them distinct from Wabash and Gulf pigtoes. Their morphological descriptions of Texas and Triangle pigtoes, however, were extremely narrow, not acknowledging the full range of variation in either, and did not identify their tissue collection sites. *Fusconaia lananensis* listed from the Neches River are problematic given that this species occurs in tributaries of the Neches River, but not in the Neches River itself. Further, Burlakova et al. (2012) did not address the atypical *askewi*, *flava*, and *chunii* types from Texas that have never been studied biochemically, but, nonetheless, concluded that all *Fusconaia* in Texas are Texas Pigtoe.

Some recent surveys have found Texas Pigtoe to be more numerous, particularly in the Sabine drainage, than earlier studies had suggested (Ford 2009; Howells 2010b). Indeed, Burlakova et al. (2012) indicated "on average, *F. askewi* was the third most abundant species" in their "statewide" surveys. However, the objective of most of their field work was to examine locations with either abundant/diverse assemblages, or where rare species were known to occur (Burlakova and Karatayev 2010). This focus could have made "rare" species appear more abundant than they actually are. In more extensive surveys of various habitats in all the East Texas rivers, Ford et al. (2012) found the Texas Pigtoe to be common only in the upper Sabine River and only in rocky riffle sites, which are not a major component of any of these rivers. Texas Pigtoe (and some animals resembling Triangle Pigtoe) also was abundant in a single tributary of the lower Sabine River in Louisiana (CRR). The historic and recent Howells statewide database rates Texas Pigtoe as 10th and the Burlakova/Karatayev database provided to Texas Parks and Wildlife Department placed it 16th in relative abundance among all Texas unionid records.

It is possible that the Triangle Pigtoe is only an ecophenotype of the Texas Pigtoe and that true Wabash Pigtoe may not actually occur in Texas. No studies have genetically examined *F. chunii* types to clarify their status. However, because field identification is so difficult, we have limited understanding of actual distribution and abundance and, so, suggest that too little evidence is at hand to absolutely confirm any conclusion at this point in time.

Until more-definitive studies of biochemical genetics and morphological variation are available, it would seem to be premature to dismiss a rare, endemic unionid as taxonomically invalid without further confirmation. It would also be ill-considered to base status determinations on surveys focused on sites where that taxon is known to be numerous or conducted during record droughts when specimens are concentrated and easily located (as is the case in several recent surveys).

**References:**

Burlakova, L.E., and A.Y. Karatayev. 2010. State-wide assessment of unionid diversity in Texas. State Wildlife Grant Final Report to Texas Parks and Wildlife Department, Austin.

Burlakova, L.E., D. Campbell, A.Y. Karatayev, and D. Barclay. 2012. Distribution, genetic analysis and conservation priorities for rare Texas freshwater mulluscs in the genera *Fusconaia* and *Pleruobema* (Bivalvia: Unionidae). Aquatic Biosystems 8: no pagination (published online).

Christian, A.D., J.L. Harris, and J. Serb. 2008. Preliminary analysis for identification, distribution, and conservation status of species of Fusconaia and Pleurobema in Arkansas. Arkansas State University, State University.

Ford, N.B., J. Gullett, and M.E. May. 2009. Diversity and abundance of unionid mussels in three sanctuaries on the Sabine River in northeast Texas. The Texas Journal of Science 61: 279-294.
Ford, N.B., L. Williams, and M. Williams. 2012. Surveys for threatened and endangered mussels and fishes in rivers of northeastern Texas. U.S. Fish and Wildlife Service Section 6 Survey Report.
Hayes, D.M. 2010. Genetic diversity and distribution of selected freshwater mollusks (Gastropoda and Bivalvia) from west of the Mississippi River with emphasis on Arkansas taxa. Ph.D. Dissertation, Arkansas State University, Jonesboro.
Howells, R.G. 1995. Electrophoretic work at HOH on mussels. Info-Mussel Newsletter 3(2):2.
Howells, R.G. 2010a. Guide to Texas freshwater mussels. BioStudies, Kerrville, Texas.
Howells, R.G. 2010b. Texas Pigtoe (*Fusconaia askewi*): summary of selected biological and ecological data for Texas. BioStudies, Kerrville, Texas. Prepared for Save Our Springs Alliance, Austin, Texas.
Howells, R.G. 2010c. Louisiana Pigtoe (*Pleurobema riddellii*): summary of selected biological and ecological data for Texas. BioStudies, Kerrville, Texas. Prepared for Save Our Springs Alliance, Austin, Texas.
Howells, R.G. 2010d. Triangle Pigtoe (*Fusconaia lananensis*): summary of selected biological and ecological data for Texas. BioStudies, Kerrville, Texas. Prepared for Save Our Springs Alliance, Austin, Texas.
Howells, R.G., R.W. Neck, and H.D. Murray. 1996. Freshwater mussels of Texas. Texas Parks and Wildlife Press, Austin.

## Additional Information Concerning the Conquest of Europe by the Invasive Chinese Pond Mussel *Sinanodonta woodiana*. 28. News from the Czech Republic, the Netherlands, Poland, Serbia, and some General Information

**Henk K. Mienis**, The Steinhardt National Collections of Natural History, Department of Zoology, Tel Aviv University, IL-69978 Tel Aviv, Israel, *and* National Natural History Collections, Berman Building, Hebrew University, IL-91904 Jerusalem, Israel mienis@netzer.org.il

New information concerning the invasive Chinese Pond mussel *Sinanodonta woodiana* (Lea, 1834), Fam. Unionidae, in Europe appears regularly in a large variety of journals and reports. In this instalment, I present such records published in the past months in the Czech Republic, the Netherlands, Poland, Serbia and refer also to some general information.

**The Czech Republic**

In his study of the aquatic mollusc fauna of the lower part of the Lužnice River in South Bohemia, Beran (2012) mentioned the Chinese pond mussel from a single locality near its confluence with the Vltava River.

**The Netherlands**

In May 2011, three school kids found some large mussels in the valley of a small stream the Donge near Tilburg, North-Brabant. These shells turned out to be *Sinanodonta woodiana* (van der Leij, 2012). This is the first time that this invasive mussel has been reported from a more or less natural habitat in the Netherlands. The only previous record (van Peursen, 2011) was from a pond on a private plot. However, also in this new case, fish ponds seem to play a role because the specimens were actually found in ponds which were connected to the small river.

A website dealing with ponds and pond-life in the Netherlands has issued a warning neither to release specimens of the Chinese pond mussel nor fish kept together with *Sinanodonta woodiana* in ponds in natural waters, since these exotic mussels may endanger the local mussels (www.vijvervis.info/1_mossels_soorten_chinese.htm).