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UNIONIDAE OF THE RIO GRANDE (RIO BRAVO DEL NORTE) SYSTEM OF TEXAS AND MEXICO

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ABSTRACT. The Rio Grande Subprovince is redefined as being limited to the Rio Grande System of Texas and Mexico. Fifteen species of Unionidae occur there. *Quadrula couchiana* (Lea), the recently described *Disconaias conchos* Taylor, and *Potamilis metnecktayi* Johnson, bring the total number of endemic Unionidae to three. *Truncilla macrodon* (Lea), formerly regarded as endemic, is placed in the synonymy of *T. donaciformis* (Lea). Of the twelve species that occur north of the Rio Grande, only two, *Popenaias popei* (Lea) and *Cyrtonaias tampicoensis* (Lea), also occur in the Mexican Gulf Coastal Region.

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Table of Contents

INTRODUCTION

The Rio Grande (Rio Bravo del Norte) System described herein is not only a political boundary between

Texas and Mexico but also is a faunal limit. Of the nearly 300 specific and subspecific taxa of the Unionoidea which comprise the North American fauna (Williams, *et al.*, 1992), only 15 occur in the Rio Grande system, and of these only two extend into the Mexican Gulf Coastal Region.

The purpose of this paper is to bring together all of the reliable records, Recent and fossil, which indicate the past and present distribution of the Unionidae in the Rio Grande System. Several papers, freely quoted herein, deserve special mention because they are based on rather extensive recent collecting. These include Metcalf (1982), and Neck and Metcalf (1988).

The Rio Grande (Map 1a) is more than 3,000 km, or some 1,850 miles in length, and over 775 miles of it form the border between Mexico and Texas. It has its head in the San Juan Mountains of southern Colorado. It flows into New Mexico through basins comprising the Rio Grande Depression from which it exits below El Paso, Texas. Except for the introduction of *Anodonta grandis* Say to an artificial pond in El Paso, the only record of a living unionid north of this area is *Anodonta imbecillis* Say from the San Jose River (Map 1b), a tributary in central New Mexico. Tributaries in the upper part of the drainage have a relatively predictable flow, but downstream they become erratic. In the area of the Chihuahuan Desert the main channel itself is virtually dry between El Paso, Texas and the mouth of the Rio Conchos near Presidio, Texas.

The Rio Conchos (Map 1e) has its origin in the Sierra Madre Occidental, Mexico and flows northeastward across the Chihuahuan Desert to the Rio Grande. Only *Disconaias conchos* Taylor has been reported from it. The largest tributary of the Rio Grande is the Pecos River (Map 1c) which originates in the glaciated Sangre de Cristo

Mountains in northern New Mexico and flows southeast to enter the Rio Grande east of Langtry, Texas; somewhat above the Amistad Reservoir. The only living unionid found in the Pecos above Lake McMillan Reservior (Map 1d) is *Popenaias popei* (Lea) from the main channel of the Pecos and the North Spring River, both near Roswell, Chaves County, New Mexico. Below McMillan Dam in Eddy County, *Megalonaias nervosa* (Rafinesque), *Quadrula couchiana* (Lea), *Quadrula mitchelli* (Simpson), *Cyrtonaias tampicoensis* (Lea), and *Potamilis metnecktayi* Johnson have been found as fossils. Those which have been found alive occur near the confluence of the Pecos with Rio Grande.

The Devils River (Map 1g), some 540 km, or 335 miles, in length and largely in Val Verde County, now flows into the Amistad Reservoir creating Devils Lake (Map 1f). Below the Reservoir, extending from south of Del Rio, Val Verde County, the Rio Grande extends to the Gulf of Mexico. It follows a flat to gently undulating plain, the gradient going from nearly 0.75 m/km near Del Rio to 0.2 m/km near Laredo, and approaches sea level at Brownsville. Las Moras Creek (Map 1h) to the east of Devils River heads 4 miles north of Brackettville and flows for 19 km, about 12 miles, through Kinney and Maverick counties into the Rio Grande between Del Rio and Eagle Pass. This small stream supported numerous unionid species and at least one endemic fish, *Dionda diaboli* (Smith and Miller, 1986: 475).

Some 24 km, or about 15 miles, below Laredo the Mexican Rio Salado (Map 1i) and its large tributary, the Rio Sabinas, flows into what is now the Falcon Reservoir (Map 1j) on the main channel of the Rio Grande. The last tributary, Rio San Juan (Map 1k), also Mexican, has been

dammed to form the Presa de El Azúcar (or M.R. Gomez) (Map 1m) and is entirely in Mexico. The coastal plain approaches sea level near Brownsville and the general area contains numerous resacas, former courses or channels of the river. During the multiple glaciations of the Pleistocene, sea level stood much lower than present, with the result that the shoreline of the Gulf of Mexico extended at least to the edge of the Continental Shelf. Many now independent drainages of the Gulf Slope were formerly connected in their extended lower base-leveled courses, thus facilitating the distribution of fishes (Smith and Miller, 1986: 476) and unionids. It should be mentioned that Gray (1919) *Gazetteer of the streams of Texas* is still an invaluable work on the water resources of Texas.

The Mississippian or "Interior Basin" Region is essentially as defined by Van der Schalie and Van der Schalie (1950, Map 1), but in the Gulf Coastal Region the subdivisions of Johnson (1972) and Neck (1982), who divided the Western Gulf Coastal Region into three biogeographical subprovinces, are recognized. (1) The Sabine Subprovince (map 1, 9-13) which, according to Vidrine, extends to the Calcasieu River System of Louisiana and includes the Sabine, Neches, Trinity, and San Jacinto river systems because of the occurrence of *Lampsilis satura*, *Potamilis amphichaena* and "the problematical species in the genera *Fusconaia* and *Pleurobema*" (Vidrine, 1993: 196).

(2) The Central Texas Subprovince (Map 1, 1-8) includes the Brazos, Colorado, Guadelupe, San Antonio, and Nueces river systems, as well as, the shorter coastal streams, (the San Bernard, Lavaca, Mission, and Aransas rivers) and the creeks draining into the Baffin Bay Basin. Neck (1982) mentioned that the Central Texas Subprovince

had four endemic species: *Quadrula aurea*, *Q. petrina*, *Lampsilis bracteata* and *Sphenonaias* [= *Quincuncina*] *mitchelli*, but the latter also occurs in the Rio Grande Subprovince. The maps in Howells *et al.* (1996) indicate that *Quadrula houstonensis* and *Truncilla macrodon* are also endemic to the Central Texas Subprovince, though they are equivocal as to the validity of *houstonensis*. The latter is beyond the scope of the present paper, but *macrodon* is included in the synonym of *T. donaciformis*.

Howells *et al.* (1996: 62), following Neck (1984), placed *Lampsilis streckeri* Frierson in the synonymy of *Lampsilis bracteata* (Gould). Johnson (1980: 98, pl. 17. figs. 6-8) illustrated the type of *L. streckeri* from the Little Red River of Arkansas, and other specimens from Onion Creek, Texas were also figured. Johnson (1980) mistakenly regarded them all to be *Villosa vibex* (Conrad). Gordon and Kraemer (1984: 99) called attention to this egregious error and convincingly argued that *streckeri* was a distinct species exhibiting a disjunct distribution in the uplifts of the Ozark Mountains in Arkansas and the Edwards Highlands in Texas. Johnson (1978: 271, 274, map 2) had previously shown a similar disjunct distibution of *Truncilla curtisii* Frierson and Utterback [= *Epioblasma*[3] (*Torulosa*) *florentina* (Lea)] and *Truncilla lefeveri* Utterback [=*Epioblasma* (*Torulosa*) *turgidula* (Lea)] both from the White River System below the Ozark Crest, and the Tennessee and Cumberland river systems on the Cumberland Plateau.

[3] Bogan (1997), on the basis of locating specimens of the type species of both *Plagiola* and *Epioblasma*, convincingly indicated that *Epioblasma* should replace *Plagiola* as used by Johnson (1978).

Gordon and Kraemer (1984: 100) restricted the type locality of *L. streckeri* to the Little Red River, Clinton, Van Buren County, Arkansas, now inundated by Greer's Ferry Reservoir. The species is still extant in Archey and Middle forks of the Little Red River (Clarke 1987). Gordon and Kraemer (1984: 99) indicated that there is no reason to believe that *Villosa vibex* was ever found in the some 36 km, or 22 mile, long Onion Creek, which flows through Blanco, Hayes, and Travis counties, entering the Colorado River about 1.5 miles north of Garfield, Texas (Gray, 1919: 173).

Neck (1984) found only *Lampsilis bracteata* living in Onion Creek, but according to Howells *et al.* (1996: 62) the Texas Parks and Wildlife Department found no living unionids there in 1993. While apparently recently-extinct, *Lampsilis streckeri* Frierson, this relic of an ancient upper Colorado River fauna should be included among the other unionids of the Central Texas Subprovince.

(3) The Rio Grande Subprovince (Map 1, a-m) was described by Neck (1982: 38) as consisting of the Rio Grande, but its southern extention into Mexico was left unclear. Fifteen species of mussels occur in that basin (Table 1). He considered *Cyrtonaias tampicoensis*, which occurs from the Central Texas Subprovince through the Mexican Gulf Coastal Region to the state of Vera Cruz, to be of southern origin. Neck (1982) listed four species as not occuring north of the Rio Grande: *Popenaias popei*, *Quadrula conchiana*, *Disconaias fimbriata* (non Frierson = *Potamilis metnecktayi*) and *Truncilla cognata.* These unionids, except *P. popei*, recently discovered in the Colorado River system, and *T. cognata* (=*T. donaciformis*), are endemic to the Rio Grande System. *P. popei* is assumed to be of southern origin although it has now been found

north of the Rio Grande. It extends in the Mexican Gulf Coastal Region to the state of Vera Cruz. *D. fimbriata* and *salinasensis*, (non Simpson) are misidentifications of *Potamilis metnecktayi* Johnson. *Disconaias conchos* Taylor (1997), brings the total endemic species to three. The remaining twelve species, including the recently introduced *Potamilis purpuratus* (Howells *et al.* 1996: 100), are all of northern origin and do not extend south of the Rio Grande. Thus it is shown here that the Rio Grande Basin is the subprovince and the boundry between the Western Gulf coastal and Mexican Gulf coastal regions (see Table 1).

Strecker (1931), the first to list the Texas unionids, restricted his records to species found only on the Texas side of the Rio Grande, as did Murray and Roy (1968) in their later checklist. Howells, *et al.* (1996) do the same. The latter, in their distribution maps, show a number of records which they list as unpublished. These are sufficiently clear that the relevant ones are reported herein, being accurate at least to county. The distributional data are presented, in so far as possible, from the headwaters to mouth of the various river systems, often with the drainages of the larger tributaries treated separately. The river systems are arranged arbitrarily, from the Rio Grande either north or south but in the instance of *P. popei*, both north and south from it. The extensive collections of the National Museum of Natural History, Smithsonian Institution; Museum of Zoology, University of Michigan, Ann Arbor, Michigan; and, of course, the Museum of Comparative Zoology have been examined personally.

With the exception of *D. conchos* and *P. metnecktayi,* figures of the available type specimens of all the taxa described specifically from the Rio Grande, as well as several others, are included. Those described and figured

Table 1. Distribution of the fifteen unionid species of the Rio Grande system of Texas and Mexico.

	Texas North	Rio Grande	Pecos River	Rio Conchos	Devils River	Las Moras Creek	Rio Salado	Rio San Juan	Pesacas	Mexico South
P. popei	+	+	+	+	+	+	+	+		+
C. tampicoensis	+	+	+			+	+	+	+	+
A. imbecillis	+	+		+	+	+	+		+	
T. parvus	+	+			+	+			+	
P. purpuratus	+	+			+					
A. grandis	+	+	X						+	
Q. apiculata	+	+							+	
M. nervosa	+	+	X			+	+			
T. donaciformis	+	+					+			
Q. mitchelli	+		X		+	+	+			
L. teres	+		+			+	+		+	
U. tetralasmus	+						+		+	
P. metnecktayi		+	+				+			
Q. couchiana			X	+	+	+	+			
D. conchos				+			+			

(+) = Known records of distribution
(X) = Known only from fossil and semi-fossil records

by Lea were regarded as figured holotypes by Johnson (1974). Such a designation constitutes a valid lectotype selection under Article 746 of the International Code of Zoological Nomenclature (1985). Thus, these designations

now read: Lectotype ---- inadvertently selected by Johnson (----) as the "figured holotype."

Not all of the common species are illustrated. During the preparation of this paper, The Texas Parks and Wildlife Department published *Freshwater mussels of Texas* by Howells, Neck and Murray (1996), a useful illustrated work, which is quoted here, usually as the first reference, because of its utility as a tool for identification. References to the identification manual, *The Freshwater mussels of Tennessee,* by Parmalee and Bogan (1998) are also included when applicable. In the present work, some of the data on the plate captions are not repeated elsewhere. The arrangement of the genera is based essentially on the work of Davis and Fuller (1981) and Lydeard *et al.* (1996).

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Marrian, proofread it. Dr. Alan R. Kabat is especially thanked for making numerous corrections and for discovering some significant omissions. Mr. Adam Baldinger, whose computer skills rendered the manuscript into printable form, is thanked profoundly. He also prepared the map, table and plates.

ABBREVIATIONS:

ANSP	Academy of Natural Sciences of Philadelphia, Pennsylvania
JANSP	Journal of the Academy of Natural Sciences of Philadelphia, Pennsylvania (second series)
LACM	Natural History Museum of Los Angeles County, Los Angeles, California
MCZ	Museum of Comparative Zoology, Cambridge, Massachusetts
PANSP	Proceedings of the Academy of Natural Sciences of Philadelphia, Pennsylvania
PAPS	Proceedings of the American Philosophical Society, Philadelphia, Pennsylvania.
PUSNM	Proceedings of the United States National Museum, Washington, District of Columbia
TAPS	Transactions of the American Philosophical Society, Philadelphia, Pennsylvania
UMMZ	Museum of Zoology, University of Michigan, Ann Arbor, Michigan
USNM	National Museum of Natural History, Smithsonian Institution, Washington, District of Columbia
UTEP	Department of Biological Sciences, The University of Texas at El Paso, El Paso, Texas.

SYSTEMATIC SECTION
Family UNIONIDAE Rafinesque, 1820
Subfamily ANODONTINAE Rafinesque, 1820
Genus *Anodonta* Lamarck, 1799

Type species: *Mytilus cygneus* Linnaeus, 1758; monotypic.

Hoeh's (1990) phylogenetic analysis suggested that the subgenera *Pyganodon, Utterbackia*, and *Anodonta* should be elevated to genera. Though he had certain reservations, some authors have followed his suggestion. As such a shift is inconsistent with nomenclatural stability, the three subgenera remain here as such.

Subgenus *Pyganodon* Crosse and Fischer, 1894

Type species: *Anodonta globosa* Lea, 1841; subsequent designation by Frierson (1927: 9).

***Anodonta (Pyganodon) grandis* Say, 1829**

Recent references

Anodonta grandis [complex] -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 36 with figs., p. 203 with color figs; Parmalee and Bogan, 1998, *Freshwater mussels of Tennesee*: p. 206, pl. 100, map 99.

Anodonta grandis Say -- Strecker, 1931: 8; Metcalf, 1982: 48, pl. 2, fig. 6; Neck and Metcalf, 1988: 261.

Anodonta grandis lugbris Say -- Strecker, 1931: 10.

Anodonta grandis bealei Lea -- Strecker, 1931: 10.

NOMENCLATURAL REMARK.-- *Anodonta grandis* is a polytypic species whose synonymy includes some 39 nominal taxa (Parmalee and Bogan, 1998: 206-207).

DISTRIBUTION.-- Mississippian Region; Great Lakes, Canadian Interior Basin; and Gulf Coastal Region, to the Rio Grande System.

REMARKS.-- *Anodonta grandis* now appears to be restricted to the very lower portion of the Rio Grande. With the exception of a single lot from Cement Lake, El Paso, El Paso County, Texas (catalogued as *A. stewartiana* Lea, USNM 681635), no other unionids have been found in the main channel of the Rio Grande that far west. The Rio Grande is dry or merely a trickle between El Paso and Presido, Presido County above its confluence with the Rio de los Conchos, Mexico. Metcalf and Smartt (1972: 144) were undoubtably correct to assume that this species has been introduced.

RECORDS

RIO GRANDE SYSTEM

RIO GRANDE DRAINAGE.-- *Texas*: Cement Lake, El Paso, El Paso Co. (USNM 681635 [introduced, not seen]).

PECOS RIVER DRAINAGE.-- *Texas*: banks of arroyo entering Billingslea Draw [near] Toyah, Reeves Co. [fossil] (Metcalf, 1982: loc. 6 [not seen]).

RIO GRANDE DRAINAGE.-- *Texas*: Granjeno Lake (Strecker, 1931: 10); canals from Rio Grande, Mercedes (Ellis *et al.*, 1930: 512 [as *A. linneana* Lea]); *both* Hidalgo Co.

Subgenus *Utterbackia* F.C. Baker, 1927

Type species: *Anodonta imbecillis* Say, 1829; original designation.

***Anodonta (Utterbackia) imbecillis* Say, 1829**

(Plate 1, figure 1)

Recent references

Anodonta imbecillis Say -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 39 with figs., 204 with color figs.

Utterbackia imbecillis (Say) -- Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*: p. 242, pl. 122, map 121.
Anodonta ohiensis Rafinesque -- Strecker, 1931: 11.
Anodonta ohiensis horda Gould -- Strecker, 1931: 12.
Anodonta imbecilis [*sic*] Say -- Neck, 1987: 178; Neck and Metcalf, 1988: 261.

Relevant synonymy

Anodonta henryana Lea, 1857, *PANSP* **9**: 102; 1860 *JANSP* (2) **4**: 373, pl. 66, fig. 198 (Obs. *Unio* **9**: 55). Lectotype USNM 86692 (Matamoras, [State of] Tamaulipas, Mexico) inadvertently selected by Johnson (1974: 69) as the "figured holotype."

DISTRIBUTION.-- Mississippian Region; Lake Superior (Graf and Underhill, 1997: 410) and other Great Lakes; Southern Atlantic Slope, Peninsular Florida; and Gulf Coastal Region, west to the Rio Grande System.

RECORDS

RIO GRANDE SYSTEM

RIO GRANDE DRAINAGE.-- *New Mexico*: San Jose River [near] San Rafael, Valencia Co. (Neck, 1987: 160, Corpus Christi Museum 78S092 [not seen]).

DEVILS RIVER DRAINAGE.-- *Texas*: Beaver Lake [on Devils River, 3 mi N Juno] (USNM); Devils River (Strecker, 1931: 11 [not seen]); *both* Val Verde Co.

LAS MORAS CREEK DRAINAGE.-- *Texas*: [Las Moras Creek] Fort Clark [= Brackettville], Kinney Co. (Strecker, 1931: 11 [not seen]).

SAN LORENZO CREEK DRAINAGE.-- *Texas*: San Lorenzo Creek [Webb Co.] (USNM).

RIO SALADO DRAINAGE.-- *State of Nuevo Leon, Mexico*: canal, 20.5 mi [ca. 34 km] WNW Anahuac (MCZ).

RIO GRANDE DRAINAGE.-- *Texas*: [Rio Grande] Zapata and Starr counties (Howells *et al.*, 1996: 49 [not seen]); Cottingham Resaca, 3.5 mi [ca. 6 km] N of Brownsville, Cameron Co. (MCZ). [State of] *Tamaulipas*; *Mexico*: [Rio Grande] Matamoros (USNM).

Subfamily AMBLEMINAE Rafinesque, 1820
Genus *Megalonaias* Utterback, 1915

Type species *Unio heros* Say, 1829; original designation.

Megalonaias nervosa (Rafinesque, 1820)

(Plate 1, figure 2)

Recent references

Megalonaias nervosa (Rafinesque) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 80 with figs., p. 209-210 with color figs; Parmalee and Bogan, 1998, *Freshwater mussels of Tennesseee*: p. 159, pl. 69, map 68.

Amblema gigantea (Barnes) -- Strecker, 1931: 34.

Megalonaias gigantea (Barnes) -- Metcalf, 1982: 46, pl. 1, fig. 7, pl. 2, fig. 7.

Relevant synonymy

Unio nervosa (*Elliptio nervosa*) Rafinesque, 1820. Ann. gén. des Sci. Physiques à Bruxelles **5** (15): (aux rapides de l'Ohio). Type lost.

Unio giganteus Barnes, 1823, *Amer. Jour. Sci.* **6**: 119 (Mississippi [River], near Prairie du Chien [Crawford Co., Wisconsin]). Type destroyed by fire.

Unio eightsii Lea, 1860, *PANSP* **12**: 306; 1860, *JANSP* (2) **4**: 367, pl. 64, fig. 192 (Obs. Unio **8**: 49). Lectotype USNM 83991 (Sabinas River, [State of] New [Nuevo] Leon], Mexico) inadvertently selected by Johnson (1974: 51) as the "figured holotype."

NOMENCLATURAL REMARKS.-- Rafinesque's taxon was resuscitated from the dust bin of unrecognizable descriptions by Morrison (1969: 24) who merely asserted "*Meglonaias nervosa* Raf. 1820 (= *gigantea* Barnes, 1823)." Oesch (1984: 76) quotes, from a personal note, Stansbery's reason for accepting Morrison's revelation. "The type specimen (actually figured) was a very small one (1.5 inches wide) and very elongate for this species. It is at this small size, however, that *M. nervosa* has the characters noted by Rafinesque, characters which are lacking in all other naiades of the region." It takes a great leap of faith to

accept Stansbery's identification based, as it is, on a very meager description and a wretched drawing.

DISTRIBUTION.-- Mississippian Region; Gulf Coastal Region to the Rio Grande System.

REMARKS. -- Most of the Rio Grande records are based on fossil material. *M. nervosa* is replaced in the Mexican Gulf Coastal Region by *Megalonaias nickliniana* (Lea, 1834).

RECORDS

RIO GRANDE SYSTEM

PECOS RIVER DRAINAGE.-- *New Mexico*: Pecos River, below McMillan Reservoir; downstream from Fishing Rock; Pierce Crossing; *all* Eddy Co. [*all* Pleistocene and outside of present range] (*all* Metcalf, 1982: locs. 2-4 [not seen]).

LAS MORAS CREEK DRAINAGE.-- *Texas*: [Las Moras Creek] Fort Clark [Brackettville], Kinney Co. (Mearns, 1907: 77 as *Quadrula undulata* Barnes and as *Amblema plicata costata* Rafinesque Mearns by Strecker, 1931: 32 [not seen]).

RIO GRANDE DRAINAGE.-- *Texas*: [Rio Grande], Eagle Pass, Maverick Co. [fragment] (Metcalf, 19832: 46 [not seen]); Rio Grande, Chapeña, 2.3 km below Falcon Dam, Starr Co. [fresh shells] (Neck and Metcalf, 1988: 262).

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico*: sediments S bank Rio Salado, Municipio Villa Juarez (Metcalf, 1982: loc. 10 [not seen]). *State of Nuevo Leon, Mexico*: Sabinas River (USNM 83991); sediments of Rio Salado, 24 km S, Anahuac (Metcalf, 1982: loc. 11 [not seen]).

Genus Quadrula Rafinesque, 1820

Type species: *Obliquaria (Quadrula) quadrula* Rafinesque, 1820; tautonymy.

***Quadrula apiculata* (Say, 1829)**

Recent references

Quadrula apiculata (Say) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 105 with figures, pp. 212-213 with color figs.

Quadrula quadrula apiculata (Say) -- Strecker, 1931: 19; Metcalf, 1982: 47.
Quadrula apiculata speciosa (Lea) -- Neck, 1987: 178; Neck and Metcalf, 1988: 262.

DISTRIBUTION.-- Southern Mississippian Region; Mobile Basin; Gulf Coastal Region west to the Rio Grande System.
REMARKS.-- This species was reported from the Neuces River System in Lake Corpus Christi by Murray (1978: 5) as *Quadrula quadrula* (Rafinesque, 1820) and later from three additional localities along the Neuces River as *Q. apiculata* by Howells *et al.* (1996: 107, map). Neck (1987: 178) found a single valve further south in Dairy Lake, Llano Mesteño near Baffin Bay. Metcalf (1982: 47) suggested, that since this species had not been previously located in the Rio Grande System, it may represent an introduced population.

RECORDS

RIO GRANDE SYSTEM
RIO GRANDE DRAINAGE.-- *Texas*: Rio Grande, below Falcon Reservoir, Starr Co.; Lake Monte Alto, Hidalgo Co. (*both* Metcalf, 1982: 67 [not seen]). Resaca de los Fresnos, San Benito [Cameron Co.] (Neck and Metcalf, 1988: 262 [not seen]).

Quadrula couchiana (Lea, 1860)

(Plate 2, figure 1)

Recent references

Quadrula couchiana (Lea) -- Howells *et al.*, 1996, *Freshwater Mussels of Texas*: p. 39 with figs., p. 204 with color figs.; Strecker, 1931: 28; Metcalf, 1982: 47.

Relevant synonymy

Unio couchianus Lea 1860, *PANSP* **12**: 305; 1860, *JANSP* (2) **4** : 371, pl. 66, fig. 196 (Obs. Unio **8**: 53). Lectotype USNM 85728 (Rio Salado, [State of] New [Neuvo] Leon, Mexico) inadvertently selected by Johnson (1974: 38) as the "figured holotype."

NOMENCLATURAL REMARK.-- This dwarf species was placed in *Quadrula* s.s. by Morrison (1968: 50).

DISTRIBUTION. -- Probably endemic to the Rio Grande System.

REMARKS.-- All of the records above Devils River in the Pecos River Drainage are based on semi-fossil specimens. The record from the Nueces River is thought to be spurious.

RECORDS

RIO GRANDE SYSTEM

PECOS RIVER DRAINAGE.-- *New Mexico*: Pecos River, below McMillan Reservior; Pierce Crossing; *both* Eddy Co. [*both* Pleistocene, and outside of present range] (*both* Metcalf, 1982: locs. 2, 4 [not seen]). *Texas*: Pecos River, mouth of Hackberry Draw, Ward Co. [Pleistocene, and outside of present range] (Metcalf, 1982: loc. 5 [not seen]).

DEVILS RIVER DRAINAGE.-- *Texas*: Devils River [Val Verde Co.] (USNM).

LAS MORAS CREEK DRAINAGE.-- *Texas*: [Las Moras Creek], Fort Clark [= Brackettville], Kinney Co. (Strecker, 1931: 29 and MCZ 269875).

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico:* sediments S bank Rio Salado, Municipio Villa Juarez (Metcalf, 1982: loc. 10 [not seen]). *State of Nuevo Leon, Mexico:* sediments of Rio Salado, 24 km SE of Anahuac (Melcalf, 1982: loc. 11 [not seen]); Rio Salado (USNM).

NUECES RIVER SYSTEM

CHACON CREEK DRAINAGE.-- *Texas*: Chacon Creek, 1 mi below La Pryor (Eagle Pass Road, bridge), Zavalla Co. (Two bleached valves, USNM 524035 [not seen]); "These may be *Quadrula petrina* (Gould, 1855) which is similar." (Neck *in* Howells *et al.*, 1996: 110).

Genus *Quincuncina* Ortmann, 1922

Type species: *Quincuncina burkei* Walker, 1922; original designation.

Quincuncina mitchelli (Simpson, 1895)

(Plate 2, figures 2,3)
(Plate 4, figures 1,2)

Recent references

Quincuncina mitchelli (Simpson) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 127 with figs., p. 213 with color figs.
Elliptio tamaulipasensis (Conrad) -- Strecker, 1931: 18.
Elliptio tamaulipasensis elongata (Simpson) -- Strecker, 1931: 19.

Relevant synonymy

Unio taumilipanus Conrad, 1855, *PANSP* **7**: 256. Type (San Juan River, Taumilapas [*sic*, State of] Tamaulipas, Mexico) not located (*teste* Johnson and Baker, 1973: 172); *nomen dubium, teste* Fischer and Crosse, 1894: 621 [as *Unio tamaulipasensis*, emendation]; Martens, 1900: 521 [as *Unio tamulipanus*]; Coney and Taylor, 1986, *Western Soc. Mal. Ann. Rept. for 1985* **18**: 13 [as *Unio taumilapana*].

Unio mitchelli Simpson, 1895 *in* Dall, *PUSNM* **18**: 5; 1896, *PUSNM* **19**: 371, pl. 32, figs. 1-3. Lectotype USNM 128364 (Guadalupe River, Victoria Co., Texas) inadvertently selected by Johnson (1974: 15) as the "figured holotype."

Unio iheringi B.H. Wright, 1898, *Nautilus* **12**: 93 (San Saba River, Menard Co., Texas). Lectotype USNM 152171 is the "type" figured by Simpson (1900, PANSP **52**: 79, pl. 4, fig 5) regarded by Johnson (1967: 7) as "holotype."

Unio mitchelli elongatus Simpson, 1914, *Cat. naiades* **1**: 623. Lectotype USNM 251917 (Guadalupe River [near Kerrville], Kerr Co., Texas) selected by Johnson (1975: 12, pl. 2, fig. 5).

Quadrula (Quincuncina) guadalupensis Wurtz, 1950, *Notulae Naturae* (224): 2, figs. 1-5. Holotype ANSP 185974 (Guadalupe River, above Sequin, between routes 123 and 90, Guadalupe Co., Texas).

NOMENCLATURAL REMARKS.-- Coney and Taylor (1986: 12) pointed out, as previous authors had, that *Unio taumilapanus* [*sic*] was not sufficiently described to permit its application to any known species with certainty; it was not figured and the type is lost. Only Frierson (1927: 156) advocated its identity by placing *U. mitchelli* and other taxa

in its synonymy but without explanation. Coney and Taylor (1986) accepted *mitchelli* as the first available taxon and placed it in *Quincuncina* which they claimed was supported by both anatomical and shell characters. Howells *et al.* (1996: 127) were first to list the complete synonymy of *U. mitchelli.*

DISTRIBUTION.-- Brazos, Colorado, and Guadalupe river systems; Rio Grande System.

REMARKS.-- Most of the Rio Grande records are based on fossil material. *Q. mitchelli* has not been reported from the intervening Neuces River System.

RECORDS

RIO GRANDE SYSTEM

PECOS RIVER DRAINAGE.-- *New Mexico*: Pecos River, below McMillan Reservoir; Pierce Crossing; *both* Eddy Co. [*both* Pleistocene, and outside of present range] (*both* Metcalf, 1982: Locs. 2, 4 [not seen]). *Texas*: Pecos River, mouth of Hackberry Draw, Ward Co.; banks of arroyo entering Billingslea Draw [near] Toyah, Reeves Co. [fossil] (Metcalf, 1982: loc. 6 [not seen]).

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico:* Rio Salado, Villa Juarez [subfossil] (Metcalf, 1982: loc. 10 [not seen]). *State of Nuevo Leon, Mexico.* Rio Salado, Anahuac; China [*both* subfossil] (both Metcalf, 1982, locs. 11,12 [not seen]). *State of Taumalipas, Mexico*: Rio Salado, 4.5 mi S of Nuevo Leon (UMMZ).

GUADALUPE RIVER SYSTEM

GUADALUPE RIVER DRAINAGE.-- *Texas*: Guadalupe River, Ingram; near Kerrville; *both* Kerr Co. (*both* USNM). Guadalupe River, near Comfort, Kendall Co. (Strecker, 1931: 18). Guadalupe River, Hueca Falls, 4 mi N of New Braunfels, Comal Co. (MCZ, USNM). Guadalupe River, Victoria Co. (MCZ).

COLORADO RIVER SYSTEM

COLORADO RIVER DRAINAGE.-- *Texas*: Santa Anna, Coleman Co. (USNM).

SAN SABA RIVER DRAINAGE.-- *Texas*: San Saba River, Menardville, Menard Co. (MCZ, USNM); San Saba River, San Saba Co. (UMMZ).

LLANO RIVER DRAINAGE.-- *Texas*: Llano River, Mason Co. (USNM).

BRAZOS RIVER SYSTEM
LITTLE RIVER DRAINAGE.-- *Texas*: Leon River , Gatesville, Coryell Co. (MCZ, USNM); Leon River, Bell Co. (UMMZ).
BRAZOS RIVER DRAINAGE.-- *Texas*: Brazos River (MCZ, USNM).

Subfamily PLEUROBEMINAE Hannibal, 1912
Genus *Popenaias* Frierson, 1927

Type species: *Unio popei* Lea, 1857; original designation.

Originally described as a subgenus of *Elliptio*, *Popenaias* Frierson (1927: 10, 38) also included *Elliptio metallicus* (Say, 1831) and *Elliptio metallicus ganinus* (Pilsbry, 1910). Heard and Guckert (1971: 399, 483) elevated *Popenaias* to a genus, limited to *Elliptio popei* (Lea, 1857) from Texas and *Elliptio buckleyi* (Lea, 1843) from peninsular Florida. They also created a new subfamily Popenaiadinae comprised of *Popenaias* and *Cyrtonaias* Cross and Fischer, 1893. Fuller (1975) subsequently determined that *Cyrtonaias* belonged to the Lampsilinae.

***Popenaias popei* (Lea, 1857)**
(Plate 6, figure 1)

Recent references

Popenaias popei (Lea) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 93 with figures, p. 211 with color figs.
Elliptio popei (Lea) -- Strecker, 1931: 17.
Popenaias popeii (Lea) -- Metcalf, 1982: 45; Neck and Metcalf, 1988: 45.

Relevant synonymy

Unio popeii Lea, 1857, *PANSP* **9**: 102; 1860, *JANSP* (2) **4**: 372, pl. 66, fig. 197 (Obs. Unio **8**: 54). Lectotype USNM 85895 (Rio Salado, [State of] New [Nuevo] Leon, Mexico) inadvertently selected by Johnson (1974: 115) as the "figured holotype."

NOMENCLATURAL REMARK.-- *Unio veraepacis* Tristam (1864: 414) was mistakenly included in the synonymy of *P. popei* by both Frierson (1927: 38) and Howells *et al.* (1996: 93). The type of the former taxon, collected from the State of Vera Paz, Guatemala, was figured by Martens (1900:#516, pl. 38, fig. 1-1a) as a variety of *Unio ravistellus* Morelet, 1849.

DISTRIBUTION.-- Western Gulf and Mexican Gulf coastal regions. Colorado River System and from the Rio Grande System south to the Rio Cazodones System. State of Vera Cruz, Mexico.

RECORDS

COLORADO RIVER SYSTEM

COLORADO RIVER DRAINAGE. -- *Texas*: Concho River, 1991; collection of Angelo State University, San Angelo, Tom Green Co. [single specimen, *teste* Howells (personal communication) not seen].

LLANO RIVER DRAINAGE. -- *Texas*: Llano River, 1972; Museum of Biological Diversity, The Ohio State University, Columbus, Ohio [single specimen, *teste* Howells (personal communication) not seen].

RIO GRANDE SYSTEM

RIO GRANDE DRAINAGE.-- *Texas*: Rio Grande at San Francisco Creek, Brewster Co.; Rio Grande, Terrell Co. (*both* Howells *et al.*, 1996: 93, 211 with figs. [not seen]).

PECOS RIVER DRAINAGE.-- *New Mexico*: Pecos River, 4.5 mi NE of Roswell (USNM); North Spring River, Roswell [fresh specimens] (Cockerell, 1902: 69 [not seen]); sediments of Rio Felix (Metcalf, 1982: loc. 1) [not seen]); *all* Chaves Co. Pecos River, below McMillan Reservoir [Pleistocene] (Metcalf, 1982: loc. 2 [not seen]); Pecos River, Carlsbard, ANSP 174028; *both* Eddy Co. *Texas*: Pecos River, mouth of Hackberry Draw [Pleistocene] (Metcalf, 1982: loc. 5 [not seen]); Pecos River (Strecker, 1931: 17 [not seen]); *both* Ward Co. Lagoon in Deadman Canyon [ca. 13 mi up stream from mouth of Pecos River, living specimens], ANSP 85268 [not seen], Val Verde Co.

DEVILS RIVER DRAINAGE.-- *Texas*: Devils River (USNM, UMMZ); lower end of Blaines Lake, a widening of Devils River (Strecker, 1931: 17 [not seen]); *both* Val Verde Co.

LAS MORAS CREEK DRAINAGE.-- *Texas*: Las Moras Creek, Fort Clark [= Brackettville], Kenney Co. (Strecker, 1931: 17; MCZ 295007).

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico*: Sediments S bank, Rio Salado, Municipio Villa Juarez (Metcalf, 1982: loc. 10 [not seen]). *State of Nuevo Leon, Mexico*: Sediments of Rio Salado, 24 km S Anahuac (Metcalf, 1982: loc. 11 [not seen]; Rio Salado (USNM).

RIO GRANDE DRAINAGE.-- *Texas*: Rio Grande below Falcon Dam, Chapeño, Starr Co. (Neck and Metcalf, 1988: 262 [not seen]); Keller Resaca, Brownsville, Cameron Co. (Neck, 1987: 160, Corpus Christi Museum 785078). *State of Neuvo Leon, Mexico*: E side, Rio San Juan, China [probably Holocene] (Metcalf, 1982: loc. 12 [not seen]).

RIO SOTA DE MARINA SYSTEM

RIO SOTA DE MARINA DRAINAGE.-- *State of Tamaulipas. Mexico*: Rio Corona, 3.5 mi E of Guémez (UMMZ); Rio Purificacion, near Padilla (MCZ); Rio Sota de Marina, 4 mi SW of Padilla (MCZ).

RIO TAMESI SYSTEM

RIO SABINAS DRAINAGE.-- *State of Tamaulipas Mexico*: Rio Sabinas, E of Gomez Frias (UMMZ).

RIO GUAYALEGO DRAINAGE.-- *State of Tamaulipas Mexico*: Rio Guayalejo, 19 mi ENE of Cuidad Mante; near Magiscatzin (*both* MCZ).

Rio Panuco Drainage.-- *State of San Luis Potosi, Mexico*: Rio Frio 2.7 mi W of Rescon; Valles River, Mecos Falls, Mecos; Valles; between Valles and Pojal (*all* MCZ).

RIO CAZONES SYSTEM

RIO CAZONES DRAINAGE.--*State of Vera Cruz, Mexico*: Rio Cazones, 2.5 WSW of Poza Rica, Vera Cruz [State] (MCZ).

Genus *Uniomerus* Conrad, 1853

Type species: *Unio tetralasmus* Say, 1831; subsequent designation by Simpson (1900: 739).

Uniomerus tetralasmus (Say, 1831)

(Plate 6, figure 2)

Recent references

Uniomerus tetralasmus (Say) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 149 with figs., p. 218 with color figs.; Neck, 1987: 151; Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*: p. 240, pl. 121, map 120.

Uniomerus declivis (Say) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 147 with figs., p. 218 with color figs; Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*: p. 239, pl. 120, map 119.

Elliptio tetralasmus (Say) -- Strecker, 1931: 14.

Elliptio declivis (Say) -- Strecker, 1931: 14.

Elliptio tetralasmus manubius (Gould) -- Strecker, 1931: 16.

Uniomerus tetralasmus manubius (Gould) -- Neck and Metcalf, 1988: 261.

Relevant synonymy

Unio manubius Gould, 1855, *Proc. Bos. Soc. Nat. Hist.* **5**: 229. Lectotype MCZ 169447 (Chihuahua, 60 mi from Camp Ringgold = Rio Agualeguas, Puntiagudo, ca. 3 mi NE of General Trevino, State of Nuevo Leon [Mexico]; *teste* Taylor, 1966: 154) inadvertently selected by Johnson (1964: 239, pl. 32, fig. 5) as "measured holotype."

NOMECLATURAL REMARK.-- Johnson (1970a: 339) may have erred in regarding *U. tetralasmus* as a single polytypic species as determined by Morrison (1976: 10) who regarded populations east of the Apalachicola River System of Georgia and Alabama as *Uniomerus carolinianus* (Bosc, 1801). Morrison (1976) accepted the argument of Frierson (1903) that *declivis* (= *manubius*) was distinct from *tetralasmus*; however, the distribution of the former was taken to be "Lake Erie drainage, Ohio and Indiana; from Tennessee; from the Coosa River system in Alabama, and southwest across Texas to the south side of the Rio Grande System in Chihuahua, Mexico." Morrison also claimed that while *declivis* is gonochoristic, "*tetralasmus* individuals all

possess the female type of gill structure, and hence are evidently either parthenogenetic or hermaphroditic."

Frierson (1903) recognized *declivis* as a distinct species, only from the Gulf Coastal Region, which is more pointed posteriorly, smaller in general, with a purplish nacre; that of *tetralasmus* always being white. He also stated that *declivis* is found in rivers, whereas *tetralasmus* invariably lives in the "small streams and ponds of the south." If *declivis* is not more than a phenotypic variant of *tetralasmus*, the shape of the type specimens of *manubius* would appear to place that taxon under the synonymy of *declivis* except that the types have a white nacre.

DISTRIBUTION.-- Mississippian Region; Great Lakes; Southern Atlantic Slope, Peninsular Florida; Gulf Coastal Region, to the lower Rio Grande System.

REMARKS.-- Referring to the record, cited below, from the Rio Grande Drainage, Neck (1987: 151) stated, "No form of *Uniomerus* is known today from the lowland, heavy clay areas of the Lower Rio Grande Valley. The Camp [collection] shells have a blunted posterior ventral projection. The periostracum is yellowish horn brown with obvious growth rings, although there is no indication of long periods of habitat desiccation." He further remarked on the similarity between the Camp shells, though larger, and the type of *manubius*.

RECORDS

RIO GRANDE SYSTEM

RIO SALADO DRAINAGE.-- *State of Nuevo Leon, Mexico*: Chihuahua, 60 mi from Camp Ringgold [= Rio Agualeguas, Puntiagudo, ca. 3 mi NE of General Treniño], (MCZ 169447, MCZ 169448).

RIO GRANDE DRAINAGE.-- *Texas*: Cottingham Resaca, Brownsville, Cameron Co. (Neck, 1987: 160, Corpus Christi Museum 785056 [not seen]).

Subfamily LAMPSILINAE Ortmann, 1912
Genus *Cyrtonaias* Crosse and Fischer, 1894

Type species: *Unio berlandierii* Lea, 1834; original designation.

Originally introduced by Crosse and Fischer (1894: 556) as a section of *Unio*, *Cyrtonaias* was accepted as a subgenus of *Lampsilis* by Frierson (1927: 11, 84) and as a genus by Fuller (1975: 81) who wrote, "*Cyrtonaias* is considered to be the most primitive known representative of the Longenae, the most primitive lampsiline tribe."

***Cyrtonaias tampicoensis* (Lea, 1838)**

Recent references

Cyrtonaias tampicoensis (Lea) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 48 with figures, p. 205 with color figures; Metcalf, 1982: 50, pl. 1, fig. 4. Johnson, 1998, *Occ. Pap. on Moll.*, **5**(76): pl. 23, fig. 2, pl. 24, figs: 1, 2.

Lampsilis tampicoensis (Lea) -- Strecker, 1931: 41.

Lampsilis tampicoensis berlandieri (Lea) -- Strecker, 1931: 42.

Cyrtonaias tampicoensis berlandieri (Lea) -- Neck and Metcalf, 1988: 262.

Lampsilis tampicoensis heermani (Lea) -- Strecker, 1931: 42.

Relevant synonymy

Unio tampicoensis Lea, 1838, *TAPS* **6**: 24, pl. 7, fig. 18 (Obs. Unio **2**: 24). Lectotype USNM 84843 (River Tampico, Mexico) inadvertently selected by Johnson (1974: 143) as the "figured holotype."

Unio tecomatensis Lea, 1841, *PAPS* **2**: 30; 1842, *TAPS* **8**: 234, pl. 21, fig. 48 (Obs. Unio **3**: 72). Lectotype USNM 85338 (Tecomate River, near Tlocatalpam, [Tlacatalpan, State of Vera Cruz], Mexico) inadvertently selected by Johnson (1974: 144) as the "figured holotype."

Unio grandensis Conrad, 1855, *PANSP* **7**: 256. Type (Rio Grande, Texas) not located in the ANSP by Johnson and Baker (1973: 157). Without a figure and with only the most brief of descriptions, Simpson (1900: 588) placed this taxon in the synonymy of *Gebula rotundata* (Lamarck, 1819) but noted that that species had never been found so far west. Since this is still

true, Howells *et al.* (1996: 59) suggested Conrad's species is probably *C. tampicoensis.*

Unio berlandierii Lea, 1857, *PANSP* **9**: 101; 1860, *JANSP (2)* **4**: 369, pl. 65, fig. 194 (Obs. Unio **8**: 51). Lectotype USNM 84427 ([Rio Grande,] Metamoras, [State of Tamaulipas] Mexico) inadvertently selected by Johnson (1974: 20) as the "figured holotype."

Unio saladoensis Lea, 1860, *PANSP* **12**: 305; 1860, *JANSP(2)* **4**: 370, pl. 65, fig. 195 (Obs. Unio **8**: 52). Holotype [by monotypy] (Rio Salado, State of New [Nuevo] Leon, Mexico) lost.

Unio heermanii Lea, 1861, *PANSP* **13**: 392; 1862, *JANSP(2)* **5**: 194, pl. 26, fig. 263 (Obs. Unio **9**: 16). Lectotype USNM 83932 (Medina River, [San Antonio River System,] Texas) inadvertently selected by Johnson (1974: 69) as the "figured holotype."

Lampsilis tampicoensis kusteriana Frierson, 1927, *Check List of North American Naiades*: p. 85. Based on the figure of Kuester, 1862, Martini and Chemnitz, *Conchylien Cabinet* **2**(9): 275, pl. 93, fig. 1. Type (Tampico, [State of Tamaulipas] Mexico) in the collection of Von dem Busch, the location of which is unknown; refigured by Johnson (1972b: 145, pl. 30, fig. 1).

DISTRIBUTION.-- Western Gulf and Mexican Gulf Coastal regions; originally from the Brazos River System south to the Rio Cotaxla System, State of Vera Cruz, Mexico.

REMARKS.-- Not reported north of the Brazos River System, Texas by Strecker (1931: 41, 71), this species appears to have been subsequently introduced to more northern river systems. Found in the San Jacinto River System in 1957 at Lake Creek, near Spring, Harris Co. (MCZ 222661); the Trinity River System (Howells *et al.*, 1996: 48); and the Red River System at Texoma, Texas and Oklahoma (Mather, 1989).

RECORDS

RIO GRANDE SYSTEM

PECOS RIVER DRAINAGE.-- *New Mexico*: sediments of Rio Felix, Chaves Co.; Pecos River, below McMillan Reservoir; downstream from Fishing Rock; Pierce Crossing; *all* Eddy Co. [*all* Pleistocene and outside of present range] (*all* Metcalf, 1982: locs. 1-4 [not seen]). *Texas*: Pecos River, mouth of Hackberry Draw; SW of

Grandfalls; *both* Ward Co.; near Imperial, Pecos Co.; WNW of Imperial, Crane Co. [*all* Pleistocene and outside of present range] (*all* Metcalf, 1982: locs. 5, 7-9 [not seen]). Pecos River, above mouth of Big Fielder Draw [living specimens] (Metcalf, 1982: loc. 15 [not seen]); lagoon in Deadman Canyon [ca. 13 km upstream from mouth of Pecos River] [living specimens] (ANSP 85265 [not seen]); Pecos River, 1.28 km above mouth [living system] (Metcalf, 1982: loc. 17 [not seen]); *all* Val Verde Co.

RIO GRANDE DRAINAGE.-- *Texas*: Rio Grande, 9.7 km W of Del Rio, Val Verde Co. [living specimens] (Metcalf, 1982: loc. 18 [not seen]).

PINTO CREEK DRAINAGE.-- *Texas*: Pinto Creek, Kinney Co. (USNM).

LAS MORAS CREEK DRAINAGE.-- *Texas*: [Las Moras Creek,] Fort Clark [= Brackettville], Kinney Co. (Strecker, 1931: 42 [not seen]).

ELM CREEK DRAINAGE.-- *Texas*: Elm Creek, near Eagle Pass, Maverick Co. (USNM).

SAN ISABELL CREEK DRAINAGE.-- *Texas*: [San Isabell] Creek, 10 mi NW of Laredo, Webb Co. (MCZ).

RIO GRANDE DRAINAGE.-- *Texas*: Falcon Lake [of Rio Grande], 8 mi S of Zapata (MCZ); Arroyo Valeno (USNM); *both* Zapata Co.

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico*: Rio Sabinas (MCZ, USNM); sediments S bank, Rio Salado, Municipio Villa Juarez (Metcalf, 1982: loc. 10 [not seen]). *State of Nuevo Leon, Mexico*: Rio Salado, Lampasas (ANSP 44201 [not seen]); Rio Salado, Anahuac (MCZ). *State of Taumpalipas, Mexico:* Rio Salado, 4.5 mi S of Nuevo Laredo (UMMZ).

RIO SAN JUAN DRAINAGE.-- *State of Nuevo Leon, Mexico*: Rio San Juan, Monterey (UMMZ); E side, Rio San Juan, China [probably Holocene] (Metcalf, 1982: loc. 12 [not seen]). *State of Tamaulipas, Mexico*: [Rio San Juan], Camargo (USNM).

RIO GRANDE DRAINAGE.-- *Texas*: [Arroyo Colorado,] Mercedes, Hidalgo Co. (MCZ, USNM); [Arroyo,] 2 mi SW Harlingen (USNM); Puljivate Resaca, Brownsville (Neck, 1987: 160 [not seen]); *both* Cameron Co. *State of Tamaulipas*, *Mexico*: Rio Grande, Matamoras (USNM).

RIO CONCHOS (OR RIO SAN FERNADNO) SYSTEM

RIO CONCHOS DRAINAGE.--*State of Tamaulipas*, *Mexico*: Rio Conchos (USNM, LACM 105551).

RIO TAMESI SYSTEM

RIO SABINAS DRAINAGE.-- *State of Tamaulipas*, *Mexico*: Rio Sabinas, E of Gomes Farias (UMMZ).

RIO GUAYALEJO DRAINAGE.--*State of Tamaulipas, Mexico*: Rio Guayalejo, 19 mi ENE of Cuidad Mante (MCZ).
RIO PANUCO DRAINAGE.--*State of Vera Cruz, Mexico*: Rio Panuco, Panuco (MCZ); Rio Tampico, [Panuco] (USNM).

RIO COTAXLA SYSTEM
RIO COTAXLA DRAINAGE.--*State of Vera Cruz, Mexico*: Rio Medellín, 10 mi S of Vera Cruz (USNM).

RIO PAPALOAPAN SYSTEM
RIO PAPALPOAPAN DRAINAGE.--*State of Vera Cruz, Mexico*: Rio Tecomate, near Tlacotalpan (USNM).

Genus *Potamilus* Rafinesque, 1818

Type species: *Unio alatus* Say, 1817; subsequent designation (Morrison, 1969). Placed on the Official List of Generic Names in Zoology (1992, Bulletin of Zoological Nomenclature **49** (1): 81), replacing the well-known taxon *Proptera* Rafinesque 1819. The case is closed, but for a historical discussion of it: see Johnson (1980: 128).

Potamilus metnecktayi Johnson, 1998

Recent references

Lampsilis salinasensis Metcalf *non* Simpson, 1982, *in* Davis, *Proc. Symposium Recent Benthological Investigations in Texas and Adjacent States*: p. 48, pl. 2, fig. 2.
Potamilus salinasensis Neck and Metcalf *non* Simpson, 1988, *Texas Jour. Sci.* **40**: 262; Howells *et al. non* Simpson, 1996, *Freshwater mussels of Texas*: p. 103 with figs., p. 212 with color figs.
Potamilus (Disconaias) salinasensis Howells and Garrett *non* Simpson, 1995, Triannual Unionid Report (8): [10].

Relevant synonymy

Potamilus metnecktayi Johnson, 1998, *Occ. Pap. on Moll.*, **5** (76): 429, pl. 22, figs. 1, 2.

DISTRIBUTION.--Lower Rio Grande System.

RECORDS

RIO GRANDE SYSTEM

RIO GRANDE DRAINGE.-- *Texas:* Rio Grande at Boquillas Canyon (Howells and Ashby, 1999 [not seen]) and at San Francisco Creek (Howells *et al.*, 1996: 103), *both* Brewster Co.

PECOS RIVER DRAINAGE.-- *New Mexico*: Pecos River, below McMillan Dam, Eddy Co., [Pleistocene, outside present range] (Metcalf, 1982: loc. 2, [not seen]). *Texas*: mouth of Pecos River, at former US 90 bridge (now flooded by Amistad Reservoir), Val Verde Co. (Taylor *et al.*, July 1968 [not seen]).

RIO GRANDE DRAINAGE.-- *Texas*: Rio Grande, 6 mi W of Del Rio, Val Verde Co. (Metcalf, October 1972, UTEP 2519). Rio Grande, Chapengo gaging station (Metcalf, December 1975: UTEP 4660 [not seen]); Rio Grande, Roma (Metcalf, December 1975: UTEP 4639 [not seen]); *both* Star. Co.

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico:* sediments S bank, Rio Salado, Municipio Villa Juarez (Metcalf, 1982: loc. 10, UTEP 4844 [not seen]). *State of Tamaulipas, Mexico*: Rio Salado, 45 mi S Nuevo Laredo (M. M. Ellis, July 1929, UMMZ 66993). *State of Nuevo Leon, Mexico*: Rio Salado, Lampozos (ANSP 44200 [not seen]).

Potamilus purpuratus (Lamarck, 1819)

Recent references

Potamilus purpuratus (Lamarck) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 100 with figures, pp. 211-212 with color figs; Johnson 1998, *Occ. Pap. on Moll.*, **5** (76): pl. 23, fig 1; Parmalee and Bogan 1998, *Freshwater mussels of Tennessee*: p. 199, pl. 96, map 95.

Proptera purpurata (Lamarck) -- Strecker, 1931: 44.

DISTRIBUTION.-- Mississippian Region, Gulf Coastal Region, formerly not extending beyond the Guadalupe River System, Texas. Recently found in the Rio Grande System. Howells *et al.* (1996: 102) suggested that these records may represent an introduced population.

REMARKS.-- Earlier published records of *P. purpuratus* from the Rio Grande System have been shown to be misidentified specimens of *Crytonaias tampicoensis.*

Howell *et al.* (1996: 100) reported that *P. purpuratus* collected in 1993 from Lake Corpus Christi, Live Oak Co., Texas from the Nueces River System (between the Guadalupe River and Rio Grande systems) were from an introduced population.

RECORDS

RIO GRANDE SYSTEM
RIO GRANDE Drainage.-- *Texas*: Amistad Reservoir, Val Verde Co. (Howells *et al.*, 1996: 102 [not seen]).
DEVILS RIVER Drainage.-- *Texas*: Devils River, Val Verde Co. (Howells *et al.*, 1996: 102 [not seen]).

Genus *Disconaias* Crosse and Fischer, 1894

Type species: *Unio discus* Lea 1838; original designation

Originally described by Fischer and Crosse (1894: 556) as a section of *Unio*, *Disconaias* was elevated to a subgenus of *Actinonaias* by Baker (1922: 20) and to a genus by Taylor (1997: 420).

***Disconaias conchos* Taylor, 1997**

Recent reference
[Not identified] Howells, 1994, Info. Mussel Newsletter, **2**(11) p. 5, figs.

Relevant synonymy
Disconaias conchos Taylor, 1997, *Occ. Pap. on Moll.* **5**(75): 420, pl. 21, fig. 1. Holotype LACM 2257 (Rio Conchos, about 0.5 km W of Julimes, State of Chihuahua, Mexico).

DISTRIBUTION.-- Endemic to the Rio Conchos and Rio Salado drainages of the Rio Grande System.

RECORDS

RIO GRANDE SYSTEM

RIO CONCHOS DRAINAGE.-- *State of Chihuahua, Mexico*: Rio Conchos, 15 km NE of Saucillo (LACM 69-240.2); 1 km N of Rosetilla (LACM 69-242.1); 1.5 km NW of Rosetilla (LACM 69-243.1); *all* worn valves. Rio Conchos, about 1.2 km W of Julimes (LACM 69-239.1).

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico*: Rio Sabinas, Villa Juarez (LACM 95117).

Genus *Lampsilis* Rafinesque, 1820

Type species: *Unio ovatus* Say, 1817; subsequent designation by Herrmannsen (1849: 575).

***Lampsilis teres* (Rafinesque, 1820)**

Recent references

Lampsilis teres (Rafinesque) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 69 with figures, p. 207 with color figs.; Strecker, 1931: 37; Metcalf, 1982: 50; Neck and Metcalf, 1988: 236; Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*: p. 136, pl. 54, map 53.

NOMENCLATURAL REMARKS.-- Howells *et al.* (1996: 69) do not claim that the occasionally more or less green-rayed form of *Lampsilis teres* occurs in Texas. They do discuss, however, its taxonomy and synonymy which was misunderstood by Oesch (1984: 208) who changed what had been called *Lampsilis teres fallaciosa* (Smith, 1899) to *L. teres teres* (Smith, 1899). The typical yellow, unrayed form he changed from *L. teres teres* (Rafinesque, 1820) (which would be the correct name if there was also a valid subspecies) to *L. teres anodontoides* (Rafinesque, 1820). Actually, *Unio anodontoides* Lea, 1834 is an unrayed shell and as such is a synonym of *Unio teres* Rafinesque, 1820.

The rayed form occurs sporadically as a phenotypic variant and is not a geographically isolated subspecies. For this reason, it was rejected by Johnson (1972: 242) and Vidrine (1993: 149) as a mere subspecies. If it were one, it would be known as *Lampsilis teres fallaciosa* (Smith, 1899), as mentioned above.

DISTRIBUTION.-- Mississippian Region; Peninsular Florida; Apalachicolan Region; Mobile Basin; Gulf Coastal Region, west to the Rio Grande System.

RECORDS

RIO GRANDE SYSTEM

PECOS RIVER DRAINAGE.-- *Texas*: Lagoon in Deadman Canyon, ca. 13 km upstream from mouth of Pecos River (ANSP 85267 [not seen]); Pecos River, 28 km above mouth [1986, before inundation by Amistad Reservoir] (D.W. Taylor, personal communication [not seen]); *both* Val Verde Co.

LAS MORAS CREEK DRAINAGE.-- *Texas*: [Las Moras Creek,] Fort Clark [= Brackettville], Kinney Co. (Strecker, 1931: 50 [not seen]).

ELM CREEK DRAINAGE.-- *Texas:* Elm Creek, north of Eagle Pass, Maverick Co. (Metcalf, 1982: 50 [not seen]).

RIO GRANDE DRAINAGE.-- *Texas:* Rio Grande, Loredo, Webb Co. (Strecker, 1931: 38 [not seen]); Falcon Reservoir, 8 mi S of Zapata, Zapata Co. (MCZ).

RIO SALADO DRAINAGE.-- *State of Coahuila, Mexico:* Rio Sabinas (MCZ). *State of Nuevo Leon, Mexico*: sediments of Rio Salado, 24 km S of Anahuac (Metcalf, 1982: Loc. 11 [not seen]).

RIO GRANDE DRAINAGE.-- *Texas*: Resaca, Mercedes, Hidalgo Co. (MCZ). *Texas*: Cottingham Resaca, Brownsville (Neck, 1987: 160, Corpus Christi Museum 87S054 [not seen]); Resaca, 4 mi E of Brownsville (MCZ); *both* Cameron Co.

Genus *Toxolasma* Rafinesque, 1831

Type species: *Unio lividus* Rafinesque; by elimination [=subsequent designation], Frierson (1914: 7). Ortmann and Walker (1922: 54-55) showed *U. lividus* to be a *nomen dubium* and stated that therefore *Toxolasma* must

disregarded. Nevertheless, on the mere statement of Morrison (1969: 24) that "*Toxolasma livida* Raf. 1831 (= *glans* Lea, Dec. 1831)," Valentine and Stansbery (1971: 29) resurrected this generic name, claiming that it has priority over *Carunculina* (see Johnson, 1972: 230).

Toxolasma has been subsequently used in place of *Carunculina* by most authors; thus it is now employed here in the supposed interest of stability.

***Toxolasma parvus* (Barnes, 1823)**

(Plate 3, figure 3)
(Plate 4, figures 1-3)
(Plate 5, figures 1-3)

Recent references

Toxolasma parvus (Barnes) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 131 with figs., p. 216 with color figs.; Neck and Metcalf, 1988: 263; Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*; p. 232, pl. 115, map 114.

Toxolasma texasensis (Lea) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 133, with figs., p. 216 with color figs; Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*; p. 233, pl. 116, map 115.

Carunculina parva texasensis (Lea) -- Strecker, 1931: 45.

Carunculina parva compressa (Simpson) -- Strecker, 1931:47.

Carunculina parva mearnsi (Simpson) -- Strecker, 1931: 47.

Relevant synonymy

Unio haleianus Lea, 1842, *TAPS* **8**: 247, pl. 27, fig. 63 (Obs. Unio **3**: 85). Holotype USNM 85306 (only specimen) [male] ([Red River,] Alexandria, [Rapides Parish, Louisiana]).

Unio texasensis Lea, 1857, *PANSP* **9**: 84; 1860, *JANSP(2)* **4**: 359, pl. 61, fig. 184 (Obs. Unio **8**: 41). Lectotype USNM 85302 [male] ([Guadalupe River,] Dewitt Co., Texas) inadvertently selected by Johnson (1974: 145) as the "figured holotype."

Unio bairdianus Lea, 1857, *PANSP* **9**: 102; 1860, *JANSPE (2)* **4**: 361, pl. 61, fig. 186 (Obs. Unio **8**: 43). Type lost (Devils River, [Val Verde Co.,] Texas); probable syntype MCZ 316413, male

specimen thought to be the one mentioned by Lea as from "Mississippi" in the J.G. Anthony collection.

Unio beali Lea, 1862, *PANSP* **14**: 169; 1862, *JANSP(2)* **5**: 204, pl. 30, fig. 273 (Obs. Unio **9**: 26). Lectotype USNM 85305 [male] ([Trinity River,] Leon Co., Texas) inadvertently selected by Johnson (1974: 19) as the "figured holotype."

Lampsilis texasensis compressus Simpson, 1900, *Proc. USNM* **22**: 564; 1914, *Cat. naiades* **1**: 150. Lectotype USNM 152059 [male] (southwest Texas) selected by Johnson (1975: 11, pl. 1., fig. 5 from Las Moras Creek, Fort Clark [= Brackettville, Kinney Co.], Texas).

Lampsilis mearnsi Simpson, 1900, *PANSP* **52**: 75, pl. 1, fig. 4. Lectotype USNM 151549 [female] (vicinity of Fort Clark [= Brackettville, Kinney Co.], Texas) inadvertently selected by Johnson (1975: 14) as the "figured type;" allotype USNM 151549. The label now gives the locality as, "Elm Cr. 27 [corrected from 20] mi from Fort Clark." Mearns (1907: 75), in his description of Station 2, makes no mention of Elm Creek (now Pinto Creek) flowing into the Rio Grande west of Fort Clarke or Elm Creek to the east, an intermediate tributary to the Nueces River. His description of Station 2 does, however, mention that the head of Las Moras Creek is at Fort Clark and at a pool about 20 mi south of the Fort, *Alligator mississipiensis* Daudin was taken. Mearns was at Fort Clark from November 1892 - July 1893, and again from November 1897 - June 1898. Topotypes MCZ 87962 from Mearns, ca. 1898, are more precisely labeled as "pool, 20 mi S. Fort Clark, Kinney Co., Texas," and the type locality is here so restricted.

NOMENCLATURAL REMARKS.-- Call (1896) monographed "the *parvus* group of Unionidae," placing in synonymy many of the described taxa. While he retained *texasensis* as a species, he appears to have done do with some reluctance stating, "this form illustrates the erection of a species name upon characters that are but an expression of sex." *Toxolasma parvus* was reported from resacas on the lower Rio Grande by Neck and Metcalf (1988: 263) where specimens were said to "vary from slightly yellow brown to dark brown in color." Vidrine (1993: 169) regarded *parvus* as a creek species which showed very little sexual dimorphism and had a relatively smooth periostracum,

whereas *texasensis* was a species of larger rivers, lakes, and ponds that exhibited considerable sexual dimorphism and had a rough periostracum.

Specimens throughout the range of *parvus* have been identified as *texasensis*. Parmalee (1967: 61), for example, after describing *texasensis* from Illinois, suggested that it "is quite similar to *Carunculina parva*, only larger, and it may be only a form or variant." The three localities he gave for it (North Fork Saline River, Galatin Co.; Big Muddy River and Crab Orchard Lake, both in Williamson Co.) provide soft-substrate habitats; these are where the largest specimens, measuring 2.25 inches in length were collected. This suggests an environment similar to that mentioned for *texasensis* by Vidrine (1993).

In addition to *Unio bardianus* (female) and *U. beali* (male) which, like *U. texasensis* were described from Texas, and *U. haleianus* from Louisiana, there are two additional ecophenotypes described by Simpson. These, from the most southern extension of the range of *T. parvus,* were named as *Lampsilis texasensis compressus* and *L. mearnsi.* Both were from Las Moras Creek, a tributary of the Rio Grande, Texas. The former, from the headwaters of the creek has a thin, compressed shell with a yellowish-green to light brown periostracum. It was reported by Strecker (1931: 47) as being most abundant in small streams fed by springs in the southwestern part of Texas.

It will be noted that *mearnsi* was from a "pool," some distance from the headwaters of Las Moras Creek. Specimens have a heavy, inflated shell with a yellowish-green to light brown periostracum. Strecker (1931: 47) reported it as also from the Medina River, Medina Dam, and several other localities in the San Antonio River System [none of these seen]. Two specimens, MCZ 235490 from

the Nueces River System, Lake Corpus Christi, Mathis, San Patrico Co., Texas, resemble closely the type of *mearnsi*. Howells (1997: 32), using specimens from the Nueces River System that he regarded as *mearnsi* and specimens from the Colorado River System north to the Neches River System, determined as *texasensis*, concluded, on the basis of electrophoretic analyses, that *mearnsi* "has yet to display genetic differences to distinguish it from *T. texasensis*." However, on the basis of *T. parvus* from the Falcon Reservoir, further south on the Rio Grande, Howells also suggested that, "although the number of specimens and enzyme systems has been limited, these preliminary data suggest *T. parvus* and *T. texasensis* are clearly distinct." The specimens he examined from the reservoir might be thought of as coming from a pond on a large river. It could have been expected that they, like other samples studied, would prove to be *texasensis*. *Toxolasma parvus* is regarded here as a single variable species to which *texasensis* is but one of the several nomina that have been applied to specimens from the Rio Grande.

DISTRIBUTION.--Mississippian Region; Great Lakes into western New York state, west to Minnesota, southern Canada; Peninsular Florida; Apalachicolan Region; Gulf Coastal Region west to the Rio Grande System.

RECORDS

RIO GRANDE SYSTEM

DEVILS RIVER DRAINAGE.-- *Texas*: Devils River, [Val Verde Co.] (*Unio bairdianus* Lea; USNM).

LAS MORAS CREEK DRAINAGE.-- *Texas*: Las Moras Creek [headwaters], Fort Clark [= Brackettville] (*Lampsilis texasensis compressus* Simpson; USNM MCZ); [pool] ca. 20 mi S of Fort Clark [= Brackettville] (*Lampsilis mearnsi* Simpson; USNM, MCZ); *both* Kinney Co.

RIO GRANDE DRAINAGE.-- *Texas*: Falcon Reservoir, [Zapata Co.] (Howells, 1997: 32 [not seen]); Resacas, lower Rio Grande (Neck and Metcalf, 1988: 263 [not seen]).

Genus *Truncilla* Rafinesque, 1820

Type species: *Truncilla truncata* Rafinesque, 1820; subsequent designation by Herrmannsen (1849: 628).

***Truncilla donaciformis* (Lea)**

(Plate 7, figures 1-6)

Recent references

Truncilla donaciformis (Lea) -- Howells *et al.*, 1996, *Freshwater mussels of Texas*: p. 141, with figs., p. 217 with col. figs.; Strecker, 1931: 48; Parmalee and Bogan, 1998, *Freshwater mussels of Tennessee*: p. 236, pl. 118, map 117.

Truncilla macrodon (Lea) -- Howells *et al.* 1996. *Freshwater mussels of Texas*: p. 143, with figs., p. 217 with col. figs.; Strecker, 1931: 48.

Truncilla cognata non Lea, 1860 -- Howells *et al.* 1996, *Freshwater mussels of Texas*: p., 139 with figs, pl. 217 with col. figs. [first figure identified as *T. macrodon*]; Metcalf, 1982: 48.

Plagiola cognata (Lea) -- Simpson 1914, *Cat. naiades* 1: 310.

Relevant synonymy

Unio donaciformis Lea, 1828, TAPS **3**: 267, pl.4, fig. 3 (Obs. Unio **1**: 9). Lectotype USNM 84457 (Ohio) inadvertently selected by Johnson (1974: 49) as the "figured holotype."

Unio zigzag Lea, 1829, TAPS **3**: 440, pl. 12, fig. 19 (Obs. Unio **1**: 54). Type lost (Ohio).

Unio macrodon Lea, 1859, PANSP **11**: 154; 1863, JANSP (2) **5**: 193, pl. 26, fig. 262 (Obs. Unio **9**: 15) Holotype [based on two opposing valves] USNM 25711 ([Colorado River] Rutersville [Fayette Co.], Texas).

Unio cognatus Lea, 1860, PANSP **12**: 306; 1860, *JANSP(2)* **4**: 368, pl. 65, fig. 193 (Obs. Unio **8**:50). Holotype USNM 85004 (single valve only) (Rio Salado [State of] New [Nuevo] Leon, Mexico).

NOMENCLATURAL REMARKS.-- In the first attempt to revise these taxa, introduced by Issac Lea, and now placed

in *Truncilla*, Simpson (1900: 605) admitted to the difficulty in separating *donaciformis* and *macrodon*. He later wrote (1914: 309) of *donaciformis* that, "the pattern of coloring varies greatly, there being shells with unbroken rays...and that rarely the shell is a uniform ashy or dirty yellowish green. It is generally more inflated than *macrodon*, but it is quite probable that it gradually merges with that species in the southwest," though he (1914: 310) did concede that "*macrodon* was, less inflated and rather longer than *donaciformis*, the color patterns less vivid and [the shell] not quite as sharply pointed behind. The female shell especially is quite blunt." Strecker (1931: 48), with more material at his disposal, claimed that while typical specimens of *donaciformis* were rare in Texas, it probably intergrated with *macrodon*. While Howells *et al.* (1996: 32) regarded *macrodon* as an endemic species confined to central Texas, they also admitted (p. 142) that their concept of the validity of *truncata*, *macrodon*, and *cognata* may be questionable. The validity of *T. truncata,* a distinct and widely distributed species (see: Vidrine, 1993: 184, pl. 18, figs. P-Y, maps 130-131), is not questioned. The specimens figured by Howells, *et al.* (1996: 139) as *cognata*, *donaciformis*, and *macrodon*, as well as those mentioned by Metcalf (1982: 48), are thought to be *donaciformis*. It is a widely distributed species, the shell of which is variable and shows sexual dimorphism. *T. cognata* was based on a single old valve, and Simpson (1914: 310) described it as being close to *macrodon* and *donaciformis*, but mentioned that the shell was heavier and more inflated than either of them. His description was based on the type and an additional left valve from the Rio Salado Drainage (Plate 7, fig. 4),

subsequently identified as *macrodon*. *T. cognata* is regarded here as merely an old specimen of *donaciformis*.

DISTRIBUTION. -- Mississippian Region; Great Lakes: Michigan and Erie; Mobile Basin; Gulf Coastal Region west to the Rio Grande.

RECORDS

RIO GRANDE SYSTEM

RIO GRANDE DRAINAGE.-- *Texas*: Rio Grande, 9.7 km W of Del Rio (Metcalf, 1982: loc. 18 [MCZ]); Rio Grande (Howells *et al.*, 1996: 139, figs.); *both* Val Verde Co. Rio Grande, Eagle Pass, Maverick Co. (Metcalf, 1982: 48 [listed as *cognata*, not seen]).

RIO SALADO DRAINAGE.--*State of Nuevo Leon, Mexico:* Rio Salado (Holotype of *U. cognatus*, USNM 85004); Rio Salado, 10 km W of Anahuac [fossil specimens] (Metcalf, 1982: 48 [not seen]. *State of Tamaulipas, Mexico:* Rio Salado, near Nuevo Larado (USNM 85004a and 257105).

GUADALOUPE RIVER SYSTEM

GUADALOUPE RIVER DRAINAGE.-- *Texas*: Wimberly Lake, Hayes Co. (MCZ); Guadaloupe River, Victoria Co. (USNM).

COLORADO RIVER SYSTEM

CONCHOS RIVER DRAINAGE.-- *Texas*: Conchos River, Tom Green Co. (Howells *et al.*, 1996: 144 [listed as *macrodon*, not seen]).

LLANO RIVER DRAINAGE.-- *Texas*: Llano River, Mason Co. (Strecker, 1931: 48 [listed as *macrodon*, not seen]); Llano River, Bessemer Co. (USNM).

COLORADO RIVER DRAINAGE.-- *Texas*: Colorado River, Burnet Co. (Strecker, 1931: 48 [listed as *macrodon*, not seen]); Colorado River, Austin (MCZ) and Webberville (USNM); both Travis Co.; Colorado River, Colorado Co. (Strecker, 1931: 48 [listed as *macrodon*, not seen]); Colorado River, Wharton, Wharton Co. (MCZ).

BRAZOS RIVER SYSTEM

BRAZOS RIVER DRAINAGE.-- *Texas*: [Brazos River] Stephens Co. (Howells, et al., 1996: 144 [listed as *macrodon*]).

BOSQUE RIVER DRAINAGE.-- *Texas:* North Bosque River (MCZ) and China (USNM); Bosque River (Strecker, 1931: 48 [listed as *macrodon*, not seen]); *all* McLennan Co.

BRAZOS RIVER DRAINAGE.-- *Texas*: Aquilla Creek (Strecker, 1931: 48 [listed as *macrodon*, not seen]); Walkers Crossing [not located] (MCZ); [Brazos River] Waco (Strecker, 1931: 48 [listed as *macrodon*, not seen]); *all* McLennan Co.

LITTLE RIVER DRAINAGE.-- *Texas*: Leon River, Coryelle Co. (Strecker, 1931: 48 [listed as *macrodon*, not seen]). Brushy Creek, Thorndale, Milan Co. (USNM).

BRAZOS RIVER DRAINAGE.-- *Texas*: Brazos River, Robertson Co. (Strecker, 1931: 48 [listed as *macrodon,* not seen]). Brazos River, 11 mi SW Bryan, Brazos Co. (MCZ); race canal, nr. Ancola, Fort Bend Co. (Howells, *et al.*, 1996: 143, figs.)

TRINITY RIVER SYSTEM

TRINITY RIVER DRAINAGE.-- *Texas*: Trinity River; Elm Fork of Trinity River, nr. Owens Ferry, *both* Dallas Co. (*both* USNM); Chambers Creek of Trinity River, Navarro Co. (Strecker, 1931: 48 [listed as *donaciformis*, not seen].

SAN JACINTO RIVER SYSTEM

SAN JACINTO RIVER DRAINAGE.-- *Texas*: San Jacinto River, Montgomery Co. (Murray [in] Howells *et al.* 1996: 142 [listed as *donaciformis*, not seen])

NECHES RIVER SYSTEM

NECHES RIVER DRAINAGE.-- *Texas*: Neches River, Smith Co. (Strecker, 1931: 48 [listed as *donaciformis*, not seen]); Neches River, Rockland (UMMZ) and Town Bluff (MCZ), *both* Tyler Co., Neches River, Silsbee, Hardin Co. (Vidrine 1993, pl. 18, figs M-O).

SABINE RIVER SYSTEM

SABINE RIVER DRAINAGE.-- *Texas*: Sabine River, Smith Co. (USNM) Sabine River, Panola Co. (Howells *et al.*, 1996: 146 [not seen]). *Louisiana*: Sabine River, 18 mi SW Many, Sabine Parish (MCZ); Sabine River, Burr Ferry, Verona Parish (MCZ).

CALCACIEU RIVER SYSTEM

CALCACIEU RIVER DRAINAGE.-- *Louisiana*: Whiskey Chitto Creek; [Lake Charles]; (*both* Vidrine 1993, based on map 129).

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Key to the principal river systems mentioned in text.

Western Gulf Coastal Region

RIO GRANDE SUBPROVINCE

a. Rio Grande System

b. San Jose River

c. Pecos River

d. Lake McMillan Reservoir

e. Rio Conchos

f. Amistad Reservoir

g. Devils River

Pinto Creek*

h. Las Moras Creek

Elm Creek*

San Lorenzo Creek*

San Isabell Creek*

i. Rio Salado

j. Falcon Reservioir

k. Rio San Juan

m. Presa de El Azucar

CENTRAL TEXAS SUBPROVINCE

1. Baffin Drainage Basin

2. Nueces River System

3. San Antonio River System

4. Guadalupe River System

5. Colorado River System

6. San Saba River Drainage

7. Llano River Drainage

8. Brazos River System

Sabine Subprovince

9. San Jacinto River System

10. Trinity River System

11. Neches River System

12. Sabine River System

13. Calcasieu River System

Mexican Gulf Coastal Region

I. Rio Conchos (or Rio San Fernando) System

II. Rio Sota de Marina System

III. Rio Tamesi System

IV. Rio Cazones System

V. Rio Cotaxla System

VI. Rio Panaloapan System

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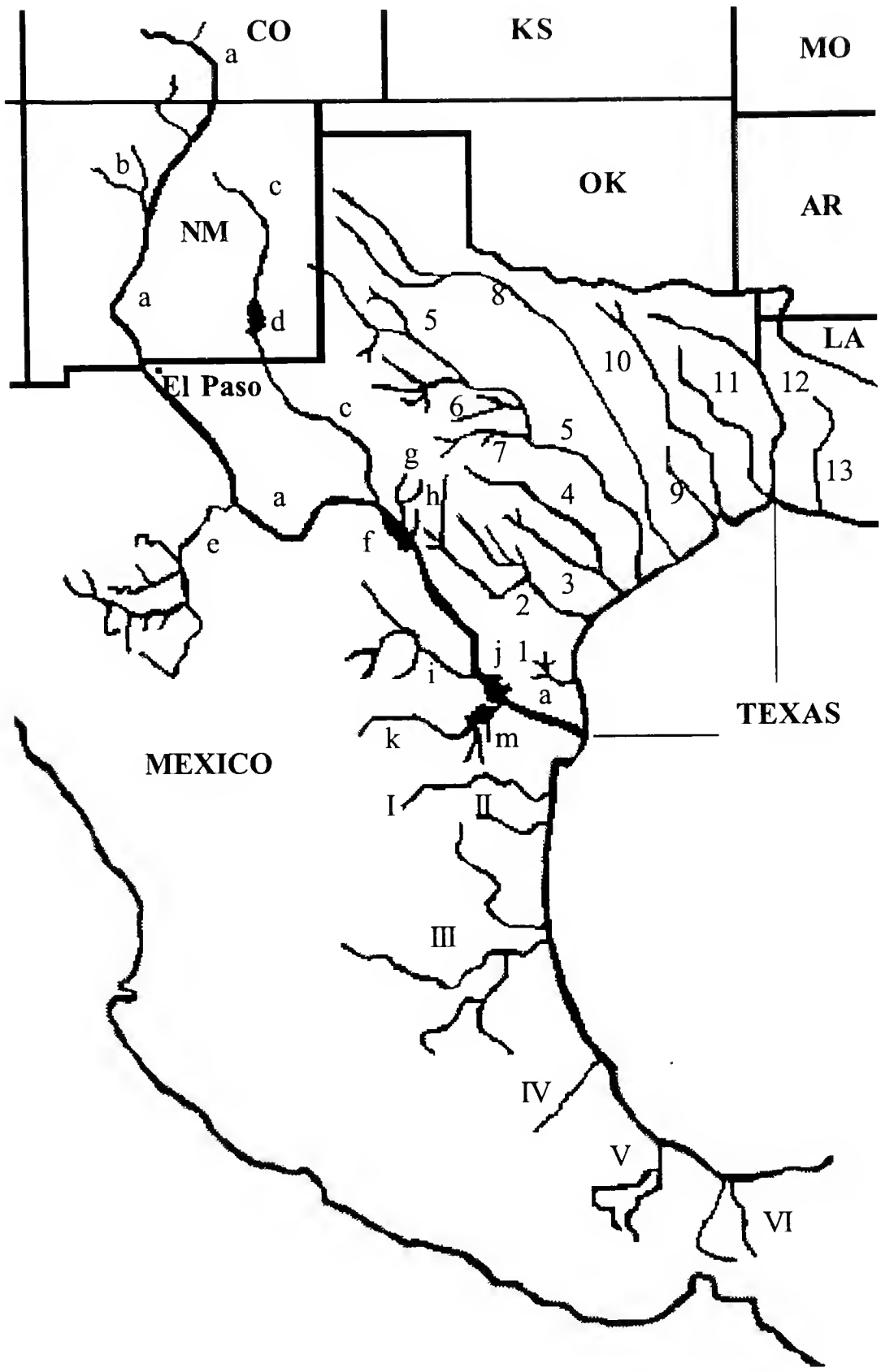
* In Table by order of appearance in text, but not indicated on Map 1.



Map 1

(The above map is an adumbration of the principal river systems mentioned in the text and listed in Table 2.)

Plate 1

Anodonta (*Utterbackia*) *imbecillis* Say, 1829

Fig. 1. *Anodonta henryana* Lea, 1857. Matamoras, State of Tamulipas, Mexico. Lectotype USNM 86692. Length 72.5 mm, height 39.5 mm, width 26 mm (approx. 1.25x).

Meglonaias nervosa (Rafinesque, 1820)

Fig. 2. *Unio eightsii* Lea, 1860. Sabinas River, State of New [Nuevo] Leon, Mexico. Lectotype USNM 83991. Length 117 mm, height 85 mm, width 45.5 mm (approx. nat. size).

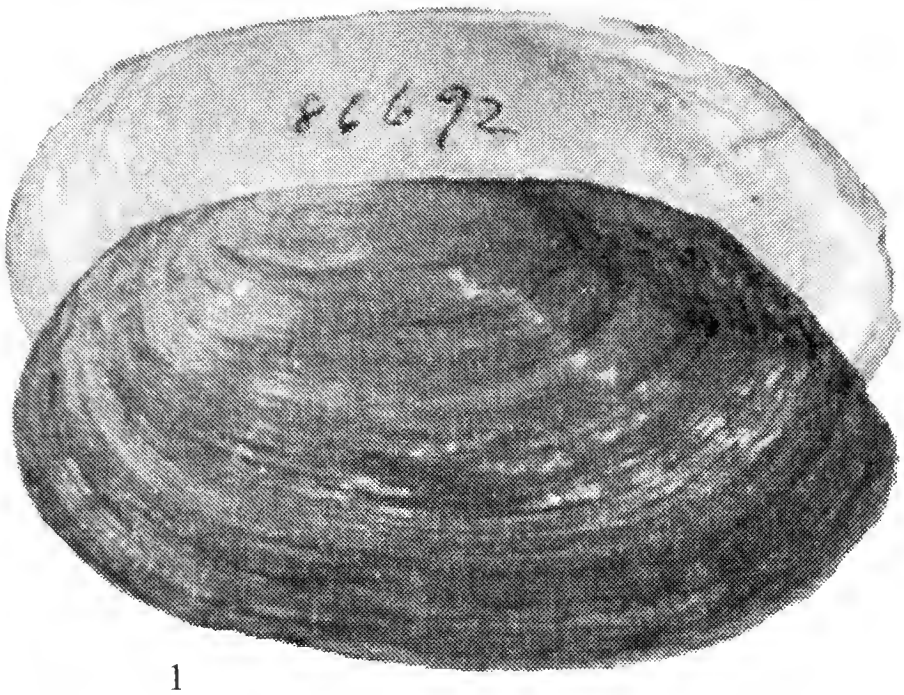


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Plate 1

Plate 2

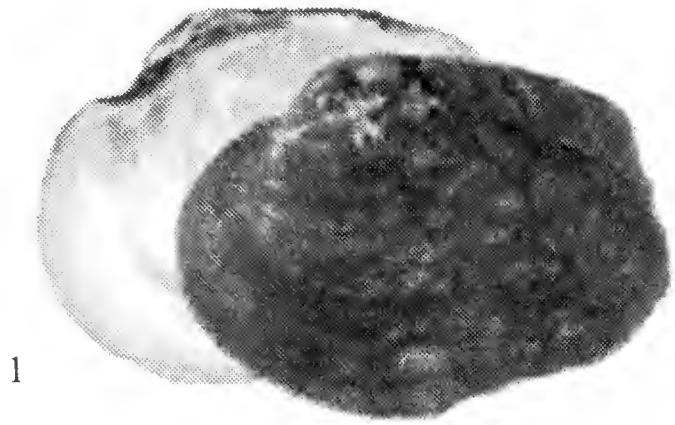
Quadrula (*Quadrula*) *conchiana* (Lea, 1860)

Fig. 1. *Unio couchianus* Lea, 1860. Rio Salado. [State of] New [Nuevo] Leon. Mexico. Lectotype USNM 85728. Length 47 mm, height 35 mm, width 25 mm (approx. 1.5x).

Quincuncina mitchelli (Simpson, 1895)

Fig. 2. *Unio mitchelli* Simpson, 1895. Guadalupe River, Victoria Co., Texas. Lectotype USNM 128364. Length 54 mm, height 32.5 mm, width 21 mm (approx. 1.5x).

Fig. 3. *Unio mitchelli elongatus* Simpson, 1914. Guadelupe River, near Kerrville, Kerr Co., Texas. Lectotype USNM 128364. Length 84 mm, height 46 mm, width 28 mm (approx. nat. size).



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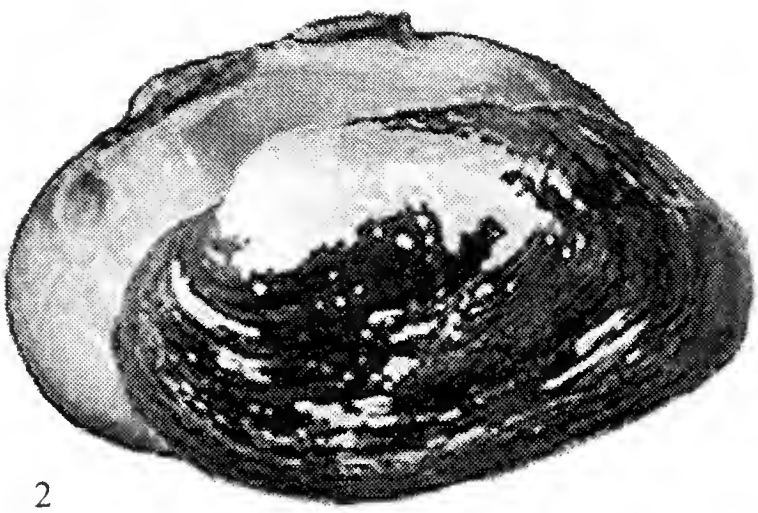

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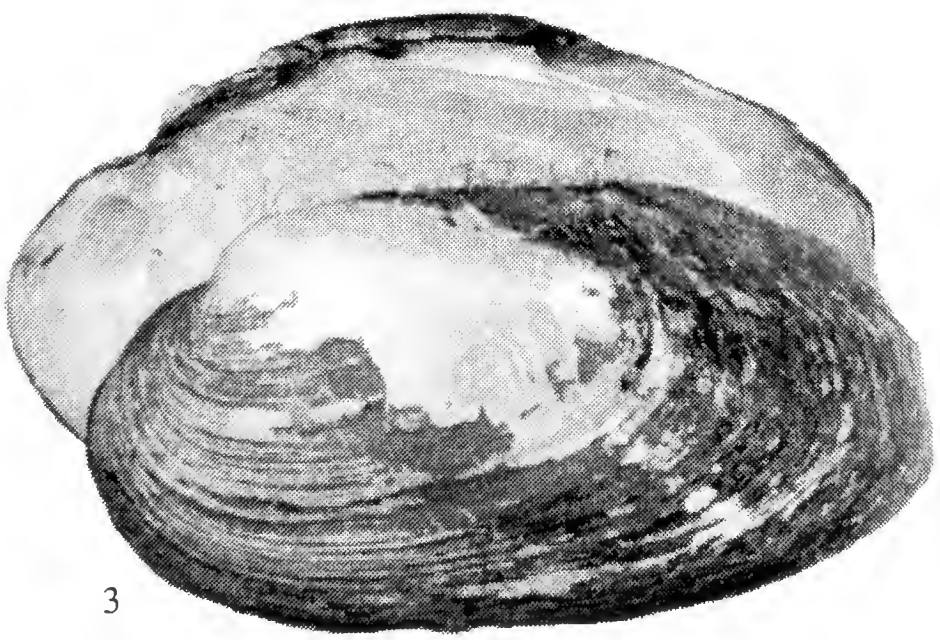

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Plate 2

Plate 3

Quincuncina mitchelli (Simpson, 1895)

Fig. 1. *Unio iheringi* B.H. Wright, 1896. San Saba River, Menard Co., Texas. Lectotype USNM 152171. Length 52 mm, height 34 mm, width 20 mm. (approx. 1.5x).

Fig. 2. *Quadrula* (*Quincuncina*) *guadalupensis* Wurtz, 1950. Guadalupe River, above Seguin, Guadalupe Co., Texas. Holotype ANSP 185974. Length 51 mm, height 32.3 mm, width 17.1 mm

Toxolasma parvus (Barnes, 1823)

Fig. 3. *Unio haleianus* Lea, 1842. [Red River], Alexandria, [Rapides Parish, Louisiana]. Holotype USNM 85306 [male]. Length 69 mm, height 39 mm, width 25 mm. (approx. 1.5x).

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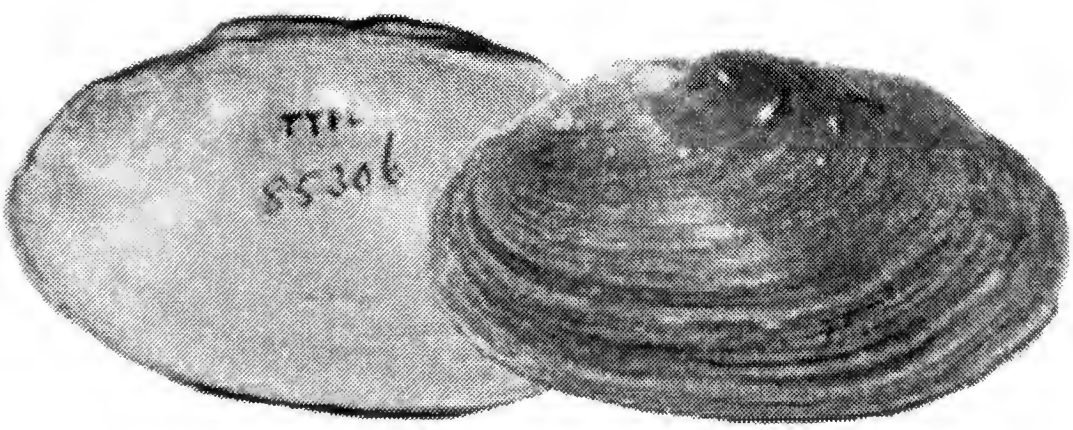

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Plate 3

Plate 4

Toxolasma parvus (Barnes, 1823)

Fig. 1. *Unio texasensis* Lea, 1857. [Guadalupe River], Dewitt Co., Texas). Holotype USNM 85302 [male]. Length 37 mm, height 19 mm, width 13 mm. (approx. 1.5X).

Fig. 2. *Unio bardianus* Lea, 1857. Devils River [Val Verde Co.], Texas. Figured type [lost, female]. Length 41 mm, height 23 mm, width 14 mm (natural size), from Lea (approx. nat. size).

Fig. 3. *Unio bealei* Lea, 1862. [Trinity River], Leon Co., Texas. Holotype USNM 85305 [male]. Length 45 mm, height 26 mm, width 15 mm (approx. 1.5X).

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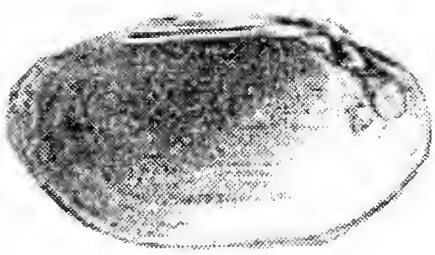

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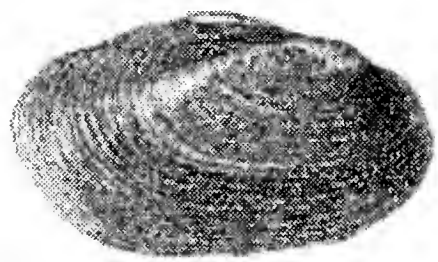

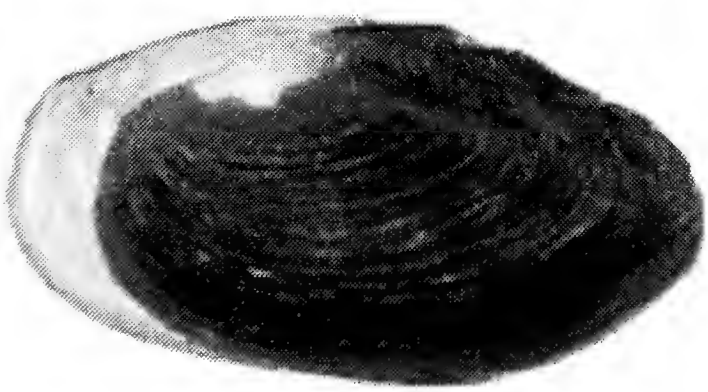

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Plate 4

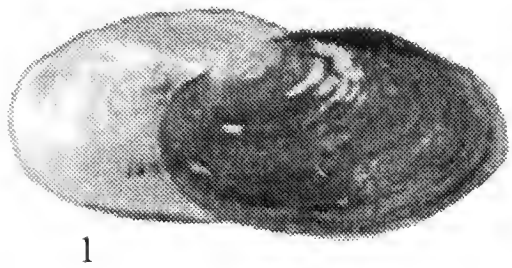
Plate 5

Toxolasma parvus (Barnes, 1823)

Fig. 1. *Lampsilis texasensis compressus* Simpson, 1900. Las Moras Creek, Fort Clark [=Brackettville, Kinney County], Texas. Lectotype USNM 152059 [male]. Length 41.5 mm, height 25 mm, width 12 mm (approx. 1.5X).

Fig. 2. *Lampsilis mearnsi* Simpson, 1900. [Las Moras Creek, a pool about 20 mi. S] Fort Clark[Brackettville, Kinney County], Texas. Holotype USNM 151549 [male]. Length 52 mm, height 34 mm, width 22.5 mm (approx. 1.5X).

Fig. 3. *Ibid.* Allotype [also] USNM 151549. Length 54 mm, height 31 mm, width 22 mm (approx. 1.5X).



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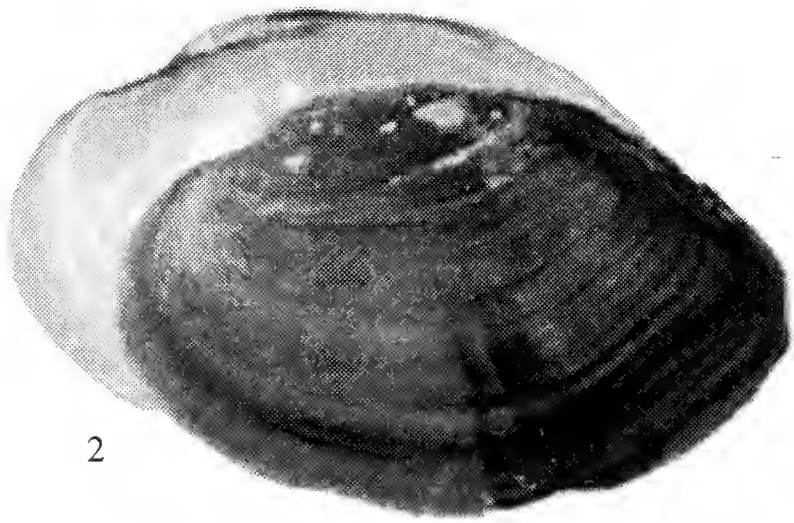

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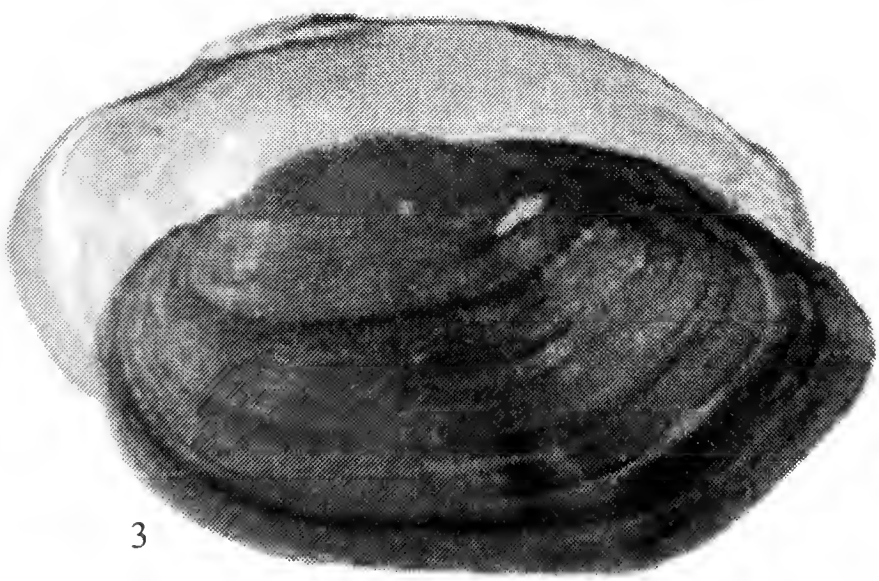

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Plate 5

Plate 6

Popenaias popei (Lea, 1857)

Fig. 1. *Unio popei* Lea, 1857. Rio Salado, State of New [Nuevo] Leon, Mexico. Lectotype USNM 85859. Length 58.5 mm, height 28 mm, width 15 mm (approx. 1.5X).

Uniomerus tetralasmus (Say, 1831)

Fig. 2. *Unio manubius* Gould, 1855 [Rio Agualeguas, Puntiagudo ca. 5 km NE General Trevino, State of Nuevo Leon, Mexico]. Lectotype MCZ 169447. Length 94 mm, height 46 mm, width 31 mm (approx. nat. size).

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Plate 6

Plate 7

Truncilla donaciformis (Lea, 1828)

Fig. 1. *Unio donaciformis* Lea, 1828. Ohio. Paralectotype USNM 84457 [male]. Length 45 mm, height 28 mm, width 18 mm (approx. nat. size), [larger than the lectotype which measures: length 38 mm, height 25 mm, width 18 mm].

Fig. 2. *Ibid.* Allotype [also] USNM 84457. Length 42 mm, height 30 mm, width 19 mm (approx. nat. size).

Fig. 3. *Unio zigzag* Lea, 1829. Ohio. Figured type [lost, male]. Length 38 mm, height 23 mm, width 15 mm (natural size), from Lea (approx. nat. size).

Fig. 4. Rio Salado, Nuevo Lorado, [State of] Tamaulipas. USNM 85004a. [single valve only]. Length 24 mm, height 17 mm, width 12 mm (approx. nat. size).

Fig. 5. *Unio cognatus* Lea, 1860. Rio Salado [State of] New [Nuevo] Leon, Mexico. Holotype USNM 85004 [probably female, single valve only]. Length 44 mm, height 28.5 mm, width 20 mm (approx. nat. size).

Fig. 6. *Unio macrodon* Lea, 1859. [Colorado River]. Rutersville, [Fayette Co.], Texas. Holotype USNM 25714 [male, unmatched valves]. Length 48 mm, height 25.5 mm, width 10 mm (approx. nat. size).

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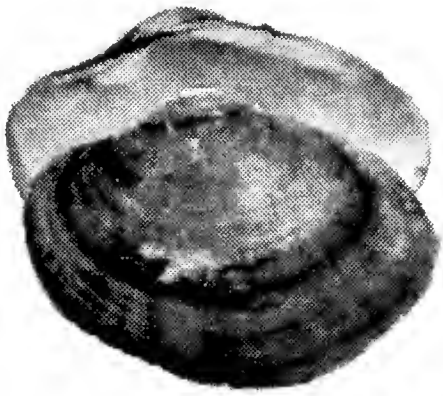

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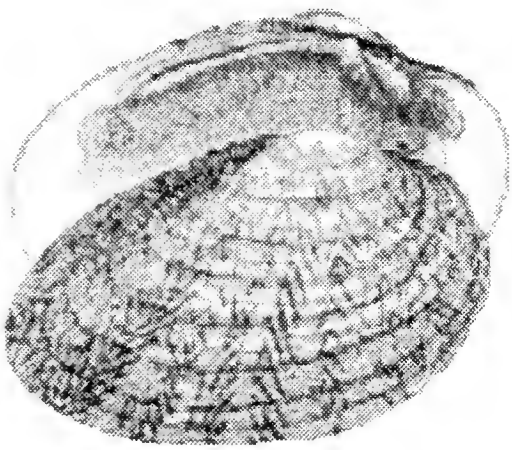

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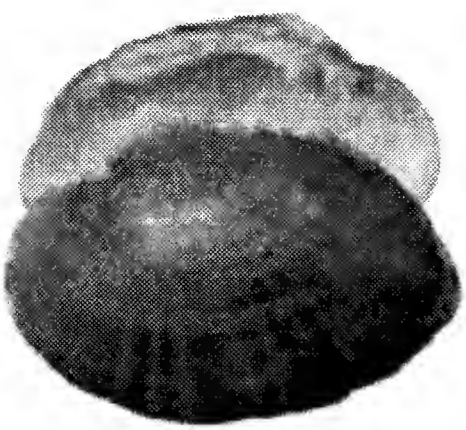

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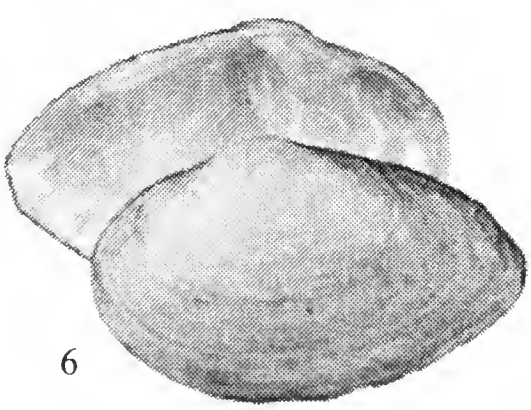

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Plate 7

TAXA OMITTED FROM "UNIONACEA" BY FRITZ HAAS, 1969

Richard I. Johnson

While searching for the type species of *Arotonaias* Martens 1900, Kabat and Boss (1997: 104) noted that this generic name was not included in the monumental compendium on the Unionacea by Haas (1969) which was meant to be complete to that date. Haas based his classification of the North and Central American species mostly on the work of Frierson (1927), which was then the latest synthesis. He inadvertently skipped over *Arotonaias*, which had appeared on the top of page 92, and missed the three species listed under it, and, of course, its type species, *Unio cyrenoides* Philippi 1847, selected by subsequent designation (Frierson, 1927: 11). The missing taxa, with their synonyms, which were also omitted, are listed below.

Arotonaias cyrenoides (Philippi, 1847)

Unio cyrenoides Philippi.
Unio sagrinatus Sowerby, 1868.
Unio newcombianus Lea, 1856.
Unio gabbianus Martens (non Lea) 1900, p. 498 pl. 39, figs. 5, 5a, 5b

Arotonaias imbricata (Morch, 1860)

Unio imbricatus Morch.
Unio encarpus Lea, 1868.

Arotonaias gabbiana (Lea, 1868)

Unio gabbianus Lea.
Unio nicaraguaensis Lea, 1868.

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THE DUCHESS, THE BRAHMIN, AND THE CHANK SHELL

Richard I. Johnson[1]

Serious shell collecting began during the Renaissance, first among general scholars or naturalists such as the humanist scholar, Desiderius Erasmus of Rotterdam, (1467-1536); the Swiss Father of Zoology, Conrad Gesner, (1516-65); and the encyclopedist, Ulisse Aldrovandi of Bologna, (1552-1605). These generalists were succeeded by physicians, such as Martin Lister (1639-1712), and apothecaries, such as Albert Seba (1665-1736). Then there were the nobility who could have their shell collections described and figured in elegant volumes such as that by Niccolo Gualtieri (1688-1744) on the collection of Cosimo de'Medici of Florence (Coomans, 1985).

By the late 18th century shell collections and curio collections had become the rage among royalty and the nobility. On April 24, 1786 began the sale of the "Genuine

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collection of the late Noble Possessor, Margaret Cavendish Bentinck (1714-1785), Duchess Dowager of Portland" which lasted for thirty-seven days. The preface to the auction catalogue claimed that this shell collection was the finest in Europe, that one fourth of the species had not been named by Linnaeus. Her Grace that had wished to have these described by the latter's pupil, Dr. David Solander (1736-1782), who died before finishing the task. When she died three years later, it was discovered she was heavily in debt, hence the auction. During her lifetime the Duchess became the leader of the British dilettanti. She entertained many visitors at both her mansion in Whitehall and at her great house at Bulstrode in Buckinghamshire. It is said that she was equally at home serving breakfast to King George III or botanising with Jean Jacques Rousseau (Dance, 1986: 73).

Solander and Sir Joseph Banks (1744-1820) had accompanied Captain James Cook (1728-1779) on his first voyage of discovery (1768-1771), and the friendly relations of the Duchess with them made it possible for her to acquire many rare shells that had been brought back on the *Endeaver* from the "South Sea." Wilkins (1955) gives a vivid account of both Solander and Banks, as well as details on the subsequent dispersal of the Portland Museum.

The anonymously printed catalogue, usually referred to as *The Portland Catalogue*, contains a number of new molluscan names based on figures from pre-Linnaean works that are regarded as having been validly introduced. A number of them are followed by an "S." Dance (1962) showed that all these molluscan names should be attributed to the Rev. John Lightfoot (1732-1788), chaplain, librarian, and mentor to Her Grace, and himself a student of botany and conchology, since it was he who produced the auction

catalogue. Copies of *The Catalogue* were numbered, 1224 being the highest I have seen.

In the world of Art, the most famous piece in the collection was the so-called Portland Vase. It is illustrated in an engraving, present in some copies of the *Catalogue*, which, with the aid of an imaginary mirror, shows it from both sides (Figure 1). The vase, in the Greek style, was probably made in Rome during the reign of the first emperor Augustus (27BC-14AD), and had been in the Barberini Palace, Rome in 1642. It was purchased by Sir William Hamilton and sold in 1784 to the Duchess of Portland just a year before her death (Keynes, 1998). It was the penultimate lot auctioned, 4155, and *The Catalogue* reveals "It is the identical urn which contained the ashes of the Roman emperor Alexander Serverus and his mother Mammea, which was deposited in the earth about the year 235 after Christ, and was dug up by order of Pope Barberini named Urban VIII between the years 1623 and 1644." It was purchased at the auction by the third Duke of Portland for 980 guineas, loaned to the British Museum in 1810, and was finally purchased by the Museum's trustees during 1945. It had been smashed by a crazy scene-painter in 1845 and rather poorly repaired. It was later more carefully restored as reported in *The Illustrated London News* (Anonymous, 1946), and even more so in 1988-89 (Williams, 1989). A recent exhibit of *The Art of the Victoria and Albert Museum* (Poulet, 1998) at Boston's Museum of Fine Arts, included one of the thirty-one original reproductions of this celebrated vase (ca. 1790) by

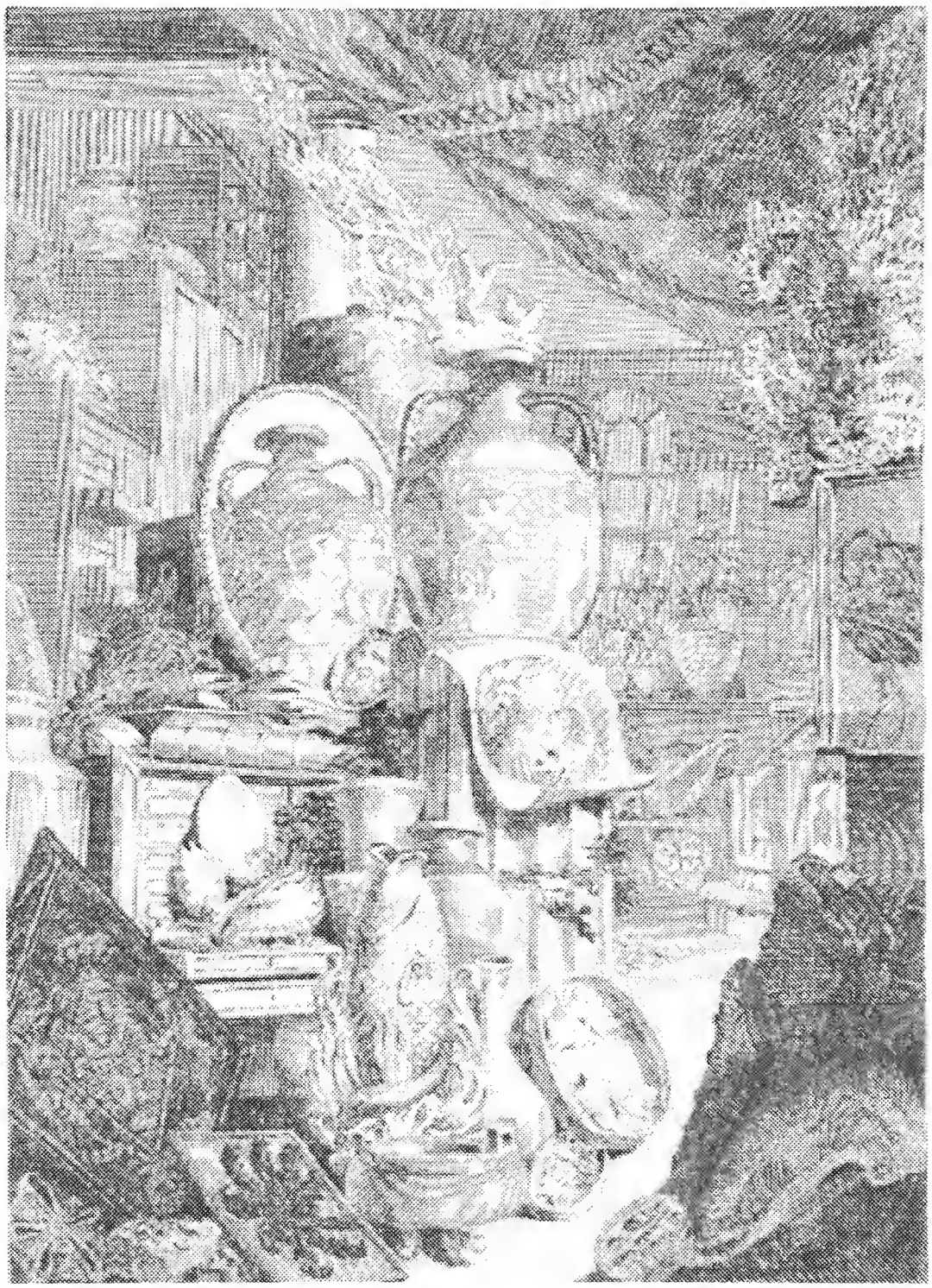

Figure 1. Frontispiece to "*The Portland Catalogue*" (Reduced in size)

the famous potter Josiah Wedgwood, (Baker and Richardson 1998: 309, fig. 140) who was the grandfather of Charles Darwin's wife, Emma. Viewing the vase brought to mind the Boston collector, Gretchen Osgood Warren who like de'Medici and the Duchess, had both position and money which she used to enhance her shell collection.

Mrs. Warren was the eldest child of Boston Brahmins, Hamilton Osgood and Margaret Cushing Pearmain. Osgood was a well-known doctor who had studied in Europe with Rudolf L.C. Virchow (1821-1902), probably the most prominent nineteenth century, German physician and later with Louis Pasteur (1822-1905) in Paris. Osgood brought Pasteur's rabies antitoxin back to the United States, which made him famous. His daughter Gretchen was both beautiful and talented. She studied singing as a mezzo-soprano under Gabriel Fauré. Later, in 1907, when she and her husband were studying at Oxford, she won a Double First in Philosophy. Returning to the United States, she was offered a lectureship at Wellesley College and a deanship at Radcliffe, both declined. On the recommendation of William James, her article, *A Philosophical Aspect of Science,* was published in 1910. It was rather critically dealt with by the anonymous editor of *The Monist* (Anonymous, 1910).

Gretchen married Frederick Fiske Warren in 1891, and their daughter, Rachel, was born in 1892. At the age of twenty-nine, Fiske was the youngest of the five children of Samuel Dennis Warren (1817-1888) and Susan Cornelia Clarke Warren (1825-1901). Beginning with nothing, the elder Warren made a fortune in the paper mills of the Cumberland Manufacturing Company, and left a trust which allowed his children to do as they wished. The eldest, Samuel II (1852-1910), a lawyer, businessman, and

sometime President of the Boston Museum of Fine Arts, committed suicide. Henry Clarke Warren (1854-99) was a scholar at Harvard University in Sanskrit and Pali. Cornelia Lyman Warren (1857-1921) never married, but was active in philanthropy, and a major supporter of Denison House, the third college settlement house in the United States. Edward Perry Warren (1860-1928) became an expatriate collector of classical antiquities, many of which are in the Boston Museum of Fine Arts, including the so-called Boston Throne, now regarded as fake by Hoving (1996). He also published *A Defense of Uranian Love* (1928) a lengthy praise of homoeroticism.

According to Green (1989: 153), the most eccentric of all the Warrens was the youngest, Frederick Fiske Warren (1862-1938). A Harvard graduate, Fiske freely expressed his opinions in his Class Reports. Even before the treaty ending the Spanish-American War was ratified by the Senate, leading opponents of America's global reach formed an Anti-Imperialist League; among them were Charles Francis Adams, Andrew Carnegie, Grover Cleveland, Charles W. Eliot, William James, Mark Twain, and Frederick Fiske Warren. Warren fell under the spell of the Philippine nationalist leader, Sixto Lopez and did not gain popularity by noting that the American presence was not welcomed by the Filipinos, or by his prescient suggestion that the occupation would cause the Japanese to increase the size of their army. He became a crank over the Single Tax movement, derived from Henry George's, *Progress and Poverty* (1879) which he had read in 1909. He owned a farm, Thanto, in Harvard, Massachusetts, where it is reported that he designed the two buildings himself, the one in which the food was prepared connected by a bridge to the one in which it was served. The house had small doors

throughout to save on materials. In addition to Thanto, the Fiske Warren's also went to Pride's Crossing north of Boston during the season and kept a winter residence at 8 Mt. Vernon Place in Boston.

Fiske and Gretchen entertained widely including guests such as Sun Yat-Sen, Booker T. Washington, William James, Clarence Darrow and Robert Frost, as well as the Single Taxers and Filipino nationalists at dinner. A copy of a letter from 1941 to her from Curator of Mollusks William J. Clench, indicates that he also was once invited to Mt. Vernon Place, where he met her daughter Rachel. John Singer Sargent had done a portrait of mother and daughter in the Gothic Room at Mrs. Gardner's Fenway Court in 1903. The painting is considered one of Sargent's best. Prose (1999: A20) has written, "Despite their tender pose [they] seem so chilly that the daughter's head resting on her mother's shoulder, could be an epaulet." It is now in the Boston Museum of Fine Arts. It is not known when Mrs. Warren first became interested in conchology, but she began a lengthy correspondence with Hugh C. Fulton in 1938 and with Clench in the early 40's. Her primary interest in shells was their beauty of shape and color, and among her books was Thompson's, *On Growth and Form* (1942). She seems to have purchased most of her shells from Hugh C. Fulton (Late Sowerby & Fulton) of London, though some came from Ward's Natural Science Establishment, Rochester, New York.

The shells were once exhibited as art objects at Harvard's Fogg Art Museum. A letter to Mr. Clench of February 17, 1943 seems to indicate that he had shown some reluctance toward giving credence to the exhibit:

> How I wish you would encourage me by seeing this small exhibition. There are hundreds of shells, and many enchanting shell-sections showing the organic and universal spiral; also several hundred photographs from nature and from nearly every art and age. These are all chosen to show spiral-influence, and to hold before eye and mind nature's faithfulness to order and beauty. I hope education will be interested and will accept the intended symbol. A brief essay on education goes with the exhibit: please be patient if I venture to send you a copy. It will come soon. Do forgive the typed letter.

Green (1989: 137) rather kindly sums up the essay *Art, Nature, Education* (1943), which accompanied the exhibit, by noting that, "she sees everything from the angle of the creative mind like a latter day Transcendentalist." Mrs. Warren also published poetry and succeeded Amy Lowell, the Imagist poet, as president of the New England Poetry Society. She only recognized poets who had written for recognized magazines or book publishers. No vanity press types were invited to join. This Brahmin lady is described in her old age by Cleveland Amory in *The Proper Bostonians* (1947: 125) as "a women of rare charm, she dedicates herself conscientiously to her salons and her writing...seldom leaves her antique-studded Beacon Hill home at all -- never, if she can help it, for purely social engagements." Guests, according to Amory, distributed themselves around a large dining room, among fragile seashells and almost equally fragile chairs, sipped tea or sherry, and discussed poetry or philosophy.

When she died in 1961 at the age of 90, most of her shells were presented to the Boston Museum of Science, where some are still on display. The shells "of scientific value" had been promised to the Museum of Comparative Zoology. In 1962, Clench, S.L.H. Fuller and I went to 8 Mount Vernon Place to pick them up. Her daughter Rachel, then herself old, explained that her husband Robert

C. Barton had been a professional Irish Revolutionary, spent a lot of time in prison, and that she was short of funds, so I gave her $200 for the few books and shells. In addition to some attractive displays her mother had created showing the variation of the Cuban land snail, *Polymita picta* (Born), and various other gastropods, there was from the collection of the Duchess of Portland:

"Lot 4023. A very fine reversed *Voluta ponderosa*, S: or heavy Volute, *extremely scarce*, from the East-Indies. A direct one is figured in Favanne, [1780] pl. 35 fig. 1." Since *A Marked Catalogue* (see under: Lightfoot, J., 1786) was published after the sale, we know that this shell was purchased by Dillon for 4 pounds and 8 shillings. An old label indicates that it was subsequently purchased by Charles Alexandre de Calonne, sometime Contrôleur général de Finances of France, who escaped to England with head and collection before the Revolution. His collection was sold in England and the label indicates that it was lot 691a in the sales catalogue prepared by Humphrey (1797). Whether it became part of the stock of the Sowerbys is moot, but it was eventually sold by Hugh C. Fulton, Conchologist to Mrs. Warren.

The first citation of *Voluta ponderosa* was for lot 566 (sold to Sykes for 5 shillings and 6 pence). Dall (1921: 98) pointed out that the printer of *The Portland Catalogue* made a typographical error in the names of Martini and Martyn, "but the references made it clear in every case, which is meant." This had been previously obvious to Dillwyn (1817), but not to Clench (1964) or Rehder (1967: 8) who was unaware that the references to Martyn 916 is actually to Martini (1777, pl. 95, fig. 916). This specimen from Martini's collection is extant. It is the type specimen of *Voluta ponderosa* and is now on display in the

Zoological Museum in Copenhagen (Abbott, 1972: 166).

Pfeiffer (1840: v) claimed that he had examined Martini's collection, then in the possession of his brother-in-law, Hermann Englebard von Nathusius (1809-1879) of Hundisburg [Hundborg, Denmark], and he (1840: 25) declared the specimen to be *Turbinella rapa* Lamarck, 1822 which Dodge (1955: 132) said is related [to *Xancus pyrum* (Linnaeus, 1767)] but is a distinct species. *Voluta ponderosa* Lightfoot, 1786 is a senior synonym of *Turbinella rapa* Lamarck, 1822, as recognized by both Pfeiffer (1840: v) and Dall (1912: 132). The second use of the taxon *Voluta ponderosa*, for lot 4023 (Figure 2) refers to a specimen of *Xancus pyrum* (Linnaeus, 1767) figured by Favanne (1780, pl. 35 fig. 1). What, if any, is the importance of this Portland specimen, MCZ 249020, with out any locality data, which was enthusiastically, but mistakenly, labelled as the holotype of *V. ponderosa* by Clench? Well, it is a sinistral specimen of the sacred chank shell, which is said to occur in about one out of every hundred thousand normally dextral ones.

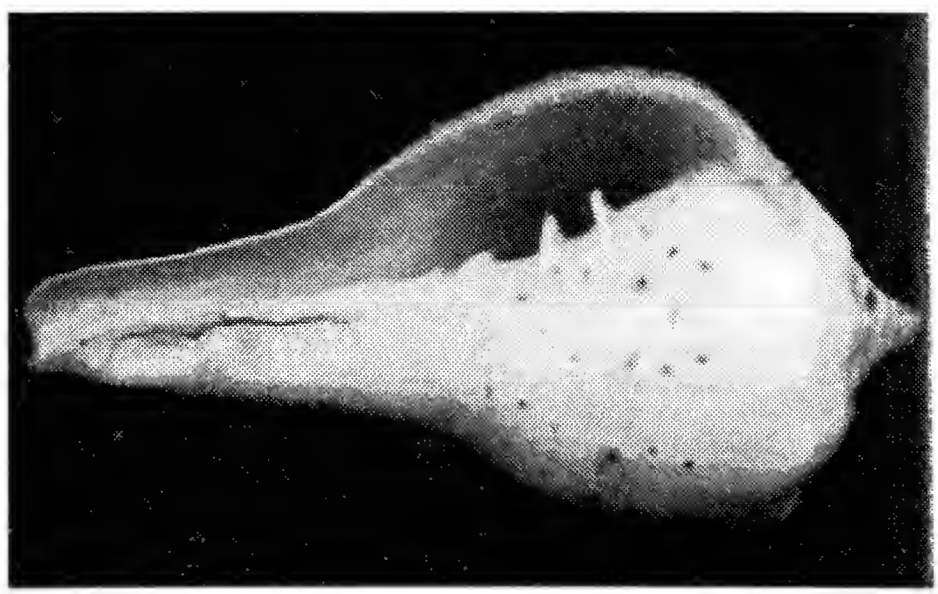

Figure 2. *Xancus pyrum* (Linnaeus, 1767) [Trincomali Coast of India] MCZ 249020. Length 83 mm, width 44 mm (approx. nat. size) = Portland Catalogue, "lot 4023. A very fine reversed Voluta ponderosa S. or heavy Volute. *extremely scarce*, from the *East-Indies*."

These are held in high religious esteem by both Indian Hindus and Buddhists. The shell is one of the symbols of Vishnu, the second god of the Hindu triad. As Tryon mentioned (1882: 69), these reversed chanks are so highly prized that they sometimes sell in Calcutta for their weight in gold or for forty to fifty pounds sterling. Clench claimed that one enterprising Yankee collected a large number of the common *Busycon sinistrum* of the Atlantic Coast and unloaded this naturally sinistral shell in India and, wisely, never returned there. A very detailed account of the sacred chank fisheries and the superstitions connected with the shell is afforded by Hornell (1914), whose taxonomy is discussed by Delsaerdt (1978). The religious use of the chank is further delineated by Rose (1974) who also first figured the Portland specimen. Jackson (1916) had earlier called the attention to the Aztec moon-cult and its relation to the chank-cult of India. Later Heine-Geldern and Exholm (1951) suggested significant parallels in the symbolic arts of southern Asia and Middle America, and subsequently Esholm (1953) wrote even more strongly, on the evidence of transpacific influences on prehistoric Mexican culture. The veneration of the Chank shells in two removed cultures may be simple coincidence, but as mentioned by Vose (1962) combined with Hindu designs such as the lotus plant and rhizome the "celestial tree" add other evidence, it should not be overlooked. While there may still be uncompromising isolationists among us, the largely overlooked works of Cohane (1969) on linguistics and Hapgood (1979) whose work on early maps indicate evidence of earlier advanced, civilized people, in the Ice Age, able to compute longitude and make maps of some lands not rediscovered until the Sixteenth Century, indicate former diffusion. While the Portland chank shell may be of

slight scientific significance, it makes a salient story.

ACKNOWLEDGEMENTS

The author is most grateful to Drs. Kenneth J. Boss, Jerry Harasewych, and Alan R. Kabat for reviewing the manuscript and making numerous helpful suggestions. Dr. Kabat also kindly supplied a number of very useful additional references. Mrs. Mary Jablokow patiently made numerous copies of the manuscript during its preparation, and my wife, Marrian, proof read it. Mr. Adam Baldinger, whose computer skills rendered the manuscript into printable form, is thanked profoundly. He also prepared the figures.

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ON THE AUTHORSHIP OF THE FIRST AMERICAN CONCHOLOGICAL MANUAL, JOHN WARREN'S, "THE CONCHOLOGIST"

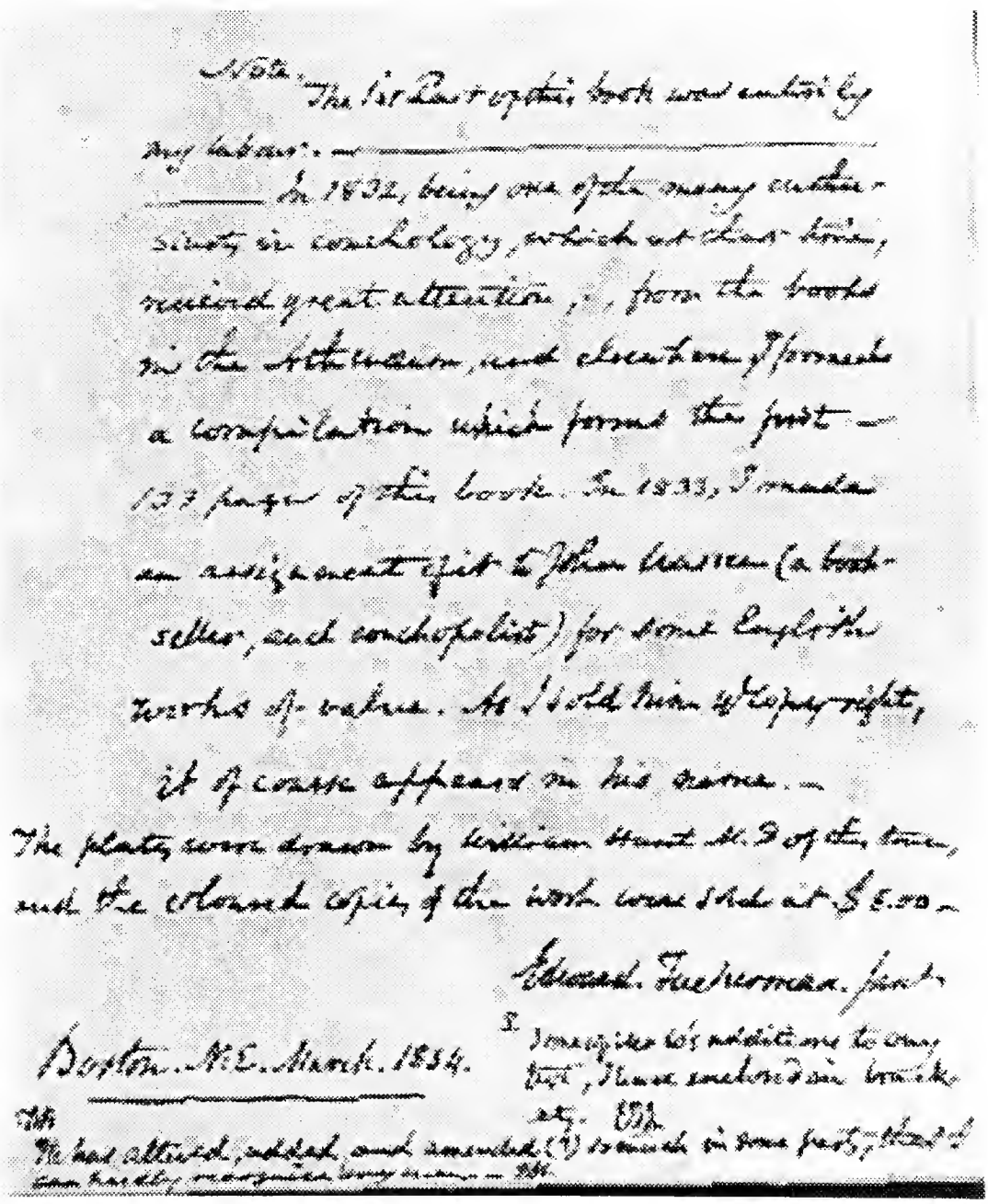
Richard I. Johnson

The first American conchological manual, *The Conchologist*, appeared in Boston during 1834, to fill a perceived need among shell collectors. Its supposed author was John Warren, a dealer in shells and curios, who, according to Dall (1888: 105), was still extant in 1857. "A stout, florid old gentleman," he supplied Miss Sarah Pratt and other Boston amateurs with handsome shells at high prices. *The Conchologist* is cobbled together from a number of sources. Not willing to make a stand regarding classification, John Warren divided the book into two sections. Warren writes, "The Linnaean System, being the least complex, I have considered in the First Part; being only thirty-six genera, with their divisions and families. The Second Part is entirely confined to the Lamarckian."

After acknowledging general thanks to a number of people amongst whom only D. Humphrey Storer and Augustus A. Gould, both members of the Boston Society of Natural History, are now remembered for having written on mollusks, Warren writes in his Preface, "To a young friend, whose modesty forbids the mention of his name, I am greatly obliged, as well as to Mr. James J. Jarvis [*sic*], a

young man of great talents, and one who bids fair to be a shining character and an ornament to society and his country." He further thanks Seth Bass, M.D. for the use of his library and for preparing a list of *Unio* (freshwater mussels).

A copy of this work in the library of the Department of Mollusks, Museum of Comparative Zoology, formerly belonging to Edward Tuckerman (1818-86), reveals that he was the "modest" compiler of the first section of this work. His note on the fly leaf is reproduced below.



"Note. The 1st Part of this book was entirely by my labor.----------In 1832 being one of the many enthusiasts in conchology, which at the time, received great attention, from the books in the [Boston] Athenaeum, and elsewhere I formed a compilation which forms the first 133 pages of this book. In 1833, I made an assignment of it to John Warren (a bookseller, and conchologist) for some English works of value. As I sold him a copyright, it of course appears in his name. The plates were drawn by William Hunt M.D. of this town, and the colored copies of this work were sold at $8.00.
Edward Tuckerman, Junr.

Boston, N[ew] E[ngland] March 1834
S. [*sic*] Some of Mr. W's additions to my text, I have enclosed in brackets. E.T. Jr.
He has altered, added and amended (?) so much in some parts, that I can hardly recognize any [more].
ETJ"

Of the Linnaean works mentioned in the preface, Wood (1815), Shaw (1800-1826), Dillwyn (1817), and Mawe (1823), all are still available in the Boston Athenaeum, as well as one not mentioned; *Time's Telescope for 1822.* Dance (1986: 143) pointed out that the Introduction to *The Conchologist* was copied almost verbatim from the anonymous, "*Outline of Conchology*" which appeared in that publication, and was dismissed by him as "high in moral tone, low in science." If Tuckerman appears somewhat irritated by some of Warren's alterations, his copy has been corrected in the light of maturity, for he was then seventeen and a sophomore at Union College in

Schenectady, New York, the oldest non-denominational college in the United States, from which he received a Bachelor's degree in 1837. He had made the compilation when he was only fifteen. When twenty one, he published, "*An imumeration of some lichens of New England*," in the Journal of the Boston Society of Natural History (1839). He early explored the White Mountains of New Hampshire for lichens where Tuckerman's Ravine is now named for him. Born into a prosperous mercantile family, he was able to earn a Master's degree at Union College, and return to Cambridge where he entered the Senior Class at Harvard, receiving an A.B. Degree in 1847. He took other degrees at Harvard, even studying for a time at the Divinity School. In 1854 he was appointed Lecturer of History at Amherst College, Amherst, Massachusetts, and later Professor of Botany there, a position he held until his death in 1886. He is remembered today as a distinguished botanist (Farlow, 1895) and elder brother of Frederick Goddard Tuckerman (1821-73), the poet, whose collected works were edited by Momady (1965).

Samuel Brooks (1815), a member of The Linnean [*sic*] Society of London, was among the first to recognize the inadequacies of the Linnaean system, and to introduce Lamarckian genera to an English audience, but since most of Lamarck's new genera were published after 1817, it was Children (1777-1852), an assistant keeper in the British Museum, who made a translation of the molluscan genera described by Lamarck in his *Historie naturelle des animaux sans vertèbres* (vols. 5-7, 1818-1822) and established type species for many of the genera. These type specimens were subsequently studied by Kennard, *et al.* (1931). Children's work originally appreared without the author's name, in the *Quarterly Journal of Science, Literature and*

the Arts published by the Royal Institution of Great Britain, between October, 1822, and January 1824. He was editor of the *Journal* during this time. It also came out under his own name as a separate work, but it is extremely rare in that form. Children, especially, and Crouch (1826) formed the basis for Gould's (1833), *Lamarck's genera of shells, with a catalogue of species*. Both the Journal and Crouch were available to him at the Boston Athenaeum. In his introduction, Gould mistakenly credits W. Leach as the author of Children's work.

From Warren's Preface, it can be assumed that James Jackson Jarves (1818-88), named for the distinguished Boston physician who attended his birth, compiled the Second Part, based on Gould's slim volume. Though no copy of it is in the Boston Athenaeum, it may well have been made available to the then 15 or 16 year lad by Gould himself or by Seth Bass. Like Gould's work, it does not contain type species of the various genera, but lists numerous species under each of them. There is nothing to suggest that Gould translated anything from the French himself, and Jarves's work is no more than an adumbration of Gould, with additional species, that were subsequently available, (possibly from Warren's stock) listed under the genera. Like Tuckerman, Jarves came from a well-to-do family. His father was the manufacturer of Sandwich Glass. Too sickly to attend Harvard University, in 1838, at the age of twenty, Jarvis went to the Hawaiian Islands and was for a number of years United States Consul in Honolulu, where he published the first newspaper ever printed there, "*The Polynesian.*" After writing a number of books about the islands, he left in 1848 to reside in Florence, Italy, where he made a distinguished collection of paintings, mostly Italian primitives. In addition to writing a

number of books on art, he exhibited his collection in the United States. The Boston Athenaeum was given the first opportunity to purchase the collection but refused. It now forms an important part of the art collection at Yale University, New Haven, Connecticut. He died in 1888 in Switzerland. "*The two lives of James Jackson Jarves*" by Steegmuller (1951) bears out the accuracy of the prediction made by Warren.

Seth Bass, physician and Proprietor of the Boston Athenaeum, founded in 1807, served as its Librarian from 1825-46 when it was still housed in the mansion in Pearl Street given to it by James Perkins (Bolton, 1907). Here he had access to the Transactions of the American Philosophical Society in which Isaac Lea described his Unios. The Boston Society of Natural History founded in 1830 kept rooms in the Athenaeum until 1833, so it is more than probable that the young authors became acquainted with some of its members.

The lithographic plates, in some copies, hand colored, were produced by one of the earliest successful Boston lithographers, Pendleton's, whose name appeared on plate 1. The firm was established in 1825 and continued by Thomas Moore until 1840. The shop trained Nathaniel Currier, later of Currier and Ives fame, and Fitz Hugh Lane, the maritime painter. Thanks to Tuckerman, we know that the artist who produced the plates was Dr. William Hunt (fl. 1834-1838) who worked at Pendleton's and is mentioned in *Boston Lithography* 1825-1880 by Pierce and Slautterback (1991: 175). Miss Sarah Pickering Pratt, a Proprietor of the Boston Athenaeum, one of those whom Warren's volume was obviously designed to inspire in collecting, presented her extensive collection of over 4,000 specimens to the Boston Society of Natural History upon

her death in 1867 with the then large sum of $10,000 for its upkeep and growth. Her collection, with all of the non-New England collection, but not the money, was transferred to the Museum of Comparative Zoology beginning in 1914.

ACKNOWLEDGEMENTS

Thanks are extended to the children of the late R. Tucker Abbott who presented the Tuckerman copy of *The Conchologist* to the Mollusk Department of the Museum of Comparative Zoology in their father's memory. Mr. Trevor Joy Johnson, Archivist of the Boston Athenaeum, kindly made all of the resources of that institution available, and Dr. Kenneth J. Boss made helpful suggestions.

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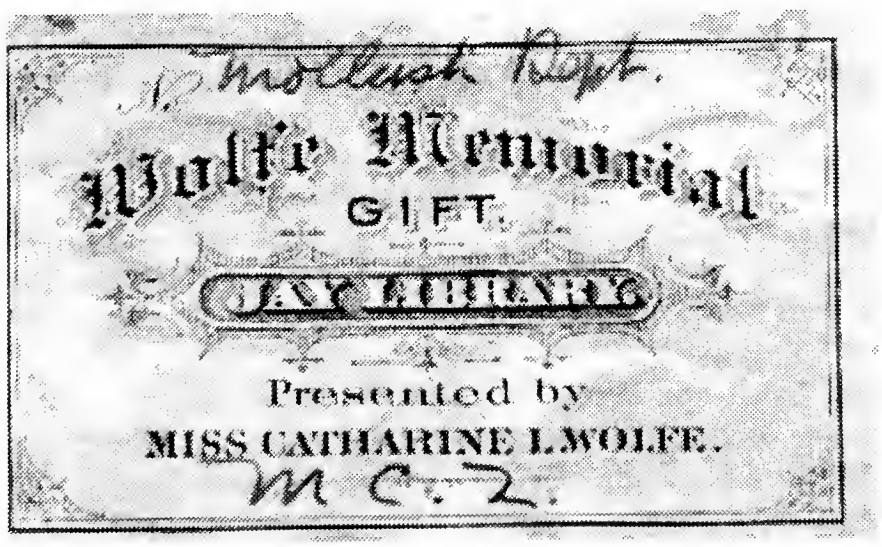
ON THE PROVENANCE OF CERTAIN BOOKS IN THE DEPARTMENT OF MOLLUSKS: ALAS, A CORRECTION AND ADDITIONAL NOTES ON JOHN CLARKSON JAY, M.D.

Richard I. Johnson

The note with a similar title which appeared in this series (Johnson, 1998: 466) contained an egregious error. It stated that Catherine I. [sic] Wolfe gave the shell collection and library of her father, Dr. John Clarkson Jay to the American Museum of Natural History in his memory. This collection was given to the American Museum of Natural History, but not by Dr. Jay's daughter. Jay was a wealthy physician from Rye, New York who died at the age of eighty-four in 1881. He had previously sold his shell collection and library to Catherine Wolfe, which he claimed had cost him $35,000. It consisted of some 14,000 species represented by 50,000 specimens for which she paid him the princely sum of $10,000. The collection of Augustus



(Book plate in the copy of Jay's Fourth Catalogue sold by the American Museum of Natural History.)

A. Gould, consisting of some 10,000 lots with type specimens representing over 350 species (Johnson 1964: 31) had been sold to the New York State Museum for $6,000 in 1867.

In addition to four catalogues of the collection, which attest to its growth, Jay published descriptions of new species in the second and third of these accompanied by plates, hand colored in some copies. He also published several other malacological works all listed below. Richards and Old (1969:4) were able to locate type specimens of all but eight of the some 40 species Jay described. Gratacap (1900: 20) mentioned that, in April 1871, a short time after the Museum opened, its first president, John David Wolfe died, and that it was *his* daughter, Miss Catherine Lorillard Wolfe who, soon thereafter, presented the Jay collection and conchological library, in his memory, as the museum's first memorial gift.

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ON "THE CHAMBERED NAUTILUS" BY OLIVER WENDELL HOLMES: REDUX

Richard I. Johnson

Through the kindness of Dr. Alan R. Kabat, I have been made aware of several studies, antedating mine (Johnson 1998), on Oliver Wendell Holmes's famous poem, *The Chambered Nautilus*. The most ambitious of these was *Historical and Contemporary Backgrounds of The Chambered Nautilus,* an essay of some 70 quarto pages, written by McColley (1947) while an employee of the Civilian Production Administration. Adkins (1937) had previously suggested several possible sources of inspiration, both poetic and scientific, which may have influenced Holmes.

The most fascinating of the articles located by Kabat was by Christy (1937), who discovered the poem, *The Nautilus and the Ammonite* by G.F. Richardson (reprinted, 1999), which appeared in May, 1851 in *The Family Visitor*, a journal published in Cleveland, Ohio. While this is a mere adumbration of the poem by Holmes, Christy argues that "bits of dross in Richardson's work appear to have been transmuted to more familiar golden felicity by Holmes." In addition, Christy continues, "there was the theme: transitions from mollusk to man, from 'oceans brim' to 'life's stormy sea,' and at the end the outlook 'to a distant strand' (to give but a few of his examples) -- the items severally insignificant, but unitedly acquiring some suggestion of significance."

Among the several founders of *The Family Visitor*, mainly containing articles advocating temperance, family values, and items of useful information, was Jared Potter

Kirtland (1793-1877). He was a physician and pioneer naturalist who published the first list of the land and freshwater shells of Ohio. His *Fishes of Ohio* appeared in *The Family Visitor*, and as a subscriber, Louis Agassiz wrote Kirtland, two months after Richardson's poem was published, inquiring "Do you collect insects?" Whether or not the letter was answered, Kirtland did describe a new butterfly, *Libythea backmanii* in the October 21, 1851 issue of the magazine (Albrecht, 1985). Christy hypothesized that Agassiz passed the poem to his good friend Holmes, whose own poem did not appear, until seven years later, in February of 1858.

While McColley, Adkins, and Christy all highlighted sources of poetic and scientific influences that may have influenced Holmes, his treatment of the material in *The Chambered Nautilus* was beyond peradventure unique as not to place him in the category of T.S. Eliot whose similarities to Madison Cawen's *Waste Land*, were hardly coincidental.

For the convenience of the reader, Holmes' poem, as orginally typset, is reprinted herein.

THE CHAMBERED NAUTILUS.

This is the ship of pearl, which, poets feign,
Sails the unshadowed main, --
The venturous bark that flings
On the sweet summer wind its purpled wings
In gulfs enchanted, where the siren sings,
And coral reefs lie bare,
Where the cold sea-maids rise to sun their
streaming hair.
Its webs of living gauze no more unfurl;

Wrecked is the ship of pearl!
And every chambered cell,
Where its dim dreaming life was wont to dwell,
As the frail tenant shaped his growing shell,
Before thee lies revealed, --
Its irised ceiling rent, its sunless crypt unsealed!

Year after year beheld the silent toil
That spread his lustrous coil;
Still, as the sprial grew,
He left the past year's dwelling for the new,
Stole with soft step its shining archway through,
Built up its idle door,
Stretched in his last-found home, and knew the old no more.

Thanks for the heavenly message brought by thee,
Child of the wandering sea,
Cast from her lap, forlorn!
From thy dead lips a clearer note is born
Than ever Triton blew from wreathed horn!
While on mine ear it rings,
Through the deep caves of thought I hear a voice that sings:--

Build thee more stately mansions, O my soul,
As the swift seasons roll!
Leave thy low-vaulted past!
Let each new temple, nobler than the last,

Shut thee from heaven with a dome more
vast,
Till thou at length art free,
Leaving thine outgrown shell by life's unrest-
ing sea!

NOTE

The library of the Boston Society of Natural History was sold for $250,000 in 1943 to the Allan Hancock Foundation, now at the University of Southern California at Los Angeles. Through the kindness of Jean E. Campon, Librarian, I am informed that the works of Griffith, Pidgeon and Roget, previously mentioned (Johnson, 1998), were available to Holmes.

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This allegorical Baroque frontispiece, flanked by statues of Cybele and Poseidon, captures the excitement for shell collecting which was to hold the European imagination throughout the eighteenth century. It was engraved by Jakob de Later after a drawing by Jan Goeree and, while it occurs in all of the Dutch editions of Rumphius, this is taken from the 1711 edition of the *Thesaurus*.

THE AMBONESE CURIOSITY CABINET BY GEORGIUS EVERHARDUS RUMPHIUS TRANSLATED, EDITED, ANNOTATED, AND WITH AN INTRODUCTION BY E.M. BEEKMAN[1]

Richard I. Johnson

This modern translation of the posthumous publication of Rumphius, *D'Amboinsche Rariteitkamer,* first published in Amsterdam in 1705 makes the entire text and plates available in English for the first time. Rumphius was among the first naturalists to record observations he had made in the field, and to give accurate records of the localities where his animals were found. He had a great talent for description and nomenclature. Many of the names he introduced were adopted later by Linnaeus. Since it was then still believed that all of nature had been created to benefit humans, Rumphius provided details on applied malacology, such as the use of shellfish as food, household articles, weapons, musical instruments, ornaments, drugs, charms, scent, and money. At a time when superstition and miracles were readily believed, he carefully recorded facts based on his own observations, but he was not totally adverse to including in his work what the Malay fishermen told him.

George Eberhard Rumpf [later latinized as Rumphius] (1627-1702) was born in Hanau on the Main River, where

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[1]Beekman, E.M. 1999. *The Ambonese Curiosity Cabinet. Translated, edited, annotated, and with an introduction.* pp. cxii, 567, 57 pls. Yale University Press, P.O. Box 209040, New Haven, Connecticut 06520-9040. $45.00 Eric Beekman received a Ph.D. from Harvard University in 1968. He is professor of Germanic languages at the University of Massachusetts, Amherst, and a scholar of Dutch colonial literature as well as a translator of note.

his father was the architect for Count Ludwig von Solms-Greifenstein-Braunfels. It was at the Count's suggestion that the young Rumpf enlisted in the Venetian army. This army had been secretly bought by the Netherlands West Indies Company for service in Brazil, but the ship Rumpf had embarked upon at Texel, Netherlands, was captured by the Portuguese. For several years, he and his companions were retained for military service in Portugal. It was here that he heard of the marvels of the East, which in 1652 led him to enlist as a midshipman in the Netherlands East Indies Company. Soon after his arrival in Batavia (now Jakarta), then Java's largest settlement, Rumpf was sent to Ambon in the Moluccas, where he spent most of his life. Ambon is a small island, thirty-two miles long and ten miles wide, in the northern regions of the Banda Sea. It was the primary source of the clove, then, a much sought after spice. The Portuguese had first arrived there and departed with a cargo of this spice in 1511. They founded a settlement in 1521, but were later driven out by the Dutch.

Rumpf was soon transferred to the civilian service and was appointed an under-merchant in 1657. At about this time, he began to study the flora and fauna of Ambon. At length, on August 20, 1662, he sent, "to the Noble, Honored, Venerable, Wise, Provident, Highly Informed Masters, the Noble Chief Directors of the East Indies Company residing in Amsterdam", a small request for aid in his undertakings (Sirks, 1945). This request was granted, though Rumphius was never allowed to forget that the business of the Company came first. He went blind in 1670 and most of his drawings of shells were destroyed in the great fire that occurred in the city of Ambon in 1687. Jutting (1959) claimed that it was not known who prepared the new figures for his work, but some were done locally.

Rumphius was aided by his son, Paulus Augustus, who at least, is known to have drawn the portrait of the blind naturalist that occurs in all of the Dutch editions of his work containing shells. Many of the engravings were prepared from drawings made in Holland from cabinets of exotic shells (thus explaining the occasional Mediterranean species) by the well known artist Maria Sibylla Merian (1647-1717)[2]. This, the *Amboinsche Rariteitkamer* appeared posthumously in 1705. The second section, pp. 57-166, pls. 17- 49 covers mollusks. Merian is known to have colored the plates in at least two copies of this edition presumably based on actual specimens. One is in the Artis Library, Amsterdam, formerly belonging to A. Vosmaer (1720-1799) sometime director of the royal zoological gardens near The Hague. The other was recently offered for sale by an Amsterdam dealer. Under the title, *Thesaurus Imaginum Piscium Testaceorum*, an edition consisting of only the plates with their explanations, a single page of introduction, and a frontispiece [reproduced here] appeared in Leiden in 1711, and was reissued there in 1739. The complete *Amboinsche Rariteitkamer* was republished in Amsterdam in 1741, finally in 1766 it was translated into German by P.L.S. Müller with the plates having been redrawn.

In recognition of his labors, Rumpf was elected to the Academia Naturae Curiosorum, founded at Schweinfurt (now in Bavaria, but then a free imperial city), in 1681 as member no. 98 and received the cognomen of "Plinius

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[2] While working in the Dutch colony of Surinam in South America, where she spent two years, Merian first observed the bird-eating spider, the largest in the world, and illustrated it in her book *Metamorphosis Insectorum Surinamensium*. This work was the culmination of her career as a zoological and botanical artist. (Dance, 1978: 50)

Indicus" which he was able to add proudly to the title pages of his works. The Holy Roman Emperor Leopold I granted the Academy imperial privileges, and from 1687 until 1870 it was known as Sacri Romani Imperii Academia Caesareo-Leopoldina Naturae Curiosorum, being located in a number of German cities. It found a permanent haven in Halle in 1878.

The cornerstone of our system of binomial nomenclature is the 10th edition of Linnaeus' *Systema Naturae* published in 1758. Some 90 works were quoted with references to mollusks, and all but two of these were located by Boss (1988), both since found, see note on p. 108). Linnaeus cited over 200 of Rumphius' figures, and since the latter gave most of his mollusks binomial names, Linnaeus transferred 32 of them directly into his own work. All of the figured shells were identified, and their nomenclature revised by Martens (1902). The nomenclature was updated by Strack ([in] Beekman, 1999: xiii-xxvi).

At the insistence of his superiors, Rumphius sold what must have been a rather complete collection of some 360 species of shells, plus other curiosities and several plants, to Cosimo III de Medici (1642-1723), Grand-Duke of Tuscany in 1682. According to Targioni Tozzetti (1903) these shells were transferred from the Imperial Gallery to the Museum of Physics and Natural History after its founding in 1778 (now Museo Zoologia dell' Universita degli studi di Firenze), though he could not locate them. Some of the duplicates, given to Niccolo Gualtieri (1688-1744) by Cosimo's son, are said to be in the Museo di Paleontologia, Pisa. Dijkstra (1997: 113) in 1990 visited what is now the Museo di Storia Naturale e del Territorio of the University of Pisa, at Certosi di Calci, near Pisa, but

failed to be able to identify for sure any shells that might have come from Rumphius. In the introduction to his sumptuous iconography of his own collection, *Index Testarum Conchyliorum* (1742: xvi), Gualtieri mentions the work of Rumphius (1705) but does not indicate whether any of his figures were based on the latter's specimens.

Francois Valentijn (1666-1725), a cleric of the Dutch Reformed Church, was sent to the East Indies where he remained for a decade. His "brother-in-law and bosom-friend," Rumphius in Ambon, encouraged him to collect natural objects and to make observations. The eventual result was five quarto volumes titled *Oud en nieuw Oost-Indiën* (1724-26), in which he described all aspects of life and commerce as well as the natural history of the islands. When back in Holland, Valentijn had access to the unpublished manuscript and plates of Rumphius' *Amboinsch Dierboek*; and made such free use of them that Rumphius' important manuscript was never printed, and has since vanished. Included in Volume 3, Part 2 (pp. 517-586) of Valentijn's compendium are 16 plates of shells which he offered as being supplementary to those in the *Amboinsche Rariteitkamer*, as well as two other plates of supposed natural objects. One of these includes some improbable fishes and a mermaid, all pirated from earlier versions in a work by Renard (1719). The mermaid's mammary dower is vastly improved upon as well as her overall attractiveness, and is mentioned here, to indicate that, unlike Rumphius, Valentijn was quite credulous. Valentijn's shells, fish and mermaid were issued as a separate publication by J. von Keulen in Amsterdam in 1754, and appeared again translated in the German by P.L.S. Müller during 1773, with the plates redrawn, the mermaid characteristically becoming more Nordic.

Albert S. Bickmore was dismissed as a student by Louis Agassiz, the founder of the Museum of Comparative Zoology, because Bickmore did unauthorized fundraising for his Ambon expedition. He was, however, successful and in 1865, he went to recollect the shells figured by Rumphius, "on the very points and head lands, and in the very bays, where Rumphius' specimens were found" (Bickmore, 1869: 14). The book *Travels in the East Indian Archipelago* appeared in 1869, but the results of the actual scientific purpose of the trip were never published, nor is it known what happened to the shells. In 1869, Bickmore was a principal founder of the American Museum of Natural History in New York City and its first curator of the Department of Public Instruction. Theodore Roosevelt, father of the president, and J.Pierpont Morgan were among the first trustees. John David Wolfe was elected first president. It was his daughter, Catherine Lorillard Wolfe, who presented the John C. Jay collection of shells and conchological library to the Museum in his memory. Strack (1993: 15) reported that, "Bickmore deposited one ton of specimens with the museum, but, except for a few shells that were identified as belonging to the Bickmore collection by Dr. W. Emerson, it is not possible to determine what the deposited specimens were." Strack and his associates mounted the "Rumphius Biohistorical Expedition" and since its return in 1990 have been preparing and publishing new identifications of the animals mentioned by Rumphius as part of a monographic series on the marine invertebrate fauna of Ambon.

Beekman has not only translated Rumphius' work, but has provided exhaustive annotations, buttressed by extensive bibleographical and archival references on seemingly every biological, historical, and literary aspect.

Beekman's translation has the advantage over the Dutch and German editions in that the colloquial and archaic Malay terms which Rumphius liberally sprinkled throughout his text are at last translated into a western language. Finally, the excellent, detailed introduction on the life and times of Rumphius accompanying Beekman's translation itself makes the work worth its price.

ACKNOWLEDGEMENTS

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LINNAEUS' MISSING MOLLUSCAN REFERENCES FOUND

Kenneth J. Boss

Boss (1988) located all but two of the bibliographic citations to molluscan taxa made by Linnaeus in the 10th and 12th editions of the *Systema Naturae* (1758; 1767). One of these citations, "*Tessin. epist. 1 n. 28 Cymbium*" occurred under *Argonauta argo* as the 8th, and then as the 11th, reference, respectively (Linnaeus, 1758: 708; 1767: 1161).

In 1991, my colleague, Professor Lisbet Koerner, then in the Department of the History of Science here, explained that this work of Tessin's was "an old literary form called a mirror for princes", his letters of instructions to the then Crown Prince, the future Gustav III of Sweden (Koerner, *in litt.*).

Carl Gustav Tessin was not only a distinguished author but also an influential advisor to Adolf Frederick and Queen Louisa Ulrica, as well as an active member of the court, government and diplomatic service. As governor or tutor to the crown prince, he wrote a volume entitled *En Gammal Mans Bref Til En Ung Prints*; this work appeared in English(1755; 1759), in Swedish (1756) as well as in French; there are also other translations and an abbreviated text (1785). A surprising number of American university libraries, as well as the Boston Atheneum and the Library of Congress, possess copies of Tessin's *Letters*.

It is to this Swedish work that Linnaeus' enigmatic citation under *Argonauta argo* refers. The English

translation in its second edition (1759), available here at Harvard, remarks that, in regard to *Argonauta argo*, "the Latin names of this testaceous animal or its shell, are cymbium, nautilus tenuis legitimus, domuncula polypi, ovum polypi, nauplium Athenaei, piscis nautitus." Tessin's letter, No. xxviii, dated 7 June 1751, written from Ulrichsdahl is contained on pages 163 - 173 of Volume 1 of the translation. Bibliographic citations to earlier works in natural history such as Rumphius, Gualtieri and d'Argenville are included in it and were subsequently utilized by Linnaeus (1758; 1767).

Also, Count Tessin, as many other Eighteenth Century aristocrats, collected minerals, rocks and fossil shells; Linnaeus (1753) wrote a volume on this collection, introducing several species' names which were referred to as *Anomia, Pinna* and *Arca*; more of these were binomial and more were subsequently cited in his *Systema.*

Dr. Alan R. Kabat kindly pointed out that the following abbreviated citation utilized by Linnaeus for mollusks was overlooked.

Müller mentioned a slug found on a mushroom and this became the original reference for *Limax albus* described in the 12th edition of the *Systema Naturae* (1767: 1081). This work on fungi was cited only once by Linnaeus under mollusca.

ABBREVIATED CITATION

Müller, *swamp. Hafn*, 1763, p. 61.

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ALBERT GALLATIN WETHERBY: MALACOLOGY AT THE CINCINNATI SOCIETY OF NATURAL HISTORY AND IN OHIO (1843-1896)

Richard I. Johnson[1]

Abstract: The development of malacology in Ohio (1843-1896), especially at the Cincinnati Society of Natural History, is discussed, and the new species of mollusks described by its members: T. H. Aldrich, W. Doherty, G.W. Harper, C.R. Judge, and A.G. Wetherby are listed. Syntypes of the following are in the Museum of Comparative Zoology: *Patula bryanti* Harper; and *Angitrema angulata, Planorbis duryi, Helicodiscus fimbriatus, Angitrema parva, Lithasia plicata, Goniobasis plicatastriata,* and *Anculosa umbilicata*, all Wetherby. Specimens of *Somatogyrus trothis* Doherty, 1878 are probable paralectotypes.

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1833-1902

From an original photograph in the A. F. Gray collection of portraits in the Mollusk Department in the Museum of Comparative Zoology.

In 1802 its seven hundred inhabitants incorporated Cincinnati, Ohio as a town. When the "New Orleans," the first steamboat on western waters, passed by in 1811, a new era was opened. By 1819, Cincinnati was a city of over 10,000 and by 1829 it was a busy port on the Ohio River with steamboat building as an important industry. Cincinnati College and the Medical College of Ohio, both founded in 1819, were each first in their field in the new West. The Western Museum, founded as a stock company which opened to the public in 1820, was one of the earliest museums in the United States. Amongst those who helped prepare the original exhibits of natural history were Dr. Daniel Drake, "the Benjamin Franklin of Ohio," immortalized by Juettner (1909), the colorful French Count Joseph Dorfeuille, who became curator, and John James Audubon, the now well-known ornithologist. Audubon's grist mill in Henderson, Kentucky had just failed, so he accepted the job of taxidermist with a regular salary. However, before he labored himself out of a job, he left for New Orleans, leaving his wife Lucy and sons temporarily in Cincinnati, where Lucy taught school. Subsequently they joined him in New Orleans, where he did some of his best bird drawings, before leaving for England, where his elephant folio, *Birds of America*, was published. By 1823, the stockholders realized that the Museum was not profitable, and since there were no buyers, they gave it to Count Dorfeuille. His only obligation was to admit original subscribers and their families to the Museum free of charge. He obviously intended to make a living from it by adding his own collections and by the purchase of one from Kentucky. An amusing inventory of the museum was published in "The Cincinnati Literary" on March 13, 1824, in the form of a poem. This poem, partially reprinted by Kellogg (1945: 5) who, quoting a contemporary's account, mentioned Dorfeuille's high standing as a scientist and educator, and as "a cyclopedia of popular knowledge who

gave didactic addresses on languages, books, birds, and I know not what besides." The press of the period noted repeatedly that this French aristocrat, a nephew of the Duchess de Richelieu, was also appreciated for his musical skill and his knowledge of the fine arts as well as science.

Sometime during 1825, Dorfeuille was visited by that most remembered of the so-called "forgotten naturalists," Constantine Samuel Rafinesque (1783-1840), who had previously visited Audubon in Henderson, Kentucky. Audubon later described an eccentric guest as having destroyed his Cremona violin whilst cavorting about stark naked in the guest room trying to knock down a cloud of bats he thought were a new species. There was no doubt as to whom he was referring, since at the time he gave Rafinesque the descriptions of several fantastic animals, among them the diamond-backed stone fish. Rafinesque published these descriptions, giving full credit to Audubon who, in the end, received more opprobrium for them than did Rafinesque. Like Audubon and Dorfeuille, Rafinesque was polylingual and had given lectures in French, Spanish, and Italian. In his autobiography, Rafinesque (1836: 77) mentioned that he gave public lectures of his discoveries at Dorfeuilles's Museum. He also visited John Cleves Symmes (1780-1829; Horsman, 2000), named after his uncle the land speculator of southwestern Ohio (Smith, 1985). Symmes's theory of concentric spheres and polar openings was to lead, somewhat indirectly, to the United States Exploring Expedition (1839-1842). Rafinesque (1819) had already described some fifty species of freshwater bivalves from the Ohio River proper in a monograph published in Brussels. Isaac Lea, who was to describe freshwater and land shells from 1828-1874, received as a starter a small barrel of shells from his brother, Thomas G. Lea, whose mercantile interests were in Cincinnati (Scudder, 1885: ix). Before Thomas died in 1844, Isaac described about the same number of Unionidae

from the general area as had Rafinesque. Many of his beautifully delineated taxa have since been taken to be synonyms of the latter's often rather sketchedly defined ones. Among those who Rafinesque (1836:93) accused of ignoring his work were Daniel H. Barnes (1785-1828; Fairfield, 1887; 94-96); Isaac Lea (1792-1886; Scudder, 1885, vii-lvii); and Thomas Say (1787-1834; Weiss and Zeigler, 1831). The same accusation was lodged against Samuel Prescott Hildreth (1783-1863; Abbott, 1973: 115) of Marrietta, Ohio, who was born in Methuen, Massachusetts, became a respected physician, and published numerous papers on medicine, as well as on the freshwater shells found near his home in Marrietta, Ohio (1828).

In 1827, the reputation of the Queen City drew Mrs. Frances Trollope (1780-1863), mother of the famous author, Anthony Trollope, even though malaria and cholera were prevalent and would be for years to come. In Cincinnati, Mrs. Trollope continued her disastrous three-year struggle to wrest a fortune from the frontier. Here she met and liked Dorfeuille and had something pleasant to say about him and his museum in the midst of her otherwise vitriolic attack on American life. "He is a man of taste and science, but a collection formed strictly according to their dictates would by no means satisfy the western metropolis." Thus she excused him for having wax figures and for constructing, "a pandemonium in the upper story...one of the most amusing exhibitions imaginable (Trollope, 1832)." On an upper floor open only after dark with dim artificial light was the "infernal Regions," or Dorfeuille's Hell, which contained tableaux representing scenes from Dante. The exhibit was constructed with the aid of Hiram Powers who would later become a famous sculptor. It was described in detail by Thomas Trollope (1887), also a son of Mrs. Trollope, who had seen it as a stripling. Dorfeuille took time to send Isaac Lea several

new species of land snails which he had collected locally and which were named after him. Weiss and Zeigler (1931:155) quote a letter written in 1834 by Thomas Say, from New Harmony, Indiana, where he was producing his *American Conchology* (1830-1834), to Dorfeuille ordering more type from a foundry in which the latter must have had an interest.

In 1835, unable to eke out sufficient living from the museum, Dorfeuille gave the newly formed Western Academy of Sciences 10,000 natural history specimens and a large library. He was Curator of this new institution until he removed to New York in 1837 to open up a new Inferno. The original Inferno, closed for renovations, reopened in 1838 but by 1853 had faded away.

Along with Dr. Hildreth, also writing on Ohio mollusks was Jared Potter Kirtland (1793-1877; Albrecht, 1985) of Cleveland, who too was a physician. Originally from Connecticut, Dr. Kirtland was a Yale graduate. He had taught at the Ohio Medical College in Cincinnati, and later was a founder of the Cleveland Medical College. As a naturalist, Dr. Kirtland is best remembered as an ornithologist and as a founder of the Cleveland Museum of Natural History. He also wrote an important paper on sexual differences in the Unionidae and made the first official list of the shells of Ohio.

Benjamin Tappan (1773-1857), a native of Massachusetts, studied at Yale and later became a lawyer. He settled in Ravenna Township, which he founded, and later practiced law at Steubenville, where he was a partner with Edwin M. Stanton who became President Lincoln's Secretary of War. Whilst his contribution to Ohio malacology was modest, Dr. Hildreth, who visited him, mentioned that, "the freshwater shells amount to nearly 100 species, the great number of which are peculiar to our streams. The family of the Unios alone contains about 90 species, all natives of the western waters." Tappan and

Hildreth were among the 30 founding members of the Historical and Philosophical Society of Ohio in Columbus during February 1831. When he became a U.S. Senator from Ohio, Tappan was active in the formation of the Smithsonian Institution and in superintending the results of the United States Exploring Expedition (1839-1842).

Joseph Sullivant (1809-1884; Abbott, 1973: 164) of Columbus, published a list of the shells in his cabinet (1838). Henry Moores (1812-1895), originally from Hudson, New York, but who lived in Columbus from 1852-1896, made a collection of Recent and fossil North American shells which became the nucleus of the now outstanding freshwater mollusk collection, created by David H. Stansbery, of the Museum of Biological Diversity at the Ohio State University also in Columbus. The Hildreth collection is also there, the largest segment of which was received from Marrietta College in 1979. With the exceptions mentioned, Cincinnati was the center of malacological activity in Ohio, though a modest one, during the Nineteenth Century.

The Western Academy produced only an anonymous "official" list of unios in 1849. By this time, John Gould Anthony, originally from Providence, Rhode Island, had been active in the institution since its inception and remained so until 1863 when he moved to Cambridge, Massachusetts to become an Assistant in Charge of Shells at Louis Agassiz's Museum of Comparative Zoology. His papers on the Ohio molluscan fauna are included here. A complete list of his works, as well as a biography, was written by Turner (1946). Anthony held offices of Secretary, Librarian, and Curator of the Western Academy. On various occasions, meetings were held in his home. He had probably become acquainted with Agassiz when the latter was in Cincinnati for the meeting of the American Association for the Advancement of Science in 1851.

At this meeting, Dr. Kirtland from Cleveland demonstrated with a display of shells a confirmation of his paper of 1834 in which he had claimed that freshwater mussels consisted of males and females. Previously thought to be hermaphroditic individuals, males and females had sometimes been classified as different species. Agassiz stated that he and the leading German scientists in this field were entirely of Kirtland's view. Kirtland (1840) also described the byssus by which young mussels attach themselves to stream bottoms.

After selling his extensive shell collection to the Portland Society of Natural History, Jesse Wedgwood Mighels moved from his native Maine to Cincinnati in 1847 to become Professor of Obstetrics and Diseases of Women and Children. He was well known to Dr. Daniel Drake, who commented favorably on his medical papers (Juettner, 1901: 319). Mighels probably made the acquaintance of John G. Anthony with whom he had formerly corresponded. Though he made no malacological contributions while in Ohio, he much lamented the destruction by fire in 1854 of the collection he had previously sold to the Portland Society, (Johnson, 1948).

Another New Englander who settled in Chillicote, Ohio and became a corresponding member of the Western Academy in 1835, was Alexander Bourne of Wareham, Massachusetts, who, as early as 1823, was in Ohio building canals. The effect these thousands of miles of waterways might have on the fauna was then of no interest. Benjamin Tappan was one of the Canal Commissioners.

The records of the Western Academy of Science are scant, but among its founders was Robert Buchanan (1797-1879: Graham, *et al*, 1880) who served as its President for a number of years. Buchanan gave money, books, and his collection to the Academy. With the gradual demise of the Academy, a new group formed the Cincinnati Society of

Natural History in 1870 which took over the decayed collections and small purse of the older institution.

In February 1874, A.G. Wetherby wrote to J. G. Anthony in Cambridge, Massachusetts, "I see many of your labels among the specimens [of Buchanan], and I can see where a part of your 49 years has aided *others* as it now aids me." He also mentioned in it a letter he had received from Isaac Lea, who said that if his "species are synonyms no person will rejoice more than himself to see them eliminated" (Departmental Collection).

The University of Cincinnati, the first municipal university chartered in Ohio under the earliest municipal university statute in the United States, was founded, as was the Society of Natural History, in 1870. Among the institutions included in it were Cincinnati College and Drake's Medical College of Ohio. Buchanan served as President for over 20 years and remained so until his death.

Papers by members of the new Society were published in *The Cincinnati Quarterly Journal of Science,* volumes 1 and 2 (1874-1875), a commercial venture, largely devoted to the rich local paleontology. One short article on malacology by C. S. Miller appeared, a paper previously read before the Society, as well as two by W.W. Calkins, a member of the Chicago Academy of Sciences, on the Mollusca of Illinois.

The first and only large bequest the Society ever received was a gift of $50,000 in 1875. This allowed the Society of Natural History to publish its first and only number of its Proceedings during January, 1876, in which Albert Gallatin Wetherby (1833-1902) described five new species of Strepomatidae (=Pleuroceridae). A month later, Wetherby and his friend, George Harper, published privately a list of shells found in the vicinity of Cincinnati. From then until 1894, Wetherby contributed numerous papers on Recent mollusks and paleontology to *The*

Journal of the Cincinnati Society of Natural History. Wetherby was born in Pittsburgh, Pennsylvania in 1833, and while still a boy, his parents moved to Cleveland, Ohio where he was educated through college. In 1861, he moved to Cincinnati to become Principal of the Woodburn Public School. His talent in natural history led to his appointment as Professor to the new University of Cincinnati in 1870. It was said that his enthusiasm for his favorite studies was such that the chairs of both Botany and Geology were added to his duties, and after six years of being overworked, he reluctantly resigned. He held several positions before 1886, when he became manager of a large tract of land belonging to the Roan Mountain Steel and Iron Company. His home in Magnetic City, North Carolina was located in a beautiful valley, about 3000 feet above sea level, surrounded by towering mountains, where he and his wife entertained visiting naturalists. It was here, among descendants of Oliver Cromwell, who had gone into the mountains to hide from the wrath of Charles II, that Wetherby pursued his interest in land snails, which he published in the Journal of the Society. He also made numerous contributions to geology, paleontology, and botany, as attested by his friend George W. Harper (1902), but these are beyond our interest here. Harper was principal of the Cincinnati Woodward High School, became President of the Society of Natural History, and continued its interest in mollusks.

In 1882, Arthur Fairfield Gray (1855-1944) of Watertown, Massachusetts, spent that year building a large manufacturing plant in Cincinnati, and while there his interest in malacology led to his publishing a list of all of the works on the subject pertaining to Ohio until 1881 in the Journal (Johnson, 2002).

In 1889, Truman Heminway Aldrich (1848-1932; Abbott, 1973: 59) described several new species from Borneo. These had been supplied to him by William

Doherty, one of Wetherby's high school student compilers of the Anonymous List (1876). The penultimate paper was by Frank Collins Baker (1867-1943) then listed as a member of the Chicago Academy of Sciences. The last paper remotely malacological was published in 1906 by Kindahl with the esoteric title, "Orthography of the names of naiades." Regarding this last paper, one is reminded of the old story of a meeting of the International Zoological Society where it was agreed that the topic for the following year would be the elephant. The British came back with a volume, *Hunting the elephant with gun and camera*, the French with *La vie sexuelle d'elephant*, and the Germans with two volumes on the etymology of the word "elephant".

With no further large gifts ever received, the Society struggled on. A depressing article appeared regarding its future in its Journal (**22**, no. 2) in 1917. It was not until 1945 that the fourth and final number of volume 22 of the Journal appeared. The Junior Society published Proceedings during 1930 and 1931 and even a Guide Booklet to the Conchological Exhibit, by Albert D. Loring, Curator of Conchology, Junior Society of Natural Sciences. What became of it and the collection, listed by James (1885), which included syntypes of the taxa described by Wetherby and others, is unknown. It is probable, however, that it is part of the Museum of Natural History and Science, housed in the Cincinnati Museum Center since 1995, located in what was once the magnificent art deco Union Terminal. Several requests for information about the shell collection have gone unanswered. The International Code of Zoological Nomenclature (2000) 74.7.3 requires that, "to be valid, a lectotype designation made after 1999 must contain an express statement of the purpose of the designation." Should lectotypes be required for any of the taxa described by A. G. Wetherby, the

syntypes in the Museum of Comparative Zoology meet the requirements of Recommendation 74D.

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McMillan and Fogan (1966: 20) suggested that Charles Moore Wheatley (1822-1882) was the author of the above mentioned catalogue since they found a note on the back of the title page of a copy of it which read, "Mr. Wheatley seems to have given up the shells. I could not procure a copy of his catalogue here but beg you will accept my only copy." Johnson (1959: 72) listed two papers by Wheatley, a privately printed *Catalogue of the shells of the United States, with their localities*, published in 1842, and a second edition which appeared in 1845. From the early 1850's, and for many years thereafter, Isaac Lea described many new species of fresh water shells received from Wheatley. In his *Synopsis* (1871), he included both Wheatley *Catalogues* (pp. 168, 169) in the bibliography as well as the Western Academy one anonymously (p. 171). One might assume that if anyone knew the authorship of the Western Academy Catalogue, it would be Lea and that peradventure the author of the quoted note affixed it to the wrong "Catalogue," except that the Preface of the Anonymous (1876) list of Cincinnati mollusks acknowledges indebtedness to "the old catalogues of Kirtland, *Wheatley* [author's italics], Anthony, and Shaffer."

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Wheatley, Charles M. 1849. See under: Anonymous.

Recent molluscan taxa described in the Proceedings and Journal of the Cincinnati Society of Natural History and other Recent ones described elsewhere by members of the Society (1876-1889)

Abbreviations

ANSP—Academy of Natural Sciences of Philadelphia, Pennsylvania
BSNH—Boston Society of Natural History, Boston, Massachusetts
CSNH—Cincinnati Society of Natural History, Cincinnati, Ohio
MCZ—Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts
MHNG—Muséum d'historie naturelle, Genève, Switzerland
UMMZ—Museum of Zoology, The University of Michigan, Ann Arbor, Michigan
USNM—National Museum of Natural History, Smithsonian Institution, Washington, District of Columbia.

Listed alphabetically by author.

Aldrich, Truman H.

The location of the types of any of the species described by Aldrich, listed below, is unknown.

broti Aldrich, *Alycaeus* 1889, Jour. Cincinnati Soc. Nat. Hist. **12** (1): 25, pls. 3, figs. 2, 2a, 2b (Kusan and Penggiron districts in southeastern Borneo and from the Kinan and Kiwa Rivers). Two dead syntypes.

dohertyi Boettger [in] Aldrich, *Clausilia* (*Euphaedusa*) 1889, Jour. Cincinnati Soc. Nat. Hist. **12** (1): 26, pl. 3, fig.4, 4a-4c (South East Borneo). [No mention as to disposition of specimens].

kusana Aldrich, *Trochomorpha* 1889, Jour. Cincinnati Soc. Nat. Hist. **12** (1): 24, pl. 3, fig. 3, 3a, 3b (Kusan and Penggiron districts in south eastern Borneo and from the Kinan and Kiwa Rivers). Seven syntypes.

lacunoides Aldrich, *Paludomus* 1889, Jour. Cincinnati Soc. Nat. Hist. **12** (1) 23, pl. 3, figs. 1, 1a-1c (Kusan and Penggiron districts in south eastern Borneo and from the Kinan and Kiwa Rivers). Twenty syntypes.

Doherty, William.

morseana, Doherty, *Cioneila (Zua)* 1878, Quarterly Journal of Conchology **1** (15): 342, pl. 4, fig. 2 (Kenton County, Kentucky and Hamilton County, Ohio) No collections named, presumably ANSP, Wetherby, J. Lewis and Doherty, not mentioned as in CSNH by James (1885). Listed as, *Cioneila lubrica morseana* Doherty by Pilsbry, 1948, Land of Mollusca of North America **2** (2): 1049, who found no type material.

trothis Doherty, *Somatogyrus* 1878, Quarterly Journal of Conchology **1** (15): 341, pl. 4, fig. 1 (on stones in the Ohio River, above the mouth of the Five-mile Creek Campbell County, Kentucky, also leaves in Five-mile Creek). Mentioned as in the collections of ANSP. A. G. Wetherby, J. Lewis, and Doherty, not mentioned as in CSNH by James (1885). Lectotype ANSP 57027a designated by Baker, 1964, Proceedings of the Academy of Natural Sciences of Philadelphia **116** (4): 177, labeled as a synonym of *Somatogyrus aureus*

Tryon 1865. Two probable paralectotypes MCZ number 323751 from UMMZ 70032 ex B. Walker collection labeled, "mouth of Five-mile Cr., Campbell Co., Ky." The original label has not been retained and the one in the handwriting of Calvin Goodrich does not bear Walker's catalogue number. While it is impossible to identify the source of the specimens, the accuracy of the rather obscure locality argues that they are more than topotypes.

Harper, George W.

bryanti Harper, *Patula* 1881, Proc. Cincinnati Soc. Nat. Hist. **4** (3): 258, figs. 1, 1a (Mitchell County, North Carolina); Wetherby, 1881, *ibid.* p. 328. Not mentioned by James (1885) as in the CSNH. Two syntypes MCZ 61570 from Wetherby, to Thomas Bland, ex A. F. Gray collection.

Judge, Charles R.

cincinnatiensis Judge, *Pupa* 1878. Jour. Cincinnati Soc. Nat. Hist. **9** (1): 10, fig. (both sides of the Ohio River, near Cincinnati [Hamilton Co., Ohio]). Syntype CSNH *teste* (James: 1885: 44); also in personal collection and that of James Lewis, Mohawk, New York [both probably lost].

Wetherby, Albert G.

None of the syntypes mentioned by Wetherby as in the United States National Museum could be located (R. Hershler, pers. comm., 2000).

angulata Wetherby, *Angitrema* 1876, Proc. Cincinnati Soc. Nat. Hist. no 1: 11, pl. 1, fig. 5. (Stone River, Rutherford Co. Tennessee). Nineteen syntypes MCZ 1409 from Wetherby, ex Richard E. Call collection; 21 syntypes MHNG, ex Brot collection.

copei Wetherby, *Helix* or *H. vultuosa copei* 1878, The American Naturalist **12**:185, text figs. (Under logs in pine woods twenty miles north of Beaumont, Hardin County, Texas). Lectotype ANSP 82316, the figured type, designated by Pilsbry, 1940, Land Mollusca of North America **1** (2): 820, fig. 484 a, b.

duryi Wetherby, *Planorbis (Helisoma)* 1879, Journal Cincinnati Soc. Nat. Hist. **2**(2): 99, fig. 4 (Everglades of Florida; among the shells received from the Miami County). *Helisoma duryi* (Wetherby) F. C. Baker, 1945, Molluscan Family Planorbidae, pl. 33, figs. 11, 13, 14, pl. 103, figs. 20-31, pl. 104, figs. 1-7. Syntype MCZ 4507 from Charles Dury ex R. E. Call collection.

fimbriatus, Helicodiscus 1881, Jour. Cincinnati Soc. Nat. Hist. **4**(4): 331 (gorge of the Tellico River, Monroe Co., Tennessee). Syntype [not located] figured by Binney, Bull. Mus. Comp. Zool. **4**(8): 148, pl. 1 fig. D. Four syntypes MCZ 1723 from Wetherby, ex Richard E. Call collection and 6 syntypes MCZ 15296 from Wetherby in E.R. Mayo collection ex BSNH.

hecoxi Wetherby, *Ariolimax columbiana* 1880, Jour. Cincinnati Soc. Nat. Hist. **3** (1): 38 (Santa Cruz, California). Not preserved [nomen nudum]. See: Pilsbry, 1948, Land Mollusca of North America **2** (2): 715, note 40.

parva Wetherby, *Angitrema* 1876, Proc. Cincinnati Soc. Nat. Hist. no 1:9, pl. 1, fig. 2 (Stone River, Rutherford Co., Tennessee). Fourteen syntypes MCZ 1421 from Wetherby, ex R. E. Call collection; 11 syntypes MHNG, ex Brot collection.

perfragilis Wetherby, *Zonites*: 1881, Jour. Cincinnati Soc. Nat. Hist. **4** (4): 326 [nomen nudum]; 1894, *ibid.* **16**: 215 (Rutherford County, Tennessee) Types lost, *teste* Wetherby. *Mesophix* (?) *perfragilis* (Wetherby); Pilsbry, 1946, Land Mollusca of North America **2** (1): 327 ("in a sink-hole in a cedar glade on the

Murphreesboro Pike about two miles out of Nashville," Rutherford Co., Tennessee (in letter to Pilsbry).

plicata Wetherby, *Lithasia* 1876, Proceedings of the Cincinnati Soc. Nat. Hist. no. 1: 9, pl. 1, fig. 1 (Green River, Clay's Ferry, Jackson County, Kentucky). Nineteen syntypes CSNH (*teste* James, 1885). Syntype MCZ number 323752 from UMMZ 130661 with the locality corrected on label to Kentucky River, but the Kentucky River proper does not border on Jackson County) ex A. G. Wetherby, Bryant Walker collection. Charles M. Wheatley collection in ANSP (not found); MHNG, ex Brot collection (not found).

plicatastriata Wetherby, *Goniobasis* 1876, Proc. Cincinnati Soc. Nat. Hist. no 1: 10, pl. 1, fig. 3 (Stone River and Mill Creek, Rutherford County, and Sinking Creek, near Shelbyville [Bedford County]; *all* Tennessee). Three syntypes MCZ 88383 from Stone River, Rutherford County; Tennessee, ex Boston Society of Natural History; 3 syntypes MHNG ex Brot collection.

umbilicata Wetherby, *Anculosa* 1876, Proc. Cincinnati Soc. Nat. Hist. no 1:11, pl. 1 fig 4 (Stone River, Rutherford County, Tennessee). Six syntypes MCZ 136613, ex Boston Society of Natural History; 12 syntypes MHNG, ex Brot collection.

EARLIEST AMERICAN NATURAL HISTORY LITHOGRAPH

Richard I. Johnson

Charles-Alexandre Lesueur (1778-1849), French artist and naturalist, is best known to malacologists for having described the common Atlantic Coast squid, *Loligo peali* Lesueur, 1821, named for a son of Charles Wilson Peale. Having early shown remarkable sketching ability, Lesueur

accompanied Nicholas Baudin to Tasmania and Australia as an artist (1800-1804), but most of the drawings he made were never published. Lesueur met William Maclure in Paris during 1815, and accompanied him to the United States as a paid companion and naturalist. In Philadelphia, both became active in the Academy of Natural Sciences, founded in 1812. It was here that Lesueur met Thomas Say, "Father of American Conchology", whom he would later accompany to Robert Owen's settlement at New Harmony, Indiana.

Lithography had been invented by Alois Senefelder (1771-1834) in Munich. In 1798 he perfected his method of printing, based on the antipathy of grease and water. Polished marble is marked with a grease crayon, treated chemically, inked, sponged with water. So long as the stone is damp, the printers' ink adheres only to the greasy marks. This form of planographic printing was first used by Lesueur to illustrate two fish, published on a single folding plate (10) in *Jour. Acad. Nat. Sci.* **2** (1) Oct. 1821. Only three copies (and mine) are known. Apparently unsatisfied with his work, Lesueur, who since 1817 had been engraving copper plates to illustrate his own articles and those of other naturalists for intaglio printing, returned to his earlier method before many copies of the Journal were distributed. The following June, he produced two drawings on imported limestone, rather than on Kentucky marble. They were printed for the Journal in New York by Barnet and Doolittle, the first lithographic firm in the U. S. The year 1822 is generally regarded as the date for the first use in the U. S. of lithography for natural history illustrations.

Reference

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ARTHUR FAIRFIELD GRAY (1855-1944), HIS MALACOLOGICAL CONTRIBUTIONS

Richard I. Johnson[1]

Abstract: Arthur Fairfield Gray (1855-1944): his life is briefly sketched and his malacological contributions are listed. The lectotype of the one species he described, *Unio borealis* Gray, 1882, previously selected, is figured.

Arthur Fairfield Gray was born in 1855 at Beverly, Massachusetts, the son of Samuel F. and Abigail (Whitehouse) Foster Gray. It is reported in the very important sounding *Representative Citizens of the Commonwealth of Massachusetts* (Hurd: 1902: 734-736) that is was impossible to identify Gray's immigrant progenitor in direct line or to trace his parental ancestry farther back than his great-grandfather, James Gray, of Beverly and Harrison, Maine who was a cordwainer.

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Despite this lamentable limitation, there follow several pages of genealogy which indicate that Gray's people were all early settlers in New England and active in both the French and Indian Wars and the American Revolution.

From 1861 to 1872, Gray was educated in the schools of Danvers, Massachusetts, and received no higher education. He early became interested in natural history, and having an artistic temperament, turned his attention to supplying illustrations for scientific works. Early in 1872, at the age of 17, Gray entered the office of Shedd and Sawyer, a firm of civil engineers who built water works, sewerage plants, and mill buildings. During the ten years Gray was with Shedd & Sawyer, he gained a thorough knowledge of construction methods and engineering. When he was 27 his first article on mollusks was published. It was a letter to Charles Darwin, on the transportation of a fresh-water mussel on a duck's foot, which Darwin submitted to *Nature.* It was later reprinted by Kew (1893:80). In 1882, Gray planned and supervised the building of a large manufacturing plant near Cincinnati, Ohio. While there he also found time to publish a definitive bibliography of all the papers dealing with the molluscan fauna of Ohio through 1881 for the Cincinnati Society of Natural History (CSNH). He had become engaged in the study of mollusks at CSNS and made the acquaintance of A. G. Wetherby, with whom he had corresponded extensively between 1877-1879 whilst living at Danversport.

In 1884, Gray married Mabel Stone, a native of Hamburg, Illinois, born in 1863. The Grays had three children: Warren, born in 1885 who died in infancy; Arthur Harrison, born in 1888; and Helen, born in 1894. Mrs. Gray was said to have come from a long and honorable line of New England ancestry on both the paternal and maternal side. Through her mother she was a descendent of John Alden and Priscilla Mullins of the Plimouth Plantation,

made famous by Henry Wadsworth Longfellow in his poem, "The Courtship of Miles Standish." This connection once established it would be anticlimactic to continue here with another page of who begat whom as did Hurd, who may well have been more impressed with the Gray genealogy than with the Grays themselves.

From 1882-1884, Gray lived in Danversport, Massachusetts, where he was the superintendent and manager of a large industrial plant. In 1884, the newlywed Grays moved to Lawrence, Massachusetts where he took charge of transforming the Arlington Mills of that city by supervising the erection of many mills for that fast growing textile manufacturer. A large number of surviving postcards, addressed both to Danversport and Lawrence, indicate that Gray was also busy preparing drawings of land snails for Thomas Bland (1809-1883) and William Greene Binney (1833-1909), though he had been making illustrations of shells for publication at least since 1878, as acknowledged by Calkins (1878:235) of the Chicago Academy of Sciences, who dealt in "Lumber, Lath, and Shingles, Etc., by the Cargo."

In 1890, Gray established his own architectural and engineering firm in the Exchange Building on State Street in Boston, Massachusetts, which he maintained until 1933. Subsequently, he ran the firm from his home at 22 Fayette Street, Watertown, Massachusetts. In addition to being a capable and artistic designer of mill structures, Gray built railway stations for the Boston and Maine Railroad at Malden and Newburyport, Massachusetts, and bank buildings at Peabody, Hyde Park, and Salem, Massachusetts, as well as pumping stations for sewerage plants at East Boston and Deer Island. Fifty-three sets of drawings of public buildings produced with his partner, Frank M. Blaisdell, are held in the Special Collections Department in the Frances Loeb Library at Harvard University.

From 1888, over forty years would go by before Gray would again contribute to molluscan literature with a biography of W. G. Binney. He was, however, active in the Boston Malacological Club, founded in 1910 by five gentlemen, at the home of Francis N. Balch in Jamaica Plain. Elected were President Edward Sylvester Morse (1838-1925; Champion, 1947); Vice-President Francis Noyes Balch (1874-1960; Champion, 1961); Secretary Treasurer, Rev. Henry W. Winkley (1858-1918; Johnson, 1918); Executive Committee, Charles Willison Johnson (1863-1932; Gray, 1933) and John Ritchie, Jr. (1851-1939; Anonymous, 1939.) When the Club held its first meeting on March 10, 1910, thirteen members were present, and while it is not now known if Gray was among them, during the first fifty years of the club's existence (it persists to this day) Gray was an active member and President between 1923-1927. No one else had served so long in that position.

William J. Clench (1897-1984; Abbott, 1984) was appointed Curator of Mollusks, Department of Mollusks, at the Museum of Comparative Zoology (MCZ) in 1926 and began a correspondence with Gray, which would continue almost to the death of the latter, regarding the disposal of his collection and library both of which he wished to go to the MCZ. In September, 1927, Gray mentioned a trip to Bermuda with Dr. Mark (Edward Laurens Mark, 1847-1946) who, in addition to being a distinguished Harvard professor and author of a definitive work on *Limax* (1881), was then the Director of the Bermuda Biological Station. Gray suggested that he wanted examples of the shells he collected in Bermuda to be in the Museum. On January 9, 1934, Gray wrote to Clench, referring to his collection and library, that since he was celebrating his 79th birthday, he thought, "it was time to place these things." Gray presented his Bermuda collection to the MCZ in 1934, but it was not until 1938 that he gave to the Museum some 500

lots of North American land shells he had received mostly from Binney and Bland. These were duplicates from both collections. The MCZ bought the main Bland collection in 1868 (Clench, 1933: 80). The Binney collection is in both the National Museum of Natural History and the American Museum of Natural History (Gratacap, 1901). The Department of Mollusks also received Gray's extensive collection of photographs of early conchologists but, alas, it did not include one of himself. He also gave several of the original copper plates used to produce the illustrations in works by both Thomas Say and William G. Binney. A number of letters to Gray from W. G. Binney, Thomas Bland, A.G. Wetherby, and others are preserved in the special collections of the library of the MCZ.

Gray continued to offer his library for sale, but the Director Dr. Thomas Barbour (1884-1946; Peters, 1948), who had spent much of his own fortune on modernizing the MCZ, did not make the funds available, and Curator Clench could not afford to purchase it himself. Gray had been a subscriber to a deluxe set of the land snail portion of Tryon's *Manual of Conchology* from its beginning (1885) and volume 28, the final volume, still had a couple of numbers to go before completion (1935). He had purchased a number of items from the library of W. B. Binney, which included Thomas Say's *American Conchology* (1830-1834 [-38]) a smoke-damaged copy from his father, Amos Binney (1803-1847; Dall, 1888:122) which had been used by the younger Binney when he was preparing a reprint of Say's complete works. There was also Thomas Bland's copy of Say's original work, and a slightly smoke damaged copy of S. S. Haldeman's *Monograph* (1840-1845).

The proposed sale of books to the Museum of Comparative Zoology never took place. Instead, in 1942, the entire Gray library was sold to George Goodspeed, then a well known Boston book dealer, who paid 35 cents a

volume for the library, which also contained Gray's engineering books. Those of us from the Museum were among the first to see the books, but one copy of Thomas Say's *Conchology* had already been sold to a communist group for $200 because of its association with Robert Owen's communist experiment at New Harmony, Indiana. The other copy was never mentioned. The *Manual of Conchology* had also disappeared, but many of the remaining books were purchased for the Department of Mollusks by Richard Winslow Foster (1920-1964; Turner, 1970) including the Haldeman (1840-1845); Conrad, *American Marine Conchology* (1841-[34]); B. Delessert's great folio illustrating J.P.B. Lamarck's types (1841); many rare works of J. R. Bourguignat (1829-1892); Servain, 1891); and others.

This author (Johnson, 1975) bought one of the great rarities, in a book of bound separates: Say's article on conchology from the 1817 edition of Nicholson's Encyclopedia. This is the first article on American Conchology and possibly the only known separate of it. Say had sent the article to C. S. Rafinesque (1783-1840; Boewe, 1982) which had then been bought by S. S. Haldeman (1812-1880; Dall, 1888), W. G. Binney, and finally A. F. Gray.

Gray died two years after the sale in 1944 from the effects of Parkinson's disease, at Watertown, Massachusetts where he had resided for fifty years. He had been a Town Meeting Member, School Committeeman, Parks Commissioner, Library Trustee, author of a Report on Laying out of Ridgelawn Cemetery (1899), and also had had time to become a Knights Templar in the Masonic Order. Mrs. Gray died previously in 1931. The Gray house still stands, at 20 Fayette Street, but in poor condition in what is now an ethnic neighborhood, secluded, but near what has become a busy intersection.

Acknowledgments

Most of the data on the life of Arthur Fairfield Gray was gleaned from a researcher's report by Trevor Joy Johnson, former Archivist of the Boston Athenaeum, to whom we are most grateful.

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Fig. 1. The book plate delineated by Gray himself, was kindly supplied by Thomas G. Boss, a distinguished collector.

Fig. 2. *Unio borealis*, Gray, 1882: (Ottawa River at Duck Island [below Ottawa, Ottawa Co.]; Leamy's Lake, near Hull, Quebec; *both* Canada). Lectotype MCZ 51470 from the former locality, selected by Johnson, R. I. 1956. The types of naiades (Mollusca:Unionidae) in the Museum of Comparative Zoology. *Bulletin of the Museum of Comparative Zoology* **115** (4): 108 (September). Length 81 mm, height 50 mm, width 42 mm. Female (slightly reduced).

Fig. 1

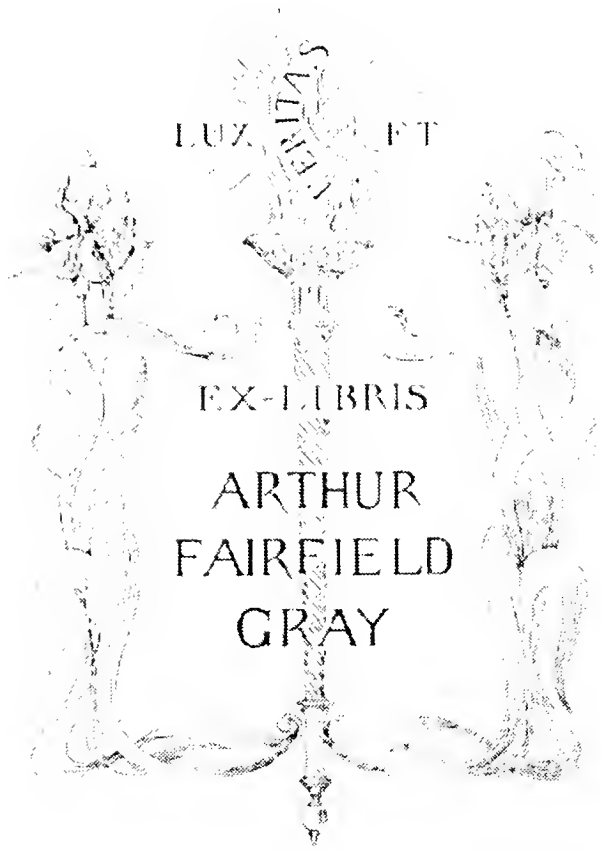
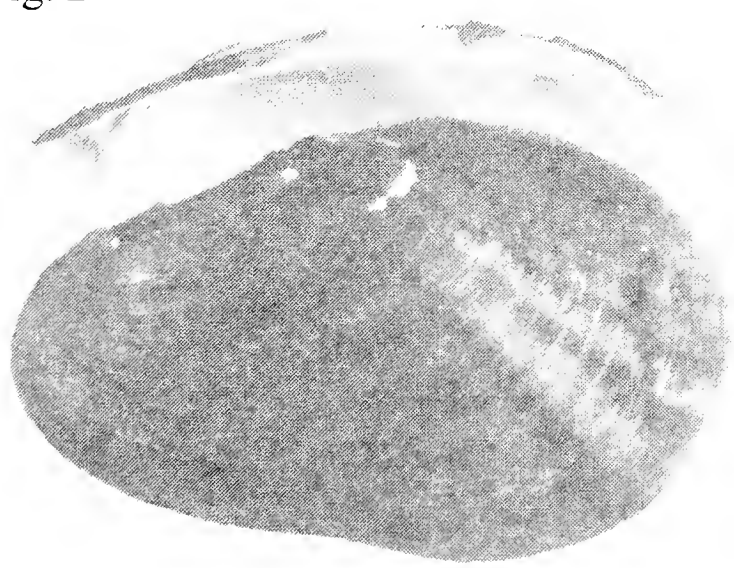


Fig. 2



THE MOLLUSK COLLECTION OF THE BOSTON SOCIETY OF NATURAL HISTORY AND ITS DISPOSITION

Richard I. Johnson

The Boston Society of Natural History was founded in 1830, but the first Curator of Mollusks, T. J. Whittmore, was not appointed until 1839. It was a few years before then that Amos Binney, J. P. Couthouy [Johnson, 1946, *Occ. Pap. Moll.* **1** (5)], A. A. Gould [Johnson, 1949, *Occ. Pap. Moll.* **1** (14)], and D. H. Storer were describing new species of mollusks in the Society's Journal and mentioning that specimens had been deposited in the collection. The first Catalogue of Mollusks, which had since disappeared, had several thousand entries, and was invaluable to me in determining accurately Couthouy's type specimens. The present seven substantial catalog volumes, consisting of some 27,000 entries, seems to have been begun toward the end of the Nineteenth Century.

Sarah Pickering Pratt (1807-1866) left her showy, but not scientifically valuable collection to the Society, along with the then considerable sum of $10,000 for its care. A similar collection was received upon the death of Edward Richards Mayo (1891). Among the more important collections received before the turn of the century were the Hawaiian Achatinellidae of J. T. Gulick [Johnson, 1996, *Bull. Mus. Comp. Zool.* **155** (4)] and the Edward W. Roper collection of Cyrenidae. A significant New England collection was assembled by Dwight Blaney, List of shell-bearing mollusca of Frenchman's Bay, Maine, [1904, *Proc. Boston Soc. Nat. Hist.* **32** (2)]. In 1914, all but the New England collections were sent to the MCZ. After the Society gave up research in 1946 and became the Museum of Science, even the extensive New England collection was transferred to the MCZ.

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THE MARVELOUS, MONSTROUS, MYTHICAL, MARINE MOLLUSK, *COCHLEA SARMATICA* THEVET, 1575

Richard I. Johnson[1]

Abstract: Thevet in his *Cosmographie universelle* (1575) figured a shell, probably the one now known as *Cassis madagascarensis* Lamarck, 1822, which actually occurs in the Atlantic Ocean in the vicinity of southeastern Florida, the Bahamas, and Greater Antilles. In this shell, he placed a fantastic animal from the Baltic Sea, the description and figure of which were to be reproduced by credulous savants for nearly the next century and a quarter. Since the original figure, showing the snail in its supposed habitat, and the English translation of its description are not generally available, they are both reproduced.

Fabulous beasts populated the human imagination during the Middle Ages and Renaissance, and as noted by Dance (1979), the line separating real animals from

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imaginary ones could be very thin. The major chronicler of the monsters believed to inhabit the northern sea between Iceland and the Scandinavian Peninsula was Olaus Magnus (1490-1557), Archbishop of Uppsala, who portrayed many of them in his now very rare, separately published map, *Carta Marina* (1539). Following the Reformation, Magnus left his native Sweden and took up residence in Rome. There he published the first comprehensive description and history of medieval Scandinavia, *Historia de gentibus septentrionalibus* (1555). This work included a simplified version of the *Carta Marina*, with more detailed delineations in the text of the creatures portrayed on it. Among these were the Monk Fish, and the Bishop Fish, now thought to have been invented from squid parts, as well as a fanciful version of a giant squid. All of these are discussed by Ellis (1998). Also portrayed by Magnus is a great sea serpent attacking a ship, and Saint Brendan (ca. 486-578) is shown mistaking a basking whale for an island a thousand years after this supposed event took place. From a modern translation of *Navigatio Sancti Brendani* (1991), which made its original appearance in about 800, one surmises that Brendan, in his currach, not only reached the Canary Islands, but also the American coast as far south as Florida. A similar voyage was more recently made by Severin (1978). Magnus's treatise also illustrated daily work and customs. It showed men flensing a whale, as well as people on skis, which is believed to be the first illustration of this means of transportation. The book was sufficiently popular to be translated into Italian and published in Venice (1565), while the original edition was reprinted in Basel (1567). Most of the illustrations in the subsequent printings were made from the original wood blocks.

It seems strange that Olaus Magnus, despite his expertise in this area, was unaware of the partially imaginary snail later described by André Thevet (1502-

1590) in his *Cosmographie universelle* (1575). Though the shell resembles that of a living species, *Cassis madagascarensis* Lamarck, 1822, we might forgive Magnus for not being cognizant of yet another fanciful animal. Schlesinger and Stabler (1986) point out that little is known about Thevet's early life except that he was a native of Angoulême, and somehow came under the protection of the powerful La Rochefoucauld family, received a university education at Potiers and Paris, and became private secretary to the Cardinal of Amboise. Later, he became a most successful man of the cloth, holding a number of official positions at court and in the Church. He became *aumonier* to Catherine de Medici, Royal Cosmographer to four kings, a Canon here, and Abbot there, and Overseer of the Royal Collection of Curiosities at Fontainebleu. Thevet was one of the most widely traveled Frenchmen of his day. He spent time in the Levant and later went to Brazil, returning by a northerly route past Haiti, Cuba, Florida, and "very close to Canada," by which he apparently meant that he had been to the region north of the Carolinas.

Although he never returned to North America, by the time he wrote *La Cosmographie universelle* some twenty years later, he asserted not only that he had landed in Canada, but that he had spent twenty days there examining that country and talking to the natives. The North American portion of his work was translated by Schlesinger and Stabler (1986) who said of him, "Not only did Thevet receive some of the harshest criticisms of any literary figure of his day—involving rare agreement among Catholic and Protestant writers—but his poor reputation as a scholar has continued until recent times." They do mention though, that modern scholars have found his information on some subjects, resting on no known sources, to be entirely correct. However, in addition to copying a number of Magnus's figures, Thevet added the description

and figure of the snail in its native habitat described below, which rested on no previously known written source, and contained grave anatomical inaccuracies. Ambroise Paré, the famous French Renaissance physician and expert on gunshot wounds, appears to have had access to Thevet's woodcut. His rendering of Thevet's description and illustration first appeared in his collected works (1579), which went through three additional editions, 1585, 1593, and 1607, and was translated into English by Johnson (1634). This first edition of *Deux livres de chirugie* was a small octavo volume, the second book of which, *Monstres et Prodigies* (pp. 365-380) appeared before Thevet's figure was available. Delaunay (1925) gives a detailed commentary on the book on monsters, which were included in this book. Caprotti (1988) duplicated Paré's illustration of 1579 and dated it incorrectly as from 1573. Janet Doe's *A Bibliography of the works of Ambroise Paré*...(1937) provides the most exhaustive collations of the several of Paré's works mentioned here, and on page 74, she writes that the "1573 work must have appeared before August 24, 1572."

Thevet's sixteenth century French, as copied by Paré, had a few minor discrepancies meticulously pointed out by Céard (1971:191, note 274; fig. 54). Paré's archaic French was translated into equally archaic English by Johnson (1634: 1007). This description of the imaginary gastropod has been freely rendered here, though a more modern translation by Pallister (1982) exists. Thevet mentioned that he had sent notice of a number of monstrous fishes to the late encyclopedist Conrad Gesner (1516-1566), in Geneva, but the mythical snail was not included in the latter's posthumous work. It was first illustrated in a work on natural history as a serious contribution to Conchology in 1606, by the other celebrated encyclopedist, Ulissi Aldrovandi (1522-1607) of the then-Papal State of Bologna. The woodcut appears without any background,

and has a length of 11.5 inches or 482 mm on a full folio plate. Subsequent wood cuts in Jonstonus (1603-1675) and Buonanni (1638-1725) do not exceed 5 inches or 127 mm in length. Johnstonus's *Historiae naturalis* went through four editions between 1650 and 1768.

Perhaps the best known work to include Thevet's snail is that of Buonanni (1681), who produced the first illustrated book on shells, *Ricreatione dell' ochio e della mente nell' observation' delle Chiocciole...*, (Recreation for the eyes and mind from the study of shells). Buonanni was born in Rome, and was ordained a Jesuit priest. He was a student of the German Jesuit, Athanasius Kircher (1602-1680), who became well known and learned in many branches of the humanities and sciences, among which were deciphering hieroglyphics, optics, and astronomy. In 1838, the year Buonanni was born, Kircher was called to Rome by Pope Urban VIII and appointed Professor of Mathematics at the Roman College of the Society of Jesus in 1838. He added to the College's collection his own assembled rarities of nature, art, and superstition. This, in time, became the Kircher Museum. Before his death, Kircher had written forty-four books that attest to the extraordinary variety of his interests. Buonanni succeeded to the post occupied by Kircher upon the death of the latter in 1680, and while Buonanni published his *Recreatione* the following year, based on Kircher's shells, he was not elevated to Curator of the Museum until 1689. Those shells which remained extant were deposited in the Museo dell' Instituto di Geologia e Paleontologia in Rome during 1913.

Buonanni's system of classification is of nugatory value. He promulgated many of the mythical beliefs of the earlier commentators. For example, he believed, as did Aristotle, that "all [shelled mollusks] are generated spontaneously by the mud, oysters by dirty mud and others by sandy mud," and that they were heartless and bloodless.

He was convinced that both observation and authority supported spontaneous generation, though this erroneous theory had been disproved by two other Italians, Francesco Redi (1626-1698) and Marcello Malpighi (1628-1694) some years previously. The illustrations are reasonably accurate, but reversed. The 1681 edition of the *Ricreatione* must have enjoyed considerable popular success, since it was translated from Italian into Latin to appeal to a much wider, international audience, and appeared three years later (1683) with numerous additional wood cuts.

In 1709, Buonanni published a complete description of the Kircher Museum. For this work, the previously printed figures of shells were redrawn and others were added. The plates were issued again in a subsequent, enlarged, posthumous edition (1773-1782) of the Museum's contents. Some copies have colored plates which show the last serious illustration of *Cochlea sarmatica* (p. 143 pl. 32, fig. 270), a pinkish animal with a yellow and brown striped shell. This plate was reproduced in full color by Dance and Heppell (1991:26, 27) who placed the snail in the Black Sea, possibly because the present Black Sea occupies part of the area known as the Sarmatian, a local stage of the Miocene Period. None of the Seventeenth and Eighteenth Century authors who followed Thevet questioned the authenticity of his animal, and they all gave him credit for its discovery. Aldrovandi's (1606) figure was again reproduced in very reduced form by Burns (1975: 32, 33) in a small volume, *Bio Graffiti*, poems on modern biographical subjects, accompanied with the line, "To a Lonely Hermaphrodite Know Thyself."

Mann (1946:8), in his life of Fredrich Gentz (1764-1832), so called Secretary of Europe, mentioned that "the kindly, meticulous old gentleman, the austere and profound philosopher, Immanuel Kant (1724-1804), who took Gentz into the intimate circle of his disciples, let him read proofs of his writings as they came from the press, and invited the

young man to his luncheons, where there were incredible amounts of dried fish and for every guest a quarter of a bottle of Bordeaux. The conversation turned on the political events of the day...not to mention such things, say, as the geography of far lands, marvelous tales of travel, and monsters of the animal world for whose sensational descriptions the old gentleman often relied on writers whom he would have done better not to trust." Surely, the old sage of Köningsberg, then East Prussia, whose habits were so regular that people set their watches by him as he passed their doors on his constitutional, must have had a copy of Magnus or Paré. This author of *The Critique of Pure Reason* may also have remembered that Peter the Great had, in 1710, the year after his defeat of King Charles XII of Sweden at Poltava, commanded the construction of a huge sea serpent, its tail supported on numerous wagons linked together to undulate as it moved for the celebration of the marriage of his niece Anna Ivanovna, with the Grand Duke of Courland [present day Latvia] (Pflaum, 1984: xv). Tsar Peter is also remembered by a few of us for purchasing the great natural history collection of the Dutch apothecary, Albertus Seba (1665-1736) in 1717.

The earlier belief in special creation, which put no limits on what God might design, has now been repudiated by the Darwinian paradigm. However, to this day, there are some who believe in and search for strange monsters.

Cochlea sarmatica Thevet, 1575

Cochlea sarmatica Thevet, 1575. La cosmographie universelle **2:** pt. 20, Chap. 12, p. 929b, fig.

Paré, 1579. Les oeuvres de M. Ambroise Paré, p. 1058, fig.

Aldrovandi, 1606. De reliquis animalibus exanquibus libri quatour, p. 391, fig. 157.

Johnson, 1634. The works of that famous chirugion Ambrose Parey...Lib. 25, Of monsters and prodigies, p. 1007.

Jonstonus, 1650. Historiae naturalis et exanguibus aquaticus, p. 38, pl. 12, fig.

Buonanni, 1681. Ricreatione dell' occhio e della mente nell' osservation delle Chiocciole...p. 221, fig. 230.

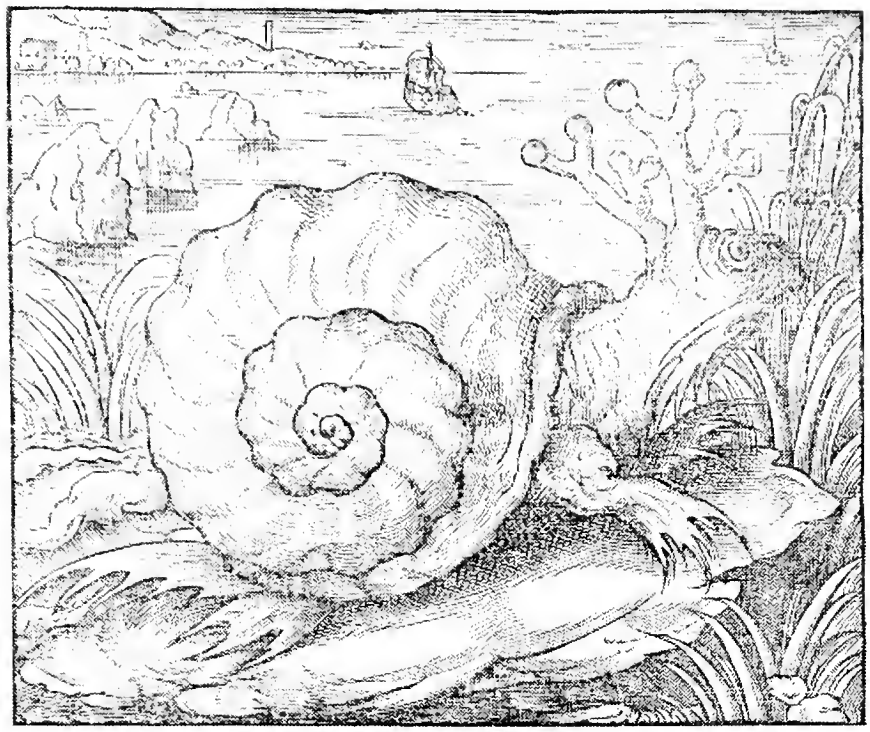
Buonanni, 1684. Recreatio mentis, et oculi in observatione Animalium Testaceorum...p. 142, fig. 230.

Buonanni, 1709. Museum Kircherianum, sive Museum a P. A. Kirchero in Collegio Romano Societatis Jesu...p. 463, fig. 230.

Buonanni, 1782. Rerum naturalium historia, nempe Quadrupedum, etc....in Museo Kircheriano...**2:** 113, 114, p. 132, fig. 230.

Description

The Sarmatian, or Eastern German, Ocean contains fishes that are unknown to hot countries, and very monstrous. Such is that which resembling a snail, equals a barrel in magnitude of body, and a stag in the largeness and branches of her horns: the ends of her horns are rounded as it were into little balls, shining like pearls, the neck is thick, the eyes shining like lighted candles, with a roundish nose set with hairs like a cat, the mouth wide, under



which hangs a piece of flesh very ugly to behold. It goes on four legs, with many broad and crooked feet, and has a long tail, and marks of different colors like a tiger, together serve for her fitness to swim. This creature is so timorous, although it is an Amphibium, that it lives both in water and ashore, yet usually it keeps itself in the sea, neither does it come ashore to feed unless it is a very bright season. The flesh is very good and pleasing meat, and the blood is medicine for such as have their livers ill affected or their lungs ulcerated, as the blood of great tortoises is good for leprosy.

Thevet mentioned that he saw this animal in Denmark, along with a number of other monstrous animals, and in effects tells the reader how lucky he is to be able to see them on the printed page rather than to expose himself to the dangers involved in searching them out. He further

noted that he had sent information on several monstrous fishes to the late Conrad Gesner [in Geneva].

Remarks: Thevet has given us a binomial name for what appears to your author to be a shell named some two hundred years later, *Cassis madagascarensis* Lamarck, 1822, described from "Madagascar," but actually from the Atlantic Ocean in the vicinity of southeastern Florida, the Bahamas, Greater Antilles. In this shell, Thevet has placed a fantastic animal from the Baltic Sea which he portrayed in its supposed native habitat, with the printed marginal note next to the figure, "Pourtract du Limaçon poisson mon strueux." The Baltic Sea was the Sarmaticus Oceanus in ancient geography, and, as mentioned, not the Black Sea as suggested by authors. Delaunay (1962: 132-133) previously suggested that the drawing of the shell was that of a large fossil ammonite found in Denmark from the Albian stage of the lower Cretaceous Period.

Thevet described his animal in more careful detail than many extant animals were to be rendered in more recent times. He mentioned its relationship to the environment as well as its medical uses, and assures us that he actually saw the animal in Denmark. Finally, he generously shared his knowledge with Gesner. Everything done well, if, alas, the animal had but existed.

Acknowledgments

Although Paré and all subsequent authors referred to Thevet, it had never occurred to me to look up his original work. It was Florence Fearrington who, in 1995, kindly called my attention to an exhibit in Harvard's Houghton Library containing Thevet opened to the very page on which *Cochlea sarmatica* was figured. Ms. Fearrington and her husband, James W. Needham, are distinguished

collectors of conchological literature and generous supporters of the Houghton Library. It is a great pleasure to thank her, as well as the officials of the Houghton Library, who enabled the reproduction of the figure. Paré (1579), which had formerly been in the library of Dr. Oliver Wendell Holmes and the Boston Medical Library, as well as Johnson (1634) were made available at the Countway Library of the Harvard Medical School. Most of the remaining items are either in the library of the Museum of Comparative Zoology or in my own library.

Drs. Alan R. Kabat and Kenneth J. Boss were kind enough to read the manuscript and make a number of significant corrections and improvements, as did my wife Marrian. Dr. Kabat also supplied the references to Delaunay (1925), Doe, and Pallister. Mr. Adam Baldinger helped with the tedious work involved in its publication.

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THE TYPE MATERIAL OF *CYPRAEA SEMIPLOTA* MIGHELS, 1845 (GASTROPODA: CYPRAEIDAE)

Richard I. Johnson

This paper addresses the status of two putative "type" lots of *Cypraea semiplota* Mighels, 1845 (Gastropoda: Cypraeidae). In 1949, while preparing a catalogue of the taxa and publications of Jesse Wedgwood Mighels, I had the opportunity to review the extent of his type material. In particular, I emphasized the fact that Mighels's own collection were sold to the Portland Society of Natural History (Maine) in 1846, and were totally destroyed by fire in 1854 (Johnson, 1949: 214). However, I then noted that Mighels had previously exchanged or sent type specimens of many of his species to various collectors, whose collections are now in the Museum of Comparative Zoology [MCZ] (C. B. Adams, J. G. Anthony and the Boston Society of Natural History), the American Museum of Natural History [AMNH] (J.C. Jay) and the Natural History Museum, London [BMNH] (H. Cuming) (Johnson, 1949: 217). Thus, I was able to select lectotypes for certain of Mighels's species from this extant type material.

For *Bulla punctostriata, Cypraea semiplota, C. insecta, Pleurotoma rugosa* and *P. pumila*, as there were no extant type specimens, I then designated "neoholotypes" (*i.e.* neotypes) from specimens in the MCZ collections (Johnson, 1949). These specimens were from the collection of W. H. Pease, who was probably the first conchologist to re-collect many of Mighels's Hawaiian species. The neotype of *C. semiplota*, MCZ 176989, was from a lot of four specimens, collected by Pease and identified by Roberts (1885: 194, pl. 19, figs. 31, 36, 37), who seems to have been the first to illustrate this species.

At that time, I obviously could not predict that my 1949 neotype designations subsequently would become invalid

under the International Code of Zoological Nomenclature as enacted in 1961 and amended most recently in 2000. In 1949, the then-operative "Règles Internationales de la Nomenclature Zoölogique" had no provision governing neotypes (Schenk & McMasters, 1948: 7-9). ICZN Article 75 (which is substantively similar in the 1961, 1964, 1985, and 2000 editions of the Code) now requires that all neotype designations, including those published before 1961, must be accompanied by "a statement that it is designated with the express purpose of clarifying the taxonomic status or the type locality of a nominal taxon," ICZN Article 75.3.2, and satisfy five other procedural requirements. More generally, a neotype "is not to be designated as an end in itself, or as a matter of curatorial routine, and any such neotype designation is invalid." ICZN Article 75.2. Thus, by retroactive application of the ICZN, the five neotype designations in my 1949 paper are, regrettably, invalid pursuant to ICZN Article 75.7.

Recently, Boyko & Cordeiro (2001: 46) reported that they had found specimens of *C. semiplota* in the AMNH for which they wrote that: "catalog books deposited in the AMNH by Witthaus list these specimens (AMNH 22824) as 'type species' received from Pease." They then claimed that this lot, comprising nine specimens, was a syntype lot, and that "Johnson's 'neoholotype' is hereby suppressed by the rediscovery of this type material" (Boyko & Cordeiro, 2001: 47). Unfortunately, these authors were wrong on two counts, as explained below. In their haste to correct the errors of their learned predecessors, Boyko & Cordeiro themselves erred.

First, AMNH 22824 does not constitute original type material. William Harper Pease did not become interested in Hawaiian shells until the late 1850s, when he began extensive collecting of shells after permanently settling in Honolulu (Oahu), the type locality of many of Mighels's species. Pease was not known to have received original

specimens from the Mighels collection, as had Anthony, C. B. Adams, and Cuming in the 1840s. Further, according to Kay (1975: 19), Mrs. Witthaus purchased only such specimens from the Pease collection in 1872 as she desired, and the rest was sold, that same year, to Louis Agassiz for the MCZ. The expression "type species" probably meant that at one time Pease intended to establish a new genus-level taxon with *C. semiplota* as the type species. It does not imply that Pease had received type specimens from Mighels. Therefore, AMNH 22824 is not part of the original type series of *C. semiplota* and is not a syntype lot. ICZN Articles 72.4, 73.2.

Second, the action taken by Boyko & Cordeiro does not count as a "suppression" of my neotype designation, because that designation was already invalid under ICZN Article 75.7, to which Boyko made no reference. If these authors had referred to the current Code, they might have seen ICZN Recommendation 75C ("An author who published an invalid neotype designation before 1961 should if possible be given an opportunity to make it valid before another author designates a neotype for the same nominal species-group taxon") and ICZN Recommendation 75D ("If an invalid neotype designation was published before 1961, the specimen then designated should be given preference when a neotype for the same nominal species-group taxon is validly designated)." These two recommendations reflect the same elementary principles of allowing prior authors to remedy their actions that were retroactively made invalid, and of maintaining taxonomic stability by avoiding the needless upsetting of neotype designations.

Since I am not a specialist in the Cypraeidae, I invite the cowrie experts to determine whether it is necessary to designate a neotype for *C. semiplota* and, pursuant to the ICZN, I recommend that the MCZ 176989 be given first consideration for any such renewed designation. I similarly

encourage these cowrie experts to determine if a neotype is needed for *C. insecta*; those who are specialists in the Turridae can make this determination for *Pleurotoma rugosa* and *P. pumila*; specialists in the Cephalaspidea can make this determination for *Bulla punctostriata*. As before, the MCZ specimens that were chosen as neotypes in 1949 should be given first consideration for any such renewed designation.

In conclusion, this paper demonstrates all too well that "two wrongs do not a right make." I trust that those who are preparing type catalogs or curating type collections (1) will properly analyze old neotype designations pursuant to the relevant provisions of the ICZN, (2) will provide other authors with the opportunity to correct their neotype designations that are retroactively invalid, and (3) will not erroneously claim that subsequently collected specimens are syntypes.

Acknowledgments

I am especially grateful to Dr. Alan R. Kabat who kindly took the time to recast my original manuscript in light of certain changes in the International Code of Zoölogical Nomenclature.

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ON THE CUNNING CHARACTER OF A COUPLE OF CONCHOLOGIST COLLECTORS, WESLEY NEWCOMB AND WILLIAM HARPER PEASE

Richard I. Johnson

After making a fortune as one of the earliest investors in the Western Union Telegraph company, Ezra Cornell (1807-1874) established the great university at Ithaca, New York in 1865, which bears his name. Soon after, in 1867, he purchased the extensive conchological collection that had been amassed by Dr. Wesley Newcomb (1818-1892), also a New Yorker. According to Tryon (1865: 378) Newcomb's was then the third largest collection in the United States, containing 10,000 species. It was exceeded in size only by that of the Academy of Natural Sciences of

Philadelphia with 13,000 and that of John Clarkson Jay (1808-1891) of New York with 12,000.
According to Clarke (1960: 137), Cornell paid $15,000 for the collection, a princely sum in those days. Clarke studied the collection, illustrated the species described by Newcomb as new, and gave an account of his life. The collection is now housed at the Paleontological Research Institution in Ithaca, not far from the University. The same year that Cornell bought the Newcomb collection, the New York State Museum bought the one of Newcomb's late friend, Augustus Addison Gould (1805-1866) of Boston for $6,000 (Johnson, 1964: 31). The remaining large, nineteenth century American general collection, Jay's, was purchased by Catherine Lorillard Wolfe for $10,000 and presented to the American Museum of Natural History in memory of her father, that institution's first director, David Wolfe, in 1871 (Johnson, 1999:90).

Dr. Fred Baker, who supplied a previously unpublished anecdote regarding the character of Wesley Newcomb and William Harper Pease, was born at Norwalk, Ohio in 1854. He began the study of Civil Engineering at the then quite new Cornell University in 1870, but his interest in natural history was so strong that he changed to a pre-medical course which also trained naturalists. While still at Cornell, he spent time away studying botany at Kew Gardens in London, then four years in Central America, where he acquired a speaking knowledge of Spanish and an interest in anthropology. He returned to Cornell submitting as a graduation thesis in 1878 a paper on the origin of the Indians of Oaxaca and Chiapas.

Baker received his medical degree from the University of Michigan only two years later in 1880 and a year after married Dr. Charlotte LeBreton Johnson, herself a physician. After a brief practice in Ohio and New Mexico, the couple settled in San Diego, California, then a frontier town of about 2,000. Fred was an active malacologist. He

accompanied the Stanford University expedition to Brazil in 1911, as surgeon and malacologist, made numerous contributions to *The Nautilus* and the *Transactions of the San Diego Society of Natural History*. When he died at the age of 83 in 1937, San Diego was then a metropolis of some 250,000 people, and his large collection was left to the then flourishing Natural History Society. Baker's productive life was described, and his complete works listed by Hertz (1994).

During 1935 and 1936, Baker was working on the description of a number of shells on which William H. Dall of the United States National Museum had left manuscript names, and was carrying on a rather extensive correspondence with William J. Clench of the Museum of Comparative Zoology as to their validity. The following reminiscence is taken from a letter to Clench dated December 1, 1935 in which Baker made a reference to the latter's good fortune in having the Pease collection, purchased by Louis Agassiz in 1871, available to him (Johnson, 1994). The life of William Harper Pease (1824-1871) was extensively researched by Greene (1960) and by Kay (1975) (who did not cite Greene's work).

Joseph Swift Emerson (1843-1930), who related the tale below, was a son of the Rev. John S. and Ursula Newell Emerson who were among the fifth missionary group, to settle in the Hawaiian Islands. He collected the local shells between 1854 and 1927, and presented his extensive collection to the P. B. Bishop Museum (Cooke, 1931). His youngest brother, Rev. Oliver Pomeroy Emerson (1845-1938) also made a collection of land snails, mostly Achatinellidae, which was willed to the Museum of Comparative Zoology. This youngest Emerson described collecting these shells, the pupu oi-oi [(the shrill-voiced shell) a sound actually made by inconspicuous tree crickets] as a youth with his neighbors, the Gulicks, in his book, *Pioneer Days in Hawaii* (1928:15, 204). John

Thomas Gulick (1832-1923), missionary and evolutionist, was to become important for anticipating the central concepts of population genetics (Addison Gulick, 1932). Baker begins:

> "Have a rather good story about Pease which I may have told you before. When I was in Honolulu I met Mr. [Joseph Swift] Emerson, son of one of the first [fifth] missionary group, a civil engineer, who was also interested in shells. He had a small but fine collection, mostly Hawaiian. When a student at Cornell in the early seventies I lived in the same house with Weslay Newcomb who did a lot of work in the Hawaiian Islands and California. He finally sold his collection to Cornell for ten thousand dollars [sic] and stayed as Hon. Curator. I saw a good deal of him, eating at the same table. Thinking to ingratiate myself with Emerson, I told him all this. He came back with the candid remark that he was [a] damned old thief, explaining that his father had charge for many years of a big missionary schooner which traded through all the South Seas, getting in trade and as gifts enormous numbers of shells from natives and others. These were supposed to belong to Emerson Sr. Before Newcomb left the Islands he suggested to him that an unnamed collection was not worth much, but that he, Newcomb, would name it up for sets of the shells. This was agreed to, but after Newcomb left they found that he had named the shells, leaving named sets for Emerson and taking the enormous bulk of the collection with him to California, later to be sold to Cornell. Then he added the Pease story as of the same kind. He said that in early days when shipping was not very carefully done, Pease made it a point to be at the wharf every time a

> steamer came in. Watching the receipts of the P. O. and Express agents, if he saw a box for anyone who was interested in shells he would say "I am just going up to his house and will deliver the package." Then he would fail to deliver it and hunt it over to see if it contained shells. So you have a part of the stealings and I saw a lot of the rest."

It may not seem fair to quote Baker's tale, casting aspersions on the character of our two conchologists especially after the passage of over one hundred years. Perhaps, the Newcomb story was based on a mere misunderstanding between Newcomb and Rev. John S. Emerson which grew in his son's mind, but the Pease one does have a ring of verisimilitude. Pease's main interest was natural history, especially the shells of the Pacific. In a letter of 1865, quoted by Kay (1975: 6), Pease wrote, "That is all I think or care about."

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FIRST COLORED ILLUSTRATIONS OF SHELLS IN THE UNITED STATES

Richard I. Johnson

Fighting over priority was universally somewhat bitter in the early days of descriptive natural history. Thomas Say (1787-1834), a conchologist and entomologist; Prince Charles Lucien Bonaparte (1803-1857) ornithologist; and a few others began to feel that some of their articles, especially those pointing out errors of others, were being rejected for publication in the *Journal of the Academy of Natural Sciences of Philadelphia*, so they organized to produce a new serial *Contributions of the Maclurian Lyceum to the Arts and Sciences*, which ran from 1827-1829, **1** (1-3): 1-84, 5 pls., 2 col. Stroud (1992: 199) noted that, "This rival organization's founders could not have been unaware of the irony implicit in naming it have Maclure, since this elderly philanthropist was still the president of the Academy and would remain so until his death in 1840." When the Academy moved to new quarters the Lyceum bought its old cases and stove for one hundred dollars.

Jacob Green (1790-1841), a native of Philadelphia was educated at the University of Pennsylvania, B. S. 1806, and had an honorary degree in medicine from Yale 1827. He became Professor at Philadelphia's Jefferson Medical College and remained there from it founding in 1825 until his death. In addition, to having published in the Academy's *Journal* (1835) he contributed two conchological articles in the Lyceum's *Contributions*, each illustrated with colored figures of the new species described: *Unio aesopus* (pl. 3), *Achatina oahuensis* and *A. stewartii* (pl. 4). In spite of its brief life the Lyceum's little coterie appears to have produced the first colored plates of shells in the United States during 1827. The following year Isaac Lea, a prominent member of the Academy, would publish quarto hand colored engravings of Unios in the *Transactions of the American Philosophical Society*. They would number 71 before he turned to lithography.

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HISTORICAL BIOGEOGRAPHY AND LATE GLACIAL ORIGIN OF THE FRESHWATER PEARLY MUSSEL (BIVALVIA: UNIONIDAE) FAUNAS OF LAKE ERIE, NORTH AMERICA

Daniel L. Graf[1]

Abstract. The objectives of this paper are two-fold: (1) to review the historical distributions of the freshwater pearly mussels (Bivalvia: Unionidae) of the Lake Erie Basin of North America and (2) to test the traditional hypothesis that all Ohio Basin mussels present in Lake Erie migrated there during the stand of Glacial Lake Maumee (between 14,400 and 13,900 years ago). Forty-four mussel species occur in the Lake Erie Basin, and these are herein divided into five faunas based upon their shared distribution patterns in the Great Lakes: the Great Lakes Fauna, the Central Great Lakes Fauna, the Erie-Michigan Fauna, the Erie Fauna, and the Northern Atlantic Slope Fauna. The spatial and temporal distributions of those faunas do not support the Glacial Lake

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Maumee dispersal hypothesis; this is corroborated by the vicariant distributions of the Great Lakes fishes. It is concluded that, although some species may have colonized Lake Erie through Glacial Lake Maumee, many other species arrived perhaps as recently as Nipissing time (6000 to 4000 years ago).

Keywords: Unionidae, Great Lakes, Biogeography, Glacial Lake Maumee.

Introduction

"If the theory of the Ice Age as held by most glacialists is a true one I think it will fully explain the present remarkable distribution of these extra-limital Mississippi Valley Naiades." -- Charles T. Simpson (1896)

Near the beginning of the 20th century, when North American malacologists began to run out of new species of naiades, or freshwater mussels (Bivalvia: Unionidae), to describe, they turned their energies toward taxonomic syntheses and biogeography (Simpson, 1900, 1914; Ortmann, 1912, 1919; Frierson, 1927). Of special interest was the mussel fauna of the Laurentian Great Lakes (Simpson, 1896; Walker, 1913; Ortmann, 1924), a molluscan community with affinities to the upper Mississippi River, the Ohio River, and, to a lesser extent, the northern Atlantic Slope (Johnson, 1980). The "metropolis" of this province, according to Walker (1913: 18), was Lake Erie. He listed 39 species as inhabitants of that basin, but it has more recently been suggested that the actual tally may be higher (*e.g.*, van der Schalie, 1945; Johnson, 1980). Due to the disagreement among recent studies, a thorough re-evaluation of the freshwater mussel fauna of the Great Lakes is long overdue. My objectives are to determine the historical freshwater mussel

assemblage of the Lake Erie Basin, their distributions within and around the basin, and to test previous hypotheses of the origin of the community.

Lake Erie is situated at the junction of Michigan, Ohio, Pennsylvania, New York, and Ontario in the United States and Canada (Figure 1). The lake trends roughly west to east for roughly 400 km and averages 60 km wide, covering over 25,700 km^2. While receiving the bulk of its input from the upper Great Lakes (Lakes St. Clair, Huron, Michigan, and Superior with a total drainage area of 592,600 km^2) via the Detroit River, the local Lake Erie catchment contributes an additional 90,400 km^2. Other major rivers draining directly to the lake are the Huron, Maumee, Sandusky and Cuyahoga rivers in the United States and the Grand River of Ontario. The sole outlet for Lake Erie is the Niagara River at Buffalo, New York. During the early part of the 1800's, the construction of a series of barge canals created aquatic connections among Lake Erie, the Interior Basin, and the Atlantic Slope.

As recently as 15,000 ^{14}C-years before present (B.P.), the entire Lake Erie Basin was completely inundated by ice associated with the latest Wisconsinan glacial maximum (Mickelson *et al.*, 1983). As with all territory north of the glacial maximum, the deglaciated areas were repopulated by colonization from unglaciated refugia (Walker, 1913; Johnson, 1980; Underhill, 1989; Graf, 1997b; Graf and Underhill, 1997). As the glaciers wasted northward, meltwater was impounded between the ice margin and the height of land separating the Great Lakes from the Mississippi Basin, forming enormous glacial lakes (Teller and Clayton, 1983; Karrow and Calkin, 1985). These glacial lakes overran present-day divides and facilitated temporary confluences between recently deglaciated areas and unglaciated refugia.

A series of such lakes formed in the Lake Erie Basin, beginning with Glacial Lake Maumee (Calkin and Feenstra,

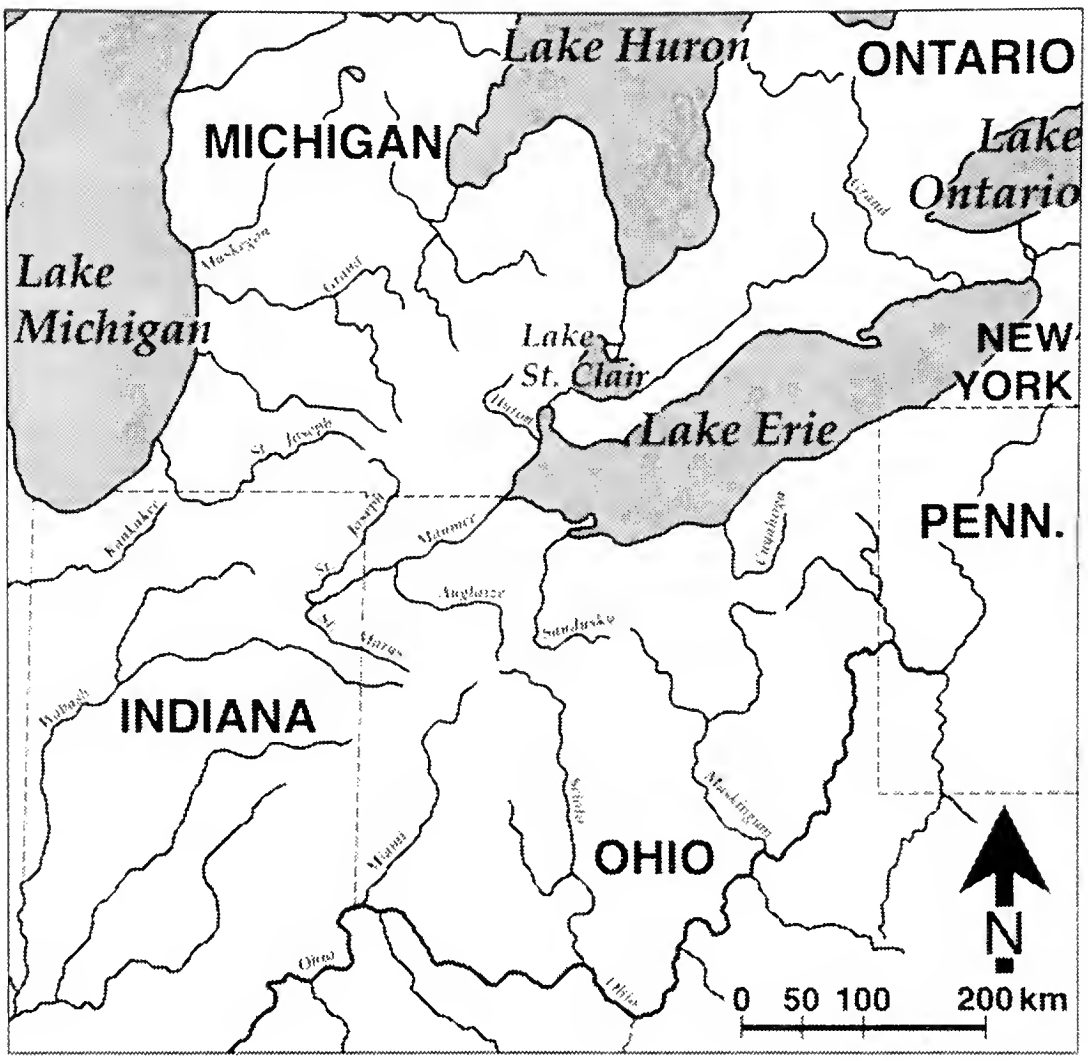

Figure 1. Map of present-day Lake Erie and adjacent basins.

1985). Ice-bounded on the north and east, Glacial Lake Maumee filled much of the present-day Maumee River Basin (Figure 2) and drained to the Ohio River via the Wabash in Indiana. Simpson (1896) and others (*e.g.*, Walker, 1913) hypothesized that this confluence between the Erie and Ohio basins allowed freshwater mussels, which are distributed by their host fishes (Johnson, 1970; Graf, 1997b), to colonize Glacial Lake Maumee through the unglaciated Wabash basin.

With the exception of Ortmann's (1924) limited discussion (see below), this theory, the Glacial Lake Maumee dispersal hypothesis, has not been tested.

Historical biogeographic hypotheses are inherently difficult to appraise since they generally lie outside the realm of experimentation (Brown and Lomolino, 1998). Instead, we must assess how well a hypothesis is corroborated by several lines of evidence and base our conclusions upon falsifiable predictions of the expected data patterns. The Glacial Lake Maumee dispersal hypothesis of the origin of the Lake Erie mussel fauna should not only be consistent with the known distribution of those taxa within the Lake Erie Basin, but also with their distributions in adjacent basins, the unionid fossil record of the region, vicariance with other aquatic taxa with similar dispersal ability (*i.e.*, the fish), and the Late Quaternary geology of the central Great Lakes.

Ortmann (1924) elaborated the Glacial Lake Maumee hypothesis of the origin of Lake Erie unionids to explain the once-puzzling distribution of mussel 'forms' among the tributaries of the basin and in the lake itself. Freshwater mussels colonized the basin through Glacial Lake Maumee, but the lake itself was hypothesized to be a barrier to river species. Since the river 'forms' could only be dispersed through continuous lotic habitats, he theorized that during a "Nipissing" low-water stand in the Lake Erie Basin, a continuous river system existed that allowed unionid dispersal throughout (Ortmann, 1924: figure 2). It is important to note that (1) Ortmann (1924) considered this theory sufficient to explain the origin of all Ohio basin mussels in the Lake Erie drainage, and (2) this interpretation has been upheld in subsequent reviews (*e.g.*, Grier, 1919; van der Schalie, 1945; Stansbery, 1961; Johnson, 1980; Clarke and Stansbery, 1988; Strayer *et al.*, 1991). The individual 'forms,' however, are no longer recognized as valid taxonomic units (Williams *et al.*, 1993).

The Glacial Lake Maumee hypothesis can now be more precisely stated based upon our improved understanding of

Figure 2. (opposite page) Two phases in the Quaternary evolution of the central Great Lakes. Arrows indicate the direction of flow. 14,000 B.P. marks the extent of Glacial Lake Maumee (14,400 B.P. to 13,900 B.P.) in the Lake Erie Basin. Glacial Lake Maumee drained via the Wabash River, its outlet near the point of present-day Ft. Wayne, Indiana. At the same time, meltwater accumulating in the Huron Basin drained west via the Grand River to the Michigan Basin and from there to the upper Mississippi Basin. By 13,600 B.P., ice in the Huron Basin had wasted far enough north to open lower outlets in the Lake Erie Basin. Lowering of the lake level ended the outflow of meltwater to the Wabash and led to drainage of the Erie and Huron basins (*i.e.*, Glacial Lake Arkona) through the Grand River to the glacial lake in the Michigan Basin.

The lower frame of the figure also depicts the hypothetical arrangement of the Wabash, St. Joseph, St. Marys, and Maumee rivers suggested by Bleuer and Moore (1972).

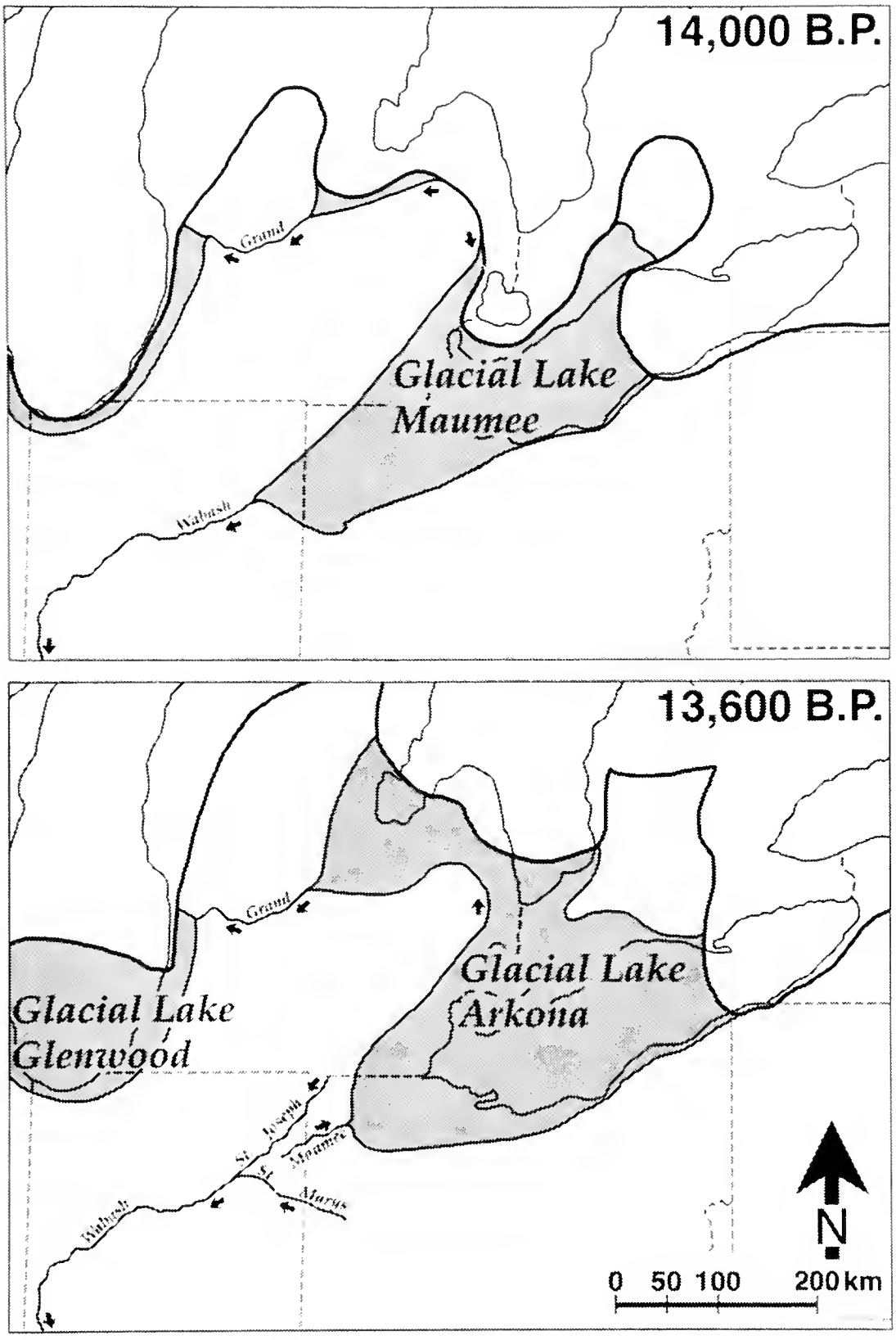
14,000 B.P.
Grand
Glacial Lake
Maumee
Wabash
13,600 B.P.
Grand
Glacial Lake
Glenwood
Glacial Lake
Arkona
St. Joseph
Maumee
St.
Marys
Wabash
N
0 50 100 200 km

Figure 2.

Late Quaternary history in the Great Lakes region. Ortmann would have had available to him only the now classic geological studies that lacked the benefit of radiocarbon dating (*e.g.*, Leverett, 1902; Leverett and Taylor, 1915). Improved synopses of eastern North American glacial history are now available that provide reasonably accurate ^{14}C dates for the various glacial maxima and lake levels (*e.g.*, Porter, 1983; Karrow and Calkin, 1985). Glacial Lake Maumee drained via the Wabash from approximately 14,400 to 13,900 B.P. (Figure 2). After that period, a series of lower lake levels occupied the Erie basin, draining either to Lake Michigan via the westward flowing Grand-Saginaw Channel (Figure 2) or to the east through Lake Ontario or Mohawk outlets in New York. Moreover, the low-water stage referred to by Ortmann (1924) was not a Nipissing (6000 to 4000 B.P.) event but probably occurred during the period of Lake Ypsilanti (13,500 to 13,000 B.P.) (Calkin and Feenstra, 1985: Figure 2). Therefore, according to the Glacial Lake Maumee hypothesis, the Ohio Basin Unionidae colonized the Lake Erie Basin before 13,900 years ago (*i.e.*, before the Maumee-Wabash connection was permanently severed).

For this restatement of the classic Glacial Lake Maumee dispersal hypothesis, I have derived three conditional predictions. These are listed in Table 1. The hypothesis that the Maumee-Wabash Channel was the source of *all* Ohio Basin freshwater mussels in Lake Erie is a bold hypothesis (in the Popperian sense) and is clearly *rejectable*. That is not to say *a priori* that the Glacial Lake Maumee dispersal hypothesis is false, only that it is falsifiable. It is the aim of this study to test the predictions listed in Table 1 and the viability of the long-standing Glacial Lake Maumee hypothesis of mussel distribution.

TABLE 1. CONDITIONAL PREDICTIONS DERIVED FROM THE GLACIAL LAKE MAUMEE HYPOTHESIS.

If all Ohio Basin freshwater mussels now present in Lake Erie entered the Glacial Lake Maumee Basin through the Wabash River, then

1. they all should have similar distributions in adjacent basins (*i.e.*, all Lake Erie mussels should also be found in the Lake Huron basin). There has been a continuous, aquatic connection between the Erie and Huron basins via Lake St. Clair for nearly 14,000 B.P. (Figure 1).

2. the fossil record should not be biased towards any particular assemblage (*i.e.*, fossiliferous Late Quaternary strata should bear representatives from each of the five freshwater mussel distributional faunas of Table 3). Thus, even if a mussel fauna is absent from Lake Huron, there should be fossil evidence of its presence in the central Great Lakes region dating from soon after the closure of the Maumee-Wabash Channel.

3. their hosts should also have colonized the basin via the same route (*i.e.*, the distributions of the fishes should also reflect Prediction 1). The distributions of other aquatic taxa (microcrustaceans, amphibians, most gastropods, *etc.*) are irrelevant as their vagility is not solely aquatic.

Methods and Rationale

Data to test each of the conditional predictions of the Glacial Lake Maumee hypothesis (Table 1) were principally derived from the published record. A survey of the relevant literature (Table 2) was used to infer the historical distributions of freshwater mussels reported from Lake Erie and the surrounding watersheds: Lake St. Clair, Lake Huron, the southern peninsula portion of Lake Michigan, and the adjacent streams of the Interior Basin (Figure 1). It was not the objective of my literature review to list every record for every species in every sub-basin of the central Great Lakes. As many of the species records are ambiguous or incomplete, the extensive collection of the University of Michigan Museum of Zoology (UMMZ), Ann Arbor, Michigan, was also examined for corroborating voucher specimens. The unionid nomenclature follows Williams *et al.* (1993), and figures of shells can be found in Burch (1975) and Cummings and Mayer (1992).

Those unionids with similar distributions were grouped into "faunas" (*sensu* Graf, 1997a, 1997b). Freshwater mussels of the same fauna are hypothesized to share similar modes and tempos of dispersal into the Lake Erie Basin. In order to reconstruct the migration of the Unionidae into the central Great Lakes with these data, it is necessary to assume that freshwater mussels require aquatic connections for dispersal. As larvae, unionids are parasitic upon specific host fish (or an amphibian in the case of *Simpsonaias ambigua*) (Coker *et al.*, 1921; Kat, 1984), and this is the only means of long-range mussel distribution (see Graf, 1998 and references therein). It has been argued that mussels might be distributed across drainage divides by birds, but this is highly unlikely (see discussions in van der Schalie, 1939; Johnson, 1970; and Graf, 1997b). There is no evidence of human introduction of freshwater pearly

TABLE 2. LITERATURE UTILIZED TO ESTABLISH HISTORICAL MUSSEL DISTRIBUTIONS IN LAKE ERIE AND ADJACENT BASINS.

Great Lakes (generally). Ortmann (1919), Goodrich & van der Schalie (1932), Burch (1975), Mackie *et al.* (1980), Johnson (1980), Clarke (1981).
Lake Erie Basin. Walker (1913), Ortmann (1924), Grier (1918, 1919, 1920a, 1920b), van der Schalie (1938, 1970), Matteson (1948), Stansbery (1961), Stansbery & Stein (1962), Johnson (1978), Strayer (1979, 1990; *et al.*, 1991), Masteller *et al.* (1993), Schloesser *et al.* (1996, 1998), and Metcalfe-Smith *et al.* (1998).
Maumee River Basin. Wilson and Clark (1912), Goodrich (1914), van der Schalie (1938, 1945), Clark (1944, 1977), and Strayer (1979).
Lake Michigan Basin. van der Schalie (1936, 1941).
Lake St. Clair Basin. van der Schalie (1938), Clarke (1973), Strayer (1980), Napela *et al.* (1996), Schloesser *et al.* (1996, 1998), Metcalfe-Smith *et al.* (1998), and West *et al.* (2000).
Lake Huron Basin. Goodrich & van der Schalie (1932), Hoeh & Trdan (1984), Morris & Di Maio (1995), and Staton *et al.* (2000).
Wabash River Basin. Johnson (1980) and Cummings & Mayer (1992).
Tributaries of the upper Ohio River. Ortmann (1919, 1924), Clark (1977), Johnson (1980), and Cummings & Mayer (1992).

mussels in the study region, although other bivalves have clearly entered the basin through anthropogenic means, *e.g.*, *Dreissena polymorpha* (Pallas, 1771) (Schloesser *et al.*, 1996, 1998; Napela *et al.*, 1996; *etc.*).

The temporal distributions of the freshwater mussels of the central Great Lakes were derived not only from the literature dealing solely with the Great Lakes (*e.g.*, Baker, 1920; Miller *et al.*, 1979, 1985; Miller and Knott, 1989) but also contiguous regions of formerly glaciated eastern North America (reviewed in Ashworth and Cvancara, 1983; Graf, 1997b). No dated fossil mussel material is available from the Lake Erie Basin.

In order to test the prediction that the vicariant pattern of fish distributions matches those of the freshwater pearly mussels, the distributions presented in various articles available in Hocutt and Wiley (1986) were consulted. Fish nomenclature follows Robins *et al.* (1991).

Results

Lake Erie Freshwater Mussels Faunas, and their Distributions in Adjacent Basins. Forty-four species of freshwater mussels occur in the Lake Erie Basin (Table 3). Johnson (1980) listed more than 50 taxa in his review, but several of those are species not supported by subsequent analyses or are nomina that have been synonymized with other Lake Erie mussels. Among the former set are *Lampsilis abrupta* and *Potamilus capax*. Neither of these has been reliably confirmed by other authors, but Johnson (1980) confined their Great Lakes distributions to the Niagara region of New York.

The synopses of Burch (1975), Johnson (1980), Mackie *et al.* (1980), Strayer (1990), and Schloesser *et al.* (1996) listed *Potamilus ohiensis* among the mussels inhabiting Lake Erie. Those observations, however, are not supported

by either the literature surveyed (Table 2) nor the collections of the UMMZ (see also Watters, 1995). Early on, *Lastena ohiensis* (Rafinesque, 1820) was considered to be either unidentifiable (Ortmann and Walker, 1922) or a synonym of *Utterbackia imbecillis* (Utterback, 1915-1916; Walker, 1918). *U. imbecillis* is found in the Lake Erie Basin (Table 3) and presumably has been at least partially responsible for this confusion surrounding the distribution of *P. ohiensis* (see also Robertson and Blakeslee, 1948).

Walker (1913) and van der Schalie (1938; Goodrich and van der Schalie, 1932) reported *Fusconaia subrotunda*, *Leptodea leptodon*, *Megalonaias nervosa*, and *Obovaria retusa*, but the inclusion of those species among the Lake Erie assemblage could not be corroborated. Although further study may indeed reveal the presence of the above mentioned mussels (*i.e.*, *F. subrotunda*, *L. abrupta*, *L. leptodon*, *M. nervosa*, *O. retusa*, *P. capax*, and *P. ohiensis*) in the Lake Erie Basin, they are hereby considered erroneous (Table 3).

Both *Lampsilis fasciola* and *Epioblasma torulosa*, which occur in the Lake Erie Basin, have been erroneously cited from the Lake Michigan Basin (Goodrich and van der Schalie, 1932; Johnson, 1978, 1980). These records have not been duplicated by subsequent surveys, no supporting specimens could be found in the UMMZ, and other details of these mussels' distributions are not consistent with their presence in that basin. For the purpose of this study, those records will be considered false. Future examination, however, may corroborate their presence.

Based on their distributions in the central Great Lakes region, the freshwater mussels of the Lake Erie Basin can be divided into five faunas (Table 3). Both the (1) Great Lakes Fauna and the (2) Central Great Lakes Fauna are distributed throughout the basins surveyed. The former, however, also inhabits Lake Superior (Graf and Underhill,

TABLE 3. FRESHWATER MUSSEL FAUNAS OF THE LAKE ERIE BASIN. VOUCHER SPECIMENS FOR EACH BASIN, WHEN AVAILABLE, ARE DEPOSITED IN THE MOLLUSK DIVISION OF THE UNIVERSITY OF MICHIGAN MUSEUM OF ZOOLOGY (UMMZ). SEE TEXT FOR EXPLANATIONS OF BASINS AND FAUNAS. LM = LAKE MICHIGAN BASIN; LH = LAKE HURON BASIN; LSC = LAKE ST. CLAIR BASIN; LE = LAKE ERIE BASIN, EXCLUSIVE OF THE MAUMEE DRAINAGE; MAU = MAUMEE BASIN; WAB AND OHIO = WABASH RIVER AND THE NORTHERN, UPPER TRIBUTARIES OF THE OHIO RIVER. '+' = PRESENT; 'O' = PRESENT BUT NO UMMZ VOUCHER IS AVAILABLE; '?' = PRESUMABLY ERRONEOUS RECORD (SEE TEXT).

	other Great Lakes			Erie Subbasins		Ohio Subbasins	
Species	LM	LH	LSC	LE	Mau	Wab	Ohio
Great Lakes Fauna:							
9 species	+	+	+	+	+	+	+
Central Great Lakes Fauna:							
16 species	+	+	+	+	+	+	+
Erie-Michigan Fauna:							
(1) *Cyclonaias tuberculata* (Raf., 1820)	+		+	+	+	+	+
(2) *Toxolasma parvus* (Barnes, 1823)	+		+	+	+	+	+
(3) *Truncilla donaciformis* (Lea, 1828)	+		O	+	+	+	+
(4) *Truncilla truncata* Raf., 1820	+		+	+	+	+	+

TABLE 3 (CONT.)

Species	other Great Lakes			Erie Subbasins		Ohio Subbasins	
	LM	LH	LSC	LE	Mau	Wab	Ohio
Erie Fauna:							
(1) *Lampsilis fasciola* Raf., 1820	?	+	+	+	+	+	+
(2) *Epioblasma torulosa* (Raf., 1820)	?	O	+	+	+	+	+
(3) *Ptychobranchus fasciolaris* (Raf., 1820)		+	+	+	+	+	+
(4) *Simpsonaias ambigua* (Say, 1825)		+	+	+	+	+	+
(5) *Toxolasma lividus* (Raf., 1831)		+	+	O	+	+	
(6) *Obovaria subrotunda* (Raf., 1820)			+	+	+	+	+
(7) *Villosa fabalis* (Lea, 1831)			+	+	+	+	+
(8) *Epioblasma obliquata* (Raf., 1820)			O	O	O	O	
(9) *Pleurobema clava* (Lam., 1819)				+	+	+	+
(10) Quadrula cylindrica (Say, 1817)					+	+	+

TABLE 3 (CONT.)

Species	other Great Lakes			Erie Subbasins		Ohio Subbasins	
	LM	LH	LSC	LE	Mau	Wab	Ohio
Erie Fauna (cont.):							
(11) *Ellipsaria lineolata* (Raf., 1820)					O	+	+
(12) *Ligumia subrostrata* (Say, 1831)					O	+	
(13) *Uniomerus tetralasmus* (Say, 1831)				O		+	+
Northern Atlantic Slope Fauna:							
(1) *Elliptio complanata* (Lightfoot, 1786)		+	+	O			O
(2) *Ligumia nasuta* (Say, 1817)		+	+	+	+		

Species erroneously attributed to the Lake Erie Basin (1) *Fusconaia subrotunda* (Lea, 1831), (2) *Lampsilis abrupta* (Say, 1831), (3) *Leptodea leptodon* (Raf., 1820), (4) *Megalonaias nervosa* (Raf., 1820), (5) *Obovaria retusa* (Lam., 1819), (6) *Potamilus capax* (Green, 1832), and (7) *Potamilus ohiensis* (Raf., 1820).

TABLE 3 (CONT.)

The Great Lakes Fauna (1) *Anodontoides ferussacianus* (Lea, 1834), (2) *Lampsilis cardium* (Raf., 1820), (3) *Lampsilis siliquoidea* (Barnes, 1823), (4) *Ligumia recta* (Lam., 1819), (5) *Lasmigona complanata* (Barnes, 1823), (6) *Lasmigona compressa* (Lea, 1829), (7) *Pyganodon grandis* (Say, 1824), (8) *Strophitus undulatus* (Say, 1817), and (9) *Utterbackia imbecillis* (Say, 1829).

The Central Great Lakes Fauna (1) *Actinonaias ligamentina* (Lam., 1819), (2) *Alasmidonta marginata* Say, 1818, (3) *Alasmidonta viridis* (Raf., 1820), (4) *Amblema plicata* (Say, 1817), (5) *Elliptio dilatata* (Raf., 1820), (6) *Epioblasma triquetra* (Raf., 1820), (7) *Fusconaia flava* (Raf., 1820), (8) *Lasmigona costata* (Raf., 1820), (9) *Leptodea fragilis* (Raf., 1820), (10) *Obliquaria reflexa* Raf., 1820, (11) *Obovaria olivaria* (Raf., 1820), (12) *Pleurobema coccineum* (Conrad, 1834), (13) *Potamilus alatus* (Say, 1817), (14) *Quadrula pustulosa* (Lea, 1831), (15) *Quadrula quadrula* (Raf., 1820), and (16) *Villosa iris* (Lea, 1829).

1997) and Lake Ontario (Metcalfe-Smith *et al.*, 1998) to the west and east, respectively. A few species of the Central Great Lakes Fauna also occur in Lake Ontario. The ubiquity of these faunas limits their biogeographic value as regards the Lake Erie region.

The four mussels found in both the Erie and Michigan basins but that are absent from the Lake Huron drainage comprise the (3) Erie-Michigan Fauna (Table 3). The (4) Erie Fauna is composed of those 13 Erie Basin mussels that are absent from Lake Michigan. Finally, *Elliptio complanata* and *Ligumia nasuta*, although both occur in the Erie Basin, were not present historically in the adjacent Interior Basin (although see Matteson, 1948). These two mussels do occur in the Atlantic drainage of New England, New York, and Pennsylvania (Johnson, 1980; Strayer, 1990) and are considered to be a part of the (5) Northern Atlantic Slope Fauna (Johnson, 1970).

Testing the Glacial Lake Maumee Hypothesis. The distributions of freshwater pearly mussels in Lake Erie and adjacent basins are inconsistent with the Glacial Lake Maumee hypothesis of mussel dispersal. While there can be little doubt that Glacial Lake Maumee drained via the Wabash River, the explicit consequences for dispersal via that route (Table 1) of all 42 Ohio basin mussel species present in the Lake Erie Basin are not evident in their present distributions (Table 3), the geological history of the central Great Lakes, vicariance with other aquatic taxa (Table 4), or what is known of the general late-glacial northern re-advance of freshwater mussels. That is, the consequent of each of the three conditional predictions listed in Table 1 is false. Each of the predictions and data supporting their falsification are discussed in turn below.

Discussion

Prediction 1: All freshwater mussels occurring in the Lake Erie Basin should have similar distributions in adjacent basins. Prediction 1 is false since there are 12 Lake Erie mussel species that are absent from the Lake Huron Basin. Of the 32 species occurring in the Huron Basin, 30 are derived from the Interior Basin (Table 3). The remaining two, *Elliptio complanata* and *Ligumia nasuta*, are clearly migrants from the northern Atlantic Slope (Matteson, 1948; Johnson, 1970, 1980) and shall not be considered further. The 25 Interior Basin mussel species of the Great Lakes and Central Great Lakes faunas that occur in Lake Huron may have entered the Great Lakes via Glacial Lake Maumee or a later Lake Erie stage, or they may have gained accesses to the Huron Basin via Lake Michigan. The source of those mussels is thus unclear as there has been confluence between lakes Michigan and Huron for more than 14,000 years: first through a channel in the Grand-Saginaw Valley (Figure 2) and then later through Lake Michigan outlets in and around the Straits of Mackinac (Hansel *et al.*, 1985). Thus, several thousand years of confluence and multiple potential sources have homogenized the Great Lakes and Great Lakes mussel faunas. Van der Schalie (1941, 1945) demonstrated that confluence in the Grand-Saginaw Valley has influenced the range of at least one mussel species, *Venustaconcha ellipsiformis* (Conrad, 1836), but he did not suggest the timing or the nature of the connection.

The 17 species of the Erie-Michigan and Erie faunas have not suffered the same homogenization. Those mussels occur in the Lake Erie Basin, either generally or limited to the Maumee River drainage, and most also inhabit Lake St. Clair. Only five species of these two faunas occur in Lake Huron (Table 3). All five of these mussels are found in the Lake Erie and Ohio basins but are

absent from the Lake Michigan and the upper Mississippi basins (except *Simpsonaias ambigua*, which is present in the Mississippi Basin). This pattern suggests that the eastern Michigan populations of those two faunas entered through a connection (or connections) between Lake Erie and Ohio Basin refugia and not via Lake Michigan. However, the distributions of all 17 Erie-Michigan and Erie mussels indicate that that confluence probably occurred later than the Wabash outlet of Glacial Lake Maumee. This is specifically supported by two observations: (1) the five species of the Erie Fauna present in the Lake Huron Basin suggest their arrival post-dated any confluence with the Michigan basin through the Grand-Saginaw Valley (around 12,500 B.P.; Hansel *et al.*, 1985), otherwise they should also be present in the Michigan Basin; (2) the absence of the remaining mussels of the Erie-Michigan and Michigan Faunas from the near-by Lake Huron Basin is also inconsistent with a model of 14,000 years of dispersal since entering the Erie Basin.

An alternative hypothesis for the distribution of these 17 species is that they entered the Great Lakes via Glacial Lake Maumee, but they have been prohibited from colonizing the Lake Huron Basin by ecological factors such as low temperatures or lack of suitable host fish. However, hypotheses of Glacial Lake Maumee dispersal and present ecological exclusion from the Huron Basin seem mutually exclusive; if mussels can not tolerate the relatively milder conditions of present-day Lake Huron, they should have also suffered from the ice-contact environment of Glacial Lake Maumee. Clarke and Stansbery (1988) suggested that the lower mussel diversity of the upper Great Lakes (*i.e.*, Superior and Huron) was due to the combination of low temperature and low calcium carbonate concentrations in those basins. I have shown elsewhere (Graf and Underhill, 1997) that, in the case of Lake Superior, the depauperate fauna is simply a consequence of the timing of the

connection of that watershed with the Mississippi Basin. The issue of host fishes is addressed below.

Prediction 2: The fossil record should not be biased towards any particular assemblage. This prediction is false since the fossil record of the central Great Lakes indicates that in strata older than Nipissing age (6000 to 4000 B.P.), only mussels of the Great Lakes and Central Great Lakes faunas are present (Baker, 1920; Miller *et al.*, 1979, 1985; Miller and Knott, 1989). No dated fossil unionid data are available for Lake Erie. Elsewhere I have argued that the earliest northern re-advance of freshwater mussels during the Late Quaternary was biased toward a few long-term brooding (*i.e.*, bradytictic) species (Graf, 1997c). This is supported by the spatial and temporal distributions of unionids in basins from Glacial Lake Agassiz (in the present-day Nelson River Basin of Minnesota, North Dakota, and central Canada) east to the northern Atlantic Slope. There is no evidence for the presence of any (except *Elliptio complanata*) but these few bradytictic mussel species before roughly 5000 B.P. in the formerly glaciated areas of eastern North America (*e.g.*, Ashworth and Cvancara, 1983; Graf, 1997b). These few species are largely those of the Great Lakes Fauna (= Upper Mississippi River Fauna *sensu* Graf, 1997a), with an analogous assemblage occurring on the northern Atlantic Slope (Graf, 1997c). These data suggest that the majority of mussel species of the Lake Erie Basin may have colonized from southern refugia as late as Nipissing time (6000 to 4000 B.P.), or perhaps more recently.

Prediction 3: The fish should also have colonized the basin via the same routes. If Glacial Lake Maumee was the sole entry point for Lake Erie freshwater mussels, it follows that it must also have been the source of the basin's fishes. Therefore, the same distributional hypotheses should hold for the fishes. However, of the more than 120 fishes inhabiting the Lake Erie Basin, 23 that occur in the

TABLE 4. LIST OF INTERIOR BASIN FISHES THAT OCCUR IN THE LAKE ERIE BASIN BUT THAT ARE ABSENT FROM LAKE HURON (UNDERHILL, 1986; BURR & PAGE, 1986).

Ammocrypta clara Jordon and Meek, 1885
Clinostomus elongatus (Kirtland, 1838)
Erimystax x-punctata (Hubbs & Crowe, 1956)
Erimyzon oblongus (Mitchell, 1814)
Etheostoma spectabile (Agassiz, 1854)
Fundulus notatus (Rafinesque, 1820)
Ictiobus cyprinellus (Valenciennes, 1844)
Lagochila lacera Jordon & Brayton, 1877
Lepisosteus oculatus (Winchell, 1864)
Lepomis humilis (Girard, 1858)
Macrhybopsis storeriana (Kirtland, 1847)
Moxostoma carinatum (Cope, 1870)
Notropis amblops (Rafinesque, 1829)
Notropis buccatus (Cope, 1865)
Notropis dorsalis (Agassiz, 1854)
Notropis photogenis (Cope, 1865)
Noturus miurus Jordon, 1877
Noturus stigmosus Taylor, 1969
Opsopoeodus emiliae Hay, 1881
Percina evides (Jordon & Copeland, 1887)
Phenacobius mirabilis (Girard, 1856)
Phoxinus erythrogaster (Rafinesque, 1820)
Pylodictis olivaris (Rafinesque, 1818)

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adjacent Interior Basin are absent from Lake Huron (Table 4; Underhill, 1986; Burr and Page, 1986). Assuming that 14,000 years is sufficient for these fish to disperse from Lake Erie to Lake Huron, their distributions do not support the Glacial Lake Maumee hypothesis of their colonization of Lake Erie.

The distributions of the freshwater mussels and the fishes are not completely independent lines of evidence since the latter are hosts for the larvae of the former. The expectation would be that the distributions of mussels and their host fishes should be closely correlated (Watters, 1992; Vaughn, 2000). Table 5 lists the suspected hosts of the 12 Erie-Michigan Fauna and Erie Fauna unionids absent from Lake Huron and their distributions. Although many of the suspected fish hosts of these mussels do occur in Lake Huron as well as Lake Erie (*e.g.*, *Ameiurus melas*, *Aplodinotus grunniens*, *etc.*), the suspected hosts of other mussels are either unknown in the central Great Lakes (*e.g.*, *C. galactura*) or are generally unknown. The known mussel-host associations do nothing to either refute or support the Glacial Lake Maumee dispersal hypothesis, and more study of the host fishes of Great Lakes mussels is obviously necessary.

TABLE 5. DISTRIBUTION OF FISH HOSTS OF ERIE-MICHIGAN FAUNA AND ERIE FAUNA FRESHWATER MUSSELS ABSENT FROM THE LAKE HURON BASIN. MUSSEL-HOST RELATIONSHIPS ARE TAKEN FROM HOGGARTH (1992; UPDATED BY HOVE, 1995, 1997; O'DEE & WATTERS, 1998). ONLY THOSE ASSOCIATIONS DEMONSTRATED BY ACTUAL TRANSFORMATION ON NATIVE FISHES WERE CONSIDERED. FISH DISTRIBUTIONS ARE TAKEN FROM UNDERHILL (1986). LE = LAKE ERIE BASIN; LH = LAKE HURON BASIN; LM = LAKE MICHIGAN BASIN. + = PRESENT.

mussel species	known hosts	host taxonomy	LM	LH	LE
C. tuberculata	*Ameiurus melas* (Raf., 1820)	Ictaluridae	+	+	+
	Ictalurus punctatus (Raf., 1820)	Ictaluridae	+	+	+
	Pylodictis olivaris (Raf, 1820)	Ictaluridae	+		+
E. lineolata	*Aplodinotus grunniens* Raf., 1819	Sciaenidae	+	+	+
L. subrostrata	*Lepomis cyanellus* Raf., 1819	Centrarchidae	+	+	+
	Micropterus salmoides (Lacepède, 1802)	Centrarchidae	+	+	+
P. clava	*Luxilus chrysocephalus* Raf., 1820	Cyprinidae	+	+	+
	Percina caprodes (Raf., 1818)	Percidae	+	+	+
	Percina maculata (Girard, 1859)	Percidae	+	+	+

TABLE 5 (CONT.)

mussel species	known hosts	host taxonomy	LM	LH	LE
Q. cylindrica	*Cyprinella galactura* (Cope, 1868)	Cyprinidae			
	Cyprinella spiloptera (Cope, 1868)	Cyprinidae	+	+	+
	Notropis amblops (Raf., 1820)	Cyprinidae		+	
T. parvus	*L. cyanellus*	Centrarchidae	+	+	+
T. dociformis	*A. grunniens*	Sciaenidae	+	+	+

U. tetralasmus, *E. obliquata*, *O. subrotunda*, *T. truncata*, and *V. fabalis* hosts unknown

Conclusions and Comments

Independently, these separate lines of evidence (*i.e.*, the freshwater mussel distributions, their fossil record, and vicariant distributions of the fishes) do not provide robust support to confirm or refute the Glacial Lake Maumee dispersal hypothesis. However, taken together they are sufficient to reject the traditional argument that all Ohio Basin Unionidae present in Lake Erie entered via the outflow of Glacial Lake Maumee. While these data suggest that some mussels found their way into the Erie Basin through other mechanisms, they do not point to what those alternative dispersal routes may have been.

The fossil evidence suggests that the mussels of the Erie-Michigan and Erie faunas may have colonized the central Great Lakes as late as 5000 B.P. Both Goodrich (1914) and Hubbs and Lagler (1958) argued that the Maumee and Wabash basins have been periodically connected in recent times, both citing early 20th century floods. Clark (1944) suggested possible Ohio-Erie confluence through the Auglaize Basin; the proximity of the Auglaize to major tributaries of the Ohio River (*e.g.*, the Scioto; see Figure 1) supports that hypothesis. On the opposite side of the Maumee Basin, Gerking (1947) proposed that the Kankakee, the St. Joseph of Lake Michigan, and the St. Joseph of the Maumee were confluent and provided a means of fish dispersal (Figure 1); there was no mention of timing. Further biogeographic studies on a finer scale than applied here will be able to determine the importance of these and other potential tributaries of the Maumee.

Between recent high waters (Goodrich, 1914) and Glacial Lake Maumee, there may have been an additional union of the Maumee and Wabash Basins. Based on the stratigraphy of the Maumee-Wabash Channel near Ft. Wayne, Indiana, Bleuer and Moore (1972: 203) argued that

"...the St. Marys and St. Joseph Rivers continued to flow sluggishly westward down the [Maumee-Wabash Channel] prior to the development of the Maumee River." Thus, the sequence of events they described:

1. Glacial Lake Maumee overflowed the Ft. Wayne Moraine, creating an outlet to the Wabash River.
2. The Glacial Lake Maumee stage ended when Erie Basin outlets were uncovered to the north and east.
3. During the period immediately following the withdrawal of Glacial Lake Maumee, the St. Marys and St. Joseph rivers drained "sluggishly westward" to the Wabash River. Thus, these two tributaries must have changed course to flow into the Maumee sometime *after* the tenure of Glacial Lake Maumee (Figure 2).
4. Any freshwater mussels (and fish) present in the St. Marys and St. Joseph rivers would have been 'captured' into the Maumee Basin.

The geological mechanism for such stream piracy may be headward migration -- the Maumee River eroded its bed in a headward direction until the Wabash was 'beheaded.' Similar scenarios have been proposed for other rivers that flow across glacial terrain (*e.g.*, the Otter Tail and the St. Louis Rivers of Minnesota [Radke, 1992; Graf, 1997b; Ojakangas and Matsch, 1982]). This study of the distribution of freshwater mussels in the Lake Erie and surrounding basins provides yet another example of the possible role of stream capture as a means of expanding the ranges of aquatic organisms.

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SAMUEL LIBERTY HARVEY FULLER (1942-2001)

Richard I. Johnson

Sam Fuller's association with the Department of Mollusks began in March 1958 when at the age of 16 he wrote, "Dear Sirs: I am sending your department several varieties of freshwater mollusks which I hope you might identify for me." This was the beginning of a beautiful friendship with Curator of Mollusks, William J. Clench which lasted until the latter's death in 1984. Fuller won a Harvard National Scholarship, which allowed him to have four years of constant contact with those of us associated with the Department of Mollusks. Upon graduation he taught briefly in Tanzania before returning to teach at the Wooster School, Danbury Connecticut which he had attended as a boy. He left there to work for Dr. Ruth Patrick of the Department of Limnology of the Academy of Natural Sciences of Philadelphia. Between 1970 and 1981 he was extremely productive, writing numerous significant papers alone and with others on the North American unionids. After leaving the Academy there was a hiatus in his work until 1985 when he again went to work on his favorite mollusks with James D. Williams of the U. S. Fish and Wildlife Service as Research Associate. He died of lung cancer in 2001.

A more detailed account of his life and a complete bibliography of Fuller's work are in preparation. While still an undergraduate, he contributed to this series: Clench, W. J., and S. L. H. Fuller, 1965. The genus *Viviparus* (Vivparidae) in North America. *Occ. Pap. Moll.* **2** (32): 385-412.