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DIVERSITY AND RELATIVE ABUNDANCE OF PREIMPOUNDMENT FRESHWATER MUSSEL (BIVALVIA: UNIONIDAE) POPULATIONS IN THE LOWER HOLSTON RIVER, TENNESSEE

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ABSTRACT—A series of freshwater mussel valves was collected from six preimpoundment sites located along the lower Holston River between river mile 36 and 26, Jefferson and Grangier counties, Tennessee. Shell from two sites, the Loy Site and Cave T-11, reflect gathering activities by prehistoric Native Americans, while shell from the other four localities reflect normal river deposition and/or muskrat feeding activity. A total of 8,460 mussel valves, representing 49 species, was identified. Approximately 80 freshwater mussel species and subspecies have been reported from the Holston River. Today (2006) there appear to be about 18 living species remaining. Species represented in these six sites reflect this loss and serve to illustrate the differences among taxa represented in relatively close locales/beds in a stretch of river.

The North Fork and South Fork Holston Rivers merge at Kingsport, Hawkins/Sullivan county lines, Tennessee, to form the Holston River proper. The river flows southwesterly for 228.4 km to the confluence with the French Broad River at Knoxville, Knox County, where they form the Tennessee River. The Holston River once flowed unobstructed from its source at Kingsport to its mouth at Knoxville. Construction of Cherokee Dam and Lake in 1941 flooded approximately one-third of the Holston River proper (Hughes, 1994). From the Cherokee Dam to its confluence with the French Broad River, the Holston River has an average gradient of 0.21 m/km (1.1 ft/mile), width of 91.5 m and a depth of 1.3 m. The substrate is composed of 15% bedrock, 5% boulders, 40% rubble, 25% gravel, and 15% sand and silt (Hill and Brown, 1980).

Construction of Cherokee Dam has produced large fluctuations in flow rate, water temperature and stream depth. These adverse environmental conditions appear to have brought about the nearly complete demise of the preimpoundment mussel fauna of this stretch of the Holston River. Analyses of shell deposits such as these provide insight into prehistoric and/or preimpoundment mussel species and abundance, and an evaluation of former and existing aquatic habitats relative to possible reintroduction of species.

MATERIALS AND METHODS

Shell recovered from two of the six study sites (Fig. 1) represent mussels collected and presumably utilized as food by Native Americans occupying these locations. The first, Cave Site T-22 situated above the right descending bank (RDB) at approximately Holston River Mile (HRM) 35.6, Grangier County, was excavated in the summer of 1963 by the late James H. Polhemus and Richard R. Polhemus. Excavation units consisted of five 1.5 m squares approximately 1 m in depth. A total of 1,172 valves, representing 36 species, was recovered (Table 1). This site was occupied by peoples of the Woodland culture, A.D. 200–600.

The second or Loy Site (40JE10), a Dallas phase Mississippian village (AD 1400) located above the RDB at HRM 24.7, Jefferson County, was excavated periodically by Richard R. Polhemus from 1986 to 1991. The majority of the 1,892 mussel valves (23 species) were recovered from three large aboriginal house floors, a total area of approximately 30 m^2. Shell from the four remaining sites (Table 2) was deposited by muskrat (*Ondatra zibethica*) feeding activity and/or through natural deposition by the river during periods of flooding and releases from the storage reservoir (Cherokee Lake). Size of the shell deposits varied considerably, from Nance Ferry (3 m by 1 m, exposed bank), to the Faust Site (10 m by 2 m, exposed and embedded in the bank). Varying quantities of shell had washed into the river adjacent to these deposits. All shell was brought to the Frank H. McClung Museum, University of Tennessee, Knoxville, where it was washed and identified by use of the research comparative mollusk collections. Taxonomy follows Turgeon, et al. (1998).

DISCUSSION

In summarizing the freshwater mussel taxa known from the river systems of Tennessee, Starnes and Bogan (1988) recorded 79 species and subspecies from the Holston River. By considering both the species and subspecies/forms, it is apparent that the Holston River once possessed one of the most diverse naiad faunas in the state, second only to the Clinch River (with 88 taxa) in East Tennessee. Of the approximately 70 Holston River freshwater mussel species identified from prehistoric aboriginal sites, those discussed in the literature (Lewis, 1870; Boepple and Coker, 1912; Ortmann, 1918; Ahlstedt, 1992), and those housed in collec-

TABLE 1. Freshwater mussel species and number of valves of each taxon identified from two archaeological and four muskrat and/or river deposits along the lower Holston River, Tennessee.

Scientific name	Common name	Site						Totals
		Loy	Cave T-22	Nance Ferry	McKinney Island	Faust	Calf Island	
Actinonaias ligamentina (Lamarck)	Mucket	42	326	49	41	382	235	1075
Alasmidonta marginata (Say)	Elktoe	0	5	1	0	2	3	11
Amblema plicata (Say)	Threeridge	11	85	1	9	16	29	151
Cyclonaias tuberculata (Rafinesque)	Purple Wartyback	72	94	13	11	79	98	367
Cyprogenia stegaria (Rafinesque)	Fanshell	0	1	6	1	19	27	54
Dromus dromas (Lea)	Dromedary Pearlymussel	175	16	2	29	65	86	373
Elliptio crassidens (Lamarck)	Elephantear	1	2	2	5	3	123	136
E. dilatata (Rafinesque)	Spike	67	50	82	29	21	75	324
Epioblasma arcaeformis (Lea)	Sugarspoon	2	7	13	260	23	98	403
E. brevidens (Lea)	Cumberlandian Combshell	4	3	1	0	51	2	61
E. capsaeformis (Lea)	Oyster Mussel	0	51	137	176	9	33	406
E. haysiana (Lea)	Acornshell	3	7	2	4	29	3	48
E. lewisii (Walker)	Forkshell	0	2	0	0	0	2	4
E. propinqua (Lea)	Tennessee Riffleshell	0	0	23	0	0	2	25
E. stewardsonii (Lea)	Cumberland Leafshell	4	3	2	8	11	7	35
E. torulosa (Rafinesque)	Tubercled Blossom	0	29	275	159	25	107	595
E. triquetra (Rafinesque)	Snuffbox	0	0	18	19	5	8	50
Fusconaia barnesiana (Lea)	Tennessee Pigtoe	0	17	3	4	15	5	44
F. cor (Conrad) and/or *F. cuneolus* (Lea)	Shiny Pigtoe and/or Finerayed Pigtoe	0	1	13	0	54	0	68
F. subrotunda (Lea)	Longsolid	72	20	34	87	570	209	992
Lampsilis abrupta (Say)	Pink Mucket	0	0	0	0	0	1	1
L. fasciola Rafinesque	Wavyrayed Lampmussel	3	39	1	0	35	7	85
L. ovata (Say)	Pocketbook	0	8	0	0	0	20	28
Lasmigona costata (Rafinesque)	Flutedshell	0	6	0	0	0	0	6
Lemiox rimosus (Rafinesque)	Birdwing Pearlymussel	154	58	7	1	76	2	298
Lexingtonia dolabelloides (Lea)	Slabside Pearlymussel	923	50	5	16	90	3	1087
Ligumia recta (Lamarck)	Black Sandshell	0	1	0	1	0	13	15
Medionidus conradicus (Lea)	Cumberland Moccasinshell	0	2	0	0	0	0	2
Obliquaria reflexa Rafinesque	Threehorn Wartyback	0	0	0	1	0	3	4
Obovaria subrotunda (Rafinesque)	Round Hickorynut	0	0	0	1	1	3	5
Plethobasus cooperianus (Lea)	Orangefoot Pimpleback	44	0	0	0	0	5	49
P. cyphyus (Rafinesque)	Sheepnose	1	4	0	7	16	8	36
Pleurobema cordatum (Rafinesque)	Ohio Pigtoe	82	2	19	51	62	78	294
P. oviforme (Conrad)	Tennessee Clubshell	0	3	0	0	0	0	3
P. plenum (Lea)	Rough Pigtoe	23	3	0	0	102	12	140
P. rubrum (Rafinesque)	Pyramid Pigtoe	11	1	45	59	25	203	344
P. cf. *sintoxia* (Rafinesque)	Round Pigtoe	0	0	0	0	0	6	6
Potamilus alatus (Say)	Pink Heelsplitter	0	0	0	0	0	2	2
Ptychobranchus fasciolaris (Rafinesque)	Kidneyshell	37	65	8	4	53	7	174
P. subtentum (Say)	Fluted Kidneyshell	3	198	0	0	38	1	240
Quadrula cylindrica (Say)	Rabbitsfoot	16	0	11	5	43	51	126
Q. intermedia (Conrad)	Cumberland Monkeyface	128	3	0	2	25	0	158

TABLE 1. Continued.

Scientific name	Common name	Site						Totals
		Loy	Cave T-22	Nance Ferry	McKinney Island	Faust	Calf Island	
Q. pustulosa (Lea)	Pimpleback	0	1	25	4	0	64	94
Q. sparsa (Lea)	Appalachian Monkeyface	14	0	0	0	2	0	16
Strophitus undulatus (Say)	Creeper	0	0	0	0	0	1	1
Toxolasma lividus (Rafinesque)	Purple Lilliput	0	2	0	0	1	0	3
T. parvus (Barnes)	Lilliput	0	0	0	0	2	0	2
Villosa iris (Lea)	Rainbow	0	7	0	0	9	0	16
V. vanuxemensis (Lea)	Mountain Creekshell	0	0	0	0	3	0	3
	TOTALS	1892	1172	798	994	1962	1642	8460

tions, 9 are considered Extinct, 20 are Endangered, 4 are Threatened, 19 are of Special Concern, and 18 are Currently Stable (Williams et al., 1993). In contrast to the prehistoric and preimpoundment figure of 79, only 13 living mussel species were recorded in a 1981 survey below Cherokee Dam (Ahlstedt, 1992). A second survey in 2002 by S. J. Fraley, J. B. Layzer and E. M. Scott for the TVA (unpublished data: Table 3) found six mussel species not encountered by Ahlstedt (1992).

Combined, mussel valves identified from these six sites totaled 8,460 specimens, representing 49 species. Shells of *Actinonaias ligamentina, Fusconaia subrotunda* and *Lexingtonia dolabelloides* comprised approximately 37% of the samples. Based on the qualitative mussel survey of the lower Holston River by Ahlstedt (1992) and Fraley, et al. (2002 unpublished data), *L. dolabelliodes* no longer occurs in the river. The mucket, *A. ligamentina*, however, is still fairly common as it was prior to impoundment. Valves of this mussel comprised 20% of the sample from the Faust Site and 28% of the sample at the Cave T-22 site. Shell recovered at the Cave T-22 Site had been gathered by the human occupants, while those from the Faust Site appear to have been deposited primarily by river action and some muskrat feeding activity. Nance Ferry and McKinney Island Site deposits appear to be the result of muskrat activity, based on the overall small size of the mussels, incisor marks on the periostracum (Fig. 2), and their presence in collapsed burrows. It would be extremely difficult if not impossible for a muskrat to transport a large adult specimen of *Actinonaias ligamentina, Cyclonaias tuberculata* or *Elliptio crassidens* to a feeding station and open it.

Certain differences in species diversity between the two aboriginal sites (Loy and Cave T-22) and deposits resulting

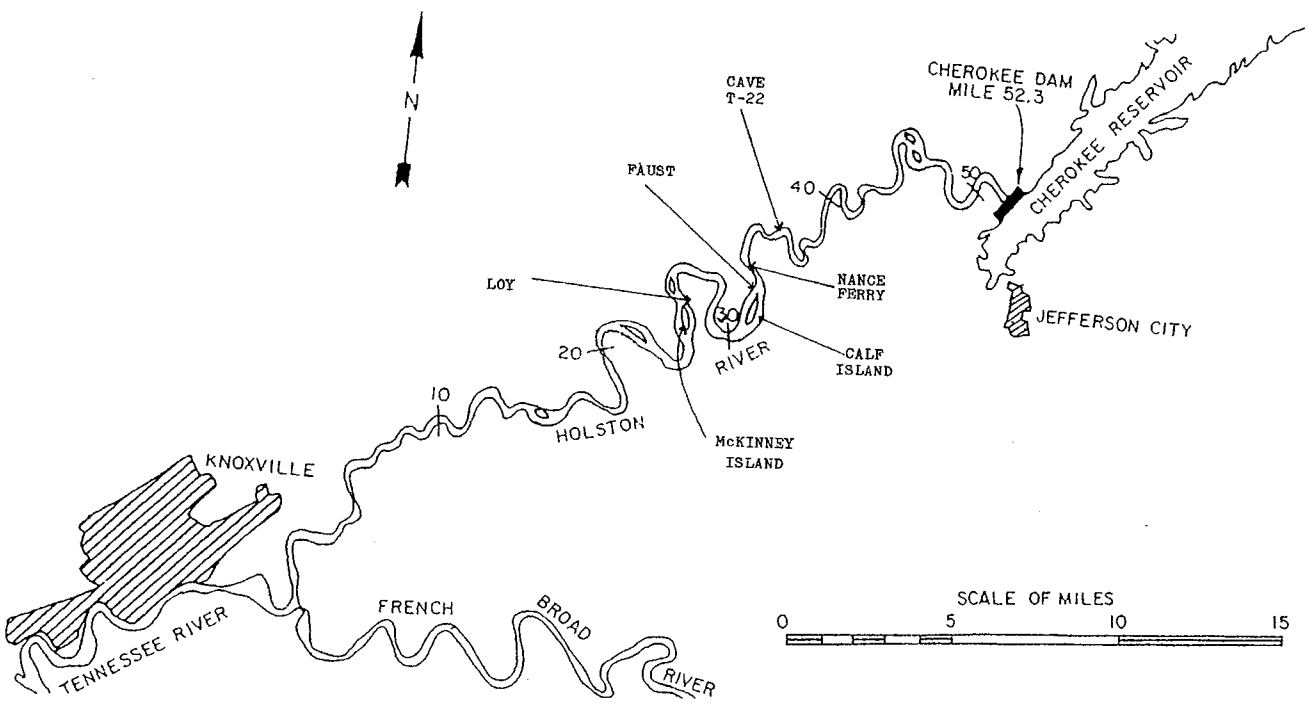

FIG.1. Schematic illustration of the lower Holston River with locations of the six shell midden sites discussed in this study. Modified from Ahlstedt (1992).

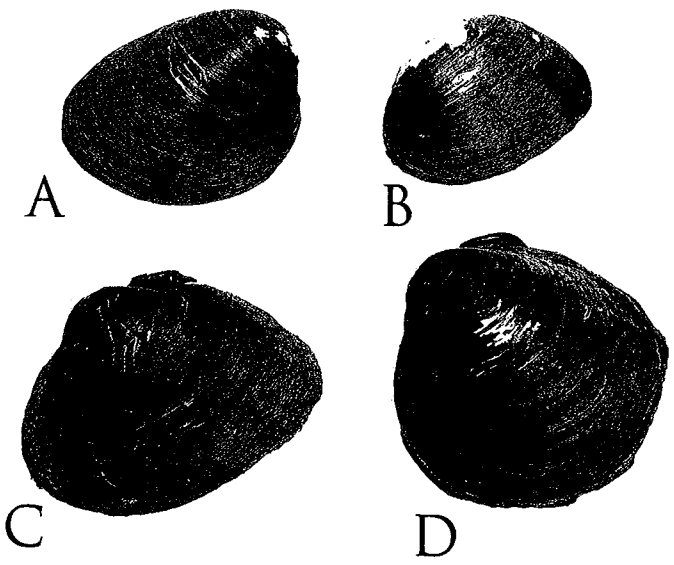

FIG. 2. Examples of freshwater mussel valves exhibiting muskrat incisor scrape marks resulting from extraction from the substrate and/or feeding activity. A: *Lexingtonia dolabelloides*, B: *Epioblasma brevidens*, C: *Fusconaia barnesiana*, D: *Obovaria subrotunda*.

from natural river action and/or preimpoundment muskrat activity are apparent. Forty-four valves of the orangefoot pimpleback, *Plethobasus cooperianus*, were recovered at the Loy Site; only five other shells of this typically big river mussel were identified from the Calf Island site. Another example of species differences between sites is the dromedary pearlymussel, *Dromus dromas*, the big river form. We identified 175 specimens (9.2%) from the Loy Site, but only 16 (1.4%) from Cave T-22 Site. A total of 128 valves of the Cumberland monkeyface, *Quadrula intermedia*, a species found typically in water ≤1 m in depth, was recovered at the Loy Site compared with three valves at the Cave T-22 site. Discrepancies in the relative abundance of a particular taxon in shell middens located along a relatively short stretch of river, in this case approximately 16 km, might be attributed to differences in normal rate of flow vs. flooding, species composition of mussel beds, season of the year, predation by muskrats, and, in the case of sites once occupied by Native Americans, selection of one species of mussel over another. The latter is suggested by the 198 valves of the fluted kidneyshell, *Ptychobranchus subtentum*, collected from Cave T-22 Site, in contrast with only three valves from the Loy Site.

Turgeon, et al. (1998) list 15 species of freshwater mussels (genus *Epioblasma*) that once occurred in Tennessee and are now considered extinct or thought to be extinct. Nine were recorded for the Holston River by Starnes and Bogan (1988) while six were identified from mussel assemblages discussed here. Although there were 24 species/subspecies within the genus *Epioblasma* found in eastern North America, only 9 survive today (Williams et al., 1993). River impoundment, biological and chemical pollutants, channelization and siltation are detrimental factors adversely affecting most mussel species. Former populations of *Epioblasma* species in the large rivers such as the Holston were unable to adapt to changed habitat resulting from dam construction (Neves, et al., 1997). Some of these extinct taxa were abundant in the lower Holston River prior to impoundment. For example, 260 valves of the sugarspoon, *Epioblasma arcaeformis*, were recovered at the McKinney Island Site and 275 valves of the tubercled blossom, *E. torulosa*, at Nance Ferry. Presently no species of *Epioblasma* survives in the lower Holston River.

Habitat conditions of a free flowing river, including riffles, shoals and stabilized substrate, are usually adversely affected by dam construction. For example, mussel species diversity and abundance in the preimpoundment Tennessee River was unparalleled (Ortmann, 1925), but with major dam construction the majority of species inhabiting shoals and riffles were extirpated. This study has shown a similar consequence in the Holston River below Cherokee Dam. However, a few mussel species indicative of the free flowing Holston River survive in abundance under impoundment conditions (Table 3). In addition to the mucket, *Plethobasus cyphyus, Cyclonaias tuberculata, Quadrula pustulosa* and *Lampsilis ovata* have been the most successful in adapting to lower Holston River impoundment.

Approximately 9% of all valves recovered from the six study sites consisted of three closely related taxa of the genus *Pleurobema*: *P. cordatum, P. plenum* and *P. rubrum*. In addition, six valves from the Calf Island Site may be referable to *P. sintoxia*. Only one species, *P. cordatum*, was found (14 specimens) by Ahlstedt (1992) in his mussel survey of the lower Holston River. Fraley, Layzer, and Scott (2002, unpublished data) recorded 10 individuals of *P. cordatum* in their survey, and 22 specimens of *P. sintoxia*. Twenty-five species represented in these six sites totaled 50 or less specimens each. At the Loy site, for example, one species, the slabside pearlymussel, *Lexingtonia dolabelloides*, comprised approximately 50% of all identified valves. Three species of *Epioblasma* from the McKinney Island Site accounted for 60% of all mussel valves

TABLE 2. Four muskrat/river depositon sites and two archaeological sites (Cave T-22, Loy) in the lower Holston River containing freshwater mussel shell accumulations.

Site	River mile	County	Year excavated	No. of valves	No. of species
Cave T-22	35.6	Grainger	1963	1172	36
Nance Ferry	33.2	Jefferson	1999	798	28
Faust	32.2	Grainger	2002–05	1962	35
Calf Island	31.5	Jefferson	2002	1644	39
McKinney Island	25.2	Jefferson	1988	994	27
Loy	24.7	Jefferson	1986–91	1892	23

TABLE 3. Living freshwater mussel taxa and number of each recorded during two surveys of the lower Holston River, Tennessee.

Scientific name	Common name	Survey	
		Ahlstedt (1992)	Fraley, Layzer, Scott unpublished data (2002)
Actinonaias ligamentina	Mucket	123	538
Amblema plicata (Say)	Threeridge	9	9
Cyclonaias tuberculata (Rafinesque)	Purple Wartyback	20	59
Elliptio crassidens (Lamarck)	Elephantear	1	5
E. dilatata (Rafinesque)	Spike	6	27
Fusconaia subrotunda (Lea)	Longsolid	0	44
Lampsilis abrupta (Say)	Pink Mucket	0	7
L. fasciola Rafinesque	Wavyrayed Lampmussel	1	0
L. ovata (Say)	Pocketbook	52	105
Lasmigona complanata (Barnes)	White Heelsplitter	0	2
Leptodea fragilis (Rafinesque)	Fragile Papershell	4	4
Ligumia recta (Lamarck)	Black Sandshell	7	11
Plethobasus cyphyus (Rafinesque)	Sheepnose	20	72
Pleurobema cordatum (Rafinesque)	Ohio Pigtoe	14	10
P. sintoxia (Rafinesque)	Round Pigtoe	0	22
Potamilus alatus (Say)	Pink Heelsplitter	6	6
Ptychobranchus fasciolaris (Rafinesque)	Kidneyshell	0	1
Pyganodon grandis (Say)	Giant Floater	0	1
Quadrula pustulosa (Lea)	Pimpleback	20	72
Villosa vanuxemensis (Lea)	Mountain Creekshell	0	3
	TOTALS	306	1,132

recovered. These figures likely reflect the former preimpoundment species ratios. As mentioned earlier, the source or method of accumulation would affect the species assemblage.

The diversity of mussel species represented in all six sites suggest preimpoundment shoals with a stable substrate consisting of cobbles, coarse sand and gravel and probably scattered pockets of silt and mud. Normal periods of flow would have consisted of moderate to swift current and a 0.5 to 1.5 m depth. As discussed, the taphonomy of these shell deposits varied from human and rodent selection to natural river deposition during periods of flooding. Since construction of Cherokee Dam in 1941 until the present (2006), approximately 75% of the naiad taxa has been extirpated in the lower Holston River downstream from the dam. Under the prevailing aquatic habitat conditions, there is little possibility of the preimpoundment mussel fauna becoming reestablished.

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