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Aboriginal Utilization of Freshwater Mussels at the Aztalan Site, Wisconsin

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ABSTRACT. — Archaeological excavations at the late prehistoric (ca. A.D. 1000–1150) Aztalan site adjacent to the Crawfish River in Jefferson County, Wisconsin, have resulted in the recovery of more than 8500 freshwater mussel valves representing 23 species. Three species once typical of the region's small rivers—the spike (*Elliptio dilatata*), the fatmucket (*Lampsilis siliquoidea*), and the ellipse (*Venustaconcha ellipsiformis*)—together comprised more than 80 percent of all mussel valves identified in the Aztalan assemblage. The contextual analysis of these molluscan remains indicates that the aboriginal peoples living at Aztalan made persistent, small-scale use of local mussel populations as a food resource, punctuated by occasional larger-scale harvests that focused on certain high-yield mussel habitats. Large shells of the washboard mussel (*Megalonaias nervosa*) and perhaps some valves of the threeridge mussel (*Amblema plicata plicata*) appear to have been brought to Aztalan for use as agricultural tools (= hoe blades) from the Mississippi River more than 160 km (100 mi) away. The presence of the snuffbox mussel (*Epioblasma triquetra*) in the Aztalan assemblage may indicate a northern range extension of this species into Wisconsin during the Neo-Atlantic climatic episode (A.D. 900–1200). Finally, the Crawfish River in the vicinity of Aztalan has undergone severe degradation during the Historic Period, all but destroying its once flourishing mussel community.

INTRODUCTION

The purpose of this paper is to examine the prehistoric human use of freshwater mussels at Aztalan (47Je1). Aztalan, by some estimations, is the most significant archaeological site in Wisconsin. The site is located along the Crawfish River, a tributary of the Rock River in Jefferson County, Wisconsin (Fig. 1). The most impressive archaeological component at Aztalan is the remains of a settlement founded by Middle Mississippian peoples who arrived in southeastern Wisconsin at about A.D. 1000, probably as colonists from the Cahokia area in the vicinity of modern-day East St. Louis, Illinois.

The predominant archaeological features at Aztalan are two pyramidal mounds, a plaza, a village area, and an extensive midden along the river bank. A sequence of stockade lines encloses more than 9 hectares (20 acres) in the Middle Mississippian portion of the site (Barrett 1933; Freeman 1986; Goldstein 1985; Lapham 1855; Richards 1985). After one or perhaps two centuries of occupation, Aztalan was abandoned for reasons that are unclear.

The earliest descriptions of prehistoric Aztalan appeared in the popular press of the 1830s (Barrett 1933:24; Freeman 1986). In 1850, Increase A. Lapham did some limited digging and conducted the first accurate survey of Aztalan, publishing his description and maps in 1855 (Barrett 1933:28–34; Lapham 1855:41–50, Plates 34, 35). S. A. Barrett of the Milwaukee Public Museum was the first archaeologist to undertake large-scale and systematic excavations at Aztalan in 1919, 1920, and 1932 (Barrett 1933:19). Aztalan was purchased by the state in 1948 for the creation of a park. Exploratory excavations were initiated in 1949–1950, followed by restoration of the two pyramidal mounds and a portion of one stockade line in 1951–1954 through the

Beamers, Bobwhites, and Blue-Points: Tributes to the Career of Paul W. Parmalee. James R. Purdue, Walter E. Klippel, and Bonnie W. Styles (Editors). 1991. Illinois State Museum Scientific Papers, Vol. 23, Springfield (also as The University of Tennessee, Department of Anthropology Report of Investigations No. 52, Knoxville).

efforts of several cooperating archaeologists (see Baerreis 1958:2–5). Additional salvage work was conducted by Joan E. Freeman of the State Historical Society of Wisconsin in 1964, 1967, and 1968. In 1984, Lynne Goldstein and John D. Richards of the University of Wisconsin-Milwaukee sampled the central plaza and midden area along the river.

METHODS AND MATERIALS

The six "samples" of freshwater mussel valves considered in this report were recovered from archaeological contexts at Aztalan by five separate institutions between 1919 and 1984. In three samples, the number of valves, but not the side, for each taxon is provided in the literature (Parmalee 1960:Table 1). The remaining samples are listed by number of left and right valves, minimum number of individuals (MNI) and the relative abundance (%) of each species in tabular form. The MNI for a particular taxon is sometimes very different than one-half of the total number of valves. The reason(s) for this imbalance in valve side distribution is unknown (presumably a sampling error), but it does affect the MNI count, so valve side data are included. The MNI count has relevance for evaluation of harvesting episodes, food value versus time expenditure, etc. A summary table presents the relative abundance based on total valves for the five least-biased samples.

The taxonomy used in this report (Appendix 1) follows Turgeon et al. (1988). A series of voucher specimens for each mussel species from Aztalan analyzed by the author and representative valves from most other prehistoric shell assemblages mentioned are deposited at the Ohio State University Museum of Zoology, Columbus, Ohio.

PHYSICAL SETTING

The Crawfish River is a major headwater tributary of the Rock River in the Eastern Ridges and Lowlands province (Martin 1965:272, 278) of southeastern Wisconsin (Fig. 1). The Rock River is part of the Mississippi River drainage basin and enters the Mississippi River at Rock Island, Illinois, some 210 km (130 mi) southwest from its departure at the Wisconsin-Illinois border. The Rock River and its tributaries within Wisconsin drain an area of 8960 km² (3460 mi²) (Henrich and Daniel 1983:296). This region was covered by the Green Bay Lobe of the late Pleistocene (Laurentide) ice sheet between 20,000 and 13,000 years B.P. (Mickelson et al. 1983). The geologically youthful Rock River drainage in Wisconsin flows through a glaciated landscape, rich in wetlands. The Crawfish River itself drains an area of 2025 km² (782 mi²), and some 1980 km² (765 mi²) of this are above the site of Aztalan (Henrich and Daniel 1983:282).

Early historic descriptions portrayed the Crawfish River as a clear water stream some 60 m (200 ft) in width and composed of a series of long, low gradient pools connected at irregular intervals by rapids. A survey of the Crawfish River was conducted by Captain T. J. Cram, of the United States Topographical Engineers, who stated,

> In ascending this branch from its mouth, at Jefferson, the minimum depth of water for six miles, is believed to be not less than four feet in low stages. About one and a half miles above Aztalan there is a rapid, during the lowest stages of water, the depth is not over ten inches. Above the rapid the water is tranquil, and has a depth of five feet for about ten miles; above which there occurs a series of rapids with only about ten inches of water for half a mile. (Capt. Cram; cited in Lapham 1846:148)

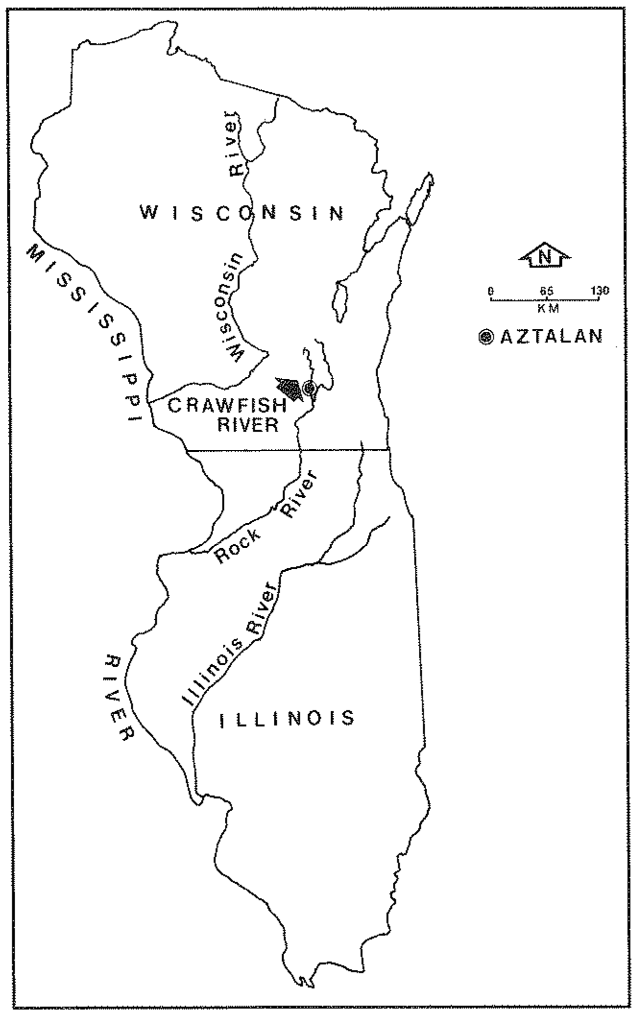

Figure 1. Location of the Aztalan site and selected rivers of Wisconsin and Illinois.

The Crawfish River was essentially a stream that ". . . was deep enough to form a good waterway for canoe travel" (Barrett 1933:37; see also Lapham 1846:15). Although the Crawfish of the early Historic Period has sometimes been portrayed as a deep stream, suitable for navigation by small cargo vessels (Hawkins 1940:38), this type of navigation was almost certainly restricted to flat-bottomed boats during high-water periods.

The shallow-water margins of the Crawfish River are reported to have been lined with aquatic vegetation, including stands of wild rice (*Zizania aquatica*). Euro-American settlement in the 1830s brought land clearance, and by the 1840s dams had been constructed along the Crawfish and Rock rivers for grist and saw mills. Agriculture rapidly expanded in the 1850–1860 period, with a boom in wheat prices and more land clearance during the Civil War (Hawkins 1940:38–39). Agricultural intensification brought heavy loads of smothering silt (see Ellis 1936) into the dammed pools of the Crawfish, blanketing the sand, gravel, and boulder substrate and muddying its waters to this day.

In 1887 the common carp (*Cyprinus carpio*), a native of Asia, was introduced into the Crawfish River, and these fish are blamed with destroying the wild rice and other aquatic vegetation (Becker 1983:424; Hawkins 1940:62). The period between 1890 and 1906 saw severe lateral erosion of the river banks (Hawkins 1940:62) adding to the problem of siltation.

FRESHWATER MUSSELS: STRUCTURE AND BIOLOGY

Freshwater mussels, or more correctly naiades, are aquatic mollusks of the class Pelecypoda (syn. Bivalvia) that are bivalved, have a nacreous (= mother-of-pearl) interior and pass through a larval parasitic stage in their early development, unlike true mussels, clams, and oysters. In this report the vernacular term freshwater mussel, or mussel, will be used. The following discussion follows Baker (1927, 1928), Parmalee (1967), and the summary presented in Theler (1987a).

Depending on the species involved, the shell of an adult freshwater mussel can range in length from 2 to 20 cm (1.5 to 8 in.). The two halves or valves serve to protect the animal's soft tissue and are joined together by a dorsal hinge ligament. Below the hinge ligament of most taxa, there is a set of interlocking "teeth," which assist in holding the two valves in their proper position. Many of the heavier-shelled mussels have a great variety of species-specific exterior shell ornamentation, that include arrangements of knobs, bumps, and grooves. These shell characteristics represent evolutionary adaptions to high-energy aquatic environments. Mussel species with thin, smooth, lightweight shells have evolved to fill low-energy aquatic niches. There are a number of species that exhibit great phenotypic variability in shell form as a response to ecological conditions. The 50 or so freshwater mussel species that live in the upper Midwest can be identified to the species level by one or more shell characteristics, provided the ecophenotypic variation is understood for the stream system or region.

Mussels live partially buried in the substrate of streams or lakes with inhalant and exhalant siphons circulating water for feeding, oxygen, and breeding activities. Mussels are active during the warm months when breeding, growth, and calcium carbonate additions to the shell take place. At the onset of winter, mussels begin a period of dormancy.

Although mussels may be found in a wide variety of habitats, the areas that support high densities (> 15 individuals/m^2) are small streams and rivers having a stable sand and gravel substrate with a moderate to strong current. High density mussel aggregates, or "beds," are associated with optimal areas of current and substrate that often result in linear configurations with mussel beds orientated parallel to the runs and pools of the stream channel flow.

The eggs of the female mussel are fertilized by sperm which are taken in with water exchanged through the inhalant siphon. Water tubes in the gills serve as brood pouches for the young, or glochidia, during their early development. The number of glochidia present ranges from a few thousand to a million or more. After a period of embryonic development, the female mussel discharges the glochidia into the water, and they must attach themselves to a suitable host within a short time or they will die. The host for the parasitic stage in the mussel's development is usually a fish. At least one mussel, *Simpsonaias ambigua*, has a salamander host, the mudpuppy, *Necturus maculosus maculosus*.

The glochidia attach to the gills, skin, or fins of the proper host where the glochidia become encapsulated by the fish's skin. The parasitic stage normally lasts 10–30 days, during which time adult mussel organ systems are formed. Having completed organ development, the transformed glochidia break out of the encapsulation, and fall as a juvenile mussel to the stream or lake bottom. Sexual maturity is reached in one to eight years depending on the species. Many species may live 20–40 years, with individuals of some species reaching nearly 70 years. A critical relationship exists between the naiad and its fish host species. The fish and glochidia must of necessity occupy the same habitat during the breeding cycle stage of host infestation, and the juvenile mussel must be dropped in a suitable habitat to survive. It is unfortunate that the glochidia-host relationship is poorly understood or unknown for so many mussel species.

RESULTS

Freshwater Mussel Samples from Aztalan

In 1959 Paul W. Parmalee undertook an analysis of the extant animal remains from Aztalan. Parmalee's study of the freshwater mussel shells included his own analysis of collections at the Milwaukee Public Museum and the Department of Anthropology, University of Wisconsin-Madison. Data on a third series of Aztalan mussel shells were acquired from Lawrence College, Appleton, Wisconsin (Parmalee 1960:2–3, Table 1).

Milwaukee Public Museum Sample

The Aztalan mussel shells housed at the Milwaukee Public Museum (MPM) were recovered during excavations directed by S. A. Barrett in 1919, 1920, and 1932. In his description of specific excavations, Barrett (1933) often referred to "clam shells" encountered in a variety of refuse-related contexts. In Barrett's discussion of pit-feature content during the excavation of section II at Aztalan, he stated,

> In most instances there were also greater or less quantities of the shells of the several species of clams found in the adjacent river. Some of these pits were almost completely filled with these clam shells, others had them scattered promiscuously through the contents of the pit, and still others had special layers of the clam shells interspersed with other refuse. (Barrett 1933:108).

Barrett (1933:357–358) later considered Aztalan shell material under the heading of "Foods," listing five local freshwater mussel species identified by T. E. B. Pope, a curator of zoology at the MPM (see Table 1).

When Parmalee analyzed the MPM collection in 1959, it contained 287 identifiable freshwater mussel valves representing 14 taxa. The 287 valves include 101 (35.2%) shells that had been perforated for use as "hoes" or similar tools. The species used for hoe manufacture are divided between 96 *Amblema plicata plicata* (threeridge mussel) valves and 5 *Megalonaias nervosa* (washboard mussel) valves (Parmalee 1960:3; P. W. Parmalee, unpubl. notes, 28 Dec. 1959). It can be assumed from the discussion of individual pit fills and published photographs (Barrett 1933:Plate 20), that the 186 unmodified shells housed at the MPM in 1959 do not represent all specimens excavated. Given the period of Barrett's work, it is surprising that any unmodified shells were saved. That the MPM collection is heavily weighted as a result of selective collection of modified shells can be evaluated to some degree by reference to excavations by the University of Wisconsin-Milwaukee (UW-Milwaukee) at Aztalan in 1984. The UW-Milwaukee excavation sampled the stratified river bank midden area. This resulted in the recovery of 1965 unmodified shells and only 6 perforated shell hoes or scrapers.

University of Wisconsin-Madison Sample

A variety of faunal remains were recovered during excavations directed by David A. Baerreis (1958) at Aztalan in 1949 and 1950. Mussel shells were found in relative low density at 36 separate proveniences. The maximum number of valves recorded for a single provenience was 72 specimens from Feature 59 (P. W. Parmalee, unpubl. notes, 1959). In all, 454 identifiable valves of 17 taxa were represented (see Table 1 and Parmalee 1960:Table 1).

Lawrence College Sample

In the early 1950s, Chandler W. Rowe of Lawrence College conducted excavations at Aztalan, finding one pit feature that contained 1234 mussel shells representing 14 taxa. These shells were identified and tabulated by Robert Chew, a biologist at Lawrence College. The entire shell sample was discarded at some point following analysis due to a lack of storage space (C. W. Rowe to P. W. Parmalee, letter, 31 March 1959). The species composition and relative abundance of the Lawrence College sample (Table 1) is probably indicative of a single harvest episode, and will be discussed later in this paper.

State Historical Society of Wisconsin 1967 Sample

Excavations undertaken at Aztalan by the State Historical Society of Wisconsin in 1967 encountered two overlapping refuse filled pits, designated as Features 42 and 42A. Both features were partially filled with freshwater mussel shells and small quantities of other refuse. It appears that Feature 42 was first filled with shells and at some later point in time the Feature 42A pit intruded through the margin of Feature 42 (see Fig. 2). The shell deposits were removed from each feature in matrix blocks and placed in paper bags and stored in cartons at the State Historical Society of Wisconsin in Madison.

In 1981, Joan E. Freeman, Curator of Anthropology at the State Historical Society of Wisconsin and director of the 1967 Aztalan excavations, granted the author permission to analyze shell material from Features 42/42A. An examination of each bag did not reveal any apparent differences in the relative density of shell for each feature, and a grab sample was taken to represent 18.2 percent of Feature 42 and 50 percent of Feature 42A. The cleaning and analysis of the 1967 shell was carried out at the Department of Anthropology, University of Wisconsin-Madison, where the shell material is stored. The shell from both pits was found to be in an overall excellent state of preservation, in part due to their "storage" in matrix. A small number of artifacts were found mixed with the shell and included one rim of an Aztalan collared vessel from Feature 42A.

A total of 5028 mussel valves representing at least 2475 individuals and 17 species are represented in the

Table 1. Freshwater mussels recovered at Aztalan by the Milwaukee Public Museum; University of Wisconsin-Madison and Lawrence College (modified after Parmalee 1960:Table 1).

	Milwaukee Public Museum		UW-Madison		Lawrence College	
	Valves	%	Valves	%	Valves	%
Anodonta sp.	2	1.1	1	0.2	11	0.9
Strophitis undulatus	5	2.7	1	0.2	38	3.1
Alasmidonta marginata	0	0	1	0.2	2	0.2
Alasmidonta viridis	0	0	1	0.2	0	0
Lasmigona complanata complanata	2	1.1	3	0.7	1	0.1
Lasmigona costata	0	0	12	2.6	27	2.2
Megalonaias nervosa	2[h]	1.1	0	0	0	0
Quadrula pustulosa pustulosa	4*	2.2	0	0	2	0.2
Quadrula nodulata	0	0	2	0.4	0	0
Amblema plicata plicata	50*[h]	26.9	35	7.7	6	0.5
Fusconaia flava	3*	1.6	15	3.3	119	9.6
Pleurobema coccineum	6	3.2	9	2.0	2	0.2
Elliptio dilatata	66	35.9	309	68.1	564	45.7
Actinonaias ligamentina	13*	7.0	19	4.2	0	0
Venustaconcha ellipsiformis	6	3.2	0	0	26	2.1
Truncilla sp.	0	0	0	0	2	0.2
cf. *Potamilus alatus*	0	0	1	0.2	0	0
Ligumia recta	4	2.2	3	0.7	0	0
Lampsilis siliquoidea	16*	8.6	29	6.4	432	35.0
Lampsilis cardium	7	3.8	11	2.4	2	0.2
Epioblasma triquetra	0	0	2	0.4	0	0
Totals	186	100.6	454	99.9	1234	100.2

* taxa identified in Milwaukee Public Museum collection by T. E. B. Pope
[h] reported shell hoes not included in count

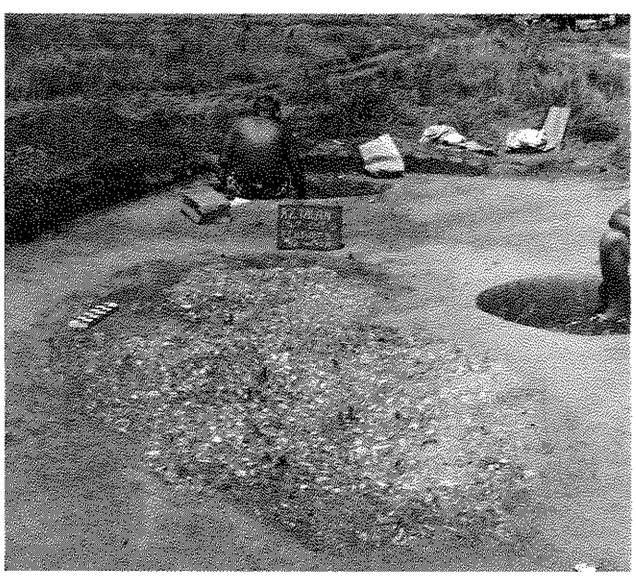

Figure 2. Aztalan pit Feature 42 and 42A, State Historical Society of Wisconsin excavation, 1967.

combined analyzed portions of Features 42 and 42A. The species represented, total number of valves, minimum number of individuals (MNI), and relative abundance (%) for each species are presented in Table 2. In both Features 42 and 42A, the majority of valves were found to be in "nested" sets of two to six matched shells within, or interlocking, one another. This configuration of nested valve sets makes it clear that when these shells were deposited, they were open with their joining hinge ligament attached. The hinge ligament (a proteinaceous structure) of an opened mussel becomes very brittle within a few hours when removed from water. It is evident that mussels were opened, probably by steaming or baking (see Theler 1987a:54–55), shucked of meat, and the shells deposited in the pits. Features 42/42A are probably the pits in which the mussels were steamed. Finally, it should be noted that David A. Baerreis (pers. comm., 1982) was of the opinion that some deposits of shells such as those found in Features 42/42A represent shells that were intentionally cached for future use as tempering material in pottery manufacture.

Table 2. Freshwater mussels recovered in Features 42 and 42A at Aztalan by the State Historical Society of Wisconsin 1967 excavations.

	Feature 42					Feature 42A				
	Valves					Valves				
	Left	Right	Total	MNI	%	Left	Right	Total	MNI	%
Anodonta grandis	7	3	10	7	0.6	3	3	6	3	0.3
Anodonta ferussacianus	8	3	11	8	0.6	2	2	4	2	0.2
Strophitus undulatus	47	44	91	47	3.7	35	39	74	39	3.3
Alasmidonta viridis	18	16	34	18	1.4	13	12	25	13	1.1
Alasmidonta marginata	0	0	0	0	0	0	1	1	1	0.1
Lasmigona costata	14	14	28	14	1.1	18	11	29	18	1.5
Lasmigona compressa	4	5	9	4	0.3	6	2	8	6	0.5
Quadrula pustulosa pustulosa	4	3	7	4	0.3	1	1	2	1	0.1
Amblema plicata plicata	17	16	33	17	1.3	5	5	10	5	0.4
Fusconaia flava	81	76	157	81	6.3	61	55	116	61	5.1
Pleurobema coccineum	14	20	34	20	1.6	3	2	5	3	0.3
Elliptio dilatata	614	618	1232	618	48.4	686	676	1362	686	57.3
Actinonaias ligamentina	2	1	3	2	0.2	3	4	7	4	0.3
Venustaconcha ellipsiformis	272	292	564	292	22.9	148	155	303	155	12.9
Villosa iris	0	0	0	0	0	1	1	2	1	0.1
Lampsilis siliquoidea	130	137	267	137	10.7	162	187	349	187	15.6
Epioblasma triquetra	8	8	16	8	0.6	13	9	22	13	1.1
Subtotals	1240	1256	2496	1277	100.0	1160	1165	2325	1198	100.2
Unidentifiable valves	56	73	129	—	—	43	35	78	—	—
Totals	1296	1329	2625	1277	100.0	1203	1200	2403	1198	100.2

University of Wisconsin-Milwaukee 1984 Sample

In 1984 Lynne Goldstein and John D. Richards from the UW-Milwaukee conducted excavations at Aztalan to evaluate aspects of the site formation process and to assess the integrity of the remaining archaeological deposits (Goldstein 1985:61–62; Richards 1985:72–75). The UW-Milwaukee excavations focused on the extensive midden area that lies along the bank of the Crawfish River (Barrett 1933:83–85). In 1987 the author studied the shell material from the UW-Milwaukee excavations. Prior to analysis, the shell had been segregated from other material and cleaned by UW-Milwaukee personnel. The mussel valves were identified at the University of Wisconsin-La Crosse and returned to UW-Milwaukee's Archaeological Research Laboratory where they are now stored.

UW-Milwaukee's 1984 excavations recovered 1965 unmodified mussel valves representing at least 1012 individuals of 18 species (Table 3). One to 330 shells were found in 76 separate proveniences in the river bank midden's stratified sequence. Some refuse clusters in the midden, such as Feature 20 that contained 200 mussel valves and other debris, were interpreted to be *in situ* dumping episodes (Richards 1985:95).

In addition to unmodified material, there are six mussel valves of four species that were intentionally perforated for use as hoe or scraper-type tools. Also recovered was a marine snail, *Marginella apicina* (common Atlantic marginella), that had a portion of its upper whorl margin ground away so that a thread or sinew could pass through the shell. Parmalee (1960:4) reported one other marginella bead from S. A. Barrett's work at Aztalan.

The Aztalan Mussel Assemblage

A total of 8592 valves of 23 freshwater mussel species are represented in the six Aztalan samples (Table 4). For the present, we will not consider the 186 unmodified valves in the MPM collection due to a possible sampling bias; so we are left with 8406 valves from five samples.

The most abundant mussel species recovered at Aztalan is *Elliptio dilatata* (spike), representing 49.9 percent (= 4197 valves) of the five combined samples. The shells of *E. dilatata* are uniformly the small river ecoform or phenotype [= *Elliptio dilatatus delicatus* (Simpson)], see Baker (1927, 1928:128–130). This phenotype inhabits a sand and/or gravel substrate in 0.3–0.6 m of water (Baker 1928). In eastern Wisconsin, the author has found the small

Table 3. Freshwater mussels recovered at Aztalan by the University of Wisconsin-Milwaukee 1984 excavation.

	Valves				
	Left	Right	Total	MNI	%
Anodonta grandis	7	7	14	7	0.7
Anodonta ferussacianus	2	0	2	2	0.2
Strophitus undulatus	50	30	80	50	4.9
Alasmidonta viridis	7	6	13	7	0.7
Lasmigona complanata complanata	0	1	1	1	0.1
Lasmigona costata	35	33	68	35	3.5
Lasmigona compressa	11	7	18	11	1.1
Quadrula pustulosa pustulosa	2	1	3	2	0.2
Amblema plicata plicata	19	16	35	19	1.9
Fusconaia flava	61	51	112	61	6.0
Pleurobema coccineum	1	2	3	2	0.2
Elliptio dilatata	394	336	730	394	38.9
Actinonaias ligamentina	6	4	10	6	0.6
Venustaconcha ellipsiformis	31	34	65	w	3.4
Ligumia recta	1	0	1	1	0.1
Lampsilis siliquoidea	374	357	731	374	37.0
Lampsilis cardium	2	2	4	2	0.2
Epioblasma triquetra	3	4	7	4	0.4
Subtotals	1006	891	1897	1012	100.1
Unidentifiable valves	32	36	68	—	—
Totals	1038	927	1965	1012	100.1

river phenotype of *E. dilatata* in dense concentrations embedded in a mixed silt, sand, and gravel substrate in the quieter waters adjacent to riffles and the runs that connect riffles with pools.

Lampsilis siliquoidea (fatmucket) is second in abundance at Aztalan with 1808 valves, representing 21.5 percent of the five sample total. While second in overall abundance, it is equal to *E. dilatata* in the 1984 UW-Milwaukee sample, and ranks second or third in the other four assemblages. In small rivers, *L. siloquoidea* is most typically encountered in a silt/sand substrate under a slow to moderate current.

The mussel species ranking third in abundance at Aztalan is *Venustaconcha ellipsiformis* (ellipse), having a total 958 valves, equalling 11.4 percent of the assemblage. *V. ellipsiformis* is a taxon characteristic of the well-oxygenated riffles and runs of small rivers. It is usually found in a mixed sand and gravel substrate under a moderate to swift current in 0.3 m or less of water (Baker 1928:264; Klippel, Celmer, and Purdue 1978:265; Parmalee 1967:57). In Wisconsin this species now appears restricted to a few, relatively clean streams in the southeast (Baker 1928:265; Mathiak 1979:47), but in prehistory was established in southwestern Wisconsin (Theler 1987b).

Elliptio dilatata, *Lampsilis siliquoidea*, and *Venustaconcha ellipsiformis* together comprise the bulk (82.8%) of the Aztalan assemblage, with only 4 of the remaining 20 species contributing more than 1 percent each. These four are *Fusconaia flava* (the Wabash pigtoe) with 519 valves, equalling 6.2 percent of the five samples; *Strophitus undulatus* (squawfoot) with 284 valves (3.4%); *Lasmigona costata* (fluted-shell) with 164 valves (2.0%); and *Amblema plicata plicata* (threeridge) with 119 valves (1.4%). All four taxa are typical of smaller rivers in the upper Midwest where they are often found in a silt/sand and/or gravel substrate under variable water depths in a moderate current.

Next in abundance are 10 mussel species, each contributing from 0.9 percent to 0.1 percent of the combined five samples. In descending order of relative abundance, they are *Alasmidonta viridis* (slippershell) with 73 valves, equalling 0.9 percent of the combined samples, *Pleurobema coccineum* (round pigtoe), *Epioblasma triquetra* (snuffbox), *Actinonaias ligamentina* (mucket), *Anodonta grandis* (giant floater), *Lasmigona compressa* (creek heelsplitter), *Anodontoides ferussacianus* (cylindrical papershell), *Quadrula pustulosa pustulosa* (pimpleback), *Lampsilis cardium* (pocketbook), and *Lasmigona complanata*

Table 4. Summary data for freshwater mussels from archaeological contexts at Aztalan and historical occurrences in the Rock River drainage of Wisconsin (Key: UW = University of Wisconsin; F = Feature; MPM = Milwaukee Public Museum; R = River; WI = Wisconsin).

			Archaeological						F. C. Baker (1927, 1928)		H. Mathiak (1979)	
Institution:	UW-Madison	Lawrence College	SHSW F42	SHSW F42A	UW-Milwaukee	Combined Five Samples	MPM	Recent Subfossils at Aztalan	Crawfish R. at Aztalan	Rock R. Drainage WI	Crawfish R. at Aztalan	Rock R. Drainage WI
Number of identifiable valves:	454	1234	2496	2325	1897	8406	186	301				
	%	%	%	%	%	%	%	%	0 = absent		+ = present	
Anodonta imbecillis	0	0	0	0	0	0	0	0	0	0	0	+
Anodonta grandis	0	0	0.4	0.3	0.7	0.4	0	0.7	+	+	+	+
Anodonta sp.	0.2	0.9	0	0	0	0.1	1.1	0	0	0	0	0
Anodontoides ferussacianus	0	0	0.4	0.2	0.1	0.2	0	0	0	+	+	+
Strophitus undulatus	0.2	3.1	3.6	3.2	4.2	3.4	2.7	1.7	+	+	+	+
Alasmidonta marginata	0.2	0.2	0	0.1	0	<0.1	0	0.3	+	+	0	+
Alasmidonta viridis	0.2	0	1.4	1.1	0.7	0.9	0	0	0	+	0	+
Lasmigona complanata complanata	0.7	0.1	0	0	0.1	0.1	1.1	1.7	+	+	+	+
Lasmigona costata	2.6	2.2	1.1	1.2	3.6	2.0	0	0	0	+	0	0
Lasmigona compressa	0	0	0.4	0.3	0.9	0.4	0	0	0	0	+	+
Megalonaias nervosa	0	0	0	0	0	0	1.1	0	0	0	0	0
Quadrula pustulosa pustulosa	0	0.2	0.3	0.1	0.2	0.2	2.2	0.3	0	+	0	+
Quadrula nodulata	0.4	0	0	0	0	<0.1	0	0	0	0	0	0
Amblema plicata plicata	7.7	0.5	1.3	0.4	1.8	1.4	26.9	13.5	+	+	+	+
Fusconaia flava	3.3	9.6	6.3	5.0	5.9	6.2	1.6	1.3	+	+	+	+
Cyclonaias tuberculata	0	0	0	0	0	0	0	0.3	0	0	0	0
Pleurobema coccineum	2.0	0.2	1.4	0.2	0.2	0.6	3.2	6.1	+	+	0	+
Elliptio dilatata	68.1	45.7	49.4	58.6	38.5	49.9	35.9	46.8	+	+	0	+
Obliquaria reflexa	0	0	0	0	0	0	0	0	0	+	0	0
Actinonaias ligamentina	4.2	0	0.1	0.3	0.5	0.5	7.0	13.8	0	+	0	0
Venustaconcha ellipsiformis	0	2.1	22.6	13.0	3.4	11.4	3.2	0.3	0	+	0	+
Truncilla sp.	0	0.2	0	0	0	<0.1	0	0	0	0	0	0
c.f. *Potamilus alatus*	0.2	0	0	0	0	<0.1	0	0	0	+	0	0
Toxolasma parvus	0	0	0	0	0	0	0	0.3	0	+	+	+
Ligumia recta	0.7	0	0	0	0.1	<0.1	2.2	0.7	+	+	+	+
Villosa iris	0	0	0	0.1	0	<0.1	0	0	0	0	0	0
Lampsilis siliquoidea	6.4	35.0	10.7	15.0	38.5	21.5	8.6	9.1	+	+	+	+
Lampsilis cardium	2.4	0.2	0	0	0.2	0.2	3.8	3.0	0	+	0	+
Epioblasma triquetra	0.4	0	0.6	0.9	0.4	0.6	0	0	0	0	0	0
Totals	99.9	100.2	100.0	100.0	100.0	100.6	100.6	99.9				

complanata (white heelsplitter), with five valves, contributing 0.1 percent to the assemblage. These 10 species are associated with a range of aquatic habitats, from quiet water to high-energy riffles.

There are six species each representing less than 0.1 percent of the total: these are *Quadrula nodulata* (wartyback), *Truncilla* sp. (fawnsfoot or deertoe), a possible occurrence of *Potamilus alatus* (pink heelsplitter), *Ligumia recta* (black sandshell), *Villosa iris* (rainbow shell), and *Alasmidonta marginata* (elktoe). One additional species represented only in the MPM sample is *Megalonaias nervosa* (washboard).

Sample Variability and Mussel Harvests

The combination of the five Aztalan samples, while useful for discussion of the most numerous mussel taxa represented at the site, also masks potentially interesting intersample variation. Since some mussel species are associated with specific habitats, variation in the distribution of niche-specific species may allow the identification of aquatic habitats where mussels were harvested, or may even help isolate specific harvest episodes.

A case in point is the third most abundant mussel species at Aztalan, *Venustaconcha ellipsiformis*. In the UW-Madison sample no *V. ellipsiformis* valves were found, the Lawrence College sample contained 26 valves that represented 2.1 percent of that sample, and the UW-Milwaukee sample contained 65 shells comprising 3.4 percent of the total. In the final two Aztalan samples, both from SHSW 1967 excavations, the abundance of *V. ellipsiformis* is found to be dramatically greater than in the other samples. Feature 42A produced 303 *V. ellipsiformis* valves, equalling 13 percent of that sample, while Feature 42 had 564 *V. ellipsiformis* shells that contributed 22.6 percent to the total. The striking difference in the intersample abundance of this taxon is most readily explained by habitat-specific exploitation. *V. ellipsiformis* lives in a sand and gravel substrate in riffles and runs, normally under a strong current. Feature samples 42 and 42A also contained the greatest number of *Epioblasma triquetra* and the only Aztalan specimens of *Villosa iris*, both species with habitat preferences similar to *V. ellipsiformis*. In contrast, mussel species typical of low energy regimes, such as *Lampsilis siliquoidea* are less common in Features 42 and 42A when compared to the Lawrence College or the UW-Milwaukee samples.

It is proposed that the high density of *Venustaconcha ellipsiformis* in Features 42/42A is indicative of a mussel harvest focused on a riffle/run habitat. If one can presume long-term stability of this habitat type, the same "rapids" (= riffle habitat) that Captain Cram described up the Crawfish River from Aztalan (see Physical Setting) may have been the location harvested. It is also possible that the prehistoric people at Aztalan inadvertently created a riffle habitat adjacent to their village by construction of a fish dam across the Crawfish River at Aztalan (Yerkes 1981:542), or upriver (Stuebe 1976:258–259), producing a riffle immediately below the dam (see Cobb 1978:37, Fig. 4). However, the species composition of the UW-Milwaukee and Lawrence College mussel samples indicates that harvests focused on lower energy pools, similar to the local conditions described at the site in the early nineteenth century. Feature 42 is distinct with a larger component of riffle species with *V. ellipsiformis* nearly twice as common compared to 42A, indicating each feature fill represents separate collecting episodes. It should be recalled that Features 42/42A contained a high frequency of matched valve sets indicating rapid burial of shells following the removal of the meat. Features 42/42A species composition should be contrasted with the Lawrence College sample, also an assemblage from a single pit. Each of these samples may represent a single harvest and consumption episode.

Mussel Density

In April 1981 the author attempted to estimate both the density of living mussels and the number of individuals that could be harvested per hour in good quality, small river habitats in eastern Wisconsin. Density studies were conducted on the East Branch of the Milwaukee River and on the Mukwonago River. In sections of these streams with riffle and run habitats having a moderate to swift current over a mixed sand and gravel bottom in 0.3–0.7 m of water, mussels (principally *Elliptio dilatata* and *Venustaconcha ellipsiformis*) were estimated to have a density of 10–25 individuals/m^2. This estimate is similar to that of riffle habitat in a Missouri small river, where 17.4 mussels/m^2 were encountered (Klippel et al. 1978:260), but somewhat under that recorded for good habitats in larger rivers (see Theler 1987a:27).

Harvest Rates

Three timed mussel "harvests" were made by the author on the Mukwonago River to establish an estimated harvest rate. In the areas collected, mussels were visible, their margins protruding above the sand and gravel substrate. The timed harvests were located in different portions of a riffle/run habitat known to have a substantial mussel population. Each mussel harvest was timed by a second person, who halted a collection after a 5-minute period, when mussels were identified and their numbers recorded. Extrapolating from the timed Mukwonago collections, one person could potentially harvest more than 400 mussels per hour in a good quality, small stream habitat (Theler 1987a:51–52). In the present report, a more conservative estimate for a small river mussel collector is set at 200 mussels/hour to allow reasonable time for rest and movement to new harvest locations. Employing density figures and harvest rates, an estimate of the time and area involved in particular harvest episodes on the aboriginal Crawfish River and the return in food value can be made.

Extrapolating from the Feature 42 volumetric samples, the projected total number of mussels represented is 7040 individuals. At a harvest rate of 200 mussels/person/hour, the Feature 42 fill represents 35.2 person-hours of harvesting activity, or in other words, five people gathering mussels for a 7-hour period. The projected total number of mussels present in Feature 42A is 2394 individuals, and this number would represent 12 person-hours of harvest, or five people collecting mussels for about two and one-half hours. In a good-quality habitat having a mussel density of 15 individuals/m^2, the 9434 individuals projected for Features 42/42A would represent a harvested area of 630 m^2. Following intensive mussel exploitation, it would take 10 years or longer for mussels to become reestablished and grow to a usable size.

Four mussel taxa contributed about 90 percent of the individuals represented in Features 42 and 42A. The soft tissue weight value for *Elliptio dilatata* is 12 g/individual, and for *Fusconaia flava* is 16 g/individual (Parmalee and Klippel 1974:424, Table 1). An estimate of 15 g/individual is assigned to *Lampsilis siliquoidea* on the basis of the uniformly small size of individuals from the Features 42/42A assemblage. An estimate of 5 g/individual for soft tissue of *Venustaconcha ellipsiformis* is based on a sample of 98 specimens collected in the Mukwonago River and is presented below:

	Weight of Soft Tissue (in grams)	Shell Dimensions (in millimeters) length	width
Range	1.4–13.4	35–74	18–42
Mean	5.08	52.5	29.7

The additional 13 species in Features 42/42A represented about 10 percent of the mussels and are assigned a value of 10 g/individual for soft tissue. This weight estimate is in accordance with the predominantly small size of mussels recovered from these features and at Aztalan generally.

The total estimated meat weight projected for Feature 42 is 75.7 kg, and for Feature 42A it is 27.7 kg. Data presented by Parmalee and Klippel (1974:431, Table 4) indicate that about 60 calories are represented in 100 g of mussel tissue. The 103.4 kg of projected mussel meat for Features 42/42A would then represent 62,040 calories. Assuming a dietary intake of 2400 calories/person/day, the mussel meat would represent a 25-person-day supply contributed to the diet from about 48 person-hours of effort. The protein content of mussel tissue is about 8 or 9 percent of fresh weight (Parmalee and Klippel 1974:432), with the 103.4 kg of mussel meat projected in Features 42/42A contributing about 8.3 kg of protein. A person needs about 60 g of protein/day (National Academy of Science 1980:16–28, 46–51), suggesting the 103.4 kg of mussel tissue would contribute roughly a 165-person-day supply of protein from the 48 hours of harvest time.

Mussel Resources: Biomass and Sustained Yields

Some rough estimates can be made for the biomass and potential sustained yield of freshwater mussels in the vicinity of Aztalan. The Crawfish River is about 60 m (200 ft) in width. If we assume aboriginal harvesters might travel 1.6 km (1 mi) up or downstream in search of mussels, then more than 190,000 m^2 of riverine habitat would be available for harvest. Given the apparent high quality of the prehistoric Crawfish River, a modest density estimate of 3 mussels/m^2 (see Klippel, Celmer, and Purdue 1978:260) would suggest 570,000 mussels lived within the 190,000-m^2 search area near Aztalan. About 5 percent, or 28,500 mussels, could probably be harvested annually on a sustained yield basis. Estimating 10 g of soft tissue per mussel, this annual harvest of 28,500 individuals would result in 285 kg of mussel meat. Harvesting about 100 mussels per hour, this would involve about 285 hours, or one person-hour of harvest time for each kilogram of meat. One kg of mussel tissue will provide about 600 calories, or one-quarter of the 2400 calories required daily for adult humans. If we increase our rate of harvest in good-quality habitats to 200 mussels/hour, then a 1-hour harvest would produce 1200 calories, or one-half the daily requirement.

Species Discussion

Megalonaias nervosa (Washboard)

Seven *Megalonaias nervosa* valves are recorded in the MPM sample (Parmalee 1960:3, Table 1), and five of the seven were modified to produce hoes (P. W. Parmalee, unpubl. notes, 1959). *M. nervosa* valves can appear quite similar in form and size to some ecophenotypes of *Amblema plicata plicata* (threeridge), the most commonly used species in the manufacture of shell hoes at Aztalan (Barrett 1933:357; Parmalee 1960:3). A brief search among the extant Aztalan shell hoes at the MPM by the author in 1989 located three *M. nervosa* valves that had been modified by perforation to produce hoes. All three have considerable use wear, and were probably discarded as exhausted tools. Two of these valves (MPM Spec. Nos. 40073 and 25919) are somewhat chalky and poorly preserved. The third valve (MPM Spec. No. 27087), although split at the perforation, has very well-preserved diagnostic beak sculpture that distinguishes *M. nervosa* from *A. plicata plicata* without question.

In Wisconsin, *Megalonaias nervosa* has been reported living only in the Mississippi River (Baker 1928:72; Mathiak 1979:55). This species has not been found in the Rock River system of Wisconsin or Illinois (Baker 1927; Miller 1972), but is present in the Illinois River and some of its larger tributaries in Illinois (Parmalee 1967:33; Starrett 1971:295–297).

In the nineteenth century, *M. nervosa* was reported to be "not common" (Shimek 1888:76) to "very rare" (Pratt 1876:165; Witter 1883:17) in the upper Mississippi River. A pre-lock and dam (1930–1931) survey of freshwater mussels by Max M. Ellis found this taxon to be widespread but uncommon in the upper Mississippi River, representing only 1.2 percent of a total sample of 6902 mussels (van der Schalie and van der Schalie 1950:454, Table 1). More recent mussel surveys in the upper Mississippi River show an increase in the relative numbers of *M. nervosa*. In navigational pools 9 through 11, adjacent to southwestern Wisconsin, Thiel (1981:Table 3) found 2.4 percent (Pool 11) to 10.6 percent (Pool 9) of all living mussels were *M. nervosa*, while down the Mississippi River in Pool 15 in the vicinity of Rock Island, Illinois, Oblad (1980:214) recorded *M. nervosa* constituting 78.9 percent of one mussel population he surveyed.

Archaeological sites adjacent to the upper Mississippi River have produced few valves of *Megalonaias nervosa*. In samples totaling more than 29,000 identifiable valves from prehistoric middens adjacent to modern navigational pools 10 and 11 where Thiel (1981) recorded substantial populations, no *M. nervosa* valves were found (Theler 1987a, 1987c). A shell midden (11Ri337) at the site of the Rock Island Rapids produced only four *M. nervosa* shells among 6920 identifiable valves (Van Dyke et al. 1980:231). Matteson (1961:58, Table 1) reports six *M. nervosa* shells among the 6590 valves he analyzed from an Archaic shell midden near the mouth of the Rock River. In La Crosse County, Wisconsin, the Valley View site (47Lc34) had only three *M. nervosa* valves among the 541 specimens recovered (Stevenson 1985:311, Table 3). One or two *M. nervosa* valves have been recovered from other archaeological sites in Wisconsin, but always as very rare members of the assemblage (Theler 1983:79, 1987b).

Megalonaias nervosa appears to have been a rare species in the prehistoric past based on the number of individuals represented in aboriginal shell middens, and it was a rare species in the nineteenth and early twentieth centuries, becoming locally common since changing habitats have favored its increase. *M. nervosa*'s preferred habitat is a silt or silt and gravel substrate in 1–3 m of water under a slow to moderate current velocity. The navigational lock and dam system of the upper Mississippi River constructed since the 1930s has provided an improved *M. nervosa* habitat through slower current velocity and increased silt, while some other freshwater mussel taxa have declined in number (Theler 1987a, 1987c).

It is suggested that the *Megalonaias nervosa* valves found at Aztalan were brought to the site, probably from the Mississippi River, to be used as tools. Mature *M. nervosa* often have valves measuring 100 mm (4 in.) in width and 150 mm (6 in.) in length (and occasionally larger), with each valve weighing about 0.2 kg (0.5 lb.). These large, solid shells, along with larger individuals of *Amblema plicata plicata*, appear to have been the chosen stock for shell hoe manufacture at Aztalan. It is of interest that we have large samples of mussel shell from a variety of Aztalan contexts, but no other valves of *M. nervosa* have been found. If a population of *M. nervosa* existed in the Crawfish River, subadult shells would be expected in the analyzed samples. It is only in the MPM shell assemblage, a high-graded collection with an emphasis on shell tools, that we find *M. nervosa* valves. The shell hoes at the MPM made of *A. plicata plicata* valves tend to be much larger than shells of this species recovered from Aztalan refuse contexts. Although *A. plicata plicata* grows to a large size in some smaller rivers today, this exceptional size appears to be related to increased nutrients from modern field runoff (Stansbery 1980:263). In Wisconsin, *A. plicata plicata* is a relatively uncommon species in the prehistoric small river assemblages (Theler 1987b; and this report). The larger, heavier valves of *A. plicata plicata*, like *M. nervosa*, may have been brought to Aztalan for shell hoe stock from the Mississippi River. Both species were favored for manufacture of hoes in the Cahokia area (Baker 1941:57–58).

Epioblasma triquetra (Snuffbox)

Epioblasma triquetra was identified in four Aztalan samples with a total of 47 valves, representing 0.6 percent of the assemblage. This species lives deeply embedded in a sand and gravel substrate under a swift current, usually in riffles (Baker 1928:298; Parmalee 1967:64). Surveys that have examined the freshwater mussel fauna of the Rock River system (Baker 1927; Mathiak 1979; Miller 1972) have not found *E. triquetra* living or as a subfossil. The appearance of *E. triquetra* in the Aztalan samples and absence of this species from the historic Rock River drainage deserves some discussion.

The historic occurrence of *Epioblasma triquetra* in Wisconsin marks the northern margin of this species range (Johnson 1978:250). In his comprehensive study of Wisconsin mussels, Baker (1928:299) recorded only one *E. triquetra* in the state which he took as a living individual in the Fox River near Omro, Winnebago County, Wisconsin. Baker (1928) questioned the provenience validity of *E.*

triquetra (misidentified as *Truncilla donaciformis*) from historic shell collections that were associated with a label indicating a lower Wisconsin River provenience in Sauk County, Wisconsin. It should be mentioned that Johnson (1978:244–245, 250, 290) accepted the validity of the Wisconsin River provenience, but recent mussel surveys on the Wisconsin River (Heath 1990; Stern 1983) have not found *E. triquetra*.

An archaeological sample of 164 mussel valves from the Millville site (ca. A.D. 400) adjacent to the Wisconsin River in Grant County, Wisconsin, produced valves of 20 mussel species (Theler 1983:79) but no valves of *E. triquetra*. The Brogley Rockshelter (ca. 2800 B.C. to A.D. 1200) is an aboriginal habitation site along the Platte River, a tributary of the Mississippi River in Grant County, Wisconsin. The archaeological deposits at Brogley contained nearly 6000 mussel valves representing 25 species (Theler 1987b), including an abundance of individuals characteristic of riffle habitats, but no valves of *E. triquetra*. Archaeological excavations at a series of prehistoric shell middens (variously dating ca. A.D. 1–1000) along the Mississippi River in southwestern Wisconsin produced more than 29,000 valves of 28 mussel species (Theler 1987a, 1987c) but no *E. triquetra*. Moving 120 km to the south of Wisconsin along the Mississippi River we find the former location of the Rock Island Rapids, ostensibly an ideal habitat for *E. triquetra*. Excavations of an aboriginal shell midden (dating ca. A.D. 1–200) produced nearly 7000 valves of 25 freshwater mussel species (Van Dyke et al. 1980) but, again, no shells of *E. triquetra* were found. Matteson (1961:58, Table 1) reported three *E. triquetra* valves from an Archaic Period (ca. 4000–6000 B.C.) shell midden on the lower Rock River near its confluence with the Mississippi River. A roster of freshwater mussel shells found in the vicinity of the Rock Island Rapids at Davenport, Iowa, (Pratt 1876:165) does not list *E. triquetra*, although Johnson (1978:250) reports a specimen of this taxon from this locality. A number of modern freshwater mussel surveys in the upper Mississippi River (Duncan and Thiel 1983; Mathiak 1979; Oblad 1980; Thiel 1981; van der Schalie and van der Schalie 1950) have not found this species, but a few individuals may have existed during the Historic Period (see Baker 1928:299; Fuller 1980:85).

The occurrence of a living *E. triquetra* in Wisconsin marks the northern range margin of this species. The only known prehistoric occurrences of *E. triquetra* in Wisconsin are in the samples from Aztalan. The prehistoric occupation of Aztalan at about A.D. 1000–1150 occurs during the Neo-Atlantic climatic episode (Bryson and Wendland 1967:294), a period that was warmer and perhaps moister than the preceding or succeeding periods. If some aspect of climate is exerting an influence on the distribution of *E. triquetra*, or its host fish, and its northern range limits seem to imply this, then the preceding and succeeding climatic patterns may have been disadvantageous to the viability of *E. triquetra* populations. Between A.D. 1550 and 1850 the upper Midwest experienced a particularly cool climatic episode, the Neo-Boreal (Bryson and Wendland 1967; Wendland 1978:281). By the end of the Neo-Boreal, Historic Period agriculture intensification in the upper Midwest resulted in stream degradation on an unparalleled scale (Knox 1977, 1985). A cooler Neo-Boreal climate followed by the Historic Period of stream degradation, particularly dams and siltation, may have singularly or together been contributing factors to the loss of Wisconsin *E. triquetra* populations, such as the one in the Crawfish River at Aztalan.

It is of some interest that during the 1980s a small number of living *E. triquetra* have been found in medium-sized rivers of western and northeastern Wisconsin (Doolittle 1988; David J. Heath, pers. comm., 1990). It is not known if the warmer, post-Neo-Boreal temperatures and improved water quality of recent decades have allowed the return of *E. triquetra* to Wisconsin. It may be that temperature is of little importance and that the recent finds of *E. triquetra* represent relict populations previously overlooked by mussel researchers. The ecology of this species is poorly known and even the host fish(es) remains unknown (Fuller 1980:85). The analysis of dated subfossil assemblages and the study of living *E. triquetra* populations may allow a clearer understanding of the significance of the prehistoric population of this species at Aztalan.

Elliptio complanata (Eastern Elliptio)

Five local freshwater mussel species were identified by T. E. B. Pope from shells S. A. Barrett recovered at Aztalan. These species included *Amblema plicata plicata*, *Fusconaia flava*, *Quadrula pustulosa pustulosa*, *Actinonaias ligamentina*, and *Lampsilis siliquoidea* (Barrett 1933:357–358). One additional freshwater mussel species, not native to the vicinity of Aztalan, *Elliptio complanata*, was reported by Barrett and is listed with three marine taxa under the subheading "Of shells obtained from more distant regions and probably used only for the manufacture of ornaments . . ." (Barrett 1933:358). *Elliptio complanata* is indeed a nonlocal species, native to the Atlantic slope of eastern North America. The nearest populations of *E. complanata* are found in streams flowing into Lake Superior, some 400 km (250 mi) to the north-northwest of Aztalan (Baker 1928:135; Clarke 1973:39; Matteson 1948:717–719). The identification of *E. complanata* led Barrett (1933:359) to comment, "The shell rather closely resembles some of the mussels found in the local streams about Aztalan." Two local mussels that resemble *E. complanata* are the closely related *Elliptio dilatata* (see Johnson 1970:279)—the most common species recovered at Aztalan—and the less abundant *Ligumia recta* (black sandshell). Since Barrett did not list *E.*

dilatata or *L. recta* among the species identified by Pope, and given that *E. complanata* has not been identified in subsequent analyses of Aztalan shells, it can be assumed that the assignment of *E. complanata* for Aztalan is a misidentification, and can be discounted.

Historic Subfossil and Living Mussels

Two attempts were made to assess the subfossil and living mussels in the Crawfish River at Aztalan. Interest in Crawfish River subfossils was sparked by Harold Mathiak's observations during a survey of Wisconsin mussels conducted during the 1970s, "At the Aztalan area I found only a few mussels, but dense beds of relic shells testified to their former abundance. The Crawfish River at this point was heavily silted and therefore low quality habitat" (Mathiak 1979:18).

It was hoped that *in situ* subfossil mussel beds, sealed in place by nineteenth-century silt loads might be located, collected, and analyzed. In July 1982, the author collected the Crawfish River at the southern portion of the Aztalan Park with less than ideal water conditions preventing visibility of the river bottom. The substrate over a large area was found to be composed of a firm, sticky silt, on which two valves of *Ligumia recta* and one valve of *Amblema plicata plicata* were found. These shells were relatively fresh in appearance, indicating some mussels still survive in this portion of the Crawfish River. Beneath the 10–25 cm (4–10 in.) of tacky silt, a sand, gravel, and cobble substrate zone was encountered. This zone contained a number of subfossil shells, including several matched pairs of *Elliptio dilatata* that appeared to be in their correct functioning position.

The two most common species from the substrate collection are *Elliptio dilatata* and *Lampsilis siliquoidea* (Table 5). Six additional taxa recovered beneath the silt zone include five valves of *Amblema plicata plicata* and one valve each of *Venustaconcha ellipsiformis*, *Strophitus undulatus*, *Alasmidonta marginata*, *Cyclonaias tuberculata*, and *Toxolasma parvus*. *C. tuberculata* and *T. parvus* were not present in the Aztalan archaeological samples. *T. parvus* has been reported as a historic occurrence in the Crawfish River (Mathiak 1979:41, Plate IX-E) and as a rare species in the Rock River drainage of Wisconsin (Baker 1927) and Illinois (Miller 1972). *C. tuberculata* was not reported by Baker (1927) or Mathiak (1979) in the Wisconsin portion of the Rock drainage, but is recorded as a subfossil in the Rock River in Rock County, Wisconsin, (David J. Heath, pers. comm., 1990) and living in the Rock River in Illinois by Miller (1972).

In September 1982, a second collection focused on a midstream cluster of boulders that are thought to represent a

Table 5. Recent subfossil* freshwater mussel valves recovered from the Crawfish River at Aztalan 1982.

	Muskrat Midden (?)					Substrate				
	Valves					Valves				
	Left	Right	Total	MNI	%	Left	Right	Total	MNI	%
Anodonta grandis	1	1	2	1	0.7	0	0	0	0	0
Strophitus undulatus	2	2	4	2	1.4	0	1	1	1	3.4
Alasmidonta marginata	0	0	0	0	0	0	1	1	1	3.4
Lasmigona complanata complanata	3	2	5	3	2.1	0	0	0	0	0
Quadrula pustulosa pustulosa	0	1	1	1	0.7	0	0	0	0	0
Amblema plicata plicata	17	18	35	18	12.8	3	2	5	3	10.3
Fusconaia flava	2	2	4	2	1.4	0	0	0	0	0
Cyclonaias tuberculata	0	0	0	0	0	0	1	1	1	3.4
Pleurobema coccineum	10	8	18	10	7.1	0	0	0	0	0
Elliptio dilatata	64	45	109	64	45.4	15	15	30	15	51.7
Actinonaias ligamentina	20	21	41	21	14.7	0	0	0	0	0
Venustaconcha ellipsiformis	0	0	0	0	0	1	0	1	1	3.4
Toxolasma parvus	0	0	0	0	0	1	0	1	1	3.4
Ligumia recta	1	0	1	1	0.7	0	1	1	1	3.4
Lampsilis siliquoidea	11	8	19	11	7.8	3	5	8	5	17.2
Lampsilis cardium	7	6	13	7	5.0	0	0	0	0	0
Totals	138	114	252	141	99.8	23	26	49	29	99.6

* one living *Lampsilis cardium* found in the Crawfish River is included above

portion of the Aztalan fish dam (Yerkes 1981). The water surrounding the boulders was approximately 1 m in depth. Shells were found wedged in a columnar cavity formed of smaller stones behind a larger boulder. The shell accumulation is interpreted to be a midden created by muskrats which used the large boulder as a feeding platform. The content of the boulder cavity was entirely removed and contained 250 mussel valves. The most abundant species present were *Elliptio dilatata*, *Actinonaias ligamentina*, *Amblema plicata plicata*, *Lampsilis siliquoidea*, and *Pleurobema coccineum*. *Elliptio dilatata* again constituted the most common species, but *A. ligamentina* and *A. plicata plicata* are relatively more numerous in this context than in the archaeological samples (Tables 4 and 5), perhaps reflecting a post Euro-American shift in local habitat. In his discussion of invertebrate fauna of the Crawfish River, Hawkins (1940:64) says "Clams, locally called 'elephant ears,' were harvested by the boatload and wash-tub full as late as 1920." The "elephant ears" are perhaps *Actinonaias ligamentina*.

One living mussel was found in the Crawfish River at Aztalan; a *Lampsilis cardium* was located in a sand and silt substrate 2 m from the boulder cluster. More survey and collecting on the Crawfish River will be necessary before the subfossil and living mussels populations are adequately understood.

CONCLUSIONS

(1) Assuming the mussel taxa in the Aztalan samples are representative, the Crawfish River at ca. A.D. 1000 held a fairly diverse assemblage of some 20 mussel species. The most abundant mussel species were *Elliptio dilatata*, *Lampsilis siliquoidea*, and *Venustaconcha ellipsiformis*.

(2) There were discrete aboriginal harvesting episodes that involved the collection of thousands of mussels from specific habitats. The SHSW 1967 Features 42/42A assemblages represent such harvests focused on a riffle-run habitat of the Crawfish River.

(3) The abundance of low-density accumulations of mussel shells in features and middens indicate there were persistent, small-scale harvests in the runs and pools of Crawfish River at Aztalan. The relatively small number of valves recovered in each provenience in the UW-Madison and UW-Milwaukee samples are believed to represent this type of frequent, but low-intensity mussel utilization.

(4) Projections for densities and harvest rates suggest freshwater mussels represent a potentially important seasonal dietary supplement. The people of prehistoric Aztalan could exploit on a sustained yield basis perhaps 285 kg of mussel meat per year in the vicinity of their settlement, without overtaxing the resource.

(5) It seems likely that the mussel taxon *Epioblasma triquetra* expanded its range northward into Wisconsin under the influence of the warm Neo-Atlantic climatic episode. Its later disappearance may be due to the colder climate of the Neo-Boreal climatic episode and/or Euro-American habitat disturbance.

(6) The large, heavy shells of *Megalonaias nervosa* were probably brought to Aztalan as stock for shell hoe manufacture. Some large valves of *Amblema plicata plicata* may also represent nonlocal imports for use as tools. The nearest source for *M. nervosa* valves is probably at the confluence of the Rock and Mississippi rivers, some 260 km (160 mi) south-southwest, or 160 km (100 mi) to the west at the confluence of the Wisconsin and Mississippi rivers.

(7) Some Aztalan shell deposits may represent raw material caches intended to serve as an aplastic tempering agent in ceramic manufacture. The shell fills in SHSW-1967 Features 42 and 42A and the Lawrence College sample could represent such caches.

(8) A comparison of the modern freshwater mussel fauna with the prehistoric assemblage shows a dramatic change in the molluscan populations of the Crawfish River in the vicinity of Aztalan. These changes are attributable to stream degradation, particularly siltation associated with Euro-American settlement that has largely destroyed the once extensive mussel populations of the Crawfish River.

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Appendix 1. Scientific and common names for freshwater mussels of the Rock River drainage in Wisconsin (after Turgeon et al. 1988) and synonyms used in Barrett (1933) and Parmalee (1960).

Scientific Name	Common Name	In Barrett (1933:357–358)	In Parmalee (1960:3, Table 1)
Family Unionidae			
Subfamily Andontinae			
Anodonta imbecillis Say, 1829	Paper pondshell		
Anodonta grandis Say, 1829	Giant floater		
Anodontoides ferussacianus (I. Lea, 1834)	Cylindrical papershell		
Strophitus undulatus (Say, 1817)	Squawfoot		*Strophitus rugosus*
Alasmidonta marginata Say, 1818	Elktoe		
Alasmidonta viridis (Rafinesque, 1820)	Slippershell mussel		*Alasmidonta caleolus*
Lasmigona complanata complanata (Barnes, 1823)	White heelsplitter		
Lasmigona costata (Rafinesque, 1820)	Fluted-shell		
Lasmigona compressa (I. Lea, 1829)	Creek heelsplitter		
Subfamily Ambleminae			
Megalonaias nervosa (Rafinesque, 1820)	Washboard		*Megalonaias gigantea*
Quadrula pustulosa pustulosa (I. Lea, 1831)	Pimpleback		
Quadrula nodulata (Rafinesque, 1820)	Wartyback		
Amblema plicata plicata (Say, 1817)	Threeridge	*Quadrula undulata*	*Amblema costata*
Fusconaia flava (Rafinesque, 1820)	Wabash pigtoe	*Quadrula rubiginosa*	
Cyclonaias tuberculata (Rafinesque, 1820)	Purple wartyback		
Pleurobema coccineum (Conrad, 1834)	Round pigtoe		*Pleurobema cordatum*
Elliptio dilatata (Rafinesque, 1820)	Spike		*Elliptio dilatatus*
**Elliptio complanata* (Lightfoot, 1786)	Eastern elliptio	*Unio complanatus*	
Subfamily Lampsilinae			
Obliquaria reflexa Rafinesque, 1820	Threehorn wartyback		
Actinonaias ligamentina (Lamarck, 1819)	Mucket		*Actinonaias carinata*
Venustaconcha ellipsiformis (Conrad, 1836)	Ellipse		*Actinonaias ellipsiformis*
Truncilla sp.	Deertoe or fawnsfoot		
Potamilus alatus (Say, 1817)	Pink heelsplitter		*Proptera alata*
Toxolasma parva (Barnes, 1823)	Lilliput		
Ligumia recta (Lamarck, 1819)	Black sandshell		
Villosa iris (I. Lea, 1829)	Rainbow shell		
Lampsilis siliquoidea (Barnes, 1823)	Fatmucket	*Lampsilis luteolus*	
Lampsilis cardium (Rafinesque, 1820)	Pocketbook		*Lampsilis ventricosa*
Epioblasma triquetra (Rafinesque, 1820)	Snuffbox		*Dysnomia triquetra*

* probable misidentification of *Elliptio dilatata* cited in Barrett (1933:358)

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