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MOLLUSKS OF THE SHEYENNE RIVER, NORTH DAKOTA, U.S.A.: PRESENT AND PAST

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ABSTRACT

The Sheyenne River, a tributary of the Red River in eastern North Dakota, is the longest river in the state and contains the greatest number of mollusks. Thirty-one species are known to inhabit the river: 12 mussels (unionacean bivalves), 6 pill clams (sphaeriid bivalves) and 13 snails (4 prosobranchs and 9 pulmonates). Sixteen species are known to occur in Lake Ashtabula (man-made reservoir in the middle reaches of the Sheyenne River): 4 mussels, 4 pill clams and 8 snails (3 are prosobranchs); and 7 species of mollusks (all pulmonate snails) were found in Sheyenne Lake (uppermost reaches of the Sheyenne River). Two snails, Gyraulus circumstriatus and Aplexa hypnorum, were found only in Sheyenne Lake. One pill clam (Pisidium nitidum) and 5 snails (Valvata tricarinata, Cincinnatia cincinnatiensis, Amnicola limosa, Gyraulus parvus and Helisoma anceps) occurred in greater densities in Lake Ashtabula than elsewhere. River discharge seems to be a primary factor in affecting mollusk occurrence in the Sheyenne River. Low or zero discharge relates to low mussel diversity and high discharge relates to high mussel diversity. Certain pill clams and snails seem to prefer flowing or stagnant (non-flowing) water. An unstable bottom (as one of rippled sand) seems also to primarily restrict mollusk occurrence. Other factors possibly limiting the occurrence of mollusks in the Sheyenne River are high turbidity (pill clams and snails), relatively high potassium (mussels) and lack of suitable fish host (mussels). The fossil molluscan fauna generally resembled the living fauna, but lacked 13 species (2 mussels, 4 pill clams and 7 snails). No fossil species were different from those living now, with the possible exception of the snail Campeloma decisum, whose present existence in the Sheyenne is uncertain. Mollusks inhabited the ancestral Sheyenne River that flowed into glacial Lake Agassiz at least as early as about 13,500 years ago, and the modern Sheyenne at least as early as about 2,500 years ago.

INTRODUCTION

Previous work and purpose

The Sheyenne River in eastern North Dakota is within the Hudson Bay drainage. This river is the longest in the state and has the greatest diversity of molluscan fauna. Little study, however, has been devoted to those mollusks of the river.

Coker & Southall (1915: 15) reported 4 species of mussels (unionacean bivalves) from the river at Lisbon. Winslow (1921: 10-16) listed 2 species of mussels, 6 species of pill clams (sphaeriid bivalves) and 9 species of snails (2 prosobranchs and 7 pulmonates) from the upper part of the river. Cvancara (1970) reported on the mussels from 5 stations in the lower part of the river. Peterka (1972) discussed 2 genera of pill clams and 4 genera of snails from Lake Ashtabula, a manmade reservoir on the river. Clarke (1973) reported 5 mussels, 1 pill clam and 1 snail from a single station in the lower part of the river. The only detailed study

of all mollusks of an entire river in North Dakota is that of Cvancara, Erickson & Delimata (1972). One of us (Cvancara, 1975) has recently summarized what is known of the aquatic mollusks in North Dakota.

Our report gives the distribution of mollusks of the Sheyenne River, evaluates the primary ecologic factors influencing their occurrence and compares the living mollusks with the fossil molluscan fauna associated with the river. This study should be useful in assessing the environmental impact of the in-progress irrigation Garrison Diversion Project on the Sheyenne River drainage.

Geologic setting and stream characteristics

Originating in central North Dakota (Sheridan County), the Sheyenne River generally flows east, south and northeast and joins the Red River of the North about 13 km north of Fargo (Fig. 1). It flows primarily through the undulating to hilly Drift Prairie, except for about the lower 1/4 of its length (below station 26), where it flows across the dominantly flat Red River Valley. The river flows in a trench cut during the late Quaternary when meltwater flowed southeastward from glacial Lake Souris to glacial Lake Agassiz (Aronow, 1963).

The bottom sediment is determined by the glacier- and glacial lake-related sediments and shales of Late Cretaceous age through which the river cuts. From station 2 to about station 26, the river is cut into bouldery sand, silt and clay (glacial till; forms ground and end moraine), sand and gravel (glacial meltwater deposits; form outwash plains), and marine shales, exposures of which are common from about station 12 to station 25 (Bluemle, 1965, 1973; Bluemle et al., 1967; Bluemle, unpubl. map of Ransom County; Carlson & Freers, 1975; Kelley & Block, 1967; Merritt, 1966; and Rude, 1966). Above station 26, the bottom sediment is mostly pebbly sand and sandy pebble gravel (Table 2). Shale is common to abundant in the coarser particles at many places. From below station 26 to about station 29, the Sheyenne cuts into sand and silt associated with the glacial Sheyenne delta (Baker, 1967). Within the area of the delta, the bottom sediment is primarily well-sorted sand. From below station 29 to the mouth, the river cuts into silt and clay of the plain of glacial Lake Agassiz (Klausing, 1968); here, the bottom sediment is muddy sand and mud.

The Sheyenne River, from its mouth to Sheyenne Lake, is 878 km long. (It extends upstream another 36 km as a highly intermittent stream.) Its basin upstream from gaging station 595 (Fig. 1) has an area of about 22973 km 2 (U.S. Geol. Surv., 1964: 54). The average gradient of the river is 0.28 m/km.

Discharge data for 8 gaging stations are given in Fig. 1. Flow is generally intermittent above station 16, where years in which zero discharge occurs is common. A substantial increase in discharge occurs where the river crosses the Sheyenne delta (from about station 26 to station 29), due primarily to groundwater inflow from the sandy delta deposits (Paulson, 1964). Selected aspects of water chemistry are summarized in Table 1. Specific conductance, pH, chloride, sulfate and bicarbonate content tend to increase downstream, whereas potassium shows no apparent trend for the river.

The bottom sediment generally becomes finer downstream, although it varies considerably in response to the local surficial geology as described above. Turbidity also generally increases downstream as the bottom sediment becomes finer (Cvancara, 1970: 83).

ME THODS

Most of the 31 live-mollusk stations (Fig. 1) were established by one of us (RDN) during the summer of 1966, when another of us (AMC) established 5 stations in the lower reaches

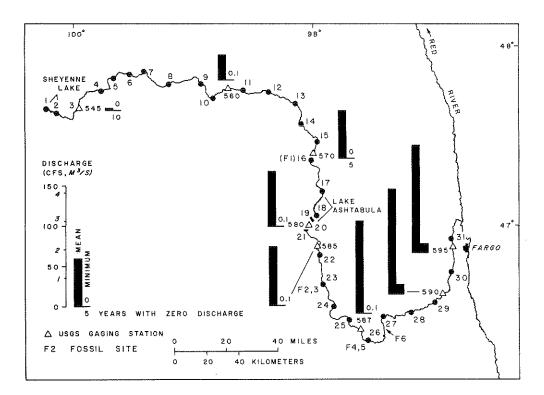


FIG. 1. Location map showing living mollusk stations (solid dots), fossil mollusk sites (F1-F6) and discharge values for 8 USGS gaging stations on the Sheyenne River. Discharge values are for the 10-year span from October 1, 1955 to September 30, 1965 except for gaging station 587; here, the period covered is October 1, 1957 to September 30, 1966. Discharge data were taken from U.S. Geological Survey (1961-1966, 1964). Cfs signifies cubic feet per second.

of the river. In 1968, one of us (AMC) established 2 stations on Sheyenne Lake and, in 1969, 2 stations on Lake Ashtabula. In 1973, 2 of us (AMC and JVA) reoccupied 6 river stations and established another on Lake Ashtabula. In 1974, one of us (AMC) reoccupied 2 additional stations in the lower reaches of the river. Mussels were collected by handpicking by feel with the hands and feet, aided in non-turbid water by a Turtox Fishscope, an aluminum alloy cylinder (0.61 m long by 0.15 m in diameter) fitted with a glass plate at one end. Other mollusks were usually collected by passing a food strainer (with wire screen) through the bottom sediment and aquatic vegetation. An Ekman dredge and a larger basket dredge were used for a few stations in Sheyenne Lake and Lake Ashtabula.

Fossil mollusks were collected from 6 sites (Fig. 1). About 1- to 2-liter samples were taken from each fossiliferous unit, dry sieved and picked for fossils.

RESULTS

Living mollusks

Thirty-one species were found inhabiting the Sheyenne River: 12 mussels, 6 pill clams and 13 snails (4 prosobranchs and 9 pulmonates) (Table 2). Most species occurred below about station 9. Sixteen species were found in Lake Ashtabula (Fig. 1): 4 mussels, 4 pill clams and 8 snails; 2 of the mussels, Amblema plicata and

Specific conductance and 5 chemical factors for 5 U.S. Geological Survey gaging stations on the Sheyenne River (gaging stations are shown on Fig. 1) 3 . TABLE 1.

 $^{
m b}$ Upper number is the maximum, middle number is the mean, and lower number is the minimum for the interval of time sampled

^aData from U.S. Geological Survey 1959-1965; 1970-1973. Locations of gaging stations are shown on Fig. 1.

Lasmigona complanata, were recovered during a separate SCUBA study (1974) of the lake's mussels to be reported on later and are not listed in Table 1 for the lake. Seven species of mollusks (all snails) were found in Sheyenne Lake. The greatest similarity occurs between assemblages in the river above and below Lake Ashtabula and between assemblages in Lake Ashtabula and in the river above the lake (Table

3). Least similarity occurs between assemblages in Sheyenne Lake and in the river below Lake Ashtabula.

Of the mussels, Anodonta grandis and Lampsilis radiata occurred most frequently and Proptera alata occurred least frequently. Only empty shells were found of Quadrula quadrula. Clarke (1973: 33), however, reported it from "1 mi E of Kindred N.D." (near USGS gaging station 590 below station 29; Fig. 1) and said later (letter dated 25 September 1974) that it was collected alive. A. grandis was found farthest upstream. Of the 2 species of Lasmigona, L. complanata occurred at more stations and in greater numbers. For Lampsilis, the same was true for L. radiata. Mussels occurred on all types of bottom but rarely among cobbles and boulders and in rippled sand.

Of the pill clams, Pisidium compressum and Sphaerium striatinum occurred most frequently and S. simile least frequently. P. compressum and S. lacustre occurred farthest upstream and S. transversum occurred farthest downstream. P. nitidum was found in greatest numbers in Lake Ashtabula. In the river, pill clams generally occurred adjacent to the banks where the bottom sediment was finer, usually in muddy very fine to fine sand.

The most frequently found snails were Physa gyrina and Cincinnatia cincinnatiensis (=Amnicola integra (Say)). P. integra was found farthest downstream. Gyraulus circumstriatus and Aplexa hypnorum were found only in Sheyenne Lake. Five snails, Valvata tricarinata, Cincinnatia cincinnatiensis, Amnicola limosa, Gyraulus parvus and Helisoma anceps, were found generally at greater densities in Lake Ashtabula than elsewhere. A. limosa was collected in the river at only one station. Of the 2 species of Helisoma, H. trivolvis was most frequently observed. In the river, the 4 prosobranch snails (Valvata tricarinata, Probythinella lacustris, Cincinnatia cincinnatiensis and Amnicola limosa) occurred in habitats similar to those of the pill clams. Other snails (pulmonates) were found generally crawling on various types of bottom sediment or attached to aquatic vegetation. The limpet Ferrissia rivularis was found commonly on mussel shells.

Campeloma decisum was represented only by empty shells at stations 28 and 29 (Fig. 1). Clarke (1973: 218) reported this species from "1 mi E of Kindred" (near USGS gaging station 590 below station 29) and said later (letter dated 25 September 1974) that it was represented by a single empty shell. He also reported (letter cited) empty shells from the Red River at Abercrombie, N. Dak. (Clarke, 1973: 218). In August, 1974, one of us (AMC) collected fossil shells of this species at station 28 from fine to medium sand in a cutbank of the Sheyenne River. It is uncertain whether this species is actually living in the river. Clarke's specimen and a few of ours appear relatively fresh and have a grayish-green periostracum. The nearest live occurrence of this species, of which we are aware, is the Otter Tail River a few kilometers upstream from Fergus Falls, Minnesota, 88.5 air km southeast of station 29. The bottom sediment at station 29 (and station 28) was mostly fine to medium, well-sorted, rippled sand in the main channel and very fine to fine muddy sand along the banks.

Six stations (3, 10, 16, 20, 22 and 29) in September, 1973 and 2 stations (28 and 31) in August, 1974 were recollected to determine if any gross changes in the molluscan fauna had occurred since 1966 when most of the collecting was done. Accounting for differences in season of collecting and different collectors for all stations but 2, no significant changes in the fauna between 1966 and 1973-74 are apparent. The molluscan fauna had apparently not degraded; in fact, additional species were collected at 5 of the 8 stations. The finding of 8 additional mussels at station 31 (Table 2) in 1974 is attributed to much lower river level (and more complete collecting) than was existent in 1966. Most notably, Ligumia recta and Proptera alata were found living in the river for the first time.

TABLE 2. Occurrence and relative abundance of live mollusk species and predominant bottom sediment at each sampled station on the Sheyenne River, Sheyenne Lake (stations 1 and 2), and Lake Ashtabula (stations 17-20).

					Station				
	Mollusk species	1 (A394) ^a	2 (A151 A350 A351)	(A143 A9		4 (A144)	5 (A152)	6 (A160)	7 (A153)
Unions	Unionacean bivalves (mussels) 1. Amblema nicata (Sav)								
2	Fusconaia flava (Rafinesque)								
3,	Quadrula quadrula (Rafinesque)			,					
4.	Anodonta grandis Say			0.7 ^b		********	e e	o)	Ø
5.	Anodontoides ferussacianus (Lea)			Φ 		a)			
9	Lasmigona complanata (Barnes)								
7	L. compressa (Lea)								
œ	Strophitus undulatus (Say)								
9.	Lampsilis ovata (Say)								
10.	L. radiata (Gmelin)			ø					ø)
Ę	Ligumia recta (Lamarck)	,			···				
12.	Proptera alata (Say)								
Sphaer	Sphaeriid bivalves (pill clams)								
13.	Sphaerium lacustre (MUller)			P					
14.	S. simile (Say)								
15.	S. striatinum (Lamarck)				a)				
16.	S. transversum (Say)		٠.						
13	Pisidium compressum Prime			4	 ¥	****			
8	P. nitidum Jenyns		av						
Gastro	Gastropods (snails)							Accessor Anna	
19.				٠.				*******	
20.	Valvata tricarinata (Say)			 U	 n			Abban fir a	
21.	Cincinnatia cincinnatiensis			D					
	(Anthony)								
22.	Probythinella lacustris (Baker)								
23.	Amnicola limosa (Say)								
24.	Fossaria obrussa (Say)						- 10-112	_	
25.	Stagnicola caperata (Say)	D							
26.	S. elodes (Say)	=	9 U						
27.	Ferrissia rivularis (Say)					\. .			
28.	Gyraulus circumstriatus (Tryon)	×							
29.	G. parvus (Say)	Ą	n			Þ			
30.	Planorbula armigera (Say)					,-			
31.	Promenetus exacuous (Say)			·	-		******		
32.	Helisoma anceps (Menke)					*****	***************************************		
33.	H. trivolvis (Say)	×		n	 دن	×			
34.	Aplexa hypnorum (Linnaeus)	υ				*********			
35.	Physa gyrina Say	n	n C	7	Ą	₹		o)	
36,	P. integra Haldeman								
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14 (A162)	£.	42.6	9.9		20.0			O		,	,,						o ho thua'r noo				SG	
13 (A150)	0.6	7.4	1.7	. O 0	25.2	.,		₹			Sec		No account of					ņ		b 	SG	
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10 (A161 A981)		43.0	5.0		24.0		M D	Φ	ບ		ψC	د	a)		Ç			a		Ü	MS	
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9 (A148)	æ	0.4	0		20.0			₩	æ						n			æ		o	SD	
8 (A159)	Unionacean bivalves 1.	131	o.		0.8	bivalves		U	17. 17.	. 2		۷.									SS	
	Unionacea 1. 2.	n 4 :	,	. %		Sphaeriid	13.	15.	16. 17.	Gastropods	19. 20.	21.	23.	24. 25.	26. 27.	28. 29.	30. 31.	32.	34.	35.	Predom- inant	bottom sediment

TABLE 2. (Cont.)

Unformacean bivealves: 1.3		19 (A393)	. 20 (A983)	21 (A165)	(A147	22 (A147 A984)	23 (A145)	24 (A164 A985)	24 4 A985)	25 (A146)	26 (A107)	27 (A109)	28 (A168 A1061)
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TABLE 3. Jaccard's similarity coefficients^a comparing numbers of molluscan species by group and general location.

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Below Lake Ashtabula	P 0	0 0 4 7	M P S A	73 50 62 63	M P S A	36 17 54 39		
Fossils	P 0 S 2	0 0 5 2	M P S A	64 33 67 59	M P S A	40 20 45 38	M P S A	75 67 54 65

aCheetham & Hazel (1969).

Fossil mollusks

Fossil mollusks were discovered at 6 sites at the middle and lower-middle reaches of the river (Fig. 1). At sites F1-F5, fossils were collected from cutbank exposures 0.6-3.0 m above river level. At F6, fossils were taken from a road-cut exposure about 11 m above river level. Most of the fossils occurred in sandy mud and muddy sand.

Twenty species of aquatic mollusks were found as fossils at the 6 sites: 10 mussels, 2 pill clams and 8 snails (Table 4). In addition, the snail Campeloma decisum was found (1974) as a fossil at station 28. Shells of the snail Cincinnatia cincinnatiensis and pill clam Sphaerium striatinum were most numerous as fossils. Shells of mussels were generally sparse. Land snails occurred in about one-half of the samples.

DISCUSSION

Living mollusks and ecologic factors

Perhaps the primary ecologic factor influencing the occurrence of mollusks in the Sheyenne River is river discharge. Low discharge or high frequency of zero discharge appears to correlate with low diversity of mussel species in the upper reaches of the river (Fig. 1, Table 2); high discharge appears to correlate with

bM=mussels; P=pill clams; S=snails; A=all mollusks; zero values reflect that no mussels or pill clams were found in Sheyenne Lake.

TABLE 4. Occurrence and relative abundance of fossil mollusks at 6 sites on the Sneyenile River (Fig. 1 shows location of fossil sites and Table 2 explains symbols).	symbo	fossil ls).	mollusks at 6	it 6 sites	on th	e Sheyenn	he Sheyenne River (Fig	g. 1 shows	locatic	n ot
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Helisoma anceps (Menke) H. trivolvis (Say)		24				1	R	. EX EX		
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a Accession number of University of North Dakota, Department of Geology. Units with lower unit numbers are relatively older.

high mussel diversity downstream. Low or zero discharge may be detrimental because of lowered dissolved oxygen, higher concentrations of dissolved salts, and increased predation accompanying the lowering of river level (Cvancara, 1970: 87). The relationship of discharge to the other mollusks seems to be more complex. Certain pill clams and snails occurred more frequently in stagnant (non-flowing)

water and others in flowing water. In this connection, the possible impact of Lake Ashtabula on the Sheyenne River molluscan fauna is instructive. Under Results, we stated that 1 pill clam and 5 snails generally occurred in greater numbers in the lake than elsewhere. Mussel diversity was also low in the lake (unpubl. results of 1974 study with SCUBA); Anodonta grandis, generally in greatest numbers in stagnant or slow-moving parts of the river, was the dominant mussel in the lake. Sheyenne Lake was characterized by certain stagnant-water species, 2 of which differed from those in Lake Ashtabula. On the other hand, species such as the pill clam Sphaerium striatinum and the snail Ferrissia rivularis seem to prefer flowing water and neither was found in Lake Ashtabula nor Sheyenne Lake.

An unstable bottom, such as one of rippled sand, seems to be a primary factor in restricting mollusks of all types. This condition was generally found where the river crosses the Sheyenne delta, and mollusks were generally sparse at stations 26-29 (Fig. 1, Table 2).

Perhaps high turbidity is a limiting factor in the lower reaches, for pill clam and snail diversity tended to decrease (Table 2) as turbidity increased markedly (Cvancara, 1970: fig. 9).

Imlay (1973) demonstrated that dissolved potassium at low levels is toxic to mussels and presented a predictive hypothesis: rivers with 4 mg/l K would contain mussels, those with 7 mg/l K (or greater) would have no mussels, and those with 4-7 mg/l K would be marginal for mussels. (Three of the 4 species he experimented with, Amblema plicata, Fusconaia flava and Lampsilis radiata, also inhabit the Sheyenne River.) At 5 gaging stations the mean potassium concentration was 6.7-11 mg/l with a maximum of 15 (Table 1) at 2 stations. Below gaging station 587 (Fig. 1), with a mean potassium concentration of 11 mg/l, mussel density appeared to be less than in the river directly above; mussel diversity, however, remained high at 10 species. Imlay (1973: 108) admitted that the (lower) Sheyenne River "slightly erodes the predictive hypothesis."

One of us has suggested (Cvancara, 1970: 87) that high chloride content may restrict the occurrence of mussels in 3 Red River tributaries of eastern North Dakota, and other mollusks may also be so affected (Cvancara, Erickson & Delimata, 1972). Imlay (1973: 108) pointed out that in the lower reaches of one of these tributaries (Park River) where the chloride content was high and mussels were absent, the potassium content was also high. He also cited some evidence (p 109) that the chloride ion is less toxic than the potassium ion. High chloride values (up to 86 mg/l) do not necessarily correspond to high potassium values in the Sheyenne River (Table 1). Further work in natural habitats is necessary to evaluate the relative effects of potassium and chlorides on mollusk occurrences.

Availability of suitable fish host may affect the occurrence of mussels in the Sheyenne River. The fish fauna is more diversified below the dam that forms Lake Ashtabula than above it, and fishes of the lower Sheyenne have been prevented from migrating into the upper reaches by the dam (Tubb, Copes & Johnston, 1966: 125). (Fish populations above the dam have resulted from planned or indiscriminate stocking.) Likewise, the mussel fauna is more diversified below the dam than above it. Two mussels, Lampsilis ovata and Ligumia recta, were found alive only below Lake Ashtabula; their distribution may be related to restricted occurrence of fish hosts. The known natural fish hosts of L. ovata are white crappie (Pomoxis annularis) and sauger (Stizostedion canadense), and those of L. recta are white crappie and bluegill (Lepomis macrochirus) (Coker et al., 1921: 153). These 3 fishes have been reported only from Lake Ashtabula or below it and not above it (Tubb, Copes % Johnston, 1966). The bluegill has been introduced into the lake (Farmer, 1974: 6).

Comparison of fossil and living faunas

The fossil molluscan fauna generally resembled the living fauna but lacked 13 species. Two mussels, 4 pill clams and 7 snails were not found as fossils. No fossil species were different from those living now, with the possible exception of the snail Campeloma decisum whose existence in the Sheyenne is uncertain. The predominance of mostly smaller fossil mollusks is possibly partly the result of destruction of thinner-shelled forms and selective sorting of smaller forms during transportation. Two apparent anomalies are the presumed lack of Valvata tricarinata and the presumed more frequent occurrence of Probythinella lacustris in the fossil material.

The total fossil fauna is most similar to those assemblages below Lake Ashtabula except for the snails (Table 3). This might be expected as most of the fossil sites are below the lake. Least similarity occurs between the fossil fauna and that found living in Sheyenne Lake.

Age of fossil mollusks

Limited age information is available for the fossil mollusks. At site F6 (Fig. 1, Table 4), shells of the mussel $Lampsilis\ vadiata$ from a fluvial terrace about 11 m above the river have been dated at $13,500\pm220$ years before present (I-2289; Moran et al., 1973: fig. 2 and p 42). Between stations 27 and 28 (Fig. 1), "clam shells" from fluvial sediment of the "ancestral" Sheyenne have been dated at $12,000\pm250$ years before present (I-2537; Moran et al., 1973: 11). Just below station 28, or about 56 river kilometers below site F6, $Lampsilis\ vadiata$, at least 2 pill clams and 4 aquatic snails were recovered from silty clay just above river level (Tuthill, 1964). These mollusks were directly associated with wood dated at $2,540\pm300$ years before present and were considered to have been deposited by the "modern" Sheyenne River (W-1185; Moran et al., 1973: 28). Therefore, mollusks inhabited the "ancestral" Sheyenne River that flowed into glacial Lake Agassiz at least as early as about 13,500 years ago and the "modern" Sheyenne at least as early as about 2,500 years ago. Fossil mollusks from sites F1-F5 probably date within this time interval (2,500-13,500 years) or are younger.

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