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SURVEY OF THE FRESHWATER MUSSELS (MOLLUSCA: UNIONIDAE) OF THE WABASH RIVER DRAINAGE PHASE I: LOWER WABASH AND TIPPECANOE RIVERS

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INTRODUCTION

The Wabash River drainage in Indiana and Illinois historically has supported a diverse and abundant mussel fauna. Around the turn of the century, approximately 75 species of unionids were known to inhabit the Wabash River drainage (Call, 1900; Blatchley & Daniels, 1903; Daniels, 1903, 1914). During the early 1940's, Goodrich and van der Schalie (1944) reported 64 species of mussels from the Wabash River and its tributaries. Commercial shelling in the early 1960's for the cultured pearl industry seriously depleted mussel populations and, in many instances, populations of commercially valuable species were extirpated (Krumholz, et al., 1970). By the mid-1960's, a serious decline in the mussel fauna of the Wabash River was apparent, and in 1967 the Indiana Department of Natural Resources issued Discretionary Order No. 136 which restricted mussel harvest methods to handpicking, short forks, tongs, or brails.

Coincidentally with the discretionary order, the Indiana Department of Natural Resources sponsored a survey of the Wabash, White, and East Fork of the White rivers during 1966 and 1967 (Meyer, 1968; Krumholz, et al., 1970; Meyer, 1974). The results of this survey were not encouraging. Thirty-four (47%) of the species reported by Goodrich and van der Schalie in the 1940's were not collected during 1966-67. Many of these species were already rare by 1944, but others which were considered common or abundant during the 40's were collected only rarely in the 1966-67 survey (Meyer, 1968; Krumholz, et al., 1970; Meyer, 1974). In addition, when sites sampled in 1966 were resampled the following year, significantly fewer mussels were collected, coinciding with a drop in the commercial harvest. Krumholz, et al. (1970) concluded from this that intensive harvesting of mussels was capable of seriously depleting populations. Also mentioned as factors responsible for the decline of the mussel fauna in the Wabash River drainage were pollution (industrial, domestic, and agricultural) and competition with the introduced Asiatic clam, *Corbicula fluminea* (Muller, 1774).

Ten years after the 1966-67 survey of Meyer (1974), Clark (1976) resurveyed the lower Wabash River from Mt. Carmel to the Ohio River for mussels. Two species collected by Meyer were not found in 1975; however, seven species not collected in 1966-67 were found in 1975 (Clark,1976) (Table 1). Even though Clark (1976) collected five more species in 1975 than in the 1966-67 survey, he expressed doubt as to whether the mussel population of the lower Wabash River was sufficiently large to support commercial shelling. Among the reasons given for the decline in the mussel fauna of the lower Wabash in 1975 was the absence of suitable habitat. Substrate samples taken in 1975 indicated that very little of the bottom was composed of gravel

Table 1. **Species collected live in the lower Wabash River, 1966-1987.**

Species	1966-67	1975	1987
Actinonaias ligamentina (Lamarck, 1819)	C	-	-
Amblema plicata (Say, 1817)	C	C	R
Anodonta grandis Say, 1829	R	-	R
Arcidens confragosus (Say, 1829)	-	-	R
Elliptio crassidens (Lamarck, 1819)	-	C	-
Fusconaia ebena (I. Lea, 1831)	R	R	R
Fusconaia flava (Rafinesque, 1820)	R	R	R
Lampsilis cardium (Rafinesque, 1820)	C	U	-
Lampsilis ovata (Say, 1817)	-	U	-
Lampsilis teres (Rafinesque, 1820)	C	R	-
Lasmigona complanata (Barnes, 1823)	C	R	R
Leptodea fragilis (Rafinesque, 1820)	C	C	A
Megalonaias nervosa (Rafinesque, 1820)	-	R	R
Obliquaria reflexa Rafinesque, 1820	R	A	A
Obovaria olivaria (Rafinesque, 1820)	C	RC	C
Pleurobema cordatum (Rafinesque, 1820)	R	R	-
Potamilus alatus (Say, 1817)	C	R	R
Potamilus capax (Green, 1832)	-	R	C
Potamilus ohiensis (Rafinesque, 1820)	R	C	C
Quadrula metanevra (Rafinesque, 1820)	R	RC	-
Quadrula nodulata (Rafinesque, 1820)	-	RC	C
Quadrula pustulosa (I. Lea, 1831)	A	A	A
Quadrula quadrula (Rafinesque, 1820)	A	A	A
Tritogonia verrucosa (Rafinesque, 1820)	-	U	R
Truncilla donaciformis (I. Lea, 1828)	-	R	R
Truncilla truncata Rafinesque, 1820	R	R	C

A = Abundant
C = Common
RC = Rather Common
U = Uncommon
R = Rare

1966-67 = Meyer, 1974
1975 = Clark, 1976
1987 = This study

and Clark (1976) cited dredging operations in this section of the river as the chief cause of habitat loss.

The decline in the North American fauna in the last 15 years has prompted the federal goverment to provide protection for several species of mussels under the Endangered Species Act of 1973 (P.L. 93-205). Although federal listing as endangered is intended to protect species from further decline and to provide for recovery if possible, specific information concerning distribution is often lacking. Such information is vital for the protection of existing populations, particularly in areas where there is political or economic pressure for further alteration of habitats.

The historical occurrence of rare and endangered mussels in the Wabash River and its tributaries, together with the present decline of the unionid fauna in North America, underscored the need to determine the status of mussels in the Wabash River drainage. Previous surveys have documented the occurrence of seven federally endangered and at least seven federal candidate species in the Wabash drainage (Call ,1900; Blatchley & Daniels 1903; Daniels, 1903, 1914; Goodrich & van der Schalie, 1944; Meyer, 1974; Clark, 1976). Historical records for these species are concentrated in the lower section of the river from the confluence of the White River at Mt. Carmel, Illinois, to the Ohio River. Areas with numerous records include New Harmony and Grand Chains, Posey Co., Indiana. Recent observations on mussels in the lower Wabash have yielded specimens of federally endangered and candidate species (Clark,1976). In 1984, INHS biologists discovered two live individuals of the fat pocketbook, *Potamilus capax* (Green, 1832) and one live fanshell, *Cyprogenia stegaria* (Rafinesque, 1820). In addition, relic shells of the spectacle case, *Cumberlandia monodonta* (Say, 1829), the ring pink, *Obovaria retusa* (Lamarck, 1819), and the clubshell, *Pleurobema clava* (Lamarck, 1819) were collected at Mt. Carmel in 1985. Indiana endangered species which were recently collected from the Wabash River include the rabbitsfoot, *Quadrula cylindrica* (Say, 1817) (relic shells), the pink papershell, *Potamilus ohiensis* (I. Lea, 1830) (live specimens), and the wartyback, *Quadrula nodulata* (Rafinesque, 1820) (live specimens) (INHS unpub. data, 1984, 1985). Also found were valves of several species not recorded in the Wabash River during the surveys of Meyer (1974) or Clark (1976).

No detailed surveys have been published on any of the headwater streams of the Wabash River drainage. However, available data from the literature (Call, 1900; Daniels, 1903; Goodrich & van der Schalie, 1944) and museum records indicated that certain species which are listed as federally endangered or are candidates for listing occurred in these tributaries. As indicated by the presence of several species of fishes considered rare in Indiana, such as *Etheostoma camurum*, *E. maculatum*, *E. tippecanoe*, *Percina evides*, and *Ammocrypta pellucida* (Keevin, et al. 1985),

the Tippecanoe River in particular seemed likely to support rare or endangered mussels. While conducting a fish survey of the Tippecanoe River in 1984, INHS biologists also collected mussel shells at many of the sites. These collections contained valves of a federal candidate species, *Pleurobema clava*, and an Indiana endangered species, *Quadrula cylindrica* .

As part of of a study of the freshwater mussels of the Wabash River drainage in Indiana, a survey of the lower Wabash and Tippecanoe rivers was initiated (Phase I). The objectives of the study were as follows.

Collect data on the distribution and status of:

1. Federally endangered species.
2. Those proposed for federal listing as endangered species.
3. State endangered species.
4. Other mussel species inhabiting the Wabash and Tippecanoe Rivers.

METHODS

Phase I. Lower Wabash (Mt. Carmel, Illinois, to the Ohio River) and Tippecanoe rivers.

Freshwater mussels were collected from 27 sites on the lower Wabash River during the spring and summer of 1987 (Table 2 & Figure 1). As stated in the original proposal, sampling sites were to be located approximately 16 km (10 mi) apart. As the project proceeded, it was obvious that the sampling of sites placed at ten-mile intervals would not give an accurate determination of the mussel fauna present in the river. As mussels are usually located in concentrated populations, an attempt was made to locate sampling sites at known "beds". The locations of these beds were determined by talking to commercial musselers and other locals that used to "dig shell" in the past. This change increased the number of sites from 12 to 27. Brail sampling consisted of three runs at a site, each approximately 0.4 km (0.25 mi) in length, on the left bank, center of the river, and right bank. In addition to brail sampling, historical localities of endangered species were visited and collected by wading and looking for shells along shore.

In the Tippecanoe River, 16 sites were sampled for mussels in the summer of 1987 (Table 3 & Figure 2). Sites were located approximately five miles apart and were chosen because of accessibility and/or historical data were available for a given location. An effort was made to sample all available habitats, but particular emphasis was placed on areas of presumed preference

Table 2. Collection sites in the lower Wabash River, 1987. B = brail sample, H = hand collected

SITE #	LOCATION	METHOD
1.	Mt. Carmel, Wabash County, Illinois. T1S, R12W, sec. 21.	B, H
2.	Northwest end of Patoka Island, 0.5 miles south of Mt. Carmel, Wabash Co., Illinois. T1S, R12W, sec. 28.	B, H
3.	Rochester, Wabash County, Illinois. T2S, R13W, sec. 14.	B, H
4.	1.5 miles south of Rochester, Wabash County, Illinois. T2S, R13W, sec. 23.	B, H
5.	0.5 mile south of Crawleyville, Gibson County, Indiana. T3S, R13W, sec. 10.	B, H
6.	Jimtown, 1 mile SW Crawleyville, Gibson County, Indiana. T3S, R13W, sec. 10.	B, H
7.	10 miles northwest of Grayville, upstream of Schuh Bend, Wabash County, Illinois. T3S, R13W, sec. 18.	B
8.	8 miles WNW Grayville, just downstream Schuh Bend, Gibson County, Indiana. T3S, R13W, sec. 7.	B, H
9.	South of Grayville, just below mouth of French Creek, White County, Illinois. T4S, R14W, sec. 4.	B
10.	0.7 miles north New Harmony, just north of Bull Island, White County, Illinois. T4S, R14W, sec. 24.	B
11.	0.5 miles north of New Harmony, just south of Bull Island, White County, Illinois. T4S, R14W, sec. 25.	H
12.	Old Dam, 1 mile south of New Harmony, Posey County, Indiana. T5S, R14W, sec. 11.	B, H
13.	Upstream end of Mink Island, Posey County, Indiana. T5S, R14W, sec. 23.	B, H
14.	Downstream end of Mink Island at the pipeline crossing, White County, Illinois. T5S, R14W, sec. 27.	B
15.	Upstream end of Twin Sister Island, Posey County, Indiana. T5S, R14W, sec. 33.	B
16.	Maunie, White County, Illinois. T5S, R10E, sec. 36.	B
17.	Grand Chains Rapids, Posey County, Indiana. T6S, R14W, sec. 8.	B, H
18.	Mouth of Big Creek, Posey County, Indiana. T6S, R14W, sec. 20.	B
19.	Little Chains, White County, Illinois. T6S, R11E, sec. 31.	B
20.	North of Greathouse Island, 5 miles east of New Haven, Posey County, Indiana. T7S, R14W, sec. 7.	B
21.	South of Greathouse Island, 5.5 miles east of New Haven, Posey County, Indiana. T7S, R14W, sec. 20.	B, H
22.	1.5 miles east of New Haven, Posey County, Indiana. T7S, R15W, sec. 22.	B
23.	Below the mouth of the Little Wabash River, Gallatin County, Illinois. T7S, R10E, sec. 27.	B
24.	3.5 miles southwest of New Haven, Posey County, Indiana. T8S, R10E, sec. 2.	B
25.	8 miles southwest of New Haven, Posey County, Indiana. T8S, R14W, sec. 18.	B
26.	Mackeys Island, Posey County, Indiana. T8S, R10E, sec. 13.	B
27.	At the confluence with the Ohio River, Gallatin County, Illinois. T8S, R14W, sec. 19.	B

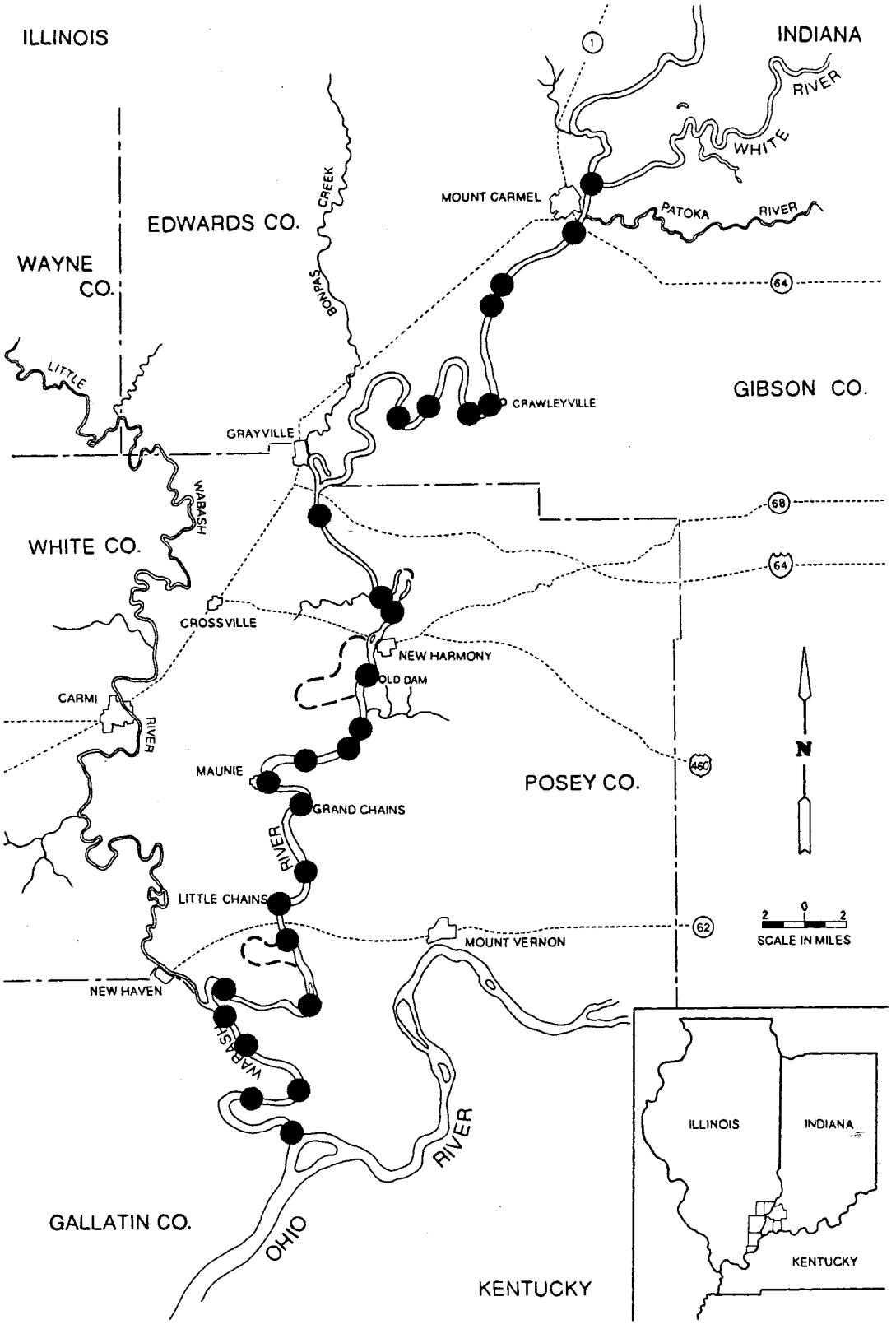


Figure 1. Collection sites on the lower Wabash River, 1987.

Table 3. Collection sites in the Tippecanoe River, 1987. Each site hand sampled for 4 man-hours.

SITE #	LOCATION
1.	Tippecanoe River, 0.5 mile SW North Webster at county road 750E bridge, Kosciusko County, Indiana. T33N, R7E, sec. 15.
2.	Tippecanoe River, 1 mile SW Oswego, Kosciusko County, Indiana. T33N, R6E, sec. 14.
3.	Tippecanoe River, 1 mile NW Warsaw at county road 300N, Kosciusko County, Indiana. T33N, R6E, sec. 30.
4.	Tippecanoe River, 2 miles S Etna Green at Ind. Route 19, Kosciusko County, Indiana. T32N, R4E, sec. 10.
5.	Tippecanoe River, at Talma, Fulton County, Indiana. T31N, R3E, sec. 12.
6.	Tippecanoe River, 3 miles N Rochester, at Route 31 bridge, Fulton County, Indiana. T31N, R3E, sec. 29.
7.	Tippecanoe River, 2 miles N Pershing, Fulton County, Indiana. T31N, R2E, sec. 21.
8.	Tippecanoe River, at Delong, Fulton County, Indiana. T31N, R1E, sec. 9.
9.	Tippecanoe River, at Tippecanoe River State Park, Pulaski County, Indiana. T31N, R1W, sec. 19.
10.	Tippecanoe River, 1.5 miles NE Pulaski, Pulaski County, Indiana. T29N, R2W, sec. 3.
11.	Tippecanoe River, 4 miles E Lakeside, Pulaski County, Indiana. T29N, R3W, sec. 30.
12.	Tippecanoe River, at Norway below Lake Shafer spillway, White County, Indiana. T27N, R3W, sec. 21.
13.	Tippecanoe River, at Lake Freeman spillway (Oakdale Dam), Carroll County, Indiana. T26N, R3W, sec. 34
14.	Tippecanoe River, at Springboro, at Ind. Route 18 bridge, 5 miles W Delphi, Carroll County, Indiana. T25N, R3W, sec. 21.
15.	Tippecanoe River, 5 miles SW Delphi, Carroll County, Indiana. T25N, R3W, sec. 33.
16.	Tippecanoe River, 1 mile N Americus, Tippecanoe County, Indiana. T24N, R3W, sec. 9.

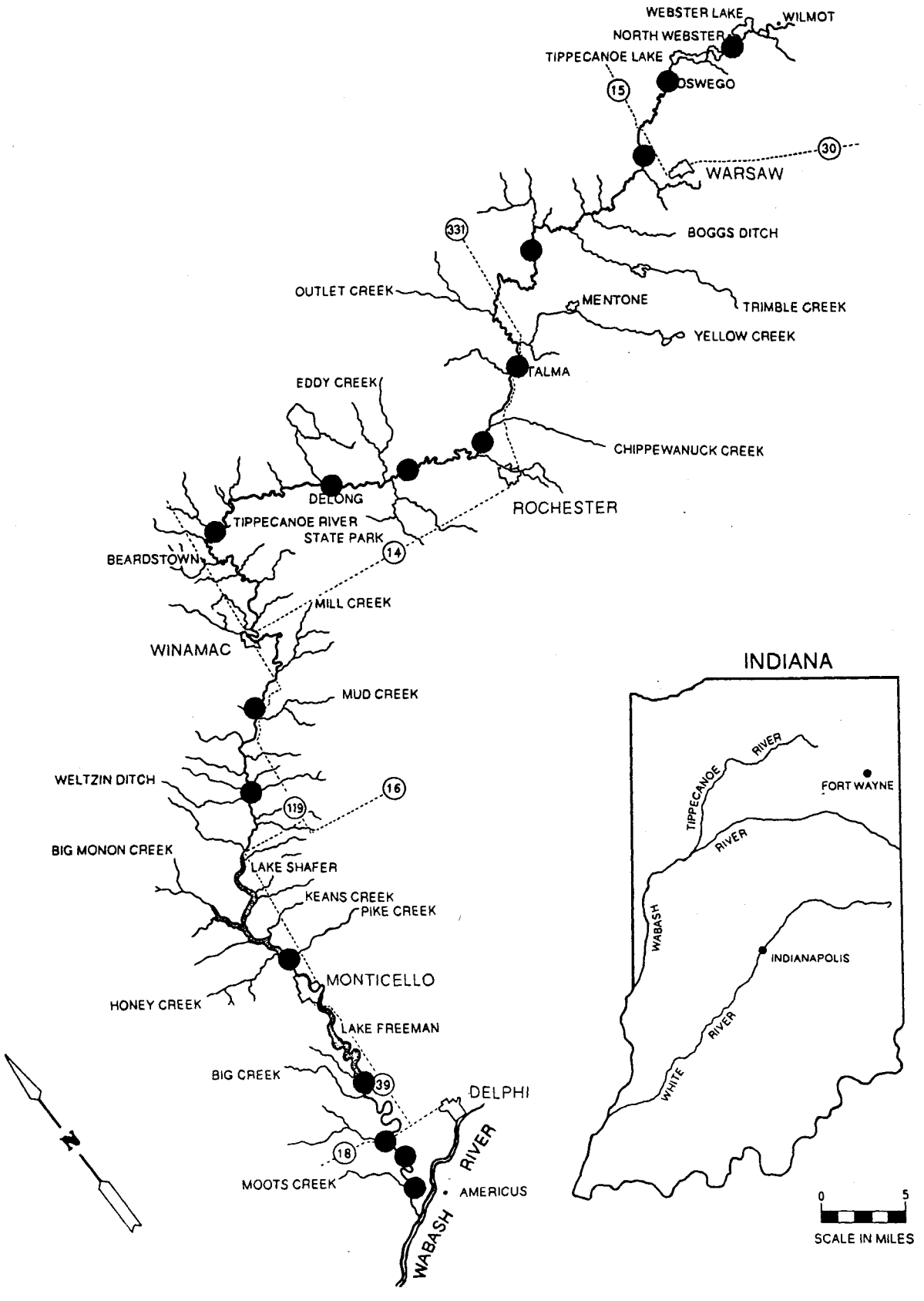


Figure 2. Collection sites on the Tippecanoe River, 1987.

(i.e., gravel bars, riffles, etc.). Living mussels and valves of dead specimens were collected by hand at each station. So that future comparisons could be made, an attempt to quantify the collection method was done by spending a total of four man-hours at each site. Vouchers of all species collected were catalogued into the Mollusc Collection of the Illinois Natural History Survey (INHS), Champaign, Illinois.

RESULTS AND DISCUSSION

A total of 43 species were collected from 27 sites in the lower Wabash River, from the mouth of the White River at Mt. Carmel to the confluence with the Ohio River (Table 4). Of those 43 species, 19 were collected live and totaled 143 individuals. The number of individuals per site ranged from 0 to 36 and the number of live species ranged from 0 to 9. The five most common species in order of abundance were *Obliquaria reflexa* Rafinesque, 1820 (16.8%), *Leptodea fragilis* (Rafinesque, 1820) (15.4%), *Quadrula quadrula* (Rafinesque, 1820) (13.3%), *Quadrula pustulosa* (I. Lea, 1831) (10.5%), and *Obovaria olivaria* (Rafinesque, 1820) (8.4%), and together they comprised 64.4% of the fauna. The remaining 14 species were represented by fewer than ten individuals each (Table 5). In terms of species present and abundances, these results are similar to those of the surveys of 1966-67 and 1975. Species considered common in 1966-67 but missing or rare from our collections included *Actinonaias ligamentina*, *Amblema plicata*, *Lampsilis cardium*, *Lampsilis teres*, *Lasmigona complanata*, and *Potamilus alatus*. Five of these species were considered uncommon or rare by 1975 (Table1).

Three state endangered species, *Potamilus capax*, *Potamilus ohiensis*, and *Quadrula nodulata*, were found live during the survey. The first species, *P. capax*, is also federally endangered and was thought extirpated from the drainage (Dennis, 1985). The low numbers of individuals collected in this survey indicate that the current mussel fauna of the lower Wabash is much reduced when compared to historical data for the area. Although effectively closed to harvest due to the low economic return on investment of time spent, this stretch of the river should be closed by mandate. The presence of the federally endangered *P. capax* in this portion of the drainage and the high likelihood of collecting it on a brail are reasons given to support this closing.

In the Tippecanoe River in 1987, 1499 live mussels representing 34 species were collected from 16 sites in 64 man-hours. An additional seven species were represented by dead shells only. The number of individuals at a site ranged from 35 to 210 and the number of live species from 10 to 17 (Figures 3 & 4; Table 6). Many of the species are reported from the drainage for the first

Table 4. Site by site listing of all mussel species collected in the lower Wabash River, 1987 (x = shells only).

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	TOTAL
Amblema plicata (Say, 1817)	x	x	x	x	x	x					x	x	1				x		2								1	4
Anodonta grandis Say, 1829	x		x														1											1
Anodonta imbecillis Say, 1829						x																						x
Arcidens confragosus (Say, 1829)													1															1
Cumberlandia monodonta (Say, 1829)	x										x																	x
Cyclonaias tuberculata (Rafinesque, 1820)	x				x						x																	x
Cyprogenia stegaria (Rafinesque, 1820)		x		x	x			x			x										x							x
Ellipsaria lineolata (Rafinesque, 1820)																	x											x
Elliptio crassidens (Lamarck, 1819)			x	x	x			x			x	x	x						x									x
Elliptio dilatata (Rafinesque, 1820)			x	x				x			x								x									x
Epioblasma flexuosa (Rafinesque, 1820)		x						x			x																	x
Epioblasma propinqua (I. Lea, 1857)								x			x																	x
Epioblasma torulosa (Rafinesque, 1820)		x		x	x			x		N	x				N					N	x	N			N	N		x
Epioblasma triquetra (Rafinesque, 1820)										O	x				O					O		O			O	O		x
Fusconaia ebena (I. Lea, 1831)	x		x	x				x			x		4	1			x		1									6
Fusconaia flava (Rafinesque, 1820)	1	x	x							M					M					M		M			M	M	x	1
Lampsilis cardium (Rafinesque, 1820)		x	x	x	x	x		x		U	x		x		U					U	x	U			U	U		x
Lampsilis ovata (Say, 1817)		x			x					S	x				S					S		S			S	S		x
Lampsilis teres (Rafinesque, 1820)	x	x	x	x	x					S	x				S					S		S			S	S		x
Lasmigona complanata (Barnes, 1823)			1	1						E					E				1	E		E			E	E		3
Lasmigona costata (Rafinesque, 1820)		x	x							L					L					L		L			L	L		x
Leptodea fragilis (Rafinesque, 1820)	2		x	10	x	x		x		S	x	4	2	1	S		x	1	2	S	x	S			S	S		22
Ligumia recta (Lamarck, 1819)				x																								x
Megalonaias nervosa (Rafinesque, 1820)			x		x																						1	1
Obliquaria reflexa Rafinesque, 1820	x		7	x	1	x		x	1		x	1	12	1					x								1	24
Obovaria olivaria (Rafinesque, 1820)	x	x	x	x	5		2	x	1				3														1	12
Obovaria retusa (Lamarck, 1819)	x	x			x			x			x																	x
Obovaria subrotunda (Rafinesque, 1820)											x																	x
Plethobasus cyphyus (Rafinesque, 1820)		x									x																	x
Pleurobema clava (Lamarck, 1819)		x	x		x			x			x								x									x
Pleurobema cordatum (Rafinesque, 1820)	x	x			x			x			x	x					x		x									x
Pleurobema rubrum (Rafinesque, 1820)				x	x																							x
Potamilus alatus (Say, 1817)	1		1	x				x					x						x									2
Potamilus capax (Green, 1832)	x	x		x		x		x			x		x				x	1			1		1	5			1	9
Potamilus ohiensis (Rafinesque, 1820)		x	x		x	x		x			x	x	x			1	x		1		1		2	1				6
Quadrula cylindrica (Say, 1817)	x		x					x			x																	x
Quadrula metanevra (Rafinesque, 1820)	x	x	x	x	x			x			x										x							x
Quadrula nodulata (Rafinesque, 1820)	x	x	1	x	1	x					x								1								2	5
Quadrula pustulosa (I. Lea, 1831)	x	x	x	x	1	x					x		10				1		3									15
Quadrula quadrula (Rafinesque, 1820)	2	x	4	x	x	1					x	2	2				1		6								1	19
Tritogonia verrucosa (Rafinesque, 1820)	x		x	x	x		1	x			x	1	x				1		x								1	4
Truncilla donaciformis (I. Lea, 1828)	x		1	x	x							x																1
Truncilla truncata Rafinesque, 1820	2		3	x	x			x			x	x	1	1														7
SPECIMENS/SITE (LIVE)	8	0	18	11	8	1	3	0	2	0	0	8	36	4	0	1	4	2	17	0	2	0	3	6	0	0	9	143
SPECIES/SITE (LIVE)	5	0	7	2	4	1	2	0	2	0	0	4	9	4	0	1	4	2	8	0	2	0	2	2	0	0	8	19
SPECIES/SITE (DEAD)	17	20	18	21	20	9	0	21	0	0	30	6	6	0	0	0	7	0	7	0	5	0	0	0	0	0	1	24
SPECIES/SITE (TOTAL)	22	20	25	23	24	10	2	21	2	0	30	10	15	4	0	1	11	2	15	0	7	0	2	2	0	0	9	43

Table 5. Numbers, relative abundance and percent composition of living mussels collected in the Wabash River, 1987.

SPECIES	NO.	RANK	%	CUMMULATIVE %
Obliquaria reflexa Rafinesque, 1820	24	1	16.8	16.8
Leptodea fragilis (Rafinesque, 1820)	22	2	15.4	32.2
Quadrula quadrula (Rafinesque, 1820)	19	3	13.3	45.5
Quadrula pustulosa (I. Lea, 1831)	15	4	10.5	56.0
Obovaria olivaria (Rafinesque, 1820)	12	5	8.4	64.4
Potamilus capax (Green, 1832)	9	6	6.3	70.7
Truncilla truncata Rafinesque, 1820	7	7	4.9	75.6
Fusconaia ebena (I. Lea, 1831)	6	8	4.2	79.8
Potamilus ohiensis (Rafinesque, 1820)	6	8	4.2	84.0
Quadrula nodulata (Rafinesque, 1820)	5	10	3.5	87.5
Amblema plicata (Say, 1817)	4	11	2.8	90.3
Tritogonia verrucosa (Rafinesque, 1820)	4	11	2.8	93.1
Lasmigona complanata (Barnes, 1823)	3	13	2.1	95.2
Potamilus alatus (Say, 1817)	2	14	1.4	96.6
Anodonta grandis Say, 1829	1	15	0.7	97.3
Arcidens confragosus (Say, 1829)	1	15	0.7	98.0
Fusconaia flava (Rafinesque, 1820)	1	15	0.7	98.7
Megalonaias nervosa (Rafinesque, 1820)	1	15	0.7	99.4
Truncilla donaciformis (I. Lea, 1828)	1	15	0.7	100.0
TOTALS	139		100	

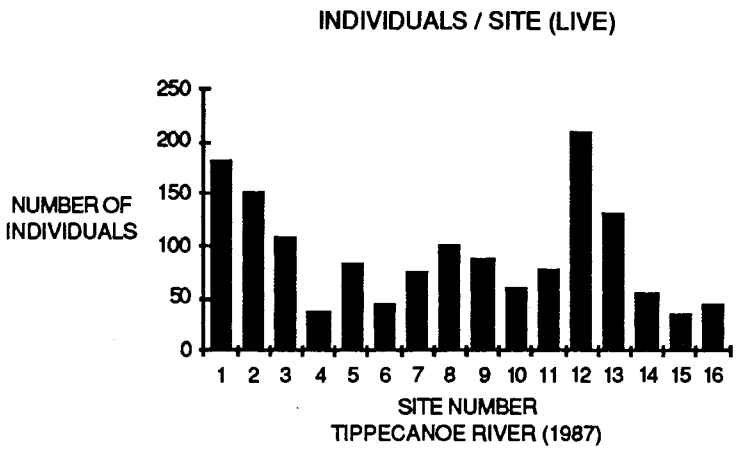


Figure 3. Number of live individuals collected per site on the Tippecanoe River, 1987 (4 man-hours/site).

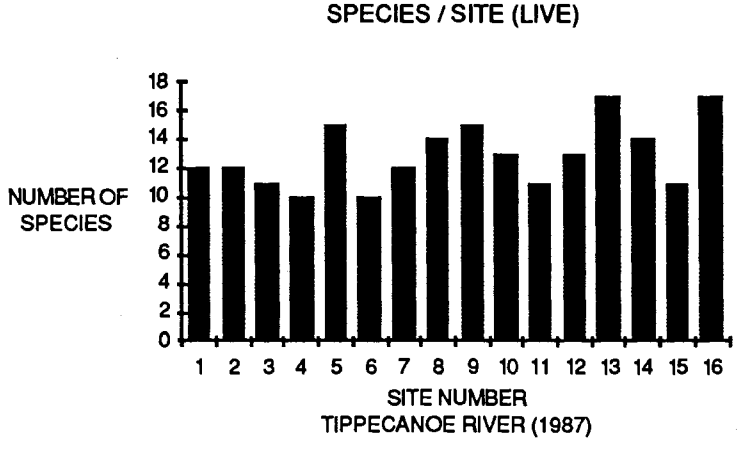


Figure 4. Number of live species collected per site on the Tippecanoe River, 1987 (4 man-hours/site).

Table 6. Site by site listing of all mussel species collected in the Tippecanoe River, 1987 (x = shells only).

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL LIVE
Actinonaias ligamentina (Lamarck, 1819)					11	4	13	27	25	8	15	2	2	5	3	2	117
Alasmidonta marginata Say, 1818		x	4		4	6	8	10	x	6	3				x	x	41
Alasmidonta viridis (Rafinesque, 1820)					x	x											0
Amblema plicata (Say, 1817)	96	x	x		x	x	x	x	x	x	x	5	38	5	5	5	154
Anodonta grandis Say, 1829	6			6	x	x			1	x		24	17		2	5	61
Anodonta imbecillis Say, 1829		x		2	1	1				2			2		x	1	9
Anodonta suborbiculata Say, 1831													5				5
Anodontoides ferussacianus (I.Lea, 1834)						x						1					1
Cyclonaias tuberculata (Rafinesque, 1820)			8		6	x	12	5	12	5	4	4	6	20	12	3	97
Cyprogenia stegaria (Rafinesque, 1820)															x	x	0
Elliptio dilatata (Rafinesque, 1820)	20	8			2	x	1	2	x	x	x		1	2	x	x	36
Epioblasma torulosa (Rafinesque, 1820)	x	x	x	x	x	x		x		x	x						0
Epioblasma triquetra (Rafinesque, 1820)												x				x	0
Fusconaia flava (Rafinesque, 1820)	14	23	8	5	9	8	5	3	1	x	2				x	3	81
Lampsilis cardium (Rafinesque, 1820)	1	10	12	10	x	x	3	12	3	3	x	6	1	1	1	2	65
Lampsilis fasciola Rafinesque, 1820	1	3	x		1	x		x		x					x	x	5
Lampsilis ovata (Say, 1817)						x											0
Lampsilis siliquoidea (Barnes, 1823)	4	5	1	5	2							2	14		1	x	34
Lasmigona complanata (Barnes, 1823)				4				1	1	x		53	25			x	84
Lasmigona compressa (I. Lea, 1829)		2	x	2	x	x											4
Lasmigona costata (Rafinesque, 1820)		1	5		4	1	7	7	6	6	2	5	3	3	1	x	51
Leptodea fragilis (Rafinesque, 1820)													3	1	x	1	5
Ligumia recta (Lamarck, 1819)			x										1	1	x	1	3
Obovaria subrotunda (Rafinesque, 1820)					6	3	4	2	1	x	1				x		17
Plethobasus cyphyus (Rafinesque, 1820)					2	x	2	1	2	2				x		1	10
Pleurobema clava (Lamarck, 1819)		3	9	x	6	x	x	x	1	x					x	x	19
Pleurobema sintoxia (Rafinesque, 1820)	4	15	26		18	8	8	12	6	6	10			1	1	3	118
Potamilus alatus (Say, 1817)													3	1	x	1	5
Ptychobranchus fasciolaris (Rafinesque, 1820)	21	53	33		x	2	x	2	5	4	3	2		4	x	2	131
Quadrula cylindrica (Say, 1817)						x		x	2	4	3				x	x	9
Quadrula metanevra (Rafinesque, 1820)														1	x	5	6
Quadrula pustulosa (I. Lea, 1831)				3	8	11	11	10	21	10	35	65	9	7	7	8	205
Quadrula quadrula (Rafinesque, 1820)										2		35	2				39
Strophitus undulatus (Say, 1817)	14	7	3	1	4	2	1	7	1	4	2		x		1	1	48
Toxolasma lividis (Rafinesque, 1831)	1	x	x		x	x	x	x		x	x		x		x	1	2
Toxolasma parvus (Barnes, 1823)				1									x				1
Tritogonia verrucosa (Rafinesque, 1820)												6	1			x	7
Truncilla donaciformis (I. Lea, 1828)																x	0
Truncilla truncata Rafinesque, 1820													x	3	1	1	5
Villosa fabalis (I. Lea, 1831)					x					x					x		0
Villosa iris (I. Lea, 1829)	1	22	1		x	x	x	x		x	x				x	x	24
SPECIMENS/SITE (LIVE)	183	152	110	39	84	46	75	101	88	62	80	210	133	55	35	46	1499
SPECIES/SITE (LIVE)	12	12	11	10	15	10	12	14	15	13	11	13	17	14	11	17	34
SPECIES/ SITE (DEAD)	1	5	6	2	10	16	5	7	3	13	6	1	4	1	17	13	7
SPECIES/SITE (TOTAL)	13	17	17	12	25	26	17	21	18	26	17	14	21	15	28	30	41

time and some are considered rare or endangered in the Midwest or throughout their range (Parmalee, 1967; Stansbery, 1970; 1971). Five species, *Quadrula pustulosa* (13.7%), *Amblema plicata* (10.3%), *Ptychobranchus fasciolaris* (8.7%), *Pleurobema sintoxia* (7.9%), and *Actinonaias ligamentina* (7.8%), comprised 48.4% of the living mussels collected in the Tippecanoe River (Table 7). Some distributional trends were apparent in the data. Seven of the species collected were found only below the dam at Lake Shafer (station 12). Whether the dam is a barrier to these species is unknown, but no evidence of these mussels was found upstream. Other species were located predominantly in the upper portion of the river and live individuals were either not found below Lake Shafer or were greatly reduced in number. Examples of these species are *Fusconaia flava*, *Lampsilis fasciola*, *Obovaria subrotunda*, *Plethobusus cyphyus*, *Pleurobema clava*, *Ptychobranchus fasciolaris*, *Quadrula cylindrica*, and *Strophitus undulatus*.

Overall the number of live species collected was high. The Tippecanoe River has one of the most diverse assemblages of freshwater mussels in the Midwest. A comparison of the Tippecanoe River with other recently surveyed Midwestern streams is given in Table 8. As stated above, the Tippecanoe mussel fauna is not only diverse, but contains rare and endangered species. Six of these species are currently on the Indiana state endangered list and 14 of the 41 species collected have been proposed for listing in Illinois. The three Indiana state endangered species found live during this study were *Quadrula cylindrica*, *Plethobasus cyphyus*, and *Pleurobema clava*, the last of which is also a candidate for listing as endangered at the federal level. Detailed accounts of all of the species reported from the rivers surveyed are given below and distribution maps are given for each species treated (Appendices I & II).

SPECIES ACCOUNTS

In the following accounts, each species is discussed individually with respect to its historical and present distribution and status in the lower Wabash and Tippecanoe rivers. These accounts are organized by rarity of the species with extinct species treated first, followed by federally endangered species, federal candidates, state endangered, state threatened, species of special concern, and others. Comparisons are made with data presented in earlier studies of the unionid fauna of Indiana (Call, 1899; Daniels, 1903; Goodrich & van der Schalie, 1944; Meyer, 1968,1974; and Clark, 1976).

The nomenclature in this report follows a draft list (to be published in late 1987 or early 1988) of molluscs prepared by the Council of Systematic Malacologists and the Committee on Scientific

Table 7. Numbers, relative abundance and percent composition of living mussels collected in the Tippecanoe River - 1987.

SPECIES	No.	RANK	%	CUMULATIVE %
Quadrula pustulosa (I. Lea, 1831)	205	1	13.7	13.7
Amblema plicata (Say, 1817)	154	2	10.3	24.0
Ptychobranchus fasciolaris (Rafinesque, 1820)	131	3	8.7	32.7
Pleurobema sintoxia (Rafinesque, 1820)	118	4	7.9	40.6
Actinonaias ligamentina (Lamarck, 1819)	117	5	7.8	48.4
Cyclonaias tuberculata (Rafinesque, 1820)	97	6	6.5	54.9
Lasmigona complanata (Barnes, 1823)	84	7	5.6	60.5
Fusconaia flava (Rafinesque, 1820)	81	8	5.4	65.9
Lampsilis cardium (Rafinesque, 1820)	65	9	4.3	70.2
Anodonta grandis Say, 1829	61	10	4.1	74.3
Lasmigona costata (Rafinesque, 1820)	51	11	3.4	77.7
Strophitus undulatus (Say, 1817)	48	12	3.2	80.9
Alasmidonta marginata Say, 1818	41	13	2.7	83.6
Quadrula quadrula (Rafinesque, 1820)	39	14	2.6	86.2
Elliptio dilatata (Rafinesque, 1820)	36	15	2.4	88.6
Lampsilis siliquoidea (Barnes, 1823)	34	16	2.3	90.9
Villosa iris (I. Lea, 1829)	24	17	1.6	92.5
Pleurobema clava (Lamarck, 1819)	19	18	1.3	93.8
Obovaria subrotunda (Rafinesque, 1820)	17	19	1.1	94.9
Plethobasus cyphyus (Rafinesque, 1820)	10	20	0.7	95.6
Anodonta imbecillis Say, 1829	9	21	0.6	96.2
Quadrula cylindrica (Say, 1817)	9	21	0.6	96.8
Tritogonia verrucosa (Rafinesque, 1820)	7	23	0.5	97.3
Quadrula metanevra (Rafinesque, 1820)	6	24	0.4	97.7
Anodonta suborbiculata Say, 1831	5	25	0.3	98.0
Lampsilis fasciola Rafinesque, 1820	5	25	0.3	98.3
Leptodea fragilis (Rafinesque, 1820)	5	25	0.3	98.6
Potamilus alatus (Say, 1817)	5	25	0.3	98.9
Truncilla truncata Rafinesque, 1820	5	25	0.3	99.2
Lasmigona compressa (I. Lea, 1829)	4	30	0.3	99.5
Ligumia recta (Lamarck, 1819)	3	31	0.2	99.7
Toxolasma lividis (Rafinesque, 1831)	2	32	0.1	99.8
Anodontoides ferussacianus (I. Lea, 1834)	1	33	0.1	99.9
Toxolasma parvus (Barnes, 1823)	1	33	0.1	100.0
TOTALS	1499		100	

Table 8. **A comparison of the number of live mussels collected in midwestern stream surveys (1912-1987).**

River	Sites	Live Species	Individuals	Man-hours	Source
Meremec River Drainage, Missouri	198	42	20589	-	Buchanan, 1980
Tippecanoe River, Indiana	16	34	1499	64	Cummings, et al., 1987
Vermilion River, Illinois	31	30	-	-	Baker, 1922
Kankakee River Drainage, Illinois & Indiana	43	29	-	-	Wilson & Clark, 1912
Embarras River, Illinois	21	27	876	84	Cummings, et al., 1986
Kaskaskia River, Illinois	19	23	498	51	Suloway, et al., 1981a
Little Darby Creek, Ohio	20	22	-	-	Stein, 1965
Illinois River, Illinois	429	22	4247	-	Starrett, 1971
Vermilion River, Illinois	29	22	639	87	Suloway, et al., 1981b
Olentangy River, Ohio	-	21	-	-	Stein, 1963
Blue River, Indiana	25	15	-	-	Weilbaker, et al., 1985
Big Indian Creek, Indiana	7	15	-		Taylor, 1982

and Common Names of the American Malacological Union (AMU) except as follows: 1.) subspecies are not recognized, 2.) members of the *Pleurobema cordatum* complex are recognized following Stansbery (1983) where *Pleurobema sintoxia* (Rafinesque, 1820) and *P. rubrum* (Rafinesque, 1820) have priority over *P. coccineum* (Conrad, 1834) and *P. pyramidatum* (I. Lea, 1840), respectively. A short synonomy containing references to previously published works on Indiana mussels is given for each species.

EXTINCT SPECIES

Epioblasma flexuosa (Rafinesque, 1820) - leafshell

Unio foliatus Hildreth: Call 1894:154; 1897:251; 1899:510.
Truncilla foliata (Hildreth): Daniels 1903:646.
Dysnomia flexuosa (Rafinesque): Goodrich & van der Schalie 1944:314; Meyer 1974:22; Clark 1976:4.

Goodrich and van der Schalie (1944) report this unique mussel from the Ohio River and Posey County, Indiana. Shells of this species were collected at three sites in 1987, but all were sub-fossil. This species has not been collected live in over 50 years anywhere in its former range and is presumed extinct (Stansbery, 1971; USFWS, 1984).

Epioblasma personata (Say, 1829) - round combshell

Unio personatus Say: Call 1894:155; 1897:252; 1899:474.
Unio pileus Lea: Call 1894:155.
Truncilla personata (Say): Daniels 1903:646.
Dysnomia personata (Say): Goodrich & van der Schalie 1944:314; Meyer 1974:22; Clark 1976:4.

This species was reported to be rare in Indiana as early as 1899 (Call, 1899). It was not collected in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). It has not been collected live in over 50 years anywhere in its former range and is presumed extinct (Stansbery, 1971; USFWS, 1984).

Epioblasma propinqua (I. Lea, 1857) - Tennessee riffleshell

Plagiola (*Torulosa*) *propinqua* (Lea): Johnson 1978:266.

Specimens from the lower Wabash River at New Harmony are represented in the collections of the University of Michigan and the Museum of Comparative Zoology at Harvard (Johnson, 1978). Sub-fossil shells of *E. propinqua* were found at two sites in the Wabash River in 1987. As with the previous species, no live specimens of this species have been collected in over 50 years anywhere in its former range and it is presumed extinct (Stansbery, 1971; USFWS, 1984).

Epioblasma sampsonii (I. Lea, 1861) - Wabash riffleshell

Unio sampsonii Lea: Call 1894:155; 1897:252.
Truncilla sampsonii (Lea): Daniels 1903:646.
Dysnomia sampsoni (Lea): Goodrich & van der Schalie 1944:314; Meyer 1974:22; Clark 1976:4.

The Wabash riffleshell was described by Issac Lea from the lower Wabash in 1861. *E. sampsonii* was not found in the 1966-67, 1975, or 1987 surveys of the river (Meyer, 1974; Clark, 1976) and it is presumed extinct (Stansbery, 1971; USFWS, 1984).

FEDERALLY ENDANGERED SPECIES

Epioblasma obliquata (Rafinesque, 1820) - white catspaw

Unio sulcatus Lea: Call 1894:155; 1896:146; 1897:252; 1899:476.
Unio ridibundus Say: Call 1896:146.
Truncilla sulcata (Lea): Daniels 1903:646.
Dysnomia sulcata (Lea): Goodrich & van der Schalie 1944:314; Meyer 1974:22; Clark 1976:4.

The white catspaw was noted as rare in Indiana (Goodrich & van der Schalie, 1944), with records from the Ohio, Wabash, White, and Maumee Rivers. This species was not collected in the lower Wabash River in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976) and is presumed to be extirpated from the lower Wabash.

We did not collect *E. obliquata* in the Tippecanoe River in 1987. However, an old shell was recently found at the Rt. 35 bridge in Pulaski County late this summer (W. Haag, Eastern Kentucky University, personal comm.) and the status of this species in the Tippecanoe River needs further investigation.

Epioblasma torulosa (Rafinesque, 1820) - tubercled blossom

Unio cincinnatiensis Lea: Call, 1894:153; 1897:251.
Unio perplexus Lea: Call 1894:155; 1896:145; 1897:252; 1899:475.
Unio phillipsii Conrad: Call 1894:155.
Unio rangianus Lea: Call 1894:155; 1897:252.
Truncilla perplexa (Lea): Daniels 1903:646.
Truncilla perplexa rangiana (Lea): Daniels 1903:646.
Dysnomia perplexa (Lea): Goodrich & van der Schalie 1944:314; Meyer 1974:22.
Dysnomia perplexa rangiana (Lea): Clark 1976:4.

As can be deduced from the long list of synonyms given for this species, *E. torulosa* is an extremely variable species throughout its range. In his early works Call (1894; 1896; 1897) treated this species under at least four names, with *E. torulosa rangiana* occurring in headwater streams and *E. torulosa torulosa* in the lower Wabash. *E. cincinnatiensis*, described by I. Lea from the Ohio River at Cincinnati, remains an enigma and may yet warrant specific status. *E. phillipsii*,

described by T.A. Conrad (1836) from the Wabash River, appears to be similar to *E. cincinnatiensis*, but may also be specifically distinct. We shall probably never know the true relationships of these forms because *E. cincinnatiensis* and *E. phillipsii* are presumed extinct. For the purpose of this report we will treat all of these forms under the name *E. torulosa.*

Call (1899) reported this species as abundant in the Wabash River but does not give specific site information. Daniels (1903) lists New Harmony for *T. perplexa* and the Tippecanoe River for *T. perplexa rangiana.* Goodrich and van der Schalie (1944) noted that this species was well represented in the Wabash River and gave Lafayette as a locality for *D. perplexa rangiana.* It was not collected in either the 1966-67 or 1975 surveys of the lower Wabash River (Meyer, 1974; Clark, 1976). In 1987, *E. torulosa* was present at six sites in the lower Wabash River, but all were sub-fossil shells and this species is most likely extirpated from this portion of the drainage.

In the Tippecanoe River survey of 1987, dead shells (many with the periostracum intact) of *E. torulosa* were collected from 9 of 16 sites (Table 6). A recent live collection of this species was made in the 1970's. Given the condition of the shells collected in 1987, it is possible that it still occurs in the river.

Lampsilis abrupta (Say, 1831) - pink mucket

Unio abruptus Say: Call 1894:153; 1897:251.
Unio orbiculatus Hildreth: Call 1894:154; 1896:145; 1897:252; 1899:492.
Lampsilis orbiculatus (Hildreth): Daniels 1903:647.
Lampsilis orbiculata (Hildreth): Goodrich & van der Schalie 1944:315; Meyer1974:23; Clark 1976:4.

Both Call (1899) and Goodrich and van der Schalie (1944) reported this species from the Wabash River. The pink mucket was not found in the 1966-67 (Meyer, 1974), 1975 (Clark, 1976), or 1987 surveys of the lower Wabash, and it is probably extirpated from this portion of the drainage.

Not collected from the Tippecanoe River in 1987.

Plethobasus cicatricosus (Say, 1829) - white wartyback

Unio cicatricosus Say: Call 1894:153; 1896:142; 1897:251.
Unio varicosus Lea: Call 1894:155; 1896:146; 1897:252; 1899:499.
Pleurobema cicatricosa (Say): Daniels 1903:651.
Plethobasus cicatricosus (Say): Goodrich & van der Schalie 1944:308; Meyer 1974:23; Clark 1976:5.

Reportedly rare in the Wabash River by 1944 (Goodrich & van der Schalie), this species was not collected in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). *P. cicatricosus* is most likely

extirpated from the Wabash River and exists only in the Tennessee River below Wilson Dam in Tennessee (Stansbery, 1970).

Plethobasus cooperianus (I. Lea, 1834) - orange-foot pimpleback

Unio cooperianus Lea: Call 1894:153; 1896:142; 1897:251; 1899:485.
Quadrula cooperiana (Lea): Daniels 1903:651.
Plethobasus cooperianus (Lea): Goodrich & van der Schalie 1944:308; Meyer 1974:23; Clark 1976:6.

Reported by Call (1899) to be common in the Wabash River, this species was considered rare in Indiana by 1944 (Goodrich & van der Schalie). *P. cooperianus* was not collected in the 1966-67, 1975, or 1987 surveys of the lower Wabash (Meyer, 1974, Clark, 1976). It is most likely extirpated from the Wabash, but a population of the orange-foot pimpleback exists in the Ohio River and may re-establish itself in the lower part of the river if conditions improve.

Pleurobema plenum (I. Lea, 1840) - rough pigtoe

Unio plenus Lea: Call 1894:155; 1896:145; 1897:252.
Quadrula plena (Lea): Daniels 1903:652.
Pleurobema cordatum (Rafinesque)(in part): Goodrich & van der Schalie 1944:309 .

A member of the *P. cordatum* species complex, the rough pigtoe was not treated as a separate species by Goodrich and van der Schalie (1944), Meyer (1974), or Clark (1976). Reported from the Tippecanoe in 1903 (Daniels), *P. plenum* was not collected in the lower Wabash or Tippecanoe rivers in 1987 and is probably extirpated from the drainage.

Potamilus capax (Green, 1832) - fat pocketbook

Unio capax Green: Call 1894:153; 1896:142; 1897:251; 1899:482.
Lampsilis capax (Green): Daniels 1903:647.
Proptera capax (Green): Goodrich & van der Schalie 1944:319; Meyer 1974:24; Clark 1976:5.

Reported as uncommon in the Wabash in 1899 (Call), *P. capax* was considered rare in the river by 1944 (Goodrich & van der Schalie, 1944). The fat pocketbook was not collected in 1966-67 (Meyer, 1974), but two specimens were found at two sites (New Harmony area and Mackey Island area) in 1975 (Clark, 1976). However, in the recovery plan for *P. capax*, Dennis (1985) stated that, based on the best available data, the last remaining population of *P. capax* existed only in the St. Francis River, Arkansas.

In the summer of 1984, a group of INHS biologists sampled at the Old Dam south of New Harmony, south of Mink Island, and Grand Chains to look for *P. capax*. Two live specimens of what we believed to be *P. capax* were found at the Old Dam site, photographed, and returned to the river. These photographs were sent to Dr. David H. Stansbery for verification. He said that a

positive identification could not be made from the photos at hand because of convergence in shell characters between *P. capax* and *L. cardium*.

In 1987, nine live specimens of *P. capax* were found in the lower Wabash River (Table 4). All were collected in water 10 to 12 feet deep. The substrate consisted of mixed mud, sand and clay, and is the same as that reported for *P. capax* in the St. Francis River drainage (Ahlstedt & Jenkinson, 1987). Age estimates, based on rings, indicated that both juveniles and adults were present and that recruitment had occurred within the last three to four years. Because of the past difficulty in securing a positive identification, one of the nine specimens collected was catalogued into the mollusc collection at the Illinois Natural History Survey (INHS 3433). On 17 August 1987, this specimen was sent to Steve Ahlstedt of the Tennessee Valley Authority where the identification was confirmed. On 19 November 1987, this specimen was shown to Dr. Stansbery at Ohio State University where it was also identified as *P. capax*.

FEDERAL CANDIDATE SPECIES

Cumberlandia monodonta (Say, 1829) - spectacle case

> *Margaritana monodonta* Say: Call 1894:153; 1896:141; 1897:251; 1899:526; Daniels 1903:650.
> *Cumberlandia monodonta* (Say): Goodrich & van der Schalie 1944:305; Clark 1976:4.

This rare species is reported to inhabit medium to large rivers with a good current. It is usually buried deep in the substrate and may be overlooked if sampling is limited to brailing (Parmalee, 1967). Goodrich and van der Schalie (1944) noted this species only from the Grand Chains region in the lower Wabash River. It was not reported from either the 1966-67 or 1975 surveys (Meyer, 1974; Clark, 1976) and only weathered dead shells were found in 1987 (Table 4). The spectacle case is probably extirpated from the Wabash River drainage. It is known in Illinois only from the Mississippi River.

Not found in the Tippecanoe River.

Cyprogenia stegaria (Rafinesque, 1820) - fanshell

> *Unio irroratus* Lea: Call 1894:154; 1896:144; 1897:252; 1899:485.
> *Cyprogenia irrorata* (Lea): Daniels 1903:649; Goodrich & van der Schalie 1944:313; Meyer 1974:22; Clark 1976:4.

Reported by Call (1899) to be numerous in the Wabash River. Goodrich and van der Schalie (1944) noted it to be a large river species confined to the Ohio, Wabash, and White rivers in Indiana. No individuals of this species were found in the lower Wabash in either 1966-67 or 1975

(Meyer,1974; Clark, 1976). One live specimen of *C. stegaria* was found near Maunie, White County, Illinois, in 1984, but only old sub-fossil shells (without periostracum) were found in 1987. This species was apparently more common in the past as judged from the number of sites at which shells were collected (Table 4) and exists today in very small numbers.

Two valves of this species were found in the lower Tippecanoe River in 1987. Both had the periostracum intact and there is a strong possibility that this species may still live there.

Hemistena lata (Rafinesque, 1820) - cracking pearlymussel

Margaritana dehiscens Say: Call 1894:153; 1896:141; 1897:251; 1899:533.
Lastena lata (Rafinesque): Daniels 1903:649; Goodrich & van der Schalie 1944:308; Meyer 1974:23; Clark 1976:4.

Reported to be rare in the Wabash in 1899 (Call, 1899). Goodrich and van der Schalie (1944) listed *H. lata* from the Wabash and Tippecanoe rivers in Indiana, but noted that it was rare throughout its range. No specimens were found in the lower Wabash by Meyer (1974), Clark (1976), or in the present study, and it is probably extirpated from this portion of the drainage.

Extirpated from nearly all of its former range, this species still survives in the Powell, Green, and Clinch rivers in Kentucky and Tennessee (Stansbery, 1970; Bogan & Parmalee, 1983). Reported in the Tippecanoe River by Daniels (1903), this species was not collected in 1987 and is most likely extirpated from the river.

Leptodea leptodon (Rafinesque, 1820) - scaleshell

Unio tenuissimus Lea: Call 1894:155; 1896:146; 1897:252; 1899:463.
Lampsilis leptodon (Rafinesque): Daniels 1903:648.
Lampsilis blatchleyi (Daniels): Daniels 1903:648.
Leptodea blatchleyi (Daniels): Goodrich & van der Schalie 1944:316; Meyer 1974:23; Clark 1976:4.
Leptodea leptodon (Rafinesque): Goodrich & van der Schalie 1944:316; Meyer 1974:23; Clark 1976:4.

Call (1899) described the habitat of the scaleshell as the muddy bottoms of the Ohio and Wabash rivers, but said that while common there, it was nowhere abundant. Goodrich and van der Schalie (1944) noted that *L. leptodon* was rare and confined to the lower Wabash and Ohio rivers. This species was not collected in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976) and is considered extirpated from the lower Wabash River.

Not collected in the Tippecanoe River in 1987.

Obovaria retusa (Lamarck, 1819) - ring pink

Unio retusus Lamarck: Call 1894:155; 1896:146; 1899:494.
Obovaria retusa (Lamarck): Daniels 1903:648; Goodrich & van der Schalie 1944:318; Meyer 1974:23; Clark 1976:4.

Noted by Call (1899) to be fairly common in most of the larger streams of the state. Goodrich and van der Schalie (1944) list its range in Indiana as the Wabash River below Lafayette and the lower White River. Not collected in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). This species is most likely extirpated from Indiana and Illinois and should be listed as endangered at the federal level.

Not collected from the Tippecanoe River in 1987.

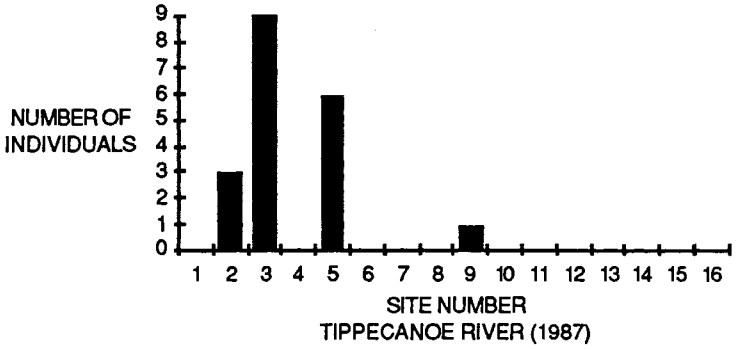
Pleurobema clava (Lamarck, 1819) - clubshell

Unio clavus Lamarck: Call 1894:153; 1896:142; 1897:251; 1899:506.
Unio mytiloides Lea: Call 1894:154; 1896:144; 1897:252.
Pleurobema clava (Lamarck): Daniels 1903:651; Goodrich & van der Schalie 1944:308; Meyer 1974:23; Clark 1976:5.

The clubshell was reported to be widely scattered in the smaller streams of the state (Goodrich & van der Schalie, 1944). It was not collected in the lower Wabash River in 1966-67 or 1975 (Meyer, 1974; Clark, 1976). In 1987 old dead shells of *P. clava* were found at 6 sites (Table 4), but none were recent and this species is presumed extirpated from the lower Wabash.

Reported from the Tippecanoe by Daniels (1903), 19 living *P. clava* were found at four sites in the river in 1987 (see graph below). In addition, recently dead shells were found at seven other sites. The clubshell ranked 18th out of 34 total species collected live in the river and was the 4th most common species collected at site 3 (Tables 5 & 6). This once common Ohio River drainage species has disappeared from much of its former range (Stansbery, 1970) and is probably extirpated in Illinois. The population in the Tippecanoe River is one of the best remaining in the Midwest and should be closely monitored to ensure its survival in Indiana.

Pleurobema clava (Lamarck, 1819)
clubshell



Simpsonalas ambigua (Say, 1825) - salamander mussel

Margaritana hildrethiana Lea: Call 1894:153; 1896:141; 1897:251; 1899:527.
Hemilastena ambigua (Say): Daniels 1903:650.
Simpsoniconcha ambigua (Say): Goodrich & van der Schalie 1944:312; Meyer 1974:24; Clark 1976:5.

The salamander mussel is sporadic in distribution and is known from streams in both the Ohio and Great Lakes drainages in Indiana, including the Wabash and Tippecanoe rivers (Clarke, 1985). It was considered rare by Stansbery (1970), but he noted that, due to its habitat (under limestone slabs), its rarity may be more apparent than real. However, it has not been collected live in Illinois in over 50 years and has been proposed for listing as endangered there. *S. ambigua* was not found in the 1966-67, 1975, or 1987 surveys of the lower Wabash River (Meyer, 1974; Clark, 1976), and is likely extirpated from that portion of the drainage.

Although reported by Clarke (1985) from the Tippecanoe, this species was not collected in 1987. However, as mentioned above it is extremely difficult to locate and may still exist in the drainage.

Villosa fabalis (I. Lea, 1831) - rayed bean

Unio fabalis Lea: Call 1894:154; 1896:143; 1897:251; 1899:458.
Micromya fabalis (Lea): Daniels 1903:646; Goodrich & van der Schalie 1944:317.

The smallest mussel in Indiana, *V. fabalis* was considered to be common in the Wabash River and Tippecanoe Lake by Call (1899) and was reported from the Tippecanoe River by Daniels (1903). Museum records for this species from Indiana are scarce. It was not found in the lower Wabash in 1966-67, 1975, or 1987 (Meyer, 1974; Clark ,1976).

Only empty shells of this species were found at sites 5, 10, and 14 in the Tippecanoe River in 1987 (Table 6). Most of the shells found appeared to have been dead for some time and it is

uncertain whether this small species was simply overlooked or if it is no longer extant in the main portion of the river. As it is frequently associated with lakes, *V. fabalis* may occur in the natural lakes in the upstream portion of the drainage. Proposed for listing as endangered in Illinois, a survey of this species is needed to determine its status in Indiana.

STATE ENDANGERED SPECIES

Epioblasma triquetra (Rafinesque, 1820) - snuffbox

Unio triangularis Barnes: Call 1894:155; 1896:146; 1897:252; 1899:473.
Truncilla triquetra (Rafinesque): Daniels 1903:646.
Dysnomia triquetra (Rafinesque): Goodrich & van der Schalie 1944:314; Meyer 1974:22; Clark 1976:4.

Reported as abundant by Call (1899) in the Wabash River. Daniels (1903) lists the Tippecanoe and Wabash rivers, among others, as localities for this species. Goodrich and van der Schalie (1944) noted that *E. triquetra* is seldom found in large numbers and usually is found in medium to large rivers, including the Wabash. It was not collected in the lower Wabash in 1966-67 or 1975 (Meyer, 1974; Clark, 1976). A sub-fossil shell was collected in 1987, but this species is probably extirpated in the lower Wabash.

In the Tippecanoe River in 1987, dead shells of this species were found at sites 12 and 16 in the lower portion of the river. Like *E. torulosa*, the snuffbox may turn up in the Tippecanoe River upon further investigation.

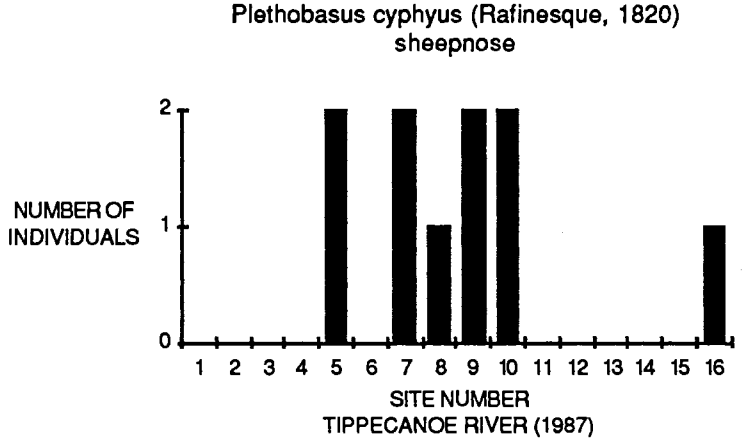
Plethobasus cyphyus (Rafinesque, 1820) - sheepnose

Unio aesopus Green: Call 1894:153; 1896:142; 1897:251.
Unio cyphyus Rafinesque: Call 1899:496.
Pleurobema aesopus (Green): Daniels 1903:651.
Plethobasus cyphyus (Rafinesque): Goodrich & van der Schalie 1944:308; Meyer 1974:23; Clark 1976:5.

Call (1899) reported the sheepnose as common in the deeper waters of the Wabash River in Indiana, but by 1944, *P. cyphyus* was considered rare in the state (Goodrich & van der Schalie, 1944). It was not collected in the lower Wabash in 1966-67 or 1975 (Meyer, 1974; Clark, 1976). In 1987, *P. cyphyus* was collected as old shells only from sites 2 and 11 and is considered extirpated from the lower Wabash River.

Reported by Daniels (1903), this species is still present in the Tippecanoe River. Ten live individuals of *P. cyphyus* were collected from six sites in 1987 (see graph below and Table 6). It was most common in the mid-portion of the river (sites 5-10) and was absent from the downstream

areas near the reservoirs. Endangered in Missouri (Buchanan, 1980; Oesch, 1984), the sheepnose has been proposed as endangered in Illinois, and the Tippecanoe population may be the largest remaining in the Wabash drainage.



Pleurobema rubrum (Rafinesque, 1820) - pyramid pigtoe

Unio pyramidatus Lea: Call 1894:155; 1897:252.
Quadrula pyramidata (Lea): Daniels 1903:652.
Pleurobema cordatum (Rafinesque) (in part): Goodrich & van der Schalie 1944:308; Clark 1974:24; Clark 1976:4.

A member of the *P. cordatum* species complex, *P. rubrum* was considered as part of that species by most of the previous workers (Goodrich & van der Schalie, 1944; Meyer, 1974; Clark, 1976). The pyramid pigtoe was not collected live in 1987 and sub-fossil shells were found at only two sites.

Reported by Daniels (1903) from the Tippecanoe River, no evidence of *P. rubrum* was found in 1987. Two old valves were collected by W. Haag (EKU) from the Tippecanoe River at the Rt. 35 bridge and are referable to *P. rubrum*. Given the condition of the shells this species is probably extirpated from the river.

Potamilus ohiensis (Rafinesque, 1820) - pink papershell

Unio laevissimus Lea: Call 1894:154; 1897:252;1899:462.
Lampsilis laevissimus (Lea): Daniels 1903:648.
Leptodea laevissima (Lea): Goodrich & van der Schalie 1944:316; Meyer 1974:23; Clark 1976:4.

Reported as rare in the Ohio and lower Wabash River in Indiana by Goodrich and van der Schalie (1944). Only one specimen was collected in 1966-67 (Meyer, 1974); however, by 1975 Clark (1976) reported this species as common in the lower Wabash. In 1987, six specimens were found

live and numerous fresh dead shells were apparent on exposed shoals and river banks. *P. ohiensis* is usually associated with quiet waters in a mud, sand, and gravel substrate (Call, 1899; Parmalee, 1967), which may account for its widespread occurrence in the increasingly silty lower Wabash River. This species should probably be downgraded in status to threatened or special concern in Indiana.

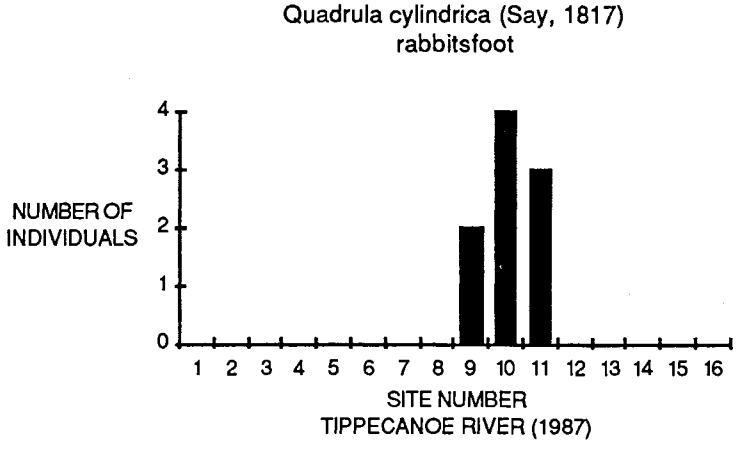
Not collected in the Tippecanoe River in 1987.

Quadrula cylindrica (Say, 1817) - rabbitsfoot

Unio cylindricus Say: Call 1894:153; 1896:143; 1897:251; 1899:468.
Quadrula cylindricus (Say): Daniels 1903:651.
Quadrula cylindrica (Say): Goodrich & van der Schalie 1944:309; Meyer 1974:24; Clark 1976:5.

Reported to be common in the Wabash River by Call (1899), the rabbitsfoot was not collected live in the lower Wabash in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). This species was once common in the lower Wabash and numerous sub-fossil shells were found on the shoals and banks of the river. It has not been collected live in the lower Wabash for many years and is most likely extirpated from this portion of the drainage.

Reported as common in the Tippecanoe River in 1903 (Daniels), nine live individuals of *Q. cylindrica* were found at sites 9, 10, and 11 in 1987 and shells were found at sites 6, 8, 15, and 16 (see graph below and Table 6). This handsome species is near extirpation in Illinois and other states and this may be one of the last populations in the upper Midwest.



Quadrula nodulata (Rafinesque, 1820) - wartyback

Unio pustulatus Lea: Call 1894:155; 1896:145; 1897:252; 1899:486.
Quadrula pustulata (Lea): Daniels 1903:651.
Quadrula nodulata (Rafinesque): Goodrich & van der Schalie 1944:309; Meyer 1974:24; Clark 1976:5.

Reported to be fairly common in the Wabash River by Call (1899), this species was not collected in 1966-67 (Meyer, 1974). Clark (1976) found the wartyback to be rather common in the lower Wabash River in 1975. In the present survey, *Q. nodulata* was also common. Although only five live individuals were collected, there were hundreds of fresh dead shells of this species present in middens along shore. Typically a large river species, *Q. nodulata* should probably be downgraded from endangered to threatened or special concern status in Indiana.

Not collected in the Tippecanoe River in 1987.

STATE THREATENED SPECIES

Fusconaia subrotunda (I. Lea, 1831) - long-solid

Quadrula subrotunda Lea: Daniels 1903:652.
Fusconaia subrotunda (Lea): Goodrich & van der Schalie 1944:307; Meyer 1974:22; Clark 1976:4.

Daniels (1903) reported the long-solid from the Wabash River at New Harmony and the Tippecanoe River in Carroll County. Typically a Cumberlandian species, records exist in museum collections from scattered localities. No specimens of *F. subrotunda* were collected in 1966-67 (Meyer, 1974), 1975 (Clark, 1976), or 1987.

Not collected in the Tippecanoe River in 1987.

SPECIES OF SPECIAL CONCERN

Pleurobema cordatum (Rafinesque, 1820) - Ohio pigtoe

Unio obliquus Lamarck: Call 1896:144; 1897:252; 1899:501.
Unio solidus Lea: Call 1896:145; 1897:252; 1899:504.
Quadrula obliqua (Lamarck): Daniels 1903:652.
Quadrula solida (Lea): Daniels 1903:652.
Pleurobema cordatum (Rafinesque)(in part): Goodrich & van der Schalie 1944:309; Meyer 1974:24; Clark 1976:5.

P. cordatum was lumped together with the other members of this species complex by Goodrich and van der Schalie (1944). However, they regarded the form *P. cordatum* to occur only in the larger rivers in the southern portion of the state. Meyer (1974) and Clark (1976) noted that this

species was rare in the lower Wabash in 1966-67 and 1975, respectively. In 1987, only old dead shells of the Ohio pigtoe were found. Still present in the Ohio River, this species is either very rare or extirpated in the lower Wabash.

Not collected in the Tippecanoe River in 1987.

Venustaconcha ellipsiformis (Conrad, 1836) - ellipse

Unio spatulatus Lea: Call 1894:155; 1897:252; 1899:455.
Lampsilis ellipsiformis (Conrad): Daniels 1903:647.
Actinonaias ellipsiformis (Conrad): Goodrich & van der Schalie 1944:313.

Although reported by Call (1899) from the Wabash and Eel rivers, Goodrich and van der Schalie (1944) stated that this species was restricted to the northwestern portion of the state in the St. Joseph River and the headwaters of the Kankakee. In Illinois, *V. ellipsiformis* is found in both the Mississippi and Wabash River drainages. Not listed by Meyer (1974) or Clark (1976). The ellipse was not found in the lower Wabash River in 1987.

Not collected in the Tippecanoe River in 1987.

OTHER SPECIES

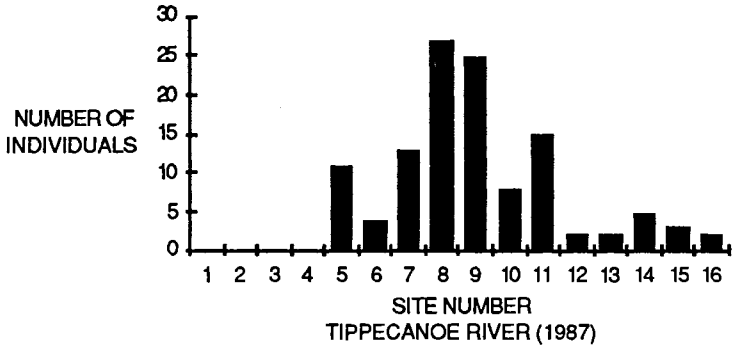
Actinonaias ligamentina (Lamarck, 1819) - mucket

Unio ligamentinus Lamarck: Call 1894:154; 1896:144; 1897:252; Call, 1899:483.
Lampsilis ligamentinus (Lamarck): Daniels 1903:647.
Actinonaias carinata (Barnes): Goodrich & van der Schalie 1944:313; Meyer 1974:21; Clark 1976:4.

The mucket was reported by Call (1899) from the Wabash River. Goodrich and van der Schalie (1944) noted that this species was found in all of the major drainage systems in Indiana, but did not specify the rivers. It was found to be common in the lower Wabash in 1966-67 (Meyer, 1974), but was not collected in the 1975 survey by Clark (1976) or in 1987.

In 1987, 117 individuals of this species were collected at 12 sites in the Tippecanoe River. It was most common at sites 8 and 9 and was the dominant species collected at those sites (see graph below and Table 6). *A. ligamentina* ranked 5th in order of abundance for all species collected from the drainage (Table 5).

Actinonaias ligamentina (Lamarck, 1819)
mucket



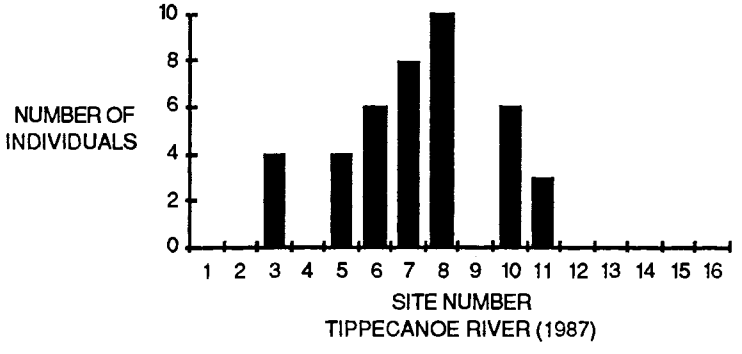
Alasmidonta marginata Say, 1818 - elktoe

Margaritana marginata (Say): Call 1894:153; 1896:141; 1897:251; 1899:521.
Alasmidonta truncata B.H. Wright: Daniels 1903:650.
Alasmidonta marginata (Say): Goodrich & van der Schalie 1944:310; Meyer 1974:21; Clark 1976:4.

The elktoe was reported from every river basin in Indiana by Call (1899), and Goodrich and van der Schalie (1944) found it to be common in headwaters throughout the state. It was not collected in the lower Wabash River by Meyer (1968; 1974), Clark (1976), or during the present study.

This species was collected from seven sites on the Tippecanoe River (see graph below and Table 6) but was not found below Lake Shafer (site 12). The elktoe ranked 13th in order of abundance with a total of 41 individuals collected (Table 5).

Alasmidonta marginata Say, 1818
elktoe

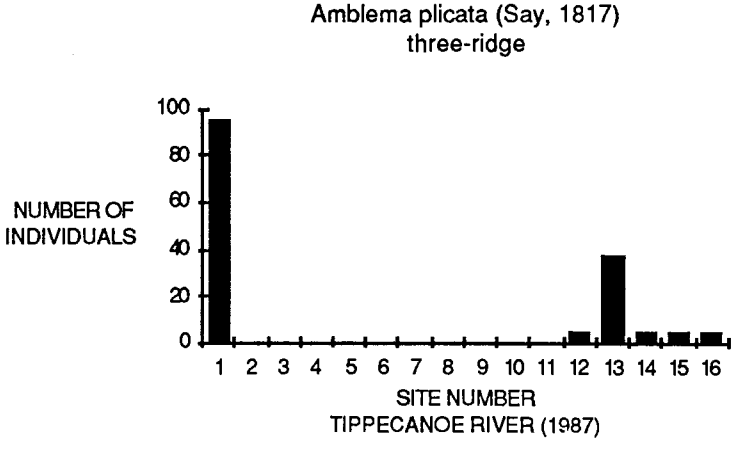


Amblema plicata (Say, 1817) - three-ridge

Unio plicatus Lesueur: Call 1894:155; 1896:145; 1897:252.
Unio undulatus Barnes: Call 1894:155; 1896:146; 1897:252; 1899:445.
Quadrula plicata (Say): Daniels 1903:651.
Quadrula undulata (Barnes): Daniels 1903:651.
Amblema costata Rafinesque: Goodrich & van der Schalie 1944:306; Meyer 1974:21; Clark 1976:4.
Amblema peruviana (Lamarck): Goodrich & van der Schalie 1944:306; Meyer 1974:21; Clark 1976:4.

Goodrich and van der Schalie (1944) reported this commercially important species as statewide in occurrence, but less common in the larger streams of the state. The three-ridge was found to be common in the lower Wabash in 1966-67 (Meyer, 1974) and 1975 (Clark, 1976). However, only four specimens were collected in 1987. The scarcity of this species may account for the fact that the commercial musselers have stopped working this stretch of river in recent years.

The three-ridge was the second most common mussel found in the Tippecanoe River in 1987 (Table 5). Shells of this species were collected from almost every site on the river (Table 6). However, the distribution of live individuals was unusual (see graph below). It was by far the most dominant species collected from site 1 with 96 mussels found, but it did not appear live in the other collections until site 12 below Lake Shafer.

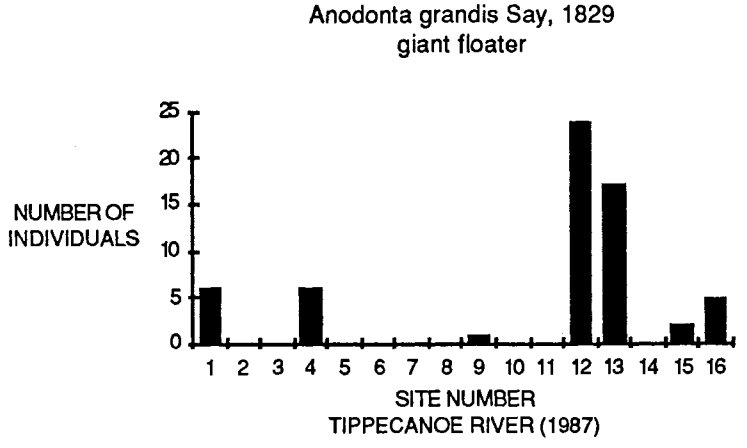


Anodonta grandis Say, 1829 - giant floater

Anodonta corpulenta Cooper: Daniels 1903:649.
Anodonta decora Lea: Call 1894:152; 1897:251.
Anodonta footiana Lea: Call 1894:152; 1896:140; 1897:251; 1899:535.
Anodonta grandis Say: Call 1894:152; 1896:141; 1897:251; 1899:531; Daniels 1903:649; Goodrich & van der Schalie 1944:311; Meyer 1974:21; Clark 1976:4.
Anodonta grandis footiana Lea: Daniels 1903:649.
Anodonta kennicottii Lea: Daniels 1903:649.
Anodonta plana Lea: Call 1894:152; 1897:251.
Anodonta salmonia Lea: Call 1894:152; 1896:141; 1897:251; 1899:534.

Call (1899) reported this species from ponds along the Wabash and Ohio rivers and from northern Indiana. Goodrich and van der Schalie (1944) referred to this as one of the most common species in the state. Two individuals of the giant floater were collected in the lower Wabash River in 1966-67, but it was not found in 1975 (Meyer, 1974; Clark, 1976). Only one live specimen was collected in 1987.

Like other thin shelled species, *A. grandis* is most common in lentic habitats. This is reflected in the high number of individuals collected in pools below Webster Lake and the reservoirs downstream (see graph and Table 6). A total of 61 specimens from 7 sites were collected in the Tippecanoe River in 1987, but most were collected at sites 12 and 13. This species ranked 6th in order of abundance for the river as a whole (Table 5).

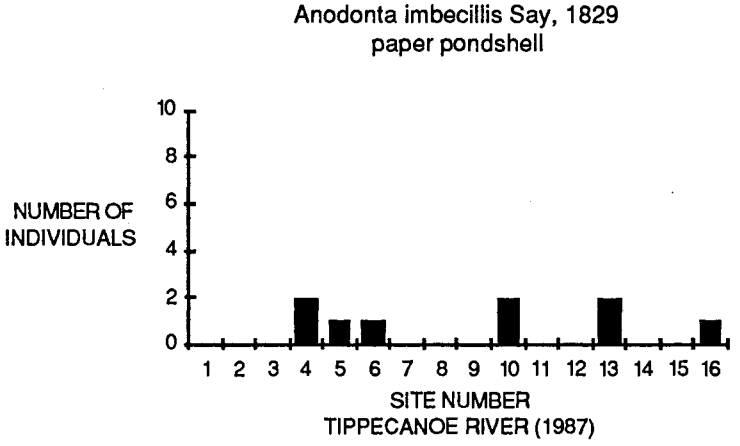


Anodonta imbecillis Say, 1829 - paper pondshell

Anodonta imbecillis Say: Call 1894:152; 1896:141; 1897:251; 1899:527; Daniels 1903:649; Goodrich & van der Schalie 1944:311; Meyer 1974:22; Clark 1976:4.

Goodrich and van der Schalie (1944) reported the paper pondshell from nearly all of the drainage systems in Indiana. However, they noted that it was sporadic in distribution and, like other thin shelled species, it was usually found in outlets of lakes, muddy banks, etc. Neither Meyer (1968; 1974) nor Clark (1976) found evidence of this species in the lower Wabash. A live specimen was found at Mt Carmel in 1985 and a single valve of this species was collected at Jimtown in Gibson County, Indiana, in 1987.

Nine specimens of the paper pondshell were collected live at six sites in the Tippecanoe River in 1987 (see graph and Table 6). This species also was represented as shells at sites 2 and 15, and thus may be found in suitable habitat throughout the drainage.



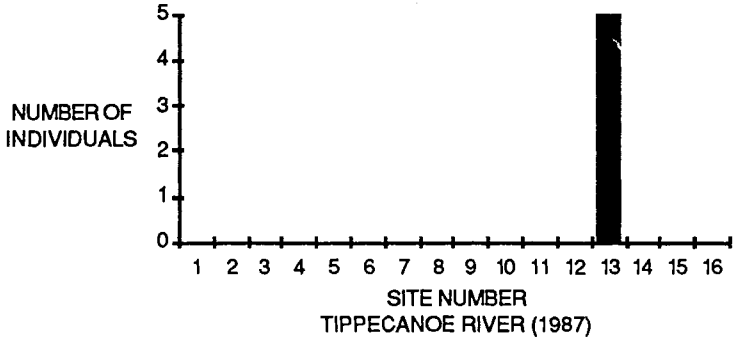
Anodonta suborbiculata Say, 1831 - flat floater

Anodonta suborbiculata Say: Call 1894:152; 1896:141; 1897:251; 1899:532; Daniels 1903:649; Goodrich & van der Schalie 1944:311; Meyer 1974:22; Clark 1976:4.

The flat floater was noted by Call (1899) to inhabit muddy bayous, backwaters, and oxbow lakes along the Wabash River. It was not collected in the lower Wabash River by Meyer (1974), Clark (1976), or during the present survey. However, the INHS Mollusc Collection has received many specimens from Dr. Brooks M. Burr and associates (Southern Illinois University - Carbondale) from a survey they conducted in the backwater ponds and oxbows of the Ohio and Wabash rivers in Illinois in 1986, and it is likely that it occurs in those same habitats in southern Indiana.

This species was collected from only one location in the Tippecanoe River in 1987 (see graph below and Table 6). These specimens were found in a small backwater area just below Oakdale Dam at the Lake Freeman spillway.

Anodonta suborbiculata Say, 1831
flat floater



Anodontoides ferussacianus (I. Lea, 1834) - cylindrical papershell

Anodonta ferruginea Lea: Call 1894:152; 1897:251.
Anodonta ferussaciana Lea: Call 1894:152; 1896:140; 1897:251.
Anodonta subcylindracea Lea: Call 1894:152; 1896:141; 1897:251; 1899:530.
Anodontoides ferussacianus (Lea): Daniels 1903:649; Goodrich & van der Schalie 1944:311; Meyer 1974:22; Clark 1976:4.
Anodontoides ferussacianus subcylindraceus (Lea): Daniels 1903:650.

Call (1899) reported this species from the Wabash River in Indiana but did not give specific locality data. Goodrich and van der Schalie (1944) described the distribution of *A. ferussacianus* as statewide in creeks and headwaters. No specimens of the cylindrical papershell were found in the 1966-67, 1976, or 1987 surveys of the lower Wabash River.

The only living specimen was collected at site 12 in the Tippecanoe River in 1987, and a dead shell was found at site 6.

Arcidens confragosus (Say, 1829) - rock pocketbook

Margaritana confragosa Say: Call 1894:152; 1896:141; 1897:251; 1899:520.
Arcidens confragosus (Say): Daniels 1903:650; Goodrich & van der Schalie 1944:311; Meyer 1974:22; Clark 1976:4.

Call (1899) noted *A. confragosus* as being limited to, but common in, the Wabash River in Indiana. Daniels (1903) listed Lafayette, Terre Haute, New Harmony, and ponds in Posey County as sites for this species in Indiana. It was not collected in 1966-67 or 1975 (Meyer 1974; Clark 1976). One specimen was collected at Mink Island, Posey County, in the lower Wabash River in 1987.

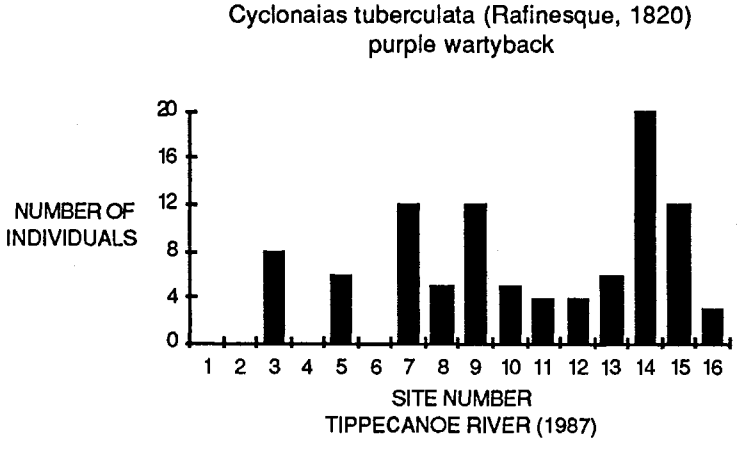
Not found in the Tippecanoe River.

Cyclonaias tuberculata (Rafinesque, 1820) - purple wartyback

Unio graniferus Lea: Call 1894:154; 1896:144; 1897:252; 1899:488.
Unio verrucosus Barnes: Call 1894:156; 1896:146; 1897:252; 1899:491.
Quadrula tuberculata (Rafinesque): Daniels 1903:652.
Quadrula granifera (Lea): Daniels 1903:652.
Cyclonaias tuberculata (Rafinesque): Goodrich & van der Schalie 1944:306; Meyer 1974:22; Clark 1976:4.

Call (1899) reported this species under two names but said both were common in the Wabash River. It was not found in either 1966-67 or 1975 (Meyer 1974; Clark 1976), and only shells were collected at three widely scattered sites in 1987 (Table 4).

The purple wartyback was common in the Tippecanoe River in 1987. Ninety-seven specimens were collected from 12 of the 16 sites surveyed and it ranked 6th in order of abundance for all species found (see graph below and Tables 6 & 7). It was especially common at site 14 and was the dominant species at that station.



Ellipsaria lineolata (Rafinesque, 1820) - butterfly

Unio securis Lea: Call 1894:155; 1896:146; 1897:252.
Unio lineolatus Rafinesque: Call 1899:469.
Plagiola securis (Lea): Daniels 1903:648.
Plagiola lineolata (Rafinesque): Goodrich & van der Schalie 1944:318; Meyer 1974:23; Clark 1976:4.

Stated by Goodrich and van der Schalie (1944) to be confined primarily to the larger rivers of the state, the butterfly was not collected in the 1966-67, 1975, or 1987 surveys of the lower Wabash River (Meyer, 1974; Clark, 1976). Probably extirpated from the lower Wabash.

Not collected in the Tippcanoe River in 1987.

Elliptio crassidens (Lamarck, 1819) - elephant-ear

Unio crassidens Lamarck: Call 1894:153; 1896:143; 1897:251; 1899:509; Daniels 1903:650.
Elliptio crassidens (Lamarck): Goodrich & van der Schalie 1944:307; Meyer 1974:22; Clark 1976:4.

Reported to be rare in the larger rivers that drain the southern portion of the state (Goodrich & van der Schalie, 1944), this species was not collected in the lower Wabash in 1966-67 (Meyer, 1974). However, it was listed as common in the same stretch of river in 1975 (Clark, 1976). Spot collecting in 1984-85 yielded two live specimens, one from 1.5 mi E Maunie and another from Mt. Carmel. In 1987, only old dead shells were found at eight sites in the lower Wabash. The elephant-ear is still present in the Ohio River in Illinois. Its status in the lower Wabash is rare.

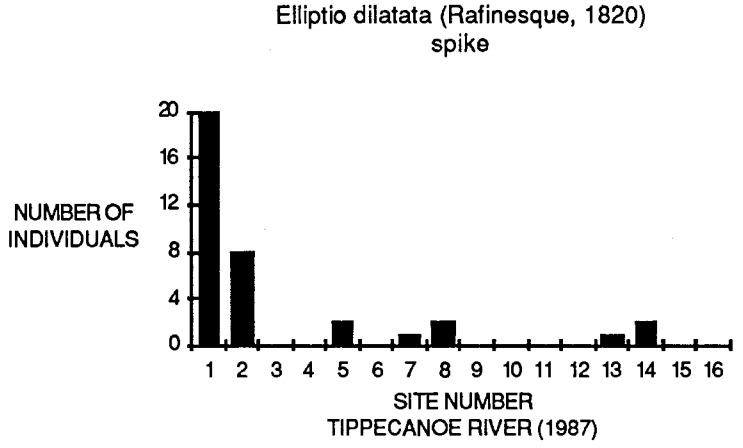
Reported by Daniels (1903) in the Tippecanoe River, there was no evidence of the elephant-ear in the collections of 1987.

Elliptio dilatata (Rafinesque, 1820) - spike

Unio arctior Lea: Call 1894:153; 1897:251.
Unio gibbosus Barnes: Call 1894:154; 1896:143; 1897:252; 1899:450; Daniels 1903:650.
Elliptio dilatatus (Rafinesque): Goodrich & van der Schalie 1944:306; Meyer 1974:22; Clark 1976:4.

Call (1899) noted that the spike was one of the most abundant species found in the Wabash River. Likewise, Goodrich and van der Schalie (1944) reported this species as among the most common in Indiana. However, by 1966-67 only weathered valves were collected from the East Fork of the White River near Shoals (Meyer, 1974) and Clark (1976) did not list this species in 1975. Only sub-fossil valves were found in 1987, and it is probable that this species is extirpated from the lower Wabash River.

E. dilatata is doing much better in the Tippecanoe River than in the lower Wabash. Thirty-five individuals from six sites were collected (see graph below and Table 6). It was most common in the headwaters (sites 1 & 2), but was found downstream to site 14. The spike was the third most abundant species found at site 1 and ranked 15th overall for the drainage (Table 7).



Fusconaia ebena (I. Lea, 1831) - ebonyshell

Unio ebenus Lea: Call 1894:154; 1896:143; 1897:251; 1899:503.
Quadrula ebenus (Lea): Daniels 1903:652.
Fusconaia ebenus (Lea): Goodrich & van der Schalie 1944:307; Meyer 1974:22; Clark 1976:4.

The ebonyshell was reported from Grand Chain in Posey County by Daniels (1903). Goodrich and van der Schalie (1944) noted its presence in the large streams of Indiana and mentioned the Wabash River at New Harmony specifically. *F. ebena* was reported as rare in the lower Wabash by Meyer (1968; 1974) and Clark (1976). Six specimens were collected from three sites in 1987 and ranked 8th in order of abundance for all species collected (Table 7).

Not present in the Tippecanoe River.

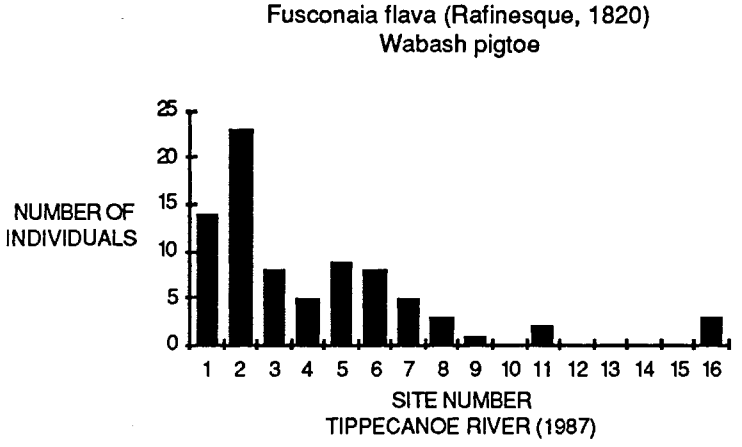
Fusconaia flava (Rafinesque, 1820) - Wabash pigtoe

Unio rubiginosus Lea: Call 1894:155; 1896:146; 1897:252; 1899:505.
Unio trigonus Lea: Call 1894:155; 1896:146; 1897:252; 1899:504.
Quadrula rubiginosa (Lea): Daniels 1903:652.
Quadrula trigona (Lea): Daniels 1903:652.
Fusconaia flava (Rafinesque): Goodrich & van der Schalie 1944:307; Clark 1976:4.
Fusconaia undata (Barnes): Goodrich & van der Schalie 1944:307; Meyer 1974:22; Clark 1976:4.

This variable species has two forms (compressed in headwaters and inflated in large rivers) and has been known under various names in the literature. Reported as common by Call (1899) and others (Daniels, 1903; Goodrich & van der Schalie, 1944), it was listed as rare by Meyer (1974) and Clark (1976). Only one live specimen was collected in 1987 and it should be considered rare in the lower Wabash.

Listed from the Tippecanoe River in 1903 (Daniels), 81 individuals of *F. flava* were collected in 1987 (Table 6). It was found at 11 of 16 sites and ranked 8th in order of abundance for all species

in the river. It was most common in the headwaters (see graph below) and disappeared from collections below the reservoirs until site 16.

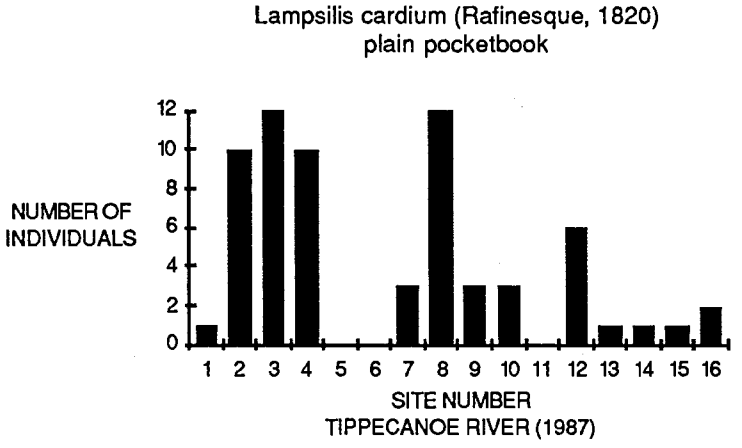


Lampsilis cardium (Rafinesque, 1820) - plain pocketbook

Unio occidens Lea: Call 1894:154; 1896:145.
Unio ventricosus Barnes: Call 1894:156; 1896:146; 1899:480.
Lampsilis ventricosus (Barnes): Daniels 1903:647.
Lampsilis ventricosa (Barnes): Goodrich & van der Schalie 1944:23; Meyer 1974:23; Clark 1976:4.

Earlier workers (Call, 1899; Daniels, 1903; Goodrich & van der Schalie, 1944) have stated that the plain pocketbook was common statewide and was considered to be common in the lower Wabash by Meyer (1974). However, by 1975, Clark (1976) found *L. cardium* to be uncommon. While common in many streams in Illinois, this species was not found live in the lower Wabash River in 1987. Dead shells were collected from nine sites, but many of these were weathered. Its status in this section of the river should be considered rare.

This species was common in the Tippecanoe River in 1987. Sixty-five individuals were collected from 13 sites and *L. cardium* ranked 9th in order of abundance for all species collected (Tables 6 & 7). It was most common in the upper and middle portions of the stream, but was present throughout the drainage (see graph below).

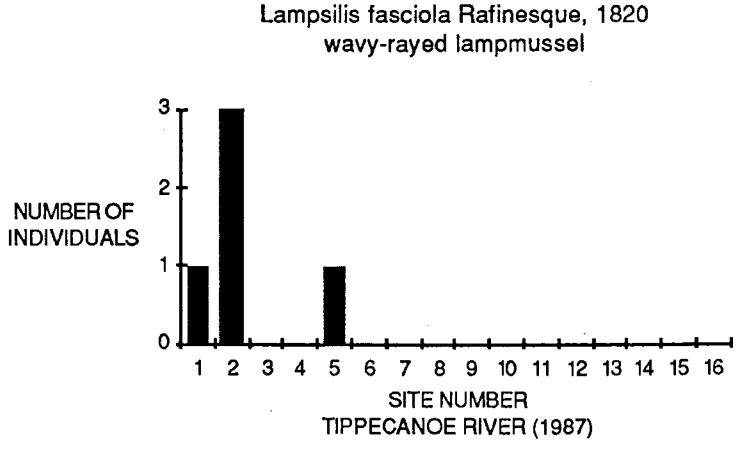


Lampsilis fasciola Rafinesque, 1820 - wavy-rayed lampmussel

Unio multiradiatus Lea: Call 1894:154; 1896:144; 1897:252;1899:479.
Lampsilis multiradiatus (Lea): Daniels 1903:647.
Lampsilis fasciola Rafinesque: Goodrich & van der Schalie 1944:315; Meyer 1974:22; Clark 1976:4.

Call (1899) reported this species as abundant in the Wabash River. Goodrich and van der Schalie (1944) noted that *L. fasciola* was a small-stream species and that it was relatively rare in the large rivers of the state. Not found in 1966-67 (Meyer, 1974), 1975 (Clark, 1976), or 1987, it is most likely extirpated in this portion of the drainage.

Reported by Daniels (1903) from the Tippecanoe River, the wavy-rayed lampmussel was collected from three sites in the upper portion of the river in 1987 (see graph below and Table 6). This species has been proposed for listing as endangered in Illinois and should be a species of special concern in Indiana.



Lampsilis ovata (Say, 1817) - pocketbook

Unio ovatus Say: Call 1894:155; 1897:252.
Unio subovatus Lea: Call 1894:155; 1896:146; 1897:252; 1899:481.
Lampsilis ovatus (Say): Daniels 1903:647.
Lampsilis ovata (Say): Goodrich & van der Schalie 1944:315; Clark 1976:4.
Lampsilis ventricosa (Barnes): Meyer 1974:23. (in part)

The pocketbook was reported from the Wabash River by both Call (1899) and Goodrich and van der Schalie (1944). This species was treated under *L. ventricosa* by Meyer (1974) in 1966-67 and thus the total number of *L. ovata* collected is unknown . Clark (1976) noted *L. ovata* as uncommon in the lower Wabash by 1975. In the present study, the pocketbook was collected as sub-fossil shells only, and it probably is extirpated from the lower part of the Wabash River drainage.

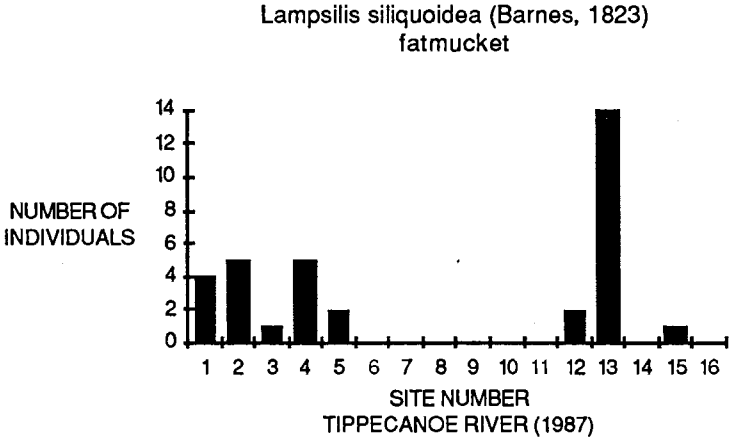
One shell of this species was collected in the Tippecanoe River in 1987. This seems to be far upstream and out of the range for this species in Indiana and it may in fact be *L. cardium*. These two species are very similar conchologically and they can be separated with certainty only by examination of the soft parts (Putnam, 1971). Its status in the Tippecanoe should be regarded as questionable.

Lampsilis siliquoidea (Barnes, 1823) - fatmucket

Unio distans Anthony: Call 1894:153; 1897:251.
Unio luteolus Lamarck: Call 1894:154; 1896:144; 1897:252; 1899:478.
Lampsilis luteolus (Lamarck): Daniels 1903:647.
Lampsilis siliquoidea (Barnes): Goodrich & van der Schalie 1944:315; Meyer 1974:23; Clark 1976:4.

Early workers (Call, 1899; Daniels, 1903; Goodrich & van der Schalie, 1944) list this species as common throughout Indiana. However, this species is usually restricted to medium to small streams and lakes and is rarely collected in large rivers. This probably accounted for the fact that no individuals of *L. siliquoidea* were collected in the lower Wabash in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976).

In the Tippecanoe River, 34 fatmuckets were collected from half of the sites sampled in 1987 (see graph below & Table 6). Most of the individuals came from below the spillway at Oakdale Dam or from the upstream portion of the drainage (sites 1-5). *L. siliquoidea* ranked 16th in order of abundance for all species collected in the drainage (Table 7).



Lampsilis teres (Rafinesque, 1820) - yellow sandshell

Unio anodontoides Lea: Call 1894:153; 1896:142; 1897:251.
Unio teres Rafinesque: Call 1899:452;
Lampsilis anodontoides (Lea): Daniels 1903:647; Goodrich & van der Schalie 1944:315; Meyer 1974:22; Clark 1976:4.
Lampsilis anodontoides fallaciosa (Simpson): Clark 1976:4.
Lampsilis fallaciosus (Simpson): Daniels 1903:647.

Goodrich and van der Schalie (1944) noted that in Indiana the yellow sandshell inhabits medium to large streams that flow into the Ohio. It was reported as common in the lower Wabash in 1966-67 (Meyer, 1974) but rare by 1975 (Clark, 1976). No live specimens of *L. teres* were found in 1987 and only sub-fossil shells were collected from the shoreline. It is probably extirpated in the lower Wabash River.

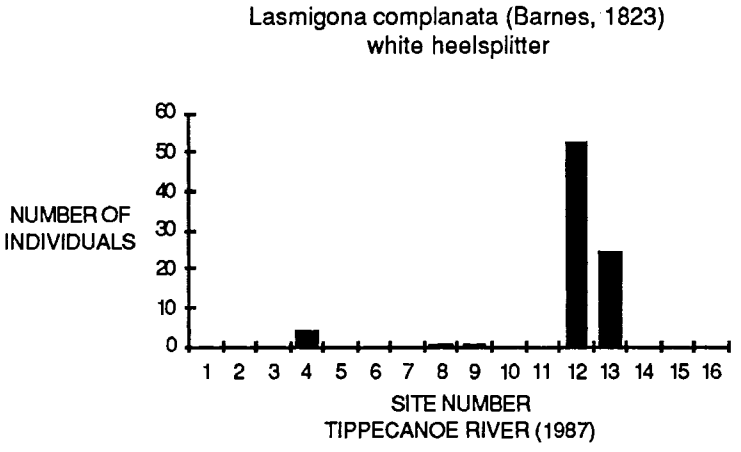
Daniels (1903) lists the Tippecanoe River in Carroll County as a location for *L. teres*. In Illinois, this species is found only in southern tributaries of the Wabash River (Embarras, Little Wabash and Saline rivers). Our collecting did not turn up any individuals of this species in the drainage and it should be considered rare.

Lasmigona complanata (Barnes, 1823) - white heelsplitter

Margaritana complanata Barnes: Call 1894:152; 1896:141; 1897:251; 1899:522.
Symphynota complanata (Barnes): Daniels 1903:650.
Lasmigona complanata (Barnes): Goodrich & van der Schalie 1944:312; Meyer 1974:23; Clark 1976:4.

Call (1899) and Goodrich and van der Schalie (1944) reported this species as common throughout Indiana. It was also common in the collections made in the lower Wabash in 1966-67 (Meyer, 1974). However, in 1975 the white heelsplitter was considered rare (Clark, 1976) and only three specimens were taken in 1987.

In the Tippecanoe, the white heelsplitter was found in quiet water areas below both spillways (Lake Shafer & Lake Freeman) and was the second most abundant species collected at sites 12 and 13. A total of 78 specimens were collected from these two sites alone (see graph below and Table 6) and *L. complanata* ranked 7th in order of abundance for all species from the Tippecanoe River in 1987 (Table 7).



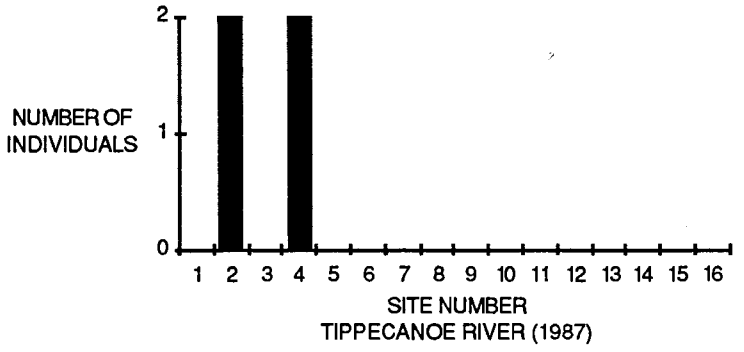
Lasmigona compressa (I. Lea, 1829) - creek heelsplitter

Unio pressus Lea: Call 1894:155; 1896:145; 1897:252;1899:459.
Symphynota compressa (Lea): Daniels 1903:650.
Lasmigona compressa (Lea): Goodrich & van der Schalie 1944:312 Meyer 1974:23; Clark 1976:4.

Both Call (1899) and Goodrich and van der Schalie (1944) reported this species as widespread in Indiana. It was not collected in the lower Wabash in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). As its common name implies, *L. compressa* is typically a headwater species and its absence in the lower Wabash is not surprising.

Reported by Daniels (1903) from the Tippecanoe River, four individuals were found at sites 2 and 4 in 1987 (see graph below & Table 6). This mussel is widespread but nowhere common in Illinois, and it has been proposed for listing as endangered there.

Lasmigona compressa (I. Lea, 1829)
creek heelsplitter



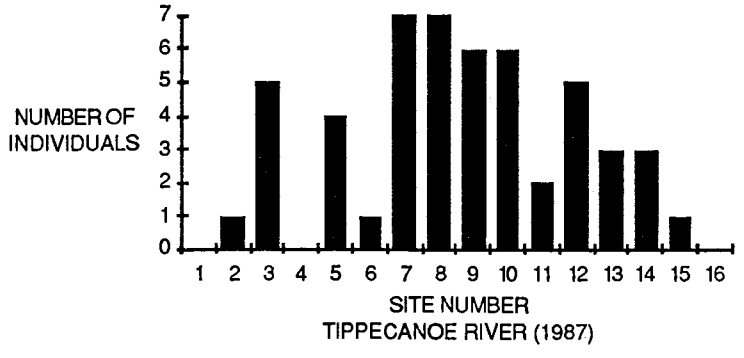
Lasmigona costata (Rafinesque, 1820) - fluted-shell

Margaritana rugosa Barnes: Call 1899:524.
Symphynota costata (Rafinesque): Daniels 1903:650.
Lasmigona costata (Rafinesque): Goodrich & van der Schalie 1944:312; Meyer 1974:23; Clark 1976:4.

The fluted-shell has been reported from every large stream and many of the smaller ones in Indiana (Call, 1899). It was not collected in 1966-67 or 1975 and only old dead shells were found in 1987 (Meyer, 1974, Clark, 1976).

Reported from the drainage by Daniels (1903), this species was widespread and common in the Tippecanoe River in 1987 (see graph below & Table 6). It was collected from every site but three and ranked 11th in abundance with 51 individulas collected (Table 7).

Lasmigona costata (Rafinesque, 1820)
fluted-shell

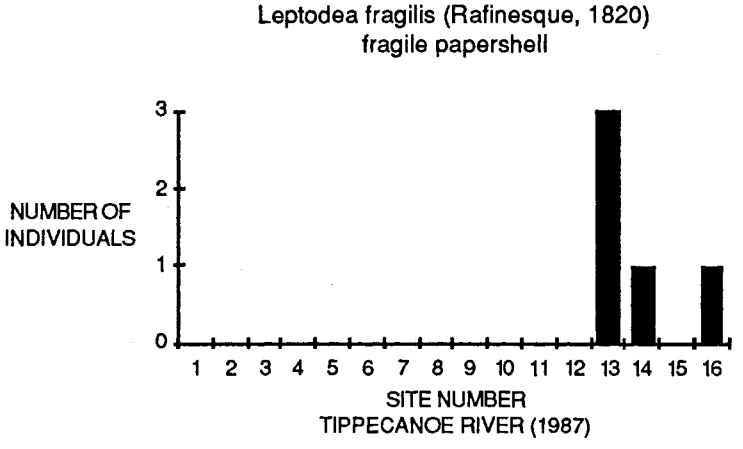


Leptodea fragilis (Rafinesque, 1820) - fragile papershell

Unio gracilis Barnes: Call 1894:154; 1896:143; 1897:252; 1899:464.
Lampsilis gragilis (Barnes): Daniels 1903:648.
Leptodea fragilis (Rafinesque): Goodrich & van der Schalie 1944:316; Meyer 1974:23; Clark 1976:4.

This is one of the most abundant species of mussels in the Wabash River drainage today. All of the earlier workers (Call, 1899; Daniels, 1903; Goodrich & van der Schalie, 1944; Meyer, 1974; Clark, 1976) considered this species to be common. It ranked 2nd in order of abundance in the lower Wabash in 1987 and is widespread in many of the southern tributaries of the drainage in Illinois (i.e., Embarras, Little Wabash and Saline rivers).

The fragile papershell is less common in the northern portion of the Wabash drainage. Records are lacking for the Vermilion and Little Vermilion rivers in Illinois. Only five individuals of this species were found in the Tippecanoe River in 1987 and all of these were below Oakdale Dam (see graph below & Table 6).



Ligumia recta (Lamarck, 1819) - black sandshell

Unio arquatus Conrad: Call 1894:153.
Unio rectus Lamarck: Call 1894:155; 1896:146; 1897:252; 1899:451.
Lampsilis rectus (Lamarck): Daniels 1903:647.
Ligumia recta latissima (Rafinesque): Goodrich & van der Schalie 1944:317; Clark 1976:4.
Ligumia recta (Rafinesque): Meyer 1974:23.

Goodrich and van der Schalie (1944) reported this species from all of the major drainages in the state and noted that it was generally associated with large rivers. However, neither Meyer (1974) nor Clark (1976) found evidence of this species in their surveys of the lower Wabash River and only one sub-fossil shell of *L. recta* was collected in 1987. The black sandshell is probably extirpated from the lower Wabash River.

Three live individuals of *L. recta* were collected from sites 13, 14, and 16 in the lower Tippecanoe River in 1987.

Ligumia subrostrata (Say, 1831) - pond mussel

Unio nasutus Say: Call 1894:154; 1897:252.
Unio subrostratus Say: Call 1894:155; 1896:146; 1897:252; 1899:457.
Lampsilis subrostratus (Say): Daniels 1903:647.
Ligumia subrostrata (Say): Goodrich & van der Schalie 1944:317.

Reported by Goodrich and van der Schalie (1944) from the Wabash River drainage in Indiana. As its common name implies, *L. subrostrata* is typically a pond or lake species which occasionally occupies backwater habitats in large rivers. It was not collected in 1966-67, 1975, or 1987 from the Wabash River. However, there are records for this species from bottomland lakes and sloughs adjacent to the Wabash and Ohio rivers in Illinois and it may be found in those habitats in Indiana.

Reported by Daniels (1903) from Tippecanoe Lake, *L. subrostrata* was not collected in the river in 1987. Based on museum records, this species is present in the drainage and probably occurs in the glacial lakes of the watershed.

Megalonaias nervosa (Rafinesque, 1820) - washboard

Unio heros Say: Call 1894:154.
Unio multiplicatus Lea: Call 1894:154; 1896:144; 1897:252; 1899:448.
Quadrula heros (Say): Daniels 1903:651.
Megalonaias gigantea (Barnes): Goodrich & van der Schalie 1944:308; Meyer 1974:23; Clark 1976:4.

The largest of the freshwater mussels in Indiana, the washboard was reported by Call (1899) as common in the Wabash and Ohio rivers. This important commercial species was not collected in the lower Wabash River by Meyer (1974), was considered rare by Clark (1976), and only one individual was taken at the mouth of the Wabash River in 1987. This, along with the disappearance of *Amblema plicata* as discussed above, may account for the inactivity of commercial musselers in the lower Wabash River today.

Obliquaria reflexa Rafinesque, 1820 - three-horn wartyback

Unio cornutus Barnes: Call 1894:153; 1896:142; 1897:251; 1899:466.
Obliquaria reflexa Rafinesque: Daniels 1903:649; Goodrich & van der Schalie 1944:318; Meyer 1974:23; Clark 1976:4.

The three-horn wartyback was reported by Call (1899) to be one of the most common mussels in Indiana, occurring wherever unionids are found. On the other hand, Goodrich and van der

Schalie (1944) stated that *O. reflexa* was found in mainly large rivers in small numbers. In the 1966-67 survey, Meyer (1974) considered *O. reflexa* to be rare in the lower Wabash, but by 1975, Clark (1976) listed it as abundant. In the 1987 survey of the lower Wabash, *O. reflexa* was the dominant mussel collected (Table 4). In fact, during low water collections, recently dead shells of this species were seen by the hundreds in middens along the shore.

Not collected in the Tippecanoe River in 1987.

Obovaria olivaria (Rafinesque, 1820) - hickorynut

Unio ellipsis Lea: Call 1894:154; 1896:143; 1897:251; 1899:495.
Obovaria ellipsis (Lea): Daniels 1903:648.
Obovaria olivaria (Rafinesque): Goodrich & van der Schalie 1944:318; Meyer 1974:23; Clark 1976:4.

The hickorynut is typically a large river species and was considered to be common in the Wabash River in Indiana (Goodrich & van der Schalie, 1944). Meyer (1974) reported *O. olivaria* common in the lower Wabash River in 1966-67 and Clark (1976) listed it as rather common in 1975. This species was the 5th most abundant species found in 1987 (Table 7) and recently dead shells of this species were numerous along the shore.

Not found in the Tippecanoe River in 1987.

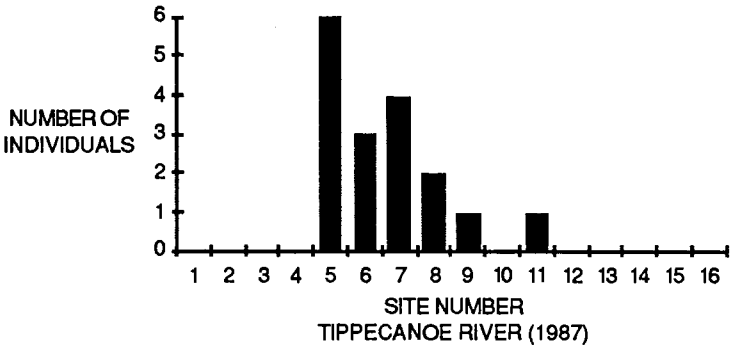
Obovaria subrotunda (Rafinesque, 1820) - round hickorynut

Unio circulus Lea: Call 1894:153; 1896:142; 1897:251; 1899:493.
Unio lens Lea: Call 1894:154; 1896:144; 1897:252.
Unio subrotundus Lea: Call 1894:155.
Obovaria circulus (Lea): Daniels, 1903:648.
Obovaria lens (Lea): Daniels 1903:648.
Obovaria subrotunda (Rafinesque): Goodrich & van der Schalie 1944:318; Meyer 1974:23; Clark 1976:4.

Both Call (1899) and Goodrich and van der Schalie (1944) reported the round hickorynut as numerous in the lower Wabash River. It was not collected in 1966-67, 1975, or 1987 in the lower portion of the drainage and is probably extirpated (Meyer, 1974; Clark, 1976).

Reported by Daniels (1903) in the Tippecanoe River, the round hickorynut was fairly common in 1987. Seventeen live individuals were found at six sites in the mid-portion of the drainage (see graph below and Table 6) and shells were located at sites 10 and 15. Nearly extirpated from Illinois, *O. surotunda* should receive special concern status in Indiana.

Obovaria subrotunda (Rafinesque, 1820)
round hickorynut



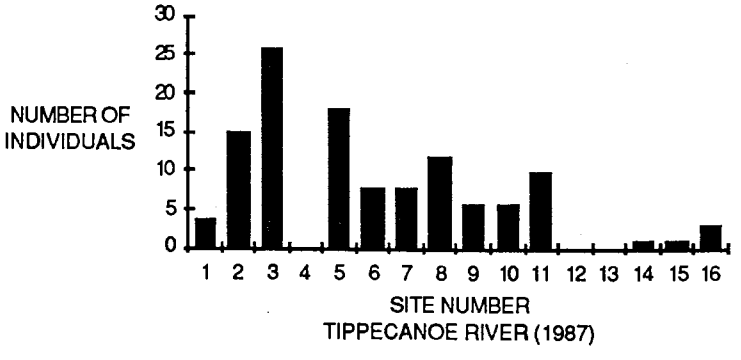
Pleurobema sintoxia (Rafinesque, 1820) - round pigtoe

Unio coccineus Lea: Call 1894:153; 1896:142; 1897:251; 1899:500.
Quadrula coccinea (Conrad): Daniels 1903:652.
Pleurobema cordatum (Rafinesque, 1820) (in part): Goodrich & van der Schalie 1944:309; Meyer, 1974:24.
Pleurobema cordatum coccineum (Lea): Clark 1976:5.

Earlier workers reported *P. sintoxia* as common throughout the state, but noted that it was more common in headwaters than in large rivers (Call, 1899; Goodrich & van der Schalie, 1944). The round pigtoe was not collected in 1975 (Clark, 1976) or in the present survey of the lower Wabash River.

P. sintoxia was the 4th most abundant species found in the Tippecanoe River in 1987 (Table 7). One hundred eighteen live individuals were collected from 13 sites throughout the drainage (see graph below and Table 6). Two of the three sites at which this species was not collected (sites 12 & 13) were at the spillways just below the reservoirs

Pleurobema sintoxia (Rafinesque, 1820)
round pigtoe

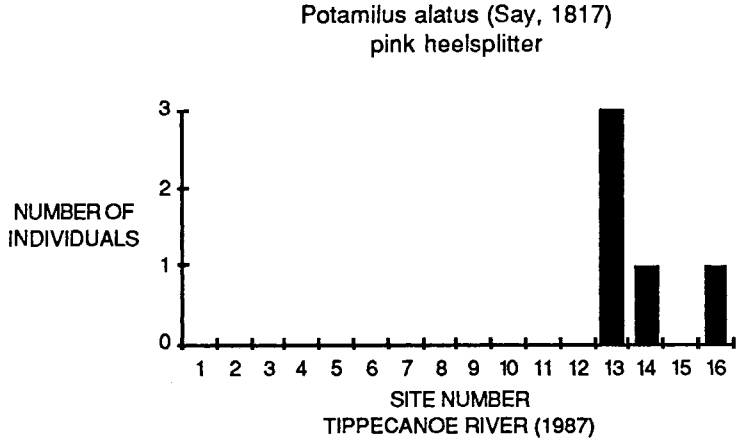


Potamilus alatus (Say, 1817) - pink heelsplitter

Unio alatus Say: Call 1894:153; 1896:142; 1899:461.
Lampsilis alatus (Say): Daniels 1903:648.
Proptera alata (Say): Goodrich & van der Schalie 1944:319; Meyer 1974:24; Clark 1976:5.

Reportedly common in the lower Wabash River in 1944 (Goodrich & van der Schalie) and 1966-67 (Meyer, 1974), this species was listed as rare in 1975 (Clark, 1976). Only two live individuals were found in 1987.

In the Tippecanoe River, the pink heelsplitter was found live at three sites (all below the reservoirs) and no shells were collected in the upstream portion of the drainage (see graph below and Table 6).



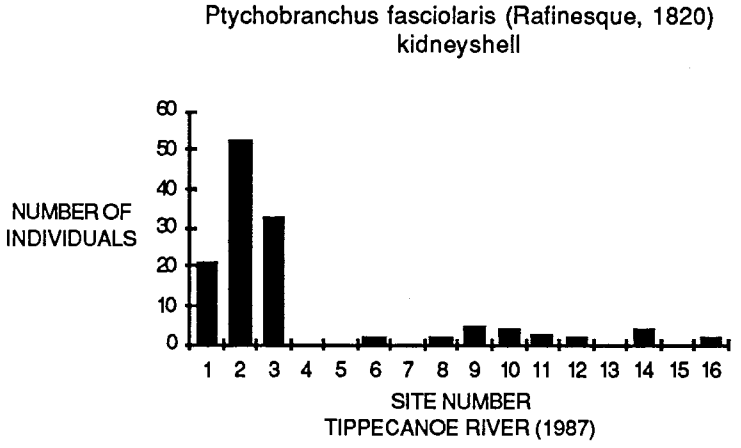
Ptychobranchus fasciolaris (Rafinesque, 1820) - kidneyshell

Unio camelus Lea: Call 1894, 153; 1896:142.
Unio phaseolus Barnes: Call 1894:153; 1896:145.
Unio phaseolus Hildreth: Call 1899:454.
Ptychobranchus phaseolus (Hildreth): Daniels 1903:649.
Ptychobranchus fasciolaris (Rafinesque): Goodrich & van der Schalie 1944:319; Meyer 1974:24; Clark 1976:5.

Reported by Call (1899) to be abundant in the Wabash River. Goodrich and van der Schalie (1944) noted that this species was usually found in small streams and was rare in large rivers. Not collected in 1966-67, 1975, or 1987 in the lower Wabash River, the kidneyshell is probably extirpated from this portion of the drainage (Meyer, 1974, Clark, 1976).

Reported by Daniels (1903) in the Tippecanoe River, *P. fasciolaris* was widespread and common in 1987. The kidneyshell was found from sites 1 to 16 but was most common in the upstream

portion of the river and was the dominant species found at sites 2 and 3 (see graph below and Table 6). This species ranked 3rd in abundance for the river as a whole with 132 individuals collected (Table 7). The size of the Tippecanoe population is encouraging inasmuch as this species has been proposed for listing as endangered in Illinois and is nearly extirpated there.



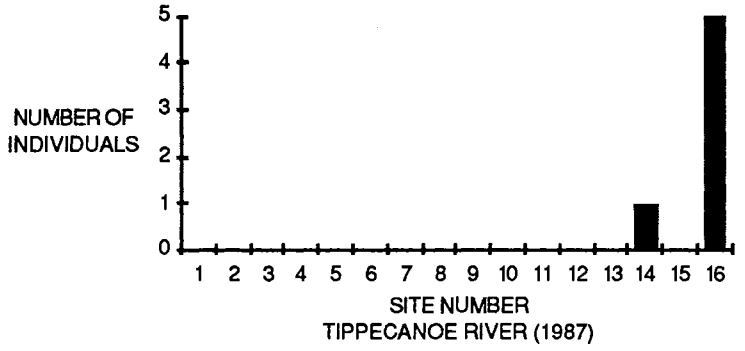
Quadrula metanevra (Rafinesque, 1820) - monkeyface

Unio metanevrus Rafinesque: Call 1894:154; 1896:144; 1897:252; 1899:467.
Quadrula metanevra (Rafinesque): Daniels 1903:651; Goodrich & van der Schalie 1944:309; Meyer 1974:24; Clark 1976:5.
Quadrula metanevra wardii (Lea): Daniels 1903:651.

Reported as common in the Wabash River by Goodrich and van der Schalie (1944), the monkeyface was listed as rare in the lower Wabash by 1966-67 (Meyer, 1974). However in 1975, Clark (1976) noted that this species was rather common in his collections. *Q. metanevra* was found as old dead shells only from eight sites in 1987 and should be considered rare or extirpated in this portion of the drainage.

In the Tippecanoe River, the monkeyface was found only below the reservoirs at sites 14 and 16 (see graph below and Table 6). Like *P. alatus*, this species is usually associated with medium to large streams (Parmalee, 1967) and this may explain its absence in the upper portion of the drainage.

Quadrula metanevra (Rafinesque, 1820)
monkeyface



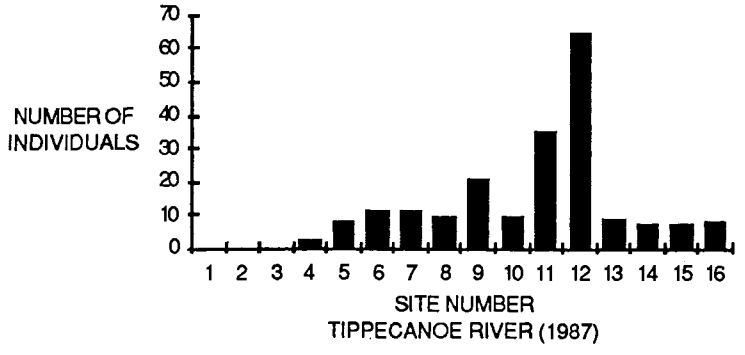
Quadrula pustulosa (I. Lea, 1831) - pimpleback

Unio dorfeuillianus Lea: Call 1894:154; 1897:251.
Unio pustulosus Lea: Call 1894:155; 1896:145; 1897:252; 1899:487.
Quadrula pustulosa (Lea): Daniels 1903:651; Goodrich & van der Schalie 1944:309; Meyer 1974:24; Clark 1976:5.

A widespread and common species in Indiana (Call, 1899; Goodrich & van der Schalie, 1944), the pimpleback was reported as abundant in 1966-67 and 1975 (Meyer, 1974; Clark, 1976). Although *Q. pustulosa* was collected live at only four sites, it was rather common in shell piles along the shore and on shoals throughout the lower Wabash River in 1987.

Reported as common in the Tippecanoe River in 1903 (Daniels), the pimpleback was the most abundant species collected there in 1987 (Table 7). A total of 205 individuals were collected from 13 sites in the river. It was most common below the Lake Shafer spillway and was the dominant species collected from that site (see graph below and Table 6).

Quadrula pustulosa (I. Lea, 1831)
pimpleback

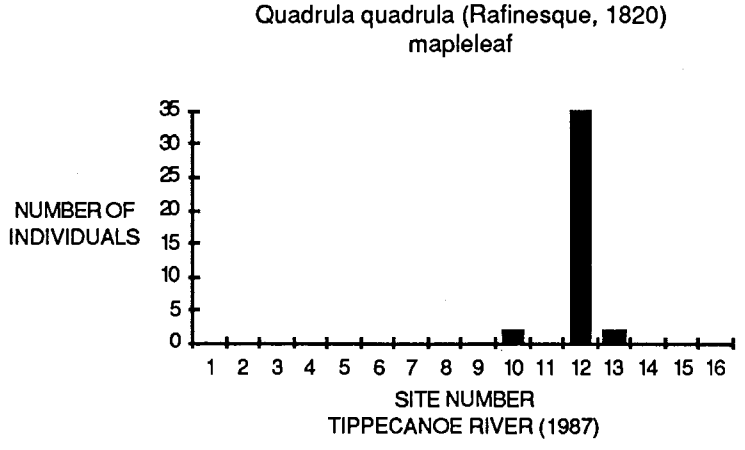


Quadrula quadrula (Rafinesque, 1820) - mapleleaf

Unio asperrimus Lea: Call 1894:153; 1896:142; 1897:251.
Unio fragosus Conrad: Call 1894;154; 1896:143; 1897:252; 1899:490.
Unio lachrymosus Lea: Call 1894:154; 1897:252; Call, 1899:489.
Quadrula lachrymosa (Lea): Daniels 1903:651.
Quadrula fragosa (Conrad): Daniels 1903:651.
Quadrula quadrula (Rafinesque): Goodrich & van der Schalie 1944:310; Meyer 1974:24; Clark 1976:5.

As with *Q. pustulosa*, the mapleleaf was reported as widespread and common throughout Indiana (Call, 1899; Goodrich & van der Schalie, 1944) and was listed as abundant in 1966-67 and 1975 (Meyer, 1974; Clark, 1976). In the 1987 survey, it was the third most common species collected in the lower Wabash and was present as fresh dead shells from many of the shoreline samples.

In the Tippecanoe River, *Q. quadrula* was found at three sites and was common only below the Lake Shafer spillway (see graph below and Table 6). This species adapts well to a lake habitat (Parmalee, 1967) and is probably common in lakes Shafer and Freeman.

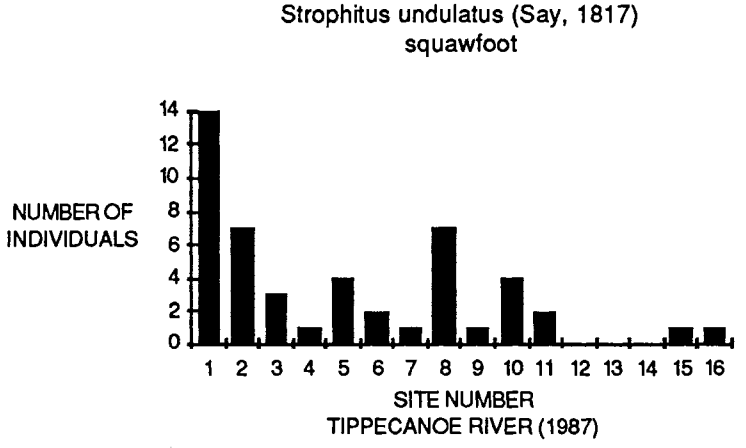


Strophitus undulatus (Say, 1817) - squawfoot

Anodonta edentula Say: Call 1894:152; 1896:140; 1897:251; 1899:529.
Anodonta pavonia Lea: Call 1894:152; 1896:141; 1897:251.
Anodonta shaefferiana Lea: Call 1894:152; 1897:251.
Anodonta undulata Say: Call 1896:141; 1897:251.
Anodonta wardiana Lea: Call 1894:152; 1896:141; 1897:251; 1899:528.
Margaritana rugosa Barnes: Call 1894:153; 1896:142; 1897:251.
Strophitus edentulus (Say): Daniels 1903:649.
Strophitus endentulus pavonius (Lea): Daniels 1903:649.
Strophitus rugosus (Swainson): Goodrich & van der Schalie 1944:312; Meyer 1974:24; Clark 1976:5.

The squawfoot was reported as common throughout Indiana but was most abundant in headwaters and rare in large rivers (Goodrich & van der Schalie, 1944). *S. undulatus* was not collected in the lower Wabash in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976).

The squawfoot is also associated with lentic habitats and was reported by Daniels from Tippecanoe Lake. This species was found at almost every site in the Tippecanoe in 1987 but was more common in the upper portion of the river. It was absent from sites 12 and 13 below the spillways (see graph below and Table 6).

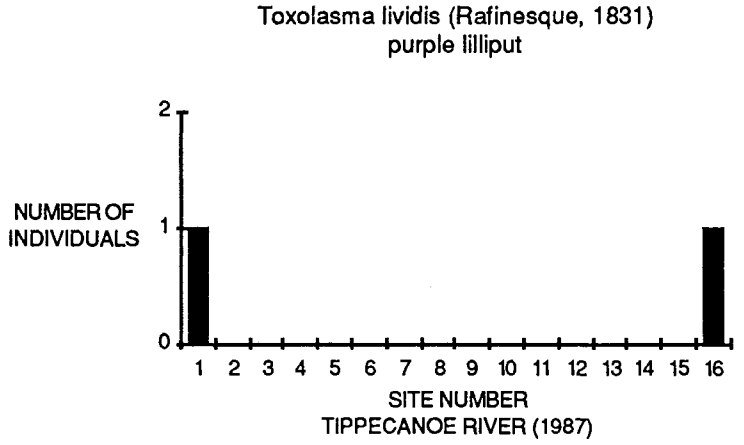


Toxolasma lividis (Rafinesque, 1831) - purple lilliput

> *Unio glans* Lea: Call 1894:154; 1896:143; 1897:252; 1899:514.
> *Lampsilis glans* (Lea): Daniels 1903:648.
> *Carunculina glans* (Lea): Goodrich & van der Schalie 1944:313; Meyer 1974:22; Clark 1976:4.

Although reported from the Wabash River by Goodrich and van der Schalie (1944), this species is characteristic of small high gradient streams and was not collected in the lower Wabash in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976).

The purple lilliput was found throughout the Tippecanoe River, but was taken live only at sites 1 and 16 (see graph below and Table 6). Given the small size of this mussel and the presence of recently dead shells at many of the sites, it is probably more widespread than our collections indicate. However, Stansbery (1970) regards *T. lividus* as on the verge of extinction. It has been proposed for listing as endangered in Illinois and should be given at least threatened or species of special concern status in Indiana.



Toxolasma parvus (Barnes, 1823) - lilliput

Unio parvus Barnes: Call 1894:155; 1896:145; 1897:252; 1899:512;
Lampsilis parvus (Barnes): Daniels 1903:648.
Carunculina parva (Barnes): Goodrich & van der Schalie 1944:313; Meyer 1974:22; Clark 1976:4.

Unlike the purple lilliput, which inhabits gravel bottomed streams with good current, *T. parvus* is often found in lakes and quiet water areas in streams. Although reported from the lower Wabash River at New Harmony (Goodrich & van der Schalie, 1944), *T. parvus* is most commonly found in smaller rivers. It was not found in the lower Wabash River 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976).

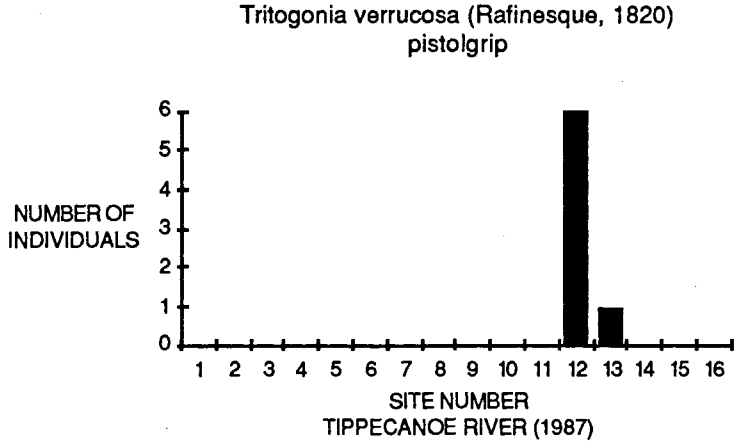
The lilliput was collected at two sites in the Tippecanoe River in 1987, but was live only at site 4 (Table 6). Its apparent rarity may be due to its small size or to its preference for lower gradient streams.

Tritogonia verrucosa (Rafinesque, 1820) - pistolgrip

Unio tuberculatus Barnes: Call 1894:155; 1896:146; 1897:252; 1899:465.
Tritogonia tuberculatus (Barnes): Daniels 1903:649.
Tritogonia verrucosa (Barnes): Goodrich & van der Schalie 1944:310; Meyer 1974:24; Clark 1976:5.

Reported from the larger rivers of southern Indiana (Goodrich & van der Schalie, 1944), the pistolgrip was not collected in the lower Wabash in 1966-67 (Meyer, 1974) and Clark (1976) listed the species as uncommon in his collections. In 1987, *T. verrucosa* was found live at four sites throughout the lower Wabash and should be considered uncommon to rare in this portion of the river.

In the Tippecanoe River, the pistolgrip was collected live from sites 12 and 13 below the spillways (see graph below and Table 6).



Truncilla donaciformis (I. Lea, 1828) - fawnsfoot

Unio donaciformis Lea: Call 1894:154; 1896:143; 1897:251; 1899:472.
Unio zigzag Lea: Call 1894:156; 1897:252.
Plagiola donaciformis (Lea): Daniels, 1903:648.
Truncilla donaciformis (Lea): Goodrich & van der Schalie 1944:319; Meyer 1974:24; Clark 1976:5.

The fawnsfoot was reported as relatively rare in Indiana, but present in the Ohio, Wabash and White rivers (Goodrich & van der Schalie, 1944). It was not collected in 1966-67 (Meyer, 1964) and was listed as rare in the lower Wabash in 1975 (Clark, 1976). Although only one live individual of *T. donaciformis* was collected in 1987, it was fairly common in a collection made at Mt. Carmel in 1984-85. Its apparent rarity may be due to the fact that this species will not be picked up on a brail and, due to its small size, is sometimes difficult to locate by hand sampling.

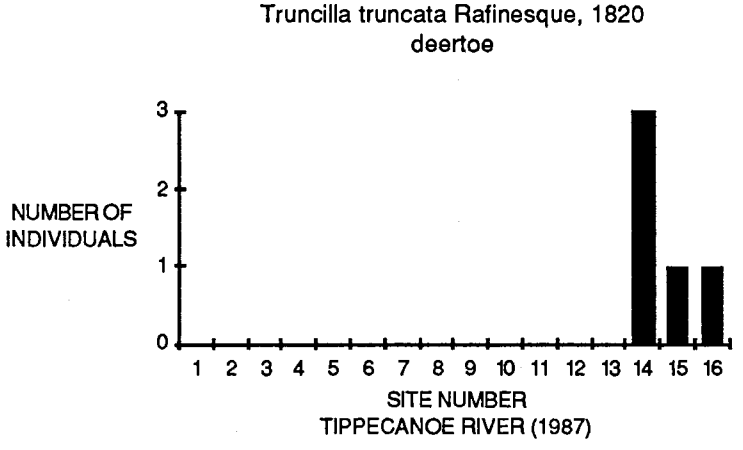
Reported from the Tippecanoe River by Daniels (1903), only dead shells of this species were collected (site 16) in 1987, but more collecting in the lower part of the river will probably turn up live specimens.

Truncilla truncata Rafinesque, 1820 - deertoe

Unio elegans Lea: Call 1894:154; 1896:143; 1897:251; 1899:471.
Plagiola elegans (Lea): Daniels 1903:648.
Truncilla truncata Rafinesque: Goodrich & van der Schalie 1944:319; Meyer 1974:24; Clark 1976:5.

The deertoe was reported to be abundant in the Wabash River by Call (1899), but was found to be rare in the lower Wabash in 1966-67 and 1975 (Meyer, 1974; Clark, 1976). While only seven live specimens were collected in the lower Wabash in 1987, many fresh dead shells were found on the shoals and in middens along shore, suggesting that this species is relatively common in this section of the drainage today.

Reported by Daniels (1903) from the Tippecanoe River, live *T. truncata* were collected only in the downstream section of the river at sites 14, 15, and 16 (see graph below and Table 6).



Uniomerus tetralasmus (Say, 1831) - pondhorn

Unio camptodon Say: Call, 1894:153; 1896:142; 1897:251;
Unio tetralasmus Say: Call, 1899:517; Daniels 1903:650;
Unio tetralasmus sayi Ward: Daniels 1903:650.
Uniomerus tetralasmus (Say): Goodrich & van der Schalie 1944:310; Meyer 1974:24.

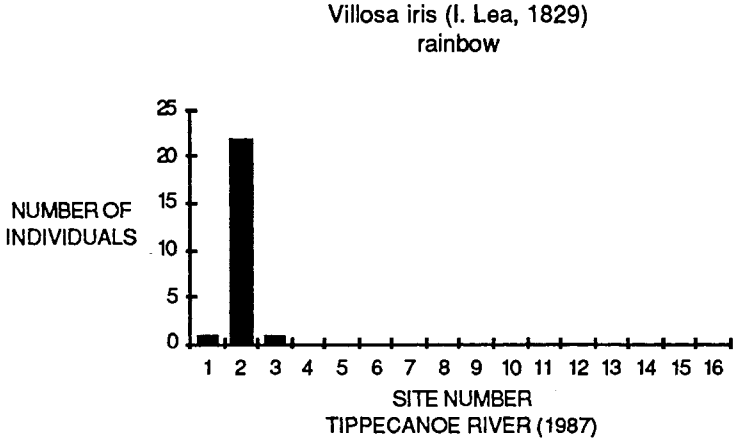
Reported from the Wabash River by Call (1899), this species was considered rare in Indiana by 1944 (Goodrich & van der Schalie, 1944). The pondhorn was not found in the lower Wabash River in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). This species usually is found in small streams or ponds and its absence in the lower Wabash is not surprising.

Not collected in the Tippecanoe River in 1987.

Villosa Iris (I. Lea, 1829) - rainbow

Unio iris Lea: Call 1894:154; 1896:144; 1897:252; 1899:456.
Lampsilis iris (Lea): Daniels 1903:647.
Micromya iris (Lea): Goodrich & van der Schalie 1944:317; Clark 1976:4.

Not reported from the Wabash River proper, this species does occur in the headwater streams of the drainage. A total of 24 individuals of *V. iris* were collected from sites 1, 2, and 3 in the Tippecanoe River in 1987 and it was the 3rd most abundant species collected from site 2 (see graph below and Table 6). The rainbow ranked 17th in overall abundance in the Tippecanoe (Table 7).



Villosa lienosa (Conrad, 1834) - little spectacle case

Unio nigerrimus Lea: Call 1896:144.
Lampsilis lienosus (Conrad): Daniels 1903:647.
Lampsilis nigerrimus (Lea): Daniels 1903:647.
Micromya lienosa (Conrad): Goodrich & van der Schalie 1944:317.
Villosa (=*Micromya*) *lienosa* (Conrad): Meyer 1974:24.

Although reported from the Wabash River in southern Indiana (Goodrich & van der Schalie, 1944), the little spectacle case is usually found only in small streams. *V. lienosa* was not collected in the lower Wabash River in 1966-67, 1975, or 1987 (Meyer, 1974; Clark, 1976). If this species ever existed in this section of the river it was probably rare.

Although not reported from or collected in the Tippecanoe River in 1987, this species is known from the Vermilion and Little Vermilion rivers in Illinois and specimens may turn up in the Tippecanoe.

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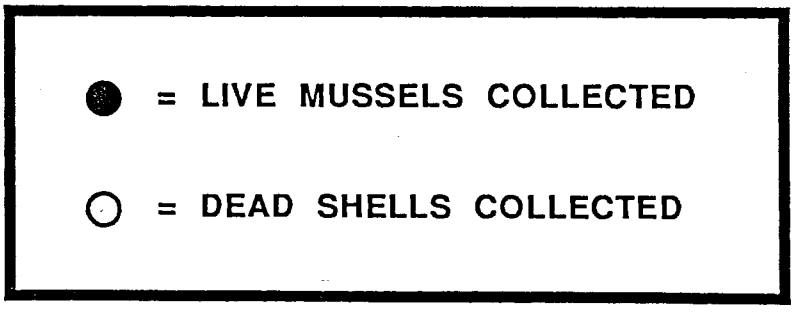
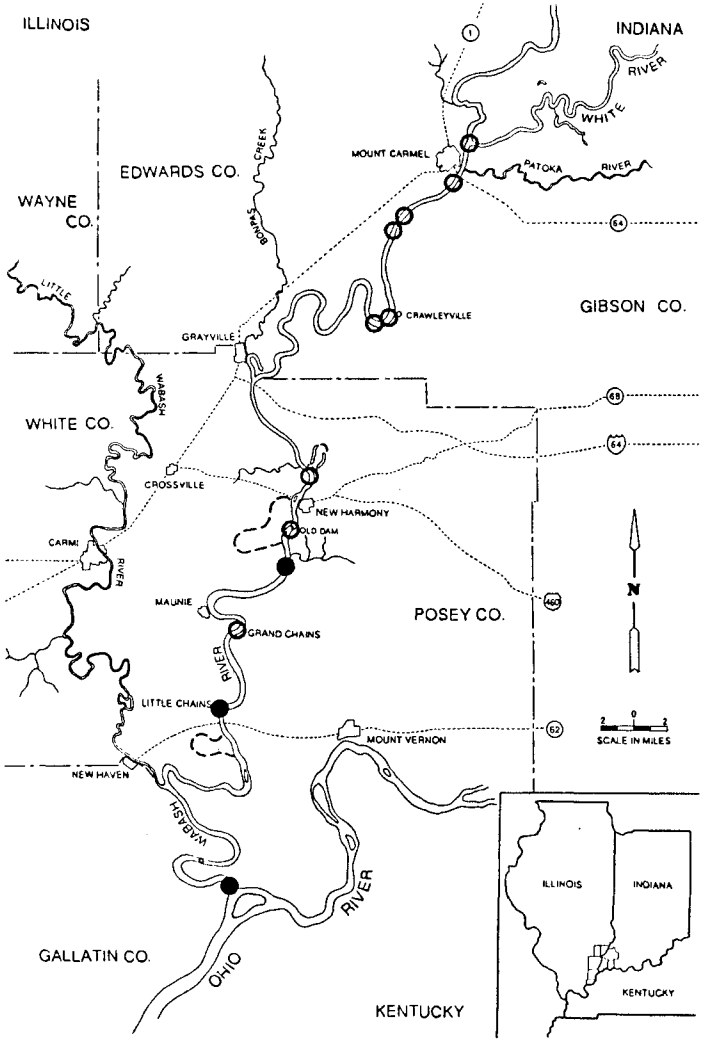
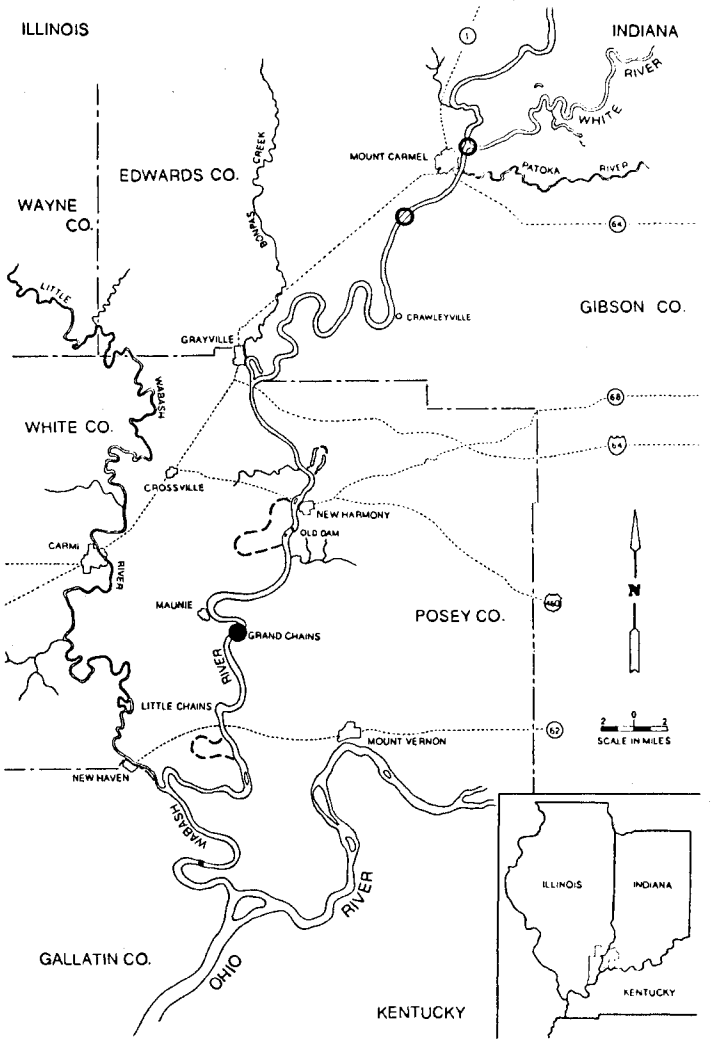
Appendix I

Distribution maps of unionids recorded from the lower Wabash River,1987.

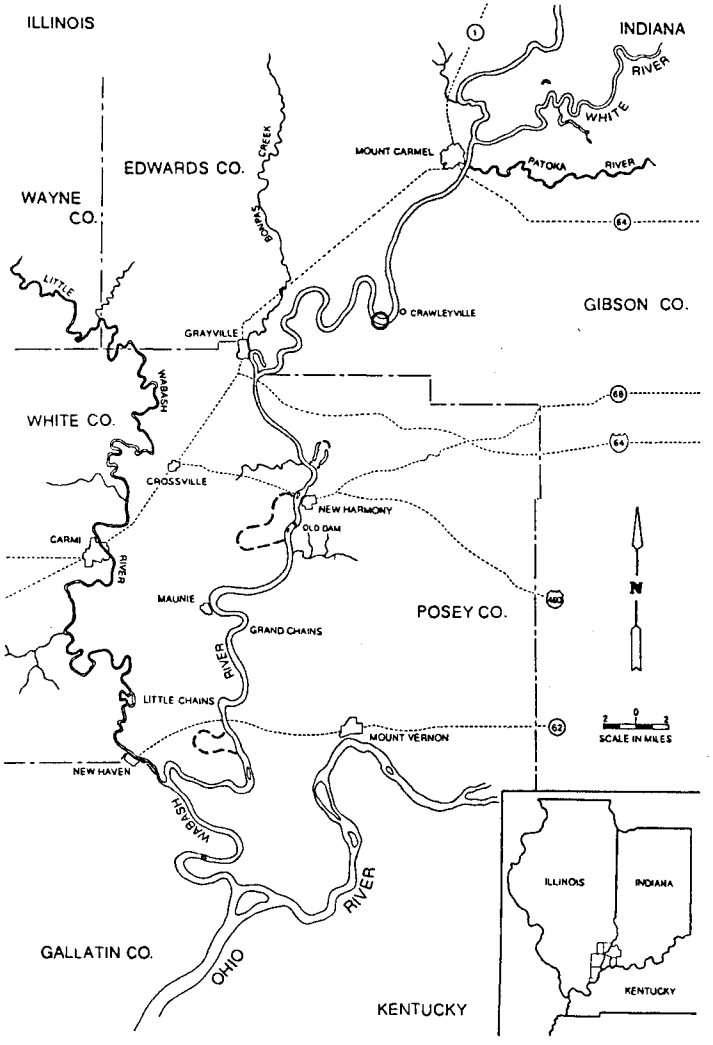




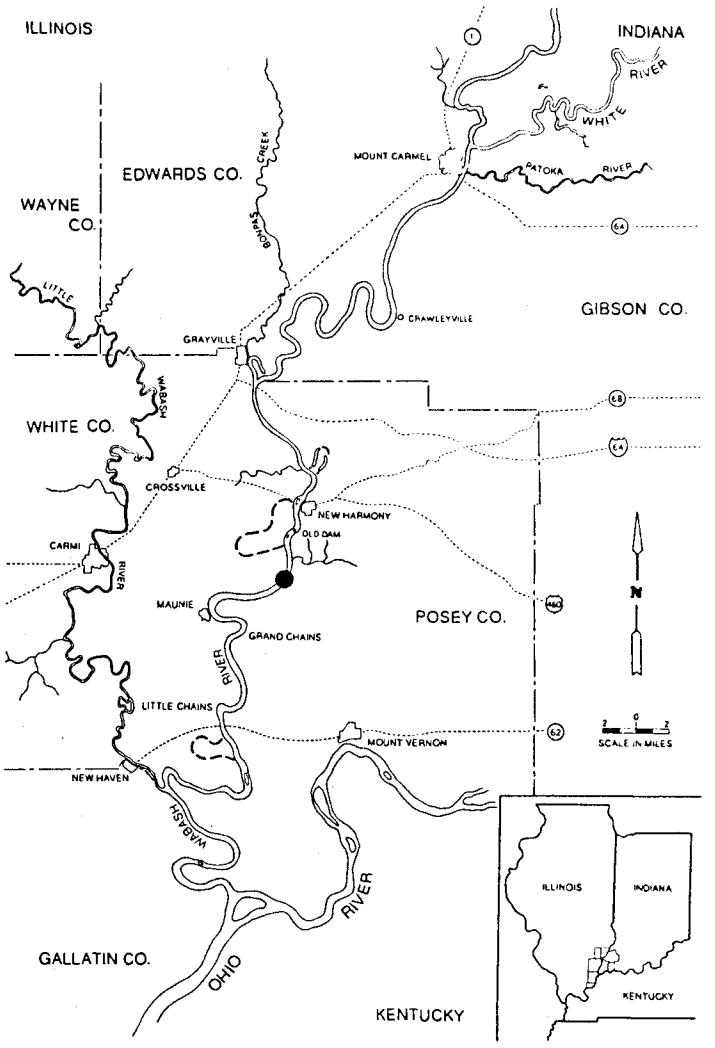
Amblema plicata (Say, 1817)
three-ridge



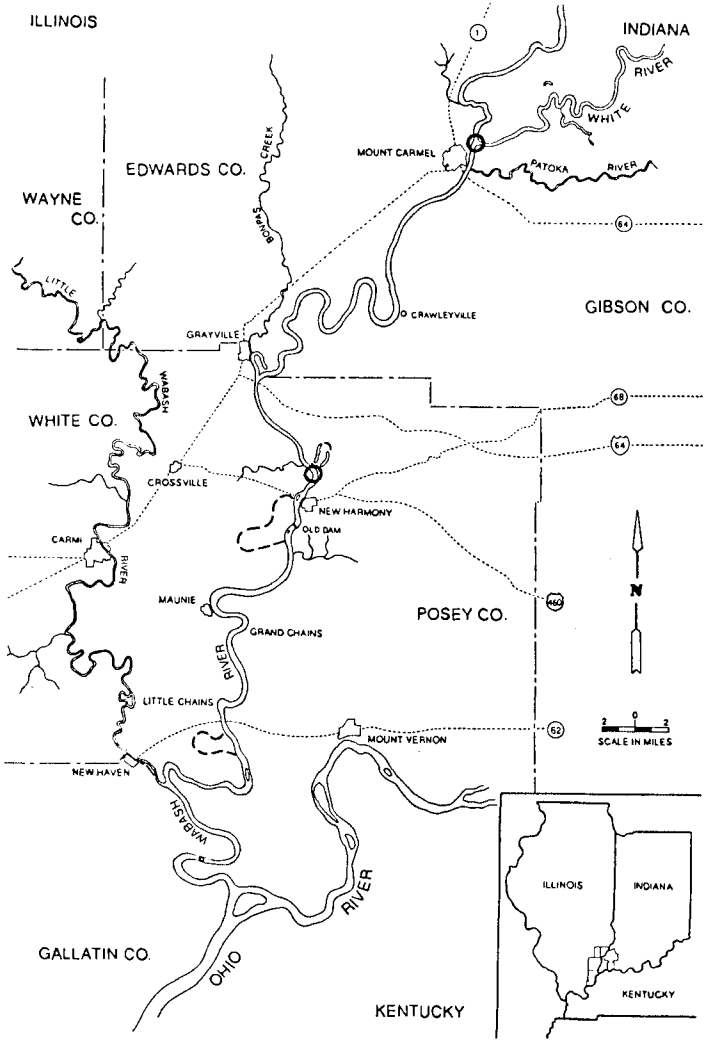
Anodonta grandis Say, 1829
giant floater



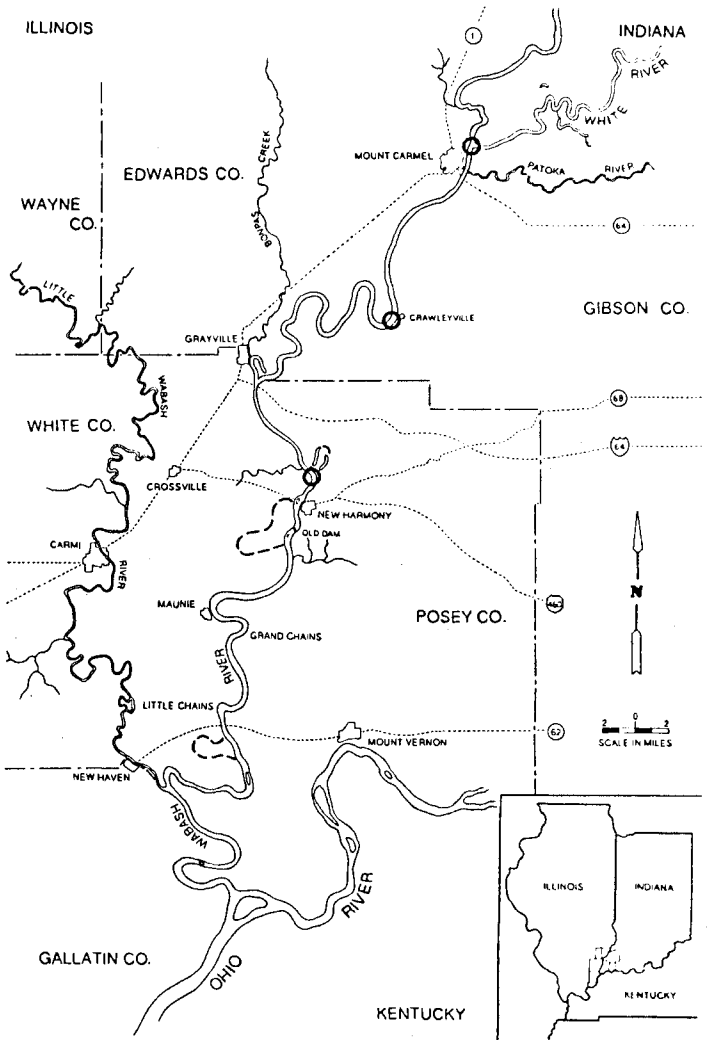
Anodonta imbecillis Say, 1829
paper pondshell



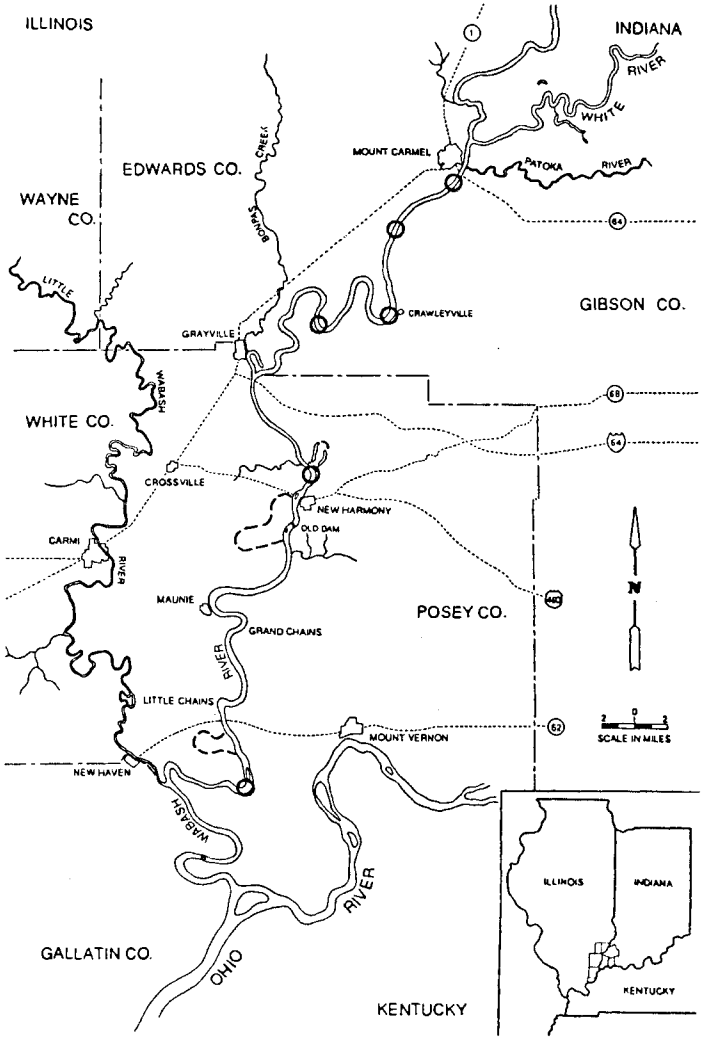
Arcidens confragosus (Say, 1829)
rock pocketbook



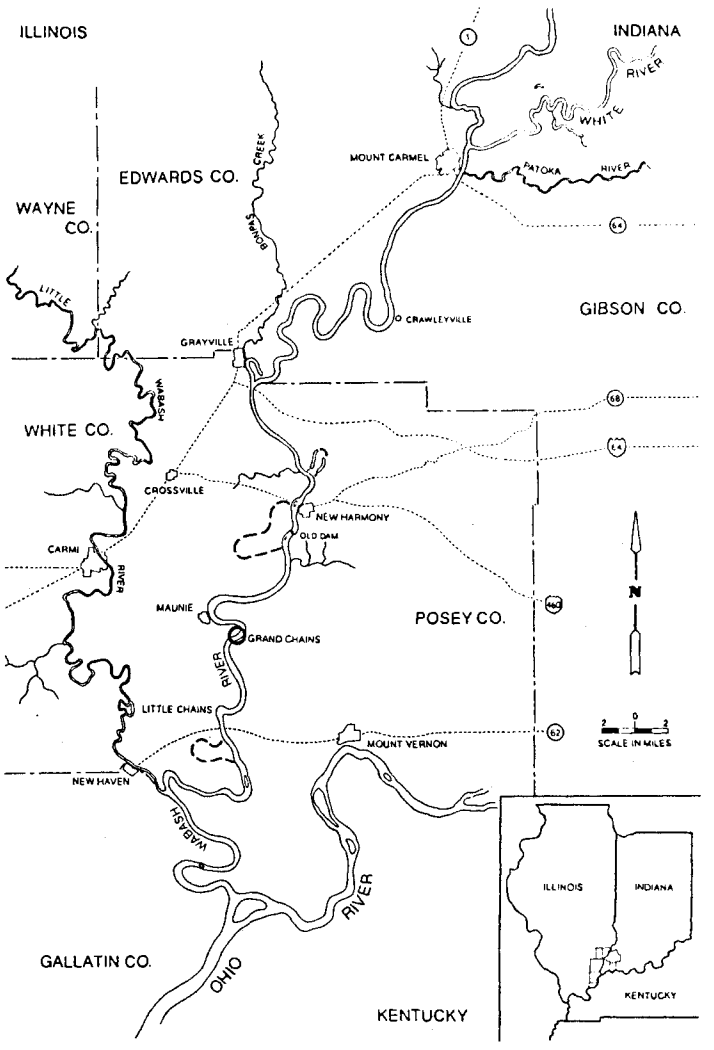
Cumberlandia monodonta (Say, 1829)
spectacle case



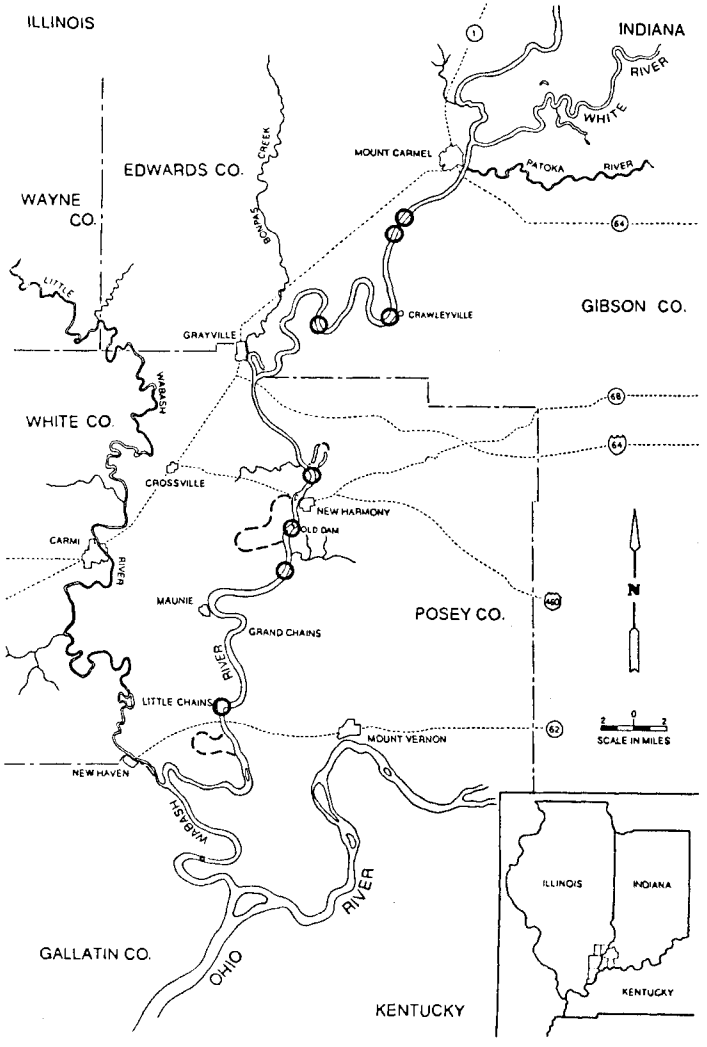
Cyclonaias tuberculata (Rafinesque, 1820)
purple wartyback



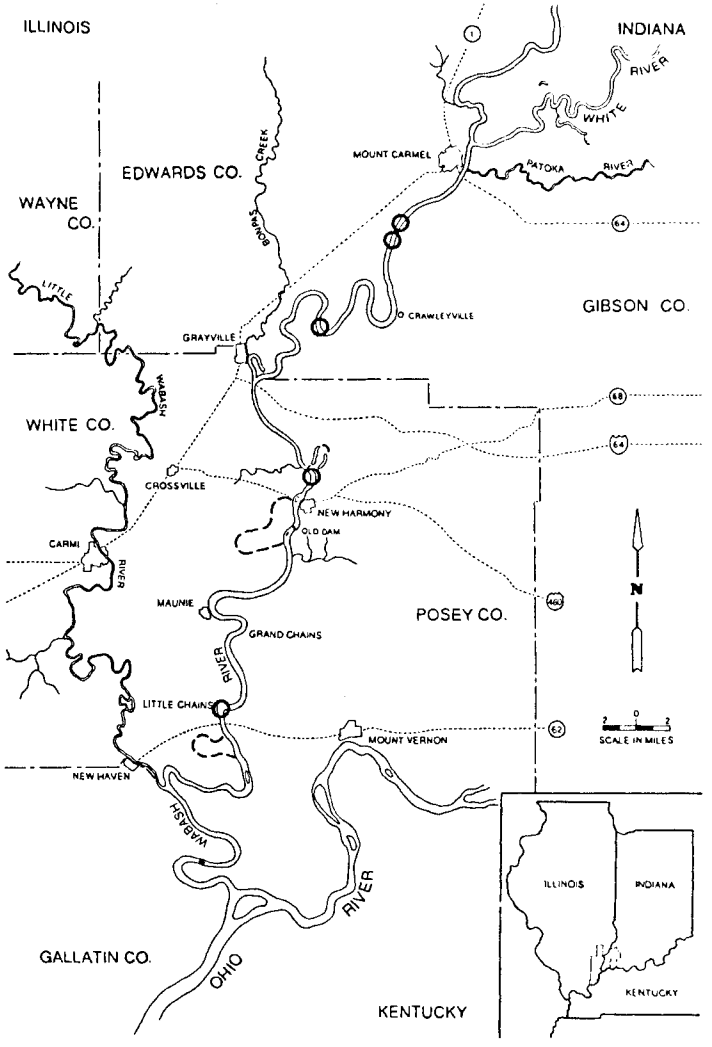
Cyprogenia stegaria (Rafinesque, 1820)
fanshell



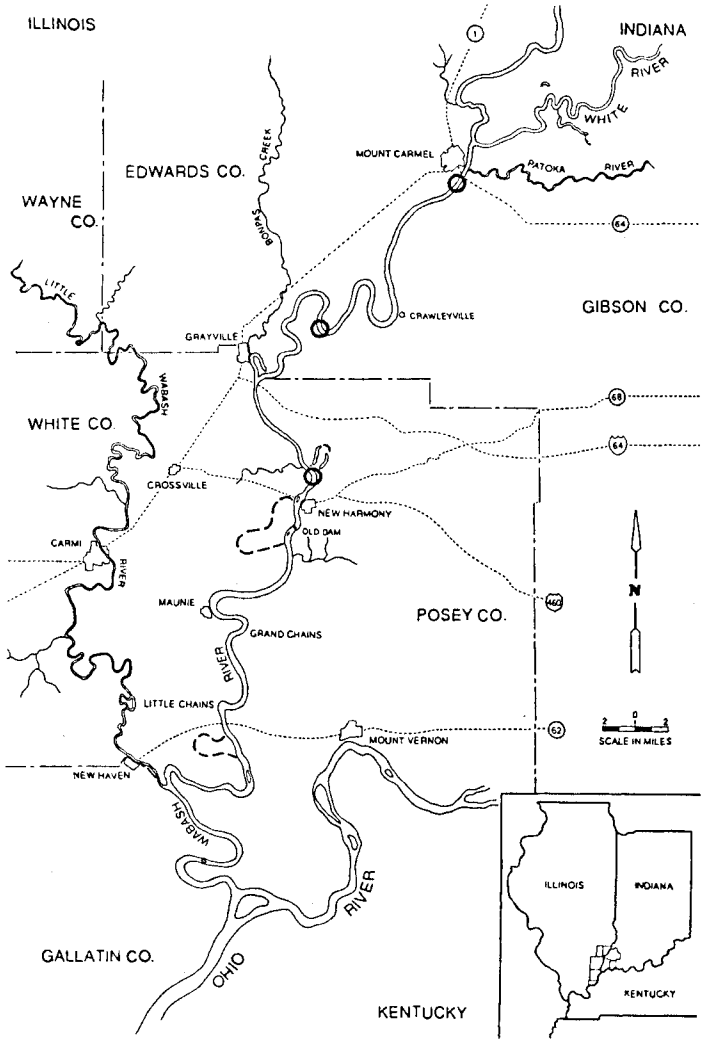
Ellipsaria lineolata (Rafinesque, 1820)
butterfly



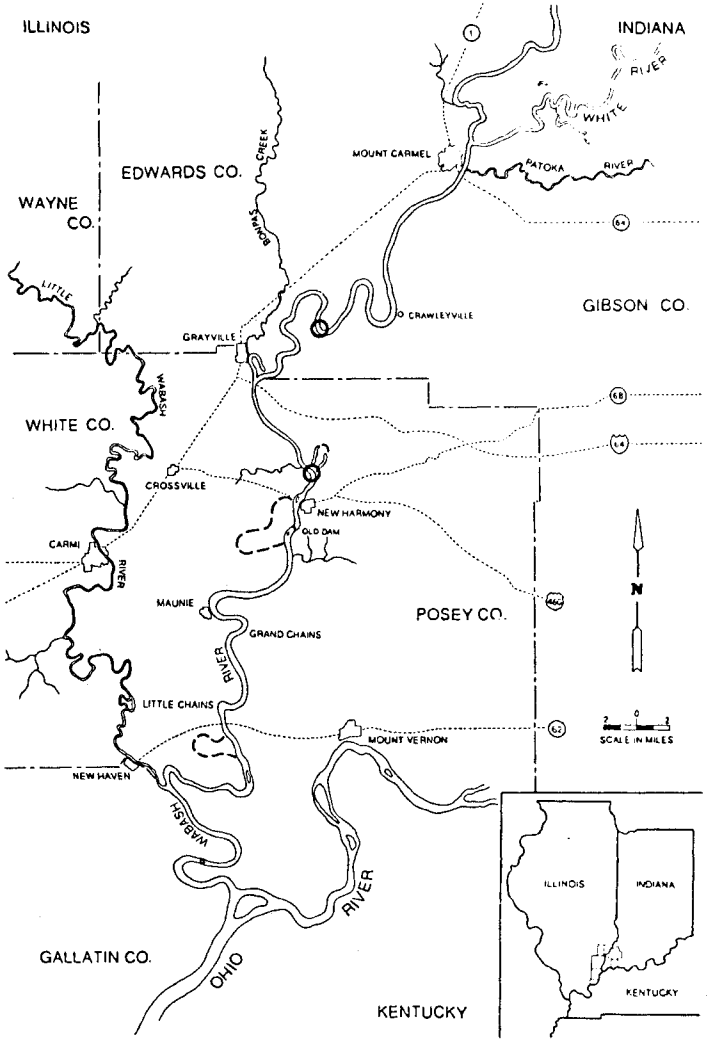
Elliptio crassidens (Lamarck, 1819)
elephant-ear



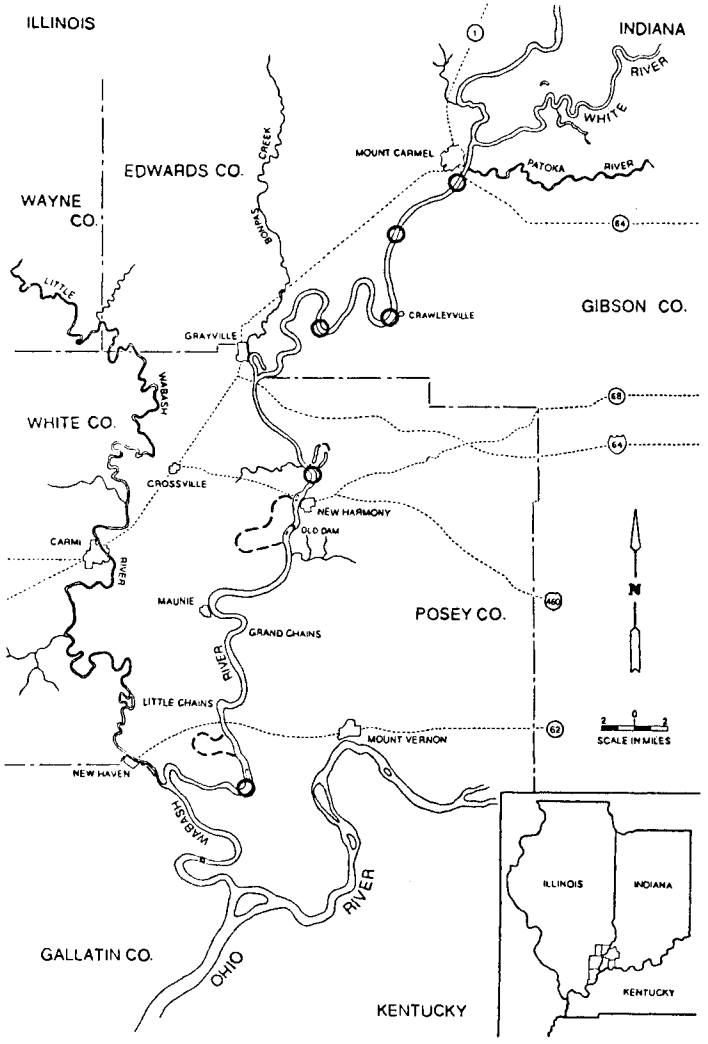
Elliptio dilatata (Rafinesque, 1820)
spike



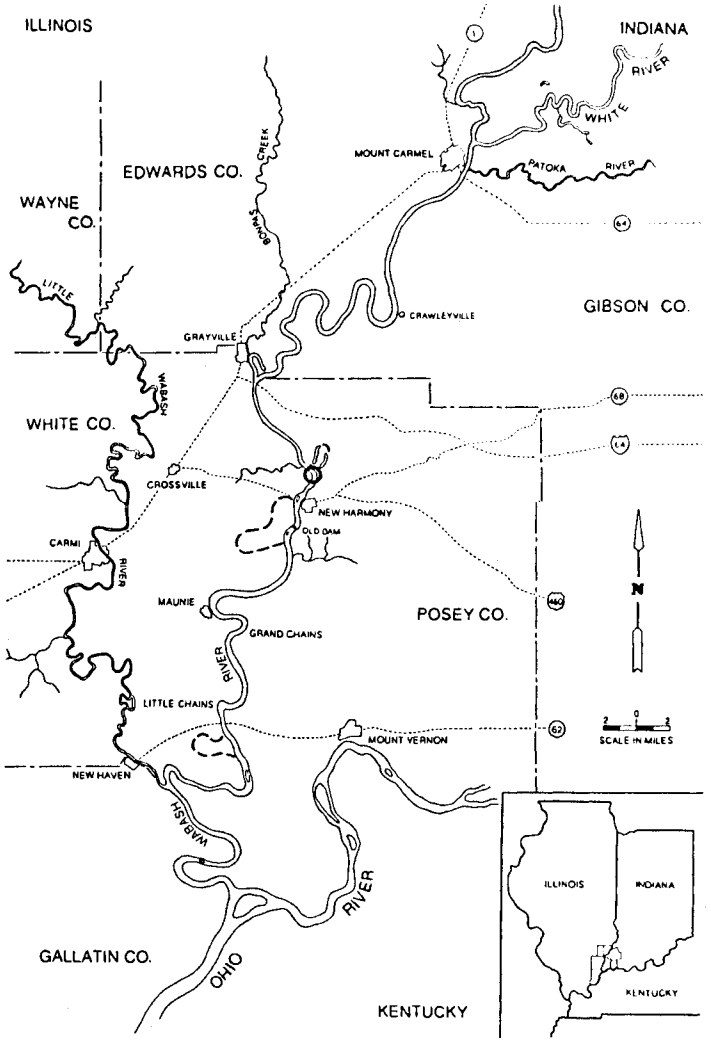
Epioblasma flexuosa (Rafinesque, 1820)
leafshell



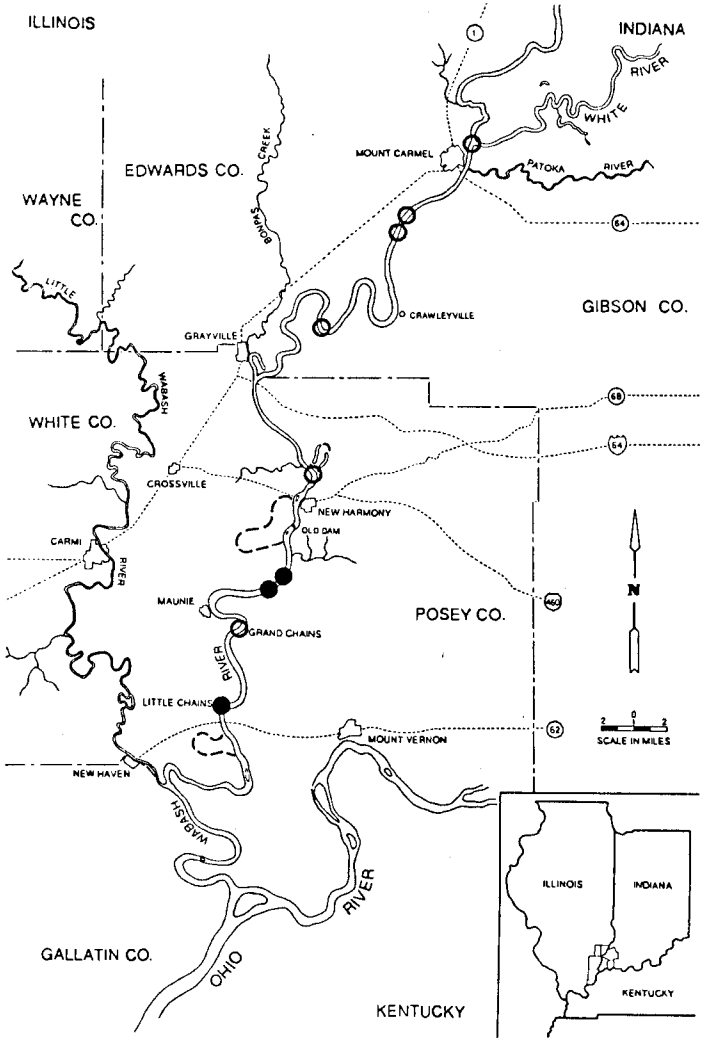
Epioblasma propinqua (I. Lea, 1857)
Tennessee riffleshell



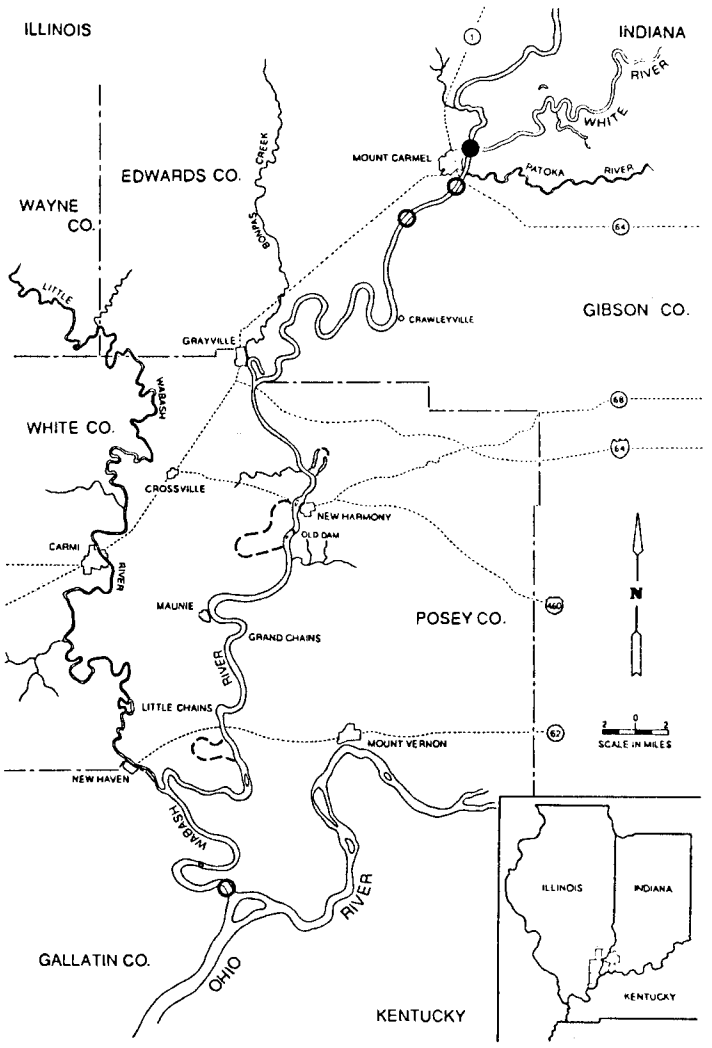
Epioblasma torulosa (Rafinesque, 1820)
tubercled blossom



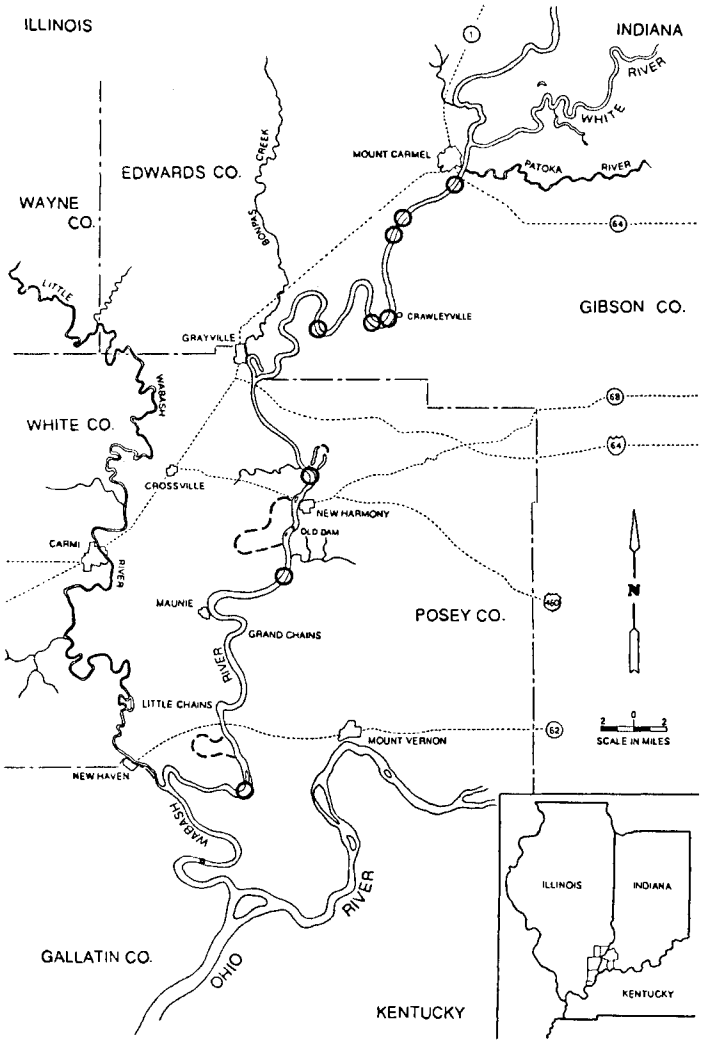
Epioblasma triquetra (Rafinesque, 1820)
snuffbox



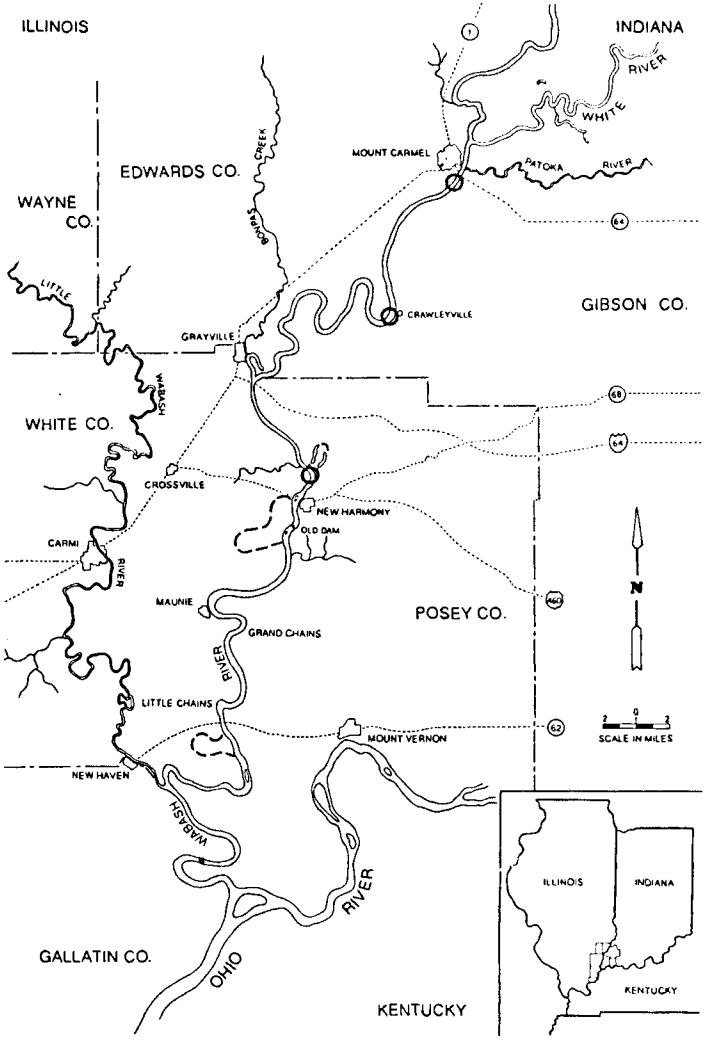
Fusconaia ebena (I. Lea, 1831)
ebonyshell



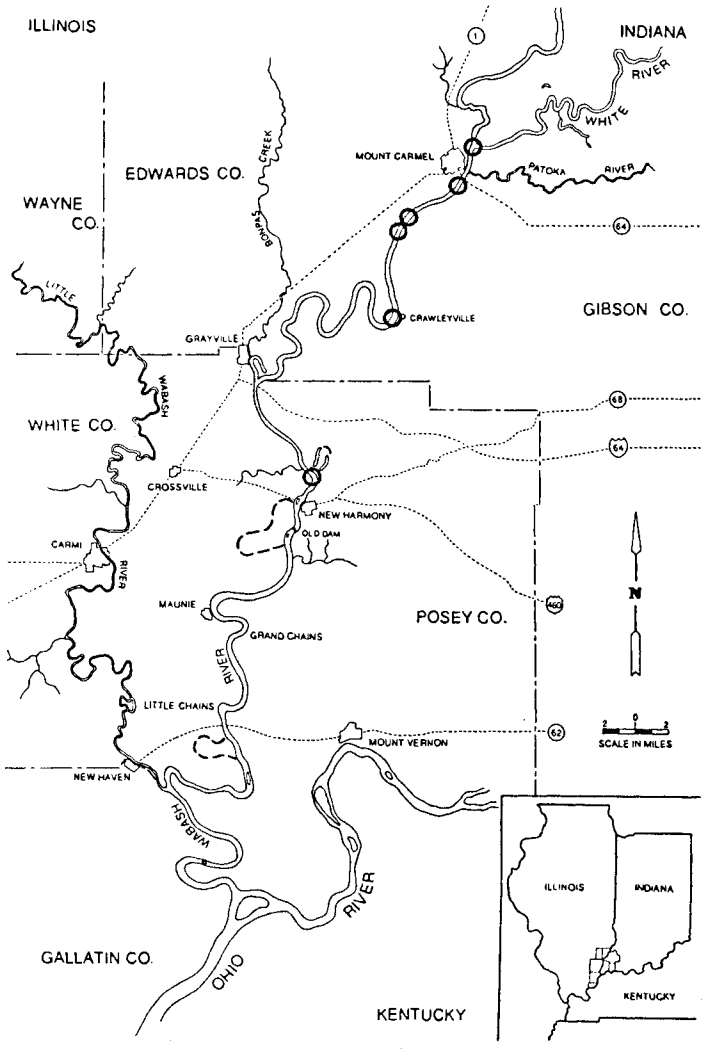
Fusconaia flava (Rafinesque, 1820)
Wabash pigtoe



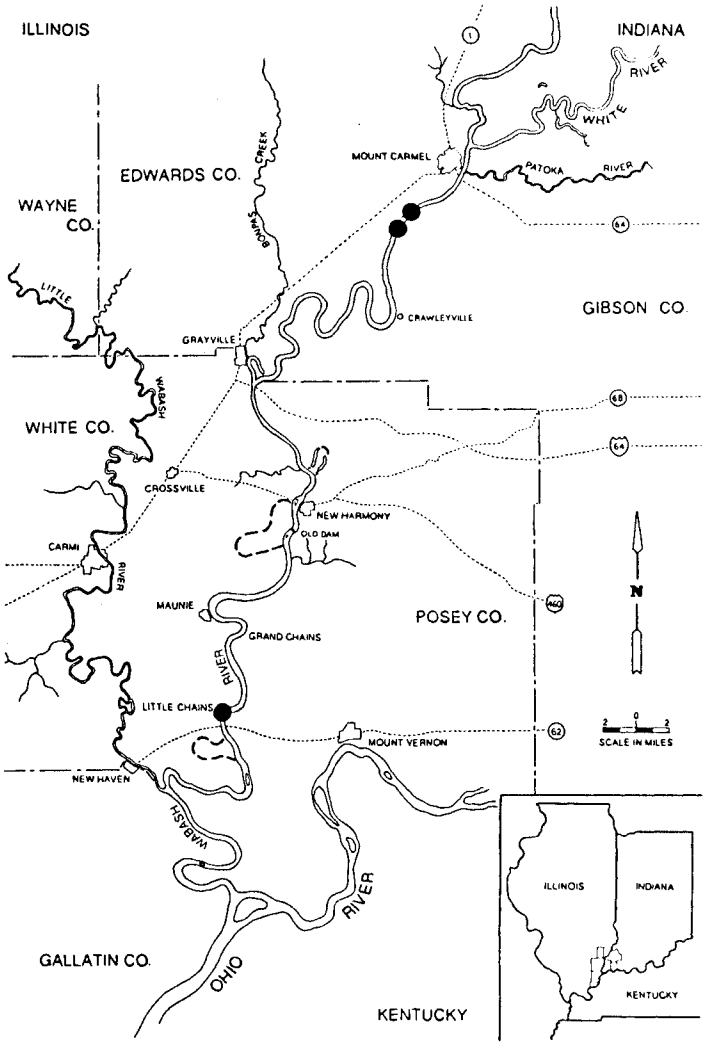
Lampsilis cardium (Rafinesque, 1820)
plain pocketbook



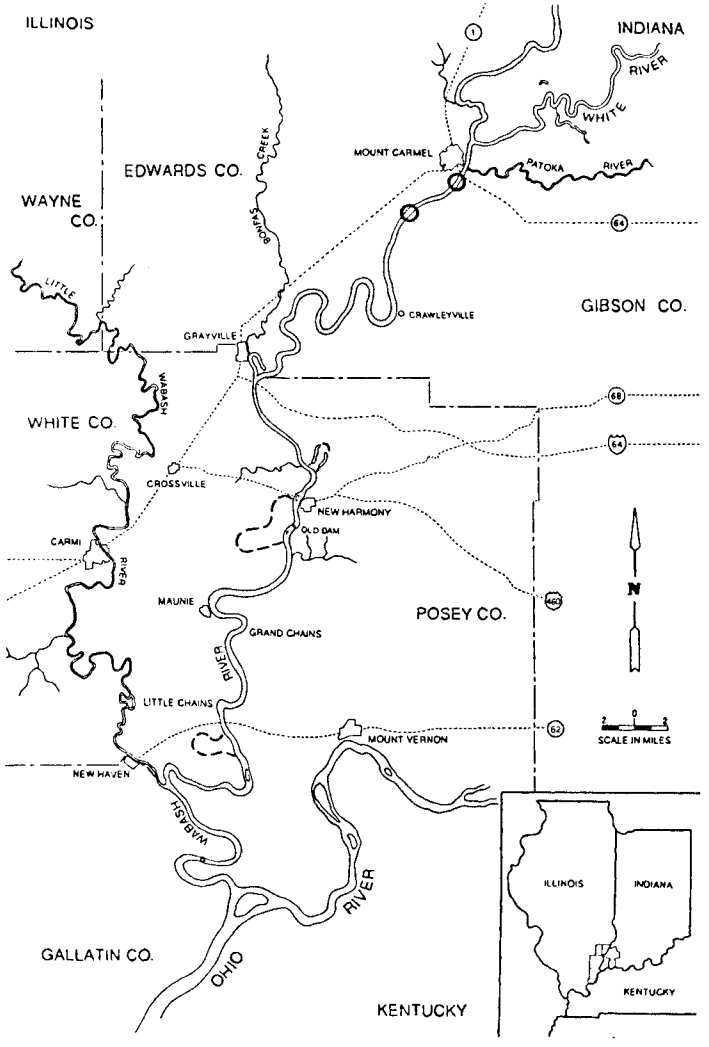
Lampsilis ovata (Say, 1817)
pocketbook



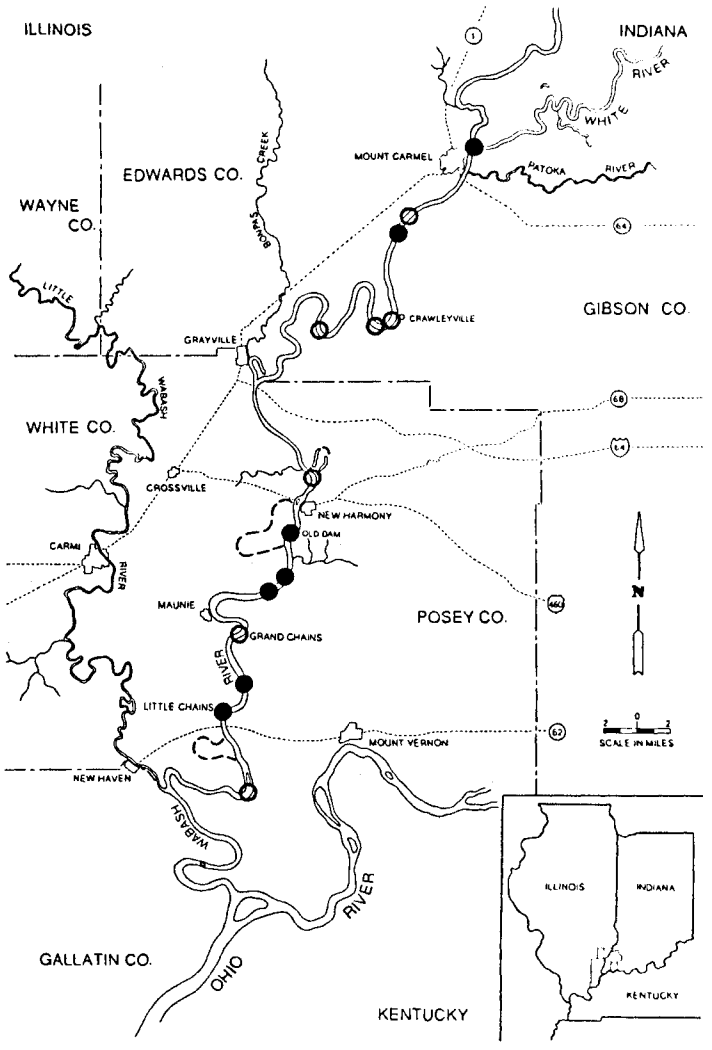
Lampsilis teres (Rafinesque, 1820)
yellow sandshell



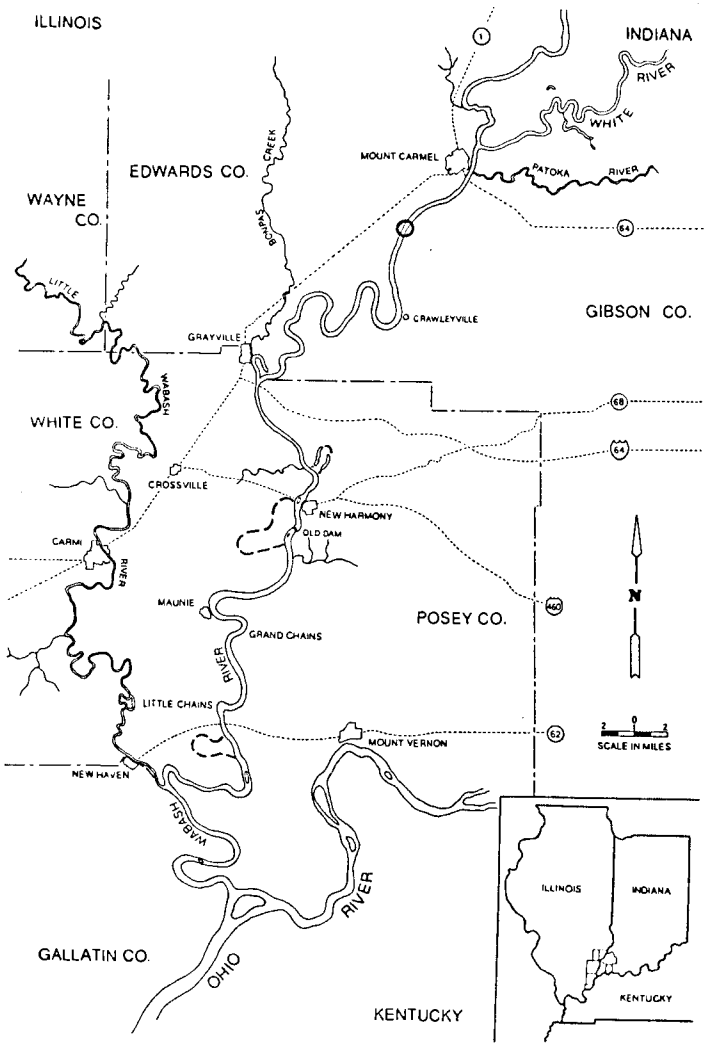
Lasmigona complanata (Barnes, 1823)
white heelsplitter



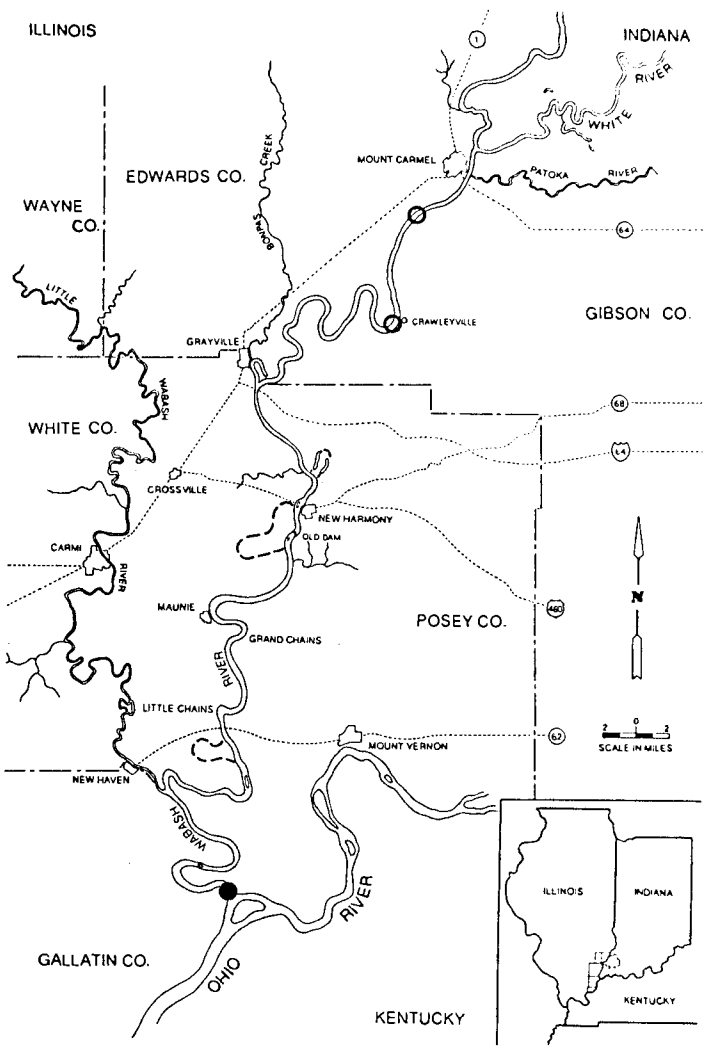
Lasmigona costata (Rafinesque, 1820)
fluted-shell



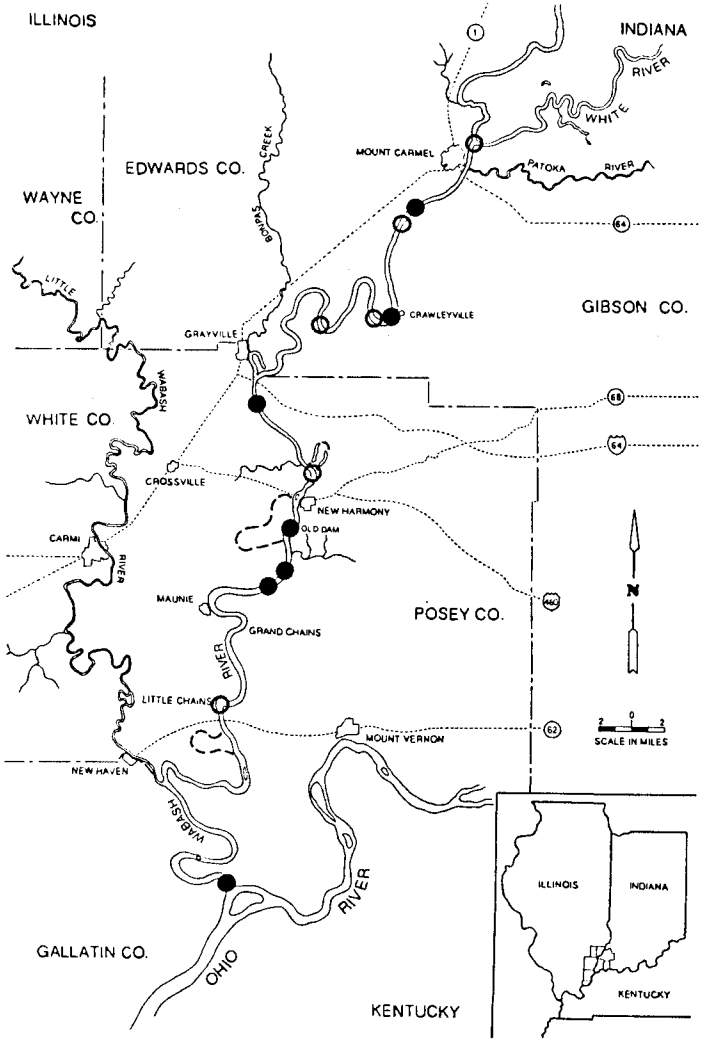
Leptodea fragilis (Rafinesque, 1820)
fragile papershell



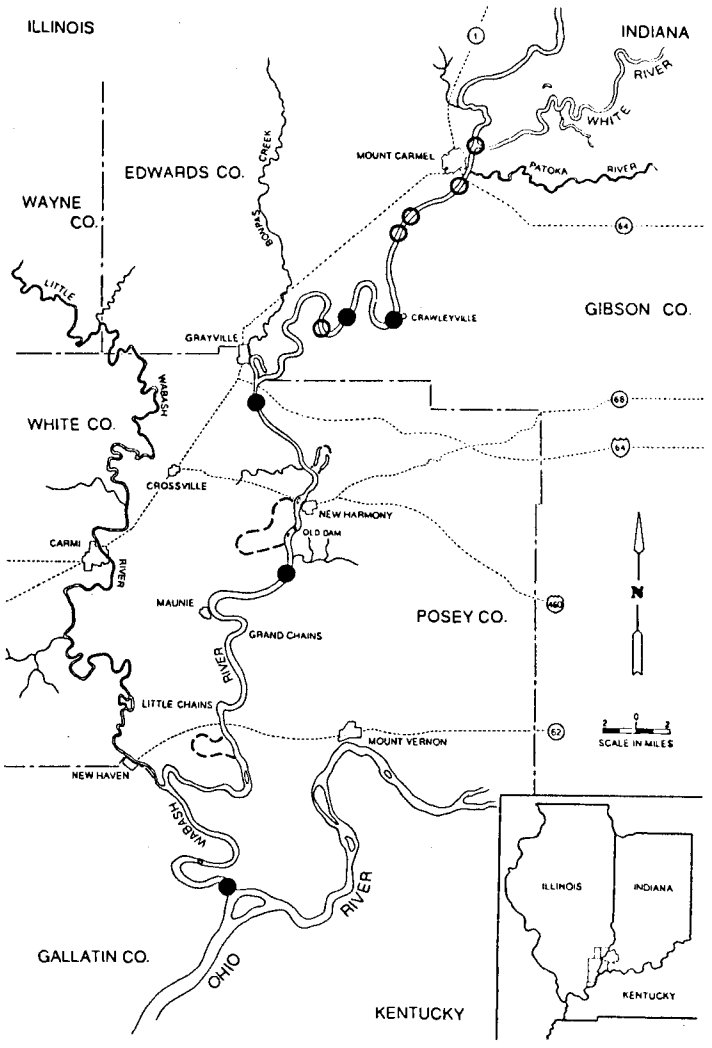
Ligumia recta (Lamarck, 1819)
black sandshell



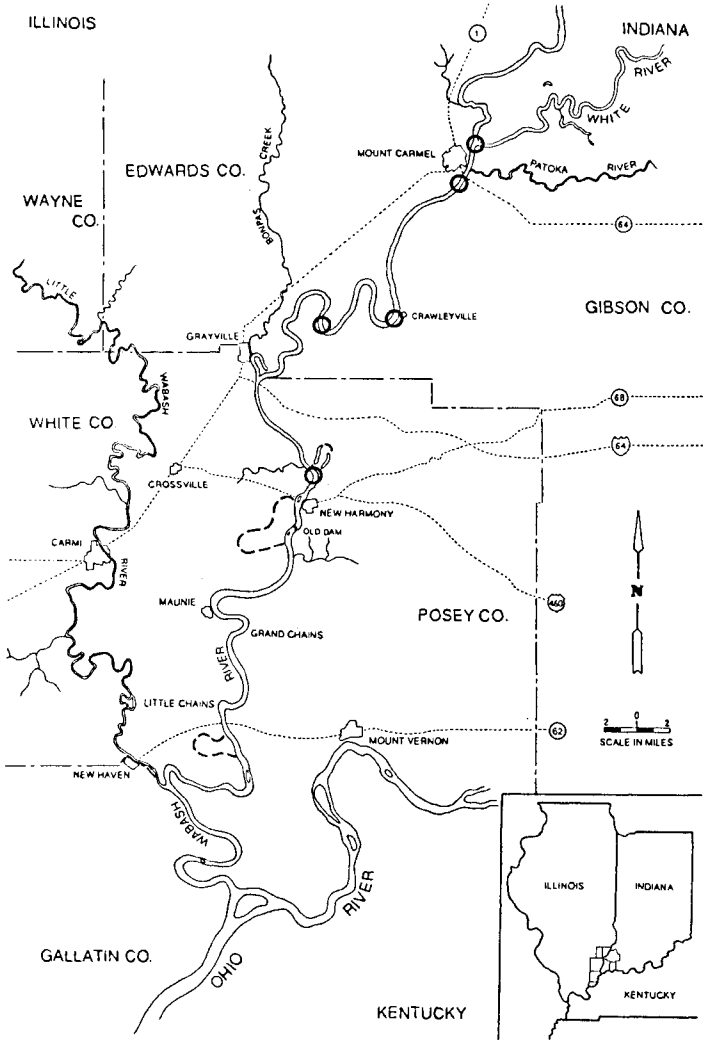
Megalonaias nervosa (Rafinesque, 1820)
washboard



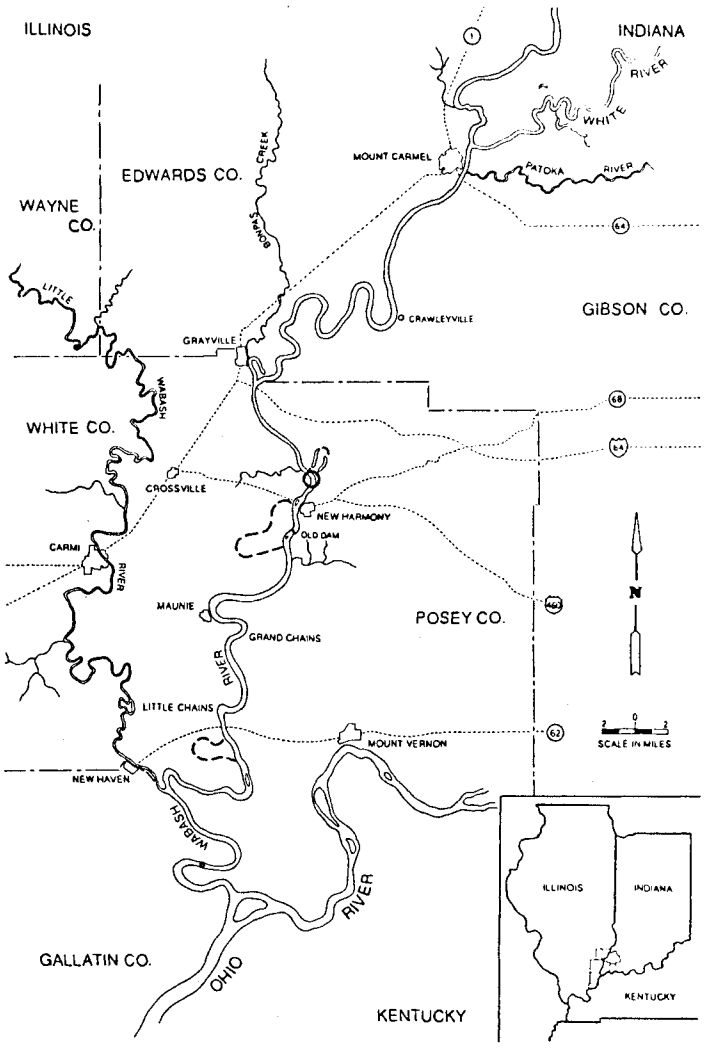
Obliquaria reflexa Rafinesque, 1820
three-horn wartyback



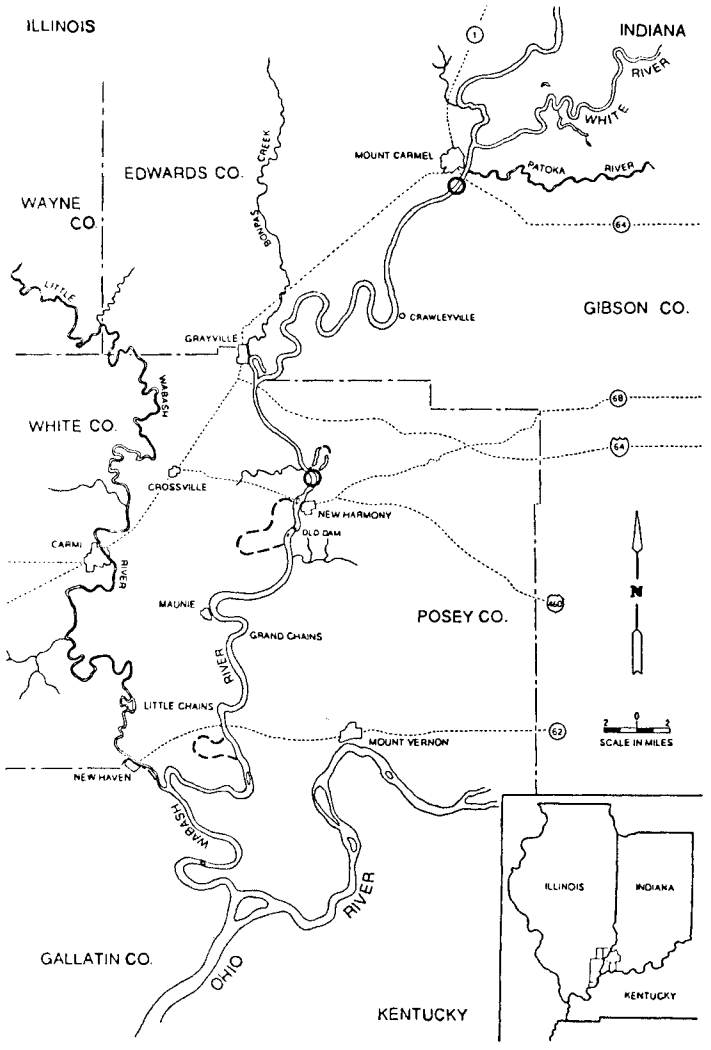
Obovaria olivaria (Rafinesque, 1820)
hickorynut



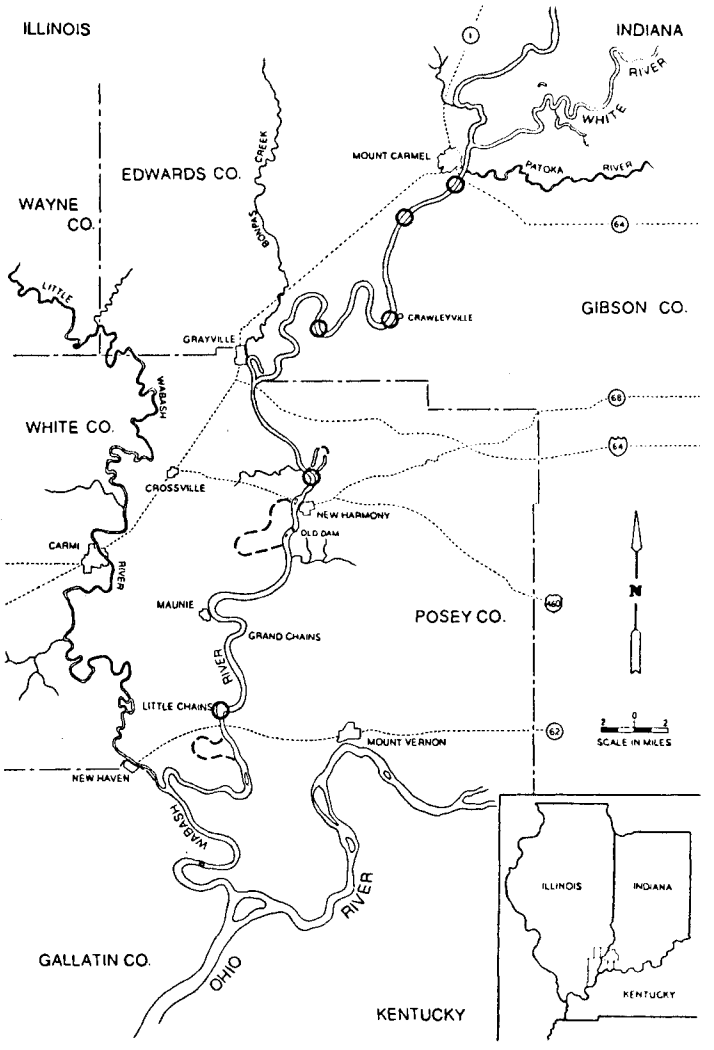
Obovaria retusa (Lamarck, 1819)
ring pink



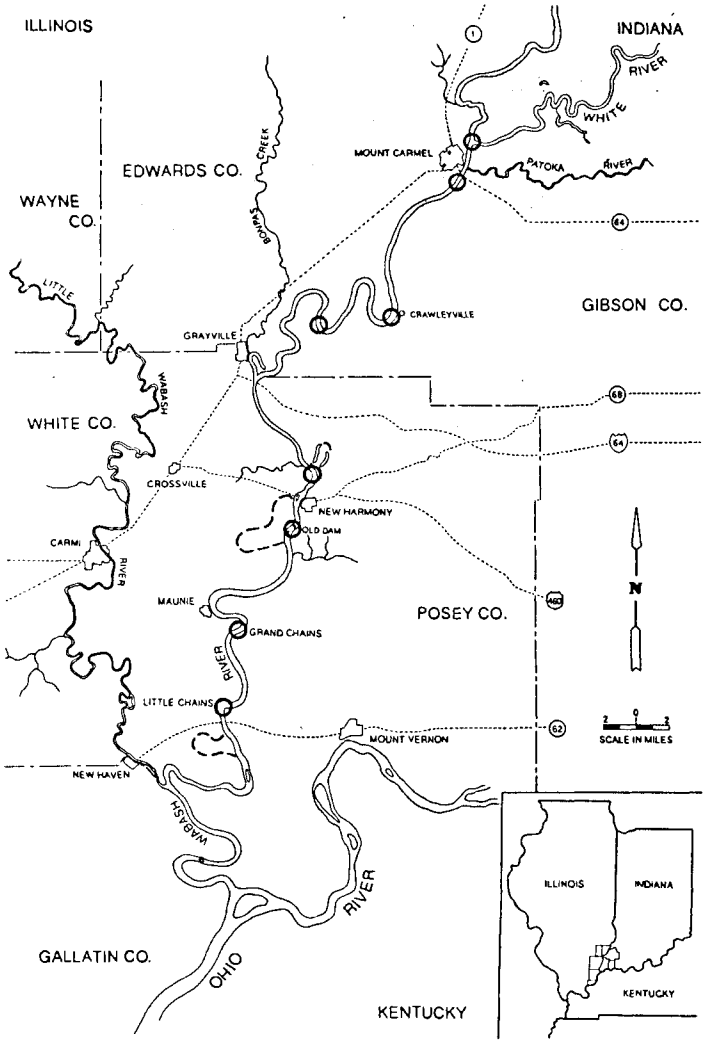
Obovaria subrotunda (Rafinesque, 1820)
round hickorynut



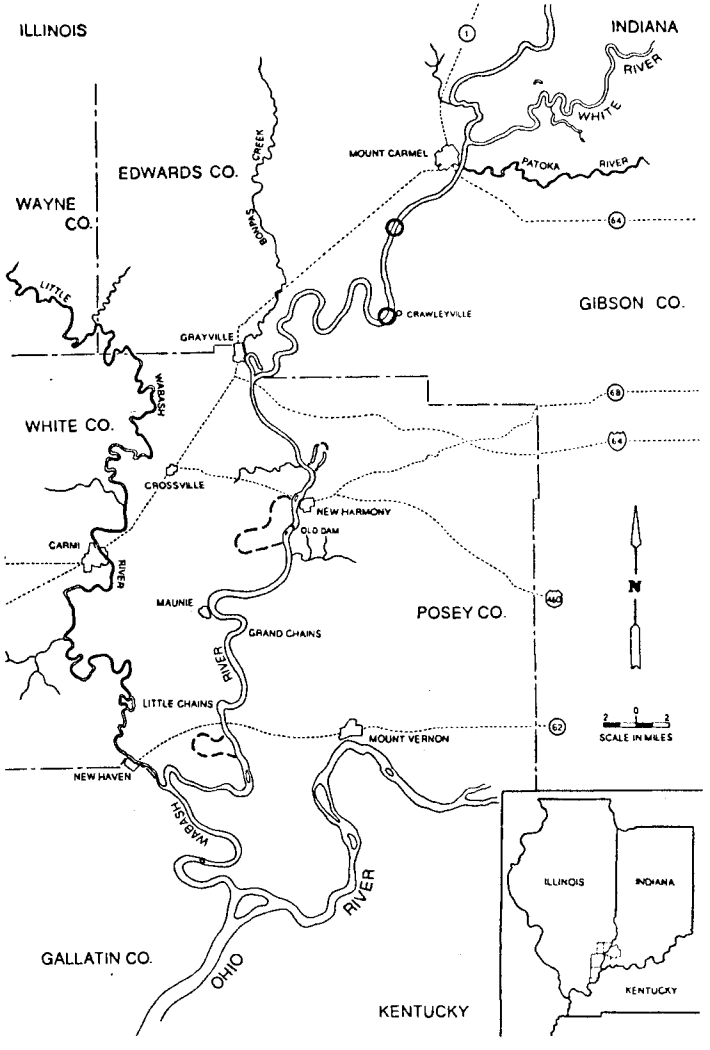
Plethobasus cyphyus (Rafinesque, 1820)
sheepnose



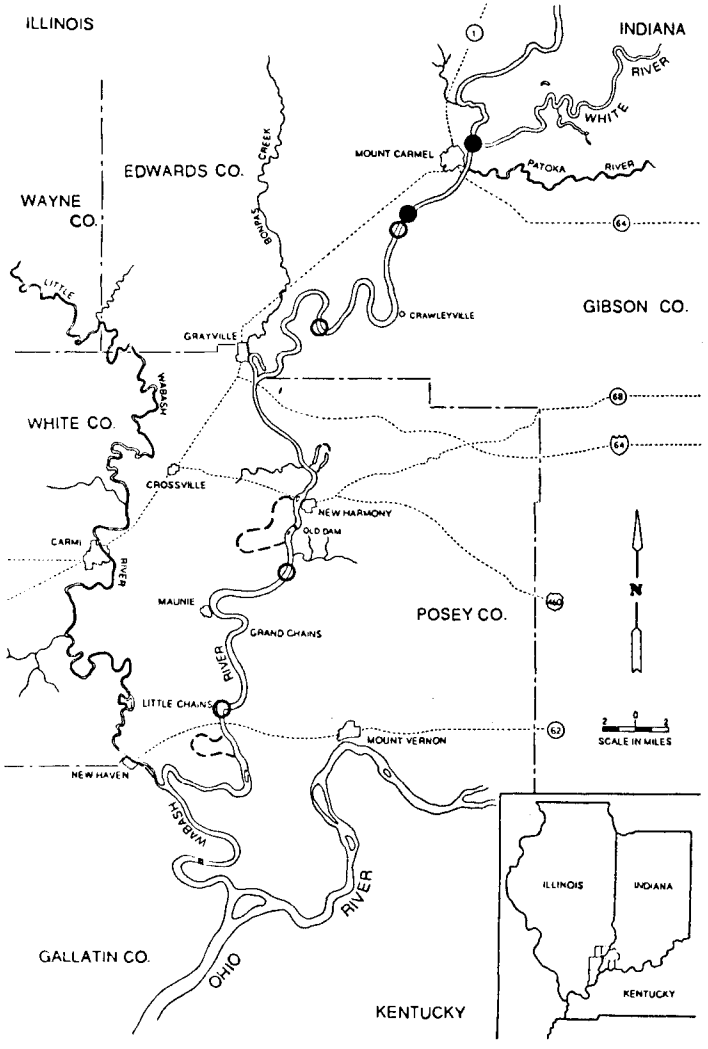
Pleurobema clava (Lamarck, 1819)
clubshell



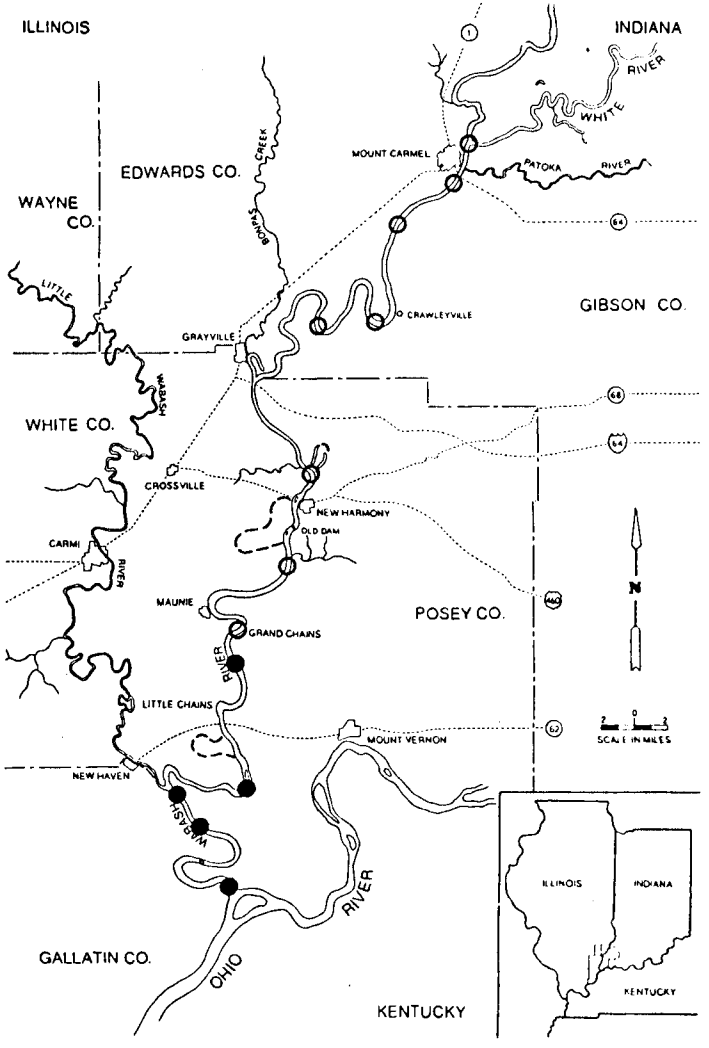
Pleurobema cordatum (Rafinesque, 1820)
Ohio pigtoe



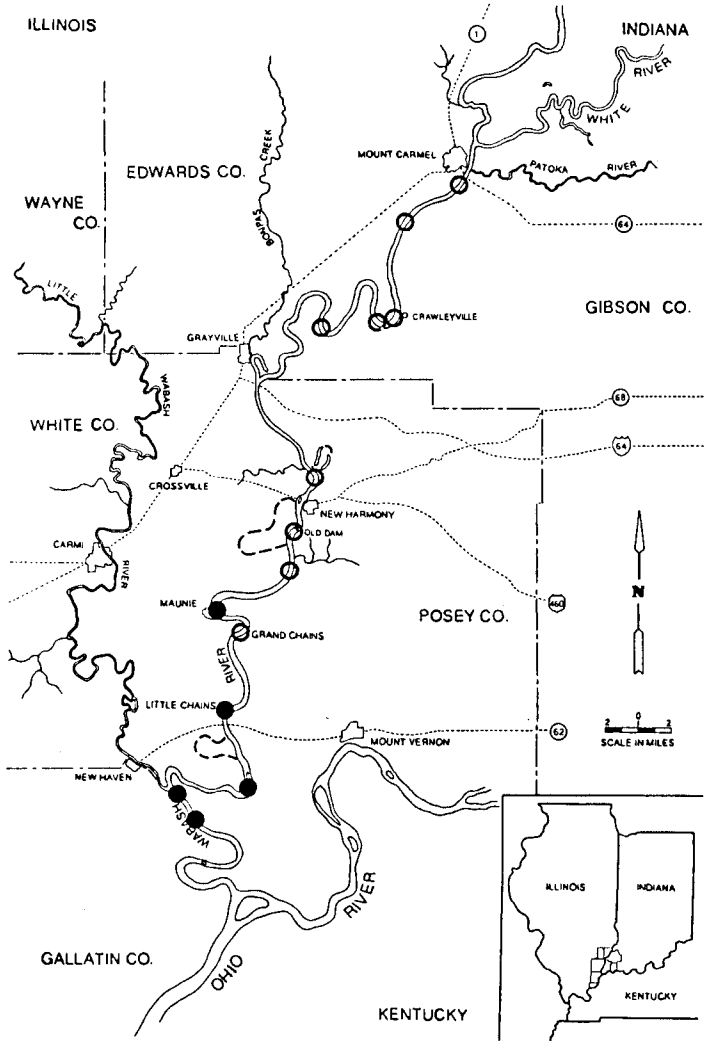
Pleurobema rubrum (Rafinesque, 1820)
pyramid pigtoe



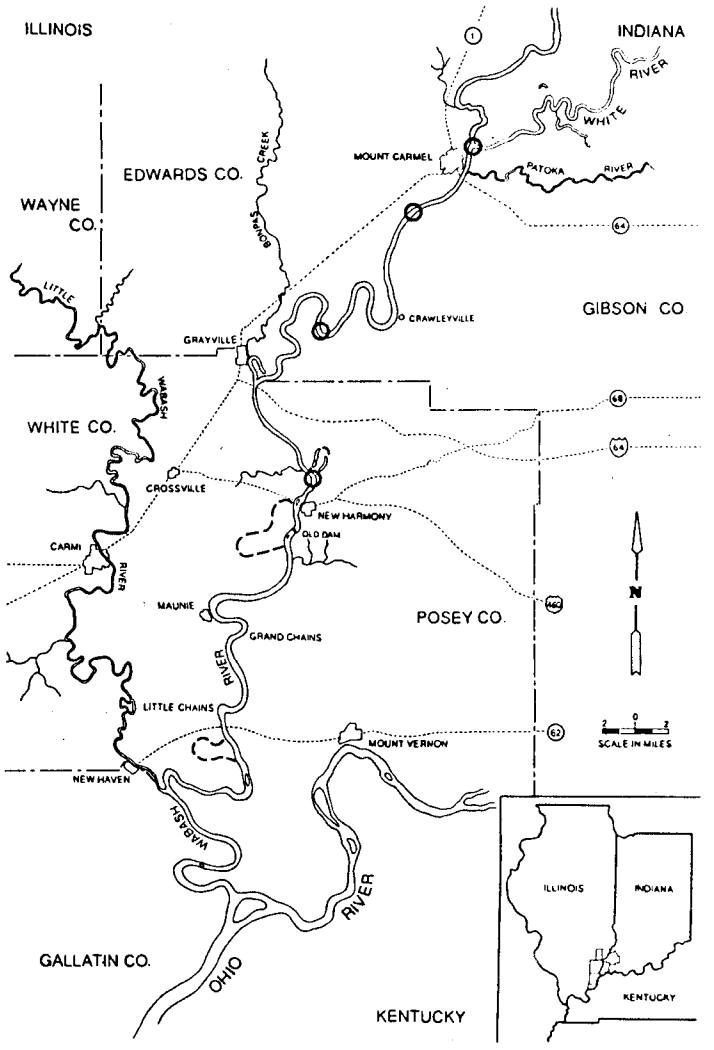
Potamilus alatus (Say, 1817)
pink heelsplitter



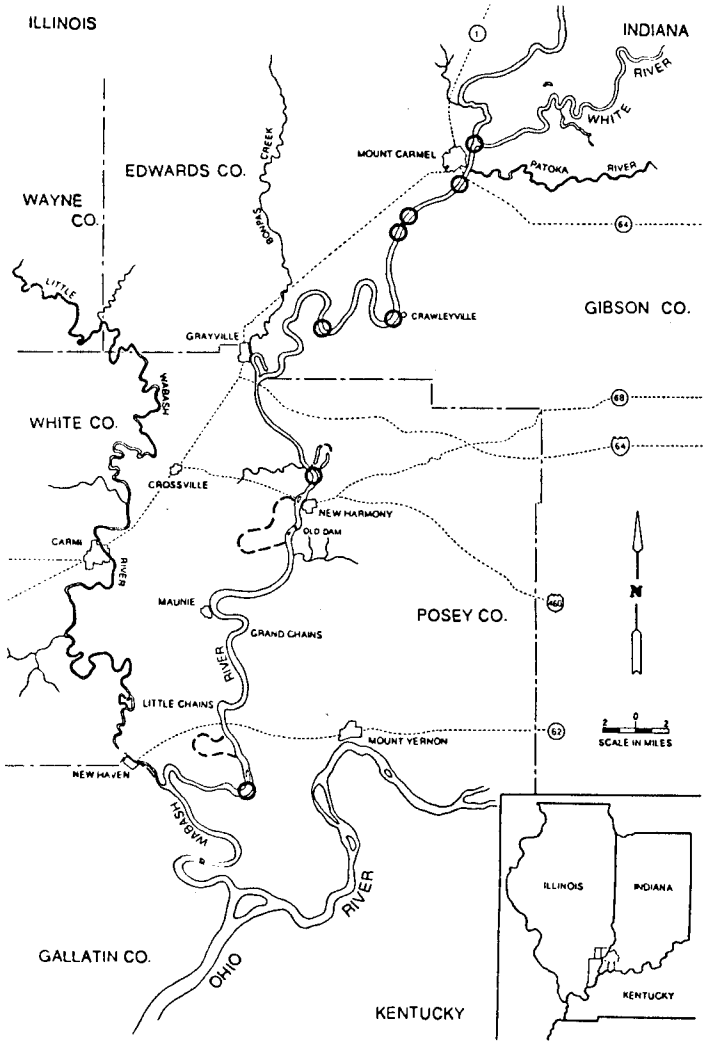
Potamilus capax (Green, 1832)
fat pocketbook



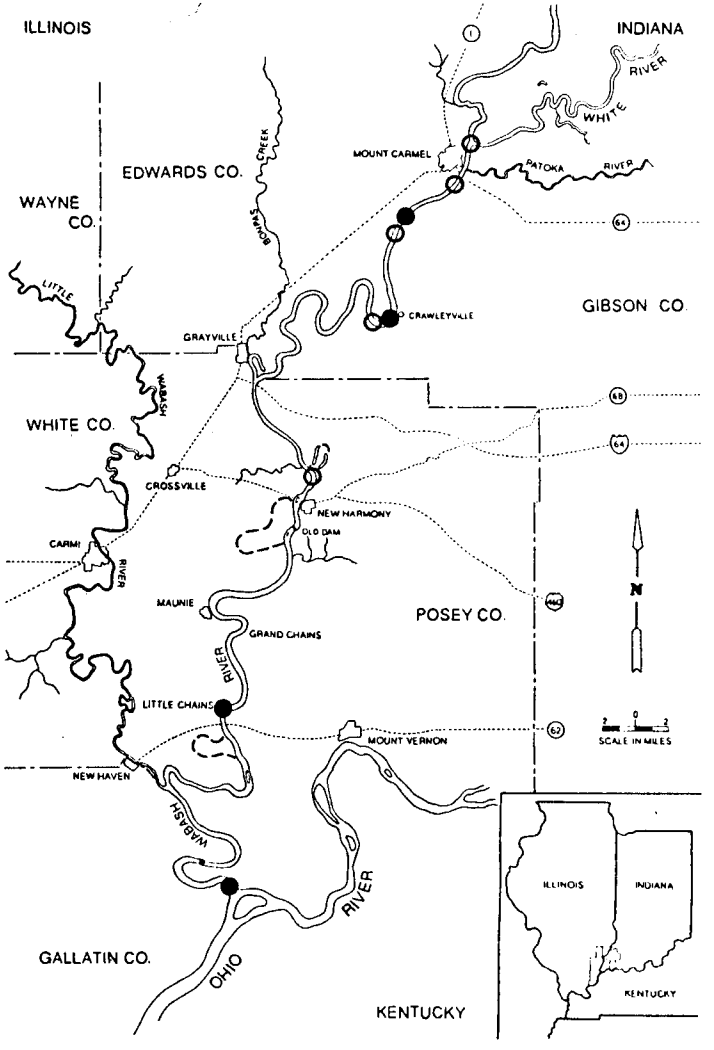
Potamilus ohiensis (Rafinesque, 1820)
pink papershell



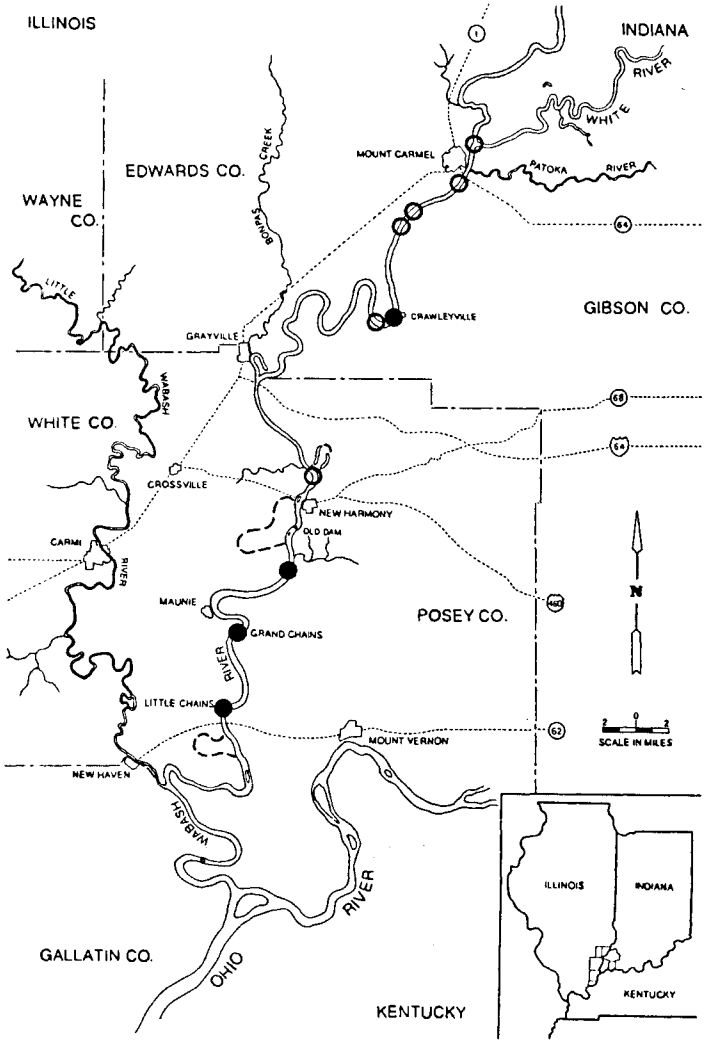
Quadrula cylindrica (Say, 1817)
rabbitsfoot



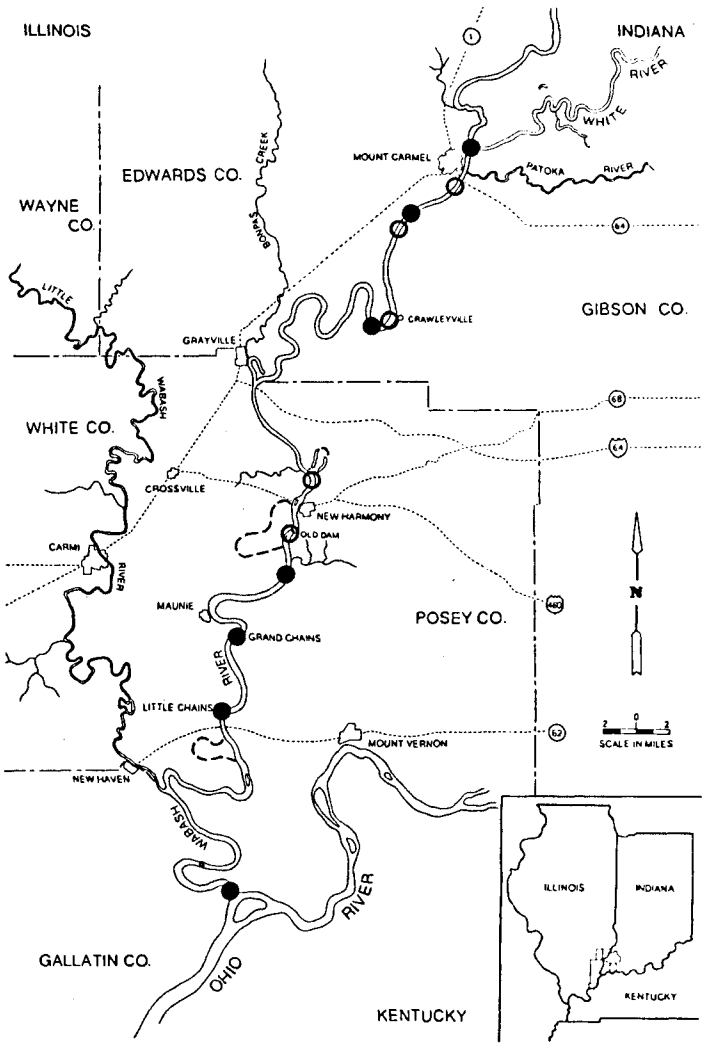
Quadrula metanevra (Rafinesque, 1820)
monkeyface



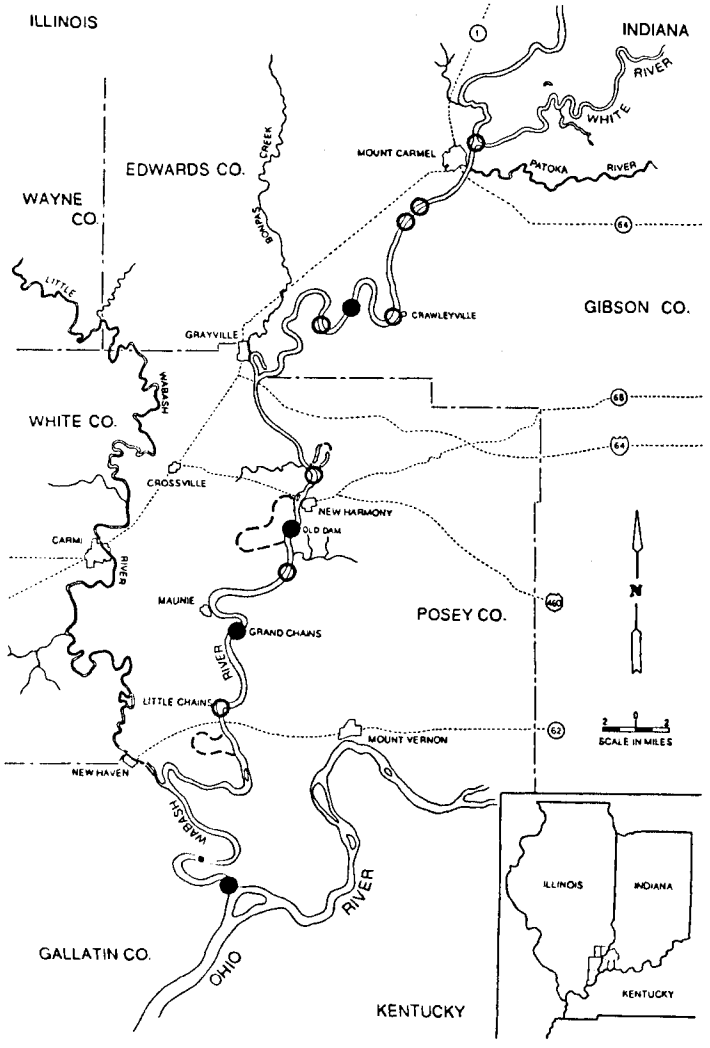
Quadrula nodulata (Rafinesque, 1820)
wartyback



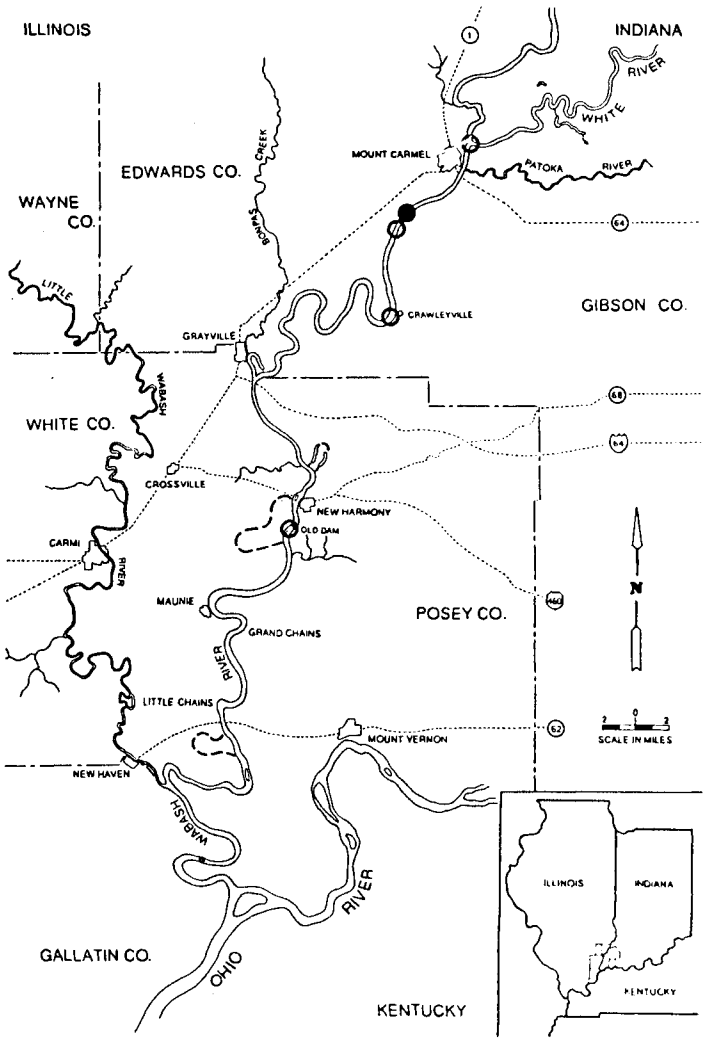
Quadrula pustulosa (I. Lea, 1831)
pimpleback



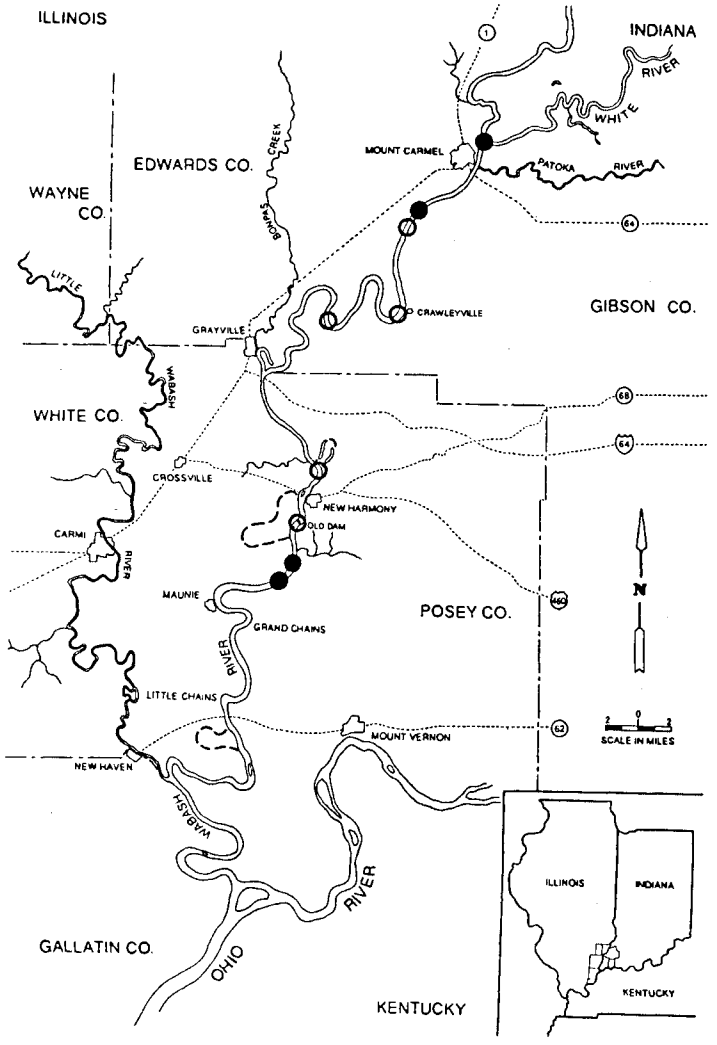
Quadrula quadrula (Rafinesque, 1820)
mapleleaf



Tritogonia verrucosa (Rafinesque, 1820)
pistolgrip



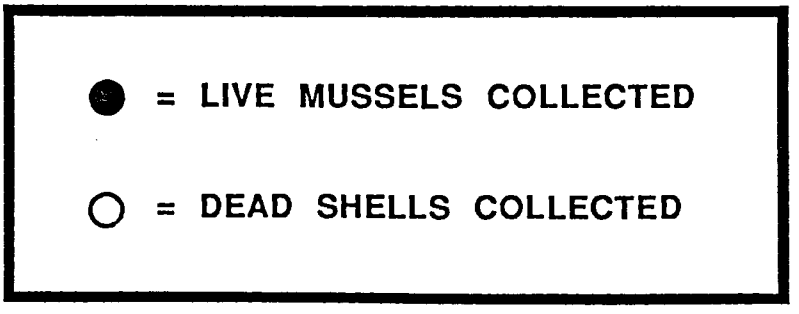
Truncilla donaciformis (I. Lea, 1828)
fawnsfoot



Truncilla truncata Rafinesque, 1820
deertoe

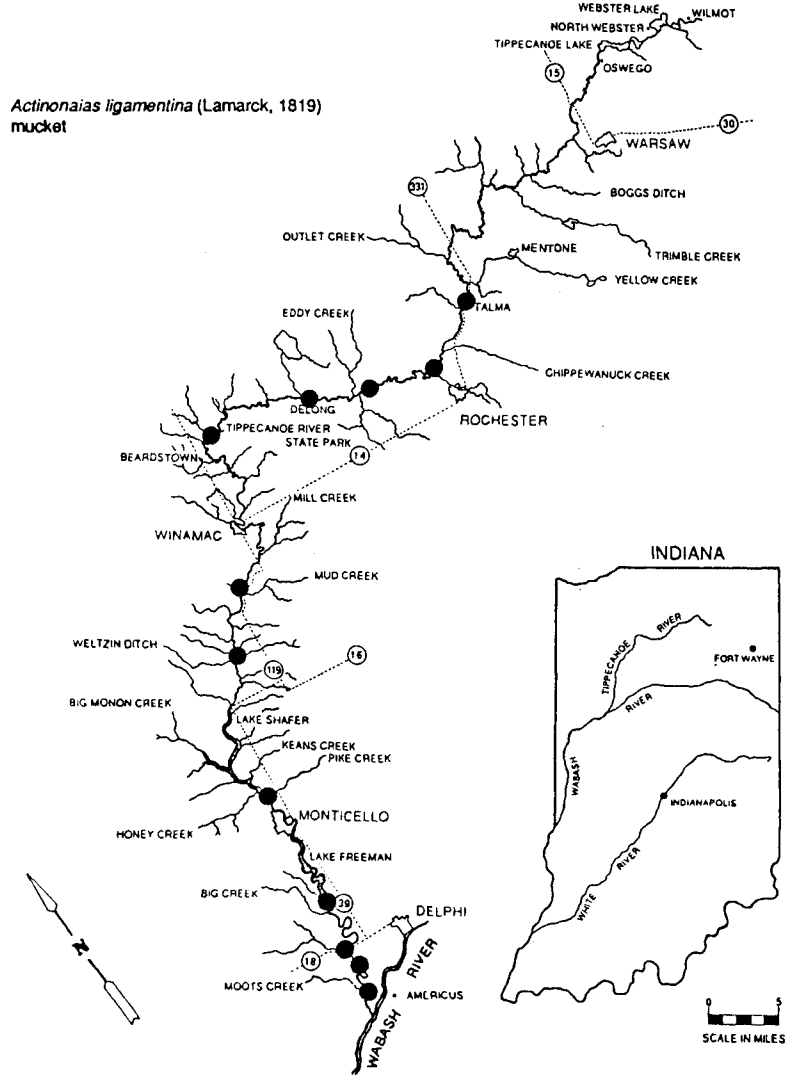
Appendix II

Distribution maps of unionids recorded from the Tippecanoe River, 1987.



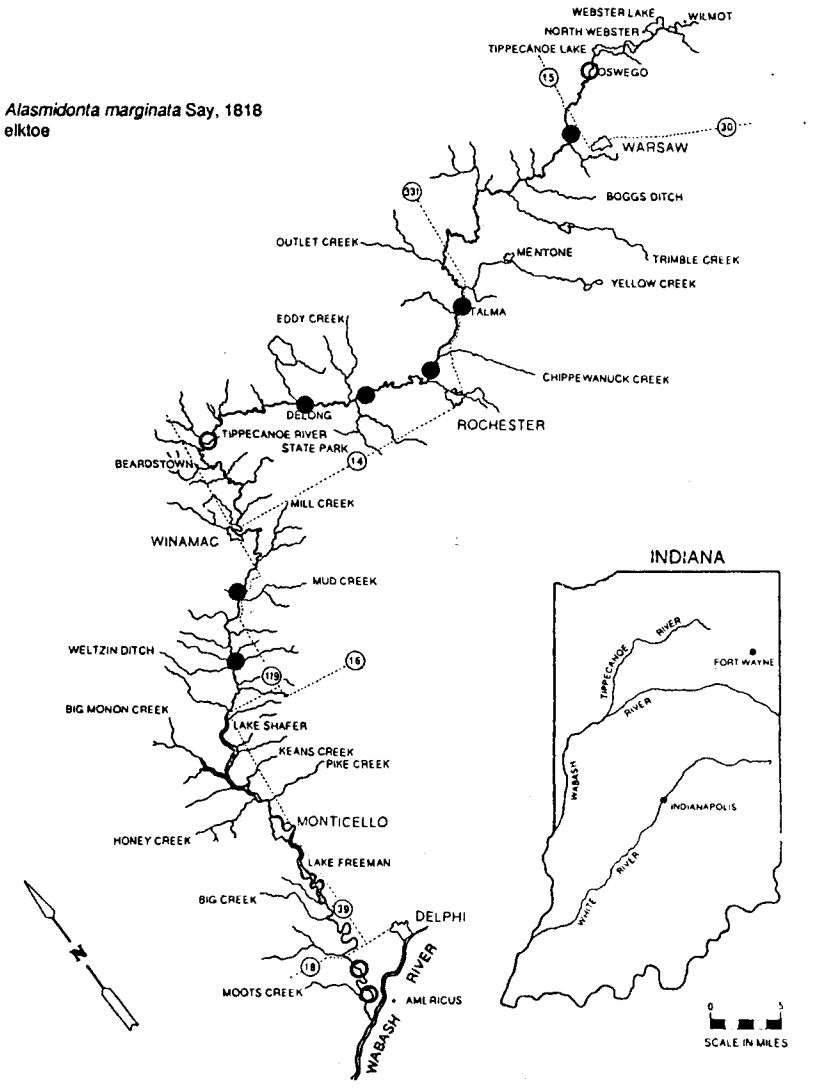
TIPPECANOE RIVER

Actinonaias ligamentina (Lamarck, 1819)
mucket



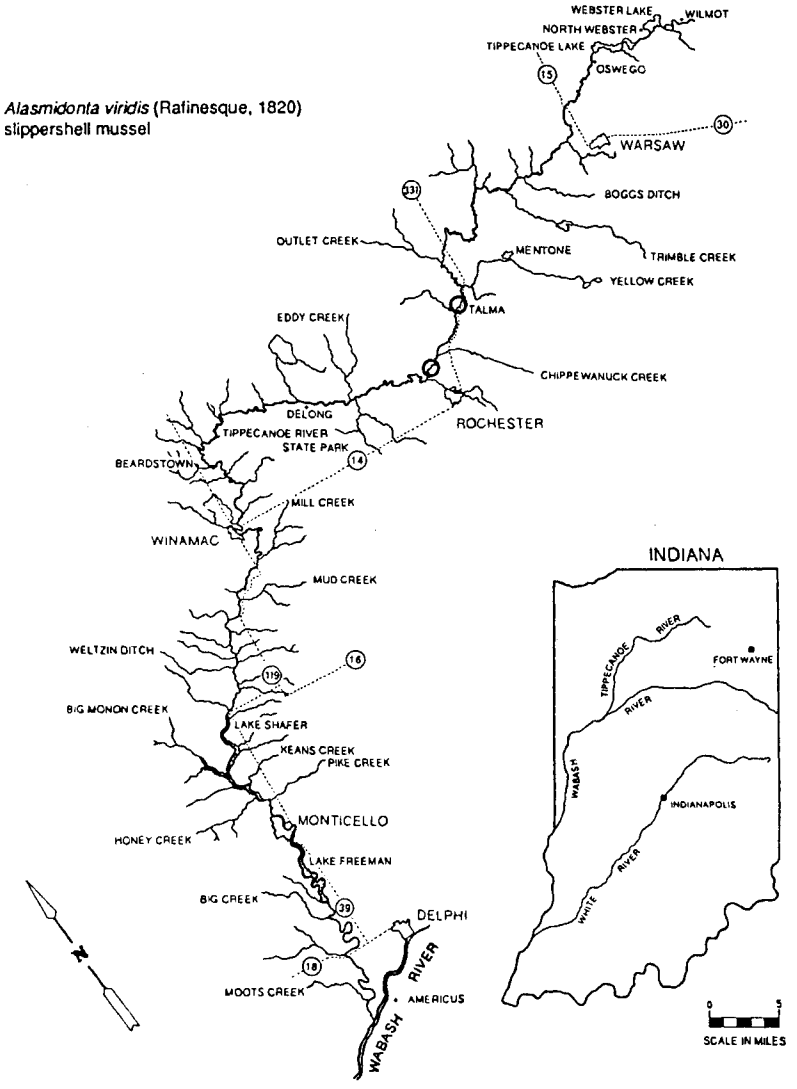
TIPPECANOE RIVER

Alasmidonta marginata Say, 1818
elktoe



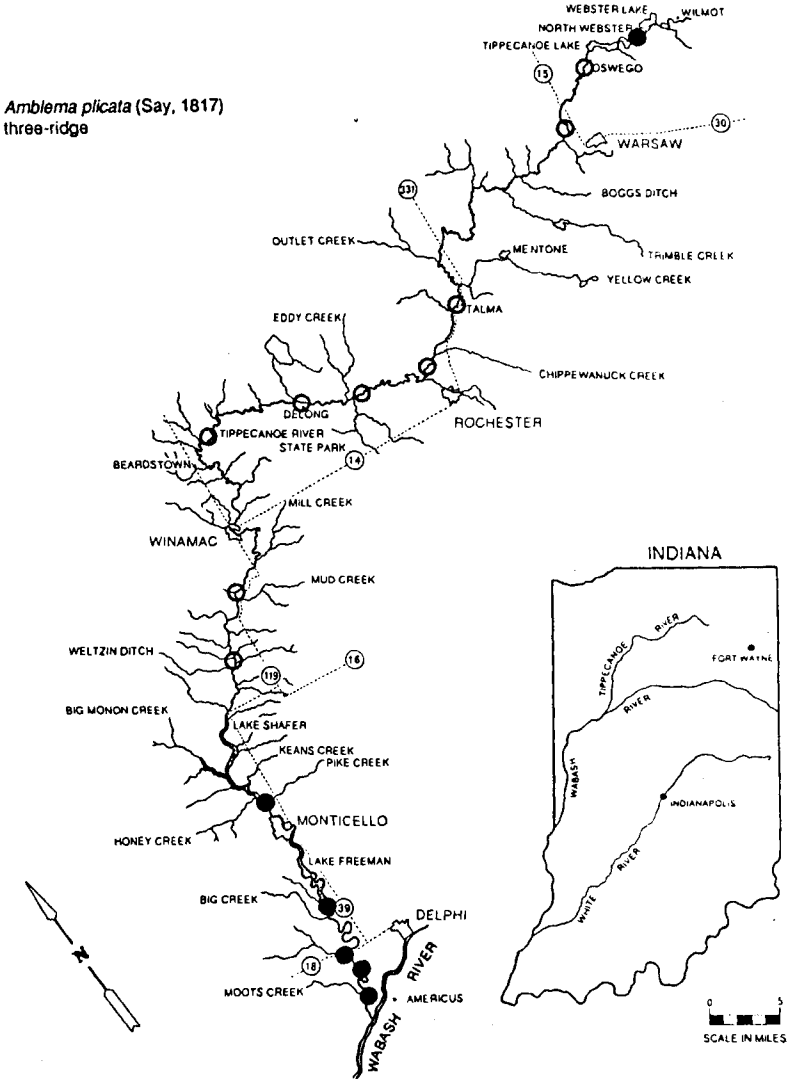
TIPPECANOE RIVER

Alasmidonta viridis (Rafinesque, 1820)
slippershell mussel



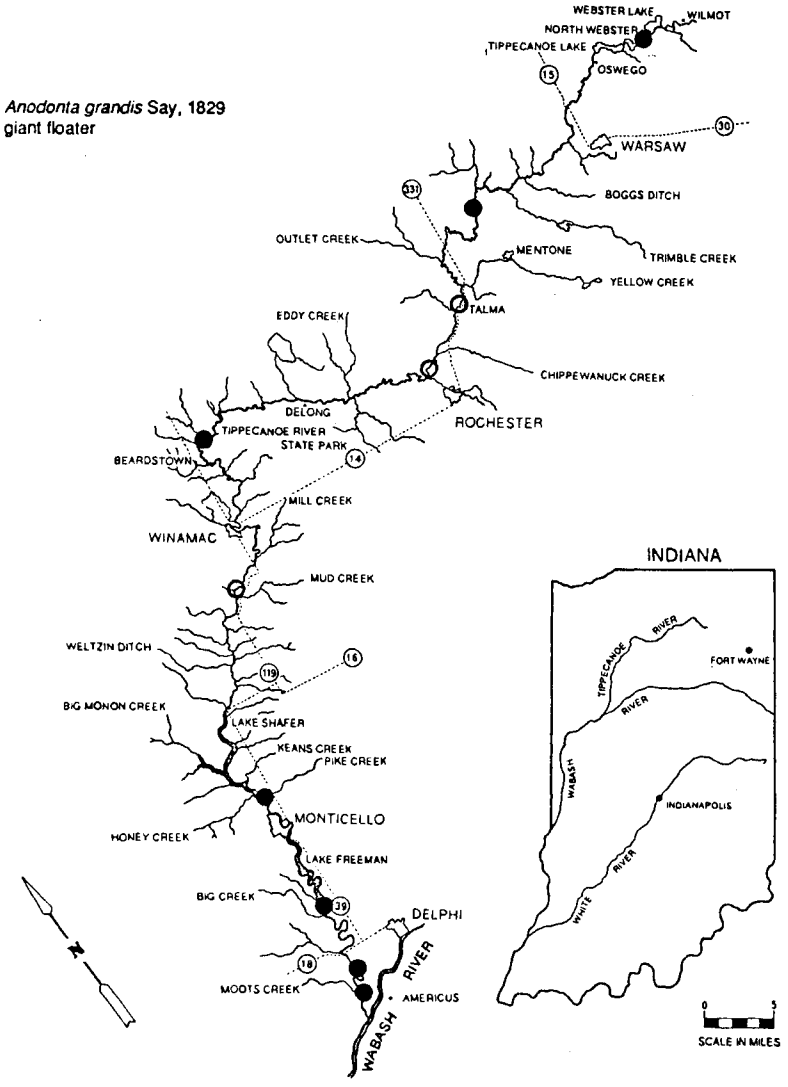
TIPPECANOE RIVER

Amblema plicata (Say, 1817)
three-ridge



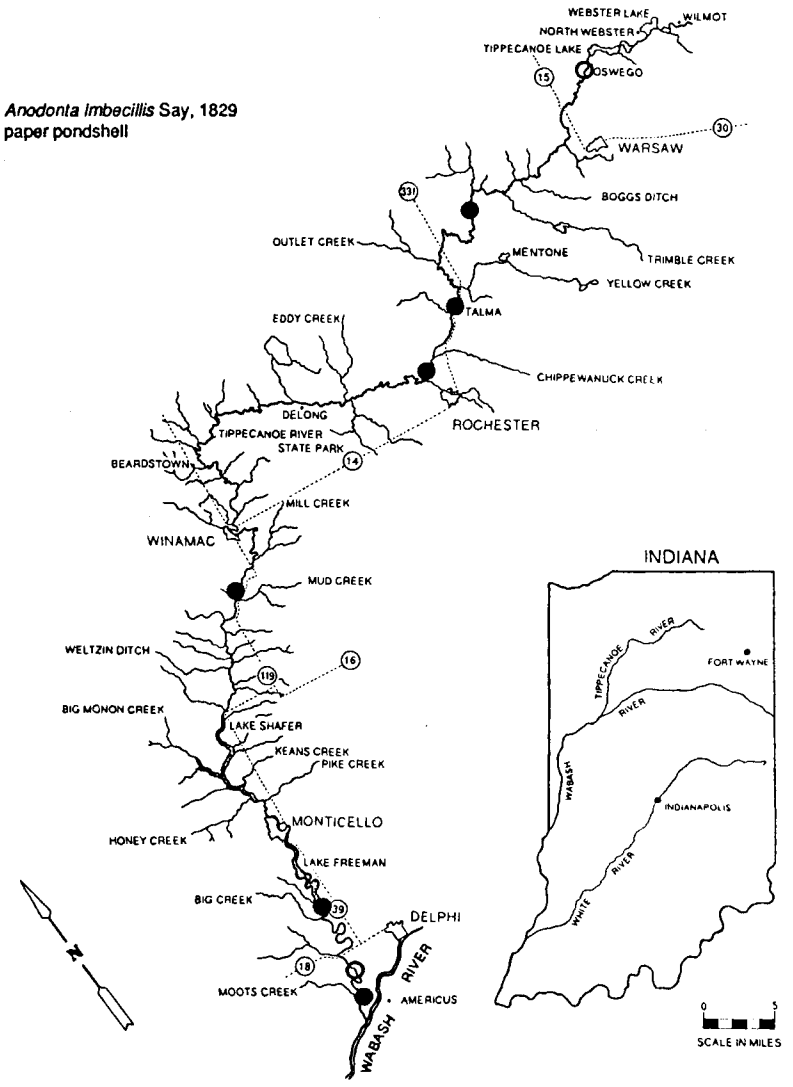
TIPPECANOE RIVER

Anodonta grandis Say, 1829
giant floater



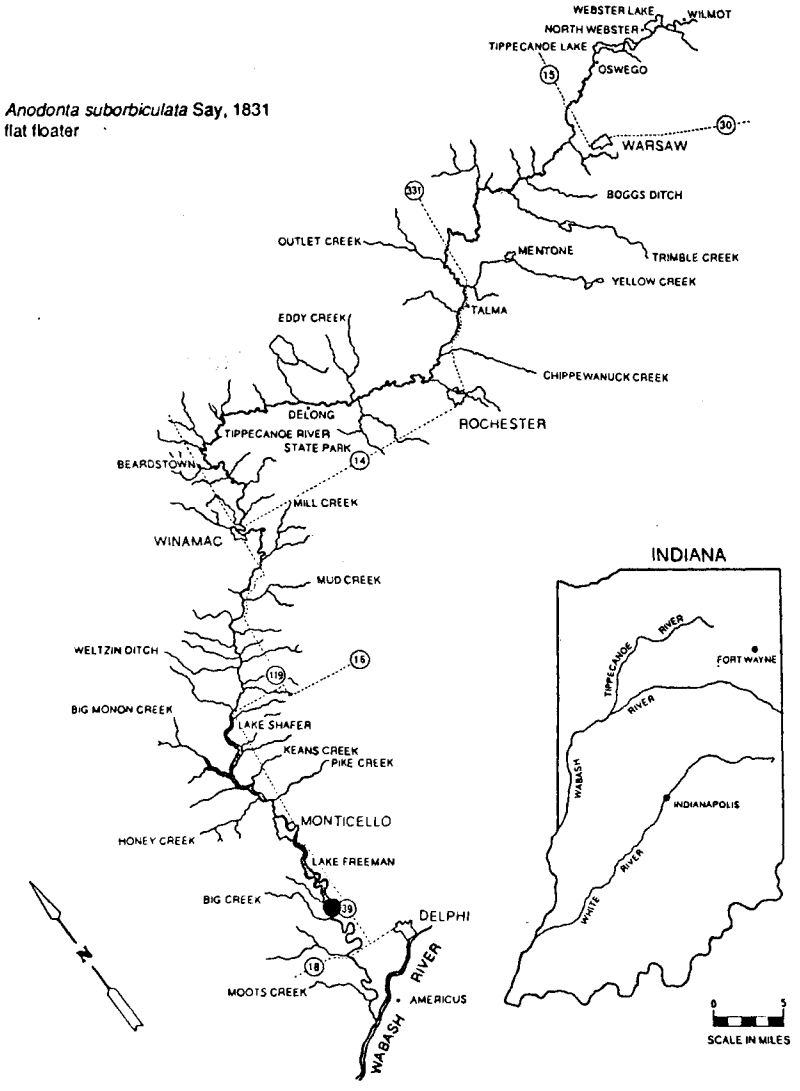
TIPPECANOE RIVER

Anodonta imbecillis Say, 1829
paper pondshell



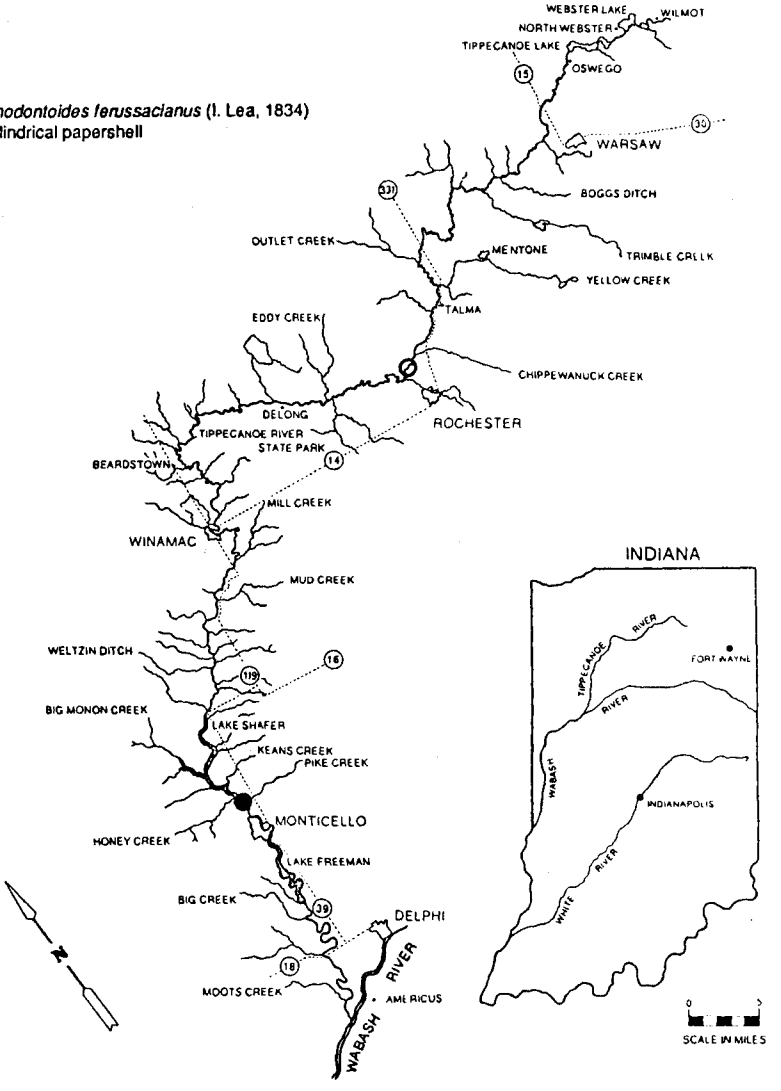
TIPPECANOE RIVER

Anodonta suborbiculata Say, 1831
flat floater



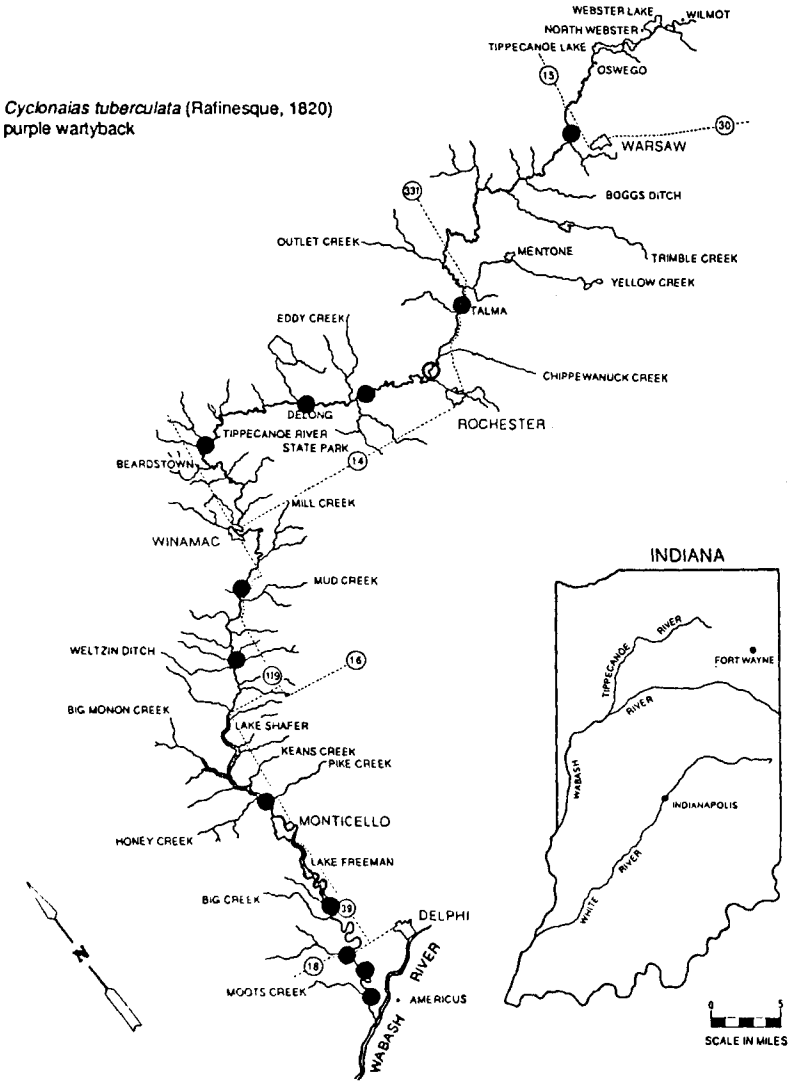
TIPPECANOE RIVER

Anodontoides ferussacianus (I. Lea, 1834)
cylindrical papershell



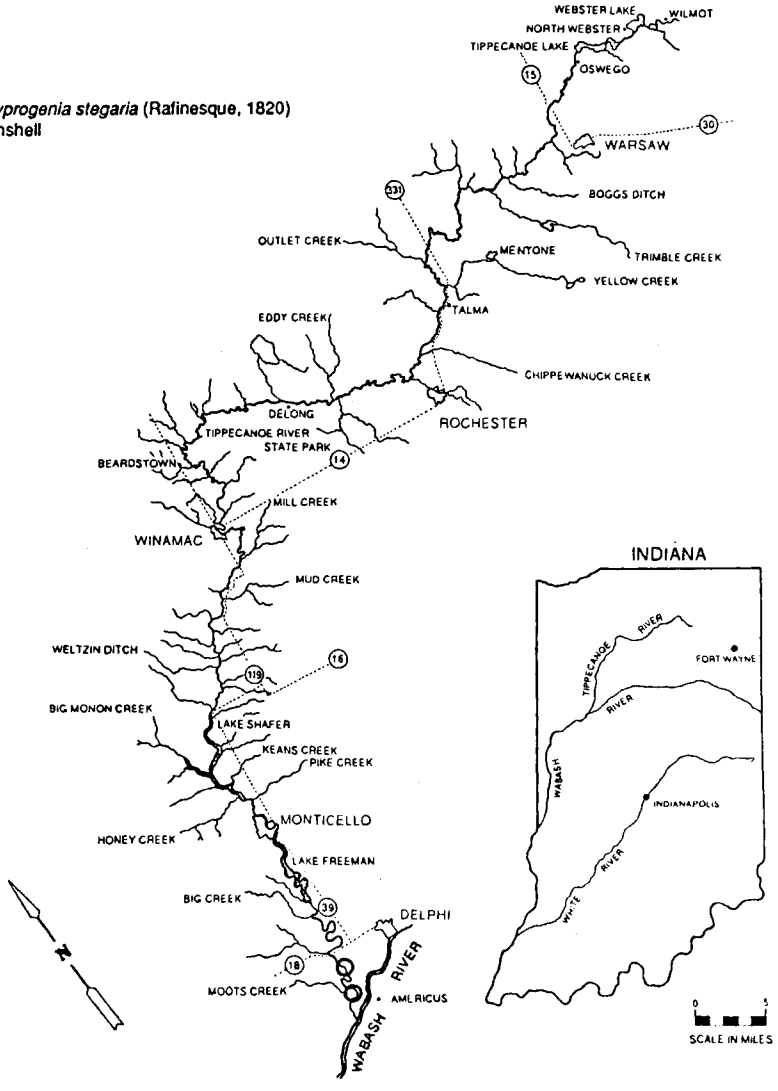
TIPPECANOE RIVER

Cyclonaias tuberculata (Rafinesque, 1820)
purple wartyback



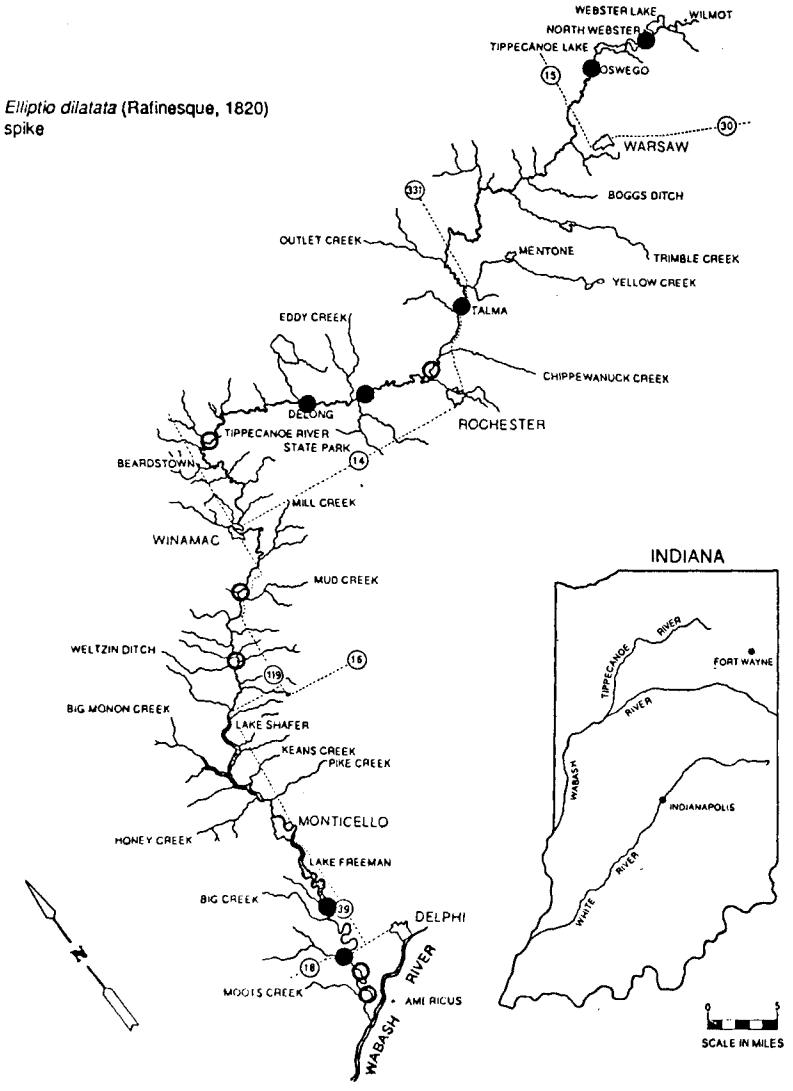
TIPPECANOE RIVER

Cyprogenia stegaria (Rafinesque, 1820)
fanshell



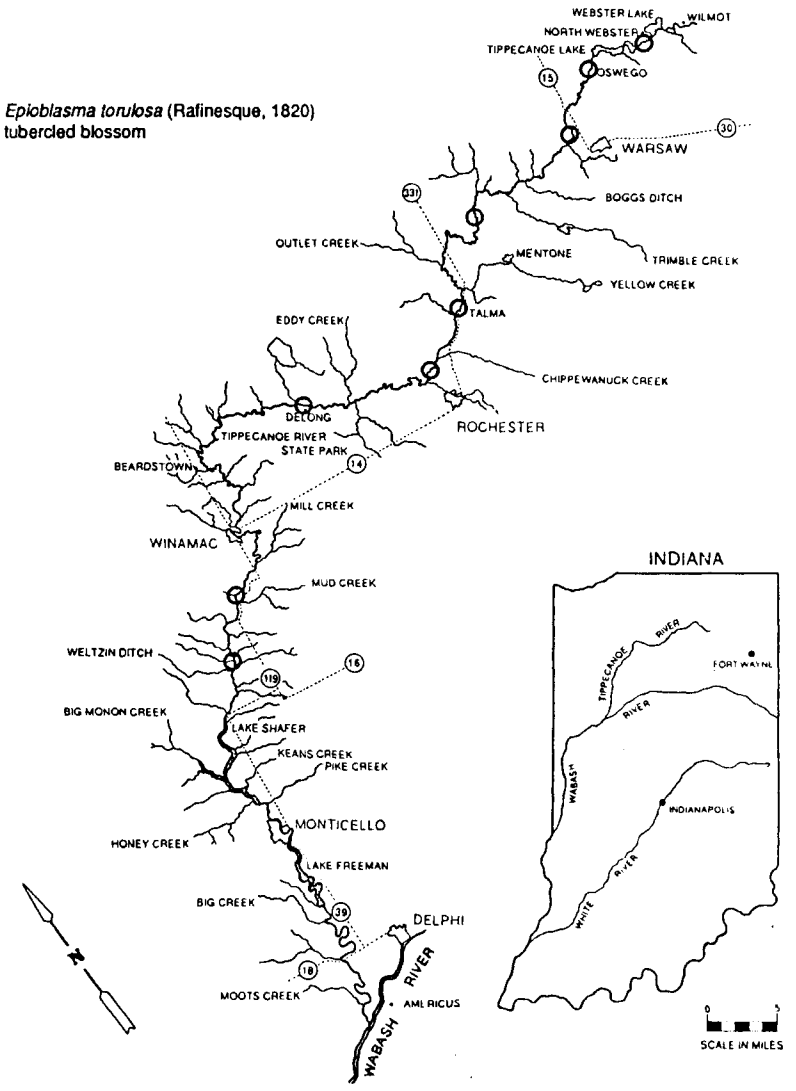
TIPPECANOE RIVER

Elliptio dilatata (Rafinesque, 1820)
spike



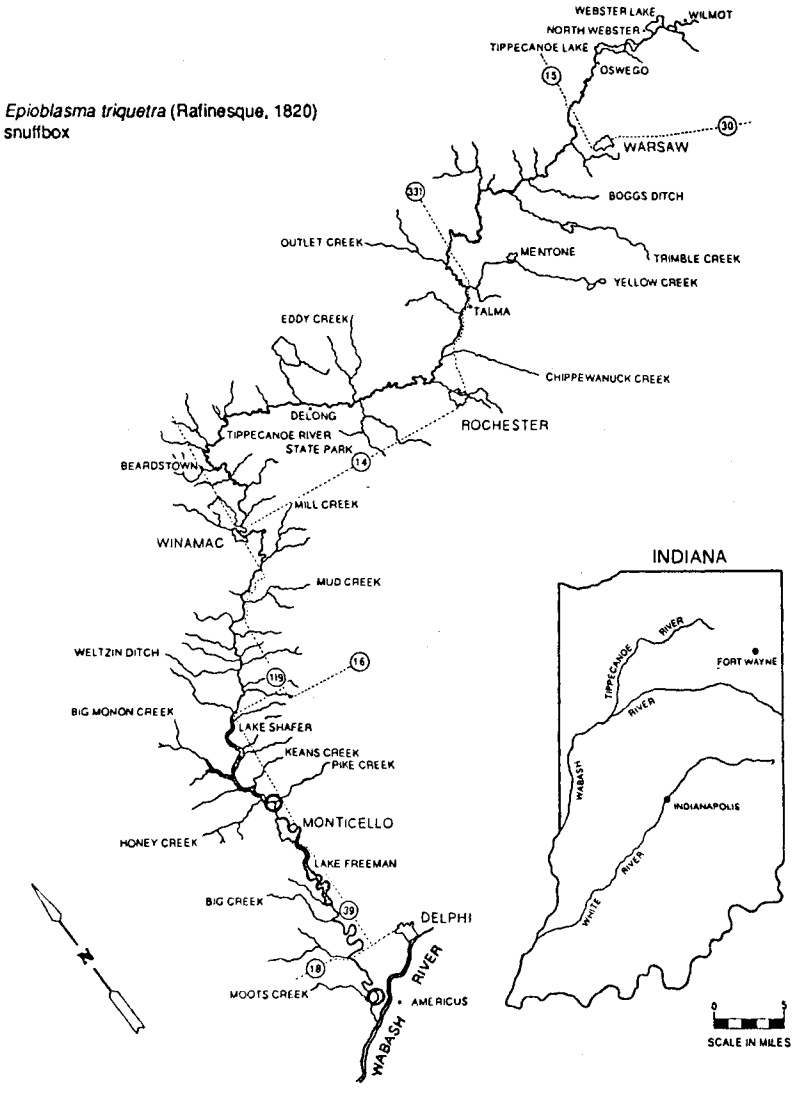
TIPPECANOE RIVER

Epioblasma torulosa (Rafinesque, 1820)
tubercled blossom



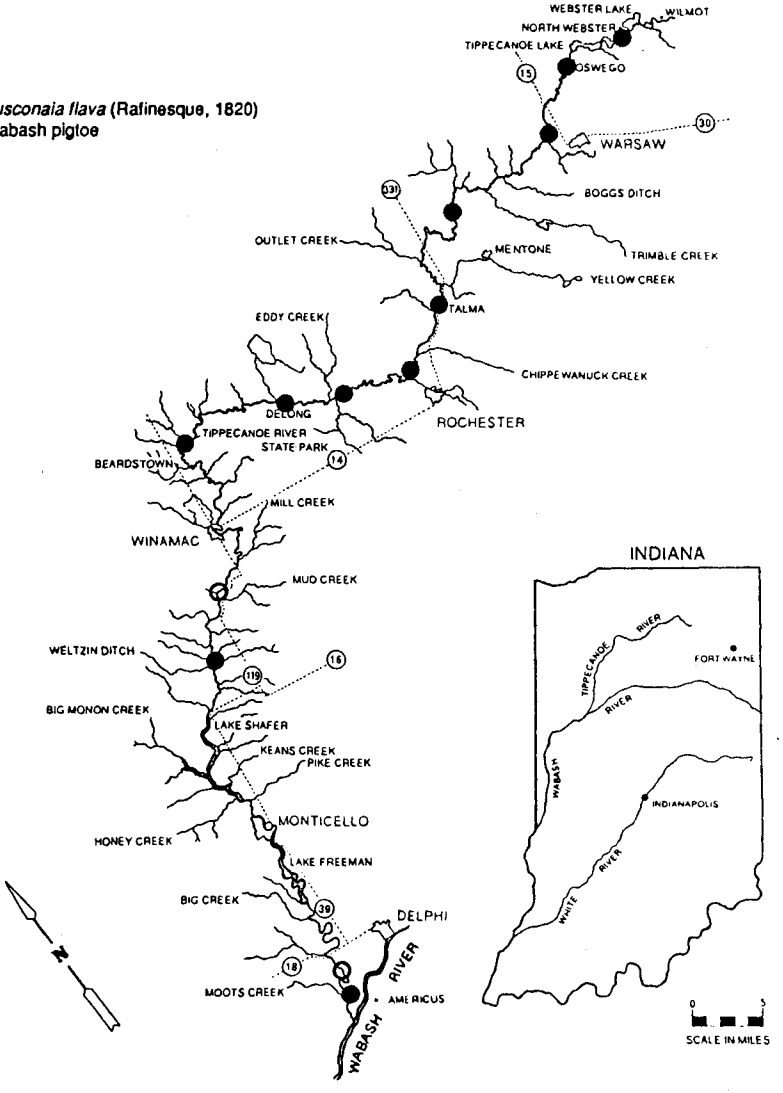
TIPPECANOE RIVER

Epioblasma triquetra (Rafinesque, 1820)
snuffbox



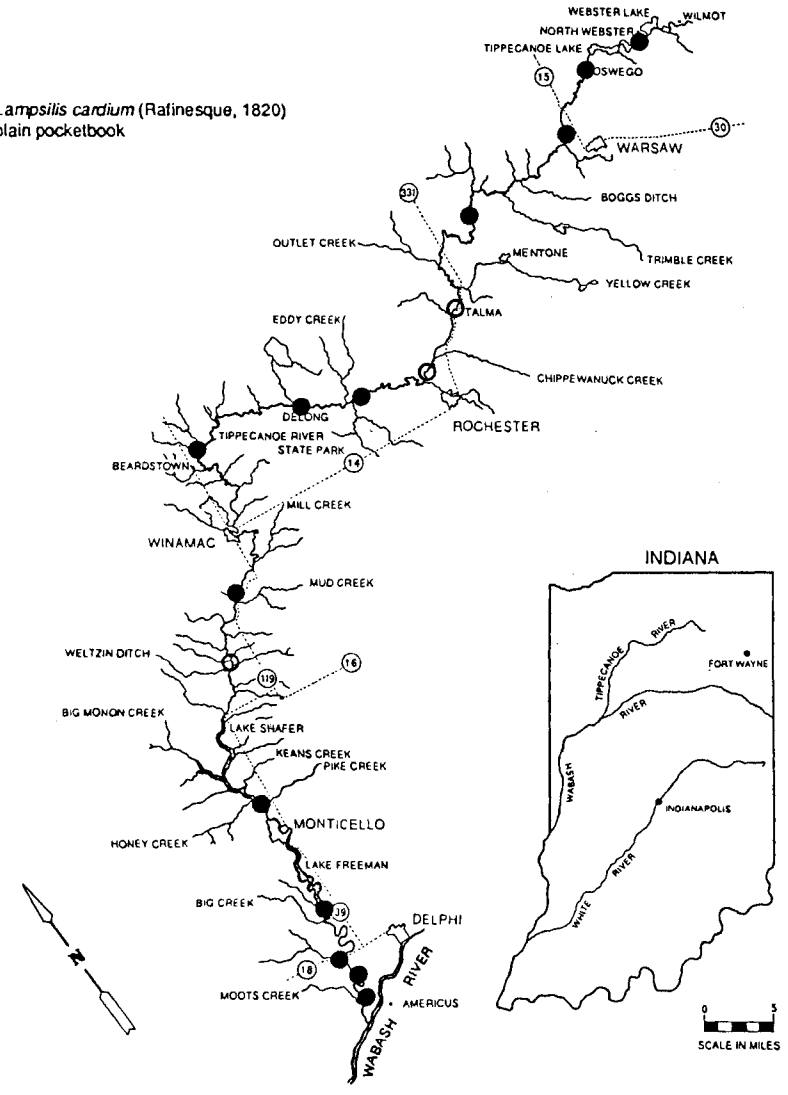
TIPPECANOE RIVER

Fusconaia flava (Rafinesque, 1820)
Wabash pigtoe



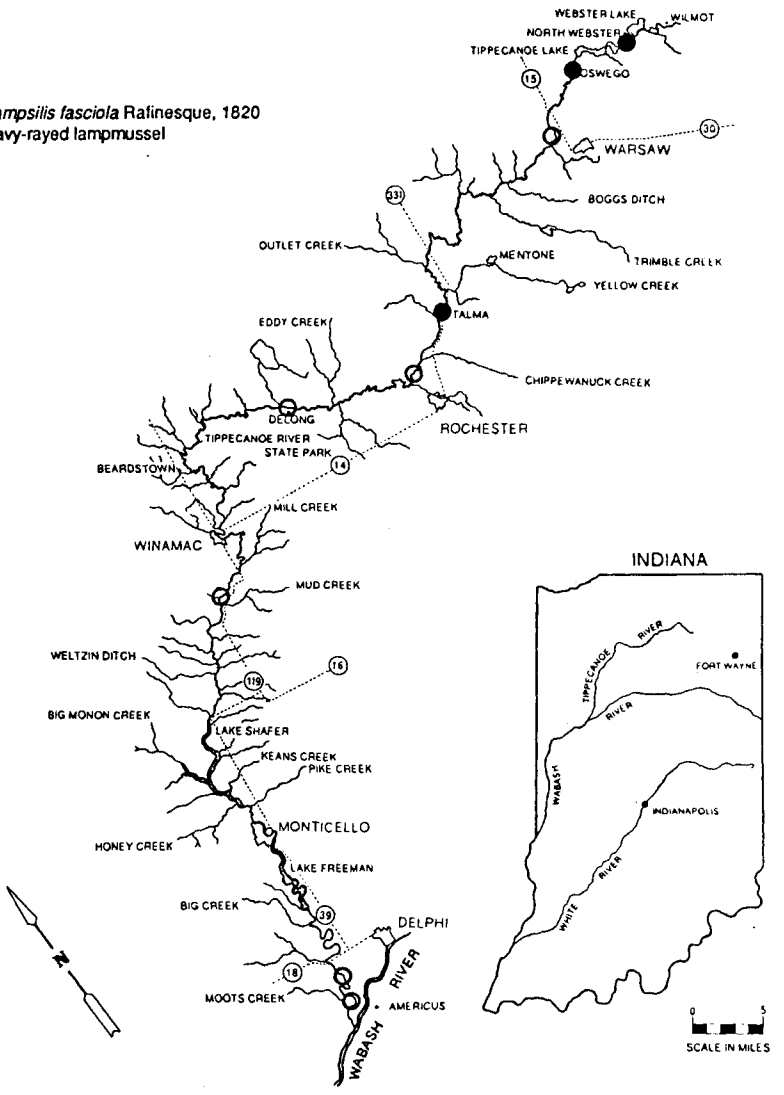
TIPPECANOE RIVER

Lampsilis cardium (Rafinesque, 1820)
plain pocketbook



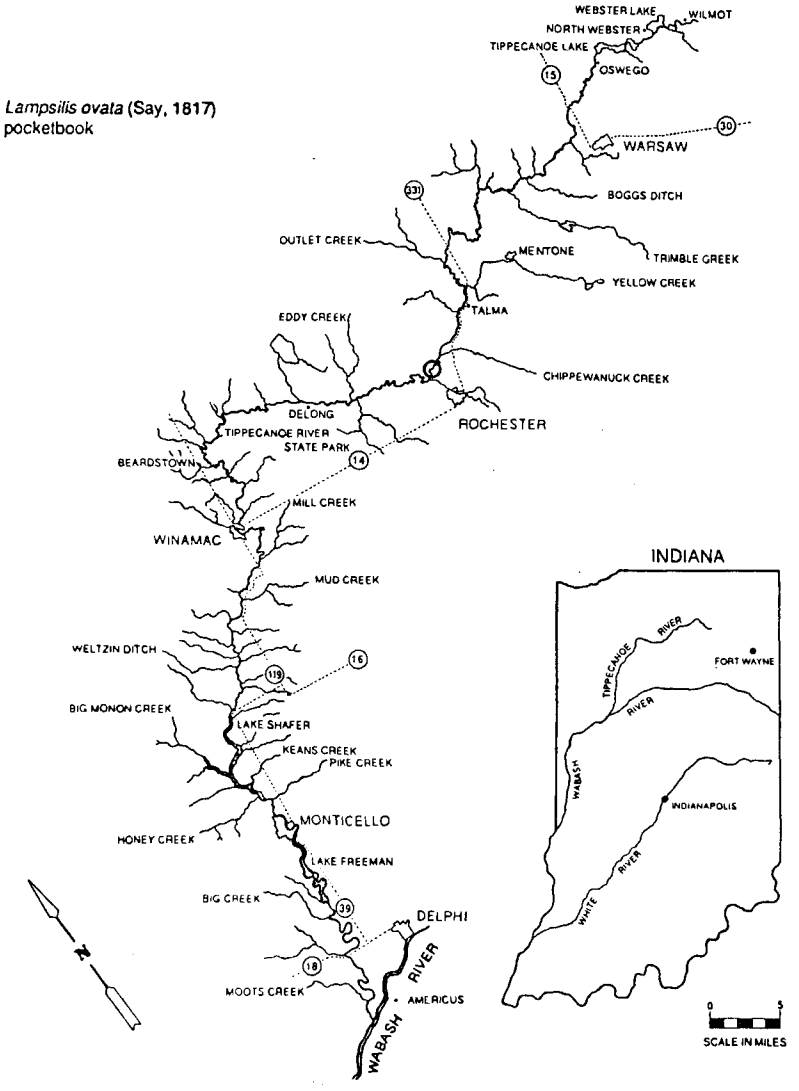
TIPPECANOE RIVER

Lampsilis fasciola Rafinesque, 1820
wavy-rayed lampmussel



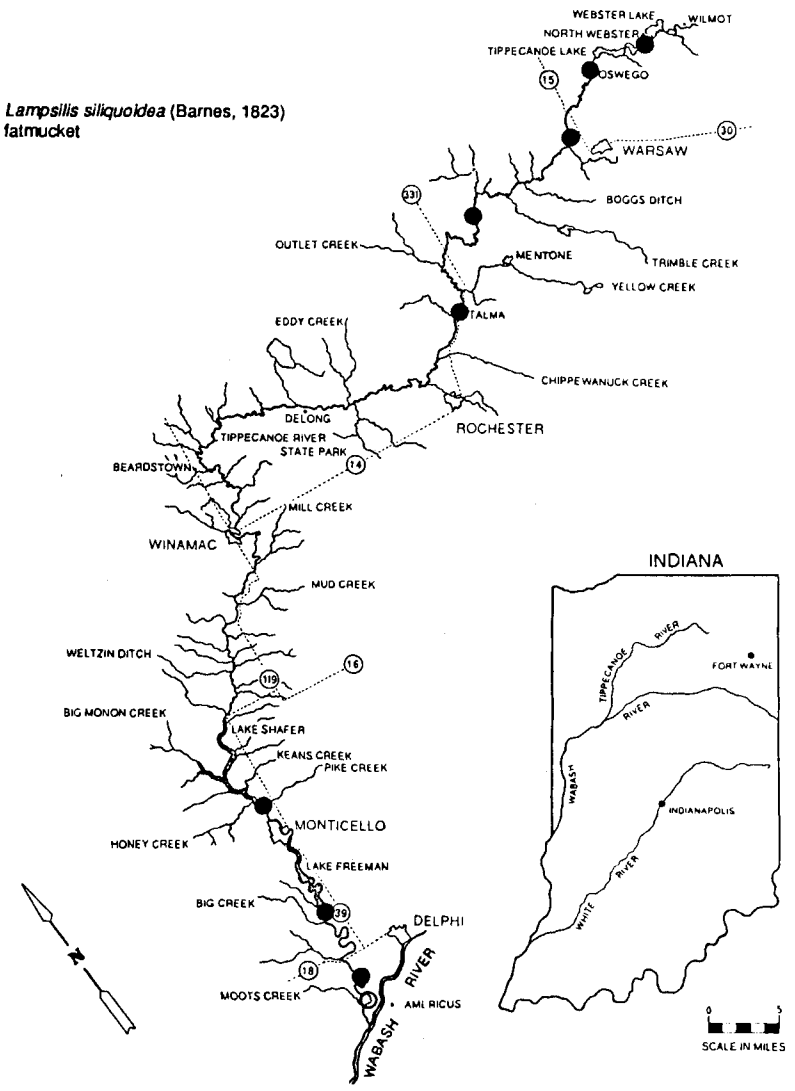
TIPPECANOE RIVER

Lampsilis ovata (Say, 1817)
pocketbook



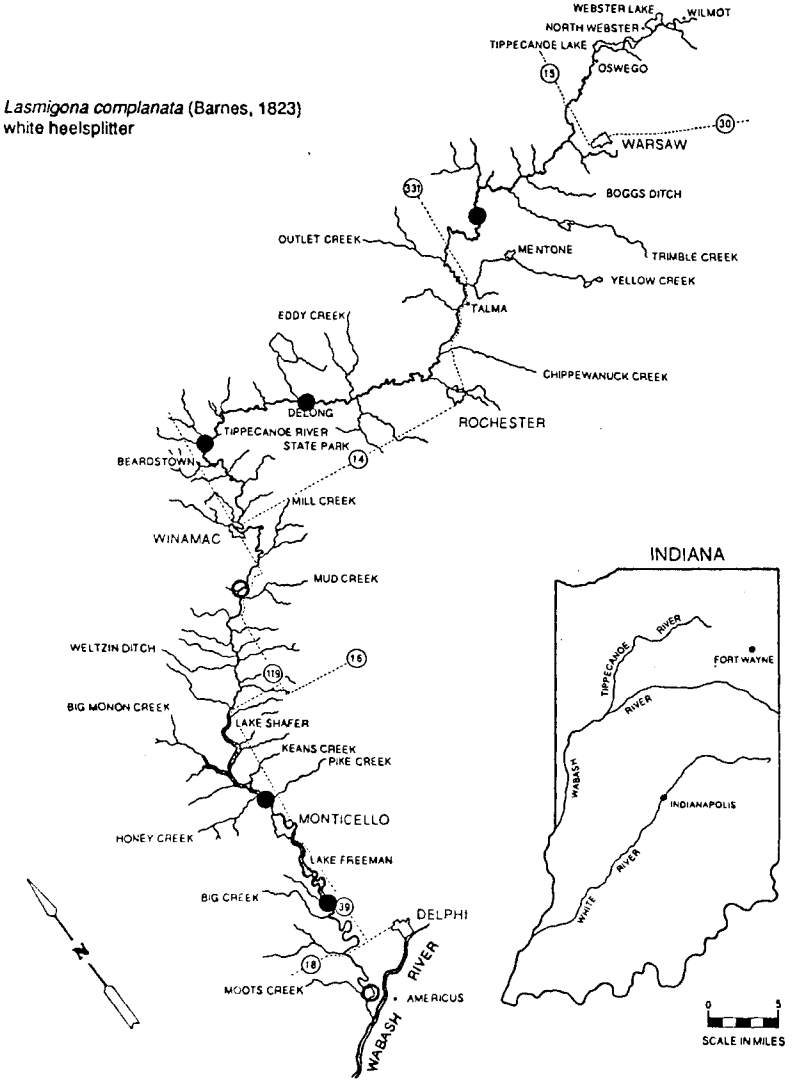
TIPPECANOE RIVER

Lampsilis siliquoidea **(Barnes, 1823)**
fatmucket



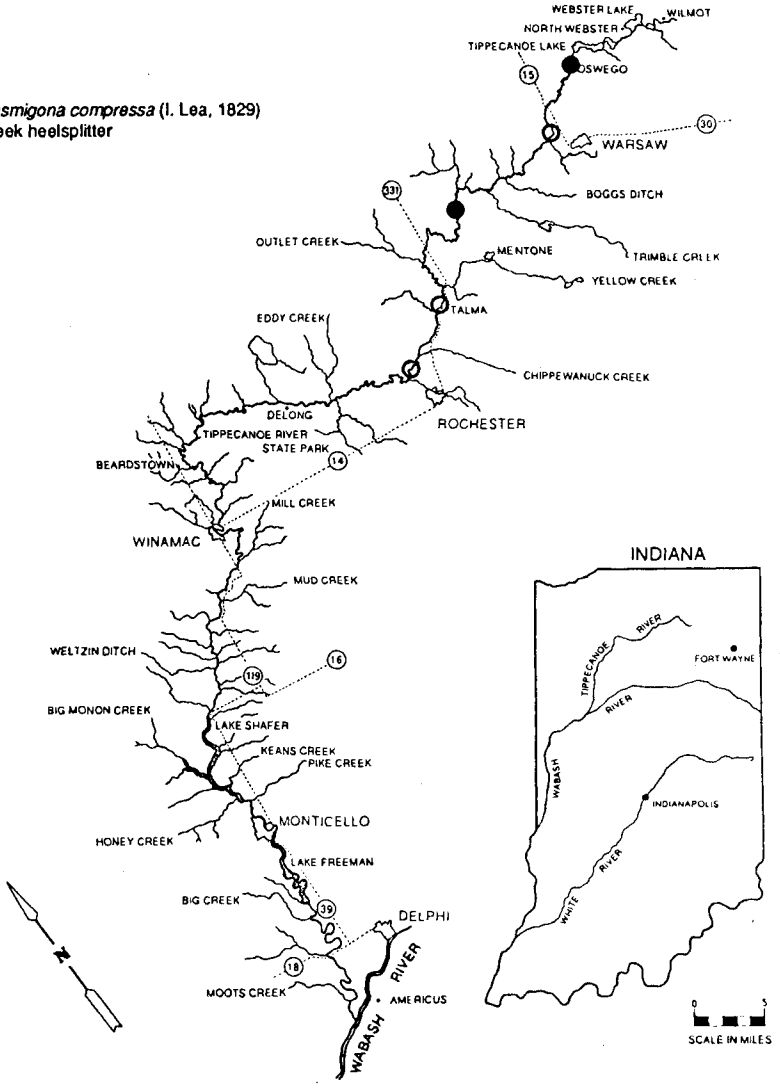
TIPPECANOE RIVER

Lasmigona complanata (Barnes, 1823)
white heelsplitter



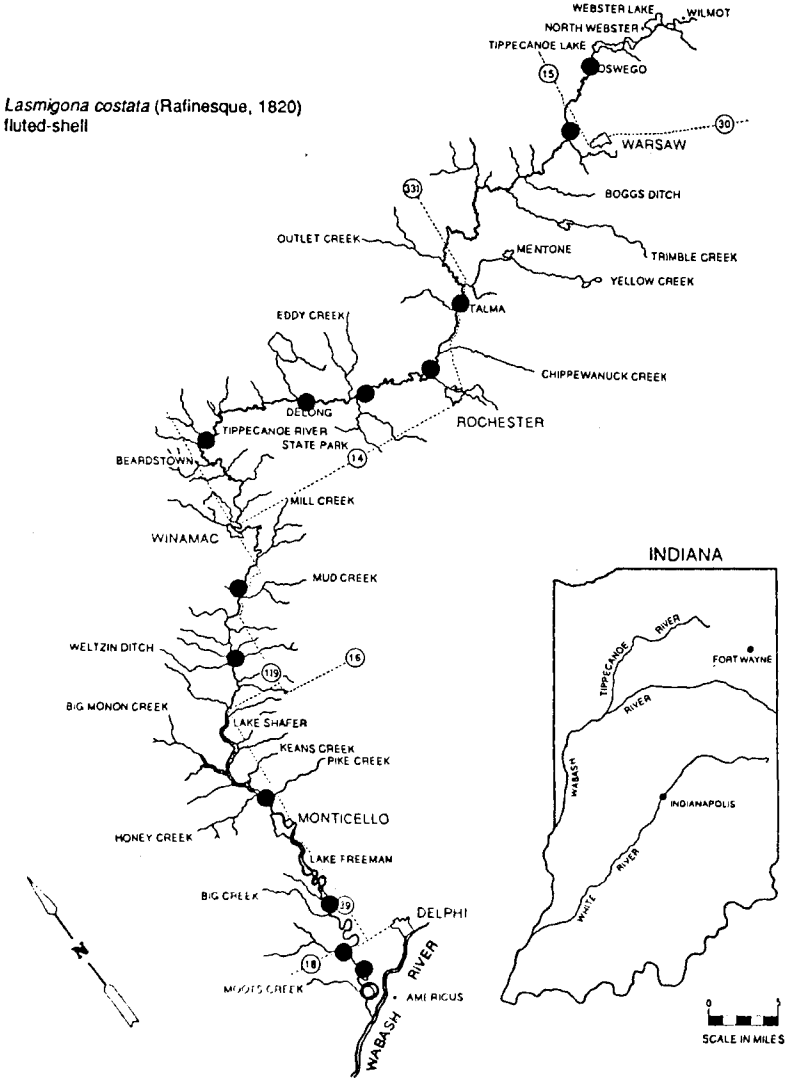
TIPPECANOE RIVER

Lasmigona compressa (I. Lea, 1829)
creek heelsplitter



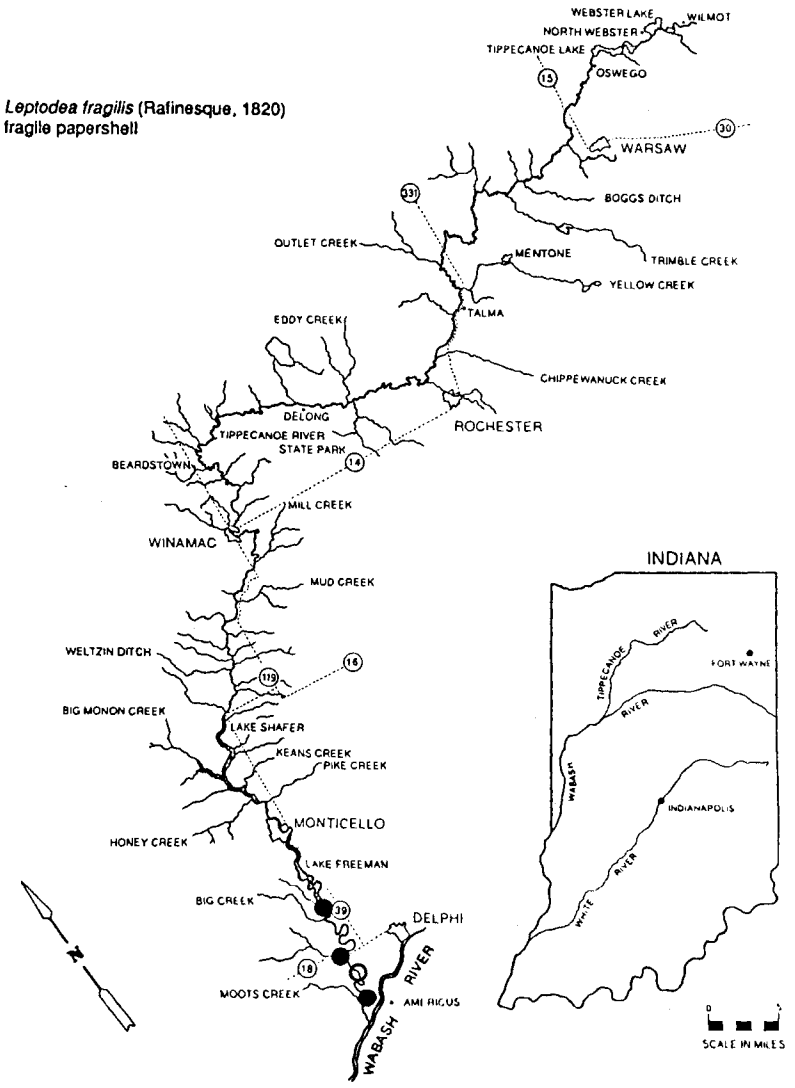
TIPPECANOE RIVER

Lasmigona costata (Rafinesque, 1820)
fluted-shell



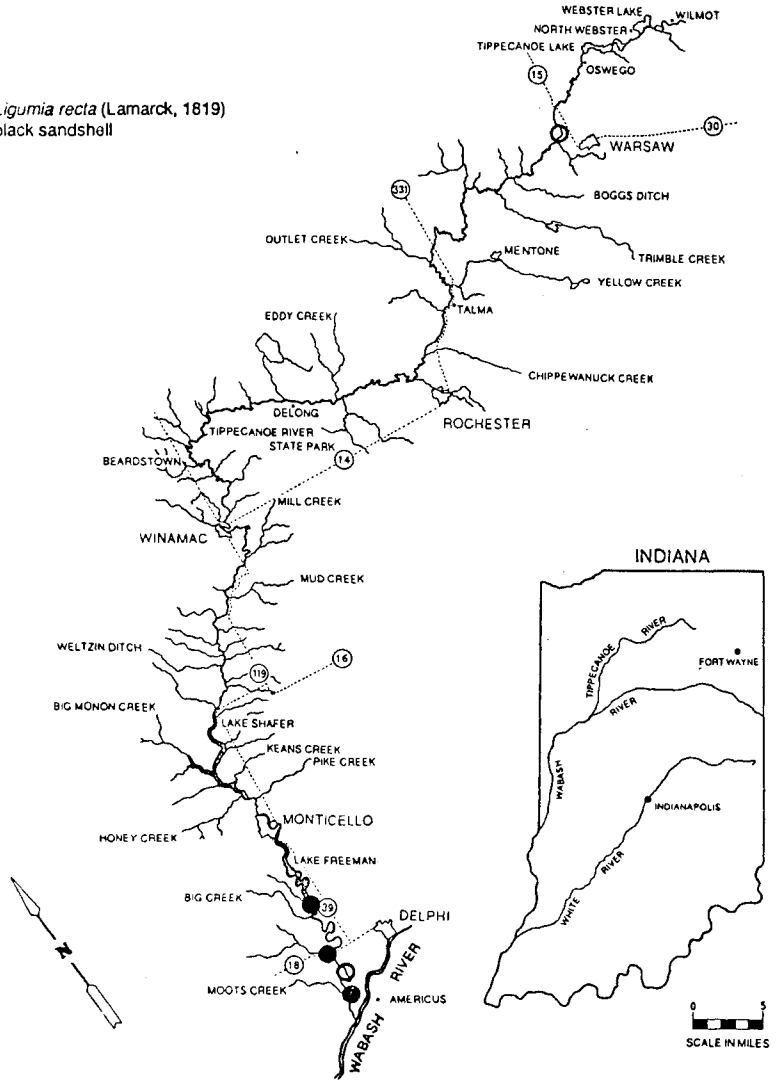
TIPPECANOE RIVER

Leptodea fragilis (Rafinesque, 1820)
fragile papershell



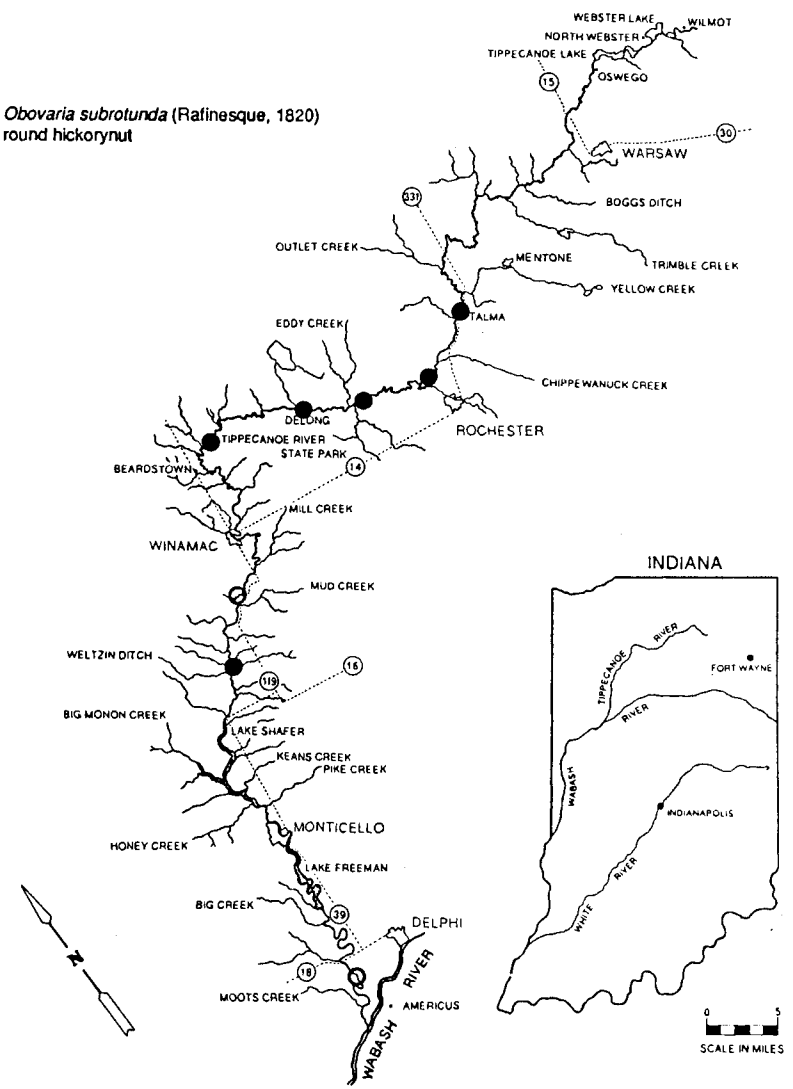
TIPPECANOE RIVER

Ligumia recta (Lamarck, 1819)
black sandshell



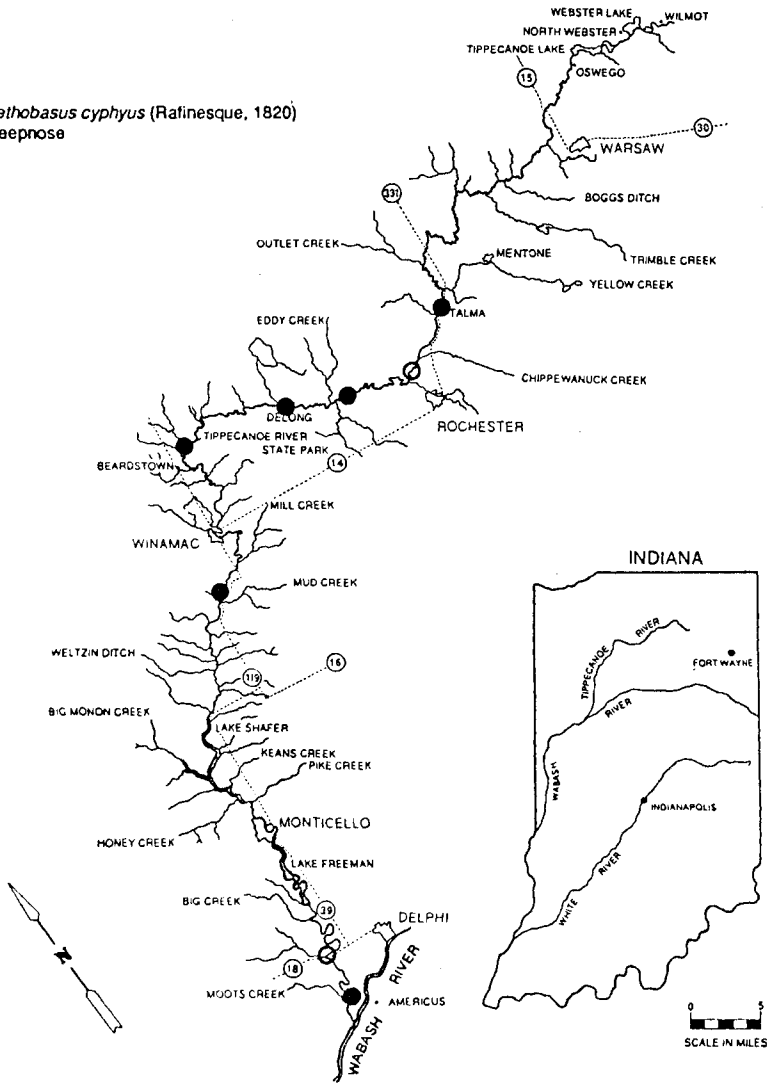
TIPPECANOE RIVER

Obovaria subrotunda (Rafinesque, 1820)
round hickorynut



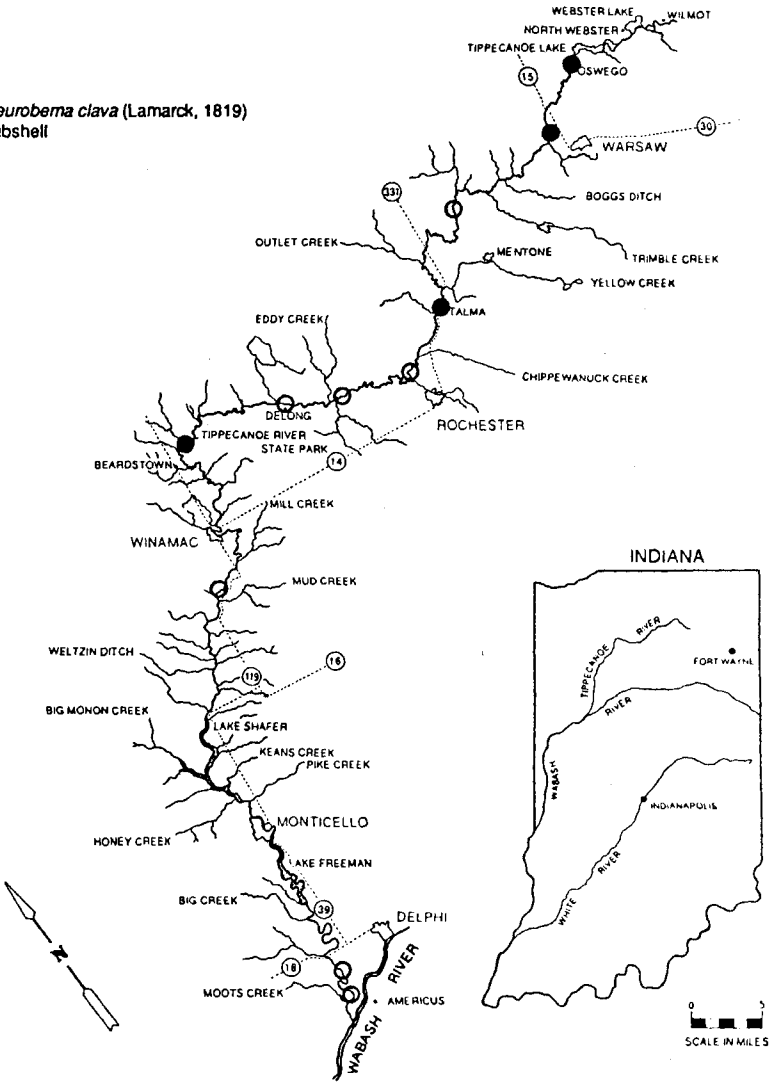
TIPPECANOE RIVER

Plethobasus cyphyus (Rafinesque, 1820)
sheepnose



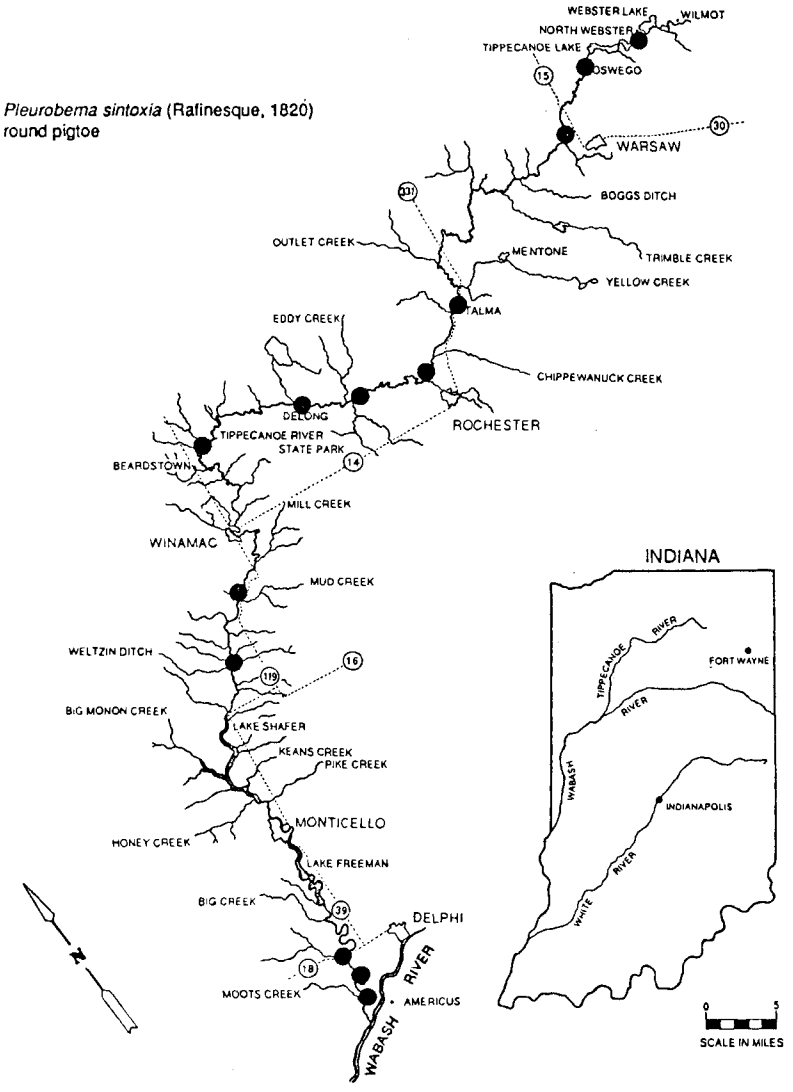
TIPPECANOE RIVER

Pleurobema clava (Lamarck, 1819)
clubshell



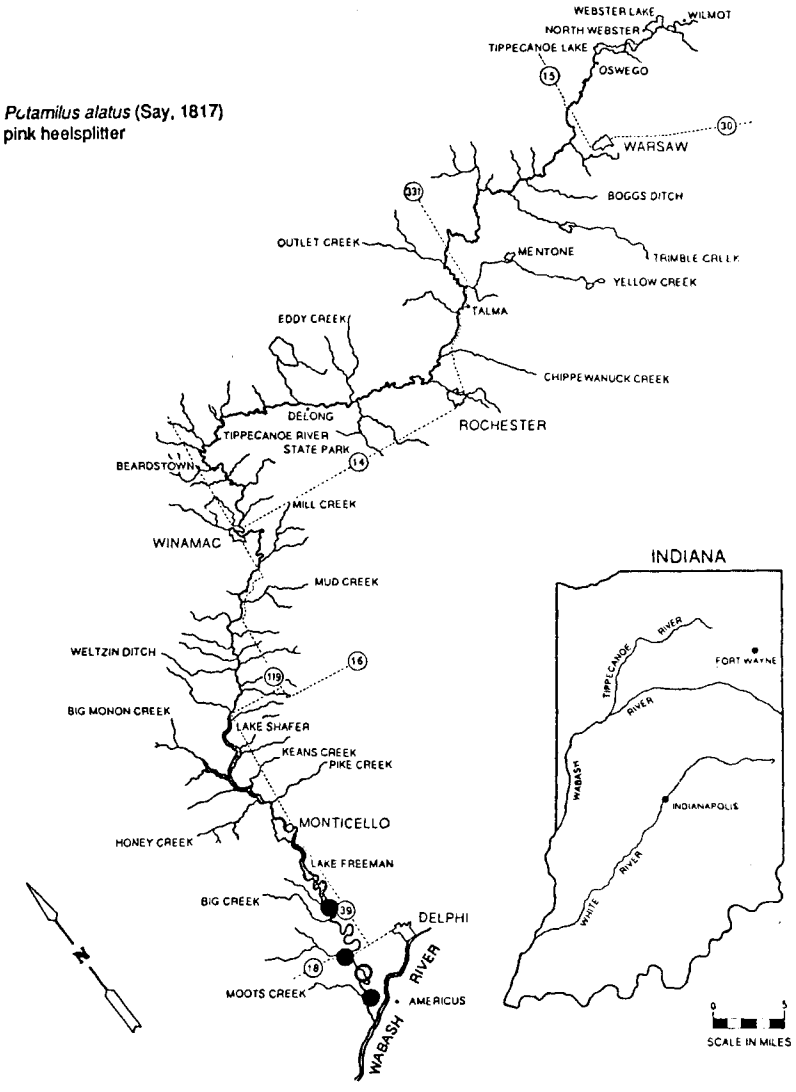
TIPPECANOE RIVER

Pleurobema sintoxia (Rafinesque, 1820)
round pigtoe



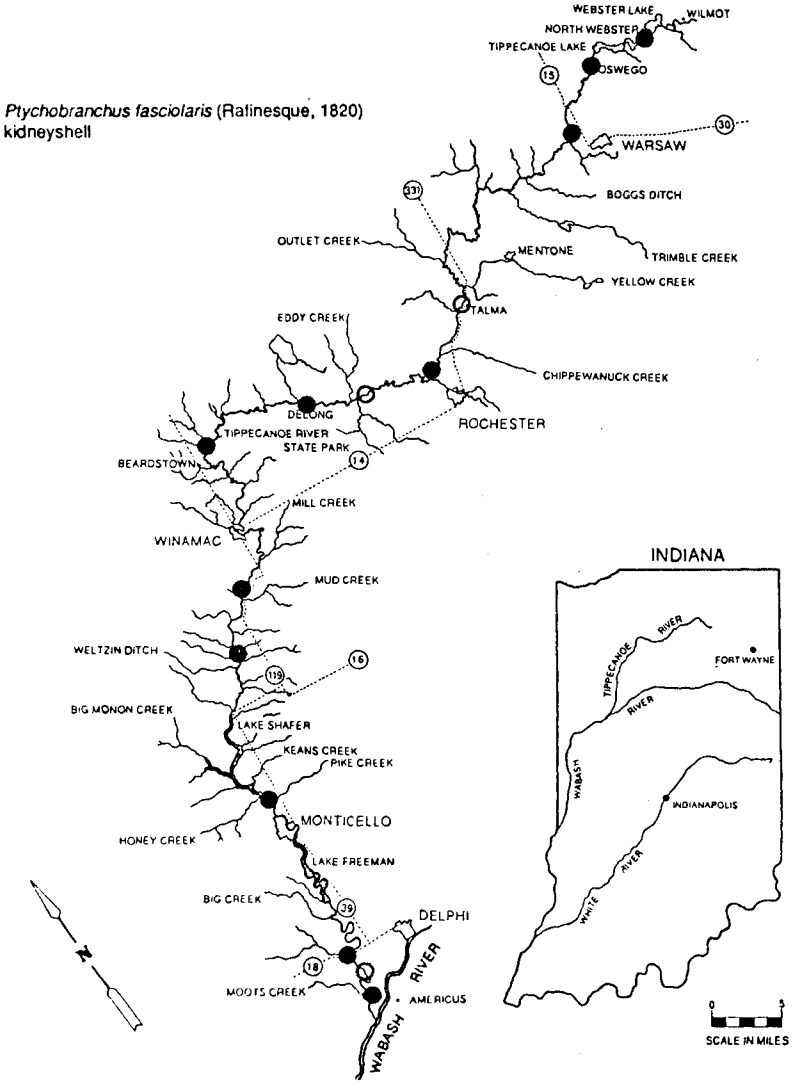
TIPPECANOE RIVER

Potamilus alatus (Say, 1817)
pink heelsplitter



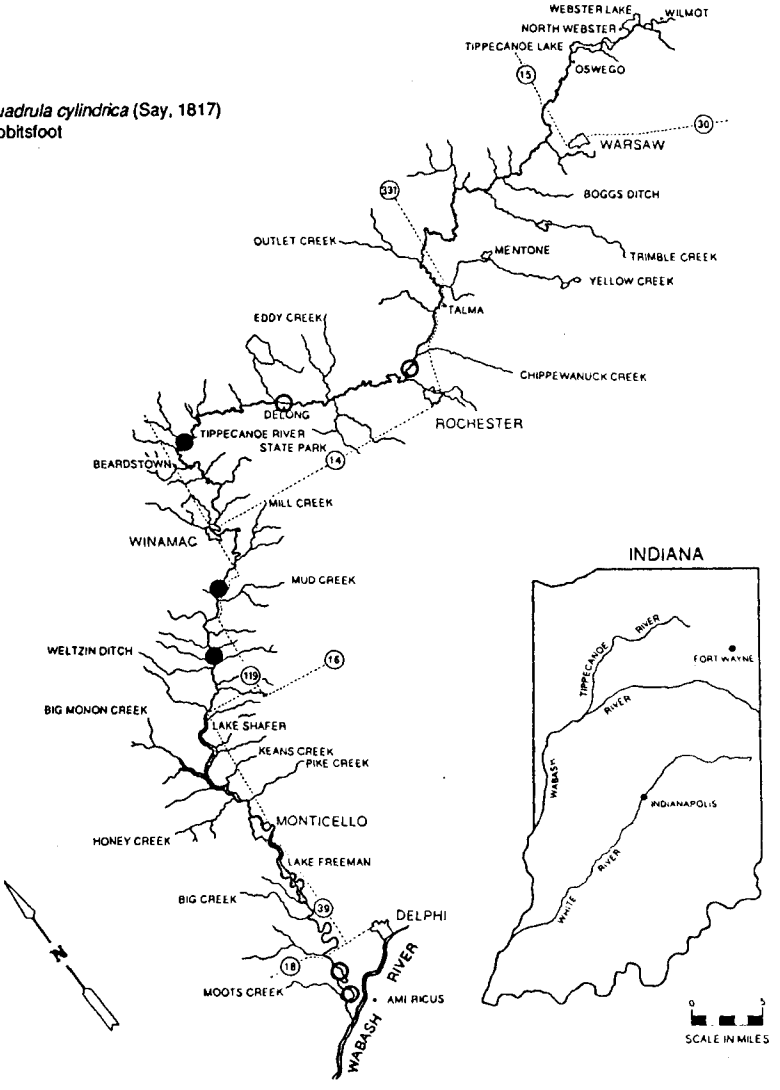
TIPPECANOE RIVER

Ptychobranchus fasciolaris (Rafinesque, 1820)
kidneyshell



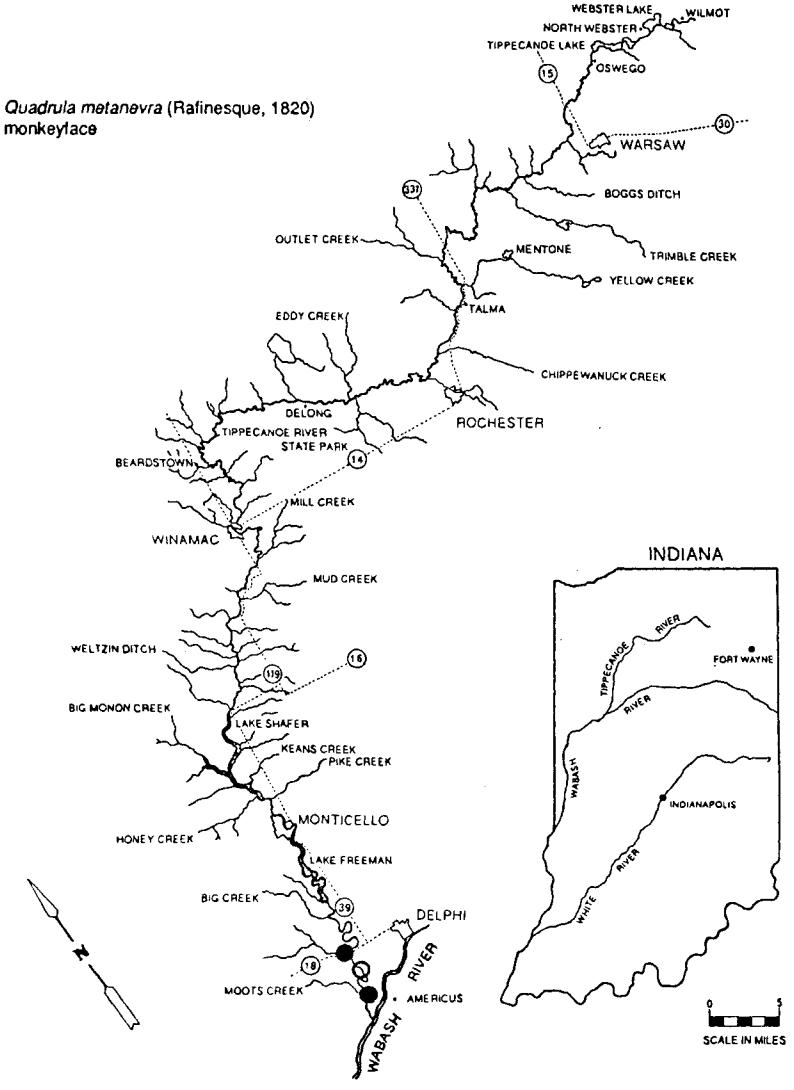
TIPPECANOE RIVER

Quadrula cylindrica (Say, 1817)
rabbitsfoot



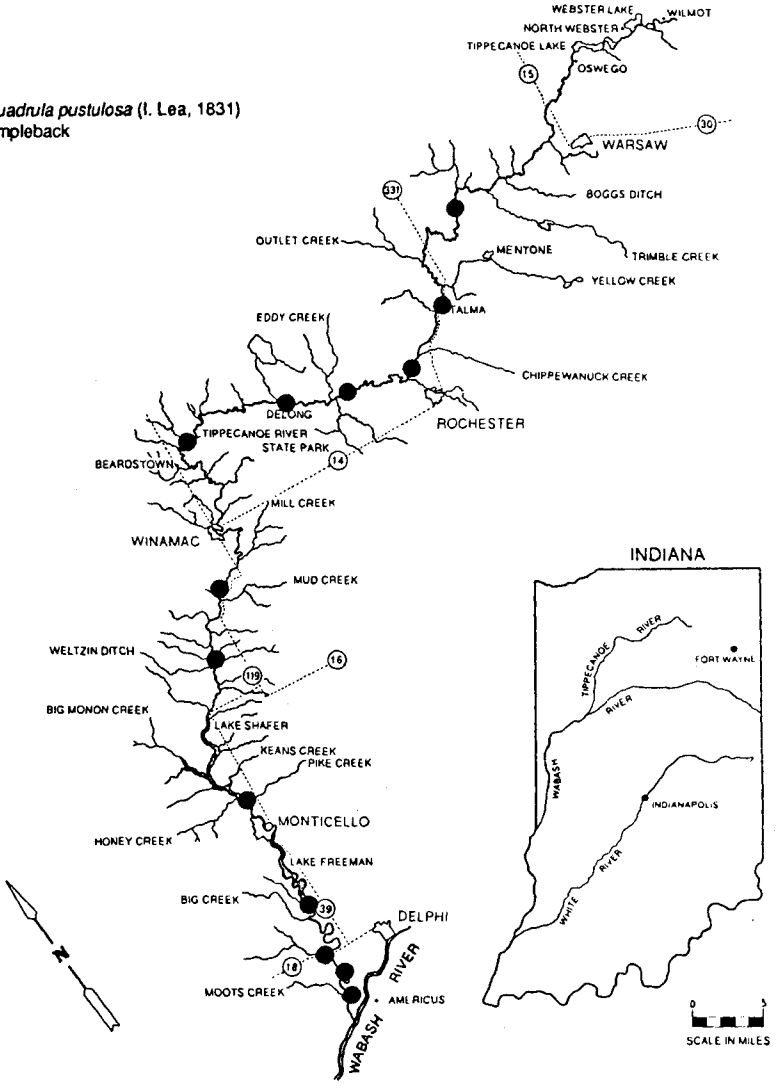
TIPPECANOE RIVER

Quadrula metanevra (Rafinesque, 1820)
monkeyface



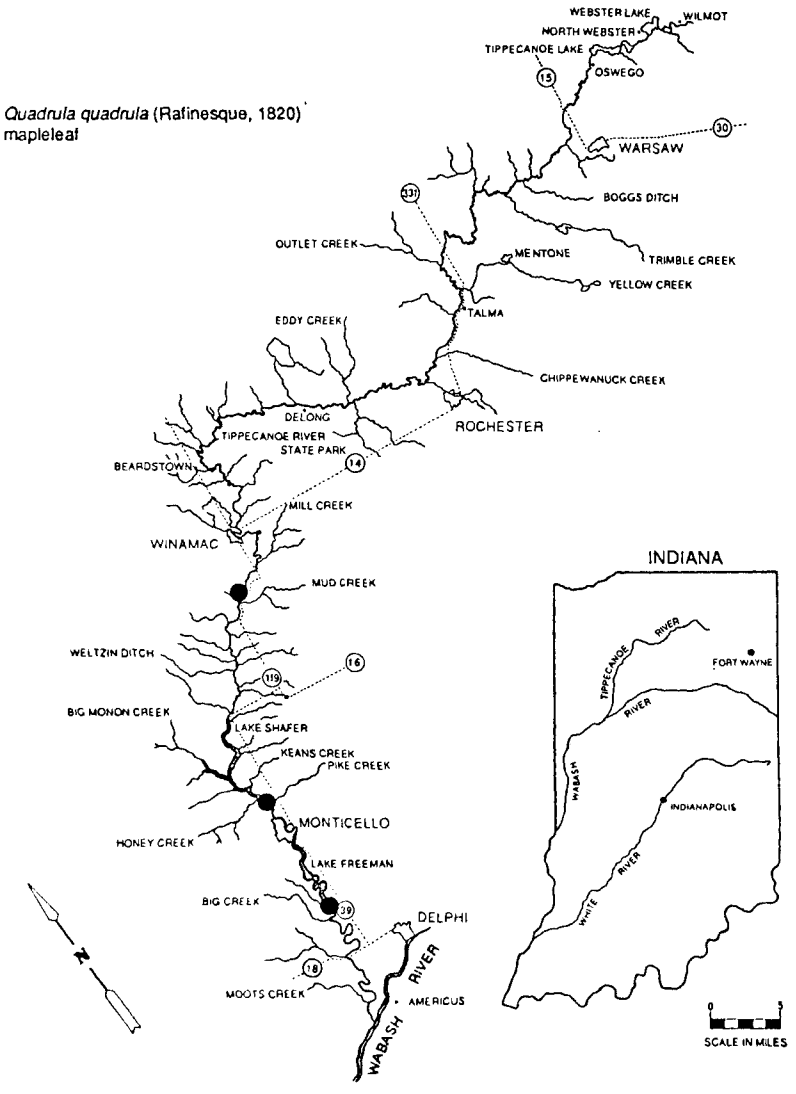
TIPPECANOE RIVER

Quadrula pustulosa (I. Lea, 1831)
pimpleback



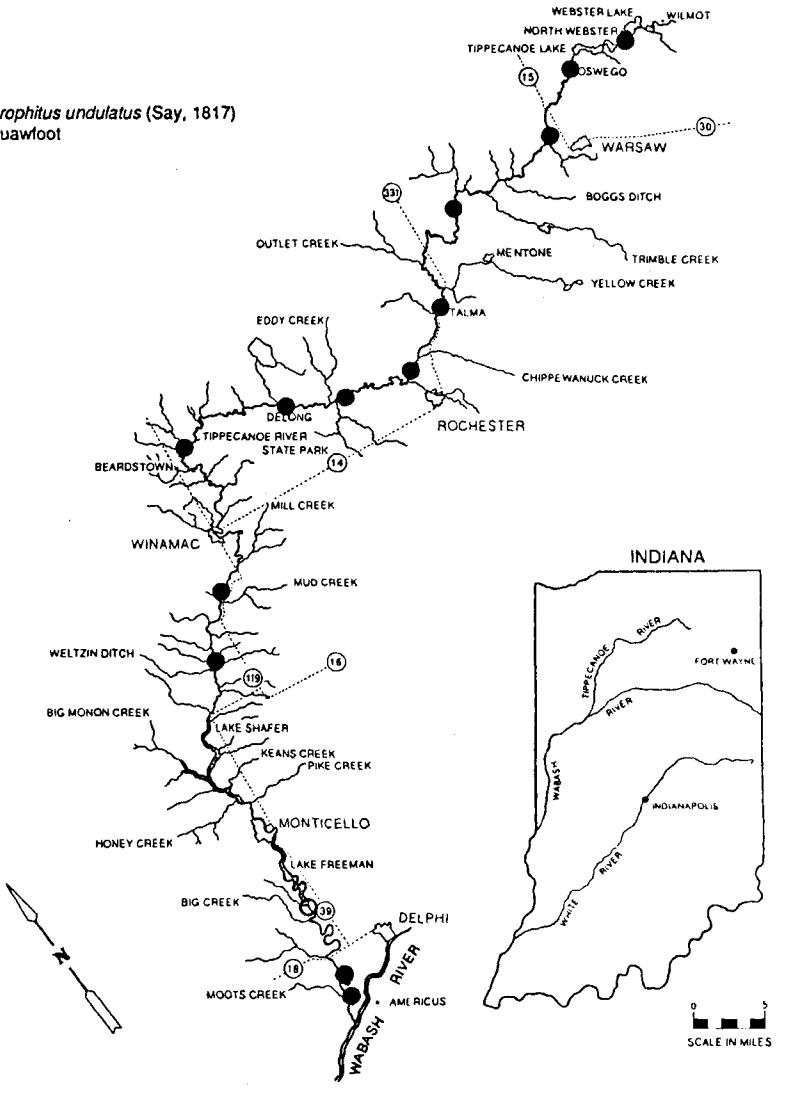
TIPPECANOE RIVER

Quadrula quadrula (Rafinesque, 1820)
mapleleaf

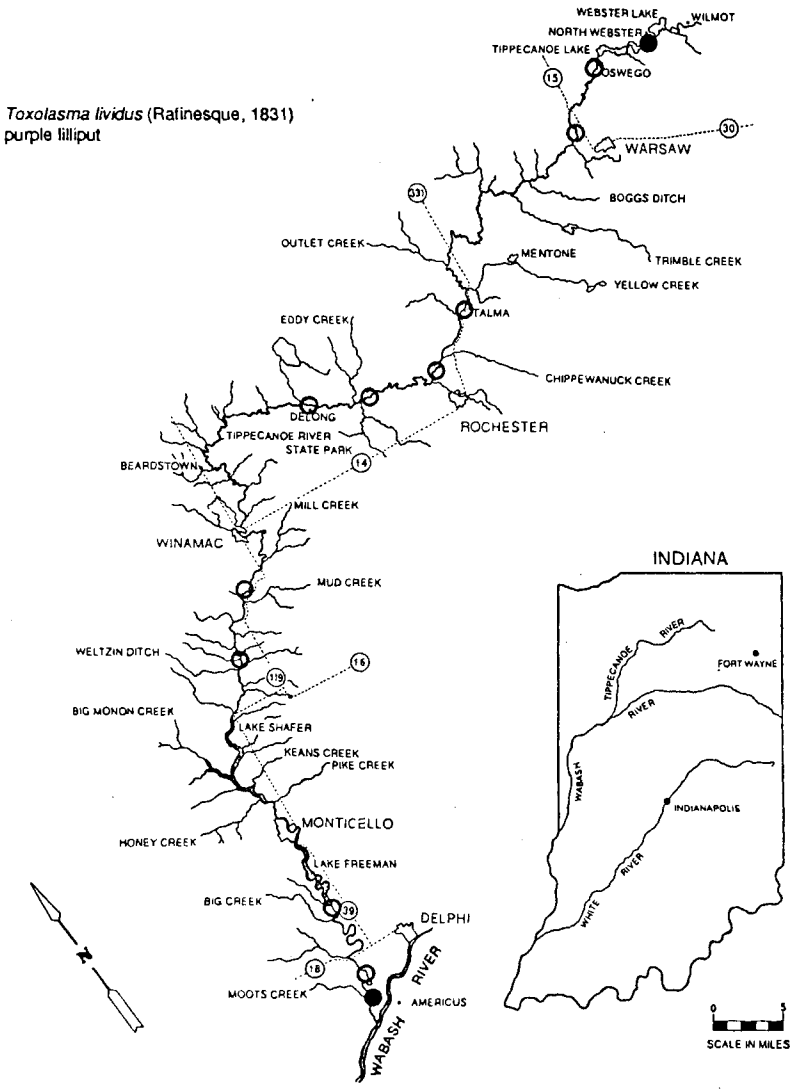


TIPPECANOE RIVER

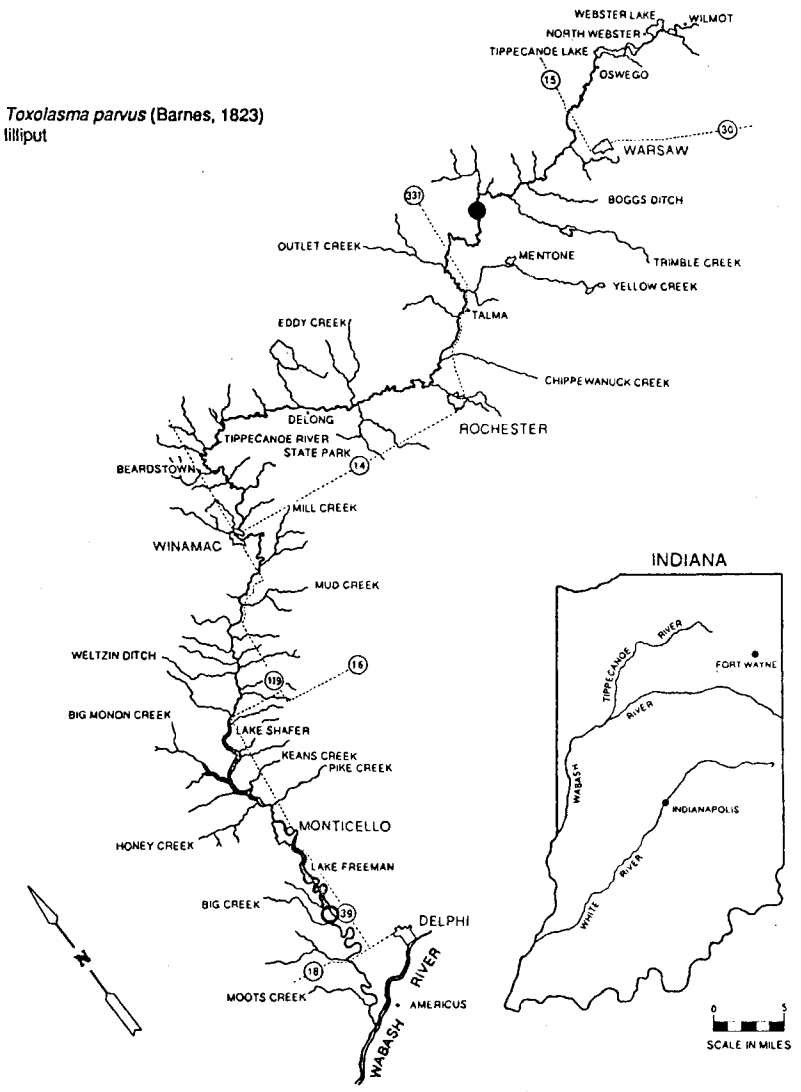
Strophitus undulatus (Say, 1817)
squawfoot



Toxolasma lividus (Rafinesque, 1831)
purple lilliput

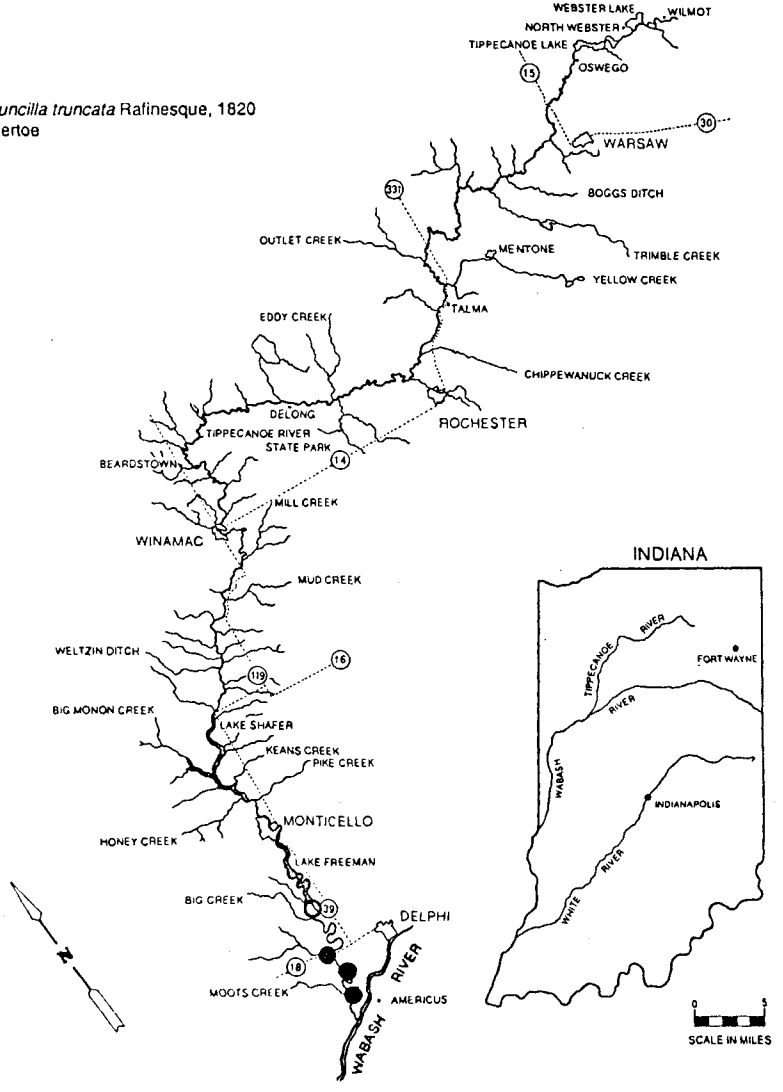


Toxolasma parvus (Barnes, 1823)
lilliput



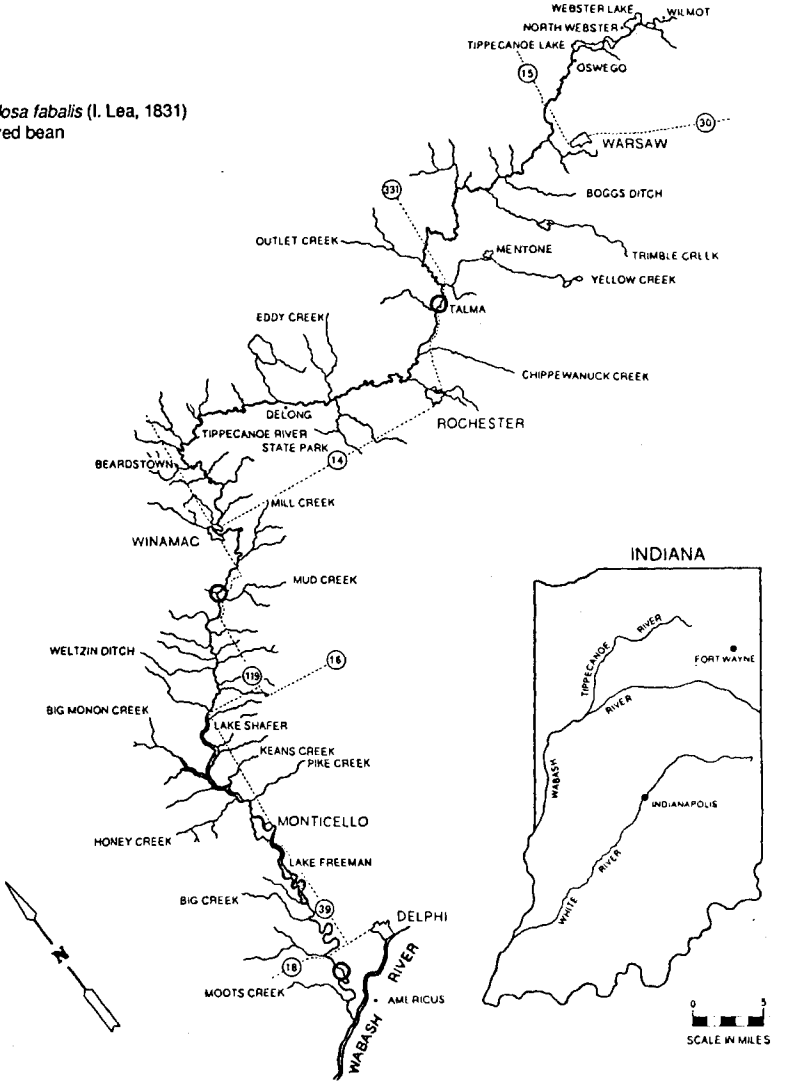
TIPPECANOE RIVER

Truncilla truncata Rafinesque, 1820
deertoe



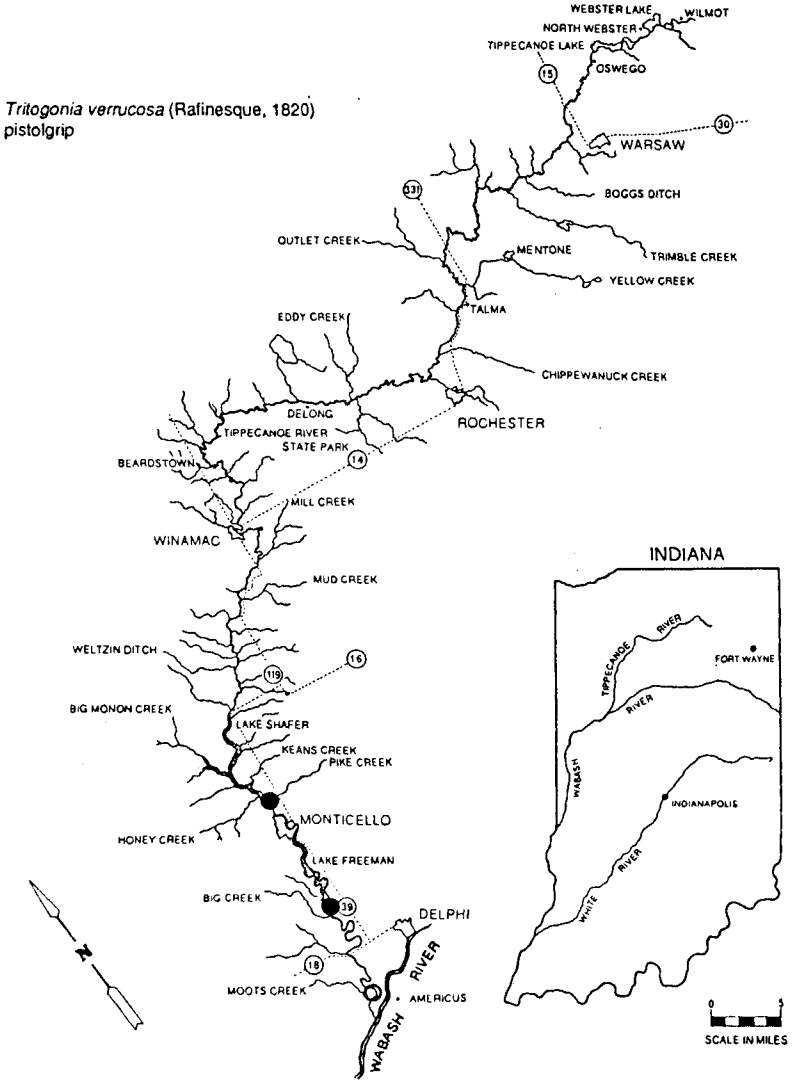
TIPPECANOE RIVER

Villosa fabalis (I. Lea, 1831)
rayed bean



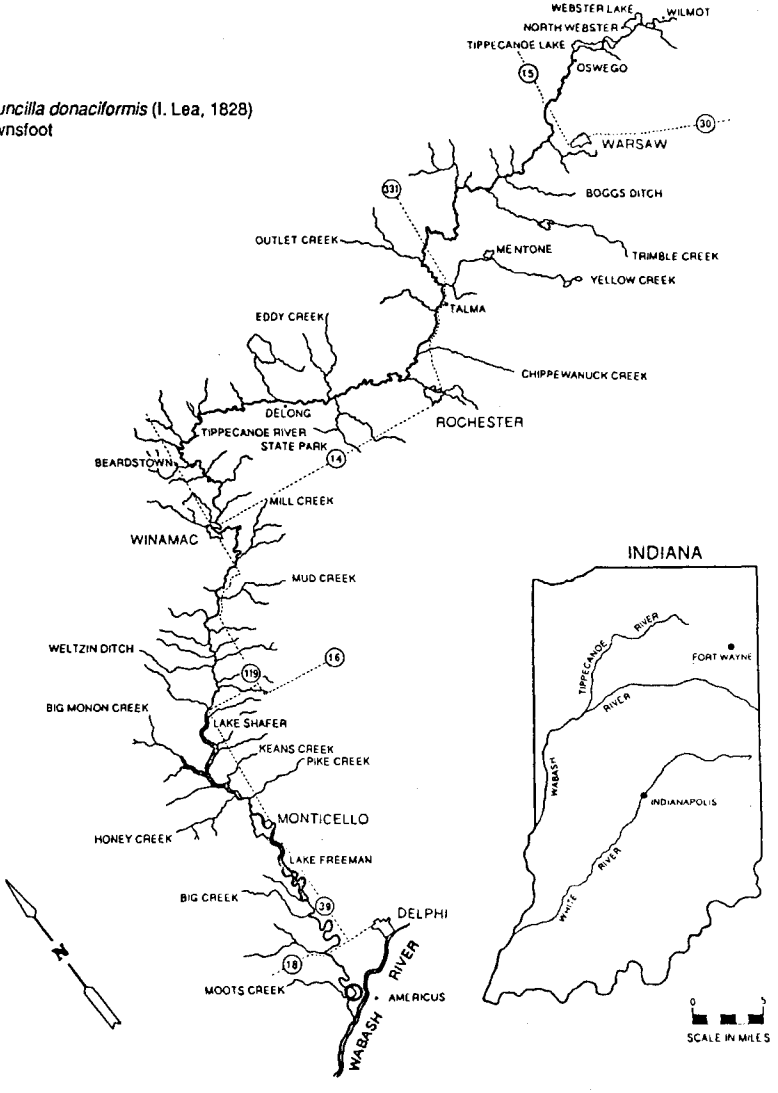
TIPPECANOE RIVER

Tritogonia verrucosa (Rafinesque, 1820)
pistolgrip

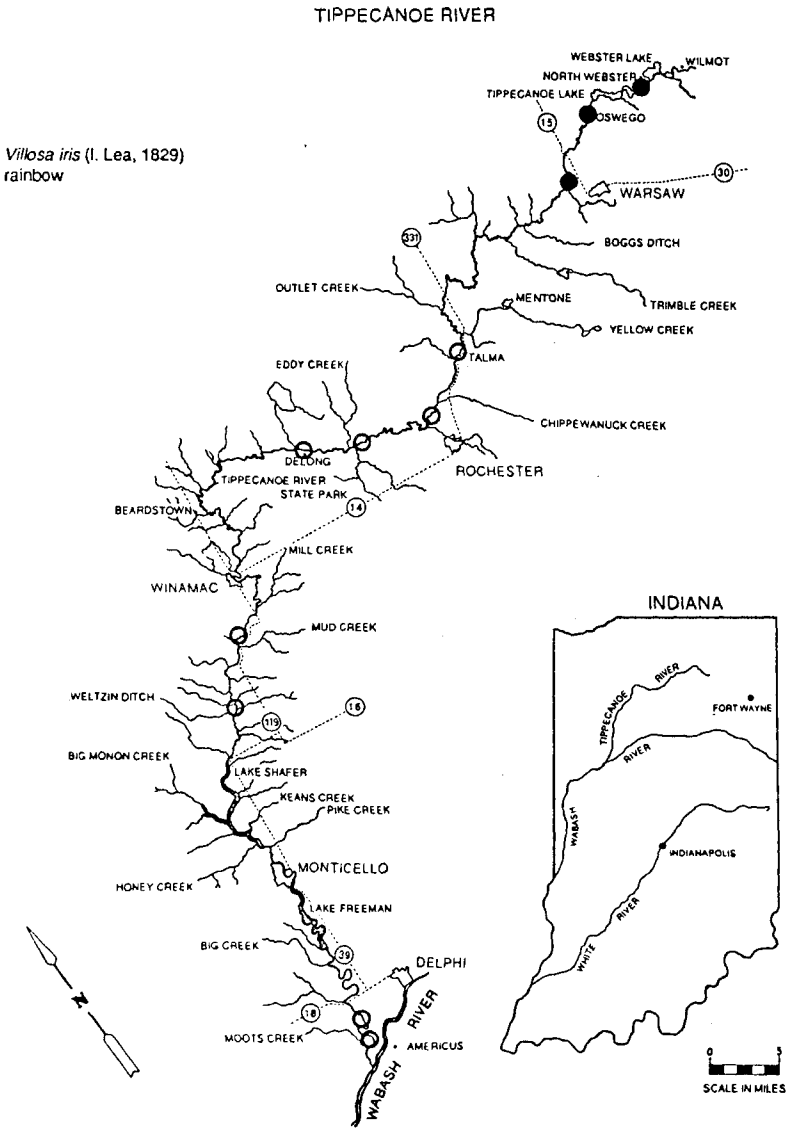


TIPPECANOE RIVER

Truncilla donaciformis (I. Lea, 1828)
fawnsfoot



Villosa iris (I. Lea, 1829)
rainbow



Appendix III

PHOTOGRAPHS OF UNIONIDS OF THE LOWER WABASH AND TIPPECANOE RIVERS

KEY TO PHOTOGRAPHS OF UNIONIDS OF THE LOWER WABASH AND TIPPECANOE RIVERS.

1. *Actinonaias ligamentina* (Lamarck, 1819)
   mucket
2. *Alasmidonta marginata* Say, 1818
   elktoe
3. *Alasmidonta viridis* (Rafinesque, 1820)
   slippershell mussel
4. *Amblema plicata* (Say, 1817)
   three ridge
5. *Anodonta grandis* Say, 1829
   giant floater
6. *Anodonta imbecillis* Say, 1829
   paper pondshell
7. *Anodonta suborbiculata* Say, 1831
   flat floater
8. *Anodontoides ferussacianus* (I. Lea, 1834)
   cylindrical papershell
9. *Arcidens confragosus* (Say, 1829)
   rock pocketbook
10. *Cumberlandia monodonta* (Say, 1829)
    spectacle case
11. *Cyprogenia stegaria* (Rafinesque, 1820)
    fanshell
12. *Cyclonaias tuberculata* (Rafinesque, 1820)
    purple wartyback
13. *Ellipsaria lineolata* (Rafinesque, 1820)
    butterfly
14. *Elliptio crassidens* (Lamarck, 1819)
    elephant-ear
15. *Elliptio dilatata* (Rafinesque, 1820)
    spike
16. *Epioblasma flexuosa* (Rafinesque, 1820)
    leafshell
17. *Epioblasma personata* (Say, 1829)
    round combshell
18. *Epioblasma propinqua* (I. Lea, 1857)
    Tennessee riffleshell
19. *Epioblasma torulosa* (Rafinesque, 1820)
    tubercled blossom (Male)
20. *Epioblasma torulosa* (Rafinesque, 1820)
    tubercled blossom (Female)
21. *Epioblasma triquetra* (Rafinesque, 1820)
    snuffbox
22. *Fusconaia ebena* (I. Lea, 1831)
    ebonyshell
23. *Fusconaia flava* (Rafinesque, 1820)
    Wabash pigtoe
24. *Hemistena lata* (Rafinesque, 1820)
    cracking pearlymussel
25. *Lampsilis abrupta* (Say, 1831)
    pink mucket
26. *Lampsilis cardium* (Rafinesque, 1820)
    plain pocketbook
27. *Lampsilis fasciola* Rafinesque, 1820
    wavy-rayed lampmussel
28. *Lampsilis ovata* (Say, 1817)
    pocketbook
29. *Lampsilis siliquoidea* (Barnes, 1823)
    fatmucket
30. *Lampsilis teres* (Rafinesque, 1820)
    yellow sandshell
31. *Lasmigona complanata* (Barnes, 1823)
    white heelsplitter
32. *Lasmigona compressa* (I. Lea, 1829)
    creek heelsplitter
33. *Lasmigona costata* (Rafinesque, 1820)
    fluted-shell
34. *Leptodea fragilis* (Rafinesque, 1820)
    fragile papershell
35. *Leptodea leptodon* (Rafinesque, 1820)
    scaleshell
36. *Ligumia recta* (Lamarck, 1819)
    black sandshell
37. *Ligumia subrostrata* (Say, 1831)
    pondmussel

38. *Megalonaias nervosa* (Rafinesque, 1820)
washboard

39. *Obliquaria reflexa* Rafinesque, 1820
mucket

40. *Obovaria olivaria* (Rafinesque, 1820)
hickorynut

41. *Obovaria retusa* (Lamarck, 1819)
ring pink

42. *Obovaria subrotunda* (Rafinesque, 1820)
round hickorynut

43. *Plethobasus cicatricosus* (Say, 1829)
white wartyback

44. *Plethobasus cooperianus* (I. Lea, 1834)
orange-foot pimpleback

45. *Plethobasus cyphyus* (Rafinesque, 1820)
sheepnose

46. *Pleurobema clava* (Lamarck, 1819)
clubshell

47. *Pleurobema plenum* (I. Lea, 1840)
rough pigtoe

48. *Pleurobema rubrum* (Rafinesque, 1820)
pyramid pigtoe

49. *Pleurobema sintoxia* (Rafinesque, 1820)
round pigtoe

50. *Potamilus alatus* (Say, 1817)
pink heelsplitter

51. *Potamilus capax* (Green, 1832)
fat pocketbook

52. *Potamilus ohiensis* (Rafinesque, 1820)
pink papershell

53. *Ptychobranchus fasciolaris* (Rafinesque, 1820)
kidneyshell

55. *Quadrula cylindrica* (Say, 1817)
rabbitsfoot

56. *Quadrula metanevra* (Rafinesque, 1820)
monkeyface

57. *Quadrula nodulata* (Rafinesque, 1820)
wartyback

58. *Quadrula pustulosa* (I. Lea, 1831)
pimpleback

59. *Quadrula quadrula* (Rafinesque, 1820)
mapleleaf

60. *Simpsonaias ambigua* (Say, 1825)
salamander mussel

61. *Strophitus undulatus* (Say, 1817)
squawfoot

62. *Toxolasma lividis* (Rafinesque, 1831)
purple lilliput

63. *Toxolasma parvus* (Barnes, 1823)
lilliput

64. *Tritogonia verrucosa* (Rafinesque, 1820)
pistolgrip

65. *Truncilla donaciformis* (I. Lea, 1828)
fawnsfoot

66. *Truncilla truncata* Rafinesque, 1820
deertoe

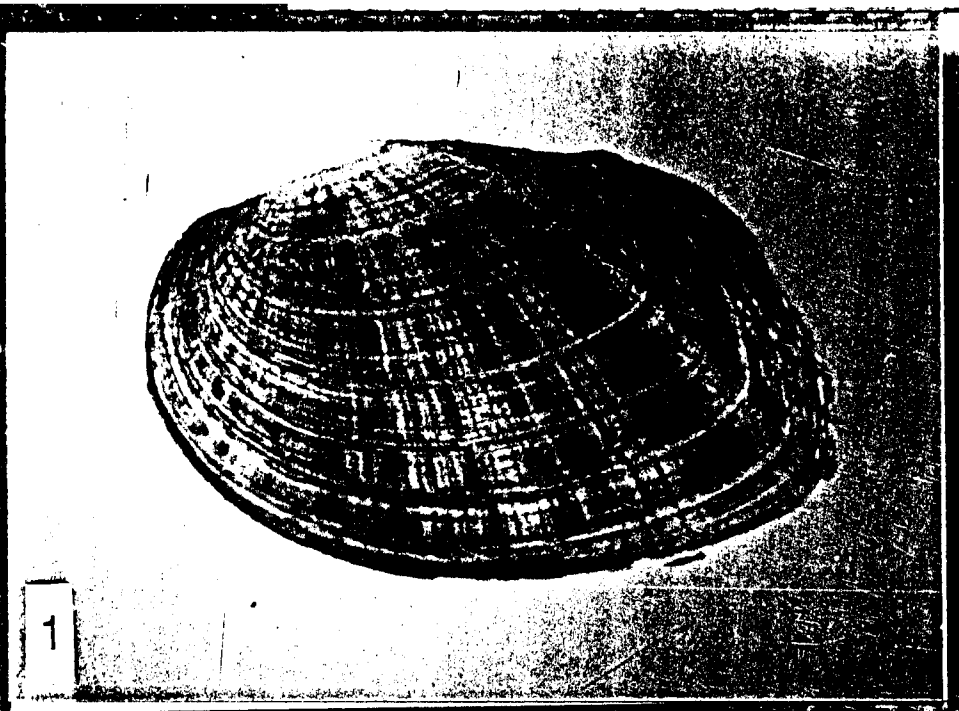
67. *Venustaconcha ellipsiformis* (Conrad, 1836)
ellipse

68. *Villosa fabalis* (I. Lea, 1831)
rayed bean

69. *Villosa iris* (I. Lea, 1829)
rainbow

70. *Villosa lienosa* (Conrad, 1834)
little spectacle case

Note: Specimens photographed were not necessarily collected from the Wabash and Tippecanoe rivers. Number 54 was inadvertently omitted.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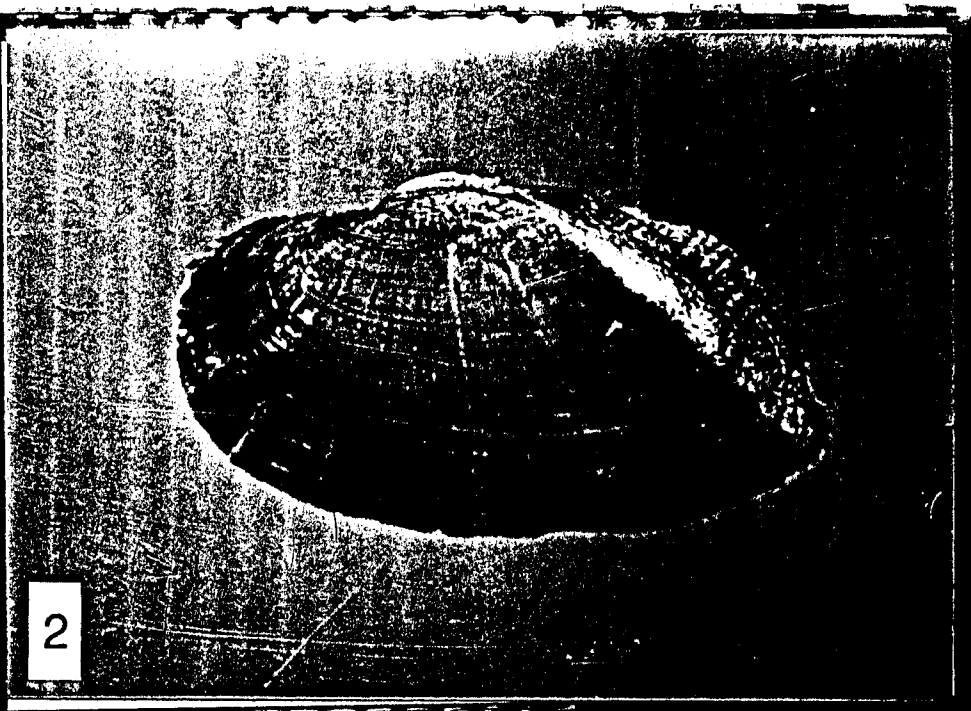
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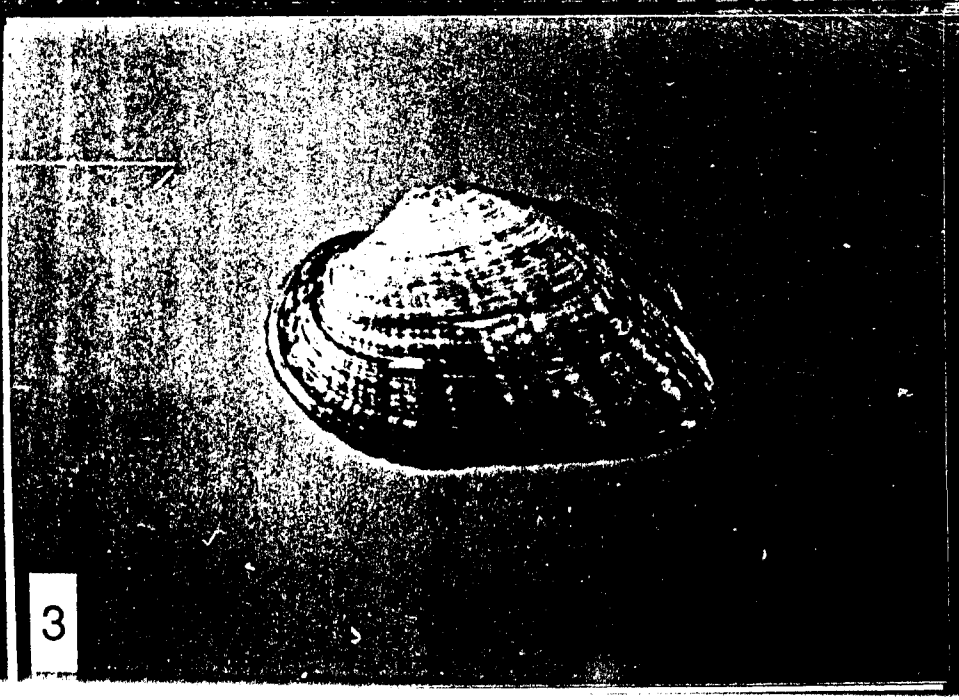
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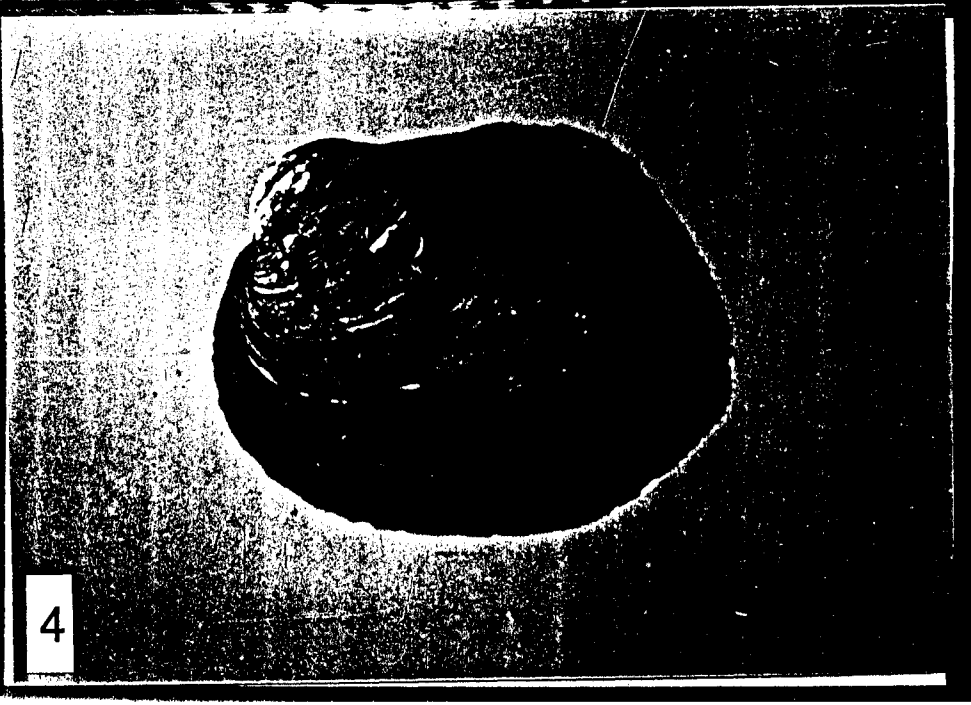
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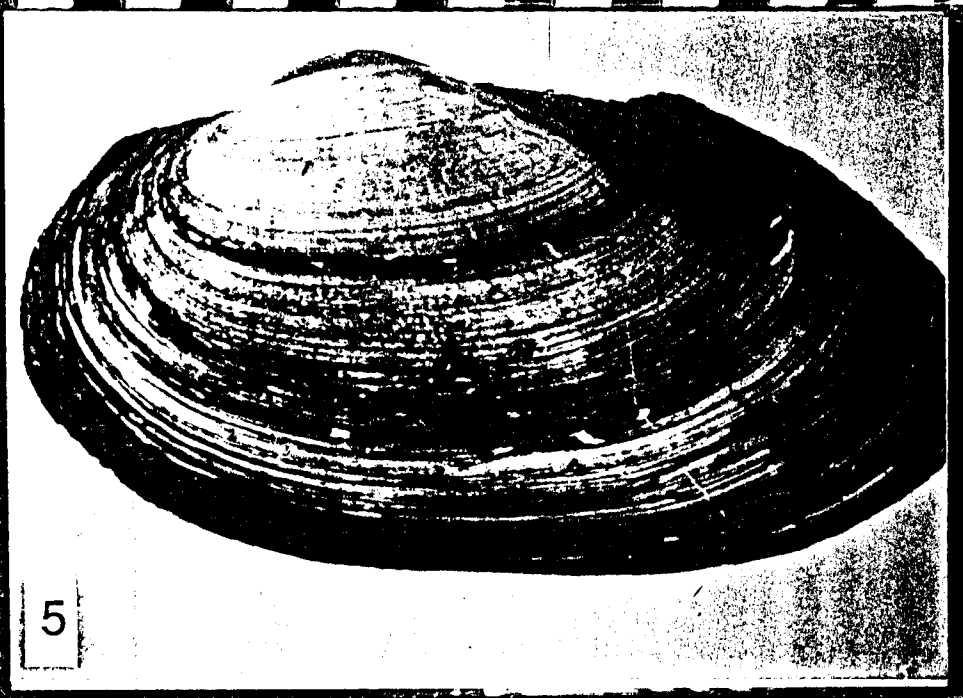
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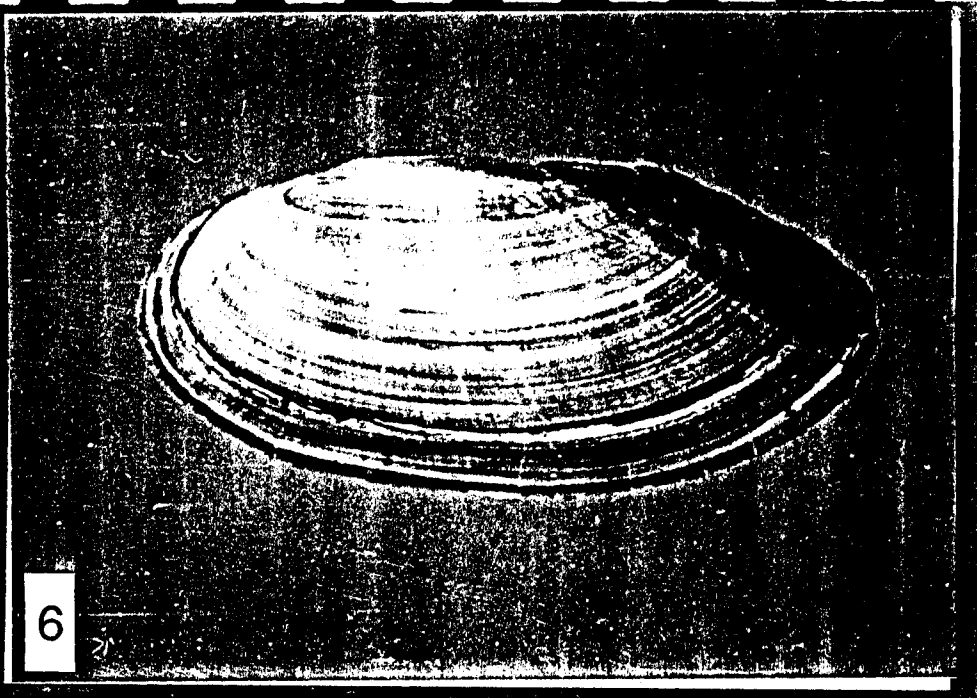
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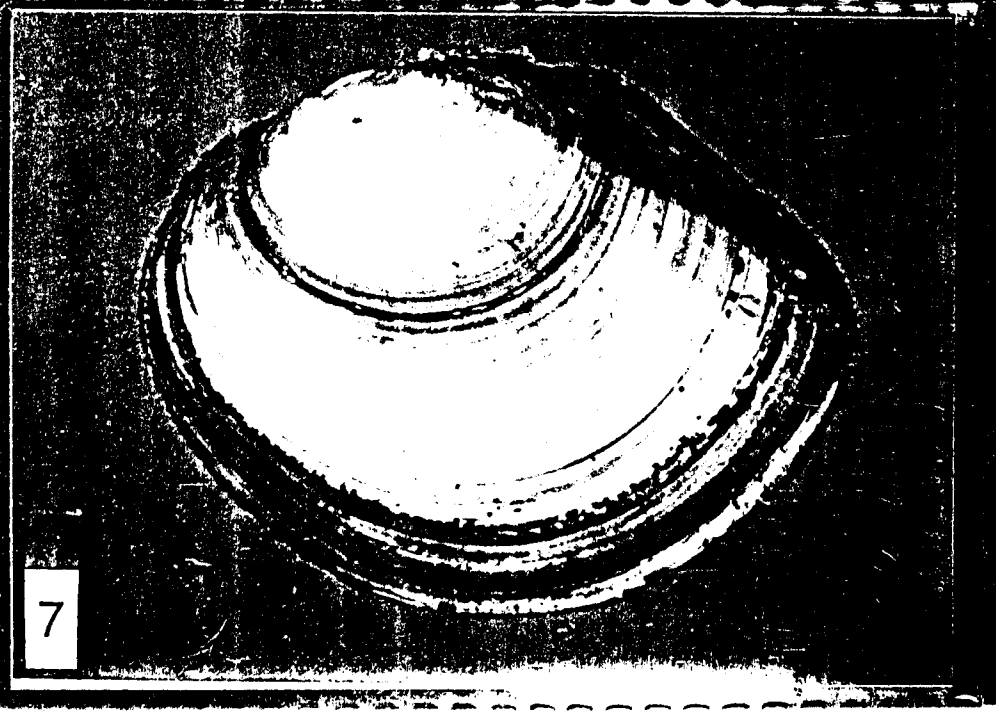
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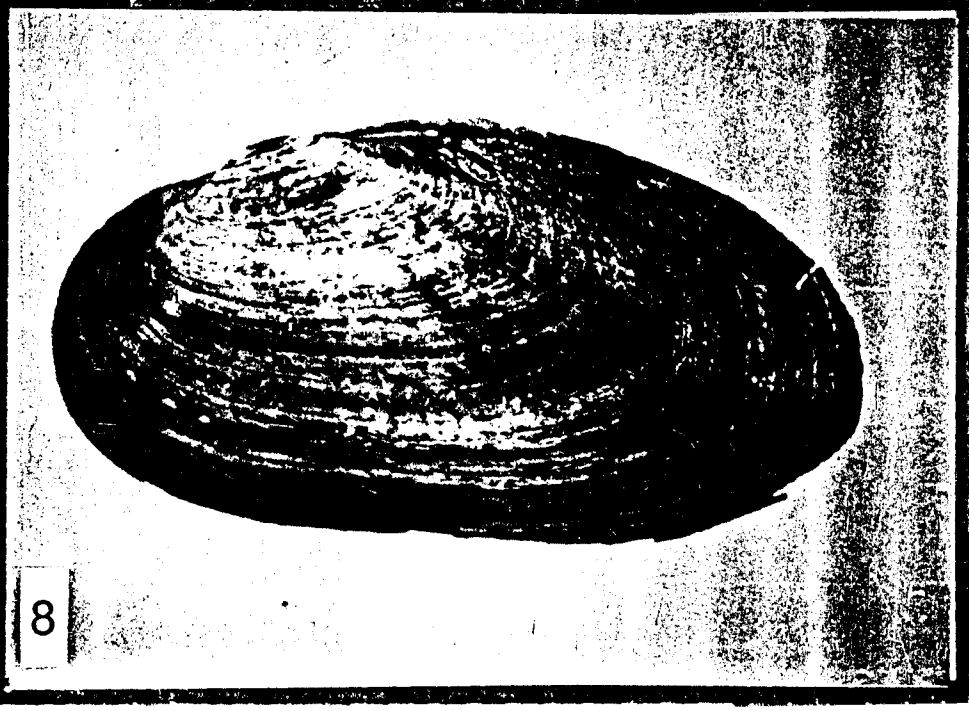
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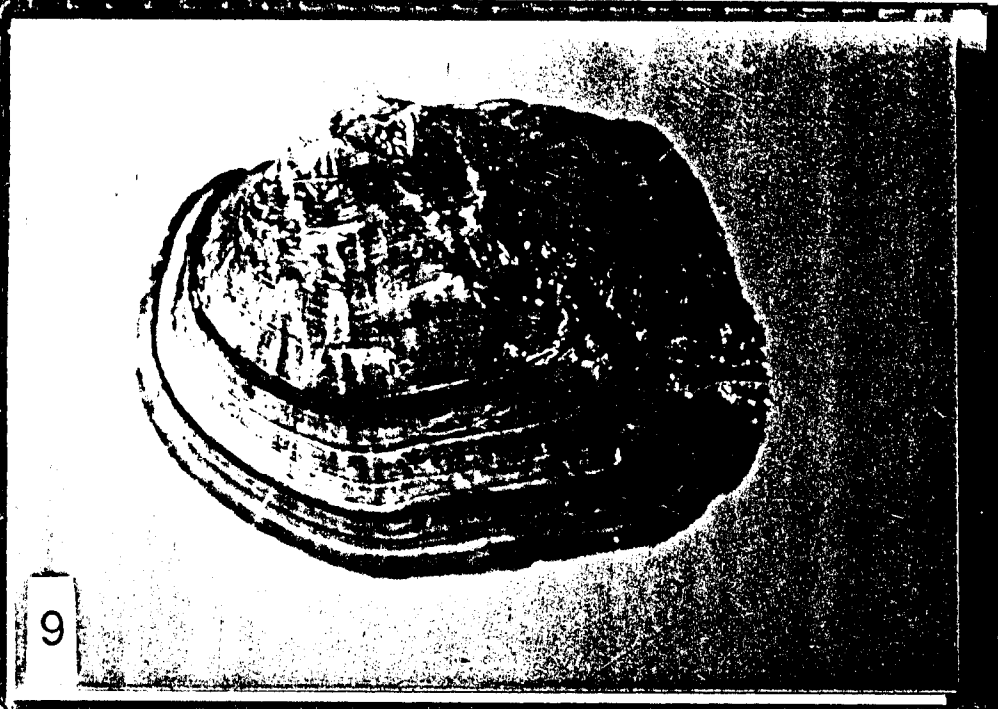

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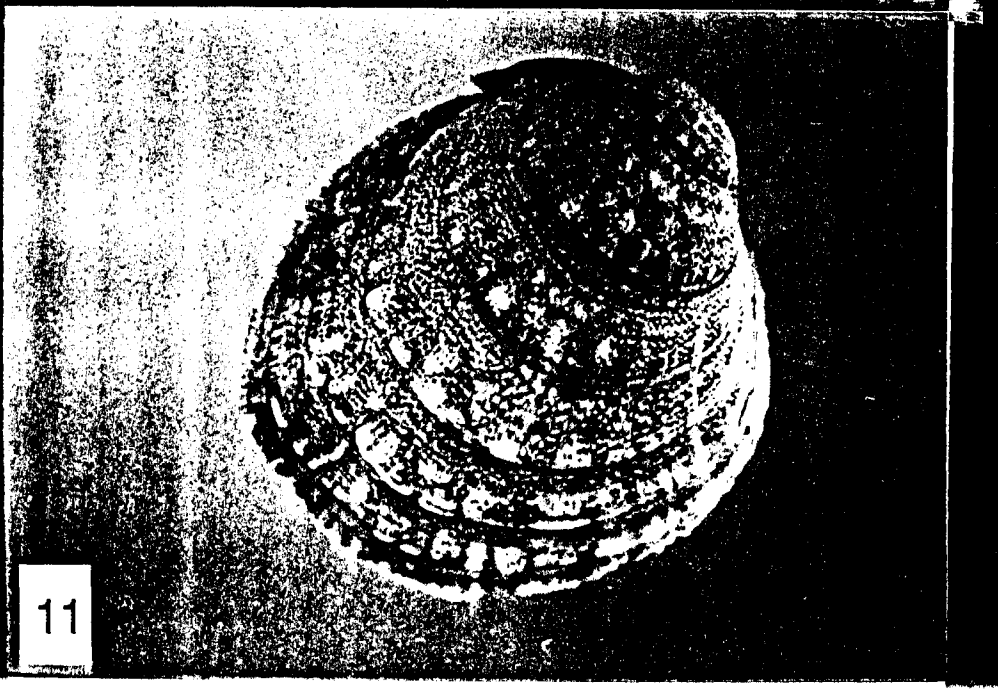

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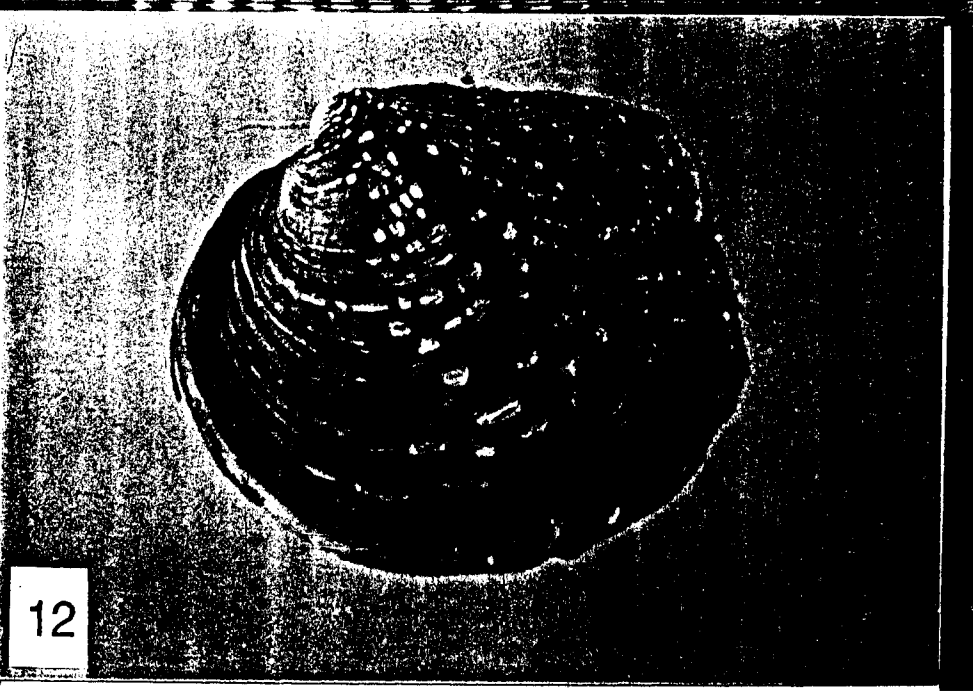

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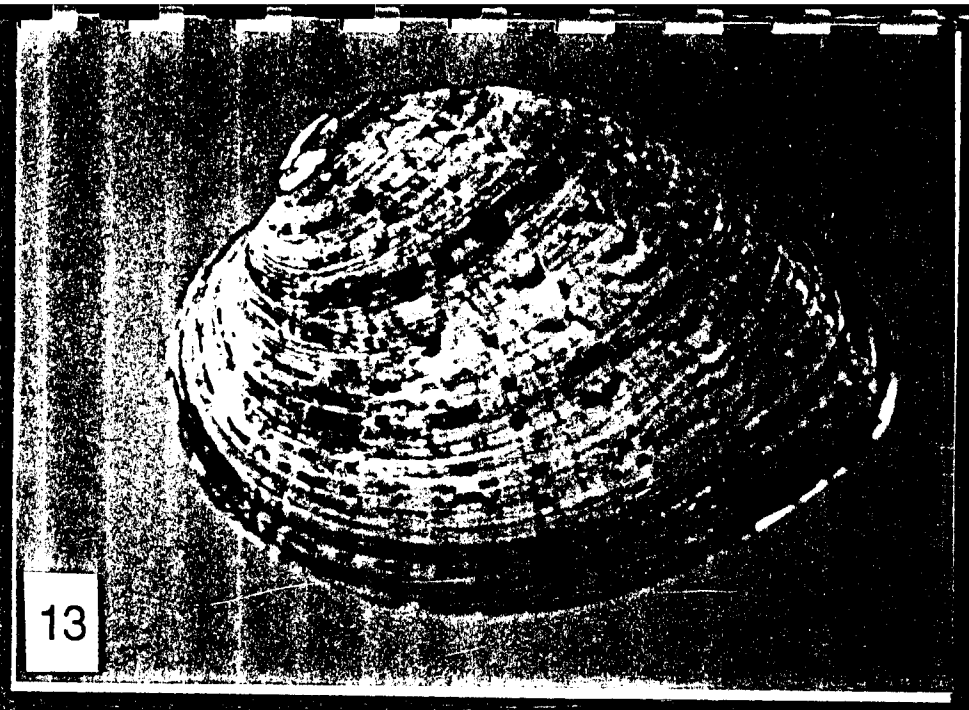

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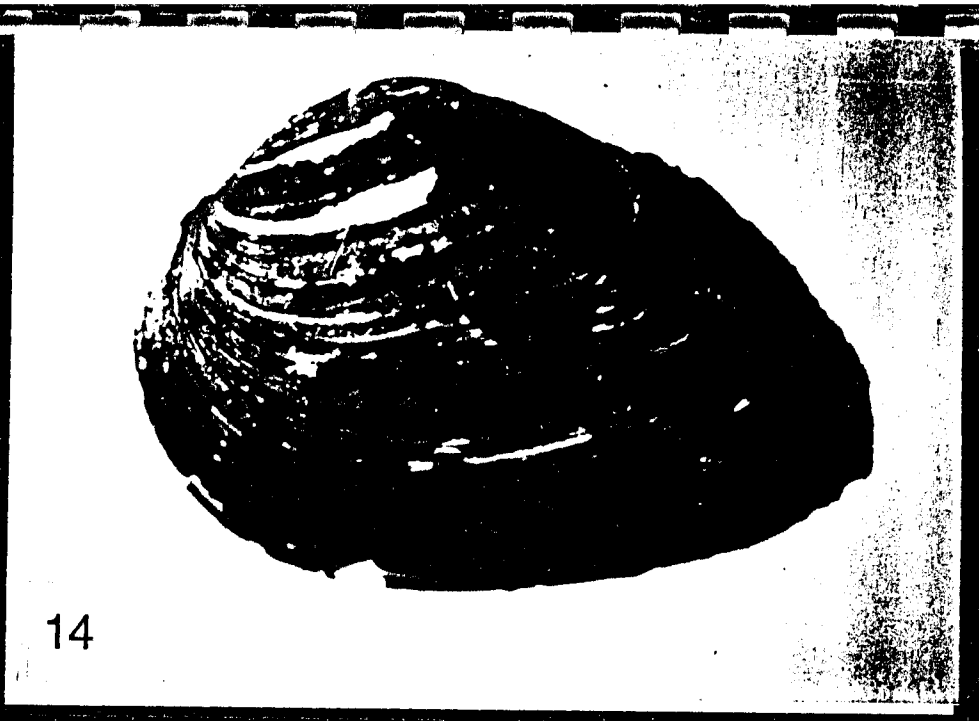

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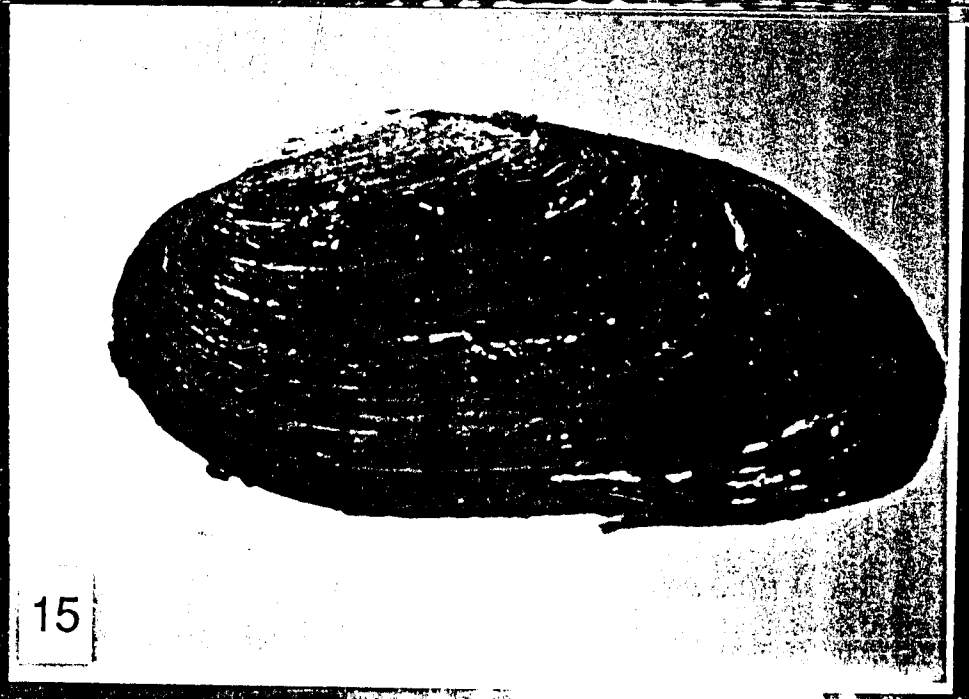

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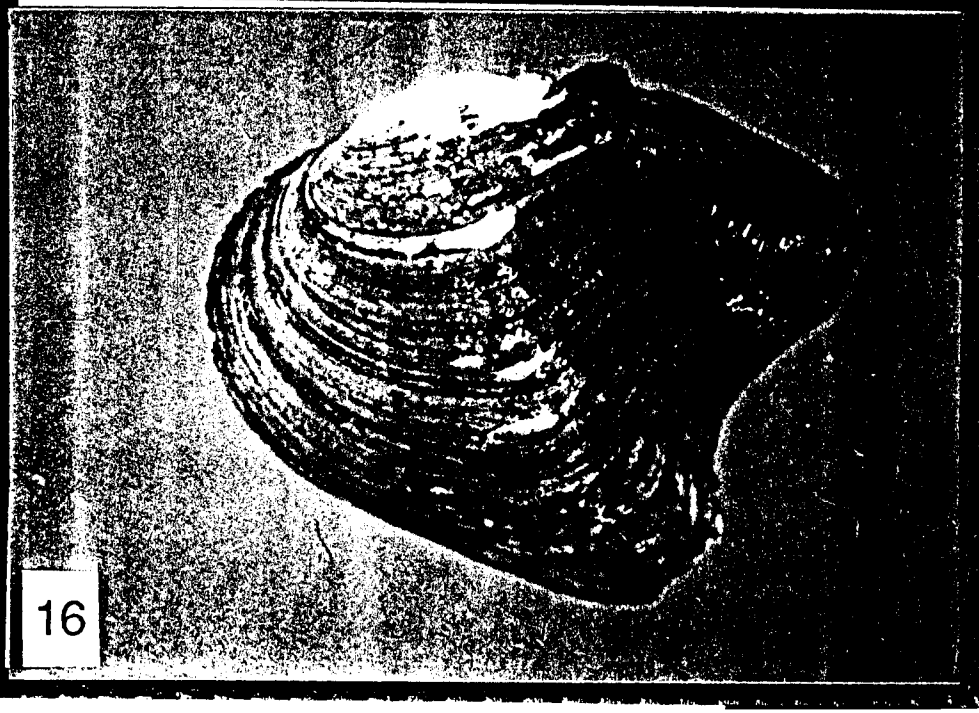

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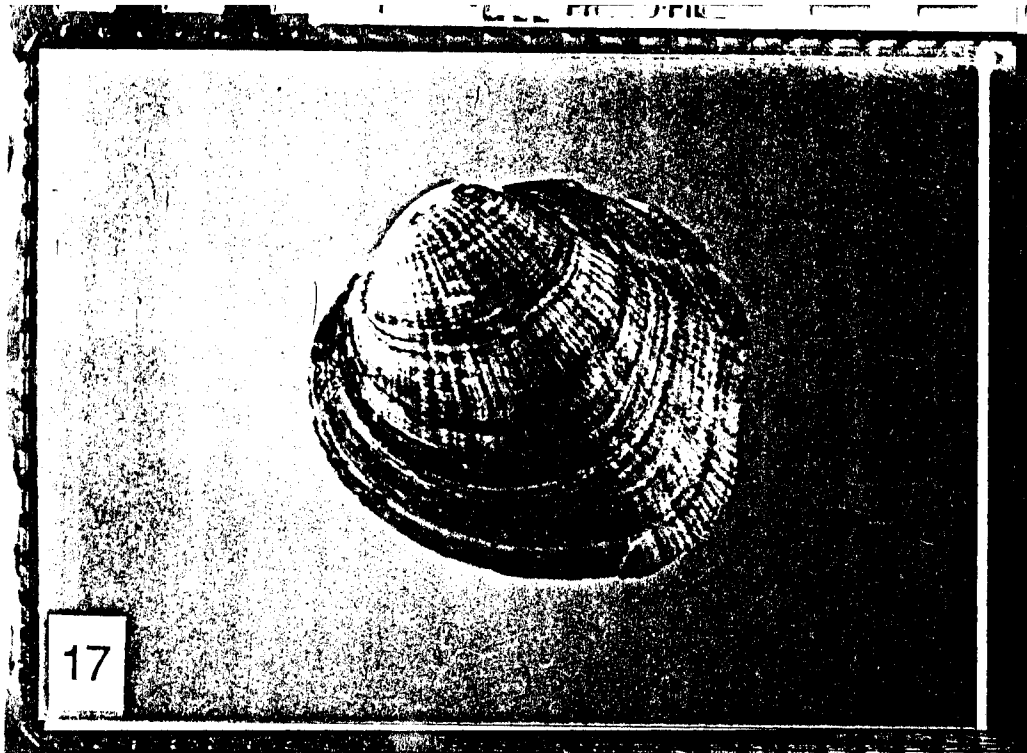
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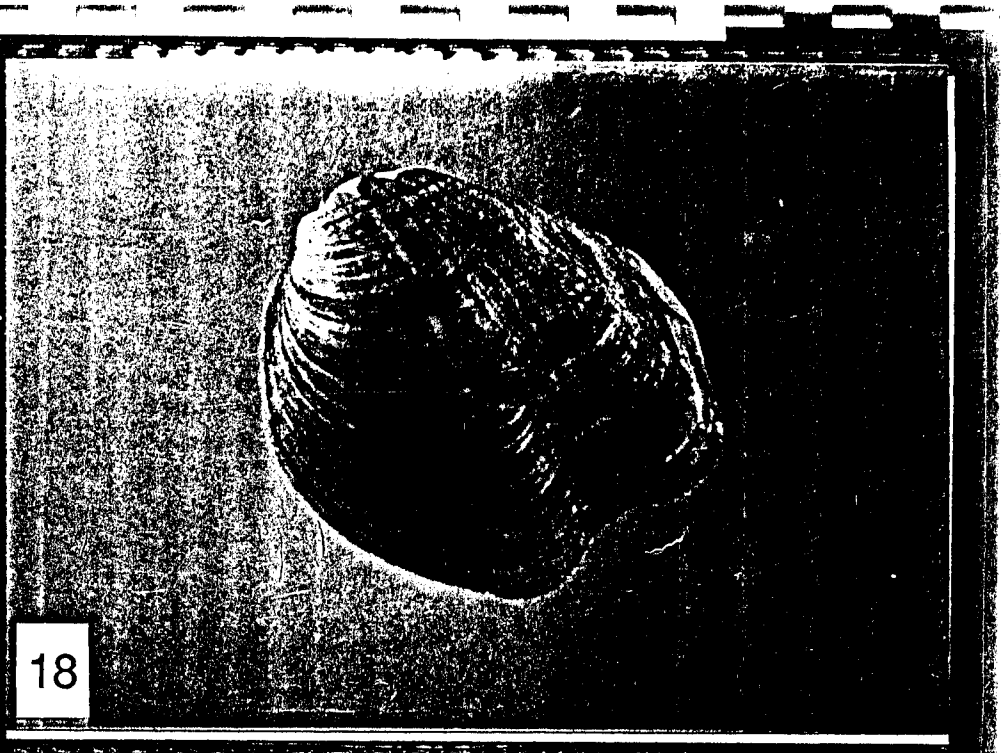
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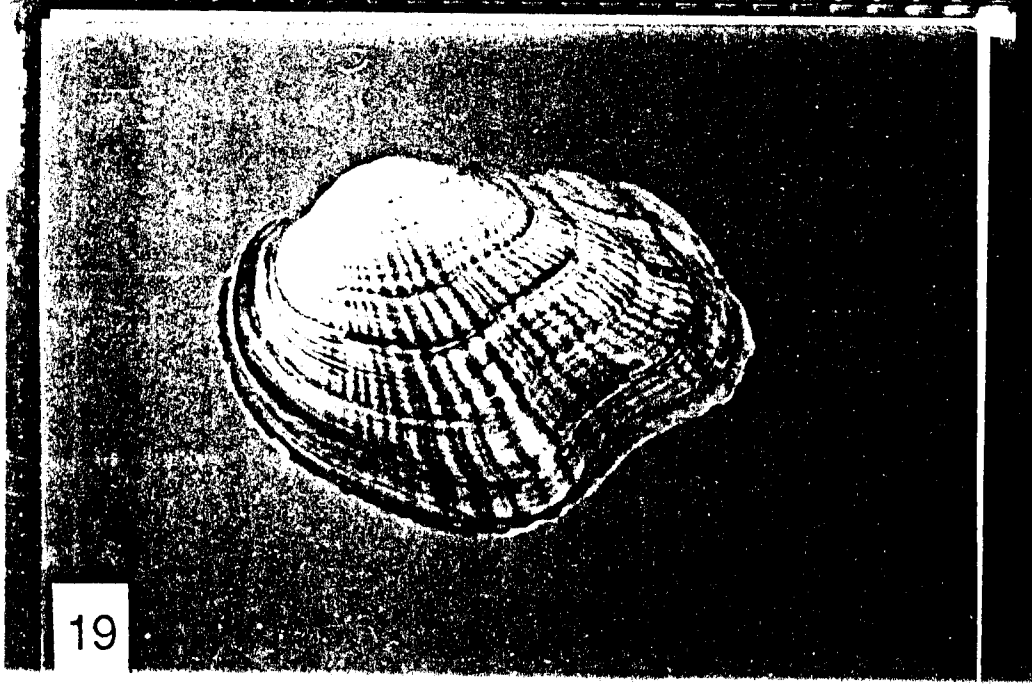
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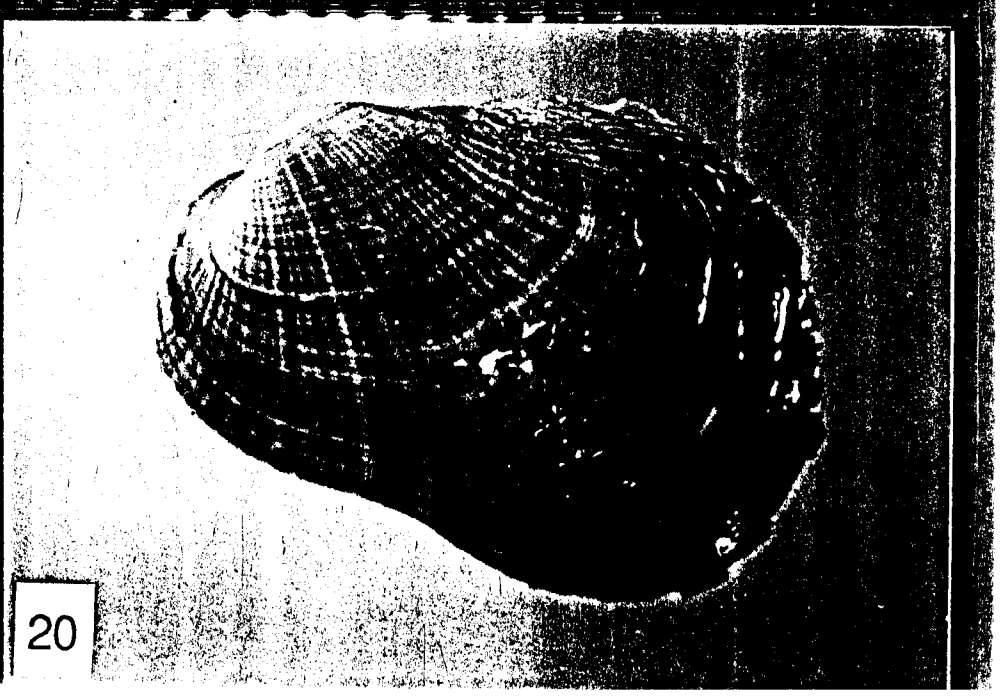
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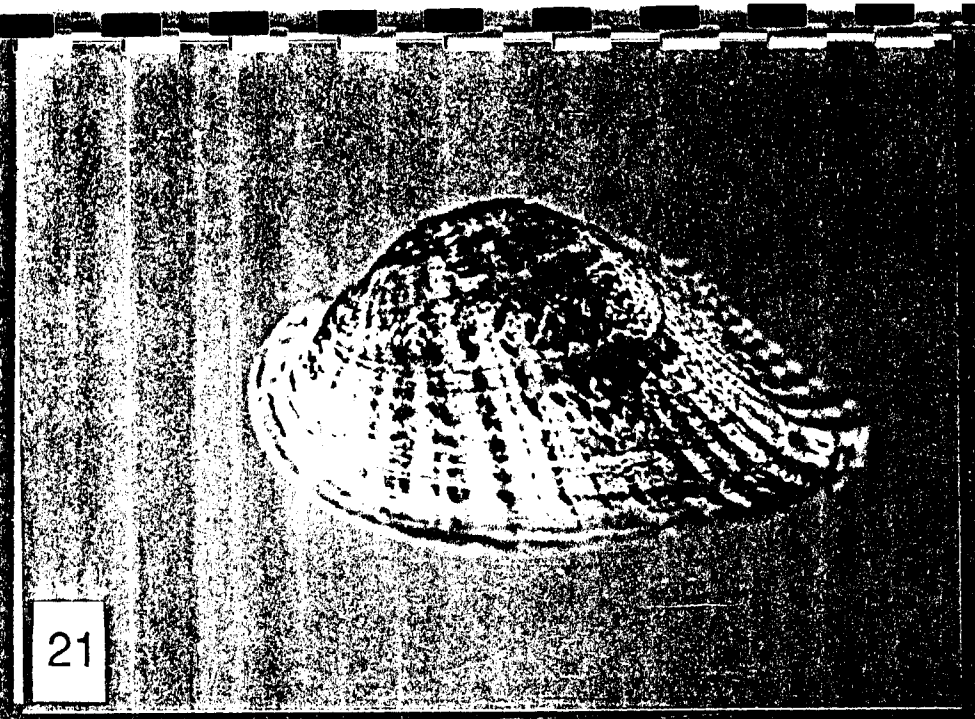

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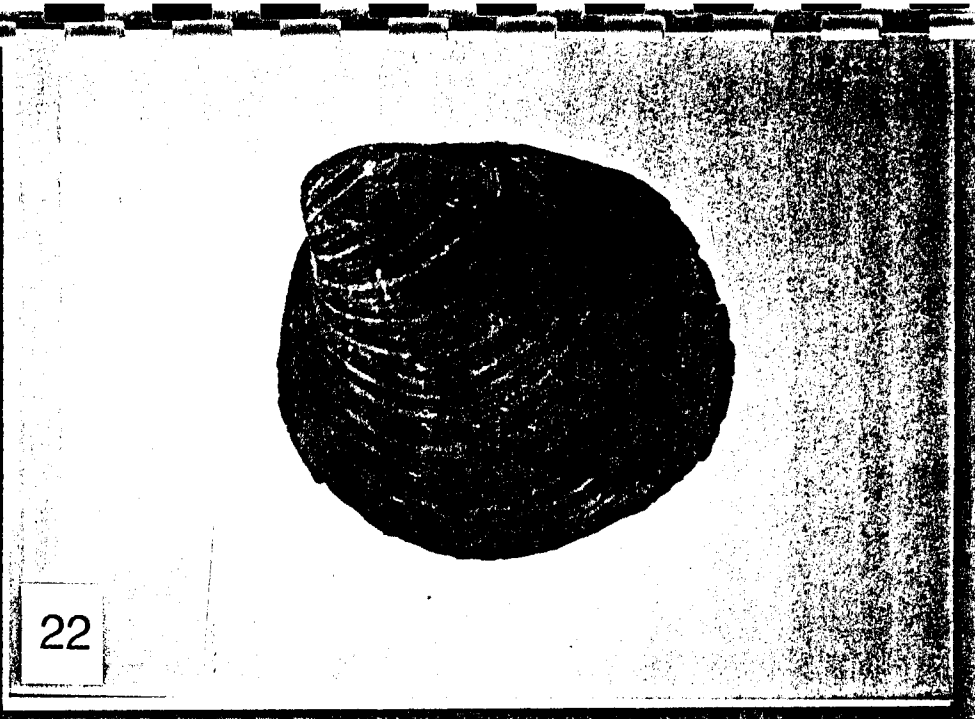

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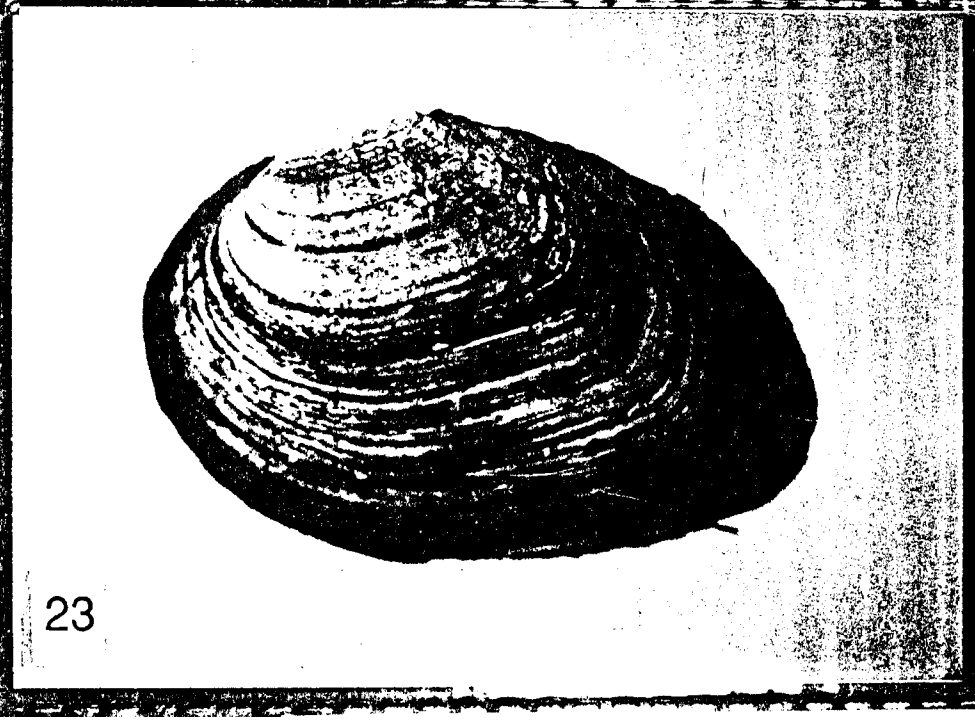

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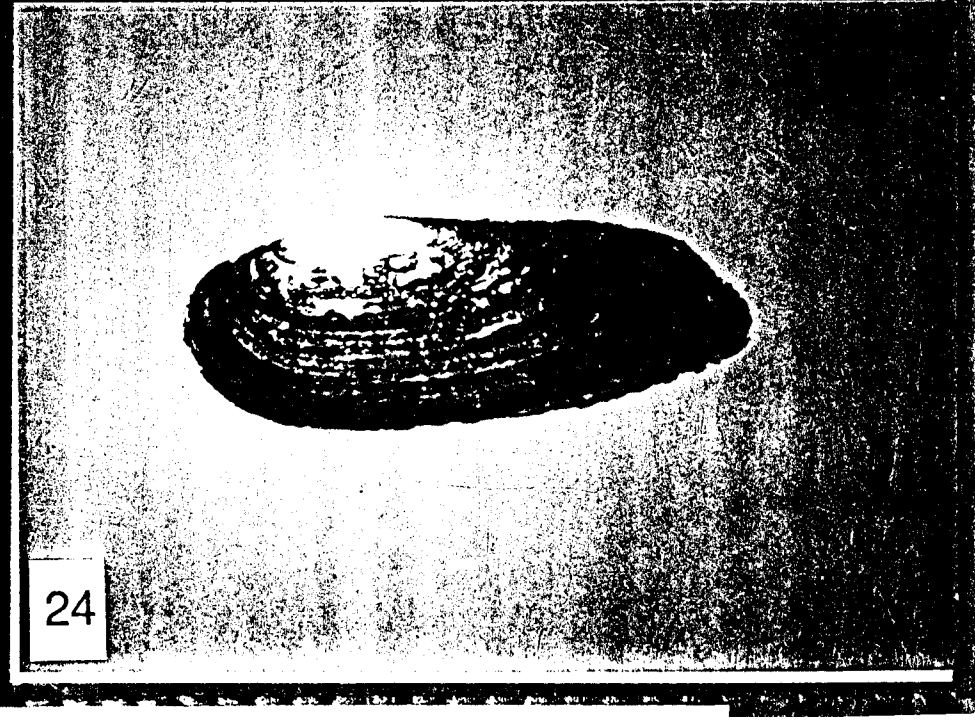

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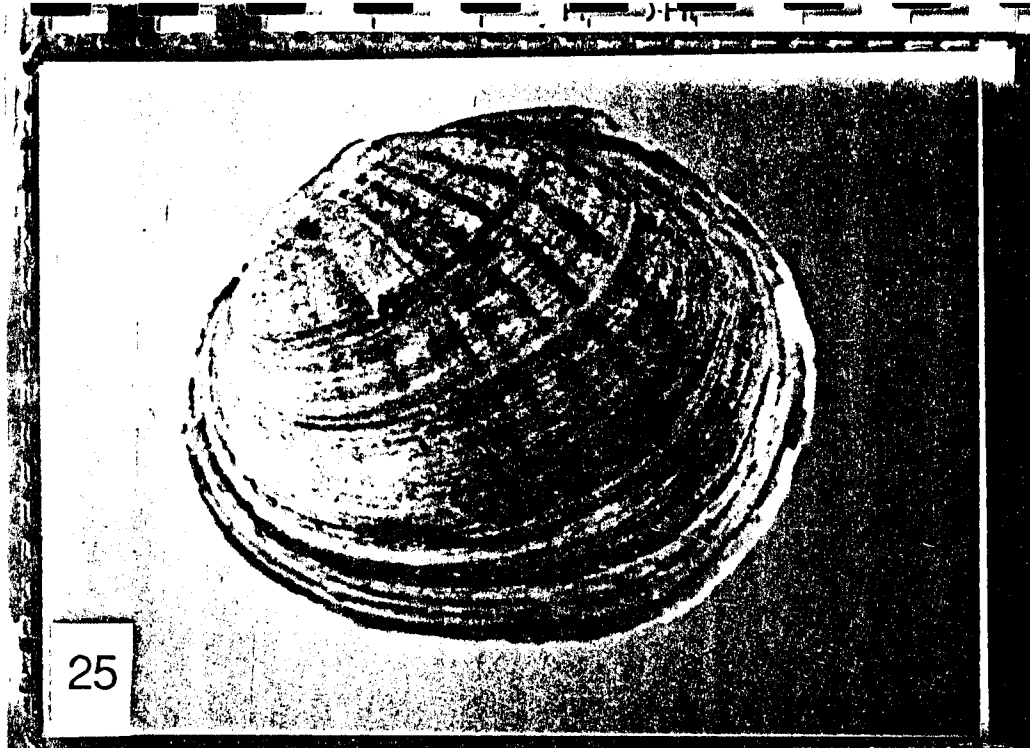
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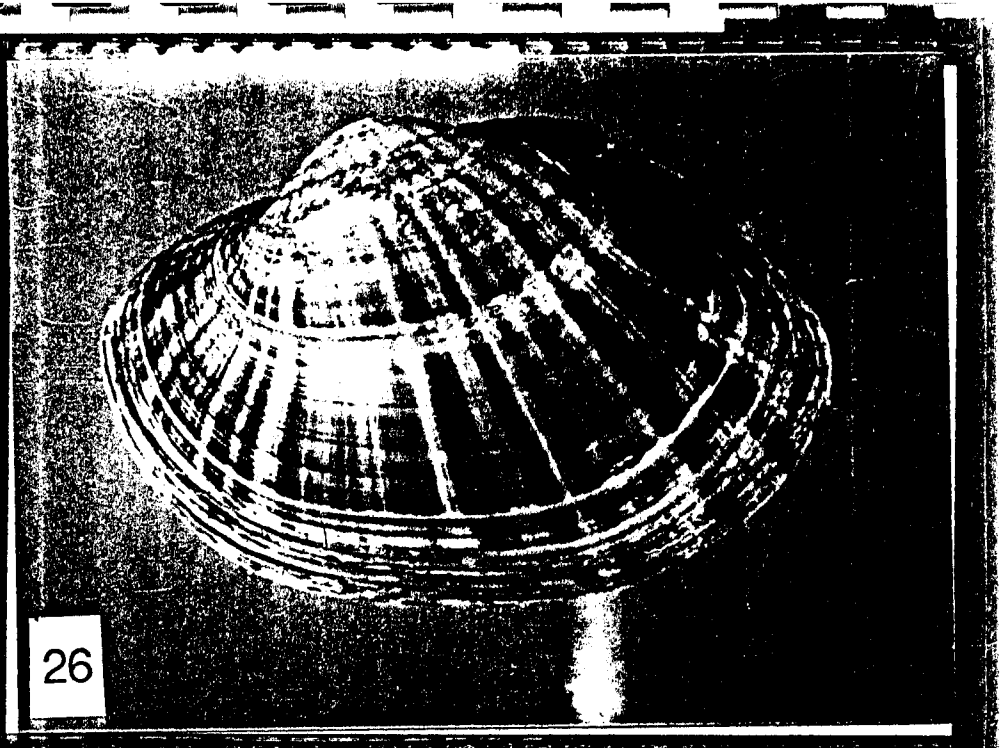
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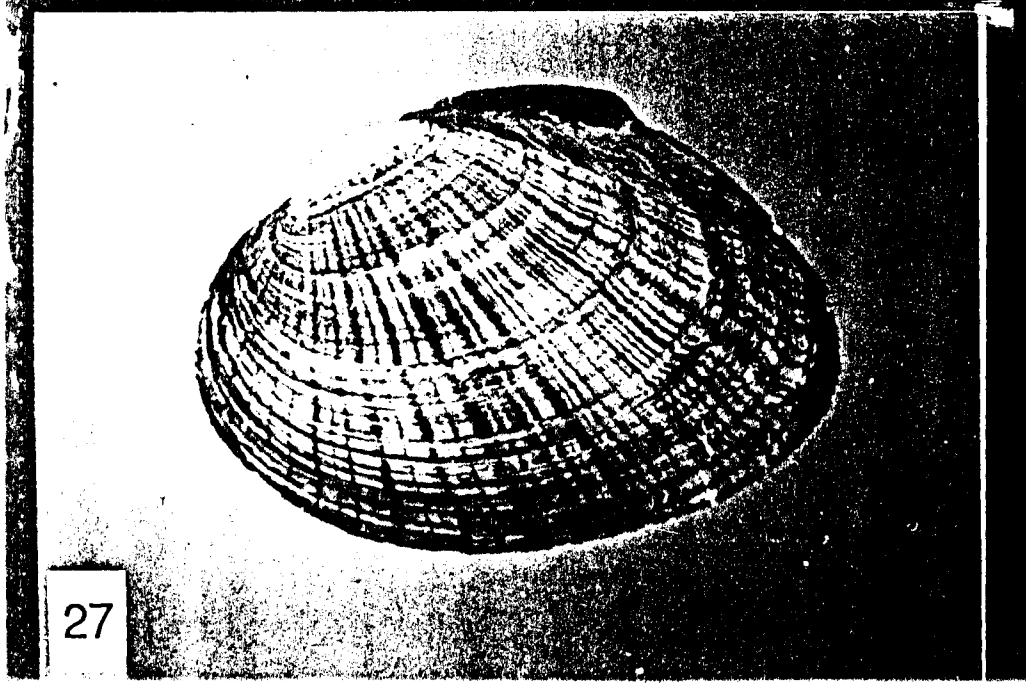
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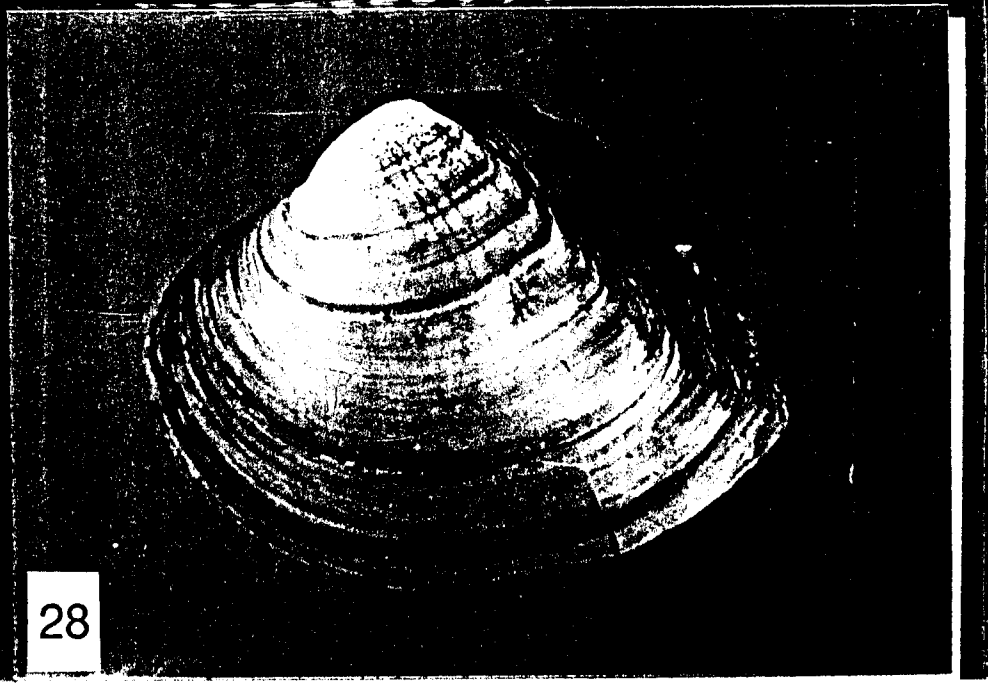
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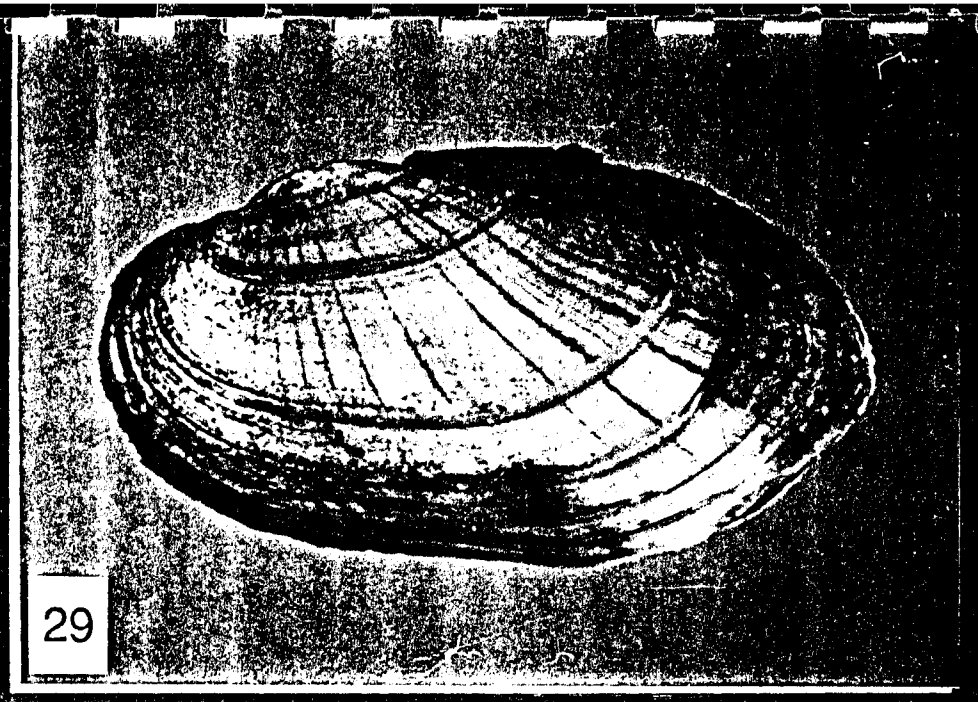

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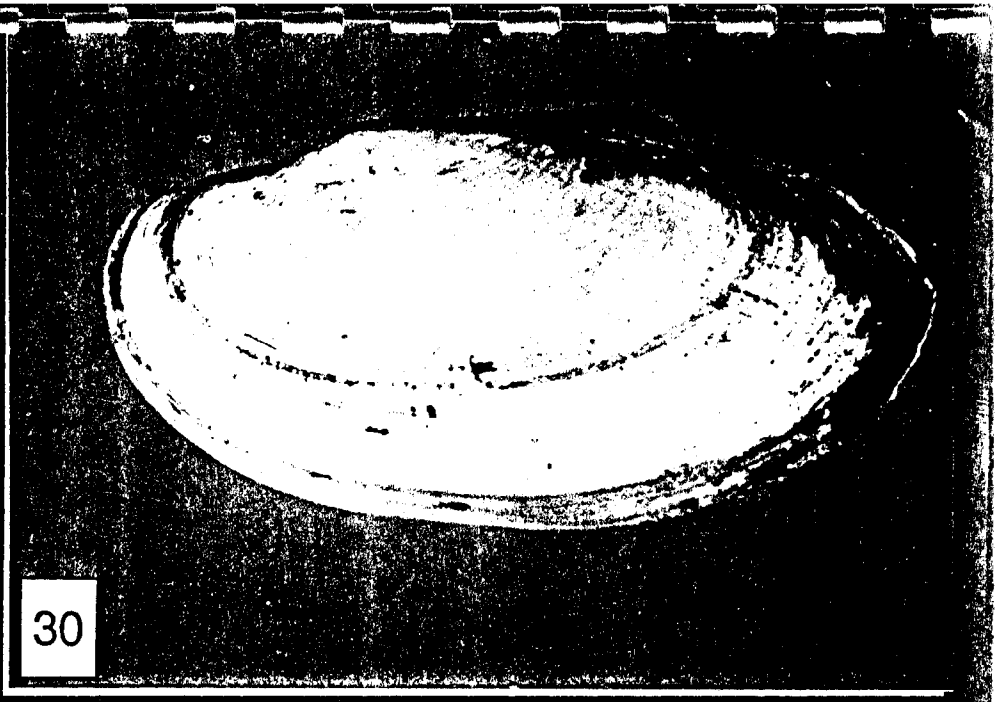

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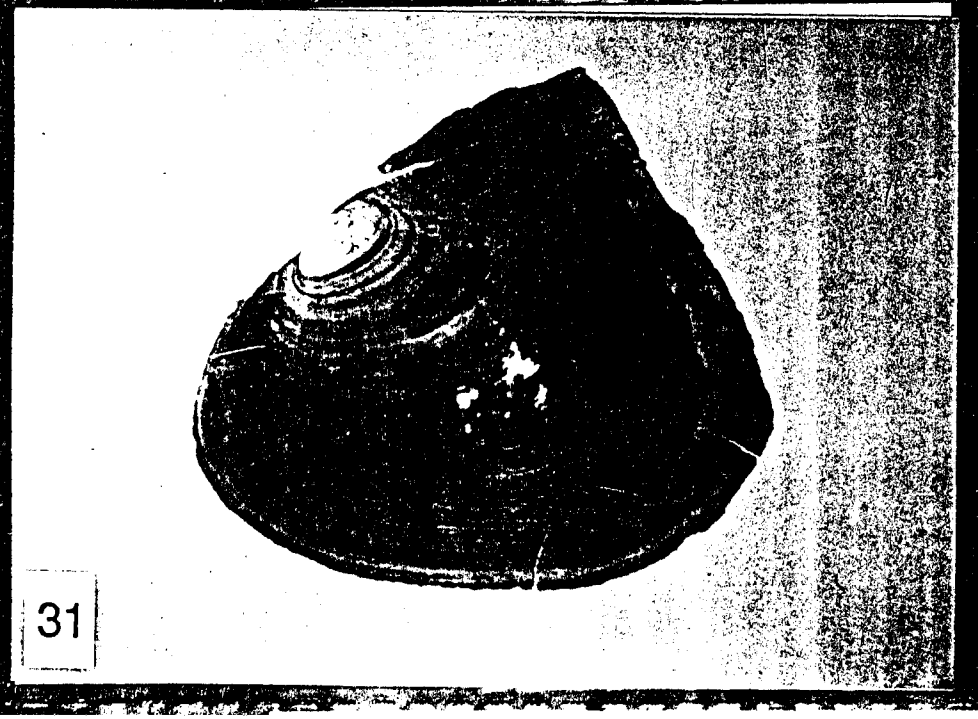

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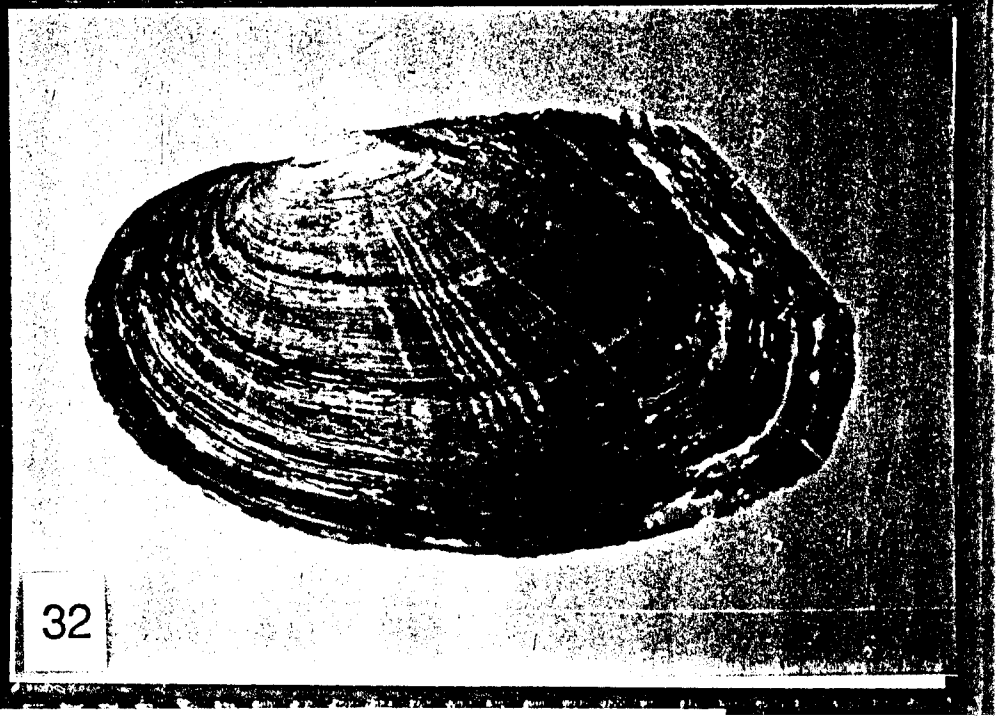

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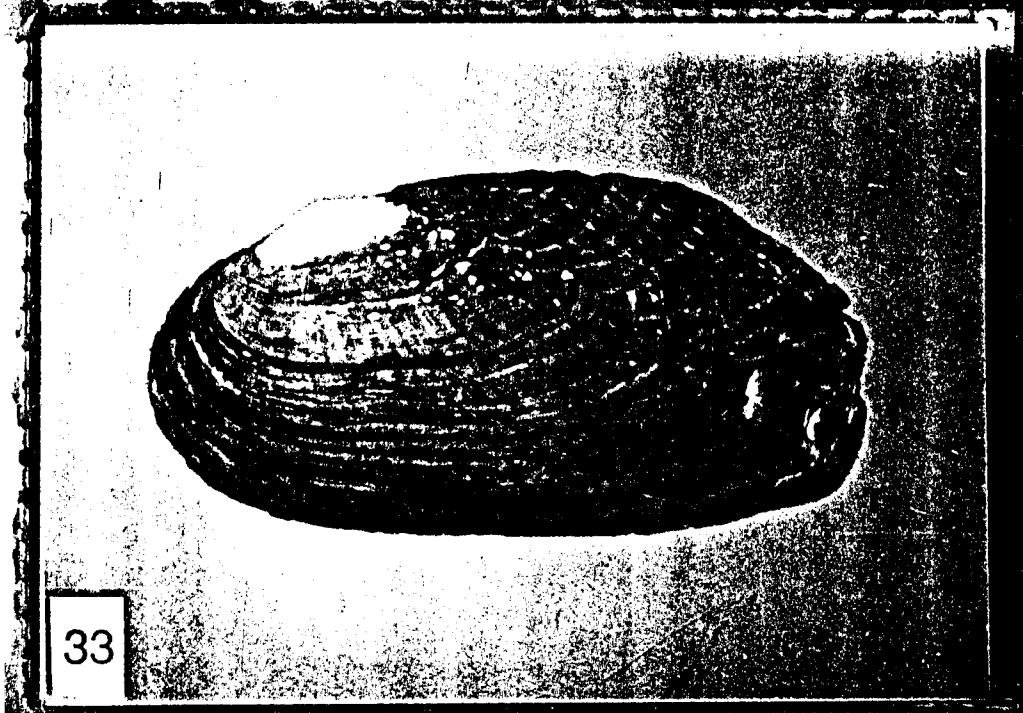

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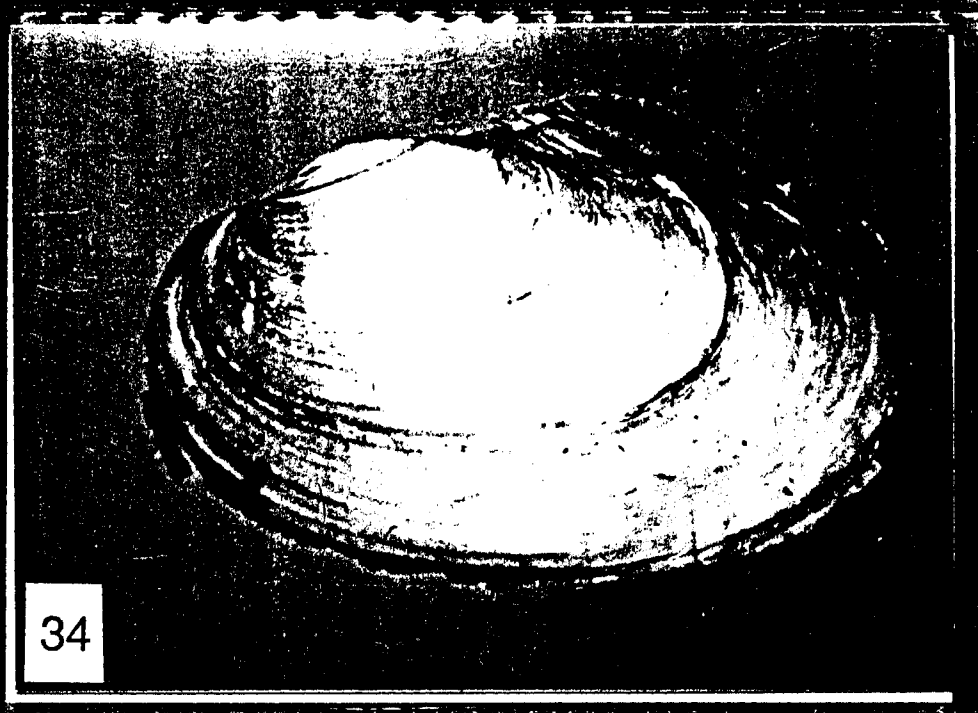

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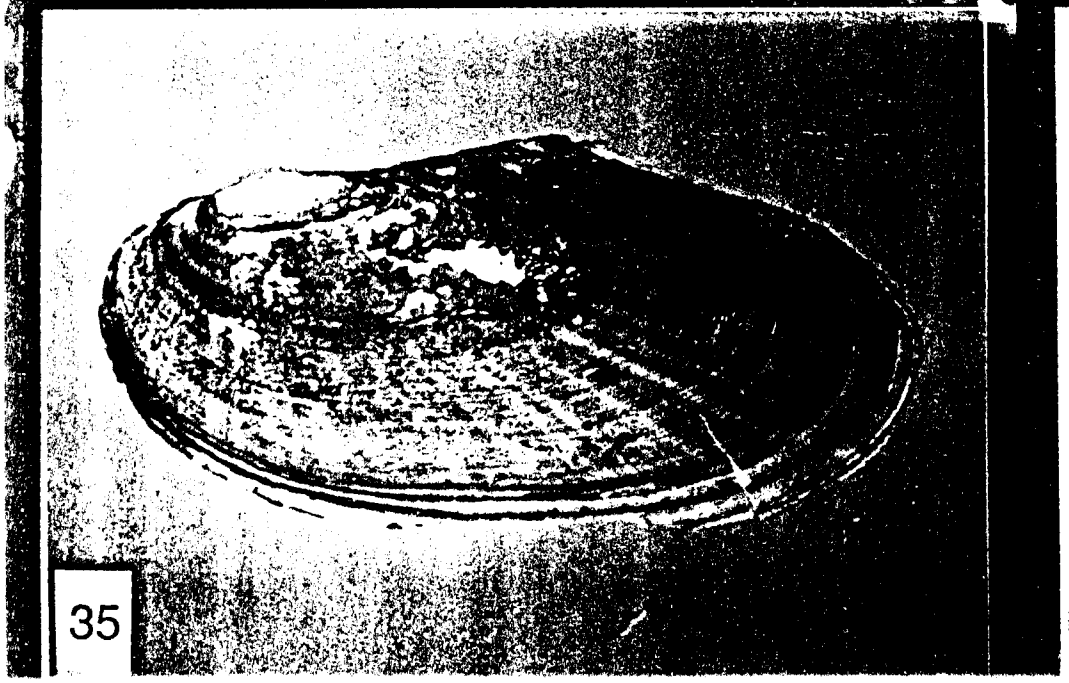

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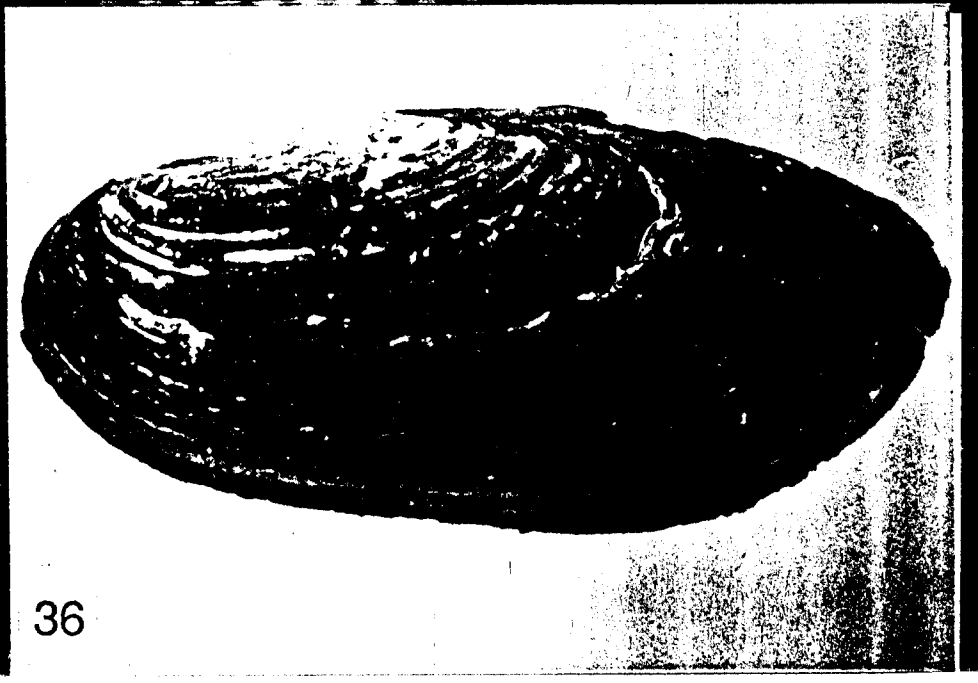

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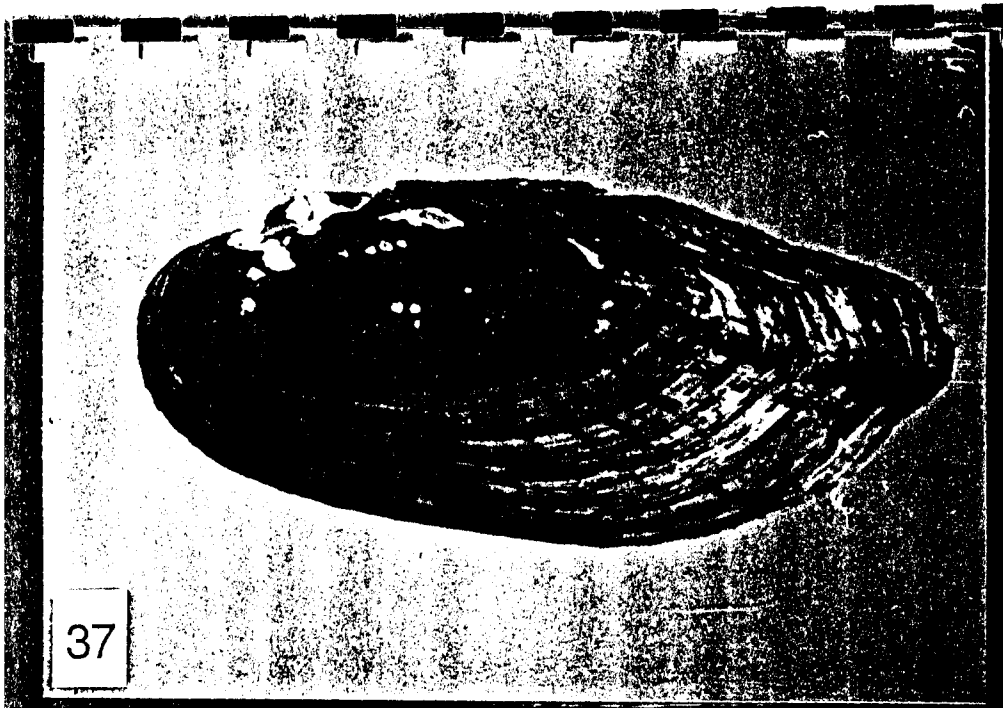

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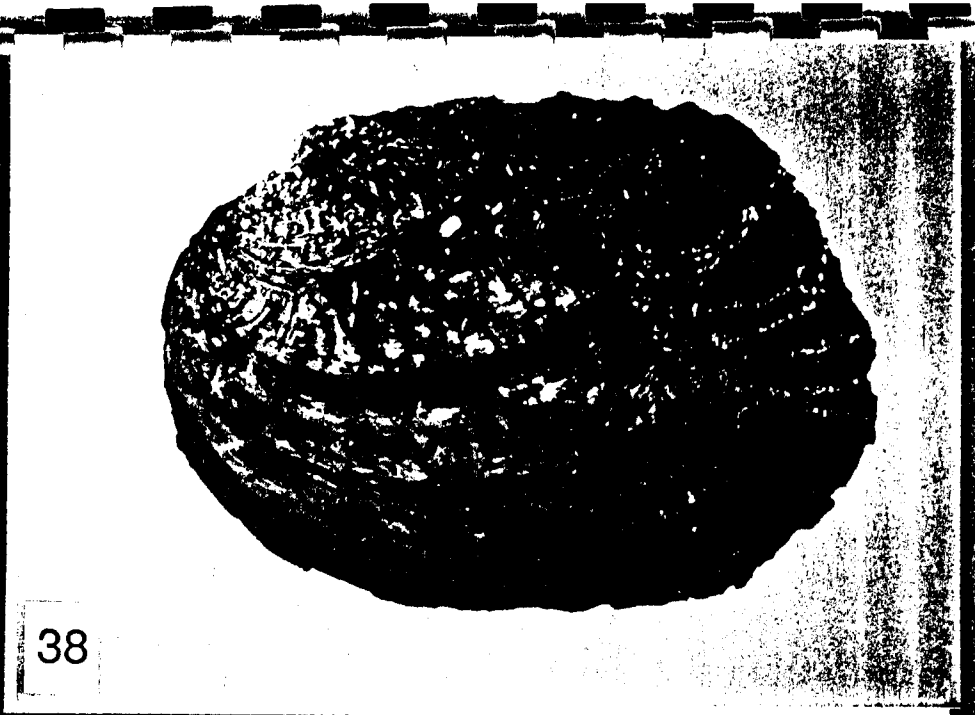

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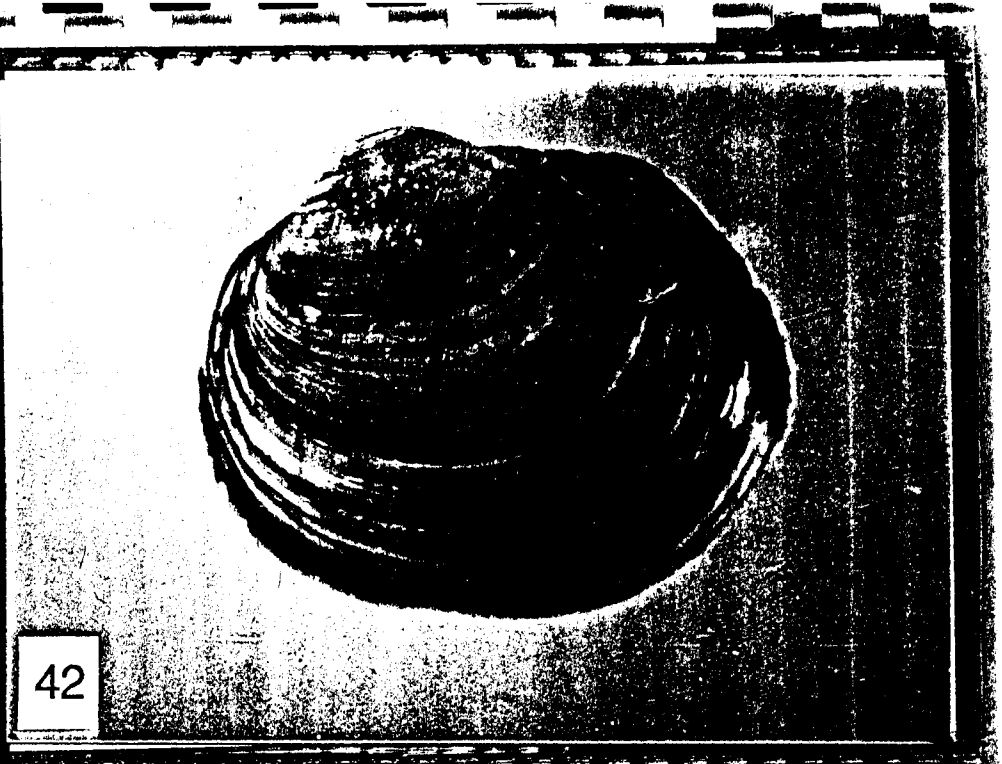

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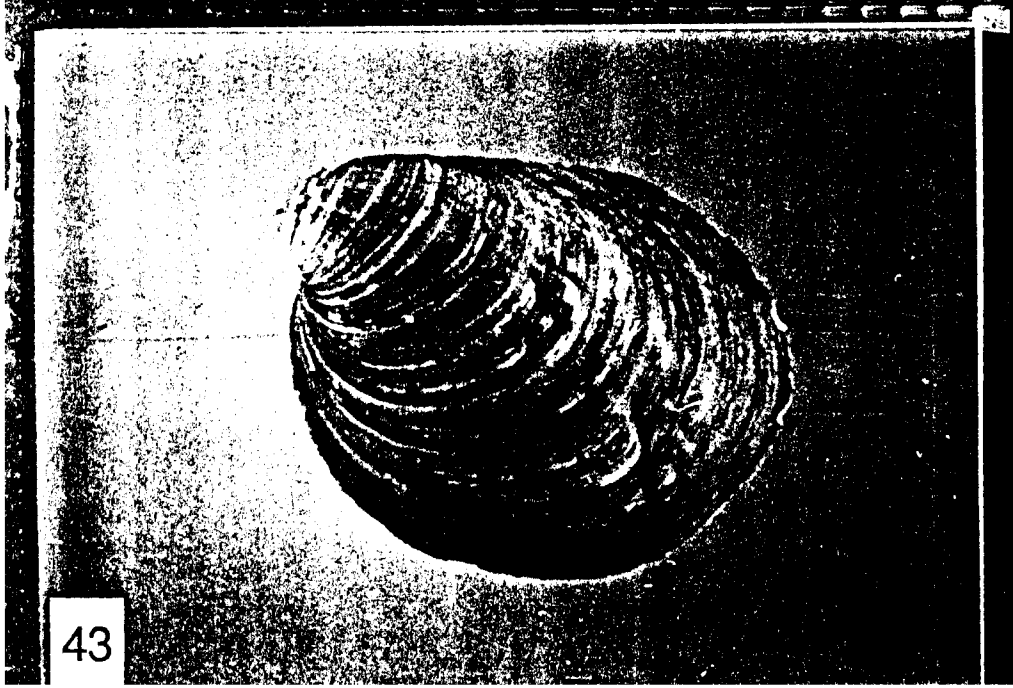

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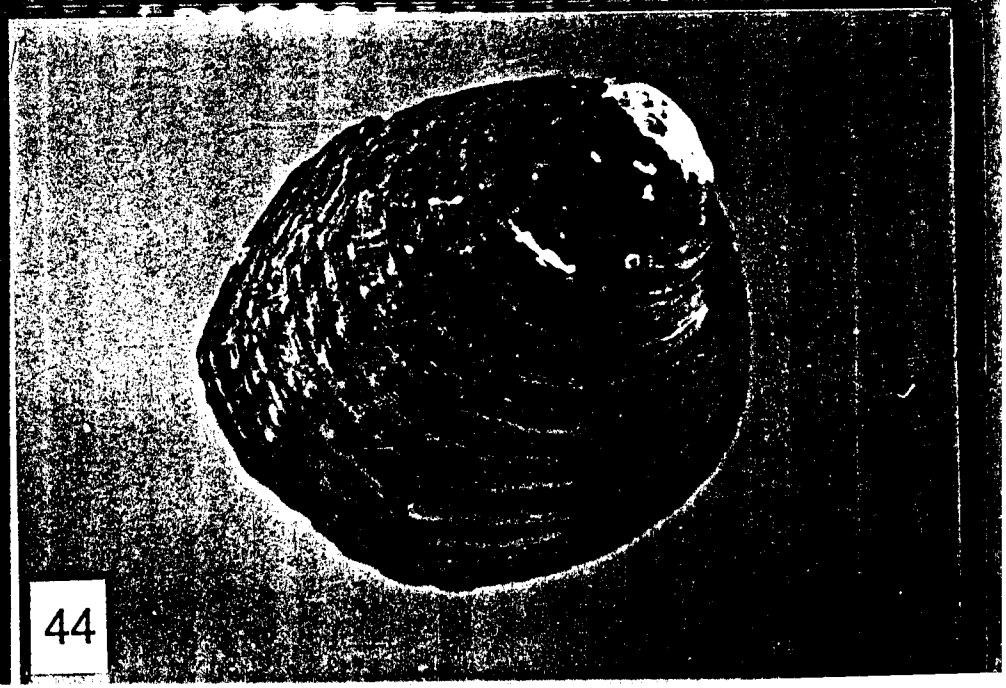

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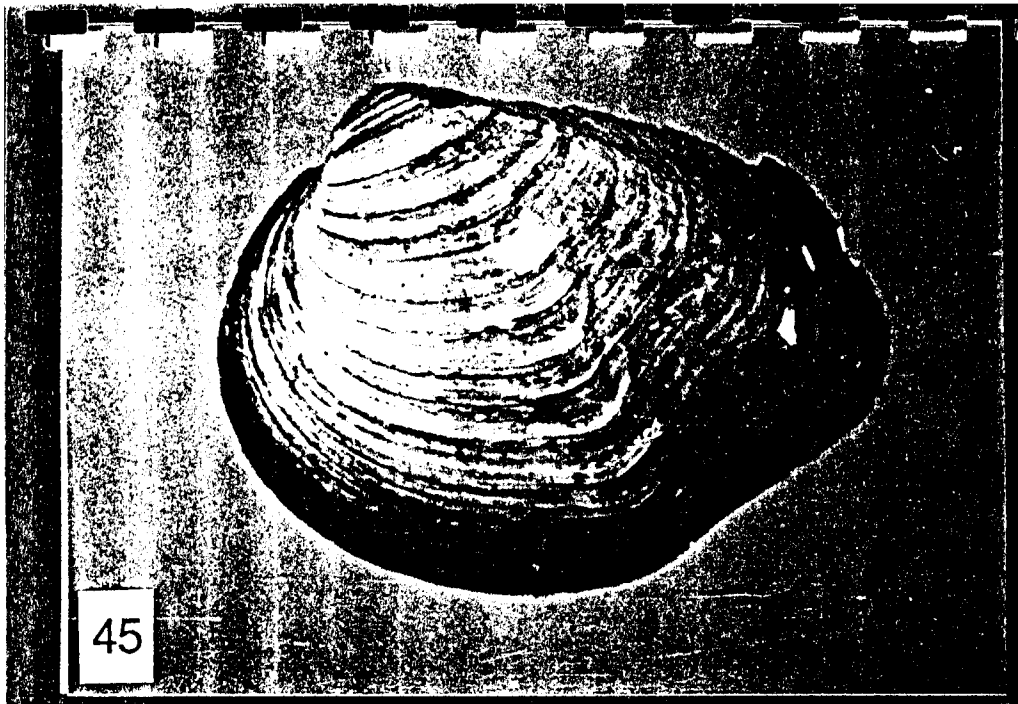
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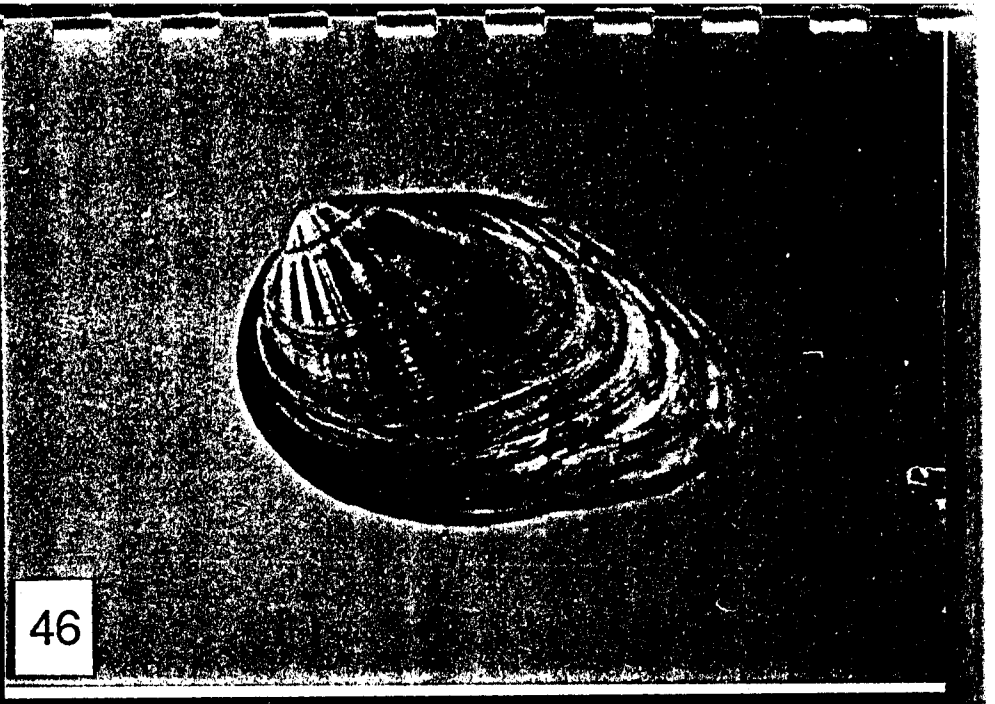
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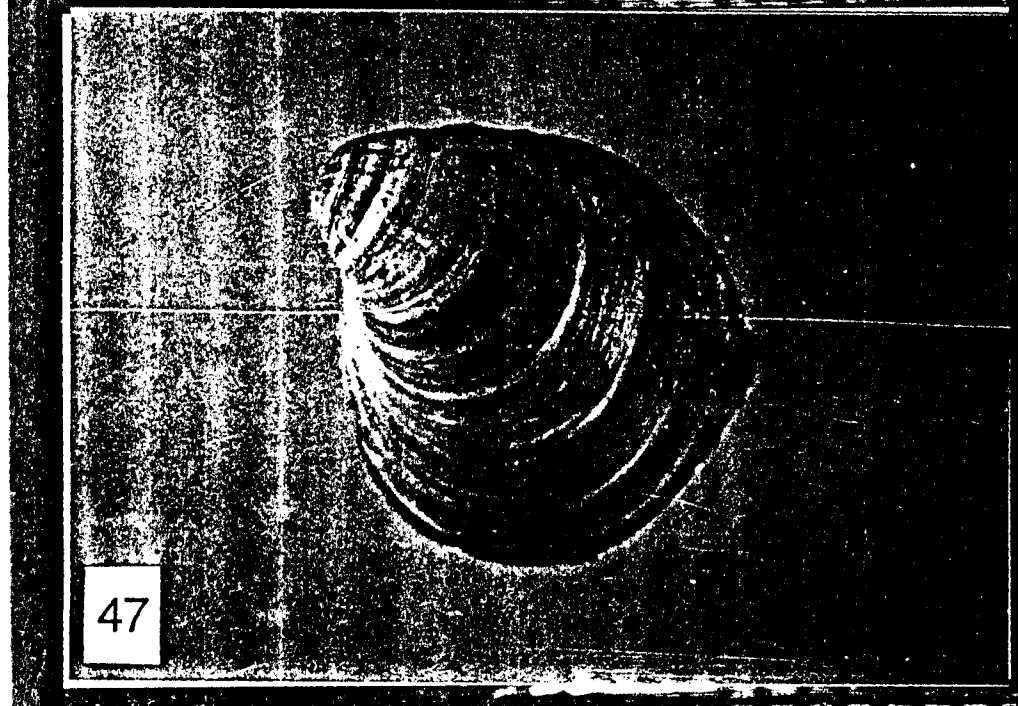
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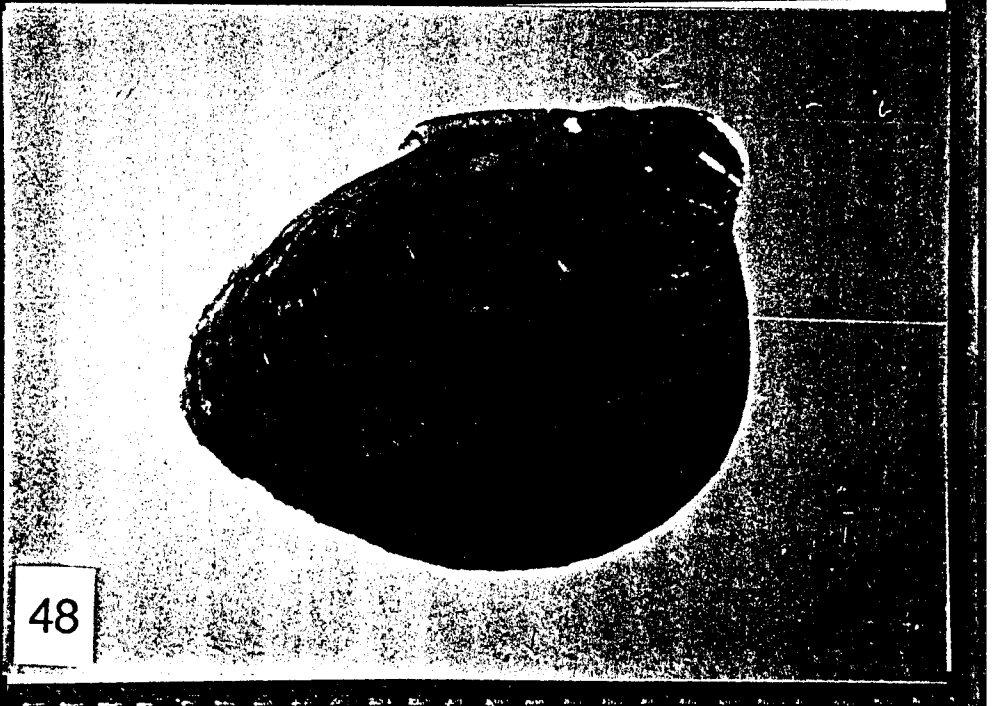
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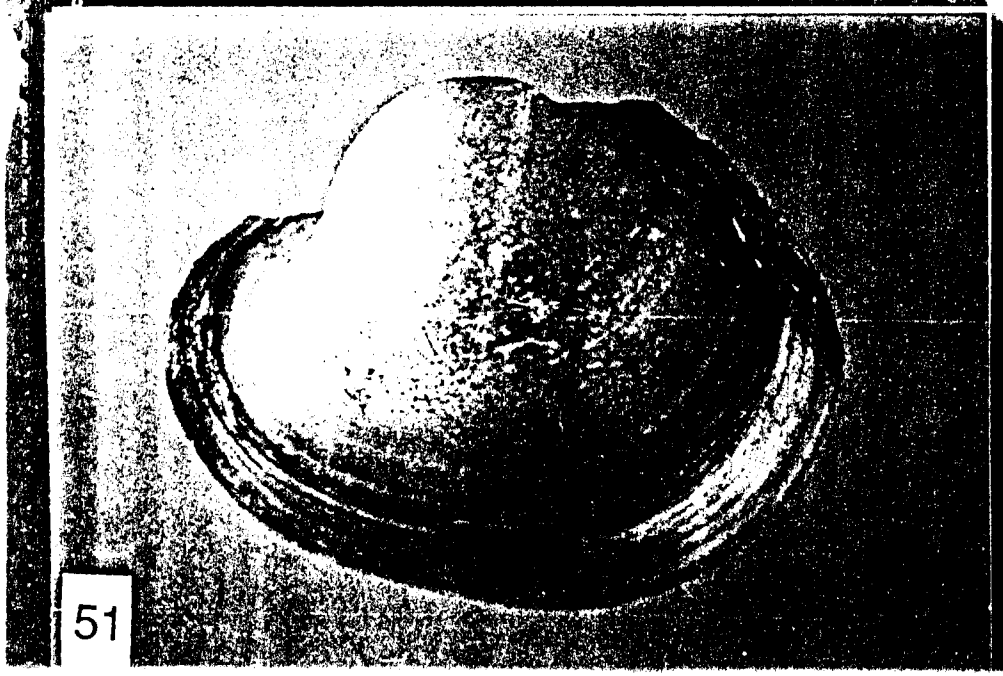

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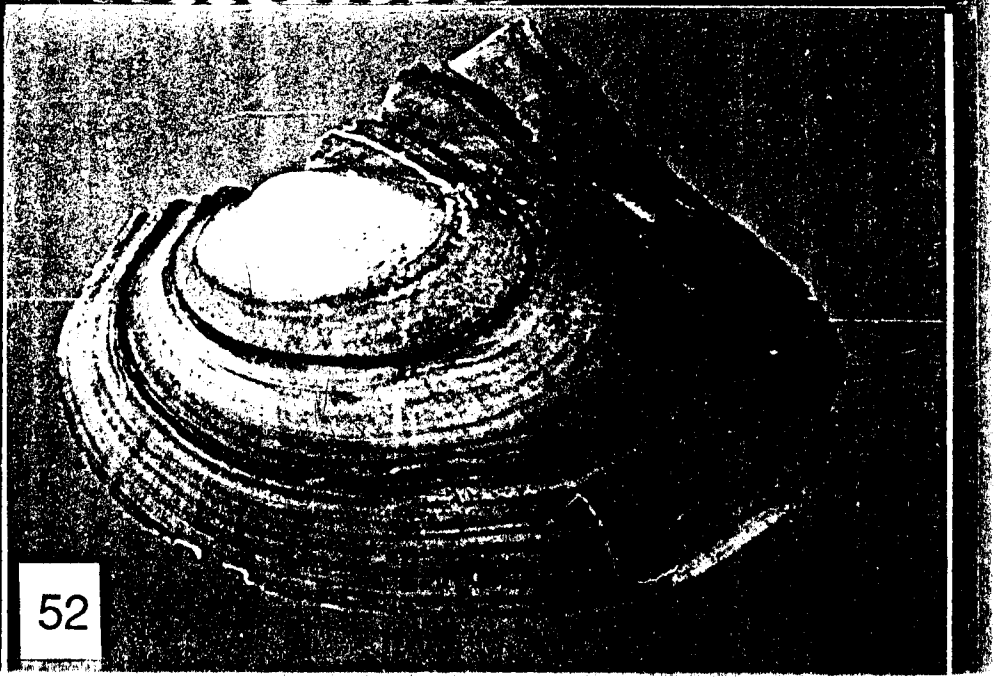

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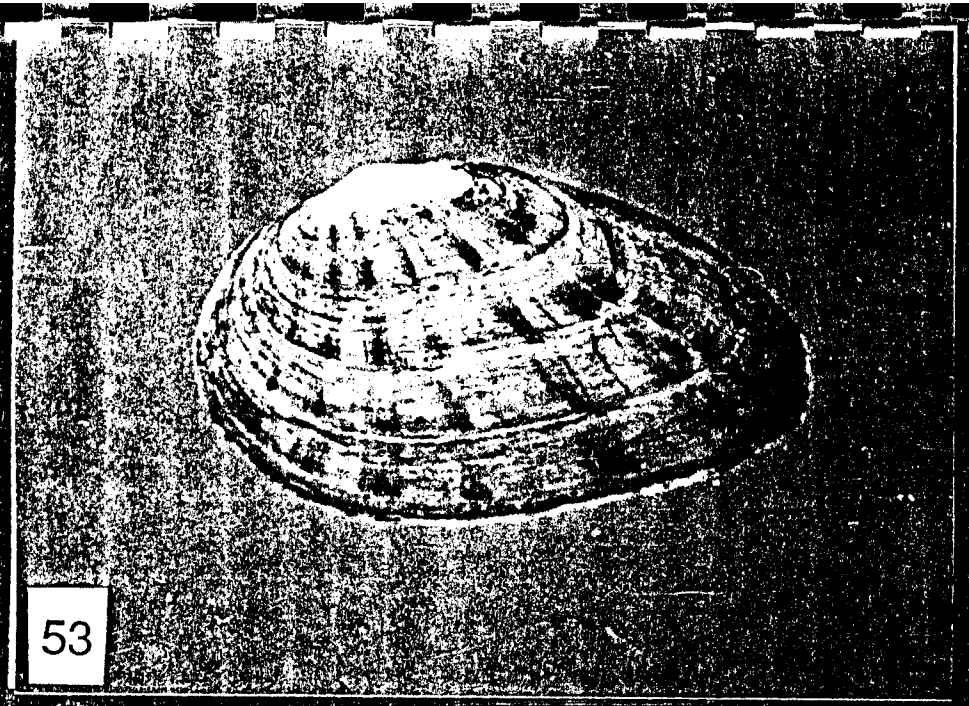

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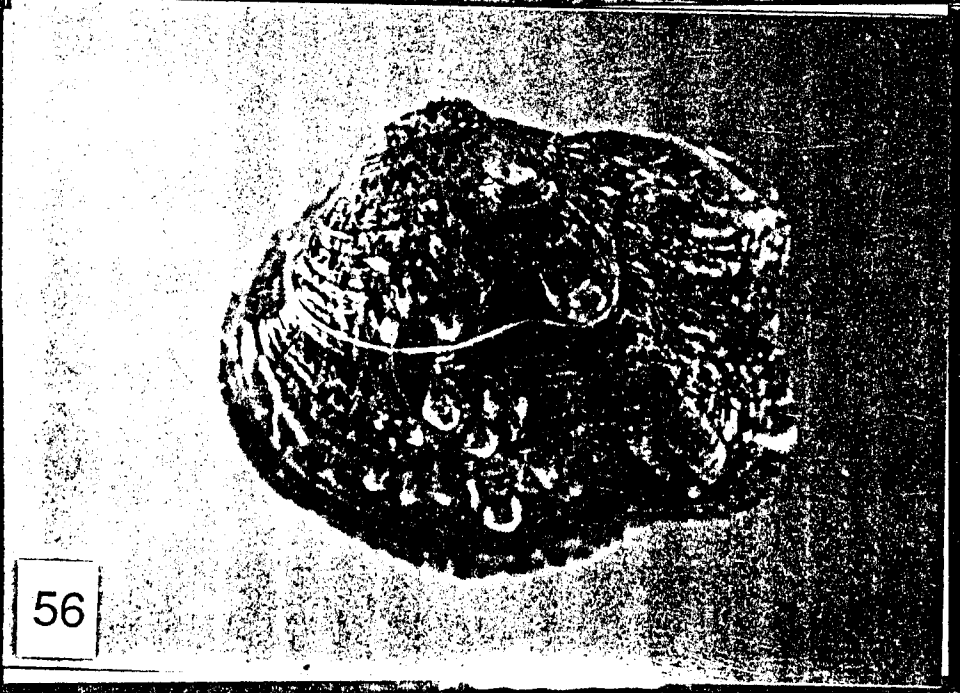

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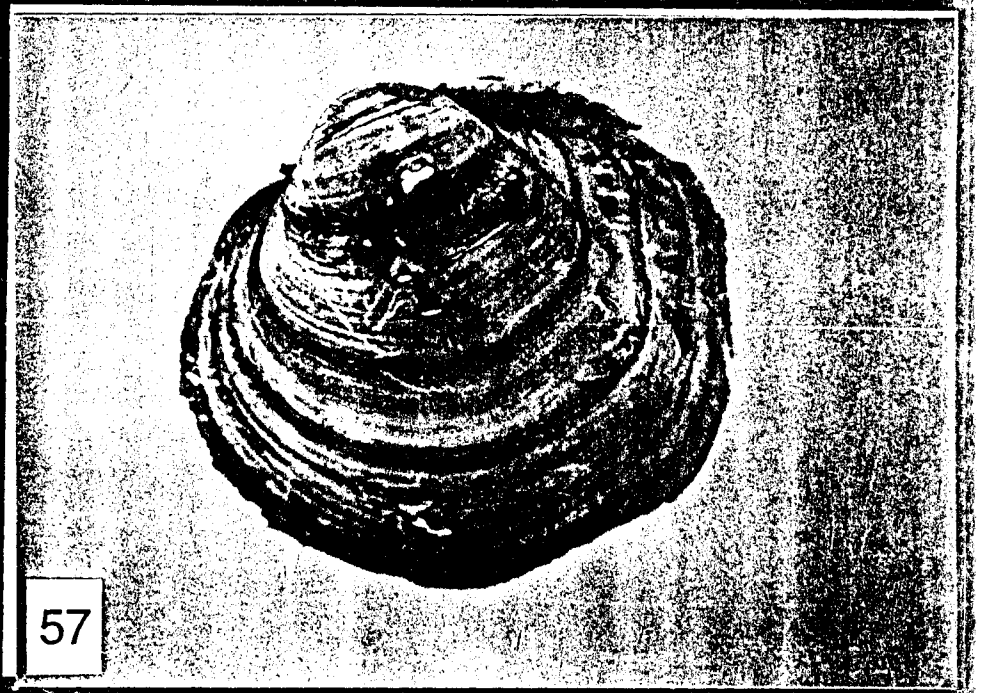

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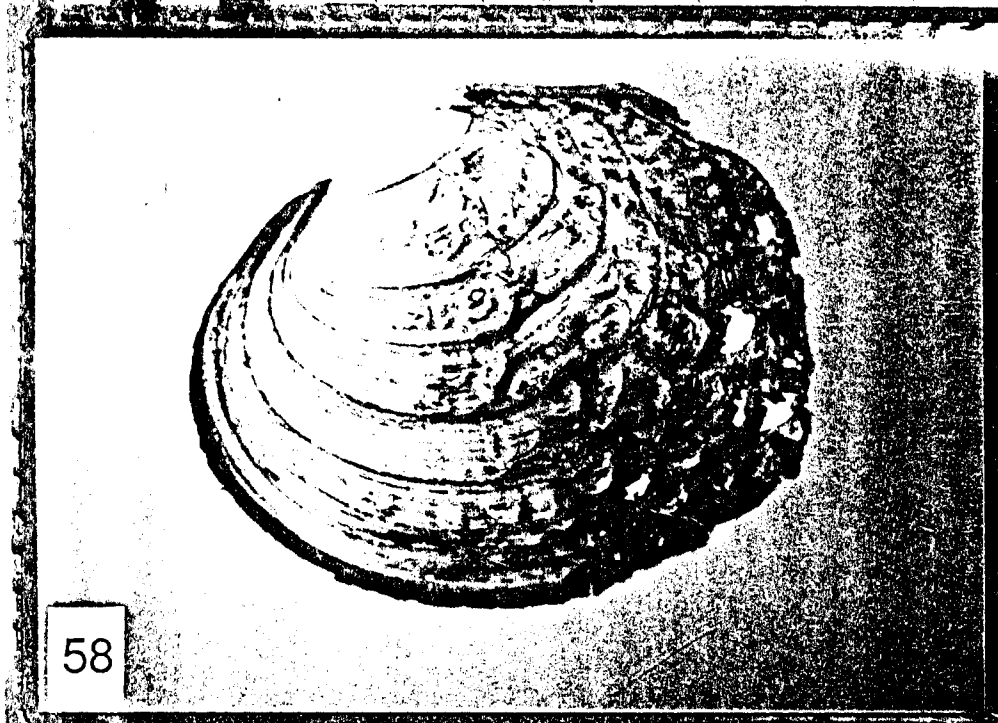
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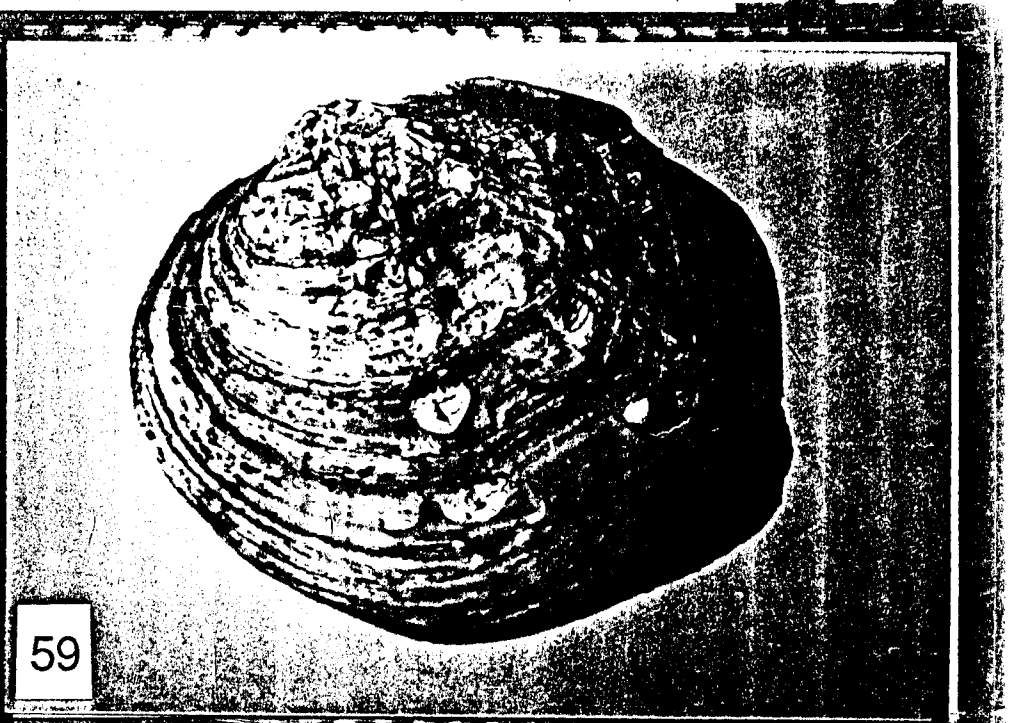
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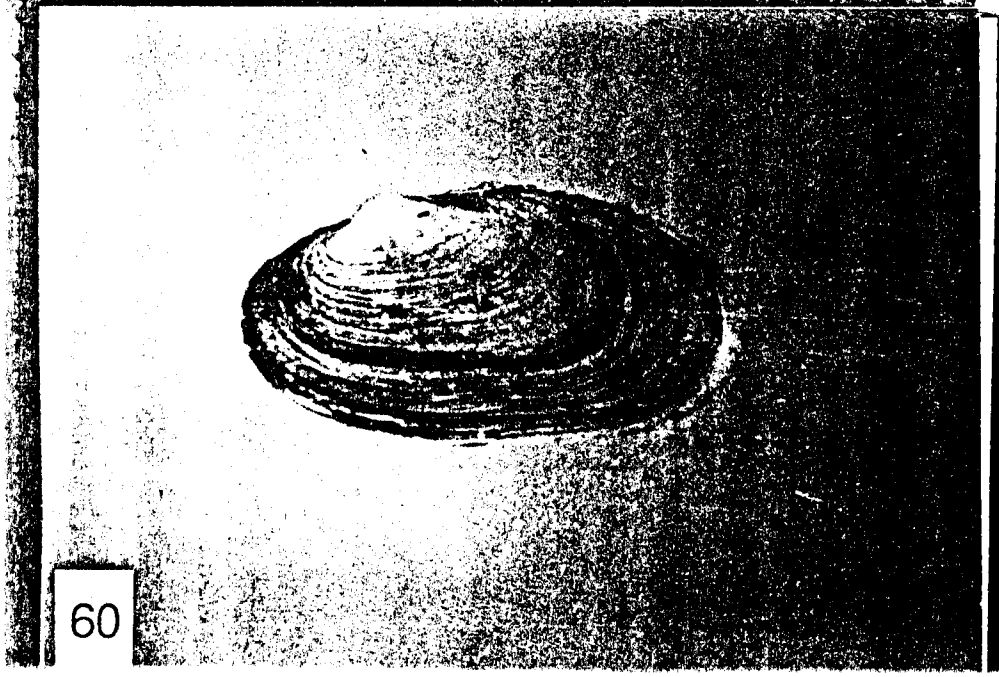
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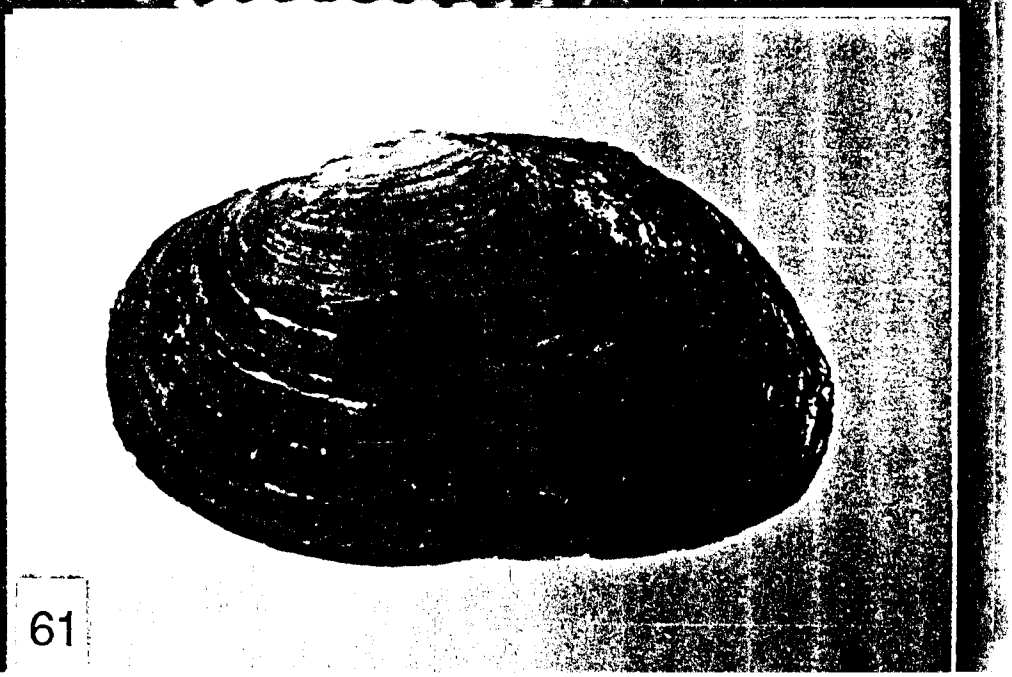
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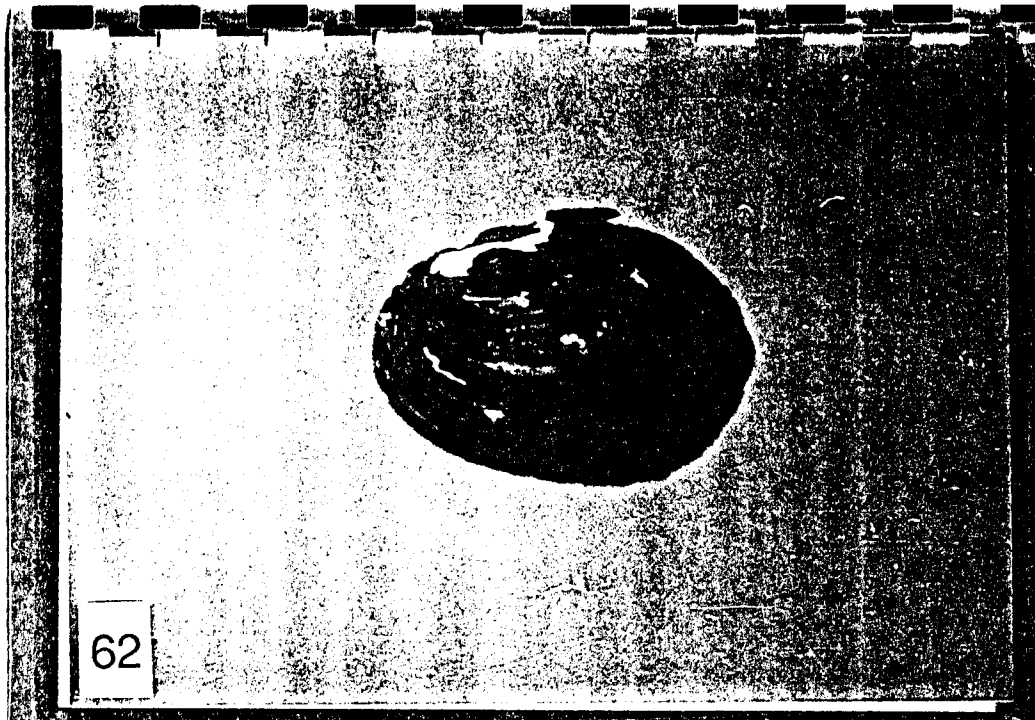

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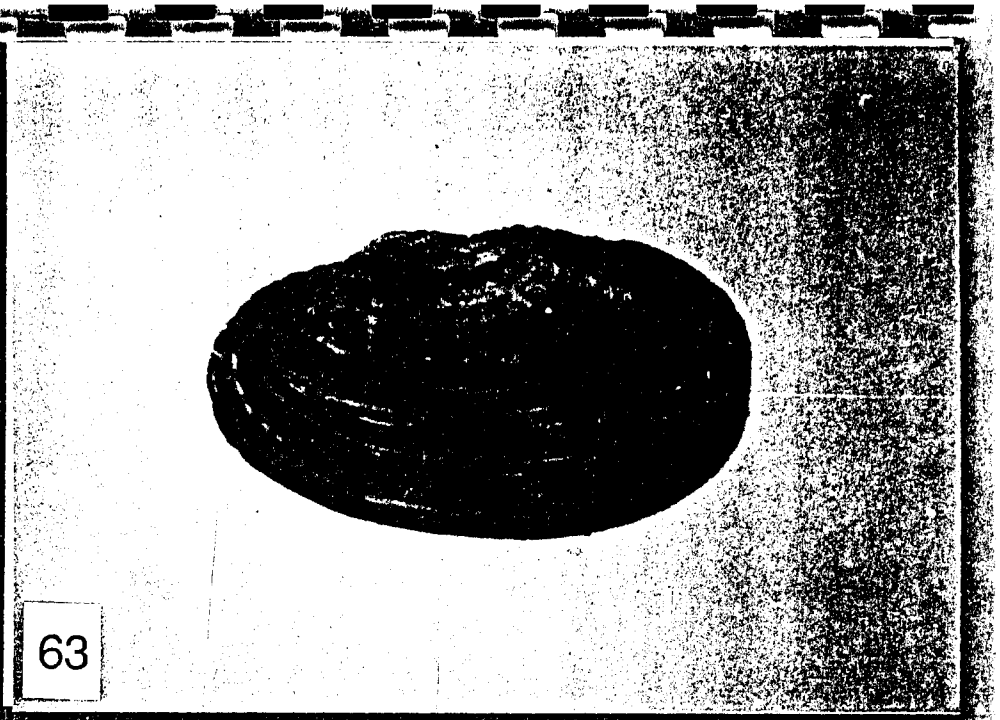

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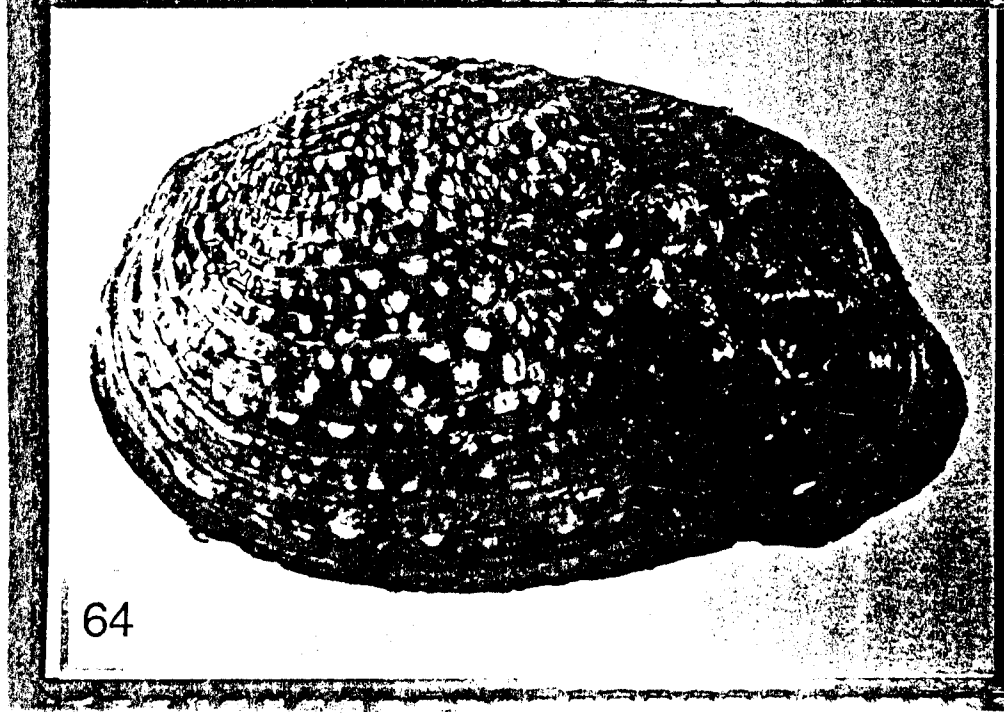

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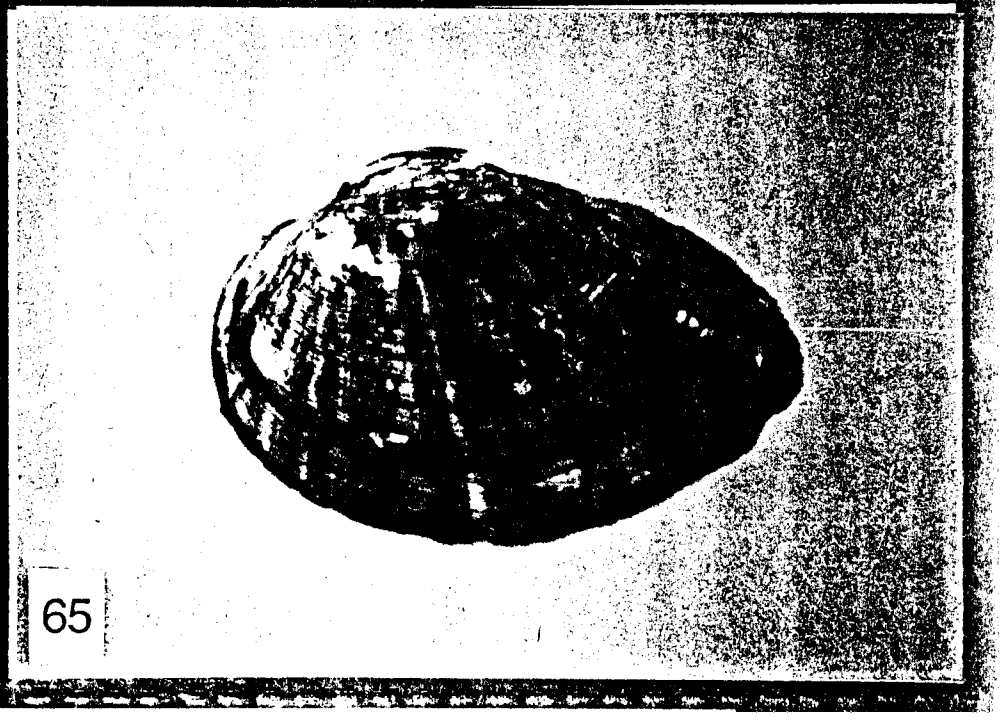

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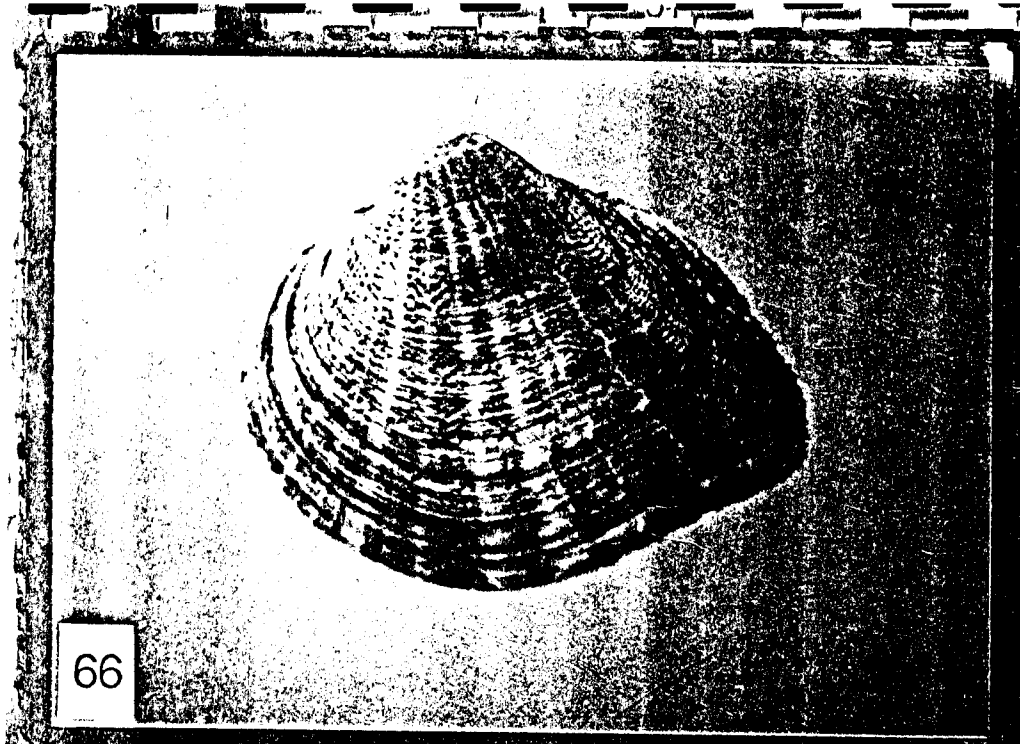

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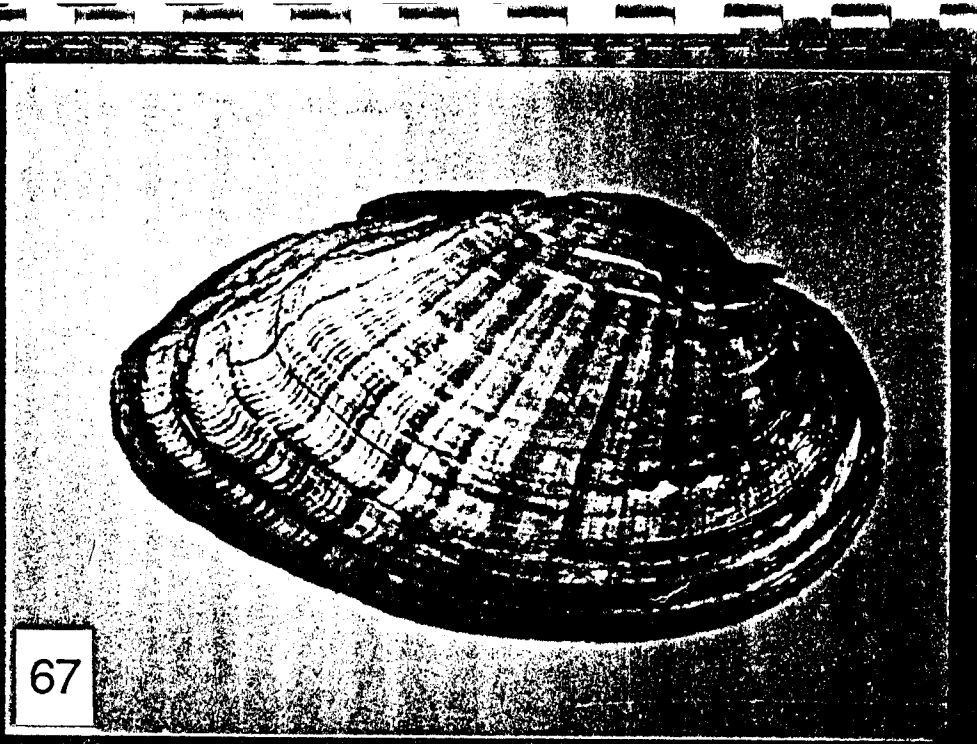

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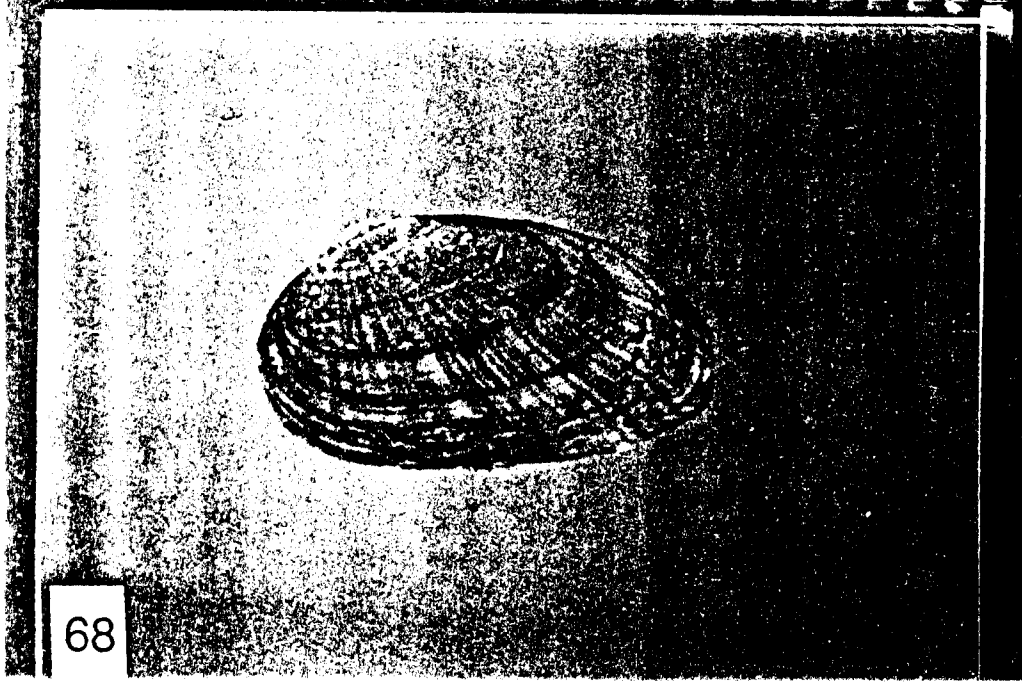

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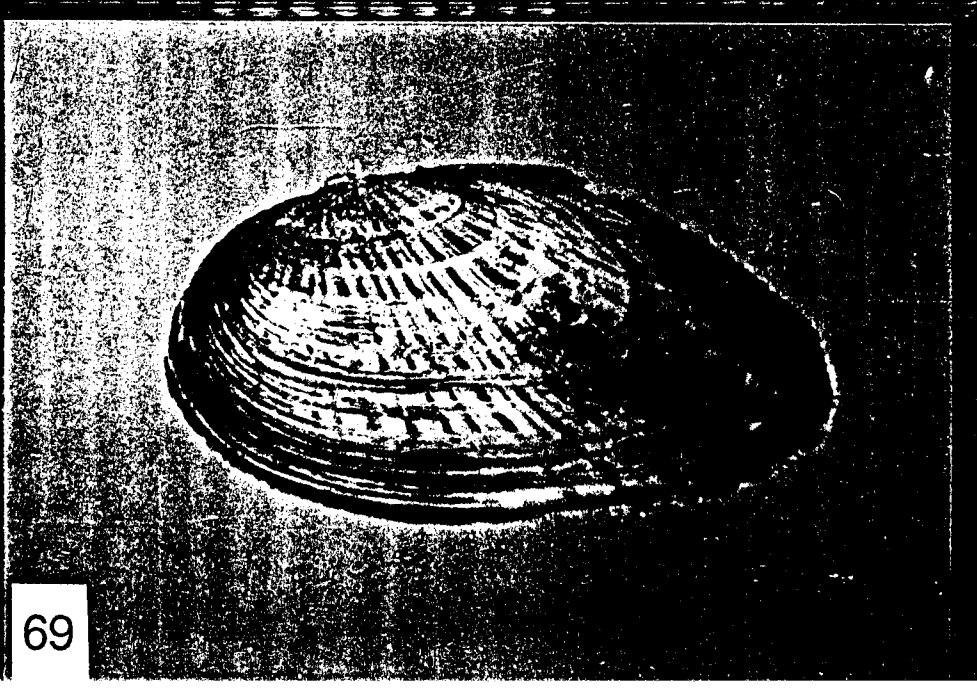

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