CHANGES IN THE FRESHWATER MUSSEL (MOLLUSCA: PELECYPODA: UNIONIDAE) FAUNA OF THE KASKASKIA RIVER, ILLINOIS, WITH EMPHASIS ON THE EFFECTS OF IMPOUNDMENT

Liane Suloway
Section of Faunistics and Insect Identification
Illinois Natural History Survey
Champaign, IL 61820

John J. Suloway
Section of Aquatic Biology
Illinois Natural History Survey
Champaign, IL 61820

Edwin E. Herricks
Department of Civil Engineering
University of Illinois
Urbana, IL 61801

ABSTRACT

During 1978 and 1979, a survey of unionid mollusks (freshwater mussels) was conducted at 19 sites in the Kaskaskia River to determine the present status of mussels in the river. A comparison of the results of the 1978-79 survey with information from collections made prior to 1906 and in 1929, 1954, and 1956 allowed a determination of the historical changes in the mussel fauna.

A total of 40 species have been reported from the Kaskaskia River since the turn of the century. Sixteen of these 40 species were not collected in 1978-79. *Amblema plicata* was by far the most abundant species in the 1978-79 collections.

There was a dramatic change in the mussel fauna between 1956 and 1978. At 17 sites sampled by hand in 1956 and 1978-79, there was a 76% reduction in the number of individual mussels; and the number of species declined from 31 to 24. Of the 19 sites sampled in 1978-79, 15 had fewer individuals and species, three had no mussels in either 1956 or 1978-79 collections, and one site had more individuals and species. The reduction was most pronounced in the reach between the two impoundments.

INTRODUCTION

Most major rivers in North America are totally or partly regulated by dams and reservoirs which alter downstream aquatic environments. Until recently, flow regulation by controlled releases from impoundments has proceeded without consideration of the ecological consequences downstream (Stanford and Ward 1979).

Some studies concerning the effects of impoundment of fluvial systems on the mussel fauna have been reported. Many of these studies have dealt with the mussel communities of the reservoir environments in such systems (Bates 1962, Klippel and Parmalee 1979, Parmalee 1955, Riggs and Webb 1956, White and White 1977). Others have recently reported changes in the naiad fauna in impounded systems as a whole without separate consideration of reservoir, headwater and tailwater environments. Two such studies, one of the upper Mississippi River (Fuller 1978) and the other on the Illinois River (Starrett 1971), were utilized for comparison with the Kaskaskia River mussel fauna because of the geographical proximity of these systems to the Kaskaskia River and the similarity of the components of the mussel fauna. The mussel fauna of the lower Tennessee River had been studied before and after the installation of many of the high dams (Bates 1962, Isom 1969 and 1971, Ortmann 1925, Scruggs 1960, Stansbery 1964, Van der Schalie 1939). Isom's 1969 study was particularly useful for comparison with the Kaskaskia River because separate consideration was given to data from reservoirs and tailwaters.

A study of the mussel fauna of the Kaskaskia River in Illinois, which has two mainstream impoundments, was undertaken with the primary objective of determining the impact of impoundment on the mussel fauna of areas upstream and downstream of reservoirs. A secondary objective was to determine the present status of the mussel fauna in terms of species composition, abundance and distribution.

MATERIALS AND METHODS

In 1978-79, 19 sites were sampled (Fig. 1). Seventeen sites were handpicked for three man-hours each and two sites (12 and 19) were brailed for 100 m, three times with a 1-1/2 m brail. Attempts were made to sample all habitats at a site, including pools, riffles and backwaters. All mussels listed from a site were collected alive. Voucher specimens were deposited at the Illinois Natural History Survey. River width, depth, substrate and nearby land use were noted at each site.

Previous studies of the Kaskaskia River mussels, which provide pre-impoundment information, include Baker (1906), Luce (1933) and the field notes and shell collections of P.W. Parmalee and of M.R. Matteson. Baker's, Luce's and Parmalee's data provide qualitative information about the mussel fauna. Data from Matteson's study are quantitative and were comparable to those of the present study because similar sampling methodology was used.

Baker, whose information was supplied by A.A. Hinkley, did not list precise collection sites or dates. Luce collected in five areas in 1929; Parmalee collected at three sites in 1954 and 1956; and Matteson collected at 27 sites in 1956. Sites sampled in the present study corresponded to those sampled by Matteson. Eight sites sampled by Matteson could not be resampled in 1978-79 because of the effects of channelization and reservoir construction.

DESCRIPTION OF THE STUDY AREA

The Kaskaskia River, which is Illinois' second longest intrastate stream, originates in east-central Illinois and flows southwesterly for 475 km before discharging into the Mississippi River. Man-made alterations in the basin began in late 1800's with channel clearing and straightening to improve agricultural drainage. Two mainstream impoundments were built by the U.S. Army Corps of Engineers, one at Carlyle was completed in 1966 (105 km^2 and the other at Shelbyville in 1970 (45km^2). To facilitate barge traffic, the lower 81 km of the river have recently been dredged and straightened and the flow controlled by a lock and dam at the mouth of the river. The main sources of pollution in the basin are from agricultural practices (fertilizer and pesticide runoff and soil erosion) and coal mining (Larimore 1978).

The 19 stations sampled were divided into four groups on the basis of location and present habitat conditions: Kaskaskia River headwaters (sites 1-9), Lake Shelbyville headwaters (10-12), Lake Shelbyville tailwaters (13-16) and Carlyle Lake tailwaters (17-19). In the Kaskaskia River headwaters, sand and silt were the predominant substrate types; small percentages of gravel occurred at sites 1, 2, 3, 5, and 7. The Lake Shelbyville headwaters substrate consisted of large percentages of silt and debris in comparison to the other sites in the river. Site 13 in the Lake Shelbyville tailwaters had a sand-gravel-silt substrate with gravel representing a larger portion of the substrate than at the sites upstream of Shelbyville. At sites 14-16, sand was the predominant substrate. In the Carlyle Lake tailwaters there were sand-gravel-silt substrates at sites 17 and 18; gravel represented relatively large percentages of the substrate in comparison to other sites.

RESULTS AND DISCUSSION

Present Abundance and Distribution

Mussels representing 24 species were collected in 51 man-hours of hand sampling. Present abundance and distribution data for each site are given in Table 1. The three most abundant species comprised 70% of the total number of individuals collected. *Amblema plicata*, a common and widespread species in Illinois, was the most abundant species (48.6% of the number of individuals collected). *Lampsilis ovata ventricosa* and *Leptodea fragilis* represented 11.6 and 10.4% of the total number of individuals collected, respectively.

In the 1978-79 study, the number of individuals found at a site ranged from 0 to 179; and the number of species ranged from 0 to 12 (Table 1). No mussels were found at nine sites (1, 2, 3, 8, 9, 11, 12, 14, and 19). Several factors may be responsible for lack of mussels at these sites. Sites 1, 2, 8, and 9 had supported no or few mussels in 1956. The fauna at site 3 had been dominated in 1956 by two species, *Anodontoides ferussacianus* and *Strophitus undulatus*, which have declined in abundance in the Kaskaskia River in the past 25 years. The sandy substrate found at site 11 in 1956 was heavily silted in 1978-79. The sand-gravel riffle at site 12, which had supported the largest mussel community in the river in 1956, was replaced by slack water from Lake Shelbyville. At site 14, mussels were restricted to the margins by a shifting sand substrate in midchannel in 1956; in 1978-79, the substrate at the margins consisted of thick silt deposited by the sloughing of the banks. During 1956, mussels were collected at site 19 on a narrow silt ledge which was not present in 1978-79.

Depauperate mussel populations (i.e., characterized by low abundance and diversity) were found at sites 4, 15 and 16. Mussel communities above Lake Shelbyville (sites 6, 7 and 10), at site 13 in the Lake Shelbyville tailwaters and in Carlyle Lake tailwaters (sites 17 and 18) were relatively healthy in terms of abundance and/or diversity (27-179 mussels representing 8-12 species).

The sites sampled by hand in the Kaskaskia River upstream of the reservoirs (sites 1-11) supported greater abundances but fewer species (32.2 individuals/site and 15 species) than the rest of the river (24.0 individuals/site and 20 species). The reach between reservoirs (sites 13-16) supported fewer species and lower abundances of mussels (12.2 individuals/site and 13 species) than either the hand sampled sites upstream of the reservoirs or in the hand sampled sites in the Carlyle Lake tailwaters (47.5 individuals/site and 18 species). Carlyle Lake tailwaters sites supported the largest average abundances and the greatest number of species compared to the other reaches.

HISTORICAL COMPARISON

Forty species of mussels have been reported in the Kaskaskia River since the turn of the century. The numbers of species collected prior to 1906, and in 1929, 1954 and 1956, and 1978-79 were 25, 23, 35, and 24 respectively (Table 2). The increase in number of species reported in 1954 and 1956 is probably the result of more intensive collecting. Sixteen species collected in studies prior to 1978-79 were not found in 1978-79; of these 16 species, three were last reported in 1906; one in 1929, and 12 in 1954 or 1956 (Table 2).

Between 1956 and 1978-79, the number of species collected declined from 31 to 24, with a concurrent 76% reduction in the number of individuals collected (Table 1). Comparisons between 1956 and 1978-79 data exclude data from sites 12 and 19 which were sampled by brail in 1978-79. The average number of individuals/sites declined from 121.4 in 1956 to 29.3 in 1978-79. Sites 3, 8, 11, and 14, which supported mussels in 1956, were lacking mussels in 1978-79. Excluding sites 1, 2, and 9, where no mussels were found in 1956, fewer individuals and number of species were found at all sites except 7 (Fig. 2). At site 7, no mussels were found in 1956, but 11 species were collected in 1978. In 1956, the habitat may have been unsuitable for mussels; Matteson noted deep silt and an oil scum on the water, neither condition was present in 1979.

Almost all species were less abundant and almost all species were found at fewer sites in 1978-79 than in 1956. Nine species collected by Matteson in 1956 were not recollected in 1978-79. The 1978-79 abundances of the five most abundant species in 1956 ranged from 4.1 to 45.6% of their 1956 abundances.

In 1956 the eight most abundant species totaled about 70% of the individuals collected; in 1978-79 the three most abundant species comprised 70% of the fauna. The remaining 30% of the individuals collected were distributed among 23 species in 1956 and 21 species in 1978-79.

There has been a substantial decrease in abundance and number of species of mussels in the Kaskaskia River between 1956 and 1978-79; these changes reflect impacts of the reservoirs and watershed land use. Similar declines have been documented recently in other rivers within Illinois: the Illinois (Starrett 1971), Kankakee (L. Suloway, in press), Little Wabash (L. Suloway, unpublished), Rock (Miller 1972), and Vermilion (Matteson and Dexter 1966, J. Suloway 1975).

EFFECTS OF IMPOUNDMENT

The Kaskaskia River can be divided into two areas on the basis of changes observed in collections between 1956 and 1978-79. Sites 1-9, or Area I, is relatively unaffected by the impoundments. The remaining sites (Area II) are either directly or indirectly affected by Lake Shelbyville and Carlyle Lake. (Comparisons between these two areas in 1956 and 1978-79 exclude sites 12 and 19). The Lake Shelbyville headwaters (sites 10-12) are subject to reduced current and periodic impoundment; silt and debris overlie the sand-gravel substrate noted in 1956. Sites downstream from the reservoirs are subject to flows modified by controlled releases from the lakes. Bank erosion, sedimentation, and substrate instability caused by high or variable flows have been observed below both reservoirs (Bhowmik 1979). Noticeable bank erosion had occurred at sites 16, 18, and 19.

Mussel populations were more reduced in Area II (89% decrease in abundance and a loss of 9 species) than in Area I (37% decrease and a loss of four species) between 1956 and 1978-79 (Table 3). The sites immediately below the reservoirs were less affected than other sites. Site 13 in the Lake Shelbyville tailwater and sites in Carlyle Lake tailwater (17 and 18) supported at least 11 species. These three sites are presently the richest in terms of abundances and number of species in Area II, whereas in 1956, they were average (Fig. 2).

Baker (1922) reported 9 more species immediately below a dam on the Vermilion River in Illinois than in the 13-km stretch above the dam. In the 19-km stretch of the Tennessee River immediately below Kentucky Dam, Williams (1969) found mussels to be fairly abundant, and he found "good" beds just below all but one of the six dams on the Green River, while the remaining areas of the river contained few, if any, living mussels. After studying the mussel fauna in an 854-km stretch of the lower Tennessee River, Isom (1969) found approximately 282-km of suitable habitat for mussels, mostly in the tailwater reaches of the river.

The potential downstream effects of impoundments are numerous (Baxter 1977). Changes in sediment transport, primary production, temperature regimes, amplitude of long period variation in water level, and fish migration patterns are some of the effects. The net effect of the conditions in many tailwater reaches is to maintain or create an environment favorable for the existence of mussels, at least in comparison to other areas of the river. It should be noted that the mussel fauna below dams still exhibit reductions in abundance in comparison to the original fauna, such as that dramatically shown for the Muscle Shoals region of the Tennessee River (Stansbery 1964) and in the Kaskaskia River.

POTENTIAL DETRIMENTAL FACTORS

Several factors have been responsible for the decline or extirpation of some of the 16 species not recollected in 1978-79. All but two species ((*Anodontoides ferussacianus* and *Truncilla truncata)* were absent or uncommon in the Kaskaskia River in 1956. Of 3,454 specimens collected by Matteson in the Kaskaskia, none of the uncommon species was represented by more than 21 specimens. Some species were collected only in areas subsequently altered by channelization and reservoir construction. *Dysnomia triquetra* was found only at site 12 in 1956, which was later inundated by Lake Shelbyville. *Fusconaia ebena* was collected at Evansville in 1956 in a reach that was recently channelized for barge traffic. Large river

species such as *Elliptio crassidens*, *Ellipsaria lineolata* and *F. ebena* (Parmalee 1967) may have been strays from the Mississippi River and, even if they were extant in the Kaskaskia, they have probably been eliminated by the recent channelization of the large river habitats of the Kaskaskia River. Since its impoundment, the Kaskaskia River may be less suitable for species preferring good current i.e., *Plethobasus cyphyus*, *Lasmigona costata*, *Dysnomia triquetra* and *Truncilla truncata*. In addition, the extirpation of any of these 16 species may be function of the presence and abundance of their fish hosts. Of the 16 mussel species not recollected in 1978-79 and for which fish hosts are known (as summarized by Fuller 1978), at least one fish host existed in the Kaskaskia River in 1977-79 (Herricks, unpub., and Illinois Natural History Survey fish collection data). However, the fish hosts for *Elliptio crassidens*, *Pletobasus cyphyus* and *Anodontoides ferussacianus* were uncommon in the Kaskaskia River in 1977-79. It is not known whether the abundances and distributions of the fish host species were or are sufficient to perpetuate the existence of any of the 16 mussel species no longer found in the Kaskaskia River.

Whatever the factors involved in the apparent extirpation of the 16 mussel species from the Kaskaskia, some of these species have suffered the same fate in other impounded systems, i.e., the lower Tennessee, upper Mississippi and Illinois Rivers. Eleven of the 16 species have not been recollected from at least one of the systems: *Dysnomia triquetra* have not been recollected in any of the three systems (Table 2).

Among the 24 mussel species collected in 1978-79 in the Kaskaskia, 23 had survived impoundment of the lower Tennessee, upper Mississippi and/or Illinois Rivers and 14 survived in all three systems (Table 2). *Alasmidonta marginata* had not been recollected in the upper Mississippi or Illinois Rivers; it is primarily an inhabitant of small rivers (Parmalee 1967) and as such has never been an important component of the upper Mississippi mussel fauna (Fuller 1978). In the Illinois River, *A. marginata* was probably eliminated by pollution before the high dams were installed (Starrett 1971).

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Table 1. Numbers of mussels collected at sites in the Kaskaskia River in A) 1956 and B) 1978-79. No live mussels were found at sites 1, 2, or 9 in 1956 or 1978-79. Nomenclature follows Burch (1975).

Species	3		4		5		6		7		8		10		11		12		13		14		15		16		17		18		19		Totals	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Actinonaias carinata carinata								1					2		2		42		76	1	1												123	2
Alasmidonta marginata								1		1							4																4	2
Ambloma plicata			19	2	50	51	57	135		31			218	2	100		2		35	4	5		3				18	8	26	9	1		534	242
Anodonta imbecillis															7													1	1		1		9	1
A. grandis grandis					2		2			1			9	5	17		1										4	1					35	7
Anodontoides ferussacianus	18		2		5		28								3		7								1								64	0
Arcidens confragosus										1			4	2	1		1		1				1				4	1	1				13	4
Carunculina parva					2		2								1		1																6	0
Dysnomia triquetra																	14																14	0
Elliptio dilatata															3		97											1					100	1
Fusconaia flava	1		4		25	5	46	6		6			7	1	13		164																260	18
F. undata																			60	1	18		75				4		6	5	1		164	6
Lampsilis ovata ventricosa	1		15		4	8	86	28		20	1		3		5		36		7	1	11		2		1		8	1	4		4		188	58
L. radiata siliquoides			7		3	2	13	5		3			8		14		39		2														86	10
L. teres													2				8		8		1		19	1			9	1	9		11		67	2
Lasmigona complanata										7			6	11	10		4		6	6	11		8		1		3		3	3			52	27
L. costata													1		2		3																6	0
Leptodea fagilis								2		2			1	2	3		7		15	14	3		24	2	7	2	33	26	12	2	15		120	52
L. laevissima										3									1	4	2		6	2	6		2		2	1	11		30	10
Megalonaias gigantea													4	1	1		1										9	1	3	5			18	7
Obliquaria reflexa																							4				1		2	2			7	2
Plethobasus cyphyus																							11										11	0
Pleurobema cordatum																			8		1												9	0
Proptera alata													1		8		1		18	4	7		2		2		14	1	5	1	1		59	6
Quadrula metanevra																														1			0	1
Q. nodulata																							19	1			4		1		1		25	1
Q. pustulosa							6						3	1	5		13		72	3	15		95		2		6		18	7			235	11
Q. quadrula													1	2	6				3	1			10				8	8	3	5	2		33	16
Strophitus undulatus	11		18	1	24		82	1		4			1		4		27		17		3		7				19	2	7	2			174	6
Trihogonia verrucosa													7		3		2		19	2	1		7		1								66	6
Truncilla donaciformis															2		2				2		6						4		1		17	0
T. truncata													6		15		7		16		2		13				1		5				65	0
Uniomerus tetralasmus								1																									1	0
Total individuals	31	0	85	3	115	66	303	179	0	79	1	0	284	27	225	0	485	0	354	41	83	0	312	6	21	2	147	52	112	43	49	0	2595	498
Total Species	4	0	8	2	8	4	10	8	0	11	1	0	18	9	22	0	23	0	17	11	15	0	18	4	8	1	17	12	18	12	11	0	32	24

Table 2. Species of mussels found prior to 1906, in 1929, 1954 and 1956, and 1978-79 in the Kaskaskia River, and their recent presence or absence in three other impounded fluvial systems—the Tennessee, upper Mississippi and Illinois Rivers.[1] Presence of live specimens is indicated by +, absence by −, no record found is indicated by a blank. Nomenclature follows Burch (1975).

Species	Kaskaskia River				Lower Tennessee River	Upper Mississippi River	Illinois River
	1906	1929	1954-56	1978-79	(1963-65)	(1977)	(1966-69)
Ambleminae: Amblemini							
Amblema plicata	+	+	+	+	+	+	+
Fusconaia ebena			+		+	−	+
F. flava		+	+	+		+	−
F. undata	+		+	+	+	[3]	+
Quadrula metanevra	+			+	+	+	−
Q. nodulata	+	+	+	+	−	+	+
Q. pustulosa	+	+	+	+	+	+	+
Q. quadrula	+	+	+	+	+	+	+
Tritogonia verrucosa	+	+	+	+	+	+	+
Megalonaias gigantea	+	+	+	+	+	+	+
Unioninae: Pleurobemini							
Elliptio crassidens	+				+	+	−
E. dilatata		+	+	+	+	+	−
Plethobasus cyphyus	+		+		+	+	−
Pleurobema cordatum		+	+		+	+	−
Uniomerus tetralasmus			+				−
Anodontini							
Alasmidonta marginata		+	+	+		−	−
Anodonta grandis grandis	+	+	+	+	+	+	+
A. imbecillis			+	+	+	+	+
A. suborbiculata			+		+	+	+
Anodontoides ferussacianus			+			+	−
Arcidens confragosus	+	+	+	+	+	+	+
Lasmigona complanata	+	+	+	+	+	+	+
L. costata		+	+		−	+	−
Strophitus undulatus	+	+	+	+	−	+	−
Lampsilini							
Actinonaias carinata carinata	+	+	+	+	+	+	−
Carunculina parva			+		+	+	+
Dysnomia triquetra			+		−	−	−
Elliptsaria lineolata	+				+	+	−
Lampsilis ovata ventricosa	+	+	+	+	(+)[2]	+	−
L. radiata siliquoidea		+	+	+		+	+
L. teres	+	+	+	+	+	+	+
Leptodea fragilis	+	+	+	+	+	+	+
L. laevissima	+		+	+	+	+	+
L. leptodon	+				−	−	
Ligumia nasuta subrostrata			+			−	
L. recta	+	+			+	+	−
Proptera alata	+	+	+	+	+	+	+
Truncilla donaciformis	+		+		+	+	+
T. truncata	+	+	+		+	+	+
Obliquaria reflexa		+	+	+	+	+	+
Total species	25	23	35	24			

[1] Tennessee River data are from Isom (1969), Stansbery (1964), and van der Schalie (1939); upper Mississippi River data are from Fuller (1978); and Illinois River data is from Starrett (1971).
[2] Reported as *L. ovata*.
[3] Fuller considered *Fusconaia undata* to be a form of *F. flava*.

Table 3. Comparison of mussel communities in Areas I and II in 1956 and 1978-79.

	Area I		Area II	
	1956	1978-79	1956	1978-79
Individuals	515	327	1548	171
Species	10	12	28	20
# Species Lost	4		9	
# Species Gained	6		1	
Change in Abundance (%)	−36.5		−89.0	

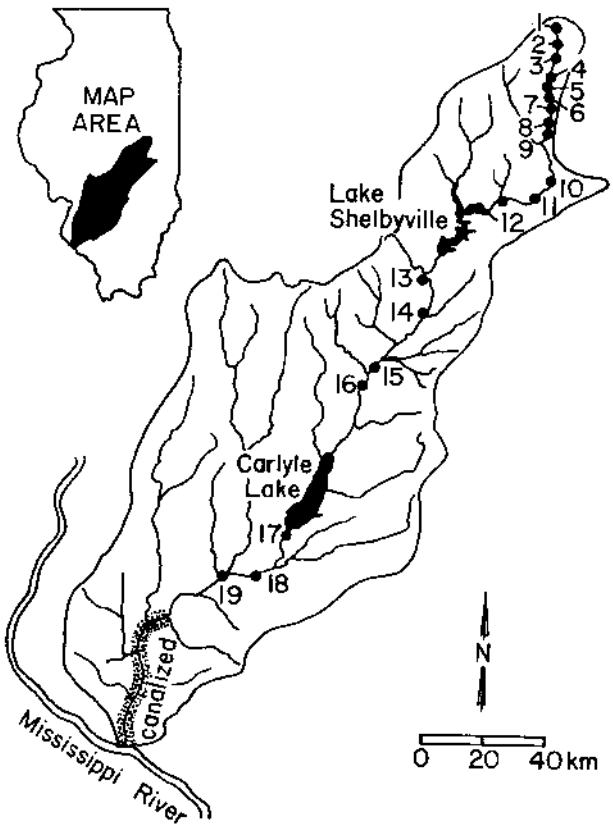

Figure 1. Sites on the Kaskaskia River sampled for mussels in 1978-79.

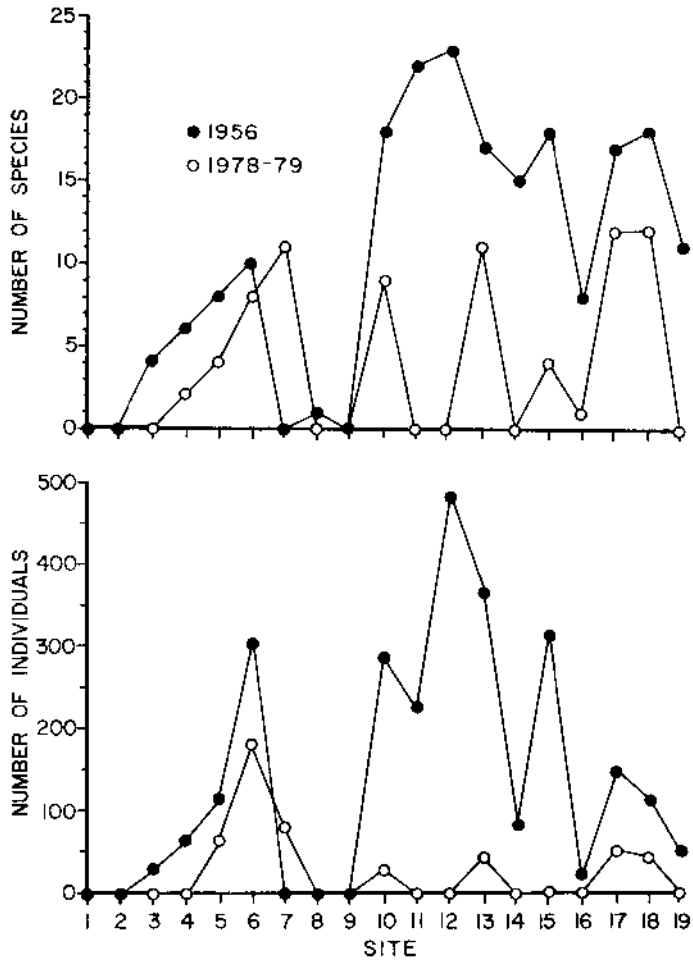

Figure 2. Number of species and number of individual mussels at sampling sites in the Kaskaskia River in 1956 and 1978-79.