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SPECIES COMPOSITION OF THE MUSSEL ASSEMBLAGES IN THE UPPER MISSISSIPPI RIVER

Daniel J. Hornbach, Andrew C. Miller and Barry S. Payne

ABSTRACT

The species composition of mussel assemblages was examined along a 476 mile reach of the upper Mississippi River (river mile 232-708, pool 7-26). At least nine qualitative samples were taken by divers equipped with either SCUBA or surface air supply at each site. From 667 qualitative samples, 15,144 mussels, belonging to 34 species (including *Corbicula fluminea*), were identified. The three ridge, *Amblema plicata*, occurred in 86.8% of the samples and comprised 28% of the total mussels collected. Five other species (*Lampsilis ovata ventricosa, Obovaria olivaria, Obliquaria reflexa, Quadrula pustulosa* and *Truncilla truncata*) were found in > 50% of the samples taken, although they composed < 10% of the entire assemblage. The major trends in assemblage change were an increase in the frequency of two dominant species (*A. plicata* and *L. ovata ventricosa*) and a decrease in frequency of three less dominant species (*Ellipsaria lineolata, Leptodea fragilis* and *Quadrula quadrula*) from downstream to upstream .

When compared to similar studies conducted within this river reach in 1930 and 1977 by other investigators, there were only 3 species fewer found in this study even though the river has undergone major modification (the construction of 28 locks and dams) since 1930. Some changes have occurred in the species composition over this time, such as an increase in the dominance of *Amblema plicata* and a reduction of the relative proportion of *Lampsilis teres* in the assemblage. These changes may be due to both general changes and site-specific alterations of the habitat.

KEY WORDS – Mussels, species composition, upper Mississippi River.

INTRODUCTION

Few studies have attempted to examine the assemblage of mussels in large river systems due, in part, to the difficulty of collecting all representatives from the habitat. Most previous studies have used brailing, but these techniques have been questioned (Sparks & Blodgett, 1983). Despite the difficulty of sampling mussels, it is apparent that they are found in fairly high density and thus may be quite important members of the benthic community in large river systems. Based on the river continuum concept model for nutrient processing in flowing water systems, it is suggested that filter-feeding organisms such as mussels may be the most important functional feeding group in large order streams (Minshall *et al.*, 1985 and references therein). In addition to their functional role in stream systems, mussels have received interest because of their commercial exploitation and the listing of some species on the federally endangered species list.

In this study we examined the assemblage of mussels in a 476 mile reach of the upper Mississippi River. A number of studies have provided data on the mussel assemblages in the upper Mississippi River (van der Schalie & van der Schalie, 1950; Perry, 1979; Fuller, 1980; Thiel *et al.*, 1980; Duncan & Thiel, 1983; Jahn & Anderson, 1986; and references in these papers) including two conducted on the same reach of river reported here: one in 1977 (Fuller, 1978) and the other in 1930 (Ellis, 1931a,b; data reported in van der Schalie & van der Schalie, 1950). Thus, we had the opportunity to examine possible changes that have occurred in this reach of river over a 47-year period. In 1930 when Ellis conducted his survey of the upper Mississippi River, there was only one major lock and dam on the river (in pool 19, river mile 364). Since that time, 28 additional locks and dams have been added, and the river has been altered to support commercial navigation traf-

fic. This management has included dredging, construction of wing dams, levees and other devices to aid in the maintenance of a 9-foot navigation channel. All of these activities have a potential impact on the mussel assemblages, either directly by influencing the substrata in which mussels reside or indirectly by affecting water quality, food availability, or the migration of fish hosts for the larval form (glochidia) of the mussels.

MATERIALS AND METHODS

Study area

The upper Mississippi River (above the confluence of the Ohio River) was once a free-flowing, braided, pool-riffle habitat with side channels, sloughs, and abandoned channels. Brunet (1977) and Tweet (1983) provide historical accountings of changes in the upper Mississippi River related to navigation traffic, and Knott (1980) described changes in the upper Mississippi River mussel fauna related to harvest for the button industry. Development of the 9-foot navigation channel, which included placement of locks, dams, dikes, wing dams and levees, converted it to a series of run-of-the-river reservoirs, characterized by relatively slow-moving water and extensive adjacent lentic habitats (Rasmussen, 1979). The upper reaches of individual pools in the upper Mississippi River typically have relatively high water velocity and riverine conditions; whereas the lower reaches are more lake-like with deep, low-velocity water and soft substrata. On a larger scale, substrata in the lower portion of the upper Mississippi River (Pools 24 to 26) consist mainly of coarse gravel, cobble and slab rock. The channel is fairly narrow and deep with comparatively few side channels, islands or backwaters. The middle reach of the upper Mississippi River (Pools 17 to 22) is characterized by fine-grained sediments, numerous islands, sloughs and backwaters. The upper reach of the upper Mississippi River (up-river of pool 17) has extensive islands, backwaters, sloughs and aquatic macrophyte communities. Sediments consist almost entirely of fine-grained sand and silt. In this study, samples of mussels were collected from pools 7 to 26, thus including representative sections of the majority of the upper Mississippi River.

Sampling Regimen

During July 1988, qualitative samples were collected in pools 11 to 26 (river mile 237 to 708, Table 1). In addition, samples were taken from pool 7 in May 1987 and May 1988, and from pool 10 in September 1987 and 1988 (Table 1). Qualitative collections were made by one or more divers equipped with either SCUBA (pools 11 to 26) or surface air supply (pools 7 and 10). Divers were instructed to search for and retain all mussels in or partially buried in the substrate. An attempt was made to collect approximately 20 individuals to constitute a sample and usually at least nine samples were taken at each site (Table 1). Due to the variation in the density of mussels and the extent of some beds, the number of mussels per sample and the number of samples per site varied. Collection was done mainly by feel since water visibility was poor and thus there was probably a bias for larger mussels to be collected. Some of the mussels collected by the divers were not alive and these were not considered as part of the sample. Mussels were brought to the boat, identified and, except for voucher specimens, returned to the river.

Voucher specimens are in the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, and in the Museum of Zoology, University of Michigan.

RESULTS

A total of 667 samples containing 15,144 mussels were taken at 23 sites along the upper Mississippi River from river mile 232 to river mile 708 (Table 1). Thirty-three species of unionids were found, as well as the introduced Asian clam *Corbicula fluminea* (Table 2). The three ridge, *Amblema plicata,* was the dominant member of the community, comprising, on average, 28% of each sample (Fig. 1A). This species occurred in 87% of the samples taken (Fig. 1B), and, in some samples, accounted for 100% of the individuals taken. Five other species (*Lampsilis ovata ventricosa, Obovaria olivaria, Obliquaria reflexa, Quadrula pustulosa* and *Truncilla truncata*) were found in over 50% of the samples taken (Fig. 1B) and overall each averaged greater than 5% of the individuals taken in each sample (Fig. 1A). Six additional species (*Ellipsaria lineolata, Fusconaia flava, Leptodea fragilis, Megalo-*

naias gigantea, Proptera alata and *Quadrula quadrula*) were found in 30 to 49% of the samples (Fig. 1B) and on average accounted for > 2.5% of the individuals in each sample (Fig. 1A). The remaining 22 species were found in less than 30% of the samples taken (Fig. 1B – eight species in the 10-29% range, seven species in the 1-9% range and seven species found in < 1% of the samples).

There was a significant correlation between the number of samples taken and the number of species collected (Fig. 2). Since a very large number of samples were taken at river mile 635 and river mile 708 it is difficult to examine strictly the shifts in assemblage structure with changing river mile. However, even with the inconsistency in sampling when the data are grouped by pool (Table 2) there does not appear to be great differences in the number of species found in the various pools. As pool number increased (*i.e.*, from upstream to downstream) there was a significant decrease in the relative percentage of the assemblage that *Amblema plicata* (Spearman rank correlation $r = -0.63$, $p < 0.05$) and *Lampsilis ovata ventricosa* (Spearman rank correlation $r = -0.7$, $p < 0.05$) constituted (Table 2). For *Ellipsaria lineolata, Leptodea fragilis* and *Quadrula quadrula*, there was a significant increase in the relative proportion of the assemblage comprised by these species (Spearman rank correlations $r = 0.87$, $r = 0.67$, $r = 0.87$ all $p < 0.05$ for the three species, respectively). For other species with relatively large sample sizes (> 500 individuals), there was no significant correlation between pool and proportion of the community that these species constituted.

TABLE 1. Sampling sites and the number of samples of bivalves taken in the Upper Mississippi River with the resulting number of species and specimens collected.

Pool	River Mile	No. samples	No. species	No. specimens
26	232	7	15	80
	233	20	18	330
	239	17	19	267
25	247	8	18	171
	259	42	21	789
24	292	9	12	172
	299	18	16	326
19	389	44	23	1036
	407	36	23	703
	409	9	14	175
18	433	45	23	975
17	439	9	12	181
	442	9	22	203
	445	27	24	561
	448	35	25	726
	450	27	24	567
14	499	9	16	200
	504	36	20	734
11	599	9	20	190
	609	54	25	1217
	612	9	13	177
10	635	124	24	2700
7	708	64	24	2664
	TOTAL	667	34*	15,144

* indicates number of different species

TABLE 2. Total number of individuals collected and the percentage contribution of each species to the sample from various pools of the upper Mississippi River.

Species	Total Number of samples	Pool								
		7	10	11	14	17	19	24	25	26
Actinonaias ligamentina (Lamarck 1819)	92	0.04	0.04	0.32	0.00	1.84	1.2	0.00	0.00	0.44
Amblema plicata (Say 1817)	4433	32.29	68.11	37.52	29.98	11.95	5.54	12.05	13.76	22.45
Anodonta grandis grandis (Say 1829)	108	0.26	0.22	0.13	0.54	1.218	1.78	0.00	0.63	1.62
Anodonta imbecillis Say 1829	652	0.04	0.00	0.00	0.00	6.72	22.73	0.20	0.10	0.00
Arcidens confragosus (Say 1829)	85	0.00	1.11	0.38	0.64	0.75	0.37	0.00	0.83	0.59
Anodonta suborbiculata Say 1831	1	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Carunculina parva (Barnes 1823)	4	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Corbicula fluminea (Müller 1774)	10	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.44
Cumberlandia monodonta (Say 1829)	11	0.00	0.00	0.00	0.00	0.19	0.16	0.00	0.00	0.00
Ellipsaria lineolata (Rafinesque 1820)	557	0.19	0.04	1.01	5.25	3.86	3.08	19.08	12.10	13.88
Elliptio dilatata (Rafinesque 1820)	25	0.00	0.41	0.88	0.00	0.00	0.00	0.00	0.00	0.00
Fusconaia ebena (Lea 1831)	3	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.15
Fusconaia flava (Rafinesque 1820)	394	2.76	3.22	4.10	2.89	1.87	0.78	1.00	2.40	6.94
Lampsilis higginsi (Lea 1857)	45	0.11	0.93	0.50	0.86	0.06	0.00	0.00	0.00	0.00
Lampsilis ovata ventricosa (Barnes 1823)	950	16.67	3.41	6.62	5.67	3.67	4.65	4.62	1.67	0.74
Lampsilis radiata siliquoidea (Barnes 1823)	5	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lampsilis teres (Rafinesque 1820)	36	0.00	0.00	0.00	0.00	0.00	0.10	0.00	2.82	1.03
Lasmigona complanata (Barnes 1823)	32	0.19	0.44	0.32	0.11	0.19	0.05	0.00	0.21	0.00
Leptodea fragilis (Rafinesque 1820)	844	1.86	0.96	0.38	2.14	10.21	13.74	2.21	10.53	5.61
Ligumia recta (Lamarck 1819)	156	0.48	1.56	1.95	2.57	0.75	0.94	0.80	0.10	0.00
Megalonaias gigantea (Barnes 1823)	376	0.00	3.52	1.13	2.78	1.68	1.72	6.43	6.47	8.27
Obliquaria reflexa (Rafinesque 1820)	1169	17.75	1.59	5.80	9.74	4.70	5.12	16.27	8.65	11.23
Obovaria olivaria (Rafinesque 1820)	1159	14.58	2.41	8.13	2.46	7.35	9.77	10.24	5.32	3.99
Potamilus alata (Say 1817)	619	2.57	3.11	1.64	5.46	5.14	4.60	0.60	11.99	2.51
Plethobasus cyphyus (Rafinesque 1820)	4	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pleurobema sintoxia (Rafinesque 1820)	5	0.07	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.15
Potamilus laevissima (Lea 1830)	115	0.78	0.00	0.19	0.00	1.93	1.31	0.00	0.52	0.30
Quadrula metanevra (Rafinesque 1820)	200	0.19	0.74	2.14	0.43	2.68	1.57	2.21	0.31	0.74
Quadrula nodulata (Rafinesque 1820)	173	0.00	0.89	2.46	0.75	1.43	2.04	1.20	0.83	0.59
Quadrula pustulosa (Lea 1831)	1164	7.98	1.26	5.74	10.49	14.41	8.99	8.23	2.61	4.43
Quadrula quadrula (Rafinesque 1820)	563	0.19	2.74	3.03	6.64	2.99	4.75	5.82	9.07	10.64
Strophitus undulatus (Say 1817)	54	0.04	0.52	1.39	0.11	0.44	0.10	0.00	0.00	0.00
Truncilla donaciformis (Lea 1828)	144	0.11	0.26	0.76	0.43	3.30	0.37	0.20	0.21	0.15
Truncilla truncata (Lea 1860)	956	0.71	2.48	13.11	10.06	10.49	4.39	8.43	8.86	3.10
Total Number of Species		24	24	26	21	27	25	18	21	23

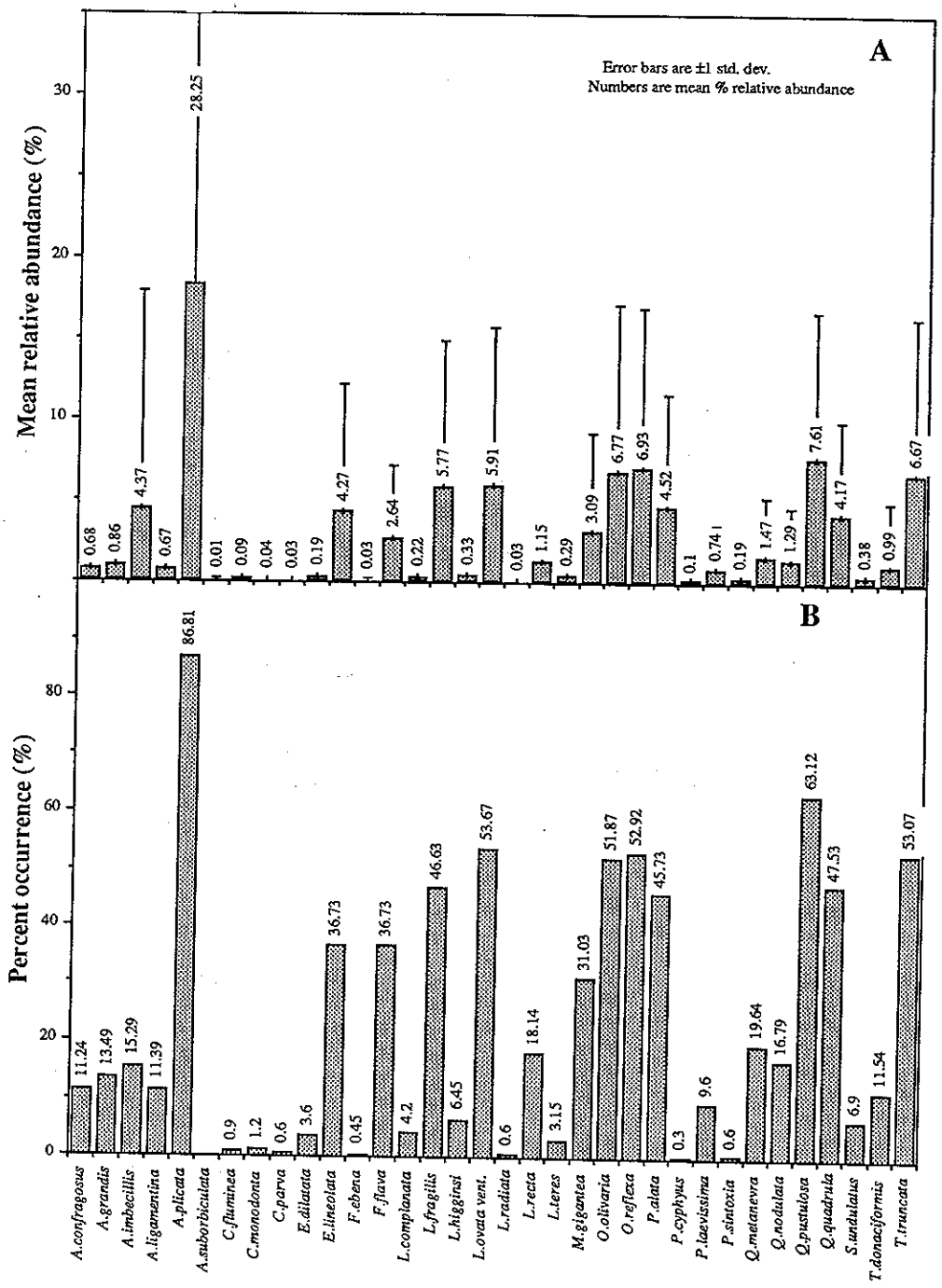

FIG. 1. Graphs of the mean relative abundance (panel A – average % of each sample comprised by each species) and percent occurrence (panel B – % of total samples in which each species was found) for the species of mussels collected for River Miles 232-708 in the Upper Mississippi River.

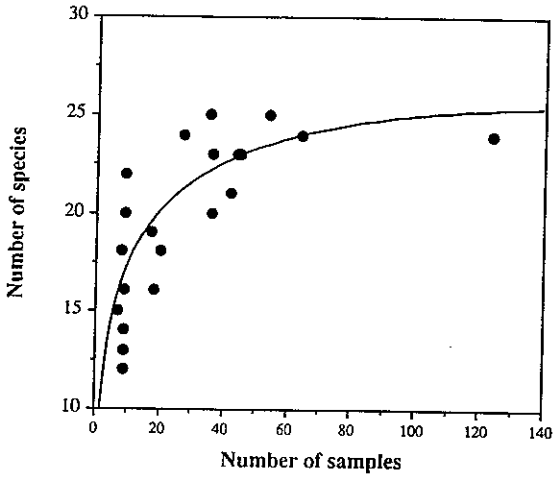

FIG. 2. Relationship between the number of samples taken and the number of species collected in the upper Mississippi River. The curve was fit by eye.

DISCUSSION

Fuller (1980), based on his 1978 study, divided the upper Mississippi into three zones. From upstream to downstream these zones are: the Natural Zone (the free-flowing region of the river above St. Anthony Falls, which provides a geographical barrier to mussel migration); the Twin Cities Zone (upper and lower St. Anthony Falls pools and pools 1 and 2) and the Recovery Zone (pools 6-10). He discussed the fact that mussel density and diversity is quite low in the Twin Cities Zone (likely due to pollution, including biocides in agricultural runoff) and that it is not until pool 6 that densities begin to increase significantly. From pool 10-20, Fuller (1980) found that the Recovery Zone persisted and from pools 21-27 the mussel fauna declined and is "consistently poor." Our study covers the Recovery Zone described by Fuller, as well as through pool 26. In our study, we found a tendency for species richness to remain relatively constant in pool 7 to pool 26 (Table 2).

For some species examined, there appeared to be changes in their relative abundance (assessed as the proportion of the community they comprise) from upstream to downstream (Table 2). The underlying causes of these changes are not well understood, but could be due to the distribution of fish hosts for the glochidia, historical patterns of distribution or to changes in sediment composition along this reach. The two taxa that have high correlations with pool number (*Amblema plicata* and *Ellipsaria lineolata* – see results) have fish hosts for their glochidia that are quite common throughout the upper Mississippi River (Fuller, 1978, 1980), and thus the trends of decreasing and increasing relative abundance downstream for *A. plicata* and *E. lineolata*, respectively (Table 1), are not likely due to the distribution of their fish hosts. Another possible explanation for the observed distributions could be related to historical patterns of distribution. However, when a correlation analysis was performed on Ellis' (1931a,b) data, the patterns as found in our data did not emerge. For example, relative abundances of *E. lineolata* decreased downstream (the opposite of that found in this study), while changes in relative abundances of *A. plicata* with river mile was only weakly correlated with increased river mile (as compared to a much

stronger correlation in the present study). Thus, it appears likely that the observed trends in relative species' abundances are due to variation in sediment type or hydrologic factors along this stretch of the river.

Fuller (1980 and references therein) recognized six major zoogeographic subdivisions of the North American mussels: the Pacific, Ozarkian, Mississippian, Cumberlandian, Apalachicolan and Atlantic faunas. The Mississippian region is one of the largest of the regions and contains an extremely diverse fauna. Grier & Mueller (1922; cited in van der Schalie & van der Schalie, 1950) reported historical records (mainly from the turn of the 20th century) of 63 species of unionids in the Mississippi River. Studies by Ellis (1931a,b; cited by van der Schalie & van der Schalie, 1950) and Fuller (1978) have also been conducted on this stretch of the river (river mile 232-708). Ellis (1931a,b) found 15-29 species per site in this stretch of the river while Fuller reported 9-25 species per site and we recorded 12-25 species per site (Table 1). Three species taken by Ellis (1931a,b) in this region of the river but not in this or Fuller's (1978) study were *Proptera capax* (42 individuals - 0.9% of the total number of mussels examined by Ellis in this stretch of the river – a federally-listed endangered species), *Simpsonaias ambigua* (one individual taken by Ellis), and *Tritogonia verrucosa* (135 individuals – 2.9 % of the total individuals taken by Ellis). Some of these differences observed could be attributed to differences in sampling method (Ellis used a 6 ft^2 dredge and Fuller sampled by brailing) and effort (Ellis examined 4,625 mussels and Fuller examined 7,283 mussels). Fuller (1980) believed that the decline in species number between the late 1800's and Ellis' work in 1930 was due mainly to changes in water quality that took place before the 9-foot navigation channel project, which brought a large degree of modification of the upper Mississippi River. In the present study, there were only three fewer species of unionids than the 36 species found by Ellis (1931a,b) in the same stretch of the upper Mississippi River, thus, channelization and the introduction of the lock-and-dam system did not seem to eliminate many of the species of mussels that occurred.

There has been, however, a change in the mussel assemblage in river mile 232-780 since Ellis' (1931a,b) study. There has been an increase in the relative number of *Amblema plicata* and a significant decline in the number of *Lampsilis teres* (Fig. 3). Despite differences in sampling technique and effort, there are great similarities in the mussel assemblage between this study and that of Fuller (1980) (Fig. 3). Fuller (1980) believed that the difference in the relative abundance between his 1978 study and Ellis' (1931a,b) study could be partially explained by the high incidence of collection by Ellis in sandbars between wing dam areas where *L. teres* is abundant. It is also possible that the shift from a relatively unregulated river system (with only one lock and dam present during Ellis' survey) to a more highly regulated system (29 Locks and Dams) with the associated changes in sediment type and discharge profiles may be responsible for the changes in the assemblages. Fuller (1980) believed that *A. plicata* is found in all types of sediment and is relatively tolerant of a wide range of water qualities and that this accounts for its increase in relative abundance in recent years. What must be realized, however, is that there may be site-specific factors that influence the changes in the mussel assemblage that has been noted.

Despite the changes that have been described in the mussel assemblage in the upper Mississippi River, they appear to be much less drastic than those noted for other river systems that have had substantial regulation. Bates (1962), for example, indicated that in the impoundment of the Tennessee River by the Tennessee Valley Authority there has been a drastic change in the mussel fauna.

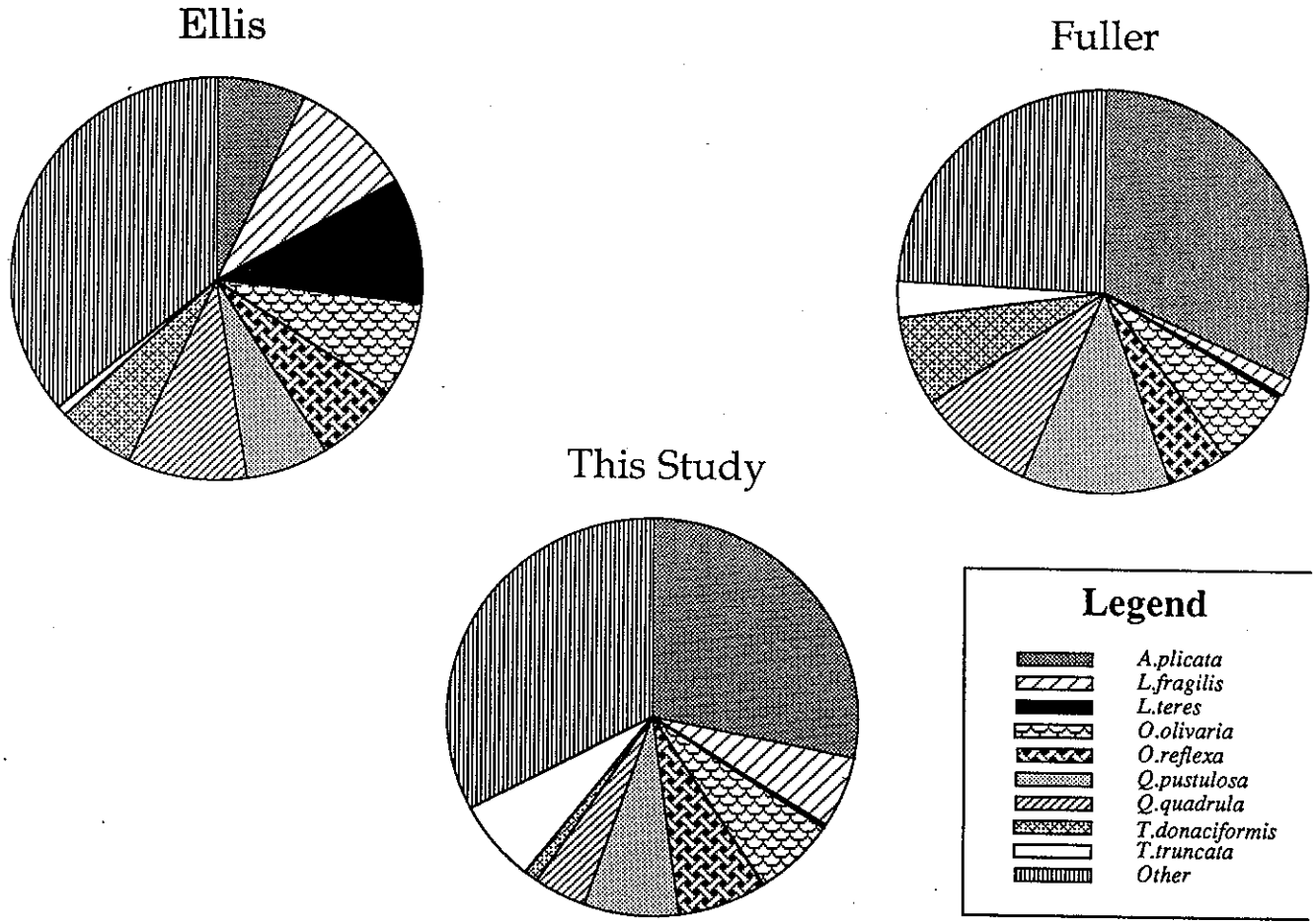

FIG. 3. Comparison of the mussel assemblage in the Upper Mississippi River (river mile 232-708) based on collections from this study and studies by Ellis in 1930 and Fuller in 1977.

Before impoundment there were records of 14 species of mussels at the impoundment site. After impoundment, only eight species were found at this site and of these only two were found before impoundment; the other six were species not previously recorded in this section of the river. The difference between the Tennessee Valley Authority impoundment and its drastic effects on the mussel assemblage and the alteration of the upper Mississippi River and its lesser effects is most likely due to the fact that the Tennessee Valley Authority project produced large reservoirs that are more lake-like than the pools produced in the upper Mississippi River. The basic riverine nature of the upper Mississippi River has been maintained and thus a large number of "native riverine" species have been retained.

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