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The Unionid Mussels of the Upper Iowa and Turkey River Watersheds

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The Iowa driftless region occupies an area of about 9,000 km^2 in the northeastern corner of Iowa and is drained by relatively old entrenched meandering streams. The Upper Iowa River and Turkey River are the largest of these streams. During the period from June, 1999 to October, 2000, a total of 193 sites were surveyed for mussels from the Upper Iowa River, the Turkey River, and their main tributaries. Surveys were conducted by hand using a 10 m bank-to-bank search at each site. Data analysis was facilitated using ArcView GIS. The presence of mussels was recorded at 75% of the sites, and live individuals were noted at 30% of the sites. Thirteen mussel species were recorded, with 5 or more species being found at 17% of the sites and 8 or more species at only 3% of the sites. Five of the species (Cylinder, Creek Heelsplitter, Squawfoot, Ellipse, and Fluted-shell) are listed as either threatened or endangered mussel species in Iowa, and no federally endangered mussels were found.

INDEX DESCRIPTORS: mussels, stream fauna, Unionid mussels.

Iowa has an area of about 9,000 km^2 (3,475 miles^2) in its northeastern corner drained by relatively old entrenched meandering streams. This region was not covered by the last southward glacial expansion, and there is little recent glacial drift on the surface. Streams of this driftless region of Iowa are largely within the drainage basins of three rivers (Upper Iowa River, Turkey River, Yellow River), that drain eastward to the Upper Mississippi River. Eckblad and Coon (1984) reviewed studies on these aquatic systems, and at that time little was known about the freshwater mussels of these inland streams.

In the United States, 69 of 304 freshwater mussel species are lisred as federally endangered or threatened, and surveys during the past several decades have documented declines in mussel populations across the continent (Havlik and Sauer 2000). The degradation of aquatic habitats is commonly mentioned in explaining this decline (Bogan 1993, Dillon 2000). This degradation includes the effects of fertilizers, herbicides, and insecticides associated with agricultural run-off (Strayer 1980, Mehlhop and Vaughn 1994) as well as industrial toxins that reach waterways (Fleming et al. 1995, Hinkey and Martin 1995). In addition, recently introduced mussel species [e.g., the Zebra mussel (*Dreissena polymorpha*) and the Asiatic mussel (*Corbicula manilensis*)] may proliferate and compete for resources with native mussel species.

Mussel populations of local Iowa habitats have been studied recently (e.g., Straka and Downing 2000), but mussel distributions and abundance in Iowa at the watershed level remain poorly known. Studies by Arbuckle and Downing (2000) have considered the statewide distribution of mussels in Iowa, with limited sampling from a number of different watersheds. Frest (1987) suggested that only 11 unionid mussel species were abundant or common in interior Iowa streams while 24 species were uncommon or rare, and 17 were thought to have been extirpated. Havlik and Sauer (2000) listed 8 Iowa mussel species as endangered and 6 species as threatened.

This study was designed to extend our understanding of the distribution and richness of the unionid mussel fauna of the Upper Iowa River and Turkey River, the two streams that provide drainage for the majority of the driftless region of Iowa. We hoped to identify specific stream reaches that had a relatively rich mussel fauna, and we hoped to determine if these two adjacent watersheds had similar mussel populations. In addition, we wanted to see if the Zebra mussel had yet established itself in either of these two watersheds.

METHODS

Mussels were sampled from 184 sites during the period from June 1999 to October 2000. Sites were selected to provide coverage of streams throughout each watershed. We used the Horton-Strahler method of ordering the tributary streams (Wetzel 2001) where the smallest permanent stream is designated as the first order, the confluence of two first-order streams creates a second order, etc. At each site a 10-meter length of stream was measured, forming a sampling quadrat (which averaged about 250 m^2) bordered by the two stream banks. This 10-meter bank-to-bank sampling procedure was used to visually detect mussels within the stream substrate at 111 sites on the Turkey River (80 first- or second-order streams; 31 third- or fourth-order streams), and 73 sites on the Upper Iowa River (26 first- or second-order streams; 47 third- or fourth-order streams. Approximately 25 min was spent searching for mussels over the streambed at each site. A water telescope was used where water depths or turbidity made it difficult to see the stream bottom. Live mussels were identified, and shell lengths were measured on site. Empty mussel valves were also identified at each site.

Stream width and mean water depths were recorded for each sampling site, and the substrate was visually characterized as silt, sand, gravel, cobble, or some combination of these. A handheld GPS unit (Garmin model 45XL) was use to obtain coordinates at each sampling site, a computer routine was used to convert coordinates to the Universal Transverse Mercator grid (UTM), and GIS software (ArcView 3.2) was used in the analysis and production of distribution maps for each mussel species.

To compare mussel distribution within watersheds, first- and second- order streams were compared with third- and fourth-order streams for both watersheds. The Shannon diversity index (H') was used to calculate mussel species diversity (Shannon and Weaver 1949), and bootstrap procedures (based upon 1,000 iterations) were

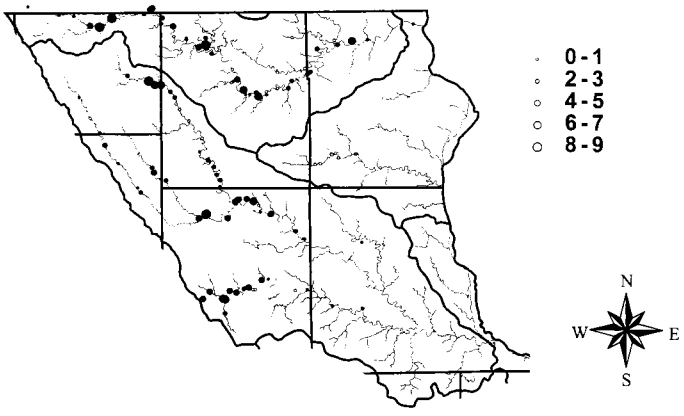


Fig. 1. Mussel sampling sites on the Upper Iowa River and Turkey River watersheds. Open circles represent sites without mussels and the diameter of filled circles represents the number of mussels species recorded for the site, scale of circle represents from 0 to 9 species.

Table 1. Distribution of sites with live mussels versus sand (including combinations of sand with silt, gravel, or cobble) and non-sand substrates for the Turkey River and Upper Iowa River Watersheds.

	Turkey River		Upper Iowa River[1]		
	Sand	Non-sand	Sand	Non-sand	Totals
Live mussels at site	38	7	8	5	58
No live mussels at site	51	15	29	26	121
Totals	89	22	37	31	179

[1]Substrate data were not available for 5 sites from the Upper Iowa River

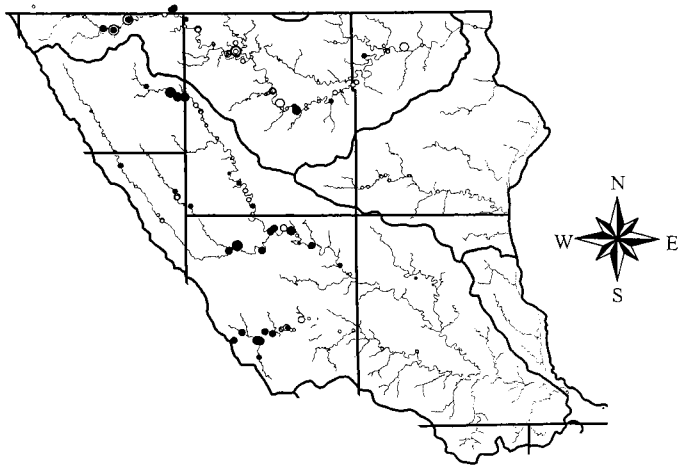


Fig. 2. Sampling sites at which live mussels were noted on the Upper Iowa River and Turkey River watersheds. Filled circles represent sites at which live mussels were noted, and circle diameter (using the scale in Fig. 1) represents number of mussel species (based upon both mussel valves and live individuals).

Table 2. Unionid mussels of the Turkey River and Upper Iowa River Watershed.[1]

Subfamily	Species	Common Name
Ambleminae	*Fusconaia flava*	Pigtoe
	Elliptio dilatata	Spike
Anodontinae	*Anodonta grandis*	Giant floater
	Strophitus undulatus	Squawfoot (T)
	Anodontoides ferussacianus	Cylinder (T)
	Alasmidonta marginata	Elktoe
	Lasmigona complanata	White heelsplitter
	Lasmigona costata	Fluted-shell (E)
	Lasmigona compressa	Creek heelsplitter (T)
Lampsilinae	*Ligumia recta*	Black sandshell
	Venustaconcha ellipsiformis	Ellispe (T)
	Lampsilis siliquoidea	Fatmucket
	Lampsilis cardium	Pocketbook

[1]Classification and names follow Cummings and Mayer (1992)
(T) = threatened, or (E) = endangered as currently listed for the State of Iowa

used to calculate 95% confidence intervals for this diversity index (Blank et al. 2001). The variance associated with each H' was also calculated according to the formula suggested by Hutcheson (1970), and the statistical procedure based upon the t-distribution was used to compare diversity indices (Zar 1999). Mussel community similarity was compared using the niche overlap index suggested by Horn (1966), and calculations were facilitated using the software *Ecological Analysis: diversity and similarity,* published by Oakleaf Systems

RESULTS

Mussels were recorded from 145/184 sampling sites, and as many as 9 different species were found at a site (Fig.1). The 111 sites within the Turkey River watershed had water depths of 0.58 ± 0.17 m (mean ± SD), and stream widths of 24.6 ± 8.92 m, while the 73 sites from the Upper Iowa River watershed had water depths of 0.75 ± 0.31m with stream widths of 26.0 ± 10.50 m. The stream widths, combined with the 10-m bank-to bank sampling procedure, resulted in a mean area searched of 246 m^2 for the Turkey River sites and 260 m^2 for the Upper Iowa River sites.

Eighty percent of the Turkey River sites (89/111) had sandy substrates or sand combined with silt, gravel, or cobble substrates, while only 54% of the Upper Iowa River sites (37/68) had similar sand or sand mixture substrates (Table 1). Gravel and gravel-cobble substrates were characteristic of only 20% of the Turkey River sites, but characterized 46% of the Upper Iowa River sampling sites. Live mussels were found at 58 of the sites (Fig. 2) with as many as 15 individuals at a site. There was no significanr association between the presence of live mussels and substrates (sand versus non-sand) in either the Turkey River (χ^2 = 0.866, P = 0.352) or in the Upper Iowa River (χ^2 = 0.329, P = 0.566).

Thirteen mussel species (family Unionidae) were identified from the Turkey River and Upper Iowa River watersheds: two species from the subfamily Ambleminae, 7 from the subfamily Anodontinae, and 4 from the subfamily Lampsilinae (Table 2). One of these species, the Fluted-shell (*Lasmigona costata*) is listed as endangered in Iowa, and 4 are listed as threatened in Iowa. No live or dead individuals of the exotic Zebra mussel were recorded from these two watersheds. Likewise, the Asiatic mussel was not observed during this survey.

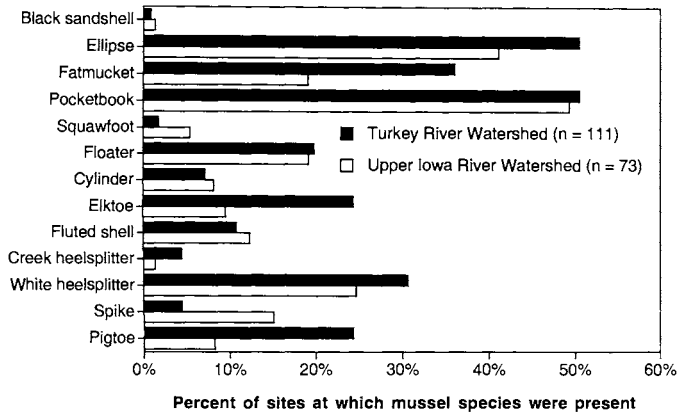


Fig. 3. Distribution of mussels by percent of sites at which that species was present.

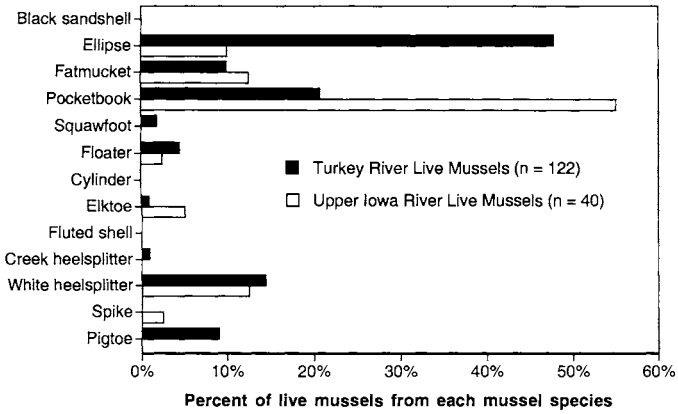


Fig. 4. Distribution of live mussel species.

The most frequently observed mussels (considering both valves and live individuals) were the Ellipse (*Venustaconcha ellipsiformis*) and Pocketbook (*Lampsilis cardium*), present at over half of the sites on the Turkey River and at 41.1% and 49.3%, respectively, of the sites on the Upper Iowa River (Fig. 3). Fatmuckets (*Lampsilis siliquoidea*) were more common on the Turkey River (36% of its sites versus 19.2% of the Upper Iowa River sites), as were the White heelsplitter (*Lasmigona complanata*) (30.6% of the Turkey River sites and 24.7% of the Upper Iowa River sites). The Elktoe (*Alasmidonta marginata*) and Pigtoe (*Fusconaia flava*) were also more frequently found on the Turkey River sites, while the Giant Floater (*Anodonta grandis*), Cylinder (*Anodontoides ferussacianus*), and Fluted-shell (*Lasmigona costata*) were of similar relative occurrence for both watersheds.

The most frequently observed live mussels were the Ellipse on the Turkey River (47.7% of total live individuals) and the Pocketbook on the Upper Iowa River (55.0% of total live individuals) (Fig. 4). Three mussel species [Black sandshell (*Ligumia recta*), Cylinder (*Anodontoides ferussacianus*), and Fluted-shell (*Lasmigona costata*)] were not found as live individuals in either river system. The Turkey River sites yielded more live individuals (n = 122) and more different species (9 live mussel species versus only 7 live species for the Upper Iowa River sites).

Eighty-five percent and 87.5%, respectively, of the live mussels were taken from first- and second- order streams of the Turkey River and Upper Iowa River (Table 3). The smaller tributary streams (i.e., first- or second- order) of the Turkey River had a significantly higher

Table 3. Live mussels present in different sized streams of the Turkey River and Upper Iowa River watersheds.

	Turkey River		Upper Iowa River	
Mussel	1st & 2nd Order (80 sites)	3rd & 4th Order (31 sites)	1st & 2nd Order (26 sites)	3rd & 4th Order (47 sites)
Pigtoe	10	0	0	0
Spike	0	0	0	1
Giant floater	6	0	1	0
Squawfoot	2	0	0	0
Elktoe	1	0	2	0
White heelsplitter	15	1	5	0
Creek heelsplitter	1	0	0	0
Ellipse	48	4	4	0
Fatmucket	11	0	5	0
Pocketbook	10	13	18	4
Total number live	104	18	35	5
Species richness	9	3	6	2
Shannon Diversity (H')[a]	1.65	0.73	1.41	0.50
H' lower 2.5% est[b]	1.32	0	0.86	0
H' upper 97.5% est[b]	2.11	1.55	1.97	1.39

[a]Logs to base e were used in these calculations
[b]Bootstrap 95% confidence interval limits for H' were based upon 1,000 iterations

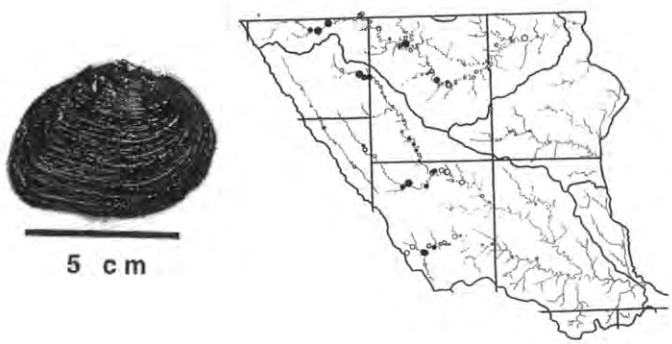
mussel diversity (H') than its larger streams ($t = 4.86$, $df = 29$, $P < 0.01$), and the same was true for the mussel diversity (H') of the Upper Iowa River ($t = 3.19$, $df = 8$, $P < 0.05$). The non-overlapping bootstrap 95% confidence intervals are in agreement with this conclusion. Community similarity was relatively high between first- and second- order streams of the two watersheds (Horn's Index = 0.743) and between third- and fourth-order streams of the two watersheds (Horn's Index = 0.770). In contrast, community similarity was lower between first- and second- order versus third- and fourth-order streams within a watershed (Horn's Index for Turkey River = 0.658; Horn's Index for Upper Iowa River = 0.692).

We identified 65 different sites at which there were four or more mussel species present. That represented 35% of the total number of sites (65 out of 184) within these two watersheds. Fifteen of these were from the Upper Iowa River watershed, and 68% of the live mussels (27 out of 40) from this watershed were recorded from these sites. Seventy-three percent of the live mussels (89 out of 122) recorded for the Turkey River watershed were taken from the 40 sites within the watershed with four or more mussel species.

The distribution of each of the 13 mussel species within the two watersheds is displayed in Figs. 5–17. Filled circles represent sampling sites where a species was present, and the diameter of the filled circle indicates the number of different species found at that site (refer to Fig. 1 for the circle diameter scale).

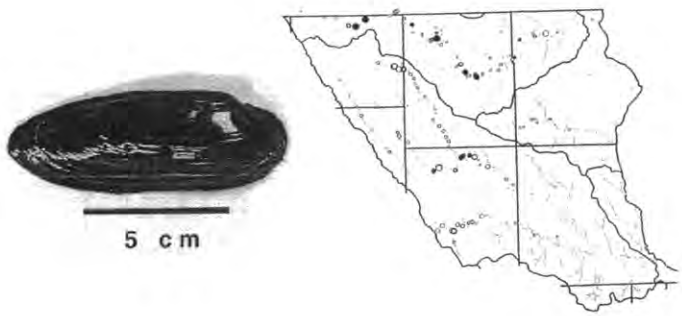
DISCUSSION

Our sampling procedure was a compromise between trying to cover entire watersheds and a more careful assessment of mussel numbers at a particular location. In that regard, we recognize our sampling bias against finding smaller mussels and live mussels (both of which are known to be part of the infauna and often less visible on the surface). A mussel study initiated by the Minnesota Department of Natural Resources (MNDNR) in 2000 included the upper



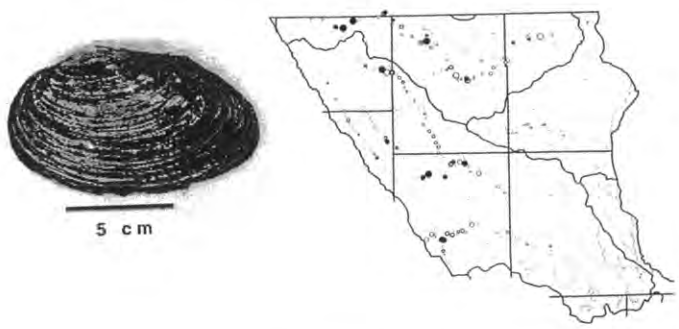
Pigtoe

Fig. 5. Distribution of Pigtoe mussels (*Fusconaia flava*); recorded at 33 sites with live individuals at 7 sites.



Spike

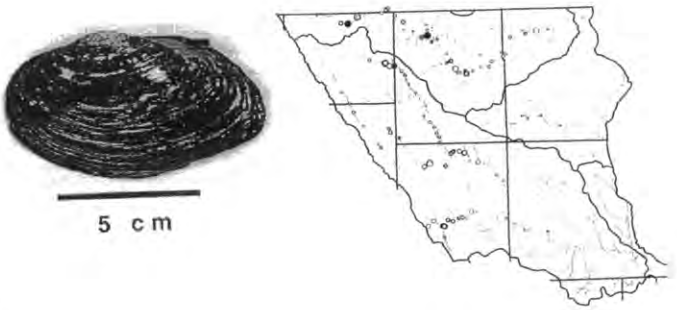
Fig. 6. Distribution of Spike mussels (*Elliptio dilatata*); recorded at 16 sites with live individuals at 1 site.



Giant floater

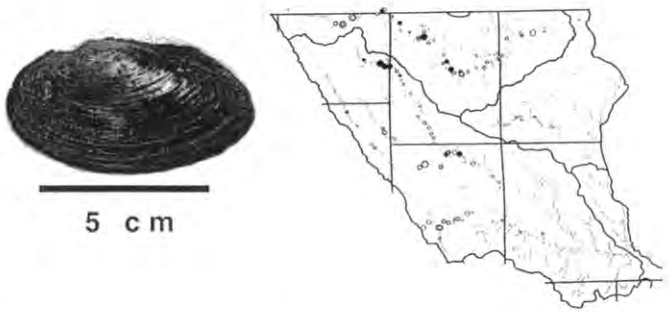
Fig. 7. Distribution of Giant floater mussels (*Anodonta grandis*); recorded at 36 sites with live individuals at 5 sites.

reaches of the Upper Iowa River watershed in Minnesota. Sampling involved a longer and more careful search for mussels, and they found a similar number of species but a larger number of live individuals (Dan Kelner, MNDNR, pers. comm.). One of the authors (B. Ostby) also participated in the Minnesota study.



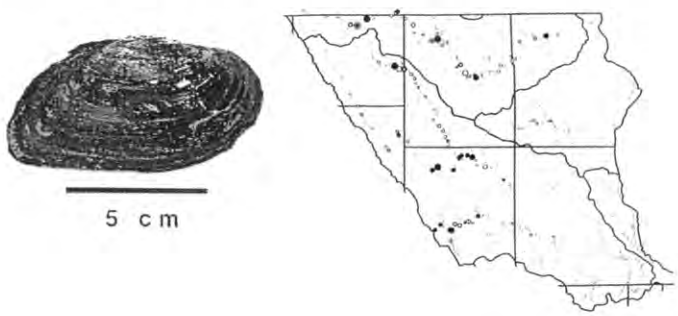
Squawfoot

Fig. 8. Distribution of Squawfoot mussels (*Strophitus undulatus*); recorded at 6 sites with live individuals at 1 site.



Cylinder

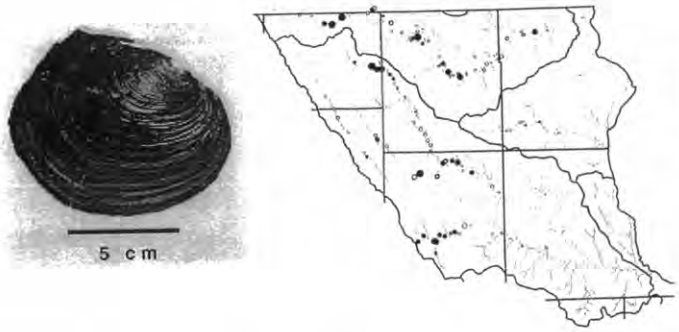
Fig. 9. Distribution of Cylinder mussels (*Anodontoides ferussacianus*); recorded at 14 sites with live individuals at 0 sites.



Elktoe

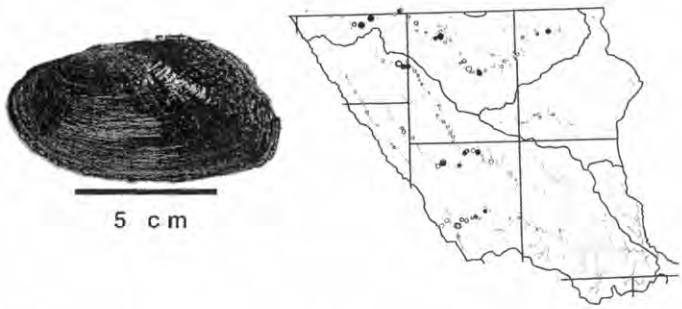
Fig. 10. Distribution of Elktoe mussels (*Alasmidonta marginata*); recorded at 34 sites with live individuals at 2 sites.

The 65 different sites at which there were four or more mussel species present represent reaches of the Upper Iowa and Turkey rivers with the highest quality mussel habitat within each watershed. In addition to the 13 mussel species reported in this study, there were also reports of live individuals of the Lilliput mussel (*Toxolasma parvus*) and relic shells of Pimpleback (*Quadrula pustulosa*) and Threeridge (*Amblema plicata*) mussels (Scott Gritters, Iowa DNR, pers. comm.) from the streams of these two watersheds.



White Heelsplitter

Fig. 11. Distribution of White heelsplitter mussels (*Lasmigona complanata*); recorded at 52 sites with live individuals at 8 sites.



Fluttedshell

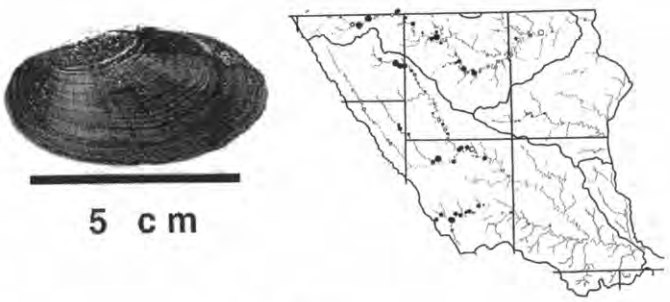
Fig. 12. Distribution of Fluted-shell mussels (*Lasmigona costata*); recorded at 21 sites with live individuals at 0 sites.

Creek Heelsplitter

Fig. 13. Distribution of Creek heelsplitter mussels (*Lasmigona compressa*); recorded at 6 sites with live individuals at 1 site.

Black sandshell

Fig. 14. Distribution of Black sandshell mussels (*Ligumia recta*); recorded at 2 sites with live individuals at 0 sites.



Ellipse

Fig. 15. Distribution of Ellipse mussels (*Venustaconcha ellipsiformis*); recorded at 86 sites with live individuals at 26 sites.

Fatmucket

Fig. 16. Distribution of Fatmucket mussels (*Lampsilis siliquoidea*); recorded at 54 sites with live individuals at 13 sites.

What is known about the broader distribution of the 13 mussel species identified from the Turkey River and Upper Iowa River Watersheds is briefly reviewed below, following the sequence of the listing in Table 2. The Pigtoe's distribution ranges throughout the entire Mississippi River drainage from western New York to eastern Kansas, Nebraska and South Dakota, south to Texas and Louisiana, and north into Canada (Parmalee and Bogan 1998). It can be found in shallow, small creeks to the deeper depths of larger river habitats (Cummings and Mayer 1992), and its heavy shell seems well suited to success in less stable hydrological environments (DiMaio and Corkum 1995). Its current population numbers appear to be stable throughout its range (Cummings and Mayer 1992, Parmalee and Bogan 1998, Havlik and Sauer 2000), including the Turkey River and Upper Iowa River watersheds.

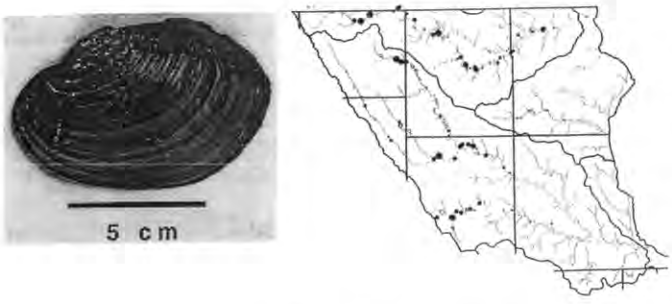


Fig. 17. Distribution of Common pocketbook mussels (*Lampsilis cardium*); recorded at 92 sites with live individuals at 29 sites.

The Spike (*Elliptio dilatata*) is distributed throughout the Mississippi River drainage from the St. Lawrence River and its tributaries south to northern Louisiana and west into Oklahoma (Parmalee and Bogan 1998). It is most common in Ohio to Missouri and is most abundant in medium to large rivers (Cummings and Mayer 1992). Firm substrates like coarse sand and gravel seem to be preferred (DiMaio and Corkum 1995). It is considered threatened in Illinois and of special concern in Minnesota, but the species has no special status in Iowa.

The Giant Floater (*Anodonta grandis*) has an extensive geographical range that includes the St Lawrence, Mississippi, and Missouri rivers' drainages, along with the Canadian Interior Basin (Parmalee and Bogan 1998). It thrives in habitats with minimal current and does well in mud-bottomed pools (Cummings and Mayer 1992). It has a large number of known fish hosts and seems to be doing well in Iowa waters.

The Squawfoot (*Strophitus undulatus*), also known as the Strange floater, is widespread in the Canadian Interior Basin, the Mississippi River drainage and most of the Atlantic Coast drainage (Cummings and Mayer 1992, Parmalee and Bogan 1998). It is considered threatened in Iowa (Havlik and Sauer 2000) and is most commonly found in small to medium sized streams with substantial current and substrates that range from fine sand to mud (Cummings and Mayer 1992, Parmalee and Bogan 1998, Strayer and Fetterman 1999). This species is unusual in that females are known to release mature glochidia that do not require a fish host (Parmalee and Bogan 1998).

The Cylinder mussel (*Anodontoides ferussacianus*) has a widespread distribution from Pennsylvania and Tennessee west to Minnesota and Colorado. It tends to favor sand or mud substrates in smaller streams as well as near-shore areas of lakes (Cummings and Mayer 1992, Parmalee and Bogan 1998). It is currently listed as threatened in Iowa and of special concern in Missouri (Havlik and Sauer 2000), and no live individuals were observed from either the Turkey River and Upper Iowa River watersheds.

The Elktoe (*Alasmidonta marginata*) is widely distributed in small to medium-size streams south to the Tennessee River basin and west to the Upper Mississippi drainage (Parmalee and Bogan 1998). It is thought to reach is greatest abundance in moderate to faster currents with a mixture of fine gravel and sand substrates (Cummings and Mayer 1992, USFWS 1999). The U. S. Fish and Wildlife service list the Elktoe as rare and declining in its Conservation Priority Report for Region 3 (USFWS 1999), and it is considered threatened in Minnesota and Iowa (Cummings and Mayer 1992). Its numbers were also low in the Turkey River and Upper Iowa River watersheds.

The White heelsplitter (*Lasmigona complanata*) has a wide tolerance of habitats, exploiting slow-water and sedimentary areas, including the permanent sloughs and backwaters of large rivers, medium-sized rivers, and also acidic small streams and lakes (Cummings and Mayer 1992, Parmalee and Bogan 1998). It prefers quiet water, usually not over one meter in depth, although can be found at depths of up to 6 meters. It thrives on mud and fine sand substrates (Parmalee and Bogan 1998) but has also been observed frequently in riffles and swift water runs (Reis 1980). Its range includes the entire Mississippi River drainage and from Pennsylvania west to Minnesota and Iowa south to Oklahoma and Louisiana. The White heelsplitter is considered widespread and common throughout its range (Cummings and Mayer 1992), and its populations appear healthy in the Upper Iowa River and Turkey River watersheds.

The Fluted-shell mussel (*Lasmigona costata*) is found in medium-sized rivers with moderately strong current and in substrates composed of a coarse sand and gravel mix although they usually prefer shallow-water gravel riffles (Parmalee and Bogan 1998). Cummings and Mayer (1992) noted that the Fluted-shell is also found in mud substrates where the flow is slow to moderate. It is widespread but relatively uncommon throughout the Midwest and endangered in Iowa (Cummings and Mayer 1992), and no live individuals were observed from either the Turkey River and Upper Iowa River watersheds.

The Creek heelsplitter (*Lasmigona compressa*) typically inhabits creeks and headwaters of small and medium rivers in fine gravel or sand and is rare in larger rivers (Cummings and Mayer 1992). Though found throughout the Upper Midwest, it is uncommon and listed as threatened in Iowa and of special concern in Minnesota (Havlik and Sauer 2000). It appeared to be a rare species in the Upper Iowa River and Turkey River watersheds.

The Black sandshell mussel (*Ligumia recta*) occurs in medium-sized to large rivers in locations that have strong currents where characteristics such as riffles and substrates of coarse sand and gravel with cobbles dominate. Found in water from several inches deep to six feet or more, it appears to have more specific habitat requirements and is often found in the company of other mussels (Cummings and Mayer 1992, Parmalee and Bogan 1998). The U. S. Fish and Wildlife service lists the Black sandshell as rare and declining in its Conservation Priority Report for Region 3 (USFWS 1999). It is widely distributed throughout the Midwest but uncommon (Cummings and Mayer 1992), and no live individuals were observed from either the Turkey River or Upper Iowa River watersheds.

The Ellipse (*Venustaconcha ellipsiformis*) is predominantly found in small to medium streams in gravel or mixed sand and gravel substrates (Cummings and Mayer 1992). It has a relatively restricted distribution to the Upper Mississippi River drainage basin and is seldom reported as being common. It is currently listed as threatened in Iowa and of special concern in Missouri (Havlik and Sauer 2000), but its populations in northeast Iowa appeared to be doing well, especially in the Turkey River watershed.

The Fatmucket (*Lampsilis siliquoidea*), like its close relative the Pocketbook, is found on a variety of substrates and has demonstrated broad habitat tolerance. Most likely found in slow moving rivers or lakes with mud substrates, it has not typically been observed in the riffles of faster rivers (Parmalee and Bogan 1998). It is considered widespread and common throughout the Midwest (Cummings and Mayer 1992).

The Pocketbook mussel (Lampsilis cardium) prefers rivers with moderate to strong currents with substrates of coarse gravel and sand and also seems to thrive on stable substrates composed mostly of mud (Cummings and Mayer 1992, Parmalee and Bogan 1998). Widespread and common throughout its range (Cummings and Mayer 1992), its populations appear relatively healthy in the Upper Iowa River and Turkey River watersheds.

The presence of mussel valves at 79% of the sampling sites suggests that suitable stream conditions for mussel populations have been historically true for much of these two watersheds. Our finding of live mussels at only 31% of the sites, provides at least circumstantial evidence that there has been a decline in living mussels in these two watersheds. The majority of the live mussels were taken from sites with four or more mussel species identified for that site. These sites appeared to have been suitable for a relatively diverse mussel community in the past, and remain as the stream locations most likely to support live mussels. As of the year 2000, there was no evidence that the Zebra mussel was present in either of these watersheds, although the potential remains that it could become established and further reduce populations of native unionid mussels.

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