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Freshwater Mussel (Bivalvia: Unionidae) Survey of the Galena River Basin, Wisconsin and Illinois

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ABSTRACT

I investigated the freshwater mussel assemblage of the Galena River basin in Wisconsin and Illinois in 2005-2006 to determine distribution and structure of the fauna. I collected 27 live individuals representing 5 species during 47 person-hours of sampling at 28 sites; I also found valves of an additional 20 species, including 5 species listed at the state level in Wisconsin and/or Illinois. Freshwater mussels were evident at 18, or 64%, of the sites. Regression analysis indicated an increase in extant species richness ($r^2 = 0.21$, $F_{0.05(2), 26} = 6.97$, $P = 0.02$) and historic species richness ($r^2 = 0.58$, $F_{0.05(2), 26} = 40.18$, $P < 0.0001$) from upstream to downstream. Expanding drainage areas usually offer decreased gradients, more habitat complexities, and higher host fish diversity. A *t*-test concluded extant and historic species richness differed significantly ($t_{0.05(1), 17} = 3.56$, $P = 0.003$) suggesting that the assemblage has been reduced.

Key Words: bivalve, Mollusca, unionids, Wisconsin Driftless Division

INTRODUCTION

The Wisconsin Driftless Division (herein after Driftless area), a region of nearly 35,000 km^2, was surrounded but never covered by late Pleistocene glacial ice (Page et al. 1992; Knox 2001; Knox 2006). Today, the area has rolling topography characterized by steep-sided (up to150 m/km vertical relief) limestone/sandstone valleys, forested ridges, and streams that have spring-fed headwaters. Situated between the tallgrass prairie to the west and the deciduous forest to the east, the Driftless area historically was dominated by tallgrass prairie, oak savanna, southern oak forest, and southern mesic forest. Today, the region has agricultural fields (e.g., row crops or grazing pastures) that have riparian areas composed of either grassy or woody buffer strips. About 40 species of freshwater mussels (Bivalvia: Unionidae) historically inhabited the Driftless area (unpublished data from the Illinois Natural History Survey [INHS] Mollusk Collection, Champaign). It appears that 5 species (13%) are extirpated from the area, and include fluted shell *Lasmigona costata*, elephantear *Elliptio crassidens*, ebonyshell *Fusconaia ebena*, sheepnose *Plethobasus cyphyus*, and mucket *Actinonaias ligamentina*.

The Galena River, one of the streams in the Driftless area, drains nearly 525 km^2. The stream originates in Grant and Lafayette counties, Wisconsin, and flows south-southwest through Jo Daviess County, Illinois, until reaching the Mississippi River (Figure 1). The Galena River basin contains a unique fish assemblage, including Ozark minnow *Notropis nubilus* and longnose dace *Rhinichthys cataractae*, which, in Wisconsin and Illinois, are found only in a few basins (INHS Fish Collection, Champaign, data). Monitoring aquatic assemblages is vital for natural resource agencies to accurately assess their statuses (e.g., rare species) and provide baseline data to evaluate the effects of human activities. However, not all aquatic assemblages have been adequately sampled. One such example is the freshwater mussel fauna. I sampled freshwater mussels in the Galena River basin to determine distribution and structure of the assemblage. Prior to this study, no comprehensive survey on the freshwater mussel fauna of the Galena River basin had been conducted. Data collected will allow future comparisons for monitoring the assemblage and provide information on which to base management goals for the basin.

METHODS

I collected freshwater mussels at 28 sites in the Galena River basin (Figure 1; Appendix 1) during August 2005 and August 2006. Four sites were selected because historical data existed for them (INHS Mollusk Collection data) and the remaining 24 sites were selected to provide coverage of streams throughout the entire watershed. Of the four historical locations, Site 19 was surveyed in 1993 and 1994 (unknown amount of effort) and Site 22 was sampled for 30 minutes in 2002, whereas incidental encounters were discovered at Site 18 in 2000 and Site 21 in 1941. I collected live freshwater mussels and valves of dead specimens by hand-grabbing for 1-2 person-hours at each site depending upon stream condition and amount of success (Tiemann 2006). For example, collecting ceased at sites where substrates were predominantly clay/silt and no specimens were found within the first hour of sampling. Hand-grabbing is a cost-effective, semi-quantitative method effective for obtaining information on relative abundance and species richness but can be biased to an unknown extent (Strayer et al. 1997; Vaughn et al. 1997). Sampling occurred while wading in all available habitats but primarily was concentrated in areas that appeared likely to support freshwater mussels, such as non-silted areas (Tiemann 2006). No effort was made to sample ponds/lakes or wetlands in the basin. Below average water levels during summer 2005 allowed sampling in the channelized, lower portions of the basin. I obtained Global Positioning System coordinates at each site using a Garmin GPS 12 XL (Garmin International, Romsey, Hampshire, United Kingdom). I classified shell material as live, fresh dead (shiny nacre), or relict (chalky nacre) based on condition of the best specimen found (Sietman et al. 2004). Identification and taxonomy followed Cummings and Mayer (1992). All live individuals were counted and returned upon completion of a site.

Extant species richness, historical species richness, and relative abundance were calculated for each site (Tiemann et al. 2005). I figured extant species richness as the number of species represented by live or fresh dead shell, historical species richness as the total number of species found including museum records located at the INHS Mollusk Collection, and relative abundance as catch-per-unit-effort (CPUE). I used simple regression analysis to test if extant species richness, historical species richness, and CPUE increased from upstream to downstream in the basin. Drainage area was determined by digitizing topographic maps. At those sites where specimens were found, I applied a *t*-test to determine if extant species richness was significantly lower than historic species richness. Statistical analyses was preformed with SAS Version 8 (SAS Institute Inc., Cary, North Carolina) and considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

I collected a total of 27 live individuals representing 5 species in 47 person-hours in the Galena River basin; I also found valves of an additional 20 species, including 5 species listed at the state level in Wisconsin and/or Illinois (Table 1, Appendix 2). Freshwater mussels were evident at 18, or 64%, of the 28 sites (Appendix 1). CPUE in the Galena River basin ranged from 0-3 individuals per hour per site (Appendix 2) and did not increase significantly ($r^2 = 0.06$, $F_{0.05(2), 26} = 1.53$, $P = 0.23$) from upstream to downstream (Figure 2a). Giant floater *Pyganodon grandis* was the most abundant and widely distributed species (12 individuals from 6 sites) followed by white heelsplitter *Lasmigona complanata* (5 individuals from 5 sites), plain pocketbook *Lampsilis cardium* (5 individuals from 3 sites), creek heelsplitter *Lasmigona compressa* (3 individuals from 2 sites), and lilliput *Toxolasma parvus* (2 individuals from 2 sites) (Appendix 2). Excluding *L. compressa*, the species found live are widespread and common throughout streams in the Midwest; *L. compressa* occasionally is found in small streams in the region (Cummings and Mayer 1992). Most of the other specimens found were relict valves (Table 1, Appendix 2). Based on historical records, some species (e.g., slippershell mussel *Alasmidonta viridis*, *T. parvus*, and ellipse *Venustaconcha ellipsiformis*) were found throughout the basin, whereas other species (e.g., pistolgrip *Tritogonia verrucosa*, pink heelsplitter *Potamilus alatus*, and threehorn wartyback *Obliquaria reflexa*) probably were not widely distributed (e.g., found only in the lower portions). The extant species in the basin were found only in small, isolated populations, which could hinder reproduction and recolonization efforts.

No live threatened or endangered species were collected; however, 5 species listed at the state level in Wisconsin and/or Illinois were found only as valves. *Alasmidonta viridis* (Wisconsin state threatened and Illinois state threatened), *E. dilatata* (Illinois state threatened), and *V. ellipsiformis* (Wisconsin state threatened) were found throughout the basin (Appendix 2). These 3 species were once widely distributed in the Midwest but are now are sporadic in their distributions (Cummings and Mayer 1992). The other 2 species, wartyback *Quadrula nodulata* and *T. verrucosa*, both listed as state threatened in Wisconsin, were found only in the downstream areas of the mainstem (Appendix 2). Both of these species are found in larger rivers or in the downstream sections of medium-sized streams (Cummings and Mayer 1992).

The number of extant species in the Galena River basin ranged from 0-3 species per site, whereas the number of historic species varied from 0-11 species (Appendix 1; Appendix 2). The differences in species richness between historic and extant ranged from 0-11 species. Extant species richness and historic species richness differed significantly ($t_{0.05(1), 17} = 3.56$, $P = 0.003$) suggesting that the freshwater mussel assemblage has declined. There was a linear increase in extant species richness ($r^2 = 0.21$, $F_{0.05(2), 26} = 6.97$, $P = 0.02$) and historic species richness ($r^2 = 0.58$, $F_{0.05(2), 26} = 40.18$, $P < 0.0001$) from upstream to downstream (Figure 2b). This positive relationship between species richness and drainage area has been shown for freshwater mussels (Watters 1992) and fishes (Edds 1993). Expanding drainage areas offer decreased gradients, more habitat complexities, and higher fish diversity to serve as glochidia hosts (Vannote et al. 1980; Watters 1992). No evidence of freshwater mussels was found in the middle portions of the basin and likely is the result of sub-optimal habitat (e.g., silt-laden cobble).

The temporal decline in species richness in the Galena River basin (80%) is substantially greater than other basins in the Driftless area region. The Apple River basin (Wisconsin and Illinois) has a 16% (26 extant species out of 31 historic species) reduction in historic species richness (Anderson and Sietman 2004), whereas the upper Iowa and Turkey river basins (Iowa) together have a 23% (10 extant species out of 13 historic species) reduction (Eckblad et al. 2002), and the Menominee, Little Menominee, and Sinsinawa river basins (Wisconsin and Illinois) have a 22% (7 extant species out of 9 historic species), 36% (9 extant species out of 14 historic species), and 33% (8 extant species out of 12 historic species) reduction, respectively (Jeremy Tiemann, Illinois Natural History Survey, unpubl. data). The Lost Mound Unit of the Upper Mississippi River National Wildlife and Fish Refuge, an area of the Mississippi River that lies on the southern edge of the Driftless area, has a 30% (26 extant species out of 37 historic species) reduction in historic species richness (Sietman et al. 2004). In the Apple, Menominee, Little Menominee, and Sinsinawa river basins, the majority (> 80%) of live individuals and species richness were found within the lower quarter of their respective basins (Anderson and Sietman 2004; Jeremy Tiemann, Illinois Natural History Survey, unpubl. data), whereas in the upper Iowa and Turkey river basins, the majority (> 85%) of live individuals and species richness were found in the headwaters (Eckblad et al. 2002). These distribution patterns were attributed to the complexity and amount of available habitat at a given site. A similar pattern of downstream distribution was seen in the Galena River for historic species richness but not extant species richness or CPUE, perhaps because the lower portion of the river has been dredged and now offers unsuitable habitat. The amount of effort per site (1-2 person-hours) in the Galena River basin was the same as in the Menominee, Little Menominee, and Sinsinawa river basins (Jeremy Tiemann, Illinois Natural History Survey, unpubl. data), but was greater than the 25 minutes per site in the upper Iowa and Turkey river basins (Eckblad et al. 2002); the amount of effort in the Apple River basin varied from 20-540 minutes per site (Anderson and Sietman 2004).

Habitat appears to be the limiting factor for freshwater mussels in the Driftless area. Mathiak (1979) suggested that the Driftless area lacks freshwater mussels because of poor habitat. Since the early 19th century, post-settlement modifications of the natural land cover have altered all aspects of the hydrologic landscape in the Galena River basin, including floods, erosion, transportation and deposition of sediments, and the morphology of stream channels and the associated floodplains (Magilligan 1985; Knox 2001; Knox 2006). Very little sand, gravel, or pebble existed in the Galena River basin. The majority of the habitat in these areas was silt-laden cobble / boulder with patches of bare bedrock or clay hardpan. Even though freshwater mussels can colonize bedrock, it is sub-optimal habitat (Sietman et al. 1999). Silt, the number one pollutant of streams in the Driftless area (Page et al. 1992), has been shown to decrease species richness of macroinvertebrates (Weigel 2003) and fishes (Wang et al. 1997). Several anthropogenic disturbances that cause siltation, including dredging, mining, unrestricted livestock access in streams, and cutting of riparian areas, have occurred in the Galena River basin (Magilligan 1985; Knox 2001; Knox 2006). These types of disturbances, along with organic pollution (e.g., effluents from sewage treatment plants), have been shown to alter stream habitat and change freshwater mussel assemblages (e.g., Aldridge 2000; Hoke 1997). Unless mitigated, these disturbances will continue to threaten the existing assemblage and might prevent the expansion / recolonization of future species.

I recognize the limitations of this study (e.g., limited number of sites and limited sampling effort). Additional surveys could be done to further explore the freshwater mussel assemblage in the Galena River basin by adding more sites (e.g., pools) and incorporating other methods (e.g., quadrat searches). Nevertheless, the reduction in freshwater mussel species richness in the Galena River basin is a cause of concern. The apparent 80% loss of a taxonomic group in a basin could result in the loss of valuable genetic diversity. Imlay (1973) suggested that the Driftless area be protected as a possible "seed area" for the redistribution of species. An active, positive partnership between natural resource agencies and landowners to promote sound management practices should aid in the preservation and restoration of this unique area.

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Table 1. Freshwater mussels collected during the 2005-2006 survey of the Galena River basin, Wisconsin and Illinois. See appendices for site-specific data. Numbers within a given species row represent the number of individuals that species was collected alive, D indicates those species collected only as fresh dead specimens, R signifies those species collected only as relict specimens, and * indicates those species not found during survey but an INHS Mollusk Collection record exits for the basin. WI-ST = Wisconsin state-threatened and IL-ST = Illinois state-threatened.

Sub-family	Scientific name	Common name	Status
Anodontinae	*Alasmidonta viridis* WI-ST, IL-ST	Slippershell mussel	R
	Anodontoides ferussacianus	Cylindrical papershell	D
	Lasmigona complanata	White heelsplitter	5
	Lasmigona compressa	Creek heelsplitter	3
	Lasmigona costata	Flutedshell	R
	Pyganodon grandis	Giant floater	12
	Strophitus undulatus	Creeper	R
	Utterbackia imbecillis	Paper pondshell	D
Ambleminae	*Amblema plicata*	Threeridge	R
	Elliptio dilatata IL-ST	Spike	R
	Fusconaia flava	Wabash pigtoe	R
	Quadrula nodulata *WI-ST*	Wartyback	R
	Quadrula pustulosa	Pimpleback	R
	Quadrula quadrula	Mapleleaf	R
	Tritogonia verrucosa WI-ST	Pistolgrip	R
Lampsilinae	*Lampsilis cardium*	Plain pocketbook	5
	Lampsilis siliquoidea	Fatmucket	*
	Leptodea fragilis	Fragile papershell	D
	Obliquaria reflexa	Threehorn wartyback	D
	Potamilus alatus	Pink heelsplitter	R
	Potamilus ohiensis	Pink papershell	R
	Toxolasma parvus	Lilliput	2
	Truncilla donaciformis	Fawnsfoot	R
	Truncilla truncata	Deertoe	R
	Venustaconcha ellipsiformis WI-ST	Ellipse	R

Figure 1. Map of the Galena River basin and sampling sites, Wisconsin and Illinois.

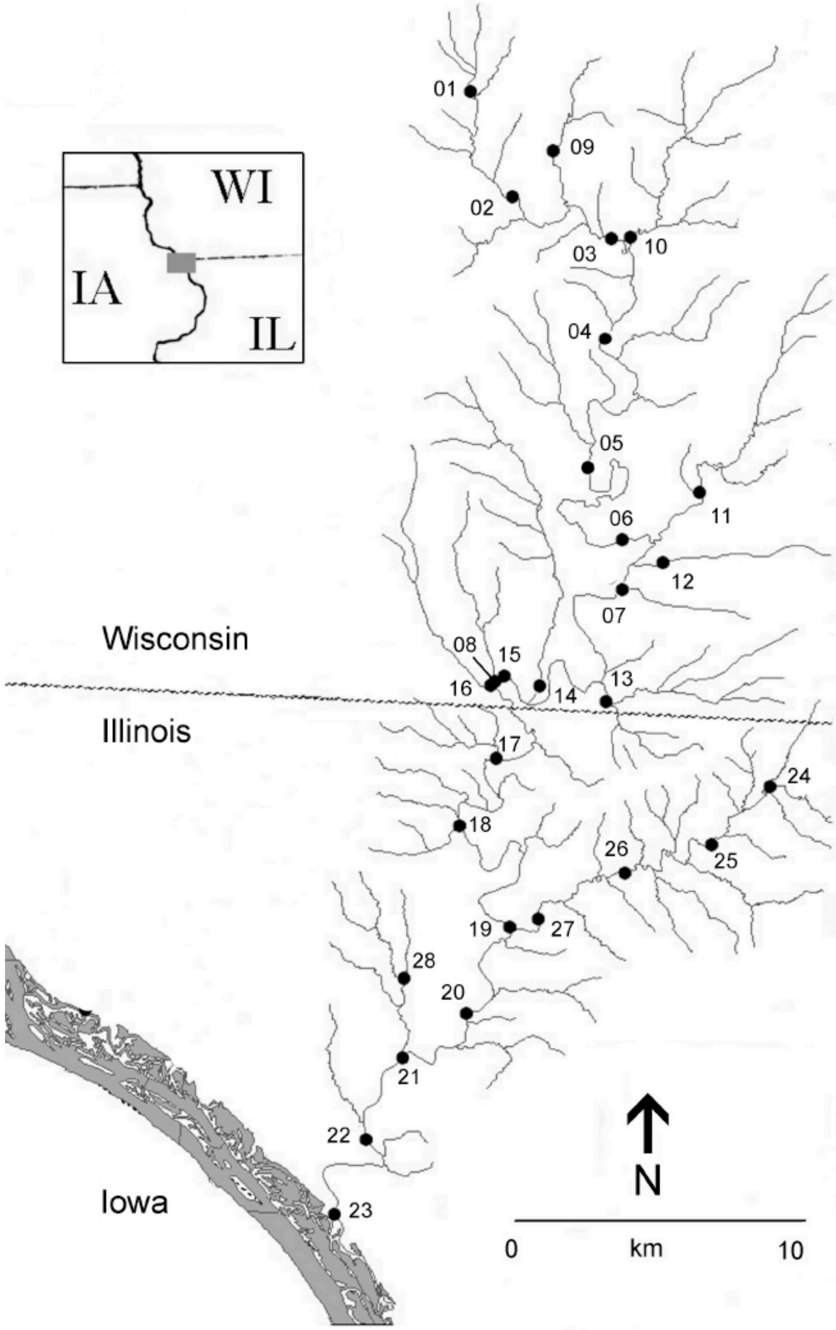
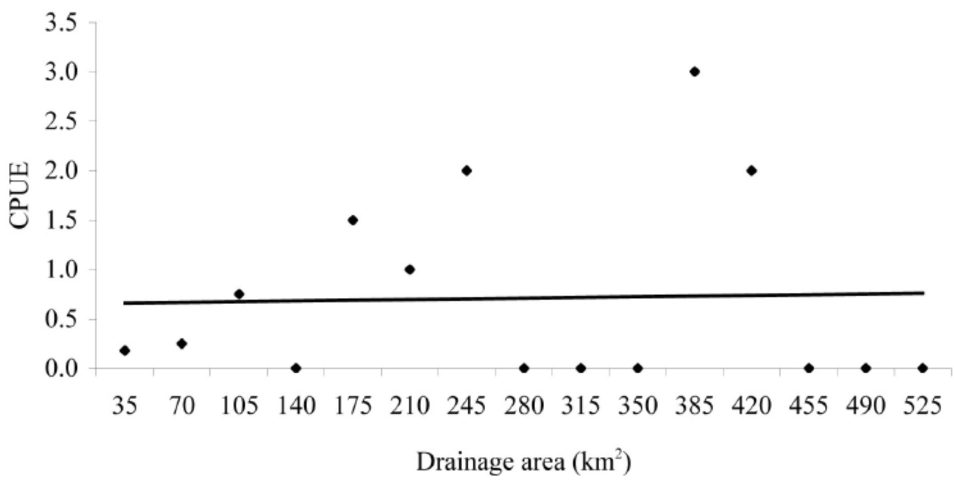
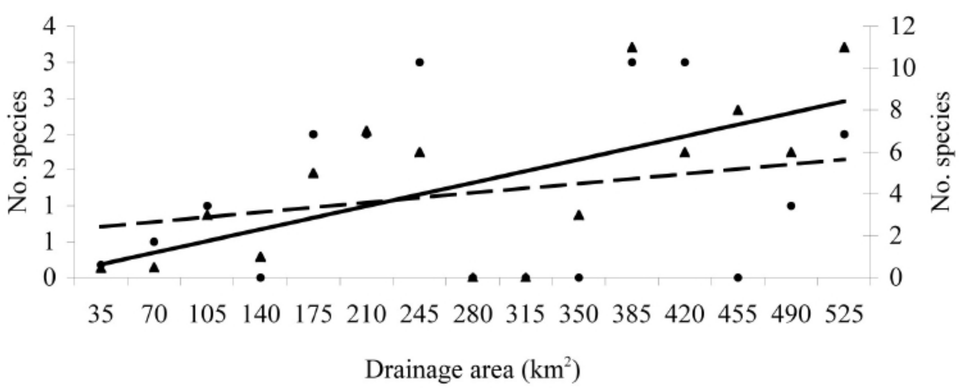


Figure 2. (a) Freshwater mussel CPUE (r^2 = 0.06, $F_{0.05(2), 26}$ = 1.53, P = 0.23) and (b) extant species richness (r^2 = 0.21, $F_{0.05(2), 26}$ = 6.97, P = 0.02) (left y-axis; circles with solid line) and historic species richness (r^2 = 0. 58, $F_{0.05(2), 26}$ = 40.18, P < 0.0001) (right y-axis; triangles with dashed line) compared drainage area in the Galena River basin, Wisconsin and Illinois.

(a)



(b)



Appendix 1

Collecting locations for the 2005-2006 freshwater mussel survey of the Galena River basin, Wisconsin and Illinois. FWM is freshwater mussel material collected at that site. L is number of species collected alive and V is number of species collected only as valves.

Site	State: County	Stream	Common location	Latitude, Longitude	FWM
01	WI: Lafayette	Galena River	4.0 mi NNE Cuba City	42.6673, -90.4134	
02		Galena River	3.0 mi NE Cuba City	42.6405, -90.3969	
03		Galena River	0.5 mi SE Jenkynsville	42.6308, -90.3621	L(2)
04		Galena River	3.0 mi E Cuba City	40.6092, -90.3602	
05		Galena River	1.5 mi E Benton	42.5714, -90.3639	L(2), V(3)
06		Galena River	2.5 SE Benton	42.5529, -90.3537	L(2), V(5)
07		Galena River	3.0 mi SSE Benton	42.5428, -90.3578	L(3), V(3)
08		Galena River	2.5 mi ESE Hazel Green	42.5161, -90.3931	
09		Pats Creek	4.0 mi NE Cuba City	42.6528, -90.3836	L(1)
10		Madden Branch	1.0 mi ESE Jenkynsville	42.6311, -90.3552	
11		Shullburg Branch	2.5 mi E Benton	42.5659, -90.3277	V(1)
12		Ellis Branch	3.0 mi SE Benton	42.5473, -90.3395	V(1)
13		Kelsey Branch	4.0 mi ESE Hazel Green	42.5108, -90.3575	
14		Coon Branch	2.5 mi ESE Hazel Green	42.5136, -90.3781	V(1)
15		Bull Branch	2.0 mi SE Hazel Green	42.5146, -90.3965	L(1)
16		Scrabble Branch	2.0 mi SE Hazel Green	42.5136, -90.3978	
17	IL: Jo Daviess	Galena River	5.0 mi N Galena	42.4947, -90.3947	
18		Galena River	4.0 mi N Galena	42.4768, -90.4066	V(3)
19		Galena River	3.0 mi NE Galena	42.4511, -90.3879	L(3), V(8)
20		Galena River	1.0 mi NE Galena	42.4285, -90.4017	L(3), V(3)
21		Galena River	Galena	42.4163, -90.4237	V(6)
22		Galena River	1.5 mi S Galena	42.4012, -90.4366	V(6)
23		Galena River	4.0 mi S Galena	42.3757, -90.4455	V(11)
24		East Fork Galena River	2.5 mi WNW Scales Mound	42.4901, -90.2991	
25		East Fork Galena River	4.0 mi W Scales Mound	42.4748, -90.3187	L(1)
26		East Fork Galena River	5.0 mi NE Galena	42.4665, -90.3483	V(4)
27		East Fork Galena River	3.5 mi NE Galena	42.4536, -90.3779	V(2)
28		Hughlett Branch	1.0 mi N Galena	42.4367, -90.4237	

Appendix 2

Site-specific data for only those locations where freshwater mussels were collected during the 2005-2006 freshwater mussel survey of the Galena River basin, Wisconsin and Illinois. Site No. is the site number, which is referenced in Appendix 1. Numbers within a given species row represent the number of individuals that species was collected alive at that site, D indicates those species collected only as fresh dead specimens, R signifies those species collected only as relict specimens, and * indicates those species represented by INHS Mollusk Collection records. Abundance is the total number of live unionids, extant species richness is the number of species represented by live or fresh dead shell material, and historical species richness is the total number of species found (including museum records). Effort is in person-hours. Note: sites 01, 02, 04, 08, 17, and 24 were sampled for two person-hours each and sites 10, 13, 16, and 28 were sampled for one person-hour each, but no evidence of freshwater mussels was found.

	Site No																	
Species	03	05	06	07	09	11	12	14	15	18	19	20	21	22	23	25	26	27
Anodontinae																		
Alasmidonta viridis			R				R				*		*					R
Anodontoides ferussacianus						R		R										
Lasmigona complanata		1	1	1						R	1	1	R					
Lasmigona compressa	1			2														
Lasmigona costata											R						R	
Pyganodon grandis	2	2		3						R	2	2				1		
Strophitus undulatus			R								*							
Utterbackia imbecillis														D				
Ambleminae																		
Amblema plicata											R	R	R	R	R			
Elliptio dilatata		R	R								R		*				R	
Fusconaia flava		R									*	R					R	
Quadrula nodulata															R			
Quadrula pustulosa															R			

Species	Site No 03	05	06	07	09	11	12	14	15	18	19	20	21	22	23	25	26	27
Quadrula quadrula															R			
Tritogonia verrucosa													R	R	R			
Lampsilinae																		
Lampsilis cardium		R	1	R						R	3	1	R		R			R
Lampsilis siliquoidea											*							
Leptodea fragilis															D			
Obliquaria reflexa															D			
Potamilus alatus														R				
Potamilus ohiensis															R			
Toxolasma parvus			R	R	1				1					*				
Truncilla donaciformis															R			
Truncilla truncata											*	R	R		R			
Venustaconcha ellipsiformis			R	R									R	R			R	
Abundance	3	3	2	6	1	0	0	0	1	0	6	4	0	0	0	1	0	0
Extant species richness	2	2	2	3	1	0	0	0	1	0	3	3	0	1	2	1	0	0
Historical species richness	2	5	7	6	1	1	1	1	1	3	11	6	8	6	11	1	4	2
Effort	2	2	2	2	1	1	1	1	1	2	2	2	2	2	2	2	2	2
Catch-per-unit-effort	1.5	1.5	1	2	1	0	0	0	1	0	3	2	0	0	0	0.5	0	0