Myers-Kinzie et al 2001

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Proceedings of the Indiana Academy of Science, Wntr-Fall 2001 p1

Occurrence and distribution of freshwater mussels in small streams of Tippecanoe County, Indiana. (Statistical Data Included) *Melody L. Myers-Kinzie; Stephen P. Wente; Anne Sp*

ABSTRACT. A mussel survey was conducted at 52 sites in 12 stream within Tippecanoe County, Indiana. The study did not include the Wa River, the Tippecanoe River, or the Middle Fork of Wildcat Creek. E 28 mussel species was found during the survey; 17 species were foun all live mussels, 58% were Lampilis siliquoidea (fatmucket). Mussel richness in each stream system was significantly correlated with wate and fish species richness. However, the presence of potential host fish did not entirely explain the mussel distribution.

Keywords: Headwater streams, mussel distribution, host fish

Surveys of freshwater mussels (unionids) in North America have doc declines of mussel species diversity and reduced distributional ranges 1968; Dineen 1971; Cummings et al. 1992). Of 297 native freshwater species in the United States and Canada, 71.7% are considered endan threatened, or of special concern (Williams et al. 1993). Changes in n populations may be a good indicator of stresses on the stream ecosyst by agriculture, industry, or urbanization (Dineen 1971).

The unionid's life cycle has the larval stage, the glochidium, parasitic host. The glochidium undergoes transformation into a juvenile musse this parasitic phase. The host-parasite relationship is specific in that o species of fish may serve as glochidial hosts for any given mussel spe transformation is complete, the juvenile mussel detaches from the fisl begins life as an independent organism (McMahon 1991). The moven bearing glochidia is the main mechanism of unionid dispersal. Wheth can then survive in any given location therefore depends on immediat environmental conditions and chance events such as droughts, floods, exposure to pollutants (Watters 1992).

Small streams are generally under-represented in mussel status report they are not included in most stream surveys and mussel populations not assessed as part of most stream faunistic surveys which usually fo and/or aquatic insects. Recent regional mussel surveys which did incl streams include the Sangamon River Basin, Illinois (Schanzle & Cum 1991), the Big Darby Creek system, Ohio (Watters 1994) and a few s tributaries of the Tippecanoe River, Indiana (Ecological Specialists, I

Factors affecting whether or not a small stream will support mussels i presence of host fish species, size of watershed area, and suitability o Mussels thought to be typical headwater species include Anodontoide ferussacianus, Alasmidonta viridis and Lasmigona compressa (Cumm

Mayer 1992); but because of the lack of small stream mussel survey d
not known to what extent these streams might support additional spec

Tippecanoe County, located in west central Indiana, includes a variety
streams as well as the confluence of the Tippecanoe with the Wabash
Land use in Tippecanoe is primarily agricultural but is undergoing rap
urbanization. The Wabash River flows through the county from north
southwest; and all streams in the county, including the Tippecanoe Ri
tributaries of the Wabash. The Tippecanoe and Wabash River watersh
contain a high diversity of unionid fauna (Goodrich & van der Schalie
Cummings & Berlocher 1990). Recent mussel surveys in the middle W
drainage include the Wabash and Tippecanoe Rivers (Cummings et al
the Tippecanoe River (Ecological Specialists, Inc. 1993) and the Midd
Wildcat Creek (Henschen 1990), and the present study did not include
waterways. Tippecanoe County is an especially good location to addre
issues because of recent surveys of fish and large river mussels, and ra
changes in land use.

There are many potential variables controlling the occurrence and dist
mussels, including water quality issues and physical habitat suitability
However, fundamental to the perpetuation of mussel life is the presen
fish. The size of the watershed can influence fish populations and, the
mussel populations (Watters 1993). Because of this unique host-paras
relationship, the discussion of factors affecting mussel distribution wi
the effects of watershed size and fish diversity, and compare mussel d
with host fish distributions.

The objective of this study was to determine the occurrence and distri
mussels in 12 small stream systems. This distribution was correlated t
watershed areas and fish species richness of the stream systems to eva
relationship of these factors to mussel species richness. Host fish distr
were compared to the presence or absence of mussels in each stream s
determine the extent to which host fish availability limits mussel distr
This study will serve as a baseline for future work with small stream m
populations.

METHODS

Description of study area.--A mussel survey was conducted at 52 sites
watersheds in Tippecanoe County, Indiana (Fig. 1) in June-August 19
same sites were surveyed for fish in 1994 (Fisher et al. 1998). The cha
of streams included in the study varied tremendously. Included were c
agricultural ditches, unaltered small streams with forested riparian co
a designated scenic waterway (Wildcat Creek) of moderate size. Strea
at the sites varied from second (Site 7) to fifth (Site 34). The smallest
was Bridge Creek, with a total watershed area of 16 [km.sup.2] and th
was Wildcat Creek, with a total watershed area of 2085 [km.sup.2] (H
1975).

Survey methodology.--Stream sites were surveyed once each by walk
length of stream bed covering at least three rifflepool sequences. Sear
varied from a minimum of 2 person-hours at the smallest sites to at le
person-hours at the largest sites on Wildcat Creek. All types of habita
visually searched, including banks, gravel bars, pools and riffles. Visi
the substrate were searched by hand digging to locate burrowed muss
site, the number and species of live mussels and mussel shells were re
Specimens were classified as live, fresh shell or weathered shell. Fres
were categorized as having the hinge ligament unbroken or the perios
largely intact. Live mussels were identified in the field and returned to
stream, with voucher specimens being collected from dead shells only
Identifications were made using the taxonomic references of Oesch (1
Watters (1995) and Cummings & Mayer (1992), and by examination
specimens housed in the Indiana State Museum. Voucher specimens a
at Purdue University.

Data analysis.--Information on mussel species distributions was comp
fish species distributions for these sites (Fisher et al. 1998) and host f
lists (Watters 1995). Regression analyses were done to evaluate the re
between the number of mussel species versus the log of the watershed
between the number of mussel species present by stream system versu
of fish species (Table 1). The regression analyses included Tippecano
mussel data from the Wabash and Tippecanoe Rivers (Cummings et a
but excluded Big Shawnee Creek. Only one site was surveyed on the
portion of Big Shawnee Creek; however, the remainder of the stream
continues through Fountain County, Indiana was not surveyed.

RESULTS

Mussel distribution.--Twenty-eight species of mussels (Table 2) were
during the survey; and of these, 219 individuals of 18 species were fo
(Table 3). Three species (Lampsilis siliquoidea, Anodontoides ferussa
Pyganodon grandis) were the most common found alive, comprising
the total. Uncommon species were Strophitus undulatus, Alasmidonta
marginata, Lampsilis teres, and Ligumia recta, each being represented
live individual.

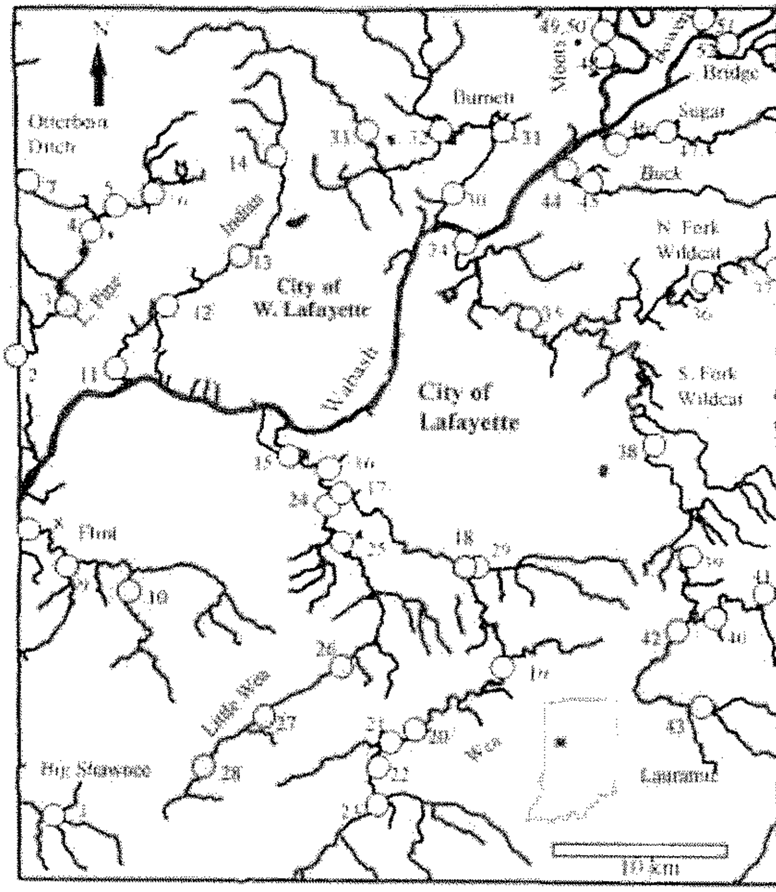


Figure 1.—Mussel sampling sites in Tippecanoe County, Indiana. Sampling sites are indicated with a circle ( ) and are labeled with numbers. The cities of Lafayette and West Lafayette are located in the central part of the county, and are separated by the Wabash River

All stream systems surveyed, except Bridge Creek, showed evidence ‹ life, whether in the form of live individuals or shells. Only weathered were found in Indian Creek, Buck Creek, Flint Run (site 10), Dismal ‹ 29), and Sugar Creek. Flint Run is a tributary of Flint Creek, and Disr is a tributary of Wea Creek. Only one weathered shell fragment of An ferussacianus was found in Indian Creek at site 13, and one weatherec Actinonaias ligamentina was found in Buck Creek at site 44.

Of all live mussels found during the study, 58% were Lampsilis siliqu They were found alive at five Wildcat Creek sites, and shells of this n found at all Wildcat Creek sites. They were also found alive in Laurar and Little Pine Creeks.

Anodontoides ferussacianus and Alasmidonta viridis were found in h areas during this study. Twenty-one live Anodontoides ferussacianus found, representing 9.6% of the total live mussels, in Little Pine Cree Creek, and Moots Creek. Four live Alasmidonta viridis specimens, re 1.8% of total live mussels, were found by digging with the hands at th visible mussel trails in Wea and Big Shawnee Creeks. Thirteen sites c Shawnee Creek, Wea Creek, Little Wea Creek, Little Pine Creek, Sug South Fork Wildcat Creek and Flint Run yielded either live mussels o Alasmidonta viridis.

Lasmigona compressa were also found in headwater areas. They were or as shells at sites in Little Pine Creek, Wea Creek, South Fork Wild Moots Creek, and Sugar Creek. Only two live individuals (sites 4 and found, representing 0.9% of total live mussels.

Three species found in both smaller streams and in the larger Wildcat system were Pyganodon grandis, Lampsilis cardium and Fusconaia fl Pyganodon grandis represented 9.6% of total live mussels, and were f shells or live individuals in Little Pine Creek and Wildcat Creek. Lam cardium was found in Wildcat Creek and Wea Creek, including a live Wea Creek site 19, and at Wildcat Creek sites 34, 36, 39 and 40. Fusc was found in Wea, Little Pine and Wildcat Creeks, including live indi Wea Creek sites 19 and 20.

Evidence of 26 species of mussels was found in the Wildcat Creek sy of these, nine species were found alive. Species found only in the Wil system, whether as live mussels or shells, were Alasmidonta marginat Amblema plicata, Cyclonaias tuberculata, Elliptio dilatata, Lampsilis Lasmigona complanata, Lasmigona costata, Leptodea fragilis, Ligumi Pleurobema clava, Potamilus alatus, Quadrula pustulosa, Quadrula qu Tritogonia verrucosa and Truncilla truncata. Mussel species that were either as live individuals or shells only in the downstream portion (sit 35) of Wildcat Creek were Quadrula quadrula, Leptodea fragilis, Pota alatus, and Truncilla truncata. Pleurabema clava and Cyclonalas tuber were each represented by one weathered valve in North Fork Wildcat

Table 1. [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Little Pine Creek	[illegible]	11	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Wildcat Creek	[illegible]	26	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Little Pine Creek contained 11 sp mussels, including two species nc any other stream in the study. The Uniomerus tetralasmus and the st of special concern Toxolasma liv Toxolasma lividus was found at c sampling site (Site 3) which had t specimens and numerous fresh sh Little Pine Creek sites in Tippeca County supported live mussels ex most upstream site (site 6) and sit tributary stream Otterbein Ditch i of Otterbein, Tippecanoe County,

Two species, Toxolasma parvus a Uniomerus tetralasmus, are new County records. Toxolasma parvu found in four streams (BowenDit Pine Creek, Wea Creek, and Wildcat Creek) and Uniomerus tetralasm stream (Little Pine Creek).

Effects of watershed area and host fish.--The number of species per w

was significantly correlated to the drainage area ([r.sup.2] = 0.91, P <
2). Correlation of the number of mussel species to the number of fish
was also highly significant ([r.sub.2] = 0.80, P < 0.01) (Fig. 3).

Comparisons were made by stream system for occurrences of mussel
fish. For each mussel species found, host fish were documented for th
system in all but two instances (Bowen Ditch and Buck Creek); howe
fish distributions exceeded mussel distributions.

DISCUSSION

Mussel distribution.--The small streams of Tippecanoe County are ho
diverse and widely-distributed mussel fauna, as demonstrated by 219
individuals of 18 species found. However, the fact that only weathere
were found in five streams implies that mussels existed in those strea
past, but are unable to do so now.

Lampsilis Siliquoidea is one of the most common mussels in Indiana
& van der Schalie 1944). In a survey of the Eel River in Indiana, Lam
siliquoidea occurred at all sites where live mussels were found (Hens
Even this nearly ubiquitous species may have its limits of tolerance to
disturbance. Lampsilis siliquoidea appears to have declined in the Sa
River drainage of Illinois, a watershed impacted by channelization,
impoundment, and agricultural, industrial and municipal runoff (Scha
Cummings 1991). Because of the lack of historical data for the small
the present study, it is not known if a similar decline is occurring in T
County.

Table 2.—Mussel species found during the study categorized as live, fresh shells, or weathered shells. The numbers refer to sites listed in Figure 1

Species	Live	Fresh shells	Weathered shells
Actinonaias ligamentina	[illegible]	[illegible]	[illegible]
Alasmidonta marginata	[illegible]	[illegible]	[illegible]
Alasmidonta viridis	[illegible]	[illegible]	[illegible]
Amblema plicata			[illegible]
Anodontoides ferussacianus	[illegible]	[illegible]	[illegible]
Cyclonaias tuberculata			[illegible]
Elliptio dilatata		[illegible]	[illegible]
Fusconaia flava	[illegible]	[illegible]	[illegible]
Lampsilis cardium	[illegible]	[illegible]	[illegible]
Lampsilis siliquoidea	[illegible]	[illegible]	[illegible]
Lampsilis teres	[illegible]	[illegible]	[illegible]
Lasmigona complanata	[illegible]	[illegible]	[illegible]
Lasmigona compressa	[illegible]	[illegible]	[illegible]
Lasmigona costata		[illegible]	[illegible]
Leptodea fragilis	[illegible]	[illegible]	[illegible]
Ligumia recta	[illegible]	[illegible]	[illegible]
Pleurobema clava			[illegible]
Potamilus alatus	[illegible]	[illegible]	
Pyganodon grandis	[illegible]	[illegible]	[illegible]
Quadrula pustulosa		[illegible]	[illegible]
Quadrula quadrula		[illegible]	[illegible]
Strophitus undulatus	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]
[illegible]		[illegible]	
[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Several species of mussels are considered to be typical of headwater s
Anodontoides ferussacianus, Alasmidonta viridis, and Lasmigona cor
(Cummings et al. 1992). Anodontoides ferussacianus was common ar
widespread in the present study. Schanzle & Cummings (1991) found
Anodontoides ferussacianus in the upstream portions of the Sangamo
its tributaries in sufficient numbers to constitute 2% of their total sam
Ecological Specialists, Inc. (1993) called it one of the most common s
collected in tributaries. Ecological Specialists, Inc. (1993) found Alas
viridis distributed in tributary streams, although it was rare. Alasmido
is known to burrow in the substrate (Watters 1995) and may be easily
Ecological Specialists, Inc. (1993) also found that the small size of th
reduced chances of finding it alive. In the present study Lasmigona cc
individuals were widely scattered and never present in great numbers.
Specialists, Inc. (1 993) found Lasmigona compressa to be rare and sc
the tributaries of the Tippecance River, as did Schanzle & Cummings
the tributaries of the Sangamon River. The present study shows that tl
headwater species Alasmidonta viridis and Lasmigona compressa are
small streams, but their ranges may be underestimated due to difficult
locating them.

Three species, Pyganodon grandis, Lampsilis cardium, and Fusconala
widespread in their distribution. These three species are able to inhabi
streams such as Little Pine Creek and Wea Creek, moderate size strea
Wildcat Creek, and large rivers such as the Wabash or Tippecanoe Ri
obser.).

Exceptional streams.--The Wildcat Creek system was exceptional in i
diversity in that it showed evidence of 26 mussel species. The four sp
only in the downstream portion are more typical riverine species that
common in the Wabash River. A troubling observation was that the
federally-endangered Pleuroberna clava and the uncommon Cyclonai
tuberculata were found only as weathered shells in the North Fork Wi
is similar to the finding of Henschen (1987) in which the Eel River, a
with a similar watershed size to Wildcat Creek, yielded only shells of
Pleurobema clava and Cyclonaias tuberculata. These species are disap
from much of their former ranges, and Wildcat Creek may be no exce
this trend.

Little Pine Creek supports 11 mussel species, including the only knov
Tippecanoe County population of Uniomerus tetralasmus. This specie
uncommon (Cummings & Mayer 1992) and was found in only one tri
the Big Darby Creek system of Ohio (Watters 1994). The state specie
concern Toxolasina lividus individuals in Little Pine Creek are isolate
others of the same species. Previous county records of Toxolasma livi
include one live individual in the Tippecanoe River near the mouth (C
et al. 1992). These populations in Little Pine Creek are vulnerable to l
extirpation from events such as ditching to facilitate agricultural drair

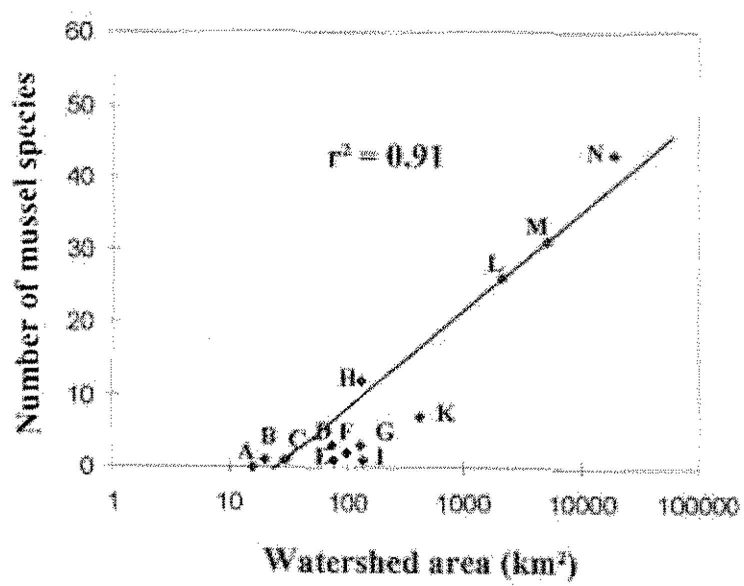
Table [illegible].-- Abundance of live mussels found in Tippecanoe County in this survey. The percentage of the total collection for the county is also shown

The discovery of two mussel spec

new county records emphasizes the importance of studying small stre
of these streams are subject to habitat modification, non-point source
and land-use changes. Without

baseline data on the biota of these streams, we may never know the m
these impacts.

Effects of watershed area and fish diversity.--The effect of watershed
increasing unionid diversity with greater watershed area. The stream
smallest watershed area, Bridge Creek (16 [km.sup.2]) is probably too
support mussels. Bowen Ditch, with a watershed area of 20 [km.sup.2
one mussel species. The habitat quality of Bridge Creek was as least a
that of Bowen Ditch and both supported nine fish species, implying th
minimum watershed size needed for mussels is approximately 20 [km
Unionid diversity is not solely a consequence of the drainage area, bu
related to the fish diversity (Watters 1992). In small systems, the num
unionids is related to the drainage area, while in larger systems unioni
is related to both drainage area and fish diversity (Watters 1992).

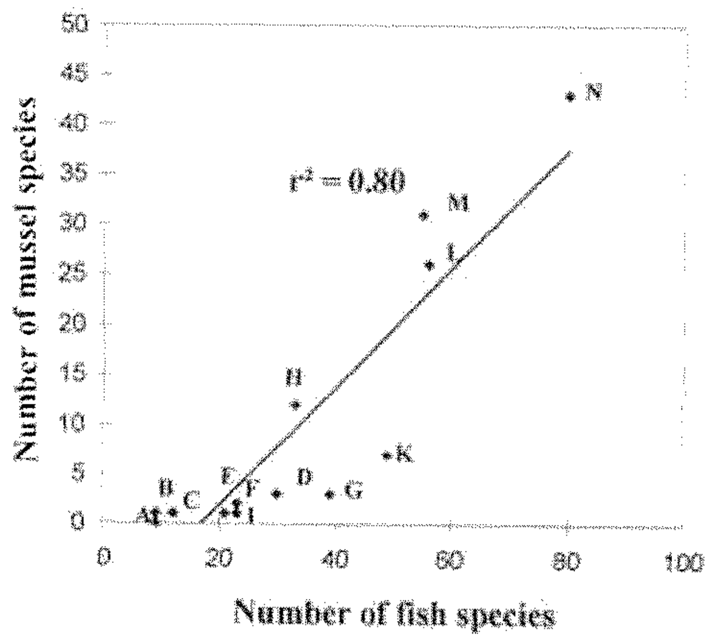


Regression between number of mussel species and number of fish spe
linear function ([r.sup.2] = 0.80). A similar analysis by Watters (1993
[r.sup.2] of 0.92, indicating the species numbers of fishes and unionic
highly correlated. The ratio of fish diversity to unionid diversity is ess
constant, and this ratio may be used to predict an expected unionid di
(Watters 1993). Deviations from expected unionid diversity based on
diversity may be attributed to several causes such as fish mobility, pre
exotic fish species, and the persistence of unionid shells many years a
death of the animal (Watters 1992).

Comparison with host fish distributions.--Host fish were documented

observed mussels in all but two instances. This apparent anomaly is u
a result of the transient nature of fish communities at any given locati
dams that would limit fish movement are present on any of the stream

For some mussel species, distributional ranges corresponded closely w
of known host fish. Examples include Potamilus alatus, Leptodea frag
Truncilla truncata inhabiting the downstream portion of Wildcat Cree
with their host fish, Aplodinotus grunn lens (freshwater drum). Anoth
is the host fish for Uniomerus tetralasmus, Notemigonus crysoleucas
shiner) that was found in only Little Pine Creek and in the Wabash Ri
a Tippecanoe County fish survey (Fisher et al. 1998); and the only kn
Tippecanoe County population of Uniomerus tetralasmus is in Little I
For most other mussel species, the ranges of the host fish greatly exce
ranges of the mussels. Hosts for Toxolasma lividus are Lepomis cyan
(green sunfish) and Lepomis megalotis (long ear sunfish) which are w
distributed throughout the county, but this mussel was limited to one
concurs with the findings of Bauer et al. (1991) that the distribution p
hosts does no t explain the distribution pattern of the mussels. The rol
fish in mussel distribution is an essential one, but other environmenta
limit whether a particular species can survive past the postparasitic st



[illegible]

In some cases where the habitat preferences of a mussel species is kn
be concluded that this, rather than the presence of host fish, is the dete
for mussel success. For example, Alasmidonta marginata usually occu
flowing streams of moderate size (Watters 1995). Alasmidonta margi
present only in Wildcat Creek, which also contains the host species A
rupestris (rock bass), Moxostoma macrolepidotum (shorthead redhors
Hypentelium nigricans (northern hogsucker), and Catostomus comme
(white sucker). However, these fish were widely-distributed througho

county. Strayer (1983) states that in addition to stream size, surface g(also a factor in defining mussel species habitats, and that hydrologica associated with surface geology is probably an important factor in det unionid distributions.

CONCLUSIONS

The distribution of mussels in Tippecanoe [T1][T2]County indicated 28 species in 12 watersheds. Of these, some species are typical of hea areas, others inhabit moderate size streams such as Wildcat Creek, an are widely-distributed throughout the county. The mussel species rich significantly correlated with fish species richness, but the pattern of h distribution did not entirely explain the patterns of mussel distributior mussels are not routinely included in small stream water quality surve of the factors influencing mussel distribution, such as habitat requirer not well known. Because of the recent decline in mussel populations, further study.

ACKNOWLEDGMENTS

The authors would like to thank Laurie Hatton and Brant Fisher for as with field work. We would also like to thank Dr. G. Thomas Watters Ohio State University and Ron Richards of the Indiana State Museum taxonomic assistance. A review of an earlier version of this manuscri] Jon Harbor was greatly appreciated.

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Table 1

Mussel and fish species richness in relation to watershed area stream system. Mussel species include live, fresh shells and w shells. Watershed areas are reported to the mouth of stream, e the Wabash River, which shows the drainage are to Lafayette, I Superscripts represent: (a)Hoggatt 1975; (b)Fisher et al. 1998 (c)Cummings et al. 1992.

Stream system	Water shed area ([km.sup.2]) (a)	Number of mussel species	Number of fish species (b)
Bridge Creek	16	0	9
Bowen Ditch	22	1	9
Buck Creek	30	1	12
Sugar Creek	74	3	30
Indian Creek	77	1	21
Flint Creek	100	2	23
Moots Creek	133	3	39
Little Pine Creek	135	11	33
Burnett Creek	139	1	23
Big Shawnee Creek	167	1	15
Wea/Little Wea Creek	422	7	49
Wildcat Creek	2085	26	56
Tippecanoe River	5050	31 (c)	55
Wabash River	19,397	43 (c)	80

Table 2

Mussel species found during the study, categorized as live, fr shells, or weathered shells. The numbers refer to sites listed 1.

Species	Live
Actinonaias ligamentima	37
Alasmidonta marginata	37
Alasmidonta viridis	1, 20
Amblema plicata	
Anodontoides ferussacianus	4, 22, 23, 50
Cyclonaias tuberculata	
Elliptio dilatata	
Fusconaia flava	19, 20
Lampsilis cardium	19, 34, 36, 39, 40
Lampsilis siliquoidea	2-4, 19-22, 34, 36, 37, 40-43
Lampsilis teres	37
Lasmigona complanata	37
Lasmigona compressa	4, 22
Lasmigona costata	
Leptodea fragilis	34, 35
Ligumia recta	34
Pleurobema clava	
Potamilus alatus	34
Pyganodon grandis	3-5, 34, 36, 37
Quadrula pustulosa	
Quadrula quadrula	
Strophitus undulatus	4, 37
Toxolasma lividus	3
Toxolasma parvus	4
Tritogonia verrucosa	
Truncilla truncata	
Uniomerus tetralasmus	
Utterbackia imbecillis	4

Species	Fresh shells
Actinonaias ligamentima	34-37
Alasmidonta marginata	36, 38
Alasmidonta viridis	3, 20, 21, 27

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