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Holeski and Graves: An Analysis of the Shore Beetle Communities of Some Channelized S

AN ANALYSIS OF THE SHORE BEETLE COMMUNITIES OF SOME CHANNELIZED STREAMS IN NORTHWEST OHIO (COLEOPTERA)[1]

Paul M. Holeski and Robert C. Graves[2]

ABSTRACT

The present shore beetle communities of some northwest Ohio streams channelized between 1937 and 1973 were studied. Quantitative and qualitative analyses were made to determine the effects of channelization on the community and the results are discussed. Ninety species, chiefly Carabidae, Heteroceridae and Staphylinidae, were collected; at least 20 not previously reported from Ohio. In addition, some species associations are noted.

Stream margins form very narrow and often unstable ecological situations which are inhabited by a diverse but specific collection of insect species. The present study is limited to the Coleoptera. In the habitats studied, the vast majority of shore beetles belonged to the families Carabidae, Staphylinidae and Heteroceridae. These either live on the surface or excavate burrows in the soil a few inches to a foot or more from the waters edge. They often venture out from the shore onto algal mats and debris or may live in the saturated mud of the land-water interface rather than on the drier soil. Lindroth (1961-69) has indicated that many of these species are highly restricted ecologically and are sensitive indicators of specific habitats.

The shore beetles are not completely terrestrial and certainly not truly aquatic but provide an interesting population of species closely tied to the narrow band on the land side of the land-water interface. Small ecological changes in this restricted habitat will alter the composition of the shore beetle population and, although several authors have briefly considered the shore beetles in their overall studies of habitat change (Hefley, 1937; Stehr and Branson, 1938; and Richardson, 1921), very few ecological studies of the insects themselves have been made. Lindroth (1961-69) discussed many of the shore-inhabiting Carabidae in his study of this family in North America. Andersen (1969) investigated the life histories and habitats of some members of the Bembidiini (Carabidae) on river banks in northern Norway. Andersen (1968), Joy (1910), and Jenkins (1960) reported on the effects of flooding on certain shore beetle species.

The ecology of shore beetles has been neglected and no studies of ecological succession among these species could be located. The "Little Auglaize Watershed Project" in northwestern Ohio (located in portions of Mercer, Van Wert, Putnam and Paulding counties) offered an unusual opportunity to study shore beetle populations and communities.

Many of the streams in this watershed were periodically channelized for flood prevention and cropland protection. These streams have undergone similar, but much less extensive channel modification several times in the past. Study sites were selected on streams channelized in 1971 and 1973 as part of the current watershed project, and on streams which were modified 15-30 years ago.

In this study shore beetle populations were sampled and compared with the dates of stream channelization in the manner in which "old field" studies have been used to determine plant succession.

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THE AREA AND ITS HISTORY

The Black Swamp region of northwest Ohio is an irregular strip about 30 miles wide lying roughly parallel to the east bank of the Maumee River from Lake Erie southwest for 120 miles to the present city of New Haven, Indiana (Fig. 1). It covers some 2,000 square miles and includes all or portions of 11 Ohio and two Indiana counties. Most of the area was originally covered with dense swamp forest with occasional oak openings and wet prairies. The wetness of the area retarded settlement even after the land to north, south and west had come under cultivation (Kaatz, 1955).

In order to make the area suitable for cultivation the Black Swamp had to be ditched and drained. Public ditch laws were enacted to construct ditches and modify the existing streams to facilitate the removal of excess water.

The streams which form the Little Auglaize Basin are almost wholly within the Black Swamp region. There is no recorded modification of these streams until 1880 when a portion of the Little Auglaize River was modified. Channelization of the other streams in the system began soon afterward and by 1905 at least parts of all major streams had undergone some modification. Until the present Watershed Project was initiated in 1965, stream treatment was done on a limited local basis with only short portions of a stream undergoing construction at any one time. This usually consisted of dredging the existing channel and removing vegetation from the channel and banks. In the recent projects, modifications consisting of dredging, vegetation removal, channel straightening, and construction of entirely new channels were done on most of the length of a stream. Table 1 shows the approximate stream modification dates in the areas where the sampling sites were located.

Table 1. The approximate dates of major modifications of streams in the Little Auglaize Watershed which included the areas of sample sites, from Van Wert-Paulding Counties Joint Ditch Records, Paulding County Engineer's Office, Paulding, Ohio.

Stream	Date of modification	Location in Paulding County, Ohio
Little Auglaize River	1907,1923, 1945,1971	Sec. 15, Washington Twp.
Dog Creek	1910,1944	Sec. 34, Washington Twp.
Middle Creek	1909,1933, 1940,1972, 1973	Sec. 21, Washington Twp.
Town Creek	1890,1942	Sec. 36, Latty Twp.
Maddox Creek	1937	Sec. 35, Latty Twp.
West Branch Creek (Hoaglin)	1905,1949	Sec. 18, Washington Twp.
Hagerman Creek	1883,1919, 1956	Sec. 29, Latty Twp.
Prairie Creek	1883,1904, 1924,1949	Sec. 15, Latty Twp., and Sec. 7, Washington Twp.

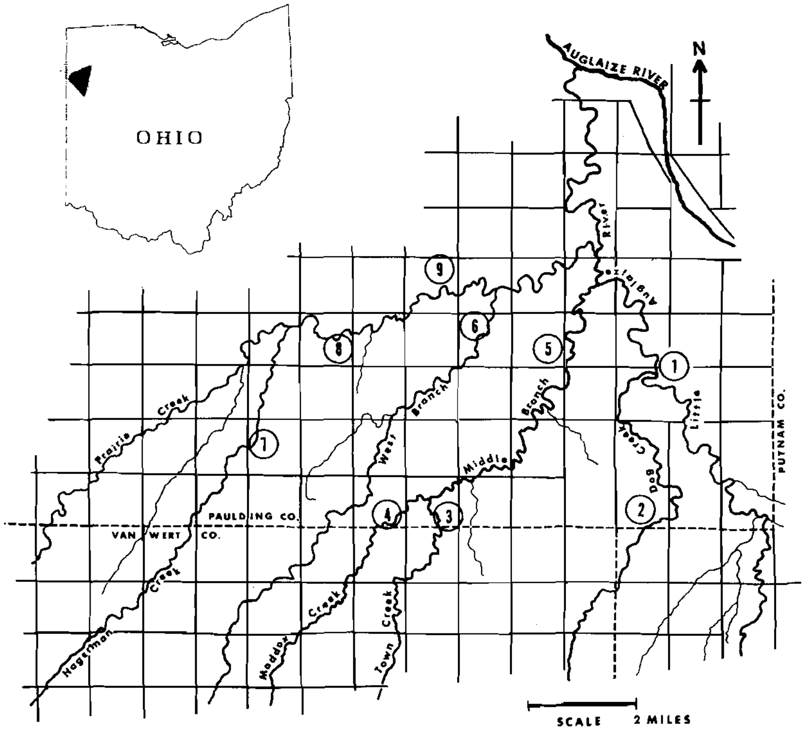

Fig. 1. The locations of sample sites on the streams of the lower Little Auglaize Watershed. 1, The Little Auglaize River; 2, Dog Creek; 3, Town Creek section of Middle Branch Creek; 4, Maddox Creek section of Middle Branch Creek; 5, Middle Branch Creek; 6, West Branch or Hoaglin Creek; 7, Hagerman Creek; 8, Prairie Creek; 9, Prairie Creek. Straight lines represent roads. The Black Swamp Region (stippled) and the Little Auglaize Watershed (black) are shown on the Ohio map outline.

COLLECTING SITES

Collecting sites were established at various points along the six streams included in the study. There were nine sites, all located in Paulding County, Ohio (Fig. 1).

Site 1. The sample site on the Little Auglaize River is shown in Figure 2. At this point the channelized stream had a bed 85 feet wide and the bank was graded to a standard 2:1 side slope. Channelization of the Little Auglaize River was completed in 1971.

At normal water levels there was an exposed silt deposit extending 20-30 inches from the shore into the stream (Fig. 2). Under conditions of high water which normally occur in the spring, this area of the shore was completely inundated while at low water levels much of the stream bed was exposed (Fig. 3). This was true for all of the streams. Samples were taken from the shore up to 24 inches back from the waterline. There was very little or no vegetation present on the exposed shore, but the graded bank was densely covered with seeded grasses and legumes.

Site 2. This area of Dog Creek was last modified in 1944, 27 years before the present study was begun in 1971. The stream channel at this point was normally 15-20 feet wide. The bank sloped gradually to the water with little vegetative cover below the high water line. Above the high water line and extending several yards to the cultivated fields there

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was a thick cover of herbaceous and woody vegetation. Some of the trees overhung and shaded areas of the shore during part of the day. Because of the shade a damp strip of shore near the water remained fairly uniform in width throughout the year. This differed from the conditions found in the recently channelized streams where most of the shore became dry during the late summer due to the lack of shading vegetation.

Sites 3, 4, and 5. Three collecting sites were located on the Middle Branch Creek complex of the Little Auglaize Watershed, one each on Maddox and Town Creeks and one on the combined channels. The Maddox Creek site (4) was located in a wooded cattle pasture. At this site the stream contained large amounts of debris, and, except under high water conditions, could best be described as a series of connected pools rather than a flowing stream. Modifications of the stream channel in this area last took place in 1937. Large trees heavily shaded the stream and maintained a damp shore throughout the season. Although this site was in an area used as a cattle pasture the shore was rarely disturbed.

On Town Creek the collection site (3) was also in a pasture, but unlike the Maddox Creek site this site was almost totally open, and was regularly disturbed by cattle. Water levels in this stream remained constant throughout most of the year and herbaceous vegetation grew almost to the edge of the water. A suitable habitat for shore insects was provided only on a narrow strip (seldom more than 15 inches wide) before a steep rise in the bank. This narrow area consisted of very soft, wet mud and cattle dung which was regularly trampled by these animals. The site was located in an area last channelized in 1942.

The nine miles of stream known as Middle Creek from the junction of Town and Maddox Creeks to the Little Auglaize River was channelized in 1972. At the location of the collection site (5) the stream was modified to a 60 foot wide bottom (USDA, 1966) as shown in Figure 4, a photograph taken in June, 1973. In August, 1973 a narrower channel was cut in the existing bottom (Fig. 5). The spoil removed in constructing the new channel consisted mainly of clay and broken rock. This material was dumped on the shore and graded to form a thin, level layer over the preexisting shore. This site was of unusual interest in that there were two major modifications of the shore within a three year period.

Site 6. At this location West Branch is a rather shallow stream with one steeply sloped bank. This section of stream was last channelized in 1949 but now shows little evidence of that work. The stream channel contained some areas of dense emergent vegetation (*Potamogeton*) and there were numerous fallen trees in the channel, all of which tended to "pond" the stream. During late summer the stream generally had no flow, the water being restricted to isolated pools. The actual sample location was the shore area of one of these pools.

Site 7. Hagerman Creek is a small stream last modified in 1956. Because of its small size and deep cut in relation to width, water levels can fluctuate rapidly and shore areas can be completely inundated within a few hours after a rain which would have little effect on the water levels of the other streams.

Sites 8 and 9. Two sites were established on Prairie Creek, one a few miles from the other. Site 9 was located in a woodlot while site 8 (Fig. 6) was a tree-lined portion of the stream in an open area of cultivated fields. The collection areas of both sites appeared similar in that the shores were composed of soft, wet mud containing large amounts of debris. These areas seldom became dry even during long periods of dry weather.

During the season of insect activity specimens were collected at each sample station on a regular basis, usually every three to four weeks. The insects became active in the spring as soon as the daily temperatures rose and the high seasonal water levels subsided. Normally this is in early April but can be as late as June depending on local conditions. Collecting ceased in the fall when cold curtailed insect activity.

The samples were made by placing a foot square (30.5 × 30.5 cm.) metal and screen frame on the shore at each collecting site, permitting a quantitative sample of a constant

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area (1 foot^2 or 0.092 m^2) to be taken. Water was splashed into the frame to force those beetles not on the surface to emerge from cracks and burrows. As most shore beetles do not readily take flight when disturbed, this method of sampling allowed the capture of most of the insects within the area of the frame. Two samples were made at each collection. Taxa were determined according to Arnett (1968), Lindroth (1961-69), and Pacheco (1963).

QUANTITATIVE RESULTS

Quantative data were tabulated and analysed by a series of information measures which included the diversity indices of Margalef (1951) and Shannon & Weaver (1963). Margalef's index,

$$d = (s - 1)/1_n N$$

relates the number of species to the number of individuals and thus is a measure of diversity in terms of species richness. It has been found in other studies (Wilhm, 1967) that higher values (usually above 3.) indicate an increased balance of species while lower values indicate an unbalanced community consisting of few species.

The Shannon & Weaver index, $H = -\Sigma(P_i \log P_i)$ does more than show the relationship between total numbers of species and individuals, it expresses the relative importance of each individual belonging to each species and thus is an expression of dominance diversity rather than species richness. Values from this index can range from 0 (when all individuals belong to the same species) to various positive values.

Quantitative data for each station are summarized in Table 2. In the three-year study more than 5,000 individuals belonging to 90 species were collected. Yearly samples were obtained by pooling totals from the six to eight collections made per year.

QUALITATIVE RESULTS

Quantitative measurements such as species diversity are useful in that they provide measurements of numbers of taxa, however, they do not provide information about the

Fig. 2. The sampling location on the Little Auglaize River (1), showing the narrow shore area exposed at average water depth.

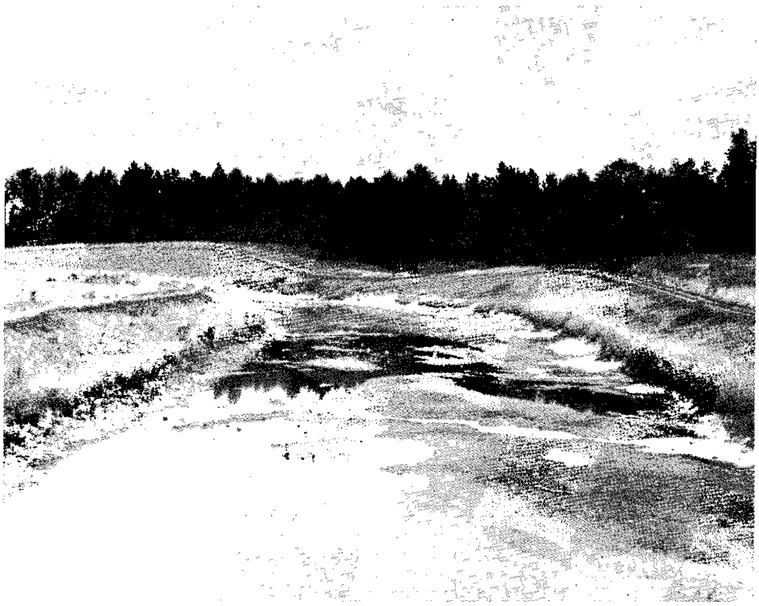

Fig. 3. The sampling location on the Little Auglaize River showing the shore area exposed at low water levels in late summer.

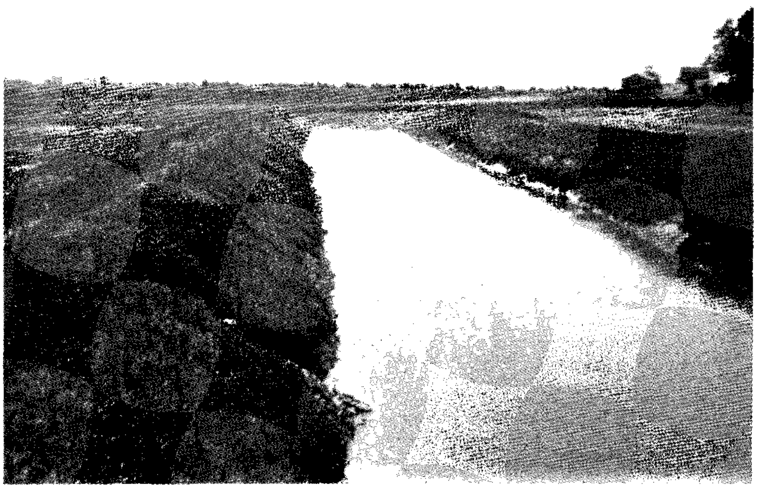

Fig. 4. The sample site area of Middle Creek (5) in June, 1973, one year after channelization. The seeded vegetation on the upper banks has been established but very little silt deposit shore has been built-up.

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Fig. 5. The same location as shown in Figure 4, August of the same year. A new narrower channel has been cut changing the nature of the shore.

Fig. 6. Site 8 on Prairie Creek, a tree-lined area in cultivated fields.

Table 2. Summary of quantitative data by station.

Parameter	Stations								
	1	2	3	4	5	6	7	8	9
1972									
Total species found	32	30	31	19	13	25	23	21	23
Total number of individuals found	181	170	216	64	29	148	56	65	113
Diversity index[a]	5.96	5.63	5.58	4.31	3.56	4.80	5.47	4.79	4.65
Diversity index[b]	2.85	2.84	2.82	2.46	2.23	2.61	2.75	2.72	2.49
1973									
Total species found	23	32	25	24	17	27	19	21	32
Total number of individuals found	327	330	303	206	169	358	125	232	412
Diversity index[a]	3.80	5.18	4.20	4.32	3.12	4.42	3.53	3.67	5.15
Diversity index[b]	1.98	2.23	2.17	1.94	1.92	2.15	2.25	1.78	2.34
1974									
Total species found	30	28	32	18	19	27	14	26	25
Total number of individuals found	222	266	375	144	121	233	107	161	220
Diversity index[a]	5.37	4.84	5.22	3.42	3.75	4.77	2.78	4.92	4.45
Diversity index[b]	2.45	2.39	2.47	1.62	2.24	2.30	1.69	2.42	2.10

[a]Margalef (1951).
[b]Shannon and Weaver (1963).

similarities of the taxa themselves. Two areas with identical species diversity could, for example, share all their species, none of their species or any combination (Wiegert, 1974). To measure relationships among species qualitative methods must be used. This study used the SIMGRA computer program based on Estabrook (1973) to test for the similarity of the communities at the collecting sites. The program allowed a comparison of species and of the number of individuals present in a species. Thus if in a comparison of two sites the species and the number of individuals in each species were the same a value of 1.0 would be obtained.

Sites were analysed through the SIMGRA program by pooling all individuals collected at a site in one year into a group and then comparing each of the groups with every other group. Table 3 was constructed from these data and shows each collection site and the four sites most similar in species and individual composition.

Table 4 lists all of the shore dwelling species collected in this study of the Little Auglaize Watershed. The total number of species collected at the sites over the three year period ranged from 28 at site 7 on Hagerman Creek to 47 at site 2 on Dog Creek (yearly totals are shown in Table 2).

Table 3. Stations most similar in species and individuals composition based on Coefficient of Similarity (C.S.) values as determined by the SIMGRA computer program.

Station	Four most similar stations and C.S. value							
	Station:C.S.		Station:C.S.		Station:C.S.		Station:C.S.	
				1972				
1	1,1974	.707	7,1973	.638	9,1972	.638	5,1972	.621
2	4,1973	.638	8,1973	.638	9,1973	.638	6,1972	.621
3	4,1973	.655	5,1974	.655	6,1973	.638	3,1974	.621
4	5,1972	.724	6,1972	.724	8,1974	.724	2,1974	.707
5	4,1972	.724	5,1973	.724	7,1974	.724	7,1972	.707
6	4,1972	.724	7,1973	.707	9,1972	.672	7,1972	.638
7	8,1972	.741	5,1972	.707	7,1974	.707	4,1974	.690
8	7,1972	.741	5,1974	.724	8,1973	.724	5,1972	.707
9	4,1972	.707	3,1973	.690	6,1972	.672	5,1974	.655
				1973				
1	5,1973	.724	5,1972	.672	4,1972	.655	5,1974	.655
2	6,1973	.690	9,1974	.690	6,1974	.672	3,1974	.621
3	7,1973	.707	5,1973	.690	9,1972	.690	4,1972	.672
5	5,1972	.724	1,1973	.707	7,1974	.707	3,1973	.690
6	2,1973	.690	7,1973	.655	7,1974	.655	3,1973	.638
7	8,1973	.741	4,1974	.724	7,1974	.724	3,1973	.707
8	7,1973	.741	7,1974	.724	8,1972	.724	9,1974	.707
9	7,1973	.672	9,1974	.672	4,1974	.655	2,1972	.638
				1974				
1	1,1972	.707	5,1974	.638	4,1973	.621	2,1973	.586
2	8,1974	.724	4,1972	.707	6,1974	.707	5,1974	.672
3	3,1973	.655	4,1974	.655	2,1974	.638	2,1973	.621
4	7,1973	.724	7,1972	.690	9,1974	.690	3,1973	.672
5	8,1972	.724	4,1972	.707	4,1973	.707	7,1974	.707
6	8,1974	.741	9,1974	.724	2,1974	.707	2,1973	.672
7	5,1973	.724	7,1973	.724	8,1973	.724	8,1974	.724
8	9,1974	.776	6,1974	.741	2,1974	.724	4,1972	.724
9	8,1974	.776	6,1974	.724	7,1973	.707	7,1974	.707

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Table 4. List of shore beetles collected in the Little Auglaize Watershed, 1972-1974. Number(s) following the species name show the station(s) at which it was collected; the letter A indicates the species was collected at all nine stations. Species most commonly collected are indicated by *, and species apparently not reported previously from Ohio are indicated by +.

CICINDELIDAE

Cicindela repanda Dejean (1)
C. duodecimguttata Dejean (1,5)

CARABIDAE

*_Bembidion rapidum_ LeConte (A)
*_B. patruele_ Dejean (A)
+_B. frontale_ LeConte (7,8)
*+_B. graciliforme_ Hayward (2,4,6,9)
*+_B. impotens_ Casey (A)
*_B. inaequale_ Say (1,2,5,6)
+_B. texanum_ Chaudoir (8)
*_B. variegatum_ Say (2,6,8,9)
*_B. versicolor_ LeConte (A)
B. mimus Hayward (1,2,3,4,6,9)
*+_B._ sp. (A)
+_Tachys anceps_ LeConte (1,6)
+_T. coruscus_ LeConte (1,6,7,8,9)
+_T. incurvus_ Say (1,2,3,5,8,9)
+_T. obliquus_ Casey (2,6,7,8,9)
T. proximus Say (8,9)
+_T. saturatus_ Casey (1,2,4,8)
*+_T. scitulus_ LeConte (1,2,3,4,6,7,8,9)
*+_T. vivax_ LeConte (1,3,4,5,6)
Chlaenius sericeus Forster (8)
Clivina bipustulata Fabricius (7,9)
C. impressifrons LeConte (3)
Dyschirius sphaericollis Say (1)
D. haemorrhoidalis Dejean (1,2,3,7)
Omophron americanum Dejean (1,2,7)
Stenolophus ochropezus Say (1,3,6,7,8,9)
S. lecontei Chaudoir (1,3)
S. comma Fabricius (8)
Bradycellus sp. (7)
Acupalpus sp. (2,8)
Agonum extensicole Say (8)
A. ferreum Haldeman (8)
*_Elaphrus ruscarius_ Say (1,2,3,4,5,6,8,9)
Patrobus longicornis (Say) (1)
Stenocrepis cuprea Chaudoir (1)
Abacidus permundus Say (7,8)

HALIPLIDAE

Peltodytes endentulus (LeConte) (1)
P. duodecempunctatus (Say) (1,2,3,6,7,9)

DYTISCIDAE

Bidessus sp. (4)
Brachyvatus sp. (3)
Copelatus sp. (2)
Hydrovatus sp. (1)
Hygrotus sp. (6)
Laccophilus maculosus Say (1,2,3,4,6,9)

HYDROPHILIDAE

Enochrus perplexus (LeConte) (2,3,6,9)
E. pygmaeus complex (3,9)
Crenitis sp. (3,8)
Helochares sp. (8,9)
Cercyon sp. (3,4,6)
Laccobius sp. (1,2,4,5,6,7,9)
Helophorus sp. (A)
Berosus sp. (2,3,9)
Tropisternus sp. (2,5,9)
Paracymus sp. (2,3,4,5,6,8,9)

STAPHYLINIDAE

*+_Acylophorus flavicollis_ Sachse (2,3,4,6,7,8,9)
Acylophorus sp. (pronus group) (2,3)
+_Erichsonius nanus_ Horn (2,3,4,6,8,9)
*_Homeotarsus bicolor_ Gravenhorst (A)
+_Lobrathium grande_ (LeConte) (9)
Lobrathium sp. (1,9)
*+_Neobisnius agnatus_ Erichson (A)
*+_N. paederoides_ LeConte (1,2,3,4,5,6,9)
+_Platystethus cornutus_ Gravenhorst (2,3)
*+_Psephidonus brunneus_ Say (A)
*+_Philonthus flavolimbatus_ Erichson (A)
Philonthus sp. (2,4,6)
*_Carpelimus_ sp. #1 (A)
*_Carpelimus_ sp. #2 (A)
Deinopsis sp. (2)
Olophrum sp. (8)
Oxytelus insignitus Gravenhorst (9)
Tachyporus sp. (4)
*_Stenus_ spp. (A)
Aleocharinae spp. (1,2,3,4,6,9)

SCARABAEIDAE

Ataenius sp. (2,6,7,8,9)

ELMIDAE

Dubiraphia sp. (3)

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Table 4 (Continued)

HETEROCERIDAE

*_Lanternarius mollinus_ (Kiesenwetter) (A)
Centuriatus auromicans (Kiesenwetter) (1,5)
*_Dampfius collaris_ (Kiesenwetter) (1,2,3,4,5,6,7,9)
*_D. undatus_ (Melsheimer) (A)
+_Neoheterocerus sandersoni_ Pacheco (2,3,6)
+_N. pallidus_ (Say) (6)
*+_N. longilobulus_ Pacheco (A)
*_Tropicus pusillus_ (Say) (1,2,3,4,5,6,8,9)
*_Lapsus tristis_ (Mannerheim) (3,7,9)

The largest numbers of species and individuals were distributed in three families: Carabidae, Heteroceridae, and Staphylinidae. The species in these three major groups were further analysed to determine their relationships. To simplify computation, any rare species (15 or fewer individuals) were eliminated, resulting in a total of 26 remaining species. These are indicated in Table 4 by an asterisk (*).

The Little Auglaize Watershed is a poorly collected area and several species were collected in this study, which, as far as could be determined, had not previously been reported from Ohio. These species are indicated in Table 4 by a +.

One species, *Lapsus tristis* (Heteroceridae), was not collected at six of the nine sites and was the only species not collected at site 6 (West Branch). Seven of the 26 species were not collected at site 7 (Hagerman Creek).

DISCUSSION

In a series of sites, 1, 2, 3, 16, 25 up to 37 years post-channelization, various seral stages of succession should have been evident. In fact, however, the quantitative results of the study did not show distinct evidence of succession. Site 5, which was actually being channelized during most of the study period, had low numbers of species and individuals present. However species diversity index values (Margalef's index) were never extremely low in comparison to the other sites, and although the Shannon index values obtained did indicate an unequal distribution to individuals among species, the inequality was not extreme.

The oldest site, 4 (37-39 years post-channelization) showed some of the lowest diversity values; the lowest Shannon diversity (1.62) of the study was computed at this site in 1974 (Table 2). This was contrary to what would have been expected had the community been undergoing succession in the classic pattern.

When all sites were compared on the basis of quantitative results, no definite patterns of change in the progression from younger to older sites were evident. In an analysis of variance there was no significant difference among the sites, nor was any significant difference shown in analysis of sites pooled into groups based on age.

The qualitative comparisons of actual species present and numbers of individuals in each of these species likewise did not show evidence of succession. Sites of a similar age should have had high Coefficient of Similarity values indicating that the composition of their shore beetle communities was similar. Sites 1 and 5 should have had high C.S. values as they were both only a few years post-channelization, and sites 6, 8, and 9 should have been similar as all were last channelized in 1949. As can be seen in Table 3, this was not necessarily true.

Sites 8, 1974, and 9, 1974, did have the greatest similarity of species composition (0.776) but otherwise there were younger and older sites which had degrees of similarity to any particular site as great or greater than the other sites in an age group. In the table of most similar sites there did not appear to be any pattern of grouping by time post-channelization. In fact, in terms of species make-up of the shore beetle community, all of the sites were fairly similar, only a few comparisons (not shown on table) produced C.S. values less than 0.500.

Some interesting relationships among the species of the three most abundant families (Carabidae, Heteroceridae, Staphylinidae) were observed. In many instances, if a particular species was collected at a site, another particular species would also be found, thus

Table 5. Species always found in association with one another, indicated by X. This table was compiled from the 26 most commonly collected species.

	Neoheterocerus longilobulus	*Lanternarius mollinus*	*Dampfius undatus*	*Bembidion patruele*	*B. impotens*	*B. versicolor*	*B.* sp.	*Neobisnius agnatus*	*Philonthus flavolimbatus*	*Psephidonus brunneus*	*Homeotarsus bicolor*	*Stenus* sp.	*Carpelimus* sp. #1	*Carpelimus* sp. #2
Neoheterocerus longilobulus	-	X		X	X	X	X	X	X			X	X	X
Lanternarius mollinus	X	-	X	X	X		X	X	X	X	X	X		
Dampfius undatus		X	-	X	X	X	X	X			X			X
Bembidion patruele	X	X	X	-		X	X	X	X	X	X		X	
B. impotens	X	X	X		-		X	X					X	
B. versicolor	X		X	X		-	X	X						
B. sp.	X	X	X	X	X	X	-	X		X	X		X	
Neobisnius agnatus	X	X	X	X	X	X	X	-		X		X		X
Philonthus flavolimbatus	X	X		X					-			X		X
Psephidonus brunneus		X		X			X	X		-	X	X		
Homeotarsus bicolor		X	X	X			X			X	-			
Stenus sp.	X	X						X	X	X		-		
Carpelimus sp. #1	X			X	X		X						-	
Carpelimus sp. #2	X		X					X	X					-

forming pairs of species always found together (Table 5). Interestingly, reverse pairing did not always occur, i.e., the second member of a pair could be present in the absence of the first. Possibly both species of a pair shared a similar range of tolerance to certain environmental conditions, but the second species had slightly broader limits allowing it to exist when or where the first could not. When all of the species pair associations for all sites during the three year period were analyzed it was found that five species: *Neoheterocerus longilobulus, Lanternarius mollinus, Bembidion patruele, B.* sp., and *Neobisnius agnatus* were always found in association with one another. When one species was present, the others were also present.

There were also pairs of species which did not occur together (Table 6). When the first species of the pair was present at a site, the other species was never collected at that time (the second species may have been collected at the site at a different time, but if so, the first species was not present). When all of these associations were analyzed it was found that there were three species, *Bembidion inaequale, Bembidion variegatum,* and *Lapsus tristis,* which were never in association. Some factor(s) favorable to any one of the species apparently was unfavorable to either of the other two.

The relationships did not appear to be the results of seasonal "peaks" in population nor did there appear to be any correlation between channelization of the sites and either

Table 6. Species not found in the presence of one another. This table was compiled from the 26 most collected species.

Neobisnius paederoides *Bembidion inaequale*	*Bembidion graciliforme* *Bembidion inaequale*
Acylophorus flavicollis *Bembidion inaequale*	*Carpelimus* sp. #1 *Bembidion variegatum*
Bembidion variegatum *Bembidion inaequale*	*Bembidion graciliforme* *Tachys vivax*
Lapsus tristis *Bembidion graciliforme*	*Bembidion variegatum* *Tachys vivax*
Lapsus tristis *Bembidion variegatum*	*Lapsus tristis* *Bembidion inaequale*
Acylophorus flavicollis *Bembidion variegatum*	

the positive or negative species associations. Both relationships existed at sites regardless of the age of the site.

The results of neither the quantitative nor the qualitative data appeared to show any definite relationships between the shore beetle community and channelization. In fact, within a few weeks after the extreme destruction of a stream shore by the channelization process, shore beetles had recolonized the area, and although fewer individuals were present, the composition of the community was essentially the same as those of streams not channelized for 30-40 years. Never more than 19 species were collected at site 5, the area of active channelization during 1972-73 (only 13 in 1972), but at site 1, 32 species (equaling the study high) were collected during the first year post-channelization, and this high species diversity continued over the following years. Although site 5 did superficially appear to differ in species composition from the other sites, statistically it was shown that there was no real difference.

On the basis of the results of the study it would appear that channelization of streams was not a major long term disruptive influence on the shore beetle community, and that succession in the sense of a series of seral stages eventually reaching a climax community did not occur.

The shore beetle community exists in the restricted habitat of the stream margin, the zone of inhabitation extending only a few inches either way from the water-shore interface. Small ecological changes such as humidity and soil moisture levels can alter the limits of the zone. It may seem surprising then, that after a major ecological change such as the massive disruption of channelization, that the shore beetle community could return virtually intact. Perhaps, however, this is not as unusual as it would seem. Each spring the habitat is completely inundated by flood water for periods of up to two weeks and after the water has subsided the area is quickly recolonized. Another extreme may occur in late summer and early fall when the streams may dry up completely. Even after a summer flash flood, in the height of seasonal insect activity, the shore beetle community appears to return to normal within a few days.

It would seem that the shore beetle community is subject to frequent periodic disruption and for this reason could be pre-adapted to a man-made event such as channelization. These species may be thought of as "perennial pioneers" adapted to rapid recolonization of an area after disruption. If this is the situation, then no important successional stages would occur after channelization because in fact, the community is adapted to this type of event. Also, if the effects of channelization on the community do not differ greatly from the effects of a natural event such as a flood or drought, then channelization would not actually be as great a disruptive force as it might appear.

It is proposed then, that the shore beetle community found in the Little Auglaize Watershed is a community made up of "perennial pioneer" species which, although closely tied and restricted to a narrow ecological zone of habitation at the water-shore interface, are also adapted to rapid recolonization of this area after major disruptions.[3]

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[3]Complete data are available in Holeski (1976).

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