Changes in the Downstream Insect and Amphipod Fauna Caused by an Impoundment with a Hypolimnion Drain[1]

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ABSTRACT

Mill Creek, a small stream in southwestern Wisconsin, was impounded to create a 150-acre recreational lake. This action had a pronounced effect on the insect and amphipod fauna of a riffle 600 ft below the dam, and also affected the fauna of a riffle 2 miles downstream. Prior to impoundment both riffles were inhabited by a diverse insect fauna that included mostly Ephemeoptera, Trichoptera, Diptera, and Coleoptera. After impoundment the reduction of the number of species in the upstream riffle was highly significant, and previously dominant families such as Baetidae (Ephemeroptera), Hydropsychidae (Trichoptera), and Elmidae (Coleoptera) were replaced mostly by increased populations of *Simulium vittatum* Zetterstedt (Diptera), *Gammarus pseudolimnaeus* Bousfield (Amphipoda), and *Chironomus* and other genera of Chironomidae (Diptera). The impoundment affected the downstream riffle similarly, but to a lesser degree. Large increases in phosphorus and nitrogen concentrations and increased siltation as a result of impoundment were probably the most important factors in altering the insect and amphipod populations.

The damming of small streams to create recreational lakes has become an increasingly common practice and its effects on the insect fauna need to be documented. When the Wisconsin Department of Natural Resources decided to impound Mill Creek, a study was initiated to determine if this action would affect the insect and amphipod fauna in the stream below. Mill Creek is a hard-water stream (total alkalinity ca. 200 ppm) in Iowa County, Wis. It was dammed near the eastern edge of Governor Dodge State Park to form a 150-acre reservoir within the park. The 12-square-mile drainage area above the reservoir is composed mostly of forested land and abandoned cropland, and contains a smaller reservoir, Cox Hollow Lake. The study was begun more than 1 year before the dam was completed, and continued for 4 years. Concurrent studies of fish populations, nutrients, vegetation, and physical characteristics of the stream were carried out by Wirth et al.[2]

METHODS AND MATERIALS

Two riffles were selected as sampling sites. The upper riffle was 600 ft below the proposed dam site and the lower riffle was 2 miles downstream. This portion of the stream runs through a pastured valley with very little bank cover, and has an average width of 15 ft and depth of 1 ft. Samples were collected with a D-frame aquatic net (Wards Scientific Establishment) by disturbing the bottom above the net and allowing organisms to float into it. This procedure was carried out across the entire stream to assure a representative sample. The sample was then placed in a white pan along with a little water, and all the insects and amphipods that could be found within 30 min were placed in 70% ethanol and returned to the laboratory for identification and enumeration. Representatives of the fauna have been deposited in the University of Wisconsin Collection.

Two samples were collected from each riffle in May, August, and December, from December 1965 through August 1969. The impoundment was completed late in 1966 and gradually filled in the spring of 1967, becoming full late in May 1967, at which time the hypolimnion drain became operational.

RESULTS AND DISCUSSION

Studies by Wirth et al.[2] showed that several changes in the chemical and physical characteristics of the stream resulted from its impoundment. These changes can be summarized as follows.

Chemical Changes.—The dam was constructed so that water from the hypolimion falls 33 ft to a concrete spillway and becomes saturated with oxygen. Dissolved oxygen levels remain at or near saturation except on some summer nights, when they drop to ca. 4.5 ppm. The lowest dissolved oxygen concentration (3.0 ppm) was recorded one night it July 1967. The only significant changes in water chemistry following impoundment were the large increases in total phosphorus and total nitrogen. Before impoundment total P in the stream averaged 0.08 ppm

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[2] T. L. Wirth, R. C. Dunst, and P. D. Uttormark. Effect of bottom water discharge upon a downstream channel. Unpublished manuscript (21 p.).

during the summer months, and total N, 0.77 ppm. During the summer immediately following impoundment (1967) levels of P and N averaged 1.24 and 3.16 ppm, respectively, and copious amounts of slime bacteria appeared in the upper riffle. Concentrations of P and N declined to 0.58 and 1.37 ppm, respectively, 2 summers later and slime bacteria were no longer present, but these concentrations were still much higher than prior to impoundment.

Physical Changes.—Maximum summer water temperatures were reduced by 2–3°C in the lower riffle and more in the upper riffle. In the winter the water was warmed to ca. 4°C in the region of the upper riffle, preventing the formation of ice, but the lower riffle was not affected and ice covered much of that section of the stream as it had previously. The 1st summer after impoundment, vegetation: *Elodea canadensis* Michx., *Potamogeton crispus* L., *P. foliosus* Raf., and *Ranunculus trichophyllus* Chaix., almost completely covered the stream, but by 1969 it covered only 30–50% of the stream and was only slightly more prevalent than before impoundment. Increasing amounts of silt were also noticed after impoundment, especially in the vicinity of the upper riffle. Silt deposition resulted from the control of runoff water by the dam and the prevention of scouring floods.

Biological Changes.—Each of the physical and chemical changes probably affected the insect and amphipod fauna. Seventy-eight taxa of insects and amphipods were collected during the study. They were identified to species whenever possible, but the larvae of many of the insects are unknown at the species level. In the Diptera, only the Simuliidae and Rhagionidae could be named to species and in the Trichoptera, none of the species could be named with certainty. Three species of *Hydropsyche* were identified, but the larvae of several species are unknown, so these identifications must be regarded as tentative. The identification of species of Ephemeroptera must also be considered tentative because the nymphs of many species are undescribed.

An analysis of variance of the number of insect taxa present before and after impoundment showed a highly significant decline in the upper riffle and also during December in the lower riffle (Table 1). Populations of taxa of which 50 or more individuals were collected during the study are included in Table 2. Preimpoundment populations (December 1965 to August 1966) were compared (Table 2) with postimpoundment populations (December 1967 to August 1968, and December 1968 to August 1969) by a 2-tailed t-test of paired observations (data transformed by $X + \frac{1}{2}$). A perusal of this table shows that impoundment caused significant changes in the fauna, especially in the upper riffle. The important changes that occurred in each order are illustrated in Fig. 1 and summarized as follows.

Ephemeroptera.—Of the 10 species that were collected, only *B. brunneicolor* and *B. cingulatus* were commonly encountered (Table 2), the nymphs being collected primarily in May and August. Both species disappeared from the upper riffle in May 1967, when the impoundment was being filled. In May 1969, some *B. brunneicolor* were again found in the upper riffle, and numbers in the lower riffle increased significantly in May and August of the last year of the study.

Trichoptera.—Six genera of Trichoptera were found, but only *Hydropsyche* and *Cheumatopsyche* larvae were common (Table 2). The latter could not be identified beyond genus. The effect of the impoundment on the hydropsychid fauna of the upper riffle was dramatic; they were not collected after May 1967 except for 2 *H. betteni* in August 1969. The decline in larval numbers in the lower riffle after impoundment was neither as abrupt nor as pronounced, but there was a highly significant decline in the population of *H. bifida* and a significant decline in numbers of *Cheumatopsyche* larvae.

Coleoptera.—Of the 9 species that were collected, only 2 were numerous. Both were Elmidae, and their populations were severely affected by the impoundment (Table 2). They completely disappeared from the upper riffle, and their numbers were much reduced in the lower riffle.

Diptera.—The family Chironomidae was represented in this stream by 24 genera, 10 of them numerous enough to be included in Table 2. Most seemed to be unaffected by the impoundment, but at least 1 species of *Chironomus* became abundant in the upper riffle immediately after impoundment, and was the dominant taxon in August and December of 1967 when slime bacteria were present.

Of the other Diptera, *S. vittatum* was the most abundant species, and its numbers increased significantly following impoundment (Table 2). The only other species of *Simulium* in Mill Creek, *S. venustum* Say, was found infrequently (14 in 4 samples) in the upper riffle before impoundment, but not afterwards. The larvae of *A. variegata* and *Tipula* spp. disappeared from the upper riffle following impoundment.

Amphipoda.—Only 2 species were encountered (Table 2). There was a significant increase in the numbers of *G. pseudolimnaeus* in both the upper and lower riffles, and *H. azteca* became fairly common in the lower riffle about a year after the stream was

Table 1.—Comparison of the numbers of taxa of insects in samples collected from Mill Creek before and after impoundment.[a]

Month	Riffle	Mean no. taxa		Variance	F[b]
		Before	After		
December	Upper	16.50	9.25	4.0	26.6**
December	Lower	21.25	15.50	4.3	15.4**
May	Upper	15.00	8.25	2.8	32.7**
May	Lower	19.50	18.50	11.0	0.2
August	Upper	19.50	11.00	1.4	77.4**
August	Lower	17.00	17.67	8.2	.1

[a] December 1965 and 1966 compared with December 1967 and 1968. May 1966 and 1967 compared with May 1968 and 1969. August 1966 compared with August 1967, 1968, and 1969.
[b] ** Significantly different at the 1% level of probability.

Table 2.—Totals of insects and amphipods in the most common taxa collected in December, May, and August from 2 riffles in Mill Creek before, during, and after impoundment.[a]

Taxon	Riffle[b]	Before	During	Months after 7–15	Months after 19–27
EPHEMEROPTERA					
Baetidae					
Baetis brunneicolor McDunnough	U	21	0	0	10
	L	12	27	22	118*[c]
B. cingulatus McDunnough	U	42	0	0	0
	L	75	130	162	45
TRICHOPTERA					
Hydropsychidae					
Cheumatopsyche spp.	U	22	22	0	0
	L	183	202	126	27*
Hydropsyche betteni Ross	U	177	81	0**[c]	2**
	L	75	42	66	34
H. bifida Banks	U	8	2	0**	0**
	L	216	63	33*	15**
H. slossonae Banks	U	24	21	0*	0*
	L	6	2	1	5
COLEOPTERA					
Elmidae					
Optioservus fastiditus (LeConte)	U	79	16	0**	0**
	L	200	184	44	18
Stenelmis crenata (Say)	U	63	1	0**	0**
	L	60	82	17*	7*
DIPTERA					
Chironomidae					
Chironomus spp.	U	0	508	345	3
	L	0	29	6	0
Cricotopus sp. A	U	2	4	79	2
	L	0	1	5	6
Cricotopus sp. B	U	2	16	0	0
	L	0	12	6	22
Diamesa spp.	U	59	203	38	147
	L	129	107	43	107
Dicrotendipes spp.	U	0	32	1	0
	L	0	1	25	0
Micropsectra spp.	U	5	80	239	41
	L	6	4	11	1
Orthocladius spp.	U	74	54	66	210*
	L	39	19	33	38
Pentaneura spp.	U	5	21	3	16
	L	1	8	11*	1
Polypedilum spp.	U	4	2	4	40
	L	1	10	4	0
Stictochironomus spp.	U	0	6	25	0
	L	0	1	30	1
Tanytarsus spp.	U	3	3	2	13
	L	2	5	18**	25
Rhagionidae					
Atherix variegata Walker	U	80	7	0	0
	L	64	6	0	1
Simuliidae					
Simulium vittatum Zetterstedt	U	173	336	901	742*
	L	307	89	453	636*
Tipulidae					
Dicranota spp.	U	1	20	24*	4
	L	36	22	11	8
Tipula spp.	U	14	8	0	0
	L	10	14	10	4
AMPHIPODA					
Gammaridae					
Gammarus pseudolimnaeus Bousfield	U	34	...	50	132**
	L	77	...	179	296*
Talitridae					
Hyallela azteca (Saussure)	U	0	...	1	1
	L	0	...	12	44

[a] Before = December 1965–August 1966. During = December 1966–August 1967 (August samples after impoundment was full). After 7–15 months = December 1967–August 1968. After 19–27 months = December 1968–August 1969.
[b] U = upper; L = lower.
[c] * Significantly different from before impoundment samples at the 5% level of probability; ** significantly different from before impoundment samples at the 1% level of probability.

dammed. In August 1967, immediately after impoundment, *G. pseudolimnaeus* was not found in the upper riffle.

SUMMARY

The creation of an impoundment on Mill Creek caused pronounced changes in the insect and amphipod fauna of the upper riffle and significant but more

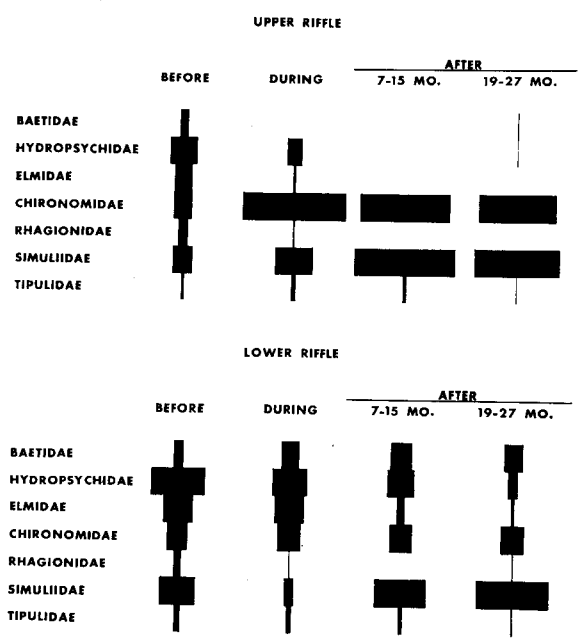

FIG. 1.—Changes in the numbers of insects in the dominant families before, during, and after the impoundment of Mill Creek.

subtle changes in the fauna of the lower riffle, 2 miles downstream. The immediate impact on the upper riffle was dramatic, with many species disappearing and *Chironomus* spp. and *S. vittatum* completely dominating the fauna. There was a tendency for a few species to reappear in reduced numbers 2 years later, but the fauna of this riffle continued to be dominated by dipterous larvae and amphipods. In the lower riffle, the numbers of several species declined gradually after impoundment, while a few became more abundant. These changes were most probably related to increases in the nutrient level and siltation of the stream as a result of impoundment, which in turn caused increased vegetation and occasional reductions in dissolved oxygen concentrations. Changes in summer and winter water temperatures may have also contributed to observed changes in the fauna of the upper riffle. Although favoring Amphipoda, *S. vittatum,* and some genera of Chironomidae, the impoundment of Mill Creek was definitely detrimental to populations of Hydropsychidae, Elmidae, and a few species of Diptera. It also resulted in a highly significant decline in the number of taxa present in the upper riffle.

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