

Plecoptera of the Ohio River: Community Composition and Species Phenologies of Nymphs Collected Near Cincinnati, Ohio¹

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ABSTRACT. Community composition of the nymphal stoneflies of the Ohio River was determined by sampling with artificial substrates at 5-week intervals from January-December, 1979, near Cincinnati, Ohio. Seven species were collected from this large river. *Isoperla bilineata*, *Perlesta placida*, and especially *Taeniopteryx burksi* were abundant at certain times of the year. Determinations of nymphal maturity, using body length measurements and wing development, coupled with the presence/absence of the various species in the samples, indicated that *P. placida* has a very short growth and maturation period. *Taeniopteryx burksi* and *P. placida* exhibited extended diapause periods in their life cycles. A comparison of the present-day stonefly composition in an Ohio River that has been modified by the placement of high-level dams, with that of the plecopteran composition in the early 1930s (low-level dams in place), showed no marked changes in community composition. Since the low-level dam navigation system was completed in the late 1920s, either the stonefly fauna has remained comparatively unaffected by damming, or any marked faunal changes had already taken place by the early 1930s as a consequence of the placement of the low-level dams.

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INTRODUCTION

Considerable research on plecopteran life cycles and community composition has taken place over the past 15 years. Species distribution and seasonal succession patterns have been delineated regionally (Doddall and Lehmkuhl 1979, Harper 1973a, b, Harper and Hynes 1972, Harper and Magnin 1969, Harper and Pilon 1970), statewide (USA) (Frison 1935, Hilsenhoff and Billmyer 1973, Stark 1979, Stewart et al 1976), and for a single stream (Neves 1978). However, since stonefly species richness seems to peak in small to medium-sized lotic systems, and because smaller systems are much easier to sample, the species composition and life cycles of plecopterans in large rivers remain relatively uninvestigated. Very large, navigable rivers have been especially overlooked, with Frison's study (1935) of Illinois stoneflies remaining the most comprehensive treatment of stoneflies in such rivers in the United States. Consequently, I used artificial substrate samplers collected approximately every five weeks in 1979 to determine the species composition of stonefly nymphs in the Ohio River, one of the largest rivers in North America. This collection of samples on a regular basis throughout the year allowed determination of overall species composition and also observation of the phenological patterns of the more commonly collected species.

Frison's study (1935) of Illinois stoneflies included Ohio River collections made in 1928-1934. At that time flow had been modified by the placement of 50 low-level dams along the length of the river. Today, 20 dams (mostly high-level) have replaced the previous low-level system, increasing the depth of the "pools" and further slowing current velocities at low river discharges. In this paper I compare the nymphal stonefly composition of the Ohio River, as determined by Frison, with that of the present-day fauna.

MATERIALS AND METHODS

STUDY AREA. The Ohio River is formed by the confluence of the Allegheny and Monongahela rivers at Pittsburgh, Pennsylvania. It flows 1578 km in a southwesterly direction, joining the Mississippi River at Cairo, Illinois. At its point of confluence with the Mississippi River the average discharge carried by the Ohio River is twice that of the Mississippi River. The drainage basin of the Ohio River includes 422,170 km² (excluding the Tennessee River drainage) and portions of 11 states.

The collection sites, used in sampling stoneflies at 5-week intervals during 1979, were situated slightly upstream of Cincinnati, Ohio, about halfway from the origin of the river to its confluence with the Mississippi. In 1979, river discharge at these sampling locations ranged from a high of 15,451 m³/sec in March to a low of 969 m³/sec in July. With its north temperate location the Ohio River shows a wide annual range of temperatures. In 1979, river temperatures at the sampling sites ranged from -0.2° C (18 and 19 February) to 28.9° C (12 August) (Fig. 1). A system of locks and dams (21 dams in 1979, 20 dams at present) over the length of the river maintains a navigational channel for year-round transport. At higher discharges the dams do not impede river flow, and the current velocity is close to that of natural conditions. At lower flows, however, the dams transform the river into a continuous series of "pools" with current velocities much reduced from natural conditions (United States Army Corps of Engineers 1980). Some current remains through the system even at low flows, however, and thermal stratification does not occur. The construction of 50 low-level dams (completed in 1929) and the present use of the high-level dams have markedly changed the character of the river at low flows. The deep "pools" now cover what previously had been exposed and shallow-water sand and gravel bars. Rock and stone riffles present in the "natural" (pre-impoundment) Ohio River have also been eliminated.

SAMPLING METHODS. The depth of large rivers such as the Ohio precludes the use of kicks, Surber, or Hess samplers for collecting nymphs. Grab samplers are also ineffective as stonefly nymphs are generally not present in the bottom substrates of the river. In a 4-year (1963-1967) macroinvertebrate study conducted by the U.S. Environmental Protection Agency, which encompassed nine sampling sites over the length of the Ohio River, not a single stonefly nymph was collected using benthic grab samplers (Mason et al 1971). Frison (1935) found that the best way to sample nymphs in large rivers was to rake up debris accumulated on the bar racks of hydroelectric plants. He commented that "nymphs of practically every species occurring in the river lodge in the mass of waterlogged leaves, branches, and trash which gather at the bottom of these racks," and that such collecting "has afforded series of many large river species which can be obtained only rarely by other means." I therefore employed a fairly similar sampling method, using rock baskets (filled with rocks, porcelain balls, and twigs) and Hester-Dendy multiplate samplers to collect stonefly nymphs on 10 sampling dates throughout 1979. A total of

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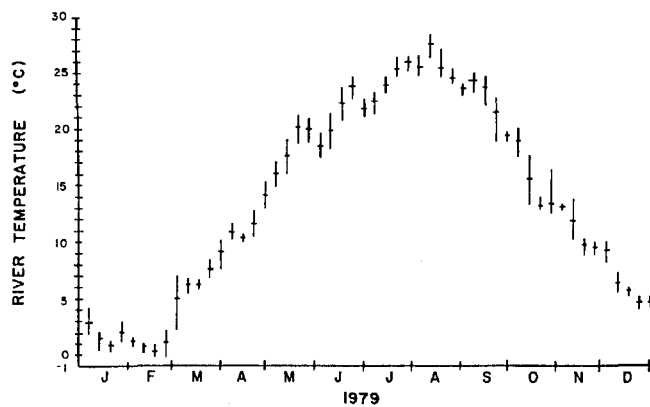


FIGURE 1. Ohio River temperatures at Cincinnati, Ohio, 1979. Each line shows weekly maximum temperature (high point of line), weekly minimum temperature (low point of line), and weekly mean temperature (horizontal mark crossing line). Data from the Ohio River Valley Water Sanitation Commission.

four rock-basket samplers and four multiplate samplers were suspended about 1 m below the surface of the river for colonization during each of the sampling periods. Depth at the samplers ranged from 3 to 15 m, depending on the sampling site and river stage. With the exception of the 28 March collections from samplers placed on 20 February, each of the colonization periods consisted of time elapsed from the previous collection date (i. e., as the "old" colonized samplers were retrieved, new samplers for colonization were placed in the river for later collection). The first collection on 27 January 1979 came from samplers placed in the river on 19 December 1978. Sampler collection dates are listed in Table 1.

The January, early and late March, and May samplers were all located at the Ohio River Launch Club (ORLC) (river km 750.1) near Cincinnati, Ohio. The June through November samplers were collected at the ORLC, the California Yacht Club (CYC) (river km 743.8), and the Cincinnati water (intake) tower (WT) (river km 744.6) Samples for December were collected from the ORLC and the WT. All samplers were recovered with the exception of those for 6 March (1 rock-basket sampler (RB) and 3 Hester-Dendy multiplate

samplers (HD) recovered), 21-27 August (3 RB and 2 HD recovered), and 2-5 October (2 RB and 3 HD recovered).

The wire rock-basket samplers were similar to those described by Mason *et al.* (1967) and Fullner (1971), and had a length of 250 mm and a diameter of 166 mm. The contents of each basket included about 26 limestone rocks, six porcelain balls, and two bundles of wooden twigs (three twigs per bundle). Each multiplate sampler consisted of a series of eight masonite plates separated by a varying number of washers (spacing varied within the sampler; all samplers were of identical configuration and spacing). Each plate measured 100 mm by 100 mm and was 3.5 mm thick. Both sampler types were suspended using 3.2-mm (diam.), steel aircraft cable, with a multiplate sampler positioned immediately below each rock-basket sampler.

After retrieval each sampler was placed in a separate plastic container and taken to the laboratory, where the samplers were disassembled, surfaces were "scraped" with a small brush, and stoneflies were collected with a U.S. Standard 60 sieve (openings = 250 μ m). Nymphs present on the mesh of the rock-baskets were included in the samples along with the stoneflies collected from the substrates within the baskets. Samples were preserved in 70% ethyl alcohol and stained with rose bengal (Mason and Yevich 1967) to facilitate picking.

Some stonefly collections shown in Table 1 are from years other than 1979, and were collected from the Ohio River on multiplate samplers between river km 646.8 and 655.7. The 5 November 1979 samples were collected from multiplate samplers placed at the Meldahl Dam (river km 701.8) (Beckett and Miller 1982).

LABORATORY METHODS. After identification, the maturation of each stonefly nymph was determined by measuring body length (see Brittain 1983) and evaluating wing development. Body lengths (mm) were measured from the most anterior point of the head (excluding the antennae) to the posterior tip of the abdomen (excluding the cerci). For each sampling date a mean body length was determined for each species collected. Wing development was judged subjectively, with a value of 0 given to each nymph in which wing pads were not present, a value of 1 to nymphs that possessed wing pads, although the wings were not well-developed, and a value of 2 to each nymph that possessed well-developed wings. A mean wing development figure was then computed for each of the collected species on each sampling date. A computed mean wing development of 2.0 would therefore indicate that on that date all nymphs of that species possessed well-developed wings (Table 1). Phenological patterns of the more commonly collected species were ascertained by examining nymphal development data and following the presence/absence of the species in the samples.

TABLE 1

Stonefly nymph collections on artificial substrates in the Ohio River near Cincinnati, Ohio for 10 sampling dates in 1979.* Collections by this author from other years or from other Ohio River sampling sites are also shown. Maturity of nymphs indicated as mean body length (MBL, mm)/mean wing development (MWD).

Species	Collection dates, 1979	N	MBL/MWD	Collection dates, other years or other Ohio R. sampling sites		N	MBL/MWD
<i>T. burksi</i>	27 Jan	6	9.3/2.0	5 Nov '79	26	3.0/0.6	
	6-14 Nov	37	3.1/0.5	10 Nov '77	1	5.0/1.0	
	27-31 Dec	162	8.8/1.9	26 Nov '75	1	4.0/1.0	
<i>S. fasciata</i>	28 Mar	2	7.5/2.0	16 Dec '75	1	8.0/2.0	
	27-31 Dec	1	5.5/1.0				
<i>I. bilineata</i>	28 Mar	3	7.2/1.7	15 Apr '81	1	13.5/2.0	
	6-14 Nov	4	2.6/0.0				
	27-31 Dec	7	4.1/0.7				
<i>P. placida</i>	2 May	2	4.0/0.0	27 May '81	1	7.0/1.0	
	1-2 Jun	6	7.4/1.0	1 Jun '76	3	7.8/1.7	
<i>A. abnormis</i>	9-11 Jul	1	6.5/0.0	15 Jun '78	11	9.2/1.8	
	1-2 Jun	1	3.0/0.0				
	9-11 Jul	2	5.5/0.0	8 Aug '78	1	12.5/0.0	
<i>A. evoluta</i>	27-31 Dec	1	15.0/1.0				
<i>Allocapnia sp.</i>	27-31 Dec	1	4.5/1.0				

*Collection dates in 1979 at the Cincinnati sampling sites were 27 Jan, 6 Mar, 28 Mar, 2 May, 1-2 Jun, 9-11 Jul, 21-27 Aug, 2-5 Oct, 6-14 Nov, 27-31 Dec.

RESULTS

Seven stonefly species were collected during 1979: *Acroneuria abnormis* (Newman), *A. evoluta* Klapalek, *Allocapnia* sp., *Isoperla bilineata* (Say), *Perlesta placida* (Hagen), *Strophopteryx fasciata* (Burmeister), and *Taeniopteryx burksi* Ricker and Ross (Table 1). At certain times of the year *I. bilineata*, *P. placida*, and especially *T. burksi* were abundant.

The collection on 27 January 1979 included a number of mature *T. burksi* nymphs (Table 1). The next collection of this species took place on 29 October at Meldahl Dam (river km 701.8) during the course of an experiment involving macroinvertebrate distribution and current velocity (Beckett and Miller 1982). Sampling earlier in the month (2-5 October) near Cincinnati did not produce any *T. burksi* nymphs. The nymphs for the 29 October-5 November period were quite small (see data for 5 November 1979, Table 1), indicating that active nymphal development in the Ohio River begins in late October to early November. Short nymphal lengths and the minor degree of wing development indicated that the nymphs are quite immature in early to mid-November (Table 1). Only one of the nymphs collected on 6-14 November near Cincinnati possessed well-developed wings, and many of the nymphs did not even possess wing pads at this time. December is obviously a time of rapid development for this species, as mean body length was 8.8 mm in late December (compared to 3.1 mm in the November samples), and most of the December nymphs had well-developed wings. Since all of the late January *T. burksi* nymphs were quite mature and this species was not present in the 6 March collections, February is probably the last month in which its emergence takes place.

Small immature *I. bilineata* nymphs first appeared in the Ohio River in early November, grew during the winter, and matured in March and April (Table 1). *Perlesta placida*, a member of the summer fauna, exhibited a very short growth and maturation period. Two immature specimens without wing pads were collected in early May. Marked maturation had taken place by 1-2 June (Table 1) with probable emergence in June, since no specimens were collected in the July samples. *Perlesta placida* data from nymphs collected in 1976, 1978, and 1981 correlated well with those from 1979. Samples from 1 June 1976 and 27 May 1981 showed near equivalent development with the early June 1979 nymphs, whereas the 15 June 1978 nymphs were quite mature (Table 1).

Although only three nymphs of *S. fasciata* were collected during the study, its developmental pattern appears to be similar to *T. burksi*, although lagging (in time) somewhat behind *T. burksi*. *Strophopteryx fasciata* nymphs were collected in the winter (late December) and late March (Table 1). The March specimens showed relatively greater body lengths than the December nymph and had well-developed wings. Small, immature *A. evoluta* nymphs were first collected in early June; this species showed marked growth over the summer (Table 1). The most mature *A. evoluta* nymph was collected on 27 December. The collections of *A. abnormis* and *Allocapnia* sp. indicate the presence of these taxa in the river. However, the collection of only a single specimen of each taxa precludes speculation as to their development in the Ohio River.

Some reports of other stonefly species from the Ohio River have proved to be inaccurate. Records of *Taeniopteryx nivalis* from the Ohio River (Mason et al 1971) have been based on identifications using the key of Frison (1935). A re-examination of these nymphs has indicated that they are really *T. burksi*. A record of *Pteronarcys* sp. from the Ohio River (United States Army Corps of Engineers 1978) is a misidentification; the identity of another nymph collected from the Ohio River and identified as *Atoperla* sp. (= *Perlinella* sp.) (United States Army Corps of Engineers 1978) remains in question.

DISCUSSION

The total of 282 stonefly nymphs collected in this study (262 in 1979, 20 from other samples) may seem rather low in comparison to the total numbers collected in studies of small to medium-sized streams. However, stonefly nymphs are uncommon in macroinvertebrate collections in very large rivers and are not easily collected from such habitats. In the 4-year Ohio River macroinvertebrate study mentioned earlier, the U.S. Environmental Protection Agency (USEPA) used artificial substrate samplers (rock-filled barbecue baskets) and grab samplers (Mason et al 1971). Despite extensive sampling efforts, no stonefly nymphs were collected in the grab samples, and a total of only 31 stonefly nymphs were collected on the artificial substrates (Mason et al 1971). In another study, the USEPA deployed 30 rock basket samplers in the Ohio River near Cincinnati in 1967 and 54 of these samplers in the same location in 1968 (Mason et al 1973). The samplers deployed in 1967 were colonized by a total of 7677 invertebrate individuals, none of which were stonefly nymphs. The samplers placed in the river in 1968 were colonized by 20,464 invertebrates, of which only two were stonefly nymphs. Beckett et al. (1983) found no stonefly nymphs in the benthos of three dike fields, a natural bank, a secondary channel, and an abandoned channel sampled with grab samplers in the Lower Mississippi River over one high flow, two moderate, and two low flow periods in 1979-1980. In comparison to these other studies, the total of 282 stonefly nymphs observed in the present study is relatively large.

Taeniopteryx burksi, a species which is widely distributed over North America (Fullington and Stewart 1980, Stewart et al 1974), was the most abundant stonefly in the Ohio River collections. The two rock-basket samplers collected at the ORLC on 27 December 1979 yielded replicates of 76 and 68 individuals per sampler. All of the other stonefly species never exceeded four individuals per sampler. Frison (1935) found that this winter stonefly was one of the most abundant species in Illinois (*T. burksi* is called *T. nivalis* in Frison's 1935 publication; see Ricker and Ross 1968). A possible reason for its abundance is its adaptability. Nymphs have been collected from a wide range of habitats, including large rivers such as the Ohio (Beckett and Miller 1982, Mason et al 1971, this study) and the Mississippi (Frison 1935), and small sand-bottom streams and slow-moving bayous (Stewart et al 1976). Although this species was collected in the present study in fairly large numbers from an area supporting a substantial current (ORLC), it has also been collected in fairly large numbers from slack waters immediately above an Ohio River dam (Beckett and Miller 1982).

Harper and Hynes (1970, 1972) have shown that in Canada the eggs of *T. burksi* hatch immediately after deposition. The nymphs then proceed through a few early instars followed by an extended nymphal diapause throughout the summer. It is apparent that in the Ohio River this species follows a similar pattern, with the nymphs resuming activity in October or November and the adults emerging from late December into February.

Frison's (1935) statements that *S. fasciata*, another winter stonefly, is less abundant and has a somewhat later emergence date than *T. burksi* in Illinois also hold true for the Ohio River. Only three specimens of *S. fasciata* were collected over the year, with two mature nymphs collected on 28 March.

Isoperla bilineata is a common species in other large rivers, as well as in the Ohio River (Frison 1935, Hilsenhoff and Billmyer 1973). The phenological pattern of *I. bilineata* in the Ohio River appears to fit well with Harper's (1973b) descriptions of the univoltine life cycles of several *Isoperla* spp. in Canada. The adults emerge in spring or early summer, producing eggs which hatch in 1 to 2.5 months. The nymphs grow rapidly over the autumn, develop very slowly during the winter, and then grow rapidly in the spring (Harper 1973b). Frison (1935) similarly described *I. bilineata* as showing its most rapid growth from January to April.

The predictability of the phenology of Ohio River stoneflies is exemplified in *P. placida*, which was common in June macroinvertebrate collections over a number of years (Table 1). In the Ohio River this species exhibits very rapid growth in May and June, with the adults emerging in June. Tkac and Foote (1978) collected *P. placida* as an adult in June and July in northeastern Ohio. *Perlesta placida* is found in lotic systems ranging from large rivers (Frison 1935, this study) to intermittent streams (Harden and Mickel 1952, Snellen and Stewart 1979, Stewart et al 1974). Although it is difficult to conceive of two more dissimilar lotic environments than an intermittent Texas stream (Snellen and Stewart 1979) and the Ohio River, the life cycle of *P. placida* seems to be quite similar in both systems. In the Texas stream, Snellen and Stewart (1979) found that peak emergence of this species occurred in June, followed by the production of eggs which went into a diapause of 5 to 6 months; hatching occurred from October into January. It seems likely that in the Ohio River the eggs diapause for at least 6 months, with hatching occurring in winter or spring.

Acroneuria evoluta (called *A. arida* in Frison (1935)) was also collected from the Ohio River by Frison. He indicated that in Illinois adult *A. evoluta* emerge in early summer. The small, immature specimens collected during the early summer in the present study were probably the offspring of adults that had just emerged recently. Unlike *T. burksi*, *S. fasciata*, and *P. placida*, nymphs of *A. evoluta* seem to be active throughout the year. The *A. evoluta* nymphs from Illinois (Frison 1935), along with the Ohio River samples, results in a collection record for this species that includes all the months of the year except October, January, and February. Although most *Allocapnia* spp. are found in small streams, *A. granulata* (Claassen) is common in large rivers (Frison 1935). The *Allocapnia* nymph collected from the Ohio River in December, 1979 may belong to this species.

The seven stonefly species collected from the Ohio River were less than the number of plecopteran taxa usually collected as nymphs in faunistic studies of streams and small rivers in North America. Monthly sampling of 11 small stream sites in Canada over a 3-year period produced a total of 9 to 18 species of nymphs per site (Harper and Hynes 1972). A similar study of 19 sites in two small Wisconsin rivers (Hilsenhoff et al 1972) produced a total of 8 to 18 species per site (nymphs only). Although one of the Wisconsin rivers had a total of 24 species (from all sites) collected as nymphs, and the other 25, these increased totals were largely a function of the inclusion of a diverse number of habitats sampled over all the study sites. In contrast, the Ohio River is a large, deep river from its origin and does not display such wide habitat diversity.

It is doubtful that increased sampling frequency or effort would have markedly increased the number of species collected in the present study. The 4-year study (1963-1967) of Mason et al (1971) over the entire length of the river produced only four stonefly species: *T. burksi*, *A. evoluta*, *A. abnormis*, and *I. bilineata* (*T. burksi* and *A. evoluta* were reported as *T. nivalis* and *A. arida*, respectively). These species were also collected in the present study.

A comparison of the 1979 results with Ohio River collections from 1928 to 1934 (Frison 1935) showed that the four most common species collected in 1979 (*T. burksi*, *P. placida*, *I. bilineata*, and *A. evoluta*) were also in Frison's (1935) collections from the river. Two species (*Taeniopteryx parvula* Banks and *Neoperla clymene* (Newman)) collected by Frison were not present in the 1979 samples. Whether these species are no longer present in the Ohio River as a result of anthropogenic effects, or were simply not collected with the sampling procedure used in the present study is not known. Although *S. fasciata* and *A. abnormis* were present in the 1979 samples and not in Frison's (1935) collections, it is highly probable that both species were present in the Ohio River at the time of his collections, since both species were collected by Frison in other large, nearby rivers (*S. fasciata* in the Rock and Wabash rivers and *A. abnormis* in the Rock, Illinois, and Mississippi rivers).

The placement of dams on the Ohio River has caused marked changes in its fish populations (Trautman 1981, Pearson and Krumholz 1984) and in the distribution of the macroinvertebrate community (Beckett and Miller 1982). However, the plecopteran community now present in the river seems to be fairly similar in composition to that present in the late 1920s and early 1930s. Since the low-level dam navigation system was completed in the late 1920s, either the stonefly fauna has remained comparatively unaffected by this activity, or any marked changes had already taken place as a consequence of the placement of the low-level dams. The stonefly habitat most affected by impoundment would have been the rock-riffle areas that existed prior to damming (Trautman 1981). Determination of the stonefly composition in other large, navigable North American rivers that have been variously modified (i.e. rivers also impounded by dams: Upper Mississippi River, Arkansas River; rivers not impounded but with flow modified by dikes and revetments: Lower Mississippi River and lower

portions of the Missouri River) could provide interesting insights as to the factors controlling large-river, plecopteran communities.

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