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EMERGENCE PATTERN OF STONEFLIES (PLECOPTERA) IN OTTER CREEK, WISCONSIN[1]

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Until recently, little was known about life cycles of stoneflies in the Great Lakes region. Frison (1935) and Harden and Mickel (1952) reported dates of collections of adult stoneflies in Illinois and Minnesota respectively, and thus suggested emergence patterns for midwestern species. But, as Harper and Pilon (1970) point out, the duration of the emergence period cannot be determined solely from adult collection records because of the relatively long life-span of adults. Recent studies in Quebec (Harper and Magnin 1969, Harper and Pilon 1970) and Ontario (Harper and Hynes 1972, Harper 1973a, 1973b) have added significantly to our knowledge of the life cycles and ecology of eastern Nearctic stoneflies.

With increased emphasis on the use of stoneflies as indicators of water quality, a knowledge of their life histories and ecological requirements becomes very important. We undertook this study to determine emergence patterns and general ecological requirements of Plecoptera in southern Wisconsin. Otter Creek was chosen because it is the only stream in the southern third of Wisconsin with a rich stonefly fauna. It originates from springs in an unglaciated area of Sauk County about 30 miles northwest of Madison (T11N, R6E, S29) and flows south to the Wisconsin River. It is a soft water stream (total alkalinity 14-18 ppm $CaCO_3$) that is low in nutrients (total N 0.12-0.14 ppm and total P 0.02-0.04 ppm) as determined from winter and summer low flow measurements. The portion of the stream that was studied descends 300 feet in 2 miles (Fig. 1) over granite rocks and through a forest of mixed hardwoods and conifers. In this area, levels of dissolved oxygen remain near saturation throughout the year and water temperatures range from $-1°$ to $19°$ C. The pH ranges from 7.2 in winter to 6.2 in summer. Typical flow volumes are 12 ft^3/sec (flow rate 2.0 ft/sec) in spring and 2.8 ft^3/sec (1.5 ft/sec) in summer at site 1, and 0.4 ft^3/sec (1.1 ft/sec) in spring and 0.4 ft^3/sec (0.9 ft/sec) in summer at site 4.

METHODS

Six collection sites were established (Fig. 1). Sites 1, 2, and 3 were 150 ft. sections of stream characterized by rock and gravel pools and rock riffles (Fig. 2). Site 4 was a 100 ft. section of a continuous rock and gravel riffle. Site 5 (Fig. 3) was a 100 ft. headwaters section of the west tributary. Site 5a was a 100 ft. section of this tributary 0.6 miles below site 5. Only winter and early spring collections were made at sites 5 and 5a because access to these sites was unattainable during the spring thaw. Adults were collected every 6 to 8 days from September 1968 to November 1969 by sampling the streambanks, rocks in the stream and all objects adjacent to the stream. Species determinations were made using keys and descriptions by Harden and Mickel (1952), Harper and Hynes (1971), Hilsenhoff and Billmyer (1973), Needham and Claassen (1925), Ricker (1952), Ricker and Ross (1968, 1969) and Ross and Ricker (1971).

A program of rearing was carried out during the study period to obtain species that might otherwise be missed. Bottom debris was gathered from sites 1 to 4; no stoneflies

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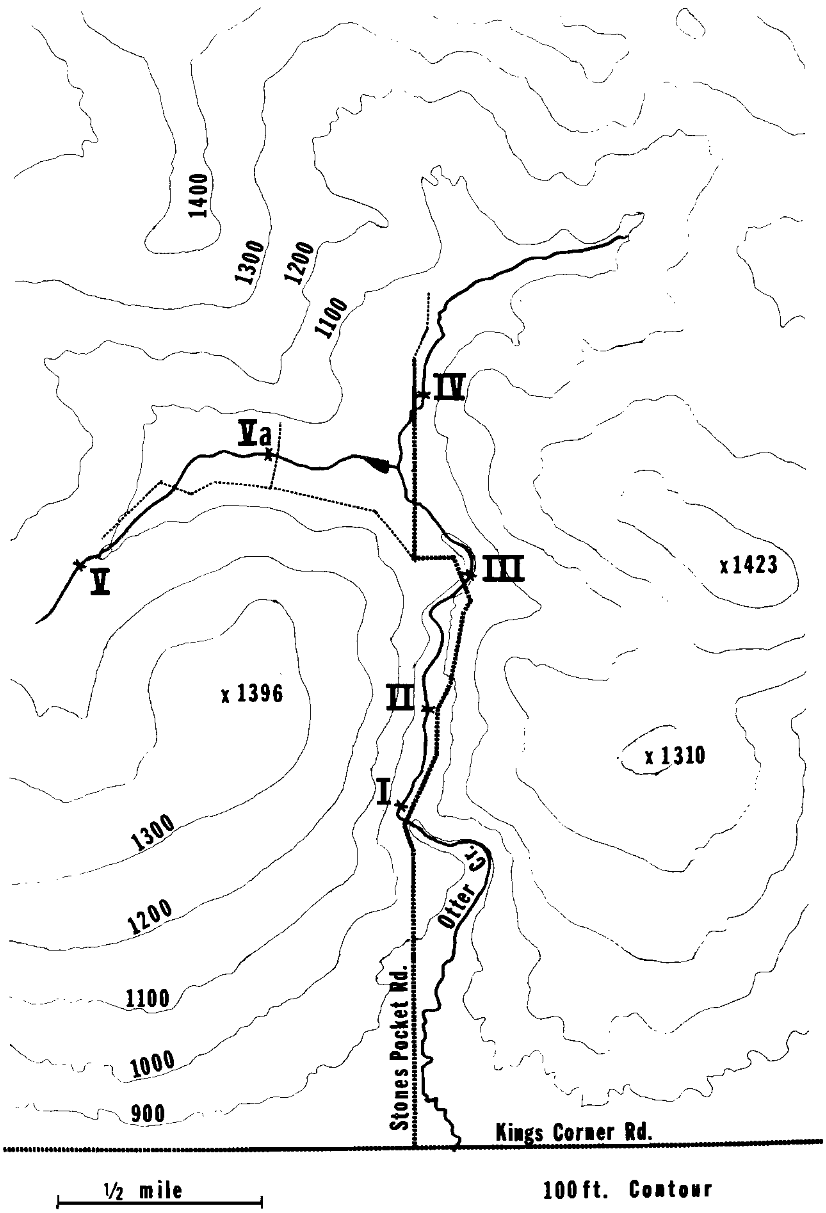

Fig. 1. Location of sampling sites on Otter Creek.

Fig. 2. Sampling site 2 in early spring.

were reared from sites 5 and 5a. Samples were placed in incubators made from 2 refrigerators that had their light switches shunted to provide continuous light. Temperatures (± 1°C) were maintained at 1.5°C Jan. 5-10, 3°C Jan. 11-March 5, 5°C Mar. 5-April 17, 6°C Apr. 17-23, 18°C Apr. 23-May 18, 19°C May 18–August 18, 20°C Aug. 18-Sept. 21, and 17°C Sept. 21-30.

RESULTS

The distribution, abundance, and emergence patterns of stoneflies in Otter Creek are summarized in Table 1. Emergence began in January when species of *Allocapnia* appeared and continued through September with *Leuctra tenuis*. The emergence of most *Allocapnia* in February and early March was closely followed by two other winter stoneflies, *Taeniopteryx nivalis* and *Paracapnia angulata* in March and early April. *Nemoura similis* emerged in April and was the only species to begin emerging during that period. The remainder of the species emerged mostly in late spring and early summer. This pattern of emergence was similar to that observed by Harper and Hynes (1972) in Ontario where many of the same species occur. The most abundant species were *Allocapnia pygmaea, T. nivalis,* and *P. angulata. Allocapnia nivicola, Leuctra sibleyi, L. tenuis, Zealeuctra narfi,* and *Isoperla cotta* were rare. *Allocapnia illinoensis, A. nivicola,* and *A. vivipara* were confined to sites 5 and 5a, while *L. sibleyi, L. tenuis, Z. narfi,* and *Allocapnia rickeri* were restricted to the lower reaches of the study area. Adults of most species were both caught in the field and reared; however, *L. tenuis* and *Acroneuria lycorias* were obtained only from reared material.

There was an apparent relationship between water temperature and emergence in many species. The study area had the typical continental climate of interior North America consisting of a large temperature range (-42° to 34°C) with frequent short

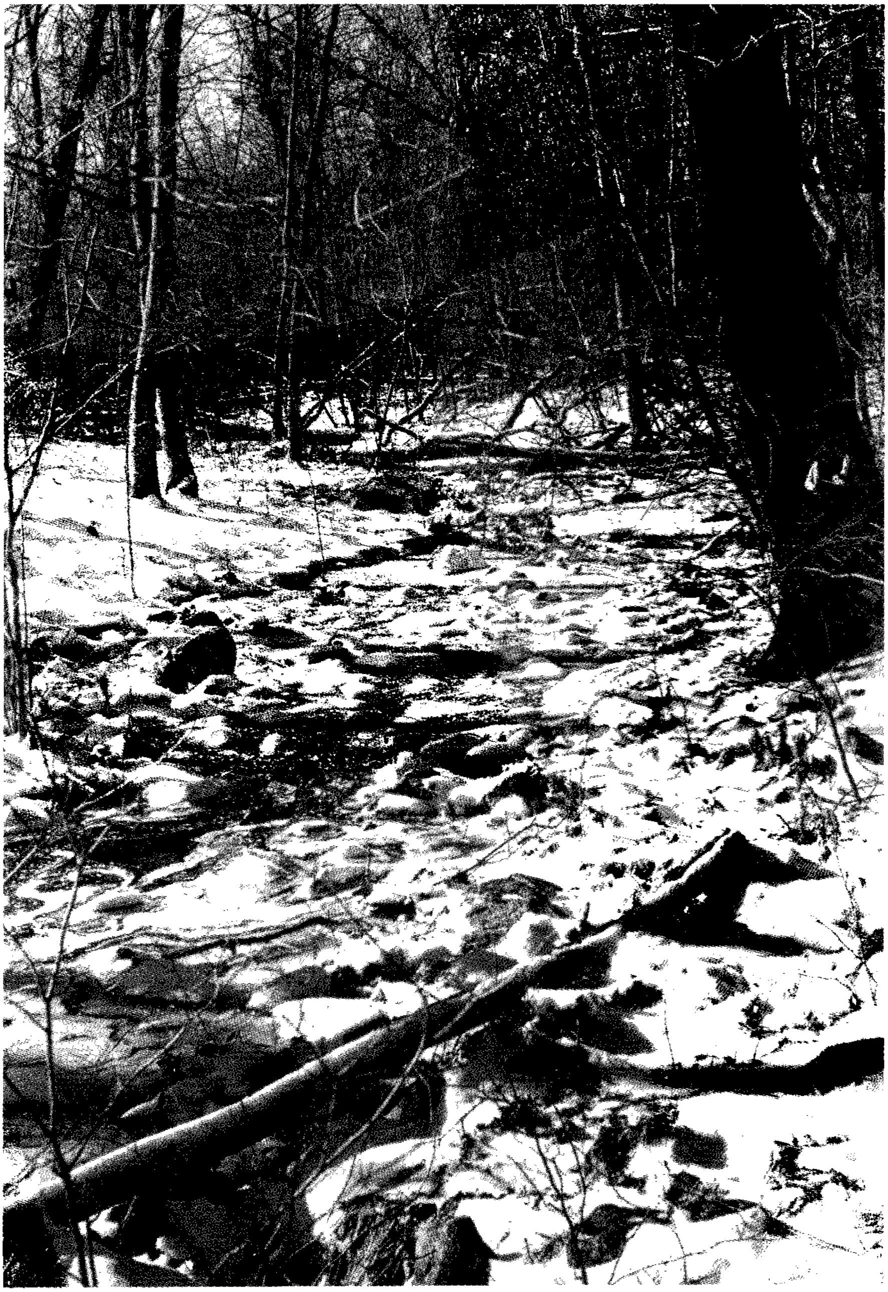

Fig. 3. Sampling site 5 in early spring.

period changes (Fig. 4). Precipitation also varied sporadically from normal during the study period (Fig. 4) with heavy snowfall throughout the 1968-69 winter. The relationship of temperature and other factors pertaining to emergence are discussed below under each species in order of their emergence. Additional details can be found in Narf (1972).

Allocapnia vivipara (Claassen, 1924) was collected almost exclusively in spring areas from mid-January to early-March (Table 1). Adults were found on rock and leaf mats, and none were observed more than 10 ft. from the stream. Harper and Hynes (1972) report this species emerging slightly later than *A. pygmaea* in Ontario.

Allocapnia pygmaea (Burmeister 1839), the most abundant species, was found mostly in faster water (Table 1). Emergence began in mid-January and continued through March. Stream temperatures at emergence were 0.5-1.5°C and incubator temperatures were 3°C. Adults were taken from all objects adjacent to the water as this species appeared to restrict its movements to the proximity of the stream. During the first half of February females outnumbered males in the field by about 2 to 1, but thereafter males predominated by more than a 2 to 1 ratio. In reared material, this trend did not appear and if anything was reversed, so no plausible explanation can be given for field observations of changing sex ratios. Harper and Hynes (1972) found males and females to have identical emergence patterns, and reported emergences to be triggered by increases in air temperatures. In Otter Creek, slight rises in water temperature may trigger emergence, since stream temperatures frequently rise to 0.5 or 1.0°C during the winter in response to above normal air temperatures and warm water from springs. This occurs even though more than 90% of the stream remains covered with ice.

Allocapnia illinoensis Frison 1935 was taken along with *vivipara* from headwater spring areas (Table 1) where massive amounts of oak leaf debris lodged among the rocks. Peak emergence was from late February to mid-March.

Allocapnia rickeri Frison 1929 was uncommon at sites 1 and 2 from late-January to mid-March.

Allocapnia nivicola (Fitch 1874) was rare (Table 1). Three adults were collected from rocks and leaf mats in early March.

Taeniopteryx nivalis (Fitch 1847) adults were collected mainly from partially submerged leaf mats from late February to April (Table 1), with males emerging about 10 days before females. Males predominated in field collections, probably because many females climbed to upper tree branches and were not collected. Reared material produced an equal sex ratio. Teneral females were often met at the waters edge for copulation by fully sclerotized males. No teneral males were observed copulating. Stream temperatures were 1.5°C and incubator temperatures 3°C at the start of emergence.

Paracapnia angulata Hanson 1961, the second most abundant species, emerged mostly from late March to Mid-April. Emergence was slowed by a temperature drop from 5° to 1°C on April 1, but continued as temperatures again rose. Emergence in the incubators began when the temperature was 3°C. Females only slightly outnumbered males in reared material, but outnumbered them 2 to 1 in the field, indicating that the males dispersed widely or had a shorter life span.

Nemoura similis (Hagen 1861) began emerging in early April, and although adults were occasionally encountered through May, emergence was apparently over by April 20. Stream temperatures at the time of emergence increased from 1° to 9°C. Reared adults began to emerge in March when the temperature was raised from 3° to 5°C.

Zealeuctra narfi Ricker and Ross 1969 was described from 10 specimens collected on April 29, 1967 from tree trunks at site 1 where they hid in crevices of the bark. This species was not taken during the study period and is apparently restricted to slower and deeper areas of the stream below site 1.

Nemoura delosa Ricker 1952 emerged from late May into mid-June (Table 1). There was no gradual buildup of adults, but a nearly spontaneous burst about May 20 and decreasing numbers until only a few emaciated females remained in late June. This differs from observations by Harper (1973) of a prolonged emergence. Adults were collected from leaf mats, boulders, and alders. Stream temperatures rose from 2°C (March) to 18°C (May) because of warmer air temperatures and solar radiation. From May 10 to 20 the temperature

The Great Lakes Entomologist, Vol. 7, No. 4 [1974], Art. 5

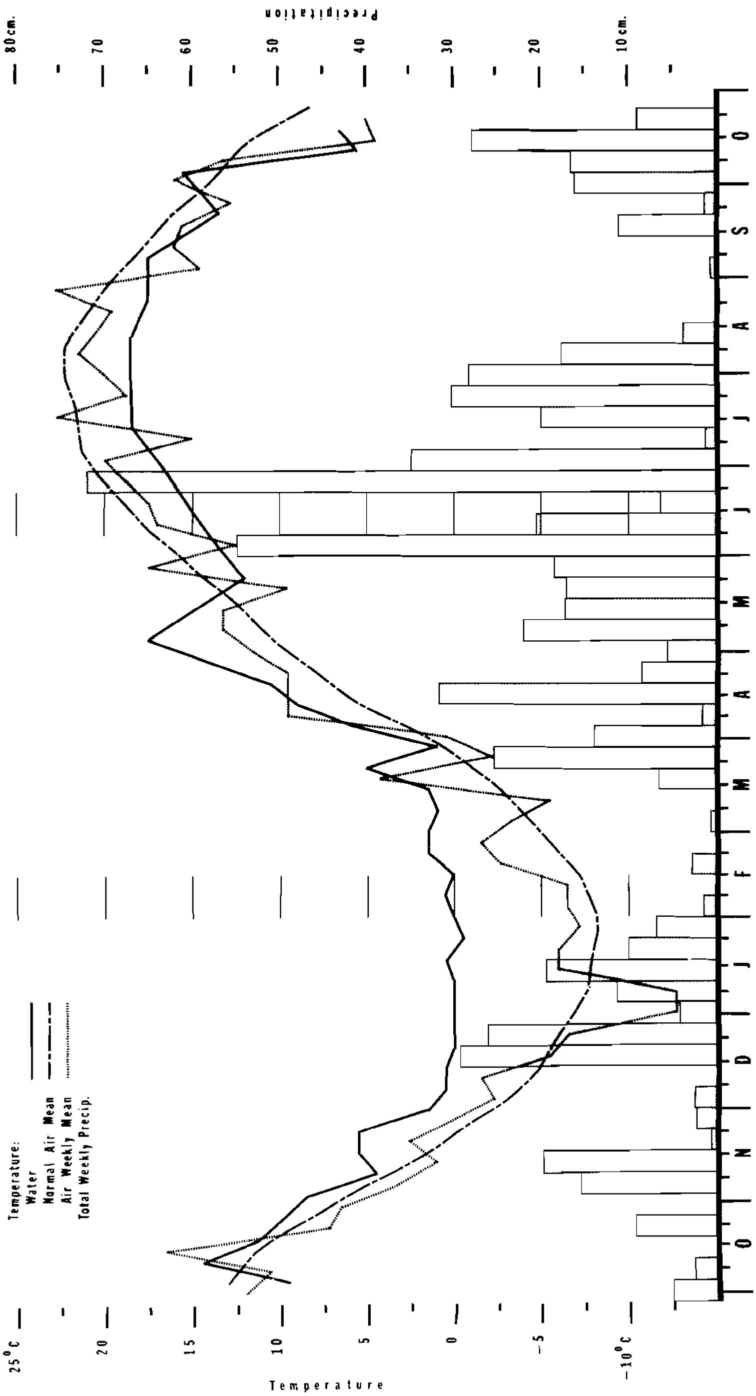

Fig. 4. Water and air temperatures, and precipitation October 1968 to November 1969.

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Table 1. Numbers of adult stoneflies collected and reared from Otter Creek and periods of collection.

		Site Number						Total		Collection Period	
Species	Source	1	2	3	4	5	5a	♂	♀	100%	50% or More
Allocapnia vivipara	Field	0	0	1	0	25	22	21	26	Jan. 18 – Mar. 22	Feb. 8 – Feb. 22
A. pygmaea	Field	268	323	511	231	1	7	790	551	Jan. 18 – Mar. 22	Feb. 15 – Mar. 1
	Reared	3	0	78	123	–	–	83	121	Jan. 22 – Mar. 29	Feb. 8 – Mar. 8
A. illinoensis	Field	0	0	0	3	58	204	167	96	Jan. 18 – Mar. 22	Feb. 22 – Mar. 15
A. rickeri	Field	19	1	0	0	0	0	14	6	Feb. 8 – Mar. 15	
	Reared	1	5	0	0	0	–	4	2	Jan. 31 – Mar. 3	
A. nivicola	Field	0	0	0	0	3	0	1	2	Feb. 22 – Mar. 8	
Taeniopteryx nivalis	Field	175	67	43	5	0	0	213	77	Feb. 22 – Apr. 5	Mar. 1 – Mar. 15
	Reared	119	94	33	6	–	–	121	131	Feb. 11 – Mar. 24	Mar. 1 – Mar. 15
Paracapnia angulata	Field	43	82	161	21	0	0	106	201	Mar. 8 – May 19	Mar. 22 – Apr. 19
	Reared	37	41	74	272	–	–	185	239	Jan. 31 – Apr. 17	Mar. 22 – Apr. 5
Nemoura similis	Field	6	25	19	3	0	0	28	25	Apr. 5 – May 3	Apr. 5 – Apr. 14
	Reared	12	4	12	7	–	–	18	17	Mar. 18 – Apr. 27	Apr. 5 – Apr. 19
N. delosa	Field	22	8	29	6	0	0	25	40	May 25 – July 13	May 25 – June 8
	Reared	45	68	19	60	–	–	94	98	May 9 – July 18	May 18 – June 1
Isoperla clio	Field	0	1	0	0	0	0	1	0	May 25	
	Reared	1	0	0	0	–	–	0	1	May 9	
I. cotta	Field	4	0	1	0	0	0	1	4	May 25 – June 28	
	Reared	0	0	2	1	–	–	2	1	May 18 – May 24	
I. dicala	Field	19	17	9	0	0	0	23	22	May 25 – July 13	May 25 – June 8
	Reared	39	24	8	5	–	–	46	30	May 9 – June 8	May 18 – June 1
Leuctra sibleyi	Field	1	1	0	0	0	0	1	1	May 25 – June 28	
	Reared	2	0	0	0	–	–	0	2	May 9 – May 27	
Acroneuria lycorias	Reared	1	0	2	2	–	–	3	2	May 9 – May 27	
Paragnetina media	Field	0	0	1	0	0	0	0	1	June 8	
	Reared	7	9	4	0	–	–	11	9	May 18 – July 9	
Leuctra tenuis	Reared	18	12	2	0	–	–	14	16	May 18 – Sept. 2	June 20 – Aug. 24

dropped from 18° to 12°C as the tree canopy developed and then increased steadily to a maximum of 19°C in July. *N. delosa* began emerging at the time of the mid-May temperature decline.

Isoperla clio (Newman 1839) was represented by one reared female and 1 male captured in the field (Table 1), although nymphs were frequently encountered at sites 1-4. This was the only species that did not adjust well to conditions in the incubators, the nymphs often dying in the rearing chambers.

Isoperla cotta Ricker 1952 was rare from late-May to late-June, and nymphs were infrequently seen in material taken for rearing.

Isoperla dicala Frison 1942 emerged in late-May and early June, with males appearing before the females (Table 1). One female was collected as late as July 13. Adults were found on moss and leaf mats close to the water, and none were observed more than 25 ft. from the stream.

Leuctra sibleyi, Claassen 1923 emerged in June and was represented by only 6 adults that were taken off tree trunks. It is a very good flier, and probably dispersed widely.

Acroneuria lycorias (Newman 1839) adults were not collected, although nymphs and exuviae were abundant in most sections of the stream. We suspect that the adults inhabit the tree canopy, making collection almost impossible. Five adults were reared; all emerged in May.

Paragnetina media (Walker 1852) nymphs were commonly collected from sites 1, 2, and 3, but only 1 adult was found (Table 1). It was collected in early June, coinciding with peak emergence from the incubators. Twenty adults were reared, emerging from late-April to early-July.

Leuctra tenuis (Pictet 1841) was not collected in the field. Thirty adults were reared from May 18 to September 2, 1969.

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