OVOVIVIPARITY AND NYMPHAL SEASONAL MOVEMENTS OF *CALLIBAETIS* SPP. (EPHEMEROPTERA: BAETIDAE) IN A POND IN SOUTHWESTERN QUEBEC[1]

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Abstract

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Callibaetis ferrugineus (Walsh) and *C. fluctuans* (Walsh) nymphs moved from the shallow, peripheral area of a pond during the late summer and autumn to the deeper water where they overwintered. In the spring they returned to the peripheral area where they were found throughout the summer. *C. ferrugineus* and *C. fluctuans* are ovoviviparous. A relationship between ovoviviparity and seasonal movements of the nymphs is suggested.

Introduction

Movement of mature mayfly nymphs from the deeper water of a stream or pond to the shallow peripheral areas is well documented when associated with emergence behavior (Verrier 1956). Less well known is the type of movement associated with seasonal changes in the temperate zone of the type described by Wodsedalek (1912) for *Heptagenia interpunctata* (Say), where the nymphs occupied a narrow strip of shallow water along the shore of a lake during the summer. In the autumn, as the water cooled but before the ice formed, they moved to deeper water. In the spring, after the ice had disappeared, they reappeared in the shallow peripheral areas. During a study on the mayfly fauna of a stream system (Gibbs 1971), *Callibaetis* spp. nymphs, numerous in association with a small pond, were studied to determine if they exhibit this type of movement.

Ovoviviparity, or the production of eggs that contain mature embryos and that hatch immediately on oviposition, has been reported for several species of *Callibaetis* (Needham *et al.* 1935; Berner 1941; Edmunds 1945). Observations on the occurrence of ovoviviparity were made on *Callibaetis* spp. encountered in my study to determine a possible relationship between nymphal movements and ovoviviparity.

Study Area and Sampling Sites

The study area at Rigaud, Quebec was described in detail by Gibbs (1973). The pond was formed by the damming of a stream originating in a series of springs approximately 2 km above the dam and had a maximum width of 40 m and a maximum depth of 3 m in front of the dam (Fig. 1). The substrate was composed of fine silt. The pond contained extensive growths of *Potomogeton* and *Spirogyra* during the summer but in the winter these growths were reduced to mats found at the bottom of the deeper areas of the pond. The shore area supported extensive stands of *Scirpus*, *Glyceria*, *Sagittaria*, and *Eleocharis*. The pH of the water varied from 5.6 to 6.5 during the study. The pond was covered with ice and snow from November to March or April.

Four sampling sites were selected (Fig. 1). Sites I and IV consisted of 30 m strips < 1 m from the shore in 15–20 cm of water. Site III was a 30 m strip 4.5 m from site IV in water 85 cm deep. Site II was a strip running parallel to site III, 8 m from the shore in water 120 cm deep.

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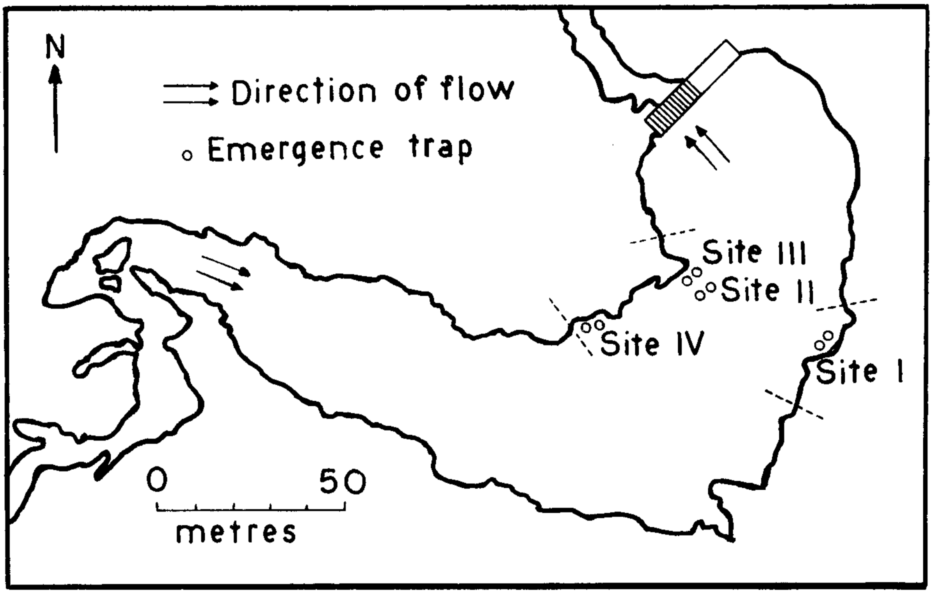

FIG. 1. Location of the sampling sites in the study pond.

Methods

Quantitative sampling for nymphs from the surface of the substrate was by means of a standardized netting procedure described by Gibbs (1973). At each site on each sampling date, five replicate samples were taken, each consisting of the organisms captured when the net was moved along the surface of the substrate for 3 m. The net used consisted of a conical net bag 75 cm long attached to a circular frame 30 cm in diameter. The proximal half of the net was made of coarse mesh netting (725 μ) and distal half of fine mesh netting (230 μ). Nymphs were sampled at intervals of 1 or 2 weeks from 27 April to 24 October. One way analysis of variance and the Student-Newman-Keuls multiple range test was used to determine significant changes (α = 0.05) in numbers of nymphs between sampling dates. Numbers were transformed to $\log_{10}$ [(number/3 m sweep) + 1] for analysis.

Adults were reared from mature nymphs using the methods of Burks (1953). Emerging adults were monitored by means of two emergence traps at each sampling site. Each emergence trap covered an area of 45.7 cm^2. Adults flying in the area of the pond and ovipositing on its surface were also collected.

Water temperature at the surface of the substrate at site II was recorded on each sampling date.

Observations and Discussion

As a result of the identification of adults reared from nymphs collected in the pond, adults collected in flight in the pond area and adults collected in the emergence traps, it was concluded that two species, *C. ferrugineus* and *C. fluctuans*, were present.

It was not possible to separate the nymphs of the two species so they were always considered together. *C. ferrugineus* adults were more frequently encountered in the reared material, in adult collections, and in the emergence traps. During the year preceding the study, 10 randomly located emergence traps in the pond yielded 226 specimens of *C. ferrugineus* and two specimens of *C. fluctuans*. During the year of the study, the eight emergence traps yielded 19 specimens of *C. ferrugineus* but no *C. fluctuans* (Table I). Thus it was concluded that most of the nymphs in the pond were *C. ferrugineus*.

Examination of ovipositing females of *C. ferrugineus* and *C. fluctuans* taken from the surface of the water of the pond showed that all contained eggs containing fully developed first instar nymphs, indicating ovoviviparity. Ovoviviparity has not previously been reported in these species, but the assumption of Berner (1941) that this mode of reproduction is widely distributed in the genus is supported here. One female imago *C. ferrugineus* reared from a nymph lived for 14 days in a gauze covered jar supplied with fresh vegetation. This is exceptional longevity for an adult mayfly and is undoubtedly associated with ovoviviparity. Berner (1941) and Edmunds (1945) have made similar observations on other species of *Callibaetis*.

The seasonal distribution of nymphs at the sampling sites is shown in Fig. 2. In April, numbers of nymphs were low at sites I, III, and IV and not significantly higher than numbers occurring in May, June, and July. Only at site II (the deepest site) were the numbers significantly higher in April and early May than they were in the following months. The decline in numbers of nymphs at site II was associated with rising water temperatures (Fig. 3) and is attributed to a gradual movement of nymphs from the deeper areas of the pond to the shallow peripheral areas. The decrease in numbers at site II cannot be attributed to adult emergence as final instar nymphs with darkened wing pads, indicating approaching metamorphosis, were not present in the samples at this site until 15 June. Adult emergence was recorded between 19 June and 2 September and occurred mainly at the two sites (I and IV) in the shallow peripheral area (Table I). Numbers of nymphs remained low at all sites during June and July. During the latter part of August and September, numbers increased significantly at sites I, II, and III reaching peaks at sites I and III in September and then decreasing significantly in October. Only at site II, the deepest site, did numbers increase significantly during October, reaching a peak on the last sampling date, 24 October. At site IV numbers remained low throughout the sampling period showing only a slight though significant increase in September. These results are interpreted to indicate that populations built up in the shallow areas (sites I and IV) and areas of intermediate depth (site III) in late summer and that the nymphs moved to the deeper water during September and October, coincident with declining water temperatures. As neither adult emergence nor final instar nymphs were recorded after the first week in September, the increase in numbers in the deeper areas of the pond could not be attributed to additions through natality. This evidence is supported by several years of casual observations in the study area. In October,

Table I. Numbers of *Callibaetis ferrugineus* collected by two emergence traps at each sampling site. Traps were cleared daily from 3 May to 28 October

Date	I	II	III	IV	Date	I	II	III	IV
19 June	1				9 August	1			
15 July	1				13 August				1
17 July				1	14 August	1			1
24 July				1	20 August				1
26 July	1			1	21 August	1	1		
2 August	1				26 August	1			1
5 August	1		1		2 September			1	

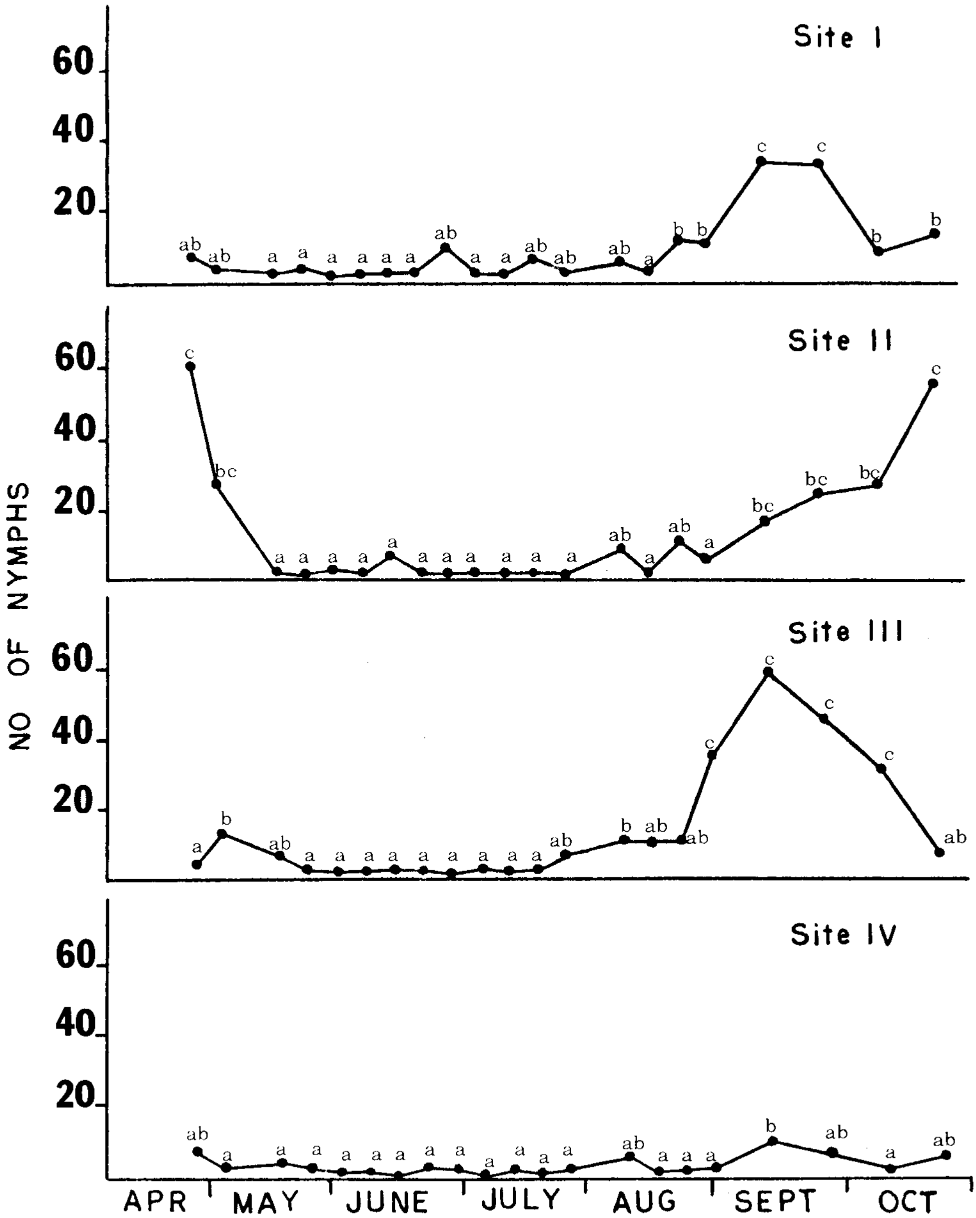

FIG. 2. Mean numbers of nymphs collected at the sampling sites between 27 April and 24 October. Numbers at each site with the same letter are not significantly different from each other $\alpha = 0.05$.

November and April, nymphs were always numerous and associated with submerged vegetation in the deeper area of the pond. At other times of the year they were rare in these areas.

Thus it is suggested that *Callibaetis* spp. nymphs move to the deeper parts of the pond in autumn where they overwinter associated with mats of vegetation and then return to the periphery in the spring. This pattern of behavior would be

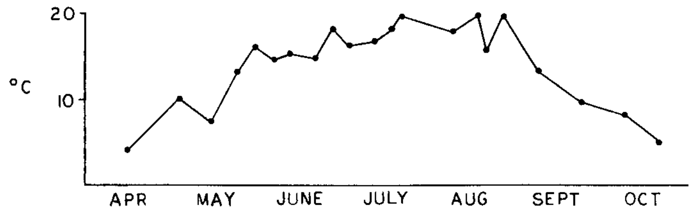

FIG. 3. Water temperature at the surface of the substrate at site II.

significant in enabling the species to overwinter in ponds where the shallow peripheral areas freeze to the substrate or are exposed by a winter draw-down and the deeper, more central areas are not. Since these species are ovoviviparous, there is no free egg stage and the ability of nymphs to survive winter conditions is of the greatest importance. Another species of mayfly, *Cloeon triangulifer*, which overwintered in high numbers in this pond, did so in the egg stage which was adapted to survive conditions where the peripheral areas of the pond froze to the substrate or were exposed (Gibbs 1973).

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