

## **Life Cycle Patterns of *Caenis simulans* McDunnough (Caenidae: Ephemeroptera) in an Alberta, Canada, Marsh**

by

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The life cycle of *Caenis simulans* appeared to be bivoltine in a parkland marsh of Alberta, Canada. Emergence was extended (3 months) and exhibited two peaks. Larger nymphs moved shoreward prior to emergence; smaller nymphs moved towards the marsh centre. No differences in life cycle patterns were detected between habitats.

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### INTRODUCTION

The mayfly genus *Caenis* is widely distributed although absent from the Australian realm and most oceanic islands (Edmunds et al., 1976). *Caenis* nymphs are commonly found among rooted vegetation of ponds and lakes and along stream margins. In nearctic regions, *Caenis* populations are typically univoltine with overwintering nymphs, or bivoltine with winter and summer generations (Clifford, 1982). Both univoltine and bivoltine populations have been reported for several caenid species including *C. horaria* (L.), *C. moesta* Bengts., *C. rivulorum* Eaton and *C. robusta* Eaton (Moon, 1939; Landa, 1968; Bradbeer and Savage, 1980). This study examines the life cycle of *Caenis simulans* McDunnough, a species for which Clifford (1982) reports no consistent life cycle type.

Workers investigating life cycle patterns of lotic *C. simulans* populations have focussed on nymphs and characterised them as univoltine with an emergence period of less than three weeks (Leonard and Leonard, 1962; Robertson, 1976; Hamilton, 1979; MacFarlane and Waters, 1982). In lentic areas, however, the emergence period is greatly extended, with a maximum flight period of over four

months (Judd, 1949, 1953; Harper and Harper, 1976). Two emergence peaks (June and August) have been reported when flight periods are extended (Hall et al., 1970; Harper and Harper, 1976) suggesting a bivoltine life cycle for lentic populations.

In this study, I attempt to clarify the life cycle for lentic populations of *C. simulans* by examining (1) size frequency distributions of nymphs in central and shoreline areas of a marsh, (2) size differentiation of nymphs moving towards and away from shore, and (3) periods of emergence.

### STUDY AREA

The study marsh (surface area: 61.4 ha, maximum depth: 1.2 m) is a permanent waterbody located within the Clifford E. Lee Nature Sanctuary (53°24'N, 113°47'W) in the aspen parkland region of central Alberta, Canada. The marsh has an irregular shoreline and a U-shaped basin. The bottom sediments are sand and mud. Aquatic plants are abundant: bladderwort, *Utricularia vulgaris* L., occupies nearshore areas and stonewort, *Chara* sp., occurs in the central basin. Stands of the emergent bulrush, *Scirpus validus* Vahl., surround the marsh.

Ice cover occurs from late October to late April and reaches maximum thickness (80 cm) in March. Water temperature increases rapidly in spring, fluctuates throughout summer and, beginning in late August, declines gradually throughout autumn (Fig. 1). Fluctuation in 1978 summer temperatures reflects erratic rainfall patterns.

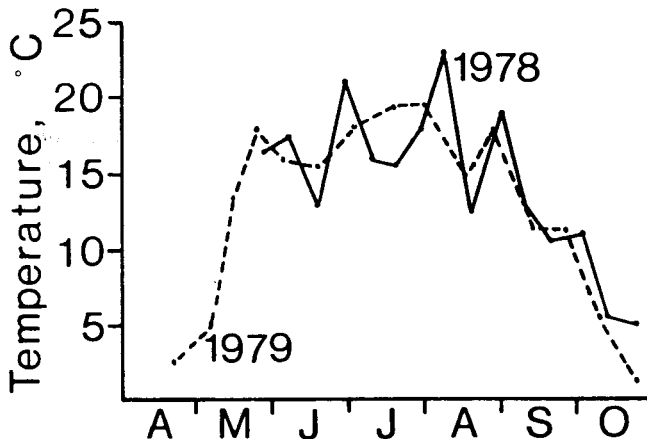


Fig. 1. Minimum surface water temperatures at the marsh centre.

## METHODS

To determine the relative abundance of particular size classes, Ekman grab samples (0.023 m<sup>2</sup>) were taken at approximately 10-day intervals from 28 May to 23 October 1978. One sample was taken from each of the *Chara* and *Utricularia* beds, representing the central and shoreline areas of the marsh, respectively. All macrophytes retained in the Ekman grab were considered as part of the sample. On 1 October 1978, strong winds prevented me from obtaining samples from the marsh centre. Samples were rinsed through a screened bucket (0.6 mm mesh) in the field. Throughout the winter (1979-1980), dip net samples (mesh size: 180  $\mu$ m) were obtained from the substrate at the marsh centre. *Caenis* nymphs were sorted live using a dissecting microscope.

As part of a larger study on invertebrate movement (Corkum, 1984), *Caenis* nymphal activity was monitored for 24 h periods at two week intervals throughout the ice-free season: 5 June to 23 October 1979 and 24 April to 22 May 1980. Five pairs of nets (180  $\mu$ m mesh, 1 m in length with a circular opening of 0.05 m<sup>2</sup>) were positioned on the substrate at equal intervals around one bay of the marsh between shoreline and open water areas as defined by emergent vegetation. One net of each pair faced inshore; the other was open to the marsh centre. Movement was inferred from the net contents collected at sunrise and sunset.

*Caenis* nymphs from both sets of field data were preserved in Kahle's fluid. Head widths (HW) of nymphs from each sample were measured at 40X magnification to the nearest 0.024 mm. If samples contained many animals, subsamples of 50 nymphs were examined. Periods of emergence, if any, were noted on each field trip.

Water temperatures (throughout the water column) were recorded at each of five net locations and at the marsh centre using a Hydrolab (Austin, Texas) thermometer with cable. A mercury pocket thermometer also was used in surface waters. Minimum surface water temperatures recorded during the sampling program are presented in Fig. 1. Surface water temperatures also are presented at the time of mayfly emergence (i.e. sunset) (Table 1). Maximum water temperatures were recorded at sunset.

Table 1. Emergence records for *Caenis simulans* throughout 1979.

Date	Time (h)	Sunset (h)	Surf. Water Temp (°C) at sunset	Weather Conditions	Comments
30 Jun	2000	2207	22	sky overcast, cloudy	mass emergence
16 Jul	2115	2156	22	sky hazy from forest fires	relatively abundant
17 Jul	1900	2155	20	hazy	exuviae on water surface
27 Aug	1945	2040	20.5	lightening, thunder, white caps on marsh	relatively abundant
28 Aug	1930	2038	20.5	cloudy, some rain	exuviae on water surface
25 Sep	1900	1930	17	sunny, clear	few emerging

## RESULTS

## Growth Patterns

The relative abundance of animals fluctuated throughout the open water season. Maximum nymphal density in shoreline areas occurred in late July to early August (21,000/m<sup>2</sup>). Similarly high densities were recorded at the marsh centre during September and October (Fig. 2). Few nymphs were collected in either location during peak emergence, i.e. the first two weeks of July. Higher nymphal densities were recorded in shoreline than centre samples immediately preceding and following this period. From mid-August until late October, densities of *Caenis* nymphs were higher in samples obtained from the marsh centre than in shoreline areas.

The size frequency distribution based on 1978 Ekman samples is illustrated in Fig. 3. Nymphal growth was rapid during spring as water temperatures increased. There was a wide range of HW (head width: 0.54 to 1.06 mm) in late May; and, although the first peak emergence occurred in early July, a portion of the nymphal population (stragglers) continued to mature throughout the summer. The greatest size range of nymphs occurred in early August (HW: 0.31 to 1.32 mm). Small nymphs (HW: 0.22 mm) appeared on 29 July 1978.

Chi square tests of homogeneity (Daniel, 1978) were used to test for differences in frequency distribution of HW between centre and shoreline habitats. Sig-

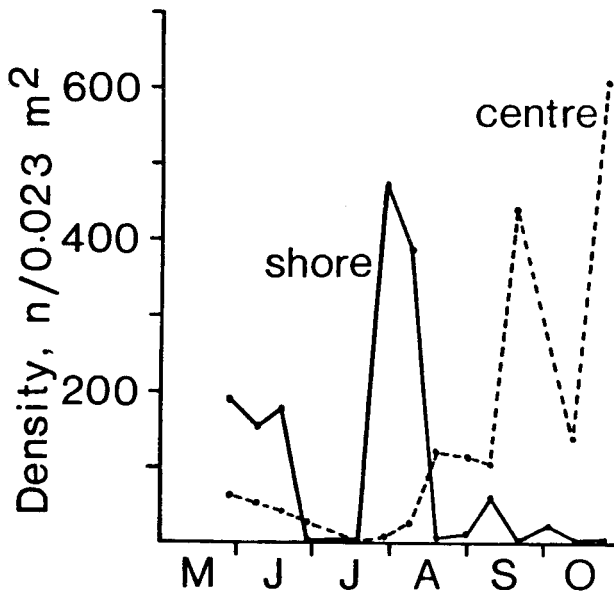


Fig. 2. Density of *C. simulans* nymphs near shore and at marsh centre collected with Ekman grab, May to October, 1978.

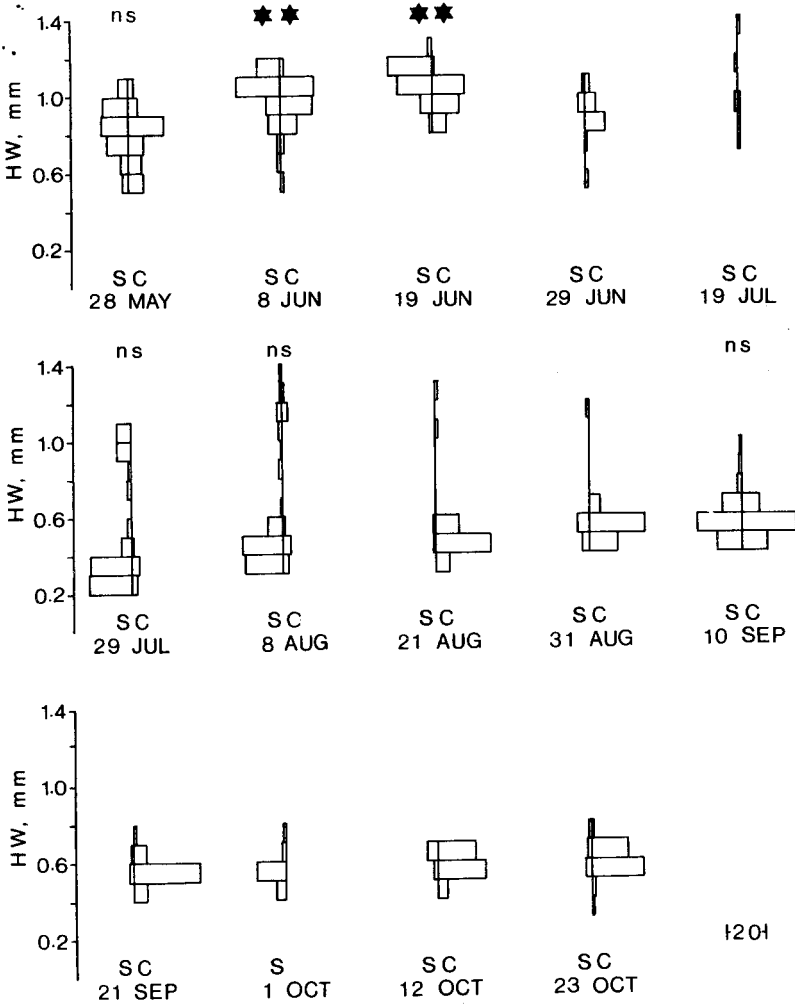


Fig. 3. Size frequency distribution (HW, head width) of *C. simulans* nymphs collected with Ekman grab in shoreline (S) and central (C) locations, 1978. Nymphs were absent from samples collected on 10 July. Significance levels represent results of Chi square tests of homogeneity. \*\* =  $p < 0.005$ , ns =  $p > 0.05$ . Unmarked dates had too few nymphs to test for significance.

nificantly larger nymphs occurred in shoreline than in centre samples in spring (8 and 19 June 1978, Fig. 3).

Size frequency distributions from winter dip net samples suggest that no nymphal growth occurred during this period (Fig. 4). Lack of winter growth has been previously reported in *Caenis* nymphs (Moon, 1939; Hamilton, 1979).

These results (Fig. 3 & 4) suggest that *C. simulans* may be univoltine with

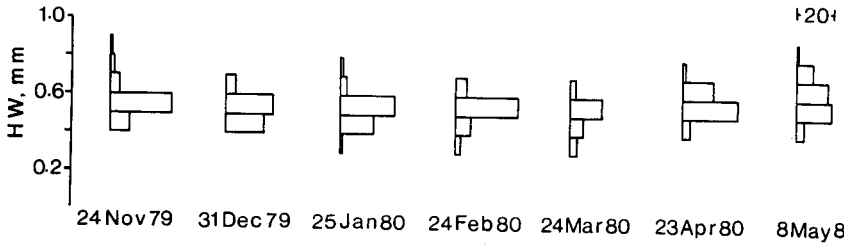


Fig. 4. Size frequency distribution (HW, head width) of *C. simulans* nymphs collected from sediments at marsh centre during ice cover.

overwintering nymphs exhibiting no growth. The growth pattern in the 1978 open water season, however, is unclear. A large size range of nymphs was obtained in spring samples and mature nymphs were present in most samples until late August (Fig. 3). A second (summer) generation of nymphs may not have been detected because of the large mesh size through which samples were washed.

#### Movement

Results from on- and offshore experiments of invertebrate movement indicate that *C. simulans* nymphs are nocturnally active throughout the open water season (Corkum, 1984). *Caenis* nymphs moved shoreward in May. Two peaks of nymphal movement towards the marsh centre occurred on 1 July and 14 August 1979 (Fig. 5).

The size frequency distributions based on nymphal movement are presented in Fig. 5. Growth is rapid in spring with mature nymphs present in mid-June samples. Nymphs representing a possible second generation appeared in the samples on 1 July 1979 (smallest HW: 0.21 mm). This fast-growing summer generation of nymphs was smaller at maturity than the winter generation.

Two distinct size classes occurred in the 1 July 1979 sample (Fig. 5). Nymphs representing the larger size class (i.e. the winter generation) emerged shortly thereafter. Small nymphs (HW: 0.10) representing the start of the next winter generation appeared on 31 July 1979; these nymphs grew throughout autumn and overwintered.

Chi square tests of homogeneity showed significant size differences among nymphs on two sample dates, 22 May 1980 and 1 July 1979. On 22 May 1980, larger nymphs were moving shoreward. Hall et al. (1970) made a similar observation; i.e., large *C. simulans* nymphs appeared to move into shallow water before emergence. On 1 July 1979, small nymphs were moving towards the marsh centre.

This interpretation of the 1979/80 data suggests a bivoltine life cycle (winter and summer generations). Size variations of nymphs in the spring samples may have resulted from differential growth rates of nymphs occupying different habitats within the marsh (see Macan, 1977; Baker and Clifford, 1981).

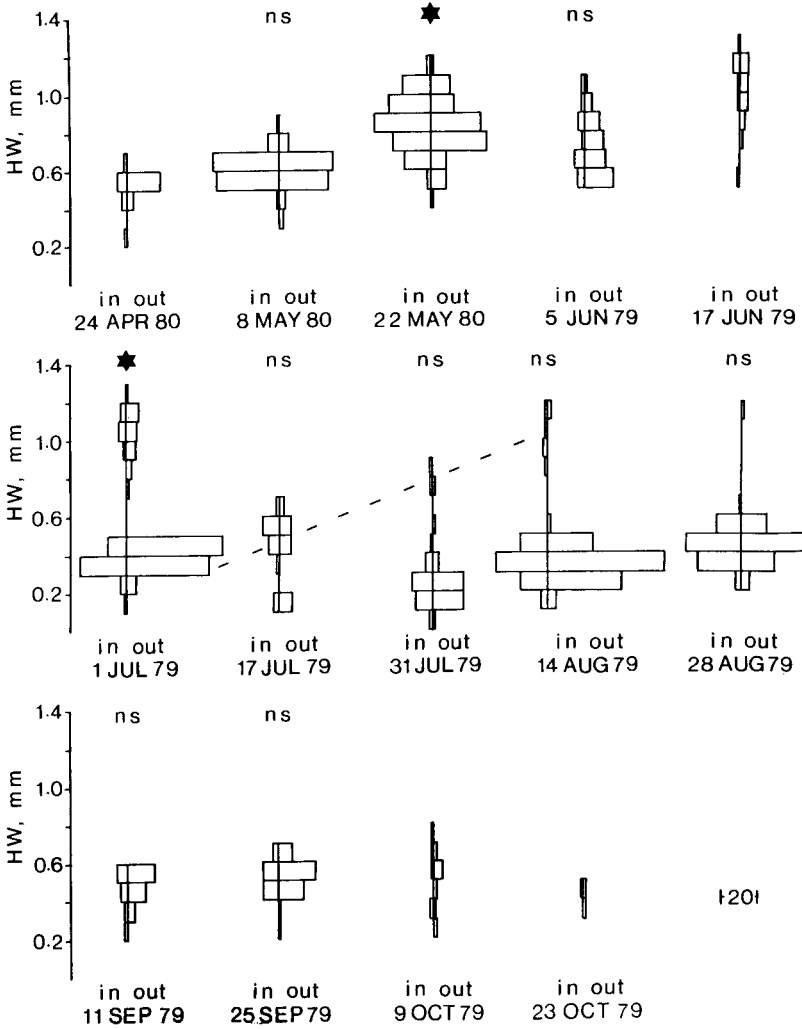


Fig. 5. Size frequency distribution (HW, head width) of *C. simulans* nymphs collected in nets open to the marsh centre (in) and facing inshore (out). Significance levels represent results of Chi square tests of homogeneity. \* =  $p < 0.05$ , ns =  $p > 0.05$ . Unmarked dates had too few nymphs to test for significance.

**Emergence**

Emergence of *C. simulans* was sporadic and prolonged from 30 June to 25 September 1979 (Table 1). The first observed emergence occurred on 30 June and the emergence period continued until mid-July. A second minor peak was evident

on 27 August 1979. The two peaks of emergence give additional support to a bivoltine life cycle pattern; if so, the duration of the summer generation is about eight weeks.

Emergence occurred just before sunset, often during inclement weather, and was most noticeable along the marsh shoreline. Lyman (1955) also noted lakeshore swarms of *C. simulans* at dusk.

*Caenis* adults, both subimago and imago, are shortlived. The subimago molts within five minutes of emergence and the imago lives for only 3 to 4 h (Edmunds et al., 1976). On 30 June, subimagines of *C. simulans* covered the surface of a light blue automobile located near the water's edge. Once a subimago landed, the exoskeleton split along the dorsal surface and within 25 s, the imago crawled out of the exuvia and flew away. The exuvia often remained attached and was trailed behind the flying imago. Lyman (1955) reported the ecdysis period to be 45 to 60 s. He also observed specimens with trailing exuviae and suggested that these mayflies may shed the exoskeleton in flight.

## DISCUSSION

Interpretation of size frequency distributions of nymphal movement (Fig. 5) and imaginal emergence patterns (Table 1) suggest that the life cycle of *C. simulans* in the study marsh was bivoltine (winter and summer generations). I consider the observations in 1978 (univoltine) as inconclusive because of the large mesh screen used to wash samples.

Lyman (1955) described a one year life cycle for *C. simulans* in Douglas Lake, Michigan. However, his observation of mature nymphs in late August and early September as well as the extended emergence period (10 June to 11 August) exhibited by the species suggests to me a bivoltine life cycle.

Bivoltinism, inferred from emergence data alone, has been suggested in studies of *Caenis* in lentic areas of temperate latitudes (Harper and Harper, 1976: 4 June and 3 August; Hall et al., 1970: late June, early August; Judd, 1949: 19 June, 30 July).

Peters and Warren (1966) observed a 16 week emergence period for *C. simulans* in northwestern Arkansas, with a strong emergence peak occurring in the third week of May and a second prolonged concentration throughout June. Because of the location of light traps, it was not clear whether adults emerged from creeks or ponds.

*Caenis simulans* nymphs moved continually on- and offshore throughout the open water season. Although large nymphs occupied shoreline areas in spring and small nymphs moved toward the marsh centre in summer, no differences in life cycle patterns were detected between habitats.

Factors which may influence nymphal movement such as dispersal from crowded locales, predator avoidance, changes in diet or pre-emergent activity were not examined in this study. Most of the movement by *C. simulans* nymphs, however, occurred at night (Corkum, 1984). Future studies on factors which induce invertebrate movement in lentic areas might reveal strong parallels between this behaviour and that of invertebrates that drift in streams.



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