THE SEASONAL DISTRIBUTION OF *CLOEON TRIANGULIFER* MCDUNNOUGH IN A POND IN EASTERN CANADA [1]

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INTRODUCTION

Cloeon triangulifer MCDUNNOUGH was described from female adults by MCDUNNOUGH (1931) and from nymphs by IDE (1937) from specimens collected in Quebec and Ontario. However, little information is available on its life cycle. Therefore, as part of a study on the seasonal distribution of mayfly species in a stream system, four sites in an artificially created pond were sampled quantitatively for two seasons for nymphs and adult emergence of this species. For purposes of brevity, only the results obtained in 1968 are presented and discussed in detail but these are essentially similar to those obtained in 1967. Limited field studies were made with the eggs in 1968.

DESCRIPTION OF THE STUDY AREA AND SAMPLING SITES

The pond had been formed by the artifical damming of a stream which originated in a series of springs approximately 2 km above the dam. The dam was partially removed in the fall before the pond froze and replaced in the spring after the danger of damage from the spring run-off had passed. After the water level had attained equilibrium following the replacement of the dam, the area and depth of the pond remained constant throughout the season (May 9 to November 3 during 1968). The pond so formed attained a length of 150 m, a maximum width of 40m and a maximum depth of 3 m in front of the dam (Fig. 1). When the dam was removed in the fall the pond area was reduced and the shoreline receded approximately 6 m at Site I and 4 m at Site IV in the sampling area. The pond had a fine silt substrate and contained extensive growths of *Potamogeton* sp. in its deeper parts, while the shoreline supported a mixed stand of *Scirpus* sp., *Sagittaria* sp., *Glyceria* sp. and *Eleocharis* sp.. It was surrounded by a wooded area containing mainly maple, poplar, birch, beech, hemlock and pine. A thick layer of ice and snow covered the pond area from November to April. The pH varied from 5.6 to 6.5 during the study.

The four sampling sites were those shown on the map (Fig. 1). Sites I and IV consisted of 30 m long strips close to the shoreline in 15-20 cm of water. Site III was a strip running parallel to Site IV 4.5 m from the shore in water approximately 85 cm deep and Site II was parallel to Site III, 8 m from the shore in water 120 cm deep.

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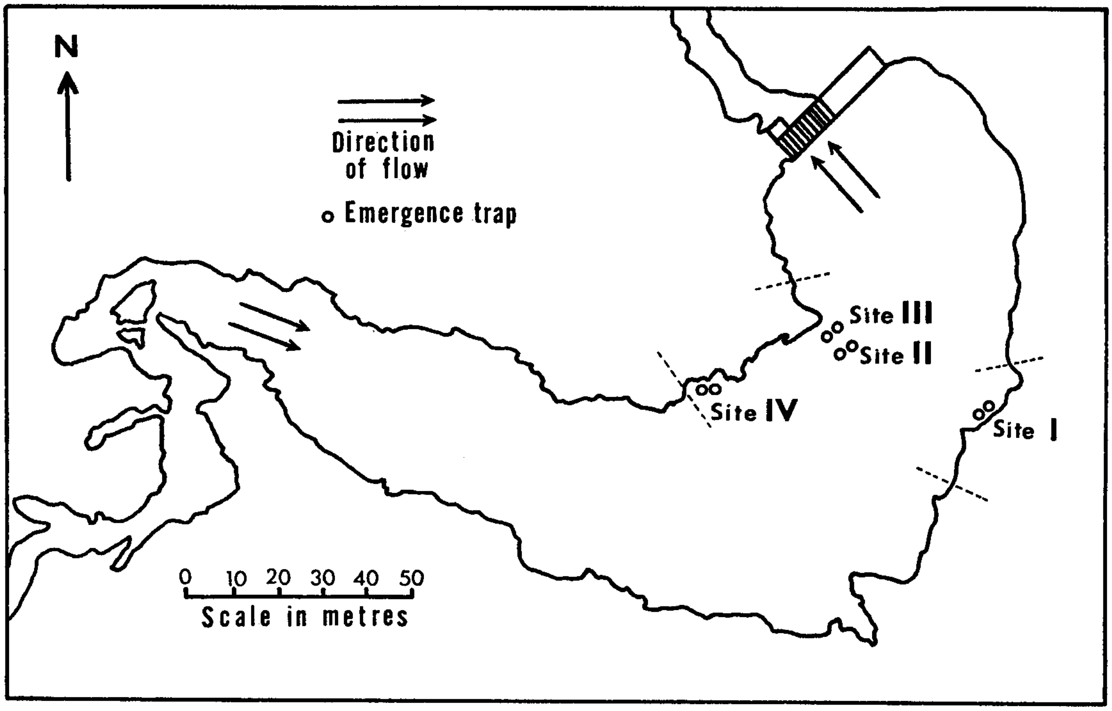

FIGURE 1. Outline map of the pond in the study area showing the sites sampled.

MATERIALS AND METHODS

Samples of nymphs were taken at weekly intervals from April to November from each of the four sampling sites using a standardized method of collection with a hand net. Each sample was comprised of five collection units, each unit consisting of the net being moved in a uniform manner 3 m along the surface of the substrate. This was accomplished at Sites I and IV by the investigator walking through the water pushing the net in front of her and following a 3 m indicator lying parallel on the shore. At Sites II and III a sample unit consisted of the net being moved in a 3 m arc around the stern of a small boat.

The net used during 1968 was designed and constructed especially for this study and consisted of a conical net bag 75 cm long attached to a circular net frame 30 cm in diameter. The top half of the net cone was made of coarse mesh netting (10 meshes/cm) and the bottom half, distal to the frame, of fine mesh netting (50 meshes/cm). Comparison of the size and numbers of nymphs taken with this net with those captured with nets made completely of either the fine or coarse netting indicated that it gave a more representative sample of the sizes of nymphs present in the population than did either of those other nets. In addition it was not possible to use the net made only of fine mesh material because in the deeper water it quickly clogged with silt and debris making it impossible to move it through the water in the uniform manner demanded by the sampling technique.

Following collection, nymphs were separated from the extraneous material, preserved in 70 per cent alcohol, identified, counted, and the head widths measured. The numbers of nymphs in the final instar and the numbers approaching metamorphosis (as indicated by the darkening of the wing pads) were also noted.

Two emergence traps were placed at each sampling site and the daily emergence was recorded throughout the season. The traps were designed and constructed for this study and each covered a 45.7 cm square.

In order to obtain eggs for the study, subimagos were collected from the emergence traps and held in the laboratory. Twenty-four hours after the final moult these females deposited their eggs if the tips of their abdomens were dipped in water. Some eggs were retained in shell vials covered with fine mesh netting and others in small sacs made of fine mesh netting. The vials and sacs were placed in the water on the surface of the substrate at Site I. Sacs of eggs were held in small beakers of water when not in the pond. Hatching was judged to have occurred when large numbers of nymphs appeared and some eggs could be seen to have hatched.

The temperature at the surface of the substrate was recorded when each sample was taken.

Results

Nymphs overwintered in low numbers and were collected in the spring (Fig. 2) at all four sites in a variety of sizes. Neither nymphs of minimum recorded size (those with head widths of 0.1-0.3 mm) nor nymphs in the final instar were present in the samples taken during April or early May. Minimum sized nymphs were first recorded from Site IV on June 4 and from Sites I, II and III on June 11. These small nymphs were frequently present in the samples throughout the remainder of the season. Final instar nymphs were first collected on May 21 and those approaching metamorphosis on May 28. Both types were recorded in the samples until November 1. The percentage of nymphs in the final instar and approaching metamorphosis is shown in Table 1. Nymphal population peaks were recorded at Sites I and IV on June 25 and at Sites II and III on July 2 (Fig. 2). A second population peak occurred at Site II on August 27.

Table 1

Percentages of nymphs of C. triangulifer in the final instar and approaching metamorphosis taken during 1967 *and* 1968

Site	*I*		*II*		*III*		*IV*	
	1967	1968	1967	1968	1967	9168	1967	1968
Final instar	12.2	12.9	9.4	11.6	13.2	7.0	12.7	10.2
App. metam.	2.6	2.2	0	0.5	0	0.7	2.8	1.8

Emergence was recorded from the four sites from June 7 to October 18 (Fig. 3).

Table 2 shows that eggs placed at Site I on September 13 hatched in 14 days while eggs placed at the same site on and after September 25 failed to hatch before winter. That these eggs were viable is shown by the fact that eggs which failed to hatch in the field did so when brought into the laboratory. The eggs remained viable after exposure to conditions at Site I during the winter. This is shown by the fact that they hatched readily in the laboratory the following spring.

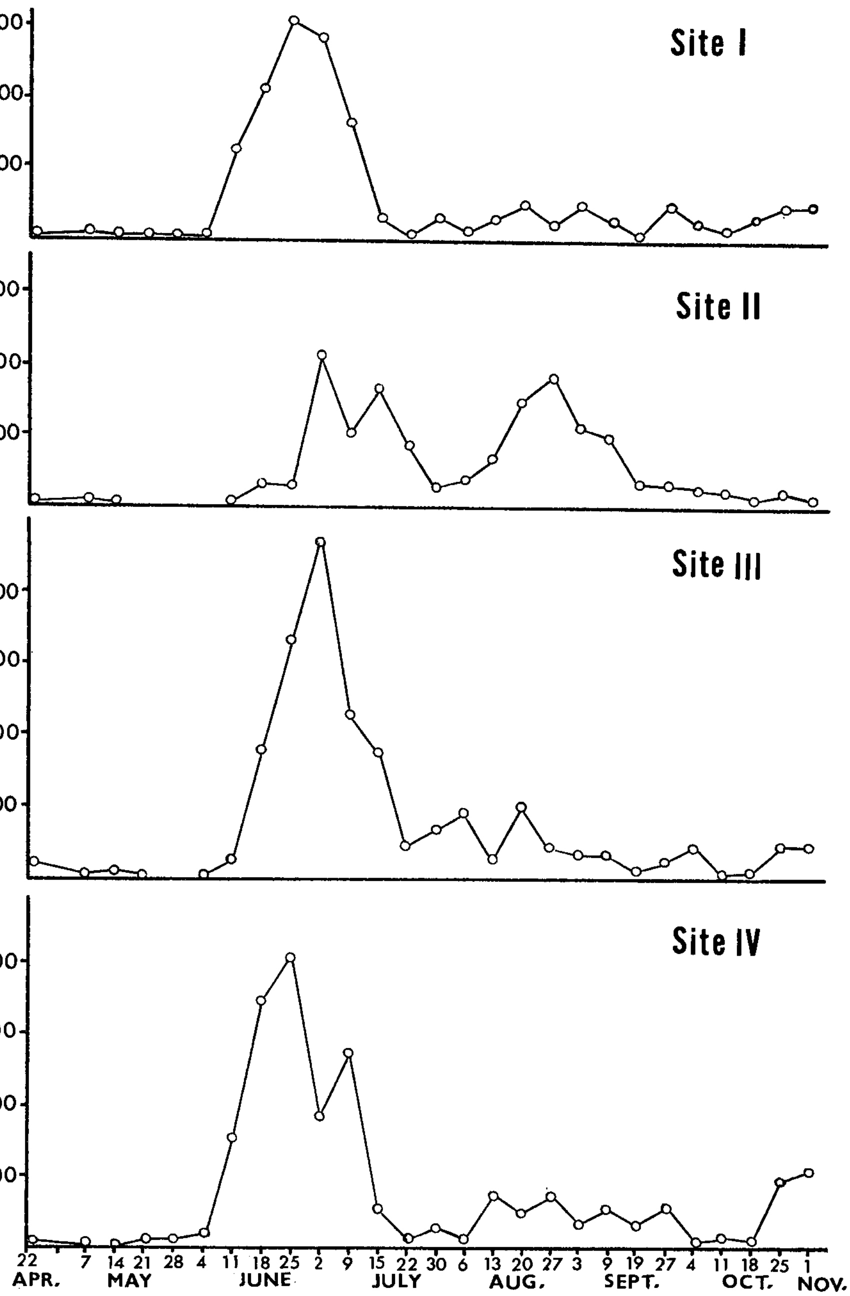

FIGURE 2. Numbers of *C. triangulifer* nymphs taken during 1968.

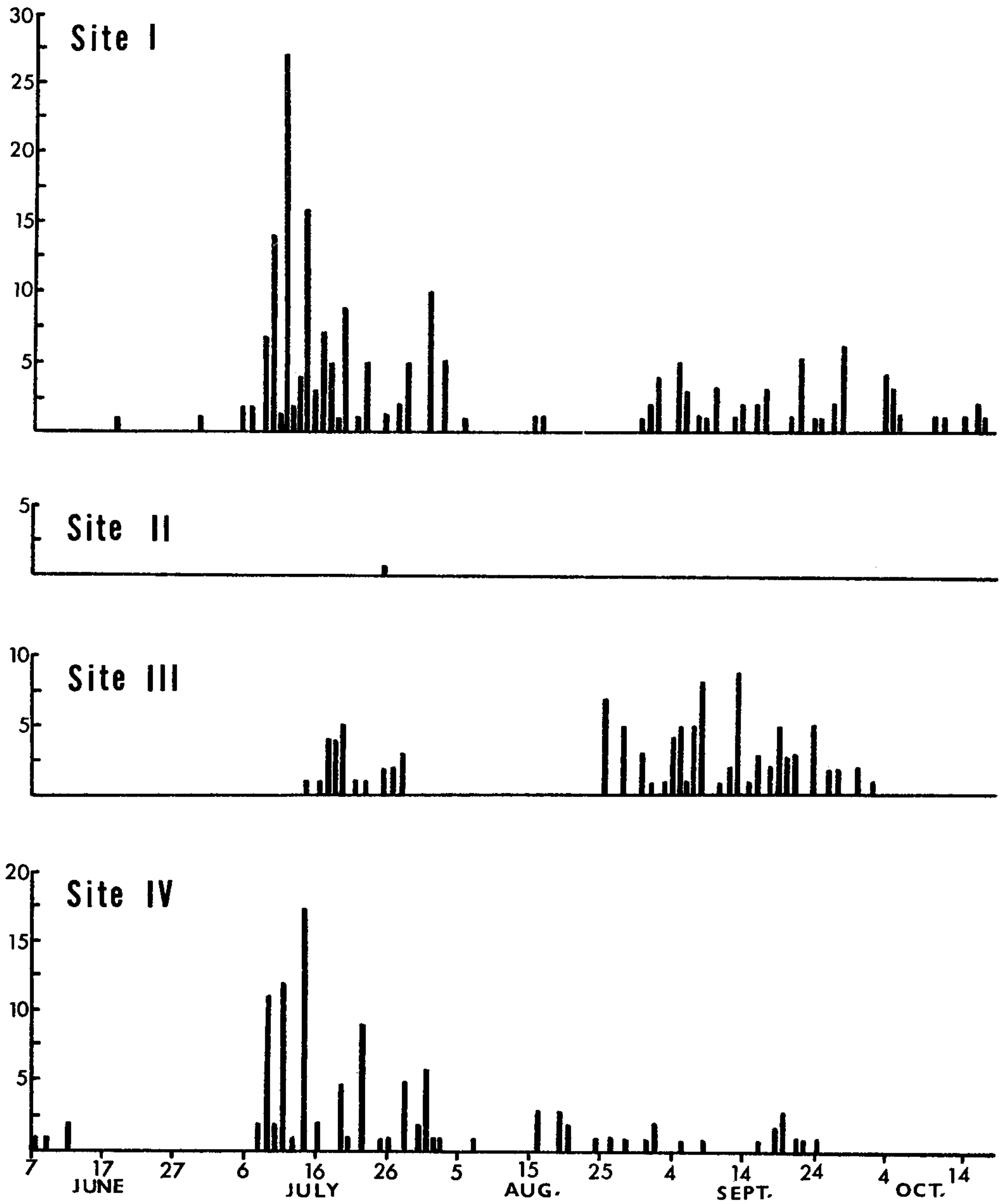

FIGURE 3. Numbers of *C. triangulifer* adults emerging daily during 1968. The numbers represent the total emergence per day from the two traps at the site.

Table 2

Studies on the eggs of C. triangulifer at Site I in 1968

Collected	*Container*	*Hatched in field*	*Brought from field to lab.*	*Hatched in lab.*
Sept. 13	Vials	Sept. 27	—	—
» 25	»	—	Oct. 15	Oct. 20
» 25	»	—	Nov. 1	Nov. 5
Oct. 11	»	—	» 1	» 8
11	Sacs	—	Apr. 26, 1969	May 2, 1969
» 18	»	—	» 26, 1969	» 2, 1969

Table 3

Temperatures recorded at the surface of the substrate during 1968 (°C)

Site	*I*	*II*	*III*	*IV*
Apr. 9	8.0	6.0	8.0	9.0
22	14.5	13.5	13.5	14.5
May 7	10.0	8.0	9.0	11.0
14	14.0	11.0	11.0	15.0
21	10.5	10.0	10.5	12.5
28	17.0	12.5	12.5	17.0
June 4	15.5	13.0	13.0	17.0
11	13.5	12.5	12.5	13.5
18	16.0	14.5	14.5	16.5
25	14.0	13.0	13.0	14.0
July 2	15.5	15.0	15.0	16.0
9	18.0	16.0	17.5	18.0
15	20.0	16.5	17.5	20.0
22	25.0	20.0	22.0	24.0
30	17.0	16.0	16.5	17.5
Aug. 6	20.0	18.0	18.5	20.0
13	18.0	16.5	16.0	18.0
20	17.0	16.5	16.0	17.0
27	16.0	15.5	16.0	17.0
Sept. 3	18.0	15.5	16.0	18.5
9	17.0	15.5	15.0	16.5
19	21.0	15.0	16.5	18.0
27	16.5	15.0	15.5	16.5
Oct. 4	12.0	12.5	12.5	12.0
11	9.5	9.0	9.0	9.5
18	16.0	10.0	12.0	15.0
25	8.5	8.5	8.5	8.5
Nov. 1	6.5	4.5	4.5	4.5

During three years of observations in the area, thousands of nymphs and adults were examined and no male specimens were seen. Nymphs reared in isolation gave rise to adults depositing eggs which hatched readily in the laboratory.

Water temperatures recorded during 1968 are shown in Table 3.

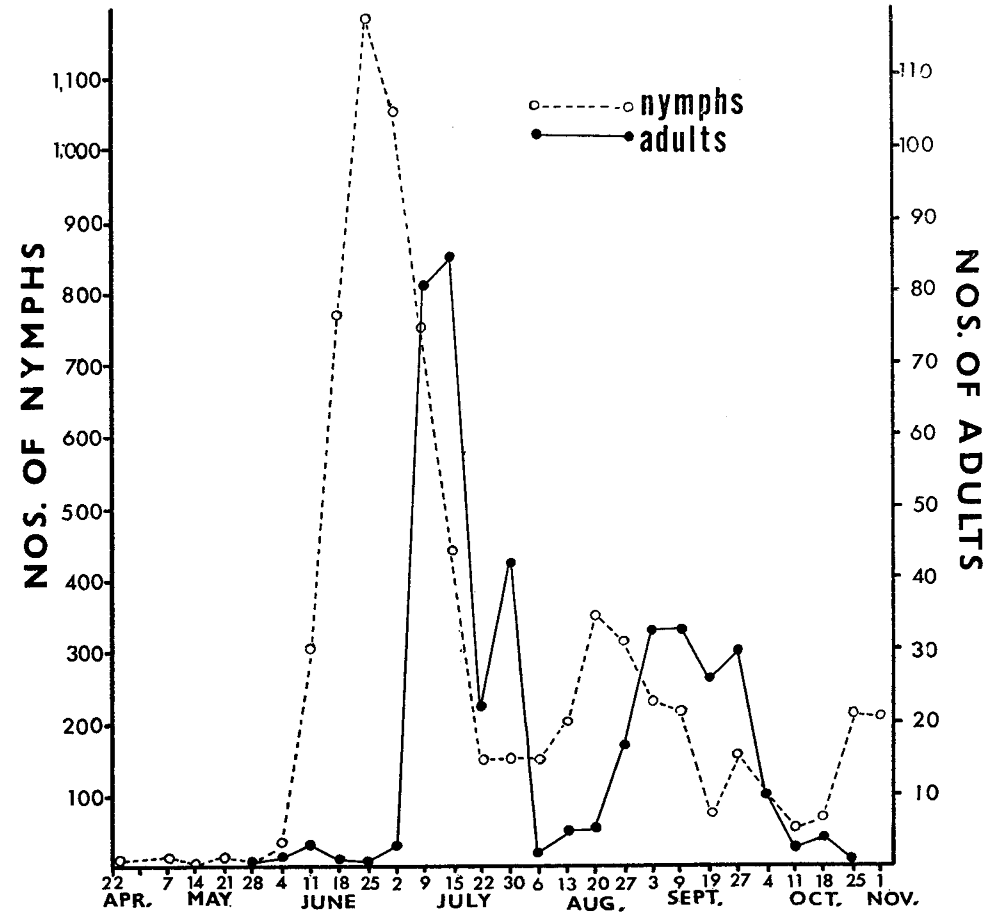

FIGURE 4. Total numbers of *C. triangulifer* nymphs taken from the four sampling sites and total numbers of adults emerging from the four sites for the week coinciding with the nymphal sampling dates during 1968.

DISCUSSION

Fig. 4 indicates that the initial peak of total nymphal population in the pond preceded the initial peak of adult population by three weeks and we have already seen that hatching had begun before adults began to emerge in the spring. It is therefore obvious that the large populations of nymphs appearing in June cannot have hatched from eggs laid in the spring by adults emerging from nymphs which had overwintered in the pond. The alternative is that they came from eggs laid the year before. Since the numbers hatching at Sites I and IV are high and these two sites were above water much of the time between October 28, 1967, and May 9, 1968 (the dates on which the dam was removed and replaced), eggs must have been able to withstand conditions which would he encountered if this hypothesis were true. The results shown in Table 2 indicate that they did have this ability. Adults were taken until mid-October and nymphs approaching metamorphosis were present until sampling ceased on the beginning of November. Therefore, it seems likely that adults were active and eggs were deposited until early November when the pond froze over. It is suggested that on some date in the fall (between September 13 and 25 at Site I in 1968) any eggs which were deposited did not hatch but accumulated on the substrate. It is also suggested that these accumulated eggs hatched in the spring when conditions (probably of increasing temperature) became appropriate.

The ability of eggs to overwinter under conditions where they were above the water line during the winter months and covered with ice and snow would appear to be a mechanism to enable this species to survive in shallow ponds and bays where the water may freeze solidly during the winter. That they also overwintered in areas of water that did not freeze solidly is shown from the occurrence at Site IV of minimum sized nymphs which must have come from overwintering eggs. The fact that temperatures were usually slightly lower at Sites II and III than at I and IV may explain why the initial nymphal population peaks were later at Sites II and III than at I and IV.

The second nymphal population peak at Site II (Fig. 2) may have been due to oviposition being concentrated in the deeper areas of the pond late in the summer. With the exception of Site II, peaks of nymphal population tended to be followed by peaks of adult emergence (Fig. 3). Only one adult was recorded emerging from Site II although substantial populations of mynphs existed here. Table 1 shows that while the percentage of nymphs taken in the final instar remains comparable in all sites during the two years of sampling, the percentage approaching metamorphosis in Sites II and III was much lower than at Sites I and IV. This suggests that there was migration of nymphs from the center of the pond towards the periphery prior to emergence.

It is evident that within the study area the normal mode of reproduction by this species was by parthenogenesis.

Acknowledgements

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Résumé

Distribution saisonnière de *Cloeon triangulifer* McDunnough dans une mare de l'est du Canada

La distribution saisonnière de *Cloeon triangulifer* a été étudiée dans une mare du Québec, Canada. Quatre sites de la mare ont fait l'objet d'échantillonages quantitatifs au cours de deux saisons mais seulement les résulttats de 1968 sont présentés ici. Les larves survivent à l'hiver en faible nombre et ont été récoltées au printemps dans chacun des quatre sites, mais aucune larve très jeune ni aucun instar final n'a été récolté en avril ou début mai. Des larves de taille minimum (largeur de la tête : 0,0-0,3 mm) ont été trouvées d'abord au début juin et pendant tout le reste de l'été. Des larves instar final ont été récoltées à partir du 21 mai et

jusqu'au 1er novembre. Les pics de populations larvaires se sont produits à la fin juin et à la fin août. L'émergence des adultes a été observée du 7 juin au 18 octobre. Les œufs placés le 13 septembre au site 1 n'ont pas éclos avant le printemps suivant. La grande population larvaire apparaissant en juin provient de l'éclosion des œufs déposés dans la mare avant l'hiver. Les larves migrent du centre de la mare vers la périphérie avant leur émergence. Pendant les trois années d'observation il n'a été vu aucune larve ou adulte mâle et il a été montré que dans la zone étudiée la reproduction se fait par parthénogénèse.

Zusammenfassung

Die jahreszeitliche Verteilung von *Cloeon triangulifer* McDunnough in einem Weiher von Ostkanada.

Die jahreszeitliche Verteilung von *Cloeon triangulifer* wurde in einem Weiher in Quebec, Kanada studiert. Vier Plätze im Weiher wurden während zwei Jahreszeiten quantitativ geprobt, aber nur Resultate von 1968 sind präsentiert. Nymphen überwinterten in kleinen Zahlen und wurden im Frühling an allen vier Plätzen gesammelt, aber keine sehr jungen, oder Nymphen im letzten Instar wurden während April oder frühem Mai beobachtet. Minimal grosse Nymphen (Kopfweite : 0.1-0.3 mm) waren zuerst im frühen Juni beobachtet worden und waren durch den Rest des Sommers anwesend. Nymphen des letzten Instars wurden zuerst am 21. Mai gesammelt und hielten bis zum 1. November. Populationsgipfel der Nymphen fand Ende Juni und Anfang August statt. Erscheinen der Erwachsenen wurde vom 17. Juni bis 18. Oktober beobachtet. Eier, die am 13. September am Platz I ausgesetzt wurden, schlüpften nicht vor dem folgenden Frühling aus. Die grossen Populationen von im Juni erscheinenden Nymphen kamen von Eiern, die im Weiher vor dem Winter abgelegt wurden. Nymphen zogen vom Zentrum des Weihers zu Peripherie vor dem Erscheinen. Im Laufe von drei Jahren von Beobachtungen wurden keine männlichen Nymphen, oder männliche Erwachsenen gesehen, und Fortpflanzung innerhalb der Studiengegend war parthenogenetisch.

Discussion

L. Berner : Did any males occur in the late fall ?

E. Gibbs : I didn't find any.

L. Berner : I noticed you indicated that you saw only females. Is fertilization necessary for the overwintering eggs ?

E. Gibbs : I don't know.

L. Berner : I found a population of this same genus in North Carolina which was all female, and I suspected this to be a parthenogenetic species. Was there any indication at all that there was any viviparity in the population you studied ?

E. Gibbs : No, there was not.

C. Fremling : Did you notice what the sex ratio of the last instar nymphs was early in the year ?

E. Gibbs : I saw only female nymphs.

C. Fremling : During the whole study ?

E. Gibbs : Yes, I didn't see any males at all.

C. Fremling : Is it a general rule that parthenogenic mayflies are female?

E. Gibbs : Yes.

C. Fremling : Do you think in this species the males ever appear?

E. Gibbs : I'll say that I have never seen males in three years in the study area. The species was originally described from female adults.

C. Fremling : In *Hexagenia*, nymphs collected from the river will have a sex ratio of one to one, but if you collect eggs from upstream and rear them in the laboratory, the sex ratio is predominately female.

J. Leonard : Mrs. Leonard and I have had a new species of *Cloeon* in manuscript for several years. We have never been able to get the male adults, but we haven't been able to get many nymphs either, so we have been waiting to see if we might be able to get male nymphs. I think parthenogenesis might be expected in this genus.

J. Peters : Do you have a summer generation, or those individuals that overwinter in the egg stage and those that overwinter in the nymphal stage?

E. Gibbs : There appear to be two main peaks of adults. I expect the eggs which hatch and overwinter give rise to adults which deposit eggs and give rise to at least one more generation during the summer.

R. Koss : I suppose that it would be curious to find out if there is a micropyle on these eggs since they aren't fertilized. Have you actually looked?

E. Gibbs : No.

H. Ross : If this species does prove to be parthenogenetic, will this be a new record for parthenogenesis for another order?

E. Gibbs : No.

H. Ross : There are plenty of parthenogenetic mayflies known?

E. Gibbs : There are some records, but not many.

D. Fremling : Are they haploid?

E. Gibbs : I don't know.

L. Berner : I don't recall if there is a male described for *C. triangulifer?*

E. Gibbs : No, there is no described male. Dr. McDunnough described it from the females.

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