EMERGENCE OF CADDISFLIES (TRICHOPTERA) AND MAYFLIES (EPHEMEROPTERA) FROM HEMING LAKE, MANITOBA

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Abstract

Can. Ent. 104: 173–183 (1972)

Forty-nine 0.1 m^2 emergence traps positioned over several substrate types and a range of water depths 0.9 to 5.5 m, from 2 June to 7 September 1967, collected 979 caddisflies and 195 mayflies. The caddisfly emergence was restricted to the period 24 June – 27 August, and mayfly emergence to the period 2–30 July.

The sex ratio for the caddisflies showed, in almost every case, a preponderance of females and no male *Neureclipsis bimaculatus* (Linn.) and *N. validus* Walk. were collected. Most of the caddisflies showed preference for a particular depth and/or substrate type. The few caddisflies which were present both in large numbers and distributed over a fairly wide depth range indicated that there is a relationship between depth distribution (temperature) and emergence time, heat perhaps being involved both in control of rate of maturation and as a releasing agent for the actual emergence.

Male *Stenonema interpunctatum canadense* (Walker) showed peak emergence about 5 days before the females and also outnumbered the females by about 3:1. No relationship seemed to exist between depth distribution and emergence time for any of the mayfly species. However, the emergence of one species, *Caenis forcipata* (McD.) may be related to weather conditions.

Introduction

The following study was undertaken during the summer of 1967 in Heming Lake, a small (640 acres), relatively shallow (max. depth 5.5 m), humic-influenced pre-Cambrian Shield lake in northern Manitoba, the limnology of which has been described by Lawler and Watson (1958).

Various works including Lawler (1963, 1965, 1966, etc.) and Watson (1963) have been published on the fishes and fish parasites of the lake but, other than a preliminary survey of the bottom fauna (Lawler and Watson 1958), little is known about the insect fauna. This study, which includes only Trichoptera and Ephemeroptera, was part of a broader investigation into organism substrate relationships, phenology, and general biology of the aquatic insect fauna of the lake. The section dealing with the chironomids will be published at a later date.

Methods

During the summer of 1967, 2 June to 7 September, 49 emergence traps were positioned in Heming Lake (Fig. 1). The traps were emptied, and water temperature and general weather conditions recorded every second day. The traps were set to give as complete coverage of substrate types and depths as possible—at depths varying from 0.9 to 5.5 m, on bottom types ranging from bedrock through stones, gravel, sand, and silt to the grey flocculent ooze found at the deeper stations. Many of the stations had either dead or growing vegetation. Underwater photographs and Ekman grab samples were used in determining substrate types.

The emergence traps used were of the type described by Hamilton (1965, unpub.). This version of the submerged, negatively buoyant funnel trap works on the same principle as that originally proposed by L. L. Rossolimo, first used by Grandilewskaja-Decksbach (1935) and later modified by various other workers. Its main advantages over most other submerged traps lie in the increased trans-

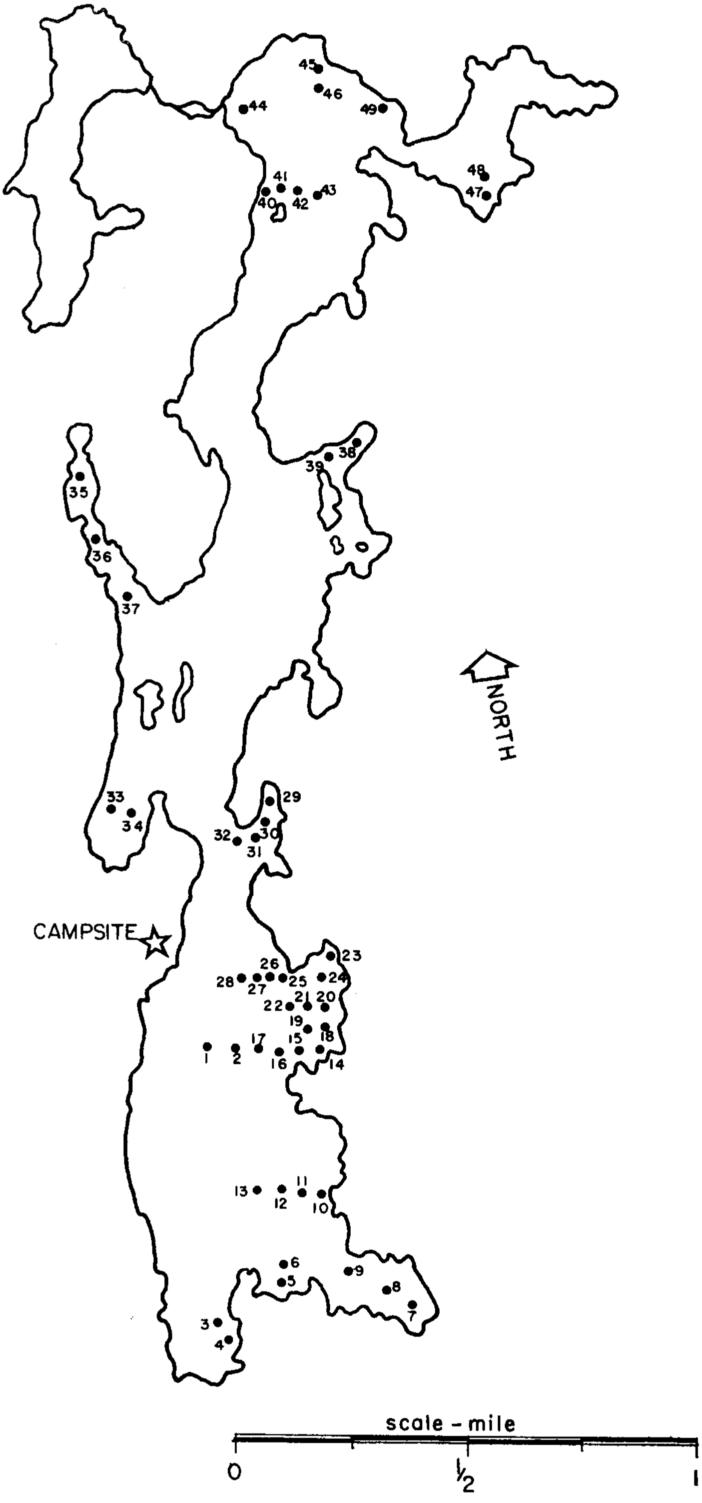


FIG. 1. Positions of emergence trap stations in Heming Lake.

parency, the ease of construction, the durability, and the ease with which the funnel can be kept clean. The traps are constructed as follows:

The funnel is constructed from 0.025-in. transparent vinyl plastic to give a base diameter of 35.8 cm (thus a sampling area of 0.1 sq. m). An 8-oz screw-top glass jar is attached to the apex of the cone by its bakelite lid in which a 4.5-cm diameter circular hole has been cut. The bakelite lid is attached to the neck of the trap by a stainless steel hose clamp. Finally, in order to give the trap negative buoyancy, and to help stabilize it, four lead weights are attached around the lower rim of the funnel (see Hamilton 1965, unpub., for more concise description).

In operation, the trap was suspended from a buoy, which was in turn anchored to the lake bottom. Samples were collected by unscrewing the glass jar, while underwater, and screwing onto it a whole lid. The jar was then removed from the water and its contents preserved in 70% ethyl alcohol.

The traps were emptied and water temperature (at 1-m intervals down through the water column at the deepest part of the lake) and general weather conditions were recorded every second day. Mayflies were identified using Needham *et al.* (1935) and Burks (1953). Caddisflies were identified following Ross (1944) and then sorted into two categories after Fremling (1960): ovulating—abdomen full or almost full of eggs; spent—with no eggs or with only a few large eggs. The figures obtained were then used to calculate the percentage of females successfully returning and laying eggs $(= \frac{\text{spent } ♀♀ \times 100}{\text{ovulating } ♀♀})$. Following Whittaker and Fairbanks (1958), the percentage similarity of community ($PS_c = \Sigma \min (a, b)$ where a and b are the percentage of total animals of the two groups occurring in samples from the various stations) was calculated, but instead of comparing two species, the two categories mentioned above (spent and ovulating), of each species of caddisfly, were compared to give an idea of substrate selectivity of the returning insect.

Results

A total of 979 caddisflies, representing 19 species, and 195 mayflies, representing 5 species, were collected in the traps over the summer. The caddisfly emergence was restricted to the period 24 June - 27 August and the mayflies to 2–30 July. In general both groups were restricted to the shallower water and coarser sediments, only isolated individuals being collected over the soft flocculent ooze found at the deeper stations.

TRICHOPTERA

Five families belonging to this order of insects were collected in the traps. Densities varied greatly, from zero at most of the stations over the soft flocculent profundal ooze, up to 1470 per sq. m (not including spent ♀♀) at station 44. The most common family, Psychomyiidae, was represented by four genera and seven species. From emergence data for this family (Table I, A) it can be seen that although large numbers of *Neureclipsis validus* were caught, not a single male specimen emerged. Males of this species have been recorded elsewhere (Ross 1944, etc.), thus the species is not parthenogenic everywhere. The other species of this genus (*N. bimaculatus*) and *Polycentropus interruptus* (Banks) also produced only females, but in these cases the numbers involved were very small. In general, very few male caddisflies emerged so that even allowing for the presence of spent females there is still a considerable imbalance in sex ratio.

Table I. Emergence data for (A) the seven psychomyiid species and (B) the four micro-caddisfly species collected in the emergence traps

	No. of specimens			Emerg. period†	Emerg. peak	Depth range (m)	Most common substrate	% similarity of community	% returned (spent) ♀♀
	♂♂	♀♀	♂♂:♀♀						
					A				
Neureclipsis bimaculatus	0	11	–	4 Jul. – 15 Aug.	No peak	1.2–2.0	Stones on silt	0.0	36
N. validus	0	317	–	24 June – 3 Aug.	2–16 Jul.	0.9–2.7	Silt with veg.	96.9	62
Nyctiophylax vestitus	8	48	1:6	4–30 Jul.	No obvious peak	0.9–4.6	Rocks or veg.	No spent ♀♀	0 No spent
Phylocentropus placidus (Banks)	4	187	1:24	2–30 Jul.	12–18 Jul.	0.9–5.5	Silt with veg.	57.9	93
Polycentropus cinereus	8	61	1:4	2 Jul. – 11 Aug.	22 Jul. – 5 Aug.	0.9–4.6	Rocks on sand	51.7	97
P. interruptus	0	21	–	6–24 Jul.	12–18 Jul.	0.9–1.2	Veg. on silt	55.5	>100
P. remotus	2	5	app. 1:1	22 Jul. – 1 Aug.	No peak	0.9–2.4	Rock and veg.	00.0	66
					B				
Hydroptila nr. *rono*	3	50	1:12	June 28 – 20 Jul.	10–14 Jul.	0.9–1.2	Veg.	67.8	62
H. salmo	4	151	1:23	20 Jul. – 15 Aug.	26 Jul. – 10 Aug.	1.1–5.2	Rocks	78.56	64
H. nr. *scolops*	1	53	1:31	28 Jul. – 17 Aug.	3–13 Aug.	0.9–4.3	Rocks	58.1	71
Oxyethira serrata	1	15	1:8	6 Jul. – 13 Aug.	No obvious peak	1.1–5.5	Rocks or veg.	42.9	87

*Adjustment for presence of spent females has been made in calculation of sex ratio.

†In each case earliest possible emergence time is given, i.e., immediately after the traps were reset on the last sampling date before any emergence occurred.

In both the Psychomyiidae (Table I, A) and the Hydroptilidae (Table I, B) total emergence periods appear to be quite short and in most of the species the peak emergence period (the middle 50% of the emergence) was restricted to a few days. In some instances a relationship appears to exist between depth and/or temperature and emergence time, the caddisflies from deeper stations emerging later than those from the shallower stations (Figs. 2, 3).

Nyctiophylax vestitus (Hagen) appears to have been the only species of these two groups in which the females do not return to the water to lay their eggs, the remaining species not only return but also show great success in their attempts to do so since the percentage return factor is always high. The percentage similarity of community, as used here to indicate selectivity for substrate in the returning females, is, of course, related to the percentage return index but it shows that *Neureclipsis bimaculatus* and *P. remotus* (Banks) although returning into the lake for egg laying, do not appear to select the kinds of substrates from which the ovulating females emerge.

Representatives of three other families emerged into the traps in Heming Lake, but since only isolated individuals of these taxa occurred, only the number and emergence times are listed below.

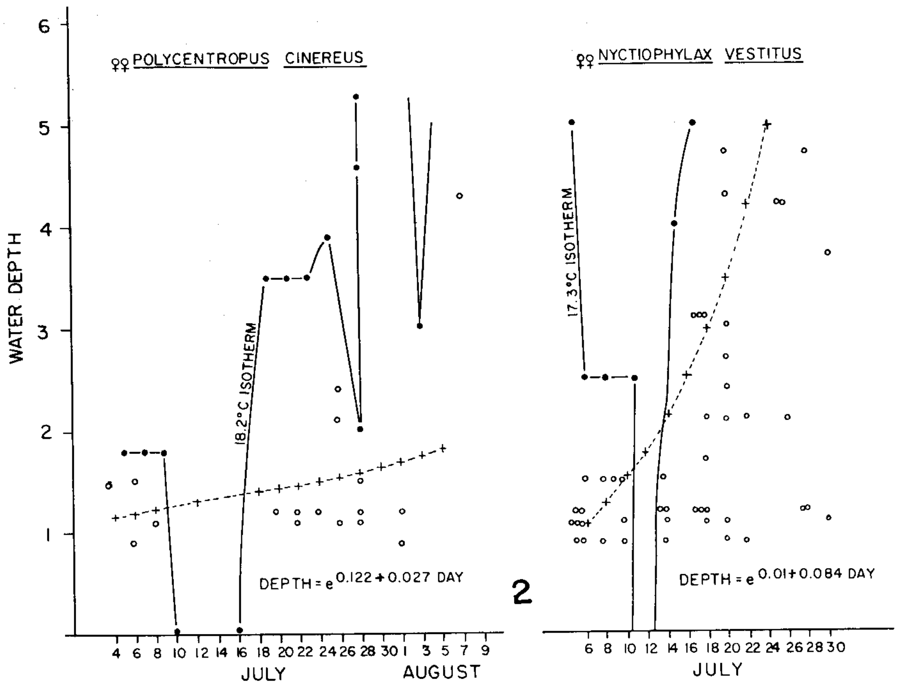
	No. of specimens	Emergence time
Leptoceridae		
Oecetis sp.	2	12 July – 3 Aug.
Triaenodes marginata Sibley	1	30 July
Mystacides sepulchralis (Walker)	3	14, 18 July
Hydropsychidae		
Hydropsyche recurvata Banks	1	16 July
Cheumatopsyche analis (Banks)	4	22 June – 27 Aug.
Phryganeidae		
Agrypnia straminea Hagen	1	25 Aug.
A. vestita (Walker)	1	14 July
Phryganea cinerea Walker	2	12, 20 July

EPHEMEROPTERA

Five species of mayflies were collected from the traps, all within the period 2–30 July. Mayflies were not collected at any of the eight stations over 3.7 m deep, and the two specimens taken in trap 37 (3.7 m) were the only ones taken at depths greater than 3.0 m. Mayflies emerged at only one of the 15 stations which had substrates of the flocculent ooze type.

Densities of mayflies (all species together) varied from 0, at the deeper stations, to a maximum of 250/sq. m at station 10, which had a rocky substrate. The maximum densities recorded for the individual species are as follows: *C. forcipata,* 140/sq. m at station 47 (vegetation over silt); *Stenonema interpunctatum canadense,* 230/sq. m at station 10 (rock); *Hexagenia limbata* (Serville), 90/sq. m at station 18 (vegetation on silt interlaced with rock). The remaining two species occurred as scattered individuals in very shallow water.

Perhaps the most striking single feature of the mayfly is the difference in peak emergence times between the two sexes of *S. i. canadense* (see Table II). This species was also the only mayfly of the three occurring in reasonably large numbers in which the males outnumbered the females significantly.



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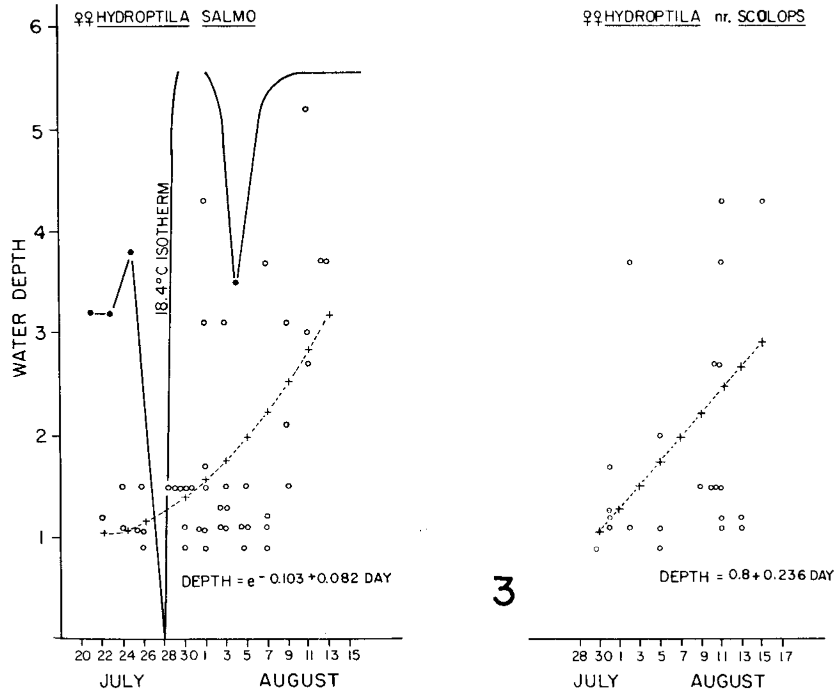

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FIG. 2. The relationship between water depth, temperature, and emergence of *Polycentropus cinereus* and *Nyctiophylax vestitus*, *Hydroptila salmo*, and *Hydroptila* nr. *scolops*.

Discussion

The reliability of floating as opposed to submerged emergence traps has been discussed by several authors including Guyer and Hutson (1955), Mundie (1956), and Morgan *et al.* (1963), who used metal sheet or mesh in constructing their traps. Kimerle and Anderson (1967) used a transparent plastic material but gave no indication of the light transmission properties of the material they used. All of these authors concluded that perhaps the most important single factor affecting the reliability of both submerged and floating emergence traps was the possibility of emerging pupae and nymphs avoiding the trap because of the shading effect produced by the light-absorbing properties of the materials used in construction of their traps. The Hamilton (1965, unpub.) version of the submerged trap has light transmission properties as outlined below (from F. A. J. Armstrong, pers. comm.). It can be seen from these results

Wavelength	350	400	450	500	550	600	650	700	750	nm
% Transmittance										
50 mm	95	95	95.5	95.5	95.5	95	93	92	82	
Distilled water										
Vinyl plastic	72	81.5	83.5	83.5	82.5	84	86	87	87	

that the transmittance of the plastic sheet is lower than the distilled water in the ultraviolet end of the scale while the reverse is true at the infrared end; throughout the remainder of the waveband the plastic material transmits approximately 10% less light than the water sample. Hutchinson (1967) states that most of the light in the ultraviolet and infrared zones is rapidly removed in the first meter and also shows that transmittance of light varies greatly from lake to lake and sample to sample depending on color, dissolved materials, air bubbles, etc. Any one of these factors can therefore produce greater variation than the 10% difference shown above. The Hamilton trap would then appear to be transparent enough to at least have partly overcome the transparency difficulty found by the above-mentioned authors.

The various authors referred to have also pointed out that both kinds of traps probably suffer loss of insects from predation by fish and by terrestrial arthropods such as spiders and mites, and if the traps are not emptied often enough or if a mass emergence occurs, some insects are liable to be drowned and lost. However, there seems little doubt that although these traps may not be quantitative in the strict sense of the word, they should be at least "relatively quantitative" in the sense of Brinkhurst (1967) and can therefore be very useful for qualitative and comparative studies.

The very short emergence periods exhibited by most of these caddisflies are probably a result of the short summer season in northern Manitoba. In some instances a definite relationship appears to exist between depth and emergence time, the caddisflies from the deeper stations emerging later than those from the shallower stations (Figs. 2, 3).

This difference may be a result of either variation of accumulated day-degrees with depth as suggested by Judd (1953), or may be the result of emergence behaviour being released by a specific temperature, or possibly is a combination of these two factors. The 17.3°C isotherm appears to fit rather well with *Nyctiophylax vestitus* emergence and the 18.2°C isotherm with that of *P. cinereus* (Hagen). The remaining species of this family show no temperature/depth/emergence correlation. However, at least some of them are very limited in their depth distribution.

Of the three species of *Polycentropus, P. interruptus* and *P. remotus* showed emergence times, which although overlapping on 22 and 24 July, were clearly separated. The third species, *P. cinereus,* had an emergence period which, although overlapping those of the other two species, showed a distinctive peak rather later than the other two. The immatures also seem to colonize slightly different niches as evidenced by the depth distribution of the three species.

Four species of "micro caddisflies" emerged into the traps. The genus *Hydroptila* was represented by three species. Of these only the males of *H. salmo* Ross fitted well with previously described species, the female of this species not having been described. The other two species were close but not identical with previously described species (Wiggins, pers. comm.), and are referred to the closest species because of the shortage of male imagines. *H.* nr. *rono* Ross (see Table I, B) was the earliest of these three to emerge and had completed its emergence before either of the other two species had started theirs. This species also showed a much more restricted depth distribution.

H. salmo was the next species to emerge and its emergence period, but not its emergence peak, overlapped with that of *H.* nr. *scolops* Ross. These two species appeared to have very similar substrate requirements although *H. salmo* was distributed a little deeper than *H.* nr. *scolops. Oxyethira serrata* Ross is, according to Ross (1944), found in the glacial lakes of Illinois in 2 or 3 ft of water and emerges from May to the middle of July. Since Manitoba is considerably further north than Illinois it is not surprising to find that the emergence period for this species in Heming Lake is up to a month later than in Illinois. The latitude and resultant cooler waters probably allow the oxygen tensions to be higher in deeper water, thus accounting for the deeper distribution.

As with the Psychomyiidae, some of these species showed a definite correlation between depth distribution, temperature, and emergence (Fig. 3), the emergence of *H. salmo* apparently being released by temperatures of 18.4°C or above. *H.* nr. *scolops* exhibited a definite relationship between depth and emergence; however, the emergence did not appear to be released by a specific temperature. *H.* nr. *rono* apparently does not colonize the deeper waters and thus did not exhibit this kind of relationship. The remaining species *O. serrata* did not occur in sufficiently large numbers for analyses of this kind.

Some female caddisflies which re-enter the water to lay their eggs appear to actively select particular substrates for oviposition (Hora 1930; Badcock 1953). If there is a correlation between the substrate selection by the adult female and the ecological requirements of the larvae and/or pupa, then spent females should re-emerge at the same stations at which the original emergence took place. The percentage similarity of community, if used to compare the previously described two stages of each species (ovulating and spent) at the various stations, would then be indicative of the selectivity of the returning females. This index and the percentage return index rely on two assumptions, the first being that unfertilized females do not enter the water and the second that females lay all their eggs in one batch or at least do not stay in the traps between periods of egg laying. The second assumption was supported by the fact that all the females collected contained either none, or only one or two eggs, or were apparently filled to capacity with eggs.

The percentage return of females varied from 0 to 100%, with, as previously mentioned, only one species apparently not returning to the water to lay eggs. The remaining figures indicate a fairly high success in returning to oviposit and presumably a fairly low loss due to predation by fishes, birds, etc. This would appear to be in accordance with the relatively unimportant part played by adults of this order, as fish food for the major fishes of the lake since Lawler (1963–65–66) shows "aerial insects" to form only a minor part of the diet of Heming Lake whitefish, burbot, and pike.

Although the percentage return and the percentage similarity of community are obviously interrelated indices, a comparison of the results obtained for the various species shows that not all the caddisflies which re-enter the water appear to actively select substrate types similar to those over which mature females of the same species have emerged. *P. remotus* and *Neureclipsis bimaculatus* both show reasonably high returns but have percentage similarity of community of zero. This would seem to indicate that the returning caddisflies of these species do not actively select the kinds of substrates over which the ovulating females emerged. However, selectivity may still be occurring since the pupal requirements may be different from those of the larvae. As already mentioned, perhaps the most striking single feature of the mayfly results in the difference in peak emergence times between the two sexes of *Stenonema* (see Table II). Although it is not uncommon in other aquatic insect orders for the males to emerge before the females, the 5-day difference in peak emergence seems rather long in a group of insects noted for their short lifespan as imagines. The males also outnumbered the females by about 3:1. However, the presence of so many more males perhaps increases their chance to mate with the females, perhaps compensating, in part, for the disparity in emergence times.

The scarcity of *Ephemera simulans* Walker is rather puzzling. Light trap and hand net collections taken by Dr. Lawler's family during the following summer (1968) indicated that this species is at least as common as *H. limbata* in Heming Lake. *Ephemerella temporalis* McD. was also much more common in relation to the other species in the light traps. Both of these species may have their maximum occurrence in water shallower than 0.9 m in Heming Lake, or shoreward migration of the mature nymphs (as recorded for *Ephemera danica* Mull by Slack (1957)) and the resultant avoidance of the traps, may partly explain this scarcity.

Heptageniidae, although classified by Needham *et al.* (1935) as "stone loving forms of rapid waters," have been recorded from lakes by Clemens (1915), Ide (1930), and others. *S. interpunctatum* is perhaps the heptageniid species most tolerant of lacustrine environments but is, in lakes, generally restricted to stones or

Table II. Emergence data for the five species of mayflies collected in the traps

	No. of specimens			Emergence period (July)	Emergence peak (July)	Depth range (m)	Most common substrate
	♂♂	♀♀	♂♂:♀♀				
Caenis forcipata	38	35	ca. 1:1	2–30	2–4	0.9–3.7	Veg.
	(+22 damaged)						
Stenonema interpunctatum canadense	37		3:1	4–14	8–12	1.1–3.0	Rock and stones
		13		10–18	14–16		
Hexagenia limbata	18	22	ca. 1:1	8–30	14–18	0.9–3.0	Rock and veg.
Ephemera simulans	4	1	–	12–18	–	0.9–1.1	Sand with scattered stones
Ephemerella temporalis	2	1	–	4–10	–	1.1–1.2	Sand with stone and veg.

rock on exposed shores of large lakes where, presumably, wave action provides the high dissolved oxygen concentrations they require.

Hexagenia limbata occulta is one of the most common mayflies in the larger rivers and lakes of Manitoba and this plus its large size make it very important as a source of fish nutrition. Watson (1963) showed that they were the major item in the diet of the whitefish, while Lawler (1963–65–66) showed that they were important in the diet of the burbot and pike in Heming Lake. This species is perhaps the best known mayfly in North America, and in Manitoba it has been extensively studied in Lake Winnipeg by Neave (1932, 1934). The Heming Lake specimens are peculiar in that they appeared over all substrates, being most common over substrates with rocks or vegetation. From most other reports the nymphs appear to prefer mud substrates. The very soft flocculent "profundal" ooze of this lake does not seem to provide a suitable habitat for this or any of the other mayflies.

The remaining species, *C. forcipata,* exhibited a rather peculiar emergence pattern of 8 days of emergence alternating with 2 days without. This pattern appeared to be correlated with weather conditions, emergence occurring during sunny days and ceasing during cloudy days. However, the weather records were not sufficiently detailed to conclusively show this relationship.

Conclusions

The trichopteran fauna of Heming Lake consists of at least 19 species, several of which apparently occur in relatively large numbers. Those species which do occur in relatively large numbers and which are distributed over a fairly broad depth range indicate that caddis emergence is related to temperature. Heat may be involved in two ways, as an accumulation of day-degrees controlling growth and maturation, or as a releasing agent for emergence behaviour. It seems probable that both these factors are involved. The day-degree accumulation controlling the rate at which the caddis larvae and pupae mature and the required water temperature then releasing the actual emergence. In general, all of the species collected had a very short emergence period, were restricted to some degree to a particular depth range and appeared to have a preference for a particular substrate type. A decided imbalance in sex ratio appears to exist in most of these species.

The mayfly fauna of the lake consists of at least five species. No correlation appears to exist between depth distribution, water temperature, and emergence in any of these species. The emergence of *C. forcipata* appeared to be related to weather conditions but the data is not conclusive. The males of one species, *S. i. canadense,* showed a peak emergence 5 days before that of the females. This imbalance in emergence times is probably compensated by the fact that the males are three times as common as the females.

Acknowledgments

Thanks are due to Mr. Allen P. Wiens, summer assistant, who emptied the traps, measured the environmental variables, and preserved and labelled the specimens; to Mr. Gordon P. McRae for the preliminary sorting of the collected material; to Dr. F. P. Ide, University of Toronto, for providing much assistance with the mayfly material and Dr. Glenn B. Wiggins, Royal Ontario Museum, for his assistance with caddisfly identifications. Drs. A. L. Hamilton and O. A. Sæther provided very useful criticisms of this manuscript.

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(Received 10 May 1971)