

Emergence and upstream flight of lotic mayflies and caddisflies (Ephemeroptera and Trichoptera) in a lake outlet, central Finland

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Temporal and spatial occurrence and upstream flight of lotic mayflies and caddisflies were studied by means of kick netting, slit traps and floating emergence traps in Lake Konnevesi and its outlet stream (Siikakoski), mainly in 1983. Twenty species of mayflies and 78 species of caddisflies were recorded. Clearly lotic mayflies in the material were *Baetis subalpinus*, *Heptagenia sulphurea* and *Ephemerella mucronata*, which occurred only in the stream samples. Females of lotic *Baetis rhodani* had a long distance upstream flight in the area and occurred frequently in the floating emergence traps especially in sandy littoral habitats of L. Konnevesi. *Procloeon bifidum* and *Nixe joernensis*, which in some regions occur mainly in streams, were frequently found in the stony littoral belt of L. Konnevesi. Most of the mayflies recorded in the area were univoltine, but *Baetis rhodani* and *Centroptilum luteolum* at least had two generations in 1983. Strictly lotic species among caddisflies were *Ceratopsyche nevae*, *Hydropsyche saxonica*, *Halesus digitatus*, *Ceraclea perplexa*, *Ylodes detruncatus*, *Athripsodes commutatus* and *Hydroptila forcipata*. These were mainly found in stream samples. A short distance upstream flight of females (c. 0.1–0.4 km) was observed in the populations of *H. siltalai*, *Psychomyia pusilla* and *Oxyethira frici* and a moderate distance flight (at least 0.6 km) by females of *Hydropsyche pellucidula*, *Cheumatopsyche lepida* and *Polycentropus irroratus*. The most abundant caddisflies of the stream Siikakoski (*Brachycentrus subnubilus*, *Neureclipsis bimaculata*, *Rhyacophila nubila*, *Agapetus ochripes*, *Micrasema setiferum* and *Hydroptila cornuta*) were frequently found also in floating emergence traps in the lake (3.7 km from the rapids). Females of *Brachycentrus*, *Neureclipsis* and *Rhyacophila* favoured traps on sandy substrata while females of *Hydroptila* were usually found in the stony belt. In the trap material of *Agapetus ochripes*, males were more abundant than females. According to emergence data, all caddisflies recorded in the area were univoltine though the emerging period of several species such as *Rhyacophila nubila* and *Neureclipsis bimaculata* was long. Maximum emergence was observed in early June when brachycentrids were swarming and another peak in August when limnephilids and leptocerids were abundant.

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1. Introduction

In two earlier papers (Bagge 1987, 1992) dealing with the trichopteran fauna of Lake Konnevesi and its outlet stream Siikakoski, I have noticed a frequent occurrence of adults of some running water species in the floating emergence traps situated in the littoral zone of the lake.

In this paper, the emergence and upstream occurrence of adults of lotic mayflies and caddisflies will be presented in more detail. The material was caught mainly in 1983 and includes both adults and larvae, thus allowing an analysis of both spatial and temporal occurrence of lotic species in the lake-stream gradient. Both the downstream drift of larvae and the upstream dispersal of adults have been considered essential factors in the colonization cycle of stream insects (cf. Müller 1954, 1982, Russev 1972, Madsen et al. 1977, etc.). However, the literature data on the length of the dispersal of mayflies and caddisflies are rather contradictory, depending mainly on the catching methods (cf. Sode & Wiberg-Larsen 1993). A wide dispersal of limnephilids and some hydropsychids especially has been observed in light catches (cf. Göthberg 1973, Svensson 1974, Bagge 1982, etc.), while results of more passive methods such as Malaise-trapping indicate much weaker dispersal (Sode & Wiberg-Larsen 1993). As stated by Sode & Wiberg-Larsen (1993), the study of dispersal of stream insects is essential in the protection and restoration of streams, since many stream insects (e.g. short-winged and wingless species) have a low capacity for migration. The problem is most acute in regions where the distance between running water habitats is long or important habitats have been destroyed.

2. Sampling methods and the study area

Larvae of mayflies and caddisflies were sampled in the stream in September 1983 and 1988 mainly by means of kick netting (1 min. kicking) and with colonization bricks (together c. 30 samples). Kick net samples were also collected at ten localities in the stony littoral belt of Lake Konnevesi in May–August 1983.

Two types of traps were used in sampling imagoes and subimagoes in May 24–September

28, 1983 (Bagge 1987). The floating emergence traps, each covering 0.36 m² were provided with a container of preservative (ethylene glycol) and were emptied once a week. The slit-traps, originally constructed by Kuusela and Pulkkinen (1978) for catching adult stoneflies, were also provided with a preservative and were emptied every tenth day. The location of the traps in the stream banks and in the littoral belt of the lake is presented in Fig. 1. Six of the ten floating traps were in the shallow stony belt, 0.2–3.1 km upstream from the rapids, and the other four were on the somewhat deeper sandy bottom (0.2, 0.4, 3.0 and 3.9 km from the outlet stream). Five slit-traps were installed on the stony bank of the stream and one trap on the stony shore of the lake c. 0.1 km upstream from the rapids.

The study area, which is situated in the southwestern corner of the lake, may be characterized as a relatively natural, undisturbed large outlet stream with a high mean flow and low concentration of both humus and nutrients (Table 1).

The stream is an important spawning area of several running water fishes including brown trout and grayling (Bagge et al. 1993) and harbours a rich fauna of filter-feeders and grazers in particular, but very few shredders.

3. Results

A total of 20 species of mayflies and 78 species of caddisflies were observed in the samples. The trichopteran and ephemeropteran fauna consisted of both lotic and lentic species, and several species such as *Caenis horaria*, *Heptagenia fuscogrisea* and many polycentropodids occurred abundantly in both lake and stream samples.

Lotic mayflies inhabiting the stream Siikakoski were *Baetis rhodani*, *B. subalpinus*, *Heptagenia sulphurea* and *Ephemerella mucronata*. Moreover, the lake material contained both larvae and subimagoes of *Nixe joermensis* and *Proclleon bifidum*, which in many areas are considered as running water species.

The lotic component in the trichopteran fauna was strong, comprising especially filter-feeders such as *Brachycentrus subnubilus*, *Neureclipsis bimaculata* and hydropsychids, scrapes such as *Agapetus ochripes*, *Psychomyia pusilla* and several *Ceraclea*

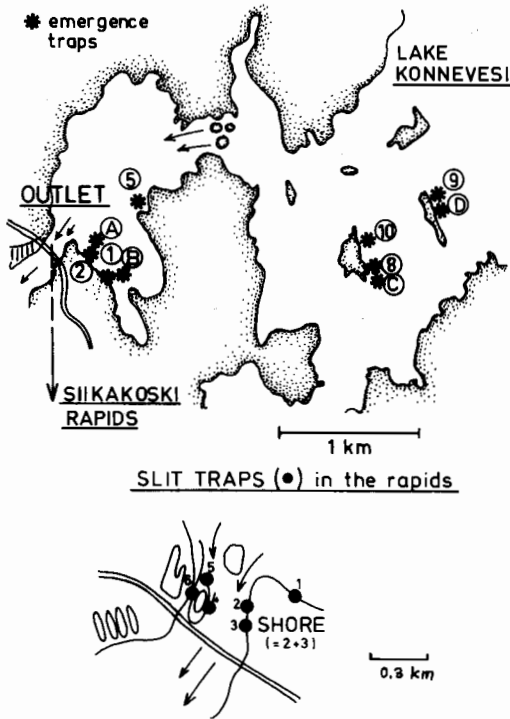


Fig. 1. Location of the traps in 1983.

spp., but only a few shredders (e.g. *Halesus* spp.). The larvae of these species were observed only in the stream samples, but adults of several species occurred frequently in the lake traps.

Table 1. Mean characteristics of the Siikakoski rapids during summer 1981 (Heinonen 1984).

Mean flow (MQ, m ³ /s)	100*	pH	7.2
Temperature °C	15	Colour mgPt/l	29
O ₂ -conc. mg/l	9.2	Total N, µg/l	355
Conductivity, ms/m	4.3	Total P, µg/l	9

*Long term MQ = 43.5 m³/s

The upstream dispersal of lotic mayflies and caddisflies

On the basis of adult material observed in the traps, four types of dispersal could be separated among the lotic mayflies and caddisflies.

1. species observed only in stream samples
2. species with a short distance upstream flight (≤ 0.2 km)
3. species with a moderate distance upstream flight (0.4–0.6 km)
4. species with a long distance upstream flight (≥ 3 km)

Lotic species observed only in the stream (Table 2) included three common mayflies and five relatively rare caddisflies. The opposite to the case for other lotic mayflies in the group larvae of *Ephemerella mucronata* were relatively rare in the kick net samples in September 1983, but very abundant on colonization bricks in autumn 1989 (Hynynen, pers. comm.).

A short distance upstream dispersal (< 0.2 km) was observed in the populations of *Halesus* spp. and *Ceratopsyche nevae*. Rare species perhaps belonging to this group were *Ylodes detruncatus*, and *Ithytrichia lamellaris* (Table 3).

A moderate distance dispersal (0.4–0.6 km) was observed in the populations of *Hydropsyche pellucidula*, *H. siltalai* and *Cheumatopsyche lepida*, which were abundant in the larval samples although numbers of the adults were low in traps (Table 3).

Adults of *Psychomyia pusilla* were abundant in the stream traps but relatively rare in the littoral zone of the lake. Rare species probably belonging to this group were *Oxyethira frici* and *Polycentropus irroratus*.

A long distance upstream flight (≥ 3 km) was observed in the populations of eight lotic species (Table 4). They were all abundant in the stream samples, with the majority of adults sampled in the

Table 2. Lotic species observed only in stream samples.

	Σlarvae	Σad.		Σlarvae	Σad.
<i>Ephemerella mucronata</i>	582	0	<i>Hydropsyche saxonica</i>	10	0
<i>Baetis subalpinus</i>	46	1	<i>Ceraclea nigronervosa</i>	6	0
<i>Heptagenia sulphurea</i>	40	1	<i>C. perplexa</i>	0	1
<i>Athripsodes commutatus</i>	0	14	<i>Hydroptila forcipata</i>	0	1

stream being males. Females dominated in the lake traps except in the populations of *Agapetus ochripes*.

A mass occurrence of mainly egg-bearing females of *Brachycentrus subnubilus* and *Baetis rhodani* was observed in lake traps on the sandy bottom c. 0.2 and 0.4 km upstream from the rapids. A further species favouring sandy areas

was *Rhyacophila nubila*, while adults of *Neureclipsis bimaculata* and *Hydroptila cornuta* were usually found in the traps of the stony belt.

The position of *Hydropsyche contubernalis* in the group is somewhat problematic since there exists a strong stream population and a small lacustrine population preferring stony substratum.

Table 3. Lotic species with a short or moderate distance upstream flight (<0.2–0.6 km).

	Stream samples		Σad. in lake traps		
	Σlarvae	Σad.	< 0.2	0.4	0.6
Short flight (≤ 0.2)					
<i>Ceratopsyche nevae</i>	29	13	3	–	–
<i>Halesus digitatus</i>	0	27	3	–	–
<i>H. tessellatus</i>	0	8	2	–	–
<i>Ithytrichia lamellaris</i>	2	1	1	–	–
<i>Ylodes detruncatus</i>	2	1	1	–	–
Moderate flight (≤ 0.6)					
<i>Hydropsyche siltalai</i>	564	123	–	6	–
<i>H. pellucidula</i>	392	32	8	2	7
<i>Cheumatopsyche lepida</i>	78	34	4	6	2
<i>Psychomyia pusilla</i>	3	124	14	2	–
<i>Oxyethira frici</i>	?	1	1	6	–
<i>Polycentropus irroratus</i>	0	2	–	–	2

Table 4. Lotic species with a long distance upstream flight (0.2–3.7 km)

	Stream samples			Σad. in lake traps					% males
	Σlarvae	Σad.	% males	< 0.2	0.4	0.6	3.0	3.7	
<i>Baetis rhodani</i>	59	1	–	412	769	40	33	23	0
<i>Brachycentrus subnubilus</i>	1890	1847	85.5	4397	7246	5	443	32	0.2
<i>Neureclipsis bimaculata</i>	135	1369	70.2	185	262	11	22	5	7.4
<i>Agapetus ochripes</i>	197	250	62.4	12	3	0	0	5	79.0
<i>Rhyacophila nubila</i>	22	286	45.5	20	27	1	11	0	1.7
<i>Hydropsyche contubernalis</i>	113	184	68.7	5	16	0	0	3	12.5
<i>Hydroptila cornuta</i>	?	118	67.8	24	6	1	8	4	7.0
<i>Micrasema setiferum</i>	74	5	100.0	22	19	0	8	0	2.0
Σtraps		5		3	2	1	3	2	

gradient. The sampling was useful for taxonomical reasons and in study of the spatial and temporal occurrence of the different species.

The traps used in catching adults were somewhat selective and thus affected on the results. The slit-traps (model Kuusela & Pulkkinen 1978) were ineffective in catching *Hydropsyche* spp. and mayflies, while the floating emergence traps were ineffective e.g. in catching subimagos of *Caenis horaria*.

In the ephemeropteran fauna of the stream, the lotic component was weak (4 species), but some "rheophilous" species such as *Nixe joerrensis* and *Procluceon bifidum* occurred frequently in the stony littoral zone of the lake.

In the trichopteran fauna, the lotic component was strong especially for filter-feeders: *Brachycentrus subnubilus*, *Hydropsyche* spp. and *Neureclipsis bimaculata* had high densities, while the abundance of shredders was low.

A long distance upstream flight (≥ 3 km) of adults was observed in the populations of *Baetis rhodani* and 7 species of caddisflies which all were abundant in the stream samples, as well. Species mainly found in the traps on sandy littoral zone were *Brachycentrus* spp., *Baetis rhodani* and *Rhyacophila nubila*, while females of *Neureclipsis* and *Hydroptila cornuta* occurred mainly in the traps of the stony belt.

A short or moderate distance upstream flight was observed in the populations of *Hydropsyche* spp., *Cheumatopsyche lepida* and *Psychomyia pusilla*, and no upstream flight in the populations of three common lotic mayflies.

Compared with the literature data (cf. Sode & Wiberg-Larsen 1993), the dispersal of *Hydropsyche* spp. and *Halesus* spp. especially was weak in the study area, but this may simply reflect differences in catching methods.

With a few exceptions (e.g. *Rhyacophila nubila*), males were in excess in the adult material of the stream, while mainly females were observed in the lake traps. However, in the catches of *Agapetus ochripes*, males were in excess also in the lake material, a fact in concordance with the sex-ratio in a Danish brook population of *A. fuscipes* (Sode & Wiberg-Larsen 1993).

The abundant occurrence of egg-bearing fe-

males in particular in the lake traps supports Müller's colonization cycle hypothesis (Müller 1954, 1982). In this case it may be a question of a prolonged upstream dispersal of females.

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Appendix: List of lotic mayflies and caddisflies recorded in the study area

Ephemeroptera

Baetis rhodani (Pictet)
B. subalpinus Bengtsson
Centropilum luteolum (Müller) ! lac.
Ephemerella mucronata (Bengtsson)
Heptagenia sulphurea (Müller)
Nixe joernensis (Bengtsson)
Procloceon bifidum (Bengtsson)

Trichoptera

Agapetus ochripes Curtis
Athripsodes commutatus (Rostock)
Brachycentrus subnubilus Curtis
Ceraclea nigronevosa (Retzius)
C. perplexa (McLachlan)
Cheumatopsyche lepida (Pictet)

Ceratopsyche nevae (Kolenati)
Halesus digitatus (Schrank)
H. tessellatus (Rambur)
Hydropsyche contubernalis McLachlan
H. pellucidula (Curtis)
Hydropsyche saxonica McLachlan
H. siltalai Döhler
Hydroptila cornuta Mosely
H. forcipata (Eaton)
Ithytrichia lamellaris Eaton
Micrasema setiferum (Pictet)
Neureclipsis bimaculata (Linnaeus)
Oxyethira frici (Klapálek)
Polycentropus irroratus (Curtis)
Psychomyia pusilla (Fabricius)
Rhyacophila nubila (Zetterstedt)
Ylodes detruncatus (Martynov)