Hydrobiologia **348:** 81–94, 1997.
I. P. Muniz (ed.), The Høylandet Reference Area.

The macrobenthos of the pristine stream, Skiftesåa, Høylandet, Norway

Kaare Aagaard[1], John O. Solem[2], Terje Nøst[1] & Oddvar Hanssen[1]
[1]*NINA, N-7005 Trondheim, Norway*
[2]*NTNU, Vitenskapsmuseet, Erling Skakkesgt 47, N-7013 Trondheim, Norway*

Key words: stream, benthos, pristine

Abstract

The species composition of aquatic insects in the boreal stream, Skiftesåa, was investigated using emergence traps, Malaise traps and kick samples. At least 13 Ephemeroptera, 16 Plecoptera, 25 Trichoptera and 120 Chironomidae species were recorded. This fauna is representative for non-polluted, northern streams. The production of macrobenthos was estimated to be only about 1 g dry weight per year and m^2, possibly due to the fluctuating flow of water.

Introduction

Aquatic insects are among the most directly affected and vulnerable organisms with respect to surface water acidification (Økland & Økland 1985; Muniz 1991). Unfortunately, we have few descriptions of the current fauna of streams in the areas now affected in Southern Norway. There is in fact, no up-to-date, complete documentation of the status of the four most important aquatic insect groups, the Plecoptera, Ephemeroptera, Trichoptera and Chironomidae, in these areas. The studies of aquatic insects carried out at Høylandet therefore renders little possibility for direct comparison with studies in the affected areas in the south of Norway. However, general knowledge of the biogeographical distribution patterns, and information from acidified and non acidified streams in other parts of Norway, Scandinavia and Europe, enable reasonable discussion of the results.

The aim of this study was to describe the natural fauna of a pristine stream in a northern coniferous area. We have tried to do this by answering three questions. Which species occur in the stream? What is their abundance and community structure? What kinds of seasonal and annual variations can be observed? When considering the answers reported here, it must be remembered that the limited amount of available material creates uncertainties.

Our sampling methods also yielded a variety of terrestrial and semi-terrestrial insects. We are only dealing with the aquatic insects in this paper. Information on other insect groups have been published elsewhere, e.g. Tabanidae (Solem et al., 1990), Limonidae (Solem & Mendl, 1989) and Diptera (Greve & Solem, 1990; Schnell 1991). Four new species of Chironomidae are described with Skiftesåa as the type locality; *Limnophyes aagaardi* Sæther, 1990, *Metriocnemus acutus* Sæther, 1995, *Metriocnemus caudigus* Sæther, 1995 and *Metriocnemus exilacies* Sæther, 1995 (Sæther, 1990; 1995).

Material and methods

Site description

The stream, Skiftesåa, is located in the pristine reference area at Høylandet in the county of Nord Trøndelag in Mid Norway (64° 38′ N, 12° 8′ E). Precipitation in Høylandet is normally generated from non-polluted air masses originating over the North Atlantic. The surrounding area of our site lies between 160 and 600 m a.s.l. The bedrock mainly consists of granite and granitic gneiss. Below 300 m, the vegetation is dominated by natural Norway spruce (*Picea abies*).

Skiftesåa is about 2 km long and originates in Lake Fuglevatn (325 m a.s.l., 20 ha). It drains into a 530 ha Lake Storgrønningen (160 m a.s.l.). The average width of the stream is around 2 m and the flow of water fluctuates greatly due to its rapid response to precipitation or smow melt events. During the thaw in May and periods of heavy rainfall in autumn, the water flow is high, but the stream nearly dries up in summer. The average water temperature in summer is about 10 °C, with a maximum not exceeding 20 °C. The pH is mainly between 5.6 and 6.5. More detailed descriptions of the hydrology and water chemistry of Skiftesåa and Ingabekken, an upstream tributary to Skiftesåa, are found in Christophersen (1991) and Vogt & Muniz (1997). The study was carried out along the lower part of the stream (160–170 m a.s.l.) over a distance of about 500 m i.e. upstream its outlet at the west shore of Lake Storgrønningen. Here, the river bed mainly consists of stones measuring 10–30 cm in diameter.

Methods

Three methods were employed to sample invertebrates in Skiftesåa: Malaise traps, emergence traps and 'kick samples'.

The Malaise traps were of ordinary type with a liquid-filled bottle at the top of the trap. Two traps were used in the summers from 1986 to 1988, one in the lowest part of Skiftesåa about 40 m from its outlet into the lake, the other a few hundred metres higher upstream. Both traps were set across the stream or part of it.

Emergence traps were used in 1987 and 1988, 8 and 6 traps respectively. They were pyramid shaped and of three sizes: 1 m^2, 0.5 m^2 and 0.25 m^2. The traps were placed in the stream between the Malaise traps and at sites where they in most seasons were able to cover water-filled areas.

Kick samples of the benthos were taken four times each summer from 1986 to 1988 at 8 localities in the lower part of Skiftesåa. Sampling was performed by putting down a dip net with a mesh width of 0.25 mm while strongly disturbing the immediate upstream bottom substrate for 1 to 5 minutes and collecting the animals drifting into the net. The samples were preserved and sorted in the laboratory. The use of these three different sampling methods gave us an opportunity to compare them. Emergence and Malaise traps sample fairly similar proportions of the dominant species (Solem, 1985).

Results and discussion

Species composition and annual variations in their abundance

Lists of all the recorded species from the four taxonomical groups and their relative abundances are shown in Tables 1–3. The total number of species of Trichoptera, Plecoptera and Chironomidae at each sampling date through the season is shown in Figure 1a. We covered the whole flight period of Trichoptera, but missed the species of Plecoptera and Chironomidae that fly the first part of the winter and early spring. The Trichoptera has a maximum species diversity during July when the Chironomidae is at its minimum.

Ephemeroptera (Table 1)

At least 13 species from this group were recorded in the kick samples from Skiftesåa. The samples were completely dominated by the genus *Baetis*. In 1986 and 1988, *B. rhodani* made up, respectively, 97.8% and 59.2% of the total sample, whereas in 1987, 76.4% was *B. vernus/B. subalpinus* and 15.5% was *B. fuscatus/B. scambus*. Four species of *Heptagenia* were found during the-year period but only *H. fuscogrisea* was abundant with 14.7% in 1988. *Ameletus inopinatus*, which has a northern distribution, made up 15% of the samples in 1988. Just a few individuals of Ephemeroptera species were caught in Malaise traps or emergence traps.

Plecoptera (Table 1)

At least 16 species were recorded from Skiftesåa. *Isoperla* sp. and *Taeniopteryx nebulosa* were only found in kick samples, but most of the other species occurred in all three types of sampling techniques. *Leuctra digitata* dominated in the material from both the emergence traps and the Malaise traps compromising about 3/4 of all individuals. Emergence and flight periods are given in Figure 1b. *Leuctra digitata* is a summer species. The abundances in kick samples, however, were not more than 21% and 8.1% in 1986 and 1987, respectively. *Siphonoperla burmeisteri* was the second most abundant species in the imagines trap samples, varying between 3.5% and about 14%. *Taeniopteryx nebulosa* was the most abundant species in kick samples in 1986, whereas *Brachyptera risi* was most common in kick samples in 1987.

Table 1. Species list of Ephemeroptera and Plecoptera from Skiftesåa in 1986, 1987 and 1988. The results are given as abundance (ind/m2) in emergence traps (ET) or as per cent (%) of total catch in Malaise traps (MT) and kick samples (KS). The Ephemeroptera are scarcely collected by Malaise traps and therefore excluded from this part of the table. Data for Plecoptera in Malaise traps and kick samples for 1988 are not analyzed.

Taxon	ET 87 ind/m^2	ET 88 ind/m^2	MT 86-1 %	MT 86-2 %	MT 87-1 %	MT 87-2 %	MT 88-1 %	MT 88-2 %	KS 86 %	KS 87 %	KS 88 %
Ephemeroptera											
Ameletus inopinatus	1.2	4.0								1.5	15.0
Baetis rhodani									97.8	2.5	59.2
Baetis vernus/subalpinus										76.4	1.6
Baetis fuscatus/scambus									1.7	15.5	7.6
Baetis sp.	0.2	6.5								0.6	
Heptagenia dalecarlica									0.1	0.4	
Heptagenia sulphurea										3.0	
Heptagenia fuscogrisea											14.7
Heptagenia joernensis									0.1		
Heptagenia sp.	6.0	2.3							0.2		0.8
Siphlonurus lacustris									0.1		0.1
Sum	7.4	12.8							100	100	100
(Total numbers of individuals)	(30)	(45)							(1130)	(2728)	(497)
Plecoptera											
Diura nanseni		0.3	0.3	0.3	0.1	0.1			13	14.1	
Isoperla sp									1	0.1	
Siphonoperla burmeisteri	11.3	28.3	4.5	9.8	5.9	3.5			1	2.3	
Brachyptera risi	1.0	2.0	3.3	3.1	0.7	1.7				32.3	
Taeniopteryx nebulosa									24	5.2	
Amphinemura borealis	0.5		0.4	0.4	0.6	0.4				0.1	
Amphinemura standfussi	3.0	9.1	1.8	2.1	1.7	0.4			2	1.9	
Amphinemura sulcicollis	1.5	5.7	1.8	2.7	5.0	1.9				0.7	
Amphinemura sp.									3	13.6	
Nemoura cinerea	0.3		0.4	0.1	1.1	0.4					
Nemurella picteti			0.4	0.3	1.1	0.3			1		
Protonemura meyeri			0.4	1.2	0.2	1.4			6	2.2	
Capnia atra	0.3				0.1						
Capnia sp.									2	8.1	
Leuctra digitata	124.5	144.6	73.3	73.7	79.4	88.3			21	8.1	
Leuctra fusca			0.1	0.1	0.5	0.1			1		
Leuctra hippopus		0.3	2.5	1.6	0.6	0.3					
Leuctra nigra	0.3	1.7	10.7	4.7	2.9	1.2			3	0.6	
Leuctra sp.									20	10.0	
Sum	142.5	192.3	100	100	100	100			100	100	
(Total numbers of individuals)	(570)	(673)	(3362)	(4354)	(5848)	(4270)			(95)	(727)	

Table 2. Species list of Trichoptera from Skiftesåa in 1986, 1987 and 1988. The results are given as abundance (ind/m^2) in emergence traps (ET) or as per cent (%) of total catch in Malaise traps (MT) and kick samples (KS). kick samples for 1987 and 1988 are not analyzed

Taxon	ET 87 ind/m^2	ET 88 ind/m^2	MT 86-1 %	MT 86-2 %	MT 87-1 %	MT 87-2 %	MT 88-1 %	MT 88-2 %	KS 86 %	KS 87 %	KS 88 %
Trichoptera											
Rhyacophila nubila	0.3	0.6	22.2	22.2	11.6	26.3	22.8	3.8	15.1		
Glossosoma sp.					0.4						
Oxyethira flavicornis			0.6	0.8							
Oxyethira frici	0.5	1.1		0.4	9.4	10.2	2.8				
Philopotamus montanus		0.3	6.6	8.4	18.1	17.5	17.1	11.5			
Plectrocnemia conspersa	2.8	1.1	16.4	34.1	18.1	23.5	17.1	11.5	42.5		
Polycentropus flavomaculatus			5.7	10.3	5.8	4.6	2.8		37.7		
Micrasema gelidum					0.4						
Apatania stigmatella						0.4					
Limnephilus centralis			7.5	4.2				50	4.7		
Limnephilus coenosus			1.3	0.4	0.7	0.7		11.5			
Limnephilus extricatus			3.1								
Limnephilus femoratus							2.8				
Limnephilus flavicornis							2.8				
Limnephilus fuscicornis			0.6				11.4				
Limnephilus rhombicus			1.9				5.7				
Limnephilus subsentralis		0.3									
Potamophylax cingulatus	2.8	0.3	24.5	14.6	26.8	11.6	2.8				
Potamophylax sp.							8.5				
Halesus digitatus					5.1						
Halesus radiatus			5.0	1.9							
Halesus tesselatus					2.9	3.5					
Micropterna lateralis				1.1		1.1		11.5			
Hydatophylax infumatus	0.3		0.6	0.8		0.4					
Chaetopteryx villosa			3.8		0.7	0.4					
Mystacides azurea							2.8				
Beraea pullata					0.7						
Sum	6.7	3.7	100	100	100	100	100	100	100		
(Total number of individuals)	(26)	(12)	(159)	(261)	(138)	(285)	(35)	(26)	(106)		

Trichoptera (Table 2)

About 25 species were caught in the Malaise traps, but only 7 species were found in the emergence traps. Kick sampling is not well suited for recording the real diversity of this group since only 4 of the most abundant species were found by this method. The most common species over three years were *Rhyacophila nubila, Polycentropus flavomaculatus, Plectrocnemia conspersa* and *Potamophylax cingulatus*, all with maximum abundances between 18 and 38%. Their flight periods are given in Figures 1c, 1d, 2a, and 2b. *P. conspersa* is an early summer species, and *R. nubila* an autumn species. The Malaise trap samples from 1988 gave a much smaller number of individuals than in the two previous years. Whereas the number of individuals of *Limnephilus centralis* remained unaltered, all the four most common species occurred in far lower abundance in 1988, than in previous years.

Chironomidae (Table 3)

More than 120 species were found in the Malaise traps. Some of these, such as *Heterotrissocladius subpilosus* and *Stictochironomus rosenschoeldi*, are lake species which do not belong to the fauna in Skiftesåa. Other

Table 3. Species list of Chironomidae from Skiftesåa in 1986, 1987 and 1988. The results are given as number of male individuals recorded in emergence traps (ET) and Malaise traps (MT)

Taxon	ET 87	ET 88	MT 86-1	MT 86-2	MT 88-1	MT 88-2
Procladius spp				1		1
Ablabesmyia monilis			8	2	2	
Macropelopia notata		2				
Macropelopia goetghebueri						1
Arctopelopia barbitarsis					1	
Conchapelopia melanops	1	7		2		5
Paramerina divisa	47	222		1		1
Trissopelopia longimana	87	317		2		
Zavrelimyia spp.	9	13				
Natarsia punctata				1	1	1
Nilotanypus dubius	24	39	3	22		4
Krenopelopia binotata	2		4	5	4	8
Parochlus kiefferi			36	31	3	15
Potthastia longimana		3				
Brillia longifurca	1			1		
Zalutschia sivertseni			1	12		
Zalutschia tornetraeskensis			2			
Hydrobaenus conformis				4		1
Heterotrissocladius cfr scutellatus		2	1	43		23
Heterotrissocladius marcidus		8		4		1
Heterotrissocaldius grimshawi			2			
Heterotrissocladius subpilosus				24		3
Heterotrissocladius sp A				1		
Heterotrissocladius maeaeri						1
Heterotanytarsus apicalis		4	6	1		
Heterotanytarsus sp A				1		
Paratrichocladius skirwithensis				1		
Cricotopus patens						1
Cricotopus cf. *pallidipes*						2
Cricotopus pulchripes		18		27		4
Cricotopus sp A						3
Cricotopus sp B			1	12		
Cricotopus sp C				2		
Mesocricotopus thienemanni		1	2	1		
Rheocricotopus cfr. *foveatus*		2		2		
Rheocricotopus effusus			1	1		4
Nanocladius cfr. *bicolor*	15	9		19		
Paracladius conversus	1	9		15		
Synorthocladius semivirens	22	45		134		
Orthocladius cfr. *decoratus*		16		12		
Orthocladius cfr. *annectens*		3				
Orthocladius sp A			8			
Eukiefferiella brevicalcar	1	3	1	2		
Eukiefferiella claripennis	3	4	1	6	2	1

Table 3. Continued

Taxon	ET 87	ET 88	MT 86-1	MT 86-2	MT 88-1	MT 88-2
Tvetenia spp	11	36				
Tvetenia bavarica			1	>80		
Tvetenia calvescens					2	647
Tokunagaia sp A				1		
Psectrocladius sp. *limbatellus-gr*						2
Psectrocladius sp. *psilopterus-gr*						1
Psectrocladius sp A			1	6		
Chaetocladius dissipatus	1		1		1	1
Chaetocladius cfr. *melaleucus*				1		
Chaetocladius sp A				2		
Metriocnemus beringensis						7
Metriocnemus acutus					1	1+1
Metriocnemus caudigus					2	
Metriocnemus eurynotus					1	
Metriocnemus exilacies					2	
Metriocnemus picipes						1
Bryophaenocladius ictericus		1	4	8	3	27
Bryophaenocladius cfr. *flexidens*				4	1	1
Bryophaenocladius inconstans				1		1
Bryophaenocladius sp A				1		
Limnophyes asquamatus		2	1		1	5
Limnophyes edwardsi		6	1			4
Limnophyes aagaardi						11
Limnophyes natalensis	1	10	3		2	32
Limnophyes pentaplastus			1			1
Limnophyes pumilo		9				
Limnophyes ninae	19	24		3		
Limnophyes minimus		6	7	2		2
Thienemannia gracilis		2			1	
Parametriocnemus stylatus		1	2	5		16
Paraphaenocladius irritus		1	1	8		7 + x
Paraphaenocladius pseudirritus		4		20		
Paraphaenocladius intercedens		1	23	29		
Paraphaenocladius impensus		3	2	4		
Paraphaenocladius exagitans monticola				1		
Pseudorthocladius pilosipennis		1			1	34
Pseudorthocladius filiformis		1		1		6
Pseudorthocladius curtistylus	1		1	5		
Psilometriocnemus europaeus		1	1			1
Gymnometriocnemus volitans		2	53	37	2	21
Gynnometriocnemus brumalis			1	6		1
Gymnometriocnemus subnudus			2	9		7
Heleniella ornaticollis				1		4
Smittia cfr. *aterrima*		1				
Smittia cf. *nudipennis*						2
Smittia sp A			1			
Smittia sp B			4	2		

Table 3. Continued

Taxon	ET 87	ET 88	MT 86-1	MT 86-2	MT 88-1	MT 88-2
Boreosmittia inariensis			1			
Pseudosmittia trilobata						4
Krenosmittia halvorseni	5	7				
Krenosmittia boreoalpina		3				
Parakiefferiella bathophila		1	1	2		1
Parakiefferiella nigra					1	1
Parakiefferiella scandica					1	
Parakiefferiella minuta				1		
Parakiefferiella sp A				2		
Parakiefferiella sp B				1		
Thienemaniella sp B.	90	342		9		1
Corynoneura lobata		44		2	2	1
Corynoneura cfr. *coronata*	9	1		4		
Corynoneura fittkaui	16	2	1			2
Corynoneura lacustris		102		2		
Corynoneura spp.	988	970			3	
Orthocladinae indet. spp		1		10		
Chironomus spp.						
Chironomus inermifrons					*	1
Dicrotendipes lobiger						1
Dicrotendipes modestus						2
Cryptochironomus albofasciatus		1				
Microtendipes chloris				1		
Paracladopelma camptolabis		1			1	1
Paracladopelma laminata						2
Paracladopelma nigritula				6	1	12
Phaenopsectra flavipes			1			
Polypedilum albicorne	7	9		1	1	6
Polypedilum scalaenum		1	6			2
Polypedilum cfr. *nubens*					1	
Polypedilum tritum					1	3
Pseudochironomus prasinatus						2
Stictochironomus histrio		1	10	3		
Stictochironomus rosenschoeldi					1	
Sergentia sp A		1	15	1		
Paratanytarsus tenuis		1	2	2		4
Paratanytarsus intricatus						1
Paratanytarsus penicillatus		2	7	1		
Micropsectra groenlandica	1	3	3	14		3
Micropsectra lacustris		1	9	3	2	
Micropsectra bidentata	12	96		4		
Micropsectra fusca		1	2			1
Micropsectra junci			1	7		1
Micropsectra recurvata	1	1	2			1
Micropsectra sp A						6
Rheotanytarsus cfr. *pentapoda*						1
Parapsectra nana	2	5	17	78	2	6
Constempellina brevicosta		20				1

Table 3. Continued

Taxon	ET 87	ET 88	MT 86-1	MT 86-2	MT 88-1	MT 88-2
Stempellinella brevis	58	256	1	28	6	15
Stempellina bausei				5		
Tanytarsus verrali						2
Tanytarsus debilis				1		
Tanytarsus brundini				3		
Tanytarsus eminulus		1				1
Tanytarsus inequalis			3	7		6
Tanytarsus occultus			1			5
Tanytarsus mendax		1	5			7
Total number of individuals	1435	2714	268	752	47	1018

Table 4. Estimated biomass as dry weights of imagines of the ten most productive species of Plecoptera, Ephemeroptera and Trichoptera emergenced from 1 m^2 of Skiftesåa

Taxon	1987 (mg/m^2)	1988 (mg/m^2)
Leuctra digitata	68.5	79.5
Trissopelopia longimana	12.4	51.3
Potamophylax cingulatus	56.0	6.0
Plectronemmia conspersa	14.2	5.5
Paramerina divisa	2.4	12.7
Corynocera spp.	6.7	8.6
Micropsectra bidentata	0.69	6.3
Heptagenia spp.	6.0	2.3
Baetis spp.	0.2	5.2
Amphinemura borealis	1.1	3.3
Total	168.2	180.7

species, such as the genera *Bryophaenocladius*, *Gymnometriocnemus* and *Metriocnemus*, are known to have terrestrial or semi-terrrestrial larvae.

About 65 species were caught in the emergence traps. It is therefore clear that these species emerge from the stream or the banks close to the stream. Such species as *Paramerina divisa* (Figure 2c) and *Trissopelopia longimana* (Figure 2d) were abundant in the emergence traps and almost absent in the Malaise traps. However, some species are not easily caught by emergence traps, but occur abundantly in the stream even though they were only recorded in the Malaise traps. *Stempellinella brevis* and *Synorthocladius semivirens* were recorded both in Malaise traps and emergence traps (Figures 3a, 3b). *S. brevis* increased in abundance from 1987 to 1988 with a factor of 5 in the emergence traps and *S. semivirens* increased with a factor of 2 for the same period. Siebert (1980) found an annual variation for *S. brevis* with a factor of 10 during a investigation period of 4 years in Breitenbach when *S. semivirens* varied with a factor of 5 from year to year. *S. semivirens* is one of the most abundant species in streams. It was the second most abundant species both in Krumbach (Röser, 1982) and Fuhlenau (Böttger et al., 1987).

Micropsectra bidentata increased in abundance with a factor of 8 from 1987 to 1988 in Skiftesåa (Figure 3c). This species was absent in the two first years of investigation in Breitenbach and then became one of the most abundant species (Siebert, 1980).

It is documented that chironomid abundance vary considerably from year to year. The investigation period in Skiftesåa of two to three years are therefore probably to short to document the full range of natural variation in abundance for this group.

Skiftesåa as a representative and pristine stream

Ephemeroptera, Plecoptera and Trichoptera are faunistically relatively well known in Norway. Nøst et al. (1986) give a review of the known distribution patterns of these groups. Most species recorded from Skiftesåa are widely distributed and common in Norway; a few of the other recorded Ephemeroptera and Trichoptera species are widely distributed, but only common at a few localities. A number of species with an eastern distribution were found in all three groups and even three species with a northern distribution, *Baetis subalpinus*, *Ameletus inopinatus* and *Diurna nanseni*.

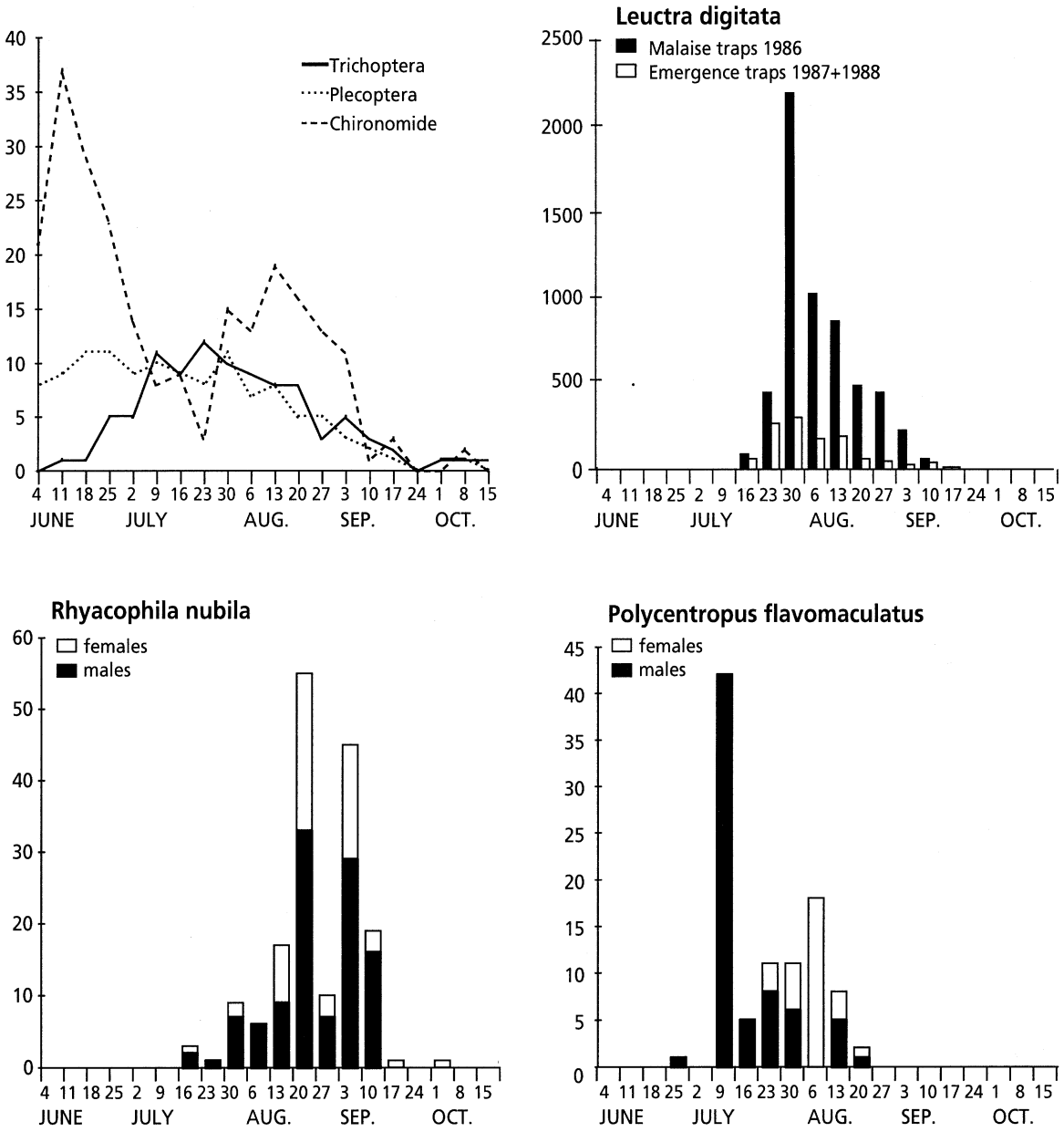

Figure 1. Species number of Tricoptera, Plecoptera and Chironomidae in the Malaise traps through the sampling season in Skiftesåa.
Total number of Leuctra digitate (males and females) recorded in traps at Skiftesåa.
Number of males and females of Rhyacophila nubila in Malaise traps in Skiftesåa.
Number of males and females of Polycentropus flavomaculatus in Malaise traps in Skiftesåa.

The species list of Ephemeroptera from Skiftesåa includes most of the species or species groups which may be expected to occur in such an environment. However, some widely distributed but local species in Norway, such as *Baetis muticus* and *Cloêon simile*, are missing. Of the species with eastern and northern distributions, *Metretopus borealis*, *Ephemerella aurivilli* and *Parameletus chelifer* are quite common in streams in this part of Norway but not found in Skiftesåa. Two species from Skiftesåa, *Baetis fuscatus* and *Heptagenia joernensis*, are by Degerman (1987) listed as highly sensitive to acidification (unable to tolerate pH<5.4).

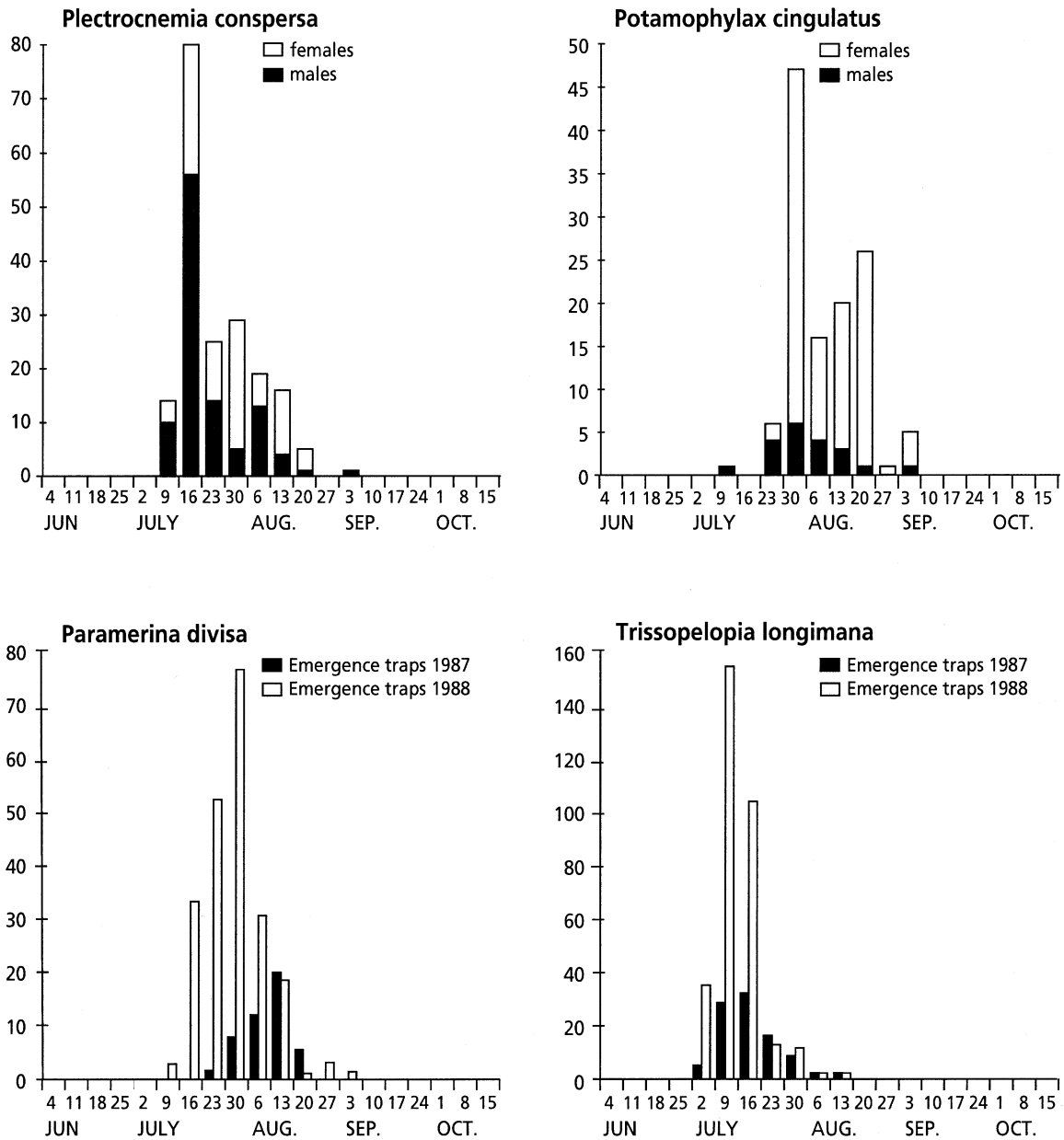

Figure 2. Number of males and females of Plectronemia conspersa in Malaise traps in Skiftesåa.
Number of males and females of Potamophylax cingulatus in Malaise traps in Skiftesåa.
Number of males of Paramerina divisa in emergence traps in Skiftesåa.
Number of males of Trissopelopia longimana in emergence traps in Skiftesåa.

The Plecoptera species list is even more complete compared with a theoretical list of possible presence of species. Apart from *Nemoura avicularis*, all the widely distributed species were found in Skiftesåa. Four species with an eastern and one with a northern distribution complete a species list typical for this part of Norway.

The Trichoptera is a more diverse group in habitat utilisation and feeding modes than the two previous ones. The Trichoptera species recorded is widely distributed, and the species assemblage in Skiftesåa is as

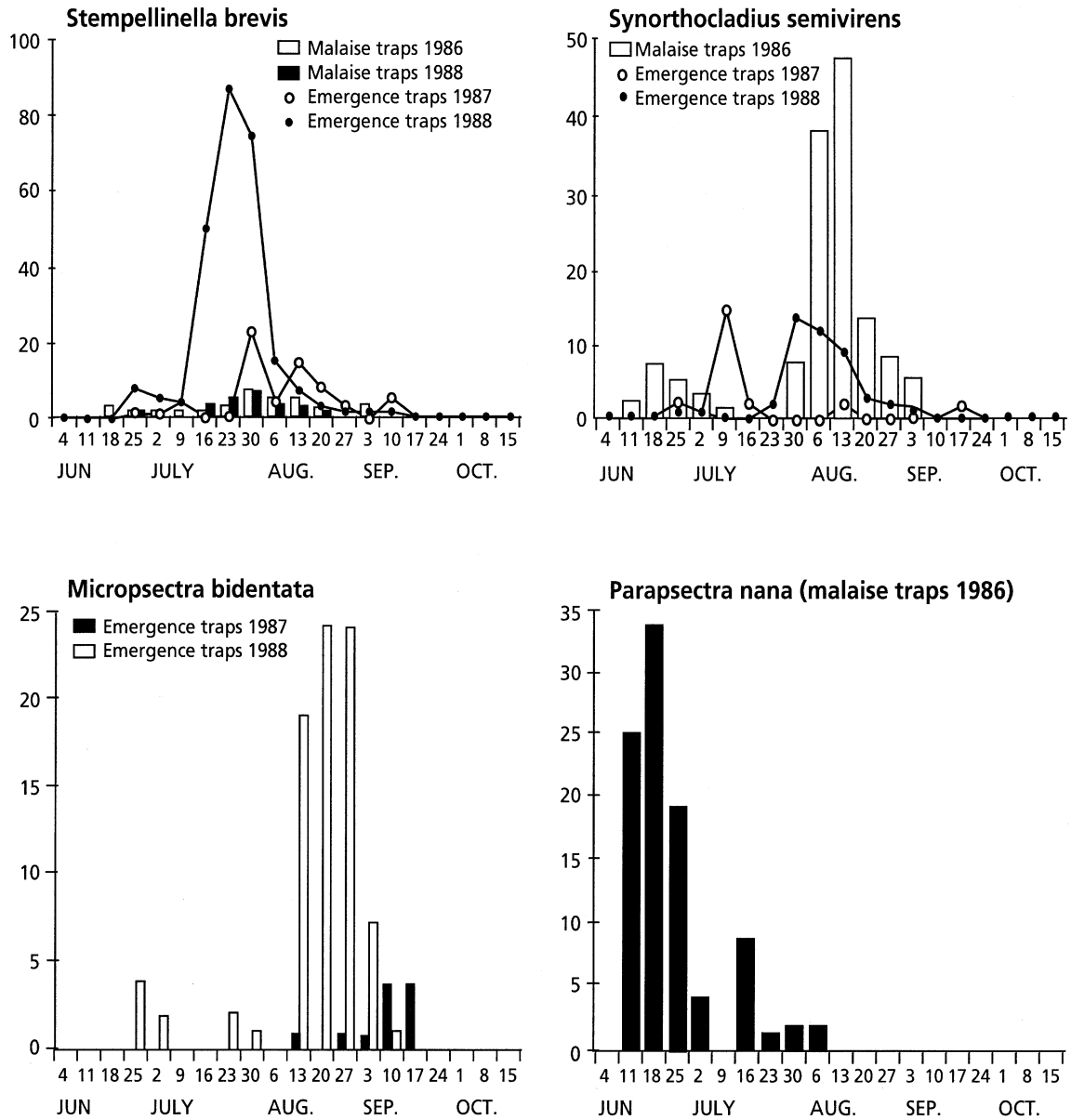

Figure 3. Number of males of Stempellinella brevis in traps in Skiftesåa.
Number of males of Synorthocladius semivirens in traps in Skiftesåa
Number of males of Micropsectra bidentata in emergence traps in Skiftesåa.
Number of males of Parapsectra nana in Malaise traps in Skiftesåa.

expected in a head water stream in the northern boreal zone. However, some *Limnephilus* species like *L. extricatus, L. femoratus, L. flavicornis, L. fuscicornis, L. rhombicus* and *L. subsentralis* may have come from standing water habitats. *Philopotamus montanus* and *Micrasema gelidum* are listed by Dergerman (1987) as beeing highly sensitive to acidification, while e.g. *Rhyacophila nubila, Polysentropus flavomaculatus, Plectronemia conpsersa* are more tolerant. *Limnephilus coenosus* has been found in temporary streams, and Skiftesåa was nearly dry in shorter periods during the sampling season.

The geographical distribution of the Chironomids of Norway is not known in detail. An DCA ordina-

tion study of the species composition of chironomids in running water in 16 watercourses in Europe, classified Skiftesåa as a site most closely related to other northern sites (Figure 4) (Aagaard, 1992). The most arctic-alpine species of high mountain streams in Norway were not found in Skiftesåa. However, some boreal species, such as in the genus *Zalutschia*, confirm the impression of the faunal composition given by the three other groups analysed, i.e. a dominance of widely distributed species, but also elements of species with easterly and northerly distributions.

The species list for the Ephemeroptera, Plecoptera and Trichoptera from Skiftesåa is very similar to that from Vindelälven in Sweden which is situated at the same latitude (Ulfstrand, 1968). However, some additional Ephemeroptera and Plecoptera species were found in Vindelälven. This is mostly due to the greater proportion of northerly distributed species in Swedish Lapland. Degerman et al. (1987) report the result of an investigation of 337 small streams in northern Sweden. This investigations was done in 1983 in order to map the extent of acidification in the mountain range. Almost all the species of Plecoptera and Ephemeroptera recorded in Skiftesåa were found in the Swedish investigation whose most common species of Plecoptera, Ephemeroptera and Trichoptera are in general the same as in Skiftesåa.

A general decrease in species numbers of Plecoptera from east to west was shown by Lillehammer (1974). A similar feature is obvious in the Trichoptera distribution list by Andersen & Wiberg-Larsen (1987). Most of the species recorded from Skiftesåa were also found in Atna in South Norway (Aagaard et al., 1989). Some widely distributed species occurring in Skiftesåa are also found in lowland streams in large parts of the European continent.

The faunal differences increase with the distance between two localties due to biogeographical factors and can make species comparisons less valuable with respect to pollution effects. However, based on the current knowledge of Scandinavian benthos, none of the analysed aquatic insect groups in our study reflect any deviations in species composition or community structures which could indicate local pollution effects.

Estimates of secondary production

Biomass estimates based on the abundance of the emerged imagines of the most important species are given in Table 4. Individual mean dry weights (DW) for most of the species have been taken from Siebert (1980) and Illies (1982) or estimated from data on closely related species of equal size. The estimates for chironomids take into account a sex ratio of about 50/50 and the larger mean weight of females.

The stonefly *Leuctra digitata* was estimated to yield the highest biomass both in 1987 and 1988, with about 69 and 80 mg DW per m^2, respectively. The chironomid *Trissopelopia longimana* and the caddisfly *Potamophylax cingulata* reached values of more than 50 mg in one of the years. The genus *Corynoneura*, which was the most abundant chironomid group in both years (247 and 319 individuals per m^2), accounts for only 7 to 9 mg DW due to the low weight of individuals (ca 0.015 mg). Because emergence traps do not collect mayflies in a representative way, these are clearly underrepresented in Table 4.

The total biomass represented by the imagines of the ten most common species was about 170–180 mg per m^2 in both 1987 and 1988. The weight of larvae corresponding to this biomass may be around 300 to 400 mg. Assuming that the production is two to three times the biomass of the individuals which reach emergence, and taking into account underestimated groups and species, the annual production in Skiftesåa seems to be at least 1.0 g dry weight per m^2. This value corresponds to the lowest values cited in a review of production by Lindegaard (1989). These were from a stream in Canada (54°N) with a substrate of shifting sand (Soluk, 1985).

Based on the estimated biomasses in Table 4, the approximate proportions of the functional feeding groups in Skiftesåa are: shredders/herbivorous species 55%, predators 34%, collectors 10%; grazers are present, but in very low numbers.

Both the low numbers of grazers and the small production are probably caused by the stream periodically drying up some years, resulting in little or no primary production.

Acknowledgments

We are grateful to Morten Tyldum for field assistance, to Terje Dalen for identification of Plecoptera larvae material, to Øivind Schnell for identification of the 1988 Chironomidae material from Malaise traps and to Richard Binns for improving the English.

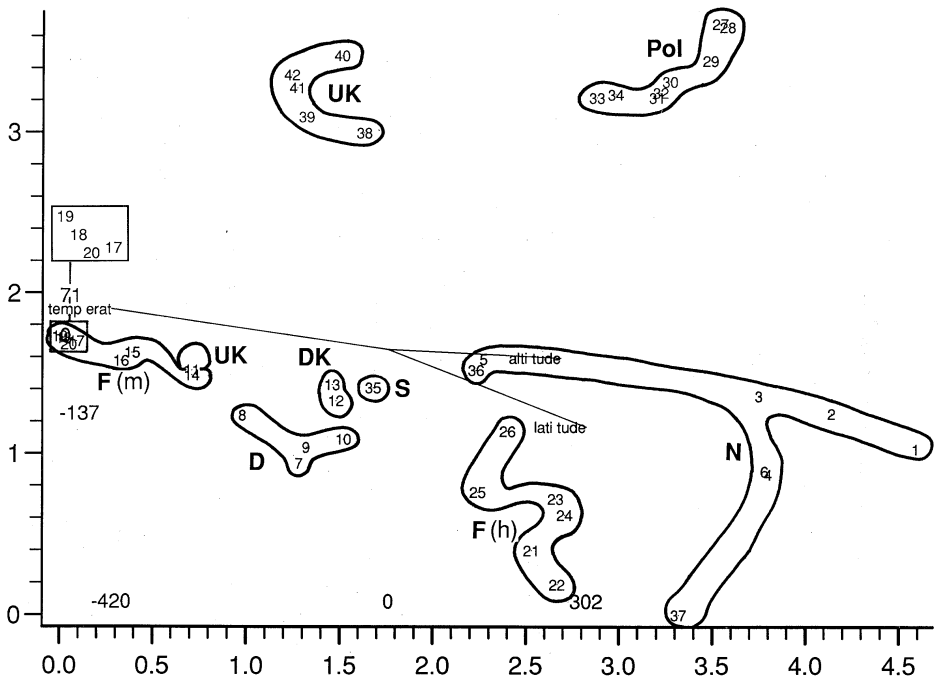

Figure 4. Ordination diagram of stream localities in Europe. Skiftesåa is site number 36 and close to site 5; Vollen i Atna (from Aagaard, 1992).

References

Aagaard, K., 1992. Ordination or typology – The search for a stable classification of running water communities. Neth. J. aquat. Ecol. 26: 441–445.

Aagaard, K., J. O. Solem, A. Lillehammer, O. Hanssen, T. Nøst & T. Dalen, 1989. Forsknings- og referansevassdrag ATNA. Utbredelse, Sonering og årsvariasjoner hos bunndyr Atna og Atnsjøen. MVU-rapport B57, 50 pp.

Andersen, T. & P. Wiberg-Larsen, 1987. Revised checklist of NW European Trichoptera. Ent. Scand. 18: 165–184.

Böttger, K., U. Holm & K. Mikowski, 1987. Vergleichende Emergenzstudien an einem naturnahen und einem naturfernen Abschnitt des Fliessgewässersystems der Fuhlenau in Schleswig-Holstein. Int. Revue ges. Hydrobiol. 72: 339–368.

Degerman, E., G. Lindgren, P.-E. Lingdell & P. Nyberg, 1987. Kartering av strömfauna och fisk i mindre vattendrag i Norrlands inland och fjälltrakter i relation til försurning. (English summary: An inventory of benthic fauna and fish in small streams in mountainous regions of northern Sweden affected by acidification.). Information från Sötvattenslaboratoriet, Drottningholm, 2: 1–64.

Greve, L. & J. O. Solem, 1990. Notes on the genus *Diastata* in Norway (Diptera, Diastatidae). Fauna norv. Ser. B, 37: 33–35.

Illies, J., 1982. Längsprofil des Breitenbachs im Spiegel der Emergenz (Ins.: Ephemeroptera, Plecoptera, Trichoptera). Arch. Hydrobiol. 95: 157–168.

Lillehammer, A., 1974. Norwegian stoneflies. II. Distribution and relationship to the environment. Norw. J. Ent. 21: 195–250.

Lindegaard, C., 1989. A review of secondary production of zoobenthos in freshwater ecosystems with special reference to Chironomidae (Diptera). Acta Biol. Debr. Oecol. Hung. 3: 231–240.

Muniz, I. P., 1991. Freshwater acidification: its effects on species and communities of freshwater microbes. plants and animals. Proc. r. Soc. Edinburgh 97B: 227–254.

Nøst, T., K. Aagaard, J. V. Arnekleiv, J. W. Jensen, J. I. Koksvik & J. O. Solem, 1986. Vassdragsreguleringer og ferskvannsinvertebrater. Økoforsk utredn. 1: 80 pp.

Økland, J. & K. A. Økland, 1986. Effects of acid deposition on benthic animals in lakes and streams. Experientia 42: 471–486.

Röser, B., 1980. Emergenz eines Mittelgebirgsbaches des Vorderwesterwaldes. Arch Hydrobiol./Suppl. 58: 56–96.

Sæther, O. A., 1990. A review of the genus *Limnophyes* Eaton from the Holarctic and Afrotropical regions (Diptera: Chironomidae, Orthocladiinae). Ent. Scand. Suppl. No. 35, 135 pp.

Sæther, O. A., 1995. *Metriocnemus* van der Wulp: Seven new species, revision of species, and new records (Diptera: Chironomidae). Annls Limnol. 31: 35–64.

Sæther, O. A. & Xinhua Wang, 1995. Revision of the genus *Paraphaenocladius* Thienemann, 1924 of the world (Diptera: Chironomidae, Orthocladiinae). Ent. scand. Suppl. 48: 3–69.

Schnell, O. A., 1991. New records of Chironomidae (Diptera) from Norway (II), with two new species synonyms. Fauna norv. Ser. B, 38: 5–10.

Siebert, M., 1980. Die Emergenz der Chironomiden im Breitenbach 1969–1973. Arch. Hydrobiol./Suppl. 58: 310–355.

Solem, J. O., 1985. Distribution and biology of caddisflies (Trichoptera) in Dovrefjell mountains, Central Norway. Fauna norv. Ser. B, 32: 62–79.

Solem, J. O., H. Kauri & P. Straumfors, 1990. Tabanidae (Diptera) community in a very little exploited northern boreal forest at HYylandet, N. TrYndelag, Norway. Fauna norv. Ser. B, 37: 63–66.

Solem, J. O. & H. Mendl, 1989. Limoniidae communities in alpine and boreal zones along the Atna River, South Norway (Diptera, Nematocera). Fauna norv. Ser. B, 36: 107–114.

Soluk, D. A., 1985. Macroinvertebrate abundance and production of psammophilous Chironomidae in shifting sand areas of a lowland river. Can. J. Fish. aquat. Sci. 42: 1296–1302.

Ulfstrand, S., 1968. Benthic animal communities in Lapland streams. A field study with particular reference to Ephemeroptera, Plecoptera, Trichoptera and Diptera, Simuliidae. Oikos suppl. 10., 120 pp.

Vogt, R. D. & I. P. Muniz, 1997. Soil and stream water chemistry in a pristine and boggy site in mid-Norway. Hydrobiologia 348: 19–38.