The genus *Metretopus* (Ephemeroptera, Siphlonuridae) in Fennoscandia — identification, faunistics and natural history

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Morphological characters are presented for the separation of nymphs and winged stages of *Metretopus alter* Bengtsson, 1930, from those of *M. borealis* (Eaton, 1871) based on Fennoscandian material. The known records of both species in Finland and Sweden are mapped, and a recent record of *M. alter* from Norway is given. Habitat preferences and phenological data of both species are presented. The documented wide distribution of *M. alter* in Fennoscandia indicates that it previously has been confused with *M. borealis*.

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1. Introduction

Metretopus Eaton is a small Holarctic genus with one Palearctic and one Holarctic species (Berner 1978). Together with the Nearctic genus *Siphloplecton*, *Metretopus* was earlier placed in the family Metretopodidae (Berner 1978). We here follow Landa & Soldán (1985) and Hubbard (1990) and recognize Metretopodinae as a subfamily of Siphlonuridae. In this view, anatomical characters of nymphs are given higher weight than wing vein patterns.

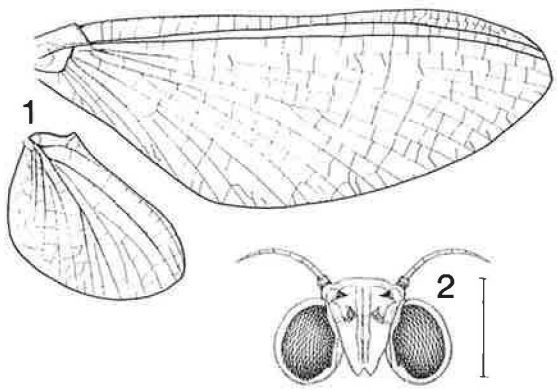
Both *Metretopus* species occur in Fennoscandia. The Holarctic *M. borealis* (Eaton, 1871) has long been considered widespread in Scandinavia and Finland. The other species, *M. alter* Bengtsson, 1930, was described from northernmost Norway. It was first recorded from Finland by Tiensuu (1939), and was later reported south to Kuusamo (Savolainen 1984, Savolainen & Saaristo 1984). Consequently, the occurrence of *M. alter* in northernmost Sweden was expected. Surprisingly, the species is widespread in Sweden and has previously been confused with *M. borealis*.

Ulfstrand (1968) suggested that *M. alter* was conspecific with *M. borealis*. This view was later adopted by Olsson (1983). Without access to material identified as *M. alter*, Berner (1978) cited the status of this species as doubtful. However, as will be shown below, the distinct morphological differences present in the two species, especially in male genitalia, make this view untenable.

The presence of *M. alter* in Sweden was first confirmed when reared males from the small Vargbäcken stream in the Västerbotten province were studied (leg. A. N. Nilsson, det. M. Saaristo). Later Engblom and Lingdell established morphological differences between nymphs of the two species and revised the Swedish material available. They are also responsible for the study

of environmental parameters in relation to occurrence of the two species. Finally, Savolainen revised and mapped the available Finnish *Metretopus* material.

The aim of this study is to aid identification of the two species, document their distributions in Sweden and Finland, and to characterize their habitat preferences. We also want to stress the need for taxonomic studies in order to improve the use of mayfly species as indicators of environmental changes.



Figs. 1–2. *Metretopus borealis* (Eaton) — 1. Imago, rigth wings, dorsal aspect. — 2. Female subimago, head, posterodorsal aspect. — Scale bars 1 mm.

2. Material and methods

The Swedish distributional records of the two *Metretopus* species chiefly come from 371 samples collected by Engblom and Lingdell. Additionally, material from Lapland (leg. S. Ulfstrand, coll. Entomological Museum, University of Lund) and Västerbotten (leg. Nilsson & O. Söderström) was studied.

The study of habitat preferences was based on 5153 samples from all over Sweden registered in Engblom and Lingdell's data base. Excluding polluted or acidified (1211 samples) and seasonally deviating samples (1208), *Metretopus* was found in 371 out of 2734 samples taken within the distributional range of the genus. Negative samples were chiefly from South Sweden or collected in lakes.

The presented data on environmental variables were based on 233 records of *M. borealis* and 69 records of *M. alter* (37 records were not identified to species).

The following Finnish collections were examined: Kuopio Museum of Natural History, Zoological Museum of the University of Oulu, Zoological Museum of the University of Helsinki, and coll. H. Hämäläinen. The examination included the material described by Savolainen & Saaristo (1981: imagines only, and 1984), Savolainen (1984) and Savolainen & Pulkkinen (1987), whereas that described by Tiensuu (1939) and Bagge & Salmela (1978) was not examined. Altogether, 119 records of *M. borealis* and 31 records of *M. alter* from Finland were mapped.

Cover of mosses, algae and vegetation was estimated with an index that varies from 0 (= absent) to 6 (continuous). Values from 1 to 5 refer to an increasing cover from very low to almost continuous.

The phenology of *M. alter* was studied in the cold, small stream Vargbäcken in the Västerbotten province (64°25′N, 19°30′E, see Nilsson 1989 and Solem & Johansson 1991 for a general description). This stream has a maximum flow of 0.2 m^3/s and the bottom substrate is chiefly sand. It freezes to the bottom in some winters and is periodically dry in summer. The highest temperature recorded in this stream was 14.1°C, and in one year the maximum temperature was 10.7°C.

3. Identification

Metretopus imagines are separated from other Fennoscandian siphlonurids by the addition of the following couplet to the key in Söderström & Nilsson (1986:114):

2. Fore wing with two supplemental veins between Cu_1 and Cu_2 (Fig. 1). Neck with posterior projection emarginate (Fig. 2) ..... *Metretopus*
— Fore wing without supplemental veins between Cu_1 and Cu_2. Neck with posterior projection truncate (*Siphlonurus*) 2

Metretopus nymphs differ from other Fennoscandian siphlonurids (and other Ephemeroptera) by the bifid protarsal claws. Bengtsson (1909) described the nymph of *M. borealis*.

The two *Metretopus* species can be separated as follows:

	M. borealis	*M. alter*
All winged specimens		
Caudal filaments pale:	without darkened annulations	with darkened annulations
Male imago and subimago		
Lateral outline of penis:	subparallel and apical lobes emarginate (Figs. 3–4)	strongly convex in distal half and with apical lobes rounded (Figs. 5–6)
Female imago		
Subgenital plate:	short and apically truncate (Fig. 7)	long and apically rounded (Fig. 8)
Postgenital plate with posterior margin:	laterally constricted (Fig. 7)	subrectangular (Fig. 8).
Nymphs > 4 mm		
Body colour pattern:	distinct (Fig. 9)	diffuse (Fig. 10)
Abdominal segments 1–8:	with dark lateral markings (Fig. 13)	without dark lateral markings (Fig. 14)
Femora:	with dark markings (Fig. 9)	without dark markings (Fig. 10)
Fullgrown nymphs		
Body length:	10–12 mm	12–14 mm
Apical lobes of protarsal claw:	narrow (Fig. 11)	broad (Fig. 12)
Sternum 9:	entirely dark or with extensive dark pattern (Figs. 15–16)	at most with narrow submarginal dark bands (Figs. 17–18)

Male nymphs with body length > 7 mm differ in shape of genitalia as described above for winged stages.

Mature female nymphs are longer than those of males (1–1.5 mm longer in *M. borealis*; Barton 1980).

Eggs of *M. borealis* were described by Bengtsson (1913), whereas those of *M. alter* are unknown.

4. Distribution and habitat preferences

Metretopus borealis (Eaton)

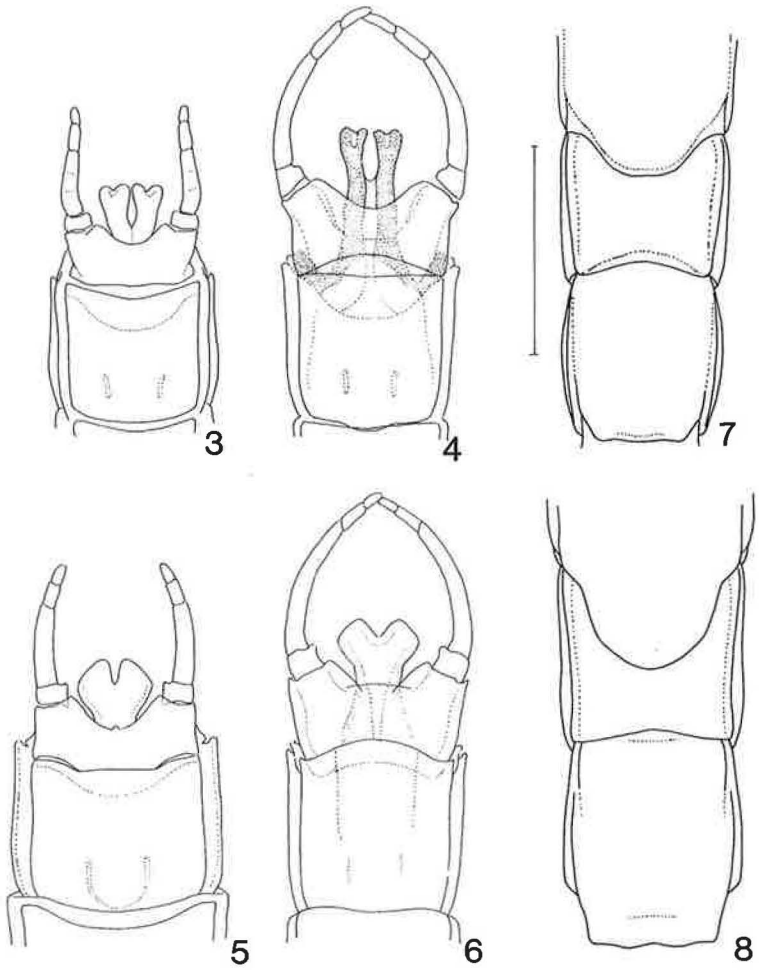
Heptagenia borealis Eaton, 1871:137 + pl. VI:11.
Metretopus norvegicus Eaton, 1901:254.

The synonymy of *M. norvegicus* and *M. borealis* was first recognized by Brekke (1938).

Distribution in Fennoscandia. Denmark: *WJ.* — Norway: *Os, HE, B, Fi* (other provincial records not revised). — Sweden (Fig. 19): *Sm, Vs, Hs–To.* — Finland (Fig. 21): *Ka, Ta, Sa, Tb–Li* (except *ObS* and *Le*). This Holarctic species is transcontinental in North America south to Michigan and Maine (Berner 1978, Harper & Harper 1981). In Eurasia it is known from Fennoscandia to East Siberia and Kamchatka (Tshernova et al. 1986). It is widespread in northern Fennoscandia and rarer to the south. In Denmark it is known only from four streams in Jutland (Jensen 1969); it is also known from Balticum (Puthz 1978).

In Sweden, *M. borealis* has a strong preference for meandering rivers with sandy bottoms and an abundance of submerged fallen trees. Occasional records were made from lakes. The species was often found in microhabitats with deposition of iron. The sites at which *M. borealis* were found are characterized in Table 1.

The following plant taxa were overrepresented when occurring together with *M. borealis*: Clorophyta, *Batrachospermum*, *Sparganium*, *Potamogeton*, *Ranunculus*, *Hippuris*, *Myriophyllum*, and *Utricularia*. Insect species overrepresented together with *M. borealis* include: Ephemeroptera: *Baetis subalpinus* Bengtsson, *Procloeon bifidum* (Bengtsson), *Siphlonurus alternatus* (Say), *S. lacustris* Eaton, *Heptagenia joernensis* Bengtsson, *Paraleptophlebia strandii* (Eaton), *Ephemerella ignita* (Poda); Trichoptera: *Oligostomis reticulata* (L.), *Ceratopsyche nevae* (Kolenati). Moreover, the isopod *Asellus aquaticus* Linnaeus and the mayflies *Leptophlebia vespertina* (L.) and *L. marginata* (L.) were significantly more often found together with *M. borealis* than with *M. alter*.



Figs. 3–8. *Metretopus*, imago and subimago. Top *M. borealis* (Eaton), bottom *M. alter* Bengtsson. — 3–6. Male, apex of abdomen, ventral aspect. 3, 5 subimago; 4, 6 imago. — 7–8. Female imago, abdominal segments 7–9, ventral aspect. — Scale bar1 mm.

Lotic sites inhabited by *M. borealis* had significantly higher pH, were wider, and had larger cover of algae and vegetation than other sites within its distributional range (Table 1).

In south Finland most records of *M. borealis* originate from large lakes, whereas it to the north chiefly has been collected from rivers.

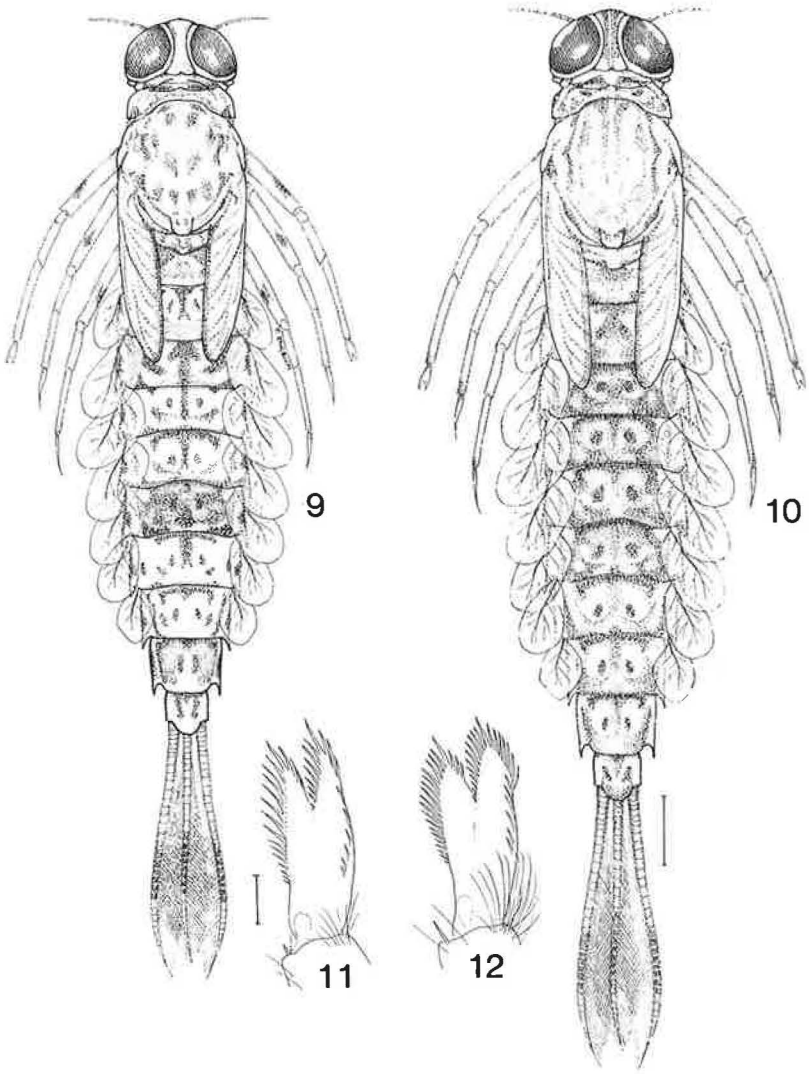
Metretopus alter Bengtsson

Metretopus alter Bengtsson, 1930:15.

Distribution in Fennoscandia. Norway: *TR, Fv.* — Sweden (Fig. 20): *Hr–To.* — Finland (Fig. 22): *Ks, LkW, Li.* Outside northern Fennoscandia this species has been recorded from the northern part of European Russia and Transbaikalia (Tshernova 1952, Tshernova et al. 1986). Besides the type locality (*TR*: Raavand) we know only one additional record from Norway (*Fv*: Alta, Gargiaelva, 7.viii.1986, 4 nymphs, leg. H. Hämäläinen). In Finland it occurs south to about 66°N and in Sweden south to 62°N.

Habitat preferences of *M. alter* in Sweden are indicated by the environmental variables listed in Table 1. The species has a strong preference for smaller streams with stony or sandy bottoms. It was often found in microhabitats with deposition of iron.

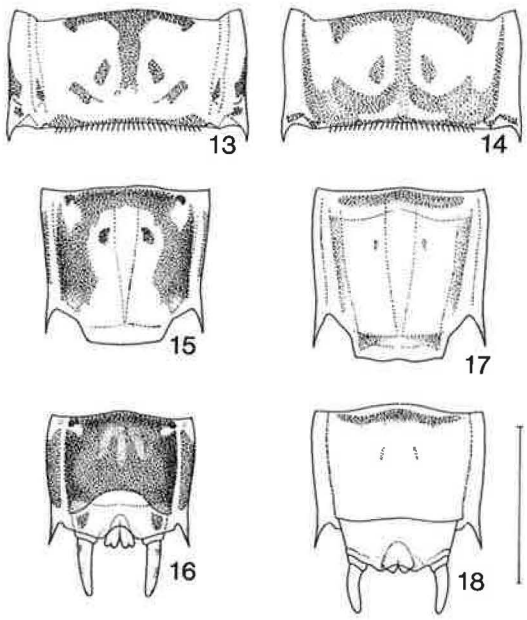
The following plant taxa were overrepresented when occurring together with *M. alter*: Clorophyta, *Batrachospermum*, *Sparganium*, *Filipen-*



Figs. 9–12. *Metretopus*, mature nymph. — Left *M. borealis* (Eaton), right *M. alter* Bengtsson. — 9–10. Dorsal habitus.— 11–12. Protarsal claw, anterior aspect. — Different scale bars for 9–10 (right, 1 mm), and 11–12 (left, 0.1 mm).

dula and *Hippuris*. Insect species overrepresented together with *M. alter* include: Ephemeroptera: *Baetis fuscatus* (Linnaeus); *B. macani* Kimmins (*sensu lato*), *B. subalpinus* Bengtsson, *Siphlonurus lacustris* Eaton, *Heptagenia joernensis* (Bengtsson), *H. orbiticola* Kluge, *Paraleptophlebia cincta* (Retzius), *Paraleptophlebia strandii* (Eaton); Trichoptera: *Oligostomis reticulata* (Linnaeus); Plecoptera: *Leuctra digitata* Kempny. Nymphs of *M. alter* were occasionally found in stagnant pools dominated by the crustacean *Polyartemia forcipata* Fischer. The stoneflies *Amphinemura sulcicollis* (Stephens) and *Diura nanseni* (Kempny) and the caddis flies *Rhyacophila nubila* (Zetterstedt) and *Plectrocnemia* spp. were significantly more often found together with *M. alter* than with *M. borealis*.

Lotic sites inhabited by *M. alter* had significantly higher pH, conductivity and alkalinity, were significantly narrower and shallower, and had a lower water current and a clearer water than other sites within its distributional range (Table 1).



Figs. 13–18. *Metretopus*, mature nymph, abdominal segment. Left *M. borealis* (Eaton); right *M. alter* Bengtsson. — 13–14. Segment 7, dorsal view. — 15, 17. Female, segment 9, ventral view. — 16, 18 Male, segment 9, ventral view.

In Finland, *M. alter* was collected in running waters of different sizes, but never in lakes.

5. Phenology and life cycles

Metretopus nymphs have in Fennoscandia been found from June to August. Söderström (1991) documented nymphal growth of *M. borealis* in a large northern river, in which nymphs occurred from early June to early August (cf. Olsson 1983). In Vargbäcken, nymphs of *M. alter* were observed from late June to early August.

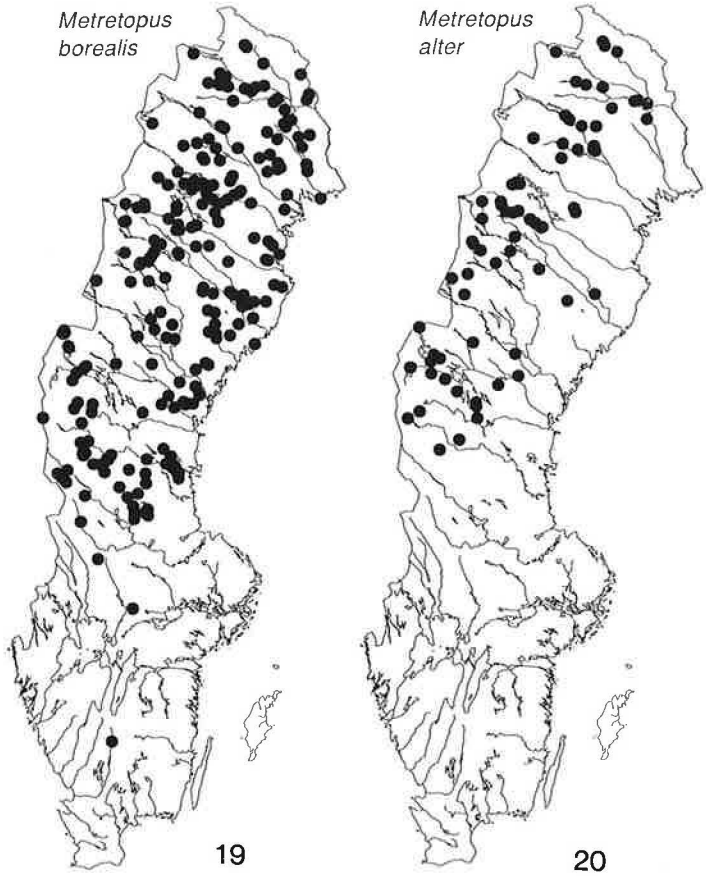
Winged specimens of *Metretopus* have in Fennoscandia been found in July and August. A single male of *M. alter* was collected as late as 5 September in Oulankajoki, northern Finland. Söderström (in litt.) captured winged specimens of *M. borealis* in emergence traps from 18 July to 29 August in River Vindelälven.

Our data support Söderström's (1991) conclusion that *M. borealis* in Fennoscandia is a univoltine summer species. Judging from phenology, *M. alter* has the same kind of life cycle. Mature nymphs of both species were found together at the same date in the stream Ådalsån in the Medelpad province.

Available data suggest that *Metretopus* in Fennoscandia overwinters in the egg stage. In Canada, however, there is an indication that nymphs of *M. borealis* may occur in winter (unpublished data of Daniel Soluk, cited in Clifford 1982; see also Barton 1980). Harper & Harper

Table 1. Range and mean (±*SD*) of selected environmental variables for running water sites with occurrence of *Metretopus borealis* ($n = 104$) and *M. alter* ($n = 33$), respectively. Columns A and B give significant differences (+ = higher, – = lower, *t*-test, $P < 0.05$) between means compared to: (A) other studied sites within a 50 km radius from sites where each species was present ($n = 1053$ for *M. borealis* and 692 for *M. alter*, respectively), and (B) sites where the other species was present.

	M. borealis				*M. alter*			
Variable	Range	Mean ± *SD*	A	B	Range	Mean ± *SD*	A	B
Altitude m a.s.l.	25–790	344 ± 172	–	–	165–690	470 ± 115	+	+
pH	6.00–7.87	6.93 ± 0.37	+	–	6.50–7.90	7.15 ± 0.38	+	+
Conductivity µS/cm	11.0–88.0	34.7 ± 16.4		–	14.0–107.0	42.4 ± 22.4	+	+
Colour mg Pt/l	5–220	56 ± 46		+	3–90	24 ± 19	–	–
Alkalinity mekv/l	0.02–0.77	0.20 ± 0.16		–	0.05–0.83	0.28 ± 0.19	+	+
Water current m/s	0.10–2.00	0.76 ± 0.40			0.10–1.50	0.69 ± 0.44	–	
Stream width m	1–100	13.4 ± 21.2	+	+	0.8–16	5.1 ± 4.0	–	–
Water depth m	0.1–2.0	0.5 ± 0.3		+	0.1–1.0	0.4 ± 0.2	–	–
Moss cover	0–6	1.8 ± 1.6			0–6	1.5 ± 1.7		
Algal cover	0–5	2.4 ± 1.4	+	+	0–6	1.7 ± 1.5		–
Vegetation cover	0–6	1.2 ± 1.3	+		0–6	1.2 ± 1.7		



Figs. 19–20. Map of Sweden with known records of *Metretopus borealis* (Eaton), and *M. alter* Bengtsson. All records were made after 1950.

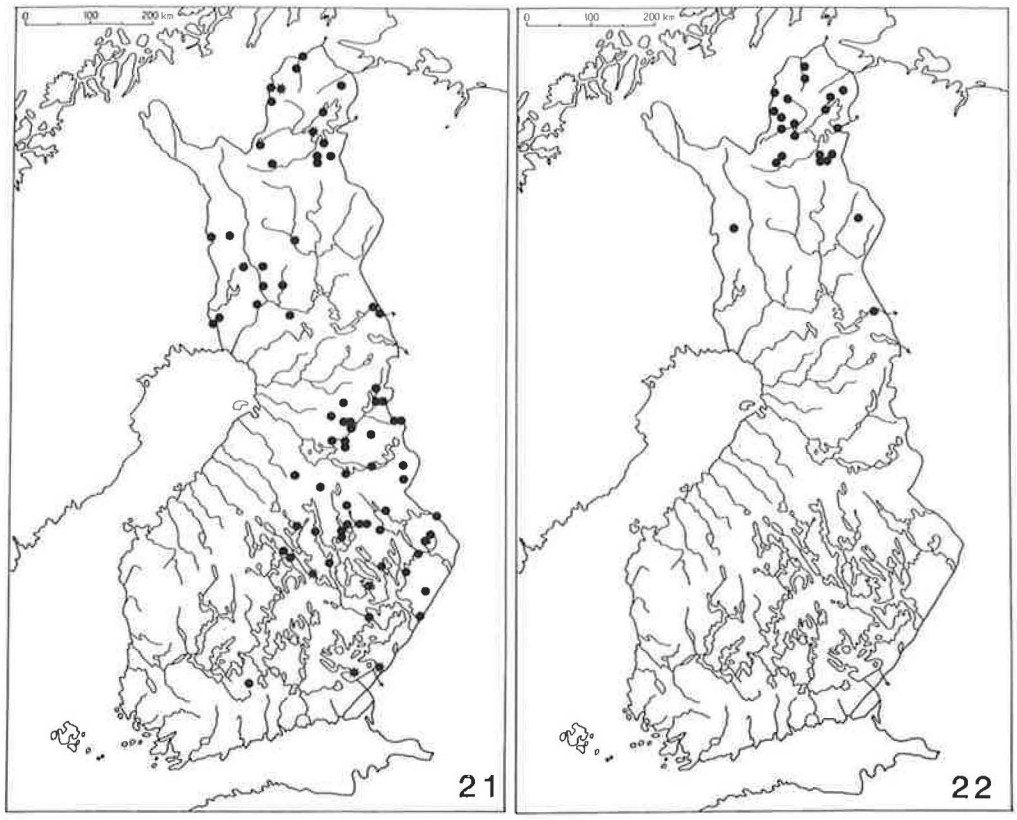
(1981) recorded imagines in northern Canada from 20 June to 6 September, which indicates overwintering of both eggs and nymphs.

Data from Vargbäcken suggest that eggs of *M. alter* need a temperature close to 10°C to hatch. In the extremely cold summer 1987 nymphs were first found on 14 July when the water temperature was 8.8°C (cf. Solem & Johansson 1991: table 1). The low abundance (only 5 nymphs found in 5 net samples taken every ten days) recorded that year may be due to the low water temperature that exceeded 10°C only briefly. *M. alter* nymphs were seemingly more abundant in the warmer years 1989–1990 when the temperature exceeded 12°C during July and August with a maximum of 14.1°C. In 1992 nymphs were first found on 20 June when water temperature had reached 11.0°C.

6. Discussion

As nymphs of the two *Metretopus* species have not been distinguished in earlier studies, and *M. alter* in Sweden by some authors has been treated as conspecific with *M. borealis*, most previous literature records of *M. borealis* need to be revised. Berner (1978:133) mentioned that two females from Swedish Lapland identified by Ulfstrand as *M. borealis* lacked the emargination of the posterior margin of the subgenital plate. This provides a strong indication that they belong to *M. alter*. Our results also indicate that *M. alter* may have a wider distribution in Norway than currently documented.

Demoulin (1951) suggested that nymphs from arctic Ural described by Esben-Petersen (1916) as *Metretopus norvegicus* Eaton instead repre-



Figs. 21–22. Map of Finland with known records of *Metretopus borealis* (Eaton), and *M. alter* Bengtsson. Dots show records of which the excact locations are known, and stars show older records of which the exact locations are unknown.

sented *M. alter*. Based on this assumption Demoulin (1951) gave some characters for the separation of nymphs of *M. alter* from those of *M. borealis*. These characters, which were based on a speculative comparison of published descriptions, are of no taxonomical value. Most likely Esben-Petersen (1916) had mixed up his leg drawings (figs. 15b & 18b), i.e. the legs attributed to *Metretopus* in fact represent *Parameletus*.

On the other hand, the differences in body length and shape of protarsal claws between mature nymphs of the two species given by Tshernova (1952) were validated by our study. The translation of Tshernova's description of claw characters given by Berner (1978:130) is somewhat misleading, as it is the relative length of the apical lobes and not of the "terminal spines" that differs. Moreover, the claw from an Alaskan nymph identified as *M. borealis* illustrated by Berner (1978:fig. 43) is more or less identical with those we have seen of *M. alter*. This provides an indication that *M. alter* may occur also in North America.

The occurrence of the two *Metretopus* species in Sweden suggests that they are sensitive to both pollution and acidification. *Metretopus* nymphs have in Sweden been found in water with a pH of 5.1 and higher (Engblom & Lingdell 1987); records below pH 6 are rare. Local extinctions of *M. borealis* in combination with increasing acidification of streams have been documented in the Swedish Jämtland and Härjedalen provinces (Engblom & Lingdell unpublished). Colonisations of acid streams after lime deposition on surrounding wetlands have also

been observed in the same region. As acidification of small streams occurs at an earlier stage at high altitudes, this threat is seemingly more severe for *M. alter* than for *M. borealis*.

In average, nymphs and winged specimens of *M. alter* have in Sweden been collected one or two weeks later than those of *M. borealis*. This difference was seemingly chiefly due to the more northerly distribution of *M. alter* in combination with its stronger preference for higher altitudes.

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