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Faunistical records of Caddis flies (Trichoptera) from Telemark, SE Norway

TROND ANDERSEN, SINDRE LIGAARD & GEIR E. E. SØLI

Andersen, T., Ligaard, S. & Søli, G. E. E. 1990. Faunistical records of caddis flies (Trichoptera) from Telemark, SE Norway. *Fauna norv. Ser. B. 37:* 49—56.

Records of 92 Trichoptera species from Telemark are given. 78 species are taken in outer Telemark, and 49 in inner Telemark. Only five species have previously been recorded from Telemark.

Eight of the species are considered as rare in Norway. Of these *Rhyacophila fasciata* Hagen, 1859, *Agraylea sexmaculata* Curtis, 1834, *Hydroptila pulchricornis* Pictet, 1834, *Orthotrichia costalis* (Curtis, 1834), *Wormaldia occipitalis* (Pictet, 1834), *Ironoquia dubia* (Stephens, 1837), *Beraeodes minutus* (Linnaeus, 1761) were taken in outer Telemark and *Hydroptila occulta* (Eaton, 1873) in inner Telemark.

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INTRODUCTION

Although Trichoptera is considered as one of the better studied insect groups in Norway (Aagaard & Hågvar 1987), the Trichoptera fauna in many regions is still very superficially known. In his list of Norwegian caddis flies Brekke (1946) recorded three species from inner Telemark (TEI), but no species from outer Telemark (TEY). Later Andersen (1983b) added two species from outer Telemark. In 1988 the caddis fly fauna in a temporarily protected nature reserve in Porsgrunn in outer Telemark was studied (Andersen & Søli 1989); the species taken during this study are included in the present paper. This study was initiated as the local authorities wanted to make the area more attractive for recreation. It was for instance suggested that the muddy bottom substratum of several small ponds in the area should be replaced with sand to make them more attractive for bathing.

Freshwater localities are among our most threatened habitats. In Norway hydroelectric exploitation has effected a high number of river systems. Acid rain has led to an increasing acidity in many freshwater systems in south Norway. In the more densely populated areas along the coast of south Norway many river systems are strongly polluted due to industrial waste and housing sewer. Seepage from farming land adds to this pollution.

Today, maintenance of the biodiversity is considered to be one of the most important tasks in nature conservation (see e.g. NOU 1980, World Commission on Environment and Development 1987). A high number of species have their northern border of distribution in south Norway. These marginal populations in south Norway may contribute to save species from extinction, as their habitats in south and central Europe in several instances are threatened due to human activities. In this context it is essential to get a better knowledge of the distribution and occurrence of insects in south Norway.

STUDY AREA, MATERIAL AND METHODS

The total material comprises approximately 8.450 imagines collected between 1974 and 1988 in 40 different localities in outer and inner Telemark, fig. 1. The exact localities, with UTM- and EIS-references are listed in table 1. The biogeographical provinces follow Strands' system as revised by Økland (1981).

Most of the material have been taken in light traps, but some specimens were also taken in malaise traps. In addition caddis flies

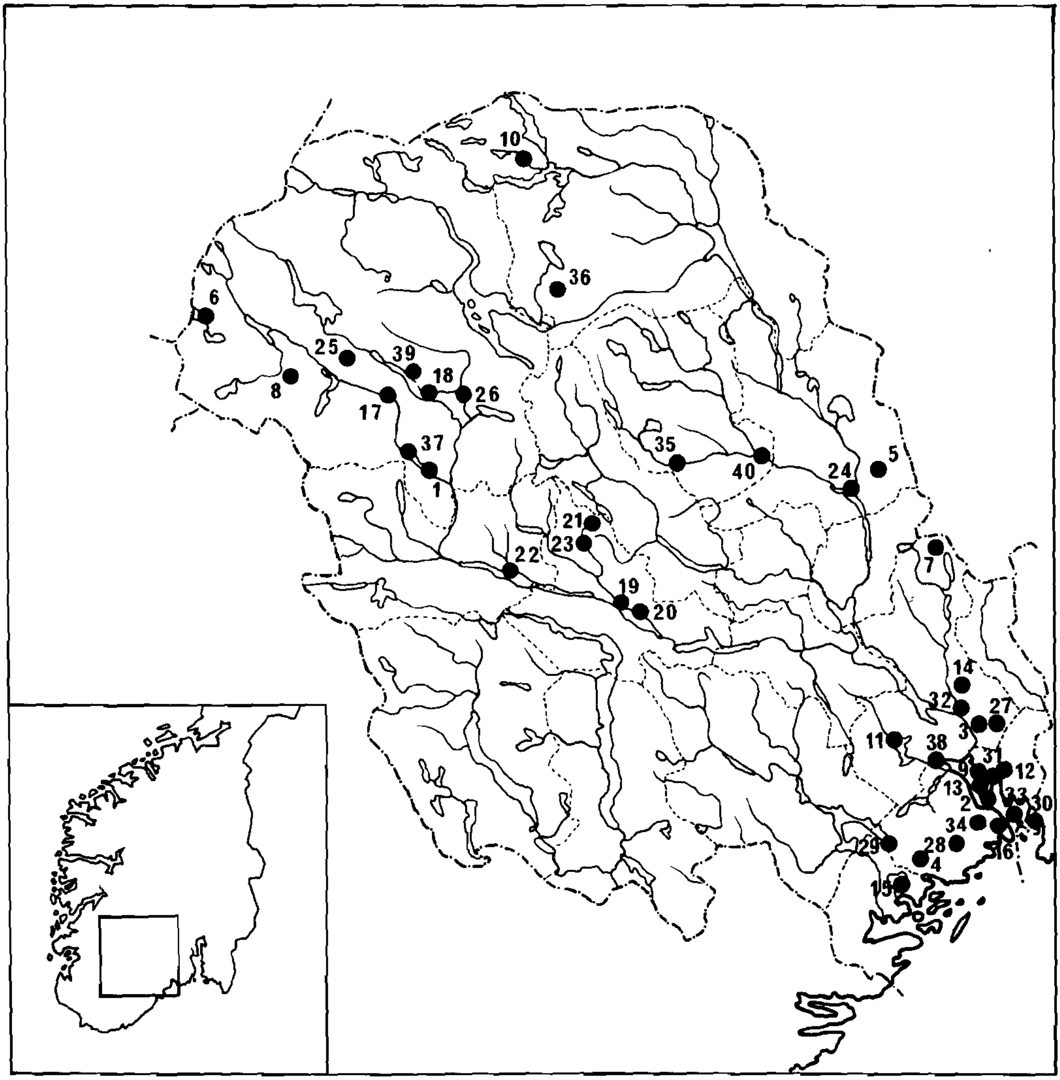

Fig. 1. Localities in outer an inner Telemark; the numbers refer to the locality numbers in table 1.

have been collected with sweepnets or have been searched for on stones and vegetation along lakes and rivers. Most of the material have been taken by the authors, but some speciemens taken by Torfinn Andersen and Sigmund Hansen are also included. In addition, a few specimens deposited in the entomological collection at the Zoological Museum, University of Bergen, have been identified.

Capture date, number of males and females caught and method are only given for species which are considered as rare.

THE SPECIES

Family Rhyacophilidae

Rhyacophila fasciata Hagen, 1859. TEY, Porsgrunn: Dammane 20 July—26 Sept. 1983 4 ♂♂ 2 ♀♀ (light trap), Dammane 15 June—19 Oct. 1988 145 ♂♂ 45 ♀♀ (light trap), 15 June—11 July 1 ♂ (malaise trap), Gravastranda 15 June—17 Sept. 1988 4 ♂♂ 2 ♀♀ (light trap), Hitterødbekken 6 June 1988 1 ♂ (net), 15 June—17 Sept. 1988 19 ♂♂ 1 ♀ (malaise trap).

Table 1. Localities in Telemark, with UTM- and EIS-reference.

No.	LOCALITY	REGION	MUNICIPALITY	UTM (32V)	EIS
1	Bøgrend	TEI	Vinje	MM378084	25
2	Dammane	TEY	Porsgrunn	NL3946	11
3	Doktorstykket	TEY	Skien	NL3660	18
4	Dørdal	TEY	Bamble	NL275363	11
5	Elgsjøen	TEI	Notodden	NM213063	27
6	Fehtedokki	TEI	Vinje	LM971355	24
7	Finnvolldalen, Gjerpen	TEY	Skien	NL304938	18
8	Flothyl	TEI	Vinje	MM138224	25
9	Gravastranda	TEY	Porsgrunn	NL3750	18
10	Grytselberget	TEI	Tinn	MM530637	34
11	Gåsodden, Kilevannet	TEY	Skien	NL228586	18
12	Herregårdsstranda	TEY	Porsgrunn	NL408529	18
13	Hitterødbekken	TEY	Porsgrunn	NL373487	11
14	Hoppestad	TEY	Skien	NL323688	18
15	Hullvatn	TEY	Kragerø	NL2333	11
16	Hydal	TEY	Bamble	NL419423	11
17	Kaldråstøl	TEI	Vinje	MM319193	25
18	Killingtveit	TEI	Vinje	MM375119	25
19	Kviteseid	TEI	Kviteseid	ML7085	17
20	Kvitsund	TEI	Kviteseid	ML733832	17
21	Liervann	TEI	Kviteseid	ML6895	17
22	Lårdal	TEI	Tokke	ML5387	17
23	Morgedalstjern	TEI	Kviteseid	ML6793	17
24	Notodden	TEI	Notodden	NM143024	27
25	Nystøl	TEI	Vinje	MM223266	25
26	Rauland	TEI	Vinje	MM429204	25
27	Ris, Gjerpensdalen	TEY	Skien	NL394594	18
28	Rønholt	TEY	Bamble	NL335377	11
29	Rørholt	TEY	Bamble	NL2140	11
30	Saga, Langangen	TEY	Porsgrunn	NL479465	11
31	Skjelsvik	TEY	Porsgrunn	NL393516	18
32	Snelltveit, Gjerpensdalen	TEY	Skien	NL363646	18
33	Solvang, Sandøya	TEY	Porsgrunn	NL424463	11
34	Stokkevannet	TEY	Bamble	NL397431	11
35	Strond	TEI	Hjartdal	MM858079	26
36	Vestre Langesjåhovda	TEI	Tinn	MM6241	26
37	Vinje	TEI	Vinje	MM342098	25
38	Voll, Herre	TEY	Bamble	NL2854	18
39	Vå	TEI	Vinje	MM345243	25
40	Åmnefossen	TEI	Hjartdal	MM998084	26

R. nubila (Zetterstedt, 1840). TEY, Porsgrunn: Gravastranda; Bamble: Rørholt. TEI, Notodden: Notodden; Hjartdal: Åmnefossen; Kviteseid: Kvitsund; Vinje: Bøgrend, Vå.

Family Glossosomatidae

Agapetus ochripes Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda. TEI, Notodden: Notodden.

Family Hydroptilidae

Agraylea sexmaculata Curtis, 1834. TEY, Porsgrunn: Dammane 15 June—12 July 1988 1 ♂ (light trap).
Hydroptila occulta (Eaton, 1873). TEI, Kviteseid: Kvitsund 11—29 July 1988 1 ♂ 3 ♀♀ (light trap).
H. pulchricornis Pictet, 1834. TEY, Porsgrunn: Dammane 15 June—12 July 1988 1 ♂ 1 ♀ (light trap); Bamble: Rønholt 27 July 1987 1 ♂ (net), Stokkevannet 27 July 1987 36 ♂♂ 3 ♀♀ (net).
H. tineoides Dalman, 1819. TEY, Porsgrunn: Dammane. TEI, Notodden: Notodden.
Ithytrichia lamellaris Eaton, 1873. TEI, Kviteseid: Kvitsund.
Orthotrichia costalis (Curtis, 1834). TEY, Porsgrunn: Dammane July 1983 2 ♀♀ (light trap), Bamble: Stokkevannet 27 July 1987 1 ♂ 2 ♀♀ (net).
Oxyethira distinctella McLachlan, 1880. TEY, Kragerø: Hullvatn. TEI, Kviteseid: Kvitsund.
O. flavicornis (Pictet, 1834). TEY, Porsgrunn: Dammane, Gravastranda; Kragerø: Hullvatn. TEI, Hjartdal: Strond; Kviteseid: Kvitsund; Vinje: Kaldråstøl, Vinje.
O. frici Klapálek, 1891. TEI, Notodden: Notodden; Kviteseid: Kvitsund.

Family Philopotamidae

Philopotamus montanus (Donovan, 1813). TEY, Porsgrunn: Dammane; Bamble: Rørholt.
Wormaldia occipitalis (Pictet, 1834). TEY, Porsgrunn: Hitterødbekken 15 June—19 Oct. 1988 33 ♂♂ 148 ♀♀ (malaise trap), 20 July 1988 23 ♂♂ 1 ♀ (net).
W. subnigra McLachlan, 1865. TEY, Porsgrunn: Dammane.

Family Psychomyiidae

Lype phaeopa (Stephens, 1836). TEY, Porsgrunn: Dammane, Saga; Bamble: Hydal, Rønholt. TEI, Notodden: Notodden.
Tinodes waeneri (Linnaeus, 1758). TEY, Porsgrunn: Dammane, Gravastranda, Solvang; Bamble: Rørholt, Stokkevannet. TEI, Kviteseid: Kvitsund.

Family Ecnomidae

Ecnomus tenellus (Rambur, 1842). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rønholt.

Family Polycentropodidae

Cyrnus flavidus McLachlan, 1864. TEY, Porsgrunn: Dammane; Skien: Hoppestad, Snelltveit.
C. insolutus McLachlan, 1878. TEY, Porsgrunn: Dammane; Skien: Gåsodden; Bamble: Rønholt; Kragerø: Hullvatn. TEI, Notodden: Elgsjøen.
C. trimaculatus (Curtis, 1834). TEY, Porsgrunn: Dammane, Gravastranda, Saga; Bamble: Dørdal, Hydal; Kragerø: Hullvatn. TEI, Notodden: Elgsjøen; Hjartdal: Åmnefossen; Vinje: Kaldråstøl.
Holocentropus dubius (Rambur, 1842). TEY, Porsgrunn: Dammane, Gravastranda, Solvang; Bamble: Hydal.
H. picicornis (Stephens, 1836). TEY, Porsgrunn: Skjelsvik; Skien: Gåsodden, Snelltveit.
Neureclipsis bimaculata (Linnaeus, 1758). TEY, Porsgrunn: Gravastranda.
Plectrocnemia conspersa (Curtis, 1834). TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Skjelsvik, Solvang; Skien: Doktorstykket; Bamble: Rørholt. TEI, Kviteseid: Kvitsund, Liervann; Vinje: Vå.
Polycentropus flavomaculatus (Pictet, 1834). TEY, Porsgrunn: Herregårdsstranda, Saga; Bamble: Dørdal, Rørholt. TEI, Notodden: Elgsjøen, Notodden; Kviteseid: Liervann; Vinje: Kaldråstøl, Rauland.
P. irroratus (Curtis, 1835). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rønholt, Rørholt.

Family Hydropsychidae

Hydropsyche angustipennis (Curtis, 1834). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rørholt.
H. siltalai Döhler, 1963. TEY, Porsgrunn: Dammane, Gravastranda.

Family Phryganeidae

Agrypnia obsoleta (Hagen, 1864). TEI, Vinje: Nystøl.
A. picta Kolenati, 1848. TEI, Kviteseid: Kvitsund.
A. varia (Fabricius, 1793). TEY, Porsgrunn: Dammane; Bamble: Rørholt. TEI, Kviteseid: Kvitsund.
Phryganea grandis Linnaeus, 1758. TEY, Porsgrunn: Dammane, Gravastranda; Skien: Snelltveit. TEI, Kviteseid: Kvitsund.
Trichostegia minor (Curtis, 1834). TEY, Porsgrunn: Dammane, Gravastranda, Solvang; Skien: Snelltveit.

Family Lepidostomatidae

Crunoecia irrorata (Curtis, 1834). TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken. TEI, Hjartdal: Åmnefossen.
Lepidostoma hirtum (Fabricius, 1775). TEY, Porsgrunn: Gravastranda; Skien: Doktorstykket; Bamble: Rørholt. TEI, Kviteseid: Kvitsund; Vinje: Kaldråstøl.

Family Limnephilidae

Ironoquia dubia (Stephens, 1837). TEY, Porsgrunn: Dammane 25—31 Aug. 1983 2 ♀♀ (light trap), Gravastranda 20 Aug.—10. Sept. 1983 13 ♂♂ (light trap), Gravastranda 12 Aug.—17 Sept. 1988 69 ♂♂ (light trap), Hitterødbekken 12 Aug.—17 Sept. 1988 1 ♂ (malaise trap).
Apatania stigmatella (Zetterstedt, 1840). TEI, Notodden: Notodden; Tinn: Grytselberget; Vinje: Vinje, Vå.
A. zonella (Zetterstedt, 1840). TEY, Porsgrunn: Gravastranda. TEI, Vinje: Fehtedokki, Vinje.
Chaetopteryx villosa (Fabricius, 1798). TEI, Vinje: Bøgrend.
Asynarchus lapponicus (Zetterstedt, 1840). TEI, Tinn: Vestre Langesjåhovda.
Glyphotaelius pellucidus (Retzius, 1783). TEY, Porsgrunn: Dammane, Gravastranda, Skjelsvik, Solvang; Bamble: Rørholt.
Limnephilus affinis Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Solvang.
L. auricula Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda.
L. binotatus Curtis, 1834. TEY, Porsgrunn: Dammane, Solvang.
L. borealis (Zetterstedt, 1840). TEY, Porsgrunn: Dammane, Gravastranda; Skien: Finnvolldalen. TEI, Vinje: Flothyl.
L. centralis Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Skjelsvik, Solvang; Bamble: Voll. TEI, Kviteseid: Kvitsund; Tokke: Lårdal; Vinje: Vå.
L. coenosus Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Solvang; Bamble: Rørholt. TEI, Tinn: Vestre Langesjåhovda; Vinje: Vå.
L. decipiens (Kolenati, 1848). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rønholt.
L. elegans Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda. TEI, Kviteseid: Kvitsund.
L. extricatus McLachlan, 1865. TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Saga; Skien: Ris; Bamble: Rørholt. TEI, Kviteseid: Kvitsund, Morgedalstjern.
L. femoratus (Zetterstedt, 1840). TEI, Vinje: Flothyl.
L. flavicornis (Fabricius, 1787). TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Skjelsvik, Solvang.
L. fuscicornis Rambur, 1842. TEY, Skien: Ris; Bamble: Rørholt.
L. griseus (Linnaeus, 1758). TEY, Porsgrunn: Dammane, Gravastranda, Solvang.
L. ignavus McLachlan, 1865. TEY, Porsgrunn: Dammane, Gravastranda, Solvang.
L. lunatus Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Solvang; Bamble: Rørholt.
L. luridus Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Solvang; Bamble: Rørholt.
L. marmoratus Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rørholt.
L. rhombicus (Linnaeus, 1758). TEY, Porsgrunn: Dammane, Gravastranda, Skjelsvik; Bamble: Rørholt.
L. sericeus (Say, 1824). TEY, Porsgrunn: Dammane, Gravastranda, Solvang. TEI: Kviteseid: Kviteseid.
L. sparsus Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Skjelsvik, Solvang. TEI, Kviteseid: Kvitsund.
L. stigma Curtis, 1834. TEY, Porsgrunn: Dammane, Gravastranda, Solvang.
L. subcentralis Brauer, 1857. TEY, Porsgrunn: Dammane, Gravastranda, Solvang.
L. vittatus (Fabricius, 1798). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rørholt.
Phacopteryx brevipennis (Curtis, 1834).

TEY, Porsgrunn: Dammane, Gravastranda, Solvang. TEI, Hjartdal: Åmnefossen.
Halesus radiatus (Curtis, 1834). TEY, Porsgrunn: Dammane, Gravastranda, Solvang. TEI, Vinje: Bøgrend.
H. tesselatus (Rambur, 1842). TEI, Hjartdal: Åmnefossen.
Hydatophylax infumatus (McLachlan, 1865). TEY, Porsgrunn: Gravastranda.
Micropterna lateralis (Stephens, 1837). TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Solvang; Bamble: Rørholt. TEI, Kviteseid: Kvitsund; Vinje: Vå.
M. sequax McLachlan, 1875. TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Skjelsvik, Solvang; Bamble: Rørholt. TEI, Kviteseid: Kvitsund; Vinje: Bøgrend.
Potamophylax cingulatus (Stephens, 1837). TEY, Porsgrunn: Dammane, Gravastranda, Skjelsvik, Solvang; Bamble: Rørholt. TEI, Vinje: Vå.
P. latipennis (Curtis, 1834). TEI, Vinje: Killingtveit, Vå.
P. nigricornis (Pictet, 1834). TEY, Porsgrunn: Dammane, Gravastranda, Hitterødbekken, Skjelsvik, Solvang. TEI, Kviteseid: Kvitsund; Vinje: Vå.
Stenophylax permistus McLachlan, 1895. TEY, Porsgrunn: Dammane, Gravastranda, Solvang.

Family Goeridae

Goera pilosa (Fabricius, 1775). TEI, Kviteseid: Kvitsund.
Silo pallipes (Fabricius, 1781). TEY, Porsgrunn: Dammane.

Family Beraeidae

Beraea pullata (Curtis, 1834). TEY, Porsgrunn: Gravastranda, Hitterødbekken.
Beraeodes minutus (Linnaeus, 1761). TEY, Porsgrunn: Dammane 15 June—12 July 1988 6 ♂♂ 1 ♀ (light trap); Skien: Snelltveit 7 June 1988 1 ♀ (net).

Family Sericostomatidae

Sericostoma personatum (Spence *in* Kirby & Spence, 1826). TEY, Porsgrunn: Dammane. TEI, Kviteseid: Kvitsund.

Family Molannidae

Molannodes tinctus (Zetterstedt, 1840). TEY, Porsgrunn: Dammane, Solvang; Bamble: Dørdal; Kragerø: Hullvatn. TEI, Notodden: Elgsjøen; Kviteseid: Kvitsund; Vinje: Kaldråstøl.

Family Leptoceridae

Athripsodes aterrimus (Stephens, 1836). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Rønholt, Stokkevannet; Kragerø: Hullvatn.
A. cinereus (Curtis, 1834). TEY, Bamble: Stokkevannet.
Ceraclea dissimilis (Stephens, 1836). TEY, Skien: Doktorstykket.
C. nigronervosa (Retzius, 1783). TEI, Kviteseid: Liervann.
C. senilis (Burmeister, 1839). TEY, Bamble: Rønholt.
Mystacides azurea (Linnaeus, 1761). TEY, Porsgrunn: Dammane, Gravastranda; Bamble: Stokkevannet; Kragerø: Hullvatn. TEI, Notodden: Notodden; Kviteseid: Morgedalstjern; Vinje: Flothyl, Kaldråstøl, Vinje.
M. longicornis (Linnaeus, 1758). TEY, Kragerø: Hullvatn.
Oecetis lacustris (Pictet, 1834). TEY, Porsgrunn: Dammane; Kragerø: Hullvatn. TEI, Vinje: Flothyl.
O. ochracea (Curtis, 1825). TEI, Kviteseid: Kvitsund.
O. testacea (Curtis, 1834). TEY, Porsgrunn: Dammane. TEI, Kviteseid: Kvitsund.
Triaenodes bicolor (Curtis, 1834). TEY, Skien: Gåsodden, Snelltveit; Kragerø: Hullvatn. TEI, Notodden: Elgsjøen.

DISCUSSION

After Brekke (1946) published his check-list on Norwegian Trichoptera, the only records from Telemark are those given by Andersen (1983b). Brekke (1946) recorded no species from outer Telemark and only three species, *Rhyacophila nubila* (Zetterstedt, 1840), *Apatania stigmatella* (Zetterstedt, 1840) and *Limnephilus coenosus* Curtis, 1834 from inner Telemark. Andersen (1983b) recorded two species, *Plectrocnemia conspersa* (Curtis, 1834) and *Phryganea grandis* Linnaeus, 1758 from the Grenland area in outer Telemark. Hence, most of the species recorded here are «new» to these faunistical regions.

Eight of the species are considered as rare in Norway (Aagaard & Hågvar 1987). Of these, *Rhyacophila fasciata* Hagen, 1859 was recorded for the first time in Norway from

Fagernes in Ramfjord in outer Troms (Forsslund 1932). The species has later been recorded from Vestfold (Andersen 1975), and has also been taken in southern Hedmark (see Aagaard & Hågvar 1987). According to Lepneva (1970) the species inhabits rapidly running brooks and rivulets. The present specimens were all taken close to small streams.

Agraylea sexmaculata Curtis, 1834 has previously only been recorded from Borrevann in Vestfold (Solem 1972). In Denmark the species inhabits lakes, but also ponds and slowly running streams (Wiberg-Larsen 1985). The present male was taken in a light trap situated close to a small, shallow pond.

Hydroptila occulta (Eaton, 1873) has previously only been taken in a few localities in outer Hordaland (Andersen 1976, Marshall 1977, Andersen & Tysse 1985). The species inhabits fast flowing streams and rivers (Marshall 1978). The present specimens were taken in a light trap situated close to a small, rapid stream.

Hydroptila pulchricornis Pictet, 1834 was recorded for the first time in Norway from Femsjøen near Halden in Østfold (Solem 1970). Later the species has been recorded from Vestfold (Andersen 1975). According to Marshall (1978) the species inhabits lakes, ponds, rivulets and brooks. All specimens from Telemark were netted in vegetation along lake shores or taken in a light trap situated close to a small, shallow pond.

Orthotrichia costalis (Curtis, 1834) was recorded as new to Norway from the lakes Borrevann and Åsrumvann in Vestfold (Andersen 1975). According to Marshall (1978) the species inhabits ponds and lakes and slowly flowing water. The present specimens have either been netted among vegetation on lake shores or taken in a light trap situated close to a small, shallow pond.

Wormaldia occipitalis (Pictet, 1834) was recorded for the first time in Norway from Hovland in Ullensvang in inner Hordaland (Andersen 1979, 1983c). Later the species has been taken in one more locality in inner Hordaland. In addition a few specimens were collected by Fritz Jensen in 1942 and 1943 from two localities in outer Rogaland (see Aagaard & Hågvar 1987). The species inhabits small, shallow springs, where the larvae are found under stones, in moss or among decaying leaves, most often under a thin layer of water (Vaillant 1976). At the small rapid stream Hitterødbekken *W. occipitalis* was the most abundant species in the material from a malaise trap. Today both localities in Hordaland are destroyed by human activities.

Ironoquia dubia (Stephens, 1837) is recorded from three localities in Vestfold (Andersen 1975, Andersen & Hansen 1990). The species inhabits ditches, springs and slow flowing streams, but also ponds rich in detritus (Hickin 1967, Lepneva 1971, Tobias & Tobias 1981). The present specimens were all taken in traps situated close to small streams; at Gravastranda the species was among the most abundant species in the light trap catches in 1988.

Beraeodes minutus (Linnaeus, 1761) was recorded for the first time in Norway from Seterstøa in Sør-Odal in southern Hedmark (Morton 1901). Later the species has been recorded from a few localities in outer Hordaland (Andersen 1980). In Denmark the species inhabits small streams particularly in wooded areas, where the larvae prefers sandy bottom with some decaying plant material (Wiberg-Larsen 1979). One of the present specimens was found resting close to a small slow flowing river, the others were taken in a light trap close to the outlet of a small stream into a small, shallow pond.

Even though the present contribution manifold the number of species known from outer and inner Telemark, there are unquestionably a high number of species still to be taken in both provinces. In the neighboring province, Vestfold, 108 species are taken (Brekke 1946, Økland 1964, Solem 1972, Andersen 1975, 1983a, Andersen & Hansen 1990 Andersen & Søli 1990). Telemark is several times larger than Vestfold and has much more varied freshwater localities, so the number of species inhabiting the region ought to be comparatively higher.

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Caddis flies (Trichoptera) from five small islands in the middle Oslofjord, SE Norway

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Andersen, T. & Hansen, L. O. 1990. Caddis flies (Trichoptera) from five small islands in the middle Oslofjord, SE Norway. *Fauna norv. Ser. B, 37:* 57—61.

Light trapping on five small islands in the middle Oslofjord in 1987, gave a total of 43 Trichoptera species. No less than 32 species belong to the family Limnephilidae; of the genus *Limnephilus* alone, 23 species were caught. As many caddis flies are strong flyers, it is supposed that the imagines of several species have dispersed from the main land.

Three of the islands, Tofteholmen, Ramvikholmen and Mølen, are situated in eastern Buskerud, while Langøya and Killingholmen are situated in Vestfold. Eight of the species taken are previously not recorded from eastern Buskerud, while two species are «new» to Vestfold.

Records of *Hydropsyche contubernalis* McLachlan, 1865, *Ironoquia dubia* (Stephens, 1837), *Grammotaulius nitidus* (Müller, 1764), *Limnephilus fuscinervis* (Zetterstedt, 1840) and *Oecetis furva* (Rambur, 1842) are given; these are all species which are considered as rare in Norway.

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INTRODUCTION

Islands and shore areas in the Oslofjord region in SE Norway are exposed to considerable pressure from human activities (see e.g. NOU 1986). Large areas are used for shore residences, campgrounds and bathing beaches. As a result the natural vegetation is worn down and unique habitats are impoverished or destroyed.

During the last years a few studies on rare and vulnerable insects in this region have appeared, all demonstrating a very species rich fauna with a comparatively high number of rare species (Andersen & Fjeldså 1984, Midtgaard & Aarvik 1984, Andersen & Søli 1989a). The present paper is based on a study of insects and spiders on six small island in the middle part of the Oslofjord in 1987, granted by Directorate for Nature Management (Hansen 1989). During this study caddis flies were collected on five of the islands.

STUDY AREA

Three of the islands, Tofteholmen, Ramvikholmen and Mølen, are situated in Buskerud, while Langøya and Killingholmen are situated in Vestfold, fig. 1.

Tofteholmen is some 0.11 km^2. The distance to the main land is approximately 2 km, while the distance to the nearest island, Ramvikholmen is about 1 km. The rocks are Cambro-Silurian sediments, which in Permian were covered by eruptives (Resvoll-Holmsen 1929). The eruptives are many places worn down so the Cambro-Silurian limestone is exposed. The island has a very rich vegetation with dry meadows rich in herbs and shrubs along the coast. The interior of the island is covered with old spruce forest (*Picea abies*) and deciduous trees, mainly lime (*Tilia cordata*). There are several small ponds along the coast, while ponds in the interior parts of the island have a more temporary appearance.

Ramvikholmen is some 0.10 km^2, and the distance to the main land is approximately 1.25 km. The geological origin and the vegetation are rather similar to Tofteholmen. Also on this island there are several small ponds along the coast. In the interior of the island there are both small temporary ponds and ponds which are more permanent. The latter are often found in crevices in the rock and they are up to 2 x 3 m in extension and half a meter deep.

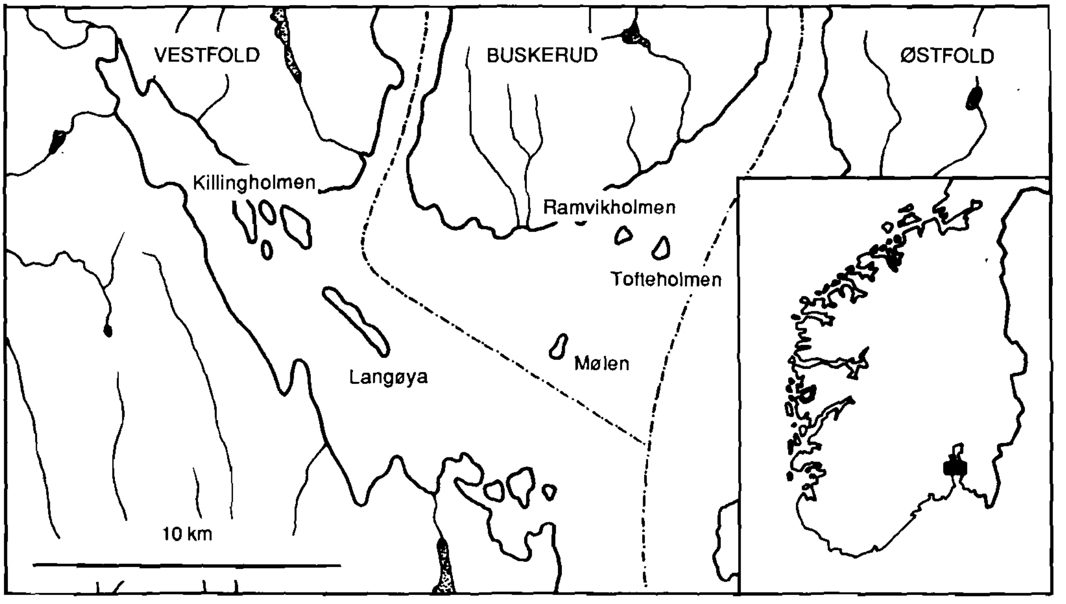

Fig. 1. The middle part of the Oslofjord area, SE Norway, showing the position of the islands Tofteholmen, Ramvikholmen, Mølen, Langøya and Killingholmen.

Mølen is some 0.25 km², and the distance to the main land is approximately 3.5 km. The rocks are of Pre-Cambrian origin (Gleditsch 1948), but along the coast there are sand banks mixed with crushed sea shells, which give rise to an interesting flora (Hagen 1950). The interior of the island is covered with old and dense lime forest. There are several small ponds along the coast. In the interior of the island there are a few more permanent ponds, particularly in crevices.

Langøya is about 1 km² and the distance to the main land is approximately 2 km. The rocks are Silurian limestone rich in fossils (Miljøverndepartementet 1985). Since 1898 the limestone has been mined for the production of cement, and to day two deep quarries covers approximately 60% of the surface of the island. In the northern part of the island there are deciduous forest, mainly birch (*Betula pubescens*) and lime, but also mixed forest and basiphilous pine (*Pinus sylvestris*) forest with a rich flora of orchids. There are also dry meadows and shrubs on the island. The large quarries are filled with water, and there are also a number of smaller and larger ponds both along the coast and in the interior of the island, many of which have a permanent character.

Killingholmen is some 0.20 km², and the distance to the main land is less than 1 km. Also on this island the rocks are Silurian limestone. There are some dry meadows along the coast and basiphilous pine forest in the interior parts of the island. A few ponds, particularly in crevices, are found on the island.

METHODS

Most of the material was collected in light traps fitted with mercury vapour bulbs. On Langøya a light trap fitted with a 700 W bulb (HQL) was operated for approximately 150 nights from early June to mid November 1987. On the other islands light traps were operated for shorter periods: Mølen and Killingholmen for five nights throughout the flight period of Trichoptera; Ramvikholmen for only one night.

On Killingholmen and Tofteholmen a few Trichoptera specimens were also collected with nets.

RESULTS

A total of 314 specimens belonging to 43 species were taken on the five islands, table 1.

Table 1. Caddis flies (Trichoptera), as males/females, collected on the islands Tofteholmen (To), Ramvikholmen (Ra), Mølen (Mø), Langøya (La) and Killingholmen (Ki) in the middle Oslofjord, SE Norway in 1987.

SPECIES	To	Ra	Mø	La	Ki
Rhyacophila nublia (Zetterstedt, 1840)	-	-	-	2/1	-
Holocentropus dubius (Rambur, 1842)	-	-	-	-/1	-
Plectrocnemia conspersa (Curtis, 1834)	-	-	-	7/3	1/-
Hydropsyche contubernalis McLachlan, 1865	-	-	-	2/2	-
Phryganea bipunctata Retzius, 1783	-	-	-	1/-	-
P. grandis Linnaeus, 1758	-	-	2/-	4/1	-
Trichostegia minor (Curtis, 1834)	-	-	1/1	-	-
Ironoquia dubia (Stephens, 1837)	-	-	-	1/-	-
Glyphotaelius pellucidus (Retzius, 1783)	-	-	1/-	18/6	-
Grammotaulius nitidus (Müller, 1764)	-	-	-	1/-	-
Limnephilus affinis Curtis, 1834	-	-	1/-	16/13	7/1
L. auricula Curtis, 1834	-	-	-	1/-	-
L. binotatus Curtis, 1834	-	-	-	1/-	-
L. borealis (Zetterstedt, 1840)	-	-	-	39/2	-
L. centralis Curtis, 1834	1/-	-	-/1	18/2	-
L. coenosus Curtis, 1834	-	-	-	1/-	-
L. decipiens (Kolenati, 1848)	-	-	-	6/-	-
L. elegans Curtis, 1834	-	-	-	1/1	1/-
L. extricatus McLachlan, 1865	-	-	-	1/-	-
L. flavicornis (Fabricius, 1787)	-	-	1/-	4/-	-
L. fuscinervis (Zetterstedt, 1840)	-	-	1/-	-/3	-
L. ignavus McLachlan, 1865	-	-	-	3/-	-
L. lunatus Curtis, 1834	-	-	-	3/-	-
L. luridus Curtis, 1834	-	-	2/-	3/-	-
L. marmoratus Curtis, 1834	-	-	-	2/-	-
L. picturatus McLachlan, 1875	-	-	-	1/-	-
L. politus McLachlan, 1865	-	-	-	1/-	-
L. rhombicus (Linnaeus, 1758)	-	-	-	4/-	-
L. sericeus (Say, 1824)	-	-	-	16/4	-
L. sparsus Curtis, 1834	-	1/-	2/3	18/4	1/-
L. stigma Curtis, 1834	-	1/-	-	7/1	-
L. subcentralis Brauer, 1857	-	-	-	5/-	1/-
L. vittatus (Fabricius, 1798)	-	-/1	-	4/-	-
Nemotaulius punctatolineatus (Retzius, 1783)	-	-	-	1/-	-
Phacopteryx brevipennis (Curtis, 1834)	-	-	-	1/1	-
Halesus radiatus (Curtis, 1834)	-	-	-	1/-	-
H. tesselatus (Rambur, 1842)	-	-	-	14/-	1/-
Micropterna sequax McLachlan, 1875	-	-	1/-	3/2	-
Potamophylax cingulatus (Stephens, 1837)	-	-	-	5/5	-
P. nigricornis (Pictet, 1834)	-	-	-	2/3	-
Athripsodes albifrons (Linnaeus, 1758)	-	-	-/2	-	-
Mystacides azurea (Linnaeus, 1761)	-	-	-	-/2	-
Oecetis furva (Rambur, 1842)	-	-	-	2/1	-

Of these, 278 specimens belonging to 41 species were collected on Langøya. On this island a light trap was collecting insects continuously from early June to mid September. On Mølen light traps were operated for 5 nights throughout the flight period. On this island 19 specimens belonging to 11 species were trapped. On Killingholmen light traps were also operated for 5 nights throughout the flight period resulting in 10 specimens belonging to 4 species. In addition single males of *Plectrocnemia conspersa* (Curtis, 1834), *Limnephilus affinis* Curtis, 1834 and *L. elegans* Curtis, 1834 were taken with nets, raising the number of species taken on Killingholmen to 6. On Ramvikholmen light traps were operated for one nigh only, resulting in 3 species, each in one specimen. On Tofteholmen one male of *Limnephilus centralis* Curtis, 1834 was netted.

DISCUSSION

The number of species and specimens caught on the different islands varies considerably. However, these differences undoubtedly reflect differences in trapping effort rather than differences in number of species actually inhabiting the different islands. Further, it is unlikely that all the species caught actually have originated on the island. Several of the species taken are known to inhabit more or less rapid streams and rivers, habitat types which lack completely on these island. The short distance to the main land, with richer fresh water localities, makes it probably that several of the species taken have flown from the main land. Caddis flies are generally known to be strong flyers, able to spread far away from their larval habitats. Particularly limnephilids are strong flyers (e.g. Crichton 1971, Svensson 1974). In the present study 32 of the totally 43 species taken are limnephilids; of the genus *Limnephilus* no less than 23 species were caught.

Nevertheless, the result are interesting from a faunistical point of view. Brekke (1946) recorded 33 Trichoptera species from eastern Buskerud and only 1 species, *L. centralis,* from Vestfold. No more records of Trichoptera species seem to have been published from eastern Buskerud, while Økland (1964), Solem (1972) and Andersen (1975, 1983) have added new species from Vestfold. Totally, 102 Trichoptera species have until now been recorded from Vestfold.

Of the species recorded here, *Phryganea grandis* Linnaeus, 1758, *Trichostegia minor* (Curtis, 1834), *Glyphotaelius pellucidus* (Retzius, 1783), *Limnephilus affinis* Curtis, 1834, *L. luridus* Curtis, 1834, *L. sparsus* Curtis, 1834, *Micropterna sequax* McLachlan, 1875 and *Athripsodes albifrons* (Linnaeus, 1758) have previously not been recorded from eastern Buskerud, while *Phryganea bipunctata* Retzius, 1783 and *Grammotaulius nitidus* (Müller, 1764) are «new» to Vestfold.

Five of the species taken are considered as rare in Norway (Aagaard & Hågvar 1978). *Hydropsyche contubernalis* McLachlan, 1865 is in Norway previously only recorded from the river Lågen at Hukstrøm bru in Lardal in Vestfold (Andersen 1975). In Denmark the species inhabits larger, slow flowing rivers (Wiberg-Larsen 1980), and in England it is a typical inhabitant of the lower, slow flowing parts of the larger river systems (e.g. Hildrew & Morgan 1974, Badcock 1976). On Langøya two males and two females were trapped. Based on the species habitat preferences in Denmark and England it seems unlikely that these specimens have originated on Langøya.

Ironoquia dubia (Stephens, 1837) was recorded as new to Norway from two localities in Vestfold (Andersen 1975). The species has later been shown to be among the dominant species in a stream in the Dammane-Gravastranda area in Porsgrunn in outer Telemark (Andersen & Søli 1989b). According to Nøst et al. (1986) the species only inhabits lakes in Norway. Elsewhere in Europe the species inhabits ditches, springs and slow flowing streams, but also ponds rich in detritus (Hickin 1967, Lepneva 1971, Tobias & Tobias 1981). Only one male was trapped on Langøya. From what is known about its habitat preferences elsewhere in Europe, it seems possible that *I. dubia* has larval populations on Langøya.

Grammotaulius nitidus (Müller, 1764) was recorded as new to Norway from Grimevatnet in Lillesand in outer Aust-Agder (Andersen & Søli 1987). The species inhabits fens and marshy areas, small overgrown water bodies, swampy spring puddles and also the potamon zone of rivers (Mosely 1939, Lepneva 1971, Tobias & Tobias 1981). The species might thus well inhabit some of the small ponds on the islands.

Limnephilus fuscinervis (Zetterstedt, 1840) was recorded from eastern Buskerud by Brekke (1946), but no exact locality was given. Later the species has been recorded from two localities in Vestfold (Andersen 1975). The species inhabits lakes and ponds (Botosaneanu & Malicky 1978). This species might therefore also have originated on Langøya.

Oecetis furva (Rambur, 1842) was recorded for the first time in Norway from two localities in Vestfold (Andersen 1975). According to Nøst et al. (1986) the species inhabits lakes in Norway. This species might thus also have originated on Langøya.

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Tabanidae (Diptera) community in a very little exploited northern boreal forest at Høylandet, N. Trøndelag, Norway

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Solem, J. O., Kauri. H. & Straumfors, P. 1990. Tabanidae (Diptera) in a very little man-exploited northern boreal forest at Høylandet, N. Trøndelag, Norway. *Fauna norv. Ser. B, 37:* 63—66.

Tabanidae from four Malaise traps run in a mixed northern boreal forest (spruce, birch and alder), located at Høylandet, N. Trøndelag (64°39'N, 12°10'E). showed *Hybomitra auripila* (Meigen) and *Haematopota pluvialis* (L.) to be abundant. In total 13 species were recorded, referring to gen. *Hybomitra, Haematopota, Chrysops* and *Heptatoma.* No *Tabanus* or *Atylotus* spp. were caught. The presence and absence of species are discussed in relation to zoogeography and presence/absence of host animals.

The *Hybomitra, Chrysops* and *Heptatoma* spp. flew earlier than *Haematopota pluvialis.* The flight period of Tabanidae was late June to early August, and they were most abundant in late July.

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1. INTRODUCTION

Taxonomy of adults and distribution in Scandinavia have been extensively studied by several authors, i.e. Kauri (1951, 1954, 1958, 1964, 1968), Karvonen (1969), Lyneborg (1960, 1961), Chvala, Lyneborg & Moucha (1972), Oldroyd (1939, 1970).

Kauri (1978) listed 37 species that live in aquatic habitats, but states that the number certainly is higher. In Europe 176 species (Chvala et al. 1971) have been recorded. In Norway the tabanid fauna counts 33 species referring to six genera (*Atylotus, Chrysops, Haematopota, Hybomitra, Heptatoma* and *Tabanus*) (Kauri 1951, 1954, 1958, 1964, 1968, Davis et al. 1971, Chvala, Lyneburg & Moucha 1972, Rognes 1980).

Pilot studies showed that the area around the lake Grønningen, Høylandet, North Trøndelag, has very little of acid precipitation, and west to the lake the forest is also very little exploited by man. These two features were the reason that a broad spectre of biological and non-biological registrations were done to learn the biotic and abiotic status of the area in more detail. With this background one of us (J.O.S) conducted sampling of insects in the area in 1986. The area is at present under consideration to be a reference area for research concerning acid precipitation.

Objectives of this study were to get knowledge of the insect fauna, its phenology, abundance and habitat preferences. The present paper gives data on Tabanidae, and it is the first study of this kind on Tabanidae in Norway.

2. STUDY AREA AND METHODS

Sampling was carried out in a forested area west to the lake Grønningen in Høylandet county, North Trøndelag province, Norway (64°39'N, 12°10'E). Sampling sites were all located in a mainly spruce forest, but mixed with some birch and alder. The forest is very little exploited by man, and this is signified by the many wind-fallen trees, both deciduous and coniferous, which are present in all stages of decomposition (Fig. 1). There has been no tree cutting in the area since 1958. The field layer in the surroundings of the traps was composed of ferns, mosses and blueberry plants. The area is a mosaic of forest, mires and bogs. Many small pools, that may be permanent or temporary are present.

Fig. 1. The sampling site 1 at the stream Skiftesåa.

The main objective of this study was to sample aquatic insects, and Malaise traps were set across streams to capture insects flying above the flowing water. Traps were set up at two streams, Skiftesåa and Tverråa, and two traps at each stream were run. Thus four sites were sampled. The traps were emptied every week from late may to October 1986, and we covered the whole flight period of tabanids.

pH of the water in Ingabekken, a small stream emptying into Skiftesåa ranged 4,8—7.2 in 1986, and this covered the few pH records from Skiftesåa also. Maximum water temperature in Skiftesåa was 18.8°C in 1988. We have no temperature recordings from 1986.

3. RESULTS

3.1 Abundance and phenology

Thirteen species were caught in the Malaise traps at Høylandet, and most common and widespread was *Haematopota pluvialis* (L.) closely followed by *Hybomitra auripila* (Meigen). These two totally outnumbered the remaining species, which together made up 8,5% of the total sample only (Tab. 1).

No tabanid species were found before late June and they were present to early August (Tab. 2). The longest flight period had *H. auripila, H. lundbecki* Lyneborg, which flew in late June and though July. *H. auripila* peaked in late July. H. pluvialis appeared 2 weeks after *H. auripila* and flew to early August. *Haematopota pluvialis* also peaked in late July as *H. auripila* did. *Hybomitra lurida* (Fallén) flew in late June, and *Chrysops nigripes* Zetterstedt and *C. relictus* Meigen were caught in early July.

The traps Tverråa 1 and Skiftesåa 1 caught most species, 11 and 8 respectively, compared to 4 at Tverråa 2 and 5 at Skittesåa 2. *H. pluvialis* was more abundant at Tverråa 1 and Skiftesåa 1, than at the other 2 traps.

H. auripila was caught at Tverråa 1, Tverrås 2 and Skiftesåa 1, but not at Skiftesåa 2, and it was most abundant at Skiftesåa 1. *Hybomitra lundbecki* were not abundant, but were present at all four sites.

Table 1. Relative abundance of Tabanidae at NTI, Høylandet, Norway.

	N	%
Hybomitra arpadi (Seilady)	2	0.3
Hybomitra auripila (Meigen)	272	46.8
Hybomitra bimaculata (Macquart)	2	0.3
Hybomitra borealis (Fabr.)	12	2.1
Hybomitra kaurii Chvala & Lyneborg	3	0.5
Hybomitra lundbecki Lyneborg	8	1.4
Hybomitra lurida (Fallén)	4	0.7
Hybomitra montana (Meigen)	22	3.8
Hybomitra tarandina (L.)	3	0.5
Haematopota pluvialis (L.)	250	43.0
Heptatoma pelluscens (Fabr.)	1	0.2
Chrysops nigripes Zetterstedt	1	0.2
Chrysops relictus Meigen	1	0.2

4. DISCUSSION

The small number of species and their low abundance may be caused by zoogeographical and environmental factors as well as by the absence of big mammals.

The absence of representatives of *Tabanus* and *Atylotus* is probably due to the northern locality of the study area (64°39'N) near the arctic circle, since most of these species have a southernly distribution. However, *T. bromius* L., *T. maculicornis* Zett. and *A. fulvus* (Meig.) have their northern distribution limit in Scandinavia at 65—66°N, and according to information on larval habitats given by Lutta 1970, Olsufjev 1977 and Lutta & Bykova 1982) it should be possible for these species to live in the habitats near our Malaise trap. Their rare occurrence seem restricted to more optimal habitats than the study area. Also elsewhere in Scandinavia these genera seem to be lacking in forest habitats. Neither *Tabanus* nor *Atylotus* were found in a forest of Scot's pine, intermingled of birch in Renådalen, Rendalen region (61°43'N) (Davis et al. 1971), nor at localities in Messaure, Sweden (Kauri 1974). Probably these species prefer open localities and avoid the northern types of forest.

The marshy forest habitats at Skiftesåa and Tverråa probably are optimal for *H. auripila* and *Haematopota pluvialis.* The low abundance of other species of *Hybomitra* and *Chryspos* may be dependent on the meagre ecological conditions of the habitat and of the absence or scarcity of big mammals. There is no bovid members in the area sampled, and the distance from areas settled by man is about 7 km in straight line. Sheep are present at higher elevated areas than sampled. Of bigger mammals deer and roe are absent, moose (*Alces alces*) is present, but scarce.

Table 2. Flight periods and numbers of Tabanidae collected at Høylandet, N. Trøndelag.

	June 25	July 1	9	16	23	30	Aug 6
Heptatoma pelluscens	0/1						
Hybomitra lurida	0/3	1/0					
Hybomitra tarandina	0/1		0/1		0/1		
Hybomitra auripila	1/18	0/41	4/66	0/2	1/137	1/1	
Hybomitra lundbecki	0/2	0/2	0/3			0/1	
Hybomitra montana	0/4	0/6			0/12		
Hybomitra borealis		0/3	0/2		0/7		
Hybomitra kaurii		0/1	0/1		1/0		
Hybomitra bimaculata			0/1			0/1	
Hybomitra arpadi					0/2		
Chrysops relictus		0/1					
Chrysops nigripes			0/1				
Haematopota pluvialis			0/20	0/1	0/189	0/32	0/8
Antall arter	6	7	8	2	7	4	1
Antall individer	30	55	99	3	350	36	8

The surroundings of Skiftesåa and Tverråa are not favourable places for the moose; the area is too wet and too poor in food (personal observation, and information given by K. Brønnbo, J. Holten and B. E. Sæther). This may also be the reason why cattle and sheep are absent.

Of more than 565 tabanid specimens collected, only eight males were caught. This certainly reflect the difference in the behaviour of males and females. Males hover in forest clearings, often at considerable heights in the tree canopy, and are thus out of the range of the Malaise traps. The females, on the other hand, require blood after mating for egg development, and some also lay their eggs on vertical objects close to the water. Hunting for a blood meal and searching for places for oviposition make females more exposed to the traps than males. This is certainly the reason for the high abundance of females in the samples.

Of the 4 sites sampled the tabanid fauna at Høylandet had a preference for Tverråa 1 and Skiftesåa 1. Two species were abundant at Skiftesåa 1, *Hybomitra auripila* and *Haematopota pluvialis,* but only *H. pluvialis* was abundant at Tverråa 1. If the tabanids are better adapted to pools, ponds and slowly flowing streams, than to fast flowing water, Tverråa 1 and Skiftesåa 1 have better oviposition and larval habitats than Tverråa 2 and Skiftesåa 2. Therefore the preference for Tverråa 1 and Skiftesåa 1 is natural, because most oviposition flight will occur here.

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Diversity of Ephemeroptera and Plecoptera in Norway relative to size and qualities of catchment area

JOHN W. JENSEN

Jensen, J. W. 1990. Diversity of Ephemeroptera and Plecoptera relative to size and qualities of catchment area. *Fauna norv. Ser. B.* 37, 67—82.

Based on data from 58 catchment areas, equations expressing the species number of Ephemeroptera and Plecoptera in relation to size of catchment area were calculated for six main regions and for Norway in general. For Plecoptera these relationships were uniform, except for a somewhat lower diversity in Sørlandet, the southernmost part of Norway. Ephemeroptera showed more variation from area to area and between regions, and the diversity was low along the west coast of Norway and especially in Sørlandet.

Significant ($p<0.05$) equations relating the number of ephemeropteran species to the fraction of the catchment area representing woodland, mean specific conductivity, maximum temperature, and maximum pH were found. For Plecoptera a significant relationship only existed in relation to pH.

The general number of species to area equations were combined with the equations expressing the relationships between species number and the environmental parameters. The expected numbers of species expressed by these models corresponded better with the recorded numbers than those calculated from size of area alone. Deviation between expected and recorded numbers was especially related to decreasing pH. In catchment areas of 250—700 km^2 in Sørlandet the number of plecopteran species seem to have been reduced by 40—25% and that of Ephemeroptera by 75%.

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INTRODUCTION

The number of species of a taxon (N) in an area may be related to the size of the area (A) by an equation of the form

$$N = CA^z \qquad (1)$$

where C and z are parameters of changing values. Such relationships have especially been formulated for various island floras and faunas, but also for non-isolated or continental ones (MacArthur & Wilson 1967). Bevanger (1986) presents equations for Norwegian birds, and like Butcher et al. (1981) he discusses their use for the design and management of nature reserves.

Since 1975 about 60 water systems have been surveyed in Norway, mainly in connection with conservation plans or hydroelectric development. The standardizing of methods and sampling frequencies make these data comparable. Based on this litterature an analyses relating the species number of Ephemeroptera and Plecoptera to size of the catchment area of the water systems was performed.

The species numbers relative to the size of the catchment areas were transformed to numbers related to areas of unit size. Thus, areas of various size may be compared, and relationships to environmental characteristics could be evaluated. These relationships were combined with the number of species to area equations into more precise models for the prediction of species numbers. Special attention is given to the effect of acidification.

METHODS AND MATERIAL

In this paper diversity is taken as the number of Ephemeroptera or Plecoptera found in a catchment area of a certain size. The catchment area may be a complete river system, one or more sections of a river system, or an area covering sections of neighbouring river

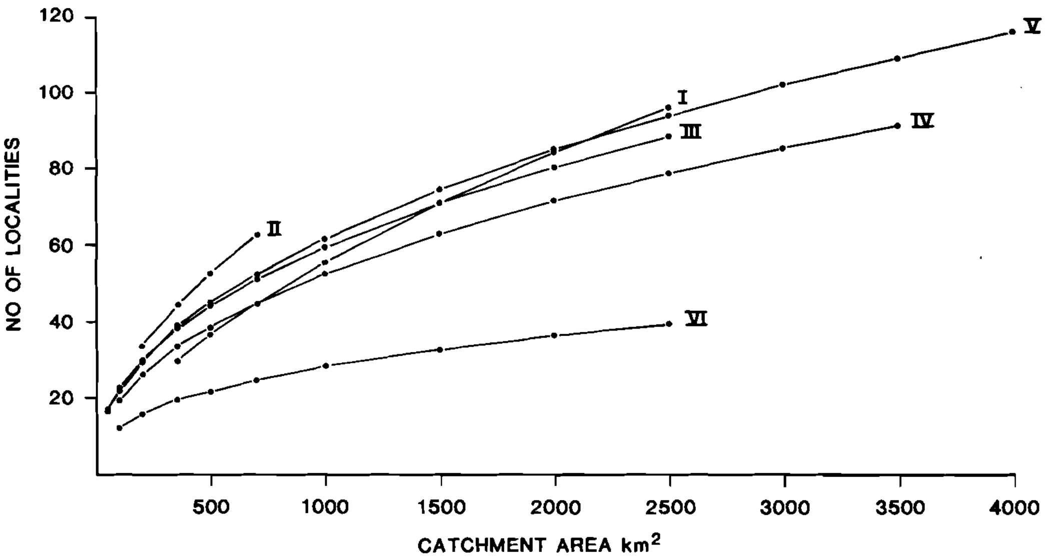

Fig. 1. The number of sampling localities in six regions of Norway in relation to size of catchment areas.

systems. The material incorporates data from 58 such areas and represents 1180 localities from the littoral zone of 415 lakes and ponds and 1201 stream localities. All areas have been surveyed to record the composition of their freshwater macroinvertebrates. The material has mainly been collected by the kick method (Frost et al. 1971). In all six regions (Fig. 2) the relationship between the number of localities (L) sampled by this method and the size of the catchment area in km² (A) was of the form:

$$L = BA^{x} \quad (2)$$

These equations were significant ($p<0.05$) for all regions, except region II, and the relationships are shown in Fig. 1. The sampling programme is comparable for all regions, except region VI.

As a qualitative describtion of the areas, the following parameters were chosen: the percentage of the area reprented by woodland (W) measured by planimeter on maps of scale 1:250000 (series 1501), mean range of specific conductivity at 18°C (K), maximum pH, and maximum water temperature in °C (T). All data concerning water quality were taken from stream localities, as most of the recorded species of both orders live in such habitats. References for data on water quality and species numbers are presented in Table 1.

The number of species (N) of each taxon was expected to increase with the size of the catchment area in km² (A) according to equation (1). Such equations were calculated for the main regions of Norway (Fig. 2) by a curve fitting programme. Based on selected catchment areas, general equations for the Norwegian fauna of Ephemeroptera and Plecoptera were calculated. Using the z values of the general equations, the number of species in catchment areas of unit size (N_u) were calulated:

$$\lg N_u = \lg N - z \lg A \quad (3)$$

The diversity of catchment areas of different size can be compared by the N_u values.

The relationships between the N_u values and the environmental parameters were tested by several curve fitting programmes, and the equations of best fit were chosen.

The best relationships between N_u and the number of sampling localities (L) for the 36 areas south of 68°N not supposed to be affected by acid precipitation, i.e. the regions I, IV, V, and rivers no. 20—23 in region III, were:

Ephemeroptera: $N_u = 2.72L^{-0.11}$ $r = 0.20$ (4)
Plecoptera: $N_u = 4.06L^{0.04}$ $r = 0.16$ (5)

For region VI they were:

Ephemeroptera: $N_u = 1.5 + 0.004L$ $r = 0.08$ (6)
Plecoptera: $N_u = 4.5 + 0.007L$ $r = 0.10$ (7)

As these relationships are far from significant, even in region VI where the frequency of localities was lowest, the sampling programme seems not to have influenced the results.

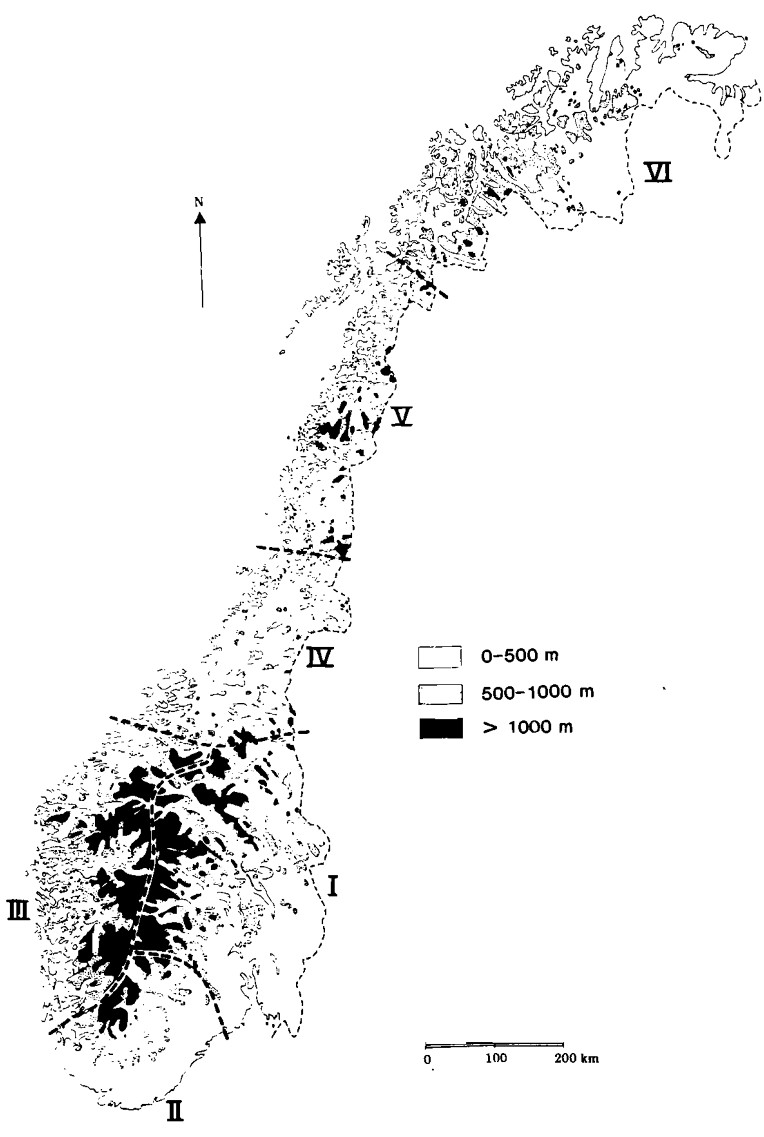

Fig. 2. The six regions of Norway used in this study and elevation in metres after Environmental Statistics (1978)

REGIONAL CHARACTERISTICS

Of the many zoogeographical factors, only altitude (Fig. 2), acid precipitation (Fig. 3), and the parameters presented in Table 1 are considered. Acid precipitation is mainly a problem in the southern parts of Norway, but occasionally it is transported as far north as 70°N (Wright & Dovland 1978).

Region I (Østlandet) represents the eastern slope of the mountain range and the lowlands towards the border with Sweden and the coast (Fig. 2). The region is forested below 1000 m, mainly with conifers. The studied catchment areas are only moderately affected by acid precipitation and some of them have sufficient buffer capacity. All of them represent sections of large river systems, and areas below 220 m are not included.

Region II (Sørlandet) is the most southerly district of Norway. Its geography changes from that of region I towards the qualities of region III. The tree line falls to 500 m in the western parts. This region is most severely

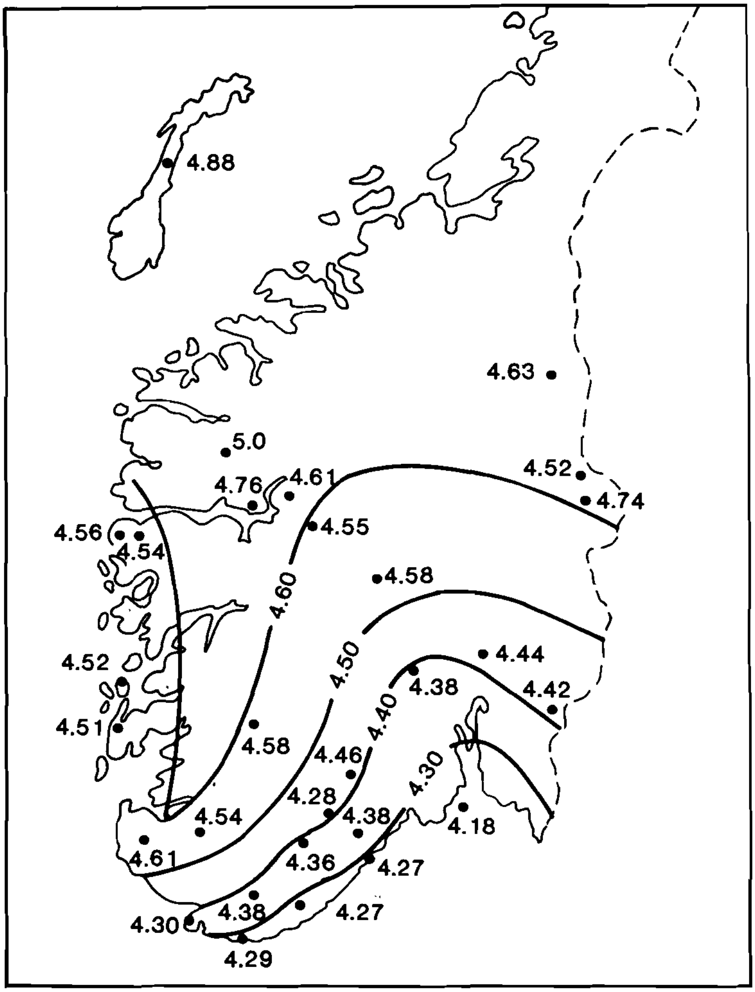

Fig. 3. Mean pH of precipitation over southern Norway based on data from July 1972 to June 1975 (After Dovland et al. 1976).

affected by acid precipitation. The buffer capacity of its waters is low, and their pH is generally below 5.5 (Wright et al. 1977). Fish populations are extinct in about half of the region, and affected in most of the remaining areas (Muniz & Leivestad 1980).

Region III (Vestlandet) is characterized by steep slopes and short rivers between the high mountains and the fjords. Water temperatures are generally low, as many rivers are fed by snow or glaciers all summer. As much as 80—95% of som ecatchment areas is located in th sub-alpine and alpine zones. The water is soft, in some cases approaching destilled water with K values of 3—4 μScm^{-1} being recorded. The waters of the region have therefore no capacity for resisting the more moderate acid precipitation penetrating northward along the coast. Only two of the studied river systems do not reach the sea.

Region IV (Trøndelag) covers the lowlands of central Norway with only small areas above 1000 m. The tree line is situated at 700—800 m. Normal K values are in the range 20—40 μScm^{-1}. The maximum pH of all river systems was >6.7. Half of them reach the sea.

Region V (Nordland) has a complex topography and geology. Some of the catchment areas are similar to those of region III, but a maximum pH >6.7 was always recorded. Others have a K>50 μScm^{-1}, and two of them (no. 42 and 44) are forested to a degree comparable to those of region IV.

Table 1. The actual catchment areas of the different regions, their size in km² (A), the percentage representing woodland (W), mean range of specific conductivity as μScm^{-1} at 18°C (K), maximum pH and temperature in °C (T). All water quality data represent lotic stations. The recorded number of species (N), this back-calculated to catchment areas of unit size (N_u), and the expected number of species from equations 9 to 12 (N_e) is also given.

							EPHEMEROPTERA			PLECOPTERA			
No	Catchment area	A	W	K	pH	T	N	N_u	N_e	N	N_u	N_e	References for basic data
Region I Østlandet													
1	Kynna	341	100	35	6.9	19.1	15	2.3	15	14	4.8	14	Sandlund & Halvorsen 1980
2	Imsa - Trya	580	60	23	7.0	15.5	16	2.1	15	19	5.9	15	Halvorsen 1985
3	Gimsa	535	25	64	7.7	14.7	12	1.6	16	17	5.3	25	Eie 1982a
4	Atna	1300	50	9	6.5	14.8	15	1.5	16	16	4.3	18	Eie 1982b
1-4	Glomma, sections	2756	55	60	7.7	19.1	31	2.4	31	22	5.1	20	The above
6	Josa, Øvre Lågen	492	20	21	7.0	11.4	10	1.4	12	17	5.4	15	Blakar 1982, Halvorsen 1982
7	Rivers in Hemsedal	356	30	10	6.6	11.8	10	1.5	10	16	5.4	14	Bjerke & Halvorsen 1982
Region II Sørlandet													
8	Sjåvatn-area	240	75	8	5.1	12.4	3	0.5	3	8	2.9	9	Spikkeland 1980a
9	Lifjell-area	725	80	12	5.0	17.3	3	0.3	4	12	3.6	14	Spikkeland 1980b
10	Lyngdalselva	683	90	22	5.2	24.2	5	0.6	4	12	3.6	11	Halvorsen 1981
Region III Vestlandet													
11	Vikedalselva	118	32	21	5.6	12.0	4	0.9	3	14	5.8	9	Haaland, Fjellheim & Hobæk 1983a
12	Granvinelvi	177	50	19	6.8	14.0	9	1.7	9	14	5.4	12	Haaland, Fjellheim & Hobæk 1983b
13	Flåmsvassdraget	279	14	17	6.8	10.0	4	0.6	9	14	5.0	13	Haaland, Hobæk & Raddum 1981a
14	Utla	330	7	5	6.2	12.0	4	0.6	7	8	2.8	13	Haaland, Hobæk & Raddum 1981b
15	Feiga	49	5	8	6.1	10.0	2	0.6	3	8	3.9	9	NOU 1983
16	Mørkri	277	9	12	6.6	10.0	7	1.1	8	16	5.7	13	NOU 1983
17	Jølstra	712	40	18	6.2	17.0	8	1.0	10	16	4.8	15	NOU 1983
18	Ørstaelva	158	53	23	6.7	12.0	6	1.0	9	14	5.5	12	Haaland, Hobæk & Raddum 1981c
19	Stordalselva	203	34	12	6.5	12.0	5	0.9	8	10	3.8	13	NOU 1983
20	Istra	66	12	13	6.2	12.6	5	1.3	4	12	4.6	10	Nøst 1981a
21	Rauma	1202	15	11	6.9	14.5	11	1.1	15	15	4.1	17	Nøst 1983, 1984a
22	Driva	2482	20	46	7.3	14.7	14	1.1	23	20	4.7	20	Nøst 1981b
23	Todalselva	251	16	10	6.6	15.0	7	1.2	9	16	5.8	13	Nøst 1981c
Region IV Trøndelag													
24	Gaula	3651	60	66	7.4	15.5	25	1.8	31	21	4.6	21	Koksvik & Nøst 1981
25	Garbergelva	159	60	23	7.0	13.7	18	3.5	10	10	3.9	12	Nøst 1981d
26	Stjørdalselva	2130	70	24	7.3	15.9	29	2.4	25	21	5.1	20	Arnekleiv & Koksvik 1980
27	Ormset-area	87	60	19	6.8	19.7	18	4.3	8	14	6.2	11	Arnekleiv & Koksvik 1983
28	Verdalselva	1464	65	28	7.0	14.2	26	2.5	20	17	4.4	18	Koksvik & Haug 1981
29	Skjækra	252	50	17	6.8	13.0	19	3.2	10	12	4.3	13	Koksvik & Haug 1981
30	Ogna	571	80	44	7.4	20.2	28	3.6	19	12	7.7	15	Nøst & Koksvik 1981a
31	Nesåa	274	35	19	6.9	19.0	14	2.3	12	17	6.0	13	Nøst & Koksvik 1980
32	Høylandsvassdraget	554	75	43	7.2	14.5	24	3.1	16	14	4.4	15	Nøst 1982a
33	Sanddøla - Luru	1592	50	28	7.1	16.2	25	2.3	21	18	4.6	18	Nøst 1982b
34	Sørlivassdraget	1174	60	15	7.0	16.8	22	2.2	19	17	4.6	17	Nøst & Koksvik 1981b
Region V Nordland													
35	Vefsna	4420	30	68	7.6	16.7	29	1.9	32	21	4.5	22	Koksvik 1976, 1979
36	Eiteråga	272	30	36	7.0	12.9	11	1.8	10	12	4.3	13	Koksvik 1979
37	Lomsdalselva	240	8	19	7.0	13.8	14	2.4	9	18	6.6	13	Arnekleiv 1981
38	Lakselva, Visten	160	30	15	6.8	13.5	9	1.8	8	17	6.7	12	Nøst 1984b
39	Bønnåa	48	14	14	6.8	14.9	4	1.2	5	6	2.9	10	Nøst 1984b
40	Ranaelva, North	749	11	21	7.0	11.7	10	1.2	12	14	4.1	16	Koksvik 1977a

Table 1 continued

No	Catchment area	A	W	K	pH	T	EPHEMEROPTERA N	N_u	N_e	PLECOPTERA N	N_u	N_e	References for basic data
41	Storvasselva	51	11	32	7.0	9.2	5	1.4	5	8	3.9	10	Koksvik 1978a
42	Valsnesvassdraget	70	65	71	7.5	15.3	12	3.0	9	14	6.4	10	Huru 1982a
43	Beiarelva	869	35	44	7.3	11.5	11	1.2	16	17	4.9	17	Koksvik 1978b
44	Lakselva, Misvær	159	50	65	7.4	15.1	16	3.1	11	14	5.5	12	Koksvik 1978c
45	Saltdalselva	1539	30	60	7.3	14.2	16	1.5	21	17	4.4	18	Koksvik 1977b
46	Sørfjordelva	111	12	14	7.0	9.2	4	0.9	6	8	3.4	11	Koksvik & Dalen 1977
47	Kobbelv	283	17	14	6.9	14.8	4	0.7	10	14	5.0	13	Koksvik & Dalen 1977
48	Hellemo-area	250	6	12	6.8	15.1	7	1.2	8	11	4.0	13	Koksvik & Dalen 1980
Region VI Troms - Finnmark													
49	Elvegårdselva	120	25	50	7.5	16.9	9	1.9	10	9	4.6	11	Huru 1982b
50	Spansdalselva	140	30	89	7.8	15.1	13	2.6	11	11	5.8	12	Huru 1980a
51	Øvre Barduelv	470	50	29	7.3	16.6	15	2.1	15	16	5.8	15	Huru 1981a
52	Nordkjoselva	184	30	66	7.8	13.5	7	1.3	11	12	4.6	12	Huru 1982c
53	Reisavassdraget	2516	15	62	7.6	19.4	19	1.5	26	22	5.2	20	Huru 1980b
54	Snøfjordvassdraget	76	1	33	7.2	14.8	3	0.7	6	10	4.5	10	Huru 1981b
55	Lakselva, Lakselv	1509	45	67	7.5	16.9	23	2.2	23	18	4.7	18	Huru 1982d
56	Julelva	338	15	31	7.1	11.2	6	0.9	10	15	5.1	14	Huru 1981c
57	Vesterelva	466	2	28	7.3	13.9	12	1.6	10	9	2.9	15	Huru 1981d
58	Komagelva	337	5	36	7.4	11.1	7	1.1	9	11	3.8	14	Eie, Brittain & Huru 1982

Region VI (Troms-Finnmark). All of this region is situated north of latitude 68°N. Finnmark, the north-eastern section, is mainly a plateau of 300—400 m in altitude. Troms has a more varied topography. The waters are generally rich in electrolytes, and this region is the only one where a maximum pH >7.0 was recorded in all areas. In the eastern, more continental parts of the region, the water temperature can be as high as in any of the other regions. The last three river systems of Table 1 are located to the Varanger peninsula, the extreme north-eastern tip of Norway. There are almost no forests and the water temperatures are low, similar to those of the coldest rivers in region III.

RESULTS

The number of species recorded in the different regions is presented in Table 1. All number of species to area equations based on these records show an increasing number of species with increasing area (Table 2). For Ephemeroptera different equations were found for the different regions. For Plecoptera they were rather uniform, except for the deviating one of region II. The fit of the equations is $p<0.05$ or better, except for Ephemeroptera in region II. However, for this region comparable data exist from only three areas.

Region II was extremely poor in ephemeropteran species (Fig. 4). The number in a catchment area of 4000 km² would be only 5, compared to 17 in region III, 21 in region V, and 28—30 in the others. The latter numbers indicate that in a catchment area of 4000 km² in the regions I, IV, and VI one would expect to find 2/3 of the 47 species, which according to Nøst et al. (1986) are recorded in Norway. Region IV is special, as high numbers of species occur in small areas.

The corresponding calculations for Plecoptera give almost identical numbers for all regions, except region II, with 21—23 species in a catchment area of 4000 km² (Table 3). This represents 2/3 of the 35 species which according to Lillehammer (1974) and Nøst et al. (1986) are recorded in Norway. Compared to this the number of species in region II is 40—25% lower within the actual range of catchment area, 240—700 km².

Based on the data from the regions I, IV, V, and catchment areas no. 20—23 in region III,

Table 2. Equations expressing the relationship between number of species (N) and size of catchment area in km² (A) in the different regions.

Region		Equation	r	P
EPHEMEROPTERA				
I	Østlandet	$N = 0.939\ A^{0.420}$	0.82	<0.02
II	Sørlandet	$N = 0.926\ A^{0.217}$	0.46	>0.05
III	Vestlandet	$N = 0.742\ A^{0.372}$	0.79	<0.01
IV	Trøndelag	$N = 8.847\ A^{0.142}$	0.74	<0.01
V	Nordland	$N = 1.593\ A^{0.313}$	0.68	<0.01
VI	Troms - Finmark	$N = 0.829\ A^{0.423}$	0.76	<0.01
PLECOPTERA				
I	Østlandet	$N = 6.972\ A^{0.138}$	0.73	<0.05
II	Sørlandet	$N = 1.019\ A^{0.376}$	1.00	<0.001
III	Vestlandet	$N = 5.171\ A^{0.167}$	0.60	<0.05
IV	Trøndelag	$N = 5.581\ A^{0.157}$	0.77	<0.01
V	Nordland	$N = 4.192\ A^{0.201}$	0.73	<0.01
VI	Troms - Finnmark	$N = 4.441\ A^{0.190}$	0.72	<0.02

what include all areas south of latitude 68°N not supposed to be affacted by acidification, the following general equations were calculated:

Ephemeroptera:

$N = 1.815A^{0.323}$ $r = 0.67$ $p<0.001$ (8)

Plecoptera:

$N = 4.474A^{0.184}$ $r = 0.77$ $p<0.001$ (9)

The corresponding curves appear in Fig. 5. There were generally more species of Plecoptera than of Ephemeroptera in catchment areas <1000 km², and vice versa. However, the river systems of region IV where with one exception always richest in ephemeropteran species.

By back-calculating the number of species to those of catchment areas of unit size (N_u), any area can be compared with the others. Thus, the regional differences within the Ephemeroptera and the uniformity of the Plecoptera fauna are again demonstrated (Table 1). The highest values for Ephemeroptera, $N_u>3.0$, were found in catchment areas <600 km² in region IV and V. Region III is generally poor in Ephemeroptera, and the lowest N_u values approach the level of region II.

Based on the catchment areas selected for the general equations, the relationships between N_u and each of the parameters W, K, and T were found. Corresponding relationships for maximum pH were calculated from the data from all catchment areas in regions I—V (Table 4). All equations for Ephemeroptera fit a significance level of $p<0.05$ or better. For Plecoptera only the equation for pH <6.6 was significant. The corresponding curves are presented in Fig. 6. Plecopteran diversity was almost unaffected by K and W. A temperature decline from 17 to 9°C seem to be of some, but not significant, influence. pH was a definite limiting factor of increasing effect below 6.6. Ephemeroptera were much more sensitive to environmental changes. The parameters could be ranked in the following order of increasing importance: K - W -T -pH. When K declined from 70 to 9 μScm^{-1}, N_u was reduced by 50%. A pH drop from 7.7

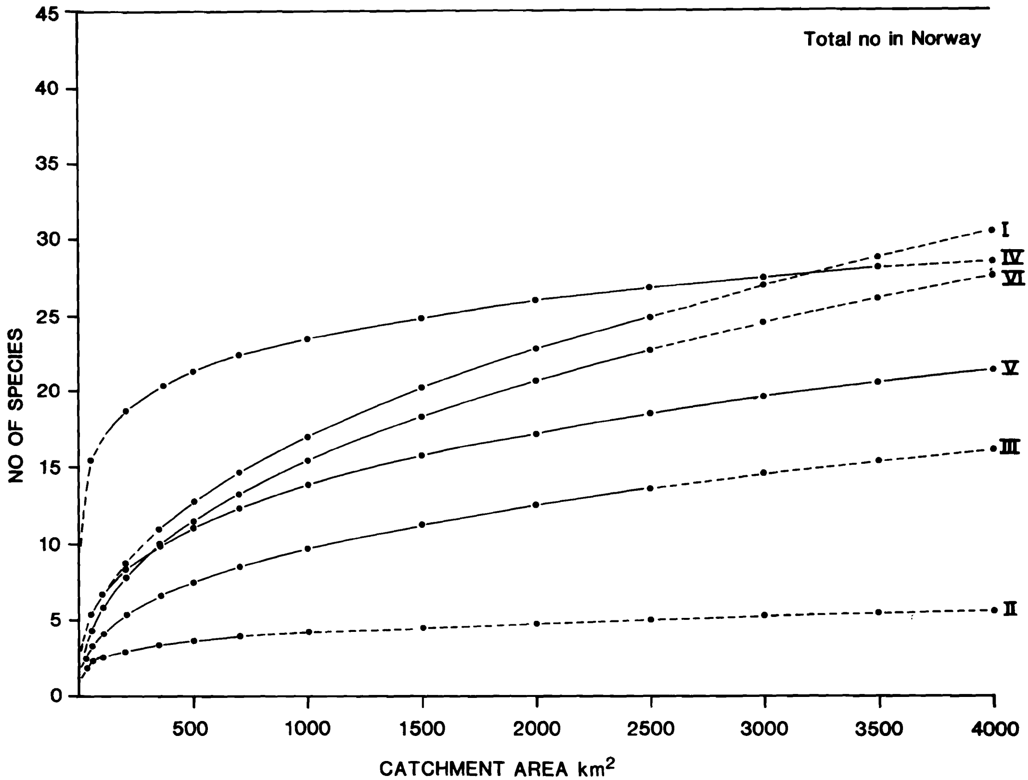

Fig. 4. The number of species of Ephemeroptera in relation to size of catchment area in the different regions, calculated from the equations of Table 2. Solid sections represent range of catchment area from which data exist.

Table 3. The number of species of Plecoptera in relation to size of catchment area in the different regions.

Region		Catchment area km^2 50	100	200	500	700	1000	1500	2000	2500	3000	3500	4000
I	Østlandet	12.0	13.2	14.5	16.4	17.2	18.1	19.1	19.9	20.5	21.0	21.5	21.9
II	Sørlandet	4.4	5.8	7.5	10.6	12.0	13.7	15.9	17.8	19.2	20.7	21.9	23.1
III	Vestlandet	10.3	11.4	12.6	14.5	15.3	16.1	17.1	17.9	18.5	19.0	19.5	19.9
IV	Trøndelag	10.3	11.5	12.8	14.8	15.5	16.5	17.6	18.4	19.0	19.6	20.0	20.5
V	Nordland	9.2	10.6	12.2	14.6	15.8	16.8	18.3	19.4	20.3	21.0	21.7	22.3
VI	Troms-Finnmark	9.3	10.7	12.2	14.5	15.4	16.5	17.8	18.8	19.6	20.3	20.9	21.5

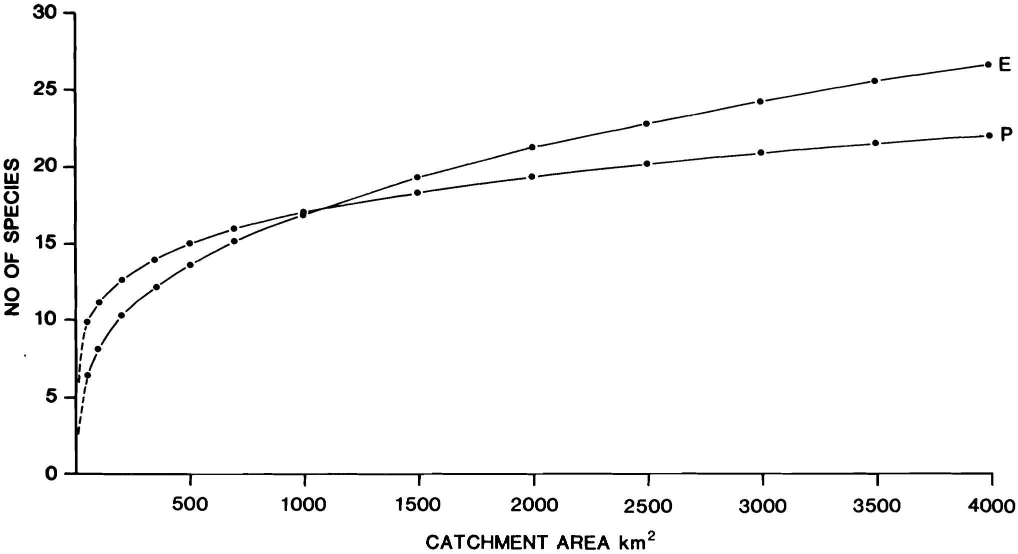

Fig. 5. The number of species of Ephemeroptera (E) and Plecoptera (P) in relation to size of catchment area calculated from the equations valid for Norway in general (8 and 9). Solid sections represent range of catchment from which data exist.

Table 4. Equations expressing the relationships between number of species back-calculated to catchment areas of unit size (N_u) and the following prarameters: mean range of specific conductivity (K), the percentage of catchment area representing woodland (W), maximum water temperature in °C (T), and maximum pH, when all water quality data represent lotic stations. The equation for pH is based on the results from all catchment areas in the regions I—V, the others on all catchment areas in the regions I, IV and V and areas no. 20—23 in region III.

	Equation	r	P
EPHEMEROPTERA			
	$N_u = 0.795\ K^{0.256}$	0.37	<0.05
	$N_u = 0.414\ W^{0.429}$	0.72	<0.001
	$N_u = 0.069\ T^{1.221}$	0.51	<0.01
	$N_u = 5.74\ 10^{-4}\ pH^{4.101}$	0.69	<0.001
PLECOPTERA			
	$N_u = 4.343\ K^{0.028}$	0.09	>0.05
	$N_u = 4.012\ W^{0.049}$	0.19	>0.05
$T \leq 15$	$N_u = 2.164\ T^{0.292}$	0.22	>0.05
$T > 15$	$N_u = 6.543\ T^{-0.094}$	0.06	>0.05
pH < 6.6	$N_u = 0.284\ pH^{1.505}$	0.53	<0.05
pH ≥ 6.6	$N_u = 8.923\ pH^{-0.314}$	-0.07	<0.05

to 5.1 reduced N_u by 80%. A pH of 5.1 seems to be close to the limit for Ephemeroptera, while it affected Plecoptera by reducing their species number by 35%.

For Ephemeroptera the expected number of species (N_e) may be calculated more precisly by correcting the general equation for the influence of the environmental parameters. $N_u{}^4$ as a function of K, W. T, and pH follows from the data of Table 4. Solving for N_u and combining with equation 8 gives:

$$N_e = 0.06K^{0.064}W^{0.107}T^{0.305}pH^{1.025}A^{0.323} \quad (10)$$

This is an adequate for equation pH >6.5. pH <6.5 becomes more limiting and the best approach is:

$$N_e = 5.740\ 10^{-4}pH^{4.101}A^{0.323} \quad (11)$$

The numbers of ephemeropteran species calculated in this way are presented in Table 1. They fit better with the recorded numbers than the values calculated from size of catchment area alone, especially for the cases of regions II and III. The model does not cope with the high records of small areas in region IV, as it limits N_u to a maximum of 2.60. Further it overestimates the species number in river systems in region III where pH >6.5.

For Plecoptera the general equation (9) is as good as any other when pH >6.6. For pH <6.6 the best approach is:

$$N_e = 0.284\ pH^{1.505}A^{0.184} \quad (12)$$

The expected species numbers of Plecoptera are generally in good agreement with the recorded ones.

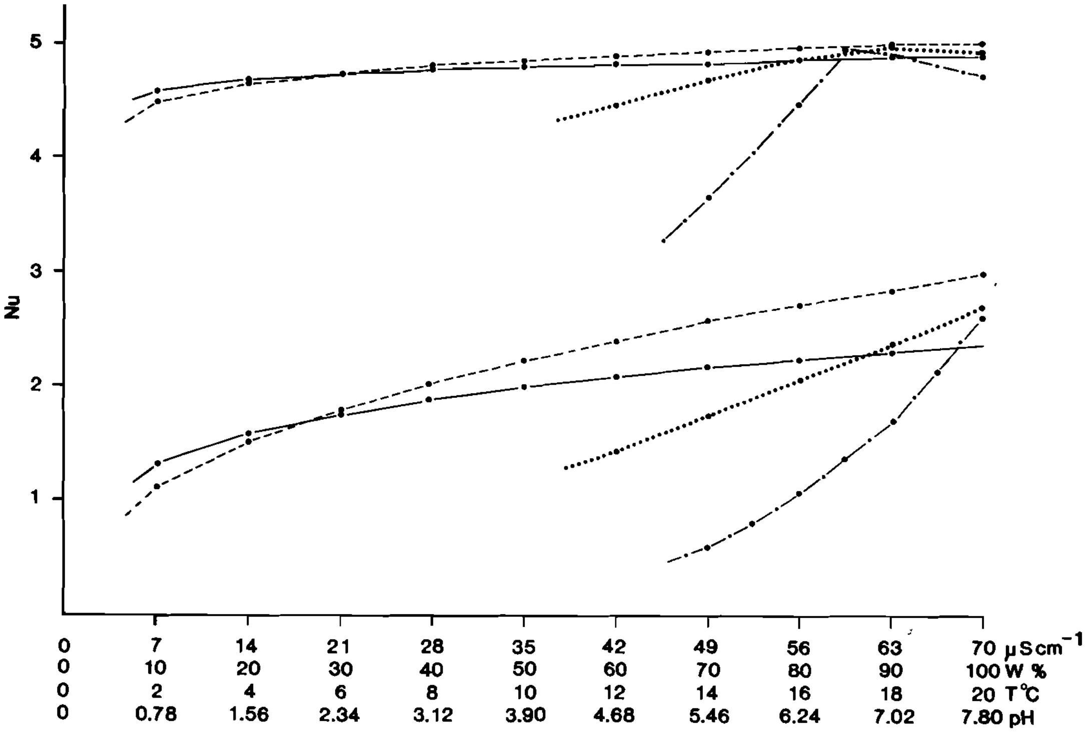

Fig. 6. The relationships between number of species in catchment areas of unit size (N_u) and mean range of specific conductivity (Scm^{-1} — solid lines), the percentage of catchment area covered with woodland (W — broken lines), maximum water temperature (T °C — dotted lines), and maximum pH (mixed lines) for Ephemeroptera above and Plecoptera below.

Expected numbers of ephemeropteran species disregarding the effect of pH were calculated from:

$$N_e = 0.283K^{0.085}W^{0.143}T^{0.407}A^{0.323} \qquad (13)$$

Curves showing such numbers are presented in Fig. 7 for selected cases. For river systems of region V, limited by K <22 μScm^{-1} and in that way comparable to those of the regions II and III, the expected numbers fell just above the recorded ones. The expected numbers of region III are higher than of region V, but the recorded ones lower, and relatively lowest in river systems of pH <6.5. The deviation between expected and recorded numbers increased with declining pH. The expected numbers in region II are even higher than in region I, but the slope of the curve is uncertain as it is based on only three cases. However, with reference to the environmental characteristics with the exception of pH, the deversity of the original ephemeropteran fauna of region II could have been close to that of region I.

According to the basic data 6 species of Ephemeroptera were found in region II: *Caenis horaria* (L.), *Leptophlebia marginata* (L.), *L. vespertina* (L.), *Siphlonurus lacustris* Eaton, *Baetis rhodani* (Pictet), and *Heptagenia fuscogrisea* (Retzius). Of these *Leptophlebia* and *Siphlonurus* occurred most regularly. Of 14 species of Plecoptera, the following 6 were recorded in all three catchment areas: *Amphinemura borealis* Morton, *A. standfussi* Ris, *A. sulcicollis* Stephens, *Nemoura cinerea* (Retzius), *Nemurella picteti* Klapálek, and *Leuctra fusca* L. 6 species were found in two areas: *Diura nanseni* (Kempny), *Isoperla grammatica* (Poda), *Brachyptera risi* (Morton), *Taeniopteryx nebulosa* (L.), *Leuctra nigra* (Olivier), and *L. hippopus* Kempny. *Siphonoperla burmeisteri* (Pictet) and *Protonemura meyeri* Pictet occurred in one area each. The frequency of the species probably reflects their tolerance to acid water.

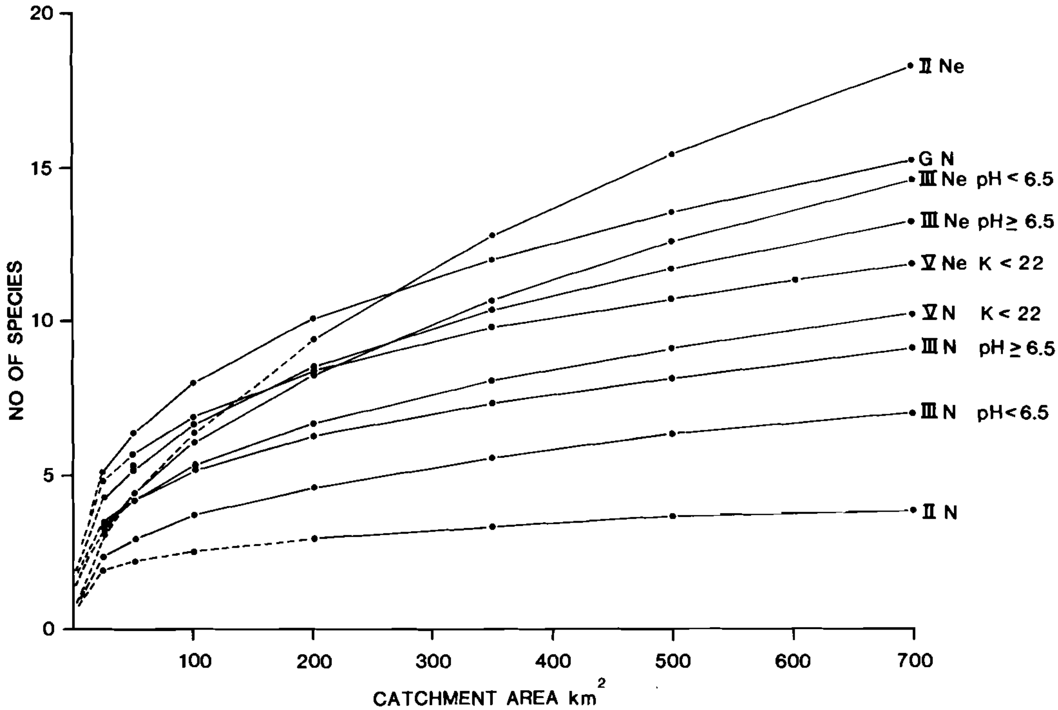

Fig. 7. Number of species of Ephemeroptera (N) based on records and expected numbers (N_e) from equation 13 disregarding pH, in relation to size of catchment area generally (G) and in region II, and for cases in regions III an V selected with references to maximum pH or mean specific conductivity (K). Solid sections represent range of catchment area from which data exist.

DISCUSSION

This analysis gives examples of how the general number of species to area equation (2), developed for terrestrial and especially island faunas, is also valid for freshwater faunas. According to MacArthur & Wilson (1967), the z value for Ephemeroptera (equation 8) is typical for island fauna and that for Plecoptera (equation 9) similar to values obtained for non-isolated fauna. The difference between the two values is related to the following facts. The plecopterans are relatively insensitive to environmental qualities. Their species numbers are therefore mainly connected to the size of the area and are relatively high in small areas. The ephemeropterans respond more to ecological variation. Their species numbers in small areas are normally lower, but with increasing area and habitat variation they reach higher numbers than the plecopterans. It is discussed whether increase in size of area alone or increased habitat diversity is responible for the increase in species numbers (Gorman 1979). Evidently the species number of an euryoecious taxon like the Norwegian Plecoptera depends mainly on the size of the area, while the habitat diversity is of more importance for more stenoecious animals like the Norwegian Ephemeroptera.

The high numbers of species in the most northern part of Norway, north of latitude 68°N, may be surprising. However, the water quality is better than in the other regions. Waters along the extreme northern coast may be cold. In the more continental districts the temperature is no more limiting than in other parts of Norway, although the summer is short. The recorded species numbers of both Ephemeroptera and Plecoptera are in good agreement with the equations established for southern Norway. This probably holds for the freshwater fauna of the region in general. In the Alta river system Jensen (1985) found for example 34 of the 76 species of Cladocera which according to Nøst et al. (1986) have been recorded in Norway.

The numbers of ephemeropteran species in Vestlandet (region III), also in the northern districts not affected by acid precipitation, are lower than expected. The mountain range along its eastern border is probably also a zoogeographical barrier.

The results concerning Plecoptera are in good agreement with Lillehammer (1974). He found the species numbers to increase from 18—20 at the coast to 27 in the eastern and more continental parts of Norway, and no south-north gradient. Thus, by the methods behind the basic data of this analysis, one should expect to find all present species anywhere along the coast within an area of 4000 km². The Vosso river system with an area of 1483 km² in region III, in which 21 species have been recorded (NOU 1983), is an example. In catchment areas no. 1—4 in region I, 22 species were recorded, while Lillehammer found 27 in the same main valley. He also recorded 27 species in the eastern part of region VI, compared to the 22 species in catchment area no. 53. The aim of the surveys behind this analysis was freshwater invertebrates in general. They were performed by field workers of varying qualifications mainly visiting the localities twice, while the studies of Lillehammer represent those of an experienced specialist. Considering this, the results obtained are satisfactory.

Lillehammer (1985) subdivided region III into a coastal area and lowlands of the inner fjords, recording only 9 species of Plecoptera from the coastal area. In the Yndesdal river system of 120 km² located close to the west coast, Haaland & Raddum (1981) found 12 species, which is equivalent to $N_u = 5.0$ and above the number expressed by the general equation (9). Lillehammer may have sampled an area of inadequate size. According to this analysis, the only districts of Norway holding especially low numbers of plecopteran species are region II and the typical coastal areas of region VI.

The independance of Plecoptera in relation to environmental variation explain their regionally uniform diversity. This is only valid when complete or large sections of river systems are considered. Lillehammer (1974) found a sharp decline in species numbers from the sub-alpine to the middle-alpine zone, both in southern and northern Norway, which was mainly correlated to falling temperature and decreasing amounts of organic allochtonous material. Similar differences with regard to elevation have been found in British streams (Hynes 1961, Minshall 1968).

As to the differences between Ephemeroptera and Plecoptera in relation to temperature, similar results were obtained by Sprules (1947). Over the temperature interval 13—20°C in a Canadian stream, he found a small decline in the number of plecopteran species, while that of Ephemeroptera increased from 10 to 28. In streams in the Tatra Mountains the ratio of Plecoptera to Ephemeroptera decreased, both in number of species and individuals, as the annual range of temperature increased (Kamler 1965).

Acid precipitation and acidification of fresh waters has a major impact in southernmost Norway. Since the 1920's it has caused the loss of an increasing number of inland fish stocks (Overrein, Seip & Tollan 1980). Reviewing Norwegian studies on Ephemeroptera and Plecoptera Leivestad et al. (1976) found the mean number of species to be about 3—4 times higher at pH 6.5—7.0 than 4.0—4.5. For Ephemeroptera this is quite in accordance with the differences between expected and recorded numbers in a catchment area of 200 km² in region II. That this ratio increased to 6 for an area of 4000 km², means that the ephemeropteran fauna of the region is limited to a few species tolerant of acid water. According to Wiederholm (1984) and Økland & Økland (1986) Ephemeroptera are among the most sensitive to acidification. Engblom & Lingdell (1984) showed the number of species in Swedish streams where pH often falls below 5.0 to be only 1/4 to 1/3 of that found in more northern and unaffected streams. According to them, all species found in region II, except *Caenis horaris,* are among the 7 most acid resistant Scandinavia ephemeropterans, tolerating pH as low as 3.5—4.5. *C. horaria* was recorded at a minimum of 5.1 in region II, while Engblom & Lingdell present an experimental limit of 5.4 and an empirical of 5.6.

This analysis definitely demonstrates that plecopterans stand acid water better than the ephemeropterans. In experiments Raddum & Steigen (1981) found three of the species present in region II, *Taeniopteryx nebulosa, Nemoura cinerea,* and *Nemurella picteti,* to be unaffected by pH 4.6—4.7. In 26 watersheds in western Norway, Raddum & Fjellheim (1984) found Plecoptera to tolerate acid water better than Ephemeroptera. Of Ephemeroptera only *Leptophlebia* and *Siphlonurus* occurred at pH <5.0 compared to 12 species of Plecoptera. Comparing two streams 50 km apart in southernmost Sweden, Otto & Svensson (1983) recorded 11 species of Ephemeroptera and 12 of Plecoptera in the one with pH range 5.9—7.3 and none ephemeropteran and 9 of Plecoptera in the other with pH range 4.2—5.9.

The conclusion that the number of species of Ephemeroptera has been reduced by 75% and that of Plecoptera by 40—25% in catchment areas of 250—700 km² in Sørlandet, the southernmost part of Norway, is quite in agreement with what is known about the effects of acidification. So are the assumptions on the impact on the ephemeropteran fauna of Vestlandet.

This work present guidelines for the importance of size when selecting river systems for conservation purposes. In Norway areas <200 km² will in general hold only small numbers of ephemeropteran species. Increasing the area above 1000 km², however, involves only a small gain of plecopteran species and some ephemeropteran. It is further possible to evaluate the species richness of a certain area in any region of Norway. The results are probably also valid for the northern half of Sweden. In catchment areas of about 500 km² Engblom & Lingdell (1984) recorded 25 species of Ephemeroptera in streams east of region IV and 17 east of region V. However, acidification seems to have reach farther north in Sweden than in Norway. In catchment area no. 1 of 341 km², 15 species of Ephemeroptera were recorded and the expected number was 16. In Fulufjäll nature reserve, 80 km to the northeast and just across the border, Engblom & Lingdell found only 6 species, a situation similar to that of region II in southernmost Norway.

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Habitat and life histories of the Trichoptera in Thjorsarver, Central Highlands of Iceland

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Larval habitats and life cycles of the Trichoptera species found in Thjorsarver, central highlands of Iceland, are described. All six species are limnephilids. *Apatania zonella* (Zett.) was mainly found in streams, whereas *Limnephilus picturatus* McL. dominated in standing waters. *L. griseus* (L.) and *L. affinis* Curt. were found in both types of waters. The habitats of *L. fenestratus* (Zett.) and *L. sparsus* Curt. larvae were not determined. All species had one generation per year. *A. zonella* and *L. griseus* emerging from stenothermal spring-fed streams, had flight periods from mid-May to August, but *L. griseus* and the other species from standing waters were emerging in late June or July. Lakes, ponds and pools were presumably frozen solid from October to May and the larvae had only the summer for growth, whereas the larvae in spring-fed streams had the whole year for growth, and this is most likely the reason for the differences in emergence patterns.

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INTRODUCTION

The construction of a reservoir for hydroelectric purposes in the River Thjorsa was under consideration by Icelandic energy authorities for several years. A reservoir would have led to flooding of the Thjorsarver oasis, which was the focal point of a major conservation issue for some years (Flechtner et al. 1982), being one of few vegetated areas of the highlands and the largest breeding ground in the world for the pinkfooted goose *(Anser brachyrhynchus)*. A general biological survey of the area was carried out in 1971—74. In connection with a limnological research project in the Thjórsárver area (Halbach and Flechtner 1976, Flechtner et al. 1982) the Trichoptera were studied specifically in 1974 as a part of a general study of Icelandic Trichoptera (Gislason 1977a, 1978a, b, 1979, 1981, 1987).

The Trichoptera in Iceland are known to occupy a wide range of habitats (Gislason 1981). The habitats in the Thjorsarver can be divided into two categories, lotic waters, which do not freeze solid and lentic waters, which presumably freeze solid. That leads to a difference of growth of the larvae inhabiting these habitats. Larvae in permanently flowing waters can grow for most or all of the year, but larvae in lentic waters only have the period from May to October for growth. The aim of this study is to explore differences in the habitat selection of the species and how the life cycles are adapted to the different habitats.

STUDY AREA

The Thjórsarver tundra meadows form one of the largest oases in the central plateau of Iceland, which is mainly unvegetated. They are at the headwaters of the River Thjórsa immediately south of the icesheet Hofsjökull (Fig. 1). The Thjorsarver lie in a large basin at an altitude of 560—600 m a.s.l. and cover a total of about 150 km², of which about 100

*) Prof U. Halbach died on 14 April 1983.

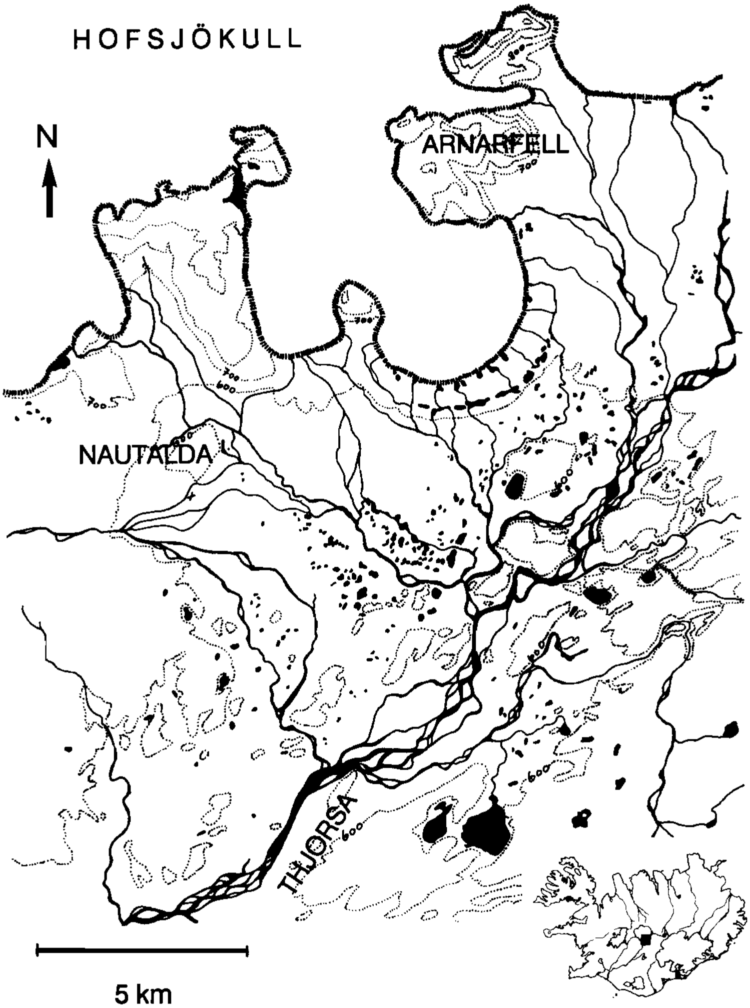

Fig. 1. A map of the Thorsarver area.

km² are vegetated. The basin is bordered to the north by the icesheet and to the west, south and east by unvegetated hills and plateaus. The meadows are intersected by numerous glacial and several spring-fed streams, with numerous pools, ponds and lakes. Swamps and marshes are characterized by sedges (*Carex* spp.) (Fig. 2). In parts of the area there are permafrost palsa mounds.

The only permanent weather station in the central highlands of Iceland is at Hveravellir (altitude 642 m a.s.l.) about 45 km northwest of Thjorsarver. Records from Hveravellir indicate a polar maritime climate similar to that of southern Greenland, Jan Mayen and west Spitsbergen. This differs from the much more widespread continental polar climate of continental America and Siberian tundra in higher percipitation and much less severe winters.

The somewhat fragmentary weather observations from Thjorsarver indicate that the climate is quite similar to that at Hveravellir. The annual mean temperature is estimated at -0.8°C with temperatures highest in July (mean 7.3°C) and lowest in February (-6.3°C). Precipitation is approximately 800 mm per year. There are about 220 days with frost and about 1240 hours of sunshine per year. The area is snow covered from about early October until May. An ice cover, usually about 50—100 cm thick in late March, forms over the bogs and marshes. About 1 m thick ice forms on lakes and ponds. Lakes become ice free about late May and the soils of the wetland usually thaw out completely early to mid-August (Thorhallsdottir 1988).

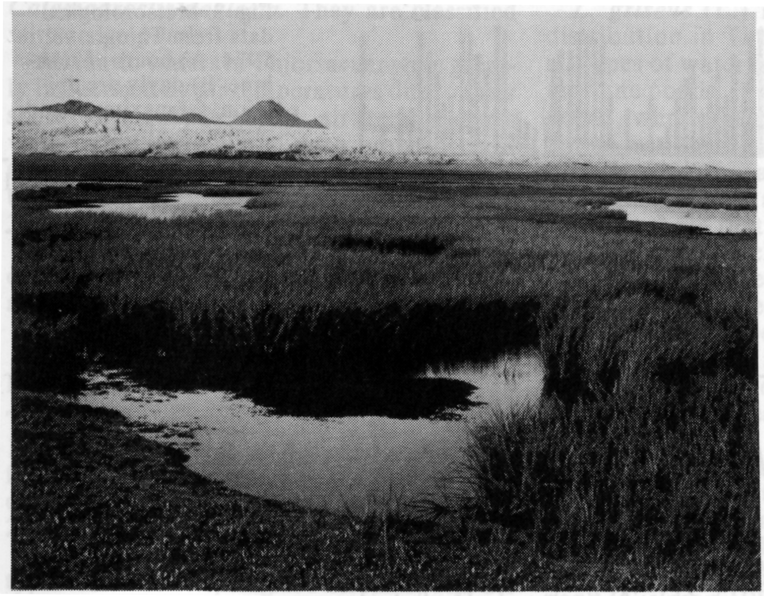

Fig. 2. A potograph taken in Thjorsarver, showing a sedge pond and the glacier Hofsjökull about 5 km away. The mountain Arnarfell (1143 m a.s.l.) stands higher than the glacier. (Photo by Erling Olafsson).

METHODS

In 1974 freshwater organisms were studied at numerous sampling sites. The sampling sites were chosen to give the greatest variety of habitats. Most water bodies were visited once, but two sampling sites were visited four times, a pool near the field station Nautalda and a pond in the *Carex lyngbyei* swamp. Two ponds, grown with *Carex* spp. were visited twice and a spring-fed stream near the field station 3 times.

Trichoptera larvae were collected with a FBA standard pondnet, mesh 0.25 mm and immediately preserved in 70% isopropanol.

Larval head capsules were measured with an precision of $\pm$ 0.03 mm under a binocular microscope to determine the instar.

Insect collections were made in the area from 5 May to 26 August 1972, from 5 May to 17 August 1973 and from 5 June to 15 August 1974. Adults were collected by a sweep net in various parts of Thjórsárver. At the field station Nautalda, in the northwestern part of the area, two types of traps were continuously operated, a window trap (1972, 1973 and 1974) and a tent trap (1974), which collected flying insects (Gislason 1977a). In 1972, pit fall traps (Barber 1931) were operated in different parts of the area. Female caddisflies were dissected to study their ovarian development according to the methods of Novak and Sehnal (1963).

RESULTS

Classification of habitats

The classification of Halbach and Flechtner (1976) of the water bodies in Thjorsarver is followed here, but slightly simplified. Habitats containing caddis larvae were the following:

Spring-fed streams had stable temperature, discharge and chemical composition throughout the year (Gislason 1977a, 1981). In Thjorsarver, the temperatures were about 5°C near the sources of the streams, but downstream the temperatures varied somewhat depending on air temperatures (Fig. 3).

Direct run-off streams were without any clear sources, receiving their water from rainwater, melting snow etc. Their temperatures, discharge and chemical composition varied.

Lentic waters were classified according to their sizes and vegetation. Lakes were larger than 3500 m^2, ponds 10—3500 m^2, and pools less than 10 m^2. Usually the water depth was 20 to 50 cm, and never exceeded 1 m.

Lakes usually had a bottom of mud and sand, with or without macrophytes. Wind could form waves, which disturbed the bottom sediment.

Moraine ponds were found immediately in front of the glaciers. Their bottoms consisted of sand and stones with little or no vegetation.

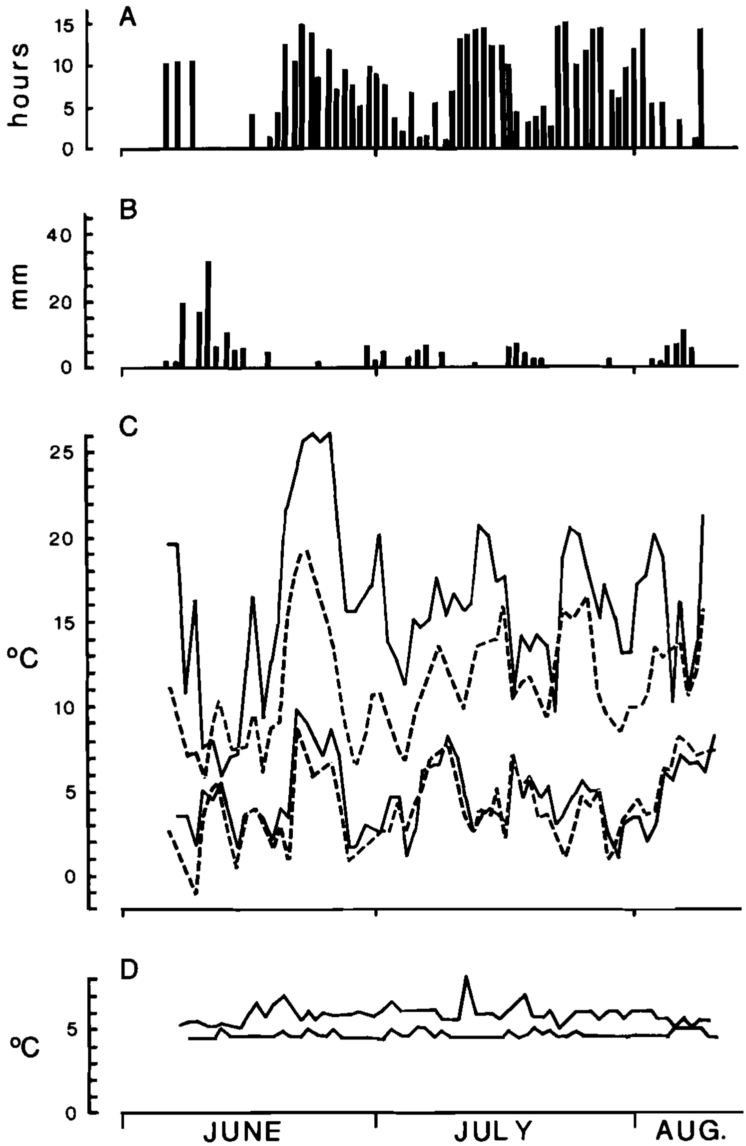

Fig. 3. Meteorological data from Thjorsarver in 1974. A) hours of sunshine, B) dayly precipitaion, C) maximum and minimum air temperatures (broken lines) and water temperatures of a pool (solid lines), and D) maximum and minimum water temperatures near the source of a spring-fed stream.

Vegetation poor ponds had less than 30% cover of sedges of mosses. Their bottoms consisted of mud.

Moss ponds had the mosses *Drepanocladus tundrae* and *Calliergon giganteum,* covering more than 30% of the bottom area.

Sedge ponds had emergent stands of *Carex rostrata* and to lesser extent *C. lyngbyei.* These water bodies were usually also vegetated with the mosses *D. tundrae* and *C. giganteum.*

One pond was found with rather dense vegetation of *Callitriche hermaphrodita, Potamogeton filiformis* and *Nitella* sp.

Pools received their water from the surrounding marshes. They had either sedges or mosses, or were without any vegetation. Some dried up in warm weather in summers.

Swamps and marshes were overgrown wetlands, water depth variable, but usually about 0 to 20 cm. They had a dense cover of *Carex lyngbyei* (or *C. nigra), C. rariflora* and

Calamagrostis neglecta. They are classified with sedge ponds.

All lentic waters in Thjorsarver were greatly influenced by air temperatures due to their shallowness. Water and air temperatures were closely associated with hours of sunshine, and the water temperatures exceeded the air temperatures in sunny weather (Fig. 3).

The chemical and physical characteristics of these waters have been described (Halbach and Flechtner 1976).

Larval habitats

Trichoptera larvae were found at 131 out of 196 sampling sites. Six species of adults were found in the area in 1972—74 (Table 1), but only four of these were found as larvae (Table 2).

Apatania zonella (Zett.) was found in 4 types of waters: spring-fed streams, run-off streams, lakes, and moraine ponds. It was the most frequent of Trichoptera species in running waters and the only species found in moraine ponds.

Limnephilus affinis Curt. larvae were infrequent in Thjorsarver. This species was found in one spring-fed stream and two ponds, one vegetation poor and the other grown with *Callitriche hermaphrodita, Potamogeton filiformis* and *Nitella* sp.

L. griseus (L.) had the broadest habitat distribution in Thjorsarver. It was found in all types of water bodies except swamps and moraine ponds. It was most frequent in moss ponds, where the main form of food for the larvae was *Salix glauca* leaves brought in by surface run-off water. *L. griseus* was also common in pools and was the only species found in those that dried up in summers.

L. picturatus McL. was the most abundant Trichoptera larvae in Thjorsarver and was found in nine types of lentic waters. It was found in all sedge ponds searched and was the only species found in the swamps. It was also found in the vegetation poor ponds and pools, which had less than 30% cover of vegetation.

Two other species, *L. fenestratus* (Zett.) and *L. sparsus* Curt., were found as adults in Thjorsarver, but search to find the larvae failed. Elsewhere in Iceland, L. *sparsus* occupies streams and *L. fenestratus* was found in a pond (Gislason 1981). In Thjorsarver, adult *L. fenestratus* were found among *Eriophorum* spp. and it was possible to let the females lay eggs, when they were kept in captivity with *Eriophorum* spp. standing in water (Gislason 1979).

Most often, only a single species of Trichoptera larva was found at each sampling site, wheras 2 species were occasionally found together (Table 2).

Table 1. Number of Trichoptera adults caught by various methods in Thjorsarver 1972—1974.

Species	Year	Research period 1972:20.6.-26.8. 1973:5.5.-17.8. 1974:5.6.-15.8. Flight-period	Caught in a window trap		Caught in a tent trap		Caught in pit-fall traps		Caught flying		Caught by sweeping vegetation or on the earth		Caught inside the field station		TOTAL	
			♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
A.zonella	1972	26.6-12.8		2				7		4		3				16
	1973	19.5-21.7								29	1	23		10	1	62
	1974	6.6-3.8		4						35		1		3		43
L.affinis	1972	5.7-2.8					1	9		1					2	9
	1973	4.7-30.7							20	2			5		25	2
	1974	19.6-5.8	8		2	1			13		1		3		27	1
L.fenestratus																
	1973	24.7-3.8							5	1			1		6	1
	1974	17.7-14.8	2						26	7	4	2	1	2	33	11
L.griseus	1972	14.6-26.8		1			8	7	7	2		1		1	15	12
	1973	19.5-17.8							30	26	4	1	10	16	44	43
	1974	16.6-15.8	11	2		1			62	19	12	11	5	4	90	37
L.picturatus																
	1972	31.7-21.8					15	13	4						19	13
	1973	24.7-8.8							7	2	49	29	1		57	31
	1974	12.7-15.8	4	2	6	2			77	31	146	167		3	233	205
L.sparsus	1973	16.7								1						1

Table 2. Habitats of Trichoptera larvae in Thjorsarver. Occurrence of larvae in different habitats expressed in percentage of collecting sites with each species and percentage of collecting sites with O, 1 and 2 species. Sites occupied with 2 species are indicated with an abbreviation of the species and the number of sites, e.g. AzLg11 is A. zonella and L. grieus cohabiting at 11 sites.

Habitat	Spring-fed streams	Run-off streams	Lakes	Moraine ponds	Moss ponds	Sedge ponds	Callitriche-Potamogeton-Nitella pond	Vegetation poor ponds	Pools
Species	%	%	%	%	%	%	%	%	%
A. zonella	84	12	6	43					
L. affinis	2						100	3	
L. griseus	29	3	19		56	43	100	47	54
L. picturat.			25		44	96		50	36
Sites with 0 species	10	85	56	57	28	4	0	31	9
Sites with 1 species	65	15	38	43	44	53	0	38	82
Sites with 2 species	25		6		28	43	100	31	9
Species cohabiting	AzLa1 AzLg11		LgLp1		LgLp5	LgLp12	LaLg1	LaLg1 LgLp9	LgLp1
Mean no. of spp/site	1.1	0.2	0.5	0.4	1.0	1.4	2.0	1.0	1.0
No. sampling sites	49	33	16	7	18	28	1	32	11

Life histories

Species occurring in spring-fed streams, *A. zonella* and *L. griseus,* had the earliest flight periods (Fig. 4). The larvae apparently overwintered as 3rd to 5th instar larvae, pupated in early spring, and started to emerge as soon as the ice cover of the streams thawed. However, the emergence extended into the summer, with mature females found in July and August.

L. griseus in standing waters had a different life cycle from those living in streams (Fig. 4). Pupae were not found until late June and were still present by the end of July. 3rd to 5th instar larvae were found in the 3rd week of June and 5th instar larvae in late July. Empty pupal cases were found from mid-June onwards. Small larvae (1st to 3rd instars) were found in the 2nd week of August. Larval growth was therefore different depending on their habitats; spring-fed streams with constant temperatures vs. standing waters with fluctuating temperatures in summers and frozen solid during the winter.

L. affinis had a flight period from mid-June to early July (Fig. 4), with ovarian development taking a short time. In June, only empty pupal cases were found and 2nd to 4th instar larvae were found in the 2nd week of August. The life cycle seems to be similar to that of *L. griseus* in standing waters.

Larvae of *L. picturatus* in a pond in a *Carex lyngbyei* swamp (Fig. 4) grew from predominantly 4th instar larvae and some 5th instar larvae in early June to pupae in mid-July. All pupae had emerged before early August, and thereafter only empty pupal cases were found. Emergence began in early July, oviposition taking place at the end of July and extending at least to the second week of August (Fig. 4).

DISCUSSION

Although the caddis larvae of Thjorsarver have a wide range of habitats, there are some trends in habitat selection (Table 2). *A. zonella* larvae were found in water bodies that had some water movements and sand, gravel and stones on the bottom. *L. picturatus* was found only in standing waters with some sedges or mosses growing at the banks. *L. griseus* on the other hand was found both in lentic and lotic waters, and so was *L. affinis.* Habitat distribution in Thjorsarver is similar to that found in other parts of Iceland (Gislason 1981), and the species composition in Thjorsarver is similar to other highland areas that

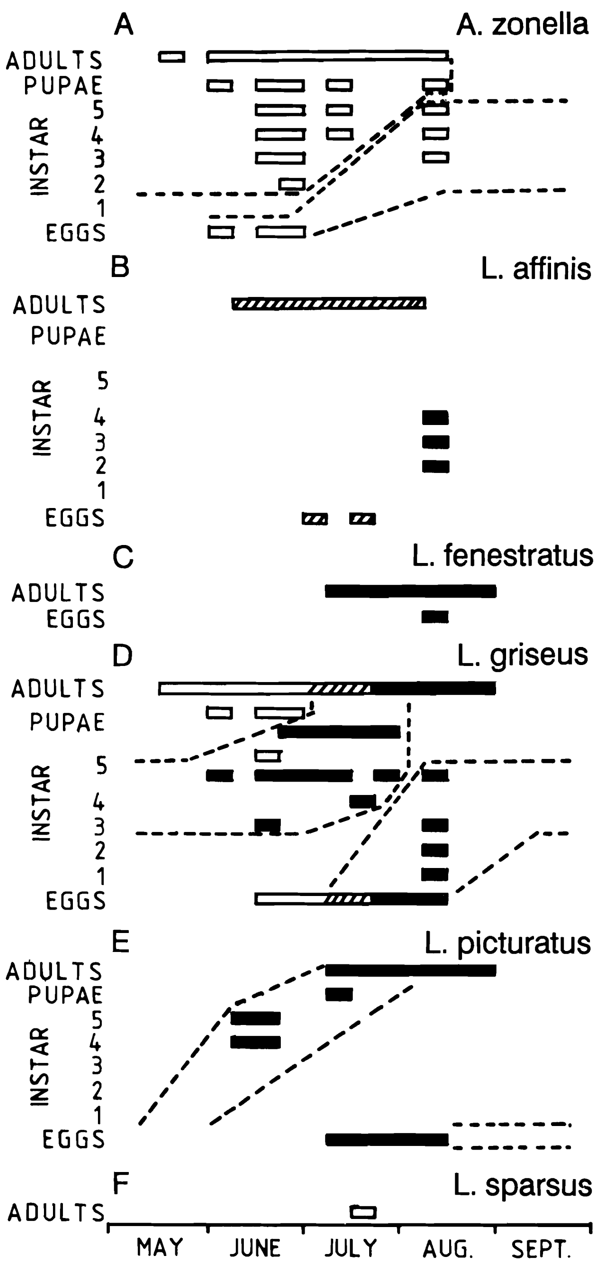

Fig. 4. Life cycles of the Trichoptera species in Thjorsarver. A) *Apatania zonella,* B) *Limnephilus affinis,* C) *L. fenestratus,* D) *L. griseus,* E) *L. picturatus,* and F) *L. sparsus.* Horizontal bars indicate occurrence of each stage. Each month is arbitrarily alotted weeks of 7 and 8 days alternately, i.e. week 1: 1—7, week 2: 8—15, week 3: 16—22, week 4: 23—30/31. Open bars: from running waters, black bars: standing waters and hatched bars: both from running and standing waters. Presence of eggs is presumed from capture of females that had oviposited. Broken lines show inferred generations.

have been studied (Gislason 1977b). *L. griseus* and *L. picturatus* shared the same habitats most often, and *A. zonella* and *L. picturatus* were never found together (Table 2). *L. griseus* and *L. picturatus* feed on detritus, decaying leaves of higher plants, but *A. zonella* scrapes diatoms from stones and has specially adapted mandibles for that type of feeding (Gislason and Sigfusson 1987). The diversity of Trichoptera larvae at each sampling site is quite low (Table 2), lower than in the lowlands of Iceland (Gislason 1981).

The presence in streams of empty pupal cases of *A. zonella* and *L. griseus* before adults were collected suggests that the flight periods of these species might have started earlier in 1972 and 1974 than shown in Table 1. They are the earliest species to appear as adults and *A. zonella* is most common in the early summer, whereas *L. griseus* is common throughout the summer. Adults of other species — those found in standing water as larvae — appear in mid summer. These standing water bodies are much affected by air temperatures and freeze solid during winter. However, the spring-fed streams never freeze solid and they do not freeze over near their sources, the ice disappearing in early spring from the lower reaches.

Temperature seems to affect the life cycles of the Trichoptera. Larvae occupying spring-fed streams, which are never frozen solid in winter and are colder than ambient air during the day in summer, have a longer larval growth and an extended flight period. Larvae in lentic waters which freeze solid in winter and become warmer than ambient air on sunny summer days, grow during the summer only and have short flight periods in mid summers.

The flight periods of the Trichoptera in the Thjorsarver area are shorter than in the lowlands of Iceland (Gislason 1978a). This is probably associated with lower temperatures and shorter growth season in the highland than in the lowlands.

ACKNOWLEDGEMENTS

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Key to the Fennoscandian larvae of Arctopsychidae and Hydropsychidae (Trichoptera)

TERJE BONGARD

Bongard, T. 1990. Key to the Fennoscandian larvae of Arctopsychidae and Hydropsychidae (Trichoptera). *Fauna norv. Ser. B, 37:* 91—100.

A key to the Fennoscandian larvae of the Trichopteran families Arctopsychidae and Hydropsychidae is provided. The following species are included: *Arctopsyche ladogensis* (Kolenati 1859), *Cheumatopsyche lepida* (Pictet 1834), *Ceratopsyche nevae* (Kolenati 1858), *C. silfvenii* (Ulmer 1906), *Hydropsyche angustipennis* (Curtis 1834), *H. bulgaromanorum* Malicky 1977, *H. contubernalis* McLachlan 1865, *H. pellucidula* (Curtis 1834), *H. saxonica* McLachlan 1884, *H. siltalai* Döhler 1963.

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INTRODUCTION

The larvae of the Trichopteran families Arctopsychidae and Hydropsychidae live almost exclusively in running water and are important members of the bottom fauna. They are net spinners, predators and/or filter feeders on drifting organic particles (Petersen 1981). Because of their different habitat preferences and pollution tolerance they are useful as biological indicators (Schuhmacher et al 1970, Scherf 1983). The catching nets of each species normally have a very distinct pattern and irregularities in net construction can reveal undesirable discharges to streams (Besch et al 1977, 1979, Petersen et al. 1983). In order to make use of this or other information on the Arctopsychidae and Hydropsychidae, it is necessary to have a key to the species present in Fennoscandia.

The Fennoscandian trichopteran fauna consist of western, eastern and northern European species. This renders the continental European keys to trichopteran larvae in most cases incomplete for the Norwegian, Swedish and Finnish fauna. This is also true for Hydropsychidae (Lepneva 1964, Sedlàk 1971, Szczesny 1974, Wiberg-Larsen 1980, Eddington & Hildrew 1981, Petersen 1981).

MATERIAL AND METHODS

The key is put together using several published works on the taxonomy of the families (Lepneva 1964, Sedlàk 1971, Sczesny 1974, Wiberg-Larsen 1980, Edington & Hildrew 1981, Petersen 1981). The quoted works show that the taxonomic characters used in this key are consistent for populations from different parts of Europe. The characters do not seem to differ in populations as far from each other as England and Finland.

Larvae examined in this study from different sources were photographed under a Wild M 400 photomicroscope with an optical fiber lamp.

The families Arctopsychidae and Hydropsychidae are easily distinguished because of the sclerotisation of all thoracic segments combined with ventrally situated gills on the abdomen. Among campodeoid larvae Rhyacophilidae also possess gills on abdomen, but these are situated laterally. In addition, only the pronotum is sclerotized in this family.

The Arctopsychidae have only one species in Fennoscandia, while the Hydropsychidae have three genera and nine species (Andersen & Wiberg-Larsen 1987). The key refers to larvae in the 4th or 5th instar and they are sampled at the following localities (number of specimens examined in brackets):

Arctopsyche ladogensis (Kolenati 1859): Gaula river, Central Norway, 19.10.1988 (>20): Figs 1,2.

Cheumatopsyche lepida (Pictet 1834): Drawings published in: Edington & Hildrew 1981 (Fig. 3), Wiberg-Larsen 1980 (Fig. 4) and Lepneva 1964 (Fig. 5).

Ceratopsyche nevae (Kolenati 1858): Gaula river, Central Norway, 2.10.1987 (>20):

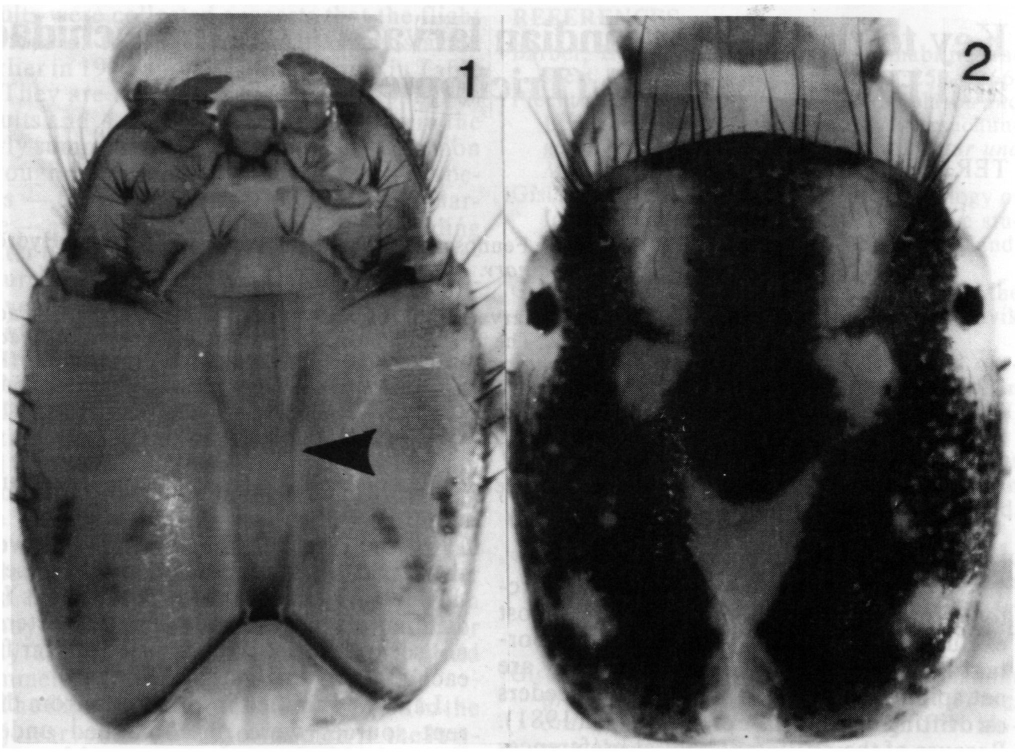
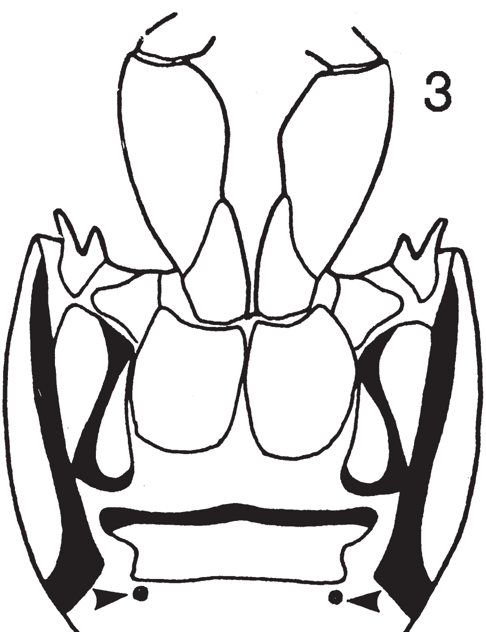
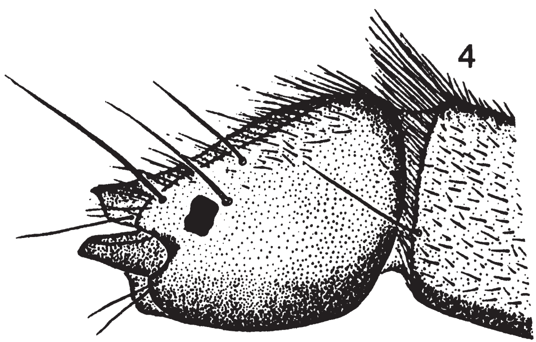
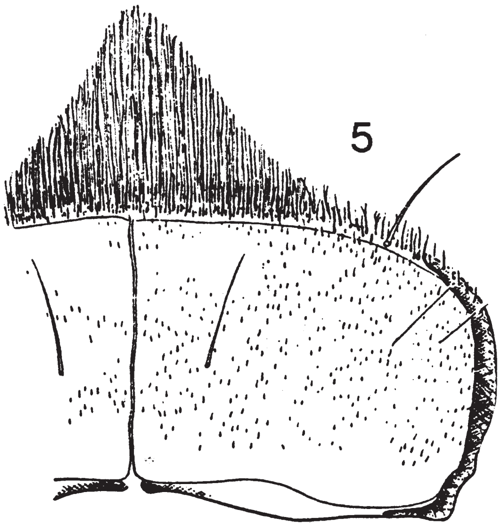


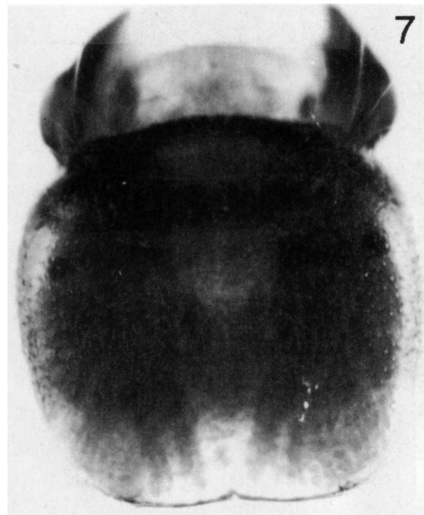
Fig. 1, 2: *Arctopsyche ladogensis* 1. Head, ventral, showing submentum 2. Head with frontoclypeus.

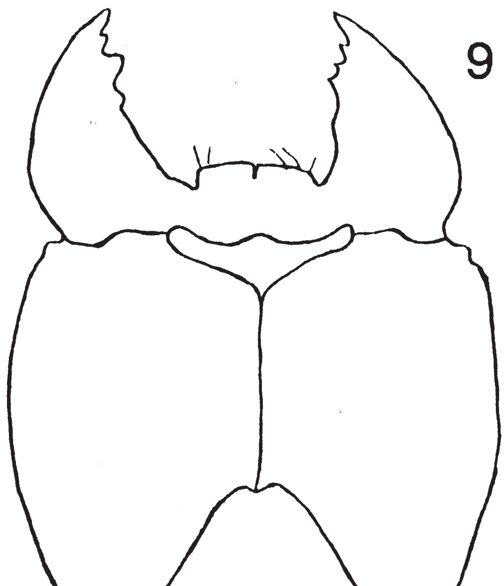


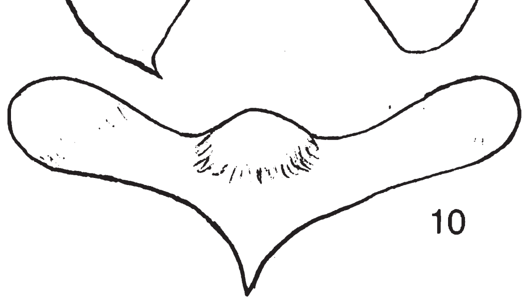




Figs 3, 4, 5: *Cheumatopsyche lepida* 3. Posterior prosternites 4. Head and pronotum 5. Pronotum, dorsal.







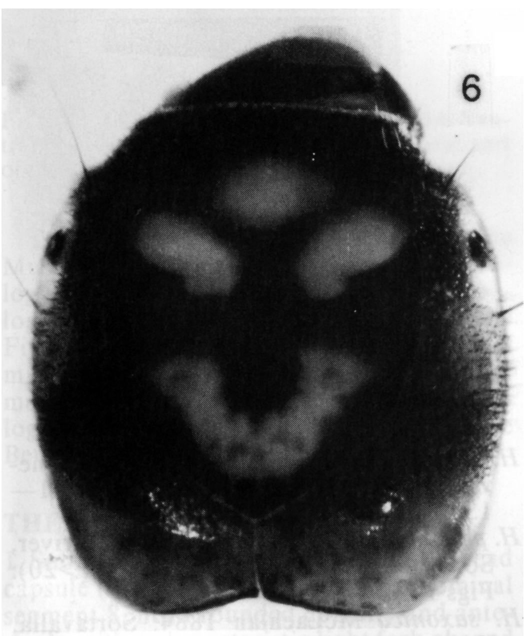
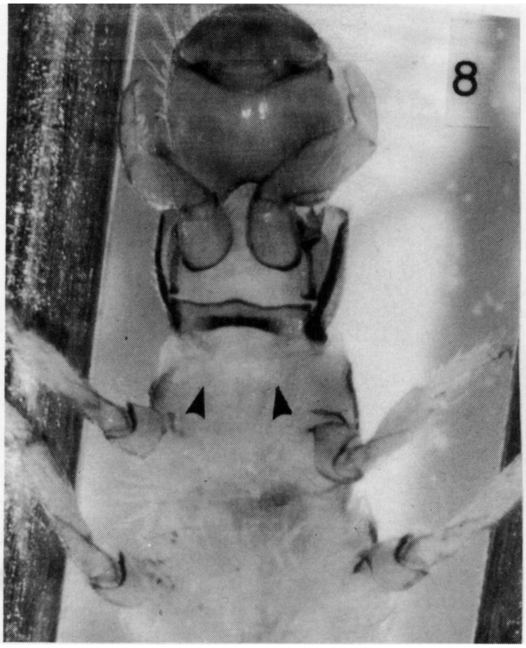
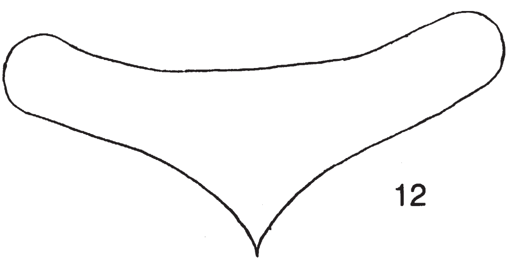
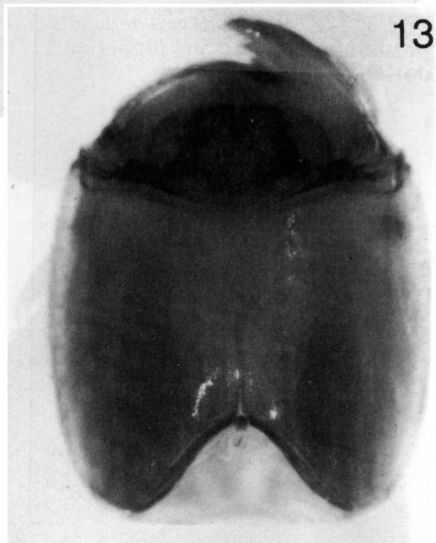


Fig. 6: *Hydropsyche siltalai* Head, dorsal.

Figs 7, 9, 10: *Hydropsyche bulgaromanorum* 7: Head, dorsal 9: Head, ventral, submentum with central lobe 10: Submentum with central lobe.







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Figs 8, 11, 12, 13: *H. contubernalis* 8: Posterior prosternites 11: Head, dorsal 12: Submentum 13: Head, ventral.

Figs 20, 22, 23. Nordelva, Central Norway. 4.10.1987 (>20): Figs 21, 26.

C. silfvenii (Ulmer 1906): Holvasselva river, Central Norway, 6.8.1987 (20): Figs 24, 25, 27.

Hydropsyche angustipennis (Curtis 1834): Åroselva river, South East Norway, 25.11.1987 (>20): Fig. 14. Sortavalla, Karelen. USSR, 6.8.1902 (3): Fig. 15.

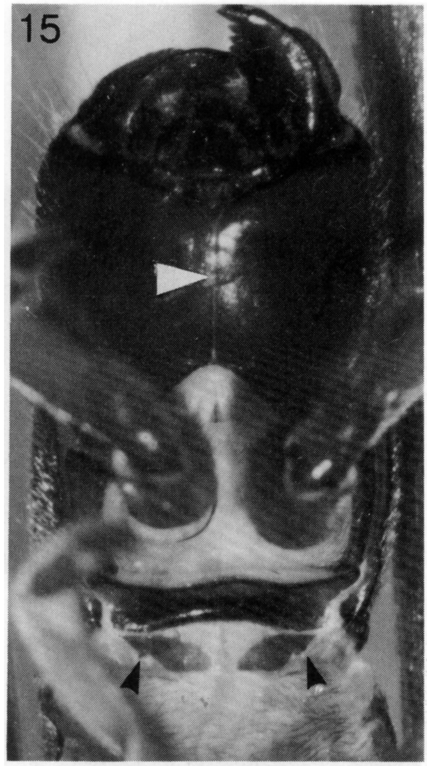
H. bulgaromanorum Malicky 1977: Po river, Cremona, Northern Italy, 13.10.1978 (3): Figs 7, 9, 10.

H. contubernalis McLachlan 1865: Konnevesi, Finland, 24.6.1978 (3): Figs 8, 11—13.

H. pellucidula (Curtis 1834): Åroselva river, South East Norway, 25.11.1987 (>20): Figs 16, 17.

H. saxonica McLachlan 1884: Sortavalla, Karelen. USSR, 6.8.1902 (12): Figs 18, 19.

H. siltalai Döhler 1963: Holvasselva river, Central Norway, 17.6.1987 (>20:) Fig. 6.



Figs 14, 15: *Hydropsyche augustipennis* 14: Ventral part of posterior prosternites 15: Lateral part of posterior prosternites, ventral ecdysial line.

The Norwegian material is deposited at the Museum of Natural History and Archaeology, University of Trondheim, and the Zoological Museum, University of Oslo. The Finnish material is deposited at Zoological museum, University of Helsinki. The Italian material is deposited at Laboratoire de Biologie Animale et Ecologie, Universite Claude Bernard, Lyon.

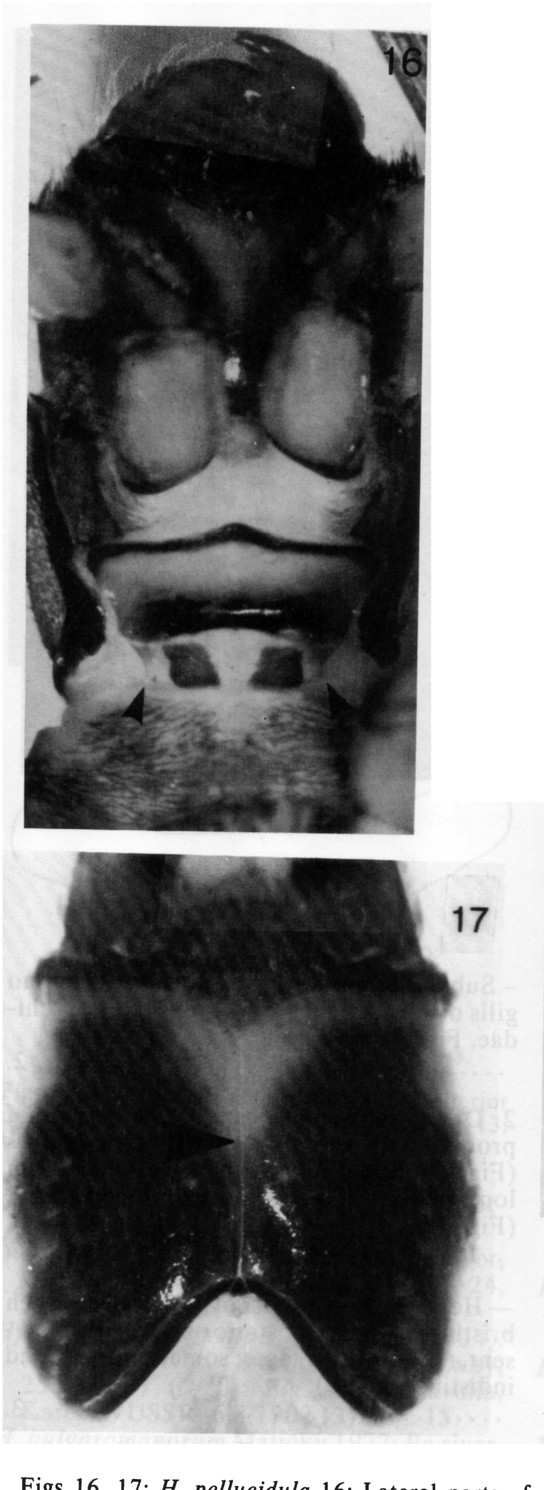
THE KEY

1. Submentum reaching posterior end of head capsule (Fig. 1). Gills present on abdominal segment 8, head rounded dorsally and anteriorly with a characteristic light fork-shaped pattern (Fig. 2). Light median longitudinal stripe on the dorsal surface of each thoracic segment:
.... *Arctopsyche ladogensis*

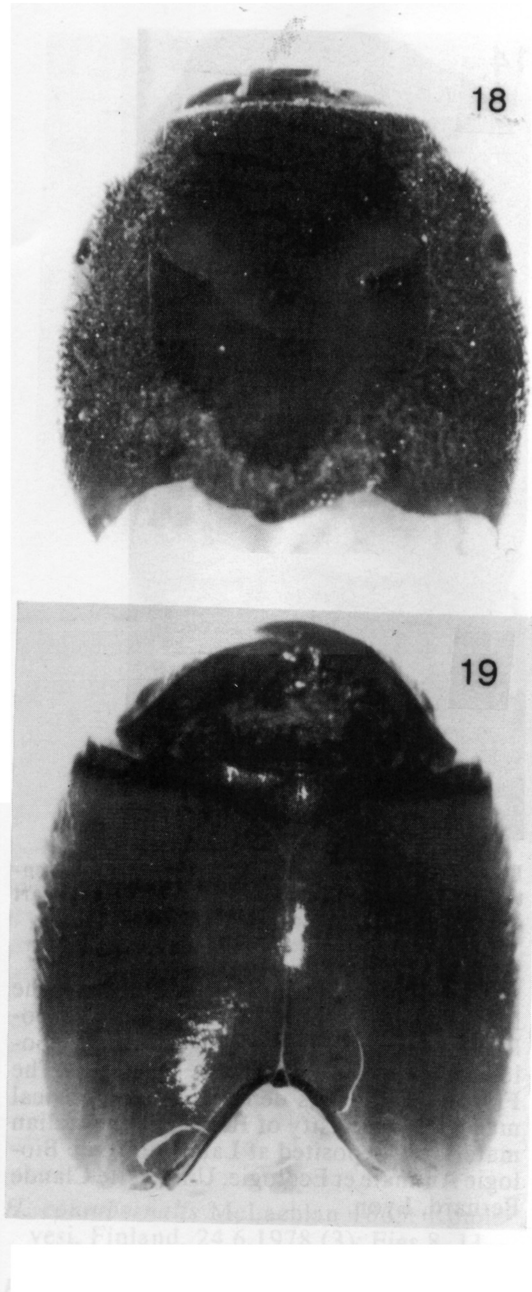
– Submentum only a tiny, bilobed plate, no gills on abdominal segment 8 (Hydropsychidae, Figs 9, 19, 23):
.... 2.

2. Dorsal part of head and anterior part of pronotum densely covered with long bristles (Fig. 4 and 5). Full grown larvae about 1 cm long. Posterior prosternites almost absent (Fig. 3):
.... *Cheumatopsyche lepida*

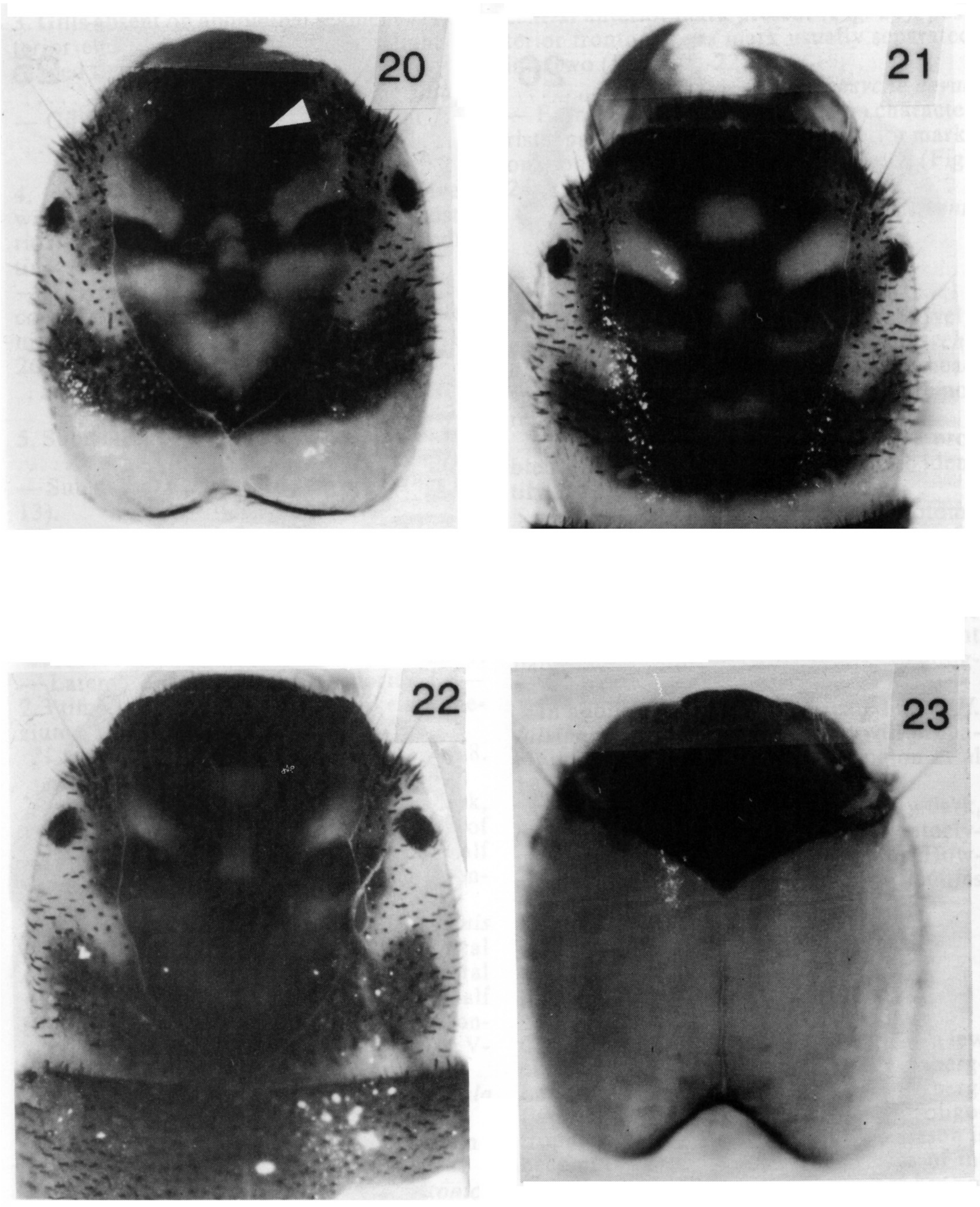
— Head and pronotum not covered with such bristles (Fig. 22). posterior prosternites present, (Fig. 14—16, note: sometimes pale and indistinct, Fig. 8):
.... 3.



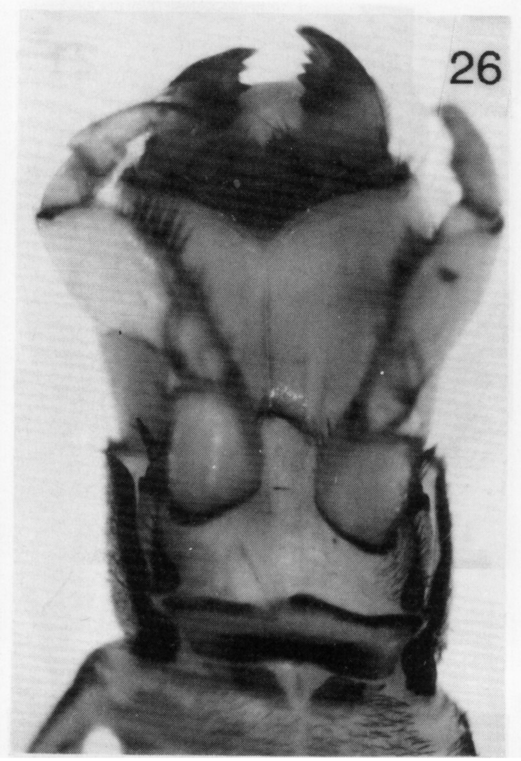
Figs 16, 17: *H. pellucidula* 16: Lateral parts of posterior prosternites 17: Ventral ecdysial line.

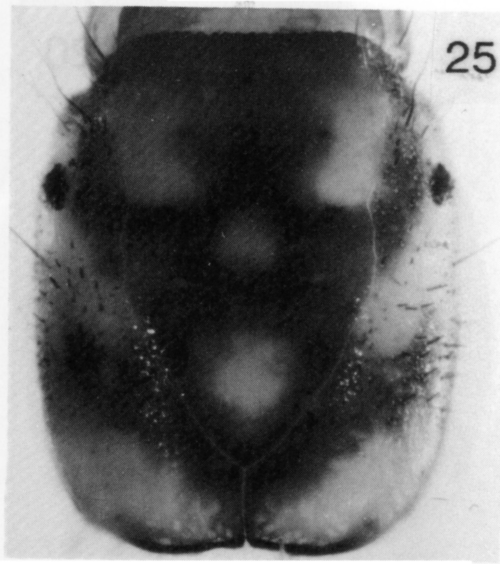


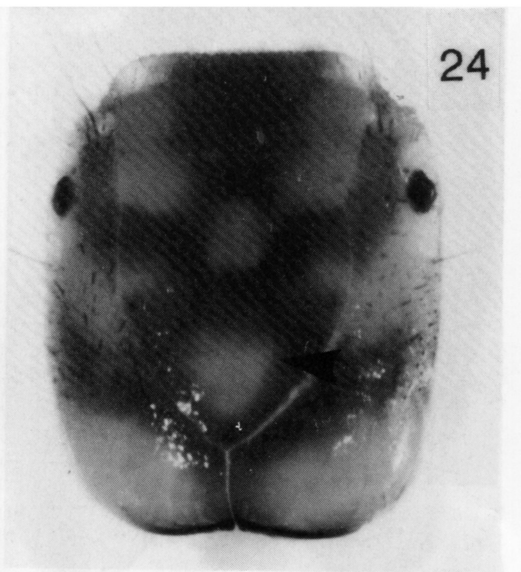
Figs 18, 19: H. saxonica 18: Head, dorsal 19: Head, ventral.



Figs 20—23, 26: *Ceratopsyche nevae* 20—22: Heads, dorsal, from different specimens 23: Head, ventral 26: Posterior prosternites







Figs 24, 25, 27: *C. silfvenii* 24: Head, dorsal, showing posterior frontoclypeus mark 25: Head, dorsal 27: Posterior prosternites and submentum.

3. Gills absent on abdominal segment 7. Posterior end of frontoclypeus with a light U-shaped figure (Fig. 6):
.... *Hydropsyche siltalai*
— Gills present on abdominal segment 7:
.... 4.

4. Anterior edge of frontoclypeus convex, with two large light areas (Figs 7,11). Posterior prosternites uniformly pale and indistinct (Fig. 8): .... 5.
— Anterior edge of frontoclypeus straight or concave (Figs 18, 20, 24), posterior prosternites more or less sclerotized (Figs 14—16, 26, 27):
.... 6.

5. Submentum with central lobe (Figs 9, 10).
.... *Hydropsyche bulgaromanorum*
— Submentum without central lobe (Figs 12, 13).
.... *Hydropsyche contubernalis*

6. Lateral parts of submentum oblonged and narrow, 2.5—3 times as wide as long (Figs 14—17):
.... 7.
— Lateral parts of submentum shorter, 1.8—2.3 times as wide as long, more like a trapezium (Figs 19, 23, 26, 27):
.... 8.

7. Lateral parts of posterior prosternites dark, ventral part oblong (Figs 14, 15), length of ventral ecdysial line of head shorter than half head width (Fig. 15), posterior area of frontoclypeus with faint or absent mark:
.... *Hydropsyche angustipennis*
— Lateral parts of prosternites light, ventral part almost square (Fig. 16), length of ventral ecdysial line of head at least as long as half head width (Fig. 17), posterior area of frontoclypeus with a more conspicuous Y or V-shaped light mark:
.... *Hydropsyche pellucidula*

8. Frontoclypeus with 2—3 marks, but no central anterior light mark (Fig. 18):
.... *Hydropsyche saxonica*
— Frontoclypeus with 6—9 light marks, at least one central mark anterior to suture, (Figs 20—22, 24, 25):
.... 9.

9. Frontoclypeus with up to 9 marks in a characteristic complicated pattern, distal central anterior mark present (Fig. 20), posterior frontoclypeus mark usually separated into two (Figs 20—22):
.... *Ceratopsyche nevae*
— Frontoclypeus with 6 marks in a characteristic pattern, no distal central anterior mark, only one posterior frontoclypeus patch (Figs 24, 25):
.... *Ceratopsyche silfvenii*

Comments on the key

The identification to species is relatively easy, except perhaps between *Hydropsyche angustipennis* and *H. pellucidula.* The head spot differences in these two species are not reliable in preserved material.

Younger instars are usually always a problem, but in most cases it is possible to identify 3rd instar larvae.

Mentum, submentum, ventral apotome and the gular sclerite are names used for the same structure (Hickin 1946, Lepneva 1964, Wiggins 1977, Lecureil 1983, Edington et al 1981, Merritt et al 1984). I have used the name submentum for the structure, as recent papers indicate that this is the correct designation.

In addition to the species treated here, *H. fulvipes* occurs in Denmark and will probably key out to *H. saxonica* (Edington et al 1981).

The material of *H. saxonica* is very dark, other specimens may have lighter frontoclypeus marks than this material reveals. However, this should not produce any difficulties for identification (Sedlàk 1971).

NOTES ON THE BIOLOGY OF *CERATOPSYCHE SILFVENII*

C. silfvenii has been recorded from only a few places in Sweden and Denmark (Wiberg-Larsen 1980, Petersen 1981), and Wiberg-Larsen states that it seems to prefer oligotrophic rivers and perhaps for this reason is becoming rarer in Denmark because of increasing eutrophication. This species has not been found in Norway since 1946 (Aagaard et al. 1987). The larvae I found in 1987 were also collected in two markedly oligotrophic rivers in central Norway, Lundesokna and Holvasselva (Traaen et al 1988, Arnekleiv et al 1988). These rivers are both low in alkalinity, pH and total phosphorous. They are also strongly humic. Lundesokna has a characteristic algal composition that indicates acid water (Traaen et al 1988). Research needs to be done to uncover more details of the biology of *C. silfvenii.*

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Records of Stratiomyidae (Diptera) from South-Eastern Norway, with som notes on the species

MORTEN FALCK AND LITA GREVE

Falck, M. and Greve, L. 1990. Records of Stratiomyidae (Diptera) from South-Eastern Norway, with som notes on the species. *Fauna norv. Ser. B. 37:* 101—104.

Records are given on the distribution of species of the family Stratiomyidae from the South-Eastern part of Norway, and notes concerning the biology of *Microchrysa polita* (L.) and *Odontomyia argentata* (Fabricius). The single record of *Clitellaria ephippium* (Fabricius) from Norway is commented on, and an additional record of *Nemotelus uliginosus* (L.) is given.

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Since Rozkošný (1973) published his survey of the Stratiomyidae of Fennoscandia and Denmark, the Norwegian fauna has been treated in several papers by Greve, Fjeldså & al. (see reference list). Several new species have been added to the Norwegian list. Thus the Stratiomyidae is one of the better studied families of Norwegian flies. Still our knowledge of the distribution of the species is far from complete, and there probably remains new species to be recorded within the country.

The following records add to our knowledge of the Norwegian distribution of the family. During our work on this family we reviewed the collection of Museum of Zoology, University of Oslo, mostly consisting of material from the 19th century. This resulted in some additional records and one clarifying comment on the records given in Rozkošný (1973).

The material is deposited either in the collections of Museum of Zoology, University of Bergen (ZMB), Museum of Zoology, University of Oslo (ZMO), or the private collection of Morten Falck (MF).

Beris chalybata (Forster, 1771)

The ZMO collection contains one specimen, labelled «Linderud 3/7 47» and «Siebke». No other records from Oslo have been published so far. The species has been taken several places in the Oslo region: AK Oslo: Trasop EIS 28 6 June 1968 1 female; Østensjøvann 29 May 1984 1 male; Hengsenga 24 June 1986 1 male; Kværner 14 June 1988 1 male 1 female; Lutdalen 19 June 1988 20 females; AK Eidsvoll: Dal EIS 37 9 June 1973 1 female (MF); AK Bærum: Ostøya EIS 28 Malaise trap A 30 May—10 June 1984 1 female, Malaise trap B 30 May—10 June 1 female, 10 June—1 July 1984 1 female; Malaise trap C 10 June—1 July 1984 1 female; 2 June 1984 1 female netted, June 4th 1988 1 male netted. BØ Hurum: Tofte EIS 28 Malaise trap 2—17 June 1985 7 females, 17 June—17 July 1985 9 females (ZMB); OS Øyer: Tretten EIS 54 11 June 1984 1 male (MF).

The species is new to BØ and OS. The Malaise trap at Tofte was run from 13 May 1985 till 1 September 1985, and was emptied 6 times. For description of the Malaise traps at Håøya and Ostøya, see Greve & Midtgaard (1986).

The 20 specimens from Oslo: Lutdalen were caught in a Malaise trap placed on a small meadow in a coniferous forest mixed with deciduous trees, with a rich vegetation of flowers and shrubs. These records seem to indicate that the species is not rare in the Oslo region.

Beris clavipes (L., 1767)

VE Tjøme: Sandøy EIS 19 2 June 1965 1 male (ZMB). AAY Grimstad: Fevik EIS 6 June 28th 1983 1 male. (MF)

Beris clavipes is new to VE and AAY. It must be considered a common species in Norway.

Beris fuscipes Meigen, 1820
OS Ringebu: Tollmoen EIS 63 7 July 1985 1 female (MF). The ZMO collection contains one female specimen from ON Dovre: Toftemo (EIS 71) July 6th 1873, leg. Siebke, Soot-Ryen det.

The only published records from Norway are from NNØ, TRY and FI, so these two finds from Oppland county are the first records from southern Norway.

Microchrysa cyaneiventris (Zetterstedt, 1842)
AK Frogn: Håøya EIS 28 Malaise trap A 3—16 June 1984 1 female; Malaise trap B 16—27 June 1984 1 female; AAY Birkenes: Sennumstad EIS 6 Malaise trap 25 June—6 August 1986 1 female (ZMB).

These are the first records of *M. cyaneiventris* from AK and AAY, and the first records from South-Eastern Norway. Hitherto *M. cyaneiventris* has only been recorded from western Norway (Greve 1980). Based on recently collected material *M. cyaneiventris* is probably not very rare in southern Norway.

Microchrysa flavicornis (Meigen, 1822)
Ø Halden: Fredrikshald (= Halden) EIS 20 1 female (ZMO); BØ Røyken: Hyggen, Kinnertangen 28 July 1986 1 male (ZMB). These are the first records from Ø and BØ.

Microchrysa polita (L., 1758)
In addition to 17 records from AK (MF) there are the following records: Ø Skjeberg: Ullerøy EIS 20 Light trap 28 July 1980 1 female; BØ Hurum: Tofte EIS 28 Malaise trap 2—17 June 1985 1 female, 17 June—17 July 1985 4 females, AAY Iveland: Grosaas EIS 5 Malaise trap 6—22 July 1982 4 females; (ZMB) AAY Grimstad: Vessøya EIS 6, 29 June 1978 1 male and 25 June 1983 1 female (MF); AAI Bygland: Kleivvollen EIS 9 Malaise trap 6—22 July 1982 1 female (ZMB); TEY Bamble, Langesund, Steinvika EIS 11 12 July 1986 1 female, and TEI Kviteseid EIS 17 18—21 June 1988 Light trap 1 female (ZMB).

Microchrysa polita is new to BØ, AAY and AAI. It has been recorded from Ø by Ardø (1957), not included in Rozkošný (1973). This is certainly the most common Norwegian Stratiomyidae species, reaching as far north as Alta in Finnmark county, and in southern Norway ascending to an altitude of 740 m above sea level (HOI, Øvre Eidfjord: Eidfjord).

The records seem to indicate that this species is tied to gardens, farmland, meadows, deciduous forest glades, hedgerows, etc. It is commonly found on the sunny leaves of deciduous trees and shrubs, often in numbers. Also it has been found in tufts of grass, on meadows in fairly open surroundings, and in dry fields of grass with *Ranunculas, Rumex, Polygonum, Hieracium* in addition to heather and mosses (Eidfjord). This seems to indicate that the species is able to survive in a great variety of biotopes. According to Rozkošný (1982) «the larvae have been bred from dung, various kinds of decaying organic material, rotting grass, garden refuse, compost, soil beneath moss on old tree-trunks, etc.» There is so far no record from purely coniferous forest localities.

Sargus flavipes Meigen, 1822
Syn. *S. splendens* Meigen, 1804 (Rozkošný, (1973)
Ø Halden: Prestebakke EIS 12 Malaise trap 30 June—28 July 1986 1 female; BØ Hurum: Tofte Malaise trap 8 August—1 September 1985 1 female; VE Sem: Sem EIS 19 11 August 1968 2 males; TEY Porsgrunn: Åsstranda 15—20 September 1983 1 male; TEI Kviteseid: Kviteseid Light trap 24—29 July 1988 1 male; AAI Iveland: Grosås EIS 5 Malaise trap 21 July—6 August 1982 1 female (ZMB).

Sargus rufipes Wahlberg, 1854
Ø Halden: Prestebakke EIS 12 Malaise trap 9 June—30 June 1986 1 female; AK Frogn: Håøya EIS 28 Malaise trap A 19 May—3 June 1984 2 females; Malaise trap B 19 May—3 June 1984 1 female; 3—16 June 1984 2 females (ZMB); AK Bærum: Kjaglidalen EIS 28 7 June 1988 1 male; AK Asker: Semsvann EIS 28 14 June 1989 2 females (MF); BØ Hurum: Tofte EIS 28 Malaise trap 2—17 June 1985 3 females; BV Rollag: Rollag EIS 35 30 May 1984 2 females: AAY Birkenes: Sennumstad EIS 6 21 May—25 June 1986 1 female; 25 June—6 August 1986 4 females; HOI Granvin: Granvin EIS 41 Malaise trap 28 May—16 June 1 female (ZMB).

The two *Sargus* species mentioned here can only be safely determined after examining the genitalia. On some occasions the species have been found on the same locality, viz. Ø Halden: Prestebakke and BØ Hurum: Tofte. *S. rufipes* seems to have an early flight period in south-eastern Norway, while *S. flavipes* has been caught in the late part of the summer and in the autumn. *S. flavipes* is new to BØ, VE, TEI and AAI. *S. rufipes* is new to Ø, AK, BØ, BV, AAY and HOI. The records indicate that this species, which has earlier been recorded from ON, NSI, TRY and TRI, is probably not rare in Norway. See also Greve and Straumfors (1988).

Odontomyia argentata Fabricius, (1794)
The species was recorded as new to the Norwegian fauna by Greve and Midtgaard (1985), one female specimen only. One of the authors have the following records: AK Oslo: Østensjøvann EIS 28 20 May 1984 1 male; 18 May 1985 3 males 1 female; 2 June 1986 3 males; 15 June 1986 1 female; 7 May 1987 2 males; Loelva at Tveita 22 May 1984 1 female; 18 May 1985 12 males (MF).

The dates varying from may 7 till June 15 with the peak in the later half of May, this is a spring and early summer species. Lake Østensjøvann is a hyper-eutrophic lake with a maximum depth of 3 metres, known for its rich fauna and flora. *O. argentata* was taken in the Northern end of the lake, the females resting on the twigs of flowering Salix, and also visiting the catkins, the males swarming above the bushes.

The river Loelva (Alna) is a meandering stream flowing through a flat, clay-rich meadow at the foot of the Tveita hill. Here the males were swarming above a quiet, isolated meander rich in plant debris, with flowering Caltha palustris and flowering Salix bushes on the banks. On all the occations the weather was warm and sunny.

The striking difference in numbers between the sexes is much due to the swarming habits of the males (the male specimens from Loelva beeing a swarm), making them easier to catch than the females.

When disturbed, the flies take to a very rapid flight. In spite of several searches during May 1989 the species was not observed, neither at the Østensjøvann nor the Loelva localities. This may indicate fluctuations in population densities from one year to another.

Odontomyia hydroleon (L., 1758)
HES: Ringsaker: Helgøya EIS 45 July 1849 (ZMO). This old record was not included in Rozkošný (1973) and *O. hydroleon* is thus new to HES. We have not seen material of this species caught recently in Norway.

Stratiomys singularior (Harris, 1776)
Synonym: *Stratiomys furcata* (Fabricius, 1794) Rozkošný, 1973. VE Tjøme: Mostranda EIS 19 4 July 1985 4 males, 1 female, 5 July 1985 1 female, 6 July 1985 3 males; 10—20 July 1985 1 female; 14—17 July 1986 1 male, 1 female (ZMB).

This is the first record of *S. singularior* from VE. The species was first collected on 10 July 1981 in the neighbouring area of Moutmarka by Svein Svendsen, Kristiansand, but we have not seen his material. The specimens were mostly netted, one female was caught in Yellow water traps between 10 and 20 July 1985. These are also the only recent of this species, while there are old material from Ø Hvaler and AK Oslo in the ZMO collection. While there might well still exist populations on Hvaler, it is very doubtful indeed, if the species has survived in the Oslo city area.

Opplodontha viridula (Fabricius, 1775)
HEN Åmot: Åmot 1 female; ON Dovre: Laurgård 1 female (ZMO); VE Tjøme: Sandøy 10 July 1966 1 female (ZMB).

These are the first records of *O. viridula* from HEN, ON, and VE. In recent surveys in Vestfold province the species has not been found in the last decade, indicating that it is not common in this area.

Clitellaria ephippium (Fabricius, 1775)
According to Rozkošný (1973 and 1983) this species was recorded by Siebke (1877) and also found at a place called Fjeldotuin by professor Esmark in 1844. Siebke records this species as «In Norvegia a prof. Esmark lecta, locum namen non indicavit (sec. Siebke).» The ZMO collection contains one male specimen, labelled «Fjeldstuen juni 1844» and «Esmark». Rozkošný obviously misread the handwritten label. Accordiing to Opheim (1981) Fjeldstuen was a locality situated approximately were now is the British embassy in the western part of the city of Oslo. The correct locality thus should read: AK Oslo: Fjeldstuen. As Siebke refers to Esmark, there probably only was this one record, and the claim that Esmark did not give the locality is erroneous.

However, this peculiar species has not been found in Norway since 1844, and must be considered extinct. According to Rozkošný (1983) it has not been recorded in Denmark and Finland, and there only exists a few records from Sweden (Öland and Småland). As it is not listed in Hedström (1985, 1986), the species seems not to have been recorded in Sweden in recent years.

Nemotelus nigrinus Fallén, 1817
BØ Røyken: Røyken EIS 28 1 male (ZMO); VE Tjøme: Moutmarka EIS 19 8 July 1983 2 females; 2 July 1985 1 female; Mostranda 22 July 1982 1 female; 8 July 1983 5 females; 30 June 1985 1 female; 6 July 1985 1 female; 12—14 July 1986 1 female; TEY Porsgrunn: Sandøy EIS 19 10 July 1986 1 male 2 females (ZMB). These are the first records from BØ, VE and TEY.

Nemotelus notatus Zetterstedt, 1842
VE Sandefjord: Sørbyøya 22 June 1984 1 male (ZMB).

This is the first record from VE and the first record since Rozkošný (1973).

Nemotelus uliginosus (L., 1767)
The ZMO collection also contains one male specimen of this species labelled «Bø in Vesterålen VII.19. Münster» and «Soot-Ryen det.». This record from EIS 143 is the first from NNV.

Oxycera trilineata (L., 1767)
VE Tjøme: Mostranda EIS 19 25 June 1969 1 female; 20 July 1983 2 males 2 females; 26 July 1984 2 females; 30 June 1985 1 male; 2 July 1985 1 female; 4 July 1985 1 female; 6 July 1985 3 males 1 female; Moutmarka 15 July 1986 5 males 13 females; Mo 22 July 1982 3 males 3 males (ZMB).

These are the first records from VE. Hitherto (Rozkošný, 1973) only recorded from Oslo: Tøyen. It is doubtful if the species has survived in Oslo city area (see above, *S. singularior)*

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Notes on Norwegian Dolichopodidae (Diptera)

TERJE JONASSEN

Jonassen, T. 1990. Notes on Norwegian Dolichopodidae (Diptera). *Fauna norv. Ser. B, 37:* 105—106.

Based on previously unidentified material at the Zoological Museum, Bergen, new distributional data are given for thirteen species of Dolichopodidae. Of these, five species are reported from Norway probably for the first time. *Thrypticus paludicola* Negrobov, 1972 is established as a junior synonym of *T. intercedens* Negrobov, 1967.

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INTRODUCTION

During the winter of 1988/89 I had the opportunity of checking some of the previously unidentified Dolichopodid material at the Zoological Museum, Bergen (ZMB). This material yielded some new and interesting distributional data for Norwegian Dolichopodidae, some of which are presented below. Species marked with an asterisk are new to Norway.

The material is conserved in alcohol and is deposited at ZMB. The sequence of species largely follows C. E. Dyte's list in Kloet and Hincks (1975). Otherwise the presentation follows Jonassen (1985, 1988).

The geographical division of the districts follows Økland (1981).

SYSTEMATIC LIST

Dolichopus atripes Meigen, 1824
First recorded as Norwegian by Jonassen (1985) from RI. Since then also recorded from NTI (Jonassen & Solem in press). the collections of ZMB included specimens from HOY and SFY. There are also unpublished records from ON and RY.

**Dolichopus cruralis* Wahlberg, 1850
NSY, Bodø: Hamarbakken, Bodin, EIS 130, 8 July 1980, 1 ♂ leg. A. Fjeldså. Primarily a northern species, previously recorded from Sweden, Finland and from the Leningrad area in the Soviet Union. It has, however, recently also been captured in Czechoslovakia (Olejniček 1984). The present specimen was captured in an oligotrophic field consisting mainly of Nardus stricta and Potentilla erecta.

**Dolichopus griseipennis* Stannius, 1831
VE, Tjøme: Sandøy, Hvasser, EIS 19, 24 August 1980, 1 ♀ leg. A. Fjeldså. Distributed over much of Europe, including southern Sweden, Denmark and Great Britain. It is therefore not surprising to find it in southern Norway.

Hercostomus cupreus (Fallén, 1823)
First recorded as Norwegian by Jonassen (1985), from RY and RI. Available records suggest a strictly south-western distribution pattern in Norway, previously known only from the district of Rogaland, where it is a common species. The ZMB collections, however, include a specimen from HOI, Etne: v/Sæbø, leg. L. Greve.

Hercostomus nigriplantis (Stannius, 1831)
VE, Tjøme: Sandøy, EIS 19, 1 ♂ leg. A. Fjeldså. Previously recorded from AK only (Jonassen 1988).

**Medetera micacea* Loew, 1857
VE, Tjøme: Sandøy, EIS 19, 21 July 1984, 4 ♂♂, 3 ♀♀ leg. A. Fjeldså. Widely distributed over much of Europe, including Denmark and Sweden.

* *Medetera pseudoapicalis* Thuneberg, 1955
HOY, Bergen: Grønningen, EIS 30, 20 June 1982, 1 ♂ leg. A. Fjeldså. A species previously recorded from central and north-eastern Europe.

Thrypticus intercedens Negrobov, 1967
The ZMB collections included two specimens that fitted the descriptioon of this seemingly rare species, one male from HOY, Os: Telleviki, EIS 31?, and another male from NSY, Bodø: Skivik, Straumøya, EIS 130, both collected by A. Fjeldså.

Both specimens were captured in similar

habitats — saline coastal meadows. The Bodø locality consisted of Atriplex spp. and Juncus gerardii. This fact lead me to re-examine the one known Norwegian specimen of *Thrypticus paludicola* Negrobov (see Jonassen 1988), since this had also been captured at a similar location.

These two species have previously been separated on the basis of minor differences in the genitalia, with the tip of the hypophallus of *intercedens* split into «einen schmalen, langen, dorsalen Forsatz und einen kurzen zugespitzten ventralen Forsatz» (Negrobov 1972), while in *paludicola* the hypophallus is said to have «2 symmetrischen proximalen Spitzen» (ibid.). I found the Norwegian specimens of intercedens/paludicola to be rather ambiguous on this point, with their genitalia all seemingly exhibiting varying and transitional shapes in regards to the splitting of the «Forsatz». This observation, together with the fact that these specimens all have been captured at strikingly similar habitats, lead me to argue that *Thrypticus intercedens* Negrobov, 1967 and *T. paludicola* Negrobov, 1972 are conspecific. As a consequence, *T. paludicola* will have to be sunk as a junior synonym of *intercedens*.

Achalcus flavicollis (Meigen, 1824)
First recorded from Norway by Jonassen (1988), from AK and RY. The material from ZMB included a female of this species from VE, Tjøme: Mostranda, EIS 19, 20 July 1985, leg. A. Fjeldså.

Neurigona quadrifasciata Fabricius, 1781)
First recorded as Norwegian by Jonassen (1985), from ON. It has subsequently been found in AK. The ZMB material includes additional specimens from VE and AAY.

Campsicmemus (Ectomus) alpinus (Haliday, 1833)
Previously recorded from RI only (Jonassen 1985). A single female is present in the ZMB material from RY, Tysvær: Ognøy, EIS 13, 7 October 1981.

Chrysotimus flaviventris (v. Roser, 1840)
First recorded as Norwegian by Jonassen (1985 — as *concinnus* (Zett.)). It has also been recorded from AK. The ZMB has a number of specimens from a couple of localities in HOI, Kvam (EIS 31).

**Sciapus longulus* (Fallén, 1823)
VE, Tjøme: Mostranda, EIS 19, 10—20 July 1985, 1 ♂; Tønsberg: Frodeåsen, EIS 19, 19 July 1982, 2 ♀♀, all leg. A. Fjeldså.

ACKNOWLEDGEMENTS

My sincere thanks go to Mrs. L. Greve Jensen for sorting out the Dolichopodidae from the collections of ZMB, thus giving me the opportunity to study and the permission to publish the above material.

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The family Platystomatidae (Diptera) in Norway

LITA GREVE

Greve, L. 1990. The family Platystomatidae (Diptera) in Norway. *Fauna norv. Ser. B, 37:* 107—110.

Platystomatidae is represented with two species, *Platystoma seminationis* (Fabricius, 1775) and *Rivellia syngenesiae* (Fabricius, 1781) in Norway. *Platystoma seminationis* is not previously recorded from the Scandinavian peninsula. The distribution of both species is mapped. Comment is given on the biology of *Rivellia syngenesiae;* there is a strong indication for association with *Lotus sp.*

Lita Greve, Zoological Museum, University of Bergen Muséplass 3, N-5007 Bergen, Norway.

INTRODUCTION

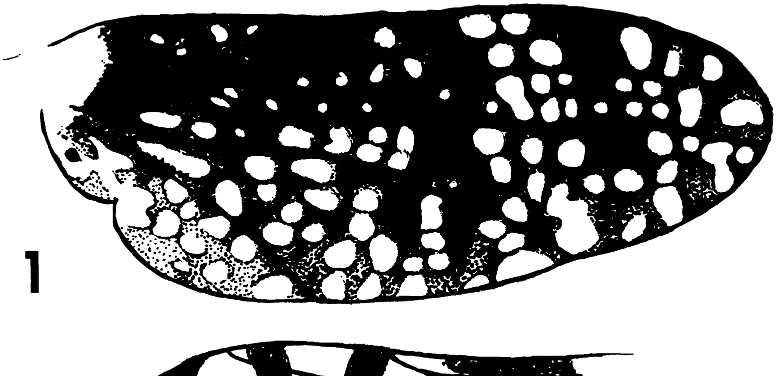
The Dipteran family Platystomatidae is closely related to the Otitidae and the Tephritidae. Approximately a thousand species of Plastystomatidae have been described on a world-wide basis; the majority occurring in the tropics of the Old World (Soós, 1984).

The fauna of NW Europe comprises only a few species, and hitherto only one species, *Rivellia syngenesiae* (Fabricius, 1781), has been recorded from Norway. Another species, *Platystoma seminationis* (Fabricius, 1775) has been found in Finland (Hackman, 1980) and in Denmark (Lyneborg, 1964) and is here recorded for the first time from the Scandinavian peninsula.

Platystomatidae are medium to small-sized flies. The head is always higher than long and the wing usually have distinct patterns.

The wing pattern of *R. syngenesiae* can be described as follows: A distal dark spot which ends just below the media, two dark bands crossing the wings from the anterior margin and ends in the cubitus and a dark basal part (Fig. 1-2). The pattern resembles somewhat species of the family Otitidae.

P. seminationis has blackish wings with rather small, white hyaline droplets spread all over (Fig. 1-1). The wing pattern resembles somewhat the pattern in some genera of the Tephritidae, but here the droplets are



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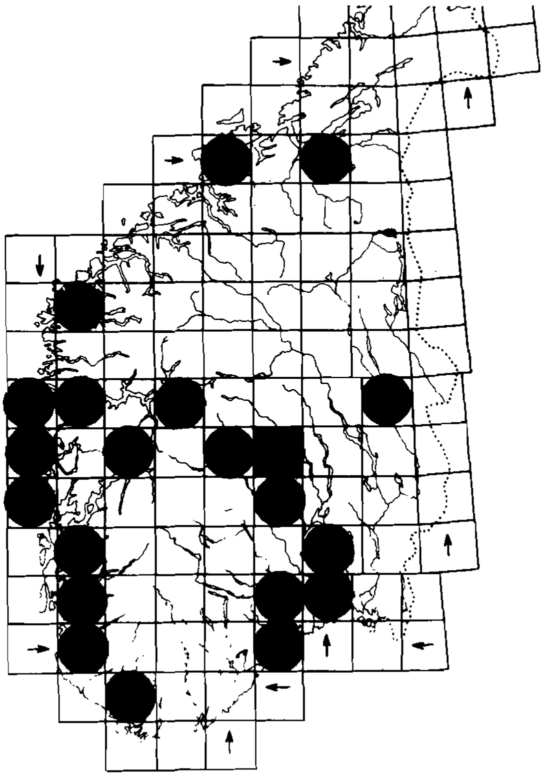

Map. 1. The distribution of Platystomatidae in Norway given as EIS — squares. *Rivellia syngenesiae* — black circles, *Platystoma seminationis* — black square.

usually larger. Aedagus is very long, at rest spirally winded as in Otitidae. Seventh tergite in the female forms an ovipository sheath.

This survey is based on all available material in Norwegian museums. Material in some private collections is included as well. All material has been examined by the author. No Norwegian material is present in major Scandinavian collections like the University museum in Copenhagen, Denmark and the University museum in Lund, Sweden. ZMO = Zoological Museum, University of Oslo. If nothing else is noted, the material is deposited in Zoological Museum, University of Bergen. The distributional records follows the revised Strand system (Økland, 1981).

SYSTEMATIC LIST

Platystoma seminationis (Fabricius, 1775)
BV, Gol: Engene EIS 44 200 m.a.s.l. 5—21 July 1982 1 ♀. This is the first record of *P. seminationis* on the Scandinavian peninsula. The specimen was taken in a Malaise trap. The locality is a flowering meadow near the farm Engene or Engjan south of Gol centre; there were many flowering *Lychnis viscaria. Ranunculus acris, Silene dioica, Viola tricolor* and *Geranium sylvaticum,* see Map. 1.

Rivellia syngenesiae (Fabricius, 1781)
Siebke (1877) recorded *R. syngenesiae* as *Ortalis syngenesiae* from two localities in Norway, viz. in AK, Oslo: Hovind and MRY, Smøla: Smøla. These specimens had been caught in June—August.

AK, 0201 Oslo: Hovind 27 June 1850 1 ♀ (ZMO). HEN, 0429 Åmot: Rena 17 July 1987 1 ♀. BV, 0817 Gol: Brenñli 16 July 1985 1 ♂; 0832 Rollag: Rollag 16 July 1985 1 ♂ 1 ♀. VE, 0922 Nøtterøy: Ekenes 21 July 1982 1 ♂; 0923 Tjøme: Kjære 18 June 1965 1 ♂ 1 ♀, Mostranda 22 July 1982 2 ♂♂ 1 ♀, 8 July 1983 21 ♂♂ 4 ♀♀, 30 June 1985 4 ♂♂ 1 ♀, 6 July 1985 8 ♂♂ 1 ♀, Moutmarka south 8 July 1983 9 ♂♂ 3 ♀♀, 20 July 1983 14 ♂♂ 2 ♀♀, Sunnane 5 July 1983 5 ♂♂ 1 ♀, Sønstegård 9 July 1983 1 ♂; 0296 Brunlanes: Brekkeseter 11 June 1988 1 ♀, Pauler 29 June 1986 1 ♂ 1 ♀ (B. Borgersen p. c./ZMB); 0927 Hedrum: Gjennes 20 June 1986 1 ♂. TEY, 1005 Porsgrunn: Porsgrunn 9 July 1982 1 ♀; 1006 Skien: Børsesjø 15 June 1981 1 specimen. AAY, 1201 Risør: Risør 22 July 1983 1 ♂; 1203 Arendal: Arendal 6 ♂♂ 2 ♀♀ (ZMO). VAY, 1404 Flekkefjord: Hidra, Osmundstø Malaise trap 21 June—3 July 1982 1 ♂, Hidra, Ysthus 14 July 1982 2 ♂♂ 1 ♀, Gyland: Store Eikås 32V LK 703724 Malaise trap 6—15 July 1982 1 ♀. RY, 1603 Stavanger: Forus 10—17 July 1985 1 ♀; 1641 Finnøy: Kirkøy 1 July 1986 1 ♀; 1642 Rennesøy: Vikevåg 6 July 1983 2 ♂♂ (T. Jonassen p.c./ZMB). RI, 1729 Forsand: Songesand 28 July 1985 1 ♂. HOY, 1801 Bergen: Korsnes, Leirvåg, 27 July 1980 1 ♀, Kyrkjetangen 25 May 1980 1 ♀, 6 June 1980 5 ♂♂ 3 ♀♀, St. Milde 1 June 1980 8 ♂♂ 4 ♀♀, 19 June 1983 11 ♂♂ 6 ♀♀, Alvøen 32V KM 901974 9 June 1985 1 ♂; 1843 Os: Øsøyri 11 June 1970 6 ♂♂ 1 ♀; 1847 Askøy: Hegreneset 22 June 1982 3 ♂♂ 1 ♀; 1863

Lindås: Hodneli 12 June 1988 2 ♂♂ 1 ♀. HOI, 1911 Etne: Holmseid 32V LN 215173 Malaise trap 8 June 1985 12 ♂♂ 6 ♀♀, v/Austreim 32V LM 300185 Malaise trap 27 June 1985 6 ♂♂ 3 ♀♀; 1931 Ullensvang: Djønno 22 May 1984 1 ♂, 5—26 June 1984 1 ♂ 1 ♀: 1032 Eidfjord: Simadalen near entrance to power station 10 August 1981 1 ♂; 1935 Voss: Mjølfjell, Solbakken 670 m.a.s. 1 July 1986. 1 specimen, observed only. SFY, 2011 Gulen: Brekke 1 July 1983 3 ♂♂ 3 ♀♀. Brekkestranda 30 June 1983 7 ♂♂ 7 ♀♀, Rutledal 1 July 1983 1 ♂ 2 ♀♀; 2043 Eid: Stårheim 32V LP 283693 3 July 1983 3 ♂♂ 7 ♀♀. SFI, 2121 Aurland: Aurland 21 July 1981 1 ♂; 2122 Lærdal: Lærdalsøyri 24 July 1981 3 ♂♂ 4 ♀♀. MRY, 2273 Smøla: Smøla 8 August 1843 1 ♂ (ZMO). STI, 2501 Trondheim: Rotvoll 21 July 1987 1 ♀.

The distribution of *R. syngenesiae* in Norway is mapped see Map. 1. The total material were 165 ♂♂ 77 ♀♀ and 2 specimens from 43 localities. There are many localities in southern Norway, few records from central and none from northern Norway. The northern border in Norway seems to be somewhere in central Norway.

Wahlgren (1919) recorded *R. syngenesiae* north to Bohuslän and Västergotland in Sweden. Later Ringdahl (1960) refers it from Skåne only.

For older Norwegian material no information of collection methods is given. Recently collected material was mostly taken with insect nets. Some specimens have also been caught in Malaise traps.

Most localities are situated in the lowlands near the coast of southern Norway. However, there are a few localities from inland areas like HEN Rena and BV Rollag. The highest altitude was Solbakken; HOI Voss, Mjølfjell near 700 m.a.s. l.

R. syngenesia is here probably at the limit of its vertical distribution, as the species has not been collected in alpine or sub-alpine regions in surveys during the last decades at Hardangervidda, southern Norway or in the Dovre mountains, central Norway.

Biotops varies from flowering meadows, wet grass meadow, road sides, sea shores and also quarries. Ardø (1951) records *R. syngenesiae* from sand-dunes. In at least 10 localities specimens has taken close to or in stands of *Lotus sp.*.

Foote (1985) records eight Nearctic *Rivellia* species from different Leguminosae species like *Amphicarpa, Robinia,* and *Aphios.* In Norway *R. syngenesiae* has often been netted in or close to the Leguminosae genus *Lotus.* The genus *Lotus* is represented in Norwegian flora with tree species. Only *L. corniculatus* L. is common in Norway, more or less continuously distributed north to Troms province (Hulten, 1971). The two other species are rare. Some material has been collected in flowering meadows — could possible be near a stand of *Lotus sp.*

I have not observed larvae or pupae on *Lotus* nodulae; actually I have not looked for them. But I think there are strong indications of *R. syngenesiae* being associated with *Lotus sp.*

ACKNOWLEDGEMENTS

I wish to thank Leif Lyneborg, Copenhagen and Roy Danielsson, Lund for information on the distribution of Platystomatidae, and Jan E. Raastad, Oslo for loan of material from Zoological Museum, University of Oslo. Bjørnar Borgersen, Østre Halsen, Terje Jonassen, Sjernarøy and Tore Randulff Nielsen, Sandnes have kindly let me examine material in their private collections. I also wish to thank Asle Bruserud, Brumunddal and Alf Jacob Nilsen, Hidra for the Malaise trap material from Engene. I am grateful to Trond Andersen for commenting upon the manuscript.

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Somatochlora flavomaculata (Van der Linden, 1825) (Odonata, Corduliidae) a new species to Norway

HANS OLSVIK

Olsvik, H. 1990. *Somatochlora flavomaculata* (Van der Linden, 1825) (Odonata, Corduliidae) a new species to Norway. *Fauna norv. Ser. B, 37:* 111—112.

Somatochlora flavomaculata was recorded in Norway twice in 1989; on June 23 at Kjennertjernet, Rakkestad in Østland county and July 26 at Holetjern, Ski in Akershus county. The species is new to the Norwegian fauna.

Hans Olsvik, Bru, N-1404 Siggerud, Norway.

INTRODUCTION

In Scandinavia *Somatochlora flavomaculata* is recorded only from Sweden, where it has two distribution areas, one in the southern part of the country, north to the Göteborg district at the western coast and north to Stockholm including Öland and Gotland at the eastern coast. The other area is situated in Norrbotten near the Finnish border (Sandhall 1987). The species seems to be missing between these two distribution areas. According to Sahlén's (1985) distribution maps the species may be found north to the south-eastern coast of the lake Vänern. The distance between this area and the Norwegian border is less than 150 kilometers. Some of the rivers running into Vänern have parts of their drainage area in southeastern Norway, and Sømme (1937) supposed that *S. flavomaculata* one day would be discovered in this part of Norway also. Sømme himself did not find the species, despite quite intensive investigations. Tjønneland (1952) drew attention to the fact that The Royal Norwegian Museum of Sciences and Letters in Trondheim possessed a specimen of *S. flavomaculata* labelled «?Lyngdal C. D.» (in Aust-Agder), but he did not consider the species as Norwegian, because no journal was found which could explain C. Dons' questionmark.

THE RECORDS

On June 23 1989 the author visited Kjennertjernet in Rakkestad (Østfold (Ø): EIS 20, UTM 32V PL 306 833, 118 m a.s.l.). Here a corduliid dragonfly was discovered, diverging from other Norwegian species both in colour, shape and behaviour. After several unsuccessful attemps to catch the specimen, all the details needed for the identification had been discovered, like yellow spots on the thorax and abdomen. This showed that the specimen was a male of *S. flavomaculata.*

The second record was made on July 26 1989 at Holetjern in Ski (Akershus (AK): EIS 28, UTM 32V PM 073 299, ca. 130 m a.s.l.). Here a *Somatochlora* sp. was observed hunting over the reed-bed, with a behaviour quite diverging from the other *Somatochlora's* at the locality. The same or a second specimen was caught about 30 minutes later. This was a *S. flavomaculata* male, the first Norwegian proof of the species, now preserved in the author's collection.

DESCRIPTION AND BIOLOGY

S. flavomaculata belongs to the family Corduliidae, a group of green metallic medium-sized dragonflies, counting one species of the genus *Cordulia* and three *Somatochlora* species previously recorded in Norway. *S. flavomaculata* can easily be recognized by the yellow spots laterally on the abdomen. The spots are larger and better visible in the female than in the male, in older males the spots can be so small and inconspicuous that determination without having the specimen in the hand or in close view is difficult.

Concerning the biology, Askew (1988) writes: «Found near small ponds, marshes, boggy meadows, dikes and ditches, usually at

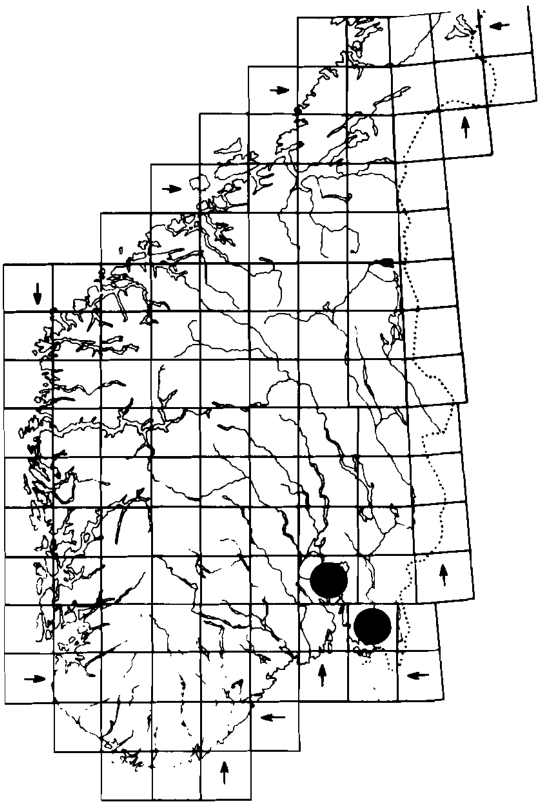

Fig. 1. The distribution of *Somatochlora flavomaculata* in Norway.

low altitude and often in rich, cultivated land. *S. flavomaculata* seldom flies over open water, frequenting instead reed-beds and rank vegetation in ditches and woodland ridges and clearings. Its flight is less rapid than of other species of *Somatochlora*». The males of the two most common green metallic dragonfly species in southeastern Norway fly almost entirely along the margins of lakes, tarns, canals and slow-flowing water courses. A *Somatochlora* flying and patrolling over the vegetation in the surroundings of a pond or a tarn, not over the open water, at lowland sites in southeastern Norway, may therefore be a *S. flavomaculata.*

DISCUSSION

Whether *S. flavomaculata* is a species breeding in Norway or just a migrator, is still an open question, because both specimens observed here were males, and they were both rather worn. The Rakkestad specimen had also, while flying, the distinctive sound of a dragonfly with worn wings. This may indicate that they had flown quite a distance or that they were relatively old specimens. The weather was warm and nice in Scandinavia for long periods in June 1989, and southern and southwestern winds predominated in this period. The habitats which *S. flavomaculata* prefers are in such cases exposed to water level reduction, which may possibly release a migration instinct. This may indicate that these specimens were migrators. The distance to the nearest record of the species in Sweden is less than 200 kilometers, which is only a small distance for a dragonfly on migration. Although there are no evidence or documentation of migratory activity by *S. flavomaculata* in the literature read by the author, such a behaviour can not be overlooked.

No new information which can explain C. Dons' questionmark concerning the record in Lyngdal has turned up. Though Dons collected some dragonflies in Lyngdal between 1916 and 1920, the record must still be regarded as too uncertain.

Before further records are made, *S. flavomaculata* must probably be looked upon as a migratory guest species, so far not established in Norway.

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I wish to thank Ove Bergersen for valuable field assistance and Oddvar Hanssen for information about the collection of the Museum in Trondheim.

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