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Semiaquatic fly (Diptera, Nematocera) fauna of fens, springs, headwater streams and alpine wetlands in the northern boreal ecoregion, Finland

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Abstract. Semiaquatic fly (Diptera, Nematocera: Tipuloidea, Ptychopteridae, Psychodidae, Dixidae, Thaumaleidae, Pachyneuridae) fauna of 36 northern boreal wetlands was studied. The studied sites differed in their habitat characteristics and geographical location. Both Malaise traps and sweep netting during one field season were used to collect nematocerans. Number of species per site ranged from 6 to 56, and in rarefaction-standardised samples from 2.7 to 27.5. The studied sites were classified by Cluster analysis, and differences in the assemblage structure were assessed by MRPP test and Indicator Species Analysis. North – south gradient, trophic status, influence of groundwater and presence – absence of flowing water were probably the most important environmental variables influencing the nematoceran community structure. Rich aapa mires situated in the southern subzone were characterized by bimodal peak of abundance of adult flies (June, August) and the highest number of species was found in August. Combining material from all sites, the number of individuals was highest in August and the number of species in July. Three craneflies new for Finland and several rare, insufficiently known and possibly threatened species were found. Male of *Dicranomyia moniliformis* Doane (Limoniidae) is redescribed and female vaginal apodeme of *Paradelphomyia nigrina* (Lackschewitz) (Limoniidae) is illustrated.
Key words: Lapland, aapa mires, palsa mires, Conservation areas, Limoniidae, Tipuliidae, Pediciidae, Cylindrotomidae, Ptychopteridae, Psychodidae, Dixidae, Thaumaleidae, Pachyneuridae, species richness, community structure, faunistics, phenology, collecting.

Soiden, lähteiden, latvapurojen ja tunturikosteikkojen sääskilajisto (Diptera, Nematocera) Suomen pohjois-boreaalisella kasvillisuusvyöhykkeellä

Lyhennelmä. Semiakvaattista sääskilajistoa (Diptera, Nematocera: Tipuloidea, Ptychopteridae, Psychodidae, Dixidae, Thaumaleidae, Pachyneuridae) tutkittiin 36 pohjois-boreaalisella kosteikolla. Tutkitut kohteet erosivat elinympäristöiltään ja maantieteellisiltä sijainneiltaan. Sekä Malaise-pyydyksiä että kenttähaavintaa käytettiin sääskien keräämiseen yhden maastokauden aikana. Lajimäärä kohteiden välillä vaihteli kuudesta 56:een ja rarefaktiolla standardisoiduissa näytteissä lajimäärä vaihteli välillä 2.7 ja 27.5. Tutkimuskohteiden luokitteluun käytettiin Cluster-analyysia, ja lajistollisia eroja luokiteltujen ryhmien välillä arvioitiin MRPP-testin ja Indikaattorilajianalyysin perusteella. Pohjois – etelä gradientti, ravinteisuusluokka, pohjaveden vaikutus ja virtaavan veden esiintyminen tai poissaolo olivat todennäköisesti keskeisimmät sääskien yhteisörakenteeseen vaikuttavat tekijät. Ravinteisilla aapasoilla, jotka sijaitsivat Perä-Pohjolan kasvillisuusvyöhykkeellä, sääskien esiintymisen runsaus oli kaksihuippuinen (kesä- ja elokuu), lajimäärä oli suurimmillaan elokuussa. Yhdistetyn aineiston perusteella sääskien yksilömäärä oli suurimmillaan elokuussa ja lajimäärä heinäkuussa. Kolme vaaksiaista oli Suomelle uusia, sekä useita harvinaisia, puutteellisesti tunnettuja ja mahdollisesti uhanalaisia lajeja löydettiin. Lajin *Dicranomyia moniliformis* Doane (Limoniidae) koiras on kuvattu uudelleen ja lajin *Paradelphomyia nigrina* (Lackschewitz) (Limoniidae) naaraan vaginaalinen apodeemi on piirretty.
Avainsanat: Lappi, aapasuot, palsasuot, luonnonsuojelualueet, Limoniidae, Tipuliidae, Pediciidae, Cylindrotomidae, Ptychopteridae, Psychodidae, Dixidae, Thaumaleidae, Pachyneuridae, lajimäärä, yhteisörakenne, faunistiikka, fenologia, keräysmenetelmät.

Contents

1. Introduction

Semiaquatic flies have been denoted to certain nematoceran (Diptera) families, in which majority of the species dwell in moist or semi-terrestrial environments (Salmela 2004, 2006, Salmela *et al*. 2007). Craneflies (Limoniidae, Pediciidae, Tipulidae, Cylindrotomidae), phantom craneflies (Ptychopteridae), moth flies (Psychodidae), meniscus midges (Dixidae) and trickle midges (Thaumaleidae) occur in a vast array of biotopes in the boreal region, from terrestrial to aquatic. The species number of Finland in these families now stands for 399, numerous species have been recently (in 2000's) found as new for the regional fauna, even in relatively better known groups such as craneflies (Figure 1). Further, two families with one species in each (Pachyneuridae, Pleciidae) have been taken in to account if present in samples. Semiaquatic fly families have been poorly known and neglected in Finland, despite their large size (craneflies) and marvellous abundance (e.g. craneflies, moth flies) in certain biotopes. Earlier studies dealing with these flies (mainly Tipuloids) have been taxonomic and faunistic in their scope (e.g. Lundström 1907a, 1907b, Lundström & Frey 1916, Mannheims 1954, 1967a, Tjeder 1963a, 1965, 1969a, Siitonen 1984, Viramo 1992), ecological studies with quantitative sampling have been almost totally lacking. Notable exception is, however, the mire investigation by Krogerus (1960), which, among other things, provides an opportunity to compare species composition and diversity of flies in mires differing in their trophic status. [Referring to Krogerus (1960), it should be mentioned that in most cases it is impossible to ascertain the exact locality of a given species and further, due to the lack of deposited specimens, identities of most species are not possible to verify.] Semiaquatic flies have been studied by the author from the beginning of 2000's, (e.g. Salmela 2001, 2003, 2004, Salmela & Ilmonen 2005, Salmela *et al*. 2007) with a serious attempt to answer the following questions: which species occur in Finland, what are their ranges, where they live and what kind of assemblages they indicate (Salmela 2006). Hopefully it will be possible to evaluate the red-list status for most of the semiaquatic nematoceran flies in Finland by 2010, although trends in their population sizes and changes in distribution areas are currently impossible to observe.

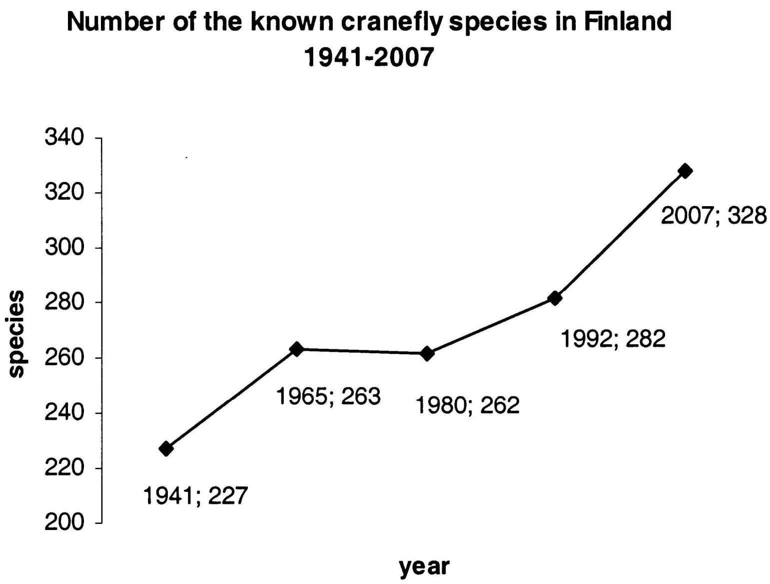

Figure 1. Number of the known cranefly (Diptera, Tipuloidea) species in Finland 1941-2007. Based on Frey *et al.* (1941), Mannheims (1965a, 1965b), Hackman (1980), Oosterbroek and Theowald (1992), Savchenko *et al.* (1992), Soós and Oosterbroek (1992) and J. Salmela (unpublished). Some tipulids and limoniids reported by Oosterbroek and Theowald (1992) and Savchenko *et al.* (1992) which have not been found from Finland (see Salmela 2006) were omitted from the figures. Recent (2000-2007) growth in the number of Finnish cranefly species is due to large sampling effort in semiaquatic and terrestrial environments.

One of the general rules in ecology is that species richness declines with increasing latitude (Begon *et al.* 1996). This is also true for craneflies, although their proportion among total insect diversity becomes higher along latitudinal gradient (Brodo 1990). As one proceeds farther north, in to the arctic, craneflies may attain enormous densities and their role in ecosystem processes (foodwebs, nutrient cycling) is highly important (Brodo 1990). Studies dealing with northern boreal or arctic craneflies have been mainly faunistic and taxonomic (e.g. Alexander 1922, Lackschewitz 1936, Tjeder 1970, 1963b, Brodo 1987) and according to Brodo (1990) ecology, distribution and community structure of high latitude craneflies are not well known. However, life cycles and growth (Hofsvang 1972, MacLean 1973) of certain species have been studied and Oosterbroek *et al.* (2007) provide a good review on the ecology and distribution of the species found from Greenland.

In the pioneer publications of the Finnish craneflies, Lundström (1907a, 1907b, 1912, Lundström & Frey 1916) listed and described species all from over Finland, including flies collected from northern regions. These flies from the northern boreal zone (Finnish Lapland, Kola Peninsula) were mainly collected by J. Sahlberg and R. Frey and are deposited in the Zoological Museum, University of Helsinki (MZH). Krogerus (1960) collected arthopods from mires in Ks: Kuusamo, northern boreal region, but his northernmost localities were in Sweden, Abisko area. Cranefly species collected within 1959-1963 from the province of Le, NW Lapland, were gathered by Mannheims (1972), and Siitonen (1984) enumerated tipuloids noted from the Inari Lapland. In addition to the publications mentioned above, northern craneflies of Finland have been rather superficially treated in a number of taxonomic studies (Mannheims 1963, 1967a, 1967b, Tjeder 1963a, 1965, 1969a, 1972, Brodo 1987). In Sweden the situation is not much better, although information provided by Tjeder (1958, 1959) has been very helpful for the students of northern craneflies. Otherwise, only faunistic and taxonomic papers enumerating craneflies collected from Swedish Lapland have appeared, with scattered notes on their phenology and habitats (e.g. Zetterstedt 1838, Tjeder 1951, 1969b, 1974, 1979, Mendl 1974, 1979). Norway, compared with Sweden and Finland, hosts perhaps the least known cranefly fauna, although important studies on the communities of craneflies along altitudinal gradient were performed in 1980's (Mendl *et al*. 1987, Solem & Mendl 1989) and Brodo (1995) listed and discussed species she collected from the alpine Finse area, South Norway. Further, ecology of tipulid larvae was studied in 1970's by Hofsvang (e.g. 1972, 1979) and Mendl (1984) reported limoniids and pediciids from the Varanger area, North Norway. Studies and notes incorporating other semiaquatic fly families in northern Scandinavia have been very few (e.g. Peus 1936, Berdén 1954, Georges 1961, Nielsen 1965, Vaillant 1967, Andersen & Håland 1995, Salmela 2003).

To conclude, detailed and quantitative nematoceran studies of northern Fennoscandian wetlands have been scarce or totally lacking. Thus, the main goals of the present study were to (i) improve the knowledge of the distribution and ecology of semiaquatic flies in the northern boreal zone, (ii) investigate patterns in the number of species and assemblage structure in localities differing in their habitat type and latitude and (iii) observe temporal succession of the species and their abundance during the collecting season. Further, one purpose was to collect good quality data for the forthcoming red-list assessment of the Finnish fauna. As emphasised in the announcement of the second international Tipulomorpha congress (Dufour 1997, p. 134), craneflies can be a very promising group for biodiversity site evaluation and habitat monitoring. Thus, one objective of this study is to provide background for the development and application of such biomonitoring purposes.

As noted by Rydin and Jeglum (2006), mire terminology in Fennoscandia has been diverse and sometimes confusing due to the national schemes describing mires and their characteristics instead of international concensus. In order to avoid confusion, and to advice readers not familiar with boreal peatlands, some concepts which are used in the text are shortly defined in the following (mainly based on Lindholm & Heikkilä 2006, Rydin & Jeglum 2006): *Aapa mires* are boreal, large patterned fens dominated by minerotrophic vegetation; *Palsa mires* occur in regions of discontinuous permafrost. These are characterised by palsa hummocks (frozen core, may be several meters high, covered by bog vegetation) and water-filled depressions; *Pounikko mires* are thin-peated, mire marging site types, hummocks in these mires are formed by ground frost, which does not melt every year, and covered by dwarf birch (*Betula nana*) and *Salix* thickets; *Fens* are sparsely wooded or open, minerotrophic mires; *Bogs* are ombrotrophic mires, usually wooded; *Flarks* are elongated, wet or waterlogged depressions in fens usually bordered by *Strings*, which are ridges characterised by lawn and hummock level vegetation; hummock – mud-bottom series refers to the depth of the water table from the ground surface, *Hummock* level being highest (dryest) from the water level (20-50 cm, shrubs dominate), followed by *Lawns* (5-20 cm, graminoids dominate), *Carpets* (below 5 to above 5 cm, mosses dominate) and *Mud-bottoms* (inundated, horizontally growing mosses); *Poor-rich* gradient refers to the pH value and cation concentration, which are both higher toward the rich end, similar to *Oligotrophic*, *Meso(eu)trophic* and *Eutrophic* series; *Helocrenes* are springs with emerging groundwater percolating through a moss carpet and *Rheocrenes* are springs where groundwater forms a spring-brook with minerogenous bottom.

2. Material and methods

2.1. Study area and study sites

The present study was performed in North Finland, within latitudes of 67°30' – 70°00'N, northern boreal ecoregion (Figure 2). Study sites were distributed in the municipalities of Kittilä (biogeographical province of Lkoc), Enontekiö (Le), Inari and Utsjoki (Li). Study sites 1-10 (Table 1, Figure 2) were part of the southern subzone, where mean annual temperature is around -1°C – -2°C, length of the thermal growing season about 120 days and mean annual precipitation around 450 mm; snow covers open ground for about 210 days each year. Sites number 11-14 and 19-21 were located in the middle subzone, below tree line, where Scots pine (*Pinus sylvestris*) is the dominating coniferous tree and Norway spruce (*Picea abies*) is becoming less abundant or absent. Mean annual temperature is around -2°C, length of thermal growing season 110-120 days, mean annual precipitation 400-450 mm and annual snow covers open ground about 210-220 days. Sites number 15-18 and 22-36 belong to the subalpine subzone, where pine is scarce or absent and birch (*Betula pubescens* ssp. *czerepanovii*) forms the tree line. Open fell areas above the tree line are called oroarctic vegetation zones. In these northernmost sites, mean annual temperature ranges from -2 to -3, length of thermal growing season from 110 to 100 days, mean annual precipitation from 400 to 450 mm and annual snow cover on open ground from 210-220 days (Atlas of Finland 1987, Tikkanen 2006).

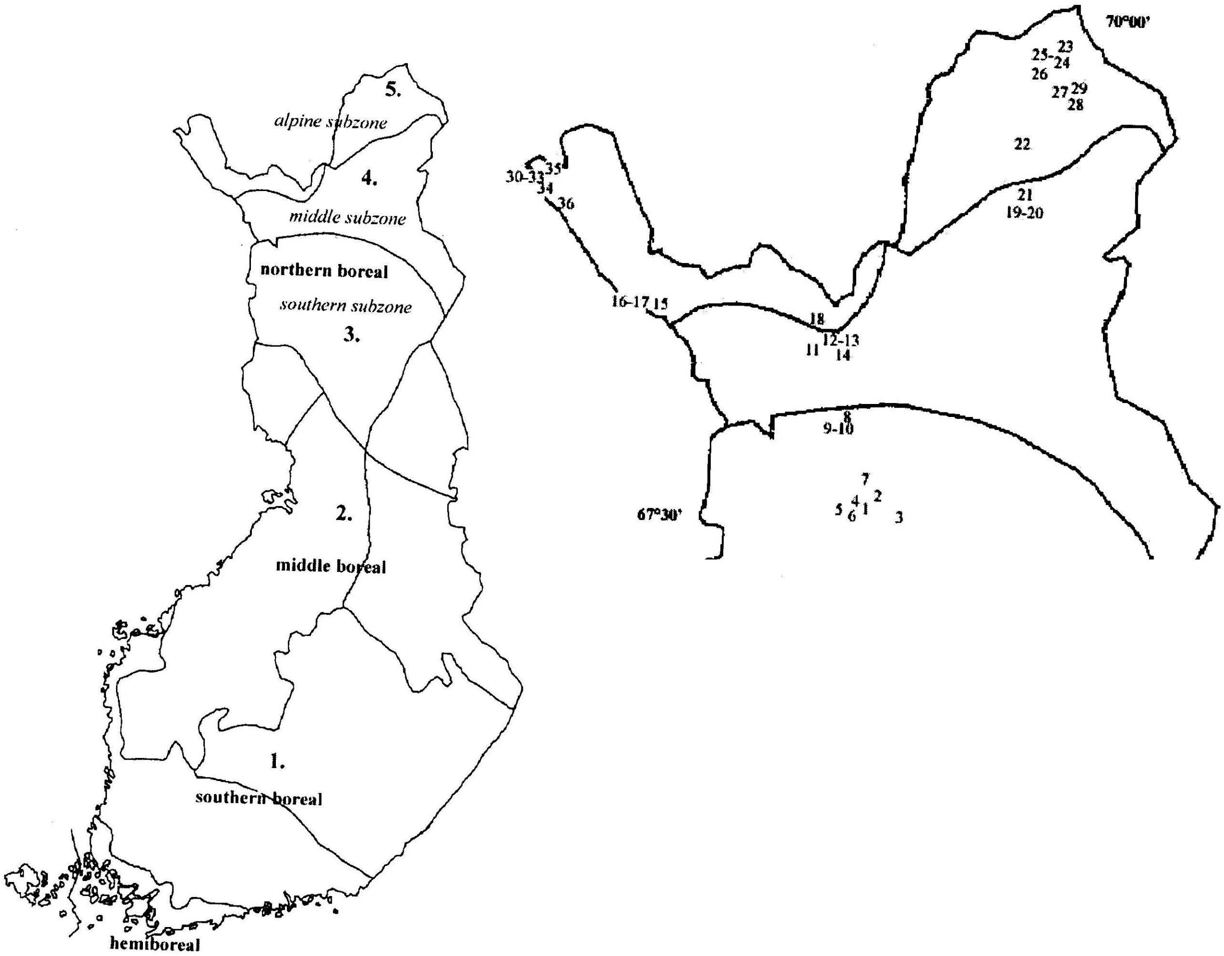

Figure 2. Left: Ecoregions or vegetation zones in Finland (modified after Ulvinen *et al.* 2002). 1=hemiboreal and southern boreal, 2=middle boreal, 3=northern boreal, southern subzone, 4=northern boreal, middle subzone, 5=northern boreal, subalpine subzone. Right: Location of the study sites in the northern boreal region, numbering refers to Table 1.

Table 1. Study sites in the northern boreal ecoregion, their location (province, municipality, latitude, longitude, altitude) and a short description of the habitat.

prov.[1]	munic.[2]	nr.[3]	study site	N[4]	E[5]	habitat	m a.s.l.
Lkoc	Kittilä	1	Taljavaaranvuoma 1	7499996	3430567	rich birch fen	200
Lkoc	Kittilä		Taljavaaranvuoma 2	7499946	3430468	rich birch fen	200
Lkoc	Kittilä	2	Vuotsonperänjänkä	7504140	3434091	rich fen	225
Lkoc	Kittilä	3	Silmäsvuoma	7500276	3438175	flark rich fen	200
Lkoc	Kittilä	4	Akaharamanvuoma 1	7501642	3427799	oligotrophic fen	200
Lkoc	Kittilä		Akaharamanvuoma 2	7501653	3427992	mesoeutrophic flark fen	200
Lkoc	Kittilä		Akaharamanvuoma 3	7501639	3428200	pine rich fen	200
Lkoc	Kittilä	5	Repsuvuoma	7503397	3413595	flark rich fen	180
Lkoc	Kittilä	6	Vasanvuoma 1	7500656	3423620	flark rich fen, rusty	180
Lkoc	Kittilä		Vasanvuoma 2	7500635	3423472	rich birch fen	180
Lkoc	Kittilä	7	Nunaravuoma	7513450	3430391	oligotrophic sedge fen	210
Lkoc	Kittilä	8	Kielisenpalo 1	7549659	3419251	eutrophic spring	205
Lkoc	Kittilä		Kielisenpalo 2	7549573	3419292	eutrophic spring fen	205
Lkoc	Kittilä	9	Vielmakoskenpalo NW 1	7548369	3418577	flark rich fen	200
Lkoc	Kittilä	10	Vielmakoskenpalo NW 2	7548460	3418563	spruce rich fen	200
Lkoc	Kittilä	11	Siettelonvuoma	7585224	3401995	mesoeutrophic spring	345
Lkoc	Kittilä	12	Palontaustanlampi N	7585522	3407929	mesoeutrophic spring fen	370
Lkoc	Kittilä	13	Palontaustanlampi NE	7585455	3408698	oligotrophic sedge fen	370
Lkoc	Kittilä	14	Narkivaara NE	7584693	3409932	rich sloping fen	335
Le	Enontekiö	15	Jietanasvuoma 1	7602993	3319343	mesotrophic flark fen	330
Le	Enontekiö		Jietanasvuoma 2	7602509	3319103	mesotrophic flark fen	330
Le	Enontekiö	16	Hietajänkkä 1	7607251	3310059	oligotrophic flark fen	335
Le	Enontekiö	17	Hietajänkkä 2	7606142	3311820	oligo-mesotrophic flark fen	335
Le	Enontekiö	18	Suttijärvi	7593955	3402921	mesoeutrophic spring	320
Li	Inari	19	Hanhijänkä 1	7674202	3505212	mesotrophic flark fen	185
Li	Inari	20	Hanhijänkä 2	7673862	3505189	mesoeutrophic spring fen	185
Li	Inari	21	Pierkivaaranjänkä	7681322	3509370	flark rich fen	170
Li	Inari	22	Perunmammarinjänkä	7703722	3509753	palsa mire, rich fen	235
Li	Utsjoki	23	Galddasjohka 1	7755514	3531820	brook, rich riparian vegetation, seepage	200
Li	Utsjoki	23	Galddasjohka 2	7753812	3531280	brook, rich riparian vegetation, seepage	225
Li	Utsjoki	25	Galddasduolbbas 1	7753741	3529780	palsa mire, mesotrophic fen	290
Li	Utsjoki	26	Galddasduolbbas 2	7753878	3529957	palsa mire, mesoeutrophic fen	290
Li	Utsjoki	27	Aksonjunni E	7740974	3531949	eutrophic spring fen	345
Li	Utsjoki	28	Buolbmatgeasjavri SE	7736725	3535800	brook, rich fen vegetation, sloping fen	250
Li	Utsjoki	29	Skalvejavri W	7741630	3534159	snow bed, brook	290
Le	Enontekiö	30	Pikku-Malla 1	7677402	3249616	rich fen, above tree line	570
Le	Enontekiö	31	Pikku-Malla 2	7677353	3249631	eutrophic spring, above tree line	570
Le	Enontekiö	32	Gihccegorzi SE 1	7677900	3248500	eutrophic spring	605
Le	Enontekiö	33	Gihccegorzi SE 2	7677684	3248818	eutrophic spring fen	605
Le	Enontekiö	34	Saana	7674910	3253442	eutrophic spring	520
Le	Enontekiö	35	Iso Jehkas W	7677303	3255866	small brook, snow bed	815
Le	Enontekiö	36	Havgajohka	7659229	3258813	brook, rich riparian vegetation	510

[1]biogeographical province, [2]municipality, [3]number of the study site (see Figure 2), [4,5]North and East coordinate (Grid 27°E).

Sites 1-18 and 36 were lying on the bedrock area called Svecokarelides, where intermediate rocks like metabasalt, greenstone, amphibolite, phyllite, mica schist and mica gneiss are prevailing. In addition, acidic rocks (e.g. granodiorite and quartz diorite) are locally common in the bedrock. Sites 1-10 belong to so called "rich fen centre of Kittilä", where basic rocks facilitate the occurrence of rich fens and herb-rich forests. Sites 19-29 were laying on the Presvecokarelidic basement complex bedrock area, where acidic rocks viz. granite veins in basement gneiss and gneiss of granulite complex are prevailing. In some areas intermediate rocks (metabasalt, amphibolite) occur. Sites 30-34 were lying on the Caledonic mountain belt, being composed of paleozoic sedimentary rocks and being famous for the occurrence of demanding calcareous flora. Quaternary deposits over the bedrock in the study area consist mainly of ground moraine, peat deposits and eskers (including delta, ice-marginal and interlobate formations), in some parts bedrock terrains are common (Atlas of Finland 1990).

All study sites were located in state-owned land and many of these were within conservation areas (e.g. Strict Nature Reserves, Mire Conservation Areas, Wilderness Areas). Permissions to collect insects from the sites were provided by Metsähallitus (Finnish Forest and Park Service) and METLA (Finnish Forest Research Institute).

36 sites were selected as study sites, that is, Malaise traps were set in these localities (see 2.2.). The main aim of the present study was to improve the knowledge on the distribution and ecology of semiaquatic flies in Finland, and, therefore, the sites were selected so that they varied in their characteristics and geographical location. Major wetlands in the study region, aapa mires, received notable study effort. In the southern and middle subzones, 20 study sites out of 21 were aapamires with a varying trophic status and groundwater influence and one site was a mesoeutrophic spring (Table 1). In the subalpine subzone, three study sites were palsa mires, three were head water streams with rich riparian vegetation and the rest (nine sites) were different types of alpine wetlands (Table 1). These sites are described below (2.3.) with more detailed information. Vegetation of the sites was investigated in July 2007, vascular plants and bryophytes (mosses and liverworts) were identified to species or genus level (Appendix 3). Plant and bryophyte species were surveyed within a five-meter radius from the Malaise trap in each site, a 30x hand lens was used in the field and some specimens were later identified with a microscope.

2.2. Collecting of the insect material

A total of 42 Malaise traps (length 110, width 70, height 140 cm) were set on 36 study sites. There were two traps in Taljavaaranvuoma, Vasanvuoma, Kielisenpalo and Jietanasvuoma and three traps in Akrahamanvuoma. The collected insect material from the above mentioned sites with more than one trap was later combined. Malaise traps were set 31st of May – 2nd of June in the sites 1-10, 4th of June – 6th of June in the sites 11-22 and 15th of June – 20th of June in the sites 23-36. Traps were emptied three times in the sites 1-22 and two times in the sites 23-36, in a roughly one month intervals. Traps were removed from the field between 24th of August and 4th of September. A solution of 50 % ethylene glycol and water with a few drops of detergent was used as a preservative in the traps. The collected material was finally stored in 80 % ethanol.

In addition to Malaise traps, nematoceran flies were collected with a sweep net (frame diameter 32 cm, mesh size <0, 5 mm) from the studied localities. Samples were taken by sweeping vegetation (tree canopy, shrubs, graminoids) near the Malaise traps (distance to trap was not more that 100 m) in the same site type as the trap was standing, and visually detected flies (mainly tipuloids) were caught. Each sample consisted of about 10-15 minutes sweeping. The collected material within the net was put in a plastic bag with a wad containing chloroform. After couple of minutes the stunted insects were dumped on a cardboard plate and the material was shed in a container with 80 % ethanol. A total of 154 sweep net samples were taken from the study sites between 31st of May and 3rd of September 2007. Total number of species per study site is thus a sum of species identified from the traps and from the sweep net material (Table 3). Further, adult semiaquatic flies were collected from 50 additional sites (1-5 net sample/site, total number of samples was 67) (see Appendix 1). Temporal succession (phenology) of adult flies, both number of species and individuals, was assessed in two week periods based on sweep net samples. Within weeks 22-23 17, 24-25 five, 26-27 40, 28-29 40, 30-31 28, 32-33 41 and 34-35 50 sweep net samples were taken, respectively.

Malaise trap and sweep net material was later sorted out in a laboratory under a microscope from petri dishes or from white plate with good illumination. The flies were identified with a microscope and voucher specimens are deposited in the private collection of the author.

Table 2. Semiaquatic fly (Diptera, Nematocera) species recorded from the study sites and other sites, their frequency (%) and abundance (number of specimens) in total catches (combined material), Malaise traps and sweep net samples. Distribution and ecology of the species in Finland are roughly assessed, based on author's database and observations. Indicator species (see 4.6., not referring to Indicator Species Analysis) are bold-faced. Names of the genera and some species names are abbreviated (full names and authors in the Appendix 2).

species	**study sites (36 sites)**						**other (50 sites)**		**distribution**[1]	**ecology**[2]
	combined		Malaise		sweep net		sweep net			
	freq.%	n	freq.%	n	freq.%	n	freq.%	n		
Limnoniidae										
Eloe maculata	0	0	0	0	0	0	2	2	1, 2, 3	lotic
Eloe trimaculata	16,7	11	13,9	9	5,6	2	26	73	1, 2, 3, 4, 5	lotic
Euph meigenii	25	110	25	104	8,3	6	2	1	1, 2, 3, 4, 5	peatland
Euph phaeostigm	8,3	16	8,3	15	2,8	1	0	0	1, 2, 3, 4, 5	eurytopic, wet
Idio linnei	52,8	233	52,8	174	33,3	59	14	25	1, 2, 3, 4, 5	peatland
Idio pulchella	33,3	29	27,8	20	11,1	9	12	16	1, 2, 3, 4, 5	eurytopic, wet
Neol nemoralis	25	375	25	339	16,7	36	16	80	1, 2, 3, 4, 5	eurytopic, terr
Para nigrina	11,1	4	11,1	4	0	0	0	0	1, 3	rich fen
Phyl fulvonervosa	11,1	37	11,1	34	2,8	3	6	3	1, 2, 3, 4	eurytopic, wet
Phyl abdominalis	22,2	36	8,3	3	22,2	33	8	8	1, 2, 3, 4	rich fen
Phyl heterogyna	16,7	98	8,3	11	16,7	87	2	2	1, 2, 3, 4	peatland
Phyl longicornis	11,1	15	11,1	15	0	0	12	22	1, 2, 3, 4, 5	swamp
Phyl squalens	86,1	382	86,1	309	41,7	73	18	27	1, 2, 3, 4, 5	peatland
Phyl umbrarum	25	32	19,4	16	16,7	16	12	8	2, 3, 4	swamp
Pila decolor	25	37	11,1	10	25	27	8	9	1, 2, 3, 4, 5	swamp
Pila meridiana	47,2	84	36,1	22	27,8	62	6	10	1, 2, 3, 4, 5	rich fen
Chei areolata	27,8	45	27,8	45	0	0	12	31	2, 3, 4, 5	peatland
Erio diuturna	44,4	299	25	49	36,1	250	8	48	1, 2, 3, 4, 5	peatland
Erio beckeri	2,8	1	0	0	2,8	1	0	0	1, 2, 4, 5	peatland
Erio flavata	38,9	390	38,9	279	19,4	111	14	16	1, 2, 3, 4	eurytopic, wet
Erio lutea	11,1	9	11,1	8	2,8	1	4	10	1, 2, 3, 4, 5	eurytopic, wet
Erio nielseni	16,7	49	13,9	17	13,9	32	0	0	1, 2, 3	rich fen
Erio sordida	13,9	38	13,9	38	0	0	0	0	1, 2, 3, 4, 5	swamp
Gono stackelber	50	119	47,2	74	16,7	45	6	91	2, 3, 4, 5	rich fen
Molo ater	16,7	369	16,7	143	5,6	226	10	38	1, 2, 3, 4, 5	eurytopic, terr
Molo crassipygus	0	0	0	0	0	0	2	3	1, 2, 3, 5	lotic
Molo flavus	30,6	1120	27,8	1088	16,7	32	10	32	1, 2, 3, 4, 5	spring
Molo propinquus	8,3	119	8,3	118	2,8	1	14	20	1, 2, 3, 5	swamp
Ormo fascipennis	5,6	5	5,6	4	2,8	1	0	0	1, 3, 4, 5	lotic
Ormo ruficauda	36,1	50	33,3	48	5,6	2	6	10	1, 2, 3, 4, 5	eurytopic, terr

Table 2. Continues.

species	study sites (36 sites)						other (50 sites)		distribution[1]	ecology[2]
	combined		Malaise		sweep net		sweep net			
	freq.%	n	freq.%	n	freq.%	n	freq.%	n		
Ormo staegeriana	13,9	23	13,9	18	5,6	5	4	9	1, 2, 3, 5	rich forest
Phyl macroura	8,3	1349	8,3	1344	2,8	5	4	5	1, 4, 5	alpine, terr
Rhab parva	5,6	5	5,6	5	0	0	0	0	5	spring?
Rhyp haemorrhoi	2,8	1	2,8	1	0	0	0	0	1, 2, 5	swamp
Scle sororcula	2,8	1	2,8	1	0	0	0	0	1, 2, 5	spring
Symp meigeni	30,6	334	30,6	330	5,6	4	4	2	1, 3, 4, 5	rich fen
Symplecta sp	2,8	1	2,8	1	0	0	0	0	4, 5	lotic?
Dicr aperta	5,6	6	2,8	1	2,8	5	0	0	1,2, 3	rich fen
Dicr autumnalis	8,3	8	2,8	1	8,3	7	0	0	1, 2, 3, 4, 5	swamp
Dicr didyma	11,1	17	11,1	11	2,8	6	6	3	1, 2, 3, 4, 5,	lotic
Dicr distendens	69,4	66	66,7	62	8,3	4	6	6	1, 2, 3, 4, 5,	peatland
Dicr halterata	0	0	0	0	0	0	2	2	1, 2, 3, 4, 5	lotic?
Dicr hyalinata	36,1	236	27,8	179	30,6	57	10	41	1, 2, 4, 5	alpine, wet*
Dicr longipennis	8,3	17	0	0	8,3	17	0	0	2, 3	rich fen
Dicr mitis	2,8	1	2,8	1	0	0	0	0	1, 2, 4, 5	swamp
Dicr modesta	5,6	2	0	0	5,6	2	6	11	1, 2, 3, 4,5	eurytopic, wet
Dicr moniliformis	5,6	2	2,8	1	2,8	1	0	0	3	rich fen
Dicr omissinervis	0	0	0	0	0	0	2	1	2, 3	lotic
Dicr patens	2,8	2	0	0	2,8	2	4	4	1, 2, 3, 4	swamp
Dicr terraenovae	55,6	250	41,7	39	52,8	211	8	9	1, 2, 3, 4, 5	peatland
Dicr ventralis	25	43	2,8	1	22,2	42	0	0	1, 3, 4	rich fen
Dicr halterella	27,8	133	11,1	42	27,8	91	8	69	1, 2, 3, 4, 5	lotic
Dicr magnicauda	2,8	1	0	0	2,8	1	6	6	1, 2, 3	swamp
Dicr lulensis	5,6	2	5,6	2	0	0	0	0	2, 5	swamp
Dicr ponojensis	75	389	41,7	53	66,7	336	10	55	1, 2, 3, 4, 5	rich fen
Dicr stigmatica	52,8	95	44,4	60	33,3	35	4	4	1, 2, 3, 4, 5	peatland
Dicr caledonica	25	32	19,4	29	8,3	3	14	17	2, 4, 5	alpine, wet
Dicr morio	0	0	0	0	0	0	2	2	1, 2, 3, 4	swamp
Dicr rufiventris	75	730	52,8	308	66,7	422	18	51	1, 2, 3, 4, 5	peatland
Dicr stylifera	8,3	8	8,3	6	2,8	2	0	0	2, 5	spring
Disc annulata	0	0	0	0	0	0	2	1	1, 2, 3	fungi
Heli longirostris	16,7	205	16,7	144	11,1	61	8	8	1, 2, 3	swamp
Limo macrostig	8,3	15	8,3	13	5,6	2	2	1	1, 2, 3, 4, 5	eurytopic, terr
Limo sylvicola	8,3	47	8,3	9	5,6	38	12	16	1, 2, 3, 4, 5	eurytopic, terr
Limo trivittata	0	0	0	0	0	0	4	3	1, 2, 3	eurytopic, terr
Meta quadrinotata	2,8	1	2,8	1	0	0	4	2	1, 2, 3, 4, 5	fungi
Meta zetterstedti	16,7	8	13,9	6	5,6	2	0	0	1, 2, 3, 4, 5	fungi
Orim attenuata	33,3	42	30,6	38	8,3	4	0	0	1, 2, 3, 4, 5	rich fen
Rhip maculata	8,3	5	8,3	5	0	0	0	0	1, 2, 3, 4, 5	eurytopic, terr
Tipulidae										
Anga tumidicorni	33,3	49	30,6	36	13,9	13	8	6	1, 2, 3, 4, 5	rich fen
Dict bimaculata	5,6	2	5,6	2	0	0	0	0	1, 2, 3, 4, 5	saproxylic
Doli nitida	0	0	0	0	0	0	4	2	3, 5	lotic?
Neph tenuipes	2,8	2	2,8	2	0	0	0	0	1, 2, 3	swamp
Prio abscondita	8,3	13	8,3	13	0	0	0	0	5	alpine, wet
Prio chosenicola	13,9	20	8,3	15	11,1	5	6	8	1, 2, 3, 4, 5	peatland
Prio pubescens	52,8	315	50	174	30,6	141	12	28	1, 2, 3, 4, 5	peatland
Prio recta	2,8	1	2,8	1	0	0	2	2	2, 3, 4, 5	alpine, wet
Prio ringdahli	25	19	22,2	16	8,3	3	8	4	2, 3, 4, 5	swamp

Table 2. Continues.

species	**study sites (36 sites)**						**other (50 sites)**		**distribution**[1]	**ecology**[2]
	combined		Malaise		sweep net		sweep net			
	freq.%	n	freq.%	n	freq.%	n	freq.%	n		
Prio serricornis	38,9	77	33,3	59	13,9	18	10	27	2, 3, 4, 5	peatland
Prio subserricorni	61,1	228	58,3	206	13,9	22	20	46	1, 2, 3, 4, 5	eurytopic, wet
Prio turcica	69,4	402	69,4	347	16,7	55	26	51	1, 2, 3, 4, 5	eurytopic, wet
Prio woodorum	0	0	0	0	0	0	2	1	2, 5	lotic
Tany atrata	16,7	7	16,7	7	0	0	0	0	1, 2, 3, 4, 5	saproxylic
Tany nigricornis	11,1	6	11,1	6	0	0	0	0	1, 2, 3, 4, 5	saproxylic
Tipu salicetorum	0	0	0	0	0	0	8	6	4, 5	alpine, wet
Tipu obscurivent	2,8	1	2,8	1	0	0	0	0	2, 5	lotic
Tipu subexcisa	2,8	1	2,8	1	0	0	2	1	2, 4, 5	lotic?
Tipu lunata	0	0	0	0	0	0	2	1	1, 2, 3, 5	eurytopic, wet
Tipu trispinosa	11,1	17	11,1	17	0	0	2	1	2, 4, 5	swamp
Tipu luteipennis	33,3	249	22,2	33	30,6	216	2	5	1, 2, 3, 4, 5	rich fen
Tipu melanoceros	86,1	589	75	453	61,1	136	18	16	1, 2, 3, 4, 5	peatland
Tipu luridorostris	0	0	0	0	0	0	2	2	1, 2, 3	lotic?
Tipu mutila	5,6	2	5,6	2	0	0	2	1	1, 2, 4, 5	saproxylic
Tipu varipennis	2,8	1	2,8	1	0	0	2	1	1, 2, 3, 4, 5	eurytopic, terr
Tipu gimmerthali	50	255	41,7	122	41,7	133	6	18	2, 3, 4, 5	rich fen
Tipu grisescens	47,2	83	47,2	50	13,9	33	8	13	1, 2, 3, 4, 5	rich fen
Tipu interserta	8,3	10	8,3	10	0	0	0	0	1, 2, 3	swamp
Tipu invenusta	36,1	280	36,1	250	13,9	30	10	16	4, 5	alpine, wet
Tipu limbata	44,4	66	38,9	57	22,2	9	4	7	1, 2, 3, 4, 5	peatland
Tipu subnodicorn	86,1	831	80,6	767	36,1	64	24	40	1, 2, 3, 4, 5	peatland
Tipu variicornis	0	0	0	0	0	0	4	5	1, 2, 3, 4	swamp
Tipu excisa	58,3	131	58,3	121	8,3	10	16	14	2, 3, 4, 5	alpine, terr
Tipu laccata	0	0	0	0	0	0	4	16	2, 3, 5	lotic?
Tipu monta verb	5,6	3	5,6	3	0	0	4	3	2, 3, 4, 5	alpine, terr
Tipu nubeculosa	16,7	11	16,7	11	0	0	0	0	1, 2, 3, 4, 5	eurytopic, terr
Tipu tchukchi	2,8	1	2,8	1	0	0	0	0	5	alpine, wet
Tipu coerulescens	0	0	0	0	0	0	2	2	1, 2, 3, 5	lotic
Tipu freyana	0	0	0	0	0	0	4	4	2, 3	lotic
Tipu lateralis	2,8	2	2,8	2	0	0	2	1	1, 2, 4, 5	swamp
Tipu moesta	25	16	25	16	0	0	14	10	3, 4, 5	alpine, wet
Tipu quadrivitta	5,6	3	5,6	3	0	0	0	0	1, 2, 3, 4	rich fen
Pediciidae										
Dicr bimaculata	11,1	9	8,3	7	5,6	2	10	15	1, 2, 3, 4, 5	lotic
Dicr guerini	25	72	19,4	43	16,7	29	10	22	1, 2, 3, 4, 5	lotic
Dicr gracilipes	8,3	28	8,3	22	5,6	6	14	136	1, 2, 3, 4, 5	lotic
Dicr pavida	2,8	2	2,8	2	0	0	12	35	1, 2, 3, 4, 5	lotic
Dicr robusta	2,8	1	2,8	1	0	0	0	0	2, 3, 5	lotic
Dicr exclusa	25	108	16,7	52	16,7	56	24	102	1, 2, 3, 4, 5	lotic
Pedi rivosa	69,4	178	66,7	171	16,7	7	8	6	1, 2, 3, 4, 5	eurytopic, wet
Tric immaculata	94,4	1539	94,4	1531	16,7	8	26	39	1, 2, 3, 4, 5	eurytopic, wet
Tric schummeli	8,3	38	8,3	37	2,8	1	0	0	1, 2, 3, 4, 5	lotic
Tric unicolor	30,6	318	30,6	315	5,6	3	6	10	1, 2, 3, 4	peatland
Ula sylvatica	5,6	2	5,6	2	0	0	2	1	1, 2, 3, 4, 5	fungi
Cylindrotomidae										
Cyli distinctissi	19,4	29	19,4	27	5,6	2	12	12	1, 2, 3, 4, 5	eurytopic, terr
Diog caudata	2,8	3	2,8	3	0	0	0	0	1, 2, 3, 4	eurytopic, terr
Phal replicata	13,9	10	13,9	9	2,8	1	4	3	1, 2, 3, 4, 5	eurytopic, wet

Table 2. Continues.

species	study sites (36 sites)						other (50 sites)		distribution[1]	ecology[2]
	combined		Malaise		sweep net		sweep net			
	freq.%	n	freq.%	n	freq.%	n	freq.%	n		
Ptychopteridae										
Ptyc hugoi	36,1	52	36,1	52	0	0	6	3	1, 3, 4, 5	alpine, wet
Ptyc minuta	72,2	464	72,2	449	13,9	15	6	13	1, 2, 3, 4, 5	eurytopic, wet
Psychodidae										
Berd freyi	11,1	1044	11,1	1006	5,6	38	4	14	2, 3, 4, 5	lotic
Chod lobata	8,3	3	8,3	3	0	0	2	1	1, 2, 3, 4, 5	fungi
Chod sp	2,8	1	2,8	1	0	0	0	0	2, 4	eurytopic, terr
Logi satchelli	66,7	101	63,9	99	5,6	2	4	2	1, 2, 3, 4, 5	eurytopic, terr
Para subnegleta	25	1804	25	1796	5,6	8	6	23	1, 2, 3, 4, 5	lotic
Peri formosa	2,8	2	2,8	2	0	0	2	1	1, 2, 3, 4	lotic
Peri rivularis	38,9	446	36,1	444	5,6	2	2	1	1, 2, 3, 4, 5	eurytopic, wet
Pneu borealis	36,1	349	36,1	349	0		0	0	1, 2, 3, 4, 5	swamp
Pneu mutua	11,1	334	11,1	299	2,8	35	0	0	1, 2, 4, 5	lotic
Pneu pilularia	5,6	17	5,6	16	2,8	1	0	0	5	spring
Pneu stammeri	11,1	9	11,1	9	0	0	4	3	2, 3, 4, 5	lotic
Pneu ussurica	41,7	347	41,7	347	0	0	0	0	1, 3, 4, 5	rich fen
Psyc grisescens	2,8	3	2,8	3	0	0	0	0	1, 2, 5	eurytopic, terr
Psyc phalaenoide	8,3	13	8,3	13	0	0	0	0	1, 2, 3, 4, 5	eurytopic, terr
Psyc itoco	5,6	5	5,6	5	0	0	0	0	1, 2, 3, 4, 5	swamp
Psyc minuta	2,8	1	2,8	1	0	0	0	0	1, 2, 3	eurytopic, terr
Tine lativentris	2,8	1	2,8	1	0	0	0	0	1, 3	eurytopic, terr
Dixidae										
Dixa nebulosa	8,3	83	8,3	12	2,8	71	10	8	1, 2, 3, 4, 5	lotic
Dixe aestivalis	25	18	2,8	1	22,2	17	8	8	1, 2, 3, 4, 5	swamp
Dixe amphibia	25	17	5,6	2	19,4	15	6	6	1, 2, 3, 4, 5	swamp
Dixe borealis	2,8	16	0	0	2,8	16	8	12	1, 2, 3, 4	swamp
Dixe hyperborea	19,4	74	2,8	1	16,7	73	14	69	1, 2, 3, 4, 5	swamp
Dixe laeta	36,1	163	0	0	36,1	163	6	14	2, 3, 4, 5	rich fen
Dixe naevia	41,7	110	8,3	6	41,7	104	14	20	1, 2, 3, 4, 5	spring
Dixe obscura	38,9	81	13,9	13	36,1	68	12	20	1, 2, 3, 4, 5	swamp
Thaumaleidae										
Thau truncata	13,9	53	13,9	52	2,8	1	0	0	1, 2, 4, 5	spring
Pachyneuridae										
Pach fasciata	2,8	2	2,8	2	0	0	0	0	1, 2, 3, 4	saproxylic

[1]distribution in Finnish ecoregions (see Figure 2): 1=hemiboreal and/or southern boreal zone, 2=middle boreal zone, 3=northern boreal, southern subzone, 4=northern boreal, middle subzone, 5=northern boreal, subalpine subzone. [2]lotic=associated with running waters, eurytopic, wet=indifferent dwellers of various wetlands, rich fen=species living in meso – eutrophic mires, swamp=surface fed habitats, eurytopic, terr=wide-ranging terrestrial species, rich forest=associated with herb-rich forests, alpine, terr=terrestrial species whose occurrence is centered on fells and alpine heaths, alpine, wet=high latitude aquatic and semiaquatic species, fungi=species whose larvae are associated with fruiting bodies of fungi, spring=species associated with spring-fed habitats, saproxylic=species whose larvae live in decaying wood.

2.3. Description of the study sites

1. Taljavaaranvuoma, Kittilä
Two Malaise traps were set in Taljavaaranvuoma, both in a rich birch fen, circa 200 m distance between them, and the insect material collected from the site was later combined. The study site was characterized by birch (up to 3-4 m length) growing on low hummocks, including scarce *Juniperus communis*. Indifferent shrubs, herbs and graminoids such as *Andromeda polifolia*, *Betula nana*, *Caltha palustris*, *Carex chordorrhiza*, *C. limosa*, *Equisetum fluviatile* and *Vaccinium uliginosum* were present, and the site harboured plants (eg. *Carex heleonastes*, *Eriophorum gracile*) and mosses (eg. *Calliergon richardsonii*, *Cinclidium stygium*, *Hamatocaulis vernicosus*, *Meesia triquetra*, *Tomentypnum nitens*) typical for rich aapamires and especially birch fens. The site was covered by lawn and carpet – mud-bottom level vegetation. Thus, no open water pools were present and hummocks were poorly developed.

2. Vuotsonperänjänkä, Kittilä
Malaise trap was placed in a slightly sloping rich fen, which was a 30-40 m wide strip between mineral land and pine bog. There was minor groundwater influence, detected by the low temperature of the water in the pools. Dwarf and scattered individuals of pine, birch and spruce were growing on hummocks and *Salix* shrubs (*S. lapponum*, *S. myrsinifolia* and *S. phylicifolia*) were abundant and very visible in the site. Ground level vegetation included mosses viz. *Bryum pseudotriquetrum*, *Paludella squarrosa*, *Pseudobryum cinclidioides*, *Sphagnum* species and *T. nitens*. The site was difficult to walk due to loosely attached hummocks and small open water pools; carpet level vegetation was poorly developed.

3. Silmäsvuoma, Kittilä
The study site was an open flark rich fen, with large soft bottom flarks covered by mosses (mainly *Scorpidium scorpioides*), and strings surrounding them covered by hummock level vegetation (eg. *A. polifolia*, *B. nana*, *Salix myrtilloides*). Mire dwelling plants and mosses, such as *C. chordorrhiza*, *Drosera rotundifolia*, *Juncus stygius*, *Menyanthes trifoliata*, *Tofieldia pusilla*, *Campylium stellatum* and *Warnstorfia procera* were present.

4. Akrahamanvuoma, Kittilä
Three Malaise traps were set in the study site, in a west – east transect with circa 200 m distance between the traps. The collected material from Akrahahanvuoma was later combined. The first trap lay in an oligotrophic fen, with scattered pines and graminoids such as *Eriophorum russeolum*, *E. vaginatum* and *Trichophorum cespitosum*. *Sphagnum lindbergii* was the dominating moss species. The site was mainly soft bottom carpet level vegetation, with adjacent strings and shallow bog pools. The second trap lay in an open mesoeutrophic flark fen, with a few stunted pines growing along strings. Mire species indicating higher trophic status than in the first site were e.g. *Carex dioica*, *C. livida*, *Pedicularis palustris*, *Utricularia intermedia* and *Loeskypnum badium*. The site was dominated by mud-bottom – carpet level vegetation, with shallow pools and narrow strings. Finally, the third site was a rich pine fen, patterned with flarks and strings. Shallow mud-bottom pools were covered by *S. scorpioides* and rich fen species viz. *Campylium stellatum*, *Sphagnum warnstorfii* and *T. nitens* characterised the carpet and lawn level vegetation.

5. Repsuvuoma, Kittilä
The study site was an open flark rich fen, housing large flarks covered by *S. scorpioides* and strings with bog vegetation (eg. *A. polifolia*, *B. nana*, *Empetrum nigrum*). The site was also harbouring *C. dioica*, *C. limosa*, *E. fluviatile*, *Trichophorum alpinum*, for example. Thus, mud-bottom and carpet level vegetation were prevailing in the site, hummock level vegetation was growing in the narrow strings.

6. Vasanvuoma, Kittilä
Two Malaise traps were set in the study site and the collected insect material was later combined. The traps were circa 200 m apart. First trap was

in an open flark rich fen, surrounded by rich birch fen on the western side. The site was dominated by carpet – mud-bottom level vegetation, bare mud and ochre deposits were visible. Plants and mosses such as *E. gracile*, *M. trifoliata*, *Sparganium natans*, *Calliergon giganteum*, *C. stygium* and *H. vernicosus* were abundant. The second trap was placed in a rich birch fen, characteristic of short (up to 4 m long) birch trees growing on low strings. Carpet level vegetation was dominant, including *C. richardsonii*, *C. stygium*, *H. vernicosus* and *M. triquetra*. Graminoids and herbs viz. *C. chordorrhiza*, *C. diandra*, *Dactylorhiza maculata* and *Pedicularis palustris* were abundant.

7. Nunaravuoma, Kittilä
The study site was lying quite close to the sites number 1-6, but it was very distant to these in terms of its floristic composition. Oligotrophic mire-dwelling species were characteristic for this open fen, *C. limosa*, *C. rostrata*, *E. vaginatum*, *Sphagnum balticum* and *S. fallax* for example. No bog-pools were present, hummocks were poorly developed and thus, lawn and carpet level vegetation was prevailing.

8. Kielisenpalo, Kittilä
Two Malaise traps were set in the study site and the collected insect material was later combined. The traps lay about 100 m apart, both placed in the vicinity of springs. The first trap was set next to a spring pool (area circa 2 m^2) followed by an outflow through the mire. The site was open, only scattered dwarf trees of spruce were present. In addition to emergent groundwater, mud-bottom pools, lawn and carpet level vegetation were dominant and hummocks formed by *Carex cespitosa* were eye-catching. Several rich fen and spring-dwelling species were found, such as *Equisetum palustre*, *Salix myrsinites*, *G. giganteum*, *Cratoneuron filicinum* and *Philonotis fontana*. The second site was also in the vicinity of a spring pool (area circa 1,5 m^2), but no outflow was formed there; emerging groundwater percolated trough the mire surface. The site was open, and except of the small spring pool no mud-bottom pools were present. Lawn and carpet level vegetation were dominating and hummocks were scarce. Plant and moss species of rich fens and springs were characteristic, *Equisetum scirpoides*, *Parnassia palustris*, *Saussurea alpina*, *Palustriella decipiens* and *P. falcata* for example.

9. Vielmakoskenpalo NW 1, Kittilä
The study site was an open flark rich fen, carpet and mud-bottom level vegetation were prevailing, but no open pools were present and hummocks were poorly developed. Graminoids viz. *Carex brunnescens*, *C. chordorrhiza*, *C. magellanica* and *C. vesicaria* were growing abundantly in the site and rich fen mosses such as *C. giganteum*, *C. stygium* and *P. squarrosa* were recorded.

10. Vielmakoskenpalo NW 2, Kittilä
The study site was a rich spruce fen, quite close to the previous site. This site was characterised by dense tree growth, especially spruce, but also grey alder (*Alnus incana*) and birch were abundant. Shallow pools were present, with surrounding lawn and hummock level vegetation. The assemblage of plants and mosses included e.g. *Carex tenuiflora*, *C. vaginata*, *E. palustre*, *Linnaea borealis*, *Salix glauca*, *Calliergon richardsonii* and *Oncophorus virens*.

11. Siettelonvuoma, Kittilä
The study site was a mesoeutrophic spring, lying in the border of large aapa mire and heath forest. The site was open, only a few birch trees were growing in the seepage area. There was a small spring pool (area 2 m^2, depth up to 70 cm) and a slow flowing, mud-bottom spring brook draining the emerging groundwater to the mire (mesotrophic spring fen, circa 1 ha in area). The seepage area was characterised by tussocks of *Calamagrostis purpurea* and carpet level vegetation. Mosses preferring spring habitats viz. *Bryum weigelii*, *Rhizomnium magnifolium*, *Warnstorfia exannulata* and *Scapania uliginosa* were present. This study site and the sites number 12-14 lay within the Wilderness Area of Puljutunturi, at some 150 m higher altitude than sites number 1-10.

12. Palontaustalampi N, Kittilä
The study site was an open, slightly sloping mesoeutrophic spring fen. No pools were present and hummocks were poorly developed, lawn level vegetation was a dominant feature. *P. squarrosa* was especially abundant moss species and other characteristic species of the site were *C. chordorrhiza*, *Eriophorum angustifolium*, *S. lapponum* and *Warnstorfia sarmentosa*.

13. Palontaustalampi NE, Kittilä
The study site was an open oligotrophic sedge fen, being some 40 m distance from heath forest. Hummock level vegetation was practically lacking and mud-bottom – carpet level was prevailing, but no large open water pools were present. *Sphagnum lindbergii* covered large areas in the study site, fen species such as *C. limosa*, *C. rostrata*, *M. trifoliata*, *T. cespitosum* and *Straminergon stramineum* were also found.

14. Narkivaara NE, Kittilä
The study site was located on an open, sloping rich fen. The site was characterised by the abundance of *Phragmites australis*, other vascular plants and mosses indicating eutrophy were *Pinguicula vulgaris*, *S. myrsinites*, *C. richardsonii*, *C. stygium*, *Scorpidium cossoni* and *Warnstorfia tundrae*, for example. No open water pools were present, and thus, lawn and hummock level vegetation were dominating. Area of this rich fen was circa four hectares, surrounded by poorer sloping fens, especially Fuscum spruce-pine mires and sedge fens.

15. Jietanasvuoma, Enontekiö
Two Malaise traps were placed in the study site; distance between them was about 400 m. However, the sites were very similar in their floristic composition and moisture level and thus the collected insect material was later combined. Both sites were open mesotrophic flark fens, characterised by poorly developed hummocks and prevailing carpet – mud-bottom level vegetation. It should be emphasized that the Jietanasvuoma was very wet, influenced by surface flow and in some parts difficult to walk. Graminoids like *C. chordorrhiza*, *C. limosa*, *C. rostrata*, *C. rotundata* and *E. fluviatile* were abundant and mosses such as *Cinclidium subrotundum*, *L. badium*, *Sphagnum subsecundum* and *Barbilophozia kunzeana* were present in the studied aapa mire.

16. Hietajänkkä 1, Enontekiö
The study site was an open, oligotrophic aapa mire, characteristic by large flarks and high strings with abundant *B. nana* shrubs. In the study site, however, mud-bottom – carpet level vegetation was dominating and shallow open water pool lay adjacent to the trap. The site was poor in plant species (10 vascular plants and mosses), *E. russeolum*, *S. lindbergii*, *S. subfulvum* and *W. procera* being abundant there.

17. Hietajänkkä 2, Enontekiö
The present study site was quite similar in floristic composition and moisture level to the previous study site: oligotrophic fen species and mud-bottom – carpet level vegetation were present here as well. Bog species viz. *B. nana*, *E. nigrum*, *E. vaginatum* and *Rubus chamaemorus* were growing on the hummocks and fen species like *C. rotundata*, *E. russeolum* and *S. fallax* were abundant in the flarks.

18. Suttijärvi, Enontekiö
The study site is probably one of the largest springs in the NW Lapland. North of the spring is a large esker area Suttijärventieva, groundwater reservoir and accumulation area of the spring. The whole northern side of the lake Suttijärvi, at the foot of the Suttijärventieva, is seepage area (helocrene vegetation) but the Malaise trap was placed in a sheltered pot-hole like formation about 120 m^2 in area. Emerging groundwater formed there a mosaic of luxuriant vegetation and spring brooks with sandy bottom. In the edges of this pot-hole some ochre deposits were present. Herbs such as *C. palustris*, *Epilobium hornemannii* and *Veronica serpyllifolia* ssp. *humifusa* and mosses like *Brachythecium rivulare*, *P. fontana* and *P. seriata* were abundant in the site, species occurring in lesser extent were *Montia fontana* and *Marchantia polymorpha*, for example. Hence, hummock level vegetation was practically absent in the site and mud-bottom – carpet level was prevailing.

19. Hanhijänkä 1, Inari
The study site was an open mesotrophic flark fen, only a few stunted pine trees were growing on the hummocks. The site had well developed strings with bog vegetation (e.g. *B. nana*, *E. nigrum*, *Ledum palustre*). Mud-bottom flarks were covered by *Sphagnum* species, *W. procera* and *S. stramineum*, mesotrophic species (e.g. *P. squarrosa*) were scarce. Flarks were wet but no open water pools were present.

20. Hanhijänkä 2, Inari
This study site located some 350 m south from the previous study site, and it was an open mesoeutrophic spring fen. Carpet and lawn level vegetation were prevailing and no open water pools were present. Mosses typical for springs and mesoeutrophic fens like *L. badium*, *Oncophorus wahlenbergii*, *P. squarrosa* and *W. sarmentosa* were abundant.

21. Pierkivaaranjänkä, Inari
The study site was an open flark rich fen, lying close to a heath forest (some 10 m distance). Hummocks were scarce and mud-bottom – carpet level vegetation was dominating. Some shallow, open water pools were present and a mud-bottom brook was flowing about 10 m distance from the trap. There were a number of plant and moss species indicating meso – eutrophy, like *Carex buxbaumii*, *C. livida*, *J. stygius*, *T. alpinum*, *C. subrotundum* and *Scorpidium revolvens*.

22. Perunmammarinjänkä, Inari
This study site was lying near to the border of Utsjoki, in Petsikko highland area. Perunmammarinjänkä was palsa mire, with relatively rich flora including many rich fen species. Huge palsa hummocks were covered by bog vegetation and flarks were characterised by *C. lasiocarpa*, *C. livida*, *C. rotundata*, *E. angustifolium*, *C. stellatum*, *Pseudocalliergon trifarium* and *S. scorpioides*, for example. Carpet – mud-bottom level vegetation was prevailing, including bare, shallow pools.

23. Galddasjohka 1, Utsjoki
Galddasjohka is a headwater stream flowing in a relatively deep river valley, draining its waters to the Lake Pulmankijärvi, in the border of Finland and Norway. Two Malaise traps were set in the stream bank, being some 1700 m apart, and these sites are here treated separately. Galddasjohka 1 was a diverse study site, having lotic, spring and alpine meadow vegetation, and thus, a rich flora was present. Conspicuous shrubs and herbs viz. *Angelica archangelica*, *Salix myrsinifolia* ssp. *borealis*, *Trollius europaeus* and *Urtica dioica* ssp. *sondenii* were abundant in the moist stream bank. Further, *Cardamine pratensis* ssp. *polemonioides*, *E. hornemannii* and *Pohlia wahlenbergii*, for example, were growing in the stony seepage and mosses like *Dichodontium pellucidum*, *Fontinalis antipyretica* and *Hygrohypnum ochraceum* were attached on stones in the brook. Galddasjohka brook was some 150 cm of width and up to 70 cm depth in the study site, with minerogenous bottom.

24. Galddasjohka 2, Utsjoki
This study site was a brook valley with luxuriant riparian vegetation and a seepage area. *Salix* bushes, most notably *S. myrsinifolia* ssp. *borealis*, were vigorous and several alpine herbs viz. *Bartsia alpina*, *Gnaphalium norvegicum*, *Luzula parviflora* and *Veronica alpina* were found. The stream bank harboured some notable and demanding mosses (*Conocephalum conicum*, *Jungermannia obovata*) and many other hygrophilous species were also noted (*B. rivulare*, *Dichodontium palustre*, *Hygrohypnum alpestre*, *P. wahlenbergii*, *Harpanthus flotovianus*). Galddasjohka brook was some 130 cm of width and up to 60 cm of depth in the study site, with minerogenous bottom.

25. Galddasduolbbas 1, Utsjoki
Galddasduolbbas palsa mire lay in the eastern side of Luovosvarri fell. Two Malaise traps were set in the mire and the collected insect material is treated separately. The first trap was lying in a mesotrophic flark fen, with adjacent palsa hummocks. Mud-bottom and carpet level vegetation were dominating; shallow open pools and a small brook flowing on bare peat surface

were present nearby. Graminoids (eg. *Calamagrostis stricta*, *Carex canescens*, *C. nigra*, *E. russeolum*) and *Sphagnum* mosses (*S. fallax, S. riparium*) were abundant.

26. Galddasduolbbas 2, Utsjoki
This study site was characterised by carpet level vegetation, some scarcely vegetated peat surfaces were also present in the vicinity, but no open water pools existed. Mesoeutrophic graminoids (eg. *Carex rariflora*, *E. angustifolium*, *Triglochin palustris*) and mosses (eg. *C. subrotundum*, *P. squarrosa*, *W. sarmentosa*) were growing in the site.

27. Aksonjunni E, Utsjoki
The study site was a eutrophic spring fen with thin peat layer lying in the eastern slope on the Aksonjunni fell. Upwelling groundwater did not form a spring brook; only thin water column was covering the surface of mosses and mud. The trap was placed few-meters-distance from the possibly calcareous fell slope. The site was rich in plant and moss species, both terrestrial and hygrophilous species (eg. *Agrostis mertensii*, *B. alpina*, *Carex bigelowii*, *C. capillaris*, *Cassiope hypnoides*, *Huperzia selago*, *Thalictrum alpinum*) were present. In the seepage area a number species indicating groundwater influence or calcareous bedrock were growing (eg. *Juncus triglumis*, *Pinguicula alpina*, *C. stygium*, *P. trifarium*, *Tayloria lingulata*).

28. Buolbmatgeasjavri SE, Utsjoki
This study site was lying southeast from the lake Buolbmatgeasjavri, in a diverse habitat consisting of brook, alpine meadow and rich fen vegetation on sloping mire. The trap was set over the brook (width 50-70 cm, depth up to 20 cm) with minerogenous bottom. The brook bank was covered by herbs and graminoids viz. *Antennaria dioica*, *Bistorta vivipara*, *C. capillaris*, *C. panicea*, *Coeloglossum viride*, *Filipendula ulmaria*, *Geranium sylvaticum* and *Parnassia palustris*. Eutrophic fen species were dominant in the surrounding thin-peat-fen (eg. *P. alpina*, *S. myrsinites*, *Saxifraga aizoides*). Moist sandy edges of the brook were inhabited by mosses *Fissidens adianthoides*, *Odontoschisma elongatum*, *Preissia quadrata* and *Tritomaria polita*, for example.

29. Skalvejavri W, Utsjoki
This study site was located 250 meters west from the lake Skalvejavri. The trap was placed near to a swift flowing stony brook, draining water from an upstream lake. Most notably, however, the site was like an amphitheatre, having steep slopes downward from the surrounding alpine heath. Due to this sheltered position, a deep snow cover accumulates during winter and the site is probably one of the latest snow-beds in the Kaldoaivi Wilderness Area. In the summer of 2007 there was about 100 m^2 area of snow left in the 21st of July, but by the beginning of August all snow had melted. The snow-bed area was sparsely vegetated but near the trap graminoids of surface-fed (swamp) habitats and fens were abundant (eg. *C. stricta*, *C. canescens*, *C. lasiocarpa*, *C. magellanica*, *C. rotundata*, *Juncus filiformis*) and mosses such as *C. subrotundum*, *S. revolvens* and *W. sarmentosa* were noted.

30. Pikku-Malla 1, Enontekiö
The study site was a eutrophic flark fen, lying above tree line in Malla Strict Nature Reserve. This study site was composed of mud-bottom and carpet level vegetation, on the northern side bordered by pounikko mire with bog vegetation. The fen harboured mosses like *C. subrotundum*, *L. badium*, *P. squarrosa*, *P. trifarium* and *Warnstorfia trichophylla*.

31. Pikku-Malla 2, Enontekiö
This study site was rich in plant and moss species, being inhabited by terrestrial and hygrophilous species. The Malaise trap was set over a small spring brook (width 40-60 cm, depth up to 5 cm) flowing on the rich alpine heath and ending up to a flark fen. Spring brook was characterised by both minerogenous and soft mud-bottom and mosses viz. *P. fontana*, *P. tomentella*, *P. wahlenbergii* and *T. polita* were attached on the stones. Alpine and calcareous species like *Arabis alpina*, *C. vaginata*, *Equisetum variegatum*, *P. alpina* and *Salix reticulata* were present.

32. Gihccegorzi SE 1, Enontekiö

This study site and the next one were located in Malla Strict Nature Reserve, within the zone of *B. pubescens* ssp. *czerepanovii*. The present locality could be assessed as eutrophic spring due to the occurrence of *P. falcata*, but mosses usually encountered in springs of non-calcareous bedrock (*D. palustre*, *P. fontana*, *S. uliginosa*, *Harpanthus flotovianus*) were abundant as well. The spring was a rheocrene brook (width circa 2-3 m, depth up to 25 cm) on a minerogenous bottom, bordered by lawn level vegetation consisting of alpine meadow (eg. *Luzula sudetica*, *Nardus stricta*, *Phleum alpinum*) and rich fen species (eg. *B. alpina*, *E. variegatum*, *Gymnadenia conopsea*, *C. stellatum*). The spring brook had quite high discharge and is probably persistent (not susceptible of drying).

33. Gihccegorzi SE 2, Enontekiö

The study site was a eutrophic spring fen, characterised by lawn level vegetation, with low hummocks and thin peat layer. There was a small trickle in the site, influenced by melt waters and groundwater. The trickle was partly dry in the mid July 2007. A rich flora was present, including meadow (eg. *A. dioica*, *Anthoxanthum odoratum*, *B. vivipara*) and rich fen species (eg. *Juncus biglumis*, *J. triglumis*, *S. reticulata*, *Meesia uliginosa*, *O. virens*).

34. Saana, Enontekiö

This study site was lying in the Nature Conservation Area of Saana fell SW slope. Malaise trap was set over a small spring brook (width circa 30-40 cm, depth up to 5 cm) flowing on a rich alpine heath with luxuriant vegetation. This site was within the zone of *B. pubescens* ssp. *czerepanovii*, but birch trees did not provide there much shading. Bottom of the brook was minerogenous; in its edge was a narrow zone of carpet level vegetation. Several alpine and calcareous plants and mosses were found, such as *Astragalus alpinus*, *B. alpina*, *S. reticulata*, *S. aizoides*, *O. virens* and *P. falcata*.

35. Iso Jehkas W, Enontekiö

This study site was lying in the middle oroarctic zone, high above the tree line. The site was a snow-bed, including a small and seasonally dry trickle flowing from a pond. There was plenty of snow left in the 19th of June when the trap was set, but the snow had totally melted until 16th of July when this locality was visited for the second time. The flora of the site was composed of high alpine shrubs and graminoids (eg. *C. bigelowii*, *C. lachenalii*, *Cassiope tetragona*, *Luzula arcuata*) and herbs (eg. *Gnaphalium supinum*, *Ranunculus nivalis*, *Saxifraga foliosa*, *Silene acaulis*), growing on mineral ground with thin layer of humus.

36. Havgajohka, Enontekiö

This study site was a head water stream (width circa 2-4 m, depth up to 50 cm) lying in birch zone. Stream substratum consisted of boulders with negligible moss growth. The riparian vegetation was rich in species, including *A. mertensii*, *C. purpurea*, *C. buxbaumii*, *Cornus suecica*, *G. sylvaticum*, *Rhodiola rosea*, *Viola biflora*. In the water level at the brook bank meso – eutrophic mosses like *B. pseudotriquetrum*, *C. stygium*, *P. squarrosa* and *S. revolvens* were growing.

2.4. Statistical methods

Cluster analysis and NMS-ordination (Non-Metric Multidimensional Scaling) were used to analyse patterns in community structure of the study sites. NMS shows the ranked distances of the sites in the ordination space in *k*-dimensions based on species abundances. The goodness-of-fit of the *k*-dimensional ordination space to the original *p*-dimensional space is expressed as a stress value (McCune & Grace 2002). A three dimensional solution with a stress value of 10.56 was selected, using Sorensen's distance measure, three as the maximum number of dimensions, random starting coordinates and stepping down in dimensionality. Cluster analysis was performed by using Sorensen's distance measure, flexible beta as a linkage method with a beta value of -0.5; percent of chaining was 1.9.

MRPP (Multi-Response Permutation Procedure) is a nonparametric method for testing the hypothesis of no difference between two or more groups of entities (McCune & Grace 2002) and it was used to assess the significance of the grouping made by Cluster analysis. An effect size is provided by chance-corrected within group agreement (*A*): when all items in a group are identical within groups *A*=1 (highest value) and if heterogeneity within groups equals expectation by chance *A*=0 (*A*<0 if less agreement within groups than expected by chance). Sorensen's distance measure was used in the analysis and 1000 Monte Carlo permutations to assess the significance of the null hypothesis of no difference between Cluster assemblages. Indicator Species Analysis (Dufrene & Legendre 1997, McCune & Grace 2002) was also used to assess the relevance of the Cluster grouping. This analysis provides an indicator value (IV), which is based on abundance and frequency of a given species in a given group of sites; it is calculated for each species in each group. IV reports per cent of perfect indication, being 100 if the species in question occurs only in a certain group of sites. Significance of the highest observed IV for each species was tested by using 1000 Monte Carlo permutations and $p<0.05$ was used as the significance level for choosing indicator species.

Malaise trap and sweep net material from the each study site were combined for the analyses. Prior to the community analyses, the data was log (x+1) transformed and an outlier analysis was performed by using Sorensen's distance measure and the PC-ORD default value of 2.0 standard deviations to identify outliers (McCune & Grace 2002). Two were found, Iso Jehkas W and Nunaravuoma with standard deviations of 3.79 and 2.36, respectively. Accordingly, these sites were removed from the species matrix and the analyses were run for 34 study sites and 138 species.

Because the sampling effort differed in the study sites, a rarefaction-standardised number of species for each site was calculated. Catches were standardised to 100 individuals, which was the lowest number of specimens in a site, by using freely available program Rarefaction Calculator (http://www2.biology.ualberta.ca/jbrzusto/rarefact.php).

3. Results

3.1. Diversity of the flies, Malaise trapping vs. sweep netting, frequent and abundant species

A total of 154 semiaquatic fly species were identified from the Malaise traps and sweep net samples, belonging to Limoniidae (69 spp), Tipuliidae (42), Pediciidae (11), Cylindrotomidae (3), Ptychopteridae (2), Psychodidae (17), Dixidae (8), Thaumaleidae (1) and Pachyneuridae (1) (Table 2, Appendix 2). The collected material was composed of 21701 individuals (Malaise traps 15718, sweep net samples 5983 individuals). From the 36 study sites, where both Malaise traps and sweep netting were used, a total of 138 species were found; seven of these were present only in sweep net samples and 47 species only in Malaise traps. Certain species were clearly more abundant or occurred on a higher frequency in either Malaise traps or sweep net samples. Species such as *Euphylidorea meigenii*, *Idioptera linnei*, *Phylidorea squalens*, *Erioptera flavata*, *Gonomyia stackelbergi*, *Symplecta meigeni*, *Dicranomyia distendens*, *Tricyphona immaculata* and *Tipula invenusta* were more numerous and/or frequent in the traps. On the other hand, *Phylidorea abdominalis*, *P. heterogyna*, *Erioconopa diuturna*, *Dicranomyia ventralis*, *D. halterella* and *D. ponojensis* were more numerous and/or frequent in the sweep net samples. Species of the family Psychodidae were quite poorly caught by sweep-netting but abundant in the Malaise traps, whereas meniscus midges (Dixidae) showed an opposite trend in their occurrence. On average, Malaise traps collected 84 % of the total number of species in the study sites (sd 11, max 100 %, min 56 %) and sweep netting yielded 44 % of the species per site (sd 15, max 70 %, min 20 %).

Table 3. Sampling efficiency, total number of specimens caught and species numbers obtained with Malaise traps and sweep netting, total species richness, rarefaction-standardised species richness and number of indicator species (see 4.6. and Table 2.) in each study site.

study site	Malaise[1]	sweep[2]	ind ∑[3]	MalS[4]	sweepS[5]	totS[6]	rarefS[7]	indicS[8]
Taljavaaranvuoma	2	10	399	28	20	31	22.9	3
Vuotsonperänjänkä	1	5	283	24	12	30	21.7	1
Silmäsvuoma	1	7	335	22	20	32	22.3	4
Akrahamanvuoma	3	13	520	28	26	38	24.6	8
Repsuvuoma	1	5	204	21	23	34	25.8	7
Vasanvuoma	2	11	1109	33	30	43	23.2	10
Nunaravuoma	1	4	547	7	2	7	3.6	1
Kielisenpalo	2	8	831	45	27	56	26	8
Vielmakoskenpalo NW 1	1	4	561	35	17	41	24.3	6
Vielmakoskenpalo NW 2	1	3	485	31	16	40	22	5
Siettelonvuoma	1	5	286	20	15	27	20	2
Palontaustanlampi N	1	3	443	23	7	24	12.2	1
Palontaustanlampi NE	1	2	137	22	5	25	22.5	2
Narkivaara NE	1	3	383	20	7	21	14.3	2
Jietanasvuoma	2	7	594	26	22	32	21.7	4
Hietajänkkä 1	1	4	100	13	17	22	22	2
Hietajänkkä 2	1	4	123	21	7	22	20.6	2
Suttijärvi	1	5	2210	15	19	27	7.8	1
Hanhijänkä 1	1	3	112	15	8	18	17.4	0
Hanhijänkä 2	1	3	104	14	11	22	21.6	0
Pierkivaaranjänkä	1	4	456	30	15	37	22.8	5
Perunmammarinjänkä	1	4	428	32	22	38	24.4	7
Galddasjohka 1	1	4	1773	51	19	51	19.6	7
Galddasjohka 2	1	4	1310	52	19	55	20.9	1
Galddasduolbbas 1	1	3	346	28	11	32	19.9	9
Galddasduolbbas 2	1	3	544	30	13	32	21	8
Aksonjunni E	1	3	358	27	6	29	20.4	3
Buolbmatgeasjavri SE	1	4	259	37	12	42	27.5	8
Skalvejavri W	1	3	750	31	18	36	20.3	6
Pikku-Malla 1	1	2	107	21	7	26	25.2	5
Pikku-Malla 2	1	2	151	24	11	28	24.2	4
Gihccegorzi SE 1	1	2	716	37	10	39	21.8	5
Gihccegorzi SE 2	1	2	632	32	8	34	20	3
Saana	1	2	320	25	15	31	20.3	6
Iso Jehkas W	1	1	1384	6	2	6	2.7	1
Havgajohka	1	2	531	35	14	40	20.6	8
mean			551			32	20.2	4.3
sd			475			11	5.6	2.9

[1]Number of Malaise traps in a study site; [2]Number of sweep-net samples taken from a study site; [3]Total number of collected specimens; [4]Number of species caught by Malaise trap(s); [5]Number of species obtained from sweep-net samples; [6]Total number of species; [7]Rarefied species richness; [8]Number of indicator species.

Mean species richness of the study sites was 32 species (sd 11, max 56, min 6, Table 3). The most species-rich locality was Kielisenpalo (site 8) in the southern subzone. Both study sites in the Galddasjohka stream valley (site 24: 55 spp; site 23: 51 spp) were rich in species and Vasanvuoma (site 6) rich birch fen harboured 43 species. Hence, most species rich assemblages of semiaquatic flies (species ≥40) were met in eutrophic fens, seepages or around headwater streams. The most species-poor sites were an oligotrophic fen (site 7 Nunaravuoma, 7 spp) and a brook flowing from a snow-bed lying in the middle oroarctic zone 815 m a.s.l. (site 35 Iso Jehkas W, 6 spp). Mean species richness of the rarefaction-standardised samples was 20.2 (sd 5.6, max 27.5, min 2.7, Table 3). In general, sites where total number of specimens was relatively low scored high in the rarefied number of species and sites with high number of specimens (and usually one or few numerically dominating species) had low rarefied species richness (Table 3).

Most common species (frequency >50 %) in the 36 study sites were *Tricyphona immaculata* (94 %), *Phylidorea squalens* (86), *Tipula melanoceros* (86), *Tipula subnodicornis* (86), *Dicranomyia ponojensis* (75), *D. rufiventris* (75), *Ptychoptera minuta* (72), *Prionocera turcica* (69), *Pedicia rivosa* (69), *Logima satchelli* (67), *Dicranomyia distendens* (64), *Prionocera subserricornis* (61), *Tipula excisa* (58), *Dicranomyia terraenovae* (56), *D. stigmatica* (53), *Prionocera pubescens* (53) and *Idioptera linnaei* (53). The 22 most numerous species (>300 individuals/species) accounted for 65 % of the total number of collected specimens. Altogether 25 species (18 % of the total 138 species) were found only from a single site. Some of these rare species perhaps become less frequent and abundant in the northern parts of their range (e.g. *Erioptera beckeri*, *Rhypholophus haemorrhoidalis*) or their preferred habitats were poorly sampled in this study. Some truly northern species (e.g. *Tipula tchukchi*) are apparently rare in Finland and are limited to the subalpine subzone in their occurrence.

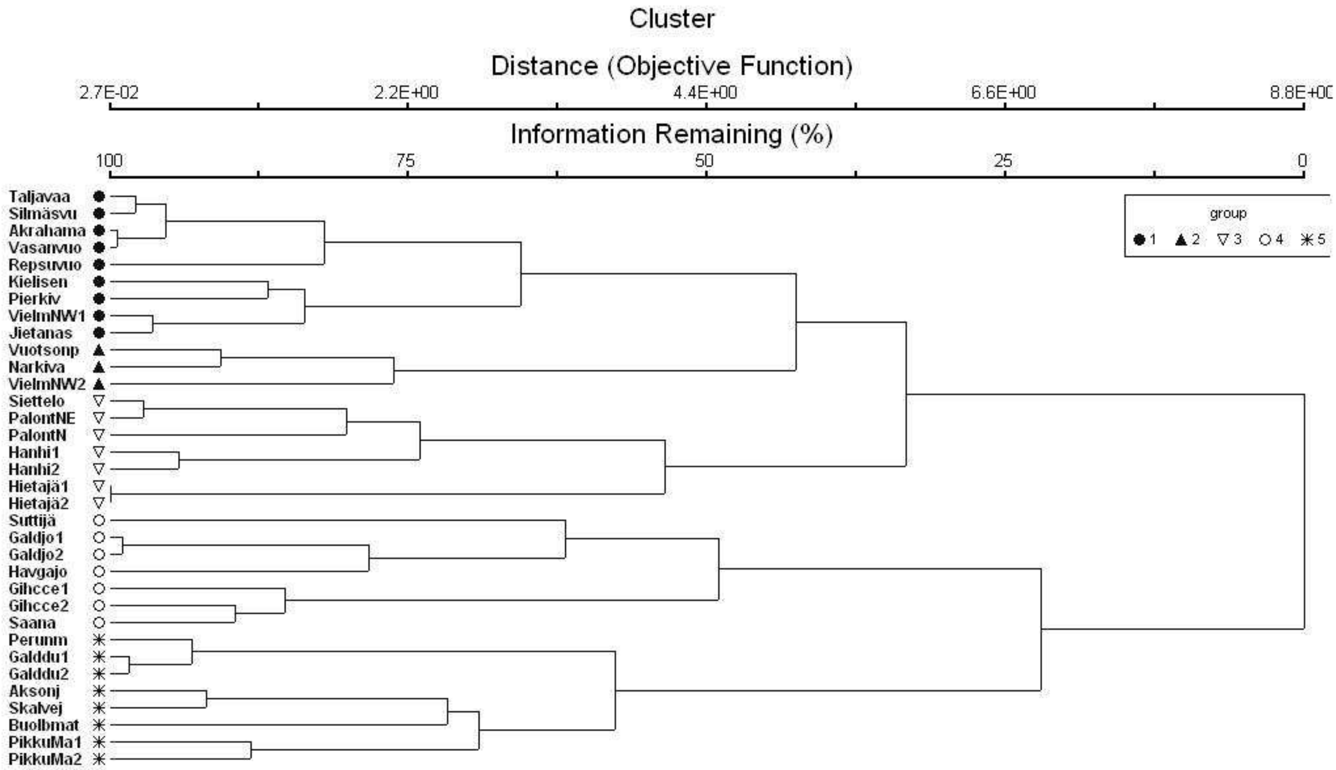

Figure 3. Cluster dendrogram of the 34 study sites (two outliers removed) indicated by their cluster group membership (1-5).

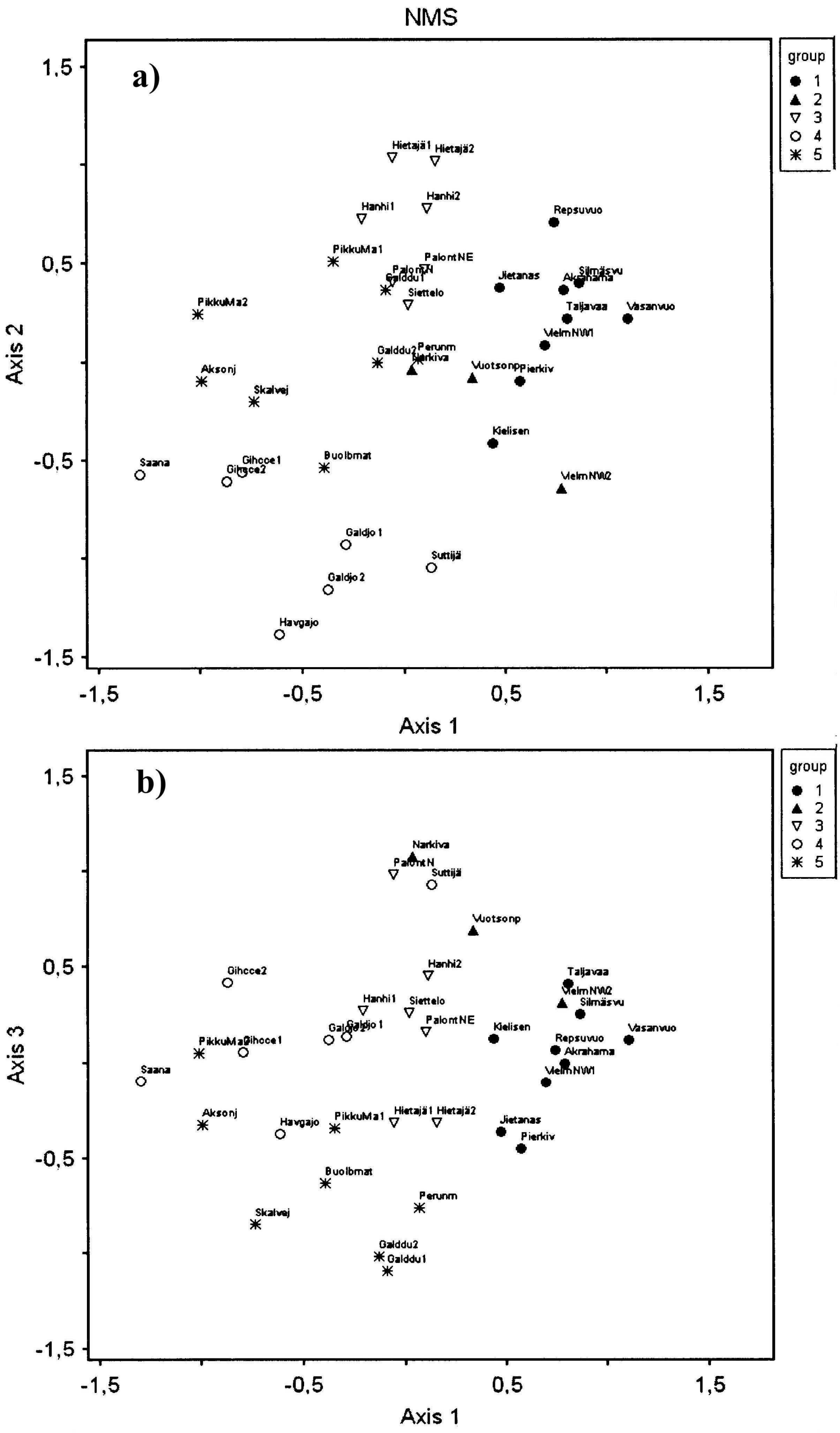

Figure 4. NMS ordination of the 34 study sites indicated by their cluster group membership (1-5) along (a) first and second and (b) first and third dimensions. Names of certain study sites are abbreviated.

3.2. Patterns in the community structure

34 study sites (two outliers were excluded from the analyses) were classified into five groups by Cluster analysis. The cluster dendrogram was pruned at the level of ≥50 % information remaining to define groups (Figure 3). Sites indicated by their group membership are also graphically shown in NMS-ordination (Figure 4). According to MRPP test, a highly significant statistical difference between groups was detected (A=0.21, p=<0.0001). Further, Indicator Species Analysis found numerous significant indicators for the cluster groups (group 1, 16 Indicator Species [IS]; group 2, 8 IS; group 4, 13 IS; group 5, 8 IS, Table 4). Southern aapa mires characterised by rich fen vegetation (group 1) are quite clearly separated from the other groups, as indicated by the NMS-ordination. Quite close to these comes a group of three sites in the southern – middle subzone (group 2), having sloping fens and rich fen vegetation as common features. Group 3 is formed by sites farther in the north than sites in groups 1 and 2, and being characterised by oligo-mesotrophic vegetation. Groups 4 and 5 are composed of sites lying in the subalpine subzone; group 4 is characterised by springs and flowing water and group 5 by palsa mires, alpine wetlands and rich fen vegetation. To conclude, north – south gradient, trophic status, influence of groundwater and presence – absence of flowing water are probably the most important environmental variables influencing the nematoceran assemblages.

Table 4. Indicator nematoceran species, their indicator values (IV) and consequent significances (p) among cluster groups.

indicator species	group	IV	p
Phylidorea abdominalis	1	88,9	0,001
Tipula luteipennis	1	74,4	0,001
Phylidorea heterogyna	1	66,7	0,003
Erioptera nielseni	1	66,7	0,005
Helius longirostris	1	66,7	0,003
Pilaria meridiana	1	64,4	0,001
Erioptera flavata	1	54,4	0,018
Dicranomyia ventralis	1	53,4	0,007
Prionocera pubescens	1	51,1	0,002
Prionocera turcica	1	49,6	0,001
Pneumia ussurica	1	47	0,01
Pilaria decolor	1	42,5	0,035
Dicranomyia terraenovae	1	41,1	0,01
Dicranomyia ponojensis	1	36,9	0,025
Dicranomyia longipennis	1	33,3	0,048
Phylidorea squalens	1	30,8	0,014
Tricyphona unicolor	2	62	0,002
Phylidorea fulvonervosa	2	55	0,024
Dixella hyperborea	2	53,8	0,005
Phylidorea longicornis	2	53,7	0,013
Phylidorea umbrarum	2	45,3	0,015
Dicranomyia stigmatica	2	43,3	0,004
Metalimnobia zetterstedti	2	40,9	0,015
Tipula gimmerthali	2	37,6	0,047
Molophilus flavus	4	71,6	0,001
Neolimnomyia nemoralis	4	67,5	0,002
Cylindrotoma distinctissima	4	60,2	0,004
Tipula nubeculosa	4	57,8	0,006
Pneumia mutua	4	57,1	0,005
Parabazarella subnegleta	4	52,5	0,013
Limonia sylvicola	4	42,9	0,022
Ripidia maculata	4	42,9	0,029
Dicranota gracilipes	4	42,9	0,028
Tricyphona schummeli	4	42,9	0,026
Dixa nebulosa	4	42,9	0,026
Berdeniella freyi	4	40,6	0,042
Dicranota bimaculata	4	36,8	0,045
Symplecta meigeni	5	77,4	0,001
Dicranomyia hyalinata	5	66,7	0,001
Prionocera ringdahli	5	55,2	0,012
Ptychoptera hugoi	5	52,9	0,006
Erioconopa diuturna	5	47,4	0,013
Dixella laeta	5	42	0,036
Angrotipula tumidicornis	5	39,6	0,041
Prionocera abscondita	5	37,5	0,032

3.3. Temporal succession of species and individuals

Temporal succession and abundance of the semiaquatic flies was assessed by using sweep-net samples; Malaise trap material was not valid for this purpose due to long collecting intervals. In the study sites 1-10 (being mostly rich aapa mires, located in the southern subzone) there was a relatively high number of species flying early in the season, and the maximum number of species were flying in the last half of August (Figure 5a). The drop of species within weeks 24-25 was due to negligible sampling effort. Two peaks in the abundance of collected specimens were observed, great proportion of nematoceran individuals occurring in the early (first half of June) and late season (last half of August) (Figure 5b). The tipulid fly *Prionocera pubescens* was actually far more abundant in the field than in the samples, especially in rich birch fens, where thousands of them were flying in the first half of June (it would have been impossible and meaningless to catch all *P. pubescens* individuals seen in its peak of flight). Thus, there is a bimodal pattern in the seasonal abundance of semiaquatic flies in aapa mires in this region. If all sweep-net material is combined, different temporal patterns in the number of species and individuals are detected (Figure 5c, d). Peak of species richness is observed within end of June – beginning of July; a slight drop in the number of species is seen within end of July – beginning of August and a subsequent rise within weeks 30-31 (Figure 5c). Abundance of the caught specimens peaked in the end of June – beginning of July and in the last half of August (Figure 5d). For example, species occurring in great abundances in the early season were *P. pubescens*, *Tipula subnodicornis* and *T. grisescens*; later in the season (weeks 26-29) *Helius longirostris*, *Prionocera turcica*, *Idioptera linnaei*, *Erioptera flavata* and *Phylidorea squalens* were abundant and *Dicranomyia rufiventris*, *D. ponojensis*, *Tipula melanoceros*, *T. luteipennis* and *Erioconopa diuturna* were very abundant in August (weeks 32-35) (Table 5). The pediciid fly *Dicranota guerini* shows some tendency of having two generations within a flying season; its abundance was highest in the late June and in the end of August. Meniscus midges *Dixella obscura* and *Dixa nebulosa* may also have a bivoltine lifecycle, but their highest abundance is clearly in the end of season (Table 5).

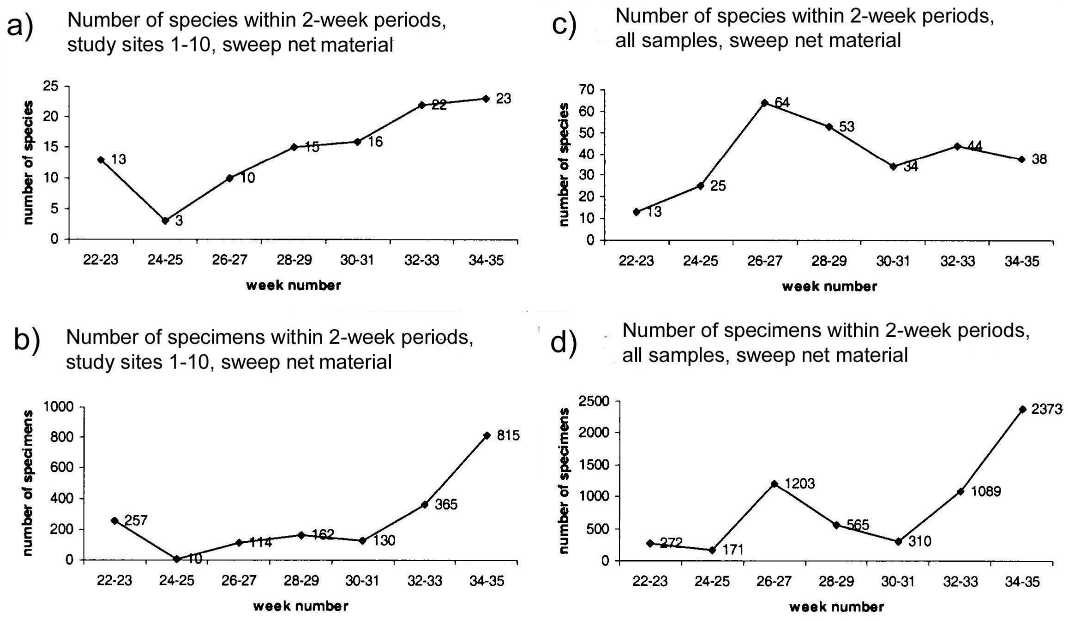

Figure 5. Patterns in the temporal succession of semiaquatic fly species (a, c) and specimens (b, d) in two-week intervals, sweep net material. Study sites 1-10 (a, b) were aapa mires located in the southern subzone, whereas figures c and d are based on all sweep net material from southern to subalpine subzones. In southern aapa mires (a) number of species is highest in the end of season (August), and number of specimens (b) is peaked in the early (June) and late (August) season. In combined material, number of species (c) is highest in July and number of specimens (d) is high in July and especially in August.

Table 5. Temporal succession of the semiaquatic flies (Diptera, Nematocera) as assessed in two-week intervals, their absolute abundances, sweep-net samples. Species are arranged according to their flying period, starting from vernal and ending to autumnal species.

	week number						
	22-23	**24-25**	**26-27**	**28-29**	**30-31**	**32-33**	**34-35**
Tipula subnodicornis	51	18	34	1			
Prionocera serricornis	43		2				
Prionocera pubescens	95	23	23	15	13		
Tipula grisescens	36	9	1				
Prionocera subserricornis	1	6	57	3	1		
Angarotipula tumidicornis	4	6	9				
Dicranota guerini	3	1	22	1		3	21
Tricyphona unicolor	2		5	6			
Helius longirostris	6		46	17			
Idioptera linnei	6	10	50	10	8		
Prionocera turcica	16	19	24	41	6		
Metalimnobia zetterstedti	1	1					
Erioptera lutea	8			2	1		
Erioptera flavata		7	32	51	35	2	
Phylidorea abdominalis		2	13	17	9		
Prionocera woodorum		1					
Phalacrocera replicata		1	3				
Prionocera chonsenicola		4	9				
Pneumia mutua		35					
Parabazarella subnegleta		7	24				
Pericoma rivularis		1	2				
Tipula mutila		1					
Pedicia rivosa		1	4	8			
Molophilus flavus		6	33	21	4		
Dicranota exclusa		5	92	22	33	5	1
Dicranota bimaculata		1	4	3	7	2	
Idioptera pulchella		3	20	2			
Dixella amphibia			8	3	2	8	
Tricyphona immaculata			37	9		1	
Phylidorea squalens			48	45	7		
Pericoma formosa			1				
Pneumia stammeri			3				
Eloeophila trimaculata			73	2			
Molophilus propinquus			16	5			
Dicranomyia morio			2				
Tipula varipennis			1				
Tipula subexcisa			1				
Tipula excisa			20	3	1		
Dicranomyia caledonica			13	7			
Molophilus ater			253	11			
Ormosia fascipennis			1				
Symplecta meigeni			6				
Pneumia pilularia			1				
Berdeniella freyi			52				
Orimarga attenuata			2	1	1		
Prionocera ringdahli			7				
Euphylidorea meigenii			4	1	1	1	
Tipula moesta			10				

Table 5. Continues.

	week number						
	22-23	**24-25**	**26-27**	**28-29**	**30-31**	**32-33**	**34-35**
Tipula lateralis			1				
Prionocera recta			2				
Dicranomyia distendens			6	4			
Erioptera beckeri			1				
Cheilotrichia areolata			28	3			
Phylidorea longicornis			14	3	4	1	
Ptychoptera hugoi			2	1			
Cylindrotoma distinctissima			1	13			
Tipula laccata			6	10			
Dolichopeza nitida			1	1			
Ptychoptera minuta			18	3	7		
Tipula montana			3				
Tipula salicetorum			6				
Tipula coerulescens			2				
Limonia macrostigma			2			1	
Dicranomyia halterata			2				
Dicranota pavida			33			2	
Neolimnomyia nemoralis			1	112	2	1	
Tipula lunata				1			
Metalimnobia quadrinotata				2			
Molophilus crassipygus				3			
Dicranomyia stylifera				2			
Erioptera nielseni				26	6		
Eloeophila maculata				2			
Tipula variicornis				5			
Tipula freyana				4			
Ormosia staegeriana				14			
Phylidorea fulvonervosa				6			
Tipula luridorostris				2			
Phylidorea umbrarum				12	12		
Dixella aestivalis				1	6	10	8
Dixella hyperborea				18	10	112	2
Tricyphona schummeli				1			
Euphylidorea phaeostigma				1			
Tipula trispinosa				1			
Ormosia ruficauda				7		5	
Pilaria decolor					16	20	
Dicranomyia terraenovae					9	34	177
Pilaria meridiana					13	58	1
Dicranomyia rufiventris					15	327	131
Tipula melanoceros					8	84	60
Dicranomyia modesta					2	3	8
Dicranomyia hyalinata					2		96
Dixella laeta					18	66	93
Limonia sylvicola					36	13	5
Dicranota gracilipes					12	102	28
Limonia trivittata						3	
Dicranomyia aperta						5	
Dicranomyia magnicauda						7	
Discobola annulata						1	

Table 5. Continues.

	week number						
	22-23	24-25	26-27	28-29	30-31	32-33	34-35
Dicranomyia didyma						1	8
Phylidorea heterogyna						87	2
Ula sylvatica						1	
Logima satchelli		1				1	2
Dixella borealis						16	12
Dixella obscura		2	3		1	20	62
Tipula luteipennis						11	210
Dixella naevia						17	107
Dicranomyia ponojensis					2	17	372
Dicranomyia ventralis						3	39
Dicranomyia stigmatica						4	35
Dicranomyia halterella			2			20	138
Dicranomyia longipennis						1	16
Dicranomyia patens						3	3
Dicranomyia omissinervis							1
Dicranomyia autumnalis							7
Phyllolabis macroura							10
Tipula gimmerthali						1	150
Dicranomyia moniliformis							1
Erioptera diuturna							298
Tipula invenusta							46
Gonomyia stackelbergi						3	133
Tipula limbata							16
Dixa nebulosa			1			6	72
Chodopsycha lobata							1
Thaumalea truncata							1

3.4. Distribution and ecology of the species

Distribution and ecology of the studied species in Finland were estimated (Table 2). Altogether 81 species were assessed as wide-ranging flies (distributed all over Finland, from south to north boreal region, including alpine subzone), 40 as northern species (distributed in middle – north boreal region), 29 as southern species (distribution in Finland up to middle subzone of the northern boreal region) and four as alpine species (distribution in Finland confined to subalpine subzone of the northern boreal region) (Figure 6a). It should be expressed here, that *Ormosia fascipennis*, *Phyllolabis macroura*, *Symplecta meigeni*, *Dicranomyia ponojensis*, *Orimarga attenuata*, *Angarotipula tumidicornis*, *Ptychoptera hugoi* and *Thaumalea truncata* were classified as northern species, although there are findings from the southern boreal region. These findings from south boreal region are, however, rather old (about 100 years old, for example *O. fascipennis* and *P. macroura*) or relict-like populations far from their main distribution area (e.g. *D. ponojensis*, *O. attenuata*). Hence, above mentioned species are defined as northern due to their main occurrence in Finland. In a similar manner, *Scleroprocta sororcula* and *Rhypholophus haemorrhoidalis* were classified as southern although there are single findings from the subalpine subzone of the northern boreal region.

Studied flies were classified to five main ecological categories and further to 12 finer-scale classes as follows: **peatland species 77** (swamp species [surface fed habitats] 26, rich fen species [mesotrophic and eutrophic mires] 19, peatland generalist species 18, eurytopic wetland species 14), **lotic species** (brooks and streams) 30,

terrestrial species 28 (eurytopic terrestrial species 17, saproxylic species [dependent on decaying wood] 5, fungi species [dependent of fruiting bodies of fungi] 5, rich forest species 1), **alpine species** 12 (alpine wetland species 9, alpine terrestrial species 3), **spring species** (groundwater fed habitats) 7 (Figure 6b).

3.5. Species new for Finland, rare and probably threatened flies

Dicranomyia moniliformis Doane (Lkoc: Akrahamanvuoma, Repsuvuoma), *Dolichopeza nitida* Mik (Lkor: Sodankylä, Li: Tievoja) and *Prionocera abscondita* Lackschewitz (Le: Pikku-Malla, Li: Galddasduolbbas) were found for the first time from Finland in the course of the present study. A total of 93 new provincial records of the semiaquatic fly species were made (Lkor 3, Lkoc 42, Le 33, Li 16 new records). In addition to the species new for the regional fauna, findings of several rare, insufficiently known and possibly threatened species such as *Paradelphomyia nigrina*, *Erioptera beckeri*, *E. nielseni*, *Rhabdomastix parva*, *Symplecta* sp*, *Dicranomyia aperta*, *D. longipennis*, *D. omissinervis*, *D. lulensis*, *D. stylifera*, *Prionocera woodorum*, *Tipula obscuriventris*, *T. subexcisa*, *T. laccata*, *T. tchukchi*, *Dicranota robusta*, *Pneumia pilularia*, *P. ussurica* and *Thaumalea truncata* were highly interesting.

[*Based on Theolwald's (1971) view, identification of the male specimen from Malla Strict Nature Reserve would lead to *S. novaezemblae scotica*. However, J. Starý has examined the specimen, and according to him this identification is no longer valid. *S. scotica* and related species will be revised in a forthcoming publication (J. Starý & F. Brodo in prep.). The specimen discussed here will be included in their studied material and reported by them in its new taxonomic concept.]

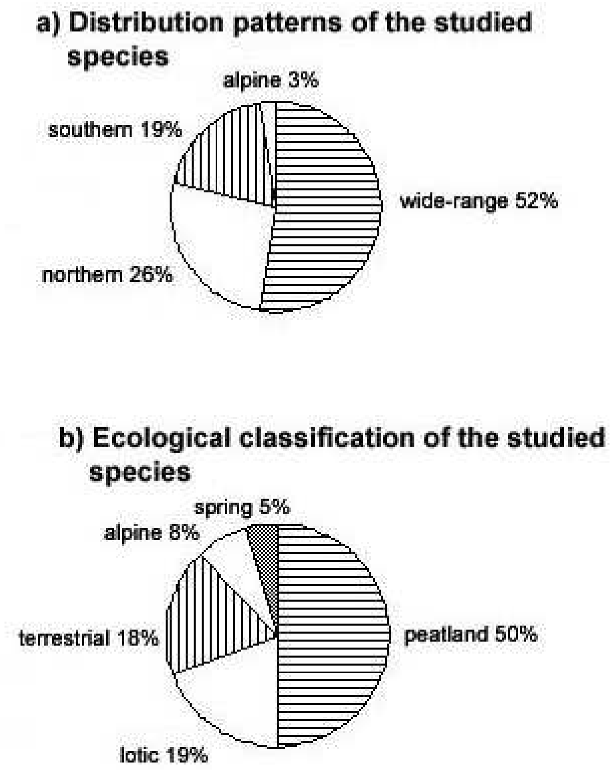

Figure 6. a) Distribution patterns of the studied 154 semiaquatic fly (Diptera, Nematocera) species in Finland, as classified here: wide-range species occurring all over Finland, from the southern boreal to the subalpine subzone (see Figure 2), northern species not occurring in the southern boreal zone, southern species extend their range up to the middle subzone and alpine species are restricted to the subalpine subzone. b) Rough ecological classification of the 154 species (for details, see 3.4.): peatland dwellers (mires, swamps, eurytopic wetland species), lotic species, terrestrial species, alpine species (both terrestrial and semiaquatic) and spring species (crenobiontic, confined to spring-fed habitats).

4. Discussion

4.1. Regional species richness of flies, abundance, sampling methods

A total of 154 species of flies belonging to nine nematoceran families were identified in this study, which is 38 % of the total number of species found from Finland. A vast number of species were craneflies, which comprised 81 % of the total number of species. Among craneflies Limoniidae was the most species rich family with a proportion 55 %. As noted by Mendl (1979), in northern regions the subfamily Limoniinae is more rich in species than Chioneinae (=Eriopterinae) which are dominant in the more southern latitudes (e.g. in Central Europe). This was also the case in the present study: Limoniinae was the most species rich subfamily (32 spp) over Chioneinae (21 spp) and Limnophilinae (=Hexatominae, 16 spp). In the three biogeographical provinces where this study was performed (Lkoc, Le, Li; only one sweep net sample was taken from Lkor) a total of 215 species belonging to the families covered here have been recorded (J. Salmela, unpublished), thus 72 % of the known regional fauna was collected.

Quite large number of specimens, 15718 exx, was collected by Malaise traps. On average, 374 individuals were caught per trap, which is higher than the mean number of 295 individuals/season of the Malaise trapping of semiaqutic flies in Finland between 1999 and 2006 (material based on 208 traps and over 61000 specimens, J. Salmela, unpublished). This difference in abundance may be due to presence of certain very productive and lack of very specimen-poor sites in the present study. Suttijärvi, Galddasjohka 1, Galddasjohka 2 and Iso Jehkas W were the sites where flies occurred in highest abundances; in the three first mentioned sites high abundance of flies was attributable to cold stenothermic and lotic psychodids, whereas in the last mentioned site alpine, terrestrial limoniid *Phyllolabis macroura* was super dominant (see 4.2.).

Among the most interesting results, in the light of methodological aspects and community studies of semiaquatic flies, is the comparison between Malaise traps and sweep netting. In the present study, the total number of species in a site was obtained by combining species number of trap(s) and sweep netting. In general, Malaise traps were quite efficient, an average of 84 % of species were caught by traps in the study sites. However, the contribution of sweep net material was significant, although less than half (44 %) of the species were caught by sweep netting in the study sites in average (in some sites, where sweep netting was performed several times in the study period [sites 1-5, 5-13 samples], only 40 to 68 % of the total number of species were caught). There were seven species, which occurred only in the sweep net samples (most notably *Dicranomyia longipennis* and *Dixella laeta*) or they were more abundant in net samples than in the traps (e.g. *Phylidorea abdominalis*, *Dicranomyia ponojensis*). On the other hand, 47 species were present exclusively in Malaise traps and sweep netting as a method is sensitive to weather conditions, collecting in rainy days or sweeping wet vegetation is certainly not very profitable. To conclude, Malaise trap is efficient in the community studies of wetland-inhabiting flies, but sweep netting may be used as an additional method in order to have a realistic picture on the abundance and frequency of certain species not properly caught by Malaise trap. Sweep netting should be performed at least four times during a season (first half of June, July, early August and last half of August) due to the temporal succession of adult flies (see 4.4.).

Some northern boreal, autumnal species extend their flying season to the September and even October, but there should be only two boreal cranefly species with such a late flight period that they would have probably been missed in this study. In Sweden, *Tipula persignata tofina* Alexander (as *T. persignata*) and *T. boreosignata* Tjeder have been collected only in September (Tjeder 1974). However, these poorly known species are not yet known to occur in Finland. Further exceptions are, of course, the wingless members of the genus *Chionea* (Limoniidae), which are present from late autumn to early spring (Mendl *et al*. 1977). *Chionea*, however, are forest-dwelling craneflies and not dependent on wetland biotopes (Tahvonen 1932, Itämies & Lindgren 1985).

4.2. Diversity of the studied communities, common and rare species

Number of species in the study sites ranged from six to 56, on average 32 species was recorded per site. This average number is higher than the mean number of species (26 spp) based on Malaise trap material from 208 wetland sites in Finland (J. Salmela, unpublished), which is partly explainable due to sweep netting in the present study. Most species rich sites were distributed over the subzones of the northern boreal ecoregion, and thus, no differences in species richness among southern, middle and subalpine subzones were noted. Further, mean species richness in the rich fens of southern subzone (sites 1-6) and in the palsa mires and rich fens in the middle (site 21) and subalpine subzones (sites 22, 25, 26) was the same, 35 species. The most diverse localities were characterised by springs, rich fen vegetation and flowing water, and the sites were lying in relatively low altitudes. In comparison, oligotrophic – mesotrophic vegetation or location in higher altitudes were in relation to lower species number. In other words, the more diverse (number of microhabitats) the environment, the richer the fly assemblage, as predicted by ecological theory (Begon *et al*. 1996). Most species rich (>60 spp) sites of semiaquatic flies in Finland (single Malaise trap in a single collecting season) are located in the southern boreal and hemiboreal region and sites where >50 species are present could be assessed as very species rich localities (Salmela *et al*. 2007). Considering mires, in a number of studies (Brunhes 1990, Brunhes & Villepoux 1990, Brunhes & Dufour 1992, Salmela 2004, Salmela & Ilmonen 2005) it has been noted that there is a positive relationship between the species richness of flies (families treated here) and the trophic status of the mire. Patterns in species richness of lotic environments are not well known, but according to Mendl *et al*. (1987) and Solem and Mendl (1989) diversity of limoniid and pediciid fauna of lotic environments declines with increasing altitude. In boreal Finland, diverse lotic communities of semiaquatic flies are associated with circumneutral pH, cold water temperature during summer and rich riparian vegetation (J. Salmela, unpublished). Most likely the conditions in the interface of the flowing water and the bank area are the crucial environmental filters influencing semiaquatic fly community composition and diversity (Brinkmann 1991).

It should be remembered that semiaquatic flies were collected only by sweep netting from a number of localities (Appendix 1) in addition to the study sites. Because no Malaise traps were used, information on the diversity and species composition of these sites is not comparable to Malaise-trapped sites. However, three sweep net sites should be mentioned here: Kutuoja and Lismajoki headwater streams in the southern subzone, and a brook flowing to Lake Davrraluobbal in Utsjoki, subalpine subzone. The two first mentioned sites were located on calcareous bedrock, being characterised by clear water, abundant submerged vegetation (e.g. *Fontinalis antipyretica*, *Caltha palustris*) and rich riparian vegetation (including *Ranunculus lapponicus*, *Lactuca sibirica*, *Polemonium acutiflorum*) with a canopy of deciduous trees (birch, alder). A total of 32 and 27 species were collected from Kutuoja (fauna of two close sampling sites combined) and Lismajoki, respectively. *Dicranomyia omissinervis*, *D. morio*, *Tipula luridorostris*, *T. laccata* and *T. freyana* were among the most interesting findings from these two sites. The brook flowing to the lake Davrraluobbal was characterised by slightly humic water and swampy shores with luxuriant vegetation (*Matteuccia struthiopteris* was eye-catching). Altogether 28 species were found from the site, including poorly known and rare craneflies viz. *Prionocera woodorum*, *Tipula laccata* and *T. moesta*. As noted above, 40-68 % of the semiaquatic fly species were collected by sweep netting from the sites with several samples during the season. Hence, the “true” total number of species from the three above mentioned headwater brooks may be close to 50.

There were 17 species which were present in >50 % of the study sites. With the exception of two species (*Ptychoptera minuta*, *Logima satchelli*) all were craneflies. These most common species tended to occur abundantly and most of them have wide distribution in Finland; only two species, *Dicranomyia ponojensis* and *Tipula excisa* have northern distribution (the former has a relict population in southern boreal Finland, Salmela 2004). These species are mainly dwellers of various types of peatlands (e.g. *Dicranomyia distendens*, *Tipula subnodicornis*) or eurytopic inhabitants of wetlands (e.g. *Tricyphona immaculata*, *Ptychoptera minuta*). There were five species whose abundance exceeded 1000 individuals in the study sites. Two of these were lotic psychodids preferring spring-fed habitats, *Berdeniella freyi* and *Parabazarella subnegleta*; the former was abundant in Galddasjohka and Havgajohka headwater streams whereas the latter was dominant species in Suttijärvi spring. *Tricyphona immaculata* was present in the almost all of the study sites, being most abundant in rich fens with spring influence (Kielisenpalo, Gihccegorzi SE 2) and headwater stream with seepages (Galddasjohka 1). *Phyllolabis macroura* was found only from three sites (all in Kilpisjärvi area, lying on Caledonian mountain belt), and being very abundant in the Iso Jehkas W, lying in the middle oroarctic zone. According to Mendl *et al*. (1987) and Solem & Mendl (1989), *P. macroura* was superior in abundance in low and middle alpine zones (circa 1000-1400 m a.s.l.) in the Norwegian mountains. Finally, *Molophilus flavus* occurred in spring-fed sites and it was most abundant in Galddasjohka 1 and Gihccegorzi SE 1. The species is common dweller of springs and cold headwater streams all over Finland (Salmela 2006).

At the other extreme in the continuum of common and rare species are those flies which were found only from one locality. 16 out of 25 of these rare species were present as singletons in the samples. Some of these rare species have probably very limited distribution in the subalpine subzone (*Symplecta* sp, *Tipula tchukchi*) or have otherwise wide distribution in Finland but become less frequent in northern parts of their range (*Rhypholophus haemorrhoidalis*, *Scleroprocta sororcula*). Certain species are not rare, but their preferred habitats were poorly sampled or the habitats studied here were suboptimal for them. Such species, for example, are *Dicranomyia patens* and *D. magnicauda*, which are dwellers of swampy shores of rivers and lakes. Some rare species are discussed below with more details.

4.3. Grouping of the study sites, indicator species and environmental variables likely to influence assemblage structure

The analysed 34 study sites were classified to five cluster groups based on their species composition and the relevance of the classification was assessed by using NMS-ordination, MRPP-test and Indicator Species Analysis. These groups or community types seemed to be best differentiated due to geographical location in north – south gradient, mire trophic status, influence of groundwater and presence – absence of flowing water. Sites belonging to group 1 were southern aapa mires with rich fen vegetation. There was a high number of significant indicator species, represented by mire-dwelling species favouring eutrophic conditions (e.g. *Phylidorea abdominalis*, *Erioptera nielseni*, *Pneumia ussurica*, *Dicranomyia longipennis*). Further, indicator species included wide-ranging species of wetlands (*Helius longirostris*, *Prionocera pubescens*, *P. turcica*), which were very abundant within the sites of this group. Group 2 was composed of three sites, sharing rich fen vegetation and sloping mire surface as unifying features. Indicator species of the present group were mainly dwellers of swamps (e.g. *Phylidorea fulvonervosa*, *P. umbrarum*) and rich fens (*Tipula gimmerthali*). Sites of the group 3 were quite clearly differentiated from the other groups in the NMS-ordination, although no significant indicator species were found. These sites lay in the middle and subalpine subzones and were characterised by oligo-mesotrophic vegetation.

Group 4 was formed by sites lying in the subalpine subzone, being characteristic of spring influence and flowing water. Indicator species of this group are dwellers of springs and cold headwater streams (*Molophilus flavus*, *Parabazarella subnegleta*, *Pneumia mutua*, *Tricyphona schummeli*, *Berdeniella freyi*) or being species of lotic waters (*Dixa nebulosa*, *Dicranota bimaculata*). Furthermore, the rest of the indicator species of this group (*Neolimnomyia nemoralis*, *Cylindrotoma distinctissima*, *Tipula nubeculosa*, *Limonia sylvicola* and *Rhipidia maculata*) prefer moist soil or are terrestrial. These species have originated to the samples from the adjacent riparian forests or alpine meadows. Sites belonging to group 5 were palsa mires or alpine wetlands in the subalpine subzone. Indicator species of this group are northern (e.g. *Symplecta meigeni*, *Prionocera ringdahli*, *P. abscondita*) or are abundant in alpine wetlands (*Dicranomyia hyalinata*, *Erioconopa diuturna*), *Dixella laeta* is characteristic of lentic, northern boreal waters. Two outlier sites, Nunaravuoma and Iso Jehkas W, were not included in the community analysis. These sites were so different in their low nematoceran diversity and species composition to other localities, and thus, their removal was reasonable for technical reasons. However, sampling of semiaquatic flies in these localities was not unsatisfactory, because high numbers of individuals was caught from both sites. Nunaravuoma was an oligotrophic fen, poor in plant and bryophyte species richness and dominated by *Tipula subnodicornis* (496 exx). Iso Jehkas W was lying high above tree line in the middle oroarctic zone, characterised by snow-bed and alpine heath vegetation. *Phyllolabis macroura* was there superior in abundance (1340 exx). Thus, the sites display a natural low diversity of flies and, most likely, if more such habitats would have been sampled (poor fens and oroarctic snow-beds) they would have formed their own cluster group in the community analyses.

4.4. Temporal succession of species and seasonal variation in abundance

Assessment of temporal succession of species (phenology) and their abundance was based on sweep net samples. These samples were collected through the study period from the end of May till the beginning of September. This collecting method was quite successful for tipuloids, ptychopterids and dixids, but performed poorly regarding psychodids. Thus, the results presented here describe well the phenology of the three first mentioned groups. Malaise traps were emptied in 4-6 week intervals, which were too long for assessing flight periods of the species. Sites 1-10, located in the southern subzone and mainly rich aapa mires, were visited several times (3-13 sweep net samples, mean 7 samples/site) during the study period and adequate view on their species composition, abundance and temporal succession was obtained. In these sites, and likely in other rich aapa mires in northern boreal region as well, relatively high number of species is on the wing in the early season, there is no peak in July and highest number of species are flying in August. Considering the abundance of semiaquatic flies, there is a peak in early June and in late August. By combining all sweep net material from southern to subalpine subzone, it is clearly seen that the highest proportion of the species are on the wing in July, and the number of individuals peaks in July and in the end of August. These results are in general concordance with studies from Swedish Lapland (Mendl 1974, Tjeder 1974, 1979) and from mountainous areas of Norway (Mendl *et al*. 1987, Solem & Mendl 1989), showing that most tipuloid species are flying in the July and August. However, data as presented here is not available for comparison.

4.5. Distribution patterns of the studied flies, northern species emphasized

Over half of the species (52 %) found in this study were wide-ranging, being distributed all over Finland. Minority of these flies are, however, more frequent in the northern parts of their range (e.g. *Euphylidorea meigenii*, *Dicranomyia hyalinata*) and thus, rare and possibly more demanding in the southern boreal zone. Although certain species have been recorded from the southern boreal zone, they were here classified as northern. These nine species could be placed in two groups: species whose findings from southern Finland are few and old (*Ormosia fascipennis*, *Phyllolabis macroura*, *Symplecta meigeni*, *Angarotipula tumidicornis*) and species which have relict-like populations in the southern boreal zone (*Dicranomyia ponojensis*, *Orimarga attenuata*, *Ptychoptera hugoi*, *Thaumalea truncata*). To clarify, findings of *A. tumidicornis* from the middle boreal (Oba: Oulu, 1 ex) and southern boreal (Sa: Taipalsaari, 1 ex) ecoregions are over 100 years old (specimens deposited in ZMH), and according to Krogerus (1960) there is one record of *O. fascipennis* from a sedge fen ("Weissmoore") in the biogeographical province of Ab (collected in 1930's, no specimen is left for verification). *D. ponojensis* and *O. attenuata* have been found from a spring-fed rich fen in Tb: Toivakka (Salmela 2004) and *T. truncata* from a mesoeutrophic spring in Ta: Ruovesi (Salmela *et al*. 2007), far from their nearest known populations in Ok and Ks (middle – northern boreal zone).

Most of the northern species, as defined here, occur throughout the northern boreal zone and may also be present in the middle boreal zone. Examples of such species are *Cheilotrichia areolata* and *Prionocera ringdahli* (Figure 7a, b). A small number of the northern species seem not to occur in the northernmost part of Finland, and thus, their distribution is limited to the middle boreal zone in south and middle subzone in north (e.g. *Phylidorea umbrarum*, *Tipula freyana*, Figure 7c, d). *Dicranomyia stylifera* (Figure 7e) may have its main distribution in the subalpine subzone and the southern populations in the coniferous zone in Ks: Kuusamo (Frey 1932, Krogerus 1960) are probably glacial relicts. Some arctic-alpine shrubs and herbs have such a distribution pattern in Finland (Saari 1978) and insects, both northern and southern species, are known to have relict populations living in springs far from their core areas (Nielsen 1950). It is not known for sure, due to the inadequate and obscure tabulation by Krogerus (1960), but *D. stylifera* may occur in spring-fed, sloping fens in Kuusamo (see Krogerus 1960, p. 143, Fig. 5). *Tipula obscuriventris* (Figure 7f) has a similar kind of distribution map as *D. stylifera*, but its abscense from the southern and middle subzones may be due to inefficient collecting. Small proportion of the studied species (3 %) was alpine, being present only in the subalpine subzone in Finland. One of these, *Rhabdomastix parva*, has been recorded merely from NW Lapland, Le: Kilpisjärvi area. There are some other poorly known and rarely caught species, all of their findings originating from the same area, e.g. *Arctoconopa forcipata* (Lundström), *A. obscuripes* (Zetterstedt) (Mannheims 1972), *Ormosia brevinervis* (Lundström) (Tjeder 1965) and *Nephrotoma lundbecki* (Nielsen) (Oosterbroek 1979). One further northern species not found in this study is *Limonia maculicosta* (Coquillett), only known from Li: Utsjoki (Siitonen 1984). Because the species is known from Swedish Lapland, Torneträsk area (Mendl 1979) and Messaure (Mendl 1974) it may also occur in NW Finnish Lapland. In addition, northern palearctic species *Tipula kaisilai* Mannheims and *T. pruinosa stackelbergi* Alexander (syn. *T. subpruinosa* Mannheims) have been caught only from Lkoc: Pallastunturit (middle subzone) 1950's, with no recent records from Finland (Mannheims 1954; *T. kaisilai* is reported from Ks: Kuusamo [Viramo 1992] but this finding is based on a female specimen and should be re-examined).

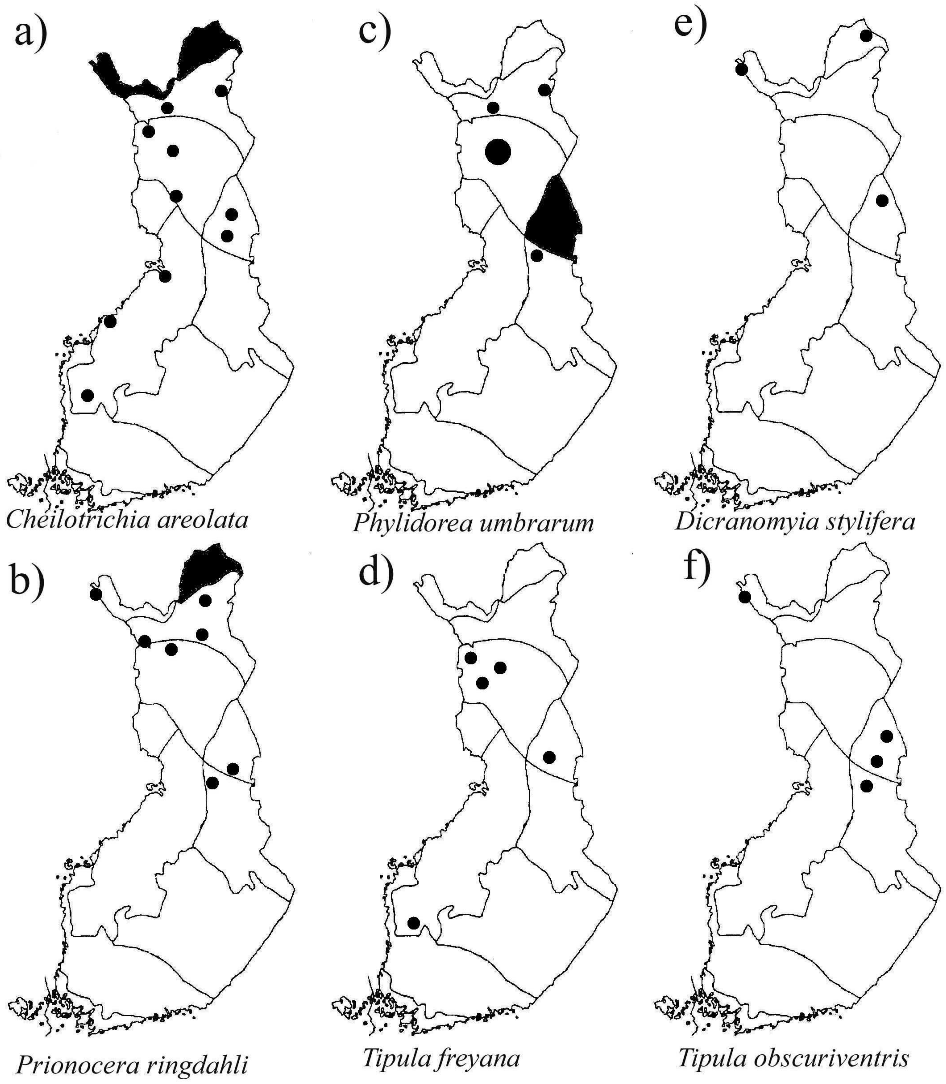

Figure 7. Three different distribution patterns of northern craneflies (Diptera, Tipuloidea) in Finland. *Cheilotrichia areolata* (a) and *Prionocera ringdahli* (b) occur throughout the northern boreal zone and extend their distribution to the middle boreal zone. *Phylidorea umbrarum* (c) and *Tipula freyana* (d) extend their range to the middle boreal zone in the south and middle subzone in the north, being thus absent from the subalpine subzone. *Dicranomyia stylifera* (e) has its main distribution in calcareous areas of the subalpine subzone and rich-fen populations in the coniferous zone in Kuusamo are probably glacial relicts. *Tipula obscuriventris* (f) has similar distribution map, but its absence from the southern and middle subzones may be due to inefficient sampling. small dot=1-4 records; large dot 5-8 records; solid black zones= several records, species is common within the colored area.

4.6. Preliminary, simple conservation value assessment based on semiaquatic flies

Almost all of the studied localities were protected Natura2000 sites, consisting of Strict Nature Reserves, Mire Conservation Areas, Wilderness Areas or other sanctuaries protected by national legislation. All study sites could be assessed pristine in their state of naturalness, meaning that they were not ditched or otherwise modified by man. For this reason, the studied sites are important for nature conservation of boreal and alpine wetlands, and could serve as reference sites for biomonitoring and assessment. These study sites were classified to assemblage types, and as noted above, their communities were differentiated by e.g. geographical location and trophic status. Further, notable differences in the richness of fly species between the sites were detected. In addition to classifying sites depending on community structure and diversity, third possible way to rank the sites is based on the number of indicators, such as rare and threatened species (Chadd & Extence 2004). Quite subjectively, but based on available information and careful consideration by the author, 28 species were selected as indicators, being species which (i) will be probably classified as red-listed (NT, VU, EN, CR) in the next national assessment, (ii) are rare or demanding species, indicative of some specific resource or habitat quality (e.g. calcareous bedrock, emergent groundwater) or (iii) species which main distribution is in boreal region or Scandinavia and could be assessed as international responsibility species of Finland (indicator species are bold-faced in the Table 2). Presence of these species in the study sites were counted, and thus based on this preliminary and simple conservation value evaluation, a rank order of the sites was obtained. Ten indicator species occurred in Vasanvuoma, 8-9 of such species were present in Galddasduolbbas 1, Galddasduolbbas 2, Akrahamanvuoma, Kielisenpalo, Havgajohka and Buolbmatgeasjavri SE. 5-7 indicator species were present in Repsuvuoma, Vielmakoskenpalo NW1, Vielmakoskenpalo NW2, Pierkivaaranjänkä, Perunmammarinjänkä, Galddasjohka 1, Skalvejavri W, Pikku-Malla 1, Gihccegorzi SE1 and Saana. In rest of the sites, number of indicator species ranged from 0-4 (Table 3). To conclude, rich birch fens and flark rich fens of the southern subzone and palsa mires of the subalpine subzone were highly valuable considering their nematoceran assemblages and sites lying on base-rich bedrock with seepages or flowing water ranked high as well. Not surprisingly, sites with high nematoceran richness harboured high number of indicator species, an exception being Galddasjohka 2, which was the second species rich site in this study (55 spp) but only one indicator species was encountered there. One should bear in mind that this classification scheme is preliminary, but flies may have great potential for biomonitoring, assessment and evaluation of wetlands and terrestrial biotopes (Dufour 1997, Stubbs 2003, Chadd & Extence 2004, Ujvarosi 2005, Salmela *et al*. 2007).

4.7. Some rare and possibly threatened species

In the following sections global distributional data of flies is obtained from http://ip30.eti.uva.nl/ccw/index.php for craneflies and http://www.faunaeur.org for other families, if not otherwise stated. Notes on the occurrence and ecology of the species in Finland are based on the database of Finnish semiaquatic flies compiled and updated by the author, unless otherwise indicated.

4.7.1. Limoniidae and Pediciidae

Paradelphomyia nigrina is apparently a rare European species, known from western Russia, Czech Republic, Latvia, Slovakia and Sweden. Tjeder (1952, as *Oxyrhiza septentrionalis*), collected a male specimen on the “boggy borders of a little cold brook” from Dalecarlia, being perhaps the only known locality of the species in Sweden (Tjeder 1955). In Finland the species has been hitherto known from two sites located in South Finland (Salmela *et al*. 2007). In the present study, *P. nigrina* was noted from four sites (rich fens in Kittilä, southern subzone), it was found only in Malaise traps and only one female was collected from each site. The female vaginal apodeme of *P. nigrina*, an anatomical character not previously depicted, is here illustrated (Figure 8). *P. nigrina* is obviously a rare species of rusty seepages and rich fens in Finland, occurring from southern boreal zone up to southern subzone of the northern boreal ecoregion. Most probably a species indicating high conservation value of its occupied habitats and should be classified as threatened in Finland.

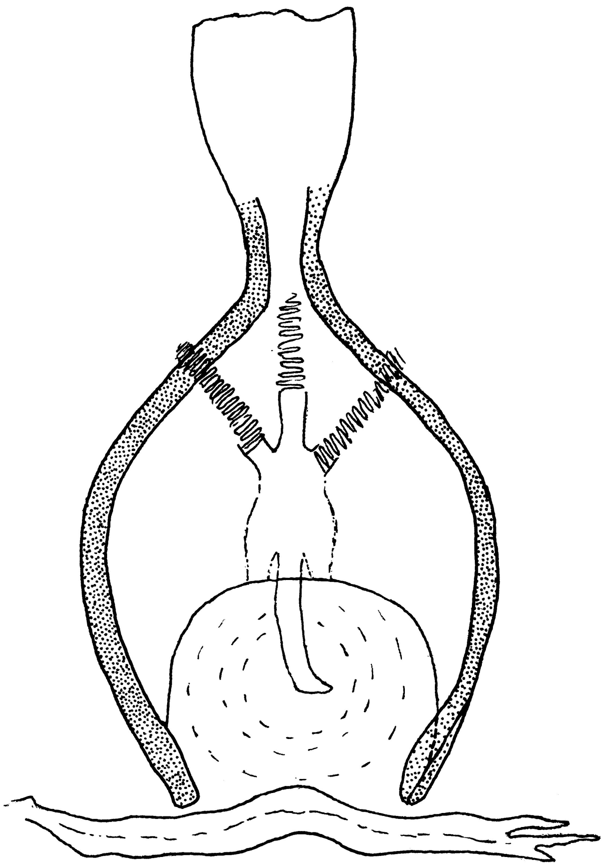

Figure 8. Female vaginal apodeme of *Paradelphomyia nigrina* (Lackschewitz) (Diptera, Limoniidae), ventral view. Peripheral frame is quite strongly sclerotised, median structure less so and spermathecal ducts (three) are hyaline, coiled.

Erioptera beckeri is a wide-spread but rare limoniid, known from Denmark, Sweden and Russia (from the European part to the Far East). In Finland, *E. beckeri* is a tyrphobiontic species, occurring in open, mainly poor peatlands, most of its records are from the southern part of the country (Salmela & Ilmonen 2005, Salmela *et al*. 2007). There is an old material collected by R. Frey from Lkoc: Muonio in 1911, which were determined by Lundström (1912) as *E. fuscipennis* Meigen. The author has re-examined this material, and all specimens proved to belong to *E. beckeri*. Despite this old record from Muonio, there has been no other record from the northern boreal zone. In this study, one male was collected by sweep netting in the end of June from Li: Perunmammarinjänkä. *E. beckeri* is apparently quite rare peatland-dwelling species in Finland, perhaps confined to pristine sites with unaltered hydrology and becoming less frequent in northern latitudes.

Erioptera nielseni is a European species, present in northern and western parts of the continent (e.g. Baltic countries, British Isles, Netherlands, Czech Republic, Austria) and interestingly, the species is recorded neither from Sweden nor Russia. The species is rare in Finland, it has been collected from the southern parts of the country from mires of varying trophic status (from oligotrophy to eutrophy) (Krogerus 1960, Salmela & Autio 2007). In this study *E. nielseni* was found from six localities, all rich fens lying in the southern subzone. Hence, the species could be assessed as mire-dwelling, southern limoniid, occurring in wet sites and perhaps preferring meso-eutrophic mires (Boyce 2004, Salmela & Autio 2007). Most likely, *E. nielseni* could be a reliable indicator of unaltered mire hydrology.

Rhabdomastix parva is a northern European species, found from a handful of localities in Norway (mainly Dovre), Sweden (Abisko, Messaure), Finland (Kilpisjärvi) and Iceland (Skaftafell) (Tjeder 1964, Mendl 1974, Mendl *et al*. 1987, Solem & Mendl 1989). So far, only females have been collected and the species is currently without subgeneric position (Starý 2003). In Finland *R. parva* has been collected only from Le: Kilpisjärvi area: there are two old specimens in ZMH (Palmgren & Linberg leg 6.-13.7. 1959 “Kilpisjärvi”, R. Frey leg “Saana”) and in this study the species was found from two close lying spring-fed sites in Malla Strict Nature

Reserve (Gihccegorzi SE 1 and 2). The species is probably associated with alpine brooks and seepages with calcareous influence (Tjeder 1964). Being rare and having limited geographical range, the species fulfils the requirements of an endangered species.

Dicranomyia aperta is a holarctic species, in the nearctic region known only from Alaska and having a wide distribution in the palearctic (from East Siberia to British Isles). According to Stubbs (1998) and Boyce (2004) the species inhabits ombrotrophic peat bogs, and species is threatened in Britain (Boyce 2004). Quite contradicting view concerning Great Britain is presented by Crossley (2007) who has found *D. aperta* from calcareous springs and flushes, adults have been observed to visit flowers of *Parnassia palustris*. With no doubt, *D. aperta* is in Finland confined calcareous springs and rich fens; it has been recorded from 16 sites locating in areas of basic bedrock. Thus, *D. aperta* is a rare and demanding limoniid in Finland and it should be classified as threatened. As many other hygrophilous craneflies, the species is probably sensitive to the changes in mire hydrology following ditching.

Dicranomyia longipennis has a wide distribution in the holarctic region, in the nearctic its known from Canada and USA, in the palearctic its range covers a number of European countries, Russia (from west to the Far East) and Japan. Compared to the other species within subgenus *Dicranomyia*, the species is dorso-ventrally flattened and its wings are very narrow, leaving no doubt to the identification. Alexander (1925) discovered the species from a spring-fed mire with rich vegetation (e.g. hemlock and red maple in hummocks, *Carex* spp and ferns in “boggy areas”) in Massachusetts (USA). Tjeder (1932) was first to find *D. longipennis* from Sweden (“*Carex-Equisetum* mire”) and later Tjeder (1958), in his review on the Limoniinae of Sweden, diagnosed the species as “very scarce” and according to him the species was collected from “marshes by lakes and also sandy shores with sparse vegetation of *Juncus*”. Further, Mendl (1974) reported four specimens in August and September of *D. longipennis* from Messaure area. There has been only one record from Finland prior 2007, a male collected by J. Sahlberg from Obb: Kemijärvi (Lundström 1907a). *D. longipennis* was here discovered from three rich fens in the southern subzone, being present only in sweep net samples. The species was collected by the author from a calcareous spring fen in Ks: Kuusamo in August 2007. Accordingly, *D. longipennis* is probably a northern boreal species in Finland, occurring in rich fens. In addition to calcareous seepages and rich fens, the species should be searched from other biotopes of high electrolyte concentrations, such as Baltic coastal meadows to clarify its distribution and ecology in Finland.

Dicranomyia moniliformis is a holarctic species, known from USA, Canada and Sweden. The original description by Doane (1900) was very short, providing illustration on the wing venation (plate VII, fig. 8) but no information on the male hypopygium. *Dicranomyia penicillata*, described from North Dakota (USA) by Alexander (1927) proved to be a synonym of *D. moniliformis* (Oosterbroek 2007). Alexander’s (1927) description was accurate and included an illustration of the male hypopygium (plate 1, fig. 5). Thus, the identification of the Finnish material is based on this article and no comparative material from the nearctic region have been studied. The species has been found from northern Sweden, Messaure area (Mendl 1974); three specimens were caught in August, but details of the collecting localities are totally lacking. *D. moniliformis* is here reported for the first time from Finland, it was collected from Lkoc: Kittilä, Akrahamanvuoma (sweep net, 1 ex) and Repsuvuoma (Malaise trap, 1 ex) flark rich fens in August. Due to the scarcity of the records in the palearctic region and hardly accessible taxonomic literature, the species is here shortly redescribed: Male. **Head** dorsally brownish, rostrum yellowish. Antennae 14-segmented, dark brown. Scape elongate, pedicel short and globular, basal flagellomeres short and globular, increase in length and decrease in width towards apex. Palpi dark brown. **Thorax** dark brown (specimen in alcohol, pruinosity can not be seen), coxae of 2nd and 3rd legs yellowish brown. Femora yellowish brown in their base, darkening towards tarsi. Wings relatively narrow, length about 8-9 mm, width about 1,5 mm. **Hypopygium** relatively large (within subgenus *Dicranomyia*). 9th tergite dark brown, bearing light hairs in the distal edge. Gonocoxite dark brown, ventromesial side densely covered by light hairs. Ventromesial projection of gonocoxite distally rounded, bearing light hairs with contrasting dark alveoli. Aedeagus armed on both sides with apophysis, being darkly sclerotised in their base, hyaline and dark in the distal end, including some hyaline ill-defined outgrowths in the distal end. Parameres narrowed and curved apically. Dorsal gonostylus (Figure 9a) curved, tip distinctly and abruptly pointed, darkening toward the tip. Ventral gonostylus (Figure 9a) relatively large, above the base of the rostrum (or rostral prolongation) widened distally, covered by hairs which are darker than the integument. Rostrum stout, bearing two spines and a basal hyaline seta. Ventrad of the base of the rostrum a lobe bearing two sets of yellowish brown stout hairs (Figure 9b). *Taxonomic remarks*. Among its nearctic congeners, *D. moniliformis* is related to *D. haeratica* (Osten Sacken) and *D. geyserensis* (Alexander) (see Alexander 1943, 1966). In the western palearctic, the species is most likely closest to *D. hyalinata*, shearing, for example, the following characteristics: dense setosity of the ventromesial side of the gonocoxite, general structure of the aedeagal complex (aedeagal arms, apophysis, parameres) and hairy lobe of the ventral gonostylus (much weaker in *D. hyalinata*). *D. moniliformis* is, however, readily distinguished from its congeners due to details in the structure of male hypopygium, especially the conspicuous lobe of the ventral gonostylus is peculiar to *D. moniliformis*.

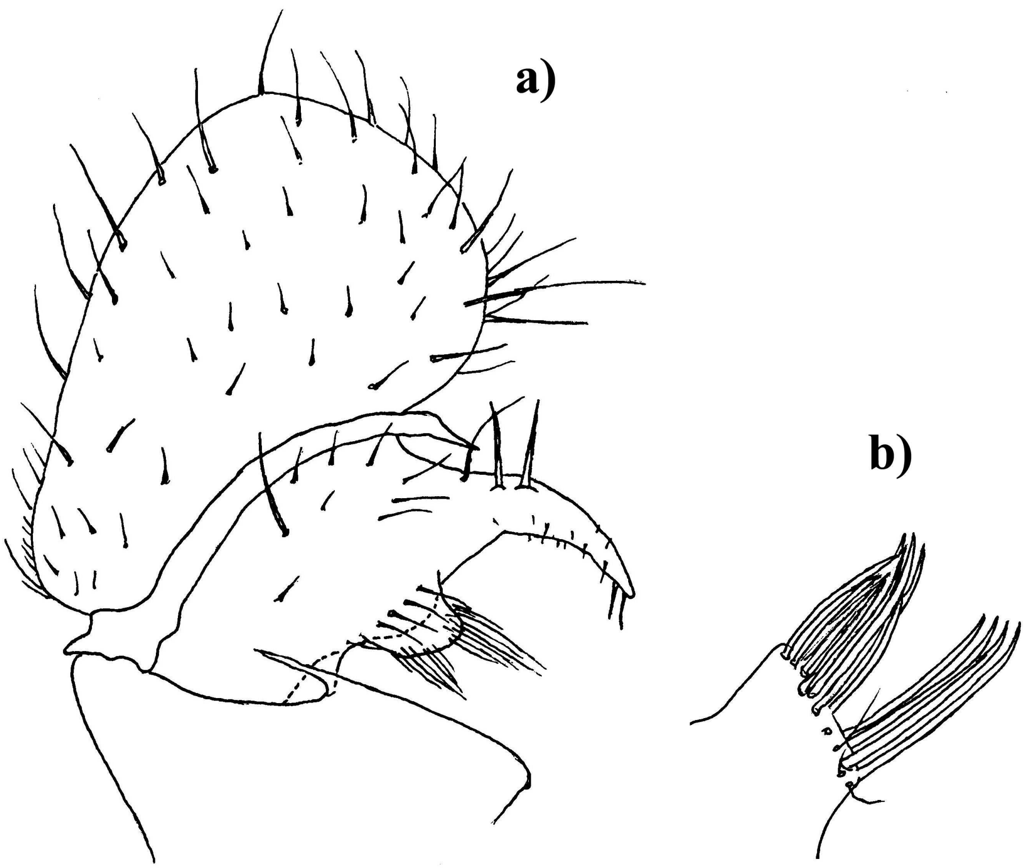

Figure 9. Male dorsal and ventral gonostyli (a, dorsal view) and hairy lobe of the ventral gonostylus (b, ventro-lateral view) of *Dicranomyia moniliformis* Doane (Diptera, Limonidae). Drawn to different scales. Rostral prolongation of the ventral gonostylus may appear somewhat wider depending on the angle to the observer.

Dicranomyia omissinervis is a palearctic limoniid ranging from British Isles to Russian Far East, it is recorded from several European countries (e.g. Sweden, Lithuania, Romania, Czech Republic). According to Godfrey (1999) the species is inhabitant of exposed riverine sediments (minerogenous substrata in lotic environments). Finnish records prior to 2007 are from northern Finland, four localities in the provinces of Obb and Ks. Adults have been caught around cold headwater streams with rich riparian vegetation. Only one male from Lkoc: Kittilä, Lismajoki headwater stream (site 15 in the Appendix 1) was noted, and thus *D. omissinervis* was not present in the study sites. Hence, *D. omissinervis* is rare and probably threatened species of headwater streams characterised by good water quality (slightly alkaline or circumneutral, cold temperature) and minerogenous shores, locating in areas of calcareous bedrock.

Dicranomyia lulensis was described from Sweden (Tjeder 1969b), the type material from Lule Lapmark was caught around brooks. Later 12 specimens from August and September were reported by Mendl (1974) from Messaure area in Sweden. In Finland, the species has been earlier found from a headwater stream in Ks: Kuusamo, and there are no records outside Sweden and Finland. In this study, *D. lulensis* was collected from two sites in Le: Hietajänkkä 1 (oligotrophic fen) and Havgajohka (headwater stream). Distribution and ecology of the species are still poorly known, and thus, more studies are needed to reveal its range and occupied habitats in Fennoscandia.

Dicranomyia stylifera is a European species, known from Fennoscandia, British Isles and Central European mountains. In Great Britain the species is rare and threatened inhabitant of calcareous flushes and springs in mountainous areas (Falk 1991), in Sweden *D. stylifera* is also a rare high altitude and latitude species (Tjeder 1958, Mendl 1979). In Finland it was reported by Frey (1932) from Ks: Kuusamo, Kitkajoki and later by Krogerus (1960) from rich fens around Korvasvaara in Kuusamo, but the localities may now lie in the Russian side of the border. The author of this report has caught one male from Li: Utsjoki, Kaldoaivi Wilderness Area in 2003. There is also one old specimen in the ZMH (R. Frey leg) from Le: Malla, identified by B. Mannheims, but the tip of the abdomen is broken off, thus hindering verification. However, in this study *D. stylifera* was recorded from three wet alpine sites with calcareous flora (Buolbmatgeasjavri SE, Pikku-Malla 1, Saana). As discussed above (4.5.), *D. stylifera* is a northern boreal species in Finland, its main distribution is in the subalpine subzone and rich fen populations in the coniferous zone in Kuusamo are probably glacial relicts.

Dicranota robusta is a European species, known from Fennoscandia, British Isles and Central Europe. The species is associated with swift flowing streams and brooks (Tjeder 1959, Hancock 1991). *D. robusta* has been only occasionally found from Sweden (Tjeder 1959, Mendl 1974) and Norway (Mendl *et al*. 1987, Solem & Mendl 1989), from coniferous and alpine zones. Type material of the species was collected from Finland (Lkoc: Muonio and Kittilä, Lundström 1912) and except this old material, *D. robusta* has been noted from three headwater stream in Kuusamo. In this study the species was collected only from Havgajohka (1 ex). All the recent records from Finland are from headwater streams characterised by minerogenous bottom, clear water and slightly alkaline or neutral water quality.

4.7.2. Tipulidae

Dolichopeza nitida is a European species, known from Sweden, Central European Alps and Russia, having a boreo-alpine distribution pattern. Its first record from Sweden was made by Tjeder (1974) from Messaure area, and there are probably no other published records from Fennoscandia. In this study *D. nitida* is thus reported for the first time from Finland. It was collected from two sites, lying in the southern (Lkor: Sodankylä) and subalpine (Li: Utsjoki) subzones. The former site was a swampy shore of a stream, and the latter a small brook with luxuriant riparian vegetation. It should be mentioned here, that the author of this has seen one male deposited in ZMH collected by R. Frey from Russian Karelia, “Kantalaks”

(=Kantalahti in Finnish). Apparently a rare species, most likely its larvae dwell in running waters. Swedish and Finnish records are from the end of June and early July.

Prionocera abscondita is a rare palearctic species known only from Russia (Petsamo district, Kola Peninsula and Dudinka, east of Ural Mountains) (Brodo 1987). Apparently, no recent (post 1930) records of this arctic tipulid exist. The species was collected from three study sites; two of these were close lying palsa mires in Li: Galddasduolbbas and one was oroarctic flark fen in the Malla Strict Nature Reserve (Pikku-Malla 1). It is likely, that *P. abscondita* is in Finland confined to the northernmost fell areas in the subalpine subzone and should be considered as threatened due to scarcity of the records and small distribution area.

Prionocera woodorum is a holarctic species, its original description was based on a material collected from Canada (Brodo 1987). In her description Brodo (1987) also reports a specimen collected from Sweden, Abisko, but this specimen was a female and differed from the type material with certain characteristics and hence, the record of *P. woodorum* in the palearctic remained questionable. The species was discovered from Finland in 2006 and 2007 by the author, from four headwater streams in the border of middle and northern boreal zones, provinces of Oba and Ks. In this study one male was collected in the immediate vicinity of a brook flowing to the lake Davrraluobbal (Li: Utsjoki, Kaldoaivi Wilderness Area). The specimen was picked from the vegetation in the mid June. To conclude, *P. woodorum* is low in numbers, is on the wing in June and in Finland it has been only collected around brooks. Other Finnish species of the genus are dwellers of peatlands and swamps.

Tipula obscuriventris is a western palearctic species, known from several European countries (see Dufour 1991, Przhiboro & Kluge 2005). The larvae of the species live in running water (Hemmingsen 1965, as *T. saginata*). The species has been rarely caught in Finland, there are three records from the province of Ks (Kuusamo, Taivalkoski, northern boreal) and one from Ok (Puolanka, middle boreal). Its first record from Finland, Paanajärvi (Frey 1932) is now in the Russian side of the border. *T. obscuriventris* was found only from Le: Havgajohka in this study. Being rare and probably demanding of good water quality (clear and cold water, pH ± neutral) the species could classified as threatened in Finland.

Tipula subexcisa is a palearctic species, ranging from Fennoscandia to Russian Far East. The description of the species was based on material collected from Finnish Lapland (Lkoc and Li, Lundström 1907b). *T. subexcisa* is since then only rarely noted, from Ks: Kuusamo (Krogerus 1960) and Li: Inari and Utsjoki (Siitonen 1984). In this study, the species was found from Le: Suttijärvi and Li: Galddasjohka near the lake Pulmankijärvi. Both sites were characterised by exposed mineral deposits (sand and gravel) and the development of the larva may be dependent on saturated or moist minerogenous substrates (the closely related *T. (Lindneriana) bistilata* lives in such conditions [Godfrey 1999]). The species is still poorly known and further records hopefully clarify its distribution and ecology in Finland.

Tipula laccata is a palearctic species, ranging from Fennoscandia to Russian Far East. It was described by Lundström and Frey (1916) based on material collected from Kola Peninsula, Ponoi. In Finland, there is only one finding from Ks: Kuusamo (Viramo 1992, specimen deposited in Oulu univ. zool. mus. and seen by the author). In this study *T. laccata* was collected from Lkoc: Kutuoja and Li: brook flowing to lake Davrraluobbal. Both sites were headwater stream with rich riparian vegetation. With no doubt, the species is a rare northern tipulid in Finland, perhaps favouring calcareous districts and should be considered as threatened in Finland.

Tipula tchukchi is a palearctic species, ranging from Finland and Sweden to Russian Far East. The species was recorded for the first time from Finland and Sweden by Mannheims (1967a, as *T. (Vestiplex) bo*). The record from Sweden originated from Lycksele Lappmark, 850-900 m a.s.l. and the Finnish one from Le: Saana, 1024 m a.s.l. (Mannheims 1967). *T. tchukchi* has been reported from Li: Utsjoki by Siitonen (1984) and the author of this have identified one male from Utsjoki, near river Teno, caught in the vicinity of small pond with seepages and sandy bottom. In this study only one male from Li: Galddasjohka 1 was collected. According to the present knowledge, *T. tchukchi* is a subalpine species in Finland, probably dwells in alpine wetlands and occurs in altitudes within and above birch zone.

4.7.3. Psychodidae and Thaumaleidae

Pneumia pilularia is a European psychodid, known also from northern Africa and Tajikistan (Ježek & Hájek 2007). The species is perhaps quite common in Central Europe (Ježek & Hájek 2007), occurring in springs and lotic waters (Fisher 1996, Wagner *et al*. 1998). *P. pilularia* is, however, most probably a rare species in Fennoscandia: it is known from Denmark (Wagner 1997), but it was not reported by Nielsen (1961, 1964) in his papers dealing with Danish fauna. Records by Lindegaard *et al*. (1975) from a Danish spring were uncertain due to identifications based on immature stages. So far, the species is not noted from Sweden but is likely to occur there. Prior this study, it has been recorded only once from Finland, from Le: Saana SW slope calcareous spring in 2004 by the author. In this study *P. pilularia* was noted again from Saana and also from Li: Galddasjohka 1. The species is probably a crenobiontic (confined to springs and seepages) in Finland, known only from the subalpine subzone and fulfils the criteria of being threatened species.

Pneumia ussurica is a palearctic species, known from Russian Far East (Wagner 1994) and Finland (Salmela 2004). In Finland the species has been known only from two rich fens (Tb: Toivakka, Ab: Karjalohja) in southern Finland. In this study *P. ussurica* was quite abundant in flark rich fens and birch fens in the southern subzone. It was abundant in Perunmammarinjänkä palsa mire with eutrophic vegetation and small number of individuals was also noted from Li: Galddasjohka 1, Galddasduolbbas, Buolbmatgeasjavri and Le: Havgajohka. Due to these new records, the view on the distribution of the species in Finland has drastically changed. It seem to be chiefly a northern species with scattered localities in the southern Finland, living in rich fens and other localities of high conservation status. Hence, *P. ussurica* could be assessed as nationally Near Threatened and regionally vulnerable species.

Thaumalea truncata is a European species, known from Central Europe, British Isles and Fennoscandia (Wagner 2002). Its occurrence in Finland was recently reviewed by Salmela *et al*. (2007): the species lives in springs and cold headwater brooks in northern and middle boreal zones, single relict-like population is known from a spring in southern boreal zone (Ta: Ruovesi). In this study *T. truncata* was present in five sites, mainly spring-fed localities in the subalpine subzone, being abundant in Li: Skalvejavri W. Species can be classified as crenophilous (preferring springs and seepages) and cold-stenothermic in Finland, and could be assessed as nationally Near Threatened and regionally vulnerable.

5. Conclusions

In the present study a relatively large number of individuals and species were caught from northern boreal wetlands. The studied material was collected from large area, ranging from southern to subalpine subzones, encompassing several wetland biotopes differing in their characteristics. Over 90 new provincial records were made, three species were found new for Finnish fauna and knowledge on the occurrence and distribution of dozens of flies was much improved. Geographical position in a north – south gradient, mire trophic status, influence of seepages and presence – absence of flowing water were most likely the best determinants of the community composition in the studied sites. A number of eurytopic and indifferent species living in wide array of habitats were recorded, but a notable number of species showed marked fidelity to certain environments, as indicated by community analyses. Variation in species richness was high among study sites. Most species poor (≤7 spp) assemblages were found in an oligotrophic fen and a snow-bed high (>800 m a.s.l.) above the tree line. Species rich (≥40 spp) assemblages were present in rich fens and headwater streams with diverse riparian vegetation (seepages, alpine meadows). Malaise traps were found to be efficient in the community studies of boreal wetlands, but sweep netting may contribute certain species which otherwise are underrepresented or absent in Malaise traps. The studied nematoceran families are on the wing through the season, but due to temporal succession, adult specimens of different species appear and cease to fly in different times. Hence, in order to obtain comprehensive faunistic view, collecting of adult flies in the northern boreal region should be started in the end of May – beginning of June and should continue up to early September. There are numerous northern species which were not recorded in this study; most of these are still known only from their first and only Finnish finding locality, dating back several decades. Despite relatively large sampling effort in this study, the nematoceran fauna of certain habitats remain insufficiently known, such as large rivers, swampy lake shores and headwater streams, for example. Thus, searching of rare and potentially threatened species as well as quantitative sampling of semiaquatic flies should be continued in northern boreal Finland.

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Summary

Semiaquatic fly (Diptera, Nematocera) fauna of fens, springs, brooks and alpine wetlands was investigated in the northern boreal ecoregion, southern, middle and subalpine subzones, within biogeographical provinces of Lkoc, Le and Li, Finland, during one field season. The main goal of the present study was to improve the knowledge on the nematoceran fauna of northern wetlands, especially patterns in diversity and assemblage structure, and have a better picture on the distribution of the semiaquatic flies in Finland. In order to collect flies, a total of 42 Malaise traps were set in 36 main study sites. In addition to Malaise trapping, a total of 154 sweep net samples were taken from the study sites. Further, adult semiaquatic flies were collected from 50 other localities (additional sites).

A total of 154 semiaquatic fly species were identified, belonging to families Limoniidae (69 spp), Tipuliidae (42), Pediciidae (11), Cylindrotomidae (3), Ptychopteridae (2), Psychodidae (17), Dixidae (8), Thaumaleidae (1) and Pachyneuridae (1). The collected material was composed of 21701 individuals (Malaise traps 15718, sweep net samples 5983 exx). From the 36 study sites, where both Malaise traps and sweep netting were used, a total of 138 species were found; seven of these were present only in sweep net samples and 47 species only in Malaise traps. Mean species richness of the study sites was 32 species. On average, Malaise traps collected 84 % of the total number of species in the study sites and sweep netting yielded 44 % of the species per site. Most common species (frequency >50 %) in the 36 study sites were *Tricyphona immaculata* (94 %), *Phylidorea squalens* (86), *Tipula melanoceros* (86), *T. subnodicornis* (86), *Dicranomyia ponojensis* (75), *D. rufiventris* (75), *Ptychoptera minuta* (72), *Prionocera turcica* (69), *Pedicia rivosa*

(69), *Logima satchelli* (67), *Dicranomyia distendens* (64), *Prionocera subserricornis* (61), *Tipula excisa* (58), *Dicranomyia terraenovae* (56), *D. stigmatica* (53), *Prionocera pubescens* (53) and *Idioptera linnei* (53). The 22 most numerous species (>300 individuals/species) accounted for 65 % of the total number of collected specimens. 25 species (18 % of the total 138 species) were found only at a single site. In the rich aapa mires located in the southern subzone, the number of specimens peaked in the early (June) and late season (August) whereas the number of species was highest in the last half of August. Combining material from all sites, the number of species was highest in July and the number of specimens in August.

Dicranomyia moniliformis Doane (Lkoc), *Dolichopeza nitida* Mik (Lkor, Li) and *Prionocera abscondita* (Lackschewitz) (Le, Li) were found for the first time in Finland in the course of the present study. A total of 93 new provincial records of the semiaquatic fly species were made (Lkor 3, Lkoc 42, Le 33, Li 16 new records). In addition to the species new for the regional fauna, findings of several rare, insufficiently known and possibly threatened species such as *Paradelphomyia nigrina*, *Erioptera beckeri*, *E. nielseni*, *Rhabdomastix parva*, *Dicranomyia aperta*, *D. longipennis*, *D. omissinervis*, *D. lulensis*, *D. stylifera*, *Tipula obscuriventris*, *T. subexcisa*, *T. laccata*, *T. tchukchi*, *Dicranota robusta*, *Pneumia pilularia* and *P. ussurica* were highly interesting. Male of *D. moniliformis* is redescribed and female vaginal apodeme of *P. nigrina* is illustrated for the first time.

According to the community analyses (Cluster analysis, Non-Metric Multidimensional Scaling, Multi-Response Permutation Procedure, Indicator Species Analysis) five different assemblage types were identified. North – south gradient, mire trophic status, spring influence and presence of lotic water were likely the most important environmental factors influencing community composition. Among study sites, most species rich assemblages of semiaquatic flies (species ≥40) were characterised by rich fen vegetation, seepages or flowing water. The most species-poor sites were an oligotrophic fen (7 spp) and a brook flowing from a snow bed lying in alpine heath 815 m a.s.l. (6 spp).

Malaise trap was found to be very efficient in collecting semiaquatic flies of the wetlands (families covered in the present study), but additional collecting of adult flies with a sweep net gives a more realistic picture on the frequency and abundance of certain species which for some reason are hard to collect with Malaise traps. In order to obtain a comprehensive faunistic view, collecting of semiaquatic flies in the southern – middle subzone should be started in the beginning of June and it should continue up to the last week of August – beginning of September. In more northern latitudes in the subalpine subzone collecting may be started later (after the middle of June) but collecting should continue up to the end of August.

References

Alexander, C.P. 1922: The Crane-Flies (Superfamily Tipuloidea, Order Diptera). –Report of the Scientific Results of the Norwegian Expedition to Novaya Zemlya 1921 5: 1-16 (published by Videnskapsselskapet I Kristiania).

Alexander, C.P. 1925: The crane-flies (Tipulidae) of New England: first supplementary list. –Occasional Papers of the Boston Society of Natural History 5: 169-174.

Alexander, C.P. 1927: Undescribed crane flies from the Holarctic region in the United States National Museum. –Proceedings of the United States National Museum 72: 1-18.

Alexander, C.P. 1943: Records and Descriptions of North American Crane-Flies (Diptera) Part IV. Tipuloidea of the Yellowstone National Park. –American Midland Naturalist 30: 718-764.

Alexander, C.P. 1966. The Diptera or true flies of Connecticut. Part VI. First Fascicle. –Bulletin Connecticut State Geological and Natural History Survey 64: 1-509.

Andersen, T. & Håland, Ø. 1995: Norwegian Moth Flies (Diptera: Psychodidae). –Fauna norvegica ser. B 42: 125-130.

Atlas of Finland 1987: Folio 131. Climate. National Board of Survey and Geographic Society of Finland, Helsinki.

Atlas of Finland 1990: Folio 123-126. Geology. National Board of Survey and Geographic Society of Finland, Helsinki.

Begon, M., Harper, J.L. & Townsend, C.R. 1996: Ecology. Individuals, populations and communities. 3rd edition, Blackwell Science, 1068 pp.

Berdén, S. 1954: Taxonomical notes on Psychodidae (Diptera, Nematocera). II. Four new species of Pericoma from Fennoscandia. –Opuscula Entomologica 19: 33-39.

Boyce, D.C. 2004: A review of the invertebrate assemblage of acid mires. –English Nature Research Reports 592: 1-110.

Brinkmann, R. 1991: Zur Habitatpräferenz und Phänologie der Limoniidae, Tipulidae und Cylindrotomidae (Diptera) in Bereich eines norddeutschen Tieflandbaches. –Faunistisch-Okologische Mitteilungen, Supplement 11: 1-156.

Brodo, F. 1987: A revision of the genus Prionocera (Diptera: Tipulidae). –Evolutionary Monograph 8: 1-93.

Brodo, F. 1990: Crane flies (Diptera:Tipulidae) of the Arctic Islands. –In Harrington, C.R. (ed), Canadas Missing Dimension, Vol. 2. Canadian Museum of Nature, Ottawa: 471-484.

Brodo, F. 1995: Analysis and additions to the crane fly fauna of Finse, South Norway (Diptera: Tipulidae). –Fauna norvegica ser. B 42: 11-20.

Brunhes, J. 1990: Les Limonides des tourbieres acides du Massif Central et des groupements vegetaux peripheriques (Dipt. Tipuloidea). –Bulletin de la Societe Entomologique de France 94: 247-258.

Brunhes, J. & Villepoux, O. 1990: Etudes structurales et dynamiques sur les ecosystemes de tourbieres acides. II. Le peuplement des Dipteres Limonides. –Bulletin de Ecologie 21: 91-104.

Brunhes, J. & Dufour, C. 1992: Etudes structurales et dynamiques sur les ecosystemes de tourbieres acides. III – le peuplement des Tipulides (Diptera, Tipulidae). – Bulletin de Ecologie 23: 17-26.

Chadd, R. & Extence, C. 2004: The conservation of freshwater macroinvertebrate populations: a community-based classification scheme. –Aquatic Conservation: Marine and Freshwater Ecosystems 14: 597-624.

Crossley, R. 2007: Dicranomyia aperta Wahlgren, 1904 (Diptera, Limoniidae) - an association with grass of Parnassus (Parnassia palustris Linnaeus). –Dipterists Digest (second series) 14: 11-12.

Doane, R.W. 1900: New North American Tipulidae. –Journal of the New York Entomological Society 8: 182-198.

Dufour, C. 1991: The identity of Tipula (Emodotipula) saginata Bergroth and T. (E.) obscuriventris Strobl, and the description Tipula (E.) leo sp. n. from the Sierra Nevada in Spain (Diptera, Tipulidae). –Mitteilungen der Schweizerischen Entomologischen Gesellschaft 64: 81-91.

Dufour, C. 1997: Compte rendu du deuxieme congres international sur les Tipulomorpha (Diptera) a Aletsch (1er au 5 Juillet 1996). –Bulletin de la Societe Neuchateloise des Sciences Naturelles 120: 133-135.

Dufrene, M. & Legendre, P. 1997: Species assemblages and indicator species: the need for a flexible asymmetrical approach. –Ecological Monographs 67:345-366.

Falk, S. 1991: A review of the scarce and threatened flies of Great Britain (part 1). –Research and survey in nature conservation 39.

Fischer, J. 1996: Bewertungsverfahren zur Quellfauna. –Crunoecia 5: 227-240.

Frey, R. 1932: Bidrag till kännedomen om Finlands harkrankar (Dipt.). –Memoranda Soc. Fauna Flora Fennica 9: 29-31.

Frey, R. Storå, R. & Tiensuu, L. 1941: Enumeratio Insectorum Fenniae, VI. Diptera. –Helsinki, 63 s.

Georges, D. 1961: Diptéres Psychodidae paléarctiques recueillis par M. le Dr. J. Clastrier. –Trav. Lab. Hydrobiol. Piscic. 53: 101-109.

Godfrey, A. 1999: A Review of Diptera from exposed riverine sediments based on literature records. –Dipterists Digest (seconds series) 6: 63-82.

Hackman, W. 1980: A check list of the Finnish Diptera. I. Nematocera and Brachycera (s.str.). –Notulae Entomologicae 60: 17-48.

Hancock, E.G. 1991: Notes on the biology of Dicranota robusta Lundstroem (Diptera; Tipulidae). –Dipterists Digest (first series) 6: 20-22.

Hemmingsen, A.M. 1965: The lotic cranefly, Tipula saginata Bergroth, and the adaptive radiation of the Tipulinae, with a test of Dyars law. –Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening 128: 93-150.

Hofsvang, T. 1972: Tipula excisa Schumm. (Diptera, Tipulidae), life cycle and population dynamics. –Norsk entomologisk Tidskrift 19: 43-48.

Hofsvang, T. 1979: The larvae of Tipula (Arctotipula) salicetorum Siebke, 1870 (Diptera, Tipulidae). – Entomologica Scandinavica 10: 238-240.

Itämies, J. & Lindgren, E. 1985: The ecology of Chionea species (Diptera, Tipulidae). – Notulae Entomologicae 65: 29-31.

Ježek, J. & Hájek, J. 2007: Psychodidae (Diptera) of the Orlické hory Protected Landscape Area and neighbouring areas with description of two new species from the Czech Republic. –Acta Entomologica Musei Nationalis Pragae 47: 237-285.

Krogerus, R. 1960: Ökologische Studien über nordische Mooratrhopoden. Artenbestand, ökologische Faktoren, Korrelation der Arten. –Commentiones Biologicae 21: 1-238.

Lindegaard, C., Thorup, J. & Bahn, M. 1975: The invertebrate fauna of the moss carpet in the Danish spring Ravnkilde and its seasonal, vertical, and horisontal distribution. –Arch. Hydrobiol. 75: 109-139.

Lindholm, T. & Heikkilä, R. 2006: Geobotany of Finnish forests and mires: the Finnish approach. –In: Lindholm, T. & Heikkilä, R. (eds.), Finland – land of mires. –The Finnish Environment 23: 95–104.

Lackschewitz, P. 1936: Das Genus Tipula (Diptera Nematocera) in der Arktis und dem borealen Waldgebiet Eurasiens. –Travaux de l'Institut Zoologique de l'Academie des Sciences de l'USSR 4: 245-312.

Lundström, C. 1907a: Beitrage zur Kenntnis der Dipteren Finnlands, 3. Cylindrotomidae und Limnobiidae. –Acta Soc. Flora Fauna Fennica 29 (8): 1-31.

Lundström, C. 1907b: Beitrage zur Kenntnis der Dipteren Finnlands, 2. Tipulidae (Tipulidae Longipalpi Ost.-Sack.). –Acta Soc. Flora Fauna Fennica 29 (2): 1-27.

Lundström, C. 1912: Beitrage zur Kenntnis der Dipteren Finnlands, 8, suppl. 2, Mycetophilidae, Tipulidae, Cylindrotomidae und Limnobiidae. –Acta Soc. Flora Fauna Fennica 36: 1-70.

Lundström, C. & Frey, R. 1916: Beitrage zur Kenntnis der Dipteren Finnlands. 10. Suppl. 4. Bibionidae, Chironomidae, Tipulidae. –Acta Soc. Flora Fauna Fennica 44: 1-26

MacLean, S.F. jr. 1973: Life cycle and growth energitics of the Arctic crane fly Pedicia hannai antenatta. –Oikos 24: 436-443.

McCune, B. & Grace, J. B. 2002: Analysis of ecological Communities. With a contribution from Dean L. Urban. MjM Software Design, Gleneden Beach, Oregon, U.S.A.

Mannheims, B. 1954: Die Tipuliden Ostfennoskandiens (Dipt.). –Notulae Entomologicae 34: 29-50.

Mannheims, B. 1963: Eine Tipula der osatasiatischen “semipterna“-Gruppe in Finnland (Dipt., Tipulidae). – Notulae Entomologicae 43: 69-74.

Mannheims, B. 1965a: Enumeratio Tipulidarum Fenniae. – Lounais-Hämeen Luonto 20: 1-3.

Mannheims, B. 1965b: Sechzehn für Finnland neue Limoniiden mit Liste der Tipulidae, Limoniidae, Cylindrotomidae, Liriopeidae, Trichoceridae und Phryneidae (Diptera, Nematocera) Südwest-Hämes. – Lounais-Hämeen Luonto 20: 4-9.

Mannheims, B. 1967a: Tipula (Vestiplex) bo sp.n. und andere Tipuliden aus Fennoskandien (Diptera). –Notulae Entomologicae 47: 147-156.

Mannheims, B. 1967b: Eine für Europa neue Ctenophora-Art (Diptera, Tipulidae) mit faunistischen Angaben über Tipuliden und Limoniiden Fennoscandiens. –Bonn. zool. Beitr. 18: 199-206.

Mannheims, B. 1972: The invertebrate fauna of the Kilpisjärvi area, Finnish Lapland. 16. Diptera Tipuloidea. – Acta Soc. Pro Fauna Flora Fennica 80: 233-237.

Mendl, H. 1974: Småharkrankarna (Diptera, Tipulidae: Limoniinae) i Messaureområdet. – Norrbottens Natur Småskrift 1: 68-71.

Mendl, H. 1979: Limoniiden (Diptera, Nematocera) aus dem Gebiet des Tornetrask (Schwedisch-Lappland). – Fauna Norrlandica 1979 (5): 1-39

Mendl, H. 1984: Beitrag zur Limoniiden-Fauna des Varanger-Gebietes (Norwegen: Sør Varanger/Fø und Varanger Halbinsel/Fn) (Diptera Nematocera, Limoniidae). –Fauna Norrlandica 1984 (6): 1-20.

Mendl, H., Müller, K. & Viramo, J. 1977: Vorkommen und Verbreitung von Chionea araneoides Dalm., C. crassipes Boh. und C. lutescens Lundstr. (Diptera, Tipulidae) in Nordeuropa. –Notulae Entomologicae 57: 85-90.

Mendl, H., Solem, J.O. & Bretten, S. 1987: Distribution and seasonal abundance of adult Limoniidae (Insecta, Diptera, Nematocera) in the Dovrofjell National Park, South Norway. –Fauna norvegica ser. B 34: 63-72.

Nielsen, A. 1950: On the zoogeography of springs. – Hydrobiologia 2: 313-321.

Nielsen, B.O. 1961: Studies on the Danish Psychodidae (Diptera Nematocera). –Entomologiske Meddelelser 31: 127-152.

Nielsen, B.O. 1964: Studies on the Danish Psychodidae (Diptera: Nematocera) II. –Natura Jutlandica 12: 149-161.

Nielsen, B.O. 1965: Psychodidae from Norway and Sweden. –Opuscula Entomologica: 30: 141-152.

Oosterbroek, P. 1979: The western palaearctic species of Nephrotoma Meigen, 1803 (Diptera, Tipulidae) Part 4, including a key to the species. –Beaufortia 29: 129-197.

Oosterbroek, P. 2007: Catalogue of the Craneflies of the World (Diptera, Tipuloidea: Pediciidae, Limoniidae, Cylindrotomidae, Tipulidae). http://ip30.eti.uva.nl/ccw/index.php (last update 12.12.2007).

Oosterbroek, P. & Theowald, B. 1992: Family Tipulidae. –In: Soós, A., Papp, L. & Oosterbroek, P. (eds.), Catalogue of the Palaearctic Diptera: 56-178. Hungarian Natural History Museum, Budapest, 1: 1-463.

Oosterbroek, P., Brodo, F., Lantsov, V. & Starý, J. 2007: The Tipulidae and Limoniidae of Greenland (Diptera, Nematocera, Craneflies). –Entomologiske Meddelelser 75: 3-33.

Peus, F. 1936: Zur Kenntnis der Dixiden-Fauna Nordeuropas (Dipt., Nematoc.). –Norsk entomologisk tidsskrift 4: 117-127.

Przhiboro, A.A. & Kluge, N.J. 2005: First record of Tipula (Emodotipula) obscuriventris from NW Russia (Diptera: Tipulidae). –Zoosystematica Rossica 14: 164.

Rydin, H. & Jeglum, J. 2006: The Biology of Peatlands. Oxford University Press. 343 pp.

Saari, V. 1978: Special features of the flora of northern Kuusamo. –Acta Univ. Oulu A. 68.1978. Biol. 4: 85-90 (in Finnish with English abstract).

Salmela, J. 2001: Adult craneflies (Diptera, Nematocera) around springs in southern Finland. –Entomologica Fennica 12: 139-152.

Salmela, J. 2003: New records of the families Psychodidae, Dixidae and Thaumaleidae (Diptera, Nematocera) from Finland. –Studia dipterologica 10: 143-152.

Salmela, J. 2004: Semiaquatic flies (Diptera, Nematocera) of three mires in the southern boreal zone, Finland. –Memoranda Soc. Fauna Flora Fennica. 80: 1-10.

Salmela, J. 2006: Suomen vaaksiaiset, kummitussääsket, perhossääsket, sinkilähyttyset ja norosääsket (Diptera, Nematocera) – ekologia, levinneisyys ja uhanalaisuus. Alustava raportti. [*Ecology, distribution and redlist status of craneflies, phantom midges, mothflies, meniscus midges and trickle midges in Finland (Diptera, Nematocera). Preliminary report*]. Privately published, 75 pp. In Finnish with English summary.

Salmela, J. & Ilmonen, I. 2005: Cranefly (Diptera: Tipuloidea) fauna of a boreal mire system in relation to mire trophic status: implications for conservation and bioassessment. –Journal of Insect Conservation 9: 85-94.

Salmela, J. & Autio, O. 2007: Semiaquatic flies of Kivineva mire, Middle boreal Finland, and redescription of *Cylindrotoma borealis* Peus, 1952 stat. n. (Diptera, Nematocera). –International Journal of Dipterological Research 18: 47-55.

Salmela, J., Autio, O. & Ilmonen, J. 2007: A survey on the nematoceran (Diptera) communities of southern Finnish wetlands. –Memoranda Soc. Fauna Flora Fennica 83: 33-47.

Savchenko, E.N., Oosterbroek, P. & Starý, J. 1992: Family Limoniidae. –In: Soós, Á., Papp, L. & Oosterbroek, P. (eds.), Catalogue of the Palaearctic Diptera: 183-374. Hungarian Natural History Museum, Budapest, 1: 1-463.

Siitonen, O. 1984: Tipuloidea (Diptera) of Inari Lapland. –Kevo Notes 7: 67-69.

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

Soós, A. & Oosterbroek, P. 1992: Family Cylindrotomidae. –In: Soós, Á., Papp, L. & Oosterbroek, P. (eds.), Catalogue of the Palaearctic Diptera. 179-182. Hungarian Natural History Museum, Budapest, 1: 1-463.

Starý, J. 2003: Revision of European species of the genus Rhabdomastix (Diptera: Limoniidae). Part 1: Introduction and subgenus Lurdia subgen. n. –European Journal of Entomology 100: 587-608.

Stubbs, A.E. 1998: Test key for subfamily Limoniinae. Bulletin of the Dipterists Forum 45 (circulated in the letter).

Stubbs, A.E. 2003: Tipulidae and Allies - Craneflies. –Managing Priority Habitats for Invertebrates 17: 1-158. Distributed on DEFRA-Buglife CD-ROM 2004 and 2006.

Tahvonen, E. 1932: Berichte über die Chionea-Arten in Finnland. –Notulae Entomologicae 12: 40-46.

Theowald, B. 1971: Drei holarktische Symplecta-Arten (Diptera, Limoniidae). –Beaufortia 19: 45-56.

Tikkanen, M. 2006: Unsettled weather and climate of Finland. –In: Lindholm, T. & Heikkilä, R. (eds.), Finland – land of mires. –The Finnish Environment 23: 7-16.

Tjeder, B. 1932: Beitrage zur Kenntnis Schwedischer Diptera Nematocera. 1. –Entomologisk Tidskrift 53: 93-103.

Tjeder, B. 1951: Diptera Nematocera. Fam. Tipulidae. –In: Brinck & Wingstrand (eds.), The mountains fauna of the Virihaure Area in Swedish Lapland. –Lunds Uni. Arsskrift 2(46): 100-101

Tjeder, B. 1952: A new Oxyrhiza (Dipt. Tipulidae). –Opuscula Entomologica 17: 125-127.

Tjeder, B. 1955: Catalogus Insectorum Sueciae. 14. Diptera: Fam. Tipulidae. –Opuscula Entomologica 20: 229-247.

Tjeder, B. 1958: A synopsis of the Swedish Tipulidae, 1. Subfam. Limoniidae: tribe Limoniini. –Opuscula Entomologica 23: 133-169.

Tjeder, B. 1959: A synopsis of the Swedish Tipulidae, 2. Subfam. Limoniinae: tribe Pedicini. –Opuscula Entomologica 24: 1-9

Tjeder, B. 1963a: Notes on Cheilotrichia areolata (Lundstr.) (Diptera, Limoniidae). –Notulae Entomologicae 43: 133-136.

Tjeder, B. 1963b: Three subapterous crane-flies from Alaska (Dipt. Tipulidae). –Opuscula Entomologica 28: 229-241.

Tjeder, B. 1964: Neuroptera, Trichoptera and Diptera – Tipulidae from Iceland with a redescription of Rhabdomastix parva Siebke. –Opuscula Entomologica 29: 143-151.

Tjeder, B. 1965: Notes on Ormosia brevinervis (Lundstr.) (Diptera, Tipulidae). –Notulae Entomologicae 45: 149-153.

Tjeder, B. 1969a: Limnophila prolixicornis Bergroth in Lundstrom, 1907, and L. umbrarum Krogerus, 1937. Notes and lectotype designations (Diptera, Tipulidae). –Notulae Entomologicae 49: 254-256.

Tjeder, B. 1969b: Three new Tipulidae from Sweden (Diptera). –Opuscula Entomologica 34: 250-256.

Tjeder, B. 1970: Rhypholophus affinis Lundbeck, 1898, from Greenland; redescription and lectotype designation (Diptera: Tipulidae). –Entomologiske Meddelelser 38: 253-256.

Tjeder, B. 1974: Harkrankar (Tipulidae, partim) och Glansmyggor (Ptychopteridae) i Messaureomradet. –Norrbottens Natur Småskrift 1: 1-5.

Tjeder, B. 1979: Ptychopteridae and Tipulidae (Cylindrotominae and Tipulinae) from the Abisko Area, Torne Lapland Sweden (Ins.: Diptera). –Fauna Norrlandica 1979 (9): 1-12.

Ujvarosi, L. 2005: Limoniidae and Pediciidae (Insecta: Diptera) assemblages along mountainous streams: additions to assess the biodiversity in wet habitats in Carpathians, Romania. –Acta Biol. Debr. Hung. 13: 233–248.

Ulvinen, T., Syrjänen, K. & Anttila, S. 2002 (eds.): Suomen sammalet: levinneisyys, ekologia, uhanalaisuus. –Suomen ympäristö 560: 1-354.

Vaillant, F. 1967: Two Dixid flies from near the arctic circle in Sweden (Dipt.). –Opuscula Entomologica 32: 284-288.

Viramo, J. 1992: Koillismaan (Ks) vaaksiaisista (Diptera, Tipulidae). –Oulanka Reports 10: 33-40.

Wagner, R. 1994: On a collection of Psychodidae (Diptera) from the Far East of Russia. –Studia dipterologica 1: 75-92.

Wagner, R., Fischer, J. & Schnabel, S. 1998: The dipteran community of central European springs: a summary. –In: Botosaneanu, L. (ed.), Studies in crenobiology. The biology of springs and springbrooks: 157-165. Bachhuys Publishers, Leiden.

Wagner, R. 1997: Diptera Psychodidae, Moth Flies. –In: Nilsson, A. N. (ed.), Aquatic Insects of Noth Europe – A Taxonomic Handbook: 133-144. Vol. 2. 440 pp.

Wagner, R. 2002: Insecta: Diptera: Thaumaleidae Bd. 21/11. –In: Schwoerbel J. & Zwick, P. (ed.), Süsswasserfauna von Mitteleuropa: 38-107. Spektrum Akademischer Verlag, Heidelberg, Berlin.

Zetterstedt, J.W. 1838: Sectio tertia. Diptera. Dipterologis Scandinaviae amicis et popularibus carissimus. Insecta Lapponica. Lipsiae [=Leipzig]: 477-868.

Appendix 1. Additional sites, where only sweep-net samples were taken, their location and short description of the habitats.

nr	prov.	municipality	site	N	E	habitat
1	Lkoc	Kittilä	Taljavaaranvuoma	7500	3429	rich fen
2	Lkoc	Kittilä	Paartoselkä E	7503220	3412880	mesotrophic fen
3	Lkoc	Kittilä	Kievanavuoma	7497900	3435800	mesotrophic fen
4	Lkoc	Kittilä	Siikajärvi	7500050	3443550	eutrophic lake shore, *Stratiotes*-lake
5	Lkoc	Kittilä	Kutuoja	7502000	3443750	headwater stream, rich riparian vegetation
6	Lkoc	Kittilä	Kutuoja	7501800	3445300	headwater stream, rich riparian vegetation
7	Lkoc	Kittilä	Kuolajärvi	7501900	3443500	eutrophic lake shore, *Stratiotes*-lake
8	Lkoc	Kittilä	Manto-oja	7500000	3443700	headwater stream, rich riparian vegetation
9	Lkoc	Kittilä	Haurespää S	7508600	3445150	spring-fed lake, rich fen on the shore
10	Lkoc	Kittilä	Haurespää S	7507800	3445800	mesoeutrophic spring, rich forest
11	Lkoc	Kittilä	Siekuvuoma	7548800	3423150	mesotrophic fen
12	Lkoc	Kittilä	Vielmakoskenpalo NW	7548000	3418650	rich flark fen
13	Lkoc	Kittilä	Kielisenmaa N	7550500	3420300	mesotrophic fen
14	Lkoc	Kittilä	Vielmaoja	7550250	3420100	brook
15	Lkoc	Kittilä	Lismajoki	7550200	3421490	headwater stream, rich riparian vegetation
16	Lkoc	Kittilä	Lismajoki	7750500	3422400	headwater stream, rich riparian vegetation
17	Lkoc	Kittilä	Siettelonvuoma E	7584300	3403000	mesotrophic fen
18	Lkoc	Kittilä	Kapperapalo SW	7585100	3402400	brook flowing on rich fen
19	Lkoc	Kittilä	Pulju wilderness area	7586	3405	mesotrophic fen
20	Lkor	Sodankylä		7489	3461	shore of a small river
21	Le	Enontekiö	Suttijärvi	7593900	3402950	shore of a spring-fed lake
22	Le	Enontekiö	Saana SW-slope	7674	3253	rich birch forest, alpine rich fen
23	Le	Enontekiö	Iso Malla S	7678	3246	alpine brook
24	Le	Enontekiö	Malla Strict NR			several habitats
25	Li	Utsjoki	Petsikko	7714401	3508647	pond, rich fen
26	Li	Utsjoki	Davrraluobbal	7755370	3535500	brook flowing to D-luobbal, rich riparian vegetation
27	Li	Utsjoki	Guovdajavri N	7752	3532	palsa mire
28	Li	Utsjoki	Guovdajavri	7751	3533	outlet brook
29	Li	Utsjoki	Guovdajavri	7751750	3532900	mesotrophic, swampy lake shore
30	Li	Utsjoki	Urra-Galddoaivi	7744400	3533400	snow-bed, spring-fed brook
31	Li	Utsjoki	Alla Galddoaivi E	7746200	3530900	alpine fen
32	Li	Utsjoki	Alla Galddoaivi NW	7747600	3530150	lake 377 masl, alpine fen
33	Li	Utsjoki	Vuopme Galddojavri	7749	3534	lake shore
34	Li	Utsjoki	Vuopme Galddojavri SE	7747	3533	brook
35	Li	Utsjoki	Buolbmatgeasjavri W	7738850	3535000	brook, rich riparian vegetation
36	Li	Utsjoki	Buolbmatgeasjavri SW	7737150	3535300	brook
37	Li	Utsjoki	Buolbmatgeasjavri S	7736750	3535300	willow swamp
38	Li	Utsjoki	Njuckabealjohka	7736500	3535200	stream flowing to Buolbmatgeasjavri
39	Li	Utsjoki	Askkasjohka	7746600	3533850	brook
40	Li	Utsjoki	Askkasjohka	7748700	3534200	outlet of the lake Vuopme Galddojavri
41	Li	Utsjoki	Skalvejavri NW	7742	3534	alpine fen
42	Li	Utsjoki	Galddasjohka	7755	3531	headwater stream, rich riparian vegetation
43	Li	Utsjoki	Galddasjohka	7751500	3529900	brook, spring, snow-bed
44	Li	Utsjoki	Tievoja	7736400	3535400	brook, rich riparian vegetation
45	Li	Utsjoki	Tievoja	7735	3535	small lake, seepage area
46	Li	Utsjoki	Skalvejavri	7741	3534	small brook flowing to lake Skalvejavri
47	Li	Utsjoki	Galddasjohka			stream shore, exposed sediments, close to lake Pulmankijärvi
48	Li	Utsjoki	Aksonjunni S	7740100	3531550	mesotroophic fen in a lake shore
49	Li	Utsjoki	Goallaguottetjohka	7740	3533	alpine brook
50	Li	Utsjoki	Luovosvarri	7754500	3529250	palsa mire

Appendix 2. Semiaquatic flies (Diptera, Nematocera) and their presence in the study sites (Malaise traps and sweep-net samples) and other sites. Numbering of the sites refers to Table 1 for study sites and Appendix 1 for other sites. Species are arranged as in the Table 2.

species	study sites	other sites
Eloeophila maculata (Meigen, 1804)	-	5
Eloeophila trimaculata (Zetterstedt, 1838)	23,24,27,28,29,32	15,26,28,29,30,34,35,36,38,40,44,45,46
Euphylidorea meigenii (Verrall, 1886)	8,11,13,23,27,29,31,32,33	37
Euphylidorea phaeostigma (Schummel, 1829)	12,32,33	-
Idioptera linnei Oosterbroek, 1992	1,2,3,4,5,6,8,9,13,15,16,17,18,18,20,22,25,29,33	1,2,11,13,27,37,46
Idioptera pulchella (Meigen, 1830)	2,15,16,17,24,25,26,27,28,29,33,34	5,26,27,29,30,37
Neolimnomyia (Brachylimnophila) nemoralis (Meigen, 1818)	10,23,24,27,28,32,33,34,36	5,6,10,15,16,18,22,38
Paradelphomyia (Oxyrhiza) nigrina (Lackschewitz, 1940)	6,8,9,10	-
Phylidorea (Paraphylidorea) fulvonervosa (Schummel, 1829)	2,12,14,20	6,7,20,
Phylidorea (Phylidorea) abdominalis (Staeger, 1840)	1,3,4,5,6,8,9,21	1,4,7,13
Phylidorea (Phylidorea) heterogyna (Bergroth, 1913)	3,4,5,6,8,9	9
Phylidorea (Phylidorea) longicornis (Schummel, 1829)	2,1,24,28	6,15,16,18,26,29
Phylidorea (Phylidorea) squalens (Zetterstedt, 1838)	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,19,20,21,22,	3,4,7,11,13,25,26,27,29
	23,24,25,26,27,28,29,30,31,32	-
Phylidorea (Phylidorea) umbrarum (Krogerus, 1937)	1,2,3,4,6,7,8,10	1,6,7,8,16,18
Pilaria decolor (Zetterstedt, 1851)	5,6,8,9,10,15,20,21,22	1,7,12,26
Pilaria meridiana (Staeger, 1840)	1,3,4,5,6,7,8,9,11,13,15,18,21,22,26,30,32	4,9,12
Cheilotrichia (Empeda) areolata (Lundström, 1912)	5,9,14,15,22,23,25,26,29,30	4,26,29,30,42,45
Erioconopa diuturna (Walker, 1848)	4,5,13,15,16,21,22,25,26,27,28,29,30,32,33,34	22,23,24,43
Erioptera (Erioptera) beckeri Kuntze, 1914	22	-
Erioptera (Erioptera) flavata (Westhoff, 1882)	1,4,6,8,9,10,11,12,13,14,15,17,20,21	1,2,7,12,15,16,18,
Erioptera (Erioptera) lutea Meigen, 1804	23,25,26,32	2, 10
Erioptera (Erioptera) nielseni de Meijere, 1921	1,3,4,5,6,8	-
Erioptera (Erioptera) sordida Zetterstedt, 1838	5,9,21,22,25	-
Gonomyia (Gonomyia) stackelbergi Lackschewitz, 1935	4,6,8,9,10,11,21,22,23,24,25,26,28,29,32,33,34,36	12,22,24
Molophilus (Molophilus) ater (Meigen, 1804)	2,14,23,24,27,33	35,36,40,42,45
Molophilus (Molophilus) crassipygus de Meijere, 1918	-	15
Molophilus (Molophilus) flavus Goetghebuer, 1920	8,14,18,23,24,27,31,32,33,34,36	30,38,40,45,46
Molophilus (Molophilus) propinquus (Egger, 1863)	24,28,29	15,20,26,28,30,38,40
Ormosia (Ormosia) fascipennis (Zetterstedt, 1838)	18,23	-
Ormosia (Ormosia) ruficauda (Zetterstedt, 1838)	10,11,12,13,19,23,24,27,28,31,32,34,36	6,18,20
Ormosia (Ormosia) staegeriana Alexander, 1953	30,31,32,33,34	10,22
Phyllolabis macroura (Siebke, 1863)	32,33,35	22,24

Appendix 2. Continues.

species	study sites	other sites
Rhabdomastix (Rhabdomastix) parva (Siebke, 1863)	32,33	-
Rhypholophus haemorrhoidalis (Zetterstedt, 1838)	32	-
Scleroprocta sororcula (Zetterstedt, 1851)	24	-
Symplecta (Psiloconopa) meigeni (Zetterstedt, 1838)	22,25,26,27,28,29,30,31,32,34,36	46, 50
Symplecta (Symplecta) sp	31	-
Dicranomyia (Dicranomyia) aperta Wahlgren, 1904	5,6	-
Dicranomyia (Dicranomyia) autumnalis (Staeger, 1840)	1,4,24	-
Dicranomyia (Dicranomyia) didyma (Meigen, 1804)	24,29,34,36	6,22,43
Dicranomyia (Dicranomyia) distendens Lundström, 1912	1,2,3,5,6,8,9,10,11,12,13,14,15,16,17,19,21,23,24,27,30,	27,29,45
	31,32,33,34	-
Dicranomyia (Dicranomyia) halterata Osten Sacken, 1869	-	36
Dicranomyia (Dicranomyia) hyalinata (Zetterstedt, 1851)	22,23,24,25,26,27,28,29,30,31,32,33,34,	22,23,24,42,43,
Dicranomyia (Dicranomyia) longipennis (Schummel, 1829)	4,5,6	-
Dicranomyia (Dicranomyia) mitis (Meigen, 1830)	25	-
Dicranomyia (Dicranomyia) modesta (Meigen, 1818)	5,18	15,16,26
Dicranomyia (Dicranomyia) patens Lundström, 1907	10	8,15,
Dicranomyia (Dicranomyia) omissinervis de Meijere, 1918	-	15
Dicranomyia (Dicranomyia) terraenovae Alexander, 1920	1,2,3,4,5,6,8,9,10,11,12,14,15,16,18,19,20,21,23,24	1,12,24,26
Dicranomyia (Dicranomyia) ventralis (Schummel, 1829)	3,4,5,6,9,16,18,20,21	-
Dicranomyia (Dicranomyia) moniliformis Doane, 190	4,5	-
Dicranomyia (Idiopyga) halterella Edwards, 1921	2,8,10,18,23,24,28,29,31,36	5,15,26,43
Dicranomyia (Idiopyga) magnicauda Lundström, 1912	9	4,7,15
Dicranomyia (Idiopyga) lulensis (Tjeder, 1969)	16,36	-
Dicranomyia (Idiopyga) ponojensis Lundström, 1912	1,2,3,4,5,6,8,9,10,11,12,13,15,16,17,18,20,21,22,	12,23,24,26,43
	23,24,25,26,28,29,30,32	-
Dicranomyia (Idiopyga) stigmatica (Meigen, 1830)	1,2,3,4,5,6,8,9,10,12,14,17,18,21,22,23,24,32,33	22,24
Dicranomyia (Melanolimonia) caledonica Edwards, 1926	14,23,26,27,28,33,34,36	22,29,30,35,36,40,46
Dicranomyia (Melanolimonia) morio (Fabricius, 1787)	-	15
Dicranomyia (Melanolimonia) rufiventris (Strobl, 1900)	1,2,3,4,5,6,8,9,10,11,12,13,14,15,18,19,20,21,23,	4,7,12,24,26,28,35,42,43
	24,27,29,30,31,32,33,34	-
Dicranomyia (Melanolimonia) stylifera Lackschewitz, 1928	28,30,34	-
Discobola annulata (Linnaeus, 1758)	-	6
Helius (Helius) longirostris (Meigen, 1818)	1,3,4,5,6,9	2,4,7,14

Appendix 2. Continues.

species	study sites	other sites
Limonia macrostigma (Schummel, 1829)	12,23,24	5
Limonia sylvicola (Schummel, 1829)	23,24,33	5,6,8,22,24,26
Limonia trivittata (Schummel, 1829)		6,12
Metalimnobia (Metalimnobia) quadrinotata (Meigen, 1818)	8	6,15
Metalimnobia (Metalimnobia) zetterstedti (Tjeder, 1968)	2,3,8,9,10,23	-
Orimarga (Orimarga) attenuata (Walker, 1848)	5,6,8,12,20,22,23,27,28,32,33,34	-
Rhipidia (Rhipidia) maculata Meigen, 1818	23,24,34	-
Angarotipula tumidicornis (Lundström, 1907)	4,6,11,13,15,17,22,26,28,29,30,31	21,33,35,48
Dictenidia bimaculata (Linnaeus, 1760)	10,24	-
Dolichopeza nitida Mik	-	20,44
Nephrotoma tenuipes (Riedel, 1910)	5	-
Prionocera abscondita Lackschewitz, 1933	25,26,30	-
Prionocera chosenicola Alexander, 1945	13,15,16,17,25	25,27,48
Prionocera pubescens Loew, 1844	1,3,4,5,6,8,9,11,13,15,16,17,19,20,22,25,26,31,31	1,2,3,13,27,48
Prionocera recta Tjeder, 1948	25	31
Prionocera ringdahli Tjeder, 1948	8,9,21,22,25,26,27,28,29	32,44,46,48
Prionocera serricornis (Zetterstedt, 1838)	1,2,3,4,6,8,9,10,15,22,25,26,30,31	2,3,19,30,32
Prionocera subserricornis (Zetterstedt, 1851)	1,2,3,4,6,8,9,11,13,15,15,17,19,20,21,22,24,25,26,28,30,31	2,11,13,15,27,29,30,41,44,48
Prionocera turcica (Fabricius, 1787)	1,2,3,4,5,6,8,9,11,12,13,15,16,17,18,20,21,22,25,	1,2,3,4,7,11,13,18,25,27,37,44,45
	26,28,29,30,31,36	-
Prionocera woodorum Brodo, 1987	-	26
Tanyptera (Tanyptera) atrata (Linnaeus, 1758)	1,6,9,12,15,17	-
Tanyptera (Tanyptera) nigricornis (Meigen, 1818)	4,6,15,17	-
Tipula (Arctotipula) salicetorum Siebke, 1870	-	30,33,38,48
Tipula (Emodotipula) obscuriventris Strobl, 1900	36	-
Tipula (Lindnerina) subexcisa Lundström, 1907	18	47
Tipula (Lunatipula) lunata Linnaeus, 1758	-	8
Tipula (Lunatipula) trispinosa Lundström, 1907	24,28,29,36	39
Tipula (Platytipula) luteipennis Meigen, 1830	1,3,4,5,6,8,9,10,12,15,16,17	12
Tipula (Platytipula) melanoceros Schummel, 1833	2,4,5,6,7,9,10,11,13,14,15,16,17,18,19,20,21,22,23,	6,12,22,23,24,26,27,35,49
	24,25,26,27,28,29,30,32,33,34,35,36	-
Tipula (Pterelachisus) mutila Wahlgren, 1905	11,28	17
Tipula (Pterelachisus) varipennis Meigen, 1818	24	47

Appendix 2. Continues.

species	study sites	other sites
Tipula (Savtshenkia) gimmerthali Lackschewitz, 1925	1,2,3,6,8,9,10,13,14,15,18,21,22,23,24,31,32,33	22,24,26
Tipula (Savtshenkia) grisescens Zetterstedt, 1851	1,2,3,4,6,8,9,10,11,12,14,22,23,24,25,32,33	3,19,22,32
Tipula (Savtshenkia) interserta Riedel, 1913	1,6,8	-
Tipula (Savtshenkia) invenusta Riedel, 1919	12,15,22,23,24,25,26,27,29,32,33,35,36	22,24,26,43,49
Tipula (Savtshenkia) limbata Zetterstedt, 1838	8,9,10,15,16,19,22,24,26,27,28,29,32,33,34,36	22,24
Tipula (Savtshenkia) subnodicornis Zetterstedt, 1838	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,19,20,22,	2,3,11,15,29,30,31,32,37,46,48,50
	23,25,26,27,28,29,30,31,32,33,34	-
Tipula (Schummelia) variicornis Schummel, 1833	-	5,6
Tipula (Vestiplex) excisa Schummel, 1833	4,9,11,16,17,19,20,21,22,23,24,25,27,28,29,30,31,33,34,35,36	22,26,27,29,30,40,42,46
Tipula (Vestiplex) laccata Lundstrom & Frey, 1916	-	5,26
Tipula (Vestiplex) montana verberneae Mannheims & Theowald, 1959	22,35	27,44
Tipula (Vestiplex) nubeculosa Meigen, 1804	21,23,24,32,34,36	-
Tipula (Vestiplex) tchukchi Alexander, 1934	23	-
Tipula (Yamatotipula) coerulescens Lackschewitz, 1923	-	38
Tipula (Yamatotipula) freyana Lackschewitz, 1936	-	5,6
Tipula (Yamatotipula) lateralis Meigen, 1804	36	40
Tipula (Yamatotipula) moesta Riedel, 1919	8,10,15,21,23,25,28,32,35	26,27,29,37,40,41,48
Tipula (Yamatotipula) quadrivittata Staeger, 1840	6,21	-
Dicranota (Dicranota) bimaculata (Schummel, 1829)	18,26,32,36	15,3,41,44,48
Dicranota (Dicranota) guerini Zetterstedt, 1838	8,11,18,24,28,29,31,33,36	30,32,43,48,49
Dicranota (Paradicranota) gracilipes Wahlgren, 1905	23,24,36	5,15,23,26,28,35,43
Dicranota (Paradicranota) pavida (Haliday, 1833)	36	5,15,42,44,46,50
Dicranota (Paradicranota) robusta Lundström, 1912	36	-
Dicranota (Rhaphidolabis) exclusa (Walker, 1848)	8,18,23,27,29,31,32,34,36	15,22,26,30,34,35,36,38,40,41,44,46
Pedicia (Pedicia) rivosa (Linnaeus, 1758)	1,2,3,4,8,10,11,12,13,14,18,19,20,21,23,24,26,27,28,	6,8,26,40
	29,30,31,32,33,36	-
Tricyphona (Tricyphona) immaculata (Meigen, 1804)	1,2,3,4,5,6,8,9,10,11,12,13,14,15,16,17,18,19,20,21,	6,10,26,27,29,35,36,37,40,41,45,46,48
	22,23,24,25,26,27,28,29,30,31,32,34,36	-
Tricyphona (Tricyphona) schummeli Edwards, 1921	24,33,34	-
Tricyphona (Tricyphona) unicolor (Schummel, 1829)	1,2,4,6,7,8,10,11,12,13,14	5,6,11
Ula (Ula) sylvatica (Meigen, 1818)	10,19	6
Cylindrotoma distinctissima (Meigen, 1818)	23,24,28,31,33,34,36	5,10,15,22,26,44
Diogma caudata Takahashi, 1960	10	-

Appendix 2. Continues.

species	study sites	other sites
Phalacrocera replicata (Linnaeus, 1758)	8,16,17,29,36	27,48
Ptychoptera hugoi Tjeder, 1968	8,9,21,22,23,24,25,26,27,28,29,30,32	5,46,48
Ptychoptera minuta Tonnoir, 1919	2,3,4,5,6,8,9,10,13,15,16,17,19,20,21,22,23,24,25,	7,27,30
	26,27,28,29,30,31,36	-
Berdeniella freyi (Berdén, 1954)	23,24,28,36	42,44
Chodopsycha lobata (Tonnoir, 1940)	21,24,32	15
Chodopsycha sp	14	-
Logima satchelli (Quate, 1955)	1,2,3,4,5,7,8,9,11,12,13,14,15,16,17,18,19,20,21,23,24,28,34,36	8,26
Parabazarella subnegleta (Tonnoir, 1922)	8,18,23,24,27,29,31,32,36	40,44,46
Pericoma formosa Nielsen, 1964	8	14
Pericoma rivularis Berdén, 1954	1,2,3,6,8,10,13,18,22,23,24,28,33,36	37
Pneumia borealis (Berdén, 1954)	1,8,9,10,21,22,23,24,27,28,33,34,36	-
Pneumia mutua (Eaton, 1893)	18,32,33,34	-
Pneumia pilularia (Tonnoir, 1940)	23,34	-
Pneumia stammeri (Jung, 1954)	8,24,29,36	13,38
Pneumia ussurica (Wagner, 1994)	1,3,4,5,6,8,9,10,21,22,23,25,26,28,36	-
Psycha grisescens (Tonnoir, 1922)	24	-
Psychoda phalaenoides (Linne, 1758)	4,23,24	-
Psychodocha itoco (Togunaka & Komyo, 1954)	8,24	-
Psychodula minuta (Banks, 1894)	10	-
Tinearia lativentris (Berdén, 1952)	5	-
Dixa nebulosa (Meigen, 1830)	23,24,36	5,7,8,15,42
Dixella aestivalis (Meigen, 1818)	2,3,5,6,8,18,21,22,36	5,7,9,15
Dixella amphibia (De Geer, 1776)	4,6,8,12,13,21,22,26,28	9,12,30
Dixella borealis (Martini, 1929)	10	5,6,8,15
Dixella hyperborea (Bergroth, 1889)	2,3,6,8,10,19,21	5,6,8,9,15,16,35
Dixella laeta (Loew, 1849)	8,11,14,15,20,21,22,25,26,27,28,29,30	24,27,43
Dixella naevia (Peus, 1934)	2,3,8,9,10,11,15,18,20,21,23,24,26,28,34	6,7,9,15,22,26,43
Dixella obscura (Loew, 1849)	8,9,11,18,21,22,23,24,25,26,29,30,31,36	7,8,15,26,40,43
Thaumalea truncata Edwards, 1929	29,31,32,34,36	-
Pachyneura fasciata Zetterstedt, 1838	10	-

Appendix 3. Vascular plants, bryophytes (mosses and liverworts) recorded from the study sites within a five-meter radius from the Malaise trap. Numbering of the sites refers to Table 1.

species	**stydy sites**
Agrostis capillaris L.	8
Agrostis mertensii Trin.	23,24,27,35,36
Andromeda polifolia L.	1,3,4,5,6,7,8,9,12,13,14,15,16,17,20,21,22,26,27,30,32,33
Alchemilla sp	23,24,32,33
Alnus incana (L.) Moench	10
Angelica archangelica L. ssp. *archangelica*	23,24,32,33
Antennaria dioica (L.) Gaertn.	27,28,33
Anthoxanthum odoratum ssp. *alpinum* (Á. Löve & D. Löve) Jones & Melderis	24,27,31,32,33,35,36
Arabis alpina L.	31
Astragalus alpinus L. ssp. *arcticus* Lindm.	34
Bartsia alpina L.	24,27,28,31,32,33,34
Betula nana L.	1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,17,19,20,21,22,26,27,28,30,31,32,33,34,36
Betula pubescens Ehrh.	1,2,4,6,10,11,12,18,19,21,24,31,32,33,34,36
Bistorta vivipara (L.) Gray	23,24,27,28,31,32,33,34,35
Calamagrostis purpurea (Trin.) Trin. ssp. *phragmitoides* (Hartm.) Tzvelev	11,18,24,36
Calamagrostis stricta (Timm) Koeler	23,24,25,29
Calluna vulgaris (L.) Hull	4
Caltha palustris L.	1,8,10,18,23,24,29,36
Cardamine pratensis L. ssp. *polemonioides* Rouy	23
Carex acuta L.	8
Carex bigelowii Torr. Ex Schwein.	27,29,35
Carex brunnescens (Pers.) Poir.	9
Carex buxbaumii Wahlenb.	21,22,32,36
Carex canescens L.	8,9,10,11,19,23,24,25,26,29,36
Carex capillaris L.	27,28,34
Carex cespitosa L.	2,8,9,33,36
Carex chordorrhiza L.	1,3,4,5,6,7,8,9,12,14,15,22
Carex diandra Schrank	1,6
Carex dioica L.	1,2,4,5,6,8,14,21,27,28,31,33
Carex heleonastes L.	1
Carex lachenalii Schkuhr	35
Carex lapponica O. Lang.	25,26

Appendix 3. Continues.

species	**stydy sites**
Carex lasiocarpa Ehrh.	1,3,6,15,20,22,29
Carex limosa L.	1,3,4,5,6,7,13,15,17,21,22
Carex livida (Wahlenb.) Willd.	4,21,22
Carex magellanica Lam. ssp. *irrigua* (Wahlenb.) Hiitonen	9,10,19,20,22,26,27,29,30
Carex nigra (L.) Reichard ssp. *juncella* (Fr.) Lemke	10,23,24,31,32
Carex nigra (L.) Reichard ssp. *nigra*	25,27,29,32,34
Carex norvegica Retz. ssp. *inferalpina* (Wahlenb.) Hultén	31
Carex panicea L.	28,34
Carex pauciflora L.	5
Carex rariflora (Wahlenb.) Sm.	26
Carex rostrata Stokes	7,8,9,12,13,14,15,20,22,27,28
Carex rotundata Wahlenb.	15,16,17,22,25,26,27,28,29
Carex tenuiflora Wahlenb.	10
Carex vaginata Tausch	10,27,28,31,32,33,34,36
Carex vesicaria L.	9,10,20,22,36
Cassiope hypnoides (L.) D. Don	27,29,35
Cassiope tetragona (L.) D. Don	35
Cerastium fontanum Baumg.	24
Cirsium helenioides (L.) Hill	24,28
Coeloglossum viride (L.) Hartm.	28,32,33
Cornus suecica L.	23,27,34,36
Dactylorhiza incarnata (L.) Soó	4
Dactylorhiza maculata (L.) Soó	3,6,32,33
Deschampsia cepitosa (L.) P. Beauv.	32
Drosera longifolia L.	3,4,5,6,21
Drosera rotundifolia L.	1,3,4,6,8
Eleocharis quinqueflora (Hartmann) O. Schwarz	22
Empetrum nigrum L.	1,2,3,4,5,6,8,9,11,14,17,18,19,20,21,22,25,27,30,31,32,33,34,35
Epilobium angustifolium L.	24
Epilobium palustre L.	1,8,10,11,12,14,23,25,
Epilobium hornemannii Rchb.	11,18,23,24,31
Equisetum arvense L.	8,23,32
Equisetum fluviatile L.	1,2,3,4,5,6,8,9,12,15

Appendix 3. Continues

species	**stydy sites**
Equisetum palustre L.	2,8,9,10,22,27
Equisetum pratense Ehrh.	18,24,27,30,31,33,34,36
Equisetum scirpoides Michx.	8
Equisetum sylvaticum L.	11,32
Equisetum variegatum Schleich. ex Weber & Mohr	31,32,33
Eriophorum angustifolium Honck.	11,12,13,14,15,19,20,21,22,26,27,28,29,30,32,33,36
Eriophorum gracile W.D.J. Koch ex Roth	1,6,9
Eriophorum russeolum Fr. ex Hartm.	4,15,16,17,25
Eriophorum vaginatum L.	1,2,4,5,6,7,17,21
Euphrasia sp	24,31,32,33
Festuca rubra L.	27,28
Filipendula ulmaria (L.) Maxim.	23,24,28,36
Galium uliginosum L.	1,8,10,23,24,28,36
Geranium sylvaticum L.	24,28,36
Geum rivale L.	24
Gnaphalium norvegicum Gunnerus	24,31
Gnaphalium supinum L.	35
Gymnadenia conopsea (L.) R.Br.	2,32,33,34
Gymnocarpium dryopteris (L.) Newman	23,24
Hieracium sp	23,32,33,35
Huperzia selago (L.) Bernh. ex Schrank & Mart.	27,28,32,35
Juncus biglumis L.	27,32,33,35
Juncus filiformis L.	24,27,29
Juncus stygius L.	3,21
Juncus triglumis L.	27,32,33
Juniperus communis L.	1,10,24,28,33,34,36
Ledum palustre L.	2,4,10,16,17,19,20,21,22,25
Linnaea borealis L.	10
Listera cordata (L.) R. Br.	27,31,32,34
Luzula arcuata Sw. ssp. *arcuata*	35
Luzula parviflora (Ehrh.) Desv.	24
Luzula pilosa (L.) Willd.	10
Luzula spicata (L.) DC.	35

Appendix 3. Continues.

species	**stydy sites**
Luzula sudetica (Willd.) DC.	23,24,27,32,36
Melampyrum pratense L.	34
Melampyrum sylvaticum L.	1,2,6,8,34
Melica nutans L.	28
Menyanthes trifoliata L.	1,3,4,5,6,7,8,9,12,13,14,15,22
Milium effusum L.	24
Molinia caerulea (L.) Moench	28
Moneses uniflora (L.) A. Gray	6
Montia fontana L.	8,18
Myosotis decumbens Host.	24
Nardus stricta L.	27,29,32,33,35
Orthilia secunda (L.) House	2, 10
Parnassia palustris L.	1,8,24,28,29,33,36
Pedicularis lapponica L.	31
Pedicularis palustris L.	1,3,4,6,21
Petasites frigidus (L.) Fr.	35
Phleum alpinum L.	23,24,29,31,32
Phragmites australis (Cav.) Trin. ex Steud	14
Phyllodoce caerulea (L.) Bab.	27,31,34,35
Picea abies (L.) H. Karst.	2,5,8,10,
Pinguicula alpina L.	24,27,28,31,32,33,34
Pinguicula vulgaris L.	8,14,24,27,32,34
Pinus sylvestris L.	2,4,5,6,19
Poa alpigena (Fr.) Lindm.	8,23,24,31,32
Potentilla crantzii (Crantz) Beck ex Fritsch	24
Potentilla erecta (L.) Raeusch.	28
Potentilla palustris (L.) Scop.	1,2,5,8,9,10,11,12,15,18,20,23,25,26,27,29,30,31,36
Pyrola minor L.	6,9,14,27,31,32,36
Pyrola rotundifolia L.	2,6,8
Ranunculus nivalis L.	35
Ranunculus sp	31,32
Rhodiola rosea L.	36
Rubus arcticus L.	8

Appendix 3. Continues.

species	**stydy sites**
Rubus chamaemorus L.	2,4,8,10,11,16,17,19,20,21,22,25,30
Rubus saxatilis L.	36
Rumex acetosa L.	31,34
Salix glauca L. ssp *glauca*	10,11,21,27,28,32,33,34,36
Salix glauca L. ssp. *stipulifera* (Flod. ex Häyrén) Hiitonen	8,31
Salix herbacea L.	29,31,35
Salix lanata L. ssp. *lanata*	27,31
Salix lapponum L.	1,9,10,11,12,15,20,21,22,28,30,31,32,33,34,36
Salix myrsinifolia Salisb. ssp. *myrsinifolia*	2,8
Salix myrsinifolia Salisb. ssp *borealis* (Fr.) Hyl.	23,24
Salix myrsinites L.	8,9,14,22,27,28,34
Salix myrtilloides L.	3,9,15,21
Salix phylicifolia L.	2,6,10,11,18,21,23,24,36
Salix reticulata L.	31,33,34
Salix sp	23,24
Saussurea alpina (L.) DC.	8,28,31,33,34,36
Saxifraga aizoides L.	28,34
Saxifraga cernua L.	31
Saxifraga foliosa R. Br.	35
Saxifraga stellaris L.	32,33,35
Scheuzeria palustris L.	3
Selaginella selaginoides (L.) P. Beauv. ex Schrank & Mart.	1,8,24,27,28,31,32,33,34,35,36
Sibbaldia procumbens L.	29,35
Silene acaulis (L.) Jacq.	35
Solidago virgaurea L.	1,28,34
Sparganium natans L.	6
Stellaria borealis Bigelow	11,18
Taraxacum sp	24,27,28,31,32,33
Thalictrum alpinum L.	27,28,31,32,33,34,36
Tofieldia pusilla (Michx.) Pers.	3,4,5,6,8,27,31,32,33,34
Trichophorum alpinum (L.) Pers.	1,3,4,5,6,14,21,22
Trichophorum cespitosum (L.) Hartm.	4,5,6,8,12,13,20,21,22,27,28,29,32,33,34,36
Trientalis europaea L.	1,23,24,27,31,33

Appendix 3. Continues.

species	stydy sites
Triglochin palustris L.	26,27,32
Trollius europaeus L.	23,24,27,28,31,32,33,36
Urtica dioica L. ssp. *sondenii* (Simmons) Hyl.	23
Utricularia intermedia Hayne	3,4,21
Vaccinium microcarpum (Turcz. ex Rupr.) Schmalh.	1,2,4,5,7,8,12,15,16,17,19,20,21,22,
Vaccinium myrtillus L.	11,19,22,27,31,32,33
Vaccinium oxycoccos L.	1,3,5,6,7,8,9
Vaccinium uliginosum L.	3,4,6,8,9,15,19,20,21,22,24,25,26,27,30,31,32,33,34,36
Vaccinium vitis-idaea L.	9,10,12,17,19,21,31,34,35
Veronica alpina L. ssp. *alpina*	24,31
Veronica serpyllifolia L. ssp. *humifusa* (Dicks.) Syme	18
Viola biflora L.	23,24,27,28,31,32,35,36
Viola epipsila Ledeb.	8,12,28,29,36
Aulacomnium palustre (Hedw.) Schwägr.	1,2,3,4,5,6,8,9,10,11,18,33,34
Blindia acuta (Hedw.) Bruch & Schimp.	32,33,34
Brachytechium rivulare Schimp.	18,23,24
Brachythecium sp	10
Bryum pseudotriquetrum (Hedw.) P. Gaertn. et al.	1,2,6,8,9,10,23,27,28,29,31,32,33,36
Bryum weigelii Spreng.	11,18,23,31
Bryum sp	34,36
Calliergon giganteum (Schimp.) Kindb.	6,8,9
Calliergon richardsonii (Mitt.) Kindb.	1,2,6,10,14
Campylium protensum (Brid.) Kindb.	36
Campylium stellatum (Hedw.) Lange & C.E.O.Jensen	3,4,6,8,9,10,22,28,31,32,33,34,36
Cinclidium stygium Sw.	1,6,8,9,14,22,27,31,36
Cinclidium subrotundum Lindb.	15,21,22,26,29,30
Climacium dendroides (Hedw.) F.Weber & D.Mohr	36
Conostomum tetragonum (Hedw.) Lindb.	27,29,35
Cratoneuron filicinum (Hedw.) Spruce	8
Dichodontium palustre (Dicks.) M.Stech	24,32,33
Dichodontium pellucidum (Hedw.) Schimp.	23,24
Dicranum bergeri Blandow ex Hoppe	22
Dicranum bonjeanii De Not.	3,9

Appendix 3. Countinues

species	stydy sites
Dicranum sp	11,19,22,31,34,35,36
Fissidens adianthoides Hedw.	28
Fissidens osmudoides Hedw.	33
Fontinalis antipyretica Hedw.	23,24
Hamatocaulis vernicosus (Mitt.) Hedenäs	1,6,
Helodium blandowii (F.Weber & D. Mohr) Warnst.	1,6,8,14,18
Hygrohypnum ochraceum (Turner ex Wilson) Loeske	23,24
Hygrohypnum alpestre (Sw. Ex Hedw.) Loeske	24
Hylocomnium splendens (Hedw.) Schimp.	4,10,28
Loeskypnum badium (Hartm.) H.K.G.Paul	4,6,9,12,14,15,20,21,22,30,35
Meesia longiseta Hedw.	1
Meesia triquetra (Richt.) Ångstr.	1,6
Meesia uliginosa Hedw.	33
Oncophorus virens (Hedw.) Brid.	10,31,33,34
Oncophorus wahlenbergii Brid.	20,24,26,27,31,36
Onchophorus elongatus (I.Hagen) Hedenäs	21
Paludella squarrosa (Hedw.) Brid.	1,2,6,8,9,11,12,14,19,20,22,26,27,30,31,34,36
Palustriella decipiens (De Not.) Ochyra	8
Palustriella falcata (Brid.) Hedenäs	8,32,34
Philonotis fontana (Hedw.) Brid.	8,18,31,32
Philonotis seriata Mitt.	18,23
Philonotis tomentella Molendo	24,27,31,32
Plagiomnium elatum (Bruch & Schimp.) T.J.Kop.	1
Plagiomnium ellipticum (Brid.) T.J.Kop.	1,2,8,10,18,23,
Pleurozium schreberi (Willd. ex Brid.) Mitt.	7,10,17,19,21,24,33,34,36
Pohlia drummondii (Müll.Hall) A.L.Andrews	23
Pohlia wahlenbergii (F.Weber & D.Mohr) A.L.Andrews	18,23,24,31
Pohlia sp	29
Polytrichastrum sp	11,18
Polytrichum piliferum Hedw.	35
Polytrichum strictum Menzies ex Brid.	7,17
Polytrichum sp	15,25,26,31,33,36
Pseudobryum cinclidioides (Huebener) T.J.Kop.	2,9,10,11,18,24,25

Appendix 3. Continues.

species	**stydy sites**
Pseudocalliergon trifarium (F.Weber & D.Mohr) Loeske	6,22,27,30
Racomitrium microcarpon (Hedw.) Brid.	32
Rhizomnium magnifolium (Horik.) T.J.Kop.	9,10,11,18,23,24,32
Rhizomnium pseudopunctatum (Bruch & Schimp.) T.J.Kop.	1,8,9,10,11,14,28,30,31,32,34
Rhizomnium punctatum (Hedw.) T.J.Kop.	36
Sanionia sp	9,10,21,29,31,36
Schistidium sp	24,29,36
Scorpidium cossoni (Schimp.) Hedenäs	8,9,14,30,31,32
Scorpidium revolvens (Sw. ex Anonymus) Rubers	6,8,9,14,21,22,27,28,29,31,33,34,36
Scorpidium scorpioides (Hedw.) Limpr.	3,4,5,6,9,21,22,27,29,30,36
Sphagnum angustifolium (C.E.O.Jensen ex Russow) C.E.O.Jensen	2,4,9,10
Sphagnum balticum (Russow) Russow ex C.E.O.Jensen	7
Sphagnum centrale C.E.O.Jensen ex Arnell & C.E.O.Jensen	1,15
Sphagnum compactum DC.	15,35
Sphagnum fallax (H. Klinggr.) H. Klinggr.	7,17,19,25
Sphagnum fuscum (Schimp.) H.Klinggr.	2,3,4,5,8,19,20
Sphagnum lindbergii Schimp. ex Lindb	4,13,16,17,19,20,21
Sphagnum magellanicum Brid.	7
Sphagnum riparium Ångstr.	19,25
Sphagnum rubellum Wilson	1,2,3,4,7,9,10,11,17,22,28,31,32,34
Sphagnum squarrosum Crome	10,15,26
Sphagnum subfulvum Sjörs	9,15,16,21,22,26,30
Sphagnum subsecundum Nees	1,15,22
Sphagnum teres (Schimp.) Ångstr.	1,2,12,14,22
Sphagnum warnstorfii Russow	1,3,4,5,8,14,22,30,31,32,33,34
Sphagnum sp	24,36
Sphlagnum vasculosum Hedw.	22,27
Straminergon stramineum (Dicks. ex Brid.) Hedenäs	1,4,6,8,9,11,12,13,14,15,19,20,21,22,23,25,26,27,29,30,31,32,36
Tayloria lingulata (Dicks.) Lindb.	27,31,33
Tomentypnum nitens (Hedw.) Loeske	1,2,3,4,6,8,31,33,34
Warnstorfia exannulata (W.Gümbel) Loeske	9,11,18,23,25,29,31,32
Warnstorfia procera (Renauld & Arnell) Tuom.	1,3,4,5,6,9,12,13,14,15,16,17,19,21,22,26
Warnstorfia sarmentosa (Wahlenb.) Hedenäs	8,9,11,12,20,21,22,26,27,29,30,31,32

Appendix 3. Continues.

species	**stydy sites**
Warnstorfia trichophylla (Warnst.) Tuom. & T.J.Kop.	8,30,32
Warnstorfia tundrae (Arnell ex Lindb. & Arnell) Loeske	8,14
Aneura pinguis (L.) Dumort.	6,9,14,23,31,33,34
Barbilophozia kunzeana (Huebener) Müll. Frib.	9,15,19,20,22
Barbilophozia sp	24,27,34
Blepharostoma trichophyllum (L.) Dumort.	10,28
Cephalozia sp	22,25,29
Chiloscyphus polyanthos (L.) Corda	10,24
Cladopodiella fluitans (Nees) H.Buch	9,14
Conocephalum conicum (L.) Dumort	24
Harpanthus flotovianus (Nees) Nees	24,31,32
Jungermannia exsertifolia Steph. ssp. *cordifolia* (Dumort.) Vána	32
Jungermannia obovata Nees	24
Leiocolea sp	1,31
Lophozia sp	7,10,12,21,24,30,31
Marcanthia polymorpha L.	18,23
Mylia anomala (Hook.) Gray	8,17,19,22
Odontoschisma elongatum (Lindb.) A.Evans	27,28,29
Pellia sp	24,29,36
Preissia quadrata (Scop.) Nees	28
Ptilidium ciliare (L.) Hampe	12,14,20,21
Riccardia chamaedryfolia (With.) Grolle	15,21,29
Scapania hyperborea Jörg.	20,21,22,27,29
Scapania irrigua (Nees) Nees	9,10,14,21,23,24,27,30,32
Scapania paludicola Loeske & Müll.Frib.	1,3,4,5,9,15,19,22,26
Scapania uliginosa (Sw. ex Lindb.) Dumort.	11,32
Scapania undulata (L.) Dumort	23,24
Tritomaria polita (Nees) Jörg.	11,27,28,31,32,33,34,36
Tritomaria quinquedentata (Huds.) H.Buch	24,28,33,36