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A survey on the nematoceran (Diptera) communities of southern Finnish wetlands

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We examined the community composition and diversity of nematoceran flies (Diptera) in 14 wetland habitats (springs, mires, streams) located in southern Finland. Based on NMS ordination and Cluster analysis, groundwater influence and vegetation type discriminated the studied communities quite clearly. A total of 8,606 specimens belonging to 156 species were identified, distributed as follows: Limoniidae (80 species), Psychodidae (26), Tipulidae (20), Pediciidae (10), Dixidae (9), Cylindrotomidae (4), Ptychopteridae (4), Thaumaleidae (1), Pleciidae (1) and Pachyneuridae (1). The most species rich locality, Ruottaniitty rich fen in Ruovesi, harboured 69 species, while only 12 species were found from the least diverse locality; mean species richness of the studied sites was 40,3. *Molophilus pullus* (Limoniidae), *Tinearia lativentris* (Psychodidae) and *Dixella nigra* (Dixidae) are reported for the first time from Finland and the ecology and distribution of several rare and preliminary red-listed flies are discussed. We conclude that nematocerans have great potential as tools for bioassessment, conservation and monitoring of wetlands in the boreal region. We emphasize the importance of nearly pristine and species rich spring-fed fens in Ruovesi for the biodiversity preservation of Finnish wetlands.

1. Introduction

Nematoceran flies (Diptera) are a diverse group of insects displaying an overwhelming variety of life history traits and ecological niches. Craneflies (Tipulidae s.l.), for example, are represented by 3,122 species in the Palaearctic region (Oosterbroek 2006), including species from truly terrestrial to truly aquatic (Brindle 1960, 1967). Although flies are species rich and ecologically important group in most habitats, detailed studies on their patterns in diversity and assemblage structure are scarce. In the present study, we have studied flies belonging to 10 families, totalling 397 species in Finland (J. Salmela, unpublished). In a recent review, where most of the families were treated, the majority of the species were assessed as dwellers of moist or semiaquatic environments, wetlands (Salmela 2006). Nematocerans, compared to many other invertebrates, are less studied and poorly known, but their value for bioassessment and nature conservation has been recently recognized by Stubbs (2003), Chadd and Extence (2004) and Ujvarosi (2005). Further, wetland-inhabiting flies have been red-listed in a number of European countries (Falk 1991, Dufour 1994, Falk

& Chandler 2005, Farkač et al. 2005), acknowledging the vulnerability of these insects due to degradation of most wetlands. A preliminary list of threatened semiaquatic flies in Finland was proposed by Salmela (2006).

Wetlands encompass a large variety of biotopes, sharing shallow water, saturated soil and characteristic submerged and emergent vegetation as common features (van der Valk 2006). Wetlands, such as mires, small lotic waters and sea shore meadows, are a prominent component of the Finnish landscape and their importance for the regional biodiversity is immense. Natural state of many wetland biotopes, like brooks and mires, has strongly decreased due to human influence, especially in Southern Finland (Ohtonen et al. 2005, Lindholm & Heikkilä 2006). Nematoceran communities living in springs (Salmela 2001, 2005) and mires (Salmela 2004, Salmela & Ilmonen 2005) have been studied, but huge gaps in the knowledge of assemblage structure and diversity of most wetland types still exists (Salmela 2006). In the present study, our aim was to examine pristine or nearly pristine springs, fens and streams in Southern boreal Finland. We wanted to have a better picture of the concerned fly families, especially addressing the community composition and diversity, but also to improve our knowledge of occurrence of rare and potentially threatened species in southern Finland.

2. Material and methods

2.1. Study area and studied sites

The studied sites are located in southern Finland, in the biogeographical provinces of Ab, N and Ta (Table 1). The localities lie within Southern boreal ecoregion, those in Karkkila, Kiikala and Loppi in the subzone of south-western Finland and coast of Ostrobothnia, and sites in Ruovesi and Tampere belong to subzone of Lake Finland (see eg. Ulvinen et al. 2002). The mean annual temperature in the study region is 3–4 C° (mean temperature in July 15–16 C° and in January –7 to –8 C°) and the mean annual precipitation 600–650 mm (Atlas of Finland 1987). The bedrock in the area consists mainly of acid minerals, such as granites, gneisses and granulite (Atlas of Finland 1990).

Ruovesi, Ruottaniitty

Two Malaise traps were set in Ruottaniitty, in a mesoeutrophic spring and in a rich fen, sites are here treated separately. The mesoeutrophic spring was shaded by Norway spruce (*Picea abies*) and alders (*Alnus glutinosa* and *A. incana*) and vascular plants viz. *Filipendula ulmaria*, *Stellaria nemorum* and *Chrysosplenium alterniflorum* occurred there abundantly. A moss species *Brachythecium rivulare* dominated the spring-fed vegetation, *Plagiomnium ellipticum* was less abundant. Spring-fed vegetation covered the ground layer in the eastern hill of the Ruottaniitty and it was very difficult to walk there due to soft bottom. The rich fen was relatively open, inhabited by dwarf Norway spruce, willow (*Salix*) and birch (*Betula*). The rich fen was clearly spring-fed and emerging groundwater was probably iron rich due to bare ochre deposits. *Sphagnum teres*, *S. squarrosum* and *Bryum weigelii* were abundant near the trap and *Bryum pseudotriquetrum* and *Marchantia polymorpha* were also recorded. The rich fen is known to harbour several rare and demanding vascular plants, such as *Dactylorhiza incarnata*, *D. traunsteinerii*, *Rumex acetosa* var. *fontanopaludosus* and *Eriophorum gracile* (see Kääntönen 2005 for details).

Ruovesi, Jakamakangas

The Malaise trap in Jakamakangas was set in the bank of a forest stream. The site was shaded by Norway spruce, *A. incana* was less abundant. The surrounding area was a moist spruce forest with a strong influence of seepages. *Trichocolea tomentella*, a threatened liverwort species favouring springs and seepages (Ulvinen et al. 2002), was growing in the stream bank, also *Rhytidiadelphus subpinnatus*, *R. triquetrus*, *Dicranum polysetum*, *Mnium hornum*, *Hylocomiastrum umbratum*, *Rhizomnium magnifolium*, *S. squarrosum*, *Pellia* sp and *Plagiochila asplenoides* were found. The brook was characterized by clear and cold water and minerogenous bottom material.

Tampere, Peräjoki

Peräjoki is an outlet stream flowing from the Lake Peräjärvi. The Malaise trap was set in the stream bank, which was herb-rich forest dominated by *A. incana*, *Prunus padus* and Norway spruce. Relatively large amount of decaying wood was pecu-

Table 1. Studied wetlands, their location, vegetation type and measured environmental variables.

Site	Province	Municipality	Site type	N[1]	E[2]	T C	pH	Cond[4]	TBA[5]
Ruottaniitty spring	Ta	Ruovesi	mesoeu.spring	6862386	3345554	5,9	6,63	3,4	35
Ruottaniitty fen	Ta	Ruovesi	mesoeu.spring-fen	6862360	3345528				6
Jakamakangas	Ta	Ruovesi	brook, seepage	6858164	3343836	11,8	6,42	2,3	47
Peräjoki	Ta	Ruovesi	brook, herb-rich	6841811	3345335	14,1	6,54	8	30
Kilpilampi	Ta	Ruovesi	oligotrophic fen	6863510	3350510				0
Röykkeenneva	Ta	Ruovesi	mesoeu.spring-fen	6865880	3352260				
Pärjänlähteet	Ta	Ruovesi	meso.spring	6865600	3352470				
Kökköpäänpuro	Ab	Karkkila	brook, forest	6722894	3342232	9,9 (5,4)	4,96	3,2	40
Hongistonpuro	Ab	Karkkila	brook, herb-rich	6720373	3352747	7,2 (0,9)	6,31	9,4	27
Varesjoki, brook	Ab	Kiikala	brook, forest	6707428	3313780	10,3 (3)	6,58	3,9	35
Varesjoki, spring	Ab	Kiikala	mesoeu.spring	6707463	3313800	7,3 (1,2)	6,84	9,7	24
Melkutin, outlet	Ta	Loppi	brook, swamp	6739401	3341023	15,2 (5,6)	7,03	5	16
Kiljava	N	Nurmijärvi	mesoeu.spring	6712021	3373388	8,3 (2,8)	6,85	9,4	32
Suntelinaho	Ab	Karkkila	seepage, spruce mire	6716459	3343070	7,6 (3,3)	4,92	3,3	22

1) North coordinates, 2) East coordinates (Grid 27°E); 3) parenthes presents standard deviation of the mean water temperature, in other sites only one measurement; 4) specific conductivity mS/m; 5) tree basal area.

liar for the site. Bryophytes such as *R. subpinnatus*, *Pseudobryum cinclidioides*, *Climacium dendroides*, *Chiloscyphus polyanthus* and *P. asplenoides* were growing in the stream bank. The bottom of the stream consisted of minerogenous material and the stream was fed by surface run-off.

Ruovesi, Kilpilampi

Kilpilampi was a small, polyhumic lake in an oligotrophic fen. The site was located in the Siikaneva national park. The studied site was open mire and the Malaise trap was placed near the shore of the lake. The ground layer was dominated by *Sphagnum* mosses, *Carex lasiocarpa* and *C. rostrata*.

Ruovesi, Röykkeenneva

Röykkeenneva was a mesoeutrophic spring fen. The trapping site was relatively open, only dwarf Norway spruce, birch and willow were present. Several bryophytes indicating groundwater influence, such as *B. rivulare*, *Philonotis fontana*, *Calliergonella cuspidata*, *B. weigelii*, *Sphagnum warnstorfii* and *Pseudobryum cinclidioides* were recorded near the Malaise trap. There were no distinct water flow or pools in the immediate vicinity of the trap but pools and a stream flowing water from Pärjänlähteet (see below) were about 10–15 m distance from the trap. Emerging groundwater is probably rich in iron since ochre deposits were common in the surface of the fen. The vascular plant flora of the spring fen is overviewed by Kääntönen (2002).

Ruovesi, Pärjänlähteet

Pärjänlähteet was a complex of large spring pools and a springbrook draining the water. *Cardamine amara* was abundant in the pools but spring-living mosses were very scarce and the edges of the pools were *Sphagnum* dominated. The surrounding vegetation could be classified as pine bog. The Malaise trap was set near one spring pool.

Karkkila, Kökköpäänpuro

The studied stream is a 0,5 m wide, acidic brownwater stream draining small, mostly ditched mires. No bryophytes were found in the stream, which had a mixed detritus and sand substrate. The surroundings were dominated by dense growth of young Norway spruce and the ground layer by the mosses *Dicranum polysetum* and *Sphagnum girgensohnii.* The stream was dry in the beginning of August 2006.

Karkkila, Hongistonpuro

The brook was fed by springs upstream of the study site, but no large spring sources were located in the immediate vicinity of the trap. The water was clear and cold, and the substrate was dominated by sand and silt, and the submersed vegetation by *Fontinalis antipyretica* and *Cardamine amara*. The surroundings were mesic mixed forest dominated by *A. incana* and Norway spruce, and the ground layer by diverse bryophyte flora (eg. *Plagiomnium medium*, *Rhytidiadelphus subpinnatus*, *Pleurozium schreberi*, *Rhizomnium magnifolium*, *Hylocomium splendens*). Flow remained constant and water cold through the summer.

Kiikala, Varesjoki stream
Varesjoki is a 3 to 5 m wide headwater stream flowing in a deep ravine carved in a sandy delta. The northern bank is full of groundwater seeps, whereas the southern bank is mixed forest on a sandy ground dominated by Norway spruce. The ground layer was formed by mixed forest bryophytes (eg. *Pleurozium schreberi*, *Dicranum polysetum*, *Hylocomium splendens*, *Rhytidiadelphus subpinnatus*). The trap was set on the southern stream bank. Stream flow was reduced in July–August but did not cease.

Kiikala, Varesjoki spring
The trap was set on the northern side of the stream, opposite to the previous trap, on a helocrene spring 5 m away from the stream. The site was relatively open and the ground layer was densely covered by vascular plants (eg. *Filipendula ulmaria*) and bryophytes (eg. *Calliergon giganteum*, *C. cuspidatum*, *Chiloscyphus polyanthus*, *Rhizomnium magnifolium*, *Philonotis fontana*). A 10 cm wide rill with constant flow drained the spring into the Varesjoki stream.

Loppi, Melkutin, outlet stream
The trap was set on the bank of a clear-water stream approximately 100 m below the outlet of lake Melkutin on a fen covered by reed (*Phragmites australis*) and bryophytes indicating meso to meso-eutrophy (eg. *Riccardia* sp., *Aneura pinquis*, *Fissidens adianthoides*, *Bryum pseudotriquetrum*, *Sphagnum contortum*). The surroundings were sparse mixed forest (Norway spruce, *A. incana*, birch, willow). The flow remained constant throughout the season.

Nurmijärvi, Kiljava
The trap was set over a 0,5 to 0,8 m wide stream originating from numerous spring sources upstream of the site, with patches of *F. antipyretica*. The immediate surroundings of the trap were spruce fen dominated by Norway spruce and alder, and a rich bryophyte flora including spring-preferring species (eg. *Pleurozium schreberi*, *Rhizomnium magnifolium*, *Plagiomnium ellipticum*, *Rhodobryum roseum*, *Mnium hornum*). The closest large spring source was 50 m upstream of the site. Flow and temperature remained constant.

Karkkila, Suntelinaho
Malaise trap was set over a small trickle combining surface flow and seeping groundwater immediately above the site, with submersed growths of *Warnstorfia exannulata* and *Scapania undulata*. The surroundings were dominated by Norway spruce and willow, and the ground layer by *Sphagnum girgensohnii* and *Hylocomium splendens*. Surface flow occurred only in May–June 2006, but a small (diam. < 1 m) pool above the trap remained wetted throughout the season.

2.2. Collecting of insects and environmental variables

We used Malaise traps (length 110, height 140, width 70 cm) to collect adult insects. One trap was placed in each site, over small trickles, stream banks or helocrene vegetation. The traps were placed in 28th of April to 5th of May and the traps were emptied in one month intervals; the traps were removed from the field in the end of September. We used 50% ethylene glycol as a preservative in the traps and the material was later stored in 70% ethanol. The studied nematoceran families were sorted and identified in the laboratory. The insect material in Röykkeenneva, Pärjänlähteet and Kilpilampi was collected in 2005; in other sites the collecting took place in 2006.

Specific conductivity, water temperature and pH were measured in most sites with a portable instrument (WTW pH/Cond 340i). Tree basal area was measured using a relascope and geographical coordinates of the Malaise traps were obtained using satellite navigator.

2.3. Statistical methods

We used Nonmetic Multidimensional Scaling (NMS) and Cluster-analysis to analyse patterns in sample structure (McCune & Grace 2002). In the NMS ordination we used Sorensen's distance measure, three as the maximum number of dimensions, stepping down in dimensionality and hundred runs with real data. A two-dimensional solution with a stress value 9,11 was finally selected. In the Cluster-analysis we used Sorensen's distance measure and flexible beta as a linkage method (with flexible beta value of –0.500). Shannon-Wiener and Simpson's diversity indices were calculated to interpret species diversity. Prior NMS and Cluster analysis the data matrix was log (x + 1) transformed. All analyses were run with PC-Ord 4.0 programme (McCune and Mefford 1999).

3. Results

A total of to 8,606 specimens belonging 156 species were identified (Appendix 1). Limoniidae (80 spp) was the most species rich family followed by Psychodidae (26), Tipulidae (20), Pediciidae (10), Dixidae (9), Cylindrotomidae (4), Ptychopteridae (4), Thaumaleidae (1), Pleciidae (1) and Pachyneuridae (1). The most common (frequency >50%) species in our samples were *Tricyphona immaculata* (92,9%), *Phylidorea fulvonervosa* (85,7), *Erioptera lutea* (85,7), *Tipula variicornis* (85,7), *Pedicia rivosa* (85,7), *Neolimnomyia nemoralis* (78,6), *Ormosia depilata* (78,6), *Metalimnobia quadrinotata* (78,6), *Ula sylvatica* (78,6), *Molophilus flavus* (71,4), *Clytocerus ocellaris* (71,4), *Ormosia ruficauda* (64,3), *Dicranomyia modesta* (64,3), *Metalimnobia zetterstedti* (64,3), *Pedicia straminea* (57,1), *Pericoma rivularis* (57,1), *Pneumia mutua* (57,1) and *Logima satchelli* (57,1). Six most numerous species (*Scleroprocta sororcula* 1339 exx, *M. flavus* 1059, *P. mutua* 850, *T. immaculata* 796, *O. depilata* 343, *Parajungiella pseudolongicornis* 258) accounted for 54% of the total number of individuals. 44 species, 28% of the total number of species, were encountered only from one site. *Molophilus pullus*, *Tinearia lativentris* and *Dixella nigra* are here reported for the first time from Finland. Our samples included several preliminary red-listed and poorly known rare flies, such as *Eloeophila submarmorata*, *Neolimnomyia batava*, *Paradelphomyia nigrina*, *Arctoconopa zonata*, *Erioptera beckeri*, *Molophilus bifidus*, *M. corniger*, *Ormosia loxia*,

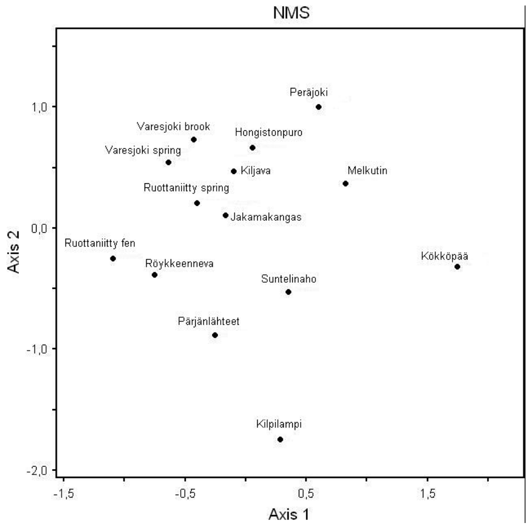

Figure 1. A two-dimensional NMS ordination of the studied wetland localities (see Table 1).

Rhabdomastix laeta, *Metalimnobia tenua*, *Tipula maxima*, *T. marginella*, *T. quadrivittata*, *Sycorax silacea*, *Ulomyia cognata*, *U. fuliginosa*, *Thaumalea truncata*, *Penthetria funebris* and *Pachyneura fasciata* (for details, see Discussion).

Ruottaniitty rich fen harboured 69 nematoceran species and it was the most species rich site in our survey. Altogether 56 and 55 species were recorded from Ruottaniitty spring fen and Kiljava spring, respectively. Only 12 and 16 species were found from Kökköpäänpuro stream and Kilpilampi oligotrophic fen, respectively. The mean species richness in the 14 studied sites was 40,3. Shannon-Wiener and Simpson diversity indices ranked Kiljava spring, Peräjoki stream and Ruottaniitty rich fen as the most diverse localities and Suntelinaho, Röykkeenneva and Kilpilampi as least diverse sites (Appendix 1).

NMS ordination (Figure 1) and Cluster dendrogram (Figure 2) separated strongly spring-fed sites from surface water streams and mires. Ruottaniitty spring, Jakamakangas, Kiljava and Hongistonpuro form quite clear cluster group, as do the two close lying sites in Varesjoki. Two species rich sites characterized by spring-fed vegetation, ochre deposits and open canopy, Ruottaniitty rich fen and Röykkeenneva, are grouped together. The other sites form less similar cluster groups, but Kilpilampi, Pärjänlähteet and Suntelinaho (rela-

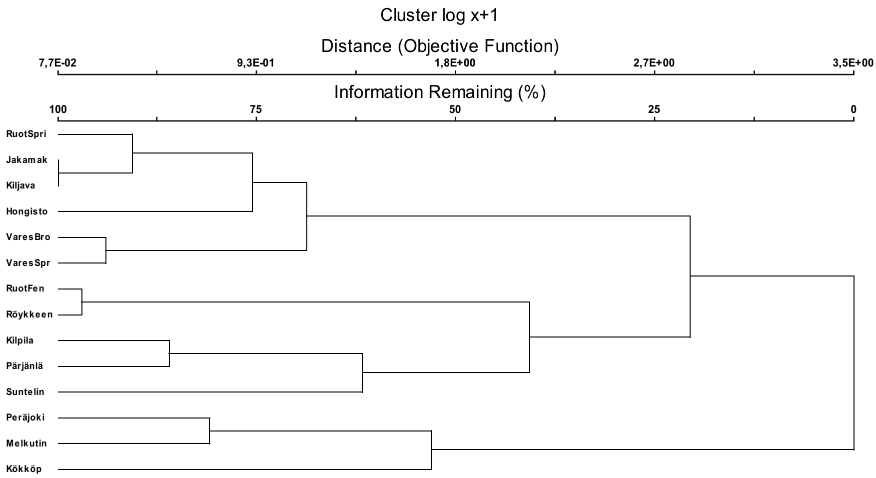

Figure 2. Cluster dendrogram of the studied wetland localities (see Table 1), based on Sorensen's distance measure and flexible beta linkage method.

tively open canopy, oligo-mesotrophic vegetation) are separated from Peräjoki, Melkutin and Kökköpää (surface-fed streams).

4. Discussion

4.1. Patterns in diversity and assemblage structure

According to the results of the present study, the diversity of wetland sites can vary greatly. Because we collected flies following the same protocols in all localities it is considered that differences in species richness and community structure are mainly due to environmental factors. The most species rich site, Ruottaniitty rich fen, harboured a total of 69 species, a number that is very high according to our experience. So far, the highest number of semiaquatic flies, 70 species, from a single Malaise trap in a season is recorded from Karkali Strict Nature Reserve, South Finland (J. Salmela in prep.). The species richness recorded around springs or brooks in southern Finland ranges typically from 20 to 50, numbers exceeding 50 are relatively high (J. Salmela, in prep). The high number of species in Ruottaniitty rich fen is probably facilitated by groundwater influence (presence of crenobionts and crenophilous species) and rich fen conditions (presence of demanding peatland species). High amount and probably large reservoir of groundwater provides moisture in dry summers and persistence of the prevailing conditions. Spring persistence may favour the existence of species with low dispersal capabilities that could have otherwise gone extinct. As shown by Glazier (1991), Hoffsten and Malmqvist (2000) and Smith et al. (2003), spring permanence is a crucial factor for the survival of crenobiontic taxa and explaining community composition of springs. Further, spring permanence may explain the occurrence of red-listed, southern crenobiontic species in the best available springs in the periphery of their distribution, such as southern Finland (Ilmonen 2007).

Röykkeenneva and Ruottaniitty are close lying, spring-fed sites, having groundwater reservoirs in Siikakangas and Särkikangas, respectively.. The both localities are relatively species rich, harbouring several crenophilous species. In addition to the studied sites, there are several other persistent, pristine or nearly pristine springs around the Siikakangas. Long term existence of spring-dwelling nematoceran populations in the area might be promoted by the metapopulation structure, facilitating the re-colonization of habitats from nearby patches. It is likely, that some spring-fed habitats around Siikakangas are more important (sources) to the metapopulation structure than others (sinks) (Hanski 2005).

On the other hand, the least diverse sites in our survey were oligotrophic fen (Kilpilampi) and surface-fed, small acidic stream flowing trough spruce forest with dense canopy. Our results are in concordance with the general notion that nematoceran diversity is lowest in ombro – oligotrophic mires and species richness increases with higher trophic status (Brunhes & Villepoux 1990, Brunhes & Dufour 1992, Salmela 2004, Salmela & Ilmonen 2005). Based on the results presented here and other experience of the authors, sites characterized by spring-fed water are among the most species rich sites in Finland, facilitating the presence of several species dependent on the persistent nature of the habitat. To conclude, spring fauna and its conservation are central for the general biodiversity and its preservation in boreal freshwater environments.

According to the results, the nemaroceran fauna in the studied sites were roughly divided to spring-fed and surface-fed sites. Sites characterized by springbrooks or trickles with minerogenous bottom were discriminated from those of rich fen vegetation and ochre deposits. Further, sites with oligotrophic vegetation, pine bogs and slight ground water influence were separated from surface-fed streams. Not surprisingly, environmental conditions and resources provided by the habitat have a great influence on assemblage structure. It is likely, that low temperature of the spring-fed sites is an effective environmental filter, hindering the life cycle development of the species adapted to warmer habitats (Ward 1992).

4.2. Rare and potentially threatened species

Molophilus pullus (Limoniidae), *Tinearia lativentris* (Psychodidae) and *Dixella nigra* (Dixidae) were found for the first time from Finland. *Molophilus pullus* has not been recorded from other Fennoscandian countries, it is currently known from Latvia, Lithuania, Central Europe, Romania and former Yugoslavia (Savchenko et al. 1992, Palkaniškis et al. 2000). According to Mendl (1978) the species is an inhabitant of small flowing waters. One male of *M. pullus* was discovered from Kiljava springbrook. The finding is rather surprising, since limoniid fauna of springs in southern Finland is quite well known (Salmela 2001, Salmela 2006) but perhaps novelties for regional fauna are still to be expected from springs and seepages. The moth fly *T. lativentris* was originally described from Sweden (Berdén 1952) and the species has a wide Holarctic distribution (Ježek & Yagci 2005). The ecology of *T. lativentris* is not well known but it probably consumes

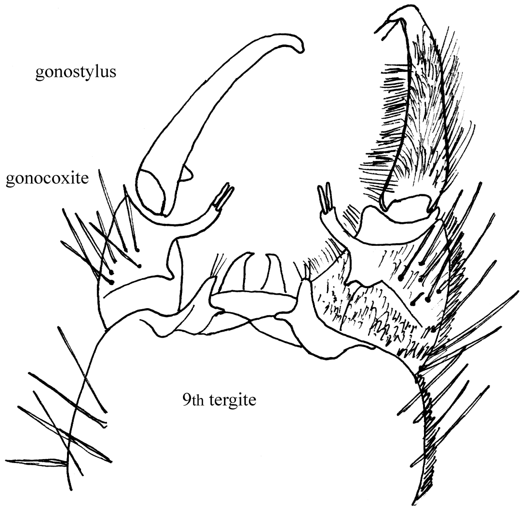

Figure 3. Male hypopygium of *Dixella nigra* (Staeger, 1840), dorsal view.

dead organic matter. One female of the species was found from Varesjoki spring. The dixid fly *D. nigra* is known from Central and North Europe (Rozkosny 1990). Only one male of the species was found from the Melkutin outlet stream. The existing figures of the male hypopygium (Nielsen 1937 as *Paradixa nigra*, p. 122, Fig. 2; Martini 1929 as *Dixa nigra*, p. 41, Fig. 55) are rather old or even misleading (Peus 1934 as *Dixa nigra*, p. 200, Fig. 4). Thus, we have illustrated the male hypopygium (Figure 3). The species is readily distinguished from its Palaearctic congeners due to the morphological details of gonostylus and gonocoxite. The internal structures under 9th tergite are not shown.

The distribution and ecology of the rare and poorly known flies in Finland discussed here are based on the database of semiaquatic flies, if not otherwise indicated. The database is maintained by J. Salmela. All existing information from Finnish museum collections, publications dealing with Finnish fauna and authors personal observations are included in the database (Salmela 2006).

Eloeophila submarmorata is known from six sites in Finland. One of the records is old (R. Frey leg, probably from early decades of 20th century) but the recent ones have been collected 2001–06. All the recent records originate from samples collected from springs or springbrooks from the provinces of Ab (3 sites), Ta (1 site) and Oa (1 site).

The species is preliminary classified as Near Threatened due to its occurrence in springs and scarcity of records (Salmela 2006). *Neolimnomyia batava* is collected from six localities in Finland, from the provinces of N, Ab and Ta. All except one site are headwater streams, characterized by stony bottom and large fluctuations in discharge. The species is probably confined to South Finland, apparently favouring small streams as a habitat. *N. batava* is currently classified as Data Deficient (Salmela 2006). *Paradelphomyia nigrina* is one of the rarest limoniids living in springs and seepages of southern Finland. Its first record was made from Ta: Muurame, Partastenmäki, a site characterized by deciduous trees, ochre deposits and groundwater influence. In this study *P. nigrina* was found from Ruottaniitty rich fen. The species could be classified as crenophilous species, living in species rich sites with high conservation value. Salmela (2006) classified *P. nigrina* as Data Deficient, but the new discovery from Ruottaniitty, however, has much clarified the occurrence and ecology of the species and it should be regarded as threatened species.

Arctoconopa zonata has a wide distribution in Finland (provinces Ab, Kl, Ta, Oa, Ok, Oba, Obb, Ks, Lkor, Le), but it is noted from only 16 sites, six of these are old records (Frey, Hellen, J. Sahlberg, Wuorentaus leg). According to our findings, *A. zonata* is absent from source areas but it usually occur in cold headwater brooks. Salmela (2006) listed *A. zonata* as Least Concern, but the species may well be a suitable limoniid for the assessment and monitoring of headwater brooks. *Erioptera beckeri* is a mire dwelling species, recorded from ten localities in Finland (provinces N, Ta, Sa, Oa, Kb, Ok, Lkoc). Salmela and Ilmonen (2005) collected *E. beckeri* from single ombrotrophic site in Kauhaneva National Park and all other recent records mede between 1967–2005 are from fens, mainly oligotrophic ones. The species is preliminary classified as Least Concern, but we assume that *E. beckeri* is demanding, tyrphobiontic limoniid, confined to undisturbed open peatlands and species suitable for biomonitoring and assessment of mires. *Molophilus bifidus* is preliminary classified as Critically Endangered species in Finland (Salmela 2006). The species is known from four sites (provinces Ab, Ta, St), all of them characterized by groundwater influence. In Great Britain *M. bifidus* is a specialist species of forest seepages (Boyce 2002). The records from Finland indicate its crenobiontic mode of life and confidence to permanent, large springs and seepage areas. *Molophilus corniger* was preliminary assessed as Near Threatened species (Salmela 2006) due to its dependence on spring habitats and southern distribution. The species is, however, not very rare: it is collected from 23 localities from the provinces of Ab, N, Ta, Tb and Sb. In this study *M. corniger* was found from six localities, all of them more or less spring-fed. *Ormosia loxia* is a rare limoniid collected from three brooks, all located in the province of N. The species is also recently found from Latvia (Salmela & Vartija 2007) and, concerning the new records, *O. loxia* seem to inhabit headwater brooks surrounded by deciduous trees. The species is, due to insufficient knowledge, classified as Data Deficient in Finland (Salmela 2006). *Rhabdomastix laeta* is known from seven sites in Finland (provinces Ab, Ta, Oa, Ks, Li), of these two are old records (Bergroth and Frey leg). There is one finding from a eutrophic lake shore, but all other recent records are made from cold headwater brooks with minerogenous bottom. According to Starý (2004) members of the subgenus *Rhabdomastix* are associated with sandy edges of lotic waters.

Metalimnobia tenua was originally described as a subspecies of *M. quadrinotata* (Savchenko & Krivolutskaya 1976) but recently Starý (2005) raised *M. tenua* to species level due to sympatric occurrence of the species in Central Europe (dozens of localities in Austria, Czech Republic, Slovakia). *M. tenua* is distinguished from *M. quadrinotata* by paler coloration, somewhat larger size and shape of male parameres (narrower and rounded apex; in *quadrinotata* broader and truncate, Starý 2005). Both species are noted to from sympatric populations in Finland, too. So far, *M. tenua* is found from 11 localities, all lying in South and Middle boreal Finland (provinces N, Ta, Tb, Oa, Ok). Ecology of the species is not known, but the larvae of the congeners infest fruiting bodies of fungi (Yakovlev 1994).

Tipula maxima is the largest representative of the family Tipulidae in Finland. Despite its large size (wing span about 60 mm) and conspicuous wing pattern, there are only a few specimens deposited in Finnish collections (provinces Al, Ab, N, Sa). The species is known from 12 localities, 7 of the records are old and without detailed information on the collection site. The new records are from springs and headwater brooks and *T. maxima* may favour seepage areas. Salmela (2006) classified *T. maxima* as Vulnerable species. *Tipula marginella* is known from the South Finland, provinces Ab, Ta and St. There are a number of specimens in the collection Natural History Museum Forssa, dating from 1960's. The recent records are around rich fens, brooks and streams. The species is red-listed (RBD3) in Great Britain (Falk 1991) and according to Stubbs (2003) the larvae of *T. marginella* need bare, wet mud for development. Although Salmela (2006) listed the species as Least Concern, *T. marginella* may be a suitable species for assessment and monitoring of certain type of rich fens and lowland streams. Indeed, distribution and ecology of the species should be clarified in Finland. *Tipula quadrivittata* is relatively rare species in Finland, recorded from 16 localities of which 10 are from 1940's or older (provinces Ab, Ka, Ta, Kb, Tb, Oba). Krogerus (1960) found *T. quadrivittata* from a fen (Weissmoore) and a rich fen (Braunmoore) from the province of Kb and recently the species was collected from a Baltic coastal meadow in Oba. In this study the species was discovered from Ruottaniitty rich fen, being there very abundant. According to the present knowledge, *T. quadrivittata* thrives in rich fens and sea shore meadows and it could probably serve as an indicator of habitat quality and conservation value of wetlands (Salmela 2006).

Sycorax silacea was assessed as Critically Endangered by Salmela (2006), but due to recent findings, this classification was premature. This tiny, spring-dwelling psychodid was considered to be strictly crenobiontic species but it obviously can occur in spring-fed brooks outside seepage areas. In the present study, *S. silacea* was found from four sites, being especially abundant in Hongistonpuro. Clearly, the species lives in spring-fed habitats in southernmost Finland and is in need of monitoring, but it is not in immediate risk of extinction. Most likely, it should be treated as Vulnerable or Near Threatened in Finland. Two Finnish species of the genus *Ulomyia*, *U. cognata* and *U. fuliginosa*, are both spring-living psychodids, the former is classified as Endangered and the latter as Near Threatened (Salmela 2006). Both species have been met from South Finland, *U. cognata* from the provinces of Ab, Ta, Tb and *U. fuliginosa* from Ab, N, Ta, St. Apparently *U. cognata* is confined to source areas while *U. fuliginosa* might penetrate further downstream of the spring-brook.

Thaumalea truncata was quite recently discovered from Finland, being the only representative of the family Thaumaleidae in Finland (Salmela 2003). The species is preliminary assessed as Vulnerable in Finland (Salmela 2006) and it was thought to occur in North Finland only. The species is collected from 13 springs or cold headwater brooks, most of them lying in the North boreal and Middle boreal region (provinces Ta, Ok, Ks, Obb, Li). In this study, *T. truncata* is reported for the first time from the province of Ta and the locality in Ruottaniitty spring is the southernmost in Finland. The species is clearly confined to seepage areas and spring-fed reaches of brooks and it may be a suitable species for biomonitoring and assessment of these habitats in Finland.

Pentethria funebris is the only member of the family Pleciidae in North Europe, considered by some authors as a subfamily within Bibionidae (eg. Fitzgerald & Werner 2004). Lundström (1910) reported *P. funebris* from 10 localities and afterwards the species is collected from three sites by J. Salmela (unpublished records) (provinces Ab, N, Kl, Ta, Sa, Sb, Kb, Oba). The new records are around herb-rich forests with seepages (Ruottaniitty spring, Karkali Strict Nature Reserve) and from a wet brook side (Pudasjärvi, Salmioja). The larvae of the species are saprophagous, living in moist forests or even in semi-aquatic conditions (L. Paasivirta, pers. comm.). *P. funebris* is also recently found as a new species for Latvia, where it proved to be locally abundant in moist herb-rich forests (Salmela & Vartija 2007). The species is apparently incapable of flight, and thus, having low dispersal capacities. *P. funebris* is red-listed in Sweden (Near Threatened), presumed to live there in spruce mires (Gärdenfors 2005). The adults of the species are quite easy to observe in the end of May – early June due to their relatively large size and conspicuous tramp in the forest floor. According to our knowledge, *P. funebris* should be red-listed in Finland and the species could be used as an indicator of valuable grooves and forested seepages.

Pachyneura fasciata is the only species of the family Pachyneuridae in the West Palaearctic, its larvae develop in decaying wood (Krivosheina & Mamaev 1988). The findings of the species in Fennoscandia were gathered by Väisänen (1982) and further Finnish records made in 2000's by Salmela & Ilmonen (2004). The species is red-listed in Finland (Rassi et al. 2001), Norway (Kålås et al. 2006) and Sweden (Gärdenfors 2005), and the species has been thought to be tied in old-growth forests. However, the new records from Finland indicate that *P. fasciata* can survive in managed forests too, if coniferous or deciduous dead trees are present (J. Salmela, unpublished records). The species is effectively collected by Malaise trap and the rarity of the species may be due to inconspicuous mode of life and difficulties to recognize it in the field. *P. fasciata* is recorded from 39 sites in Finland, most of them in Ks (19) others in Ab, N, Ta, Sa, Sb, Oa, Kb, Ok, Oba, Obb, Lkor and Lkoc. In this study the species was recorded from Ruottaniitty and Kiljava springbrook.

5. Concluding remarks

In the present study we have studied patterns in diversity and community structure of freshwater wetlands lying in South Finland. According to the results, the studied nematoceran communities were best separated by groundwater influence and vegetation type. Further, several rare and demanding flies were found, including poorly known and preliminary red-listed species. The nematoceran families covered here occur abundantly and often in species rich assemblages in wetlands, numerous species showing marked fidelity for a given biotope. We agree with Stubbs (2003), Chadd and Extence (2004) and Ujvarosi (2005) that flies are good tools for bioassessment, conservation and monitoring of wetlands and nematocerans should more widely used for these purposes in Fennoscandia.

As presented by Kääntönen (2005), the spring-fed fens in Ruovesi (Ryökkeenneva and Ruottaniitty studied here) form a species rich and threatened entity with high conservation value. Both Ruottaniitty and Röykkeenneva, supplemented with Pärjänlähteet spring-complex, are species rich sites in a national view, harbouring several rare and demanding flies. As the area of rich fens has strongly decreased in southern Finland (Lindholm & Heikkilä 2006), the nearly pristine fens in Ruovesi are important for the conservation of wetland biodiversity in Finland.

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Appendix 1. Nematoceran flies (Diptera) and their absolute abundances collected from the studied localities in 2005 and 2006. In addition, Shannon-Wiener's and Simpson's diversity indices for each site are presented. 1 = Ruottaniitty, spring, 2 = Ruottaniitty, rich fen, 3 = Jakamakangas, 4 = Peräjoki, 5 = Kilpilampi, 6 = Röykkeenneva, 7 = Pärjänlähteet, 8 = Kökköpäänpuro, 9 = Hongistonpuro, 10 = Varesjoki, brook, 11 = Varesjoki, spring, 12 = Melkutin, 13 = Kiljava, 14 = Suntelinaho.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Limoniidae														
Austrolimnophila (Archilimnophila) unica (Osten Sacken, 1869)			1	1										
Eloeophila maculata (Meigen, 1804)	1	10	1			1					2		1	
Eloeophila submarmorata (Verrall, 1887)										4	17			
Eloeophila trimaculata (Zetterstedt, 1838)				1				2				1	1	
Epiphragma (Epiphragma) ocellare (Linnaeus, 1760)	1	1	1	1						2	1	2		
Euphylidorea meigenii (Verrall, 1886)		1				1	1							
Euphylidorea phaeostigma (Schummel, 1829)							2					2		
Idioptera pulchella (Meigen, 1830)				1	1							1		
Limnophila (Limnophila) schranki Oosterbroek, 1992				3					3	10	5	1		
Neolimnomyia (Brachylimnophila) nemoralis (Meigen, 1818)	5	3	11	2	1		1		6	7	23	7	14	
Neolimnomyia (Neolimnomyia) batava (Edwards, 1938)									1					
Paradelphomyia (Oxyrhiza) fuscula (Loew, 1873)	3	42	7			55				2	4		4	
Paradelphomyia (Oxyrhiza) nigrina (Lackschewitz, 1940)		10												
Phylidorea (Paraphylidorea) fulvonervosa (Schummel, 1829)	1	44		1	2	8	1	3	2	1		1	1	1
Phylidorea (Phylidorea) ferruginea (Meigen, 1818)												1		
Phylidorea (Phylidorea) squalens (Zetterstedt, 1838)		7			61	1	2							
Pilaria decolor (Zetterstedt, 1851)		3									1			
Pilaria discicollis (Meigen, 1818)	1	2												
Pilaria meridiana (Staeger, 1840)		6												
Arctoconopa zonata (Zetterstedt, 1851)									1					
Cheilotrichia (Empeda) cinerascens (Meigen, 1804)	1					2	7		1		1		3	
Crypteria limnophiloides Bergroth, 1913				1										
Erioptera (Erioptera) beckeri Kuntze, 1914					2									
Erioptera (Erioptera) divisa (Walker, 1848)		3												
Erioptera (Erioptera) flavata (Westhoff, 1882)		46			2	10	9							
Erioptera (Erioptera) lutea Meigen, 1804	1	13	7	2	1	4	3		5		6	1	2	2
Erioptera (Erioptera) sordida Zetterstedt, 1838		2				2	3							
Gonomyia (Gonomyia) simplex Tonnoir, 1920				2					1					
Gonomyia sp		1	1	2					1	1			1	
Molophilus (Molophilus) appendiculatus (Staeger, 1840)			1	1					13				4	
Molophilus (Molophilus) bifidus Goetghebuer, 1920		19												
Molophilus (Molophilus) bihamatus de Meijere, 1918				3									4	
Molophilus (Molophilus) corniger de Meijere, 1920			60			3			34	1	1		11	
Molophilus (Molophilus) crassipygus de Meijere, 1918				11				7	3	1		8		1
Molophilus (Molophilus) flavus Goetghebuer, 1920	82	34	57			499	84		5	7	3		32	256
Molophilus (Molophilus) medius de Meijere, 1918		3		1					1					
Molophilus (Molophilus) ochraceus (Meigen, 1818)								1					1	
Molophilus (Molophilus) pullus Lackschewitz, 1927													1	
Ormosia (Ormosia) clavata (Tonnoir, 1920)				32										
Ormosia (Ormosia) depilata Edwards, 1938	9	3	36			4		2	172	7	13	24	52	21
Ormosia (Ormosia) lineata (Meigen, 1804)	1			3			33					2	9	
Ormosia (Ormosia) loxia Starý, 1983													1	
Ormosia (Ormosia) pseudosimilis (Lundström, 1912)	1		7											
Ormosia (Ormosia) ruficauda (Zetterstedt, 1838)	1	5	5	4				14	19	2		12	5	
Ormosia (Ormosia) staegeriana Alexander, 1953	1			7							2		5	
Rhabdomastix (Rhabdomastix) laeta (Loew, 1873)			3							3				
Rhypholophus haemorrhoidalis (Zetterstedt, 1838)	5		3										2	
Scleroprocta sororcula (Zetterstedt, 1851)	15	15	9			1277					18		4	1
Tasiocera (Dasymolophilus) exigua Savchenko, 1973			19	8					47			4	26	
Atypophthalmus (Atypophthalmus) inustus (Meigen, 1818)		1							1	1			3	
Dicranomyia (Dicranomyia) autumnalis (Staeger, 1840)		1												
Dicranomyia (Dicranomyia) consimilis (Zetterstedt, 1838)							1							
Dicranomyia (Dicranomyia) didyma (Meigen, 1804)		12				8	1							

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dicranomyia (Dicranomyia) distendens Lundström, 1912		12	3	1	18	13	19							5
Dicranomyia (Dicranomyia) frontalis (Staeger, 1840)										1				
Dicranomyia (Dicranomyia) modesta (Meigen, 1818)	1	2			2	3	1	3			1	2		1
Dicranomyia (Dicranomyia) terraenovae Alexander, 1920		21												
Dicranomyia (Dicranomyia) ventralis (Schummel, 1829)		1												
Dicranomyia (Idiopyga) halterella Edwards, 1921		1												
Dicranomyia (Idiopyga) stigmatica (Meigen, 1830)		19				10								
Dicranomyia (Melanolimonia) rufiventris (Strobl, 1900)		47				3								
Dicranomyia sp						1								
Dicranomyia (Numantia) fusca (Meigen, 1804)				1									2	
Discobola annulata (Linnaeus, 1758)				1								1		
Helius (Helius) flavus (Walker, 1856)		11				1								
Helius (Helius) longirostris (Meigen, 1818)		5				4								
Limonia flavipes (Fabricius, 1787)	1		2						1	1			17	1
Limonia macrostigma (Schummel, 1829)	1			1					2	1	1	1	4	
Limonia phragmitidis (Schrank, 1781)									1					
Limonia sylvicola (Schummel, 1829)	1		2											
Limonia trivittata (Schummel, 1829)		26												
Lipsothrix ecucullata Edwards, 1938	4		1	5					1	2	2		1	
Metalimnobia (Metalimnobia) bifasciata (Schrank, 1781)				1				2	2					2
Metalimnobia (Metalimnobia) quadrimaculata (Linnaeus, 1760)								1	9	2		1	2	2
Metalimnobia (Metalimnobia) quadrinotata (Meigen, 1818)	4	1	3	4		2	2		12	14	3	2	6	
Metalimnobia (Metalimnobia) tenua Savchenko & Krivolutskaya, 1976	2		3											
Metalimnobia (Metalimnobia) zetterstedti (Tjeder, 1968)	2		4			1	2		27	6	3		2	3
Neolimonia dumetorum (Meigen, 1804)				1			1			1				
Rhipidia (Rhipidia) maculata Meigen, 1818			2			4	1		1					
Rhipidia (Rhipidia) uniseriata Schiner, 1864							1							
Tipulidae														
Dictenidia bimaculata (Linnaeus, 1760)						1						1		
Nephrotoma analis (Schummel, 1833)										1				1
Nephrotoma lunulicornis (Schummel, 1833)		1												
Tanyptera (Tanyptera) atrata (Linnaeus, 1758)		1			1							1		1
Tipula (Acutipula) fulvipennis De Geer, 1776						1					8			
Tipula (Acutipula) maxima Poda, 1761										10	1			
Tipula (Beringotipula) unca Wiedemann, 1817						1			1				1	
Tipula (Platytipula) luteipennis Meigen, 1830		4												
Tipula (Platytipula) melanoceros Schummel, 1833					1									
Tipula (Pterelachisus) irrorata Macquart, 1826										5			1	3
Tipula (Pterelachisus) varipennis Meigen, 1818					2	6								
Tipula (Savtshenkia) grisescens Zetterstedt, 1851		2								1	3			
Tipula (Savtshenkia) interserta Riedel, 1913		1												
Tipula (Savtshenkia) subnodicornis Zetterstedt, 1838	2	8	2		11	7	13							
Tipula (Schummelia) variicornis Schummel, 1833	5	3	32	13		2	3	4	6		11	16	5	26
Tipula (Vestiplex) nubeculosa Meigen, 1804													1	3
Tipula (Vestiplex) scripta Meigen, 1830				1					1		1			
Tipula (Yamatotipula) marginella Theowald, 1980		2												
Tipula (Yamatotipula) pruinosa pruinosa Wiedemann, 1817				1					1					
Tipula (Yamatotipula) quadrivittata Staeger, 1840		97												
Pediciidae														
Dicranota (Dicranota) bimaculata (Schummel, 1829)						1			1	4			1	
Dicranota (Paradicranota) gracilipes Wahlgren, 1905				1										
Dicranota (Rhaphidolabis) exclusa (Walker, 1848)														12
Pedicia (Crunobia) straminea (Meigen, 1838)	58		7			11			4	1	3		14	2
Pedicia (Pedicia) rivosa (Linnaeus, 1758)	4	55	6		8	18	12	3	3	31	40		3	12
Tricyphona (Tricyphona) immaculata (Meigen, 1804)	151	93	48	2	8	144	29		101	15	89	54	13	49
Tricyphona (Tricyphona) livida Madarassy, 1881	1		26						6		1		5	
Tricyphona (Tricyphona) unicolor (Schummel, 1829)		1		1										
Ula (Ula) mixta Starý, 1983			1		1	3	2							

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ula (Ula) sylvatica (Meigen, 1818)	4	2	1	3		3	2		1	2	1		3	1
Cylindrotomidae														
Cylindrotoma distinctissima (Meigen, 1818)						1				1				
Diogma glabrata (Meigen, 1818)		1				3				2				
Phalacrocera replicata (Linnaeus, 1758)		2				2			1					
Triogma trisulcata (Schummel, 1829)		12				4					1			
Ptychopteridae														
Ptychoptera contaminata (Linnaeus, 1758)						1								
Ptychoptera lacustris Meigen, 1830									4					
Ptychoptera minuta Tonnoir, 1919		36				13	27		2			2		
Ptychoptera scutellaris Meigen, 1818	9	162				1			1	2				
Psychodidae														
Sycorax silacea Haliday in Curtis, 1839									82	9	9		1	
Clytocerus ocellaris (Meigen, 1818)	29	11	4	2		5			99	31	42	24	2	
Clytocerus rivosus (Tonnoir, 1919)		22												
Clytocerus tetracorniculatus Wagner, 1977		3				7						165		
Parabazarella subnegleta (Tonnoir, 1922)									2				2	
Pericoma formosa Nielsen, 1964										5			1	
Pericoma rivularis Berdén, 1954	28	7	2	10		9			44		4		1	
Pneumia borealis (Berdén, 1954)													1	
Pneumia bugeciana Vaillant, 1981	75	1	1			10			3					
Pneumia mutua (Eaton, 1893)	366	178	8			33	18			54	155		38	
Pneumia trivialis (Eaton, 1893)	2	67		5		1			70	3			15	
Ulomyia cognata (Eaton, 1893)	7					6				3	3			
Ulomyia fuliginosa (Meigen, 1818)										4	170			
Chodopsycha lobata (Tonnoir, 1940)		2							5					
Logima satchelli (Quate, 1955)	4	4	1	4						2	1	2	1	
Psychoda phalaenoides (Linne, 1758)	1	2	1	3		1							2	6
Psychodocha gemina (Eaton, 1904)	3	1	2	6							12		2	
Psychodocha itoco (Togunaka & Komyo, 1954)			1											
Psychoda sp											1			
Tinearia alternata (Say, 1824)										1				
Tinearia lativentris (Berdén, 1952)											2			
Parajungiella consors (Eaton, 1893)						3								
Parajungiella pseudolongicornis (Wagner, 1975)	1	244		1		9					3			
Paramormia polyascoidea Krek, 1971									4					
Peripsychoda auriculata (Curtis, 1839)									1				1	
Philosepedon balkanicum Krek, 1970	1		2	2				1		1			4	
Dixidae														
Dixa dilatata Strobl, 1900						1				2	95			
Dixa nebulosa (Meigen, 1830)				1							2	24		
Dixa submaculata Edwards, 1920	16												3	
Dixella aestivalis (Meigen, 1818)						1						1		
Dixella amphibia (De Geer, 1776)		1										1		
*Dixella borealis (*Martini, 1929)							1							
Dixella filicornis (Edwards, 1926)									1		3			
Dixella naevia (Peus, 1934)		5				8								
Dixella nigra (Staeger, 1840)												1		
Thaumaleidae														
Thaumalea truncata Edwards, 1929	3													
Pleciidae														
Penthetria funebris Meigen, 1804	17													
Pachyneuridae														
Pachyneura fasciata Zetterstedt, 1838	1	1											4	
Number of individuals	933	1465	394	158	122	2234	282	43	816	267	768	366	346	412
Number of species	47	69	42	44	16	56	29	12	51	45	44	31	55	23
Shannon-Wiener H'	2,25	3,13	2,89	3,21	1,78	1,58	2,46	2,13	2,72	3,04	2,54	2,06	3,27	1,52
Simpson D	0,8	0,92	0,92	0,93	0,71	0,62	0,86	0,84	0,89	0,92	0,87	0,76	0,94	0,59