Oribatid mites of Alpine Fennoscandia

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Heggen, M. P. 2010. Orbatid mites of Alpine Fennoscandia. Norw. J. Entomol. 57, 38–70.

The diversity and distribution of oribatid mites in alpine regions of Fennoscandia have been studied by many scientists since at least 1902. Increased focus on biodiversity in general and distributions in alpine regions in particular creates a need for a summary of these many published studies. The information that can be drawn from published articles is limited by their varying quality, and further studies are needed to explore altitudinal patterns of species richness. Some interesting distributional patterns are, however, revealed in this synthesis.

Ceratoppia sphaerica (L. Koch, 1879), *Chamobates cuspidatiformes* (Trägårdh, 1904), *Camisia borealis* (Thorell, 1871), *Malaconothrus globiger* Trädgårdh, 1910, *Mycobates sarekensis* (Trägårdh, 1910), *Trichoribates monticola* (Trägårdh, 1902), *Phauloppia lucorum* (C. L. Koch, 1841), and *Trichoribates setiger* (Trägårdh, 1910) show an alpine distribution in this data-set. *Adoristes ovatus* (C. L. Koch, 1840), *Conchogneta traegardhi* (Forsslund, 1947), *Diapterobates humeralis* (Hermann, 1804), *Hemileius initialis* (Berlese, 1908), *Heminothrus longisetosus* Willmann, 1925, *Melanozetes mollicomus* (C. L. Koch, 1839), *Moritzoppia splendens* (C. L. Koch, 1841), *Moritzoppia neerlandica* (Oudemans, 1900), *Oppiella nova* (Oudemans, 1902), and *Suctobelbella subtrigona* (Oudemans, 1900) are all found to have a distribution limited by altitude. Some species may additionally show signs of altitudinal limitations, and should be investigated further. *Belba compta* (Kulczynski, 1902), *Edwardzetes edwardsi* (Nicolet, 1855), and *Oribatula tibialis* (Nicolet, 1855) are equally present along the entire altitudinal gradient. *Liochthonius lapponicus* (Trägårdh, 1910), *Liochthonius sellnicki* (Thor, 1930), *M. sarekensis*, *Camisia foveolata* Hammer, 1955, *O. nova*, *Oromurcia bicuspidata* Thor, 1930, *Suctobelbella acutidens* (Forsslund, 1941), and *Tectocepheus velatus* (Michael, 1880) all thrive in glacier-forelands.

Key words: Acari, Oribatida, Alpine environments, Fennoscandia, Distribution, Diversity.

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Introduction

Through the Convention on Biological Diversity, the Fennoscandian countries of Finland, Norway, and Sweden are committed to reduce significantly the loss of biodiversity by 2010 (United Nations Environment Programme 1993). This has led to a renewed attention to biodiversity loss and the urgent need to survey current biodiversity has emerged, for example through the initiation of national centres. Data on biodiversity have, however, been collected since the early days of pioneer naturalists who collected and identified what they found. This approach changed towards a more structured and rigid sampling and later to investigations of ecosystems and species traits. Much relevant basic knowledge on biodiversity can be obtained from all these studies.

Biodiversity is not only important in its own right. Anthropogenic changes of the environment and climate are occurring at an alarming speed and many organisms and environments have been suggested as suitable models for studying

the ecological aspects of climate change (e.g. Parmesan & Yohe 2003). Among these is the alpine environment, where the altitudinal gradient may serve as an analogue to future climate changes (e.g. Körner 2000, Hodkinson 2005). This increases the importance of knowledge on species diversity and distribution in alpine areas. A majority of the fauna is soil-dwelling, and small arthropods, mainly Collembola and Acari, dominate together with enchytraeids, Diptera larvae, etc. (Solhøy et al. 1975, Solhøy 1997). A similar pattern is found in arctic condtions (Sømme 1981). At a lichen-heath on Hardangervidda, South Norway, oribatid mites accounted for 50% of the total abundance of Acari, and up to 70–90% of their biomass (Solhøy 1975).

Species richness is, in general, negatively correlated with altitude and latitude (discussed in Rahbek 1995), as increasing altitude and latitude pose severe restrictions on the environment. These factors are closely linked, and a species altitudinal range may change within its latitudinal range (Schatz 2004). The structuring factors of these trends are keenly debated, but it seems likely that both ecological and evolutionary factors are important (for discussion, see Lomolino 2001 and Colwell et al. 2004). When methodological factors such as sampling effort and gradient length are considered, the relationship between species and altitude often shows a hump-backed distribution with highest diversity at intermediate levels, possibly due to the mid-domain effect (Rahbek 1995, Colwell et al. 2004, Romdal & Grytnes 2007). The diversity of oribatid mites is also highest in warm temperate regions (Maraun et al. 2007).

The species distributional range increase with both latitude and altitude (Rapoport 1982, Stevens 1992). It has been suggested that the main structuring factor behind this may be physiological tolerances, as the upper thermal limits are rarely affected by geographical patterns while the lower thermal limits often are (Addo-Bediako et al. 2000). Mites and many other arthropods may have a range of adaptations to increase their cold hardiness (Cannon & Block 1988, Sømme

1997). Some of these processes are connected with resistance to another important altitudinal factor, namely increasing evaporation (Holmstrup 1992, Sjursen & Sømme 2000). The level of short-wave radiation also increases with altitude (Hodkinson 2005), having potentially deleterious effects on living organisms (Caldwell et al. 1998). At the ecological scale of the mites, however, the environment will be affected by micro-, local-, and regional effects. Indirectly, these physical factors may also constrain the mites through their habitat, namely the plant communities within which they live. Altogether, these factors increase the need for special adaptations to live in the alpine environment and to limit the range of mite species in alpine environments (Sømme 1997).

These altitudinal factors will limit all invertebrates living in alpine areas. One example is the reduction of larger decomposers in alpine environments (Solhøy 1997, Maraun et al. 2008). Behan (1978) first hypothesized that this increased the importance of oribatid mites, and several researchers have later adopted this hypothesis (e.g. Maraun et al. 2007). The fungal community in the soil has higher species diversity and fungal abundance in the presence of oribatid mites. Mites are thought to enhance the recovery of the microbial system in the soil, primarily through the dispersal of fungal spores, stimulating energy metabolism of microorganisms by grazing, and stimulating microbial growth by reducing nutrient loss from the system (summarized in Maraun et al. 1998).

While the importance of alpine areas as key environmental areas is increasingly recognized, the need for knowledge of their oribatid fauna increases. However, old literature may be hard to obtain, and it is hard to acquire a complete overview of earlier published material. The first descriptions of oribatid mites from alpine Fennoscandia date back to the beginning of the previous century (Trägårdh 1902). As a result, it is useful to compile previously reported species in this environment. A range of articles on oribatid mites in these areas has been published, as well as catalogues of mites from the Fennoscandian

countries (Mehl 1979, Lundqvist 1987, Niemi et al. 1997). However, only the Finnish checklist is regularly updated (Niemi et al. 2009). This review expands beyond the distributional data in these checklists, including information about habitats, altitude, and alpine zones in the relevant faunistic and ecological papers.

The aims of this article are: (1) to map the distribution and species diversity of oribatid mites in alpine areas in Fennoscandia, and (2) based on published material, search for possible structuring environmental factors on the oribatid assemblages. Information on the current state of knowledge can suggest further ways to investigate alpine oribatids.

Material and Methods

This study is based on material from previously published articles on oribatid mites from alpine Fennoscandia. From the first paper by Trägårdh (1902), 32 articles have been published on alpine oribatid mites. These studies range from thorough faunistic and ecological surveys with several sites (e.g. Trägårdh 1902, 1910, Willmann 1943, Dalenius 1960, Karppinen 1971, Solhøy 1976b, Seniczak et al. 2006) to taxonomic descriptions or ecophysiological studies focusing on one or a few species (e.g. Sømme & Conradi-Larsen 1977a, 1977b, Seniczak et al. 1990a, 1990b). Nine unpublished theses have also been included in order to try to provide the best overview possible. Only one published article (Thor 1937) is not included here. This was excluded as the information provided was insufficient to infer the alpine origin of the sampling sites. An overview of oribatid mites reported from alpine Fennoscandia is listed in Appendix 1. This list refers to the sites in Appendix 2, which also includes information on the different sites and types of studies.

Full consensus has not been achieved on the taxonomy of oribatid mites. As it is not within the scope of this article to review the taxonomy, the species list follows the classification in Subías'(2004, 2009 [updated]) list of the oribatid mite species of the world. Following Subías was

chosen as it is the only complete and updated overview of oribatid mites. Still, one exception is taken and explained in the species list. Where species names have been synonymised since their reports, the originally published name is included. The taxonomies of some particularly interesting or controversial species are commented in the species list.

Alpine areas are defined as being above the potential altitudinal woodland limit (e.g. Moen 1999). The tree-line in Fennoscandia varies according to geographical patterns, in a gradient peaking at about 1200 m a.s.l. in central Norway, decreasing towards the western coast (ca 500 m a.s.l.), towards the east (1000 m a.s.l.), and gradually towards the north, at 600 m a.s.l. in northern Sweden, 300 m a.s.l. in northern Finland and near the coast in Finnmark, Norway (Nordic Council of Ministers 1984). In the same way, the arctic area is defined as being north of the potential latitudinal tree-line. The arctic/alpine zone is delimited where the altitudinal and latitudinal tree-line meets (Nordic Council of Ministers 1984).

The alpine oribatid species are listed in accordance with the alpine zones; sub-alpine, low-alpine, middle-alpine, and high-alpine zones (Fremstad 1997, Moen 1999). These are all additionally influenced by local conditions and associated variations in vegetation. Towards the northern parts of Fennoscandia, conditions are more affected by latitude than altitude (Nordic Council of Ministers 1984). In this study, these arctic sites are divided into sub-arctic/alpine sites and arctic/alpine sites. In addition, glacier-forelands are included as a special habitat. All definitions of the alpine zones follow Fremstad (1997) and Moen (1999).

The sub-alpine zone (sA) is characterized by birch forest, often consisting of *Betula pubescens*. It includes mainly northern or alpine flora and vegetation.

The low-alpine zone (lA) starts where trees disappear and dwarf-shrubs and shrubs dominate. It mainly consists of alpine ridges and snow

patches. This zone is often vegetated by different species of *Salix*, along with *Empetrum hermaphroditum*. *Juniperus communis – Betula nana* heath, *Phyllodoce caerulea – Vaccinium myrtillus* heath, and peat-forming mire vegetation are all limited to this zone within the alpine area. On periodically dry soils, heath occurs, while meadows occur on wetter ground. The formation of podsolic soils does not occur above this zone.

The middle-alpine zone (mA) starts where *Vaccinium myrtillus* ceases to dominate the leeside vegetation. In general, it has continuous vegetation including dwarf-shrubs like *Salix herbacea* and herbs such as *Ranunculus* spp. and *Saxifraga* spp. In late snow patches, the soil can be unstable and solifluction may occur.

The high-alpine zone (hA) lacks a continuous vegetation layer and the vegetation is dominated by lichens and bryophytes. Stony soils with stone polygons and block-fields may be common.

Glacier-forelands (Gf) are characterized by newly exposed ground, rather than by their altitude, and this habitat type is hence treated separately. Vegetation here is limited by primary succession.

The sub-alpine/arctic zone (saA) resembles the sub-alpine zone, although it is limited by its northern latitude rather than by altitude. It is characterized by the same species as the sub-alpine zone.

The arctic/alpine zone (aA) is also limited by its northern latitude rather than by altitude, but it resembles the alpine zones. The botanical criteria for the southern arctic zone in northern Norway are the same as for the low-alpine zone. In Fennoscandia, arctic areas are limited to the northernmost parts of Finnmark, Norway, and hence are not divided into further subdivisions. In Norway, where the alpine and the arctic zones meet, the limit between these zones is usually unclear.

The sub-alpine zone is a natural part of a study of alpine regions. In articles where the focus is on non-alpine areas, it can be impossible to know if any sites studied are from the sub-alpine forest. Here, I have tried to include this zone where it is specifically mentioned. Consequently, some forest studies may include samples from sub-alpine forest without being included in this study.

All alpine zones are divided into a range of different habitats, with snow cover as one of the most important local environmental factors (Moen 1999). From ridges to snow-bed communities, the amount and length of the snow cover increase. On the ridges this gives cold conditions with a high risk of desiccation, whereas in the better protected snow-beds the temperature and moisture are higher whereas the growing season is shorter. This pattern is clearest in the low-alpine zone, and ceases upwards (Moen 1999). In addition, the habitats are affected by topography, drainage and waterlogging of the soil, slope and exposition, substrate, and soil movements by cryoturbation, solifluction, and weathering (Fremstad 1997).

When designations to specific alpine zones are not given in the original literature, these are inferred, based on information given in the original papers, such as altitude and vegetation, information from other scientific papers, or personal knowledge of the sites. These designations follow the alpine zones described previously. Only seven of the 166 sites could not be assigned to any alpine zone. As Thienemann (1941) states, the term lichen zone used by Trägårdh (1910) and repeated by Colloff (1993) corresponds to the high-alpine zone. Appendix 2 includes an overview of ecological information from the cited papers. The ecological information was occasionally limited, while for the most extensive descriptions the information had to be summarized. The latter mainly concerns the works by Trägårdh (1910) and Dalenius (1960). However, the information included in Appendix 1 is sufficient to identify these samples in the original literature.

Arctic areas in Fennoscandia are limited to a small region in the northern part of Norway. This arctic fauna was compared with the fauna at Svalbard. Species records are from the faunistic surveys

summarized in Coulson and Refseth (2004) and Coulson (2007). For each faunistic survey the number of reported species is calculated per article, and will be an over-representation in comparison with the number of species per site reported in this article.

A map of the localities shows that they are distributed unevenly, and they were thus grouped into three different regions. South (S) consists of 60 localities, North West (NW) includes 79 localities, and North East (NE) includes 26 localities (Figure 1).

Data Analysis

The analysis of this data-set is limited by some inherent restrictions. First, only a few of the original papers includes information on the abundances of the oribatid mites, so my data-set only contains presence/absence data. Second, this data-set is unbalanced as certain geographical areas and alpine zones are better investigated

than others. These factors limit the interpretation and numerical analysis of the data. Exploratory statistics were used to reveal basic patterns in the distributions. As the purpose of this was to search for ecological patterns in the distribution of the alpine oribatids, only samples from faunistic surveys were included. Only sites with a minimum of five species were used.

A divisive partitioning technique TWINSPAN (two-way indicator species analysis) was used to group the sites. This method divides the data-set based on differences in species occurences. The resulting classification was assessed along with information on the indicator species of the divisions and on ecological, geographical, and other information about the sites. TWINSPAN was performed using WinTwins, version 2.3 (Hill & Šmilauer 2005).

Species richness was analyzed with simple box-plots, illustrating the numbers of species found in the faunistic surveys. Comparisons between
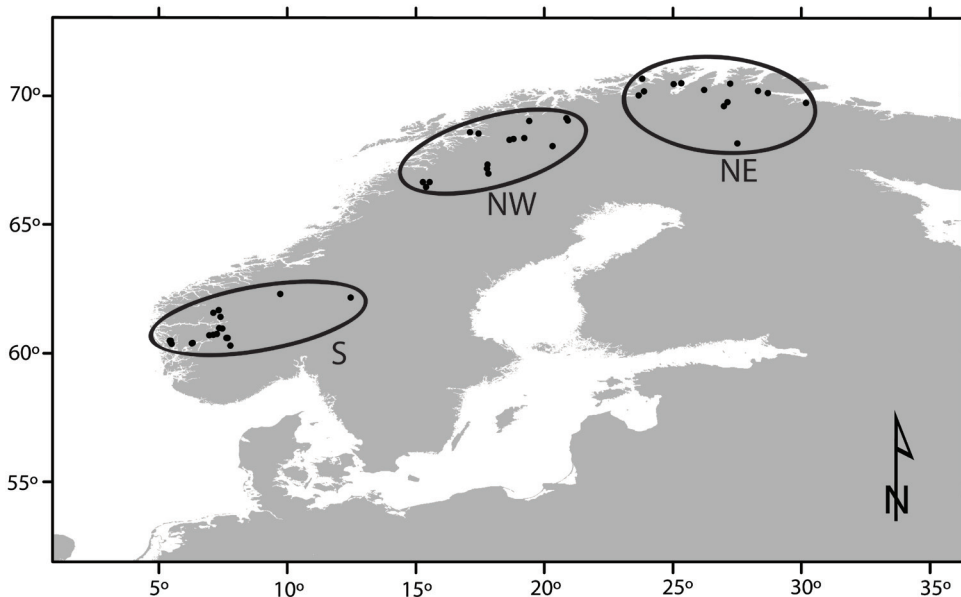

Figure 1. Map of Fennoscandia with the sites and geographical regions distinguished. Some of the sites are clustered together and appear as one site on the map. The South comprises 61 sites, the North West comprises 26 sites, and the North East comprises 79 sites. For a full overview of the sites, see Appendix 2.

the geographical regions and between the alpine zones were made. An extended transect were also investigated by including the data from Svalbard as an additional geographical zone.

The patterns of species distributions in the geographical and alpine zones were also investigated. A preliminary detrended correspondence analysis (DCA) of the data reveals a very long DCA axis1 (4.14 standard deviations, eigenvalue 0.427, total inertia 10.628) and further ordinations were therefore performed with unimodal-based methods. A correspondence analysis (CA) was performed on all sites from faunistic studies with more than 5 recorded species. Biplots of the first and second CA axes were drawn, with the sites tagged according to geographical regions. Correlations between the alpine zones and the distribution of alpine oribatid mites were investigated using canonical correspondence analysis (CCA) looking at inter-species distances. Glacier-forelands and alpine and arctic zones were used as simple binary environmental explanatory variables. Geographical areas and original articles were included as supplementary variables. The articles with more than three sites were used as separate variables. Many of the Norwegian studies have either been published in cooperation with or supervised by Torstein Solhøy. These were grouped together in one group, consisting of the following articles: Solhøy (1975), Solhøy et al. (1975), Solhøy (1976b), Solhøy and Koponen (1981), Alvheim (1982), Cifarelli (1997), Basilico (2000), Furlan (2000), Johannessen (2002), Riva-Caballero (2004), and Hågvar et al. (2009). The statistical significance of the species-environmental variable relationships were assessed by a Monte Carlo permutations test with 499 permutations, as implemented in Canoco for Windows version 4.5 (ter Braak & Šmilauer 2002).

Results

One hundred and ninety one species of oribatid mites have been published from 166 alpine sites in Fennoscandia (Appendix 1). The number of species recorded varies greatly with sampling effort, extraction techniques, and research aim. There may be a range of causes for this, but the most important are probably differences in sample size and extraction efficiency. Five species are noted as "species inquirenda". Although the taxonomy and true identity of these species are unclear, they are included in the data analysis, as they may represent a taxon distinct from the other species at these sites. Information about the sites is listed in Appendix 2.

The TWINSPAN analysis of presence/absence data is designed to reveal patterns in the site composition and in the species distribution. As this data-set is based on faunistic and ecological studies, it consists of a subset of 112 sites with 183 species. The TWINSPAN results in a partitioning, where the sites are divided into 41 groups, based on nine split levels. At the first level, the data are split into two groups. One of these is characterized by *Eupelops septentrionalis* (Trägårdh, 1910) and *Chamobates cuspidatiformis* (Trägårdh, 1904) and consists of 17 sites. All sites in this group are from the NW area and the three reported hA sites are in this group. This first group is further split with *Edwardzetes edwardsi* (Nicolet, 1855), *Nothrus biciliatus* C. L. Koch, 1841, and *Mycobates sarekensis* (Trägårdh, 1910) as indicator species for one of the sub-groups. All sites in this group were published by Trägårdh (1902, 1910) from Swedish Lapland and Sarek. *Liochthonius sellnicki* (Thor, 1930), *Eupelops torulosus* (C. L. Koch, 1839), and *Ceratoppia sphaerica* (L. Koch, 1879) are indicators of the other sub-group, where all sites were published by Dalenius (1960) from Swedish Lapland. The other group is characterized by *Tectocepheus velatus* (Michael, 1880) and *Moritzoppia neerlandica* (Oudemans, 1900) and consists of 95 species. It is further split by *Heminothrus peltifer* (C. L. Koch, 1839) and *M. sarekensis* characterizing one sub-group, and *Oppiella nova* (Oudemans, 1902), *Ceratozetes gracilis* (Michael, 1884), *Carabodes subarcticus* Trägårdh, 1902, *Conchogneta traegardhi* (Forsslund, 1947), and *Suctobelbella subcornigera* (Forsslund, 1941) characterizing the other. Not all divisions may be explained, but some clusters reveal interesting patterns. At

the fifth split level, one group only consists of arctic sites, while another mainly comprises sites from glacier-forelands. Interestingly, not only Trägårdh and Dalenius get their sites closely grouped. Eighteen of the 32 clusters consisting of more than one site are published by the same author. This is also often appropriate for adjacent clusters. All sites in a cluster from the third split level are published by Karppinen (1956b, 1962, 1971), and an adjacent cluster is also published by this author. All the sites of Cadwalladr (1969) and most of the sites from Willmann (1943) are additionally clustered together. Although some ecological considerations have been mentioned, it seems as the author identities are the most important explanatory factor for the majority of these groups.

Species Richness

The faunistic and ecological surveys were used to investigate species richness. Both the geographical and alpine zones show similar species richness (Figure 2). The arctic zone appears to have a higher richness than the sub-arctic zone, although the maximum observed number of species in each locality decreases with environmental severity. The differences in richness between the alpine zones were not tested statistically due to the large differences in the group size.

Geographical Distribution

Between 19 and 38% of the species are specific to one geographical region, while 22% of the mites have been found in all regions (Table 1). The ratio between the species specific to each region and the number of species in that region range from 19% in the intermediate region North West to 33 and 38% in the South and North East regions. Neighbouring geographical groups have more species in common than groups further apart. South has 65 species in common with North West, and North East has 61 species in common with North East. South and North East, the two groups farthest apart, share only 47 species. Only five species are present in these two groups, but not in the intermediate North West group.
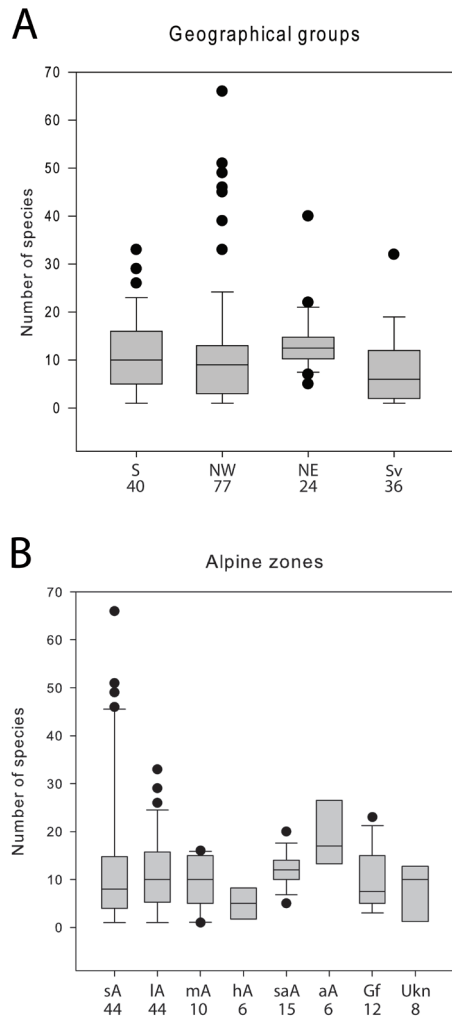
Figure 2. **A**: Species richness, as number of species per site, in the three geographical regions of alpine Fennoscandia. The data from Svalbard (Sv) are based on number of species per published paper, as listed in Coulson and Refseth (2004) and Coulson (2007). **B**: Species richness, as number of species per site, in the alpine zones. Below each zone is the number of sites for that group. The box plots show the median and upper and lower quartiles. Where n is nine or more, the 95% range and outliers are also indicated.

Table 1. Summary of the number of species in the alpine regions in Fennoscandia. The total species richness is compared with the three geographical groups. Abbreviations: Spp=species, No=number.

	Total	South	North West	North East
No. spp total	190	104	81	137
No. sites	166	61	26	79
No. specific species		34	15	53
Ratio, specific spp/spp		0.33	0.19	0.38

As noted earlier, some of the clusters in the TWINSPAN follow geographical patterns. Most clusters are based on sites from a single geographical region, but no groups of clusters contain all data from any of them.

The geographical regions are grouped in the correspondence analysis (CA axis 1: 42.9%, axis 2: 38.1%) (Figure 3). Both the South and North East are quite closely clustered into separate groups. Along the first CA axis they are both situated around the origin and at the slightly negative side on the first axis. Along the second axis they are more clearly separated from each other. The North West is not so tightly clustered, and overlaps and expands beyond both South and North East (Figure 3). In the canonical correspondence analysis, North West and South are both found to be significant explanatory factors (Figure 5) (CCA eigenvalues: 1. axis
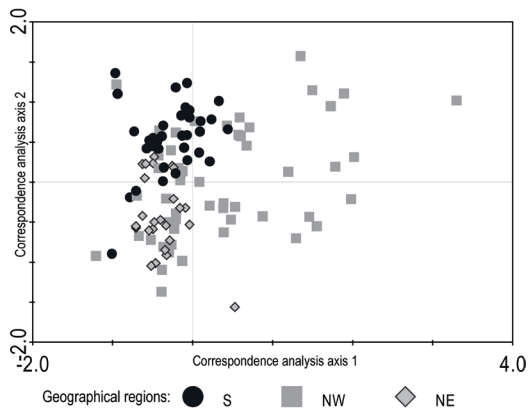
0.293, 2. axis 0.2238, cumulative percentage variance of species-environment relation: 55.3% for axis 1 and 100% for axis 2, p=0.002).

Altitudinal distribution

The altitudinal distribution of the oribatid mites has to be considered in relation to the varying altitude of the tree-line in Fennoscandia. Consequently, glacier-forelands, and alpine and arctic vegetation zones were used as explanatory variables in a CCA (CCA eigenvalues: 1. axis 0.258, 2. axis 0.228, total inertia 10.628, p≤0.012). sA, hA, saA, aA, and Gf were all found to explain significant parts of the variation (p≤0.002). The CCA biplot (Figure 4) shows a division into three parts, with the alpine zones in the lower part of the diagram, the arctic zones closely grouped on the top left, and glacier-forelands on the top right. Within the group of the alpine zones sA is separated from the more closely correlated lA, mA, and hA zones.

As the TWINSPAN clusters seem to be best explained by the original authors of the reports, these and geographical regions were included as supplementary or passive variables in the CCA. They are not included in the calculations, but are displayed on the plot according to how they relate to the data (Figure 5). There is a clear correlation between the studies and the ecological zones. The NE region is naturally related to the arctic samples. All investigated glacier-forelands are from the S region, and these variables are strongly correlated.

Figure 3. Correspondence analysis (CA) biplot of the sites based on the presence/absence of oribatids in alpine Fennoscandia. The three geographical regions are distinguished on the plot.

Discussion

A literature review is naturally limited by the number and quality of reviewed studies. This survey was conducted to shed light on
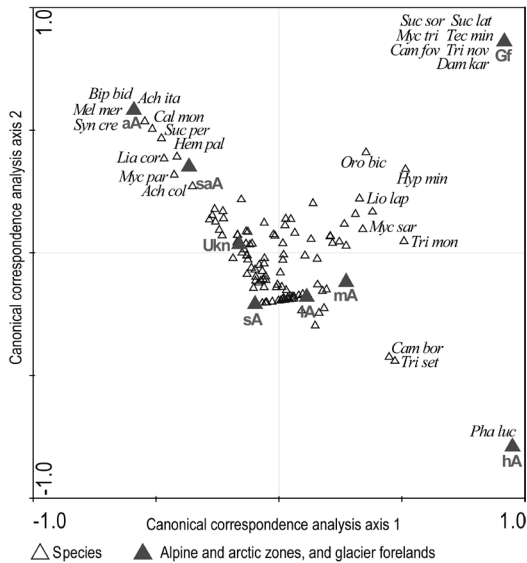
Figure 4. Canonical Correspondence Analysis (CCA) biplot showing the oribatid mites of alpine Fennoscandia in relation to alpine zones. Only species with ecologically interesting positions are named on the plot. The species names are abbreviated as follows: *Ach col: Achipteria coleoptrata, Ach ita: Achipteria italica, Bip bid: Bipassalozetes bidactylus, Cal mon: Caleremeus monilipes, Cam bor: Camisia borealis, Cam fov: Camisia foveolata, Dam kar: Damaeus karelicus, Hem pal: Heminothrus paolianus, Hyp min: Hypocthonius minutissimus, Lia cor: Liacarus coracinus, Lio lap: Liochthonius lapponicus, Mel mer: Melanozetes meridianus, Myc par: Mycobates parmeliae, Myc sar: Mycobates sarekensis, Myc tri: Mycobates tridactylus, Oro bic: Oromurcia bicuspidata, Pha luc: Phauloppia lucorum, Suc lat: Suctobelbella latirostris, Suc per: Suctobelbella perforata, Suc sor: Suctobelba sorrentensis, Syn cre: Synchthonius crenulatus, Tec min, Tectocepheus minor, Tri mon: Trichoribates monticola, Tri nov: Trichoribates nova,* and *Tri set: Trichoribates setiger.*

the distribution of alpine oribatids based on published records of oribatid mites from alpine Fennoscandia. However, there are many limitations to the interpretation of a data-set like
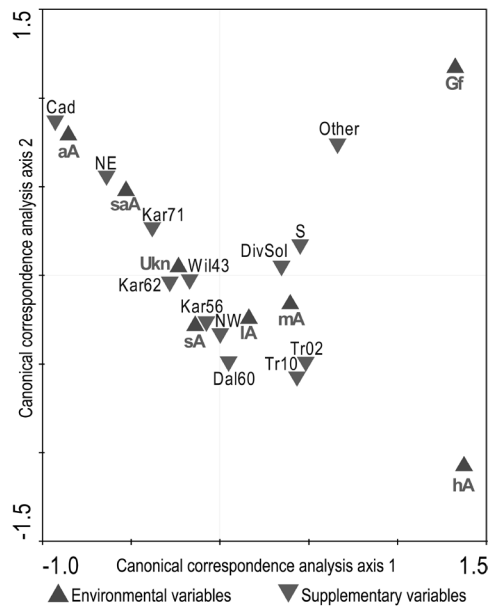
Figure 5. Canonical Correspondence Analysis (CCA) biplot showing the relationship between the environmental and supplementary variables. The supplementary variables include geographical zones and the articles reporting more than three sites. Alpine and geographical zones follow the abbreviations used in the article. The articles are referred to as follows: Cad69: Cadwalladr 1969, Dal60: Dalenius 1960, Kar56: Karppinen 1956, Kar62: Karppinen 1962, Kar71: Karppinen 1971, Tr02: Trägårdh 1902, Tr10: Trägårdh 1910, DivSol: Miscellaneous articles and unpublished theses by Torstein Solhøy and coworkers, Other: the other articles.

this, and it is important to be aware of these before any conclusions are attempted. These restrictions may also lead to insights into how future studies should be designed.

Limitations of the data-set

The largest constraints on this data-set are the amount and quality of sampling. One of the challenges is the uneven cover of the alpine areas of Fennoscandia (Figure 1, Table 1). Some alpine areas are not covered at all, and large areas are

only covered with a few samples. This data-set is also limited by the uneven number of sites and samples investigated in the main vegetation zones. The majority of the samples are from sub- and low-alpine areas, and the middle- and high-alpine zones are clearly under-represented.

In any study using literature spanning more than 100 years, one of the shortcomings will inevitably be the lack of consistent sampling design. Laboratory methods, species descriptions, and research focus have changed over time. Trägårdh (1902) published his first paper before publication of the extraction of soil fauna with moisture gradients (Berlese 1905), and he was dependent on hand-picking of the mites. At the time of his second paper, Trägårdh (1910) used extraction funnels, and the number of species per site increased.

During these 100 years, knowledge on oribatid mites has increased and their taxonomy has changed. In 1902 only 55% of the species reported here were described, and the number of descriptions has increased gradually. It is likely that some of these species would be assigned to other species with better techniques and modern literature. Even today some oribatid groups are well investigated whereas others are in need of revision. The genera Eobrachychthonius, Liochthonius, Phthiracarus, and Eupelops are among these. Some of the most problematic species are discussed in footnotes in the species list.

A restricted number of scientists have been working in these areas and 60% of the sites in this report are published by only four authors (Trägårdh 1902, 1910, Willmann 1943, Karppinen 1956a, 1956b, Dalenius 1960, Karppinen 1962, 1971). The effect of this is inflated by the fact that many authors seem to have some favourite habitats where they collect samples. Of Willmann's (1943) 14 samples, 12 are moss-samples, and most of them from wet habitats. This aquatic origin is not surprising, as these samples were collected by the freshwater biologist August Thienemann. Dalenius' (1960) samples are, in contrast, primarily from heath and sub-alpine forest. The selection of

habitats will also affect the species represented in the species list. For instance, the aquatic *Limnozetes*, *Hydrozetes*, and *Mucronothrus* are only reported from three localities, showing how few studies include truly aquatic environments. Other specific habitats, as lichen-sites, might also largely be lacking from the material. This problem is enlarged by the incomplete information on the sites and samples in most of the papers cited here. Karppinen's information on his samples is, for instance, basically site descriptions. He does not include information on whether his samples are taken from the litter layer, moss within the habitat or other micro-habitats which will affect the species assemblages. In combination, these different sampling and extraction methods may be the most important explanation of the author-based TWINSPAN clusters. The species distributions do not, however, seem to be affected by this. Only 33% of the species are restricted to the sites investigated by these four authors. It thus seems as if the authors selected primarily on sampled habitats.

Species richness

In this data-set, the species richness is similar for all the separate alpine zones (Figure 2). According to theory, species richness would be expected to decrease with altitude (Rahbek 1995). However, this material would probably not be sufficient to reveal any such trends. The variation between sites is large and the range varies with the number of sites. This suggests that the richness would increase with more sites. The reported species numbers are also surprisingly low. In the low-alpine zone the mean species richness is 10 species per sample. Solhøy (1975) investigated the oribatid community in low-alpine environments specifically and found 14 species in lichen heath and 16 in wet meadow. The different authors also show dissimilarities with respect to species richness. For example, Cadwalladr (1969) found between 14 and 40 species per sample while Karppinen (1971) found only 1 to 14 species. There seems to be no good ecological explanation for this difference from the presentations of their sites, and the species numbers for some of Karppinen's sites

seem surprisingly low (Appendix 2). Karppinen's samples were transported to Helsinki prior to extraction (Karppinen, personal communication to T. Solhøy), and this process would probably affect the extraction efficiency. The highest numbers of species per site also seem surprisingly high. Six sites are reported to have forty or more species. Four of these are published by Dalenius (1960), which generally have a higher species number than the other cited articles. Karppinen (1956b) and Cadwalladr (1969) published the other two sites. It seems likely that this high species number is a result of large samples, possibly with a range of microhabitats included.

For a majority of the articles reported here, the published information on the sampling regime is incomplete. This complicates the use of sampling design for separations between biologically realistic estimates and artificially low reports and restricts the interpretation of the data-set. Thus, no safe conclusions on patterns in species richness in the alpine areas can be made.

Theoretically, one might expect a decrease in species richness with increasing latitude. Seemingly contradicting this, the sub-alpine/arctic sites seem to have lower richness than the more extreme alpine/arctic sites. However, the high richness in the alpine/arctic zone is from only six samples, highlighting the limitations of this data-set. In a comparable arctic area at Svalbard, where 36 papers are reported, the richness is lower again, and is around the level of the sub-arctic/alpine zone (data from Coulson & Refseth 2004, Coulson 2007). The numbers from Svalbard are not completely comparable, as they present species richness in each paper, rather than in each site. The species list from Spitsbergen also probably over-reports the number of oribatid species (see comment in Coulson & Refseth 2004). Correcting for this overestimate would further lower the arctic species richness on Svalbard, giving an even stronger indication of lower species numbers at increasing latitudes.

Geographical distribution

The CA plot reveals strongest similarities within the South and North East regions (Figure 3). This coincides with a higher number of geographically specific species in these groups, reaching 33 and 38%, respectively (Table 1). In North West, only 19% of the species are specific to this area and the CA plot shows a group with wider distributions, overlapping with the two other groups. Additionally, the majority of species found in two groups are restricted to adjacent geographical groups. This suggests a gradual change in oribatid mites from south to north. However, when the fauna from alpine Fennoscandia is compared with arctic areas of Svalbard, the similarity does not increase with geographical proximity. From the South, 30% of the species are also found on Svalbard, while the corresponding values in the North West and North East are 26%. Some of the species only found in the South are also found on Svalbard. Although the data-set from Svalbard is incomplete and probably includes too many species (Coulson & Refseth 2004), it seems premature to identify any geographical patterns from the Fennoscandian data-set.

The geographical patterns will additionally be affected by the arctic sites, as all of them are situated in the North East region. The highest species specificity in the North East can be an effect of influence of the Arctic Ocean. Many primarily arctic plants are found both within and beyond the arctic zone in northern Norway (Moen 1999), and the Arctic influence may cover a large part of the North East region. Twenty three species of oribatid mites are reported more often from arctic than alpine areas in Fennoscandia. These are: *Achipteria coleoptrata* (Linnaeus, 1758), *A. italica* (Oudemans, 1914), *Belba compta* (Kulczynski, 1902), *Passalozetes perforatus* (Berlese, 1910), *Caleremaeus monilipes* (Michael, 1882), *Camisia segnis* (Hermann, 1804), *Eulohmannia ribagai* Berlese, 1910, *Heminothrus paolianus* (Berlese, 1914), *Melanozetes meridianus* Sellnick, 1928, *Nanhermannia nana* (Nicolet, 1855), *N. sellnicki* Forsslund, 1958, *Neoribates auranticus* (Oudemans, 1914), *Nothrus palustris* C. L.

Koch, 1839, *Liacarus coracinus* (C. L. Koch, 1841), *Parachipteria punctata* (Nicolet, 1855), *Phthiracarus borealis* (Trägårdh, 1910), *P. globosus* (Koch, 1841), *P. longulus* (Koch, 1841), *P. piger* (Scopoli, 1763), *Rhinoppia subpectinata* (Oudemans, 1900), *Suctobelbella longirostris* (Forsslund, 1941), *S. perforata* (Strenzke, 1950) and *Synchthonius crenulatus* (Jacot, 1938). When compared with the distribution in other, not arctic, areas, mainly in Finland (Niemi et al. 1997), it is clear that they are not restricted to arctic habitats. Many of these species are neither found on Svalbard nor Greenland. They are also, however, not common in alpine areas in Fennoscandia. Thus, no indication of a separate arctic fauna within the Fennoscandian mainland could be found.

Altitudinal distribution

The alpine environmental variables are more or less clustered in the CCA, pinpointing the stronger correlation within the alpine sites than with sites from arctic or glacier-foreland conditions (Figure 4). High-alpine sites split off from the other alpine sites. Most of the species are distributed close to the middle of the CCA biplot, and the proximity of the environmental variables in the centre of the plot show the limited alpine influence in the data-set.

Alpine species

Camisia borealis (Thorell, 1871), *C. cuspidatiformis*, *C. sphaerica*, *Malaconothrus globiger* Trädgårdh, 1910, *M. sarekensis*, *Trichoribates monticola* (Trägårdh, 1902), and *T. setiger* (Trägårdh, 1910) are all species which are more common in the higher alpine zones than in lower. Although one should be careful with conclusions based on this survey, the trend seems clear for all of these species. *Trichoribates setiger* is one of the most extreme of these, inhabiting 57% of the high-alpine sites, but only 7% of the low-alpine sites. It is also correlated with high-alpine environments on the CCA-plot. This pattern is the same, although the occurrences are less for *C. borealis*. *Phauloppia lucorum* (C. L. Koch, 1841) is strongly correlated with these

conditions in the CCA, but this is based on one high-alpine study (Dalemius 1960). For some of the species the alpine distribution is also supported by literature from other regions. *Mycobates sarekensis* is also abundant in arctic tundra, and even more so in areas close to snow in the polar Urals (Sidorchuk 2009). From the CCA plot, *T. monticola* also seems to be correlated with high-alpine and glacier-zones (Figure 4). It is found in both sub-alpine conditions and in alpine screes in the Schlern/Sciliar Massif in the Italian Alps (Schatz 2008), but is more frequent in mosses above than below the tree-line in the Krkonoše mountains, Czech Republic (Materna 2000). This is also correlated with alpine and glacier-forelands zones in the CCA-plot. *Ceratoppia sphaerica* becomes gradually more common with altitude in Fennoscandia, and in the polar Urals it is found in the most extreme of the investigated habitats, namely near-snow assemblages (Sidorchuk 2009).

Species limited in altitudinal distribution

The sA and lA zones are represented by 45 and 59 sites, respectively, and mA and hA are represented by 11 and 7 sites. Due to this bias, one should be cautious in stating which species are limited by the most severe conditions, as the conclusion is based on the lack of presence in poorly investigated habitats. However, some species seem to be restricted by altitude, and can be divided into three groups.

Adoristes ovatus (C. L. Koch, 1840), *Conchogneta traegardhi* (Forsslund, 1947), *Diapterobates humeralis* (Hermann, 1804), *Hemileius initialis* (Berlese, 1908), *Heminothrus longisetosus* Willmann, 1925, *Melanozetes mollicomus* (C. L. Koch, 1839), *Moritzoppia splendens* (C. L. Koch, 1841), *M. neerlandica*, *O. nova*, and *Suctobelbella subtrigona* (Oudemans, 1900) are all species which are common in the lower zones but are not present in the higher alpine zones. *Oppiella nova* is present in as much as 35% of the sub-alpine sites and 41% of the sub-alpine/arctic sites, but is not reported from the high-alpine sites. The pattern is the same for all of these species although the other species are less common. *Suctobelbella*

subtrigona is also found below, but not above, the tree-line in the Krokonoše mountains, Czech Republic (Materna 2000). These species are hence considered to be limited in altitudinal distribution. *Camisia biurus* (C. L. Koch, 1839), *Metabelba pulverulenta* (C. L. Koch, 1839), *Eremeus oblongus* (C. L. Koch, 1835), and *Dissorhina ornata* (Oudemans, 1900) also seem to be restricted by altitude. However, their presences at lower altitudes are moderate, and their lack of presence at higher altitudes may simply be a result of chance. Although *C. biurus* is only present in 2–18% of the sites at lower altitudes in this study, its possible alpine limitation is supported by the reports from lower, but not higher, altitudes in the Italian Dolomites (Fischer & Schatz 2007). *Dissorhina ornata* and *E. oblongus* are also present in sub-alpine forests in the Alps, and although *D. ornata* was also found on cliffs, none of them were reported from the higher sites investigated in the Italian Dolomites (Fischer & Schatz 2007). Although still inconclusive, this supports the notion that these species might be limited by altitude, and their distribution should be investigated further.

Ceratoppia bipilis (Hermann, 1804) and *Carabodes subarticus* Trägårdh, 1902 appear to be limited in this data-set, but are found in alpine conditions in other regions. *Carabodes subarcticus* is found in the Italian Alps, reported from alpine pasture and alpine meadow at around 2500 m a.s.l. (Fischer & Schatz 2007) and it is commonly found in arctic tundra in the polar Urals (Sidorchuk 2009). *Ceratoppia bipilis* is only found below sub-alpine altitudes in the Italian Alps (Fischer & Schatz 2007), but it is present in arctic tundra in the polar Urals (Sidorchuk 2009).

Species from the entire altitudinal gradient

Belba compta, *Edewardzetes edwardsi*, and *Oribatula tibialis* (Nicolet, 1855) are more or less equally common in all the ecological zones. However, in the Krkonoše Mountains, Czech Republic, *E. edwardsi* was only found below the tree-line (Materna 2000). *Carabodes labyrinthicus* (Michael, 1879), *Chamobates cuspidatiformis*, *Eupelos septentrionalis*, *E. torulosus*, and *Tectocepheus velatus sarekensis* Trägårdh, 1910 are present in all four altitudinal zones. *Carabodes labyrinthicus* is also found both below and above the tree-line in the Krkonoše Mountains, Czech Republic (Materna 2000). *Eulohmannia ribagai* and *Malaconothrus globiger* are present in several sites in both the high and low altitudinal zones, although not in all four. Since they are found in both ends of the gradient they can be assumed to occur along the entire gradient.

Glacier-foreland species

Glacier-forelands, the areas of newly exposed ground in front of retreating glaciers, are a special habitat mainly affected by primary succession. Although the immigration to these areas is affected by the species pool in the surrounding areas, these sites separate from the alpine sites in the CCA.

Based on their relative presence within the alpine communities, *Liochthonius lapponicus* (Trägårdh, 1910), *L. sellnicki* (Thor, 1930), *M. sarekensis*, *Camisia foveolata* Hammer, 1955, *O. nova*, *Oromurcia bicuspidata* Thor, 1930, *Suctobelbella acutidens* (Forsslund, 1941), and *T. velatus* seem to be related to glacier-forelands. *Liochthonius lapponicus* and *O. bicuspidata* are also linked to glacier-forelands on the CCA-plots. Although these species are found in glacier-forelands, they are not restricted to such areas. Many of these species are also common in other non-alpine environments. Both *T. velatus* and *O. nova* are, for instance, euryecious and globally distributed (Weigmann 2006). Their listing as glacier-foreland species is consequently an indication that these species thrive in glacier-foreland conditions, not that they are restricted to these.

Oribatid mites are often asexual, displaying female parthenogenesis, thelytoky, in both otherwise sexually genera and in larger completely asexual groups (Norton & Behan-Pelletier 2009). With the exception of *O. biscuspidata* and *M. sarekensis*, all the glacier-foreland species are thelytok. This simplifies establishment after initial immigration, and some of these species are also known as early

colonizers from other habitats. For example, *T. velatus*, *L. lapponicus*, *L. sellnicki*, and *O. nova* are reported as early colonizers in post-industrial dumps (Zyromska-Rudzka 1977, Skubała 1997). In glacier-forelands, the newly exposed ground provides harsh conditions often characterized by little vegetation and repeated soil disturbance. The ability to immigrate into these areas, withstand the harsh conditions, or to recolonize the area frequently, is important. A study of more or less exposed ground in and around vehicle tracks on high arctic tundra shows an increase of *L. lapponicus* and *L. sellnicki* in disturbed sites, and *T. velatus* was only observed in connection with the tracks (Kevan et al. 1995).

The increased presence of both the alpine species *M. sarekensis* and the sub-alpine *O. nova* in glacier-forelands in Fennoscandia highlights the differences between the surrounding alpine areas and glacier-foreland conditions. Both these species obviously possess the colonizer traits needed for survival in glacier-forelands, although they normally live in different habitats.

The connection between glacier-forelands and *Damaeus karelicus* (Bulanova-Zachvatkina, 1957), *Mycobates tridactylus* Willmann, 1929, *Suctobelba sorrentensis* Hammer, 1961, *Suctobelbella latirostris* (Strenzke, 1950), *Tectocepheus minor* Berlese, 1903, and *Trichoribates novus* (Sellnick, 1928) are additionally highlighted by the CCA. All of these are, however, only found in one or two sites. Although all of these are reported from glacier-forelands, more studies are required to study their connection with glacier-foreland conditions.

Conclusions

The primary aim of this study was to get an overview of the distribution of oribatid mites in alpine Fennoscandia judged from the published information. However, the previous discussion reveals many of the challenges concerned with the present status of information on soil-dwelling oribatids in alpine Fennoscandia. The limited numbers of published papers and study areas

clearly restrict the amount of available information. Unlike Fennoscandia, there are many thorough publications on the diversity of oribatid groups published in North America. It is estimated that, even after a thorough study of the oribatid mites in Yukon, at most 40% of the oribatid species in the area is known (Behan-Pelletier 1997). Large areas of sub- and low-alpine habitats in the southern and eastern parts of Fennoscandia, and the continental areas in mid- and north-Norway remain poorly investigated. This also accounts for specialized habitats, like aquatic or high-alpine lichen habitats. It seems clear that further collection of oribatid mites within these regions and habitats would significantly increase the species number.

It is possible to classify primarily alpine or altitudinal limited species from alpine Fennoscandia. Our data-set gives some additional information about which species live in the entire altitudinal range. Certain species found within the alpine communities are particularly common on glacier-forelands. No true arctic species were revealed within Fennoscandia.

The second part of my study was to look at the structuring factors of the environment, considering the status of the present knowledge. This clearly reveals a lack of information on the details around distributional patterns, leaving additional constraints on the study design of further research. It is clear that microhabitat factors largely determine the species composition of oribatid mites. One example of the influence of microhabitat is the oribatid species richness in trees, which probably depends on the species of epiphytic lichens (Behan-Pelletier et al. 2008). Studies of habitat heterogeneity are needed to reveal the factors determining the distribution of oribatid mites in temperate regions (Maraun & Scheu 2000). Similarly, to reveal the structuring factors of the alpine oribatid community, studies of microhabitats are necessary.

Habitat descriptions vary greatly between the articles that this review is based on, limiting the information in my data-set. Comprehensive information on sampling design, with information

on sample size, sample practice, microhabitats, extraction method, selection of sample sites, and numbers of the different species of mites found are information that would make such studies more useful. Well considered studies with rigorous study designs have the potential to assess altitudinal species richness, the mid-domain effect, and species-area relationships. Such studies would greatly increase our understanding of the alpine oribatid environment.

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Appendix 1. List of all oribatid species reported from alpine areas in Fennoscandia. The records are split according to their alpine zones. The site numbers correspond to the sites in Appendix 2. sA is sub-alpine sites, lA is low-alpine sites, mA is middle-alpine sites, hA is high-alpine sites, saA is sub-arctic/alpine sites, aA is arctic/alpine sites, and Gf are sites from glacier-forelands.

ORBATIDA Dugès, 1834
PALAEOSTOMATA Grandjean, 1969
Palaeacaroidea Grandjean, 1932
Palaecaridae Grandjean, 1932
Palaeacarus Trägårdh, 1932
• *P. hystricinus* Trägårdh, 1932
lA: 125, 126

ENARTHRONOTA Grandjean, 1947
Hypochthonioidea Berlese, 1910
Hypochthoniidae Berlese, 1910
Hypochthonius C. L. Koch, 1835
• *H. rufulus* C. L. Koch, 1835
sA: 75, 121; **lA**: 146, 147, 154; **aA**: 80, 82

Eniochthoniidae Grandjean, 1947
Eniochthonius Grandjean, 1933
• *E. minutissimus* (Berlese, 1904)[1]
lA: 154; **Gf**: 157

Brachychthonioidea Thor, 1934
Brachychthoniidae Thor, 1934
Eobrachychthonius Jacot, 1936
• *E. borealis* Forsslund, 1942
sA: 41, 47, 48, 49, 50, 62, 63; **lA**: 52, 56, 67, 71; **saA**: 94, 98
• *E. latior* (Berlese, 1910)
sA: 47, 49; **lA**: 52, 56
• *E. oudemansi* (Hammen, 1952) (lA: 113)
Liochthonius van der Hammen, 1959
• *L. alpestris* (Forsslund, 1958)
lA: 46
• *L. brevis* (Michael, 1888)
sA: 41, 50*; **lA**: 54; **mA**: 44*
* = as *Brachychthonius perpusillus*
• *L. clavatus* (Forsslund, 1942)
lA: 52
• *L. hystricinus* (Forsslund, 1924)
sA: 47*, 50*, 121
* = as *Brachychthonius hystricinus*
• *L. lapponicus* (Trägårdh, 1910)
sA: 10*, 31*, 37*; **lA**: 18*, 73, 74, 77, 113, 115; **Gf**: 155, 156,

160, 161, 162; **unknown**: 26*, 34*
* as *Brachychthonius brevis* var. *lapponica*
• *L. sellnicki* (Thor, 1930)
sA: 41*, 47*, 49*, 50*, 51*, 63*; **lA**: 43*, 52*, 54*, 56*, 57*, 66*; **mA**: 58*; **hA**: 59*; **Gf**: 156, 157, 159, 163+, 164+, 165+, 166+)
* as *Brachychthonius scalaris*, + as *Liochthonius* cf. *sellnicki*
• *L. simplex* (Forsslund, 1942)
sA: 41, 47*; lA: 42, 43; **mA**: 44
*as *Brachychthonius simplex*
Sellnickochthonius Krivolutsky, 1964
• *S. immaculatus* (Forsslund, 1942)
sA: 41, 47*, 48*, 49*, 50*, 51*; **lA**: 52, 53, 57; **mA**: 44, 58; **Gf**: 156, 157, 164
*as *Brachychthonius immaculatus*
Synchthonius Hammen, 1952
• *S. crenulatus* (Jacot, 1938)
saA: 78*; **aA**: 79*, 80*, 81*, 82*
*as *S. boschmai*

MIXONOMATA Grandjean, 1969
Eulohmannioidea Grandjean, 1931
Eulohmanniidae Grandjean, 1931
Eulohmannia Berlese, 1910
• *E. ribagai* Berlese, 1910
sA: 37, 41, 47, 51, 68, 85; **lA**: 52, 57, 125, 126, 146, 147; **hA**: 19*; **saA**: 78, 93, 94, 101, 112; **aA**: 79, 82, 105; **unknown**: 33
*as *Arthronothrus biunguiculatus*

EUPTYCTIMA Grandjean, 1967
Euphthiracaroidea Jacot, 1930
Euphtiracaridae Jacot, 1930
Acrotritia Jacot, 1923
• *A. ardua* (Koch, 1841)
sA: 91*
*as *Rhysotritia ardua*
• *A. loricata* (Rathke, 1799) "sp. inq."
sA: 62*; **aA**: 79; **unknown**: 38+
*as *Oribotritia loricata*, +as *Pseudotritia loricata*
Euphthiracarus Ewing, 1917
• *E. monodactylus* (Willmann, 1919)

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[1] This is the only species in this list that does not follow the taxonomy of Subías (2009), who assigns this to *Hypochthoniella*. It is here assigned to *Eniochthonius* following Norton and Behan-Pelletier (2007).

Appendix 1. continued

sA: 41, 87

Phthiracaroidea Perty, 1841
<u>Phthiracaridae</u> Perty, 1841
Atropacarus Ewing, 1917
• *A. striculus* (C. L. Koch, 1835)
sA: 41, 75, 87*, 91*, 152; **lA**: 121, 154; **saA**: 99*, 102*; **aA**:
79, 80; **unknown**: 26*
*as *Steganacarus striculus*
Notophthiracarus Ramsay, 1966
• *N. pavidus* (Berlese, 1913)
sA: 91
Phthiracarus Perty, 1841
• *P. borealis* (Trägårdh, 1910)
sA: 14*, 35, 36, 37, 88; **lA**: 125, 126; **saA**: 99; **aA**: 79, 80, 105;
unknown: 33, 38, 108, 110
*as *Hoploderma boreale*
• *P. globosus* (Koch, 1841)
sA: 41, 92; **saA**: 95, 99, 102
• *P. longulus* (Koch, 1841)
saA: 96*, 97*
*as *P. tardus*
• *P. piger* (Scopoli, 1763)
sA: 41, 62; **lA**: 66, 68, 70, 89, 113; **saA**: 78, 99; **aA**: 79, 80,
82; **unknown**: 107

HOLOSOMATA Grandjean, 1969
Crotonioidea Thorell, 1876
<u>Trhypochthoniidae</u> Willmann, 1931
Mucronothrus Trägårdh, 1931
• *M. nasalis* (Willmann, 1929)
sA: 32, 153; lA: 154; **Gf**: 156; **unknown**: 60
Trhypochthoniellus Willmann, 1928
• *T. longisetus* (Berlese, 1904)
sA: 41*, 41+; **lA**: 42*
*as *Thrypochthonius excavatus*, +as *Thrypochthnius trichosus*
Trhypochthonius Berlese, 1904
• *T. cladonicola* (Willmann, 1919)
sA: 47, 49

<u>Malaconothridae</u> Berlese, 1916
Malaconothrus Berlese, 1904

• *M. globiger* Trädgårdh, 1910
sA: 29, 32, 50, 51; **lA**: 18; **hA**: 22; **unknown**: 26, 33, 38
• *M. monodactylus* (Michael, 1888)[2]
sA: 86*, **lA**: 114*, 117*, 147*
*as *M. egregius*
Trimalaconothrus Berlese, 1916
• *T. glaber* (Michael, 1888)
sA: 41
• *T. maior* (Berlese, 1910)
sA: 10*, 32+, 35+, 41+, 50+, 153; **lA**: 17*, 154
*as *Malaconothrus sphagnicola*, +as *T. novus*

<u>Nothridae</u> Berlese, 1896
Nothrus C. L. Koch, 1835
• *N. biciliatus* C. L. Koch, 1841 "sp. inq."[3]
sA: 6, 10, 12; **lA**: 8, 18; **hA**: 21
• *N. borussicus* Sellnick, 1928
sA: 25, 35, 41, 47, 48, 49, 51, 62, 83, 89, 91, 92; **lA**: 67, 70,
111, 117, 146, 147, 148; **mA**: 76, 151, 152; **saA**: 78, 93, 94, 98,
102, 112; **aA**: 79, 80, 82; **Gf**: 162, 165, 166; **unknown**: 27, 107
• *N. palustris* C. L. Koch, 1839
sA: 29, 50; **aA**: 79, 80, 81, 82
• *N. pratensis* Sellnick, 1928
sA: 29, 32, 36, 41, 51, 63, 84, 90; **lA**: 111, 154; **saA**: 94, 99;
unknown: 27, 28, 33, 34, 38, 108
• *N. silvestris* Nicolet, 1855
lA: 56

<u>Camisiidae</u> Oudemans, 1900
Camisia von Heyden, 1826
• *C. anomia* Colloff, 1993[4]
mA: 140
• *C. biurus* (C. L. Koch, 1839)
sA: 47, 48, 75, 89, 121, 134; **lA**: 113, 125, 126, 141, 146,
147, 148, 154; **mA**: 151, 152; **saA**: 100, 104; **Gf**: 156, 157;
unknown: 27*, 107
*as *Uronothrus kochi*
• *C. biverrucata* (C. L. Koch, 1839)
lA: 52, 54
• *C. borealis* (Thorell, 1871)[5]
lA: 16*, 52, 54; **hA**: 21*, 23*
*as *Nothrus horridus* var. *borealis*

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[2] *Malaconothrus monodactylus* is considered the senior synonym of *M. egregius, M. gracilis, M. processus* and *M. punctulatus*, as these species are
often intermingled and not properly identified (Weigmann 2006).
[3] *N. biciliatus* is considered a junior synonym of *N. anaunisensis* by Weigmann (2006).
[4] Both *C. anomia* and *C. solhoeyi* have been described recently (Colloff 1993). While *C. anomia* are only found in one instance in this study, *C.
solhoeyi* are found in many recent studies. It seems likely that some specimens reported as *C. lapponica* actually are *C. solhoeyi*.
[5] According to Seniczak et al. (2006) *C. borealis* is a junior synonym of *C. horrida*.

Appendix 1. continued

• *C. foveolata* Hammer, 1955

lA: 119, 133; **mA**: 120; **Gf**: 164, 165, 166; **unknown**: 60

• *C. horrida* (Hermann, 1804)[5]

sA: 47, 51; **lA**: 8, 70, 113, 125*, 126*, 138; **Gf**: 160, 162

*as *Camisia* cf. *horrida*

• *C. invenusta* (Michael, 1888)

lA: 136, 137

• *C. lapponica* (Trägårdh, 1910)[4]

sA: 10, 12, 31*, 47, 48, 51; **lA**: 42, 114, 117, 121, 139; **hA**: 21; **saA**: 78; **aA**: 79

*as *Platynothrus lapponicus*

• *C. segnis* (Hermann, 1804)

sA: 10; **lA**: 52; **aA**: 79, 80, 82

• *C. solhoeyi* Colloff, 1993[4]

lA: 146, 147, 148, 154; **saA**: 135; **Gf**: 155, 156

• *C. spinifer* (C. L. Koch, 1835)

sA: 47, 48, 51, 134; **lA**: 70; **mA**: 151, 152; **aA**: 79; **unknown**: 27, 33

Heminothrus Berlese, 1913

• *H. capillatus* (Berlese, 1914)

lA: 121*, 148[+]; **hA**: 131, 132; **Gf**: 156

*as *Ovonothrus septentrionales*, [+]as *Platynothrus capillatus*

• *H. humicola* (Forrslund, 1955)

sA: 47*, 48*, 49*, 88*; **lA**: 43*, 52*, 68*, 69*, 125*, 126*; **mA**: 44*; **saA**: 93*, 94*, 100*, 124*; **Gf**: 156, 157

*as *Neonothrus humicola*

• *H. longisetosus* Willmann, 1925

sA: 41*, 47*, 49*, 50*, 61*, 63*, 64*, 65*, 83*, 84*, 89*, 90*; **lA**: 43*, 113[+], 121*, 146, 147, 148; **mA**: 111*; **saA**: 98*, 102*; **aA**: 106*; **unknown**: 107*, 108*

*as *H. paolianus* var. *longisetosus,* [+]as *Paulonothrus longisetosus*

• *H. paolianus* (Berlese, 1913)[6]

aA: 78, 79

• *H. peltifer* (C. L. Koch, 1839)

sA: 2*, 3*, 10[+], 12[+], 29[!], 32[!], 36[!], 41*, 47[!], 48[!], 50[!], 51[!], 75[!], 153; **lA**: 18[+], 76[!], 114[!], 121[!], 131, 146[!], 147[!], 148[!], 154[!]; **mA**: 111[!]; **saA**: 78[!]; **aA**: 79[!], 80[!], 81[!], 82[!]; **Gf**: 156; **unknown**: 26[!], 27[!], 38[!], 107[!], 108[!]

*as *Camisia peltifera*, [+]as *Nothrus peltifer*, [!]as *Platynothrus peltifer*

• *H. punctatus* (L. Koch, 1879)

sA: 24*, 35*, 50*, 51*, 75*, 90*; **lA**: 17[+], 114[!], 130; **saA**: 98*, 99*; **Gf**: 161, 164*, 165*, 166*; **unknown**: 26*, 33*, 38*

*as *Platynothrus punctatus*, [+]as *Nothrus punctatus*

• *H. targionii* (Berlese, 1885)

sA: 10*, 11*

*as *Nothrus targionii*

• *H. thori* (Berlese, 1904)

sA: 50*; **lA**: 54*, 55*; **saA**: 78*; **aA**: 79*, 80*; **unknown**: 26

*as *Platynothrus thori*

Nanhermannioidea Sellnick, 1928
Nanhermanniidae Sellnick, 1928
Nanhermannia Berlese, 1913

• *N. dorsalis* (Banks, 1896)[7]

sA: 75*, 121*, 153*; **lA**: 146*, 147*, 148*, 154* *as *N. coronata*

• *N. nana* (Nicolet, 1855)

sA: 6, 12*, 32, 35, 41, 48, 50, 92; **lA**: 72; **saA**: 78, 97, 99, 104; **aA**: 79, 80, 105; **unknown**: 33

*as *Hermannia nanus*

• *N. sellnicki* Forsslund, 1958

lA: 45; **saA**: 100, 101, 112

Hermannioidea Sellnick, 1928
Hermanniidae Sellnick, 1928
Hermannia Nicolet, 1855

• *H. reticulata* Thorell, 1871

lA: 147; **hA**: 59; **aA**: 79

BRACHYPYLINA Hull, 1918
Damaeoidea Berlese, 1896
Damaeidae Berlese, 1896
Belba von Heyden, 1826

• *B. compta* (Kulczynski, 1902)

sA: 10*, 12*, 14*, 35, 37, 41, 47, 48, 49, 50, 51, 62, 128[+]; **lA**: 15*, 18*, 43, 52, 54, 55, 56, 57, 68; **mA**: 58, 152[+]; **hA**: 59; **saA**: 98; **aA**: 79, 81, 82; **Gf**: 162[+], 166[+]; **unknown**: 33

*misidentified as *Damaeus farinosus*, [+]as *B. verrucosa*

Damaeus C. L. Koch, 1835

• *D. auritus* C. L. Koch, 1836

sA: 89; **mA**: 111; **unknown**: 109

• *D. bituberculatus* (Kulczynski, 1902)

sA: 47, 48, 51; **lA**: 52, 53; **mA**: 58

• *D. brevitibialis* Bulanova-Zachvatkina, 1957

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[6] In northern areas are *H. paolianus* often considered a junior synonym of *H. longisetosus* (e.g. Olszanowski 1996)
[7] There has been extensive confusion concerning the nomenclature of *N. nana*, as *N. nana* sensu Willmann 1931 is identical with *N. coronata* Berlese 1913 (Forsslund 1963). *N. coronata* is now regarded a junior synonym of *N. dorsalis* (Subías 2009). *N. nanus* sensu Nicolet 1855 is a separate species (Marshall et al. 1987). Accordingly, the separation between *N. nana* and *N. dorsalis* might not be consistent between publications and should be treated with caution.

Appendix 1. continued

sA: 128

• *D. clavipes* (Hermann, 1804)

sA: 10, 37*, 47, 49, 51*, 75, 121; **lA**: 15, 146, 147, 148; **mA**: 76, 151, 152; **unknown**: 33*, 38*

*as *Belba clavipes*

• *D. farinosus* (Trägårdh, 1902)

sA: 1, 2, 3

• *D. gracilipes* (Kulczynski, 1902)

sA: 47, 51, 62

• *D. karelicus* (Bulanova-Zachvatkina, 1957)

Gf: 157

• *D. nidicola* (Willmann, 1936)

sA: 32*

*as *Belba nidicola*

• *D. onustus* Koch, 1841

sA: 41*

*as *Belba geniculosa*

• *D. tatricus* (Kulczynski, 1902)

sA: 47; **lA**: 113, 125, 126

• *D. tecticola* Michael, 1888

sA: 48, 51; **saA**: 78

• *D. verticillipes* (Nicolet, 1855)

sA: 47, 48, 49, 51; **lA**: 57, 70

Metabelba Grandjean, 1936

• *M. pulverulenta* (C. L. Koch, 1839)

sA: 62, 64, 65; **lA**: 52, 67, 70; **saA**: 102, 103; **aA**: 106

Porobelba Grandjean, 1936

• *P. spinosa* (Sellnick, 1920)

sA: 47, 48, 49, 51; **lA**: 113, 125, 126, 147; **mA**: 150, 151, 152

Niphocepheoidea Travé, 1959

Compactozetidae Luxton, 1988

Cepheus Koch 1835

• *C. cepheiformis* (Nicolet, 1855)

sA: 47, 51

• *C. dentatus* (Michael, 1888)

sA: 75

Gustavioidea Oudemans, 1900

Ceratoppiidae Kunst, 1971

Ceratoppia Berlese, 1908

• *C. bipilis* (Hermann, 1804)

sA: 10, 13, 47, 48, 51; **lA**: 8, 52, 54, 57, 121, 146, 147, 148; **aA**: 106

• *C. sphaerica* (L. Koch, 1879)

sA: 47, 48; **lA**: 52, 53, 54, 56; **mA**: 58; **hA**: 23*, 59; **aA**: 79

*as *C. bipilis* var. *sphaerica*

Liacaridae Sellnick, 1928

Adoristes Hull, 1916

• *A. ovatus* (C. L. Koch, 1840)

sA: 62*, 65*, 89*, 146*, 147*; **lA**: 55, 56; **saA**: 47, 48, 49, 50, 51, 78, 95*, 99*, 100*; **aA**: 79, 82; **unknown**: 107*

*as *A. poppei*

Liacarus Michael, 1898

• *L. coracinus* (C. L. Koch, 1841)

lA: 146; **aA**: 79, 80, 82

• *L. keretinus* Nordenskiöld, 1901

sA: 50*, 75; **saA**: 95

* as *L. holmi*

Eremaeoidea Sellnick, 1928

Eremaeidae Oudemans, 1900

Eremaeus Koch, 1835

• *E. hepaticus* C. L. Koch, 1835

sA: 41

Eueremaeus Mihelčič, 1963

• *E. oblongus* (C. L. Koch, 1835)

sA: 6, 11, 37, 47*, 48*, 49*, 50*, 61*, 62*, 64*, 124*; **lA**: 52*, 57*, 66*, 72*; **saA**: 96*; **unknown**: 33

*as *E. silvestris*

Eremelloidea Balogh, 1961

Caleremaeidae Grandjean, 1965

Caleremaeus Berlese, 1910

• *C. monilipes* (Michael, 1882)

aA: 79, 82

Oppioidea Grandjean, 1951

Autognetidae Grandjean, 1960

Autogneta Hull, 1916

• *A. longilamellata* (Michael, 1885)

sA: 1, 3, 6, 37*; **unknown**: 26*, 33*

*as *Oppia longilamellata*

• *A. parva* Forsslund, 1947

sA: 47

Conchogneta Grandjean, 1963

• *C. traegardhi* (Forsslund, 1947)

sA: 41, 47, 48, 50, 51, 61, 62, 63, 64, 65; **lA**: 43, 52, 57, 66, 71; **saA**: 93, 96, 103, 104, 124

Thyrisomidae Grandjean, 1954

Banksinoma Oudemans, 1930

• *B. borealis* (Willmann, 1943)

sA: 32*, 50*; **lA**: 57*; **unknown**: 34*

Appendix 1. continued

*as *Oribella borealis*
• *B. castanea* (Hermann, 1804) "sp. inq."
sA: 50*; **saA**: 99*

*as *Oribella castanea*
• *B. lanceolata* (Michael, 1885)
sA: 148, 153

Oppiidae Grandjean, 1951
Multioppia Hammer, 1961
• *M. (M.) wilsoni* Moritz, 1966
sA: 14*

*as *Dameosoma clavipectinatum*
Ramusella Hammer, 1962
• *R. clavipectinata* (Michael, 1885)
lA: 8
Microppia Balogh, 1983
• *M. minus* (Paoli, 1908)
saA: 101, 104*, 112*

*as *Oppia minus*
Rhinoppia Balogh, 1983
• *R. subpectinata* (Oudemans, 1900)
sA: 36*, 37*, 41, 47, 49, 50, 51, 83*, 91*; **lA**: 43, 66*, 67*, 70*, 113, 125, 126, 146, 147, 148; **mA**: 151, 152; **saA**: 78, 94*, 96*, 97*, 98*, 101, 103*, 112*; **aA**: 79, 80, 81, 82, 105*, 106*; **Gf**: 159; **unknown**: 33*, 34*

*as *Oppia subpectinata*
Berniniella Balogh, 1983
• *B. bicarinata* (Paoli, 1908)
lA: 113
Dissorhina Hull, 1916
• *D. ornata* (Oudemans, 1900)
sA: 47, 48, 49, 50, 51, 62*, 65*; **lA**: 67*, 70*, 71*, 72*, 113, 115; **saA**: 128; **aA**: 79, 81; **Gf**: 156, 159

*as *Oppia ornata*
Lauroppia Subías & Rodríguez, 1986
• *L. falcata* (Paoli, 1908)
sA: 47, 49, 50, 51; **lA**: 52, 53, 54; **mA**: 44, 58
• *L. maritima* (Willmann, 1928)
saA: 124
Moritzoppia Subías & Rodríguez, 1988
• *M. keilbachi* (Moritz, 1969)
saA: 145
• *M. neerlandica* (Oudemans, 1900)
sA: 3*, 29[+], 31[+], 32[!], 35*, 36[+], 37[+], 38[!], 41, 41[+], 47[+], 48[+], 49[+], 50[+], 51[+], 62[+], 63[+], 92[+], 121[+], 153[+]; **lA**: 42[+], 43[+], 43[!], 66[+], 67[+], 68[+], 70[+], 71[+], 114[+], 117[+], 146, 147, 154[+]; **mA**: 44[+], 77[+], 111[+];

saA: 78[+], 95[+], 97[+], 98[+], 99[+], 100[+]; **aA**: 79, 79[+], 80, 80[+], 81[+], 82, 82[+], 105[+], 106+, **Gf**: 155, 156, 157, 165[o], 166[o], **unknown**: 26[+], 27[+], 33[+], 33[!], 34[!]

*as *Eremaeus longilamellatus*, [+]as *Oppia translamellata*, [!]as *Oppia neerlandica*, [o]as *Oppiella neerlandica*
• *M. splendens* (C. L. Koch, 1841) "sp. inq."
sA: 10, 12, 14; **lA**: 56; **saA**: 96, 98, 101, 102, 112; **aA**: 106; **Gf**: 162)
• *M. unicarinata* (Paoli, 1908)
sA: 47, 48, 49, 50, 51, 62*; **lA**: 52, 66*, 67*, 70*, 146

*as *Oppia unicarinata*
Oppiella Jacot, 1937
• *O. nova* (Oudemans, 1902)
sA: 47, 48, 49, 50, 51, 61, 62, 63, 64, 65, 83, 85, 87, 91, 92, 153; **lA**: 66, 70, 113, 154; **mA**: 111; **saA**: 93, 97, 100, 101, 102, 104, 112; **aA**: 105; **Gf**: 155, 156, 157, 159, 166*

*as *O.* cf. *nova*
• *O. minidentata* (Subías, 1977)
saA: 145

Quadroppiidae Balogh, 1983
Quadroppia Jacot, 1939
• *Q. quadricarinata* (Michael, 1885)
sA: 41, 47, 49, 50, 51, 62, 121; **lA**: 42, 43, 67, 70, 146, 147; **saA**: 78, 94, 98, 101, 102, 112; **aA**: 79; **Gf**: 156, 157, 160, 162; **unknown**: 108

Trizetoidea Ewing, 1917
Suctobelbidae Jacot, 1938
Suctobelba Paoli, 1908
• *S. sorrentensis* Hammer, 1961
Gf: 156
• *S. trigona* (Michael, 1888)
sA: 41, 47, 48, 49, 50; **lA**: 42, 52, 53; **mA**: 58
Suctobelbella Jacot, 1937
• *S. acutidens* (Forsslund, 1941)
sA: 10*, 14*, 31*, 48*, 50*, 51[+], 90[+]; **lA**: 42, 47, 47[+], 49, 49[+], 66[+], 146, 147, 148; **mA**: 58[+]; **Gf**: 155, 156, 157, 165, 166; **unknown**: 34*

*as *Suctobella cornigera*, [+] as *S. sarekensis*
• *S. latirostris* (Strenzke, 1950)
Gf: 165*, 166*

*as *Suctobelbella* cf. *latirostris*
• *S. longirostris* (Forsslund, 1941)
sA: 65; **saA**: 101, 103, 112; **lA**: 66, 69, 71, 72*; **aA**: 79, 80, 82

*as *Suctobelba falcata*

Appendix 1. continued

• *S. perforata* (Strenzke, 1950)

saA: 78; **aA**: 79, 81

• *S. similis* (Forsslund, 1941)

sA: 51, 121

• *S. subcornigera* (Forsslund, 1941)

sA: 41, 47, 49, 83, 87, 89, 121; **lA**: 42, 43, 72, 146, 147; **saA**: 93, 94, 96, 100, 101, 103, 104, 112; **aA**: 106; **Gf**: 156, 157; **unknown**: 110

• *S. subtrigona* (Oudemans, 1900)

sA: 41*, 48*, 50*, 51*; **saA**: 93*, 94*, 100*, 104*

*as *S. intermedia*

Carabodoidea C. L. Koch, 1837

Carabodidae C. L. Koch, 1837

Carabodes C. L. Koch, 1835

• *C. areolatus* Berlese, 1916

sA: 36, 47, 48, 50, 51; **lA**: 53, 57; **saA**: 97; **unknown**: 27, 33

• *C. coriaceus* Koch, 1835

unknown: 27*

*as *C. nepos*

• *C. femoralis* (Nicolet, 1855)

sA: 41, 49

• *C. labyrinthicus* (Michael, 1879)

sA: 10*, 14*, 47, 49, 50; **lA**: 15*, 16*, 113, 115, 118, 123, 125, 126; **mA**: 44, 144, 151, 152; **hA**: 21*; **saA**: 96, 103, 124; **aA**: 106; **unknown**: 27, 27*

*as *C. marginepunctatus*

• *C. marginatus* (Michael, 1884)

sA: 35, 41, 47, 48, 49, 50, 61, 64, 89, 121; **lA**: 42, 43, 66, 70, 116, 146, 147, 148; **mA**: 111; **saA**: 100; **aA**: 79, 80, 81, 82; **unknown**: 40, 108, 109

• *C. minusculus* Berlese, 1923[8]

sA: 89, 121; **lA**: 116, 148

• *C. ornatus* Štorkán, 1925

sA: 39*, 41*, 47*, 50*, 51*; **lA**: 52*

*as *C. forsslundi*

• *C. subarcticus* Trägårdh, 1902

sA: 41, 47, 48, 49, 50, 51, 61, 64, 65, 88, 91; **lA**: 52, 66, 71, 72; **mA**: 58; **saA**: 93, 97, 100, 104, 124; **aA**: 105

• *C. willmanni* Bernini, 1975[8]

lA: 146, 147, 154; **mA**: 150, 151

Tectocepheoidea Grandjean, 1954

Tectocepheidae Grandjean, 1954

Tectocepheus Berlese, 1895

• *T. minor* Berlese, 1903

Gf: 156, 157

• *T. velatus* (Michael, 1880)[9]

sA: 32, 35, 36, 37, 41, 47, 48, 49, 50, 51, 61, 63, 64, 65, 85, 91, 93, 121, 153; **lA**: 66, 67, 68, 69, 70, 71, 72, 113, 114, 115, 116, 117, 125, 126, 146, 148, 154; **mA**: 77, 150, 151, 152; **saA**: 78, 95, 96, 97, 98, 99, 101, 102, 103, 104, 112, 128; **aA**: 79, 80, 81, 82, 105, 106; **Gf**: 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166; **unknown**: 26, 33, 34

• *T. velatus sarekensis* Trägårdh, 1910[9]

sA: 10, 12, 50*, 83*, 84*, 89*, 90*; **lA**: 15, 18, 42*, 43*, 47*, 49*, 122, 123; **mA**: 44*, 111*; **hA**: 20; **unknown**: 107*, 108*, 109*, 110*

*as *T. sarekensis*

Hydrozetoidea Grandjean, 1954

Hydrozetidae Grandjean, 1954

Hydrozetes Berlese, 1902

• *H. confervae* (Schrank, 1781)

sA: 24

• *H. lacustris* (Michael, 1882)

lA: 154

Ameronothroidea Willmann, 1931

Ameronothridae Willmann, 1931

Ameronothrus Berlese, 1896

• *A. lapponicus* Dalenius, 1963

lA: 142; **mA**: 143, 144, 149

PORONOTICAE Grandjean, 1954

Licneremaeoidea Grandjean, 1931

Licneremaeidae Grandjean, 1931

Licneremaeus Paoli, 1908

• *L. licnophorus* (Michael, 1882)

sA: 49, 64; **lA**: 67

Passalozetidae Grandjean, 1954

Passalozetes Grandjean, 1932

• *P. perforatus* (Berlese, 1910)[10]

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[8] *C. minusculus sensu* Willmann, 1931 is considered identical to *C. willmanni*, and is probably the only of these species which are present in alpine Fennoscandia. The original *C. minusculus* Berlese, 1923 is a separate, southern species (Weigmann 2006).

[9] The separation between *T. velatus* and *T. velatus sarekensis* is difficult and based on minor differences, even after several thorough studies (e.g. Knülle 1957, Nübel-Reidelbach 1994, Laumann et al. 2007). *Tectocepheus velatus sarekensis* the only subspecies-level included in the species list, as this is a very common group and many authors try to separate these.

[10] *Scutovertex bidactylus* (later *Bipassalozetes bidactylus*) in Willmann (1931) is probably *P. perforatus* (Strenzke, 1953).

Appendix 1. continued

aA: 82*

*as Bipassalozetes bidactylus

Phenopelopoidea Petrunkevitch, 1955

Phenopelopidae Petrunkevitch, 1955

Eupelops Ewing, 1917

• *E. acromios* (Hermann, 1804)

sA: 1, 2, 47, 49, 51; **lA**: 9, 52; **mA**: 58

• *E. geminatus* (Berlese, 1916)

sA: 75

• *E. occultus* (C. L. Koch, 1835)

sA: 41, 62; **lA**: 66

• *E. planicornis* (Schrank, 1803) "sp. inq"

saA: 93; **unknown**: 109

• *E. plicatus* (C. L. Koch, 1835)

sA: 41; **lA**: 43, 68, 114, 116, 117, 129, 146, 147, 148; **mA**: 76, 111*; **saA**: 99, 101, 112; **Gf**: 156, 166

*as E. auritus

• *E. septentrionalis* (Trägårdh, 1910)

sA: 10, 11, 12, 47, 48, 49, 50, 51; **lA**: 15, 18, 52, 53, 54, 55, 56, 57; **mA**: 58; **hA**: 22

• *E. torulosus* (C. L. Koch, 1839)

sA: 37*, 47*, 48*, 49*, 50*, 51*; **lA**: 52*, 53*, 54*, 57*, 147; **mA**: 58*; **hA**: 59*

*as Pelops duplex

• *E. uraceus* (C. L. Koch, 1839)

sA: 41; **lA**: 146

Peloptulus Berlese, 1908

• *P. phaeonotus* (C. L. Koch, 1844)

sA: 41

Limnozetoidea Thor, 1937

Limnozetidae Grandjean, 1954

Limnozetes Hull, 1916

• *L. ciliatus* (Schrank, 1803)

sA: 32; **lA**: 154; **Gf**: 157

• *L. rugosus* (Sellnick, 1923)

sA: 153

Achipterioidea Thor, 1929

Achipteriidae Thor, 1929

Achipteria Berlese, 1885

• *A. coleoptrata* (Linnaeus, 1758)[11]

sA: 89; **aA**: 79, 80, 81

• *A. italica* (Oudemans, 1914)

aA: 79

Campachipteria Aoki, 1995

• *C. fanzagoi* (Jacot, 1929)[11]

lA: 147*

*as Parachipteria willmanni

Parachipteria Hammen, 1952

• *P. magna* (Sellnick, 1928)

sA: 89*; **unknown**: 108*

*as Achpiteria magna

• *P. punctata* (Nicolet, 1855)

sA: 47, 49; **lA**: 121, 148; **saA**: 97*, 101, 104*, 112*; **aA**: 79, 105*

*as Achipteria punctata

Tegoribatidae Grandjean, 1954

Tegoribates Ewing, 1917

• *T. latirostris* (C. L. Koch, 1844)

lA: 43, 50, 51; **unknown**: 26

Oribatelloidea Jacot, 1925

Oribatellidae Jacot, 1925

Oribatella Banks, 1895

• *O. berlesei* (Michael, 1898)

sA: 47

• *O. calcarata* (C. L. Koch, 1835)

sA: 47

Ceratozetoidea Jacot, 1925

Ceratozetidae Jacot, 1925

Ceratozetella Shaldybina, 1966

• *C. cisalpina* (Berlese, 1908)

mA: 111

• *C. thienemanni* (Willmann, 1943)[12]

sA: 36, 41*, 47, 49, 51; **lA**: 52, 54, 57, 125, 126; **saA**: 78, 124; **unknown**: 27, 38)

* as Ceratozetes sp.

Ceratozetes Berlese, 1908

• *C. gracilis* (Michael, 1884)

sA: 41, 61, 62, 63, 64, 83, 85; **lA**: 66, 70, 147; **saA**: 93, 96, 101, 112; **aA**: 106; **unknown**: 107, 109

• *C. mediocris* Berlese, 1908

lA: 148

• *C. parvulus* Sellnick, 1922

sA: 61, 63, 64

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[11] *Campachipteria fanzagoi* is considered a junior synonym of *A. coleoptrata* by Weigmann (2006), and he discusses further problems with this species.
[12] *Ceratozetes* sp. from site 41 is identified as *C. thienemanni* by Karppinen (1958).

Appendix 1. continued

Edwardzetes Berlese, 1914

• *E. edwardsi* (Nicolet, 1855)

sA: 3*, 6*, 10[+], 12[+], 29, 30, 31, 35, 36, 41, 47, 48, 49, 50, 51; **lA**: 8*, 15[+], 16[+], 18[+], 43, 114, 116, 121; **mA**: 76, 77, 111, 150, 151, 152; **hA**: 21[+], 23[+]; **saA**: 99, 104; **aA**: 79; **Gf**: 156, 159, 162, 165, 166; **unknown**: 26, 33, 108

*as *Notaspis edwardsii* var. *lapponica*, [+]as *Oribata lapponica*

Euzetes Berlese, 1908

• *E. globulus* (Nicolet, 1855)

lA: 147

Fuscozetes Sellnick, 1928

• *F. fuscipes* (C. L. Koch, 1844)

lA: 114

Melanozetes Hull, 1916

• *M. meridianus* Sellnick, 1928

aA: 105

• *M. mollicomus* (C. L. Koch, 1839)

sA: 3, 4, 10, 14, 35, 41, 47, 49, 50, 51, 61, 63, 64, 65, 84, 89, 90; **lA**: 15, 42, 43, 114, 121, 147, 154; **mA**: 111; **saA**: 97, 98, 99, 100, 101, 104, 112, 128; **aA**: 79, 80, 82, 105, 106; **Gf**: 166; **unknown**: 26, 27, 33, 34, 38, 107, 109, 150*, 151*, 152*

*as *Melanozetes* cf. *mollicomus*

Oromurcia Thor, 1930

• *O. bicuspidata* Thor, 1930

sA: 75, **lA**: 114, 116, 127, 154; **mA**: 44, 150; **saA**: 78; **aA**: 79, 81; **Gf**: 156, 158, 159, 161, 162, 163, 164, 165, 166

• *O. lucens* (L. Koch, 1879)

sA: 5*, 10, 13, 51; **lA**: 7, 15, 16, 54, 57

*as *Notaspis setosa* var. *curta*

Sphaerozetes Berlese, 1885

• *S. piriformis* (Nicolet, 1855)

lA: 121

Trichoribates Berlese, 1910

• *T. monticola* (Trägårdh, 1902)

sA: 8; **lA**: 16; **mA**: 58, 77; **hA**: 23; **Gf**: 155, 156

• *T. novus* (Sellnick, 1928)

Gf: 158, 159

• *T. setiger* (Trägårdh, 1910)

lA: 16*, 55*, 56*, 114; **hA**: 20*, 21*, 23*, 59*

*as *Oribata piriformes* var. *setiger*

• *T. berlesei* (Jacot, 1929)

sA: 47*, 51*, 147*; **saA**: 102*

*as *T. trimaculatus*

Zetomimus Hull, 1916

• *Z. furcatus* (Warburton & Pearse, 1905)

lA: 154

Chamobatidae Grandjean, 1954

Chamobates Hull, 1916

• *C. cuspidatiformis* (Trägårdh, 1904)[13]

sA: 10*, 12*, 47[+], 48[+], 75; **lA**: 15*, 16*, 52[+], 53[+], 56[+], 113[l], 115[l], 121, 125, 126; **mA**: 150*, 151*; **hA**: 21*, 23*

*as *Oribata cuspidata* var. *birulai*, [+]as *C. trägårdhi*, [l]as *C. borealis*

• *C. cuspidatus* (Michael, 1884)

lA: 121, 146, 147; **mA**: 150*, 151*, 152*

*as *C.* cf. *cuspidatus*)

• *C. pusillus* (Berlese, 1895)

sA: 10*, 47[+], 48[+], 49+, 50[+], 51[+], 75[+]; **lA**: 9[l], 15*, 125[+], 126[+], 146[+], 147[+], 148[+]; **saA**: 78[+]; **aA**: 79[+]

*as *Oribata cuspidata* var. *borealis*, [+]as *C. borealis*, [l]as *Notaspis cuspidata* var. *borealis*

• *C. rastratus* (Hull, 1914)

sA: 49*

*as *C. spinosus*

• *C. schuetzi* (Oudemans, 1902)

sA: 35, 37, 41, 61, 62, 65; **lA**: 42, 43, 68, 71; **mA**: 111; **saA**: 93, 96; **unknown**: 33

Humerobatidae Grandjean, 1970

Diapterobates Grandjean, 1936

• *D. humeralis* (Hermann, 1804)

sA: 37, 47*, 48*, 49*, 50*, 51*, 62; **lA**: 52[+]; **saA**: 96*

*as *Trichoribates numerosus*, [+]as *D. numerosus*

• *D. notatus* (Thorell, 1871)

sA: 11

Punctoribatidae Thor, 1937

Mycobates Hull, 1916

• *M. parmeliae* (Michael, 1884)

saA: 98, 102, 124

• *M. sarekensis* (Trägårdh, 1910)

sA: 11, 14; **lA**: 15, 16, 113, 115, 125, 126, 154; **mA**: 77, 150[+], 151[+], 152[+]; **hA**: 21, 23; **saA**: 96*; **aA**: 79, 82, 106*; **Gf**: 160, 161, 162, 164, 165, 166; **unknown**: 107, 110

*as *Calyptozetes sarekensis*

• *M. tridactylus* Willmann, 1929

Gf: 156, 157

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[13] The taxonomy of *C. cuspidatiformis* and the junior synonyms designated by Subias (2009) are discussed by Weigmann (2006).

Appendix 1. continued

Oripodoidea Jacot, 1925
Oribatulidae Thor, 1929
Oribatula Berlese, 1895
• *O. tibialis* (Nicolet, 1855)
sA: 10, 35, 37, 47*, 48, 48*, 49, 49*, 50, 50*, 51*, 61, 75, 121, 153; **lA**: 7[+], 8[+], 15, 16, 18, 41, 52*, 53*, 55*, 56*, 57*, 66, 113, 114, 116, 125, 126, 146, 147, 154; **mA**: 9[+], 58*, 77[l], 111, 150, 151, 152; **hA**: 21, 23, 59*; **saA**: 78*, 89, 93, 94, 96, 97, 98, 100, 101, 102, 103, 112; **aA**: 79*, 80*, 81*, 82*, 106; **Gf**: 157, 165, 166; **unknown**: 27, 38, 107, 108, 109, 110)
*as *O. venusta*, [+]as *Eremaeus crassipes*, [l]as *O. crassipes*
• *O. exilis* (Nicolet, 1855)
sA: 35, 41, 47; **lA**: 16, 52, 55, 57
Phauloppia Berlese, 1908
• *P. lucorum* (C. L. Koch, 1841)
hA: 59*
*as *P. conformis*

Hemileiidae J. & P. Balogh, 1984
Hemileius Berlese, 1916
• *H. initialis* (Berlese, 1908)
sA: 10*, 12*, 29[+], 31[+], 35[+], 36[+], 37[+], 41[+], 47[+], 48[+], 49[+], 50[+], 51[+], 63[+], 75, 89[+], 92[+], 121, 153; **lA**: 15*, 43[+], 52[+], 55[+], 57[+], 68[+], 70[+], 71[+], 116, 146, 147, 148, 154; **mA**: 76; **saA**: 96[+]; **Gf**: 157; **unknown**: 26[+], 33[+], 108[+]
*misidentified as *Oribatula tibialis*, [+]as *Scheloribates confundatus*

Liebstadiidae J.& P. Balogh, 1984
Liebstadia Oudemans, 1906
• *L. humerata* Sellnick, 1928
lA: 146
• *L. similis* (Michael, 1888)
sA: 29, 37, 41, 47, 48, 50, 51, 75, 153; **lA**: 43, 114, 117; **mA**: 150, 151; **saA**: 78, 98; **aA**: 79, 81, 82

Scheloribatidae Jacot, 1935
Scheloribates Berlese, 1908
• *S. laevigatus* (C. L. Koch, 1836)
sA: 75; **lA**: 52, 56
• *S. pallidulus* (C. L. Koch, 1841)
sA: 49, 50, 51; **lA**: 55; **mA**: 58

Galumnoidea Jacot, 1925
Parakalummidae Grandjean, 1936
Neoribates Berlese, 1914

• *N. aurantiacus* (Oudemans, 1914)
sA: 47, 49; **lA**: 52; **saA**: 124; **aA**: 79, 106

Galumnidae Jacot, 1925
Galumna Heyden, 1826
• *G. dorsalis* (C. L. Koch, 1835) "sp. inq"
sA: 14
Pergalumna Grandjean, 1936
• *P. nervosa* (Berlese, 1914)
sA: 36, 47, 49, 50, 61, 63, 64; **lA**: 43, 57

Appendix 2. Summary of the alpine sites where oribatid mites have been recorded from alpine Fennoscandia. No is the site, Locality is the place of the site, C is country of origin; F: Finland, N: Norway and S: Sweden. Geo region is the geographical region used in this article; S: South, NW: North West, NE: North East. The alpine regions are listed as alpine and arctic zones; sub-alpine (sA), sub-artic/alpine (saA), low-alpine (lA), middle-alpine (mA), high-alpine (hA), arctic/alpine (aA) belts, sub-arctic/alpine sites (saA), arctic/alpine sites (aA) or glacier-forelands (Gf). Habitat is given if it is reported in the original articles or has been possible to infer in other ways. Altitude is given if it was possible to infer it from the articles or topographical maps. N species is number of species recorded in each site. Type of study corresponds to the nature/aim of the study; Fa/Ec: faunistic/ecological studies, EP: ecophysiological studies, Tax: species descriptions and taxonomical studies.

No.	Locality	C	Geo region	Alpine zone	Habitat	N species	Type of study	Altitude m a.s.l.	Study
1.	Abiskojokki, Lapland	S	NW	sA	Birch litter	3	Fa/Ec		(Trägårdh 1902)
2.	Kårsovaggejokki, Lapland	S	NW	sA	Litter and leaves	3	Fa/Ec		(Trägårdh 1902)
3.	Mt. Kårsonjuonje, Lapland	S	NW	sA	*Sphagnum* spp. at the tree limit	6	Fa/Ec		(Trägårdh 1902)
4.	Mt. Tarrakoski, Lapland	S	NW	sA	In moss by the stream	1	Fa/Ec		(Trägårdh 1902)
5.	Mt. Tarrakoski, Lapland	S	NW	sA	Under rocks in a stream	1	Fa/Ec		(Trägårdh 1902)
6.	Mt. Vorrovardo, Tarrakoski, Lapland	S	NW	sA	In *Sphagnum* spp.	5	Fa/Ec		(Trägårdh 1902)
7.	Mt. Kårsonjuonje, Lapland	S	NW	lA	Under moist rocks	2	Fa/Ec	1000	(Trägårdh 1902)
8.	Mt. Kårsonjuonje, Lapland	S	NW	lA	Under rocks at the tree limit	7	Fa/Ec	1000,1050	(Trägårdh 1902)
9.	Mt. Kårsonjuonje, Lapland	S	NW	lA	Leaves and mosses, leaves and mosses under rocks	3	Fa/Ec	1040	(Trägårdh 1902)
10.	Birch zone, Sarek, Jokkmokk, Norrbotten	S	NW	sA	In leaves and mosses	22	Fa/Ecca	370-700	(Trägårdh 1910)
11.	Birch zone, Sarek, Jokkmokk, Norrbotten	S	NW	sA	Under rocks	5	Fa/Ecca	370-700	(Trägårdh 1910)
12.	Birch zone, Sarek, Jokkmokk, Norrbotten	S	NW	sA	In *Sphagnum* spp.	11	Fa/Ecca	370-700	(Trägårdh 1910)
13.	Birch zone, Sarek, Jokkmokk, Norrbotten	S	NW	sA	Under rocks at the banks of a stream	2	Fa/Ecca	370-700	(Trägårdh 1910)
14.	Birch zone, Sarek, Jokkmokk, Norrbotten	S	NW	sA	Under the bark of a rotting birch	9	Fa/Ecca	370-700	(Trägårdh 1910)
15.	Oligotrophic heath, Sarek, Jokkmokk, Norrbotten	S	NW	lA	In leaves and mosses	13	Fa/Ecca	700-1000	(Trägårdh 1910)
16.	Oligotrophic heath, Sarek, Jokkmokk, Norrbotten	S	NW	lA	On the side of boulders,	10	Fa/Ecca	700-1000	(Trägårdh 1910)
17.	Oligotrophic heath, Sarek, Jokkmokk, Norrbotten	S	NW	lA	In moss in slowly flowing water	2	Fa/Ecca	700-1000	(Trägårdh 1910)
18.	Oligotrophic heath, Sarek, Jokkmokk, Norrbotten	S	NW	lA	East and west facing slopes of Mt. Säkok	9	Fa/Ecca	700-1000	(Trägårdh 1910)
19.	Lichen zone, Sarek, Jokkmokk, Norrbotten	S	NW	hA	In nest of *Bombus kirkbyellus*	1	Fa/Ec	1000-1300	(Trägårdh 1910)
20.	Lichen zone, Sarek, Jokkmokk, Norrbotten	S	NW	hA	Under rocks	2	Fa/Ec	1000-1300	(Trägårdh 1910)
21.	Lichen zone, Sarek, Jokkmokk, Norrbotten	S	NW	hA	In mosses and lichens	9	Fa/Ec	1000-1300	(Trägårdh 1910)
22.	Lichen zone, Sarek, Jokkmokk, Norrbotten	S	NW	hA	Mountain heath at the base of Mt. Tjäura	2	Fa/Ec	1000-1300	(Trägårdh 1910)
23.	Lichen zone, Sarek, Jokkmokk, Norrbotten	S	NW	hA	Stony soils, cryoturbated	8	Fa/Ec	1000-1300	(Trägårdh 1910)
24.	Abisko, Lapland	S	NW	sA	Spring in *Betula nana*-heathland (sample nr. 54)	2	Fa/Ec		(Willmann 1943)
25.	Abisko, Lapland	S	NW	sA	Brook by Vassijaure, in moss (sample nr. 85b), in birch region (after Thienemann 1941)	1	Fa/Ec		(Willmann 1943)
26.	Abisko, Lapland	S	NW		Thick moss, above a spring (sample nr. 118c)	13	Fa/Ec		(Willmann 1943)
27.	Abisko, Lapland	S	NW		Moss surrounding these ponds (sample 122f)	12	Fa/Ec		(Willmann 1943)
28.	Abisko, Lapland	S	NW		Moss in spring (sample 125a)	1	Fa/Ec		(Willmann 1943)
29.	Abisko, Lapland	S	NW	sA	Meltwater drained moss in *Betula nana*-heathland (sample nr. 131)	8	Fa/Ec		(Willmann 1943)
30.	Abisko, Lapland	S	NW	sA	Spring moss (sample nr. 132), in birch region (after Thienemann 1941)	1	Fa/Ec		(Willmann 1943)
31.	Abisko, Lapland	S	NW	sA	Moss in birch forest (sample nr. 136)	6	Fa/Ec		(Willmann 1943)

Appendix 2. continued

No.	Locality	C	Geo region	Alpine zone	Habitat	N species	Type of study	Altitude m.a.s.l.	Study
32.	Abisko, Lapland	S	NW	sA	Spring moss (sample nr. 143a), in birch region (after (Thienemann 1941)	11	Fa/Ec		(Willmann 1943)
33.	Abisko, Lapland	S	NW		Spring by Abisko, moss above spring outlet (sample nr. 156a)	19	Fa/Ec		(Willmann 1943)
34.	Abisko, Lapland	S	NW		Moss surrounding a bog pool (sample nr. 158a)	9	Fa/Ec		(Willmann 1943)
35.	Abisko, Lapland	S	NW	sA	Moss in birch forest (the locality is in a puddle with midges) (sample nr. 164)	14	Fa/Ec		(Willmann 1943)
36.	Abisko, Lapland	S	NW	sA	Forest moss surrounding a spring area (sample nr. 174a), in birch region (after (Thienemann 1941)	11	Fa/Ec		(Willmann 1943)
37.	Abisko, Lapland	S	NW	sA	Litter in a rich herbal birch forest (sample nr. 176)	16	Fa/Ec		(Willmann 1943)
38.	Abisko, Lapland	S	NW		Moss in spring area (sample nr. 183a)	11	Fa/Ec		(Willmann 1943)
39.	Kilpisjärvi, Lapland	F	NW	sA	Regio subalpina	1	Fa/Ec		(Karppinen 1956a)
40.	Kilpisjärvi, Lapland	F	NW		Regio alpina	1	Fa/Ec		(Karppinen 1956a)
41.	Kilpisjärvi, Lapland	F	NW	sA	Mountain birch zone	45	Fa/Ec	460-650	(Karppinen 1956b)
42.	Mt. Pikku Malla	F	NW	lA	Dwarf scrub heath land	12	Fa/Ec	680	(Karppinen 1956b)
43.	Mt. Saana	F	NW	lA	Hillsides	20	Fa/Ec	750-800	(Karppinen 1956b)
44.	Mt. Saana, Kilpisjärvi, Lapland	F	NW	mA	Mountain heath land	9	Fa/Ec	950	(Karppinen 1956b)
45.	Mt. Långfjellet, Dalarna	S	S	lA	Dwarf brush-lichen heath land	1	Fa/Ecca	1000	(Forsslund 1958)
46.	Mt. Långfjellet, Dalarna	S	S	lA	*Sphagnum* spp.	1	Fa/Ecca	1000	(Forsslund 1958)
47.	Torneträsk, Lapland	S	NW	sA	*Empetrum* heath birch forest	66	Fa/Ecca	300-800	(Dalenius 1960)
48.	Torneträsk, Lapland	S	NW	sA	*Vaccinium myrtillus* heath birch forest	39	Fa/Ecca	300-800	(Dalenius 1960)
49.	Torneträsk, Lapland	S	NW	sA	*Hylocomium* heath birch forest	46	Fa/Ecca	300-800	(Dalenius 1960)
50.	Torneträsk, Lapland	S	NW	sA	Fen birch forest	49	Fa/Ecca	300-800	(Dalenius 1960)
51.	Torneträsk, Lapland	S	NW	sA	Meadow birch forest	51	Fa/Ecca	300-800	(Dalenius 1960)
52.	Torneträsk, Lapland	S	NW	lA	*Empetrum* heath	33	Fa/Ecca	600-1050	(Dalenius 1960)
53.	Torneträsk, Lapland	S	NW	lA	Lichen heath	11	Fa/Ecca	600-1050	(Dalenius 1960)
54.	Torneträsk, Lapland	S	NW	lA	*Dryas* heath	13	Fa/Ecca	600-1050	(Dalenius 1960)
55.	Torneträsk, Lapland	S	NW	lA	*Poa alpina*-heath	9	Fa/Ecca	600-1050	(Dalenius 1960)
56.	Torneträsk, Lapland	S	NW	lA	*Carex bigelowii*-heath	12	Fa/Ecca	600-1050	(Dalenius 1960)
57.	Torneträsk, Lapland	S	NW	lA	Low alpine meadows	18	Fa/Ecca	600-1050	(Dalenius 1960)
58.	Torneträsk, Lapland	S	NW	mA	*Cassiope tetragona*-heaths	15	Fa/Ecca	1050-1400	(Dalenius 1960)
59.	Torneträsk, Lapland	S	NW	hA	Stony soils	8	Fa/Ecca	1400-	(Dalenius 1960)
60.	Mt. Risajaura, Abisko, Lapland	S	NW		Moss immersed in cold water	2	Fa/Ec		(Hammer 1960)
61.	Kilpisjärvi, Lapland	F	NW	sA	Bog at the banks of Kilpisjärvi, at the south side of Mt. Pikku-Malla (site 6)	13	Fa/Ec	460?	(Karppinen 1962)
62.	Kilpisjärvi, Lapland	F	NW	sA	Birch stand between the hotel and Tschahkajärvi, *Vaccinium* and *Empetrum*-rich heathland (site 7)	19	Fa/Ecca	550	(Karppinen 1962)
63.	Kilpisjärvi, Lapland	F	NW	sA	Bog with rich *Sphagnum* vegetation, close to previous birch stand (site 8)	13	Fa/Ecca	550	(Karppinen 1962)
64.	Kilpisjärvi, Lapland	F	NW	sA	Bog with rich *Sphagnum* vegetation, close to previous birch stand (site 9)	13	Fa/Ecca	550	(Karppinen 1962)
65.	Mt. Sodankylä, Sompio	F	NE	sA	Mt. Pyhänattanen, birch belt; *Vaccinium uliginosum*, *Empetrum*, *Pleurozium*, *Dicranum* (site 12)	11	Fa/Ecca	380	(Karppinen 1962)
66.	South aspect of Mt. Saana, Kilpisjärvi, Lapland	F	NW	lA	Mountain dwarfbush heathland, ca. 30 m. above three-line (site 1)	16	Fa/Ec	650	(Karppinen 1962)
67.	North aspect of Mt. Saana, Kilpisjärvi, Lapland	F	NW	lA	A tussock of *Juncus trifidus* (site 2)	10	Fa/Ecca	720	(Karppinen 1962)
68.	South aspect of Mt. Iso-Malla, Kilpisjärvi, Lapland	F	NW	lA	Mountain heathland with *Betula nana* (site 3)	9	Fa/Ecca	600	(Karppinen 1962)
69.	South aspect of Mt. Iso-Malla, Kilpisjärvi, Lapland	F	NW	lA	Mountain heathland with little vegetation, mainly peat (site 4)	3	Fa/Ecca	600	(Karppinen 1962)
70.	South aspect of Mt. Iso-Malla, Kilpisjärvi, Lapland	F	NW	lA	Mountain heathland, under *Betula nana*, at the edge of a brink (site 5)	16	Fa/Ecca	600	(Karppinen 1962)
71.	Mt. Sodankylä, Sompio	F	NE	lA	Peak of Mt. Pyhänattanen, poor vegetation cover with *Empetrum*, *Vaccinium* and *Cladonia* (site 10)	9	Fa/Ecca.	500	(Karppinen 1962)

Appendix 2. continued

No.	Locality	C	Geo region	Alpine zone	Habitat	N species	Type of study	Altitude m.a.s.l.	Study
72.	Mt. Sodankylä, Sompio	F	NE	lA	Mt. Pyhänattanen, at upper three-line; *Empetrum, Vaccinium uliginosum, V. myrtillus* and *Cladonia* (site 11)	7	Fa/Ecca	430	(Karppinen 1962)
73.	Mt. Långfjellet	S	S	lA	Above the three line	1	Fa/Ecca	1000	(Forsslund 1964)
74.	Sarek	S	NW	lA	Above the three line	1	Fa/Ecca	1000	(Forsslund 1964)
75.	Vatnahalsen, Aurlandsdalen	N	S	sA	At the top of the birch zone	17	Fa/Ec	800	(Løken 1966)
76.	Kvammadalen, Aurlandsdalen	N	S	mA	A lush alpine valley	6	Fa/Ec	900-1100	(Løken 1966)
77.	Lake Hornsvatn, Aurlandsdalen	N	S	mA	Stony soils	7	Fa/Ec	1286	(Løken 1966)
78.	Birch forest, Olderfjord, Finnmark	N	NE	saA	Humus in a birch forest	20	Fa/Ec		(Cadwalladr 1969)
79.	Dry heath, Olderfjord, Finnmark	N	NE	aA	Dry heath, dominated by *Vaccinium* and *Empterum* species	40	Fa/Ec		(Cadwalladr 1969)
80.	Wet heath, Olderfjord, Finnmark	N	NE	aA	Wet heath, dominated by *Vaccinium* and *Empterum* species	20	Fa/Ec		(Cadwalladr 1969)
81.	Hay meadow, Olderfjord, Finnmark	N	NE	aA	Dominated by *Rumex* and *Poa*	14	Fa/Ec		(Cadwalladr 1969)
82.	Mineral soil, Olderfjord, Finnmark	N	NE	aA	Poor vegetation cover with herbs,	22	Fa/Ec	860	(Cadwalladr 1969)
83.	Mt. Stødi	N	NW	sA	(site 65)	7	Fa/Ec	700	(Karppinen 1971)
84.	Mt. Stødi	N	NW	sA	(site 66)	4	Fa/Ec	650	(Karppinen 1971)
85.	Holmvann	N	NW	sA	Birch stand (site 86)	4	Fa/Ec	200	(Karppinen 1971)
86.	Border of Troms County	N	NW	sA	Bog on the top of a field (site 92)	1	Fa/Ec	420	(Karppinen 1971)
87.	Skjold	N	NW	sA	Top of a field with bog, growing low birches (site 94)	4	Fa/Ec	210	(Karppinen 1971)
88.	Galggojavrre	N	NW	sA	(site 104)	3	Fa/Ec	510	(Karppinen 1971)
89.	Mt. Tøfjell, Kvam, Hordaland	N	S	sA	(site 138)	15	Fa/Ec	750	(Karppinen 1971)
90.	Arctic circle	N	NW	sA	Dominant plants *Betula nana, Salix* spp., *Empetrum* spp., *Carex* spp. (site 64)	6	Fa/Ec	700	(Karppinen 1971)
91.	Mt. Saltfjell	N	NW	sA	Birch limit, height of birches about 2-3 m (site 67)	8	Fa/Ec	930	(Karppinen 1971)
92.	Mt. Saltfjell	N	NW	sA	Birch zone, height of birches about 4-5 m (site 68)	6	Fa/Ec	510	(Karppinen 1971)
93.	Skipagurra	N	NE	saA	*Betula pubescens tortuosa* stand (site 201)	13	Fa/Ec	130	(Karppinen 1971)
94.	Hammerfest	N	NE	saA	Bare, wet field where the snow had partly remained (site 168)	10	Fa/Ec	100	(Karppinen 1971)
95.	Hammerfest	N	NE	saA	Bare, wet field where the snow had partly remained (site 169)	5	Fa/Ec	100	(Karppinen 1971)
96.	Rafsbotn	N	NE	saA	Birch stand beside a lake (site 164)	14	Fa/Ec	230	(Karppinen 1971)
97.	Rafsbotn	N	NE	saA	Willows growing along the ground beside a lake (site 165)	11	Fa/Ec	230	(Karppinen 1971)
98.	Between Leirbotn-Skaidi	N	NE	saA	Bare field (site 166)	14	Fa/Ec	336	(Karppinen 1971)
99.	Between Skaidi-Porsanger	N	NE	saA	Sloping bog with abundant grasses (site 172)	14	Fa/Ec	200	(Karppinen 1971)
100.	Between Skaidi-Porsanger	N	NE	saA	Slope with birches and *Vaccinium* and *Empetrum* (site 173)	12	Fa/Ec	200	(Karppinen 1971)
101.	Mt. Vieksa	N	NE	saA	*Betula pubescens tortuosa* stand (site 185)	15	Fa/Ec	200	(Karppinen 1971)
102.	Mt. Vieksa	N	NE	saA	From small patches of very low *Betula nana* and *Empetrum* in the middle of a wide gravel and stone field (site 187)	12	Fa/Ec	170	(Karppinen 1971)
103.	Mt. Vieksa	N	NE	saA	Gravel and stone field with both *Betula pubescens tortuosa* and *Betula nana* (site 188)	8	Fa/Ec	150	(Karppinen 1971)
104.	Kirkenes	N	NE	saA	Slope with birches and with *Empetrum* spp. and *Vaccinium myrtillus* (site 195)	12	Fa/Ec	30	(Karppinen 1971)
105.	Ifjord	N	NE	aA	Bog beside a pond (site 189)	11	Fa/Ec	250	(Karppinen 1971)
106.	Ifjord	N	NE	aA	Cliff with low *Salix* stand growing along the surface (site 190)	14	Fa/Ecc	250	(Karppinen 1971)
107.	Grøen, Kvam, West coast	N	S	lA	(site 137)	11	Fa/Ec	867	(Karppinen 1971)
108.	Mt. Grøefjell, Kvam, West coast	N	S	lA	(site 144)	10	Fa/Ec	900	(Karppinen 1971)
109.	Mt. Flefjell, Kvam, West coast	N	S	lA	(site 141)	8	Fa/Ec	910	(Karppinen 1971)
110.	Mt. Røyfjell, Kvam, West coast	N	S	lA	(site 134)	5	Fa/Ec	940	(Karppinen 1971)
111.	Finse, Hardangervidda	N	S	mA	(site 134 and 135)	15	Fa/Ec	1220	(Karppinen 1971)
112.	Mt. Vieksa	N	NE	saA	*Betula pubescens tortuosa* stand	16	Fa/Ec	200	(Karppinen 1971)
113.	Stigstuv, Hardangervidda	N	S	lA	Lichen heath	17	Fa/Ec	1220	(Solhøy 1975)

Appendix 2. continued

No.	Locality	C	Geo region	Alpine zone	Habitat	N species	Type of study	Altitude m a.s.l.	Study
114.	Stigstuv, Hardangervidda	N	S	lA	Wet meadow	14	Fa/Ec	1320	(Solhøy 1975)
115.	Stigstuv, Hardangervidda	N	S	lA	Lichen heath	6	Fa/Ec	1220	(Solhøy et al. 1975)
116.	Stigstuv, Hardangervidda	N	S	lA	Dry meadow	8	Fa/Ec	1275	(Solhøy et al. 1975)
117.	Stigstuv, Hardangervidda	N	S	lA	Wet meadow	7	Fa/Ec	1320	(Solhøy et al. 1975)
118.	Stigstuv, Hardangervidda	N	S	lA	Lichen heath	1	Fa/Ec	1225	(Steigen et al. 1975)
119.	Stigstuv, Hardangervidda	N	S	lA	Mosses in a stand of *Salix herbacea*	1	Fa/Ec	1220	(Solhøy 1976a)
120.	Lake Hornsvatn, Aurland	N	S	mA	Stony soils	1	Fa/Ec	1286	(Solhøy 1976a)
121.	Mt. Håstefjell, Hordaland	N	S	lA	Moss dominated oceanic mountain, with scattered vascular plants	26	Fa/Ec	460	(Solhøy 1976b)
122.	Finse, Hardangervidda	N	S	lA	Windswept mountain ridges covered with lichen heath	1	EP	1200	(Sømme & Conradi-Larsen 1977a)
123.	Finse, Hardangervidda	N	S	lA	Windswept mountain ridges covered with lichen heath	2	EP	1200	(Sømme & Conradi-Larsen 1977b)
124.	Kevo, Lapland	F	NE	saA	Alpine heath, dominated by *Vaccinium* spp.and *Empetrum* spp., as well as mosses	9	Fa/Ec	310-320	(Solhøy & Koponen 1981)
125.	Dovre, ungrazed	N	S	lA	Ridge top with heathland, moss dominated vegetation	17	Fa/Ec	980	(Alvheim 1982)
126.	Dovre, grazed	N	S	lA	Ridge top with heathland, moss dominated vegetation with stony soils	17	Fa/Ec	1100	(Alvheim 1982)
127.	Stigstuv, Hardangervidda	N	S	lA	Moist meadow	1	Tax	1300	(Seniczak & Solhøy 1987)
128.	Kevo, Lapland	F	NE	saA	Mountain birch forest	5	Tax	120	(Koponen 1989)
129.	Stigstuv, Hardangervidda	N	S	lA	Alpine sedge meadow	1	Tax	1320	(Seniczak et al. 1989)
130.	Torbjørnstølen, Finse, Hardangervidda	N	S	lA	Gently sloping bog with mosses and sedges	1	Tax	1250	(Seniczak 1990)
131.	Finse, Hardangervidda	N	S	lA	Bog with sedges and mosses, sloping easterly	2	Tax	1220	(Seniczak & Klimek 1990)
132.	Mt. Nordnut, Finse, Hardangervidda	N	S	lA	Meadow	1	Tax	1220	(Seniczak et al. 1990b)
133.	Stigstuv, Hardangervidda	N	S	lA	Wet meadow	1	Tax	1320	(Seniczak 1991)
134.	Mt. Kvitebjørn, Bergen, Hordaland	N	S	sA	*Calluna* heath and lichen on soil	2	Tax	390	(Colloff 1993)
135.	Mt. Håstefjell, Bergen, Hordaland	N	S	sA		1	Tax	460	(Colloff 1993)
136.	Stigstuv, Hardangervidda	N	S	lA	Lichens on stone	1	Tax	1300	(Colloff 1993)
137.	Lake Styggevatn, Gaupne, Jostedalen	N	S	lA		1	Tax	1160	(Colloff 1993)
138.	Finse, Hardangervidda	N	S	lA	Lichens on stone	1	Tax	1420	(Colloff 1993)
139.	Säkokhytte, Lapland	S	NW	lA	Damp dwarf-birch litter in a small hollow in a mossy wood	1	Tax	ca. 900	(Colloff 1993)
140.	Mt. Pårtefjellet, Sarek, Lapland	S	NW	hA	On moss and lichen in lichen zone	1	Tax		(Colloff 1993)
141.	Stigstuv, Hardangervidda	N	S	lA	Snow-bed on lichen heath	1	Tax	1225	(Colloff 1993)
142.	Finse, Hardangervidda	N	S	lA	In lichens on erratic boulders	1	Fa/Ec	1200	(Tilrem 1994)
143.	Finse, Hardangervidda	N	S	mA	In lichens on erratic boulders	1	Fa/Ec	1350	(Tilrem 1994)
144.	Finse, Hardangervidda	N	S	mA	In lichens on erratic boulders	2	Fa/Ec	1240-1440	(Manazza 1995)
145.	Kevo, Finnish Lapland	F	NE	saA	Mountain birch forest	2	Fa/Ec	120	(Niemi 1995)
146.	Mt. Ulriken, Bergen, Hordaland	N	S	lA	Litter beneath *Calluna vulgaris*	29	Fa/Ec	600-640	(Cifarelli 1997)
147.	Mt. Ulriken, Bergen, Hordaland	N	S	lA	Litter beneath *Juniperus communis*	33	Fa/Ec	600-640	(Basilico 2000)
148.	Mt. Ulriken, Bergen, Hordaland	N	S	lA	Heathland covered with *Calluna vulgaris*, *Juniperus communis* or grassland	20	Fa/Ec	600-640	(Furlan 2000)
149.	Finse, Hardangervidda	N	S	mA	In lichens on erratic boulders	1	EP	1300-1380	(Hansen 2000)
150.	Finse, Hardangervidda	N	S	mA	Snow-bed	11	Fa/Ec	ca 1245	(Johannessen 2002)
151.	Finse, Hardangervidda	N	S	mA	Side slopes	16	Fa/Ec	ca 1245	(Johannessen 2002)
152.	Finse, Hardangervidda	N	S	mA	Ridge top	15	Fa/Ec	ca 1245	(Johannessen 2002)
153.	Mt. Mjølfjell, Western Norway	N	S	sA	Bog with *Vaccinium* spp., *Carex* spp., *Empetrum* spp., and *Cladonia polytrichum* and *Sphagnum* spp.	12	Fa/Ec	650	(Riva-Caballero 2004)
154.	Uppsete, Western Norway	N	S	lA	Bog with *Carex saxátilis*, *Nardus stricta* and *Sphagnum* sp.	22	Fa/Ec	830	(Riva-Caballero 2004)
155.	Nigardsbreen, Jostedalen, Sogn og Fjordane	N	S	Gf	Youngest moraine – mosses	7	Fa/Ec		(Skubała & Gulvik 2005)
156.	Nigardsbreen, Jostedalen, Sogn og Fjordane	N	S	Gf	Middle moraine – *Salix* spp.	23	Fa/Ec		(Skubała & Gulvik 2005)
157.	Nigardsbreen, Jostedalen, Sogn og Fjordane	N	S	Gf	Oldest moraine – *Betula pubescence* and *Vaccinium* spp.	17	Fa/Ec		(Skubała & Gulvik 2005)
158.	Austerdalsbreen, Veitastrond, Sogn og Fjordane	N	S	Gf	Youngest moraine – mosses	3	Fa/Ec		(Skubała & Gulvik 2005)

Appendix 2. continued

No.	Locality	C	Geo region	Alpine zone	Habitat	N species	Type of study	Altitude m a.s.l.	Study
159.	Austerdalsbreen, Veitastrond, Sogn og Fjordane	N	S	Gf	Oldest moraine – *Salix* spp.	8	Fa/Ec		(Skubała & Gulvik 2005)
160.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	Gf	Youngest moraine (deglaciated ~1955), with 9 plant species	5	Fa/Ec	ca. 1400	(Seniczak et al. 2006)
161.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	Gf	Middle moraine (deglaciated ~1934), with 14 plant species	5	Fa/Ecca.	1330	(Seniczak et al. 2006)
162.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	Gf	Oldest moraine (deglaciated ~1750), with 16 plant species	10	Fa/Ecca.	1370	(Seniczak et al. 2006)
163.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	GF	Youngest moraine (deglaciated 32-48 y ago)	3	Fa/Ec		(Hågvar et al. 2009)
164.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	GF	Moraine (deglaciated 52-66 y ago) 32-48 y ago)	7	Fa/Ec		(Hågvar et al. 2009)
165.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	GF	Moraine (deglaciated 72-227 y ago)	12	Fa/Ec		(Hågvar et al. 2009)
166.	Midtdalsbreen, Finse, Hardangerjøkulen	N	S	GF	Oldest moraine (deglaciated ~10 000 y ago)	16	Fa/Ec		(Hågvar et al. 2009)