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Contribution to the knowledge of some poorly known lichens in Poland. I. The genus *Absconditella*

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Abstract: Data on the poorly known lichen genus *Absconditella* in Poland are presented. *A. pauxilla* is reported as new to the country. New collections of the rare in Central Europe *A. delutula* and *A. sphagnorum* are provided. Additionally, new records of the very much overlooked *A. lignicola* are presented from many regions of Poland. Taxonomic remarks, known world distribution and habitat preferences for the species are included.

Kokkuvõte: Panus Poola vähetuntud samblike tundmisse. I. Perekond *Absconditella*.

Esitatakse andmed halvasti tuntud samblikuperekonna *Absconditella* kohta Poolas. *A. pauxilla* leid on maale uus. Teatatakse Kesk-Euroopas haruldaste liikide *A. delutula* ja *A. sphagnorum* uutest leidudest. Esitatakse ka sageli märkamata jäänud *A. lignicola* uued teated paljudest Poola piirkondadest. Lisatud on taksonoomilised märkused, liikide kasvukohtade ja leviku andmed maailmas..

INTRODUCTION

The lichen genus *Absconditella* Vězda comprises eight species in Europe, but since its description by Vězda (1965), they have been reported only rather sporadically in Central Europe, e.g. *A. annexa* (Arnold) Vězda by Vězda (1965), *A. fossarum* Vězda & Pišut by Vězda and Pišut (1984), *A. celata* Döbbeler & Poelt and *A. pauxilla* Vězda & Vivant by Palice (1999), *A. delutula* (Nyl.) Coppins & Kilias by Kocourková-Horáková (1998) and *A. sphagnorum* Vězda & Poelt by Guttová and Palice (1999). Only *A. lignicola* Vězda & Pišut was noted quite commonly. As it turned out later, most of the species appeared to be overlooked in the field owing to a very inconspicuous habit and mostly pioneer and ephemeral character of the species (e.g. Palice et al., 2006).

The first review of the genus *Absconditella* in Poland was presented by Bielczyk and Kiszka (2001) and included three taxa, *A. delutula*, *A. lignicola* and *A. sphagnorum*. The commonest, *A. lignicola*, was reported at that time mostly from the mountainous southern part of Poland, but also with three lowland localities from NE Poland. The remaining species seemed to be rare: *A. delutula* was found only once in Eastern Carpathians, whereas *A. sphagnorum* seemed to be confined to the post-glacial, large intermountain peat-bog in the Kotlina Orawsko-Nowotarska basin. Later, *A. celata* was discovered in the Bieszczady Mts (Bielczyk & Kiszka, 2002), and *A. fossarum* was collected from northern part of the country (Ceynowa-Giełdon, 2003), both being additions to the Polish checklist. Ceynowa-Giełdon (2003) reported a few further findings of *A. sphagnorum* from northern Poland, and some new collections of *A. lignicola* have also been published, although from only very few regions (see below, Fig. 1, and Fałtynowicz, 2003 and literature cited therein).

During our studies we have found several new records of *Absconditella* species from Poland. It appears that *A. lignicola* is much more common and widespread in Poland than previously reported. We also discovered new localities of the rare *A. delutula* and *A. sphagnorum*. Additionally, we found *A. pauxilla* Vězda & Vivant, a species hitherto unreported from Poland. This paper presents all new data concerning of *Absconditella* from Poland, and contributes to its known distribution in Central Europe.

This work is the first part of a larger series, which will present new data of some poorly known and overlooked taxa in Poland, especially those that are rarely found in Central Europe as well.

MATERIALS AND METHODS

All specimens examined are kept in following herbaria: BDPA, GPN, Hb. Kolanko, KRAM, KTC, LOD, OPUN, UGDA and WRSL. Apothecia were sectioned with a razor blade, and mounted in water. All examined localities are mapped according to the modified ATPOL grid square system (Cieśliński & Fałtynowicz, 1993; see also Kukwa et al., 2002).

A key for all known European taxa is presented by Bielczyk and Kiszka (2001).

THE SPECIES

Absconditella delutula (Nyl.) Coppins & Kilias

In Poland *A. delutula* was reported from only one locality in the Western Carpathians, but Bielczyk and Kiszka (2001) suggested it should be more common. Two additional records were mentioned by Fałtynowicz (2003) and Bielczyk (2003), but locality details have not been published until now (one record made by the first author is included in this paper). Here we present two additional records, thus confirming the opinion of Bielczyk and Kiszka (2001) on its higher frequency in the Western Carpathians. Interestingly, the species was also once discovered in a lowland area of SW Poland (see Fałtynowicz, 2003). We found the species also twice in northern Poland. Considering all data, the species seems to be widespread in the country, but rare elsewhere, similar to its status in the British Isles (Woods & Coppins, 2003).

The new mountain collections were made on siliceous sandstone pebbles in shady, forested localities, but not only in the vicinity of streams as in the case of its first Polish locality (Bielczyk & Kiszka, 2001). Based on recent spring explorations of selected parts of the Western Carpathians we believe that *A. delutula* is an ephemeral, pioneer and short-lived epilithic lichen, locally even quite common. It is usually a single colonizer of rocky substrata or sometimes found in an association with *Micarea lithinella* (Nyl.) Hedl., non-lichenized algae or young thalli of *Trapelia coarctata* (Sm.) M. Choisy. In northern Poland the species has been found on the ground and on wood, similar to those findings reported for example from Sweden (Santesson et al., 2004) and Great Britain (Coppins, 1992). As we have not seen the specimen of *A. delutula* recently reported from Iława Lakeland in northern Poland (Jando, 2004), the record is considered as unconfirmed and provisionally doubtful.

Absconditella sphagnorum can be misinterpreted as *A. delutula.* Both taxa have 1-septate ascospores, but predominantly they are distinguished by the dimensions of apothecia (e.g. Coppins, 1992; Bielczyk & Kiszka, 2001). However, as the epixylic form of *A. sphagnorum* often produces smaller ascomata than its typical, epibryophytic representatives (for example *Czarnota* 5129, see below), some anatomical differences in thickness and degree of elevation of the excipulum can be helpful in the discrimination. *A. sphagnorum* has a stout, to 50 µm wide excipulum in the upper part, thus protruding distinctly above apothecial disc, while *A. delutula* has a narrower, to 30 µm wide excipulum, not so sharply delimited from the disc. In contrast to the dimensions of the margin, the ascospores of *A. sphagnorum* are smaller, being mainly 2.5–4.0 µm wide, while those of *A. delutula* are mostly 3.5–5.0 µm wide.

Absconditella delutula is a rarely reported species elsewhere, but probably very widely distributed. It is mostly known from Europe, being sparsely recorded from e.g. Belgium (Sérusiaux et al., 2006), Fennoscandia (Santesson et al., 2004), British Isles (Coppins, 1992; Fox, 2004), Germany (e.g. Scholz, 2000; Cezanne et al., 2002; Otte & Rätzel, 2004) the Netherlands (Aptroot et al., 2004) and Ukrainian, as well as Slovak Eastern Carpathians (Khodosovtsev & Postoyalkin, 2006; Pišut et al., 2007). The species is also known from Greenland (Kristinsson at al., 2006), Vietnam (Aptroot & Sparrius, 2006) and Australia, including Tasmania (Hafellner et al., 1989; Kantvilas, 2005).

Specimens examined. [Ac–38] – Wybrzeże Słowińskie coast, 'Bielawa' nature reserve, 54°47.666'N/18°14.032'E, the ground in plant communities covering burnt places, 27.09.2006, leg. R. Markowski (UGDA); **[Bf–68] –** Biebrza Valley, Biebrzański National Park, forest sections Nos 144 and 145, near Grzędy settlement, on wood within *Betuletum pubescentis*, 15.09.2005, leg. E. Bylińska, M. Kukwa, M. Seaward (Hb. Kolanko); **[Ge–00] –** Western Beskidy Mts, Beskid Wyspowy Mts, S slope of Lubomir Mt., 49°45'16"N/20°03'07"E, on sandstone pebbles, 09.04.2007, leg. P. Czarnota 5136 (GPN, dupl. UGDA-L-14634); **[Ge–10] –** Western Beskidy Mts, Gorce Mts, 0.5 km S of Poręba Górna–Jasionów settlement, 49°35'01"N/20°02'13"E, on sandstone pebbles, 8.04.2007, leg. P. Czarnota 5137 (GPN); **[Ge–11] –** Gorce Mts, above Rzeki-Cerkowe settlement, on sandstone rocks, 7.05.2003, leg. P. Czarnota 3234 (GNP); **[Ge–12]** – Beskid Wyspowy Mts, W slope of Modyń Mt., 49°37'30"N/20°22'40"E, alt. 850 m, on sandstone pebble, 2.07.2005, leg. P. Czarnota 5014 (GPN).

Additional specimen examined. Czech Republic, CHKO Łužicke Hory ca 0.5 km W of Studeny village, 50°50.60'/14°27.16'E, on sandstone boulders near stream in broad-leaf forest, 26.03.2003, leg. P. Czarnota 3320 (GPN).

Absconditella lignicola Vězda & Pišút

This species is widespread in temperate regions of the Northern Hemisphere (Bielczyk & Kiszka, 2001 and literature cited therein). In Poland it has started to be reported for last ca 10 years. Some of the records were based on old herbarium findings, and these showed that the species should have been listed from Poland 50 years ago (Bielczyk & Kiszka, 2001).

At first, *A. lignicola* was mostly known from the Carpathians with a few additional records in NE Poland (see e.g. Fałtynowicz, 2003). Elsewhere the species seemed to be rare, despite it being found also in several localities in central Poland (Czyżewska, 2003a; Łubek, 2003). For that reason *A. lignicola* was included in some regional red lists of lichens in category NT (Near Threatened) as in the case of Opole and Upper Silesia

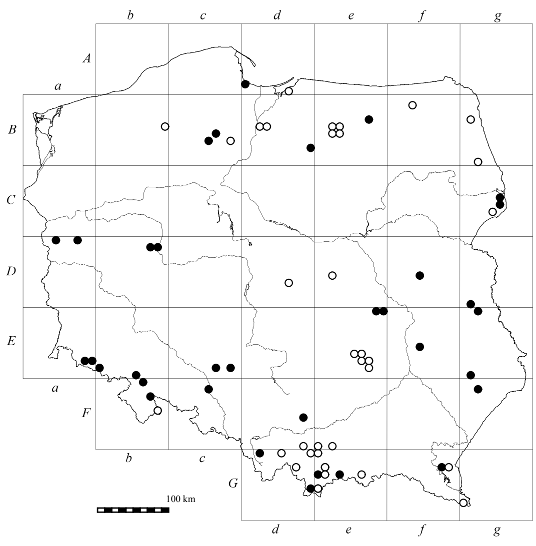

Fig. 1. Known distribution of *Absconditella lignicola* in Poland; ○ – localities reported prior to this publication, ● – new findings.

Regions (Kiszka & Leśniański, 2003) or in DD (Data Deficient) as in Pilicka Forest (Czyżewska, 2003b) and Góry Świętokrzyskie Mts (Cieśliński & Łubek, 2003). Later, the species was reported by Hachułka (2005), Kubiak (2005), Kukwa (2007) and Kukwa and Jabłońska (2007). The list of examined specimens presented below includes only those that have never been reported before, but the distribution map of *A. lignicola* in Poland (Fig. 1) is based on all its known records.

The new data presented here concurs with the results of investigations from several other European countries [e.g. in the Czech Republic (Palice, 1999)] that *A. lignicola* is not rare, but a typical ephemeral, epixylic pioneer colonizer, widespread throughout Poland, and locally even very common. In the Karkonosze Mts, for example, it has recently been recorded almost twenty times (Staniaszek-Kik, pers. comm.; see also selected specimens examined below). It has a broad ecological amplitude and grows both in natural forests (e.g. quite commonly in different ancient stands of the Białowieża Forest or upper montane spruce forest in the Carpathians), as well as in completely artificial coniferous monocultures or other heavily managed woodlands. It seems to occur in almost every type of older forest where some decaying wood is laying. Lisická (2006) went further and included *A. lignicola* into the small group of toxitolerant species (together with e.g. *Fellhanera subtilis* and *Hypocenomyce caradocensis*).

Selected specimens examined (all specimens on wood). **[Ad–80]** – Pobrzeże Kaszubskie coastland, Gdańsk Oliwa town, 'Źródliska w Dolinie Ewy' nature reserve, 54°25'N/18°32'E, 22.08.2002, leg. M. Zakrzewska (UGDA-L-9290); **[Bc–56]** – Bory Tucholskie Forest, Ustronie forest district, forest section No. 23j, 16.08.2002, leg. P. Czarnota 3103 (GPN); ibid., Dąbki forest district, forest section No. 48l, 15.08.2002, leg. P. Czarnota 3065 (GPN); **[Bc–65]** – Bory Tucholskie Forest, Biała forest district, forest section No. 129, 16.08.2002, leg. P. Czarnota 3081 (GPN); **[Bd–79]** – Wzgórza Dylewskie Landscape Park, forest section No. 100j, 13 Sept. 2002, leg. P. Czarnota (GPN 3235), **[Be–37]** – Pojezierze Mrągowskie lakeland, by NW part of Kiersztanowskie Lake, 53°57'03"N/21°13'47"E, 4.07.2006, leg. M. Kukwa 5257 (UGDA); **[Cg–45]** – Białowieża Primeval Forest, Browsk forest division, forest section No. 153, 13.06.1999, leg. K. Czyżewska (LOD-L-11120, together with *Micarea micrococca*); **[Cg–55]** – Białowieża Primeval Forest, Białowieski National Park, forest section No. 340A, 12.08.2002, leg. P. Czarnota 2944 & 2967 (GPN); ibid., forest section No. 342A, 2.05.2004, leg. M. Kukwa 3229

(UGDA-L-10233); ibid., forest section No. 399B, 52°43'22"N/23°51'11"E, 2.05.2004, leg. M. Kukwa 3243 & 3249 (UGDA-L-10247 & 12711), 10.05.2006, leg. P. Czarnota 5027 (GPN); **[Cg–64] –** Białowieża Primeval Forest, vicinity of Topiło village, forest section No. 599, 52°38'40"N/23°38'02"E, 12.05.2006, leg. M. Kukwa 5097 (UGDA); NE of Topiło village, forest section No. 599B, 52°38'36"N/23°38'04"E, 12.05.2006, leg. P. Czarnota 5019 (GPN); Białowieża forest division, forest section No. 671, 52°37'16"N/23°43'24"E, 13.05.2006, leg. P. Czarnota 5102 (GPN); **[Da–04] –** Puszcza Rzepińska Forest, ca 4 km S of Rzepin town, 52°18'03"N/14°46'37"E, 8.04.2006, leg. P. Czarnota 4844 (GPN); **[Da–07] –** Puszcza Rzepińska Forest, close the border of 'Pawski Ług' nature reserve, 52°18'44"N/15°15'27"E, 8.04.2006, leg. P. Czarnota 4801 (GPN); **[Db–17] –** Wielkopolski National Park, 'Grabina' nature reserve, near Góreckie Lake, 19.05.2004, leg. P. Czarnota 3902 (GPN); **[Db–18] –** Wielkopolski National Park, Wiry forest district, forest section No. 42, 52°17'56"N/16°49'36"E, 19.05.2004, leg. P. Czarnota 3904 (GPN); ibid., forest section no 46f, 52°17'54"N/16°49'36"E, 19.05.2004, leg. P. Czarnota 3908 (GPN); **[Df–54] –** Równina Łukowska plain, near 'Jata' nature reserve, 51°57'11"N/22°11'53"E, 21.06.2005, leg. P. Czarnota 4662 (GPN); **[Dg–91] –** Równina Łęczyńsko-Włodawska plain, Lasy Parczewskie Wood, ca 2 km NE of Stary Orzechów village, 51°30'14"N/23°02'53"E, alt. 180 m, 27.10.2004, leg. P. Czarnota 4218 (GPN); **[Ea–78] –** Pogórze Karkonoskie foothills, near Michałowice village, 50°50.325'N/15°35.430'E, alt. 620 m, 27.09.2003, leg. M. Staniaszek-Kik (WRSL); Western Sudetes, Karkonoski National Park, vicinity of Wodospad Szklarki waterfall, 50°49.922'N/15°33.575'E, alt. 540 m, 26.07.2003, leg. M. Staniaszek-Kik (WRSL); Dolne Gawry area, 50°48.444'N/15°33.991'E, alt. 710 m, 23.07.2004, leg. M. Staniaszek-Kik (WRSL); **[Ea–79] –** Karkonosze Mts, Karkonoski National Park, valley of Sopot stream, 50°48.196'N/15°37.267'E, alt. 700 m, 13.07.2004, leg. M. Staniaszek-Kik (WRSL); Hojnik Mt., vicinity of Zbójeckie Skały outcrops, 50°50.211'N/15°38.858'E, alt. 520 m, 25.07.2003, leg. M. Staniaszek-Kik (WRSL); Leśniak Mt. near Jagniątków village, 50°48.223'N/15°36.478'E, alt. ca 820 m, 13.08.2003, leg. M. Staniaszek-Kik (WRSL); **[Eb–80] –** Karkonosze Mts, Karkonoski National Park, N slope of Czarna Kopa Mt., 50°44.878'N/15°46.465'E, alt. 1120 m, 1.09.2003, leg. M. Staniaszek-Kik (WRSL); Kowary Górne settlement, 50°46.750' N/15°50.573'E, alt. 570 m, 4.09.2003, leg. M. Staniaszek-Kik (WRSL); Łomniczka Valley, 50°45.379'N/15°45.462'E, alt. 740 m, 27.07.2004, leg. M. Staniaszek-Kik (WRSL); **[Eb–95] –** Middle Sudetes, Góry Sowie Mts, S slope of Wielka Sowa Mt. above Sokolec village, 50°39'55"N/16°29'30"E, alt. 700 m, 21.04.2005, leg. P. Czarnota 4693 (GPN); **[Ec–86] –** Równina Opolska plain, Turawa forest division, forest section No. 70h, 22.08.2003, leg. M. Marzec (UGDA-L-9026); **[Ec–88] –** Wyżyna Woźnicko-Wieluńska upland, Próg Woźnicki hummock, 7 km S of Olesno town, 50°48'38"N/18°24'31"E, alt. 260 m, 4.07.2005, leg P. Czarnota 4516 (GPN); **[Ee–66] –** Góry Świętokrzyskie Mts, Świętokrzyski National Park, 'Czarny Las' nature reserve, forest section No. 42, 16.07.2001, leg. A. Donica (KTC); **[Ee–77] –** Góry Świętokrzyskie Mts, Świętokrzyski National Park, S slope of Łysa Góra Mt., 50°51'36"N/21°02'43"E, alt. 580 m, 6.05.2004, leg P. Czarnota 3829 (GPN); **[Ef–54] –** Wzniesienia Urzędowskie hills, between Urzędów and Dzierzkowice villages, alt. 200 m, 19.05.2003, leg. P. Czarnota 4194 (GPN); **[Eg–02] –** Poleski National Park, Kochanowskie forest district, forest section No. 192 b, 51°25'37"N/23°10'51"E, 27.04.2004, leg. P. Czarnota 3870 (GPN); **[Eg–91] –** Middle Roztocze, Roztoczański National Park, Stogi forest district, forest section No. 178, 50°35'42"N/23°04'42"E, alt. 250 m, 28.04.2004, leg. P. Czarnota 3896 (GPN); S of Zwierzyniec village, 'Bukowa Góra' nature reserve, 50°35'47"N/22°57'48"E, alt. ca 280 m, 30.04.2006, leg. M. Kukwa 5036a (UGDA); **[Fb–06] –** Góry Sowie Mts, S slope of Chochoł Wielki Mt., ca 1.5 km NW of Srebrna Góra village, 50°34.43'N/16°37.85'E, 22.04.2004, leg. P. Czarnota 4149 & 4146 (GPN) and M. Kukwa 3115 (UGDA-L-10301); **[Fb–27] –** Eastern Sudetes, Góry Złote Mts, ca 1.5 km S of Złoty Potok town, 50°26'20"N/16°51'18"E, alt. 450 m, 19.04.2005, leg. P. Czarnota 4463 (GPN); [**Fc–15] –** Równina Niemodlińska plain, Bory Niemodlińskie Forest, W of Gwoździce village, 50°30'34"N/17°54'54"E, alt. 130 m, decaying pine log, 23.04.2005, leg. P. Czarnota 4460 (GPN); **[Fd–58] –** Ojcowski National Park, Sąspowska Valley, near Jaskinia Łokietka karst cave, 50°12.04'N/16°49.12'E, alt. 340 m, 15.04.2004, leg. P. Czarnota 4139 (GPN); **[Fg–12] –** Puszcza Solska Forest, Kalina forest district, 'Czartowe Pole' nature reserve, 50°26'25"N/23°06'30"E, alt. ca 250 m, 28.10.2004, leg. P. Czarnota 4231 (GPN); **[Gd–02] –** Western Beskidy Mts, Beskid Śląski Mts, valley of Wapienica stream, S of Bielsko-Biała town, decaying wood, 26 Apr. 2000, leg. G. Leśniański (OPUN); **[Gd–59] –** West Tatra Mts, Tatra National Park, forest section No. 209f, Dolina Strążyska valley, 28.06.2002, leg. P. Czarnota 2827 (GPN); **[Ge–21] –** Western Beskidy Mts, Gorce Mts, Gorce National Park, Kamienica Valley, alt. 800 m, stump, leg. K. Glanc (KRAM); ibid., valley of Jaszcze Duże stream, N slope of Borsuczyny Mt, alt. 1020 m, leg. K. Glanc (KRAM); **[Ge–30] –** Kotlina Nowotarska basin, 'Bór na Czerwonem' nature reserve, 49°27.84'N/20°02.35'E, alt. 620 m, wood of pine log, 4.06.2003, leg. P. Czarnota 4186 (GPN); **[Ge–33] –** Pieniny Mts, Pieniński National Park, valley of Ociemny stream, 49°25'46"N/20°25'41"E, alt. ca 600 m, decaying stump, 13.05.2004, leg. P. Czarnota 3841 (GPN); **[Ge–50] –** Rów Podtatrzański depression, near Małe Ciche village, Pańszczykowa Polana glade, 49°17'30"N/20°03'35"E, alt. 925 m, 16.06.2004, leg. L. Śliwa 2308 (KRAM, together with *Micarea prasina*); **[Gf–27] –** Góry Sanocko-Turczańskie Mts, the main ridge of Góry Słonne Mts, 29.05.1990, leg. J. Kiszka (BDPA, together with *Micarea prasina*).

Absconditella pauxilla Vězda & Vivant

This species is here reported as new to Poland. It is a rare lichen throughout Europe, and so far in Central Europe it has been reported only by Palice (1999). Earlier the species was known only from few regions, e.g. Great Britain (Coppins, 1992; Woods & Coppins, 2003), Ireland (Seaward, 1994; Fox, 2004), French Pyrenees, the Netherlands (Palice, 1999; Aptroot et al., 2004) and Sweden (Santesson et al., 2004). It is known also from Africa (Madeira) (Pišút, 2004). Considering the so-far known distribution of *A. pauxilla*, the Polish finds extend its known geographic range to the East and confirm its occurrence in the Baltic region.

Absconditella pauxilla occupies decaying bryophytes or wood in humid niches, e.g. in peat bogs (as like in Polish cases). In Scotland it was thought to be confined to the native pinewoods of the Scottish Highlands (Coppins & Coppins, 2006), but has since been found in southern Scotland on old *Juniperus* stems (Coppins, pers. comm.) and in a conifer plantation on an attached dead twig of *Picea sitchensis* (Coppins 2007).

The Polish specimens are rather small with very few apothecia, and many of them were immature, however, in some the typical acicular ascospores were found.

Specimens examined. [Ac–86] – Pojezierze Kaszubskie lakeland, 'Staniszewskie Błoto' nature reserve, forest section No. 209, *Vaccinio uliginosi-Pinetum*, wood, 27.09.1983, leg. W. Fałtynowicz (GPN 3175); 'Kurze Grzędy' nature reserve, forest section No. 102d, *Vaccinio uliginosi-Betuletum pubescentis*, bark of stump, 26.05.2005, leg. M. Kukwa 4157 (UGDA).

Absconditella sphagnorum Vězda & Poelt

This species has been found in many places throughout Europe and is also known from North America (Coppins, 1992; Harris, 2004). So far it has been reported mostly from Sweden and Finland (Santesson et al., 2004), lowland peat-bogs in northern Ladoga region in Russian Karelia (Alstrup et al., 2005), Estonia (Aptroot et al., 2005), N Poland (Ceynowa-Giełdoń, 2003), NE Germany (Scholz 2000), as well as in Central Europe in bogs in the Polish Tatra region (Bielczyk & Kiszka, 2001), Slovak Central Western Carpathians (Guttová & Palice, 1999), Šumava Mts (Palice, 1999) and the Alps (Hafellner & Türk, 2001; Wirth, 1995). However, there are also localities known from western, hyperoceanic part of Europe (e.g. Santesson et al., 2004; Aptroot et al., 2004), including British Isles (Coppins, 1992, 1999). Possibly it may be found more frequently in large peat-bogs in the cooler zone of the Holarctic.

Decaying bryophytes (mainly *Sphagnum*) are preferred by *A. sphagnorum* as the main substratum, however, as Polish gatherings presented here show, sometimes the species grows also on wood of decaying stumps or logs, but within bog pine forest. Until now several Polish collections of *A. sphagnorum* were reported from only two regions of the country, a large inter-Carpathian peat-bog confined to the Kotlina Orawsko-Nowotarska basin (Bielczyk & Kiszka, 2001; Bielczyk & Betleja, 2003) and from the Bory Tucholskie Forest (Ceynowa-Giełdon, 2003; see distribution map included therein). The new localities presented here extend northwards the known Polish geographic range and also further to the East including the former large post-glacial basin between Vistula River and San River.

Because of its 1-septate ascospores, similar to those of *A. delutula*, lignicolous collections of both species may be confused; for differences see under *A. delutula*.

Specimens examined. [Ac–75] – Pojezierze Kaszubskie lakeland, W of Linia village, Białe Błoto peat bog, 54°28'49"N/17°53'17"E, on *Sphagnum* and *Polytrichum* on hummocks, 04.11.2004, leg. M. Kukwa 3624 (UGDA-L-11359); **[Ac–86] –** Pojezierze Kaszubskie lakeland, 'Kurze Grzędy' nature reserve, forest section No. 135h, wood in bog pine forest, 27.05.2005, leg. M. Kukwa 4211 (UGDA); **[Bc–26] –** Bory Tucholskie Forest, 0.5 km NE of Lipa village at E shore of Wdzydze Lake, by tourist track, 53°59'31"N/17°56'36"E, wood of pine in pine forest, 13.10.2006, leg. P. Czarnota 5129 (GPN); **[Ef–97] –** Kotlina Sandomierska basin, Równina Biłgorajska plain, Lasy Janowskie Landscape Park, Porytowe Wzgórze, ca 2.5 km S of Flisy village, 50°37.80'N/22°27.99'E, alt. ca 220 m, wood of pine in local bog pine forest, 10.10.2003, leg. P. Czarnota 3448 (GPN).

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Contribution to the knowledge of some poorly known lichens in Poland. II. The genus *Psilolechia*

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Abstract: *Psilolechia leprosa* is reported as new to Poland and Sudetes Mts. It was found on metal enriched melaphyre rocks. The distribution of *P. clavulifera* is reviewed and the new records show it has been very much undercollected. The chemistry of *P. lucida* in Poland was investigated and it was found to produce more substances of unknown structure, than previously reported.

Kokkuvõte: Panus Poola vähetuntud samblike tundmisse. II. Perekond *Psilolechia*.

Teatatakse *Psilolechia leprosa* esmaleiust Poolas ja Sudeedi mägedes. Antakse ülevaade *P. clavulifera* levikust koos uute leidudega. *P. lucida* keemilise koostise uurimisel leiti Poola materjalist uusi tundmatu struktuuriga aineid.

INTRODUCTION

Although a review of the genus *Psilolechia* A. Massal. was presented almost 20 years ago (Coppins & Purvis, 1987) no new species have since been recognized. So far only four taxa are known in the genus: *P. clavulifera* (Nyl.) Coppins, *P. leprosa* Coppins & Purvis, *P. lucida* (Ach.) M. Choisy and *P. purpurascens* Coppins & Purvis. The last one is still known only from Tasmania and seems to be very rare (Coppins & Purvis, 1987). The others are widespread throughout Europe, and all are known from Poland. However, only *P. lucida* was more frequently recognized so far and reported from different, mainly mountainous regions in the country (Fałtynowicz, 2003 and literature cited therein). Nevertheless, in Poland the secondary chemistry of that taxon was never studied. The first Polish report of *P. clavulifera* was published only recently (Nowak, 1998), but the record was based on a find from 1964, when the species was not recognized by Polish lichenologists. It has since been reported few times (see Fałtynowicz, 2003 and literature cited therein; Czarnota et al., 2005) (Fig. 1). Hitherto, *P. leprosa*, considered as probably an 'Atlantic' species, has not been found in this part of Europe. The new locality from western Poland extends its geographical range to the East. More intensive lichenological explorations of old mines and mineral-rich rocks, the substrata preferred by the species, are required to ascertain the real distribution of the species in this part of Europe.

The aim of this paper is to present new information and new records of three species of *Psilolechia* in Poland. The work is the second one in a series contributing to the knowledge of some poorly known lichens in the country (see Czarnota & Kukwa, 2008).

MATERIAL AND METHODS

Specimens from GPN, KRAM, KTC, POZ and UGDA were revised. Secondary substances were analyzed by TLC according to the methods of Orange et al. (2001). Solvent systems A and B were used for the identification of substances present in *P. leprosa*, whereas A and C in the case of *P. lucida*. To investigate the chemical variation of *P. lucida*, only a part of Polish collection was revised with representative gatherings from northern (lowland) and southern (mountainous) distributional ranges. The localities of all taxa are presented in the ATPOL grid square system (see Cieśliński & Fałtynowicz, 1993; see also Kukwa et al., 2002).

A key for the identification of all taxa was presented by Coppins and Purvis (1987, 1992).

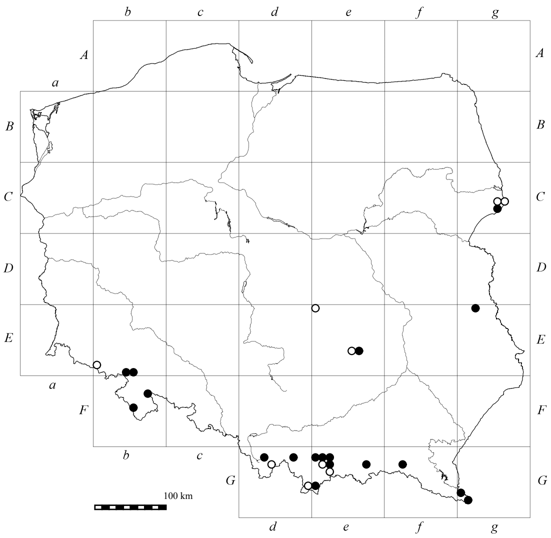

Fig. 1. Known distribution of *Psilolechia clavulifera* in Poland; ○ – localities reported prior to this publication, ● – new findings.

THE SPECIES

Psilolechia clavulifera (Nyl.) Coppins

This species was rather neglected in the past, but is better known since Coppins (1983) conducted a detailed taxonomic study of *Lecidea clavulifera* Nyl. Similar to the other European representatives of the genus, *P. clavulifera* is characterized by almost mealy, leprose thallus, small, immarginate, convex apothecia, one type of stout, multiseptate paraphyses, dacryoid ascospores and a *Psora*-type ascus (see e.g. Coppins & Purvis, 1987; Coppins, 1988; Ekman et al., 2004). It differs from other *Psilolechia* species in having conidiogenous cells arising directly from thallus hyphae (hyphomycetous anamorph like that of *Chaenotheca furfuracea*), dark coloured (mostly black) apothecia and greenish, K+ dulling hymenial pigment ('Cinereorufa-green' according to the nomenclature of Meyer & Printzen, 2000). In Poland *P. clavulifera* prefers consolidated soil, siliceous rocks and roots in dry underhangs or the root systems of upended trees. The same habitat preferences were reported also by Coppins (1983) and Coppins and Purvis (1987).

The species was rarely found in Poland (Fałtynowicz, 2003 and literature cited therein) and for that reason it was included in the general (Cieśliński et al., 2003) as well as in a few regional red lists of threatened lichens (Czyżewska, 2003; Czyżewska & Cieśliński, 2003; Kiszka & Leśniański, 2003). However, the new data presented here clearly shows that this ephemeral species is much more widespread, and especially in mountains it should be regarded as a quite common lichen. In this paper it is reported as new for many regions of Poland, including e.g. the whole Tatra Mts (see Bielczyk, 2003; Lisická, 2005).

Until recently *P. clavulifera* has been considered elsewhere as a rare species; only in Great Britain and the Czech Republic has it been reported more frequently (e.g. Coppins, 1983; Motiejūnaitė, 1999; Palice, 1999). At present it is reported throughout Europe and moreover is known in both Americas and Australoceania (Coppins & Purvis, 1987; Flakus et al., 2006). Most probably it was overlooked several times because of its similarity to other leprose, sterile species (e.g. *Chaenotheca stemonea*, *Lepraria* spp.) and very specific ecological requirements. In the light of the present data it does not seem to belong in the 'west-European' element as previously considered by Berger and Türk (1995).

Specimens examined. [Cg–65] – Równina Bielska plain, Białowieża Primeval Forest, Białowieża forest district, forest section No. 494, pine forest *Vaccinio vitis-idaeae-Pinetum*, on roots and soil among root-system of fallen *Picea abies*, 13.08.2002, leg. P. Czarnota 3031 (GPN); **[Eb–80]** – Western Sudetes, Karkonosze Mts, Łomniczka Valley, 50°45.52'N/15°45.62'E, alt. 750 m, on granite rocks within shady spruce forest, 7.07.2003, leg. P. Czarnota 3681 (GPN); ibid., alt. 800 m, on shaded vertical wall of granite boulder, 7.07.2003, leg. P. Czarnota 3455 (GPN); ibid., 50°44.60'N/15°43.98'E, alt. 1200 m, at the base of shaded granite boulders by stream, 7.07.2003, leg. P. Czarnota 3453 (GPN); ibid., Karpacz-Wilcza Poręba near Storczyk student hostel, 50°45'N/15°45'E, alt. ca 700 m, in underhangs on vertical wall of granite boulder within shady spruce plantation, 7.07.2003, leg. P. Czarnota 3540 (GPN); see Dimos-Zych & Czarnota 2007); ibid., 2.05.2002, leg. M. Kukwa 1520 (UGDA); **[Eb–94] –** Middle Sudetes, Góry Kamienne Mts, ca 1 km W of Grzmiąca village, by Rybnica stream, 50°42'20"N/16°18'55"E, alt. ca 450 m, on vertical walls of melaphyre rocks in shaded valley, 21.04.2005, leg. P. Czarnota 4468 (GPN); **[Eb–95] –** Middle Sudetes, Góry Sowie Mts, S slope of Wielka Sowa Mt., above Sokolec village, 50°40'01"N/16°29'43"E, alt. 770 m, on wood of spruce root in underhang, 21.04.2005, leg. P. Czarnota 4686 (GPN); ibid., 50°39'50"N/16°29'16"E, alt. ca 690 m, on metamorphic boulders within artificial spruce forest, 21.04.2005, leg. P. Czarnota 4700 (GPN); **[Ee–66] –** Wyżyna Kielecka upland, Góry

Świętokrzyskie Mts, Świętokrzyski National Park, Podgórze forest district, 'Czarny Las' nature reserve, forest section No. 42, on root-system of fallen tree, leg. A. Donica, 16.07.2001 (KTC); **[Eg–02] –** Polesie, Równina Łęczyńsko-Włodawska plain, Poleski National Park, Kochanowskie forest division, forest section no.192 b, 51°25'35"N/23°10'49"E, on bark of *Pinus sylvestris*, 27.04.2004, leg. P. Czarnota 3885 (GPN); **[Fb–27] –** Eastern Sudetes, Góry Złote Mts, by the road between Złota Góra and Lądek Zdrój towns, 50°23'23"N/16°50'46"E, alt. ca 590 m, on metamorphic rocks within forest, 19.04.2005, leg. P. Czarnota 4615 (GPN); **[Fb–45] –** Middle Sudetes, Góry Bystrzyckie Mts, by the road between Poręba village and Spalone Pass, 50°14'10"N/16°34'29"E, alt. ca 610 m, on decaying bark of roots of *Picea abies* in underhangs, 20.04.2005, leg. P. Czarnota 4773 (GPN); ibid., on metamorphic rocks 'gneiss', leg. P. Czarnota 4400 (GPN); **[Gd–13] –** Western Beskidy Mts, Beskid Śląski Mts, E slope of Barania Góra Mt., on clayey soil and roots of fallen *Picea abies* root-system within shady spruce-beech forest, 10.05.2002, leg. P. Czarnota 2797 (GPN); **[Gd–17] –** Western Beskidy Mts, Pasmo Babiogórskie Range, NE slope of Polica Mt., Skawica forest district, forest section no. 23, alt. 770 m, on roots and soil in underhang, 4.06.2004, leg. P. Czarnota 3934 (GPN); **[Gd–24] –** Beskid Żywiecki Mts, Pilsko range, Romanka Mt., alt. ca 1200 m, on vertical, shaded walls of sandstone boulders, 09.1964, leg. J. Nowak (KRAM-L–16948; see Nowak 1998); **[Gd–59] –** Rów Podtatrzański depression, Magura Witowska range, N of Hawryłówka glade; 49°17'30"N/19°50'37"E, alt. 890 m, on roots of *Picea abies*, 17.07.2004, leg. L. Śliwa 3246 (KRAM; see Śliwa 2006); **[Ge–10] –** Western Beskidy Mts, Gorce Mts, Rabka – Zaryte settlement, by Raba River below Królewska Góra hill, alt. 480 m, on roots and soil in underhang, 16.12.2006, leg. P. Czarnota 4949 (GPN); **[Ge–11] –** Western Beskidy Mts, Gorce Mts, E slope of Kudłoń Mts, the beginning of Rosocha stream, alt. 1120 m, clayey soil and roots of fallen spruce, 6.11.2001, leg. P. Czarnota 2684 (GPN); ibid., E slope of Gorc Troszacki Mt., the beginning area of Gorcowy Potok stream, alt. 1080 m, on clayey soil and roots of fallen spruce, 20.12.2000, leg. P. Czarnota 2692 (GPN); ibid., alt. 1100 m, leg. P. Czarnota 2387 (GPN); **[Ge–12] –** Western Beskidy Mts, Beskid Wyspowy Mts, W slope of Modyń Mt., ca 0.5 km E of Zalesie village, 49°37'23"N/20°22'37"E, alt. 890 m, in underhang on bark of stump and roots of *Picea abies* within spruce-fir mountain forest, 2.07.2005, leg. P. Czarnota 4596 (GPN); **[Ge–21] –** Western Beskidy Mts, Gorce Mts, Kamienica Valley below Bieniowe glade, alt. 840 m, on clayey soil, 15.05.1997, leg. P. Czarnota 1680 (GPN; see Czarnota 2000); ibid., W slope of Kudłoń Mt., alt. 1240 m, on clayey soil and roots of fallen spruce within upper spruce forest, 6.11.2001, leg. P. Czarnota 2683 (GPN); ibid., on small sandstone pebbles in fallen root-system of *Picea abies*, leg. P. Czarnota 2681 (GPN); ibid., S slope of Kudłoń Mt., alt. 1150 m, in root-system of *Picea abies*, leg. P. Czarnota 2680 (GPN); **[Ge–22] –** Gorce Mts. Lubań Range, valley of Rolnicki stream, alt. 660 m, 18.10.2004, leg. P. Czarnota 5235 & A. Wojnarowicz (GPN); **[Ge–27] –** Beskid Niski Mts, Experimental Forest of Agriculture University in Kraków, Kopciowa forest district, vicinity of Krzyżówka settlement by the road to Tylicz village, 49°29'03"N/20°56'57"E, on bark at the base of *Abies alba* trunk within fir-spruce mountain forest, 25.09.2005, leg. P. Czarnota 4562 (GPN); **[Ge–32] –** Western Beskidy Mts, Gorce Mts, Mraźnica glade, SE slope of Lubań, alt. 950 m, 9.08.1968, leg. K. Glanc (KRAM-L–36976; see Czarnota et al. 2005); **[Ge–50] –** Tatra Mts, High Tatra Mts, Roztoka Valley near Wodogrzmoty Mickiewicza waterfall, 49°13'N/20°04'E, alt. 1120 m, on small underhanged roots of *Picea abies* within shady upper spruce forest, 8.08.2003, leg. P. Czarnota 3331 (GPN); **[Gf–22] –** Middle Beskidy Mts, Beskid Niski Mts, S slope of Piotruś Mt., above Stasianie settlement, 49°28'11"N/21°44'57"E, alt. ca 670 m, on sandstone outcrop within shady Carpathian beech forest, 5.08.2004, leg. P. Czarnota 4053 (GPN); **[Gg–60] –** Eastern Beskidy Mts, Bieszczady Mts, S of Stuposiany village, SE of former village Pszczeliny, alt. ca 650 m, on decaying stump inside mixed mountain forest, 29.07.1959, leg. Z. Tobolewski (POZ); **[Gg–71] –** Bieszczady Mts, Bieszczadzki National Park, Sianki forest district, forest sec. no 78i, on clayey soil among root-system of fallen *Picea abies* within mixed forest, 19.06.2002, leg. P. Czarnota 2862 (GPN); ibid., Górny San forest division, E slope of Piniaszkowy Garb Mt., alt. 880 m, 24.08.1999, on soil between roots of fallen fir tree, leg. J. Kiszka (KRAP; published as *Micarea bauschiana*; specimen originally labeled: Sianki, by stream, loc.12).

Psilolechia leprosa Coppins & Purvis

Psilolechia leprosa is regarded as a saxicolous lichenized fungus confined to metal-enriched habitats and occurring especially frequently on underhangs, shaded siliceous or slightly calcareous rocky walls contaminated by copper or other heavy metals (e.g. iron), mainly in artificial (e.g. in old mines), but also in natural habitats (Coppins & Purvis, 1987; Purvis & Halls, 1996). In the oceanic area of Europe it has also been found on bricks (e.g. Boom & Boom, 2006). Here it is reported as new to Poland and the Sudetes Mts.

In Poland the species has been collected only once, in Góry Kamienne Mts, a part of the Sudetes Mts. It is probably common in that region as that mountain range has many metal-enriched geological formations, e.g. iron-rich red melaphyre, a substratum of the Polish finding. In Poland *P. leprosa* was accompanied by *Lepraria* sp., *Micarea botryoides*, *M. lignaria*, *M. myriocarpa*, *M. sylvicola* and *Psilolechia clavulifera*.

Considering its whitish-green, mealy, usually leprose and sterile thallus, *P. leprosa* morphologically resembles many species of the genus *Lepraria* as also previously suggested by Coppins and Purvis (1987). Particularly, *L. crassissima* is similar, as it also reacts C+ red. Those taxa differ chemically and ecologically; gyrophoric acid is responsible for the red reaction in *P. leprosa* (Coppins & Purvis, 1987), while in *L. crassissima* nordivaricatic acid reacts in the same way (Kukwa, 2006). *P. leprosa* grows usually on metal-enriched, siliceous rocks, whereas *L. crassissima* usually prefers calcareous substrata including sandstone and pure limestone (Czarnota & Kukwa, 2001; Kukwa, 2006).

Psilolechia leprosa seems to be a widespread, regionally quite common and probably Atlantic species in Europe. It is known from British Isles, Scandinavia and Greenland (Coppins & Purvis, 1987; Seaward, 1994; Santesson et al., 2004), Iceland (Kristinsson & Heidmarsson, 2006), Belgium (Boom & Boom, 2006; Diederich et al., 2006), German Lower Saxony (Scholz, 2000), the Netherlands (Aptroot et al., 2004) and Sicily (Boom, 1992). In Central Europe it was previously known only from crystalline rocks in the Romanian Ratezat Mts (Ciurchea, 1998).

Chemistry: thallus C+ red; TLC: gyrophoric acid (major), lecanoric acid (trace), porphyrilic acid (submajor), three terpenoids, one in high concentration (Rf class A 6–7; B5) and two in traces (Rf classes A6, B6 and A5–6, B6).

Specimen examined. [Eb–94] – Middle Sudetes, Góry Kamienne Mts, ca 1 km W of Grzmiąca village, by Rybnica stream, 50°42'20"N/16°18'55"E, alt. ca 450 m, on vertical walls of melaphyre rocks in shaded valley, 21.04.2005, leg. P. Czarnota 4470 (GPN).

Additional specimen examined. United Kingdom. West Cornwall, V.C. 1, Redruth, Todpool, St. Day, Poldice Mine, 10/742429, alt. c. 65 m, north-facing granite-mortar walls associated with Cu and Sn, leg. P. W. James & O. W. Purvis (BM, holotype).

Psilolechia lucida **(Ach.) M. Choisy**

A widespread species throughout the world (e. g. Coppins & Purvis, 1987; Øvstedal & Lewis Smith, 2001; Flakus et al., 2006) growing on natural (various siliceous as well as calcareous rocks) and artificial (concrete, bricks) rocky substrata, usually in shaded places, often in sheltered underhangs. Occasionally it was found also on a hard wood, bark at the base of trees, roots, epilithic bryophytes, humus and clayey soil (Coppins & Purvis, 1987; Tønsberg, 1992; Palice et al., 2003). In Poland it is locally common (Bielczyk, 2003; Fałtynowicz, 2003 and literature cited therein). In the northern part of the country it seems to be confined to postglacial boulders and old brick walls of buildings. In southern regions it grows on natural, vertical rocky walls and stones shaded by forest.

Coppins and Purvis (1987) indicated two chemical races of *P. lucida*, first, known all over the world, with rhizocarpic acid as a major secondary substance together with some unknown substances (see also Tønsberg, 1992) and second, reported only from Australia and New Zealand, with rhizocarpic acid and zeorin. All so far examined Polish specimens represent the first chemotype. In studied material we found, however, that there are 8 unknown substances in minor to trace amounts, 7 of them being most probably terpenoids. All of them were detectable only on plates developed in solvent C. On plates in solvent A the position of some overlap, therefore the number was lower and the result similar to those reported by Coppins and Purvis (1983). Rhizocarpic acid was usually accompanied by an unknown related substance in Rf classes A5 and C5.

Substances detected by TLC (38 specimens examined): rhizocarpic acid, commonly with related substance in Rf classes A5, C5, unknown substance (pale white orange after charring in traces Rf class A4–5, C5), 7 substances, probably terpenoids (one white-blue A6, C6, three white-green A5 & C5–6, A? (not observed) & C5, A5 & C5, three white-blue A5 & C5, A? (not observed), C3–4 & A3, C3).

Rhizocarpic acid is also known from morphologically similar *Chrysothrix flavovirens* Tønsberg, recently found in Poland and other European countries, including those bordering with Baltic See (Kowalewska & Jando, 2004). However, this species differs in the presence of 'chrysophthalma' unknown, whereas *P. lucida* produces several unidentified substances (probably terpenoids), not found in *Ch. flavovirens*. Both species differ also in the ecology as *Ch. flavovirens* grows on tree bark, whereas *P. lucida* is mostly saxicolous and only sporadically is found as a facultative epiphyte (Tønsberg, 1992, 1994; Kowalewska & Jando, 2004).

The green algae *Stichococcus*, mentioned by Coppins and Purvis (1987) as the second, but rare photobiont in *P. lucida*, has not been observed in Polish collections.

Specimens examined. **[Bc–36]** – Bory Tucholskie Forest, 'Kręgi Kamienne' nature reserve, near Odry village, on granite postglacial boulder, 7.03.2004, leg. M. Kukwa (UGDA-L–9766); **[Bc–70]** – Pojezierze Krajeńskie lakeland, Prusinowo village, on brick wall of church, 07.1998, leg. M. Kukwa (UGDA-L–9107); **[Bd–43]** – Pojezierze Iławskie lakeland, Postolin village, on brick wall of gothic church, 30.09.1997, leg. W. Fałtynowicz (UGDA-L–9242); **[Bd–53]** – Pojezierze Iławskie lakeland, between Szadowo and Trzciano villages, SW part of the forest section no. 121A, 53°47'15"N/19°02'35"E, on granite, 28.03.2005, leg. M. Kukwa 2842 (UGDA-L–11869); **[Bg–40]** – Kotlina Biebrzańska basin, Puszcza Augustowska Forest, forest section no. 72, close to 'Glinka' nature reserve, on bark of *Pinus sylvestris* at the edge of forest, 21.09.1986, leg. S. Cieśliński (KRAM-L–31889); **[Cg–65]** – Równina Bielska plain, Białowieża village, 52°42'N/23°52'E, on brick wall and stones of orthodox church, 26.03.2001, M. Kukwa (observ.; cum apothecia); **[Fb–06]** – Middle Sudetes, Góry Sowie Mts, fortress in Srebrna Góra village, on shaded granite rocks, 50°34'32"N/16°38'45"E, 22.04.2003, leg. M. Kukwa 3106 (UGDA-L–10292); ibid., ca 2 km N of Nowa Wieś Kłodzka, W slope of Wielki Chochoł Mt., 50°34'54"N/16°37'22"E, on granite rock within beech forest, 22.04.2003, leg. M. Kukwa 3118 (UGDA-L–10801); **[Fb–37]** – Eastern Sudetes, Góry Złote Mts, near Lądek Zdrój town, on metamorphic rocks, 19.10.1959, leg. K. Glanc (KRAM-L–38769); **[Fb–45]** – Middle Sudetes, Góry Bystrzyckie Mts, by the road between Poręba village and Spalone Pass, on vertical walls of metamorphic outcrops and roots of spruces in underhangs, 50°14'10"N/16°34'29"E, alt. 610 m, 20.04.2004, leg. P. Czarnota 4770 (GPN); **[Fc–31]** – Eastern Sudetes, Góry Opawskie Mts, by Jarmołtówek village, 50°17'21"N/17°26'20"E, alt. 480 m, on walls of volcanic rocks, 19.04.2005, P. Czarnota (observ.); **[Fd–93]** – Western Beskidy Mts, Beskid Mały Mts, Magurka glade, ca 550 m, on sandstone, 24.08.1960, leg. J. Nowak (KRAM-L–7892); **[Fd–94]** – Beskid Mały Mts, Cupel Mt., ca 900 m, on sandstone in rocky wall, 24.08.1960, leg. J. Nowak (KRAM-L–9429 & 9430); ibid., valley of Żarnówka Mała stream, on sandstone boulder by the bank of stream, 23.08.1960, leg. J. Nowak (KRAM-L–9426, 9427, 9428 & 9431); **[Fd–99]** – Western Beskidy Mts, Beskid Makowski Mts, Zawadka village, ca 470 m, on sandstone in a rocky wall, 26.04.1966, leg. J. Nowak (KRAM-L–17330); **[Gd–06]** – Western Beskidy Mts, Beskid Żywiecki Mts, Jałowiec range, Surzynówka Mt. near Stryszawa village, ca 670 m, on sandstone in rocky wall, 5.09.1965, leg. J. Nowak (KRAM-L–15444) and ca 800 m, on sandstone in a cheap, 3.09.1965, leg. J. Nowak (KRAM-L–15422); ibid., Surzynówka Mt. near Zasepnica village, ca 800 m, on sandstones in a cheap, 3.09.1965, leg. J. Nowak (KRAM-L–15451) and ca 670 m, 5.09.1965, leg. J. Nowak (KRAM-L–15505); **[Gd–07]** – Beskid Żywiecki Mts, Jałowiec range, Magurka Mt. near Zasepnica village, ca 870 m, on sandstone in a rocky wall, 2.09.1965, leg. J. Nowak (KRAM-L–15502); **[Gd–09]** – Beskid Makowski Mts, Tokarnia – Liberdy settlement, ca 580 m, on sandstone, 15.10.1966, leg. J. Nowak (KRAM-L–43501); ibid., Tokarnia village, valley of Rusnaków stream, ca 480 m, 27.04.1966, leg. J. Nowak (KRAM-L–17371) and ca 460 m, both on sandstones in rocky walls, 31.05.1996, leg. J. Nowak (KRAM-L–42754); ibid., Pcim – Maniakówka settlement, ca 450 m, on sandstone in rocky wall, 31.05.1996, leg. J. Nowak (KRAM-L–42747); **[Gd–15]** – Beskid Makowski Mts, Pewel range, Cuprynik Mt. near Koszarawa village, 740 m, on sandstone in rocky wall, 22.07.1965, leg. J. Nowak (KRAM-L–15241); **[Gd–17]** – Beskid Żywiecki Mts, Polica range, valley of Skawica Sołtysia stream, ca 550 m, on sandstone, 19.06.1965, leg. J. Nowak (KRAM-L–16022); **[Gd–24]** – Beskid Żywiecki Mts, Pilsko range, Sucha Góra Mt. near Milówka village, ca 960 m, on sandstone in rocky wall, 27.09.1964, leg. J. Nowak (KRAM-L–16521, 16704 & 16780); ibid., Żabnica Duża – Skałka settlement, ca 600 m, on sandstones in a rocky wall, 27.09.1964, leg. J. Nowak (KRAM-L–16702); ibid., Okrągła Mt. near Złatna settlement, ca 850 m, on sandstone in a rocky wall, 5.09.1964, leg. J. Nowak (KRAM-L–14755); **[Gd–33]** – Beskid Żywiecki Mts, Praszywka Mt. near Będoszka village, ca 1030 m, on sandstones in a cheap, 12.08.1964, leg. J. Nowak (KRAM-L–13820 & 13821); **[Gd–34]** – Beskid Żywiecki Mts, Pilsko range, Złatna settlement, Pod Sobolówką glade, ca 900 m, on sandstone in a rocky wall, 5.09.1964, leg. J. Nowak (KRAM-L–14754); **[Ge–10]** – Western Beskidy Mts, Gorce Mts, Poręba Wielka – Zapały settlement, ca 580 m, on sandstones by the bank of Koninka River, 19.03.1995, leg. J. Nowak (KRAM-L–41821); ibid., Rabka – Zaryte settlement, by the bank of Raba River, alt. 480 m, on vertical walls of sandstone outcrops, 24.10.2000, leg. P. Czarnota (GPN 2337); **[Ge–21]** – Gorce Mts, valley of Kamienica stream, alt. 1060 m, on sandstone boulders within shady beech forest, 19.07.1999, leg. P. Czarnota (GPN 2142); **[Ge–22]** – Gorce Mts, S slope of Twarogi Mts above Ochotnica village, on sandstone rocks in a field-block, 540 m, 7.08.1967, leg. K. Glanc (KRAM-L–38770) and 10.08.1967, leg. K. Glanc (KRAM-L–38768); ibid., alt. 510 m, 5.11.1999, leg. P. Czarnota (GPN 2151); **[Ge–32]** – Gorce Mts, SE slope of Lubań Mt., Mraźnica glade, on sandstone, 950 m, 9.08.1968, leg. K. Glanc (KRAM-L–36976); **[Ge–36]** – Western Beskidy Mts, Beskid Sądecki Mts, 'Żebracze' nature reserve, alt. 870 m, on sandstone outcrops within Carpathian beech forest, 5.07.2001, leg. P. Czarnota (GPN 2547); **[Gf–22]** – Middle Beskidy Mts, Beskid Niski Mts, S slope of Piotruś Mt., above Stasianie forester's lodge, 49°28'11"N/21°44'57"E, alt. *ca* 670 m, on shaded sandstone outcrop in underhangs, 5.08.2004, leg. P. Czarnota (UGDA-L–13162).

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The preliminary checklist of liverworts of the Komi Republic (Russia)

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Abstract: The first checklist of liverworts of the Komi Republic (Russia) is presented. It reports 164 species and 9 varieties of liverworts belonging to 61 genera and 28 families.

Kokkuvõte: Komi Vabariigi (Venemaa) esialgne helviksammalde nimestik

Komi Vabariigi (Venemaa) esimene helviksammalde nimestik. Nimestikus on 164 liiki ja 9 varieteeti, mis kuuluvad 61 perekonda ja 28 sugukonda.

INTRODUCTION

The Komi Republic is situated in the North-East of European Russia in the taiga and tundra zone (Fig. 1). About 70% is covered by forests, mainly by spruce and pine forests (Atlas Komi ASSR, 1964). Its area is 416,000 km² which is larger than e.g. Finland (338,000 km²), Germany (357,000 km²) and Italy (301,000 km²). The territory is predominantly a plain but includes an ancient medium-height elevation, the Timan Ridge, with maximum elevation of 471 meters, and the ridges of the Northern, Sub-Polar and Polar Urals in the East with the highest mountain of 1900 m.

The liverwort flora of the Komi Republic has been studied for over 100 years. The works of Zikendrath (1900) and Pole (1915) contain the earliest data on the liverworts. At times of the early Soviet period there was almost no works devoted to liverworts. The study of the bryoflora of Komi restarted in early 1960-ies when bryologists I.D. Kildjushevsky and G.V. Zheleznova came to the Institute of Biology in Syktyvkar. They put in order all the accumulated collections of liverworts and published a series of works (Zheleznova, 1974; Zheleznova & Schljakov, 1976; Kildjushevsky & Zheleznova, 1974; Kildjushevsky, 1975). Besides, they collected in various parts of the Republic: the Middle Timan (Zheleznova, 1982b; 1985a,b,c), the Bolshezemelskaya Tundra (Gecen, 1978; Zheleznova, 1982a) and the Urals (Degteva, 1997; Zheleznova & Shubina, 1998 a, b; Bakalin et al., 2001). At the same time the geobotanic studies increased with several articles containing data on liverworts (Katenin & Boch, 1970; Zinovjeva, 1973). At present active studies are done by M. Dulin and co-workers (Dulin, 2001, 2005, 2006, 2007; Bezgodov et al., 2003; Dulin, Konstantinova & Bakalin, 2003).

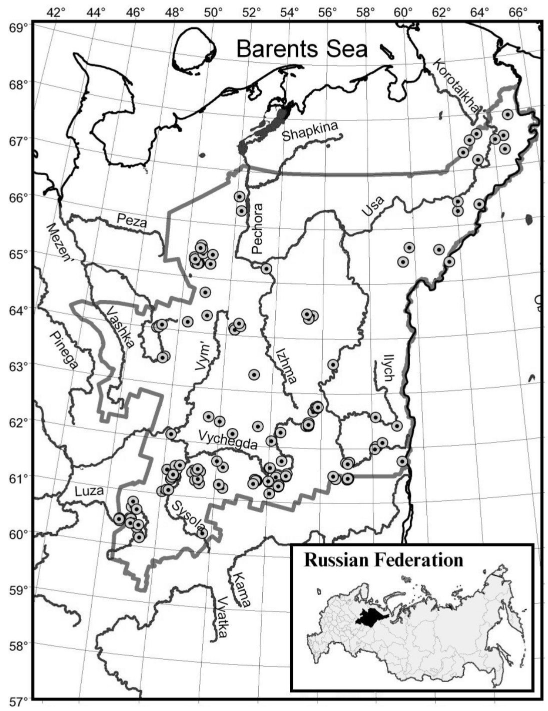

Fig. 1. The main collecting sites of liverworts in the Komi Republic.

MATERIALS AND METHODS

This checklist is based on the liverwort collections kept in the herbarium of the Institute of Biology of the Komi Science Center UB RAS (SYKO). The collection includes over 8000 specimens from which 4500 samples were collected and determined by the author since 1997. In addition literature reports were used.

The taxa are arranged in alphabetic order. Nomenclature follows Konstantinova, Potemkin & Schljakov (1992) with some updates from recent literature (Konstantinova & Vasiljev, 1994; Konstantinova & Potemkin, 1996; Grolle & Long, 2000; Damsholt, 2002). Taxonomy of *Lophozia* (Dumort.) Dumort. follows Bakalin (2005). Species which occurrence in the region is doubtful are marked with (*) symbol.

CHECKLIST OF THE KOMI REPUBLIC LIVERWORTS

Anastrophyllum michauxii (F.Weber) H.Buch
Anastrophyllum sphenoloboides R.M.Schust.
Aneura pinguis (L.) Dumort.
Anthelia juratzkana (Limpr.) Trevis.
Arnellia fennica (Gottsche) Lindb.
Athalamia hyalina (Sommerf.) S.Hatt.
Barbilophozia barbata (Schmidel ex Schreb.) Loeske
Barbilophozia hatcheri (A.Evans) Loeske
Barbilophozia lycopodioides (Wallr.) Loeske
Blasia pusilla L.
Blepharostoma trichophyllum (L.) Dumort. var. trichophyllum
Calypogeia azurea Stotler et Crotz
Calypogeia integristipula Steph.
Calypogeia muelleriana (Schiffn.) Müll.Frib.
Calypogeia neesiana (C.Massal. et Carestia) Müll. Frib.
Calypogeia sphagnicola (Arnell et J.Perss.) Warnst. et Loeske
Calypogeia suecica (Arnell et J.Perss.) Müll.Frib.
*Cephalozia affinis Lindb. ex Steph.
Cephalozia ambigua C.Massal.
Cephalozia bicuspidata (L.) Dumort. var. bicuspidata
Cephalozia connivens (Dicks.) Lindb.
Cephalozia leucantha Spruce
Cephalozia loitlesbergeri Schiffn.
Cephalozia lunulifolia (Dumort.) Dumort.
Cephalozia macounii (Austin) Austin
Cephalozia pleniceps (Austin) Lindb.
Cephaloziella divaricata (Sm.) Schiffn.
Cephaloziella elachista (J.B.Jack ex Gottsche et Rabenh.) Schiffn.
Cephaloziella grimsulana (J.B.Jack ex Gottsche et Rabenh.) Lacout
Cephaloziella hampeana (Nees) Schiffn.
Cephaloziella rubella (Nees) Warnst.
Cephaloziella spinigera (Lindb.) Warnst. (syn. C. subdentata Warnst.)
Chiloscyphus fragilis (A.Roth) Schiffn.
Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort.
Chiloscyphus polyanthos (L.) Corda
Chiloscyphus rivularis (Schrad.) Hazsl.
Cladopodiella fluitans (Nees) H.Buch
Cladopodiella francisci (Hook.) Jørg.
Conocephalum conicum (L.) Dumort.
Crossocalyx hellerianus (Nees ex Lindenb.) Meyl.
Crossogyna autumnalis (DC.) Schljakov
Dichiton integerrimum (Lindb.) H.Buch
Diplophyllum albicans (L.) Dumort.
Diplophyllum obtusifolium (Hook.) Dumort.
Diplophyllum taxifolium (Wahlenb.) Dumort.
Geocalyx graveolens (Schrad.) Nees
Gymnocolea inflata (Huds.) Dumort.
Gymnomitrion apiculatum (Schiffn.) Müll.Frib.
Gymnomitrion concinnatum (Lightf.) Corda
Gymnomitrion coralloides Nees
Haplomitrium hookeri (Sm.) Nees
Harpanthus flotovianus (Nees) Nees
Harpanthus scutatus (F.Weber et D.Mohr) Spruce
Isopaches bicrenatus (Schmidel ex Hoffm.) H.Buch
Jungermannia eucordifolia Schljakov
Jungermannia pumila With.
Kurzia pauciflora (Dicks.) Grolle
Leiocolea collaris (Nees) Schljakov (syn. L. alpestris (F.Weber) Isov.)
Leiocolea badensis (Gottsche) Jørg.
Leiocolea bantriensis (Hook.) Jørg.
Leiocolea gillmanii (Austin) A.Evans
Leiocolea heterocolpos (Thed. ex Hartm.) H.Buch
var. heterocolpos
var. arctica (S.W.Arnell) Mårtensson ex S.W.Arnell
Leiocolea rutheana (Limpr.) Müll.Frib.
Lepidozia reptans (L.) Dumort.
Liochlaena lanceolata Nees
*Lophocolea bidentata (L.) Dumort.
Lophocolea heterophylla (Schrad.) Dumort.
Lophocolea minor Nees

LOPHOZIA ASCENDENS (Warnst.) R.M.Schust.
LOPHOZIA DEBILIFORMIS R.M.Schust. et Damsh.
LOPHOZIA EXCISA (Dicks.) Dumort. var. EXCISA
LOPHOZIA LONGIDENS (Lindb.) Macoun
LOPHOZIA PELLUCIDA R.M.Schust. var. PELLUCIDA
var. MINOR R.M.Schust.
var. RUBRIGEMMA (R.M.Schust.) Bakalin
LOPHOZIA PERSSONII H.Buch et S.W.Arnell
LOPHOZIA PROPAGULIFERA (Gottsche) Steph.
LOPHOZIA SAVICZIAE Schljakov
LOPHOZIA SILVICOLA H.Buch
LOPHOZIA SUDETICA (Nees ex Huebener) Grolle var. SUDETICA
var. ANOMALA (Schljakov) Schljakov
LOPHOZIA VENTRICOSA (Dicks.) Dumort. var. VENTRICOSA
var. LONGIFLORA (Nees) Macoun
var. GUTTULATA (Lindb. et H.W. Arnell) Bakalin
LOPHOZIA WENZELII (Nees) Steph. var. WENZELII
var. GROENLANDICA (Nees) Bakalin
var. LAPPONICA H.Buch et S.W.Arnell
var. LITORALIS (Arnell) Bakalin
MANNIA PILOSA (Hornem.) Frye et L.Clark
MARCHANTIA ALPESTRIS (Nees) Burgeff
MARCHANTIA POLYMORPHA L. (syn. M. AQUATICA (Nees) Burgeff)
MARCHANTIA STELLATA Scop. (syn. M. POLYMORPHA auct.)
MARSUPELLA BREVISSIMA (Dumort.) Grolle
MARSUPELLA CONDENSATA (Ångstr. ex C.Hartm.) Kaal.
MARSUPELLA EMARGINATA (Ehrh.) Dumort.
MARSUPELLA SPHACELATA (Gieseke ex Lindenb.) Dumort.
MARSUPELLA SPRUCEI (Limpr.) Bernet
METZGERIA FURCATA (L.) Dumort.
MOERCKIA HIBERNICA (Hook.) Gottsche
MYLIA ANOMALA (Hook.) Gray
NARDIA BREIDLERI (Limpr.) Lindb.
NARDIA GEOSCYPHUS (De Not.) Lindb.
NARDIA INSECTA Lindb.
NARDIA JAPONICA Steph.
NARDIA SCALARIS Gray
OBTUSIFOLIUM OBTUSUM (Lindb.) S.W.Arnell
ODONTOSCHISMA DENUDATUM (Mart.) Dumort.
ODONTOSCHISMA ELONGATUM (Lindb.) A.Evans
ODONTOSCHISMA MACOUNII (Austin) Underw.
ORTHOCAULIS ATLANTICUS (Kaal.) H.Buch
ORTHOCAULIS ATTENUATUS (Mart.) A.Evans
ORTHOCAULIS BINSTEADII (Kaal.) H.Buch
ORTHOCAULIS FLOERKEI (F.Weber et D.Mohr) H.Buch
ORTHOCAULIS KUNZEANUS (Huebener) H.Buch
ORTHOCAULIS QUADRILOBUS (Lindb.) H.Buch
PELLIA ENDIVIIFOLIA (Dicks.) Dumort.
PELLIA EPIPHYLLA (L.) Corda.
PELLIA NEESIANA (Gottsche) Limpr.
PLAGIOCHILA ASPLENIOIDES (L. emend. Taylor) Dumort.
PLAGIOCHILA PORELLOIDES (Torr. ex Nees) Lindenb.
PLECTOCOLEA HYALINA (Lyell) Mitt.
PLECTOCOLEA OBOVATA (Nees) Lindb.
PLEUROCLADULA ALBESCENS (Hook.) Grolle
PORELLA PLATYPHYLLA (L.) Pfeiff.
PREISSIA QUADRATA (Scop.) Nees
PTILIDIUM CILIARE (L.) Hampe
PTILIDIUM PULCHERRIMUM (Weber) Vain.
RADULA COMPLANATA (L.) Dumort.
RADULA LINDENBERGIANA Gottsche ex C.Hartm.
REBOULIA HEMISPHAERICA (L.) Raddi
RICCARDIA CHAMEDRYFOLIA (With.) Grolle
RICCARDIA LATIFRONS (Lindb.) Lindb.
RICCARDIA MULTIFIDA (L.) Gray
RICCARDIA PALMATA (Hedw.) Carruth.
*RICCIA CAVERNOSA Hoffm.
RICCIA FLUITANS L.
RICCIOCARPOS NATANS (L.) Corda
SACCOBASIS POLITA (Nees) H.Buch
SAUTERIA ALPINA (Nees) Nees
SCAPANIA APICULATA Spruce
SCAPANIA CURTA (Mart.) Dumort. var. CURTA
SCAPANIA CUSPIDULIGERA (Nees) Müll.Frib.
SCAPANIA GYMNOSTOMOPHILA Kaal.
SCAPANIA HYPERBOREA Jørg.
SCAPANIA IRRIGUA (Nees) Nees
SCAPANIA MUCRONATA H.Buch
SCAPANIA NEMOREA (L.) Grolle
SCAPANIA OBCORDATA (Berggr.) S.W.Arnell
SCAPANIA PALUDICOLA Loeske et Müll.Frib.
SCAPANIA PALUDOSA (Müll.Frib.) Müll.Frib.
SCAPANIA PRAETERVISA Meyl.
SCAPANIA SCANDICA (Arnell et H.Buch) Macvicar var. SCANDICA
SCAPANIA SUBALPINA (Nees ex Lindenb.) Dumort.
SCAPANIA ULIGINOSA (Sw. ex Lindenb.) Dumort.
SCAPANIA UMBROSA (Schrad.) Dumort.
SCAPANIA UNDULATA (L.) Dumort.
SCHISTOCHILOPSIS HYPERARCTICA (R.M.Schust.) Konstant. (syn. MASSULARIA HYPERARCTICA (R.M.Schust.) Schljakov)
SCHISTOCHILOPSIS INCISA (Schrad.) Konstant. (syn. MASSULARIA INCISA (Schrad.) Schljakov)
SCHISTOCHILOPSIS LAXA (Lindb.) Konstant. (syn. MASULLARIA LAXA (Lindb.) Schljakov)
SOLENOSTOMA CAESPITICIUM (Lindenb.) Steph.

SOLENOSTOMA CONFERTISSIMUM (Nees) Schljakov
SOLENOSTOMA GRACILLIMUM (Sm.) R.M.Schust.
SOLENOSTOMA PUSILLUM (C.E.O.Jensen) Steph.
SOLENOSTOMA SPHAEROCARPUM (Hook.) Steph.
SPHENOLOBUS CAVIFOLIUS (H.Buch et S.W.Arnell) Müll.Frib.
SPHENOLOBUS MINUTUS (Schreb.) Berggr.
SPHENOLOBUS SAXICOLA (Schrad.) Steph.
TETRALOPHOZIA SETIFORMIS (Ehrh.) Schljakov
TRITOMARIA EXSECTA (Schmidel) Schiffn. ex Loeske
TRITOMARIA EXSECTIFORMIS (Breidl.) Loeske
TRITOMARIA QUINQUEDENTATA (Huds.) H.Buch
TRITOMARIA SCITULA (Taylor) Jørg.

DISCUSSION

Nowadays the liverwort flora of the Komi Republic includes 164 species and 9 varieties of liverworts belonging to 61 genera and 28 families. The records of three species (*Cephalozia affinis, Lophocolea bidentata* and *Riccia cavernosa*) in the region are doubtful. Specifically, the reports of Zinovjeva (1973) about *Cephalozia affinis* and *Lophocolea bidentata* for the Urals could be wrong, since the location of these specimens is unknown and we cannot check them. The note about *Riccia cavernosa* in the vicinity of Syktyvkar city (Pole, 1915) is also doubtful, since it was never found later and the original specimen has got lost. Not long ago the species *Lophozia savicziae* and *Lophozia debiliformis* were found in the liverwort flora of the Komi Republic (Novotný, Klimeš, 1991; Bakalin, 2005). The reference to species *Cephalozia lacinulata* J.B.Jack ex Spruce, *Geocalyx graveolens*, *Harpanthus scutatus* in the manuscript of I.D. Kildjushevsky (1975) is erroneous, as well as the reference to *Plagiochila arctica* Bryhn et Kaal. reported in the article by G.V. Zheleznova and R.N. Schljakov (1976).

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Rare liverworts in Komi Republic (Russia)

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Abstract: Data are presented on distribution and ecology of 10 rare liverwort species (*Anastrophyllum sphenoloboides*, *Arnellia fennica*, *Haplomitrium hookeri*, *Cephalozia macounii*, *Cephaloziella elachista*, *Lophozia ascendens*, *Nardia japonica*, *Scapania scandica*, *Schistochilopsis laxa*, *Sphenolobus cavifolius*) included in the Red Data Book of the Komi Republic, and 8 species (*Dichiton integerrimum*, *Harpanthus scutatus*, *Kurzia pauciflora*, *Lophozia pellucida*, *Lophozia perssonii*, *Odontoschisma denudatum*, *Scapania nemorea*, *Schistochilopsis hyperarctica*) suggested for inclusion in the new edition of the Red Data Book of the Komi Republic.

Kokkuvõte: Haruldased helviksamblad Komi Vabariigis (Venemaa)

Esitatakse andmestik Komi Vabariigi Punasesse Raamatusse kuuluva kümne helviksambaliigi kohta (*Anastrophyllum sphenoloboides*, *Arnellia fennica*, *Haplomitrium hookeri*, *Cephalozia macounii*, *Cephaloziella elachista*, *Lophozia ascendens*, *Nardia japonica*, *Scapania scandica*, *Schistochilopsis laxa*, *Sphenolobus cavifolius*) ning kaheksa helviksamblaliigi kohta (*Dichiton integerrimum*, *Harpanthus scutatus*, *Kurzia pauciflora*, *Lophozia pellucida*, *Lophozia perssonii*, *Odontoschisma denudatum*, *Scapania nemorea*, *Schistochilopsis hyperarctica*), mida on kavas lisada Komi Vabariigi Punase Raamatu uude versiooni.

INTRODUCTION

The Komi Republic is situated in the north-east of the European Russia between 59°12’ and 68°25’ N and 45°25’ and 66°15’ E. The longest stretch is (from south-west to north-east) ca 1300 km and the total area 416,000 km^2. Topographically the area is situated within the Russian Plain and the Urals. Considerable diversity of environmental conditions is the consequence of great latitudinal distance and geographical heterogeneity. Extreme northern and north-eastern part of Komi lies in tundra and forest tundra, and the rest of the area belongs to the taiga zone.

There are widespread and rare species among liverworts, as in any group of plants, and rare species often need to be protected. Protection of liverworts (as other bryophytes) is characterized by several peculiar features. These plants are usually small and can be identified only with difficulties in the field. Thus, it is difficult to protect specific species separately. The complexity of protection of rare liverwort species causes the goal of protection of areas of their concentration, such as their ecotopes with the whole specific plant complex by creation (or preservation of the existing) network of protected natural areas of different statuses (nature reserves, national parks, refuges, natural artefacts). The first steps to achieve are field surveys and compilation of checklists or lists of rare species in the areas.

MATERIALS AND METHODS

The Red Data Book of any subject of the Russian Federation is an official legal document compiled by public authorities. The Book grants them administrative and legal warrants, and thus increases possibilities for their conservation and recovery. Properly compiled plant and animal species checklists serve a legal basis for it. Legal treatment of protection of rare and endangered species, including compiling and maintaining the Red Data Book of any subject of the Russian Federation is determined by Federal Laws «On the Fauna» and «On the Nature Protection». The Red Data Book is regularly reviewed (every ten years) (Taskaev, 1998; Methodical Guidelines…, 2006).

It is necessary to highlight the following principal criteria for inclusion of species into the list of endangered species needing special protection: 1 – habitats scarcity; 2 – location on distribution area margins; 3 – presence of species in the Red Data Book of the International Union for Conservation of Nature (IUCN), in the Red Data Book of European Bryophytes, and in the Red Data Books of the former Soviet Union and Russia; 4 – endemic and relict nature of species. Rarity categories are classified according to IUCN criteria (Taskaev, 1998).

The species names follow Konstantinova et al. (1992) except for *Schistochilopsis*.

Species were attributed to geographic groups according to classification suggested by Konstantinova (2000).

RESULTS AND DISCUSSION

Investigation of the distribution of liverwort species in Komi Republic by G.V. Zheleznova and T.P. Shubina provided information to compile a list of 10 rare liverworts species to be included in the Komi Red Data Book (Taskaev, 1998). Investigations performed in 1999–2005 in Komi Republic gave information about new localities of the liverworts included in the Red Date Book. On the basis of all data the complete list of known localities is prepared. It includes the data on identified specimens, the ecological and geographical characteristics of sampling areas with coordinates, accompanying liverworts species, inventory or field number of the specimens, collection date and the name of collector (see Appendix). Reference to the basic sources of information of the species mentioned is provided.

Liverworts in first edition of the Red Data Book of the Komi Republic

Ten liverworts are included in the Red Data Book of Komi Republic, three of them belong to the second category and seven to the third.

Category 2 – vulnerable species: taxa are likely to be attributed to the Endangered category in the near future provided that the effect of adverse factors continues. The following species fall in this category:

CEPHALOZIA MACOUNII (Austin) Austin (Zheleznova, 1974; 1985; Dulin et al., 2003; Dulin, 2007). – Boreal circumpolar species. Three localities (Fig. 3).

HAPLOMITRIUM HOOKERI (Sm.) Nees (Zheleznova, 1985). – Boreal disjunct species. One locality (Fig. 1).

NARDIA JAPONICA Steph. (Schljakov, 1980; Zheleznova, 1985). – Arctic-montane Eurasian-Western American species. Two localities (Fig. 3).

Category 3 – rare species: taxa with small populations size that are at risk to become vulnerable or endangered. The following species fall in this category:

ANASTROPHYLLUM SPHENOLOBOIDES R.M. Schust. (Zheleznova & Schljakov, 1976; Zheleznova, 1985). – Arctic, almost circumpolar species. One locality (Fig. 2).

ARNELLIA FENNICA (Gottsche) Lindb. (Zickendrath, 1900; Pole, 1915; Zinovjeva, 1973; Kildjushevsky & Zheleznova, 1974; Zheleznova, 1978, 1982; 1985; Bezgodov et al., 2003; Dulin, 2007). – Arctic-montane, almost circumpolar species. Eighteen localities (including literature data) (Fig. 1).

CEPHALOZIELLA ELACHISTA (J.B.Jack ex Gottsche et Rabenh.) Schiffn. (Zheleznova, 1974; 1985). – Boreal Atlantic species. Two localities (Fig. 2).

LOPHOZIA ASCENDENS (Warnst.) R.M. Schust. (Zheleznova, 1974; 1985; Dulin, 2001, 2007). – Boreal circumpolar species. Fourteen localities (Fig. 1).

SCAPANIA SCANDICA (Arnell et H. Buch) Macvicar (Zheleznova, 1982; Bakalin et al., 2001; Dulin, 2007). – Arctic-montane, almost circumpolar species. Nine localities (Fig. 2).

SCHISTOCHILOPSIS LAXA (Lindb.) Konstantinova (Zheleznova, 1985; Dulin, 2001, 2007). – Boreal Atlantic species. Five localities (Fig. 2).

SPHENOLOBUS CAVIFOLIUS (H. Buch et S.W. Arnell) Müll.Frib. (Zinovjeva, 1973; Zheleznova & Shubina, 1997; 1998). – Arctic almost circumpolar species. Three localities (including literature data) (Fig. 1).

The recent investigations resulted in new localities for seven rare liverworts protected in Komi Republic: *Arnellia fennica*, *Cephalozia macounii*, *Cephaloziella elachista*, *Lophozia ascendens*, *Nardia japonica*, *Scapania scandica* and *Schistochilopsis laxa*. Eight protected species were found in 10 areas of various level of protection: flora refuges "Nomburgsky" (*Anastrophyllum sphenoloboides*, *Lophozia ascendens*), "Syktyvkarsky" (*Arnellia fennica*), "Mylsky" (*Nardia japonica*), "Soivinsky" (*Arnellia fennica*, *Lophozia ascendens*), complex refuges "Udorsky" (*Cephalozia macounii*, *Cephaloziella elachista*, *Lophozia ascendens*), "Belaya Kedva" (*Arnellia fennica*), complex refuges "Sindorsky" (*Cephalozia macounii*, *Cephaloziella elachista*, *Lophozia ascendens*, *Schistochilopsis laxa*, *Scapania scandica*), forest refuge "Porubsky" (*Lophozia ascendens*), "Pechoro-Ilychsky" conservation area (*Arnellia fennica*, *Cephalozia macounii*, *Lophozia ascendens*, *Scapania scandica*), and geological conservation area "Skala Lek-Iz" (*Arnellia fennica*). Preservation of liverworts' habitats in the protected areas is efficient to fulfil the conservation goals for the rare liverworts, and effective to protect bryophytes as a whole.

Liverworts proposed for inclusion in the second edition of the Red Data Book of the Komi Republic

Discovery of two rare calciphilous species (*Lophozia pellucida* and *Schistochilopsis hyperarctica*) was an important result of our investigation. These species need protection at the regional level and were recommended for inclusion in the new issue of ”The Red Data Book of Komi Republic“. *Lophozia pellucida* is a little-known Arctic liverwort which is considered rare in Europe (ECCB, 1995). Only few localities are known in Europe, in Sweden and Norway (Söderström, 1995), as well as in Nenetsky Autonomous Region (Konstantinova & Lavrinenko, 2002) and Murmansk Region (Konstantinova, 1990; 1996; 2001). *Schistochilopsis hyperarctica* is a poorly known Arctic calciphilous species with obscure distribution. It was found only in Pinezhsky conservation area in Europe (Váňa & Ignatov, 1993).

Beside the species mentioned above, the new edition of the ”Red Data Book of the Komi Republic“ will include further six rare liverworts. Four of these are species at their easternmost and north-easternmost margin of their distribution range (*Harpanthus scutatus*, *Kurzia pauciflora*, *Odontoschisma denudatum*, *Scapania nemorea*), and two (*Dichiton integerrimum* and *Lophozia perssonii)* are confined to rare substrates (limestone and sandstone).

Scapania scandica will be excluded from the list since it is rather widely spread in the region.

The new species included in the second edition of the ”Red Data Book of the Komi Republic” fall in the following threat categories.

Category 2 – vulnerable species:

DICHITON INTEGERRIMUM (Lindb.) H.Buch. (Zheleznova, 1985). – Montane European-Greenlandic species. One locality (Fig. 3).

Category 3 – rare species:

HARPANTHUS SCUTATUS (F.Weber et D.Mohr) Spruce (Dulin et al., 2003; Dulin, 2007). – Nemoral amphi-oceanic species. Three localities (Fig. 4).

KURZIA PAUCIFLORA (Dicks.) Grolle (Dulin, 2007). – Boreal, almost circumpolar species. One locality (Fig. 4).

LOPHOZIA PELLUCIDA R.M. Schust. (Dulin et al., 2003; Bezgodov et al., 2003; Dulin, 2007). – Arctic, almost circumpolar species. Five localities (Fig. 2).

LOPHOZIA PERSSONII H.Buch et S.W.Arnell (Zheleznova, 1985; Dulin et al., 2003; Dulin, 2007). – Arctic-montane European-Siberian species. Four localities (Fig. 4).

ODONTOSCHISMA DENUDATUM (Mart.) Dumort. (Dulin, 2007). – Nemoral amphi-oceanic species. Four localities (Fig. 4).

SCAPANIA NEMOREA (L.) Grolle (Bakalin et al., 2001; Dulin, 2007). – Nemoral amphi-oceanic species. Two localities (Fig. 1).

SCHISTOCHILOPSIS HYPERARCTICA (R.M. Schust.) Konstantinova (Dulin et al., 2003; Dulin, 2007). – Arctic species with uncertain distribution. Two localities (Fig. 3).

Like the liverworts in the first edition of the Red Data Book of the Komi Republic, species suggested for conservation grow in protected natural territories of various status which enhances the opportunities for their conservation and recovery. Thus, the liverworts suggested for the new edition are registered in the following protected areas: nature reservations “Sindorsky” (*Harpanthus scutatus*), “Soivinsky” (*Lophozia pellucida*, *Schistochilopsis hyperarctica*), “Boloto Don-ty” (*Kurzia pauciflora*), “Pechoro-Ilychsky” conservation area (*Odontoschisma denudatum*).

The new edition of the Red Data Book of the Komi Republic includes thus 17 liverwort species belonging to 14 genera from 9 families. Rare protected species make 10.4% of total liverwort flora of the Republic which nowadays numbers 164 species (Dulin, 2008). The majority of the protected species are characterized by a boreal and arctic distribution type (Table 1).

Analysis of distribution of rare liverworts in main types of habitat and substrates showed that forest communities include the majority of rare species, and most species grow on soil (Table 2).

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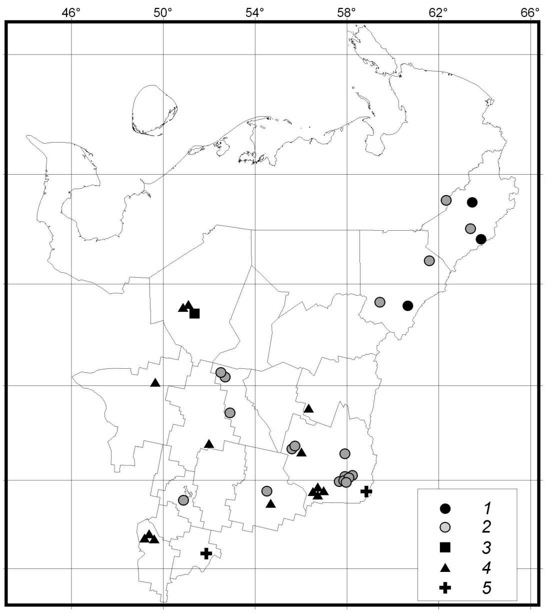

Fig. 1. Distribution of five rare liverworts in Komi Republic. 1 – *Sphenolobus cavifolius,* 2 – *Arnellia fennica,* 3 – *Haplomitrium hookeri,* 4 – *Lophozia ascendens,* 5 – *Scapania nemorea.*

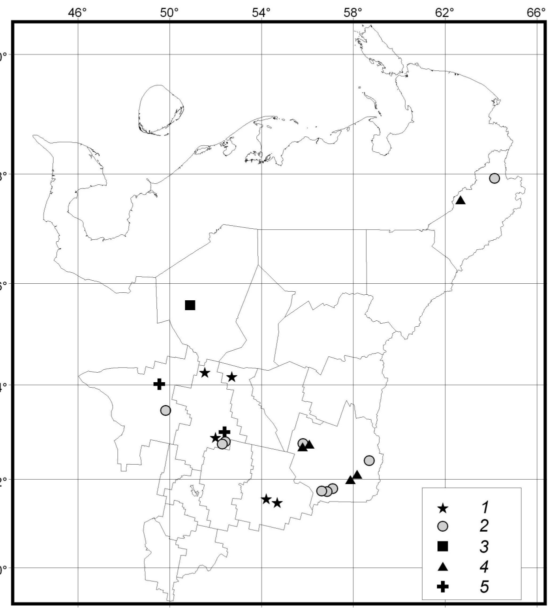

Fig. 2. Distribution of five rare liverworts in Komi Republic. 1 – *Schistochilopsis laxa,* 2 – *Scapania scandica,* 3 – *Anastrophyllum sphenoloboides,* 4 – *Lophozia pellucida,* 5 – *Cephaloziella elachista.*

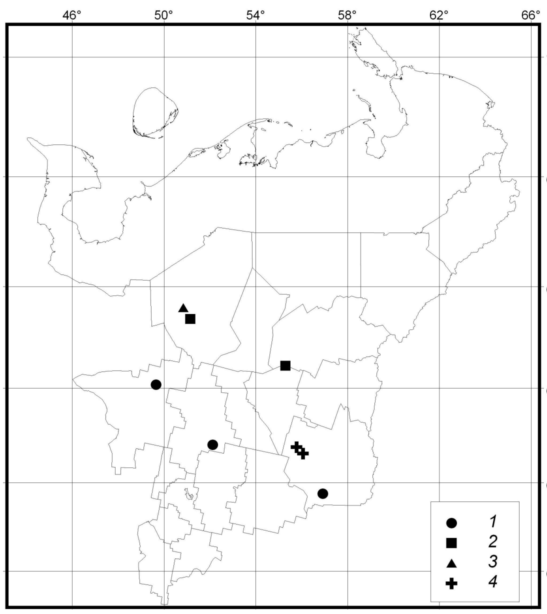

Fig. 3. Distribution of four rare liverworts in Komi Republic. 1 – *Cephalozia macounii*, 2 – *Nardia japonica*, 3 – *Dichiton integerrimum*, 4 – *Schistochilopsis hyperarctica.*

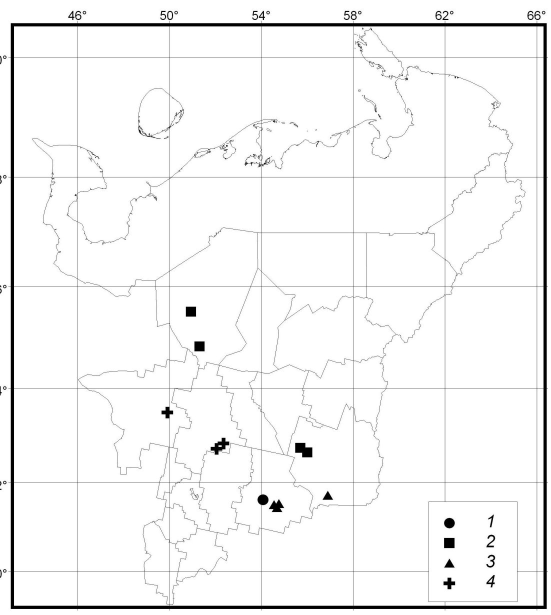

Fig. 4. Distribution of four rare liverworts in Komi Republic. 1 – *Kurzia pauciflora*, 2 – *Lophozia perssonii*, 3 – *Odontoschisma denudatum*, 4 – *Harpanthus scutatus.*

Table 1. Distribution of rare liverworts of Komi Republic according to biogeographic groups

Group	Montane	Arctic-montane	Nemoral	Arctic	Boreal	Total
Disjunct					1	1
European-Greenlandic	1					1
Eurasian-Western American		1				1
European-Siberian		1				1
Uncertain distribution				1		1
Atlantic					2	2
Circumpolar					2	2
Amphi-oceanic			3			3
Almost circumpolar		1		3	1	5
Total	1	3	3	4	6	17

Table 2. Distribution of rare liverworts according to main types of habitats and substrates. Abbreviations: A – anthropogenic; T – tundra; W – wetland; O - outcrops; B – bog; F – forest; TB – tree boles; R – rotten timber; S – stones; E – soil.

	Habitats						Substrates			
Species	A	T	W	O	B	F	TB	R	S	E
Anastrophyllum sphenoloboides					+					+
Arnellia fennica		+		+		+	+	+	+	+
Cephalozia macounii						+		+		
Cephaloziella elachista					+	+				+
Dichiton integerrimum				+					+	
Haplomitrium hookeri				+					+	
Harpanthus scutatus						+		+		
Kurzia pauciflora					+			+		
Lophozia ascendens						+	+	+	+	
Lophozia pellucida			+	+					+	+
Lophozia perssonii				+					+	+
Nardia japonica	+									+
Odontoschisma denudatum					+	+				+
Scapania nemorea			+		+					+
Schistochilopsis hyperarctica				+					+	
Schistochilopsis laxa					+	+		+		+
Sphenolobus cavifolius		+								+
Total	1	2	2	6	6	7	2	6	7	10

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APPENDIX

Known localities for rare liverworts in Komi Republic.

Abbreviations: Dist. = District; N = north; S = south; E = east; W = west. The specimens missing in herbarium SYKO are marked with field numbers.

Anastrophyllum sphenoloboides: 1) Ust-Tsilemsky Dist., 3 km N from Nonburg village (65°35' N; 50°37' E); pines, bushes and sphagnum, among hummocks; *Cephalozia leucantha*; No. 14448; 09.VIII.1973, G.V. Zheleznova.

Arnellia fennica: 1) Vorkutinsky Dist., Harbeiskiye Lakes, hydrobiologists' camp (67°32' N; 62°52' E); bush and moss tundra, on sides of hummocks; No. 3781; 17.VII.1969, I.D. Kildushevsky & G.V. Zheleznova. 2) Vorkutinsky Dist., "Gornyak" sovhoz, Un-Yaga farm (66°26' N; 62°05' E); fir and birch forest, on a path; No. 3179; 10.VII.1968, N.S. Kotelina. 3) Intinsky Dist., Kozhim River, 15 km upstream from railway bridge (65°39' N; 59°47' E); wet rocks; *Leiocolea heterocolpos*, *Scapania gymnostomophila*, *Tritomaria quinquedentata*; No. 8085; 14.VIII.1971, I.D. Kildushevsky & G.V. Zheleznova. 4) Uhtinsky Dist., Belaya Kedva River, 123 km upstream from the river mouth (64°10' N; 52°34' E), limestone outcrop at the stream influx, spruces, bushes and grass; *Preissia quadrata*; No. 17304, 17296, 17295; 12.VII.1975, G.V. Zheleznova & L.S. Fedorova. 5) Uhtinsky Dist., 71 km upstream from Belaya Kedva river mouth, at Merkushyel stream influx (64°13' N;52° 30' E); above water in the cavity of limestone outcrop; No. 17297; 21.VII.1975, G.V. Zheleznova & L.S. Fedorova. 6) Troitsko-Pechersky Dist., Pechoro-Ilychsky nature reserve, left bank of Bolshaya Shaitanovka River, 3 km WWN from its influx into Pechora River (62°01' N; 58°07' E); slope to N; No. 26061; 06.VII.1994, A.A. Kustysheva. 7) Troitsko-Pechersky Dist., Chalma mountain (62°02' N; 58°09' E); limestone outcrop, at the base of scree, on large stones and at their basis; No. 36904, 36962; 09.VII.2000, A.G. Bezgodov & I.B. Kucherov. 8) Troitsko-Pechersky Dist., Pihtovka River mouth (61°59' N; 58°06' E); limestone outcrop, on the wet shaded wall; No. 36880, 36873; 15.VII.2000, A.G. Bezgodov & I.B. Kucherov. 9) Troitsko-Pechersky Dist., left side of Pechora River valley downstream to Shezhym River mouth (62°06' N; 58° 24' E); limestone outcrop, on humus at the bottom of walls and on terraces; No. 36889, 36899, 36872; 04.VII.2000, A.G. Bezgodov & I.B. Kucherov. 10) Troitsko-Pechersky Dist., left side of Pechora River valley at Bolshaya Shaitanovka River mouth (62°02' N; 58°12' E); limestone outcrop along billabong bank, large rock scree, on the sides of rocks covered with moss; No. 36940; 13.VII.2000, A.G. Bezgodov & I.B. Kucherov. 11) Troitsko-Pechersky Dist., right bank of Ilych River, 5.5 km E from Isperedyu River mouth, Lek-Iz Rock (62°34' N; 58°09' E); rock scree, between rocks; field number 322mvd; 02.VI.2003, M.V. Dulin. 12) Troitsko-Pechersky Dist., Grishestav village suburbs, right bank of Soiva River (62°40' N; 55°41' E); limestone outcrop of N exposition; *Leiocolea badensis*; No. 36049; 06.VII.2002, B.Y. Teterjuk. 13) Troitsko-Pechersky Dist., Nizhnyaya Omra town (62°44'–62°45' N; 55°46'–55°52' E), limestone outcrops in Soiva and Nizhnyaya Omra valleys, on humus at the basis of rocks, on silt and among mosses on the rock sides; *Blepharostoma trichophyllum*, *Leiocolea collaris*, *L. heterocolpos*, *L. gillmanii*, *Scapania gymnostomophila* etc.; field numbers 252mvd, 258mvd, 262mvd, 269mvd etc.; collections of 2001, 2003, M.V. Dulin. 14) Ust-Kulomsky Dist., Jejim-Parma hill, bank of Bidz-Yel River (Vapol-Yu River affluent) (61°45' N; 54°30' E); limestone outcrop; No. 230; 06.IX.1940, B.P. Kolesnikov. 15) Syktyvdinsky Dist., Syktyvkar suburbs, 18 km of Syktyvkar – Kirov Highway, Syktyvkarsky refuge (61°33' N; 50°37' E); mixed sedge and grass forest, on rotten timber and near trunks; *Blepharostoma trichophyllum*, *Leiocolea heterocolpos*; No. 39494, 39493; 19.VIII.2004, G.V. Zheleznova.

Cephalozia macounii: 1) Udorsky Dist., 1 km E from Elva-Mezenskaya River mouth (64°04' N; 49°18' E); stream valley, grass-moss forest, on rotten timber; No. 14181; 25.VI.1972, I.D. Kildjushevsky & G.V. Zheleznova. 2) Knjazhpogostsky Dist., Sindor town suburbs, Sindorskoye Lake, 3 km SE from Ugum River mouth, near bridge across right affluent, beside railway (62°41' N; 52°01' E); sphagnum pinery, on rotten timber; *Calypogeia muelleriana*, *Cephalozia lunulifolia*, *Mylia anomala*; No. 38436; 08.VIII.2000, M.V. Dulin. 3) Troitsko-Pechorsky Dist., Yaksha town, right bank of Pechora River 2 km NW from Starikovaya River mouth to Perevalka, (61°45' N; 57°05'); spruce forest near stream, on rotten log; *Cephalozia bicuspidata*, *C. lunulifolia*, *Lophozia silvicola*, *Ptilidium pulcherrimum*; No. 37894; 08.VIII.1999, M.V. Dulin.

Cephaloziella elachista: 1) Udorsky Dist., 3.5 km along the road from Verhnemezensk town to Politovo village (64°01' N; 49°11' E); edge of sphagnum swamp; No. 15922; *Cephalozia loitlesbergeri*; 28.VI.1972, I.D. Kildjushevsky & G.V. Zheleznova. 2) Knjazhepogostsky Dist., suburb of Sindor town, Sindorskoye Lake, 3 km SE from Ugum River mouth, near bridge across the right affluent, beside railway (62°41' N; 52°01' E); sphagnum pinery, on open soil; *Calypogeia muelleriana*, *Cephalozia lunulifolia*, *Gymnocolea inflata*, *Mylia anomala*; No. 38045, 38047, 38048; 08.VIII.2000, M.V. Dulin.

Dichiton integerrimum: 1) Ust-Tsilemsky Dist., suburbs of Nonburg village, right bank of the Nonburg river, 5 km upstream from River mouth (65° 32' N; 50° 34' E); limestone outcrops, on rocks; No. 14423; 10.VII.1973, G.V. Zheleznova.

Haplomitrium hookeri: 1) Ust-Tsilemsky Dist., right bank of Tsilma River (across Philippovo village) (65°26' N; 51°08' E); sand outcrop, on the bank among rocks; No. 15638; 26.VII.1973, G.V. Zheleznova.

Harpanthus scutatus: 1) Udorsky Dist., vicinity of Glotovo village, 1.5 km SW from Borovskaya (Borovo) village, (63° 30' N; 49° 34' E); terrace, birch-spruce forest; on rotten wood; field number No.16в, 8.VII.1972, I.D. Kildjushevsky & G.V. Zheleznova. 2) Knjazhepogostsky Dist., vicinity of Sindor village, SE part of Sindor Lake; 2.5 km SE from the Ugum river mouth, right bank of the river (62°41' N; 52°01' E); mixed forest; on rotten log and stub; *Blepharostoma trichophyllum*, *Plagiochila porelloides*; field number 239mvd, 6.VIII.2000, Dulin M.V. 3) Knjazhepogostsky Dist., 3 km SE from the Ugum river mouth, right bank of the river (62°41' N; 52°01' E); birch-pine littoral forest, on the roots of an uprooted pine; field number 242mvd, 6.VIII.2000, M.V. Dulin.

Kurzia pauciflora: 1) Ust-Kulomsky Dist., vicinities of Don village, N bank of the Donskoje Lake, 9.5 km from boat station, 300 m N from lake bank (61° 37' N; 54° 02' E); oligotrophic bog "Donskoje"; a rotten stub; field number No. 47mvd, 14.VII.1999, M.V.Dulin.

Lophozia ascendens: 1) Ust-Tsilemsky Dist., left bank of Tsilma River, 2 km upstream from Nonburg village (65°33' N; 50°36' E); limestone outcrops in fir and birch forest, on rocks; *Blepharostoma trichophyllum*; No. 14444; 07.VIII.1973, G.V. Zheleznova. 2) Ust-Tsilemsky Dist., 1.7 km upstream from Nonburg village (65°33' N; 50°36' E); sphagnum spruce forest; *Blepharostoma trichophyllum*, *Lophocolea minor*, *Orthocaulis kunzeanus*; No. 14465; 07.VIII.1973, G.V. Zheleznova. 3) Udorsky Dist., 1 km E from Elva-Mezenskaya River mouth (64°04' N; 49°18' E); stream valley forest, on rotten timber; *Lepidozia reptans*; No. 14181; 25.VI.1972, I.D. Kildjushevsky & G.V. Zheleznova. 4) Vuktylsky Dist., 0.6 km S from Savinobor village (63°32' N; 56°27' E); hillside, fir forest, on rotten timber; *Cephalozia bicuspidata, Lophozia ventricosa*; No. 5545; 22.VI.1970, I.D. Kildjushevsky, G.V. Zheleznova & V.A. Frolova. 5) Knjazhpogostsky Dist., suburb of Sindor town, Sindorskoye Lake, 3 km SE from Ugum River mouth, right bank of the river (62°41' N; 52°01' E); birch-pine forest, on rotten timber; *Blepharostoma trichophyllum*; No. 38298; 07.VIII.2000, M.V. Dulin. 6) Troitsko-Pechersky Dist., suburb of Yaksha town, right bank of Starikovaya River, 150 m upstream from the river mouth (61°45' N; 57°06' E); spruce forest, on the lower part of birch trunk and on rotten timber; *Crossocalyx hellerianus*, *Blepharostoma trichophyllum*, *Lophozia silvicola*, *Orthocaulis kunzeanus*, *Ptilidium pulcherrimum*, *Scapania mucronata*; No. 37673, 37542; 01.VIII.1999, M.V. Dulin. 7) Troitsko-Pechersky Dist., suburb of Yaksha town, right bank of Starikovaya River, spruce forest, on rotten timber; *Crossocalyx hellerianus*, *Lophozia longidens*, *Ptilidium pulcherrimum*, *Tritomaria exsecta*; No. 37080; 30.VII.1999 M.V. Dulin. 8) Troitsko-Pechersky Dist., right bank of Pechora River, Gasnikov backwater, 300 m S from a house along the left bank of the stream (61°44' N; 56°59' E); spruce forest, on rotten timber; *Blepharostoma trichophyllum*, *Calypogeia suecica*, *Cephalozia lunulifolia*, *Scapania apiculata* etc.; No. 37694; 07.VIII.1999, M.V. Dulin. 9) Troitsko-Pechersky Dist., right bank of Pechora River, Volosnitskaya billabong, 800 m N from the house near mouth of the billabong (61°43' N; 57°03' E); spruce-fir forest, on rotten timber; *Blepharostoma trichophyllum*, *Crossocalyx hellerianus*, *Lophocolea heterophylla*, *Ptilidium pulcherrimum*; No. 37307; 03.VIII.1999, M.V. Dulin. 10) Troitsko-Pechersky Dist., 3 km SEE from Nizhnyaya Omra town, right bank of Nizhnyaya Omra River (62°45' N; 55°52' E); forest, on rotten timber; *Crossocalyx hellerianus*; field number 290mvd; 29.VI.2001, M.V. Dulin. 11) Ust-Kulomsky Dist., suburbs of Don town, right bank of Vychegda River, SE bank of Kadamskoye Lake, along western bank of Podkadomje Lake (61°29' N; 54°41' E); quaking birch-aspen-pine forest, on rotten timber; *Blepharostoma trichophyllum*, *Crossocalyx hellerianus*, *Lophocolea heterophylla*, *Ptilidium pulcherrimum*, *Scapania apiculata* etc.; No. 37003, 37019, 36998, 36997, 36992, 36990, 36995, 36986, 37058; 21.VII.2000, M.V. Dulin. 12) Priluzsky Dist., suburbs of Porub-Kepovskaya village, 6 km NNE, source of Yakim stream (60°48' N; 49°01' E); spruce forest, on rotten timber; *Blepharostoma trichophyllum*, *Calypogeia muelleriana*, *Cephalozia lunulifolia*, *Riccardia latifrons*, *Ptilidium pulcherrimum*; field number 298mvd; 25.VII.2001, M.V. Dulin. 13) Priluzsky Dist., 8 km of the road from Spasporub town to Porub-Kepovskaya village, 500 m SSE from Ust-Choy village (60°42' N; 48°59' E); pinery, on rotten timber; *Cephalozia lunulifolia*, *Crossocalyx hellerianus*, *Lophozia ventricosa,* etc.; field number 311mvd; 28.VII.2001, M.V. Dulin. 14) Priluzsky Dist., suburbs of Spasporub town, 18 km of the road Zanulje town – Spasporub town, left bank of Deb River (60°40' N; 49°11' E); quaking aspen forest, on rotten timber; *Blepharostoma trichophyllum*, *Calypogeia muelleriana*, *Cephalozia lunulifolia*, *Crossocalyx hellerianus*, *Lophozia ventricosa* etc.; field number 312mvd; 28.VII.2001, M.V. Dulin.

Lophozia pellucida: 1) Vorkutinsky Dist., N part of Bolshoy Harbey Lake, on the island, located 1 km S from the hydrobiologists' camp (67°38' N; 63°14' E); on the landslide, on soil; No. 3749; 18.VII.1969, I.D. Kildjushevsky & G.V. Zheleznova. 2) Troitsko-Pechersky Dist., 2.5 km SEE from Nizhnyaya Omra settlement, right bank of Nizhnyaya Omra River (62°46' N; 55°51' E); rock outcrop along the river bank, on soil among stones and among moss, on wet terraces of limestone outcrops; *Arnellia fennica*, *Leiocolea collaris*, *L. gillmanii*, *Orthocaulis quadrilobus*, *Preissia quadrata*, *Pellia endiviifolia*, *Scapania gymnostomophila*, *Tritomaria scitula*; field number 262mvd; 25.VI.2001, M.V. Dulin. 3) Troitsko-Pechersky Dist., 2 km SSE from Nizhnyaya Omra settlement, right bank of Soiva River, "Soivinsky" refuge (62°44' N; 55°50' E); small rock outcrops of N exposition, on soil and on terraces; *Arnellia fennica*, *Athalamia hyalina*, *Preissia quadrata*, *Pellia endiviifolia*, *Solenostoma confertissimum*; field number 258mvd; 24.VI.2001, M.V. Dulin. 4) Troitsko-Pechersky Dist., left side of Pechora River valley across the Shezhym River mouth (62°06' N; 58°25' E); limestone outcrops; in a wet cavity, on humus; *Preissia quadrata*; No. 36918; 25.VI.2000, A.G. Bezgodov & I.B. Kucherov. 5) Troitsko-Pechersky Dist., left side of Pechora River valley, Pihtovka River mouth (61°59' N; 58°06' E); limestone outcrops, on wet shaded wall; *Arnellia fennica*, *Blepharostoma trichophyllum*, *Leiocolea gillmanii*, *Sphenolobus minutus*, *Tritomaria quinquedentata*; No. 36880, 15.VII.2000, A.G. Bezgodov & I.B. Kucherov.

Lophozia perssonii: 1) Ust-Tsilemsky Dist., 7 km upwards the Pechorskaya Pizhma from Levkinskaya, right riverbank, limestone outcrops (64° 44' N; 50° 58' E); on humid rocks; No. 15408, 15409; 12.VII.1973, Zheleznova G.V. 2) Ust-Tsilemsky Dist., 5 km downwards from Nonburg village, right bank of the Tsilma river (65° 31' N; 50° 40' E); rocky riverbank slope; No. 14439a; 6.VIII.1973, Zheleznova G.V. 3) Troitsko-Pechersky Dist., vicinity of the Nizhnaya Omra, 2.5 km SW, the left bank of the Soiva river (62°45' N; 55°46' E); limestone outcrops, rocky talus overgrown with pine, birch and aspen; on-soil; field number 269mvd, 26.VI.2001, M.V. Dulin. 4) Troitsko-Pechersky Dist., 1 km SE from Nizhnaya Omra village, left bank of Soiva river (62°45' N; 55°49' E); rocky outcrops of carbonate bedrocks; among the mosses on rock ledges; *Preissia quadrata* and *Leiocolea collaris*; field number 252mvd, 23.VI.2001, M.V. Dulin.

Nardia japonica: 1) Ust-Tsilemsky Dist., 1.2 km along the road from Myla village to Philippovo village (65°26' N; 50°43' E); roadside ditch, on soil; *Nardia insecta*; No. 15367; 01.VII.1973, G.V. Zheleznova. 2) Pechorsky Dist., 1.5 km SE from Zelenoborsk town (64°27' N; 55°20'

E); old sward road, on soil; *Scapania curta*; No. 33071, 33070; 29.VII.2000, G.V. Zheleznova.

Odontoschisma denudatum: 1) Troitsko-Pechersky Dist., 15 km SE from Yaksha village, right bank of the Volosnitskaya oxbow (61°43' N; 57°03' E); edge of a sphagnum bog; on soil in a pit left by an uprooted tree; *Gymnocolea inflata*; field number 126mvd, 3.VIII.1999, M.V. Dulin. 2) Ust-Kulomsky Dist., vicinity of Don lake, SE bank of the Kadam lake (61°29' N; 54°41' E); at the edge of a sandy road in a pine forest, and on the road at the edge of a bog; field number 227mvd, 225mvd, 21.VII.2000, M.V. Dulin. 3) Ust-Kulomsky Dist., S part of the Donskoe bog, between the Large Kadam lake and the Middle Kadam lake (61°31' N; 54°43' E); a raised bog; on sandy soil of a road; *Mylia anomala* and other liverworts; field number 229mvd, 21.VII.2000, M.V. Dulin. 4) Ust-Kulomsky Dist., W bank of the Podkadomje lake (61°28' N; 54°41' E); water discharge valley, in a birch-pine forest; on peaty soil, around a burnt stub; *Cephalozia lunulifolia* and *Lepidozia reptans*; field number 230mvd, 22.VII.2000, M.V. Dulin.

Scapania nemorea: 1) Kojgorodsky Dist., 10 km SE from Kazhim village, basin of the Nul river, forest brook Tarasovka, forest quarter No. 103 (60° 21' N; 51° 41' E); on soil on the brook bank; field number No. 177mvd, 22.VI.2000, M.V. Dulin. 2) Troitsko-Pechersky Dist., right bank of the Bolshaja Khozja river, 5 km from its confluence with the Unja river (61° 45' N; 59° 09' E); in a zone between a bog and a birch-spruce forest; *Harpanthus flotovianus*, *Obtusifolium obtusum*; No. 33703, 33674, 13.VII.1985, G.V. Zheleznova.

Scapania scandica: 1) Vorkutinsky Dist., 1.5 km SEE from Halmer-Yu settlement (67°55' N; 64°50' E); dwarf birch-moss tundra, on soil; *Cephalozia bicuspidata*, *Gymnomitrion concinnatum*, *Solenostoma pusillum*; No. 4252; 30.VII.1969, I.D. Kildjushevsky & G.V. Zheleznova. 2) Udorsky Dist., 3 km NNE from Glotovo village (63°28' N; 49°29' E); birch-spruce forest, on rotten timber; *Blepharostoma trichophyllum*, *Geocalyx graveolens*, *Lophozia ventricosa*, *Tritomaria exsectiformis*; No. 40217, 40218; 09.VII.1972, I.D. Kildjushevsky & G.V. Zheleznova. 3) Troitsko-Pechersky Dist., suburb of Yaksha town, right bank of Pechora River, right bank of Starikovaya River, 4 km NEE from the house in the Starikovaya River mouth (61°45' N; 57°07' E); deep ditch with water, on rotten timber; *Cephalozia bicuspidata*, *C. lunulifolia*, *Lophozia ventricosa*; No. 37106; 31.VII.1999, M.V. Dulin. 4) Troitsko-Pechersky Dist., 150 m upstream from Starikovaya River mouth (61°45' N; 57°06' E); spruce forest, on the lower part of birch trunk and on soil; *Blepharostoma trichophyllum*, *Barbilophozia lycopodioides*, *Crossogyna autumnalis*, *Lophozia longidens*, *L. ventricosa*; No. 37871, 37864; 01.VIII.1999, M.V. Dulin. 5) Troitsko-Pechersky Dist., Gasnikov backwater, 300 m S from the house on the left bank of the stream (61°44' N; 56°59' E); spruce forest, on rotten timber; *Blepharostoma trichophyllum*, *Cephalozia lunulifolia*, *Calypogeia muelleriana*, *Geocalyx graveolens*, etc.; No. 37625; 07.VIII.1999, M.V. Dulin. 6) Troitsko-Pechersky Dist., left bank of Ilych River, 7 km SSE from Ydzhyd-Ljaga River mouth (62°24' N; 58°59' E); birch forest, on rotten timber in a hollow filled with water; herbarium PABG, field number 62; 23.VI.1986, G.V. Zheleznova. 7) Troitsko-Pechersky Dist., 2.5 km E from Nizhnyaya Omra settlement, left bank of Nizhnyaya Omra River near the bridge, 262 km of the road from Uhta town to Troitsko-Pechorsk settlement (62 46' N; 55°51' E); on soil; *Cephalozia bicuspidata*, *Lophozia ventricosa*, *Orthocaulis kunzeanus*, *Plectocolea hyalina*; field number 265mvd; 25.VI.2001, M.V. Dulin. 8) Knjazhpogostsky Dist., Sindor town suburbs, Sindorskoye Lake, 2.5 km SE from Ugum River mouth, right bank of the river (62°41' N; 52° 01' E); mixed forest, on rotten timber; *Blepharostoma trichophyllum*, *Geocalyx graveolens*, *Orthocaulis kunzeanus*, *Scapania praetervisa*, *Tritomaria exsectiformis*; No. 38175; 06.VIII.2000, M.V. Dulin. 9) Knjazhpogostsky Dist., Sindor town suburbs, Sindorskoye Lake, circumlittoral at the embranchment of railway (62°41' N; 52° 01' E); birch forest, on soil; *Cephalozia bicuspidata*, *Nardia geoscyphus*, *Scapania curta*, *S. irrigua*; No. 38072; 04.VIII.2000, M.V. Dulin.

Schistochilopsis hyperarctica: 1) Troitsko-Pechersky Dist., 1 km SE from Nizhnyaya Omra town, left bank of Soiva River, "Soivinsky" refuge (62°45' N; 55°49' E); rock outcrop of carbonate minerals, on soil in wet shaded cavities; field number 252mvd; 23.VI.2001, M.V. Dulin. 2) Troitsko-Pechersky Dist., 2.5 km SEE from the Nizhnyaya Omra town, right bank of Nizhnyaya Omra River (62°46' N; 55°51' E); rock outcrops of limestone along the river bank, on wet rock terraces; *Leiocolea collaris*; field number 262mvd; 25.VI.2001, M.V. Dulin.

Schistochilopsis laxa: 1) Uhtinsky Dist., 135.2 km upstream from Belaya Kedva River mouth (64°10' N; 52°34' E); sphagnum swamp, on soil; *Calypogeia sphagnicola*; No. 17184; 05.VII.1975, G.V. Zheleznona & L.S. Fedorova. 2) Knjazhpogostsky Dist., Sindor town suburbs, Sindorskoye Lake, 3 km SE from Ugum River mouth, near the bridge across the right affluent of the river, beside railway (62°41' N; 52°01' E); sphagnum pinery, on soil; No. 38435; 08.VIII.2000, M.V. Dulin. 3) Knjazhpogostsky Dist., 160 km NW from Chinjavoryk settlement, Sredne-Timansky bauxite mine, right bank of Vorykva River, road to the basalt quarry (64°19' N; 51°08' E); spruce forest, on soil; field number 463mvd; 24.VI.2005, M.V. Dulin. 4) Ust-Kulomsky Dist., suburbs of Don village, right bank of Vychegda River, SE bank of Kadamskoye Lake, along the W bank of Podkadomje Lake (61°29' N; 54°41' E); swamp with rare small pines, on sphagnum moss; *Calypogeia sphagnicola*, *Cephalozia loitlesbergeri*, *Mylia anomala*; No. 37016, 37011; 21.VII.2000, M.V. Dulin. 5) Ust-Kulomsky Dist., 19-20 km of the road Ust-Kulom village–Ust-Nem village (61°37' N; 54°04' E); meso-oligotrophic swamp with birches, on rotten stub; *Calypogeia sphagnicola*, *Cephalozia pleniceps*; field number 219mvd; 19.VII.2000, M.V. Dulin.

Sphenolobus cavifolius: 1) Vorkutinsky Dist., suburbs of Vorkuta town, 2 district, sovhoz "Tsentralny", behind the cemetery on a hill (67°30' N; 64°05' E); No. 2677; 08.VII.1960, I.S. Hantimer & G.Y. Eliseeva.2) Intinsky Dist., Lemva River drainage-basin, left bank of Parnoka-Yu River, 10 km upstream from the mouth, piedmont of Tisva-Iz mountain (65°35' N; 61°05' E); dwarf birch-sphagnum tundra, in wet lowering on soil; No. 12936; 16.VIII.1973, N.I. Nepomilueva.

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The species of the former *Toninia coeruleonigricans* group in Estonia

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Abstract: The Estonian specimens originally named *Toninia coeruleonigricans* auct. (= *Toninia caeruleonigricans*), formally revised as *Toninia sedifolia* were checked again recently. Two species, *T. physaroides* (Opiz) Zahlbr. and *T. sedifolia* (Scop.) Timdal were recognized. A key for determination of sterile specimens of the closely related taxa *T. opuntioides* (Vill.) Timdal, *T. physaroides* and *T. sedifolia* is provided.

Kokkuvõte: *Toninia coeruleonigricans* rühm Eestis

Vaadati üle Eestist kogutud varem sinakaks nappsamblikuks (*Toninia sedifolia*) määratud herbaareksemplarid. Osutus, et herbaariumis säilitatav materjal esindab tegelikult kaht nappsambliku (*Toninia*) liiki – *T. physaroides* (Opiz) Zahlbr. and *T. sedifolia* (Scop.) Timdal. Artiklis esitatakse kolme sarnase liigi (*T. opuntioides* (Vill.) Timdal, *T. physaroides* ja *T. sedifolia*) steriilsete eksemplaride määramistabel.

INTRODUCTION

Two species of the genus *Toninia*, namely *Toninia sedifolia* (Scop.) Timdal and *T. verrucarioides* (Nyl.) Timdal, are currently known from Estonia. Specimens originally named *T. coeruleonigricans* auct. (= *T. caeruleonigricans*), formally revised as *T. sedifolia* were checked again recently in TU by the first author. The reexamination of the *T. sedifolia* specimens revealed that the material consisted of two species – *T. physaroides* and *T. sedifolia*. Both species grow in rather similar habitats, i.e. on calcareous grasslands (alvars) with thin soils, being members of the *Fulgensietum bracteatae* community (Paal, 1998). The species are usually associated with cyanophilic lichens, especially species of the genera *Leptogium* and *Collema* (Timdal, 1992; Ott et al., 1995). As the morphology of the thalli of the two species is quite similar, and one of the species, *T. physaroides*, remains often sterile, the distinction of these species is often difficult, especially in the field. Since the key to the *Toninia* species in the monograph of Timdal (1992) uses mainly apothecial characters, the identification of sterile thalli of these species is almost impossible. Only studying the detailed species descriptions of the monograph led the first author to characters important for differentiating them. In this paper we (1) summarize all data available for the *T. physaroides* and *T. sedifolia* in Estonia and (2) present a simple key to three common European terricolous species with squamulose-bullate thallus – *T. opuntioides* (Vill.) Timdal, *T. physaroides* and *T. sedifolia*.

MATERIAL AND METHODS

All specimens previously determined as *Toninia sedifolia* in TU, TBA, ICEB (40 specimens) and two additional specimens of *T. opuntioides* from VBI were checked over using routine methods described in Jüriado et al. (2004). The lichen substances were determined with thin layer chromatography (TLC) method following the standard procedure (Orange et al., 2001) and using solvent system A. The lichen substances are only determined for chemical groups, since their chemical nature is not known precisely.

THE SPECIES

Key for squamulose-bullate European species of *Toninia*

1. Squamules bullate to columnar, green, olivaceous green, with pseudocyphellae (Fig. 1a); wall of the medullary hyphae 2–4(–5) µm (Fig. 2a); lichen substances absent. ....*Toninia physaroides*
– Squamules more or less flattened, orbicular to irregularly lobed, more or less imbricate, olivaceous green to brown, without pseudocyphellae; wall of the medullary hyphae 1–1.5 µm (Fig. 2b); lichen substances present. 2
2. Squamules often flattened and widening towards end, imbricate (Fig. 1c), dark olivaceous to reddish brown, pruinose along and near the margin on both the upper and lower side. Unspecified lichen substance Y present, unspecified lichen substance C absent or present (TLC; Fig. 3). .... *Toninia opuntioides*
– Squamules more or less flattened, orbicular to irregularly lobed, sometimes imbricate (Fig. 1b), olivaceous green to brown, often pruinose. Unspecified lichen substance Y absent, unspecified substance C present (TLC; Fig. 3). ..*Toninia sedifolia*

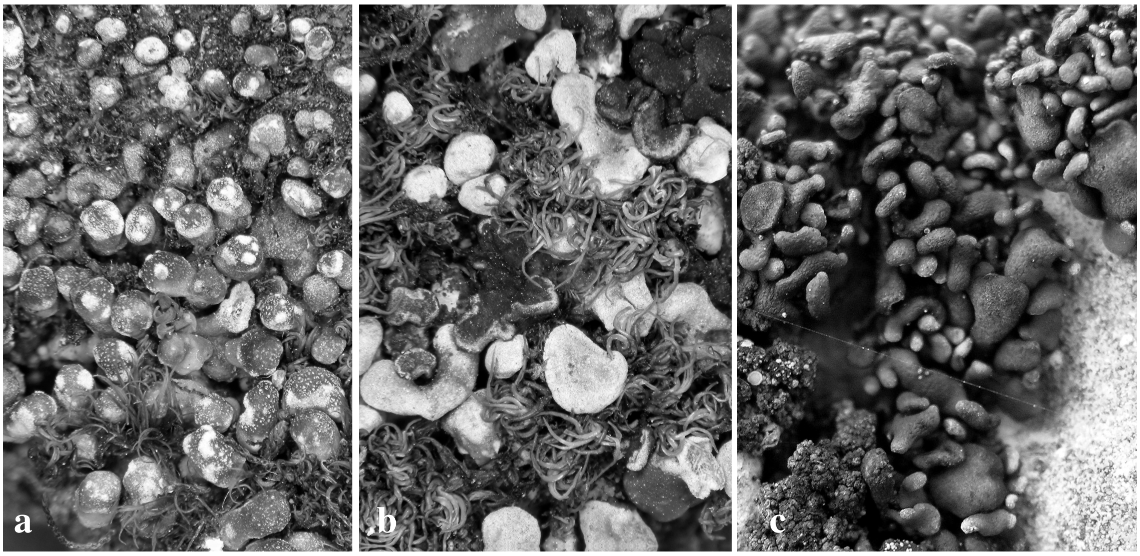

Fig. 1. a – *Toninia physaroides* (TU-38582, magnification 1×, photo A. Suija); b – *T. sedifolia* (TU-38592, magnification 1×, photo A. Suija); c – *T. opuntioides* (photo E. Farkas).

Toninia physaroides (Opiz) Zahlbr.

Description. Thallus squamulose, squamules bullate to columnar, sometimes branched, scattered to contiguous (Fig. 1a), green, olivaceous green, epruinose to densely pruinose, usually with pseudocyphellae (the pseudocyhellae are not always clearly visible on pruinose thalli). Medullary hyphae thick-walled, the wall 2–4(5) µm wide (Fig. 2a). Apothecia rare, noted only at two specimens (TU-38585; L. Kannukene coll. no. 6214, TBA). Apothecia lecideine, black, marginate when young, epruinose; epithecium grey, K+ violet, N+ violet; hypothecium colourless to pale brown; the rim of the true excipulum grey, the inner part colourless. Ascospores two-celled, fusiform; according to Timdal (1992) 11.5–18.5 × 3.5–5 µm (Estonian material 11–16 × 3–4 µm, n = 10).

Chemistry. Lichen substances usually absent; no substances is detected in Estonian specimens.

Distribution. Widely distributed in the Northern Hemisphere (Timdal, 1992); recorded from North- and West-Estonian islands in Estonia.

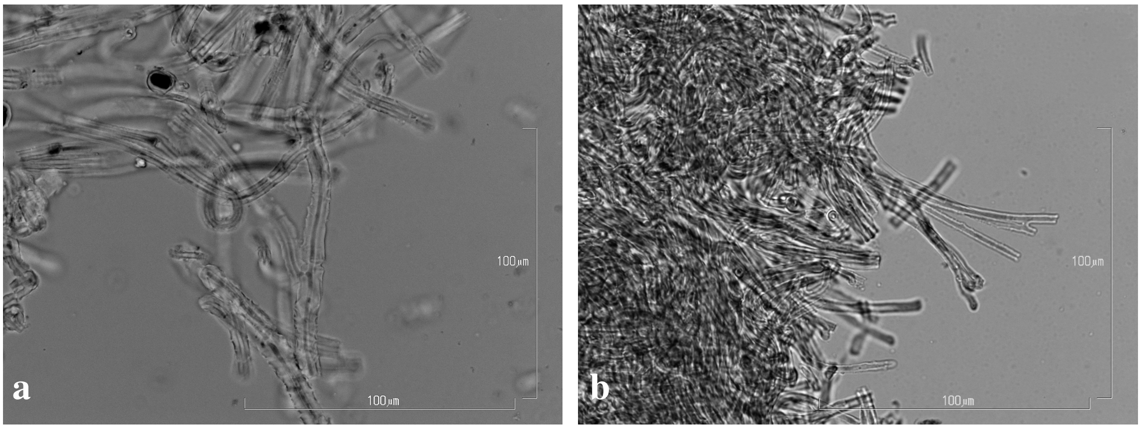

Fig. 2. Medullary hyphae (in Lactophenol Cotton Blue). a – *Toninia physaroides* (TU-32542, photo A. Suija); b – *T. sedifolia* (TU-38593, photo A. Suija).

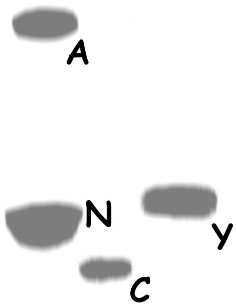

Fig. 3. Chromatogram (part) developed in solvent system A. From left to right: reference; *T. sedifolia* (TBA; Nilson, 1980); *T. opuntioides* (VBI; Farkas & Lökös, 27 Aug 2006). N – norstictic acid; A – atranorin; C – lichen substance C; Y – lichen substance Y.

Specimens studied. Harju county, Suur-Pakri island (59°19'N 23°55'E), leg. H. Trass 14 July 1960 (TU); Väike-Pakri island (59°21'N 23°57'E), leg. H. Trass, 14 July 1960 (TU); Väike-Pakri island, northern part (59°21'N 23°57'E), on klint, leg. S. Pärn, 14 July 1960 (TU-38591); Väike-Pakri island (59°20'52''N 23°59'42''E), leg. A. Suija coll. no. 25, 29 July 2007 (TU); Pakri, leg. H. Trass, 14 July 1969 (TU); Hiiu county, Hiiumaa, island, at the road between Heltermaa and Suuremõisa (58°51'N 23°00'E), leg. collector unknown (TU-38579); Vahtrepa Landscape Reserve, Vohilaid islet, alvar at the ruins of the house (58°54'N 23°01'E), leg. A. Suija & I. Jüriado coll. no. 651, 7 July 2004 (TU-39241); Lääne county, Vormsi island, ca 1 km from Hullo towards Rumpo (58°58'N 23°15'E), beach barrier, leg. H. Trass 12 July 1960 (TU-38580); Osmussaar island, close to military barracks (59°17'N 23°22'E), leg. T. Randlane & I. Jüriado coll. no. 26, 28 July 1993 (TU-38590); Kirimäe (58°55'N 23°45'E), leg. P. Wasmuth, 1910 (TU-38578); Saare county, Saaremaa island, Asva alvar (58°25'N 23°00'E), leg. H. Trass, 19 June 1959 (TU); Saaremaa island, Asva (58°25N 23°00E), leg. H. Trass, 19 June 1959 (TU); Saaremaa, Saare, leg. S. Pärn, 19 June 1959 (TU); Saaremaa island, Karala (58°15'N 21°53'E), leg. H. Trass, July 1983 (TU-32541); Saaremaa island, Pilguse alvar (58°16'N 21°59'E), leg. H. Trass, 19 July 1983 (TU-32542); Saaremaa island, Tagamõisa peninsula, ca 1 km from Tagamõisa towards Veere (58°28'N 22°01'E), alvar pine forest, leg. H. Trass, 29 Aug 1991 (TU-38581); Saaremaa island, Sõrve peninsula (58°00'N 22°05'E), leg. H. Trass coll. no. 146, July 1982 (TU-38582; TU-38583); Saaremaa island, Sõrve peninsula, Kaugatoma cliffs, on mosses (together with *T. sedifolia*), leg. L. & J. Martin coll. no. 296 (ICEB); Saaremaa island, Sõrve peninsula, Lõpe alvar (58°04'N 22°11'E), leg. T. Randlane coll. no. 7, 20 June 1983 (TU-38586); Saaremaa island, Võrsna alvar (58°24'N 22°45'E), leg. H. Trass, 23 June 1959 (TU); Same locality, leg. H. Trass, 1 July 1965 (TU-38584); Same locality, leg. T. Randlane coll. no. 294, 5 July 1980 (TU-38585); Saaremaa island, between the villages Reo and Kuusiku (58°19'N 22°39'E), alvar shrublands with junipers, on ground, leg. L. Kannukene coll. no. 6531, 3 May 1979 (TBA); Saaremaa island, from the road between Kuressaare (Kingissepa) and Kihelkonna ca 0.5 km towards Oriküla (58°19'N 22°19'E), gravel alvar, on ground, leg. L. Kannukene coll. no. 6221 and coll. no. 62141, 21 Aug 1979 (TBA); Undva peninsula, between village Tammese and Kehila (58°25'N 22°02'E), alvar shrublands with junipers, on ground, leg. L. Kannukene, 23 July 1966 (TBA); Saaremaa island, SW direction from the Asva stronghold (58°25'N 23°01'E), alvar shrublands with junipers, leg. L. Kannukene coll. no. 6581, 4 Oct 1979 (TBA); Saaremaa island, S direction from the Undu manor (58°28'N 23°10'E), alvar shrublands with junipers, leg. L. Kannukene coll. no. 6679, 2 Oct 1979 (TBA); Muhumaa island, at the village Võiküla (58°33'N 23°23'E), on alvar grassland, leg. T. Randlane coll. no. 57, 14 June 1986 (TU-38587); Muhumaa island, Üügu cliffs (58°40'N 23°15'E), leg. A. Suija 30 May 2004 (TU-38589); Muhumaa island, between Rässa and Tümena (58°32'N 23°21'E), alvar shrublands with junipers, on ground, leg. L. Kannukene coll. no. 7588, 4 Aug 1979 (TBA); Muhumaa island, Kantsi village (58°35'N 23°14'E), alvar shrublands with junipers, on ground, leg. L. Kannukene coll. no. 7296, 4 Aug 1979 (TBA).

Toninia sedifolia (Scop.) Timdal

Toninia caeruleonigricans auct., non (Lightf.) Th. Fr.

Description. Thallus squamulose, squamules imbricate, scattered to contiguous (Fig. 1b), olivaceous green to brown epruinose to densely pruinose, pseudocyphellae absent. Medullary hyphae with narrow wall, the wall 1(–1.5) µm wide (Fig. 2b). Apothecia common, lecideine, black, sometimes pruinose, marginate when young; epithecium grey, K+/– violet, N+/– violet (Estonian material exclusively K+ violet); hypothecium medium brown to dark reddish brown; excipulum uniformly coloured, medium to dark reddish brown. Ascospores two-celled, fusiform to narrowly fusiform, according to Timdal (1992), 12–24 × 3–5 µm (Estonian material 8–21.5 × 2.5–4 µm, n = 24).

Chemistry. Only lichen substance (chemotype) C, which is possibly a depside according to Timdal (1992) from the three chemotypes of the species has been detected in Estonian material. The lichen substance C forms a greenish grey spot (Rf class 3) in solvent system after treatment with sulphuric acid (Fig. 3).

Distribution. Widely distributed in both hemispheres (Timdal, 1992); recorded from seven scattered localities in northern part of Estonia and West-Estonian islands.

Specimens studied. Harju county, Vasalemma, Rummu old strip mine (59°13'N 24°12'E), leg. S. Pärn, 6 Aug 1960 (TU-38592); Vasalemma, old strip mine (59°13'N 24°12'E), leg. S. Pärn, 6 Aug 1960 (TU-38593); Saare county, Muhumaa island, exact locality unknown, leg. A. Bruttan (TU-38576); Muhumaa island, Üügu cliffs (58°40'N 23°14'E), alvar, leg. T. Randlane coll. no. 44, 12 June 1984 (TU-38588); Locality unknown, leg. A. Bruttan (TU-38577); Saaremaa island, from the road between Kuressaare (Kingissepa) and Kihelkonna ca 0.5 km towards Oriküla (58°19'N 22°19'E), gravel alvar, on ground, leg. L. Kannukene coll. no. 6221 and coll. no. 62141, 21 Aug 1979 (TBA); Saaremaa island, Sõrve peninsula, Kaugatoma pank, on mosses (together with *T. physaroides*), leg. L. & J. Martin coll. no. 296, det. L. Martin (ICEB); Saaremaa island, Pilguse alvar (58°16'N 21°59'E), leg. H. Trass, 19 July 1983 (TU-32536); Vilsandi island (58°23'N 21°51'E), on ground, leg. E. Nilson, 7 Aug 1980 (TBA).

Specimens used for comparison.

Toninia opuntioides (Vill.) Timdal Hungary, Bükk Mts, Mt. Kemesnye-kö, 2 km SSE of Mályinka, S slope (48°08'02,2"N, 20°30'05,8"E), on calcareous rocks/soil, leg. E. Farkas & L. Lökös, 27 Aug 2006, det. E. Farkas (VBI; dupl. in TU); Vértes Mts, Mt. Kopasz-hegy, on S slope and plateau, c. 1.5 km W of Csákberény (47°20'55,8"N 18°18'41,6"E), on calcareous rocks/soil, leg. E. Farkas & L. Lökös, 19 Aug 2006, det. E. Farkas (VBI; dupl. in TU).

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Lichens from Arsuk and Paamiut – Frederikshåb, South West Greenland

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Abstract: A total of 263 taxa of lichens are reported from two localities in South West Greenland. *Peltigera britannica* and *Porpidia thomsonii* are reported as new to West Greenland. 4 lichens are new to South West Greenland, viz. *Bacidia bagliettoana*, *Baeomyces carneus*, *Caloplaca psoricida* and *Rhizocarpon subareolatum*. A new taxon, *Lecanora swartzii* ssp. *soralifera*, is described. Geology, climate and vegetation of the localities are briefly treated.

Kokkuvõte: Arsuki ja Paamiuti (Edela-Gröönimaa) samblikud.

Teatatakse 263 samblikutaksoni leidmisest Edela-Gröönimaalt. *Peltigera britannica* ja *Porpidia thomsonii* on uued läänepoolsele Gröönimale. *Bacidia bagliettoana*, *Baeomyces carneus*, *Caloplaca psoricida* ja *Rhizocarpon subareolatum* on uued Edela-Gröönimaale. Kirjeldatakse uus alamliik *Lecanora swartzii* ssp. *soralifera*. Lühidalt tutvustatakse leiukohtade geoloogiat, kliimat ja taimestikku.

INTRODUCTION

Owing to comprehensive contributions from many botanists, in particular during the latest 60 years, knowledge of the occurrence and distribution of the lichens in South West Greenland has increased considerably. However, precise information about the composition of the local lichen floras is often lacking. Repeated investigations of specific localities with focus on a part of the flora, for example a particular taxonomic group, might well indicate a possible influence of environmental changes, but they do not allow more thorough comparative studies of, for example, the different effects on the ongoing climatic changes. Investigations of this type are already carried out at Zackenberg in North East Greenland (Hansen, 2006a) and will be commenced in South West Greenland in the summer of 2008. The purpose of the present study of the lichen flora of Arsuk and Paamiut is, together with previous similar studies, to establish a basis for investigations of floristic changes caused by different environmental, especially climatic, changes. Before the present study the available lichen material in the herbarium C from these areas consisted of about 100 collections of more or less common species. The mineralogists, F. R. Johnstrup and A. N. Kornerup, and the botanists, N. Hartz, L. K. Rosenvinge and J. Vahl, collected lichens near Arsuk and Paamiut in the eighteenth century (Branth & Grønlund, 1888; Branth, 1892). M. S. Christiansen collected some epiphytic lichens at Grønnedal in 1946 (Alstrup, 1982). E. Dahl (1950) and K. Hansen (1971) carried out many collections of macrolichens in these areas in 1937 and 1965, respectively. Surveys of the previous investigations of the lichen flora of the southernmost part of South West Greenland have been given by the two last-mentioned authors and Hansen & Lund (2003) and Hansen (2006b).

Localities and geology

The following two localities were investigated by the author (Fig. 1).

1. Arsuk. 61°11'N, 48°28'W. Alt. 0–150 m. 8–20 July 1993. Archaean gneiss with amphibolite horizons and scattered occurrences of dolerite (Escher & Stuartt Watt, 1976). – The settlement, Arsuk, has c. 350 inhabitants. It is located in a small valley at the south side of Arsuk Fjord a few kilometres from the outer coast and just south of the 1418 m high mountain, Kuungnaat. The basal part of the mountain facing Arsuk and the coastal lowland strip around the mountain (Fig. 2) were studied by the author.
2. Paamiut/Frederikshåb. 62°00'N, 49°41'W. Alt. 0–300 m. 22–29 July 1993. Archaean gneiss with layers of amphibolite. The gneissic rocks are intersected by dykes composed

of dolerite. – The town, Paamiut, has 2300 inhabitants and is situated in an inlet just north of the entrance to Kvanefjord. Like Arsuk the town is located close to the outer coast. The distance between Paamiut and Arsuk is 134 km. The author studied the surroundings of Paamiut including the low mountains, "De rådne Fjelde"(max. alt. 210 m) south of the town.

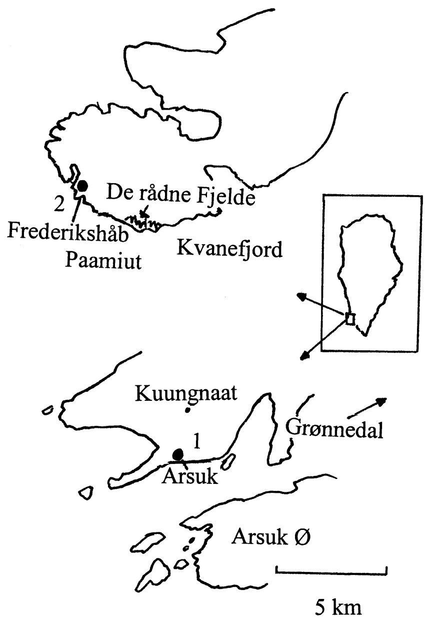

Fig. 1. Location of the two investigation areas in South West Greenland. 1 – Arsuk. 2 – Paamiut/ Frederiksdal.

Climate

The Paamiut area has a low arctic and hyper-oceanic climate. The mean temperature of the warmest month, July, is 5°C at Paamiut, while the mean temperature of the coldest month, February, is -6°C according to measurements made by Asiaq/Grønlands Forundersøgelser. The annual precipitation is c. 875mm (1996). The climatic conditions at Arsuk are presumably comparable with those of Paamiut, although the annual precipitation is somewhat smaller.

MATERIAL AND METHODS

Lichens were collected at numerous sample plots at the two localities situated in South West Greenland. The collected material, a total of 690 specimens of lichens, was studied with Zeiss light microscopes. Selected specimens of *Stereocaulon* and *Lepraria* were identified by means of HPTLC. The material is deposited at the Botanical Museum, University of Copenhagen (C).

RESULTS AND DISCUSSION

Presence of willow copses is an important parameter in the subdivision of South and South West Greenland in vegetational zones (Feilberg, 1984; Hansen, 2006b). The climate in the hyper-oceanic, low arctic zone, in which Paamiut is located, does not allow development of willow scrubs and accordingly is very poor in lichen epiphytes. Willow copses occur, however, more or less abundantly in the oceanic, low arctic zone, where Arsuk is situated. Although the epiphytic lichen flora of Arsuk consists of comparatively many species, this group of lichens is still better represented in the subcontinental, subarctic inland zone characterized by extensive birch- and willow scrubs (Dahl, 1950; Hansen, 1978; Alstrup, 1982). The lichen flora of Arsuk is also similar to that of the subarctic region in its rich occurrences of lichens restricted to neutral and slightly alkaline soil such as, for example, *Catapyrenium daedaleum*, *Diploschistes muscorum*, *Lecanora geophila*, *Placidium lachneum* and *Psora decipiens* (Hansen, 2000, 2001). A few lichens, viz. *Cladonia floerkeana*, *C. pyxidata*, *Miriquidica atrofulva*, *Porpidia flavocaerulescens*, *Rhizocarpon copelandii*, *R. inarense* and *R. jemtlandicum*, were collected on a boat trip to the naval station, Grønnedal (61°14'N, 48°05'W), near Ivigtut in Arsuk Fjord. – Mostly rare species of particular interest reported from the present investigation areas, but not during the trip in 1993, are listed together with the references in the following.

Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw. (Alstrup, 1982)
Caloplaca borealis (Vain.) Poelt (Hansen et al., 1987)
Cladonia decorticata (Flörke) Spreng. (Dahl, 1950)
C. scabriuscula (Delise) Nyl. (Dahl, 1950; Thomson, 1984)
C. turgida Hoffm. (Dahl, 1950)
Lecidea lithophila (Ach.) Ach. (Branth, 1892)
L. praenubila Nyl. (Branth & Grønlund, 1888)
Melanelia stygia (L.) Essl. (Dahl, 1950)
Nephroma expallidum (Nyl.) Nyl. (K. Hansen, 1971)

Phaeocalicium compressulum (Nyl. Ex Vain.) A. Schmidt (Alstrup, 1982; Thomson, 1997)
Schaereria fuscocinerea (Nyl.) Clauzade & Roux (Branth & Grønlund, 1888)
Solorina octospora Arnold (Dahl, 1950)
Staurothele fuscocuprea (Nyl.) Zschacke (Branth & Grønlund, 1888)
Thelignya lignyota (Wahlenb.) P. M Jørg. & Henssen (Dahl, 1950)

General remarks on the lichen vegetation

The most striking feature as regards the terricolous lichen flora of Arsuk is its rich contents of eutrophic species, i. e. lichens restricted to neutral or slightly alkaline soil. *Catapyrenium daedaleum, Cladonia pocillum, Diploschistes muscorum, Peltigera venosa, Physconia muscigena, Placidium lachneum, Psora decipiens, P. globifera, Solorina bispora, Toninia sedifolia* and *T. squalida* all belong to this group of lichens (Gelting, 1955; Hansen, 1978). They grow on mineral soil originating from weathered basaltic rocks and among mosses on a thin layer of soil on such rocks, which cut through Kuungnaat as almost black dykes. Like the rocks composed of amphibolite they are more resistant than the surrounding gneiss. Saxicolous lichens such as *Dimelaena oreina, Hypogymnia austerodes, Lecanora argopholis, Lobaria scrobiculata, Nephroma parile, Umbilicaria polyphylla, Xanthoparmelia conspersa* and *Xanthoria elegans* have a distinct preference for such protruding, south-facing rocks, which are often influenced by guano from ravens and other bird species. The scattered boulders around Arsuk and blocks in screes also hold a nitrophilous lichen flora composed of species such as *Acarospora peliscypha, Candelariella vitellina, Physcia dubia, Protoparmelia badia, Rhizoplaca melanophthalma, Umbilicaria arctica* and *Xanthoria candelaria. Brodoa oroarctica, Ochrolechia tartarea, Parmelia saxatilis, P. sulcata, Platismatia glauca, Pseudephebe pubescens, Sphaerophorus fragilis* and *Umbilicaria hyperborea* are additional lichens on boulders in the screes. *Caloplaca alcarum, C. scopularis, C. verruculifera, Lecanora contractula* and *L. straminea* occur just above the *Verrucaria ceuthocarpa*-zone on gneissic seashore rocks manured by different sea

Fig. 2. The western part of Kuungnaat, "Vestre Bjergryg" and to the left the bay, "Paatussoq"and the lowland area with rare plants, for example, the small saprophytic orchid, *Corallorhiza trifida*. The rocks are rich in epilithic lichens.

birds. Rust-stained lichens such as, for example, *Miriquidica atrofulva*, *Porpidia flavocaerulescens*, *P. melinodes* and *Tremolecia atrata* grow more or less abundantly on somewhat moist, north-facing basaltic and gneissic rocks near Arsuk. Species such as *Amygdalaria panaeola*, *Caloplaca nivalis*, *Miriquidica nigroleprosa*, *Rhizocarpon bolanderi* and *Vestergrenopsis isidiata* also prefer this type of habitat.

Mixed dwarf shrub heaths dominated by *Betula glandulosa*, *Empetrum hermaphroditum* and species of *Ledum* occur in somewhat protected places among rocks around Arsuk. This community is rich in macrolichens such as *Cladonia mitis*, *C. stellaris*, *C. stygia*, *Nephroma arcticum*, *Stereocaulon alpinum* and *S. paschale*. *Ochrolechia frigida* and *O. lapuënsis* are the dominant microlichens in these heaths. *Alectoria nigricans*, *A. ochroleuca*, *Bryoria chalybeiformis*, *Flavocetraria cucullata*, *F. nivalis*, *Hypogymnia physodes*, *Sphaerophorus globosus* and other fell-field lichens are restricted to places exposed to strong winds such as the top of hills. Epiphytic lichens such as *Lecanora boligera*, *L. fuscescens*, *Nephroma parile*, *Parmeliopsis ambigua*, *P. hyperopta*, *Pertusaria carneopallida*, *Tuckermannopsis chlorophylla* and *Varicellaria rhodocarpa* occur more or less abundantly on twigs of, for example, *Salix glauca* and *Juniperus communis*. The fairly rich occurrence of epiphytic lichens is the most pronounced difference from the lichen flora of Paamiut.

Empetrum heaths with *Cladonia bellidiflora*, *C.crispata*, *C. cyanipes*, *C. mitis*, *C. stygia*, *C. subfurcata*, *C. squamosa*, *C. uncialis*, *Nephroma arcticum*, *Stereocaulon alpinum* and *S. paschale* form a characteristic community in the coastal area near Paamiut. An *Empetrum-Salix herbacea community* with *Cetrariella delisei*, *Cladonia ecmocyna*, *C. trassii* and *Pertusaria oculata* is common in this area. *Arctoparmelia andrejevii*, *Cetrariella delisei* and *Cladonia trassii* are also typical components of the flora bordering the marshes and fens. Snow-patches dominated by *Salix herbacea* and *Solorina crocea* occur preferably on north-facing slopes. Mixed dwarf shrub heaths dominated by *Empetrum*, *Vaccinium uliginosum*, *Betula glandulosa* and *Ledum groenlandicum* replace the pure *Empetrum* heaths at some distance from the coast. They are in many ways comparable with the mixed dwarf shrub heaths at Arsuk as regards their contents of lichens, although they are richer in, for example, *Cladonia stellaris* and *Flavocetraria nivalis*. Typical fell-field lichens such as *Alectoria sarmentosa* ssp. *vexillifera*, *Bryocaulon divergens*, *Bryoria chalybeiformis*, *Cladonia amaurocraea*, *Hypogymnia physodes* and *Thamnolia vermicularis* occur on gravely soil on the top of hills and on plains exposed to winds.

"Bella Vista" is the name of a small mountain top in Paamiut. It holds a very characteristic saxicolous vegetation of the following nitrophilous lichen species: *Caloplaca alcarum*, *Candelariella arctica*, *Lecanora straminea*, *Physcia caesia*, *P. dubia*, *Polysporina simplex*, *Rhizocarpon grande* and *Xanthoria candelaria*. A somewhat richer nitrophilous community with *Candelariella vitellina*, *Dimelaena oreina*, *Melanelia disjuncta*, *M. infumata*, *Parmelia saxatilis*, *P, sulcata*, *Phaephyscia endococcina*, *P. orbicularis*, *P. sciastra*, *Physcia tenella* (var. *marina*), *Physconia detersa*, *Placynthium asperellum*, *Rhizocarpon geminatum*, *Sporastatia testudinea* and the three *Xanthoria* species listed below occurs on the uppermost part of "De rådne Fjelde", which apparently is influenced both by guano from sea birds and sea salt. "De rådne fjelde" are a number of comparatively low and strongly weathered mountains just southeast of the town. The widely distributed saxicolous community dominated by lichens with a black or brown thallus, for example, *Allantoparmelia alpicola*, *Brodoa oroarctica*, *Melanelia hepatizon*, *Orphniospora moriopsis*, *Pseudephebe minuscula*, *Umbilicaria havaasii*, *U. hyperborea*, *U. proboscidea* and *U. torrefacta* covers the lover parts of "De rådne Fjelde" and is just as common here as on the gneissic rocks at Arsuk. *Verrucaria degelii* grows at sea level on such rocks. The basaltic dykes support a saxicolous flora of rust-stained lichens similar to that described from Arsuk, and in addition the less conspicuous species, *Acarospora sinopica* and *A. smaragdula*.

Annotated list of lichens

The following list of lichens is based on the author´s collections, which include totally 263 taxa. The list cannot be considered representative as regards a number of lecideoid and leprose, crustose lichens, which have been neglected during the present investigation. Nomenclature follows Santesson et al. (2004) with some exceptions. Numbers 1 and 2 indicate the two localities listed above. Annotations are given as regards the substrate of the lichens, the plant communities in which they occur and presence of apothecia (ap.) or perithecia (pe.); "st." means that the specimen is sterile. The frequency is mentioned, where it was possible to estimate it. The following estimation classes are used: rare, common, locally abundant. Collections which have been distributed previously from the herbarium (C) as part of "Lichenes Groenlandici Exsiccati" (LGE) are stated by their numbers. These numbers can also be found in Index of Lichenes Groenlandici Exsiccati fascicle I–XXX (Hansen, 2006c). Selected references are cited.

ACAROSPORA BADIOFUSCA (Nyl.) Th. Fr. – 1, 2. On gneissic rocks manured by birds, together with, for example, *Arctoparmelia centrifuga*, *Candelariella arctica* and *Rhizocarpon grande*; ap.

A. MOLYBDINA (Wahlenb.) A. Massal. – 2. On gneissic seashore rocks, together with *Caloplaca alcarum*, *Lecanora straminea*, *Physcia dubia* and *Xanthoria candelaria*; ap.

A. PELISCYPHA (Th. Fr.) Arn. – 1, 2. On gneissic rocks manured by birds; ap.

A. SINOPICA (Wahlenb.) Körb. – 2. On siliceous rocks coated with limonite; ap.; rare.

A. SMARAGDULA (Wahlenb.) A. Massal. – 2. On basaltic rocks; ap.

ALECTORIA NIGRICANS (Ach.) Nyl. – 1, 2. On soil in dwarf shrub heaths and fell-fields; st.; common.

A. OCHROLEUCA (Hoffm.) A. Massal. – 1, 2. On soil in dwarf shrub heaths and fell-fields; st.; common.

A. SARMENTOSA (Ach.) Ach. ssp. VEXILLIFERA (Nyl.) D. Hawksw. – 1, 2. On soil in fell-fields, together with, for example, *Cetraria muricata*, *Flavocetraria nivalis* and *Sphaerophorus globosus*; st.; locally abundant. LGE 542.

ALLANTOPARMELIA ALPICOLA (Vain.) Essl. – 1, 2. On gneissic rocks, together with, for example, *Calvitimela armeniaca*, *Ochrolechia tartarea* and *Rhizocarpon inarense*; ap.

AMANDINEA CACUMIUM (Th. Fr.) H. Mayrhofer & Sheard – 1. On siliceous rocks manured by birds, together with *Dimelaena oreina* and *Xanthoria elegans*; ap.

A. PUNCTATA (Hoffm.) Coppins & Scheid. – 1. On gneissic rocks, together with *Lecanora swartzii*; ap.

AMYGDALARIA PANAEOLA (Ach.) Hertel & Brodo – 1, 2. On moist gneissic and basaltic rocks, together with, for example, *Caloplaca nivalis*, *Miriquidica nigroleprosa* and *Rhizocarpon bolanderi*; st.

ARCTOCETRARIA ANDREJEVII (Oksner) Kärnefelt & A. Thell – 1, 2. On moist soil in dwarf shrub heaths, together with *Cetrariella delisei*; st.; locally abundant.

A. SIMMONSII (Krog) E.S. Hansen – 2. On moist soil in dwarf shrub heaths; st.; locally abundant.

ARCTOPARMELIA CENTRIFUGA (L.) Hale – 1, 2. On gneissic rocks; ap.

A. INCURVA (Pers.) Hale – 1, 2. On gneissic rocks; st.

ARTHRORHAPHIS CITRINELLA (Ach.) Poelt – 1, 2. On mineral soil, together with *Candelariella placodizans*; ap.

ASPICILIA CAESIOCINEREA (Nyl. ex Malbr.) Arnold – 1. On gneissic rocks manured by birds; ap.

A. CINEREA (L.) Körb. – 1. On gneissic and other siliceous rocks; ap.

A. MASTOIDEA (Lynge) Thomson – 1, 2. On gneissic rocks; ap.

A. MASTRUCATA (Wahlenb.) Th. Fr. – 1. On gneissic rocks manured by birds, together with *Xanthoria elegans*; ap.

BACIDIA BAGLIETTOANA (A. Massal. & De Not.) Jatta – 1. On mosses on soil; ap.; rare. New to South West Greenland. Previously reported from a few localities in Central West Greenland and North East Greenland (Lynge, 1937, 1940).

BAEOMYCES CARNEUS Flörke – 2. On mineral soil; st. New to South West Greenland.

B. RUFUS (Huds.) Rebent. – 2. On clayey soil, mosses and plant remains; st.

BELLEMEREA CINEREORUFESCENS (Ach.) Clauzade & Cl. Roux – 1. On gneissic rocks; ap.; rare.

BIATORA VERNALIS (L.) Fr. – 2. On soil rich in humus; ap.

BRODOA OROARCTICA (Krog) Goward – 1, 2. On gneissic rocks manured by birds; ap.

BRYOCAULON DIVERGENS (Ach.) Kärnefelt – 1, 2. On soil in dwarf shrub heaths, together with *Alectoria ochroleuca* and *Sphaerophorus globosus*; st.

BRYORIA CHALYBEIFORMIS (L.) Brodo & D. Hawksw. – 1, 2. On soil in dwarf shrub heaths, together with, for example, *Cetraria muricata* and *Sphaerophorus globosus*; st. LGE 543.

BUELLIA DISCIFORMIS (Fr.) Mudd – 1. On mosses; ap.

B. PAPILLATA (Sommerf.) Tuck. – 1. On dead twig of *Salix*, together with *Lecanora fuscescens* and *Rinodina archaea*; ap.

B. PULVERULENTA (Anzi) Jatta – 1, 2. On *Physconia muscigena*; ap.

CALOPLACA ALCARUM Poelt – 1, 2. On gneissic seashore rocks manured by birds, together with *Lecanora contractula*, *L. straminea* and *Xanthoria elegans*; ap.

C. CERINA (Ehrh. ex Hedw.) Th. Fr. – 1. On mosses; ap.

C. FRAUDANS (Th. Fr.) H. Olivier – 1, 2. On weathered gneissic rocks, together with *Candelariella vitellina*; ap.

C. JUNGERMANNIAE (Vahl) Th. Fr. – 1. On mosses and plant remains, together with *Cladonia pocillum*; ap.

C. NIVALIS (Körb.) Th. Fr. – 1, 2. On *Andreaea*; ap.

C. PSORICIDA E.S. Hansen, Poelt & Søchting – 1. On *Psora rubiformis* on soil; ap.; rare. New to South West Greenland. Also known from Central and North West Greenland and Central and North East Greenland (Hansen et al., 1987).

C. SCOPULARIS (Nyl.) Lettau – 1. On gneissic seashore rocks manured by birds, together with *Lecanora contractula* and *Xanthoria elegans*; ap.; rare.

C. TETRASPORA (Nyl.) H. Olivier – 1. On mosses; ap.

C. TIROLIENSIS Zahlbr. – 1, 2. On mosses and plant remains, together with, for example, *Physconia muscigena*; ap.

C. VERRUCULIFERA (Vain.) Zahlbr. – 1. On gneissic seashore rocks manured by birds, together with *Lecanora contractula* and *Verrucaria ceuthocarpa*; st.; rare. Probably neglected in East Greenland, from where no reports are available so far (Hansen et al., 1987; Thomson, 1997).

CALVITIMELA AGLAEA (Sommerf.) Hafellner – 1, 2. On gneissic rocks; ap.

C. ARMENIACA (DC.) Hafellner – 1, 2. On gneissic rocks, together with *Orphniospora moriopsis*; ap.

CANDELARIELLA ARCTICA (Körb.) R. Sant. – 2. On gneissic rocks manured by birds, together with *Acarospora badiofusca*, *Lecanora polytropa* and *Rhizocarpon grande*; ap.; rare.

C. DISPERSA (Räsänen) Hakul. – 1. On *Placynthium asperellum* on gneissic rocks; st.; rare.

C. PLACODIZANS (Nyl.) H. Magn. – 1, 2. On mineral soil, together with *Placidium lachneum*; ap. LGE 535.

C. VITELLINA (Hoffm.) Müll. Arg. – 1, 2. On weathered rocks; ap.

CATAPYRENIUM DAEDALEUM (Kremp.) Stein – 1. On mineral soil, together with *Placidium lachneum*; pe.

CETRARIA ERICETORUM Opiz – 1, 2. On soil in dwarf shrub heaths; st.

C. ISLANDICA (L.) Ach. – 1, 2. On soil in dwarf shrub heaths, together with, for example, *Cladonia mitis* and *Stereocaulon alpinum*; st.; common.

C. MURICATA (Ach.) Eckfeldt – 1, 2. On soil in dwarf shrub heaths and fell-fields, together with *Alectoria sarmentosa* ssp. *vexillifera*, *Sphaerophorus globosus* and *Thamnolia vermicularis*; st.; common.

C. NIGRICANS Nyl. – 2. On soil rich in humus, together with *Sphaerophorus globosus*; st.

C. SEPINCOLA (Ehrh.) Ach. – 1. On twigs of *Juniperus*, together with, for example, *Parmelia septentrionalis*, *Parmeliopsis ambigua* and *Tuckermanopsis chlorophylla*; ap.; rare.

CETRARIELLA DELISEI (Bory ex Schaer.) Kärnefelt & A. Thell – 1, 2. On soil in moist places in dwarf shrub heaths, together with, for example, *Arctocetraria andrejevii* and *Cladonia crispata*; ap.; common.

CHAENOTHECA FURFURACEA (L.) Tibell – 1. On peat; ap.; rare.

CLADONIA AMAUROCRAEA (Flörke) Schaer. – 1, 2. On soil in dwarf shrub heaths; ap.

C. ARBUSCULA (Wallr.) Flot. – 2. On soil in dwarf shrub heaths and fell-fields; st.; rare.

C. BELLIDIFLORA (Ach.) Schaer. – 1, 2. On soil in moist places in dwarf shrub heaths; ap.

C. BOREALIS S. Stenroos – 1, 2. On soil in dwarf shrub heaths, together with, for example, *Cladonia bellidiflora*; ap. LGE 538.

C. CARNEOLA (Fr.) Fr. – 1, 2. On soil rich in humus in dwarf shrub heaths; ap.

C. CHLOROPHAEA (Flörke ex Sommerf.) Spreng. – 1, 2. On soil in dwarf shrub heaths; ap.

C. CORNUTA (L.) Hoffm. – 1, 2. On soil in dwarf shrub heath, together with, for example, *Cladonia carneola*; ap.

C. CRISPATA (Ach.) Flot. – 1, 2. On soil in moist dwarf shrub heaths; ap.

C. CYANIPES (Sommerf.) Nyl. – 1, 2. On soil rich in humus in dwarf shrub heaths, together with, for example, *Cladonia cornuta*; st.

C. DEFORMIS (L.) Hoffm. – 1, 2. On soil in dwarf shrub heaths; st.; rare.

C. ECMOCYNA Leight. – 1, 2. On soil in moist dwarf shrub heaths and near snow-patches; ap. LGE 540.

C. FIMBRIATA (L.) Fr. – 1. On soil rich in humus in dwarf shrub heaths; st.; rare.

C. FLOERKEANA (Fr.) Flörke – 2. On soil rich in humus in dwarf shrub heaths, together with *Cladonia bellidiflora*, *C. borealis* and *C. cornuta*; ap.; rare.

C. GRACILIS (L.) Willd. – 1, 2. On soil in dwarf shrub heaths; ap.

C. LUTEOALBA Wheldon & A. Wilson – 1, 2. On soil rich in humus in dwarf shrub heaths; st.; rare.

C. MACROPHYLLA (Schaer.) Stenh. – 1, 2. On soil rich in humus in dwarf shrub heaths; st.

C. MACROPHYLLODES Nyl. – 1, 2. On soil rich in humus in dwarf shrub heaths; ap.

C. MITIS Sandst. – 1, 2. On soil in dwarf shrub heaths and fell-fields; st.; rare.

C. PHYLLOPHORA Hoffm. – 1, 2. On soil in moist places in dwarf shrub heaths; st.

C. PLEUROTA (Flörke) Schaer. – 1, 2. On soil in moist places in dwarf shrub heaths, together with, for example, *Cladonia bellidiflora*; ap.

C. POCILLUM (Ach.) O.J. Rich. – 1, 2. On mineral soil and mosses; st.

C. PYXIDATA (L.) Hoffm. – 1, 2. On soil rich in mosses; st.

C. SQUAMOSA Hoffm. – 1, 2. On soil and plant remains in moist places in dwarf shrub heaths; ap.

C. STELLARIS (Opiz) Pouzar & Vězda – 1, 2. On soil in dwarf shrub heaths, together with, for example, *Cladonia mitis*, *C. stygia* and *C. uncialis*; st.

C. STYGIA (Fr.) Ruoss – 1, 2. On soil in moist dwarf shrub heaths; st.; locally abundant.

C. SUBFURCATA (Nyl.) Arnold – 2. On soil in moist dwarf shrub heaths, together with, for example, *Cetraria islandica*, *Cladonia phyllophora* and *C. uncialis*; ap.; rare.

C. SULPHURINA (Michx.) Fr. – 1, 2. On soil rich in humus, together with *Ochrolechia frigida* and *Pertusaria oculata*; st.

C. TRASSII Ahti – 1, 2. On soil in moist places in dwarf shrub heaths, together with, for example, *Cladonia crispata*; st.

C. UNCIALIS (L.) F.H. Wigg. – 1, 2. On soil in dwarf shrub heaths, together with *Cladonia stellaris*; st. LGE 534.

COLLEMA BACHMANIANUM (Fink) Degel. var. MILLEGRANUM Degel. – 1, 2. On mosses on soil; st.

DERMATOCARPON MINIATUM (L.) W. Mann – 1. On moist siliceous rocks; pe.; rare.

DIMELAENA OREINA (Ach.) Norman – 1, 2. On gneissic rocks manured by birds, together with, for example, *Candelariella vitellina*, *Melanelia disjuncta* and *Sporastatia testudinea*; ap.

DIPLOSCHISTES MUSCORUM (Scop.) R. Sant. – 1. On neutral to slightly alkaline soil in dwarf shrub heath; ap.; rare.

EPHEBE HISPIDULA (Ach.) Horw. – 1, 2. On moist gneissic rocks; st.

FLAVOCETRARIA CUCULLATA (Bellardi) Kärnefelt & A. Thell – 1, 2. On soil in dwarf shrub heaths and fell-fields, together with, for example, *Alectoria nigricans*, *A. ochroleuca* and *Cetraria muricata*; st.

F. NIVALIS (L.) Kärnefelt & A. Thell – 1, 2. On soil in dwarf shrub heaths and fell-fields, together with, for example, *Cetraria islandica*, *Cladonia amaurocraea* and *Sphaerophorus globosus*; ap.

FRUTIDELLA CAESIOATRA (Schaer.) Kalb. – 1, 2. On mosses in snow-patches, together with *Lepraria frigida*, *Pertusaria oculata* and *Solorina crocea;* ap.

FUSCOPANNARIA PRAETERMISSA (Nyl.) P.M. Jørg. – 1. On mosses and alkaline soil, together with *Physconia muscigena*; st.

GYALECTA FOVEOLARIS (Ach.) Schaer. – 1. On alkaline soil; ap.; rare.

HYPOGYMNIA AUSTERODES (Nyl.) Räsänen – 1. On soil in dwarf shrub heaths; also on twig of *Salix glauca*, together with *Rinodina turfacea,* and on mosses on basaltic rock; st.

H. PHYSODES (L.) Nyl. – 1, 2. On soil in fell-fields, together with, for example, *Alectoria sarmentosa* ssp. *vexillifera*, *Cetraria muricata* and *Sphaerophorus globosus*; st.

H. SUBOBSCURA (Vain.) Poelt – 1. On neutral to alkaline soil in dwarf shrub heath; st.; rare.

IONASPIS LACUSTRIS (With.) Lutzoni – 1. On moist siliceous rock in depression in heath, together with *Rhizocarpon lavatum* and *Vestergrenopsis isidiata*; ap.

I. SUAVEOLENS (Fr.) Th. Fr. ex Stein – 1. On almost pure quartz, together with *Staurothele fissa*, *Tremolecia atrata* and *Vestergrenopsis isidiata;* ap.

LECANORA ARGOPHOLIS (Ach.) Ach. – 1. On gneissic rocks, together with *Lecidea atrobrunnea*; ap.

L. ATROMARGINATA (H. Magn.) Hertel & Rambold – 1, 2. On different siliceous rocks, together with *Rhizocarpon geminatum* and *Xanthoria elegans*; ap.

L. BOLIGERA (Norman ex Th. Fr.) Hedl. – 1. On bark of *Salix glauca*, together with *Naetrocymbe punctiformis* and *Parmeliopsis hyperopta*; ap.; rare.

L. CENISIA Ach. – 1. On basaltic rock, together with *Rhizocarpon geographicum*; ap.

L. CHLOROLEPROSA (Vain.) H. Magn. – 1. On moist gneissic rocks; ap.

L. CONTRACTULA Nyl. – 1, 2. On gneissic seashore rocks manured by birds, together with, for example, *Xanthoria elegans*; ap.

L. FUSCESCENS (Sommerf.) Nyl. – 1. On twigs of *Juniperus communis*, together with, for example, *Parmeliopsis ambigua* and *Rinodina archaea*; ap.

L. GEOPHILA (Th. Fr.) Poelt – 1. On mineral soil; st.; rare.

L. INTRICATA (Ach.) Ach. – 1, 2. On gneissic rocks, together with, for example, *Allantoparmelia alpicola* and *Rhizocarpon inarense*; ap.

L. LEPTACINA Sommerf. – 2. On soil; ap.

L. MARGINATA (Schaer.) Hertel & Rambold – 1, 2. On gneissic rocks; ap.

L. POLYTROPA (Ehrh. ex Hoffm.) Rabenh. – 1, 2. On gneissic rocks, together with, for example, *Lecanora straminea* and *Umbilicaria hyperborea*; ap.; common.

L. STRAMINEA Wahlenb. ex Ach. – 1, 2. On gneissic seashore rocks manured by birds, together with, for example, *Lecanora contractula* and *Xanthoria candelaria*; st.

L. SWARTZII (Ach.) Ach. ssp. SWARTZII – 1. On overhanging gneissic rock; ap.; rare.

L. SWARTZII ssp. SORALIFERA E.S. Hansen subsp. nov. *Valde affinis L. swartzii ssp. swartzii , sed sorediis crassis in soraliis plus minusve confluentibus in facie thalli formantibus differt. Soralia ejusdem coloris quam thallus sed paulo clariora. – Lecanora swartzii* ssp. *soralifera* is similar to *L. swartzii* ssp. *swartzii*, but has granulose soredia produced in more or less confluent soralia on the surface of the thallus. The soredia have almost the same colour as the thallus, but is somewhat paler. Holotype: S.W. Greenland, Arsuk, 61°11'N, 48°28'W; overhanging gneissic rock; 10 July 1993, E. S. Hansen ESH 93.434 (C; no.: C-L-19096; Mycobank: MB511984). – 1. On gneissic overhanging rock; st.

LECIDEA ATROBRUNNEA (Ramond ex Lam. & DC.) Schaer. – 1, 2. On gneissic rocks manured by birds; ap.

L. AURICULATA Th. Fr. – 1, 2. On strongly weathered siliceous rocks, together with, for example, *Lecanora polytropa* and *Umbilicaria torrefacta*; ap.

L. LAPICIDA (Ach.) Ach. var. LAPICIDA – 1, 2. On gneissic rocks, together with, for example, *Lecanora intricata* and *Umbilicaria hyperborea*; ap.

L. LAPICIDA (Ach.) Ach. var. PANTHERINA Ach. – 1, 2. On gneissic rocks, together with, for example, *Bellemerea cinereorufescens* and *Rhizocarpon geographicum*; ap.

L. TESSELLATA Flörke – 1. On gneissic rocks; ap.

LECIDELLA EUPHOREA (Flörke) Hertel – 2. On dead twig of *Salix glauca*, together with *Caloplaca tiroliensis* and *Rinodina archaea*; ap.

L. STIGMATEA (Ach.) Hertel & Leuckert – 1. On strongly weathered siliceous rock, together with *Candelariella vitellina* and *Lecanora polytropa*; ap.; rare.

LECIDOMA DEMISSUM (Rutstr.) Gotth. Schneid. & Hertel – 1, 2. On mineral soil; ap.

LEPRARIA EBURNEA J.R. Laundon – 1, 2. On soil and mosses in snow-patches, together with, for example, *Frutidella caesioatra* and *Pertusaria oculata*.

L. NEGLECTA (Nyl.) Erichsen – 1, 2. On mosses and gneissic rocks.

L. VOUAUXII (Hue) R.C. Harris – 1, 2. On mosses, together with, for example, *Rinodina mniaraea*. Thallus contains pannaric acid and atranorin (HPTLC).

LEPROCAULON SUBALBICANS (I.M. Lamb) I.M. Lamb & A.M. Ward – 1, 2. On mosses. LGE 544.

LEPTOGIUM LICHENOIDES (L.) Zahlbr. – 1, 2. On soil and mosses; st.

LICHENOMPHALIA ALPINA (Britzelm.) Redhead, Lutzoni, Moncalvo & Vilgalys – 1, 2. On mineral soil and peat.

L. HUDSONIANA (H.S. Jenn.) Redhead et al. – 1, 2. On mosses and peat. LGE 537.

LOBARIA SCROBICULATA (Scop.) DC. – 1, 2. On siliceous and basaltic rocks; st. The species belongs to the distinctly continental element in the lichen flora of South West Greenland (K. Hansen, 1971; Thomson, 1984).

LOPADIUM CORALLOIDEUM (Nyl.) Lynge – 1. On soil; st.

MASSALONGIA CARNOSA (Dicks.) Körb. – 2. On mosses on soil, together with *Leprocaulon subalbicans*; st.

MEGASPORA VERRUCOSA (Ach.) Hafellner & V. Wirth – 1. On plant remains; ap.; rare.

MELANELIA COMMIXTA (Nyl.) A. Thell – 1, 2. On siliceous rocks; ap.

M. DISJUNCTA (Erichsen) Essl. – 1, 2. On gneissic rocks, together with, for example, *Dimelaena oreina*, *Rhizocarpon bolanderi* and *R. geographicum*; st.

M. HEPATIZON (Ach.) A. Thell – 1, 2. On gneissic rocks, together with, for example, *Brodoa oroarctica* and *Parmelia saxatilis*; ap.; common.

M. INFUMATA (Nyl.) Essl. – 1, 2. On gneissic rocks manured by birds, together with, for example, *Parmelia sulcata*, *Physcia dubia* and *Xanthoria candelaria*; st.

M. SEPTENTRIONALIS (Lynge) Essl. – 1. On twigs of *Juniperus communis*, together with, for example, *Tuckermanopsis chlorophylla*; ap.; rare.

M. SOREDIATA (Ach.) Goward & Ahti – 1. On gneissic rock, together with *Aspicilia caesiocinerea* and *Rhizocarpon bolanderi*; st.; rare.

MICAREA DENIGRATA (Fr.) Hedl. – 2. On bark of *Salix glauca*; ap.; rare.

MIRIQUIDICA ATROFULVA (Sommerf.) A.J. Schwab & Rambold – 1, 2. On gneissic rocks rich in iron minerals, together with, for example, *Porpidia flavocaerulescens*; st.

M. NIGROLEPROSA (Vain.) Hertel & Rambold – 1, 2. On gneissic and basaltic rocks; st.

MYXOBILIMBIA LOBULATA (Sommerf.) Hafellner – 1. On mosses on soil; ap.

NAETROCYMBE PUNCTIFORMIS (Pers.) R.C. Harris – 1. On bark of *Salix glauca*; ap.; rare. The species is so far known only from South West Greenland, but should be searched for on bark substrates in other parts of Greenland (Branth & Grønlund, 1888; Alstrup, 1982; Thomson, 1997).

NEPHROMA ARCTICUM (L.) Torss. – 1, 2. On mosses in dwarf shrub heaths; st.

N. BELLUM (Spreng.) Tuck. – 1. On mosses; ap.; rare.

N. PARILE (Ach.) Ach. – 1. On mosses and twigs of *Salix glauca*, together with, for example, *Pertusaria carneopallida*; st.

OCHROLECHIA FRIGIDA (Sw.) Lynge – 1, 2. On mosses, soil and plant remains in dwarf shrub heaths; ap.; common.

O. GRIMMIAE Lynge – 1, 2. On *Racomitrium lanuginosum*; ap.

O. LAPUËNSIS (Räsänen) Räsänen – 1, 2. On soil rich in humus and plant remains, together with, for example, *Sphaerophorus globosus*; ap.

O. TARTAREA (L.) A. Massal. – 1, 2. On gneissic rocks; ap. LGE 500.

O. UPSALIENSIS (L.) A. Massal. – 1. On mosses, soil and plant remains in dwarf shrub heaths; ap.

OPHIOPARMA VENTOSA (L.) Norman – 1, 2. On gneissic rocks, together with *Brodoa oroarctica* and *Ochrolechia tartarea*; ap.

ORPHNIOSPORA MORIOPSIS (A. Massal.) D. Hawksw. – 1, 2. On gneissic rocks; ap.; common.

PANNARIA HOOKERI (Borrer ex Sm.) Nyl. – 1, 2. On moist siliceous rocks, together with, for example, *Tremolecia atrata*; ap.; rare.

PARMELIA OMPHALODES (L.) Ach. – 1. On gneissic rocks; st.

P. SAXATILIS (L.) Ach. – 1, 2. On gneissic rocks; rarely on twigs of *Salix glauca*; ap.; common.

P. SULCATA Taylor – 1, 2. On gneissic rocks manured by birds; st.

PARMELIOPSIS AMBIGUA (Wulfen) Nyl. – 1. On twigs of *Salix glauca* and *Juniperus communis*; st.; rare.

P. HYPEROPTA (Ach.) Arnold – 1. On branch of *Salix glauca*, together with *Parmeliopsis ambigua*; st.; rare.

PELTIGERA APHTHOSA (L.) Willd. – 2. On mosses in moist habitats; st.

P. BRITANNICA (Gyeln.) Holt.-Hartw. & Tønsberg – 2. On mosses in moist habitats; st. New to West Greenland. Previously reported from North East Greenland and also known from, for example, Iceland and the Faeroe Islands (Alstrup et al., 1994, 2000; Orange, 1990; Vitikainen, 1994).

P. CANINA (L.) Willd. – 1, 2. On mosses; st. LGE 545.

P. DIDACTYLA (With.) J.R. Laundon – 1, 2. On mosses; st.

P. KRISTINSSONII Vitik. – 1. On mosses; ap.

P. LEUCOPHLEBIA (Nyl.) Gyeln. – 1. On mosses in moist habitats; ap.

P. MALACEA (Ach.) Funck – 1, 2. On mosses in moist habitats; st.

P. RUFESCENS (Weiss) Humb. – 1. On soil; st.

P. SCABROSA Th. Fr. – 1, 2. On mosses; st.

P. VENOSA (L.) Baumg. – 1. On moist soil; ap.; rare.

PERTUSARIA BRYONTHA (Ach.) Nyl. – 1. On *Racomitrium lanuginosum*; ap.; rare.

P. CARNEOPALLIDA (Nyl.) Anzi – 1. On twigs of *Salix glauca*, together with, for example, *Nephroma parile*; ap.; rare.

P. CORIACEA (Th. Fr.) Th. Fr. – 1. On soil in dwarf shrub heath, together with *Alectoria ochroleuca* and *Sphaerophorus globosus*; ap. LGE 539.

P. DACTYLINA (Ach.) Nyl. – 2. On plant remains, together with *Cetraria muricata* and *Rinodina turfacea*; st.

P. GEMINIPARA (Th. Fr.) C. Knight ex Brodo – 1, 2. On soil and mosses; st.

P. OCULATA (Dicks.) Th. Fr. – 1, 2. On soil and mosses in snow-patches; st.

P. PANYRGA (Ach.) A. Massal. – 1, 2. On mosses; ap.

PHAEOPHYSCIA ENDOCOCCINA (Körb.) Moberg – 1, 2. On gneissic rocks manured by birds, together with, for example, *Xanthoria elegans*; ap.

P. ORBICULARIS (Neck.) Moberg – 2. On gneissic rocks manured by birds, together with, for example, *Melanelia infumata*, *Physcia dubia* and *Xanthoria candelaria*; st.; rare. Previously reported from a few localities in West Greenland (Moberg & Hansen, 1986).

P. SCIASTRA (Ach.) Moberg – 1. On gneissic rocks manured by birds, together with *Rhizocarpon geminatum* and *Xanthoria elegans*; st.

PHYLLISCUM DEMANGEONII (Moug. & Mont.) Nyl. – 1, 2. On gneissic rocks, together with, for example, *Calvitimela aglaea*; ap.

PHYSCIA CAESIA (Hoffm.) Fürnr. – 1, 2. On gneissic and basaltic rocks manured by birds; st.

P. DUBIA (Hoffm.) Lettau – 1, 2. On gneissic rocks manured by birds, together with, for example, *Xanthoria candelaria* and *X. sorediata*; st.

P. PHAEA (Tuck.) J.W. Thomson – 1. On gneissic rocks manured by birds, together with *Xanthoria elegans*; ap.; rare.

P. TENELLA (Scop.) DC. – 2. On gneissic rocks; st.; rare.

PHYSCONIA DETERSA (Nyl.) Poelt – 2. On siliceous rock manured by birds; st.; rare.

P. MUSCIGENA (Ach.) Poelt – 1, 2. On mosses, together with, for example, *Caloplaca tiroliensis* and *Leptogium lichenoides*; st.

PLACIDIUM LACHNEUM (Ach.) de Lesd. – 1. On mineral soil; pe.; rare.

PLACOPSIS GELIDA (L.) Linds. – 1, 2. On basaltic rock and strongly weathered siliceous rocks; st.

PLACYNTHIUM ASPERELLUM (Ach.) Trevis. – 1. On siliceous rocks manured by birds, together with, for example, *Lecanora argopholis* and *L. intricata*; st.

P. PANNARIELLUM (Nyl.) H. Magn. – 1. On moist gneissic rocks, together with *Rhizocarpon lavatum*; st.

PLATISMATIA GLAUCA (L.) W.L. Culb. & C.F. Culb. – 1. On soil in fell-fields and on gneissic rocks, together with, for example, *Alectoria nigricans* and *Sphaerophorus fragilis*; st.; rare.

POLYCHIDIUM MUSCICOLA (Sw.) Gray – 1. On plant remains; ap.

POLYSPORINA SIMPLEX (Davies) Vězda – 2. On gneissic rock manured by birds, together with, for example, *Xanthoria elegans*; ap.

PORPIDIA FLAVOCOERULESCENS (Hornem.) Hertel & A.J. Schwab – 1, 2. On gneissic and basaltic rocks with patches of limonite, together with, for example, *Miriquidica atrofulva*, *Rhizocarpon grande* and *R. polycarpum*; ap.

P. MELINODES (Körb.) Gowan & Ahti – 1. On gneissic and basaltic rocks, together with, for example, *Porpidea flavocaerulescens*; st.

P. THOMSONII Gowan – 1. On gneissic rock; ap. New to West Greenland.

PROTOPANNARIA PEZIZOIDES (Weber) P.M. Jørg. & S. Ekman – 1. On mosses, together with *Pertusaria geminipara*; ap.

PROTOPARMELIA BADIA (Hoffm.) Hafellner – 1, 2. On gneissic rocks manured by birds; ap.

PSEUDEPHEBE MINUSCULA (Nyl. ex Arnold) Brodo & D. Hawksw. – 1, 2. On gneissic rocks, together with, for example, *Calvitimela armeniaca* and *Orphniospora moriopsis*; ap.; common.

P. PUBESCENS (L.) M. Choisy – 1, 2. On gneissic rocks, together with, for example, *Parmelia omphalodes*; ap. LGE 541.

PSORA DECIPIENS (Hedw.) Hoffm. – 1. On mineral soil, together with *Catapyrenium daedaleum* and *Placidium lachneum*; ap.; rare.

P. GLOBIFERA (Ach.) A. Massal. – 1. On mineral soil; ap.; rare.

P. RUBIFORMIS (Ach.) Hook. – 1, 2. On mineral soil and strongly weathered rock; ap.

PSOROMA HYPNORUM (Vahl) Gray – 1, 2. On mosses in dwarf shrub heaths; ap.; common.

P. TENUE Henssen var. BOREALE Henssen – 2. On soil in dwarf shrub heath, together with *Cladonia bellidiflora*; ap.; rare.

RHIZOCARPON BOLANDERI (Tuck.) Herre – 1, 2. On siliceous and basaltic rocks manured by birds; ap.

R. GEMINATUM Körb. – 1, 2. On siliceous rocks manured by birds; ap.; common.

R. GEOGRAPHICUM (L.) DC. – 1, 2. On different siliceous rocks; ap.; common.

R. GRANDE (Flörke) Arnold – 1, 2. On siliceous rocks manured by birds; ap.

R. HOCHSTETTERI (Körb.) Vain. – 1. On siliceous rock, together with *Umbilicaria torrefacta*; ap.; rare.

R. INARENSE (Vain.) Vain. – 1, 2. On gneissic rocks; ap.; common.

R. JEMTLANDICUM (Malme) Malme – 2. On gneissic and basaltic rocks with a thin layer of limonite, together with, for example, *Miriquidica nigroleprosa*; ap.

R. LAVATUM (Fr.) Hazsl. – 1. On moist gneissic rock; ap.

R. MACROSPORUM Räsänen – 1. On gneissic rock; ap.; rare. Known so far only from a few localities in South West and North East Greenland (Thomson, 1997).

R. POLYCARPUM (Hepp) Th. Fr. – 2. On gneissic rocks, together with *Lecanora polytropa*, *Pseudephebe minuscula* and *Rhizocarpon geographicum*; ap.; rare.

R. PRAEBADIUM (Nyl.) Zahlbr. – 2. On gneissic and basaltic rocks; ap.

R. RITTOKENSE (Hellb.) Th. Fr. – 1, 2. On gneissic rocks, together with, for example, *Allantoparmelia alpicola*; ap.

R. SUBAREOLATUM E.S. Hansen – 2. On *Rhizocarpon grande* on gneissic rock; ap.; rare. New to South West Greenland. Recently described from Upernavik Ø in North West Greenland and Danmarks Ø in North East Greenland (Hansen, 2007).

RHIZOPLACA MELANOPHTHALMA (DC.) Leuckert & Poelt – 1. On siliceous rocks manured by birds; ap.; rare.

RINODINA ARCHAEA (Ach.) Arnold – 1, 2. On twigs of *Salix glauca* and *Juniperus communis*; ap.

R. MNIARAEA (Ach.) Körb. – 1. On mosses, together with *Lepraria vouaxii*; ap.

R. OLIVACEOBRUNNEA C.W. Dodge & G.E. Baker – 2. On *Lobaria scrobiculata* on gneissic rocks; ap.; rare.

R. TURFACEA (Wahlenb.) Körb. – 1, 2. On plant remains in dwarf shrub heaths, together with, for example, *Ochrolechia frigida*; ap.

SOLORINA BISPORA Nyl. – 1. On mineral soil; ap.; rare.

S. CROCEA (L.) Ach. – 1, 2. On soil near snow-patches; ap.; common.

SPHAEROPHORUS FRAGILIS (L.) Pers. – 1, 2. On gneissic rocks and on soil; ap.; common.

S. GLOBOSUS (Huds.) Vain. – 1, 2. On soil in dwarf shrub heaths and fell-fields; ap.; common. LGE 536.

SPORASTATIA POLYSPORA (Nyl.) Grummann – 1. On siliceous rocks, together with *Rhizocarpon geographicum* and *Umbilicaria torrefacta*; ap.

S. TESTUDINEA (Ach.) A. Massal. – 1, 2. On gneissic rocks, together with, for example, *Calvitimela armeniaca* and *Dimelaena oreina*; ap.

STAUROTHELE AREOLATA (Ach.) Lettau – 1. On gneissic rock; pe.

S. FISSA (Taylor) Zwackh – 1. On moist gneissic rocks; pe.

STEREOCAULON ALPINUM Laurer – 1, 2. On soil in dwarf shrub heaths and near snow-patches; st.; common.

S. ARENARIUM (L.I. Savicz) I.M. Lamb – 1, 2. On mineral soil; st. Thallus contains atranorin and porphyrilic acid (HPTLC).

S. BOTRYOSUM Ach. – 2. On gneissic rocks; st.; rare.

S. GLAREOSUM (L.I. Savicz) H. Magn. – 1, 2. On mineral soil and gravel; st.; common. Thallus contains atranorin and lobaric acid (HPTLC).

S. PASCHALE (L.) Hoffm. – 1, 2. On soil in dwarf shrub heaths; st.; common.

S. RIVULORUM H. Magn. – 1. On soil; st. Thallus contains atranorin (HPTLC).

S. VESUVIANUM Pers. – 1, 2. On gneissic rocks; st.; common. Thallus contains atranorin and stictic acid (HPTLC).

THAMNOLIA VERMICULARIS (Sw.) Schaer. var. SUBULIFORMIS (Ehrh.) Schaer. – 1, 2. On soil and mosses in dwarf shrub heaths and fell-fields; common.

TONINIA SEDIFOLIA (Scop.) Timdal – 1. On mineral soil, together with *Placidium lachneum* and *Psora decipiens*; ap.

T. SQUALIDA (Ach.) A. Massal. – 1. On mineral soil, together with *Polychidium muscicola*; ap.; rare.

TRAPELIOPSIS GRANULOSA (Hoffm.) Lumbsch – 1. On soil; ap.

TREMOLECIA ATRATA (Ach.) Hertel – 1, 2. On moist gneissic rocks with patches of limonite; ap.

TUCKERMANNOPSIS CHLOROPHYLLA (Willd.) Hale – 1. On twigs of *Juniperus communis*; st.; rare. Belongs to the group of continental lichens in the lichen flora of South West Greenland (Alstrup, 1982; K. Hansen, 1971).

UMBILICARIA ARCTICA (Ach.) Nyl. – 1, 2. On gneissic rocks manured by birds; ap.; common.

U. DEUSTA (L.) Baumg. – 1. On moist gneissic rocks; st.

U. HAVAASII Llano – 1, 2. On gneissic rocks; st.

U. HYPERBOREA (Ach.) Hoffm. – 1, 2. On gneissic rocks; ap.; common.

U. POLYPHYLLA (L.) Baumg. – 1. On gneissic rock; ap.

U. PROBOSCIDEA (L.) Schrad. – 1, 2. On gneissic rocks; ap.; common.

U. RIGIDA (Du Rietz) Frey – 1, 2. On gneissic rocks; ap.

U. TORREFACTA (Lightf.) Schrad. – 1, 2. On gneissic rocks; ap.; common.

U. VELLEA (L.) Hoffm. – 1, 2. On moist gneissic rocks; st.

U. VIRGINIS Schaer. – 1, 2. On gneissic rocks; ap.; common.

VARICELLARIA RHODOCARPA (Körb.) Th. Fr. – 1. On twigs of *Juniperus communis*, together with, for example, *Lecanora fuscescens*; st.; rare.

VERRUCARIA CEUTHOCARPA Wahlenb. – 1. On gneissic seashore rocks, together with *Lecanora contractula*; pe.; common.

V. DEGELII R. Sant. – 1, 2. On gneissic seashore rocks; pe.; common.

VESTERGRENOPSIS ISIDIATA (Degel.) Å.E. Dahl – 1. On siliceous rocks, together with, for example, *Staurothele fissa* and *Tremolecia atrata*; st.

XANTHOPARMELIA CONSPERSA (Ach.) Hale – 1. On gneissic rocks; st.; rare.

XANTHORIA CANDELARIA (L.) Th. Fr. – 1, 2. On gneissic rocks manured by birds; ap.; common.

X. ELEGANS (Link) Th. Fr. – 1, 2. On siliceous rocks manured by birds; ap.; common.

X. SOREDIATA (Vain.) Poelt – 1, 2. On vertical faces of gneissic rocks manured by birds; st.

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Morphology and habitat properties of *Tortula lingulata* in Estonia

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Abstract: *Tortula lingulata* Lindb. is a moss that is rare in Europe and under protection in Estonia. It grows sparsely on sandstone outcrops. Eight localities are known in Estonia. Main morphological characters of the species and environmental parameters were measured at five sites. The moss shoots were longer at sites with higher sandstone moisture, and the nerve of the leaves was wider at sites with higher moisture and conductivity level under the moss patch.

Kokkuvõte: *Tortula lingulata* morfoloogia ja kasvukohatingimused Eestis

Keeljas keerik (*Tortula lingulata* Lindb.) on kogu Euroopas haruldane ning Eestis riikliku kaitse all olev samblaliik. Ta kasvab liivakivipaljanditel, Eestis on teada kaheksa leiukohta. Mõõdeti peamised liigi morfoloogilised tunnused ja kasvukohtade keskkonnaparameetrid. Sambla varre kõrgus osutus suuremaks kõrgema niiskustasemega liivakivil ja leheroo laius suurema niiskuse ja elektrijuhtivuse korral samblalaigu all.

INTRODUCTION

Bryophytes differ greatly in distribution and habitat range. Some species have restricted distribution or specific demands for habitat conditions, occurring only in certain types of communities or on specific substrata. Such selective species are usually more vulnerable to environmental changes and human influence, and are often included in red data lists (Standards and Petitions Working Group, 2006).

Tortula lingulata Lindb. is a species that grows only on sandstone outcrops (Frey et al., 2006). This species was first described at the end of the 19th century on the basis of material collected from sandstone denudation, territory of present Latvia (Lindberg, 1880; Ingerpuu & Vellak, 2007). Sandstone bedrock is distributed all over Europe; denudations can be found from Spain to Sweden. Nevertheless data concerning the distribution of *T. lingulata* is fragmentary. In Europe it is known to occur in Estonia (Ingerpuu et al., 1998), Latvia (Ābolina, 2002), Russia (Ignatov et al., 2006), Ukraine (Bachurina & Melnichuk, 1988), Georgia (Chikovani & Svanidze, 2004), the Czech Republic (Kučera & Váňa, 2003) and Germany (Meinunger & Schröder, 2007). There are also some doubtful records from Montenegro (Sabovljevic et al., 2004) and France (De Zuttere, 1993), where it is listed as *Tortula lingulata* var. *montenegrina* (Breidl. Szyszyl.) Broth. According to Corley et al. (1981), this name is a synonym for *T. lingulata*, while Košnar (2007) shows its closeness with *T. obtusifolia* (Schwägr.) Mathieu. In Asia it has been reported from Tadjikistan, where it surprisingly grows on limestone as well as on sandstone (Mamatkulov, 1975). We did not find any data for its occurrence in other parts of the world.

Tortula lingulata is included in the European Red Data Book as an insufficiently known species (ECCB, 1995), and it belongs to the red data lists of Estonia and Latvia. It is also protected by law in both countries.

Siliceous rocky slopes are considered to be important habitat types at the European level (EU Directive, 1992). A total of ca. 260 sandstone outcrops can be found in Estonia (Kleesment, 2001). They are concentrated in southern Estonia, where Devonian sandstone is denudated, whereas those from the Cambrian and Ordovician age occur in northern Estonia (Rõõmusoks, 1983). In the total distribution area, *T. lingulata* appears to be the most frequent in Estonia and Latvia, where it is known according to herbaria data from eight and seven localities, respectively (Ābolina, 1968; Košnar, 2007). In the Czech Republic it has been found in only two localities (Košnar, 2007), in Germany in one locality in Baden-Württemberg state (Meinunger & Schröder, 2007). The number of localities in Russia, Ukraine and Georgia is unknown. The distribution of *T. lingulata* according to present knowledge is very scattered, comprising central and eastern part of Europe.

The aims of this study are to specify the habitat requirements of *T. lingulata* in Estonia and to determine whether there are any relationships between local environmental conditions and plant morphological variation.

MATERIAL AND METHODS

Material was collected and the environmental measurements were taken at five of the eight known localities of *T. lingulata* in Estonia (Fig. 1) in the summer of 2007. These five localities are distributed in the southern part of Estonia, between 58°29'N and 57°45'N; 24°49'E and 27°23'E, the distance between the sites is 25–180 km. The mean annual temperature of this region was 6.7 °C in 2006 and 6.9 °C in 2007, and annual precipitation was 605 mm in 2006 and 660 mm in 2007. The number of days with precipitation was 107 in 2006 and 138 in 2007. The climate of these years was exceptionally warm and relatively dry since the mean annual temperature for 32 years (1966–1998) was 5.5 °C, and the mean annual precipitation 700 mm (Jaagus, 1999).

In order not to harm the populations of this national protected species, only 10 shoots were collected from each site. At all localities the inclination of the sandstone below the moss patch in degrees from vertical level and the direction according to compass were measured. In addition, three close measurements (about 5–10 cm apart from each other) were done and means calculated for 1) moisture % below the moss patch and beside the moss patch (measured with Exotek HUMITEST BDD moisture detector); 2) the illumination on the moss patch and in the open area (measured with Velleman light meter DVM1300); 3) the number of shoots per 1 cm^2; 4) depth of brittle sandstone below and beside the moss patch (by penetration with a metal rod of 1 mm diameter up to resistance). Sandstone samples were collected for pH and conductivity measurements. The sandstone samples were mixed with distilled water (1:10) and kept for 24 hours before pH measurements. For conductivity measurements the sandstone samples were kept for 0.5 hours mixed with distilled water (1:5). The reaction was measured with a Lutron PH 212 pH meter and the conductivity with a WTW Cond 315i/SET.

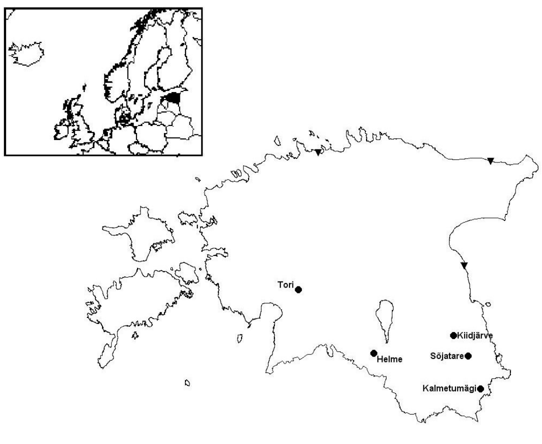

Fig. 1. Localities (all marks) of *Tortula lingulata* Lindb. in Estonia. ● – studied localities.

The total length and length of the rhizoid-covered part of each shoot was measured (n=50). Three leaves from the median part of each shoot were detached. Leaf length and width, median leaf cell length and width, the length of the leaf's basal part (with hyaline cells), basal cell length and width (in middle part between leaf margin and nerve), nerve cell length and width (in middle part of leaf and nerve), and nerve width in the basal part were measured, and means per shoot calculated. In addition, length of seta, length and width of ripe capsules (covered with operculum) from two localities (n=13) and diameter of spores from one locality and five capsules (n=50) were measured.

Spearman Rank correlation was used to find correlations between morphological characters (n=50), and between the environmental parameters together with shoot density (n=5). One-way ANOVA was used to study the influence of locality on the morphological characters, comparisons were tested with the contrasts for LS means. The morphological characters were tested for normality before analysis. All analysis were done with Statistica 6.0 (STATSOFT INC., 2001). Due to the rarity of the species the number of measurements for environmental variables remained very small (n=5), although ca. two thirds of all known localities were studied. Therefore it is not proper to use statistical methods for studying the influence of environmental parameters on morphological characters and we can only point to certain trends discovered by comparing graphically means of morphological and environmental variables.

RESULTS

Tortula lingulata grew in almost pure patches. Single shoots of *Gyroweisia tenuis* (Hedw.) Schimp., *Leptobryum pyriforme* (Hedw.) Wilson, *Barbula unguiculata* Hedw., *Hypnum cupressiforme* Hedw. and *Bryum* sp. were growing mixed with *T. lingulata,* one or two species per patch.

The exposition of the moss patches in the studied localities was to the north, north-west (2 localities), west and south-west.

Mean shoot density per 1 cm^2 was 30 ± 10 (n=15; min 17, max 60).

Archegonia were present at all localities, antheridia at two localities, and capsules were registered at two localities.

Morphometrical measures are presented in Table 1. The shoot length of *T. lingulata* varies between 1.03–2.5 mm, leaf length between 0.13–0.88 mm, cell length between 14–36 µm, cell width between 8–15 µm. The diameter of a spore varies between 10–20 µm.

Shoot length was significantly positively correlated with the length of the rhizoid covered part, leaf length, leaf width, length of leaf basal part and nerve width. Length and width of leaf, those of middle leaf cells, and basal cells were significantly positively correlated, but those of nerve cells were significantly negatively correlated (Table 2.)

Environmental measures are presented in Table 3. Moisture below the moss patch was higher than that of the sandstone beside the moss patch. The layer of the brittle part of the sandstone was a bit deeper under the moss patch. Illumination just over the moss patch was only 1.4–4.5 % of the open area illumination. The pH of the sandstone was more or less neutral. Conductivity was lower under the moss patch.

There were very few significant ($p<0.05$) correlations between environmental factors: moisture below moss patch was positively correlated with pH (R=0.9), conductivity (R=0.97) below moss patch, and shoot density (R=0.9).

According to the comparisons shoot length, rhizoid-covered part of shoot length, and height of basal part of leaf could be associated with moisture % beside the moss patch (sandstone moisture). The most easily measurable character is shoot length (Fig. 2). Nerve width could be associated with the moisture % below moss patch (Fig. 3) and conductivity. The variation of the nerve width pattern differed from the shoot length variation pattern. The factor 'location' affected the shoot length significantly ($F= 14.1$, $p < 0.0001$), but not the width of nerve, although the locations with minimum and maximum mean nerve width values differed significantly from each other.

Table 1. Morphometrical parameters of *Tortula lingulata* Lindb. in Estonia. Variables of gametophyte from 5 localities: shoot variables n=50; leaf and cell variables n=150, variables of sporophyte from two localities, n=13; spores from one locality, n=50.

Variable	Mean	Minimum	Maximum	Std. Dev.
Shoot length (mm)	1.75	1.03	2.5	0.41
Rhizoid-covered shoot length (mm)	0.38	0.13	0.88	0.16
Leaf length (µm)	964	650	1317	151
Leaf width (µm)	340	243	523	63
Length of basal part of leaf (µm)	160	53	370	77
Median cell length (µm)	21	14	36	4
Median cell width (µm)	11	8	15	1
Nerve cell length (µm)	53	27	98	12
Nerve cell width (µm)	6	2.5	12.5	2
Basal cell length (µm)	43	32.5	67	8
Basal cell width (µm)	15	11	22.5	2
Nerve width (µm)	48	37	62	6
Seta length (mm)	5.91	3.75	9.13	1.47
Capsule length (mm)	1.47	0.95	2.25	0.38
Capsule width (mm)	0.6	0.42	0.75	0.08
Spore diameter (µm)	13.3	10	20	1.71

Table 2. Spearman rank correlations between the morphological characters of *Tortula lingulata* Lindb. N = 50; bold numbers – significant correlations at p < 0.05; ns – not significant.

	1	2	3	4	5	6	7	8	9	10	11	12
1 Shoot length	1											
2 Rhizoid-covered shoot length	**0.77**	1										
3 Leaf length	**0.67**	**0.49**	1									
4 Leaf width	**0.50**	**0.29**	**0.60**	1								
5 Length of basal part of leaf	**0.63**	**0.48**	**0.71**	ns	1							
6 Median cell length	ns	ns	ns	ns	ns	1						
7 Median cell width	ns	ns	ns	ns	ns	**0.41**	1					
8 Nerve cell length	ns	ns	ns	ns	ns	ns	ns	1				
9 Nerve cell width	ns	ns	ns	ns	ns	ns	ns	**-0.35**	1			
10 Basal cell length	ns	ns	ns	ns	**0.45**	ns	ns	**0.36**	ns	1		
11 Basal cell width	ns	ns	ns	ns	**0.37**	ns	ns	**0.9**	ns	**0.46**	1	
12 Nerve width	**0.46**	ns	**0.55**	**0.55**	**0.28**	ns	ns	ns	**0.30**	**0.28**	ns	1

Table 3. Environmental variables at five localities of *Tortula lingulata* Lindb. in Estonia, n=15.

Variable	Mean	Minimum	Maximum	Std. Dev.
Moisture (%) below moss	43.8	26.6	57.7	10.5
Moisture (%) beside moss	23.9	13.8	42.2	10.1
Brittle sandstone depth below moss (mm)	1.07	0	3.33	1.23
Brittle sandstone depth beside moss (mm)	0.93	0	2.33	0.81
Illumination (% of open area illumination)	2.6	1.4	4.5	1.1
pH	6.97	6.12	7.77	0.66
Conductivity below moss (μS cm^{-1})	257.1	82.7	400	129.5
Conductivity beside moss (μS cm^{-1})	617.4	155	1690	556.9
Sandstone slope (degree from vertical)	25	10	45	13.2

DISCUSSION

The values of the morphological characteristics of Estonian populations differ somewhat from those reported in several floras. The shoot length measured by us (up to 2.5 mm) was generally shorter than that reported in other descriptions: up to 3 mm (Savitch-Ljubitskaja & Smirnova, 1970; Ignatov & Ignatova, 2003), up to 5 mm (Frey et al., 2006) and up to 6 mm (Košnar 2007). The leaf length was almost the same as that given by other studies, but the leaf width was about 40% less than that given by Ignatov & Ignatova (2003) and Košnar (2007). In addition, the width of the nerve was about 20% less than that reported by Košnar (2007).

The measurements of sporophytes and spores more or less coincided with those provided in the literature (Lindberg, 1880; Roth, 1904; Savitch-Ljubitskaja & Smirnova, 1970; Košnar, 2007); only the length of the capsule is reported to be longer by Ignatov & Ignatova (2003).

The archegonia were found to be present everywhere, but antheridia only at two sites; we did not find antheridia and archegonia on the same shoot. The species is dioecious according to S. O. Lindberg, but N. Malta (1926) mentions that it is autoicous. The sexuality of this species needs further studies.

The pH range for *T. lingulata* in Estonian localities was similar to those reported from Latvia (5.9–7.5; Apinis & Lacis, 1936).

T. lingulata grows on steep and hard sandstone outcrops. Such harsh habitat conditions must reduce the number of potential competi-

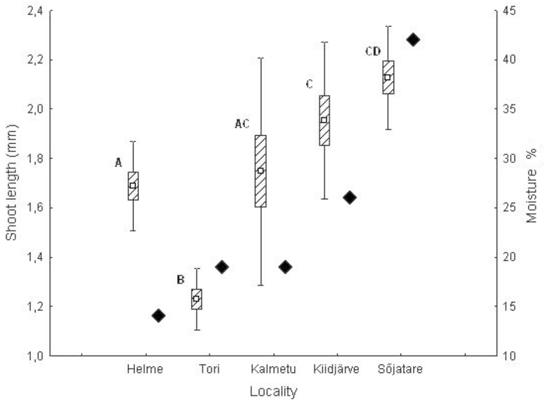

Fig. 2. Shoot length of *Tortula lingulata* Lindb. (striped boxes) and moisture % of sandstone beside moss patch (black diamonds) at different localities. Significant differences in shoot length ($p<0.05$) are marked with different letters.

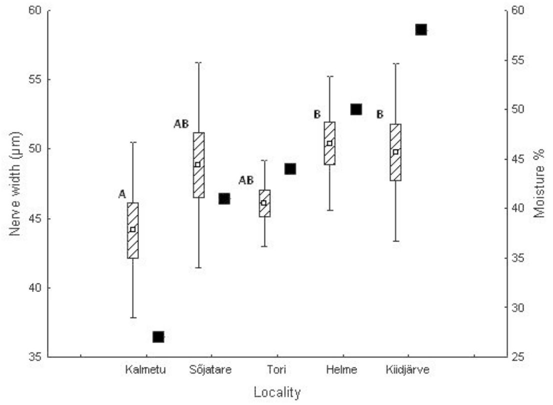

Fig. 3. Nerve width of *Tortula lingulata* Lindb. (striped boxes) and moisture % under moss patch (black boxes) at different localities. Significant differences in nerve width ($p<0.05$) are marked with different letters.

tors. Indeed, very few other bryophytes, and no vascular plants grow between or just beside the shoots of *T. lingulata*. The species is very shade tolerant; moreover, it presumably needs shade to reduce the speed of drying out. The exposition of the species (mainly north and west) apparently serves the same purpose. Habitats in Estonia could be relatively dry, maybe due to exceptionally dry and warm recent years, since the plants in our study were shorter than reported from other studies. In our study the shoots of the species were longer at sites with higher sandstone moisture. High humidity is presumably achieved through favourable relief around the moss patch that allows to obtain more rain and surface flow water that brings also more nutrients and thus promotes the growth leading to the enlargement of a whole plant (shoot, leaves and cells).

The presence of *T. lingulata* patches on sandstone raises the moisture and lowers the conductivity of the uppermost layer of sandstone below the moss. This comes apparently from the evaporation inhibition and ion uptake by the moss patch. Moisture was higher under moss patches with higher shoot density. The width of the nerve is positively associated moisture and conductivity just below the moss patch. This relationship is difficult to explain, but as nerve should help to conduct water towards the leaf tip, higher water availability under moss patch might promote the lateral growth of nerve.

This study presents statistically unsupported trends of the influence of the environmental factors on morphological characters. It is almost impossible to gather the amount of data required for sound statistical analysis for rare and protected species in the field. Thus growing from spores and laboratory experiments could give better support to the discovered relations.

Regarding the relative rarity of *T. lingulata* in Europe, Estonia has the responsibility to save the known habitats of the species on its territory. The species belongs at present to the third category of protected species, which enables to protect only 10% of the known habitats (Looduskaitseseadus, 2004). To assure the protection of all habitats, the species should belong to the first category.

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The impact of anthropogenic habitats on rare bryophyte species in Lithuania

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Abstract: Anthropogenic habitats support about one third of bryophytes known in Lithuania. Nearly half of them are rare in the country. 21 species occurring in anthropogenic habitats of Lithuania are of high conservation value. Possibility to conserve bryophyte species restricted to anthropogenic habitats is discussed.

Kokkuvõte: Haruldased sammaltaimed Leedu antropogeensetes kasvukohtades

Antropogeensetes kasvukohtades leidub umbes kolmandik Leedu sammaltaimedest. Neist peaaegu pooled on Leedus haruldased. Kaitse seisukohast on olulised 21 liiki. Käsitletakse antropogeensete kasvukohtade sammalde kaitse probleeme.

INTRODUCTION

Human activity directly and indirectly influences environmental conditions causing changes in landscapes. Agriculture, urbanization, recreation, roads and many other human impacts cause loss of natural habitats. Many plant species have declined as a result of habitat destruction, fragmentation and reduction. Lost natural habitats are replaced by artificial or seminatural habitats, or they become increasingly fragmented into more numerous, but smaller remnant patches. An inherent part of the current biodiversity are plant species restricted to anthropogenic habitats. Man-made habitats can be divided into arable land with weed vegetation and settlements, their surroundings, industrial areas harbouring ruderal vegetation (Lososova et al., 2006). In case of bryophytes, a number of species is mainly, or sometimes only, found in artificial habitats (ECCB, 1995). Recently a wide range of investigations on bryophyte distribution was performed in agricultural landscapes of Europe (Sauberer et al., 2004; Zechmeister et Moser, 2001; Zechmeister et al., 2002; Zechmeister et al., 2003a; Zechmeister et al., 2003b).

Lithuania (area 62.7 thousand km^2) is situated on the western edge of East European Plain. It is a part of the Baltic geomorphological province. Lithuania is the land of plains, variegated with hilly highlands: plains constitute 50%, hilly highlands 21%, plateus 29% (Basalykas, 1981) of the territory.

Anthropogenic habitats are significant components of Lithuanian landscape (Fig. 1). Farming land covers nearly 54% of the total area of Lithuania with arable land and grasslands accounting for 70.5%. Due to extraction of natural deposits, landscape of 0.5% of the territory was disturbed, mostly (75%) during peat extraction. At present gravel and sand pits are mainly concentrated in the hilly landscape and in the river valleys (Kavaliauskas & Baškytė, 2000). Dolomite and limestone quarries are restricted to the northern Lithuania. Areas of open rocks in abandoned quarries exceed sparing areas of natural outcrops occurring on the banks of the rivers Mūša and Nemunėlis (northern Lithuania). Ruderal vegetation is mosaically scattered throughout the country occurring in settlements and industrial areas, along roads and railways, on the banks of the ditches, etc. Artificial substrata (concrete constructions, bricks, tiles, etc.) are most common in urban territories, which cover about 3% of the territory.

Human activity influences structure of bryoflora by altering natural habitats. Up to the middle of the 20th century mires covered about 7.3% of the territory of Lithuania (Mierauskas et al, 2005), at present only 2.4%; part of them are modified by drainage and peat extraction. The majority of streams and rivers have been canalized (regulated channels make up to 82% of all water courses) (Kavaliauskas & Baškytė, 2000).

The major part of bryological investigations in Lithuania has been focused on bryophytes of natural ecosystems. The first bryological investigations of anthropogenic habitats, i.e. arable fields, (Andriušaitytė, 2001, 2002) proved them

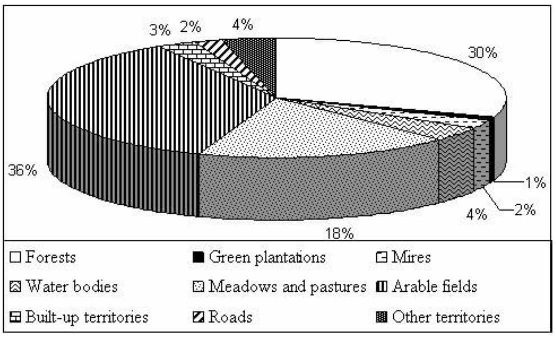

Fig. 1. Structure of Lithuanian territory according to land use (following Kavaliauskas & Baškytė, 2000).

to be rich in both common and rare species. This paper is focused on bryophytes occurring in wider range of anthropogenic habitats – arable land, bare ground in ruderal habitats, dolomite and limestone quarries, on artificial substrata (concrete constructions) and in artificial water bodies.

The aim of this study was to assess conservation value of anthropogenic habitats by ascertaining their role in Lithuanian bryoflora diversity and providing suitable habitats for rare bryophyte species. It is an attempt to look at anthropogenic habitats as an inherent part of the country and to answer questions: 1) what part of Lithuanian bryoflora is supported by anthropogenic habitats; 2) how many rare species are restricted to anthropogenic habitats and 3) is it necessary and possible to conserve rare bryophyte species in anthropogenic habitats.

METHODS AND MATERIALS

The analysis is based partly on the same data (herbaria BILAS and WI, literature references) which were used to compile Lithuanian bryofloras (Jukonienė, 2003, Naujalis et al., 1995) and the Red Data Book (Rašomavičius, 2007). Data of targeted investigations by the author in 6 dolomite and limestone quarries (still used and abandoned) in Northern Lithuania in 1996–1997 as well as the data of investigations by D. Andriušaitytė and the author in arable fields (186 study sites all over Lithuania) in 1998–2001 comprise the largest amount of the material concerning anthropogenic habitats. Data on bryophytes of concrete constructions (35 sites) and ruderal habitats (39 sites) were collected during general studies on bryoflora of particular territories throughout Lithuania in 1986–2006. The main sampling in arable lands was performed in autumn (between September and November) and in spring (between March and May). Sampling in other habitats took place in various time of the year. Specimen data are stored in BILAS Herbarium database using BRAHMS software. The specimens of anthropogenic habitats were selected using queries in the database (about 2500 specimens were selected: 1600 from arable land, 900 from other habitats). About 50 specimens of anthropogenic habitats collected by A. Minkevičius in 1926–1928 and E. Kerbelis in 2000 were found in WI Herbarium. Data on common species have been supported by field notes as well. Finally, the analysis was supplied with the data from phytocoenological references (Rašomavičius & Biveinis, 1996; Stancevičius, 1959).

Three types of anthropogenic habitats are analyzed: habitats with disturbed ground, epilithic habitats and artificial water bodies. The first group includes arable land (crop fields and fallow land ≤ 4 years) and first stages of ruderal habitats (banks of the ditches, roadsides, sand and gravel pits). Epilithic habitats include artificial substrata (concrete constructions) and open rock in dolomite and limestone quarries.

The numbers of species of natural habitats: forests, meadows, mires, bolders, sands (including coastal and continental dunes), are given according to floras (Jukonienė, 2003; Naujalis et al., 1995).

Categories of the species included into the Red Data Book of Lithuania follow the same classification used in the IUCN Red List (1976):

0 (Ex) – Extinct or possibly extinct species.

1 (E) – Endangered species on the verge of extinction yet can be saved but only with implementation of special conservation measures.

2 (V) – Vulnerable species whose population numbers and abundance is rapidly decreasing.

3 (R) – Rare species with a small number of populations due to their biological characteristics.

4 (I) – Indeterminate species, which can not be included in the other categories due to lack of data.

5 (Rs) – Restored species once included in the Red List whose abundance has since been restored.

According to frequency, species of anthropogenic habitats are divided into 5 groups: very rare species (1–3 localities), rare (4–9 localities), less frequent (10–20 localities), rather common (more than 20 localities, but in quite narrow range of habitats), common – widely distributed in various habitats).

The names of the species follow R. Grolle, D. G. Long (2000) (hepatics) and M. O. Hill et al. (2006) (mosses).

RESULTS

It was ascertained that anthropogenic habitats support 125 bryophyte species, representing about 27% (15% of hepatics and 30% of mosses) of total species number known in Lithuania (455 species). According to the colonized substrata, bryophytes of anthropogenic habitats are mainly terricolous and epilithic species. Anthropogenic habitats with disturbed ground are occupied by the largest number of species. The abundance of bryophyte species in arable land (about 22% of the country's bryoflora) is lower than in forests and is similar to that in mires (Fig. 2). Bryoflora in primary stages of ruderal habitats (banks of the ditches, roadsides, etc.) is similar in species composition but of lower diversity.

The abundance of bryophytes on open rock in quarries and on artificial epilithic substrata outnumbers their abundance on natural outcrops and stones (Fig. 3).

No particular bryophyte species strongly restricted to artificial water bodies were ascertained; however, 15 hydrophilous species use them as additional habitats.

About half of bryophyte species known from anthropogenic habitats are rare in Lithuania (found in less than 10 localities) and more than one third are found in 1–3 localities. The largest number of rare species was recorded on disturbed ground. However, the proportion of rare species on epilithic substrata is larger than the proportion of rare species on disturbed ground (Fig. 4).

About 45% of all species restricted to anthropogenic habitats have not been recorded in their natural habitat alternatives (Fig. 5), part of them are very rare species (Table 1). 25% of rare species are found both in anthropogenic and natural habitats, e.g. *Gyroweisia tenuis*, *Homomallium incurvatum*, *Lophozia badensis* and *Riccia canaliculata* (Fig. 6).

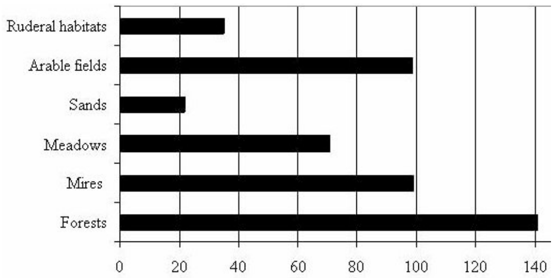

Fig. 2. Number of terricolous bryophyte species in various habitats.

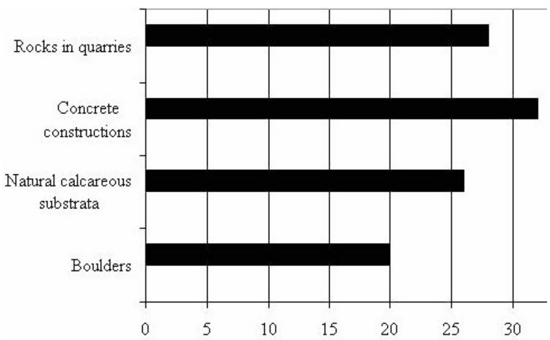

Fig. 3. Number of bryophyte species on various epilithic substrata. The data cover main quarries and natural outcrops of Northern Lithuania. Data on bryophytes of concrete constructions and boulders represent general investigations of particular territories throughout Lithuania.

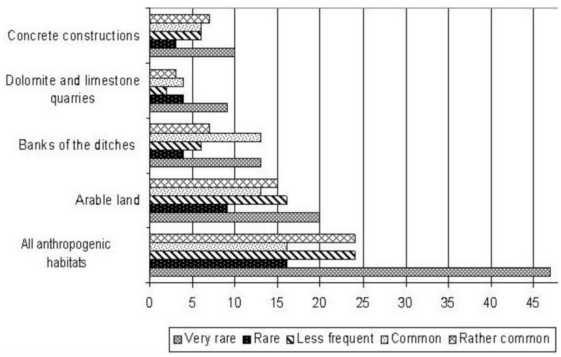

Fig. 4. Number of bryophyte species of different frequency categories in anthropogenic habitats of Lithuania.

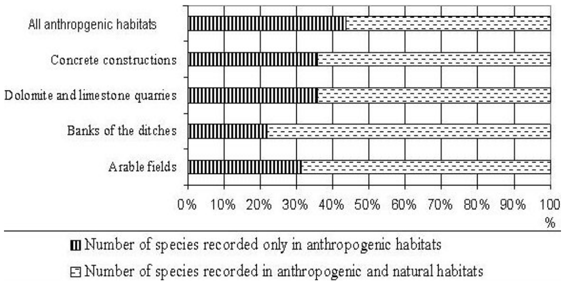

Fig. 5. Bryophyte species (%) recorded in anthropogenic habitats and in both anthropogenic and natural habitats.

21 species recorded in anthropogenic habitats of Lithuania are of high conservation value, they are included into the Red Data Book of Lithuania or Red Data Book of European Bryophytes (Table 2). The Red Data Book of Lithuania (Rašomavičius, 2007) includes 19 bryophyte species restricted to anthropogenic habitats, and it makes 20% of all redlisted species. It is somewhat lower comparing to the percentage (27%) of all species of anthropogenic habitats in Lithuanian bryoflora. Species included into the Red Data Book of Lithuania represent all main anthropogenic habitats: disturbed ground

Table 1. List of rare species recorded only in anthropogenic habitats of Lithuania (abbreviations: af – arable fields, bd – banks of the ditches, cc – concrete constructions, dlq – dolomite and limestone quarries)

Species	Number of localities			
	af	bd	dlq	cc
Acaulon muticum (Hedw.) Müll. Hal.	9			
Aloina aloides (Koch ex Schultz) Kindb.			1	
Aloina rigida (Hedw.) Limpr.			5	
Archidium alternifolium (Hedw.) Mitt.	1			
Atrichum angustatum (Brid.) Bruch et Schimp.		1		
Bryum bicolor Dicks.	3	1		
Bryum funckii Schwägr.			1	1
Bryum gemmilucens R. Wilczek et Demaret	2			
Bryum ruderale (Crundw.) Nyholm	1			
Ditrichum flexicaule (Schwägr.) Hampe			2	
Ditrichum pusilum (Hedw.) E. Britton ex Williams	5	1		
Fissidens dubius P. Beauv.				1
Microbryum floerkeanum (F. Weber & D. Mohr) Schimp.	3			
Pallaviccinia lyellii (Hook.) Carruth		1		
Philonotis caespitosa Jur.		2		
Pohlia camptotrachela (Renauld & Cardot) Broth.	7			
Pohlia lescuriana (Sull) Ochi	2			
Pohlia melanodon (Brid.) A.J.Shaw	4			
Protobryum bryoides (Dicks.) J. Guerra & M.J. Cano	4	1		
Pseudoleskeella catenulata (Brid. ex Schrad.) Kindb.				2
Pterygoneurum ovatum (Hedw.) Dixon	1		1	
Pterygoneurum subsessile (Brid.) Jur.	1			
Riccia huebeneriana Lindenb.	4			
Syntrichia papillosa (Wilson) Jur.				1
Tortula obtusifolia (Schwägr.) Mathieu				1
Trematodon ambiguus (Hedw.) Hornsch.		1		
Trichostomum crispulum Bruch		1	2	
Weissia squarrosa (Nees & Hornsch.) Müll. Hal.		1		

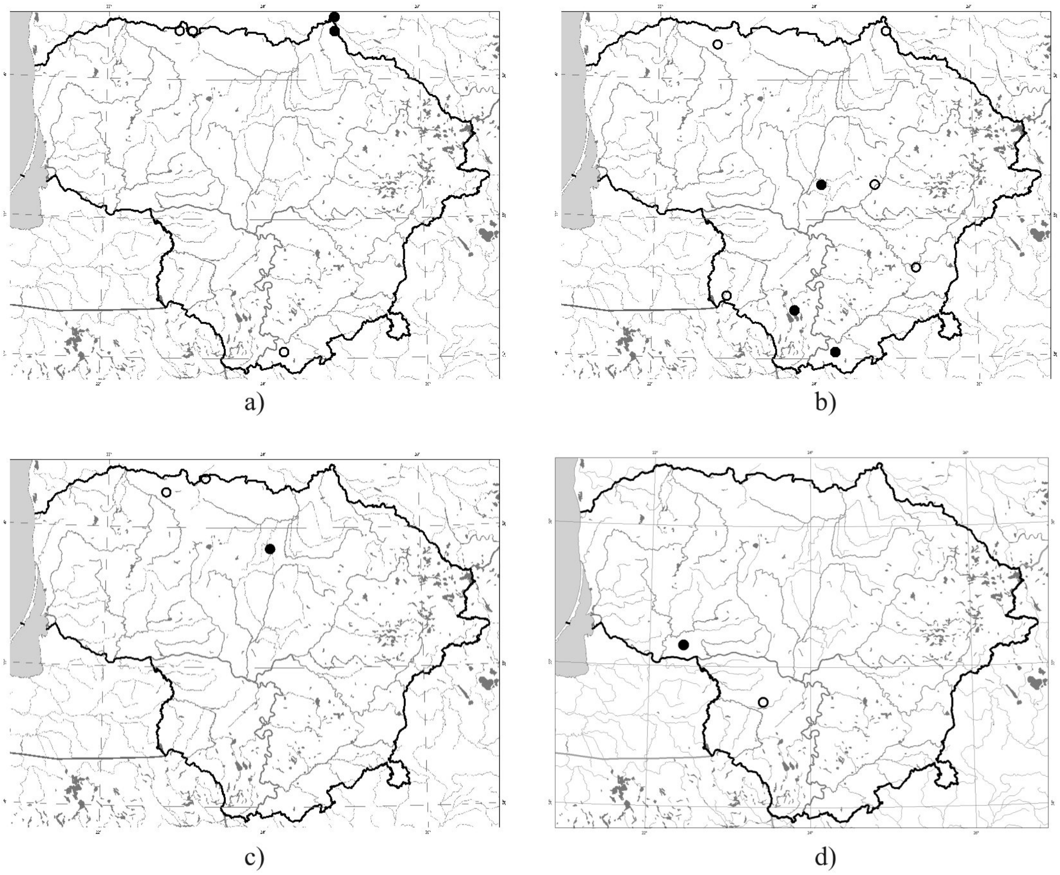

Fig. 6. Preliminary distribution of *Leiocolea badensis* (a)*, Homomallium incurvatum* (b), *Gyroweisia tenuis* (c) and *Riccia canaliculata* (d) in Lithuania (• – natural habitats, o – anthropogenic habitats).

(arable fields, banks of the ditches, roadsides), dolomite and limestone quarries, concrete constructions, artificial water bodies (Table 2).

The majority of anthropogenic localities of the redlisted bryophyte species are outside the protected territories of Lithuania (Table 2).

DISCUSSIONS

Though anthropogenic habitats increase the importance of common species with ruderal strategy (Motiekaitytė, 2002; Kuwatz, Mac Donald, 2004), even in case of vascular plants anthropogenic habitats, especially arable fields, are rich in rare plant species (Hulina, 2005). Data from Lithuania support some of the published data about the importance of anthropogenic habitats for the richness of bryophyte species, especially those restricted to open environment and thus limited to areas with appropriate level of disturbance (Zechmeister et al., 2003; Vanderpoorten et al, 2004) and to artificial calcareous substrata (concrete constructions) (Ignatov, 1989; Rykovskij et al., 1989). Species of open ground form a significant proportion of many national Red Lists (ECCB, 1995). In Sweden about 20% of bryophytes occurring in agricultural land and urban habitats are redlisted (Gärdenfors, 2005).

Our analysis shows that man-made habitats are important for rare species of Lithuanian bryoflora in 2 aspects: they can ensure existence of the species in the territory and provide larger scale distribution for species occurring in similar natural habitats. All analysed anthropogenic habitats, except artificial water bodies, harbour rare bryophyte species that have not been recorded in their natural habitat alterna-

Table 2. Bryophyte species of high conservation value occurring in anthropogenic habitats. (Abbreviations: af – arable fields, awb – artificial water bodies, bd – banks of the ditches, cc – concrete constructions, dq – dolomite quarries, lq – limestone quarries, rs – roadsides; RDBL – Red Data Book of Lithuania; ERDB – Red Data Book of European bryophytes)

Species	RDBL	ERDB	Anthropogenic habitats	Number of localities in anthropogenic habitats	
				Total	In protected territories
Atrichum angustatum (Brid.) Bruch et Schimp.	R		bd	1	1
Bryum funckii Schwägr.	R		dq	1	1
Bryum neodamense Itzigs.		R	dq	1	1
Campylium protensum (Brid.) Kindb.	I		lq	1	0
Didymodon tophaceus (Brid.) Lisa	I		bd	2	0
Fissidens dubius P. Beauv.	R		cc	1	0
Fissidens exilis Hedw.	I		bd	1	1
Fossombronia wondraczekii (Corda) Dumort.	I		af	15	1
Gyroweisia tenuis (Hedw.) Schimp.	R		dq	2	1
Homomallium incurvatum Schrad. ex Brid.	R		cc	3	0
Microbryum floerkeanum (F. Weber & D. Mohr) Schimp.		K	af	3	0
Pallaviccinia lyellii (Hook.) Carruth	E	V	bd	1	1
Philonotis caespitosa Jur.	I		bd, af	2	1
Pogonatum nanum (Hedw.) P. Beauv.	R		af, rs	4	4
Protobryum bryoides (Dicks.) J. Guerra & M.J. Cano	R		af, gp	5	0
Pterygoneurum subsessile (Brid.) Jur.	R	RT	af	1	0
Riccia huebeneriana Lindenb.	I	R	af	2	0
Ricccia canaliculata Hoffm.	I		awb	1	0
Ricciocarpos natans (L.) Corda	I		awb	5	2
Trematodon ambiguus (Hedw.) Hornsch.	R		bd	1	1
Weissia squarrosa (Nees & Hornsch.) Müll. Hal.	R		bd	1	1

tives in Lithuania. Non occasional rarity of these species is proved by their distribution in neighbouring countries. The list presented in Table 1 includes 8 of 12 moss species ascertained as very rare for the Baltic countries that are known only from Lithuania and characterised by highest temperature indices (Vellak et al., 2007). The majority of other listed species are rare in Latvia (Abolina, 1994), Estonia (Ingerpuu et al., 1994) and Belarus (Rykovkij, Maslovskij, 2004). Species that inhabit arable ground or banks of the ditches constitute the majority of species recorded exceptionally in anthropogenic habitats; nevertheless, the chance of their occurrence in similar natural habitats should be taken into account, as bare soil appearing naturally provides similar habitats (ECCB, 1995). Rare bryophyte species of arable fields in Lithuania are known from the (*Nano)Cyperion flavescentis* Koch 1926 ex Libbert 1932, *Festuco-Brometea* Br.-Bl. & R. Tx. 1943, *Cratoneurion commutati* Koch 1928 etc. communities occupying both anthropogenic and natural habitats (sites kept open by disturbance or erosion, alluvial sand or gravel, loamy and silty soils in the flood zone of rivers, near springs and lakes, etc.) in Europe (Dierßen, 2001).

Anthropogenic habitats are especially significant for epilithic species of the country. It was ascertained that the shortage of habitats (rocks with high pH) determines high number of rare species with higher pH points in the Baltic countries (Vellak et al., 2006). The areas of natural calcareous rocks in Lithuania are the smallest comparing with the two neighbouring countries. Four times higher number of bryophyte species was registered on natural dolomite outcrops in Latvia (Ābolina, 1968, 1994) than in Lithuania. Some rare species (e.g. *Bryum funckii*, *Fissidens* *dubius*), known to occur in natural habitats in Latvia or Estonia, are found in Lithuania only in anthropogenic habitats. In such situation (shortage of natural rocks) anthropogenic epilithic habitats are essential in providing larger scale distribution for the species occurring in similar natural habitats. Larger distribution scale of bryophytes is provided both by concrete constructions and limestone and dolomite quarries.

The majority of bryophytes of anthropogenic habitats, particularly those occupying bare ground, are often small-sized and short-living species. So the rarity of such bryophytes may depend on insufficient knowledge of their distribution due to their inconspicuousness. Nevertheless, the above-mentioned facts suggest the need to preserve bryophyte species found in anthropogenic habitats as part of plant diversity of the country. It is important for nature conservation in Europe to compile Red Data Lists of species (redlisting) and protect their habitats and sites (Hallingbäck, 1995).

Formally all redlisted species in Lithuania are protected by law because the Red Data Book of Lithuania serves as a legal document on which the protection of rare and endangered species is based (Rašomavičius, 2007). Protection of 19 bryophyte species known from anthropogenic habitats (Table 2) in the sites or protection of their habitats is more complicated. Management plans prepared for protected territories are aimed to restore and conserve natural habitats, and the measures sometimes do not coincide with the special requirements of bryophytes. Anthropogenic habitats are occupied by species that tolerate or even prefer human activities. So the continuation of particular management is more important than protection of the sites (ECCB, 1995; Jacquemart et al., 2003; Vanderpoorten et al., 2005). The best situation is with species of abandoned dolomite quarries, which, as natural calcareous outcrops, are habitats of European importance (Rašomavičius, 2000), thus management plans for maintaining favourable status for the habitat benefit the bryophyte species. The majority of localities of species occurring in arable fields, on concrete constructions, in artificial water bodies and in used quarries are outside the protected territories. They are exposed to various threats: from alteration of the habitat quality to its complete destruction. Species occurring in arable land are threatened by very intensive management (Zechmeister et Moser, 2001; Zechmeister et al., 2003) as well as by long-term abandonment as they can be outcompeted by vascular plant species (ECCB, 1995). The most unpredictable situation is for rare species occurring in still used quarries. So, conservation programs of the species occurring in anthropogenic habitats should include recommendations for arable land use at least in the sites with the highest concentration of rare species. Maintenance of open rock in dolomite and limestone quarries after their closing and of old concrete constructions as suitable substrata for rare bryophyte species is of high importance for such countries like Lithuania having small areas of natural calcareous outcrops.

CONCLUSIONS

During centuries anthropogenic habitats have become inherent part of Lithuanian landscape. Bryophytes occurring in habitats created by agriculture, urbanization and other human activities constitute about 27% of the country's bryoflora. About half of them are rare in Lithuania. For 25% of rare species anthropogenic habitats are additional for larger scale distribution as they are more abundant comparing with natural habitat alternatives; the others have not been recorded in natural habitats since now.

Although 20% of bryophyte species occurring in anthropogenic habitats of Lithuania are protected by law (Red Data Book of Lithuania), their protection in the sites is problematic. In protected territories they can not survive without human activity, i.e. special management that satisfies special requirements of bryophyte species. Special conservation measures, such as recommendations for management of the sites with high concentration of rare species and preservation of substrata suitable for bryophyte diversity in non protected territories, are needed.

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Checklist of the species of the genus *Lactarius* (Phallomycetidae, Agaricomycetes) in Estonia

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Abstract: 62 species of genus *Lactarius* of Phallomycetidae (Agaricomycetes) from the family *Russulaceae* (Russulales) have been recorded in Estonia. A checklist of these species with ecological, phenological and distribution data is presented.

Kokkuvõte: Riisika (*Lactarius*) perekonna (Phallomycetidae, Agaricomycetes) perekonna liikide kriitiline nimestik Eestis.

Esitatakse kriitiline nimestik koos ökoloogiliste, fenoloogiliste ja levikuliste andmetega riisika (*Lactarius*) perekonda kuuluva 62 liigi kohta Eestis.

INTRODUCTION

The following eight scientific papers have been contained the precise data on the *Lactarius* species in Estonia: Kalamees, 1962, 1971, 1978, 1979a, 2000; Järva & Parmasto, 1980; Järva, Parmasto & Vaasma, 1998; Urbonas, Kalamees & Lukin, 1986.

The present checklist contains 62 *Lactarius* species recorded in Estonia. Most species included have been proved by relevant exsiccata in the mycological herbarium TAA(M) of the Institute of Agricultural and Environmental Sciences of the Estonian University of Life Sciences. The following taxa, *Lactarius circellatus* Fr. 1838, *L. umbrinus* (Paulet) Fr. 1838, *L. subdulcis* ss. Kalamees, 1979a, *L. serifluus* (DC: Fr.) Fr. 1838 (?=*L. cremor* ss. auct. Est.), *L. tabidus* ss. Kalamees, 1978, 1979a, 1980 (?=*L. omphaliformis* Romagn. 1974) and *L. aspideus var. flavidus* (Boud.) Neuhoff 1956 (?=*L. acris* ss. Leisner 1962) (see Kalamees, 1978, 1979a; Järva & Parmasto, 1980; Urbonas, Kalamees & Lukin, 1986; Järva, Parmasto & Vaasma, 1998) are omitted in checklist: there are no specimens of these in TAA(M) supporting their presence in Estonia.

This is not only a taxonomic list of the species of *Lactarius*, it also provides data on the ecology, phenology and occurrence of these species in Estonia (see also Kalamees 1979b, 1980, 1982, 2001). The following data are given on each taxon: (1) the Latin name with a reference to the initial source; (2) most important synonyms; (3) reference to most important and representative pictures (iconography) in the mycological literature used in identifying Estonian species; (4) data on the ecology, phenology and distribution; (5) references to herbarium specimens available in Estonia, using the internationally accepted abbreviation of the fungal collection, TAA (M); (6) comments.

Checklist principally following the Index Fungorum. By the characterization of fungal sites the publication of Paal (1997) is used. The frequency of the occurrence of taxa is estimated according to a 6-point scale: very rare – 1–2 localities, rare – 3–5 localities, rather rare – 6–10 localities, rather frequent – 11–20 localities, frequent – 21–50 localities, very frequent – 51 or more localities.

Abbreviations of iconography are following:
Basso – Basso, 1999
CD – Courtecuisse & Duhem, 2000
Cetto1 – Cetto, 1979a
Cetto2 – Cetto, 1979b
Cetto3 – Cetto, 1979c
D – Dähncke, 2001
HVV – Heilmann-Clausen, Verbeken & Vesterholt, 1998
KL – Kalamees & Liiv, 2005
KM – Konrad & Maublanc, 1928
Korh – Korhonen, 1984
Kriegl – Krieglsteiner, 2000
K – Kränzlin, 2005
Lge – Lange, 1940
March6 – Marchand, 1980
MH – Michael & Hennig, 1970
N – Neuhoff, 1956

Phil – Phillips, 1981
Rick – Ricken, 1915

LIST OF SPECIES

LACTARIUS Pers., Tent. disp. meth. Fung.: 63. 1797.

L. ACERRIMUS Britzelm., Bot. Zbl. 54 (4): 98. 1893
Syn.: *L. zonarius* ss. auct. p.p.; *L. insulsus* ss. auct. pl.
Icon.: Basso p.335; CD 1527; HVV p.125; K 1; Kriegl p.384; Lge 173*F-F1*, as *L. insulsus*; March6, 515; MH 20; N 16; Phil p.80.
Ecol. & Distr.: In eutrophic boreo-nemoral deciduous forests and wooded meadows, particularly in broadleaved forests, mainly in West Estonia and on islands, under *Quercus robur*, July to September, rather rare, often in large groups; ectomycorrhizal with *Q. robur*; calciphilous.
Voucher specimens studied: TAA(M) 121668, 141445, 177257.

L. AQUIZONATUS Kytöv., Karstenia 24 (2): 60. 1984
Icon.: Basso p.415; CD 1519; HVV p.119; KL 324; Korh pp.97–100.
Ecol. & Distr.: In coniferous, deciduous and mixed forests, also on paludifying ground, August and September, frequent; ectomycorrhizal with deciduous and coniferous trees.
Voucher specimens studied: TAA(M) 70653, 76557, 144750.

L. ASPIDEUS (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 336. 1838
Icon.: Basso p.225; CD 1562; HVV p.97; Korh p.124; Lge 170*F*; MH 14; N 12.
Ecol. & Distr.: In paludifying forests and brushwoods, under *Salix* spp., August to October, rather rare; ectomycorrhizal with *Salix* spp.
Voucher specimens studied: TAA(M) 123643, 142667, 176121.

L. AURANTIACUS (Pers.) Gray, Nat. Arr. Brit. Pl. (London) 1: 624. 1821
Syn.: *L. mitissimus* (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 345. 1838; *L. aurantiofulvus* J. Blum ex Bon, Docums Mycol. 16 (no. 61): 16. 1985.
Icon.: Basso pp.543, 559, as *L. mitissimus*; CD 1576, as *L. aurantiofulvus*; D pp. 978, as *L. mitissimus*, 980, as *L. aurantiacus*; HVV p.179; K 5; KL 350, as *L. mitissimus*; KM 338; Korh p.186, as *L. mitissimus*; Kriegl p.406; Lge 173A, as *L. aurantiacus* var. *mitissimus*, 173D; March 6, 558; N 55–56, as *L.* mitissimus; Phil p.89, as *L. mitissimus*.
Ecol. & Distr.: In coniferous, deciduous and mixed forests, more often in spruce and spruce-mixed forests, also on oligotrophic paludifying ground, especially in *Vaccinium myrtillus* boreal, *Oxalis* boreal, *Aegopodium* boreo-nemoral and drained peatland site types, July to November; rather frequent; ectomycorrhizal with coniferous and deciduous trees.
Voucher specimens studied: TAA(M) 70645, 71814, 185646.

L. AURIOLLA Kytöv., Karstenia 24 (2): 54. 1984
Icon.: Basso p.419; HVV p.113; Korh p.81.
Ecol. & Distr.: In eutrophic boreo-nemoral spruce forests, on wet ground, especially in *Aegopodium* site type, September, very rare; ectomycorrhizal with *Picea abies*; calciphilous; in Estonia only two localities: Saare Co., Saaremaa Island, Viidumägi Nature Reserve, Viidumägi, 23 Sept 2006 (V. Liiv) and Järva Co., Endla Nature Reserve, Kirikumäe, 4 Sept 2005 (M. Vaasma).
Voucher specimens studied: TAA(M) 177694, 183039.

L. AZONITES (Bull.) Fr., Epicr. syst. mycol. (Upsaliae): 343. 1838, f. **AZONITES**
Syn.: *L. fuliginosus* var. *albipes* (J.E. Lange) Bon, Docums Mycol. 10 (nos 37–38): 92. 1980 [1979]; *L. fuliginosus* ss. auct. p.p.
Icon.: Basso pp.647, 798; CD 1602; D p.948; HVV pp.239, 241; K 6; KL 352; Korh p.183; Kriegl p.378; March6, 566, as *L. albipes*; N 43; Phil p.87.
Ecol. & Distr.: In broadleaved forests and wooded meadows, especially under *Quercus robur*, in West Estonia, July to September, rare; ectomycorrhizal with deciduous trees; calciphilous.
Voucher specimens studied: TAA(M) 123606, 123776, 143870.

L. BADIOSANGUINEUS Kühner & Romagn., Bull. trimest. Soc. mycol. Fr. 69: 361. 1954 [1953]
Syn.: *L. hepaticus* ss. Kalamees; auct. p.p.
Icon.: Basso p.499; CD 1596; D p.989; K 7; HVV p.185; Korh pp.198, 199; March6, 581; N 60.
Ecol. & Distr.: In moist and paludifying

coniferous and mixed forests, especially in ombrotrophic and mixotrophic bog and drained peatland pine forests, among *Sphagnum* spp., September and October, rather frequent; ectomycorrhizal with coniferous trees.
Voucher specimens studied: TAA(M) 122615, 142265, 144418.

L. bertillonii (Neuhoff ex Z. Schaef.) Bon, Docums Mycol. 10 (nos 37–38): 92. 1980 [1979]
Syn.: *L. vellereus* var. *bertillonii* Neuhoff ex Z. Schaef., Česká Mykol. 33: 9. 1979; *L. vellereus* ss. auct. p.p.
Icon.: Basso p.711; CD 1515; HVV p.255; K 8; KL 319; Korh p.71
Ecol. & Distr.: In deciduous, coniferous and mixed forests and brushwoods, especially in the vicinity of *Quercus robur* and *Corylus avellana*, August and September, rather frequent; ectomycorrhizal with deciduous, probably also on coniferous trees.
Voucher specimens studied: TAA(M) 72595, 123668.

L. camphoratus (Bull.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 346. 1838
Syn.: *Agaricus subdulcis-camphoratus* Bull.: Fr., Syst. mycol. (Lundae) 1: 70. 1821.
Icon.: Basso p.591; CD 1586; HVV p.215; K 12; KL 356; Korh p.188; Kriegl p.407; March6, 572; N 63.
Ecol. & Distr.: In spruce and spruce-mixed forests, also on oligotrophic paludifying ground, particularly in *Vaccinium myrtillus* boreal, *Oxalis* boreal, *Aegopodium* boreo-nemoral and drained peatland site types, July to September, very frequent; a most common Estonian *Lactarius* species; ectomycorrhizal with *Picea abies*.
Voucher specimens studied: TAA(M) 70417, 73035, 142316.

L. chrysorrheus Fr., Epicr. syst. mycol. (Upsaliae): 342. 1838
Syn.: *Lactarius theiogalus* (Bull.) Gray, Nat. Arr. Brit. Pl. (London) 1: 624. 1821, ss. orig., non auct.
Icon.: Basso p.319; CD 1579; Cetto2, 623; HVV p.123; K 13; KL 345; Korh p.172; Kriegl p.390; Lge 172*A*; March6, 552; MH 12; N 20.
Ecol. & Distr.: In oak and oak-mixed forests, in sandy and alvar pine forests with oak underwood, on Saaremaa Island only, August to October, rare (four localities); ectomycorrhizal with *Quercus robur*; calciphilous.
In the Red Data Book of Estonia: rare (categ. 3); protected by law (categ. II) (Kalamees & Vaasma, 1998; Järva et al., 1999).
Voucher specimens studied: TAA(M) 142202, 144036, 171945, 189601.

L. citriolens Pouzar, Česká Mykol. 22: 20. 1968
Syn.: *L cilicioides* ss. auct. p.p.; *L. resimus* ss. auct. p.p.
Icon.: Basso p.423; CD 1518; HVV p.121; KL 327; Korh pp.95, 96; MH 6, as *L. cilicioides*; March6, 512; N 9, as *L. cilicioides*.
Ecol. & Distr.: In deciduous and mixed forests and wooded meadows, especially in eutrophic boreo-nemoral and eutrophic alvar forests in the vicinity of broadleaved trees, particularly *Quercus robur*, July to September, rather frequent, especially in West and North Estonia; ectomycorrhizal with deciduous trees.
Voucher specimens studied: TAA(M) 70667, 77005, 113231.
Comments: In earlier Estonian mycological literature, *L. citriolens* and *L. resimus* are treated together under the latter name. Thus, the real distribution of *L. citriolens* in Estonia requires further investigation.

L. controversus (Pers.: Fr.) Pers., Observ. mycol. (Lipsiae) 1: 39. 1800 [1799]
Icon.: Basso pp.339, 780; CD 1512; HVV p.137; K 15; KL 321; Korh p.102; Kriegl p.391; Lge 169*C*; March6, 504; MH 4; N 4; Phil p.77.
Ecol. & Distr.: in aspen and aspen-mixed forests and wooded meadows, July to September, rare; ectomycorrhizal with *Populus tremula*; in Estonia 5 localities in Pärnu, Lääne, Tartu and Viljandi counties.
In the Red Data Book of Estonia: rare (categ.3); protected by law (categ. II) (Kalamees & Vaasma, 1998; Järva et al., 1999).
Voucher specimens studied: TAA(M) 142051, 143864, 175647.
Comments: The spores of the specimens found in Estonia are subglobose to globose and specific to small, thus, different from larger ellipsoid spores referred to in literature (cf. Heilmann-Clausen, 1998; Basso, 1999).

L. cyathuliformis Bon, Docums Mycol. 8 (nos 30–31): 69. 1978
Syn.: *L. obscuratus* ss. auct. pl.
Icon.: Basso pp.615, 797; HVV p.211.
Ecol. & Distr.: In eutrophic paludifying,

minerotrophic mobile water swamp and floodplain alder and alder-mixed forests, only under *Alnus* spp., August and September, rather frequent; ectomycorrhizal with *Alnus incana*, *A. glutinosa*.
Voucher specimens studied: TAA(M) 80538, 114822, 171590.

L. deliciosus (L.: Fr.) Gray, Nat. Arr. Brit. Pl. (London) 1: 624. 1821.

Syn.: ? *L. deliciosus* f. *rubescens* J. Aug. Schmitt, Z. Pilzk. 39: 238. 1974 [1973].
Icon.: CD 1552.
Ecol. & Distr.: In pine and pine-mixed forests, particularly in dune pine forests, very frequent, in North and West Estonia, especially in sandy forests on the seashore, August to November; ectomycorrhizal with *Pinus sylvestris*.
Voucher specimens studied: TAA(M) 50294, 113402, 141869.
Comment: Only *L. deliciosus* f. *rubescens* with milk turning reddish has been recorded in Estonia up to the present time.

L. deterrimus Gröger, Westfälische Pilzbriefe 7: 10. 1968
Syn.: *L. deliciosus* var. *piceus* Smotl., Atlas hub jedlých a nejedlých: 218–219. 1947; *L deliciosus* ss. auct. mult.; *L. semisanguifluus* ss. auct. p.p.
Icon.: Basso p.265; CD 1556; D p.954; HVV pp.151–153; K 18; KL 332; Korh pp. 110, 111; Kriegl p.353; Lge 177*A-A1*, as *L. semisanguifluus*; March6, 524; N 22, as *L. semisanguifluus*.
Ecol. & Distr.: In spruce and spruce-mixed forests, especially in eutrophic paludifying and minerotrophic mobile water swamp forests, in spots abundant, August to October; ectomycorrhizal with *Picea abies*; a most common Estonian *Lactarius* species.
Voucher specimens studied: TAA(M) 113282, 124451, 142468.

L. evosmus Kühner & Romagn., Bull. trimest. Soc. mycol. Fr. 69: 361. 1954 [1953]
Syn.: *L. zonarius* ss. auct. p.p.
Icon.: Basso p.343; CD 1528; HVV pp.127, 129; K 20; KL 329; Korh p.101, as *L. zonarius*; March6, 516; N 15, as *L. zonarius*.
Ecol. & Distr.: In eutrophic boreo-nemoral and paludifying forests and wooded meadows, under *Populus tremula* and *Quercus robur*, August to October, very frequent, especially in West Estonia; ectomycorrhizal with deciduous trees.
Voucher specimens studied: TAA(M) 114623, 146395, 177693.
Comments: In earlier Estonian mycological literature, *L. evosmus* was treated together with *L. zonarius* using the latter name. Also outside Estonia, these species have also been regarded as synonyms. A more thorough investigation has proved that these are two different, good taxonomic species. In northern countries (see Korhonen, 1984) and at least in West Estonia and on the Saaremaa Island, *L. evosmus* is a very frequent species (see Kalamees, 2000; Kalamees & Liiv, 2005).

L. fennoscandicus Verbeken & Vesterh., Cryptog. Mycol. 19 (1–2): 87. 1998
Syn.: *L. deterrimus* ss. Korhonen (in part), Suomen rouskut (Keuruu): 103–104. 1984.
Icon.: Basso p.268; HVV p.155; Korh pp.108 (lower left), 109, as *L. deterrimus*.
Ecol. & Distr.: In spruce and spruce-mixed forests, July and August, rare; ectomycorrhizal with *Picea abies*.
Voucher specimens studied: TAA(M) 145833, 147970, 172818.
Comments: The real distribution of *L. fennoscandicus*, that in Estonia has been treated together with *L. deterrimus*, requires further investigation. The species is probably frequent in our territory.

L. flexuosus (Pers.: Fr.) Gray, Nat. Arr. Brit. Pl. (London)1: 624. 1821
Misapplied: *L. circellatus* (Kalamees & Liiv, 2005).
Icon.: Basso p.93; K 22; KL 338, as *L. circellatus*; Korh pp.151–154; MH 36; N 32.
Ecol. & Distr.: In coniferous, deciduous and mixed forests, rare, July to October, predominantly ectomycorrhizal with coniferous trees, but also related to deciduous trees (see Neuhoff, 1956; Michael & Hennig, 1970).
Voucher specimens studied: TAA(M) 73130, 74589, 185650.

L. fuliginosus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 348. 1838
Syn.: *L. azonites* ss. auct. p.p.
Icon.: Basso p.655; CD 1601; HVV p.245; K 23; KL 353; KM 324; Korh p.182; Kriegl p.182.
Ecol. & Distr.: In deciduous and mixed forests, especially in *Vaccinium myrtillus* boreal,

Aegopodium boreo-nemoral and *Dryopteris* paludifying site types, July to October, rather rare; ectomycorrhizal with deciduous trees.
Voucher specimens studied: TAA(M) 74661, 74949, 176313.

L. fulvissimus Romagn., Bull. trimest. Soc. mycol. Fr. 69: 362. 1954 [1953]
Icon.: Basso pp.550, 551; HVV p.197; K 24; KL 351; Kriegl p.409; March6: 561.
Ecol. & Distr.: In broadleaved forests, parks, September and October, very rare; ectomycorrhizal with deciduous trees; calciphilous; in Estonia only one locality: Hiiu Co., Hiiumaa Island, Suuremõisa, in park, in years 2001 and 2004 (K. Kalamees and V. Liiv).
Voucher specimens studied: TAA(M) 172915, 185851.

L. glaucescens Crossl., Naturalist: 5. 1900
Syn.: *L. piperatus* var. *glaucescens* (Crossl.) Hesler & A.H. Sm., North American Species of Lactarius (Ann Arbor): 186. 1979; *L. piperatus* ss. auct. p.p.; *L. pe(a)rgamenus* ss. auct. mult.
Icon.: Basso pp.727, 804; CD 1510, as *L. pergamenus*, 1511; HVV p.251; K 25; Korh pp.68–69, as *L. pargamenus*; March6, 502, as *L. pergamenus*, 503; MH 2, as *L. piperatus*; N 2.
Ecol. & Distr.: In deciduous and mixed forests, in eutrophic boreo-nemoral broadleaved forests, September, rare; ectomycorrhizal with deciduous trees.
Voucher specimens studied: TAA(M) 121655, 124189.

L. glyciosmus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 348. 1838
Icon.: Basso p.467; CD 1573; HVV p.171; K 26, KL 346; Korh p.168; Lge 171*A*, *A1*; N 42.
Ecol. & Distr.: In coniferous, deciduous and mixed forests, particularly in *Vaccinium vitis-idaea* and *V. myrtillus* oligo-mesotrophic boreal, *Oxalis* mesotrophic boreal, *Aegopodium* and *Hepatica* eutrophic boreo-nemoral, *Corylus* boreo-nemoral hillock, *Dryopteris* eutrophic paludifying and in drained peatland forest site types; July to October, very frequent; ectomycorrhizal with *Betula pendula* and *B. pubescens*.
Voucher specimens studied: TAA(M) 70457, 73031, 77232.

L. helvus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 347. 1838
Syn.: *L. aquifluus* Peck, Rep. N.Y. St. Mus. nat. Hist. 28: 50. 1876.
Icon.: Basso p.471; Cetto3, 1049; HVV p.175; K 27; KL 341; Phil p.86.
Ecol. & Distr.: In moist and oligotrophic paludifying coniferous and mixed forests, mixotrophic and ombrotrophic pine forests, wooded oligotrophic bogs, heaths, oligotrophic boreal heath pine forests, July to October, very frequent, in spots abundant; ectomycorrhizal with coniferous trees, especially *Pinus sylvestris*; a most common *Lactarius* in Estonia.
Voucher specimens studied: TAA(M) 50965, 70513, 71312.

L. hysginus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 337. 1838
Syn.: *L. curtus* ss. auct. eur.
Icon.: Basso pp.141, 771; CD 1537, as *L. curtus*; HVV p.81; K 29; Korh pp.138–140; Kriegl p.395; Lge 175*B*; MH 28; N 37.
Ecol. & Distr.: In spruce and spruce-mixed forests, in September, very rare; ectomycorrhizal with coniferous trees, especially *Picea abies*; in Estonia only one locality: Valga Co., Lüllemäe, 9 Sept 1986 (K. Kalamees).
Voucher specimen studied: TAA(M) 143300.

L. lacunarum Romagn. ex Hora, Trans. Br. mycol. Soc. 43: 444. 1960
Syn.: *L. decipiens* Quél., Comptes rendu Assoc. Franc. Avanc. Sci. 14: 448. 1885; *L. decipiens* var. *lacunarum* Romagn., Bull. trimest. Soc. mycol. Fr. 54: 223. 1938 (nom. nud.).
Icon.: Basso p.531; CD 1595; HVV p.199; K 32; KL 357; Korh pp.196, 197; Lge 174*E*; March6, 580.
Ecol. & Distr.: In eutrophic paludifying, peatland and drained peatland forests, in eutrophic boreo-nemoral and minerotrophic swamp forests, especially in swamp holes under *Alnus* spp., June to November, very frequent, in spots abundant; ectomycorrhizal with deciduous trees; a most common *Lactarius* in paludifying forests of Estonia.
Voucher specimens studied: TAA(M) 122486, 143288, 185655.

L. leonis Kytöv., Karstenia 24 (2): 46. 1984
Icon.: Basso p.435; HVV p.109; K 33; KL 328; Korh p.88.
Ecol. & Distr.: In spruce and spruce-mixed forests, in eutrophic alvar site type, also on wet ground, August and September, rare, in West and North Estonia, on Saaremaa and Hiiumaa

islands; ectomycorrhizal with *Picea abies*; calciphilous.
Voucher specimens studied: TAA(M) 113403, 182932, 185702, 185833.

L. lignyotus Fr., Nuovi Ann. Sci. Nat.: 25. 1857
Icon.: Basso pp.659, 799; CD 1605; Cetto2, 627; HVV p.227; K 35; KM 326; Korh pp.181, 182; Kriegl p.379; MH 62; N 47.
Ecol. & Distr.: In spruce and spruce-mixed forests, especially in *Oxalis* mesotrophic boreal site type, rather rare, August and September; ectomycorrhizal with *Picea abies.*
Voucher specimens studied: TAA(M) 74855, 176879, 180136.

L. lilacinus (Lasch) Fr., Epicr. syst. mycol. (Upsaliae): 348. 1838
Icon.: Basso p.479; CD 1574; K 36; HVV p.169; KL 342; Korh p.169; March6, 550; N 39.
Ecol. & Distr.: In moist and wet alder (*Alnus* spp.) and deciduous forests with alder undergrowth, brushwoods, September and October, very frequent, in spots abundant; ectomycorrhizal with *Alnus incana* and *A. glutinosa.*
Voucher specimens studied: TAA(M) 71844, 113351, 183282.

L. luridus (Pers.: Fr.) Gray, Nat. Arr. Brit. Pl. (London) 1: 625. 1821
Icon.: Basso p.196; K 37; HVV p.85.
Ecol. & Distr.: In wet deciduous forests, especially in eutrophic paludifying site type, August, very rare; ectomycorrhizae on deciduous trees; in Estonia only one locality: Lääne Co., Matsalu National Park, Meelva, 27 Aug 2005 (K. Kalamees).
Voucher specimen studied: TAA(M) 177202.
Comments: The real distribution of *L. luridus*, that in Estonia has been treated together with *L. uvidus*, requires further investigation. The species is probably more frequent in our territory.

L. mairei Malençon, Bull. trimest. Soc. mycol. Fr. 55: 34. 1939
Syn.: *L. mairei* var. *mairei; L. mairei* var. *zonatus* A. Pearson, Naturalist: 102. 1950; *L. pearsonii* Z. Schaef., Česká Mykol. 22: 19. 1966.
Icon.: Basso p.375; CD 1526; HVV p.165; MH 8, 9.
Ecol. & Distr.: In oak and oak-mixed forests, in eutrophic boreo-nemoral site type, September, rare; ectomycorrhizal with *Quercus robur*; calciphilous; in Estonia three localities in Saare, Lääne and Tartu counties.
In the Red Data Book of Estonia: rare (categ. 3); protected by law (categ.II) (Kalamees & Vaasma, 1998; Järva et al., 1999).
Voucher specimens studied: TAA (M) 113454, 121569, 171613.

L. mammosus Fr., Epicr. syst. mycol. (Upsaliae): 347. 1838
Syn.: *L. fuscus* Rolland, Bull. Soc. mycol. Fr. 15: 76. 1899; *L. confusus* S. Lundell, Fungi Exsiccati Suecici: 8. 1939.
Icon.: Basso p.486; HVV p.173; K 39; KL 347; Korh p.167; Kriegl p.416; March6, 548, as *L. fuscus*; MH 40; N 41.
Ecol. & Distr.: In coniferous and mixed forests, especially in sandy pine forests, in forest rides, ditch banks, forest roads and paths, in sandy ground, August to October, rather frequent; ectomycorrhizal with coniferous and deciduous trees.
Voucher specimens studied: TAA(M) 84507, 114629, 128282.

L. musteus Fr., Epicr. syst. mycol. (Upsaliae): 337. 1838
Icon.: Basso pp.172; HVV p.77; K 40; KL 337; Korh p.136; MH 25; N 25.
Ecol. & Distr.: In sandy pine and pine-mixed forests, especially in *Cladina* oligotrophic boreal heath site type, ombrotrophic drained bogs, August and September, rather rare; ectomycorrhizal with *Pinus sylvestris*.
Selected material studied: TAA(M) 114588, 121501, 185879.

L. necator (Bull.: Fr.) Pers., Observ. mycol. (Lipsiae) 2: 42. 1800
Syn.: *L. turpis* (Weinm.) Fr., Epicr. syst. mycol. (Upsaliae): 335. 1838. *L. plumbeus* ss. auct. pl., nec ss. orig. (=nom. dub.).
Icon.: Basso p.69, as *L. turpis*; CD 1541; Cetto1, 181; HVV p.43, as *L. plumbeus*; K 75, as *L. turpis*; KL 340; KM 318, as *L. plumbeus*; Korh p.136; Kriegl p.375, as *L. turpis*; March6, 538; N 30. as *L. turpis*.
Ecol. & Distr.: In deciduous, coniferous and mixed forests, especially in birch (*Betula* spp.) and spruce (*Picea abies*) forests, particularly in *Vaccinium vitis-idaea* and *V. myrtillus* oligo-mesotrophic boreal, *Oxalis* mesotrophic boreal, *Aegopodium* eutrophic boreo-nemoral, *Dryopteris* eutrophic paludifying and drained

peatland site types, also on oligotrophic bog ground, July to October, very frequent, in spots abundant; ectomycorrhizal with deciduous and coniferous trees; a most common *Lactarius* species in Estonia.
Voucher specimens studied: TAA(M) 51001, 70160, 70356.
Comments: *L. necator* has been neotypified by Noordeloos & Kuyper (1999); according to these authors, this name has priority over *L. turpis*, and *L. plumbeus* is a name not applicable for this species.

L. obscuratus (Lasch) Fr., Epicr. syst. mycol. (Upsaliae): 346. 1838
Syn.: *L. obscuratus* var. *obscuratus; L. obscuratus* var. *radiatus* (J.E. Lange) Romagn., Bull. trimest. Soc. mycol. Fr. 90: 145. 1974; *L. obnubilus* (Lasch) Fr., Hymenomyc. eur. (Upsaliae): 438. 1874.
Icon.: Basso pp.619, 622, 788; CD 1607; HVV p.207, 209; K 42; Korh p.201; Kriegl p.417; Lge 176*C-C1*, as *L. obnubilus*; March6, 583; MH 65; N 66.
Ecol. & Distr.: In eutrophic paludifying, minerotrophic swamp and floodplain alder and alder-mixed forests, July to October, rather frequent; ectomycorrhizal with *Alnus incana* and *A. glutinosa.*
Voucher specimens studied: TAA(M) 177267, 185595, 185596.

L. olivinus Kytöv., Karstenia 24 (2): 49. 1984
Icon.: Basso p.439; HVV p.111; KL 326; Korh p.85.
Ecol. & Distr.: In spruce and spruce-mixed forests, mainly in alvar site type, August and September, rather frequent, in West Estonia and Saaremaa Island; ectomycorrhizal with *Picea abies*; calciphilous.
Voucher specimens studied: TAA(M) 75588, 76281, 177695.

L. piperatus (L.: Fr.) Pers., Tent. disp. meth. Fung.: 64. 1797.
Syn.: *L. pergamenus* ss. auct. mult.
Icon.: Basso pp.731, 805; Cetto2, 637, as *L. pergamenus*; CD 1509; HVV p.249; K 46; KL 320; Korh pp. 67, 70; March6, 501; MH 1, as *L. pergamenus*; N 1; Phil p.77.
Ecol. & Distr.: In deciduous forests, especially in eutrophic boreo-nemoral broadleaved and alvar forests, under *Quercus robur*, mainly in North and West Estonia, July to September, rather rare; ectomycorrhizal with deciduous trees; probably calciphilous.
Voucher specimens studied: TAA(M) 124190, 141814.

L. pubescens (Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 335. 1838
Syn.: *L. cilicioides* (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 334. 1838, ss. auct.; *L. albus* J. Blum, Les Lactaires. Etudes Mycologiques (Paris): 115. 1976; *L. blumii* Bon, Docums Mycol. 9 (no. 35): 39. 1979.
Icon.: Basso p.383; CD 1523; D p.943; HVV p.161; K 50; KL 323; Korh pp.70, 72, 73; Kriegl p.370; March6, 509, as *L. blumii*; Phil p.78.
Ecol. & Distr.: In birch and birch-mixed forests, brushwoods, wooded meadows, parks, in mineral as well as paludifying ground, August to October, very frequent, in spots abundant; ectomycorrhizal with *Betula pendula* and *B. pubescens*; a most common *Lactarius* in Estonia.
Voucher specimens studied: TAA(M) 121539, 143910, 146340, 175491.

L. pyrogalus (Bull.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 339. 1838
Syn.: *L. hortensis* Velen., České houby 1: 163. 1920; ?*L. umbrinus* (Paulet) Fr., Epicr. syst. mycol. (Upsaliae): 339. 1838; *L. circellatus* ss. auct. p.p.
Icon.: Basso p.811; CD 1532; HVV p.53; K 51; KL 339; Korh p.133, as *L. hortensis*; Lge 174*A*; March6, 532; N 33.
Ecol. & Distr.: In deciduous, coniferous and mixed forests with *Corylus avellana* undergrowth, especially in *Oxalis* and *Corylus* site types, in parks, *Corylus*-brushwoods, August to October, very frequent; ectomycorrhizal with *Corylus avellana*; a most common *Lactarius* in Estonia.
Voucher specimens studied: TAA(M) 70823, 73442, 95617.

L. quietus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 343 1838
Icon.: Basso pp.503; CD 1581; HVV p.193; K 53; KL 343; Korh pp.170, 171; Kriegl p.419; Lge 176*E*; March6, 556; MH 38; N 64; Phil p.88.
Ecol. & Distr.: In oak and oak-mixed forests, August to October, rather frequent; ectomycorrhizal with *Quercus robur.*
Voucher specimens studied: TAA(M) 74736, 177222, 185861.

L. repraesentaneus Britzelm., Ber. naturw. Augsburg 28: 136. 1885
Icon.: Basso p.240; CD 1558; HVV p.105; K 54; Korh pp.121, 122–123; Kriegl p.365; March6, 525; MH 13; N 11.
Ecol. & Distr.: In spruce and spruce-mixed fotrests, September, rather rare; ectomycorrhizal with *Picea abies*.
Voucher specimens studied: TAA(M) 26386, 74830, 122520.

L. resimus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 336. 1838
Icon.: Basso p.443; CD 1517; HVV p.117; K 55; Korh p.96, 97; Lge 170*E*; March6, 511; MH 10.
Ecol. & Distr.: In deciduous and mixed forests, especially near *Betula* spp., also in coniferous forests with birches, on acid ground, August and September, very rare; ectomycorrhizal with deciduous trees; in Estonia only two localities: Pärnu Co., Põlendmaa, Kivinina, 23 Aug 1966 and Lääne-Viru Co., Muraka Nature Reserve, Mustassaare (K. Kalamees).
Voucher specimens studied: TAA 74628, 76216.
Comments: Three different species – *L. resimus*, *L. aquizonatus* and *L. citriolens* – were treated together under the name *L. resimus* in earlier Estonian mycological literature. Most of these finds actually belong to the species *L. citriolens* or *L. aquizonatus*, the true *L. resimus* is very rare in Estonia.

L. roseozonatus (H. Post) Britzelm., Ber. naturw. Augsburg 30: 29. 1890
Syn.: *L. flexuosus* var. *roseozonatus* H. Post in Fr., Monogr. Hymenomyc. Suec. (Upsaliae) 2: 163. 1863.
Icon.: KL 336; Korh p.154.
Ecol. & Distr.: In aspen and aspen-mixed forests, also on oligotrophic paludifying ground, July to October, rather frequent; ectomycorrhizal with *Populus tremula*.
Voucher specimens studied: TAA(M) 74838, 123590, 182883.

L. rufus (Scop.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 347. 1838
Icon.: Basso p 491; CD 1569; Cetto1, 180; HVV p.177; K 58; KL 349; Korh p.166; Kriegl p.422; Lge 176*A*; March6, 545; N 65; Phil p.86.
Ecol. & Distr.: In pine and pine-mixed forests, on sandy ground, in ombrotrophic bog and wooded bog pine forests, especially in oligo- to mesotrophic boreal, oligotrophic bog and drained peatland site types, July to November, very frequent, in spots abundant; ectomycorrhizal with *Pinus sylvestris*; a most common and well-known *Lactarius* in Estonia.
Voucher specimens studied: TAA(M) 70298, 141943, 146156a.

Lactarius sanguifluus (Paulet) Fr., Epicr. syst. mycol. (Upsaliae): 341. 1838
Icon.: Basso p.305; CD 1549; D p.952; HVV p.147; K 62; KM 323; N 24.
Ecol. & Distr.: In coniferous forests, preferably in eutrophic alvar pine, rarer in spruce forests, August to October, rather rare, only in North and West Estonia; ectomycorrhizal with coniferous trees, especially *Pinus sylvestris*; calciphilous.
Voucher specimens studied: TAA(M) 50654, 123327, 182538.

L. scoticus Berk. & Broome, Ann. Mag. nat. Hist., Ser. 5, 3: 208. 1879
Syn.: *L. torminosus* var. *gracillimus* J.E. Lange, Dansk bot. Ark. 9 (no 6): 98. 1938; *L. favrei* H. Jahn, Int. J. Mycol. Lichenol. 1 (1): 98. 1982; *L. pubescens* var. *scoticus* (Berk. & Broome) Krieglst., Beitr. Kenntn. Pilze Mitteleur. 7: 69. 1991; *L. pubescens* ss. auct. p.p.
Icon.: Basso p.387; HVV p.163; K 63; Korh p.72; Lge 169*E*, as *L. torminosus* var. *gracillimus*; March6, 508, as *L. pubescens*.
Ecol. & Distr.: In eutrophic paludifying and minerotrophic stagnant water swamp to mixotrophic bog birch and birch-mixed forests, brushwoods, wooded meadows, especially in mixotrophic bog site type, also in drained peatland forests, only on paludifying ground, August and September, frequent; ectomycorrhizal with *Betula pubescens.*
Voucher specimens studied: 143893, 177624, 185817.

L. scrobiculatus (Scop.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 334. 1838
Icon.: Basso p.410, 446; CD 1520; Cetto1, 183; HVV p.107; K 64; KL 325; Korh pp.86–87; Kriegl p.373; March6, 513; N 10.
Ecol. & Distr.: In coniferous and mixed forests, especially in eutrophic boreo-nemoral, eutrophic paludifying and minerotrophic swamp to mixotrophic bog spruce and spruce-mixed forests, in *Calla* swamp site type, August to

November, very frequent, in spots abundant; ectomycorrhizal with *Picea abies*.
Voucher specimens studied: TAA(M) 114626.

L. SEMISANGUIFLUUS R. Heim & Leclair, Revue Mycol., Paris 15; 79. 1950
Icon.: Basso p.289; Cetto1 172; CD 1555; HVV p.149; K 65; Kriegl p.358; March6, 523.
Ecol. & Distr.: In pine and pine-mixed forests, especially in oligotrophic boreal heath, oligo-mesotrophic boreal and eutrophic alvar forests, August to October, rather rare; ectomycorrhizal with *Pinus sylvestris.*
Voucher specimens studied: TAA(M) 120687, 124463, 143395.

L. SPHAGNETI (Fr.) Neuhoff, Pilze Mitteleuropas (Stuttgart): 181. 1956
Icon.: Basso p.507; D p.991; HVV p.187; Korh pp.199, 200; March6, 554; N 61.
Ecol. & Distr.: In oligotrophic paludifying and drained peatland coniferous forests, among *Sphagnum* spp., September, very rare; ectomycorrhizal with coniferous trees; in Estonia only two localities in Jõgeva Co.: near Mõisamaa, 4 Sept 1960 (K. Kalamees) and Endla Nature Reserve, Tooma, 3 Sept 2005 (M. Vaasma).
Voucher specimens studied: TAA(M) 71730, 183024.

L. SPINOSULUS Quél. & Le Bret., Bull. Soc. Amis Sci. Nat. Rouen, Série II 2 (15): 168. 1879
Icon.: Basso p.394; D p.970; HVV p.167; K 68; Korh p.172; March6: 551, MH 45; N 7.
Ecol. & Distr.: In coniferous, deciduous and mixed forests, parks, July to September, rather rare, usually in large groups; ectomycorrhizal with *Picea abies* and *Betula pendula.*
Voucher specimens studied: TAA(M) 73133, 73225, 124521.

L. SUBUMBONATUS Lindgr., Bot. Notiser: 200. 1845
Syn.: *L. serifluus* ss. auct. pl.; *L. cimicarius* ss. auct.
Icon.: Basso p.606; CD 1591; HVV p.225; Lge 173*B*, as *L. cimicarius*; March6, 576.
Ecol. & Distr.: In broadleaved forests, especially eutrophic alvar site type, September, very rare; ectomycorrhizal with *Quercus robur*; calciphilous; in Estonia only one locality: Hiiu Co., Hiiumaa Island, Sarve Peninsula, Sarve Nature Reserv, 14 Sept 2001 (V. Liiv).
Voucher specimen studied: TAA 172914.

L. SYRINGINUS Z. Schaef., Česká Mykol. 10: 171. 1956
Icon.: HVV p.61
Ecol. & Distr.: In deciduous and mixed forests, mainly in eutrophic boreo-nemoral site type, August, very rare; ectomycorrhizal with *Betula* spp.; in Estonia only one locality: Lääne Co., Matsalu National Park, Matsalu, 26 Aug 2005 (K. Kalamees).
Voucher specimen studied: TAA(M) 177189.
Comments: Further studies must demonstrate, is this species not an extreme variety of *L. vietus***.**

L. TABIDUS Fr., Epicr. syst. mycol. (Upsaliae): 346. 1838
Syn.: *L. thei(j)ogalus* ss. auct. pl.; *L. subdulcis* ss. auct. p.p.
Icon.: Basso p.635; CD 1594, as *L. theiogalus*; HVV p.201; K 71; KL 355, as *L. theiogalus*; Korh pp.195–196, as *L. theiogalus*; N 57, as *L. theiogalus.*
Ecol. & Distr.: In moist and paludifying coniferous, deciduous and mixed forests, June to October, very frequent, in spots abundant; ectomycorrhizal with deciduous and coniferous trees, prefers *Betula* spp.; a most common *Lactarius* in Estonia.
Voucher specimens studied: TAA(M) 71611, 73132, 185579.

L. TORMINOSUS (Schaeff.: Fr.) Gray, Nat. Arr. Brit. Pl. (London) 1: 623. 1821
Icon.: Basso pp.402, 403, 784; D p.942; K 72, KL 322; Korh pp.71, 74; Kriegl p.373; Lge 169A; MH 5; N 6; Phil p.78;.
Ecol. & Distr.: In birch and birch-mixed forests, mainly on mineral ground but also on oligotrophic bog ground, especially in *Vaccinium vitis-idaea* and *V. myrtillus* oligo-mesotrophic boreal, *Oxalis* mesotrophic boreal, *Aegopodium* eutrophic boreo-nemoral, *Corylus* meso-eutrophic boreo-nemoral and *Dryopteris* eutrophic paludifying site types; July to November; very frequent; predominantly ectomycorrhizal with *Betula pendula*; a most common *Lactarius* in Estonia.
Voucher specimens studied: TAA(M) 70350, 121574, 142440, 177160.

L. TRIVIALIS (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 337. 1838
Icon.: Basso p.153; CD 1547; KL 334; Korh pp.157, 158; Kriegl p.401; March6, 544; N 35.
Ecol. & Distr.: In coniferous, deciduous and

mixed forests, in all forest site types, also in eutrophic paludifying and ombrotrophic forests, July to November; very frequent; ectomycorrhizal with coniferous and deciduous trees; a most common *Lactarius* species in Estonia.
Voucher specimens studied: TAA(M) 70338, 70418.

L. utilis (Weinm.) Fr., Monogr. Hymenomyc. Suec. (Upsaliae) 2 (2): 159. 1863
Icon.: Basso p.184; HVV p.73; KL 335; Korh p.156.
Ecol. & Distr.: In coniferous, deciduous and mixed forests, in all forest types, also in oligotrophic bog and eutrophic paludifying forests, July to October, very frequent; ectomycorrhizal with coniferous and deciduous trees; a most common *Lactarius* species in Estonia.
Voucher specimen studied: TAA(M) 71860.

L. uvidus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 338. 1838
Icon.: Basso p. 213; CD 1566; HVV p.83; K 76; KL 344; Kriegl p. 366; March6, 530; N 13, 13a.
Ecol. & Distr.: In moist and paludifying deciduous, coniferous and mixed forests, in peatland forests, mainly in *Vaccinium myrtillus* oligo-mesotophic, *Oxalis* mesotrophic boreal, *Aegopodium* eutrophic boreo-nemoral, *Dryopteris* eutrophic paludifying, minerotrophic swamp and drained peatland forests, August to October, very frequent; ectomycorrhizal with deciduous and coniferous trees.
Voucher specimens studied: TAA(M) 70574, 71017, 71825.

L. vellereus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 340. 1838, **var. vellereus**
Syn.: *L. vellereus* var. *velutinus* (Bertill.) Bataille, Hist. Lich. Sticta: 35. 1908.
Icon.: Basso pp.715, 827; CD 1513; D p.934; HVV p.253; K 77; Kriegl p.361; Lge 170*B*; March6, 505; N 3; Phil p.76.
Ecol. & Distr.: In deciduous forests, August, very rare; ectomycorrhizal with deciduous trees; in Estonia only one locality: Valga Co., Karula National Park, Rebase, under *Populus tremula*, 23 Aug 1984 (S. Veldre).
Voucher specimen studied: TAA(M) 141465.
Comments. In earlier Estonian mycological literature, *L. vellereus* is described as a typical species in Estonia, it was not separated from *L. bertillonii*. The latter species is actually a common fungus in our territory, while *L. vellereus* altogether is a rare species.

L. vietus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 344 1838
Icon.: Basso p.129; CD 1542; HVV p.59; K 78; KL 348; Korh p.135; Kriegl p.402; Lge 177*D*; March6, 539; N 34; Phil p.86.
Ecol. & Distr.: In deciduous and mixed forests, especially in birch and birch-pine forests, also on oligotrophic bog ground, in all forest types, in spots abundant, July to October, very frequent; ectomycorrhizal with *Betula* spp.
Voucher specimens studied: TAA(M) 71500, 73186, 176132.

L. violascens (J. Otto: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 342 1838
Syn.: *L. luridus* ss. auct. p.p.
Icon.: Basso pp.217, 816; CD 1564; HVV p.87; K 79; Kriegl p. 367; Lge 173*C*; March6, 528; MH 15: N 14.
Ecol. & Distr.: In deciduous, coniferous and mixed forests, mainly in broadleaved forests, August and September, rare; ectomycorrhizal with deciduous trees.
Voucher specimens studied: TAA(M) 76387, 144334, 146402.

L. volemus (Fr.: Fr.) Fr., Epicr. syst. mycol. (Upsaliae): 344. 1838.
Icon.: Basso p.703; CD 1583; Cetto1, 176; HVV p.247; K 80; Korh pp.184, 185; Kriegl p.429; Lge 176*G*; MH 54; Phil p.88.
Ecol. & Distr.: In deciduous, especially broadleaved forests, August and September, rare; ectomycorrhizal with deciduous trees.
Voucher specimens studied: TAA(M) 76920, 114576, 182733.

L. zonarioides Kühner & Romagn., Fl. Analyt. Champ. Super. (Paris): 474. 1953
Syn.: *L. bresadol(i)anus* ss. auct.; *L. insulsus* ss. auct.
Icon.: Basso p.359; CD 1531, as *L. bresadolanus*; HVV p.133; K 81; Korh pp.101–102, as *L. bresadolianus*; Kriegl p.389, as *L. bresadolanus*; March6, 519; N 18.
Ecol. & Distr.: In coniferous forests, September, very rare; ectomycorrhizal with *Picea abies*; in Estonia only one locality: Lääne-Viru Co., Uhtna, 23 Sept 1992 (K. Kalamees, M. Vaasma & A. Jakobson).
Voucher specimen studied: TAA(M) 145561

L. zonarius (Bull.) Fr., Epicr. syst. mycol. (Upsaliae): 336. 1838

Syn.: *L evosmus* ss. auct. p.p.; *L. insulsus* ss. auct. pl.

Icon.: Basso p.367; CD 1529; HVV p.131; K 82; KL 330; Kriegl p.403; March6, 517; N 17, as *L. insulsus*.

Ecol. & Distr.: In deciduous forests, wooded meadows, under *Quercus robur* and *Populus tremula*, September, rather rare; ectomycorrhizal with deciduous trees.

Voucher specimens studied: TAA(M) 121667, 145945, 177272.

Comments: In earlier Estonian mycological literature, the species *L. zonarius* is considered as a frequent species in Estonia. Unfortunately, it was then not differentiated from the species *L. evosmus*. According to the most recent data available, *L. evosmus* is frequent and *L. zonarius* is rare in Estonia. The true distribution of *L. zonarius* and its mycorrhizal relation to tree species requires further investigation.

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Factors important for epiphytic lichen communities in wooded meadows of Estonia

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Abstract: The epiphytic lichen communities in open and overgrown wooded meadows in Estonia were examined. From 29 study stands, 179 taxa of lichens, lichenicolous and allied fungi were identified, 41 of them are nationally rare, red-listed or protected. Non-metric multidimensional scaling (NMS) was performed to examine the main gradients in species composition and to relate these gradients to environmental variables. The response of lichen species richness to the influence of the environmental variables was tested using a general linear mixed model (GLMM). We revealed that overgrowing of wooded meadows caused significant changes in lichen communities on trees: richness of lichen species decreased and the composition of species changed. Photophilous lichen communities with many species of macrolichens in open wooded meadows were replaced with associations of more shade-tolerant microlichen species. The composition of epiphytic lichen communities were also influenced by the tree species composition, diameter of trees and the geographical location of the stand.

Kokkuvõte: Eesti puisniitude epifüütseid samblikukooslusi mõjutavad tegurid

Epifüütseid samblikukooslusi uuriti Eesti avatud ja kinnikasvanud puisniitudel. 29 proovialalt registreeriti kokku 179 taksonit samblikke, lihhenikoolseid ja lähedasi seeneliike, millest 41 on kas haruldased, kuuluvad Eesti Punasesse Raamatusse või on riikliku kaitse all. Samblike liigilise koosseisu ja keskkonnaparameetrite vaheliste seoste analüüsimiseks kasutati ordinatsioonanalüüsi NMS (mittemeetriline mitmedimensionaalne skaleerimine). Keskkonnaparameetrite mõju samblike liigirikkusele analüüsiti kasutades üldist lineaarset segamudelit (GLMM). Leidsime, et puisniitude kinnikasvamine põhjustab epifüütsetes samblikukooslustes olulisi muutusi: samblike liigirikkus väheneb ning liigiline koosseis muutub. Avatud puisniitudel asenduvad suursamblike liigirikkad valguslembesed samblikukooslused rohkem varju taluvate pisisamblike kooslustega. Samblike liigilist koosseisu mõjutavad veel prooviala puuliigiline koosseis, puude läbimõõt ning prooviala geograafiline asukoht.

INTRODUCTION

Wooded meadows are mosaic vegetation complexes which consist of small copses of deciduous trees and shrubs alternating more or less irregularly with open regularly mowed meadow glades (Hæggström, 1983). Wooded meadows have been widespread in the countries around the Baltic Sea (e.g. Estonia, Sweden, southern part of Finland), particularly on the islands (Hæggström, 1983). These semi-natural man made habitats have very high diversity of vascular plants due to evolutional and historical reasons (Hæggström, 1983; Kull & Zobel, 1991; Pärtel et al., 2007).

Traditional management of wooded meadows includes raking and picking of fallen branches in spring, mowing in July, aftermath is grazed by cattle in autumn and clearings of trees and shrubs are carried out in late autumn or winter (Hæggström 1983, Kukk & Kull, 1997; Mitlacher et al., 2002). Pollarding of trees for winter fodder in wooded meadows was popular in Finland, Sweden and Norway (Hæggström, 1983; Austad, 1988; Moe & Botnen, 2000), but not in Estonia (Kukk & Kull, 1997).

In Estonia, wooded meadow-like ecosystems have existed around settlements approximately 7000–8000 years (Kukk, 2004). Mowed wooded meadows, however, were prevailing in the cultural landscape of Estonia in the 18th century, covering roughly 20% of Estonian area (about 850 000 ha) at their peak (Kukk & Kull, 1997). The area of managed wooded meadows in Estonia decreased after World War II, mostly due to the collectivization of farm land and rapid progress of intensive agriculture (Kukk & Kull, 1997). Some of the wooded meadows were cultivated, some afforested or left to overgrow. Today, the area of wooded meadows has decreased significantly, and probably only 1500–2000 ha are being managed (Kukk & Sammul, 2006), which forms 0.2% of the former territory of these habitats in Estonia.

Diversity of epiphytic lichens in wooded meadows is high with many rarities (Thor, 1998; Thor & Nordin, 1998; Leppik & Saag, 2005). It has been supposed, that most epiphytic lichens prefer an environment of 'open shade' (Stoutesdijk & Barkman, 1992; Renhorn et al., 1997), a combination of good illumination and some shelter from desiccative winds (Rose, 1992). Sparse and mosaic allocation of the trees in wooded meadows should offer favorable conditions. The question emerges, what will happen with the lichen community after these conditions change, management stops and wooded meadows grow over with deciduous wood?

The concern of future decline of these semi-natural habitats actuated us to study the epiphytic lichen community of wooded meadows. So far, only the lichen community of open wooded meadows in Estonia has been shortly described (Leppik & Saag, 2005). In this study, at the stand level, the effect of overgrowing, tree species composition, diameter of trees and geographical location of the stands on lichen species composition will be discussed.

MATERIALS AND METHODS

Study sites and environmental variables

Estonia is located in the hemiboreal sub-zone of the boreal forest zone, i.e. in the transitional area where the southern boreal forest sub-zone changes into the spruce-hardwood sub-zone (Laasimer & Masing, 1995). Characteristic tree species in wooded meadows of Estonia is *Quercus robur*, rather common are also *Betula pendula, B. pubescens, Populus tremula, Fraxinus excelsior* and *Alnus glutinosa,* the conifers *Picea abies* and *Pinus sylvestris* are more rare (Paal, 2007).

Historically the islands and western Estonia were the regions most rich in wooded meadows, while in central and eastern Estonia wooded meadows never were so widespread (Kukk & Kull, 1997). During 2004–2006, 29 stands were selected for the study according to the general distribution of wooded meadows in Estonia (Fig. 1). GIS (Geographic Information System) based database of Estonian Seminatural Community Conservation Association and Web map server of Estonian Land Board (Maainfosüsteemi avalik kaardiserver, 2005) were used for the selection of study sites and stands. In every study site, if available, a pair of open and overgrown

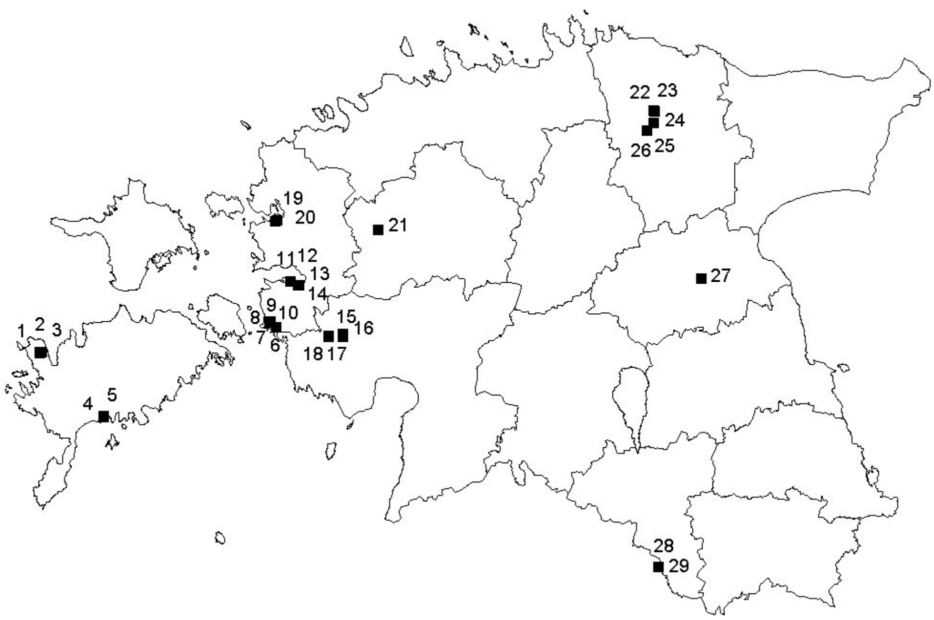

Fig. 1. Location of the studied wooded meadows in Estonia. Quadrate denotes the centre of the study site; the number indicates the study stand (n=29).

stands was selected for investigation. Most of the overgrown wooded meadows resembled deciduous forests and have not been mowed approximately for 50 years. Geographical coordinates of each study stand were recorded by means of GPS or were measured using the digital map of Estonia (Maainfosüsteemi avalik kaardiserver, 2008) (Table 1). Stands were located in three regions: western island (n=5), western part of the mainland (n=16) and eastern part of the mainland (n=8). In addition, every study stand was characterized by distance from the gravel road, canopy cover, the number and proportion of different tree species and mean diameter of studied trees (Table 1). The digital map of Estonia was used to measure the distance from the center of the stand to the nearest gravel road (log-transformed) and to estimate

Table 1. Main characteristics of the studied stands: No – number of a stand; Name – name of a stand, Habitat – open and overgrown stands (* restored recently, dense canopy; ** with the influence of sea; *** restored ten years ago; **** with young brushwood); Latitude – latitudinal coordinates of a stand (N); Longitude – longitudinal coordinates of a stand (E); Region – stands location in three regions: western island (Island of Saaremaa), western and eastern part of the mainland; Dist – distance from the nearest gravel road (km); Studied trees – tree species and the number of the studied trees (Ag – *Alnus glutinosa*; Ai – *Alnus incana*; B – *Betula* spp.; Fe – *Fraxinus excelsior*; Pa – *Picea abies*; Ps – *Pinus sylvestris*; Pt – *Populus tremula*; Qr – *Quercus robur*; Tc – *Tilia cordata*); Cov – canopy cover (%); DBH – mean diameter of studied trees at breast height (cm); Tot – total number of lichen species in a stand; Val – number of valuable lichen species in a stand.

No	Name	Habitat	Latitude	Longitude	Region	Dist	Studied trees	Cov	DBH	Tot	Val
1	Tagamõisa I	open	58°27’41”	22°0’22”	Island Saaremaa	0.17	6Qr3B2Fe1Tc	0.30	37	53	3
2	Tagamõisa II	overgrown	58°27’37”	21°59’51”	Island Saaremaa	0.57	4Qr4B2Fe2Pt	0.85	30	40	3
3	Tagamõisa III	overgrown*	58°27’42”	21°59’53”	Island Saaremaa	0.60	6Qr4B2Tc	0.65	35	52	2
4	Loode I	open	58°14’15”	22°26’27”	Island Saaremaa	0.03	9Qr3Fe	0.60	48	48	5
5	Loode II	overgrown	58°14’13”	22°26’34”	Island Saaremaa	0.11	9Qr3Fe	0.80	43	34	3
6	Pouli	open	58°34’	23°37’	West-Estonia	0.20	5Qr4Pt2B1Ai	0.15	41	46	1
7	Laelatu I	open	58°35’3”	23°34’17”	West-Estonia	0.06	4Fe4Qr2B2Pt	0.40	29	56	5
8	Laelatu II	overgrown	58°35’13”	23°34’36”	West-Estonia	0.09	4B4Fe2Pt2Qr	0.90	37	56	4
9	Laelatu III	open**	58°34’59”	23°34’15”	West-Estonia	0.08	5Qr4Fe2B1Pt	0.40	26	54	4
10	Laelatu IV	open***	58°35’9”	23°34’16”	West-Estonia	0.14	6Fe5Qr1B	0.45	26	54	5
11	Suuremõisa I	open	58°43’49”	23°42’28”	West-Estonia	0.07	6Qr3B2Fe1Ag	0.45	55	45	2
12	Suuremõisa II	overgrown	58°43’48”	23°42’36”	West-Estonia	0.20	5Qr4Ag2B1Pt	0.85	54	36	1
13	Allika I	open	58°43’2”	23°46’24”	West-Estonia	0.16	4Fe3B3Pt2Qr	0.40	34	43	2
14	Allika II	overgrown	58°43’3”	23°45’55”	West-Estonia	0.15	5Pt3Qr2Fe2Pb	0.75	43	36	2
15	Kalli-Nedrema I	open	58°32’13”	24°4’18”	West-Estonia	1.70	3Fe3Pt3Qr2B1Pa	0.50	44	49	3
16	Kalli-Nedrema II	overgrown	58°32’31”	24°4’22”	West-Estonia	1.34	4Pt4Qr3B1Ps	0.70	43	36	2
17	Peantse I	open	58°32’5”	23°58’14”	West-Estonia	0.07	7Pt2B2Ps1Qr	0.40	28	39	4
18	Peantse II	open****	58°31’58”	23°58’17”	West-Estonia	0.22	6Ps3B3Pt	0.50	28	38	6
19	Uuemõisa I	open	58°56’58”	23°37’5”	West-Estonia	0.11	12Qr	0.20	54	53	3
20	Uuemõisa II	overgrown	58°56’46”	23°36’9”	West-Estonia	0.36	12Qr	0.60	63	37	2
21	Sipa	open	58°55’	24°19’	West-Estonia	0.05	5B3Pt2Ps1Pab1Qr	0.25	42	50	2
22	Mädapea I	open	59°19’17”	26°15’45”	East-Estonia	0.50	6Qr6B	0.35	66	53	4
23	Mädapea II	overgrown	59°19’30”	26°15’28”	East-Estonia	0.33	7Qr5B	0.70	53	31	2
24	Järni	open	59°16’53”	26°15’10”	East-Estonia	0.11	12Qr	0.25	55	55	5
25	Lasila I	open	59°15’15”	26°12’16”	East-Estonia	0.91	12Qr	0.25	49	53	4
26	Lasila II	overgrown	59°15’19”	26°12’20”	East-Estonia	0.93	12Qr	0.80	44	37	2
27	Tammemetsa	open	58°43’	26°33’	East-Estonia	0.17	4B4Ag2Pt1Pab1Qr	0.40	41	48	2
28	Koiva I	open	57°41’20”	26°11’11”	East-Estonia	2.04	8Qr2B1Pa1Tc	0.20	57	59	8
29	Koiva II	overgrown	57°41’21”	26°11’16”	East-Estonia	1.91	8QrB2B1Pa1Tc	0.70	50	42	3

the percent of canopy cover of each study stand. The number of tree species and the proportion of different tree species were evaluated per study stand. Proportion of neutral-barked trees in a stand was a percent of trees with slightly acid to sub-neutral bark (average pH≥5 according to Barkman 1958, i.e. *Alnus incana*, *Fraxinus excelsior*, *Populus tremula* and *Tilia cordata*) from all studied trees in a stand. Proportion of acid-barked trees in a stand was a percent of trees with more acid bark (average pH<5 according to Barkman 1958, i.e. *Alnus glutinosa*, *Betula* spp., *Picea abies* and *Pinus sylvestris*). *Quercus robur* was considered separately since the bark pH of oak is known to be more acid (average pH=4.5) than that of other temperate broad-leaved trees (Barkman, 1958; Watson et al., 1988). The diameter of each sample tree (DBH) was measured at 1.2 m above ground level and the mean DBH of all studied trees per study stand was used in the statistical analyses.

Lichen sampling

In every stand, 12 sample trees in the area of one ha were selected according to the composition and proportion of tree species in a stand (Table 1). Epiphytic lichen communities were investigated on temperate broad-leaved trees (*Fraxinus excelsior*, *Quercus robur* and *Tilia cordata*), on other deciduous tree species (*Alnus glutinosa*, *A. incana*, *Betula* spp. and *Populus tremula*), and on conifers (*Picea abies* and *Pinus sylvestris*).

On every sample tree, the occurrence of lichen species on the stem up to two meters above ground level was recorded. In addition to lichenized fungi, lichenicolous and allied fungi were examined. Hereafter, all these taxa will be mentioned as 'lichens'. The species list of lichens per study stand was compiled, considering the recorded taxa on all twelve sample trees.

The specimens which were hard to identify in the field were collected for indoor investigation. Stereomicroscope, light microscope, UV light and standardized thin-layer chromatography (TLC) were used for identification of lichens in the laboratory. The reference material is deposited in the lichen herbarium at the Natural History Museum of the University of Tartu (TU).

The total number of lichen species and the number of valuable species (protected, red-listed and rare species with up to 10 localities in Estonia) per stand were considered in data analyses. The nomenclature of lichens, lichenicolous and allied fungi follows Randlane et al. (2007). Data about the species frequency are derived from Randlane and Saag (1999) and updated according to the Database of Estonian lichens *eSamba* (2008) and Atlas of the Estonian lichens (2008). The list of protected lichen species is presented according to the official decrees (Keskkonnaministri määrus nr 51, 2004; Vabariigi Valitsuse määrus nr 195, 2004) and the red-listed lichen species are according to Randlane et al. (2008).

Statistical analyses

The influence of environmental variables on the lichen species richness and the number of valuable lichens was tested using a general linear mixed model (GLMM; Littell et al., 1996) with the stepwise selection procedure, implemented in the program package SAS ver. 8.2 (proc MIXED; SAS Institute Inc., 1989). The categorical factor 'Region' was considered fixed factor and the pair of open and overgrown stands in a study site was treated as repeated observations per study site.

Non-metric multidimensional scaling (NMS; Kruskal, 1964a, b; Mather, 1976) with Sørensen distance was used in PC-ORD version 4.25 (McCune & Mefford, 1999) to examine the main gradients in species composition and to relate these gradients to the environmental variables. To reduce noise, the species appearing only in three study stands were removed from the data set prior to ordination. The frequency of lichen species on twelve sampled trees were used in data analyses. NMS analysis was run in autopilot mode, using slow and thorough settings (comparing 1 to 6-dimensional solutions, 40 runs with real data, 50 runs with randomized data, instability criterion 0.00001 and maximum number of iterations 400). Pearson correlations (r) with ordination axes for all quantitative variables and species were calculated. Pearson squared correlations (r^2) were calculated for the axes to express total variation in lichen community composition and for the environmental variables and axes to express strength of correlations of ordination axes with environmental variables (McCune & Mefford, 1999).

RESULTS

In total, 179 species and infraspecific taxa of lichens, lichenicolous and allied fungi were identified during this study (Appendix). Three lichen species were identified as new to Estonia: *Biatoridium delitescens*, *Leucocarpia dictyospora* and *Lecanora thysanophora* (Suija et al., 2006, 2007). All these species were found to inhabit oak trees in overgrown wooded meadows. *Lecanora thysanophora* has also been found on other tree species in deciduous forests of Estonia (Suija et al., 2007).

Most of the recorded lichen species are frequent in Estonia, except 33 species which are categorized as rare (Appendix). Ten of all recorded species are either red-listed or protected by the law in Estonia (Appendix). The overall number of valuable lichen species recorded in studied wooded meadows was 41.

On average, 46 epiphytic lichen species per wooded meadow were recorded; the highest number of species was 59 and the lowest 31 (Table 1). According to the stepwise model, the total number and the number of valuable lichen species were both negatively influenced by the variable 'Canopy cover' (Table 2, Fig. 2). The other considered variables did not influence the species richness of lichens significantly.

Analyzing the composition of lichen species with NMS, the best solution was a three dimensional configuration (final stress 11.3, number of iteration 118). Proportion of variance in lichen community composition represented by those three axes was 88%. Pearson squared correlation coefficients (r^2) were 0.39, 0.18 and 0.30 for the first, second and third axis, respectively. Correlations of environmental variables with ordination axes are presented in Table 3.

The variation of the data along the first axis is mainly determined by canopy cover. Open wooded meadows with low canopy cover are mostly on the right side and overgrown stands with high canopy cover are on the left side of the ordination plot (Figs 3, 5). According to the ordination scores of the lichen species, the lichens associated with open wooded meadows are located mostly in the positive side of the first axis (e.g. *Candelariella xanthostigma*, *Lecidella flavosorediata*, *Evernia prunastri, Ramalina fastigiata* and *R. fraxinea*; Figs 4, 6) and the lichens associated with overgrown habitats are located mostly in the negative side of the first axis (e.g. *Chaenotheca ferruginea*, *Dimerella pineti*, *Lepraria eburnea*, *L. lobificans* and *Micarea prasina*; Figs 4, 6).

The gradient directed along the second ordination axis is mainly related to the composition of tree species in wooded meadows (Fig. 3; Table 3). On the lower part of the ordination plot are the stands with many tree species and higher amount of sub-neutral barked trees in a stand, and on the upper part are the stands dominated mainly by large-diameter oak trees. The lichens characteristic to the trees with sub-neutral bark are located in the negative side of the second axis (e.g. *Lecidella subviridis* and *Lecanora rugosella*; Fig. 4) and the lichens predominately found on oak trees (e.g. *Calicium salicinum*, *Chaenotheca trichialis*, *Chaenothecopsis vainioana*, *Lobaria pulmonaria* and *Physconia perisidiosa*) are in the positive side of the second axis (Fig. 4). Also the third axis demonstrates the gradient associated with the composition of tree species in a wooded meadow, the variable acid-barked trees has the highest correlation with the third axis (Fig. 5, Table 3).

The importance of the geographical location of the stand (variable 'Longitude'; Fig. 5; Table 3) is observable in the ordination plot of the first and third axes: the stands from western Estonia are on the upper left side of the ordination plot and the stands from eastern Estonia are on the lower right side of the ordination plot.

Other considered environmental variables ('Latitude' and 'Distance from gravel road') did not provide reliable information for data interpretation (Table 3).

Table 2. The results of general linear mixed model analysis (GLMM) for the total number of lichen species and for the number of valuable lichen species. Abbreviations: df – degrees of freedom; Slope – slope of the regression line; SE – standard error; p – significance value.

	Total no. of lichen species			No. of valuable lichen species		
Factor	df	Slope (±SE)	p	df	Slope (±SE)	p
Intercept	1; 16		<0.0001	1; 18		<0.0001
Canopy cover	1; 11	-23.416 (±4.898)	0.0006	1; 9	-2.767 (±1.042)	0.026

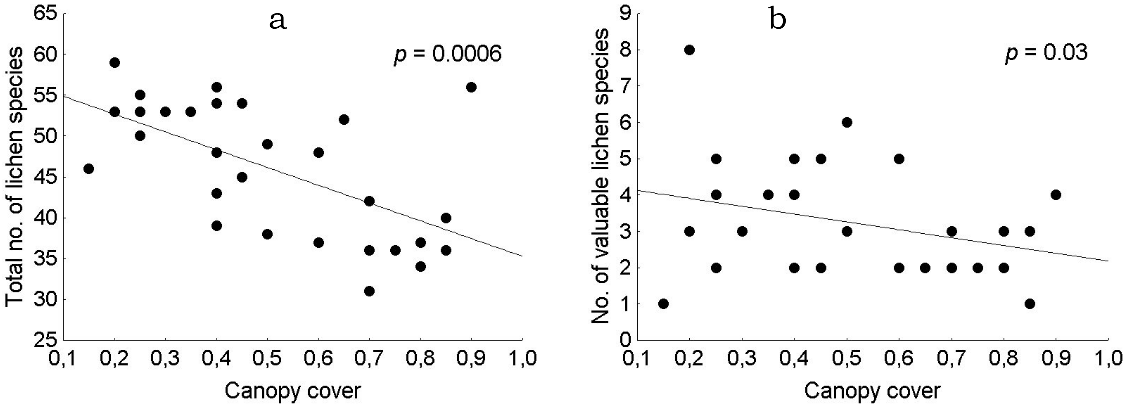

Fig. 2. Relationship between canopy cover and total number of lichen species (a) and the number of valuable lichen species (b) according to general linear mixed model (see Table 2).

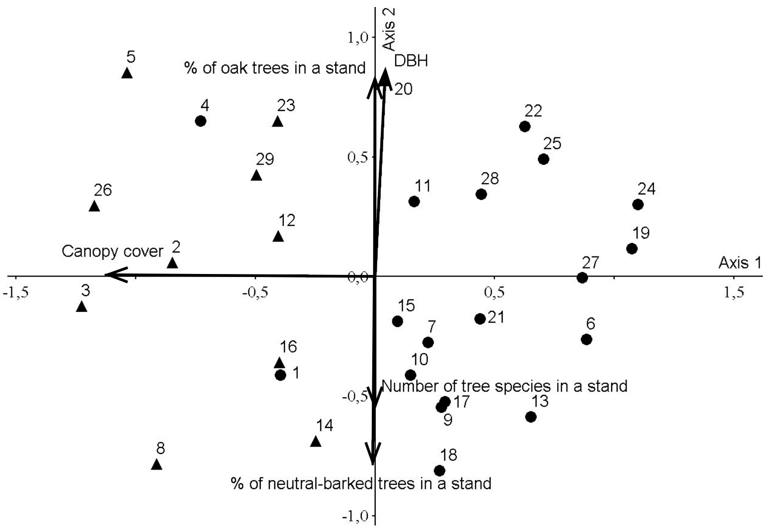

Fig. 3. NMS ordination (axes 1 vs 2) of stands in species space with joint plot overlays of environmental variables and habitat type: open (●) and overgrown (▲) stands (see Table 1). Pearson correlations (r) for quantitative environmental variables are presented in Table 3, variables are shown if $r^2 \geq 0.2$.

DISCUSSION

Overgrowing of semi-natural open wooded meadows influences drastically the composition and richness of vascular plants (Kull & Zobel, 1991; Wahlman & Milberg, 2002; Mitlacher et al., 2002) and, according to our study, causes also significant changes in the lichen communities on trees. The cessation of traditional management (hay mowing) and succession of meadows to deciduous woods result in impoverishing of lichen communities: both the total number and the number of valuable lichen species decrease with increasing canopy cover. This result is in accordance with earlier study by Arup et al. (2003) who detected slight decrease in species richness of lichens in similar habitats on the Island of Öland, south-eastern part of Sweden.

Furthermore, the composition of epiphytic lichens also changes with increasing density of the tree canopies in wooded meadows (Figs 3, 5). Some recorded crustose lichens (e.g., *Caloplaca flavorubescens*, *Candelariella xanthostigma*, *Lecidella flavosorediata* and *Ochrolechia arborea*) prefer open wooded meadows with sparse canopy cover (Figs 4, 6). Simultaneously, more lichens of foliose and fruticose growth forms occurred in the open habitats than in the

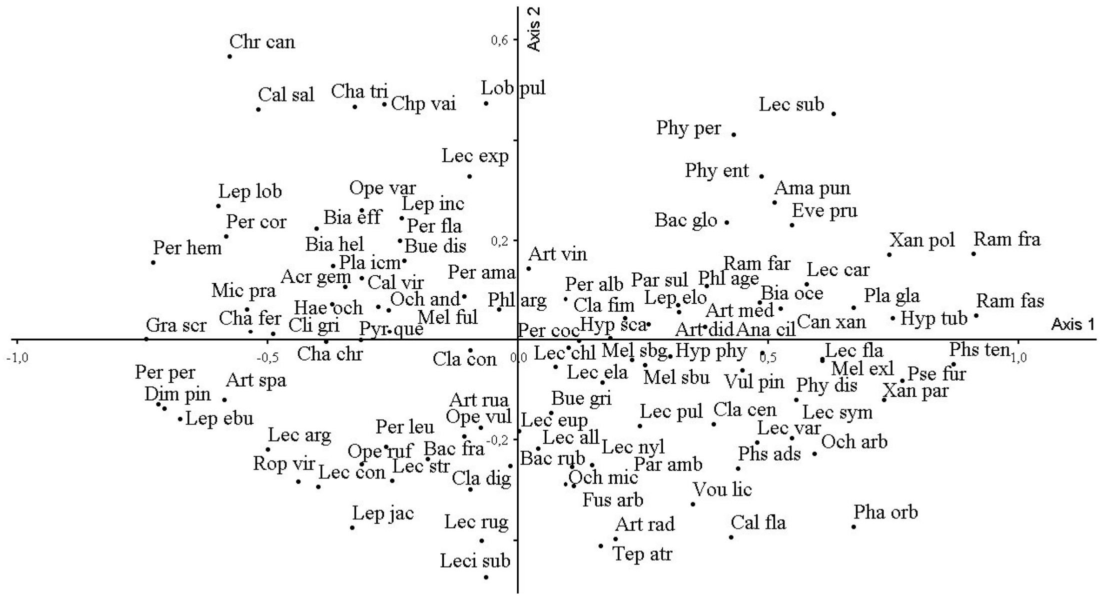

Fig. 4. NMS ordination (axes 1 vs 2) of lichen species. Abbreviations of species names are given in Appendix.

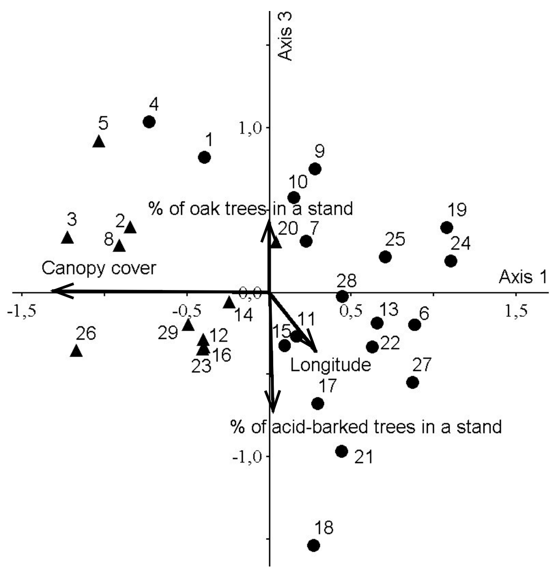

Fig. 5. NMS ordination (axes 1 vs 3) of stands in species space with joint plot overlays of environmental variables and habitat type: open (●) and overgrown (▲) stands (see Table 1). Pearson correlations (r) for quantitative environmental variables are presented in Table 3, variables are shown if $r^2 \geq 0.2$

overgrown stands (Figs 4, 6). Barkman (1958) has declared that most of foliose and fruticose lichens are photophilous. In wooded meadows, during the development of denser tree canopy, the photophilous lichen communities with many species of macrolichens are replaced with associations of more shade-tolerant microlichen species (e.g. *Chaenotheca trichialis*, *Lepraria eburnea* and *Micarea prasina*; Figs 4, 6). Similar changes in the composition of epiphytic communities on *Fraxinus excelsior* between open meadow and overgrown stands have been detected also in western Norway (Moe & Botnen, 1997, 2000).

At the stand level, similarly to high forest (Oksanen, 1988; Jüriado et al., 2003; Will-Wolf et al., 2006), the composition of tree species determined the composition of lichen species in wooded meadows. In boreal forest region, the epiphytic vegetation on the trees with most acid bark, i.e. *Picea abies*, *Pinus sylvestris* and *Betula* spp., is very different from the lichen vegetation on the trees with sub-neutral bark, mainly *Populus tremula* and temperate broad-leaved trees (Barkman, 1958; Cieśliński, 1996). In this study, the wooded meadows with mostly large-diameter oak trees supported assemblages of lichen species different from stands domi-

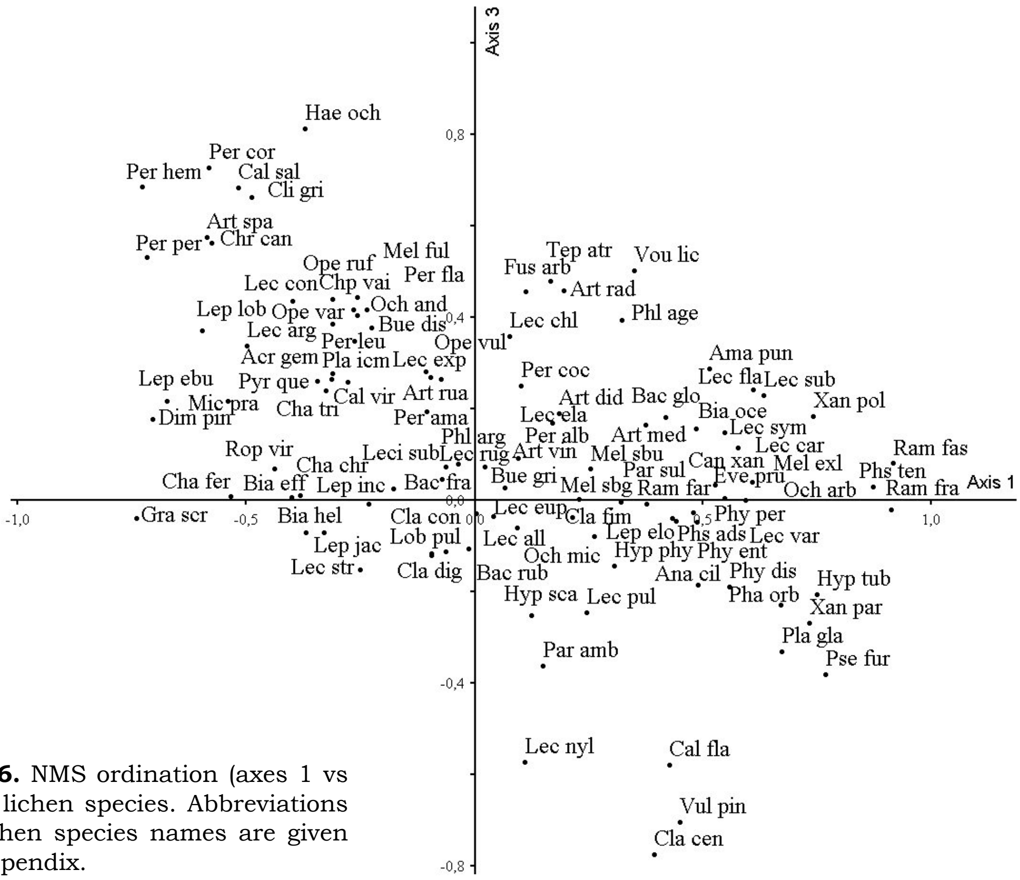

Fig. 6. NMS ordination (axes 1 vs 3) of lichen species. Abbreviations of lichen species names are given in Appendix.

Table 3. Pearson correlations (r) of quantitative environmental variables with the NMS ordination axes. An environmental variable is considered important (*) if $r^2 \geq 0.20$ with at least one ordination axis.

Environmental variable	Axis 1	Axis 2	Axis 3
Latitude	0.29	0.14	-0.19
Longitude*	0.41	0.31	-0.45
Distance from gravel road	-0.16	0.22	-0.20
Number of tree species in a stand*	-0.01	-0.60	-0.29
% of neutral-barked trees in a stand*	-0.08	-0.72	-0.05
% of acid-barked trees in a stand*	0.11	-0.37	-0.64
% of oak trees in a stand*	-0.02	0.74	0.49
DBH (mean diameter of studied trees)*	0.17	0.76	-0.03
Canopy cover*	-0.87	0.05	0.09

nated by acid- or by subneutral-barked trees. The large diameter of trees is also known to be an important factor to support high species richness of lichens and occurrence or abundance of specific lichen species (Lyons et al., 2000; Hedenås & Ericson, 2000; Gustafsson et al., 1992; Benson & Coxson, 2002). Difference of the oak-dominated stands from the stands dominated by other tree species is apparently related also to the properties of oak bark. Bark of oak trees has generally higher porosity and absorptive capacity than bark of other tree species (Rose, 1974).

In the composition of lichens in wooded meadows, similarly to high forests (Jüriado et al., 2003), we can detect the distinction of the stands between western and eastern part of Estonia. Several lichen species i.e. *Pertusaria coronata*, *P. hemisphaerica* and *P. pertusa* (Fig. 6), probably favoured by milder coastal climate (Tønsberg, 1992; Wirth, 1995), are more characteristic to the wooded meadows in the western part of Estonia, particularly western Island of Saaremaa, than to the wooded meadows in the eastern part of Estonia.

We can conclude that open wooded meadows are important habitats for epiphytic lichens and the composition of lichen species is influenced by similar factors as in high forests. Overgrowing of wooded meadows change the composition of lichen communities and decreases the species richness of lichens. Therefore, the structure of the remaining stands of wooded meadows should be maintained by hay mowing or cutting to conserve the peculiar biodiversity of semi-natural habitats.

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Appendix. List of the recorded lichenized, lichenicolous (#) and non-lichenized (+) fungi in wooded meadows of Estonia. Abbrev – abbreviations of species names used in Figs 4 and 6 (macrolichens are in bold). Freq – frequency classes in Estonia: rr – very rare, 1–2 localities; r – rare, 3–5 localities; st r – rather rare, 6–10 localities; st fq – rather frequent, 11–20 localities; fq – frequent, 21–50 localities; fqq – very frequent, 51 or more localities (Randlane & Saag 1999); rare frequency classes are in bold. Red-listed – Red-listed and protected lichen species in Estonia: NT – Near threatened, VU – Vulnerable; PC II, III – protection categories.

	Species	Abbrev	Freq	Red-listed
	Acrocordia cavata (Ach.) R. C. Harris		st fq	
	Acrocordia gemmata (Ach.) A. Massal.	Acr_gem	fq	
	Amandinea punctata (Hoffm.) Coppins & Scheid.	Ama_pun	fqq	
	Anaptychia ciliaris (L.) Körb.	**Ana_cil**	fqq	
	Arthonia didyma Körb.	Art_did	st fq	NT
	Arthonia leucopellaea (Ach.) Almq.		fqq	
	Arthonia mediella Nyl.	Art_med	st fq	
	Arthonia radiata (Pers.) Ach.	Art_rad	fq	
#	*Arthonia ruana* A. Massal.	Art_rua	fq	
	Arthonia spadicea Leight.	Art_spa	fq	
	Arthonia vinosa Leight.	Art_vin	st fq	
	Bacidia arceutina (Ach.) Arnold		fq	
	Bacidia fraxinea Lönnr.	Bac_fra	fqq	
	Bacidia rubella (Hoffm.) A. Massal.	Bac_rub	fq	
	Bacidia subincompta (Nyl.) Arnold		st fq	
	Bactrospora dryina (Ach.) A. Massal.		**r**	
	Biatora chrysantha (Zahlbr.) Printzen		**r**	
	Biatora efflorescens (Hedl.) Räsänen	Bia_eff	fq	
	Biatora globulosa (Flörke) Fr.	Bac_glo	st fq	
	Biatora helvola Körb.	Bia_hel	fq	
	Biatora ocelliformis (Nyl.) Arnold	Bia_oce	st fq	
	Biatoridium delitescens Arnold & Hafellner		**rr**	
	Bilimbia sabuletorum (Schreb.) Arnold		fq	
	Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw.		fqq	
	Buellia arnoldii Servít		**st r**	
	Buellia disciformis (Fr.) Mudd	Bue_dis	fqq	
	Buellia griseovirens (Turner & Borrer ex Sm.) Almb.	Bue_gri	fqq	
	Buellia schaereri De Not.		st fq	
	Calicium abietinum Pers.		fqq	
	Calicium adspersum Pers.		**st r**	
	Calicium glaucellum Ach.		fqq	
	Calicium pinastri Tibell		**r**	
	Calicium salicinum Pers.	Cal_sal	fq	
	Calicium viride Pers.	Cal_vir	fqq	
	Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr.		fqq	
	Caloplaca chrysophthalma Degel.		**st r**	
	Caloplaca flavorubescens (Huds.) J. R. Laundon	Cal_fla	fqq	
	Caloplaca lucifuga G. Thor		**r**	NT
	Candelaria concolor (Dicks.) Stein		**st r**	
	Candelariella xanthostigma (Ach.) Lettau	Can_xan	fq	
	Chaenotheca brachypoda (Ach.) Tibell		fq	
	Chaenotheca chlorella (Ach.) Müll. Arg.		fq	
	Chaenotheca chrysocephala (Turner ex Ach.) Th. Fr.	Cha_chr	fqq	
	Chaenotheca ferruginea (Turner & Borrer) Mig.	Cha_fer	fqq	
	Chaenotheca furfuracea (L.) Tibell		fqq	
	Chaenotheca phaeocephala (Turner) Th. Fr.		fq	
	Chaenotheca stemonea (Ach.) Müll. Arg.		fq	
	Chaenotheca trichialis (Ach.) Th. Fr.	Cha_tri	fqq	
+	*Chaenothecopsis pusiola* (Ach.) Vain.		st fq	
#	*Chaenothecopsis vainioana* (Nádv.) Tibell	Chp_vai	**st r**	
	Chrysotrix candelaris (L.) J. R. Laundon	Chr_can	fq	
	Cladonia cenotea (Ach.) Schaer.	**Cla_cen**	fqq	
	Cladonia coniocraea (Flörke) Spreng.	**Cla_con**	fqq	
	Cladonia digitata (L.) Hoffm.	**Cla_dig**	fqq	
	Cladonia fimbriata (L.) Fr.	**Cla_fim**	fqq	

	Cliostomum flavidulum Hafellner & Kalb		**rr**	
	Cliostomum griffithii (Sm.) Coppins	Cli_gri	st fq	
	Cyphelium inquinans (Sm.) Trevis.		st fq	NT, PC III
#	*Cyphelium sessile* (Pers.) Trevis.		**r**	
	Dimerella pineti (Ach.) Vězda	Dim_pin	fq	
	Evernia prunastri (L.) Ach.	**Eve_pru**	fqq	
	Fuscidea arboricola Coppins & Tønsberg	Fus_arb	st fq	
	Fuscidea praeruptorum (Du Rietz & H. Magn.) Wirth & Vězda		**r**	
	Fuscidea pusilla Tønsberg		**st r**	
	Graphis scripta (L.) Ach.	Gra_scr	fqq	
	Haematomma ochroleucum (Neck.) J. R. Laundon	Hae_och	st fq	
	Hypocenomyce scalaris (Ach.) M. Choisy	**Hyp_sca**	fqq	
	Hypogymnia physodes (L.) Nyl.	**Hyp_phy**	fqq	
	Hypogymnia tubulosa (Schaer.) Hav.	**Hyp_tub**	fqq	
	Imshaugia aleurites (Ach.) S. L. F. Meyer		fqq	
	Lecania cyrtella (Ach.) Th. Fr.		fq	
	Lecania naegelii (Hepp) Diederich & Van den Boom		fq	
	Lecanora allophana Nyl.	Lec_all	fqq	
	Lecanora argentata (Ach.) Malme	Lec_arg	fqq	
	Lecanora cadubriae (A. Massal.) Hedl.		**st r**	
	Lecanora carpinea (L.) Vain.	Lec_car	fqq	
	Lecanora chlarotera Nyl.	Lec_chl	fqq	
	Lecanora conizaeoides Nyl. ex Cromb.	Lec_con	st fq	
	Lecanora expallens Ach.	Lec_exp	fq	
	Lecanora hagenii (Ach.) Ach.		fqq	
	Lecanora norvegica Tønsberg		st fq	
	Lecanora pulicaris (Pers.) Ach.	Lec_pul	fqq	
	Lecanora rugosella Zahlbr.	Lec_rug	fqq	
	Lecanora saligna (Schrad.) Zahlbr.		fq	
	Lecanora sambuci (Pers.) Nyl.		st fq	
	Lecanora strobilina (Spreng.) Kieff.	Lec_str	st fq	
	Lecanora subintricata (Nyl.) Th. Fr.	Lec_sub	**st r**	
	Lecanora symmicta (Ach.) Ach.	Lec_sym	fqq	
	Lecanora thysanophora R.C. Harris		**r**	
	Lecanora varia (Hoffm.) Ach.	Lec_var	fqq	
	Lecidea nylanderi (Anzi) Th. Fr.	Lec_nyl	fqq	
	Lecidella elaeochroma (Ach.) M. Choisy	Lec_ela	fqq	
	Lecidella euphorea (Flörke) Hertel	Lec_eup	fqq	
	Lecidella flavosorediata (Vězda) Hertel & Leuckert	Lec_fla	**st r**	
	Lecidella subviridis Tønsberg	Leci_sub	**st r**	
	Lepraria eburnea J. R. Laundon	Lep_ebu	fq	
	Lepraria elobata Tønsberg	Lep_elo	st fq	
	Lepraria incana (L.) Ach.	Lep_inc	fqq	
	Lepraria jackii Tønsberg	Lep_jac	fq	
	Lepraria lobificans Nyl.	Lep_lob	fq	
	Lepraria vouauxii (Hue) R. C. Harris		**rr**	
	Leucocarpia dictyospora (Orange) R. Sant.		**rr**	
	Lobaria pulmonaria (L.) Hoffm.	**Lob_pul**	fqq	NT, PC III
	Megalaria grossa (Pers. ex Nyl.) Hafellner		st fq	NT, PC III
	Melanelia exasperatula (Nyl.) Essl.	**Mel_exl**	fqq	
	Melanelia fuliginosa (Fr. ex Duby) Essl.	**Mel_ful**	fqq	
	Melanelia olivacea (L.) Essl.		fqq	
	Melanelia subargentifera (Nyl.) Essl.	**Mel_sbg**	fq	
	Melanelia subaurifera (Nyl.) Essl.	**Mel_sbu**	fqq	
	Micarea melanobola (Nyl.) Coppins		**r**	
	Micarea prasina Fr.	Mic_pra	fqq	
	Mycoblastus fucatus (Stirt.) Zahlbr.		st fq	
+	*Mycomicrothelia confusa* D. Hawksw.		**st r**	
	Naetrocymbe punctiformis (Pers.) R. C. Harris		st fq	
	Nephroma parile (Ach.) Ach.		st fq	VU, PC III
	Ochrolechia androgyna (Hoffm.) Arnold	Och_and	fqq	
	Ochrolechia arborea (Kreyer) Almb.	Och_arb	st fq	
	Ochrolechia microstictoides Räsänen	Och_mic	fq	
	Ochrolechia szatalaënsis Verseghy		**st r**	
	Ochrolechia turneri (Sm.) Hasselrot		**r**	
	Opegrapha atra Pers.		st fq	NT

	Opegrapha rufescens Pers.	Ope_ruf	fq	
	Opegrapha varia Pers.	Ope_var	fq	
	Opegrapha vulgata Pers.	Ope_vul	st fq	
	Pachyphiale fagicola (Hepp) Zwackh.		**st r**	
	Parmelia saxatilis (L.) Ach.		fqq	
	Parmelia sulcata Taylor	**Par_sul**	fqq	
	Parmeliopsis ambigua (Wulfen) Nyl.	**Par_amb**	fqq	
	Peltigera membranacea (Ach.) Nyl.		st fq	
	Peltigera praetextata (Flörke ex Sommerf.) *Zopf*		fqq	
	Pertusaria albescens (Huds.) M. Choisy & Werner	Per_alb	fqq	
	Pertusaria amara (Ach.) Nyl.	Per_ama	fqq	
	Pertusaria coccodes (Ach.) Nyl.	Per_coc	fqq	
	Pertusaria coronata (Ach.) Th. Fr.	Per_cor	st fq	
	Pertusaria flavida (DC.) J. R. Laundon	Per_fla	**r**	
	Pertusaria hemisphaerica (Flörke) Erichsen	Per_hem	st fq	
	Perusaria leucostoma A. Massal.	Per_leu	st fq	
	Pertusaria pertusa (Weigel) Tuck.	Per_per	st fq	
	Phaeophyscia ciliata (Hoffm.) Moberg		fq	
	Phaeophyscia orbicularis (Neck.) Moberg	**Pha_orb**	fqq	
	Phlyctis agelaea (Ach.) Flot.	Phl_age	fq	
	Phlyctis argena (Spreng.) Flot.	Phl_arg	fqq	
	Physcia adscendens (Fr.) H. Olivier	**Phs_ads**	fqq	
	Physcia aipolia (Ehrh. ex Humb.) Fürnr.		fqq	
	Physcia dubia (Hoffm.) Lettau		fqq	
	Physcia stellaris (L.) Nyl.		fqq	
	Physcia tenella (Scop.) DC.	**Phs_ten**	fq	
	Physconia detersa (Nyl.) Poelt		st r	NT
	Physconia distorta (With.) J. R. Laundon	**Phy_dis**	fqq	
	Physconia enteroxantha (Nyl.) Poelt	**Phy_ent**	fqq	
	Physconia perisidiosa (Erichsen) Moberg	**Phy_per**	fq	
	Placynthiella icmalea (Ach.) Coppins & P. James	Pla_icm	fqq	
	Platismatia glauca (L.) W. L. Culb. & C. F. Culb.	**Pla_gla**	fqq	
	Pseudevernia furfuracea (L.) Zopf	**Pse_fur**	fqq	
	Pycnora sorophora (Vain.) Hafellner		fq	
	Pyrrhospora quernea (Dicks.) Körb.	Pyr_que	fq	
	Ramalina baltica Lettau		fq	
	Ramalina farinacea (L.) Ach.	**Ram_far**	fqq	
	Ramalina fastigiata (Pers.) Ach.	**Ram_fas**	fqq	
	Ramalina fraxinea (L.) Ach.	**Ram_fra**	fqq	
	Ramalina pollinaria (Westr.) Ach.		fqq	
	Rinodina efflorescens Malme		**st r**	
	Rinodina exigua Gray		fq	
	Ropalospora viridis (Tønsberg) Tønsberg	Rop_vir	st fq	
+	*Sarea difformis* (Fr.) Fr.		**r**	
	Sclerophora coniophaea (Norman) J. Mattsson & Middelb.		st fq	NT, PC II
	Sclerophora pallida (Pers.) Y. I. Yao & Spooner		fq	PC III
	Scoliciosporum chlorococcum (Stenh.) Vězda		fq	
	Strangospora moriformis (Ach.) Stein		**st r**	
	Strangospora pinicola (A. Massal.) Körb.		**r**	
	Tephromela atra (Huds.) Hafellner ex Kalb	Tep_atr	fqq	
	Tuckermannopsis chlorophylla (Willd.) Hale		fqq	
	Usnea hirta (L.) F. H . Wigg.		fqq	
#	*Vouauxiella lichenicola* (Linds.) Petr. & Syd.	Vou_lic	fq	
	Vulpicida pinastri (Scop.) J. -E. Mattsson & M. J. Lai	**Vul_pin**	fqq	
	Xanthoria candelaria (L.) Th. Fr.		fqq	
	Xanthoria fulva (Hoffm.) Poelt & Petutschnig		**st r**	
	Xanthoria parietina (L.) Th. Fr.	**Xan_par**	fqq	
	Xanthoria polycarpa (Hoffm.) Th. Fr. ex Rieber	**Xan_pol**	fqq	

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The distribution of epiphytic bryophyte and lichen species in relation to phorophyte characters in Latvian natural old-growth broad leaved forests

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Abstract: Epiphytic bryophyte and lichen species distribution was studied in representative natural old-growth broad leaved forests in Latvia. Overall 120 epiphytic bryophyte and lichen species were found in 13 forest stands. Seven Latvian red-listed bryophyte (*Antitrichia curtipendula, Lejeunea cavifolia, Metzgeria furcata, Neckera complanata, Neckera pennata, Dicranum viride, Jamesoniella autumnalis*) and four red-listed lichen species (*Lobaria pulmonaria, Opegrapha viridis, Pertusaria pertusa, Thelotrema lepadinum*) were recorded. The relationships of total epiphytic bryophyte and lichen species richness and red-listed epiphytic bryophyte and lichen species richness with substrate factors (phorophyte species, DBH (diameter at breast height), tree bark crevice depth and tree bark pH) were evaluated.

Kokkuvõte: Epifüütsete sambla- ja samblikuliikide leviku seos forofüüdi omadustega Läti vanades looduslikes laialehistes metsades

Epifüütsete sambla- ja samblikuliikide levikut uuriti tüüpilistes Läti vanades looduslikes laialehistes metsades. Kokku leiti kolmeteistkümnel uurimisalal 120 epifüütset sambla- ja samblikuliiki, nende seas seitse punase raamatu samblaliiki (*Antitrichia curtipendula, Lejeunea cavifolia, Metzgeria furcata, Neckera complanata, Neckera pennata, Dicranum viride, Jamesoniella autumnalis*) ja neli samblikuliiki (*Lobaria pulmonaria, Opegrapha viridis, Pertusaria pertusa, Thelotrema lepadinum*). Hinnati kogu sambla ja sambliku liigirikkuse ning punasesse raamatusse kuuluvate sammalde ja samblike liigirikkuste seoseid substraadi omadustega (forofüüdi liik, DBH (tüve diameeter rinna kõrgusel), korba lõhede sügavus ja korba pH).

INTRODUCTION

Broad leaved forests reached their maximum distribution area in Latvia in the Atlantic period, approximately 7400 years ago (Zunde, 1999). Latvia is located in the hemiboreal vegetation zone on an ecotone between the boreal and nemoral biomes, resulting in a mixture of coniferous and deciduous forests. The present forest cover is close to 55% (VMD, 2007) of Latvian territory and broad leaved forests cover 1 % of the total forest area (Priedītis, 1999). Due to agricultural intensification, the coverage of broad leaved forests has decreased in Latvia in the past (Dumpe, 1999). The loss and fragmentation of natural habitats, by agriculture, forestry and urbanization are the main causes decreasing biodiversity at local, regional and global scales (Hanski 2005). Due to fragmentation, broad leaved forests in Latvia are mostly restricted to river valleys, lake islands and slopes (Priedītis, 1999). A number of protected broad leaved forest habitats in the European Union are found in Latvia: Fennoscandian natural old broad leaved forests, Subatlantic oak-hornbeam forests of the Carpinion betuli, Tilio-Acerion forests of slopes, screes and ravines, riparian mixed forests of *Quercus robur*, *Ulmus glabra* and *Fraxinus excelsior* (Council Directive 92/43/EEK, 1992). In these nutrient-rich forests with an abundance of deciduous tree species and characteristic high transpiration rates, rich epiphytic bryophyte cover and lichen species diversity have been observed (Āboliņa, 1968; Priedītis, 2000; Bambe, Lārmanis, 2001; Ek et al., 2002; Anonymous 2003; Mežaka et al., 2008).

Studies on epiphytic bryophyte and lichen species are not complete in Latvia and are based mostly on species-focused taxonomic works (Āboliņa, 1968; Piterāns, 2001; Āboliņa. 2001; Bambe & Lārmanis, 2001; Bambe, 2002; Znotiņa, 2003). Epiphytic bryophytes in Latvia have been more studied in forests of slopes, screes and ravines (Mežaka & Znotiņa, 2006), but complete studies about epiphytic bryophyte and lichen ecology in other types of broad leaved forests are lacking.

Substrate has an important role in determining distribution of epiphytic species (Barkman, 1958; Āboliņa, 1968; Weibull, 2001;

Snäll et al., 2004; Mežaka & Znotiņa, 2006; Paltto et al., 2006; Marmor & Randlane, 2007). Earliest studies about Latvian bryophytes (Āboliņa, 1968) indicate particular tree species importance in bryophyte species distribution. Epiphytic bryophyte and lichen species composition varies depending on tree species and it is highly related with bark chemical and physical properties (Barkman, 1958). However, little is known about epiphytic bryophyte and lichen community composition on various broad leaved tree species in Latvia (Āboliņa, 1968).

Epiphytic bryophytes prefer trees with larger diameter at breast height (Ingerpuu & Vellak, 2007; Hazell et al., 1998). Bark crevice depth is a significant factor affecting epiphytic species distribution (Slack, 1976; Gustafsson & Eriksson, 1995; Snäll et al., 2004, creating various microhabitats for epiphytes on a small scale.

Tree bark pH is one of the most important factors affecting bryophyte (Weibull, 2001) and lichen species distribution (Barkman, 1958). In Latvia bryophyte species were classified into ecological groups based on substrate acidity since the beginning of the 20th century (Apinis & Diogucs, 1935; Apinis & Lācis, 1936). The relationship between lichen species richness and tree bark pH has not been studied in Latvia.

The aim of the present study is to provide information about the total and red-listed epiphytic bryophyte and lichen species richness in relation to main characteristics of the phorophyte in Latvian broad leaved forests.

MATERIALS AND METHODS

Study areas

Epiphytic bryophytes and lichens were studied in 13 old-growth broad leaved forest stands located in various parts of Latvia (Fig. 1). The mean annual precipitation in Latvia is 600 mm and the annual air temperature is 5.56 °C (Temņikova, 1975). The studied territories were selected based on the Woodland Key Habitat (WKH) inventory data (Ek et al., 2002; Anonymous, 2003).

All selected forest stands were located in old-growth forests, having trees with different diameter, dead wood in various decay stages and crown openings. The most common were Fennoscandian natural old broad leaved forests (Table 1).

Field work

The present study was conducted from summer 2006 to autumn 2007 in spring, summer and autumn seasons. Studied sample plot in forest stand was selected randomly in a representative place characterizing whole forest stand. One sample plot 20×20 m was established in each studied forest stand. Epiphytic bryophytes and lichens were studied on 30 tree stems with a minimal DBH (diameter at breast height) of 10 cm in each sample plot. In cases of insufficient number of trees, an adjacent sample plot (20×20 m) was made.

Epiphytic bryophyte and lichen presence and absence was recorded up to a 2 m height all around the tree in total of 390 trees. Unknown bryophyte and lichen specimens were collected for identification in the laboratory. Bryophyte species nomenclature follows Grolle & Long (2000); Smith (2004), Āboliņa (2001), and lichen species nomenclature after Piterāns (2001).

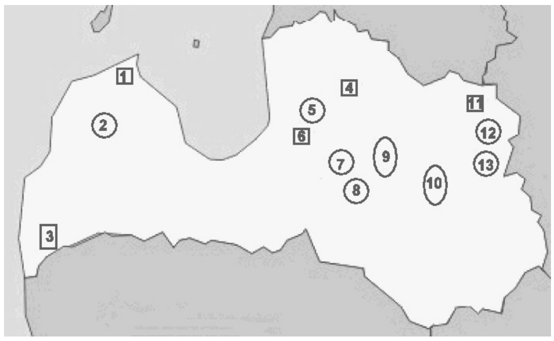

Fig. 1. Studied areas in Latvia. 1 – Zilie kalni in Slitere National Park, 2 – Moricsala Nature Reserve, 3 – Dunika Nature Reserve, 4 – Zilais kalns Nature Reserve, 5 – Lauri forest stand, 6 – Nurmiži Ravine Reserve in Gauja National Park, 7 – Laubere microreserve, 8 – Aizkraukles purvs un meži Nature Reserve, 9 – Vērenes gobu un vīksnu audze Nature Reserve, 10 – Pededzes lejtece Nature Reserve, 11 – Korneti-Peļļi Nature Reserve, 12 – Jaunanna Nature Reserve, 13 – Vjada Nature Reserve. Squares – Tilio-Acerion forests of slopes, screes and ravines, circles – Fennoscandian natural old broad leaved forests, rectangular – Subatlantic and medio-European oak-hornbeam forests of Carpinion betuli, ovals – Riparian mixed forests of *Quercus robur, Ulmus glabra, Fraxinus excelsior.*

Table 1. Studied forest characteristics. Mean DBH – mean tree diameter at breast height.

Study area	Mean DBH (m)	Studied tree species	Forest stand area (ha)
Aizkraukles purvs un meži Nature Reserve	0.28	*Betula pendula, Quercus robur, Tilia cordata, Ulmus glabra*	4.8
Dunika Nature Reserve	0.34	*Carpinus betulus*	1.8
Jaunanna Nature Reserve	0.36	*Betula pendula, Tilia cordata, Ulmus glabra*	1.8
Korneti-Peļļi Nature Reserve	0.37	*Acer platanoides, Quercus robur, Sorbus aucuparia, Tilia cordata*	3.4
Laubere microreserve	0.26	*Acer platanoides, Alnus incana, Fraxinus excelsior, Tilia cordata*	1.9
Lauri forest stand	0.33	*Acer platanoides, Alnus incana, Quercus robur, Tilia cordata, Sorbus aucuparia*	5.9
Moricsala Nature Reserve	0.39	*Acer platanoides, Quercus robur, Tilia cordata*	2.0
Nurmiži Ravine Reserve in Gauja National Park	0.27	*Acer platanoides, Fraxinus excelsior, Populus tremula, Ulmus glabra, Ulmus laevis*	5.9
Pededzes lejtece Nature Reserve	0.26	*Quercus robur, Ulmus glabra, Betula pendula, Alnus incana, Salix caprea, Alnus glutinosa, Fraxinus excelsior*	4.8
Vērenes gobu un vīksnu audze Nature Reserve	0.30	*Alnus incana, Sorbus aucuparia, Ulmus glabra, Ulmus laevis*	1.2
Vjada Nature Reserve	0.26	*Acer platanoides, Fraxinus excelsior, Tilia cordata, Ulmus glabra*	0.3
Zilais kalns Nature Reserve	0.35	*Populus tremula, Quercus robur, Tilia cordata*	7.3
Zilie kalni in Slitere National Park	0.39	*Acer platanoides, Fraxinus excelsior, Populus tremula, Ulmus glabra*	5.0

Tree diameter at breast height (m), bark pH, and bark crevice depth (mm) were measured. Samples for tree bark pH measurements were collected and bark crevice depth was measured at 1.20m height on north exposure on all studied trees, one measurement per tree.

pH measurements

In total 390 tree bark samples were measured for bark pH. Bryophyte and lichen remnants were removed from tree bark to avoid their influence on pH value. Tree bark samples were cut in small pieces (medium size 0.001 g). An amount of 0.5 g of bark pieces was shaken in 20 ml 1M KCl (pH 5.50) solution for one hour in 100 ml flasks and pH measured with a pHmeter (GPH 014, Greisinger Electronic).

Data analysis

Prior to data analysis, outliers (z-score value ≥ 3) for quantitative data were removed based on distribution of residuals. Univariate GLM (General linear model) was used to determine significant factors (*Acer platanoides, Alnus incana, Carpinus betulus, Fraxinus excelsior, Populus tremula, Quercus robur, Tilia cordata, Ulmus glabra, Ulmus laevis* as tree species, DBH, tree bark crevice depth and tree bark pH) affecting total epiphytic species richness, epiphytic bryophyte and lichen species richness, total red-listed epiphytic species richness, red-listed lichen species richness.

Multiple Comparisons after Post-Hoc Scheffe test were used for checking differences between epiphytic species richness and tree species. Spearman rank correlation was used for check of autocorrelations. Four tree species consisting less than 10 tree individuals (*Sorbus aucuparia, Betula pendula, Alnus glutinosa* and *Salix caprea*) were removed from this analysis. A total of 352 trees were included in data analysis by GLM and Multiple Comparisons after Post-Hoc Scheffe test. Data were analysed using SPSS for Windows, Release 15.0.0, SPSS Inc.

RESULTS

In total 120 epiphytic (63 bryophyte and 57 lichen) species were found on 390 trees from 13 species – *Carpinus betulus, Fraxinus excelsior, Acer platanoides, Ulmus glabra, Tilia cordata, Ulmus laevis, Sorbus aucuparia, Alnus incana, Populus tremula, Betula pendula, Quercus robur, Alnus glutinosa, Salix caprea* (Table 2). *Tilia cordata* was the most common tree species. The most common bryophyte species (>200 records on trees) were *Hypnum cupressiforme, Homalia trichomanoides*, *Radula complanata* and lichens were *Lepraria* spp. and *Phlyctis argena*. Seven red-listed Latvian bryophyte species (vulnerable species – *Antitrichia curtipendula, Lejeunea cavifolia, Metzgeria furcata, Neckera complanata, Neckera pennata,* rare species – *Dicranum viride, Jamesoniella autumnalis* (Āboliņa, 1994)) and four red-listed lichen species (vulnerable species – *Lobaria pulmonaria,* rare species – *Opegrapha viridis, Pertusaria pertusa, Thelotrema lepadinum,* (Piterāns & Vimba, 1996)) were found.

Some bryophyte and lichen species were found exclusively on one tree species. For example, *Antitrichia curtipendula* was found only on *Carpinus betulus*, and *Opegrapha viridis* on *Tilia cordata.* Several bryophyte species common on soil were also found on tree stems: *Climacium dendroides*, *Hylocomium splendens*, *Pleurozium schreberi*, *Rhodobryum roseum* and *Thuidium tamariscinum.*

The species richness of various epiphytic bryophyte and lichen species varied among tree species (Fig. 2a). The highest total epiphytic species (mean 11.7) and bryophyte species richness (mean 8.1) were found on *Populus tremula* and lichen species richness on *Sorbus aucuparia* (mean 6.2 species) and *Tilia cordata* (mean 4.5 species).

Significant differences were found in total species richness between *Acer platanoides* and *Populus tremula* and bryophyte species richness varied significantly between *Tilia cordata* and *Fraxinus excelsior* (Table 3).

Latvian red-listed species (mean 1.7) were more common on *Carpinus betulus* (Fig. 2b), as well as on *Fraxinus excelsior* and *Acer platanoides* compared with other tree species. Significant differencies were found in red-listed epiphytic bryophyte and lichen species richness between *Carpinus betulus, Fraxinus excelsior, Acer platanoides* and other tree species (Table 3). Red-listed lichen species were not found on *Sorbus aucuparia, Ulmus laevis, Betula pendula* and *Alnus incana.* Tree species was the most significant factor explaining various groups of epiphytic bryophyte and lichen species richness (Table 4). Red-listed bryophyte species richness was removed due to high autocorrelation (r=0.960) with total red-listed species richness after Spearman rank correlation.

Bark pH value varied among tree species (Fig. 3). The highest mean pH (6.13) was found for *Ulmus laevis* and the lowest (3.53) for *Betula pendula.*

DBH explained total and red-listed bryophyte and lichen species richness, but tree bark pH affected significantly only lichen species richness. Bark crevice depth did not explain epiphytic bryophyte or lichen species richness (Table 4).

DISCUSSION

In the present study *Hypnum cupressiforme*, an ubiquitous species, *Radula complanata* and *Homalia trichomanoides* were the most common bryophyte species. *Radula complanata* is one of the most frequent epiphytic bryophyte species in Central Sweden (Hazell et al., 1998). *Homalia trichomanoides* was the most common indicator species in the WKH inventory data in Latvia (Anonymous, 2003), *Lepraria* spp, and *Phlyctis argena* were the most common lichens in the present study, as described previously (Piterāns, 2001). The most common red-listed bryophyte species in Latvia were *Metzgeria furcata* and *Neckera pennata* as also found in the WKH inventory (Anonymous, 2003), but *Lejeunea cavifolia* and *Neckera complanata* common in the WKH inventory, were not frequent in the present study. The WKH inventory was conducted in various forest types in Latvia, but the present study was focused on old – growth broad leaved forests exclusively. *Thelotrema lepadinum*, one of the rarest species in the present study, was common in the WKH inventory. On the other hand *Pertusaria pertusa*, the most common red-listed lichen species in the present study, was one of the rarest lichen species observed in the WKH inventory (Anonymous, 2003). Probably there is a need to update the information on species in the Latvian bryophyte and lichen red-lists based on data in the present study and in the WKH inventory. The most recent data on red-

Table 2. Epiphytic bryophyte and epiphytic lichen species occurrence. Number of tree stems for species is given in brackets. [v] – vulnerable and [r] – rare red-listed species in Latvia.

Epiphyte species	Tree species													
Bryophytes	*Carpinus betulus* (30)	*Fraxinus excelsior* (45)	*Acer platanoides* (38)	*Ulmus glabra* (51)	*Tilia cordata* (118)	*Ulmus laevis* (16)	*Sorbus aucuparia* (5)	*Alnus incana* (12)	*Populus tremula* (14)	*Betula pendula* (8)	*Quercus robur* (47)	*Alnus glutinosa* (5)	*Salix caprea* (1)	Total
Amblystegium serpens	1	13	15	30	28	16	2	3	7	-	11	1	-	127
Amblystegium subtile	-	1	1	1	1	-	-	-	-	-	-	-	-	4
Amblystegium varium	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Anomodon attenuatus	-	6	-	4	2	2	-	1	1	-	2	5	1	24
Anomodon longifolius	-	4	10	4	1	5	-	-	7	-	-	-	-	31
Anomodon viticulosus	-	2	1	3	13	-	-	-	-	-	2	-	-	21
Antitrichia curtipendula[v]	4	-	-	-	-	-	-	-	-	-	-	-	-	4
Blepharostoma trichophyllum	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Brachythecium glareosum	-	-	1	-	-	1	-	-	-	-	-	-	-	2
Brachythecium oedipopodium	3	-	-	3	6	-	-	-	-	-	3	2	-	17
Brachythecium populeum	-	8	2	4	8	-	-	-	-	-	2	-	-	24
Brachythecium rutabulum	2	17	16	17	28	-	-	3	6	-	16	3	1	109
Brachythecium salebrosum	-	1	2	2	3	-	-	-	-	1	3	-	-	12
Brachythecium velutinum	-	-	1	-	1	-	-	-	-	-	-	-	-	2
Campylium chrysophyllum	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Cirriphyllum piliferum	-	2	1	2	1	1	-	1	1	-	1	-	-	10
Climacium dendroides	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Dicranum montanum	2	-	1	3	47	-	-	2	-	7	26	5	-	93
Dicranum scoparium	1	-	-	-	10	-	-	1	-	2	3	-	-	17
Dicranum viride[r]	-	4	-	1	7	-	-	-	-	-	3	-	1	16
Eurhynchium angustirete	1	4	5	10	20	1	-	1	1	1	3	-	-	47
Eurhynchium hians	-	4	-	9	3	7	-	1	9	-	2	1	-	36
Eurhynchium pulchellum	-	-	-	1	-	2	-	-	-	-	-	-	-	3
Eurhynhium striatum	7	8	5	1	9	2	-	4	1	-	-	-	-	37
Fissidens adianthoides	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Fissidens bryoides	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Frullania dilatata	15	20	4	5	7	1	1	-	4	-	-	-	1	58
Homalia trichomanoides	11	41	31	43	50	7	1	7	12	2	18	5	1	229
Homalothecium sericeum	10	2	8	4	7	1	-	-	-	-	-	-	-	32
Hylocomium splendens	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Hypnum cupressiforme	28	26	12	24	93	5	3	9	14	8	42	2	1	267
Isothecium alopecuroides	20	9	7	5	8	-	-	-	1	-	3	-	-	53
Jamesoniella autumnalis[r]	-	-	-	-	2	-	-	-	-	1	-	-	-	3
Jungermannia leiantha	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Lejeunea cavifolia[v]	-	4	1	4	1	1	-	-	1	-	-	-	-	12
Leucodon sciuroides	5	21	16	21	13	15	-	1	3	-	6	-	-	101
Lophocolea heterophylla	-	-	1	-	3	-	-	1	1	1	1	-	-	8
Metzgeria furcata[v]	17	19	13	16	39	2	1	4	1	1	2	-	-	115
Mnium hornum	-	-	-	-	7	-	-	-	1	-	7	-	-	15
Mnium stellare	-	-	1	1	2	-	-	-	-	1	-	-	-	5

Table 2 (continued)

Epiphyte species	Tree species													
Bryophytes	*Carpinus betulus* (30)	*Fraxinus excelsior* (45)	*Acer platanoides* (38)	*Ulmus glabra* (51)	*Tilia cordata* (118)	*Ulmus laevis* (16)	*Sorbus aucuparia* (5)	*Alnus incana* (12)	*Populus tremula* (14)	*Betula pendula* (8)	*Quercus robur* (47)	*Alnus glutinosa* (5)	*Salix caprea* (1)	Total
Neckera complanata"	14	10	11	3	1	-	1	-	1	-	-	-	-	41
Neckera pennata"	1	11	15	23	11	6	1	-	-	-	3	-	-	71
Orthotrichum affine	4	2	2	5	2	3	2	2	1	-	2	-	-	25
Plagiochila asplenioides	2	2	3	4	4	-	-	2	1	-	-	-	-	18
Plagiochila porelloides	1	-	1	-	5	-	-	-	-	-	-	-	-	7
Plagiomnium affine	-	4	4	5	10	-	-	2	-	1	1	-	-	27
Plagiomnium cuspidatum	-	3	2	2	7	-	-	-	-	1	2	-	-	17
Plagiomnium undulatum	-	1	-	3	5	1	-	-	-	-	-	-	-	10
Plagiothecium cavifolium	-	1	-	1	1	-	-	-	-	-	2	-	-	5
Plagiothecium laetum	1	3	-	-	8	-	-	2	-	1	6	-	-	21
Plagiothecium latebricola	-	-	-	-	2	-	-	-	-	-	1	-	-	3
Platygyrium repens	4	14	2	10	36	-	2	4	5	1	19	4	1	102
Pleurozium schreberi	-	-	-	-	2	-	-	-	-	-	-	-	-	2
Pseudoleskeella nervosa	-	4	6	8	32	3	3	3	2	-	24	-	1	86
Ptilidium pulcherrimum	-	-	-	-	3	-	-	-	-	2	-	-	-	5
Pylaisia polyantha	4	16	2	17	10	6	2	1	9	1	8	-	-	76
Radula complanata	21	33	25	44	59	16	4	8	13	1	16	5	1	246
Rhytidiadelphus triquetrus	-	1	1	-	8	-	-	-	-	-	1	-	-	11
Rhodobryum roseum	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Sanionia uncinata	-	2	2	5	10	1	-	-	5	-	2	1	-	28
Thuidium delicatulum	-	5	1	2	5	-	-	-	2	-	2	-	-	17
Thuidium tamariscinum	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Ulota crispa	7	6	3	5	13	2	1	3	4	-	3	-	-	47
Lichens														
Acrocordia gemmata	-	6	3	5	2	5	-	-	13	-	8	1	-	43
Arthonia byssacea	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Arthonia radiata	-	10	2	4	-	-	1	1	3	-	1	1	1	24
Arthonia vinosa	-	-	3	1	3	-	-	-	-	-	-	-	-	7
Arthothelium ruanum	1	-	-	-	-	-	1	-	-	-	3	-	-	5
Bacidia friesiana	-	-	1	-	1	-	-	-	-	-	-	-	-	2
Bacidia rubella	-	2	-	7	-	3	-	-	3	2	1	-	-	18
Buellia griseovirens	-	4	-	3	1	-	-	3	-	1	-	-	1	13
Calicium abietinum	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Chaenotheca brunneola	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Chaenotheca ferruginea	-	1	1	-	-	-	-	-	-	-	3	1	-	6
Chrysotrix candelaris	-	1	-	-	3	-	-	-	-	-	-	-	-	4
Cladonia coniocraea	-	2	1	3	43	-	-	1	1	7	16	2	-	76
Dimerella lutea	-	-	2	-	1	-	-	-	-	1	-	-	-	4
Evernia prunastri	-	-	1	-	2	3	1	-	-	-	-	-	-	7
Graphis scripta	7	13	12	21	65	2	5	11	-	1	6	4	1	148
Gyalecta truncigena	-	-	-	-	-	1	-	-	-	-	-	-	-	1

Table 2 (continued)

Epiphyte species	Tree species													
Bryophytes	*Carpinus betulus* (30)	*Fraxinus excelsior* (45)	*Acer platanoides* (38)	*Ulmus glabra* (51)	*Tilia cordata* (118)	*Ulmus laevis* (16)	*Sorbus aucuparia* (5)	*Alnus incana* (12)	*Populus tremula* (14)	*Betula pendula* (8)	*Quercus robur* (47)	*Alnus glutinosa* (5)	*Salix caprea* (1)	Total
Hypocenomyce scalaris	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Hypogymnia physodes	-	-	1	-	54	-	1	2	-	6	11	-	-	75
Lecanactis abietina	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Lecanora allophana	1	-	1	-	-	-	-	-	-	-	1	-	-	3
Lecanora argentea	-	-	1	-	6	-	-	-	-	-	-	-	-	7
Lecanora carpinea	-	1	-	2	5	1	-	-	1	-	1	-	-	11
Lecanora glabrata	23	-	-	-	-	-	-	-	-	-	-	-	-	23
Lecanora rugosella	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Lecanora subrugosa	-	5	4	2	4	-	1	-	-	-	1	-	-	17
Lecidella elaeochroma	1	9	4	3	4	1	2	3	2	-	2	-	-	31
Lecidella euphorea	-	7	-	6	6	5	1	-	-	-	-	1	1	27
Lepraria spp.	30	30	33	34	87	5	4	5	10	6	45	4	-	293
Lobaria pulmonaria[v]	-	1	1	1	3	-	-	-	1	-	1	-	-	8
Melanelia exasperata	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Melanelia glabratula	-	6	5	8	43	2	2	7	-	-	3	1	-	77
Melanelia olivacea	-	1	-	1	3	2	1	1	-	-	-	-	-	9
Ochrolechia androgyna	-	-	-	-	-	-	-	-	-	-	2	-	-	2
Opegrapha rufescens	5	5	7	4	6	6	-	-	1	-	3	-	-	37
Opegrapha varia var. varia	-	2	6	2	6	2	-	-	-	-	8	-	-	26
Opegrapha viridis[r]	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Opegrapha vulgata	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Parmelia saxatilis	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Parmelia sulcata	-	3	4	2	23	3	2	2	-	-	2	-	-	41
Peltigera praetextata	-	5	2	-	5	-	-	-	-	-	5	-	-	17
Pertusaria albescens	-	-	-	1	-	1	2	-	-	-	-	-	-	4
Pertusaria amara	-	5	5	6	62	-	2	2	1	1	18	-	-	102
Pertusaria leioplaca	-	-	1	2	3	-	-	-	-	-	-	-	-	6
Pertusaria multipuncta	3	-	-	-	-	-	-	-	-	-	-	-	-	3
Pertusaria pertusa[r]	16	1	1	1	2	-	-	-	-	-	1	-	-	22
Phlyctis agelaea	-	2	-	-	1	1	-	-	-	-	-	-	-	4
Phlyctis argena	10	29	19	45	82	12	5	11	14	1	29	1	1	259
Physcia dubia	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Porina aenea	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Pyrenula laevigata	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Pyrenula nitida	4	-	-	1	-	-	-	-	-	-	-	-	-	5
Pyrenula nitidella	5	-	-	-	-	-	-	-	-	-	-	-	-	5
Ramalina farinacea	-	-	1	2	10	-	1	2	-	-	6	-	-	22
Sclerophora nivea	-	-	-	1	-	1	-	-	-	-	-	-	-	2
Thelotrema lepadinum[r]	-	-	1	1	2	-	-	-	-	-	-	-	-	4
Vulpicida pinastri	-	-	-	-	1	-	-	-	-	-	-	-	-	1

Table 3. Post-Hoc Multiple Comparisons after Scheffe between tree species and epiphytic bryophyte and lichen species richness. Ac – *Acer platanoides*, Ai – *Alnus incana*, C – *Carpinus betulus*, F – *Fraxinus excelsior*, P – *Populus tremula*, Q – *Quercus robur*, T – *Tilia cordata*, U – *Ulmus glabra*, Ul – *Ulmus laevis*, To – total bryophyte and lichen species richness, B – bryophyte species richness, L – lichen species richness, ToR– total red-listed bryophyte and lichen species richness, LR – red-listed lichen species richness, (noted if significant ($p<0.05$) difference between tree species was found), - – no significant difference ($p>0.05$).

	Ac	Ai	C	F	T	U
Ai	-	-	LR	-	-	-
C	LR	ToR	-	-	-	-
F	-	-	LR	-	B, L	-
P	To	-	ToR, LR	-	-	-
Q	ToR	-	ToR, LR	ToR	-	ToR
T	ToR	-	ToR, LR	ToR	-	-
U	-	-	LR	-	L	-
Ul	-	-	ToR, LR	-	-	-

listed bryophyte species was published in 1994 (Āboliņa, 1994), and red-listed lichen species in 1996 (Piterāns & Vimba, 1996).

Tree species was one of the most important factors explaining epiphytic species distribution. The highest number of epiphytic bryophyte and lichen species were found on *Populus tremula*, as found in several other studies from Nordic countries (Hazell et al., 1998; Snäll et al., 2004; Hedenås & Ericson, 2003). Epiphytic lichen species richness was highest on *Sorbus aucuparia*, but replication for this tree was low (6 trees) in our study. However, this agrees with studies of Pykälä et al. (2005) in Finland and Barkman (1958) in Central Europe. Jüriado et al. (2003) in Estonian natural forests observed the highest lichen species richness on *Populus tremula* and the lowest on *Sorbus aucuparia*. However, in that study boreo-nemoral forests and coniferous forests were considered together, where *Populus tremula* was more distributed among tree species.

Tree bark pH is known to be associated with epiphytic cryptogam species richness (Weibull, 2001; van Herk, 2001; Mežaka & Znotiņa, 2006; Löbel et al., 2006). Lichen species richness was lower on trees with higher bark pH, but epiphytic species richness in other epiphytic species groups were not explained significantly by bark pH in our study. Bark pH of *Populus tremula* (Gustafsson & Eriksson, 1995), *Tilia cordata* (Marmor & Randlane, 2007) and other broad leaved tree species (Loppi & Frati, 2004) were not found to be associated with epiphytic species richness. Thus the differences in cryptogamic species distribution associated with species richness might be due to some differences among tree species other than tree bark pH. Clearly also differences in the host of tree species sampled and the range of pH obtained will affect results obtained.

Relatively high lichen species richness was found on *Tilia cordata* (mean 4.65 species). *Tilia cordata* bark pH (mean 4.38) was lower compared with other studied tree species and a relatively low pH was associated with higher lichen species richness. Probably, *Tilia cordata* bark pH is too low for high bryophyte or red-listed species richness. Specific bark physical properties of *Tilia cordata* might ensure the lichen species diversity on this tree species.

Red-listed species were more common on *Carpinus betulus*. In literature *Carpinus betulus* is not described as having high epiphytic species diversity (Szövényi et al., 2004). *Antitrichia*

Table 4. Epiphytic bryophyte and lichen species depend on studied variables. Univariate GLM. - – non significant factor ($p<0.05$), Crev – bark crevice depth, DBH – tree diameter at breast height, pH – tree bark pH, epiphytic species group abbreviations as in Table 3.

Tests of Between-Subjects effects										
Variables	F					p				
	To	B	L	ToR	LR	To	B	L	ToR	LR
Crev	-	-	-	-	-	-	-	-	-	-
DBH	6.628	14.96	-	5.747	-	0.01	0.0001		0.017	-
pH	-	-	16.902	-	-	-	-	0.0001	-	-
Tree species	-	2.654	-	10.656	10.497	-	0.008	-	0.0001	0.0001

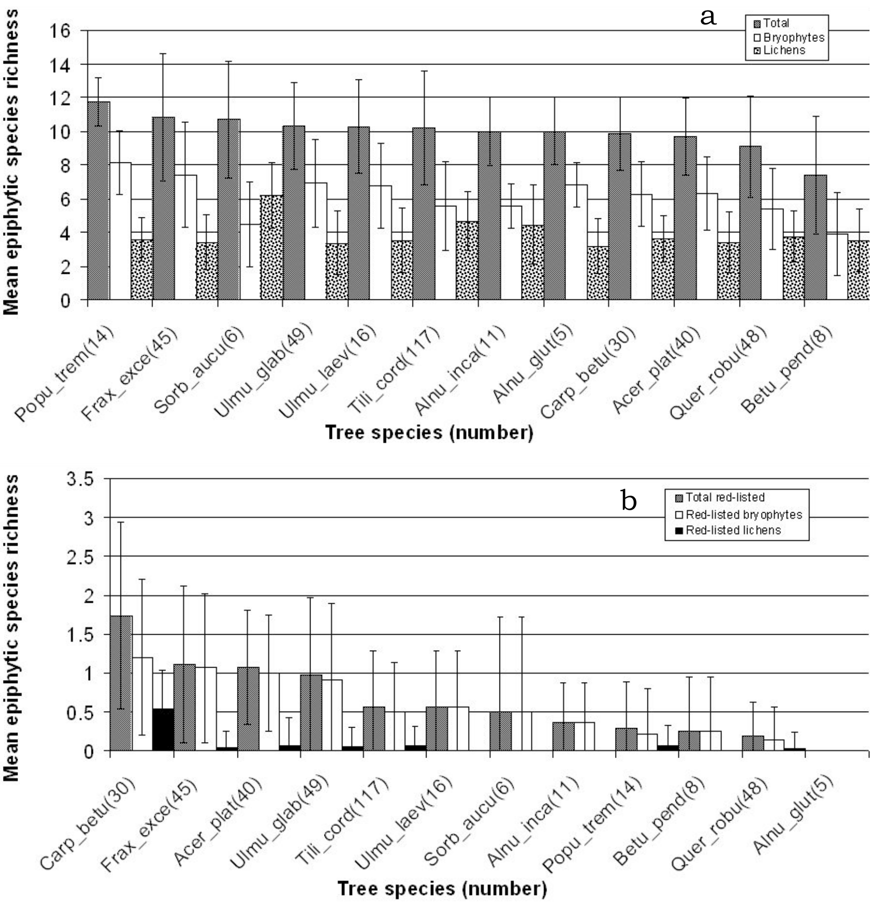

Fig. 2. Epiphytic bryophyte and lichen species richness within groups. Tree species arranged based on total epiphytic species richness (bryophytes and lichens) (a) and total red-listed epiphytic species (bryophytes and lichens) (b) among various tree species. *Salix caprea* was removed from analysis due to only one occurrence for this species. Abbreviations: Acer_plat – *Acer platanoides*, Alnu_glut – *Alnus glutinosa* Alnu_inca – *Alnus incana*, Betu_pend – *Betula pendula*, Carp_betu – *Carpinus betulus*, Frax_exce – *Fraxinus excelsior*, Popu_trem – *Populus tremula*, Ulmu_glab – *Ulmus glabra*, Ulmu_laev – *Ulmus laevis*, Quer_robu – *Quercus robur,* Sorb_aucu – *Sorbus aucuparia.* Number of tree individuals in brackets.

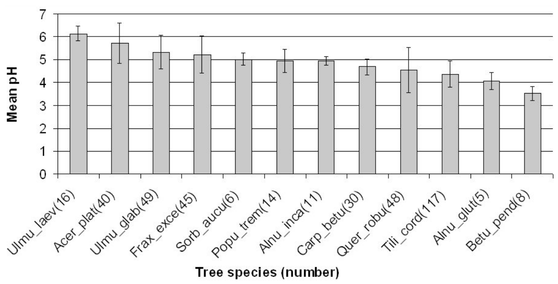

Fig. 3. Tree bark mean pH among tree species. Tree species abbreviations after Fig. 2.

curtipendula, which is red-listed in Latvia, was recorded only on *Carpinus betulus*, which is distributed only in the south-west part of Latvia (Mauriņš & Zvirgzds, 2006), where probably specific suitable conditions for *Carpinus betulus* consequently also exist for *Antitrichia curtipendula*. Probably climatic factors are the most important as *Antitrichia curtipendula* is distributed in western part of Latvia (Āboliņa, 1968). *Fraxinus excelsior*, *Acer platanoides* and *Ulmus glabra* were also rich in red-listed epiphytic bryophyte and lichen species, probably since broad leaved trees have relatively higher bark pH compared with other deciduous tree species (Barkman, 1958; Löbel et al., 2006; Mežaka & Znotiņa, 2006). *Acer platanoides* and *Fraxinus excelsior* bark is also porous with crevices, maintaining humidity (Barkman, 1958) for a longer time period, which can be an advantage for epiphytic bryophyte establishment.

DBH affected significantly positively the total epiphytic bryophyte and lichen, bryophyte and red listed species richness, but no significant relation was found between DBH and lichen species richness. Bark crevice depth was not associated significantly with any epiphytic cryptogam group species richness. This is in contrast to other studies, where these factors have been observed to be related to the lichen distribution (Stringer & Stringer, 1974; Riiali et al., 2001; Friedel et al., 2006). However, Löbel et al. (2006) concluded, that tree diameter was not significant factor in lichen species richness. Small diameter trees sometimes have deep bark crevices, for example *Ulmus glabra* (personal observations), which could create suitable conditions for epiphytic cryptogam species establishment.

Epiphytic bryophytes and lichens are important organism groups in the evaluation of forest continuity and connectivity (Ek et al., 2002). Lot of red-listed species have limited dispersal abilities and it could be the cause of using them as indicators of forest stand quality. There is still uncomplete information about cryptogam species distributions in boreal and temperate landscapes (Gustafsson et al., 2004) in Europe.

This is the first study on epiphytic bryophyte and lichen distribution in old-growth broad leaved forests in Latvia. Further studies are needed on landscape scale. In addition, experimental and survey studies investigating interactions between bryophytes and lichens need further research effort.

Conclusions

The results of the present study point to the need to update the bryophyte and lichen red-lists in Latvia, since numerous new localities for several of them were discovered.

Tree species and DBH were the most significant factors explaining most of epiphytic species groups, while tree bark pH affected significantly only lichen species richness.

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Selection of Important Bryophyte Areas in Hungary

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Abstract: Until now 99 sites could be selected as important bryophyte areas on the basis of 125 populations of 26 European red-listed species and an additional three species protected by law in Hungary. Most of the species with confirmed recent occurrences have few existing populations. The most important habitats from the point of view of the conservation of European red-listed bryophytes are places with shaded rocks or rocks in streams in forest-covered mountainous areas, which maintain 30% of the existing Hungarian populations of European red-listed species. Saline-alkali and dry rocky grasslands and loess cliffs are also very important habitats in the preservation of submediterranean, continental, and subcontinental elements. Wet grasslands nowadays are of minor importance in the preservation of rarities as they are in very bad conditions mainly due to dry climatic periods of the last decades. Similarly, the number of populations of species living on decaying wood and tree bark is not high either.

Kokkuvõte: Tähtsate Samblaalade valik Ungaris.

Praeguseks on välja valitud 99 tähtsat samblaala toetudes 26 Euroopa Punasesse Raamatusese kuuluva ning lisaks 3 Ungaris seadusega kaitstava liigi, kokku 125 populatsiooni, andmetele. Enamikul kaasaegseid kindlaid leiukohti omavatel liikidel Ungaris on väikesed populatsioonid. Euroopa Punasesse Raamatusse kuuluvate liikide kaitse seisukohast kõige tähtsamateks kasvukohtadeks on varjuliste paikade kaljud ning ojades asuvad kivid metsaga kaetud mägipiirkondades. Nimetatud kasvukohtades esineb kolmandik (30%) Euroopa Punase raamatu liikide Ungari populatsioonidest. Submediterraansetesse ja subkontinentaalsetesse elementidesse kuuluvate liikide kaitse seisukohalt on tähtsad ka sooldunud aluselised ning kuivad kivised rohumaad ja lössikaljud. Märjad rohumaad omavad tänapäeval haruldaste liikide kasvukohana vähemat tähtsust, kuna nad on viimaste aastakümnete kuivaperioodide tõttu väga halvas seisukorras. Ka kõdupuidul ning puutüvedel kasvavate liikide populatsioonide arv ei ole suur.

INTRODUCTION

The Important Bryophyte Area project can be connected with the Important Plant Area (IPA) project. In 2002, the Conference of the Parties to the Convention of Biological Diversity adopted the Global Strategy for Plant Conservation including several global targets for 2010. The targets are concentrated under 5 main groups: Understanding and Documenting Plant Diversity; Conserving Plant Diversity; Using Plant Diversity Sustainably; Promoting Education and Awareness about Plant Diversity; Building Capacity for the Conservation of Plant Diversity. Target 5 has set as an aim to protect 50% of the important areas for plant diversity by 2010. Identification of Important Plant Areas (IPAs) meets with this target. This project is lead by the Plantlife International and IUCN with other partners like Planta Europa. An IPA exhibits exceptional botanical richness and /or supports an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanical value. The IPA program considers the lowers plants and fungi as well. These plants are underrepresented in existing European conservation legislation. The IPA network is one possibility to protect and properly manage those sites, which are identified as important for the preservation of lower plants. Bryophytes were taken into consideration in the selection of IPAs in the Czech Republic, Estonia, Poland, Romania, Slovakia and Slovenia (Anderson, 2002). The Important Bryophyte Area (IBrA) project aims at identifying areas, which are important from a bryological point of view. An IBrA holds existing, viable populations of bryophyte species included in either World Red List, European Red List, or supports endemics/near endemics. The site may also represent an exceptionally rich bryophyte flora in relation to its biogeographic zone and habitat types. The IBrA project can be regarded as a part of the IPA program, but it can also be treated as separate project especially in our case, because Hungary has not participated in the IPA program.

Hungary has initiated a Natura 2000 project instead of the IPA program. In the selection of

Natura 2000 sites only the data of 5 bryophytes included in the Bern Convention and EU Habitats Directive (*Buxbaumia viridis, Dicranum viride, Hamatocaulis vernicosus, Mannia triandra, Orthotrichum rogeri*) and all *Sphagnum* species (listed in Annex V.) occuring in Hungary were taken into consideration (Demeter, 2000). According to our recent knowledge *Hamatocaulis vernicosus* has disappeared from the earlier known localities and *Orthotrichum rogeri* has not been refound within the last 50 years in Hungary.

Hungary is situated in the Carpathian basin and the whole territory of the country belongs to the Pannonian biogeographic region, which is one of the biodiversity hotspots in Europe. Several areas in the Carpathian basin have served as refugia during the last glacial periods. The mountains around the basin act as barriers but could also play a role as a mediator. The transitional character of the climate in the basin made it possible that this region became the contact zone of flora and fauna elements of different origin: boreal-montane from the Carpathians and Alps, submediterranean from the Balkans and continental from the eastern steppes. The coexistence of different elements is also supported by the highly mosaic natural landscape structure (Forró, 2007).

The aim of this paper is to present the preliminary results of IBrA project, which is not financed officially. The results derived from earlier projects for database establishment and a recently ongoing project of National Biodiversity monitoring System supported by the Environmental Ministry and several national parks of Hungary.

MATERIAL AND METHODS

The IPA site selection is based on three criteria. A.) sites of significant populations of one or more species that are of global or European conservation concern. B.) sites with an exceptionally rich flora in a European context in relation to its biogeographic range. C.) sites, which are outstanding examples of a habitat type of global or European plant conservation and botanical importance.

For the selection of IBrAs the first criterion can be applied easily. The species list of the Red Data Book of European Bryophytes (ECCB, 1995) can be used according to the suggestions of the IPA project (Anderson, 2002). The selection in Hungary has been started with the recently known Hungarian localities of the European red-listed species. The work is based on the locality database of rare bryophytes of the Hungarian Natural History Museum. This database includes the earlier and presently known localities of European and national rarities. The Hungarian bryophyte flora is well explored due to the outstanding activity of earlier bryologists, Ádám Boros and László Vajda, but their data are now 50–60 years old. After their period there was a gap in bryological activity in Hungary. Our work began 10 years ago with the search for rarities in the earlier known localities and in potential new sites. This is an ongoing task and the list of the IBrAs can be extended year by year according to newly found localities of existing populations of European rarities.

Although the number of sites selected is a national decision there is a recommendation of the IPA project. For the highly threatened species with fewer than 10 sites within the country all sites with viable population can be selected. For species with up to 20 sites the largest (5% or more of the national population) can be selected. Nomenclature of the species follows Grolle and Long (2000) and Hill et al. (2006). European distribution of the species is given according to Düll (1983, 1984, 1985).

For the selection of sites presented in this paper only the first criterion ("A") was used and the data obtained last 10 years were taken into consideration, as the IPA project requires recent knowledge about the populations.

RESULTS

According to the Red Data Book of European Bryophytes 47 European red-listed species have been reported from Hungary (ECCB, 1995 – p. 177). *Hamatocaulis vernicosus* was erroneously lacking from this list. Later on two species (*Aloina bifrons, Grimmia sessitana*) were excluded from our bryophyte flora (Erzberger & Papp, 2004), but three red-listed species (*Ephemerum sessile, Orthotrichum sprucei, Tortula brevissima*) were discovered in Hungary (Erzberger, 1998, Erzberger & Papp, 2000, 2004, Papp et al., 2000). According to the European checklist of Hill et al. (2006) *Fissidens exiguus* can be also excluded, because European specimens identified as *Fissidens exiguus* are poorly limbate forms of either

F. pusillus or F. viridulus. Hence the number of European red-listed species occuring in Hungary in the present or past is 48.

Until now 99 sites could be selected on the base of 125 populations of 26 European red-listed species and an additional three species protected by law in Hungary (Papp et al., 2002) and included in the regionally threatened (RT) category in the Red Data Book of European Bryophytes (ECCB, 1995). The other 22 European red-listed species occurring in Hungary have been not refound within the last 10 years. Most of the species with confirmed recent occurrences have very few existing populations. Only three species have more than 10 known localities. Hence all the known localities could be selected as IBrA. The number of existing populations can be seen in Table 1.

Forest-covered mountainous areas

The region richest in European red-listed species is the Bükk Mts. In this mountain area 12 localities could be selected on the base of 16 populations of 9 European red-listed species (Table 2, 3, 5). The Bükk Mts are one of the foothills of the Carpathian mountain range and part of the North Hungarian mountain range. On the plateaus and northern slopes and gorges the flora has Carpathian (montane-alpine) features,

Table 1. The number of existing populations of European red-listed species in Hungary

species of Bern Convention, EU Habitats Directive & Red Data Book of European Bryophytes	category in RDB	number of populations
Buxbaumia viridis (Moug. ex Lam. & DC.) Brid. ex Moug. & Nestl.	V	1
Dicranum viride (Sull. & Lesq.) Lindb.	V	7
Mannia triandra (Scop.) Grolle	R	1
Pyramidula tetragona (Brid.) Brid.	V	4
species of Red Data Book of European Bryophytes		
Amblystegium radicale (P.Beauv.) Schimp.	R	1
Anacamptodon splachnoides (Froel. ex Brid.) Brid.	E	1
Anomodon rostratus (Hedw.) Schimp.	R	12
Asterella saccata (Wahlenb.) A.Evans	V	11
Brachydontium trichodes (F.Weber) Milde	R	1
Campyliadelphus elodes (Lindb.) Kanda	RT	1
Campylostelium saxicola (F.Weber & D.Mohr) Bruch & Schimp.	R	1
Didymodon glaucus Ryan	V	1
Drepanocladus sendtneri (Schimp. ex H.Müll.) Warnst.	RT	2
Entosthodon hungaricus (Boros) Loeske	R	11
Fissidens arnoldii R.Ruthe	R	5
Frullania inflata Gottsche	V	3
Grimmia plagiopodia Hedw.	R	3
Hilpertia velenovskyi (Schiffn.) R.H.Zander	R	16
Lophozia ascendens (Warnst.) R.M. Schust.	R	2
Microbryum floerkeanum (F.Weber & D.Mohr) Schimp.	K	13
Neckera pennata Hedw.	V	2
Orthotrichum sprucei Mont.	R	1
Pseudocalliergon lycopodioides (Brid.) Hedenäs	RT	2
Pterygoneurum lamellatum (Lindb.) Jur.	V	5
Rhychostegium rotundifolium (Scop. ex Brid.) Schimp.	R	7
Rhynchostegiella teneriffae (Mont.) Dirkse & Bouman	R	3
Taxiphyllum densifolium (Lindb. ex Broth.) Reimers	R	4
Tortula brevissima Schiffn.	R	3
Tortula cernua (Huebener) Lindb.	R	1

Table 2. IBrAs sites characterized by shaded limestone rock habitats and occurrence of European red-listed species. A – *Anomodon rostratus,* D – *Didymodon glaucus,* M – *Mannia triandra,* R – *Rhynchostegium rotundifolium,* T – *Taxiphyllum densifolium*

locality	A	D	M	R	T
Aggteleki karst, Lófej-valley					+
Aggteleki karst, Ménes-valley	+				
Bakony Mts, Ördög-valley at Gézaháza	+				
Bükk Mts, Ablakoskő-valley	+			+	
Bükk Mts, Háromkút-valley	+				
Bükk Mts, Hór valley	+				
Bükk Mts, Kerek hill at Lillafüred			+		
Bükk Mts, Leány-valley				+	
Bükk Mts, Szalajka-valley				+	
Bükk Mts, Szeleta cave		+			
Bükk Mts, Vöröskő hill at Ómassa	+				
Pilis Mts, Fekete-hill at Pilisszentkereszt	+				
Pilis Mts, Kétbükkfa-nyereg	+				
Pilis Mts, Vaskapu	+			+	
Vértes Mts, Meszes valley at Vérteskozma	+				
Vértes Mts, Vár-valley at Csókakő	+				
Vértes Mts, Ugró-valley at Csákberény	+				

while the lower regions and southern slopes are covered by thermophilous vegetation. The most important vegetation types are the closed oak and at higher elevation the beech forests. The bedrock of this mountain area is mainly limestone, but some volcanic outcrops can also be found. The elevation ranges up to 900–950 m a.s.l. The annual rainfall is 700–800 mm and the average temperatures ranging from -3 to -4 °C in January and 19–20 °C in July. This mountain area is one of the coldest regions in Hungary. Almost all area of the mountain is protected belonging to the Bükk National Park. This mountain is one of the biodiversity hotspots of Hungary according to the distribution map of Annex I habitats and Annex II species of Habitats Directive (Horváth et al., 2003).

Most of the populations of red-listed bryophyte species found in this mountain area live

Table 3. IBrAs sites characterized by shaded volcanic rock habitats and occurrence of European red-listed species. B – *Brachydontium trichodes,* C – *Campylostelium saxicola,* F – *Frullania inflata,* R – *Rhynchostegium rotundifolium,* T – *Taxiphyllum densifolium*

locality	B	C	F	R	T
Balaton Upland, Szent György hill				+	
Börzsöny Mts, Kopolya-kövek rocks	+	+			
Bükk Mts, Szarvaskő hill			+		
Keszthelyi Mts, Tátika hill			+		
Mátra Mts, Saskő rocks					+
Mátra Mts, Sombokor rocks					+
Visegrádi Mts, Apátkúti-valley				+	
Visegrád Mts, Szerkövek rocks				+	+
Zemplén Mts, Kis-szikla rocks at Késked			+		

Table 4. IBrAs sites characterized by shaded rocky habitats in streams of limestone and volcanic bedrock and occurrence of European red-listed species. Fisarn – *Fissidens arnoldii,* Rhyten – *Rhynchostegiella teneriffae*

locality	Fisarn limestone	Rhyten volcanic
Bakony Mts, Ördög-valley at Gézaháza	+	
Balaton Upland, Szakadék valley at Pécsely	+	
Cserhát Mts, Cserkúti-stream	+	
Visegrádi Mts, Apátkúti-valley		+
Visegrádi Mts, Nyír-valley at Pilismarót		+
Visegrádi Mts, Rám-szakadék gorge, Lukács-árok valley		+

on shaded limestone rocks in humid gorges e. g. *Anomodon rostratus* and *Rhynchostegium rotundifolium* (Papp et al., 2000; Papp & Erzberger, 2003). *Didymodon glaucus* has a population in a cave entrance, which is the only locality of the species in Hungary, while the only existing population of *Mannia triandra* in the country can be found at the base of a large limestone rock wall. There are also decaying wood inhabiting bryophytes as *Buxbaumia viridis* and *Lophozia ascendens* (Papp et al., 2000). These species can be found in the same valley in Bükk Mts, in Leány-valley. This locality is supporting the

Table 5. IBrAs sites of forest habitats and occurrence of European red-listed species inhabiting decaying wood or bark of trees. B – *Buxbaumia viridis,* L – *Lophozia ascendens,* A – *Anacamptodon splachnoides,* D – *Dicranum viride,* N – *Neckera pennata*

locality	B	L	A	D	N
	decaying wood		bark of tree		
Bátorliget swamp forest				+	
Bereg region, Téb-forest at Tarpa					+
Budai Mts, Páty			+		
Bükk Mts, Hór-valley				+	
Bükk Mts, Leány-valley	+	+			
Bükk Mts, Old Forest				+	
Bükk Mts, Vár hill at Felsőtárkány				+	
Mátra Mts, Kékes forest reserve		+			
Vend region, Lujza hill at Felsőszölnök					+
Zala region, Vétyem				+	
Zemplén Mts, Piszkés-tető at Hollóháza				+	
Zemplén Mts, Vadász-tető, Vajda-valley				+	

only known population of *Buxbaumia viridis* in Hungary (Papp et al., 2002). Three larger populations of *Dicranum viride* can be found in the Bükk Mts; one in a beech forest called Old Forest, while two in oak forests (Papp et al., 2000; 2002; Papp & Erzberger, 2003). *Frullania inflata* has a small population on a volcanic outcrop at the southern part of the mountain range (Papp & Erzberger, 2003), while *Tortula brevissima* was discovered some years ago on a rhyolite tuff outcrop at the southern border of the mountains (Erzberger, 1998; Papp et al., 2000). Some parts of the mountains provide suitable conditions for more than one European red-listed species e. g. Leány-valley, Hór-valley, Ablakoskő-valley. The sizes of the selected sites are small (1–10 km^2) and they are scattered all over the mountains. The population sizes are also usually small, but most of them are stable.

Several other IBrAs can be selected in the forest belt of mountainous areas of Hungary in the North Hungarian (Aggteleki karst, Börzsöny Mts, Cserhát Mts, Mátra Mts, Zemplén Mts) and Transdanubian mountain ranges (Bakony Mts, Balaton Upland, Gerecse Mts, Keszthelyi Mts, Pilis-Visegrádi Mts, Vértes Mts). In these mountainous regions species with different habitat requirements (shaded rock walls; rocks in streams; tree barks; decaying wood in humid forests) occur. Out of the sites of Bükk Mts 8 shaded limestone rocky places can be designated to the populations of *Anomodon rostratus* (Papp et al., 2000, Papp & Erzberger, 2003). At two sites *Rhynchostegium rotundifolium* can also be found (Papp & Erzberger, 2003) (Table 2). Several sites with volcanic rocks can be selected on the basis of the populations of *Frullania inflata*, *Rhynchostegium rotundifolium*, *Taxiphyllum densifolium* and one site with the small populations of *Campylostelium saxicola* and *Brachydontium trichodes* (Papp et al., 2000; 2002; Papp & Erzberger, 2003) (Table 3). Streams with limestone rocks can be selected to protect *Fissidens arnoldii* and streams with volcanic rocks for the preservation of *Rhynchostegiella teneriffae* (Erzberger, 2002; Papp et al., 2000; Papp & Erzberger, 2003) (Table 4.). Very few sites can be selected, which maintain rarities living on decaying wood or tree barks in humid forests. Apart from the Leány-valley in Bükk Mts, there is only one more site with *Lophozia ascendens*, a liverwort inhabiting decaying wood (Papp et al., 2000, 2002). Apart from the 3 sites of *Dicranum viride* in the Bükk Mts, 4 more sites can be selected for the protection of this species (Papp et al., 2002; Papp & Erzberger, 2003). On the basis of the populations of other species living on tree barks only 3 sites can be selected; *Neckera pennata* and *Anacamptodon splachnoides* (Papp et al., 2000; Papp & Erzberger, 2003) (Table 5). These latter species in 1950–60 had several localities in Hungary (20–25 sites). The drastic reduction of the distribution of these species reflects the effects of intensive forestry activity in our country. Almost no intact forest exists nowadays in Hungary. The shaded rocky habitats are also threatened by forestry, since cutting of the overshadowing forest around the rock walls creates drier and more exposed environmental conditions. Fortunately most of the rocky places are situated in quite steep slopes which make forestry activities difficult.

Dry rocky grasslands

Dry rocky grasslands are important habitat types from a conservation point of view at a European level and are listed on Annex I of the EU Habitats Directive (Horváth et al., 2003).

11 limestone grassland sites can be selected on the base of the existing populations of *Asterella saccata*. These are situated mainly in the Transdanubian mountain range in Vértes, Gerecse, Budai and Pilis Mts (Papp & Erzberger, 2003). On the site of the Remete-hill in Budai Mts *Pyramidula tetragona* can also be found (Papp & Erzberger, 2003). One isolated, but quite large population of *A. saccata* can be found in the southern part of Hungary on Szársomlyó-hill in the Villányi Mts (Papp et al., 2000; Papp & Erzberger, 2000). In another site in the Villányi Mts, a small population of *Microbryum floerkeanum* was discovered (Papp & Erzberger, 2000). 3 basaltic grasslands were selected in the Balaton Upland region as the other localities of *Pyramidula tetragona* (Papp et al., 2000, 2002), and another basaltic grassland area in Visegrádi Mts as the locality of *Grimmia plagiopodia.* Altogether 16 grasslands were selected (Fig. 1). Dry rocky grasslands can be found in mosaics in thermophilous oak forests mostly on the southern slopes of mountains. Most of the limestone grasslands are situated in the Transdanubian mountain range. Grasslands formed on volcanic bedrock can be found mainly in the Northern Hungarian mountain range. On the basis of the occurrence of European red-listed species from the latter region IBrA sites can not be selected and in the Transdanubian range there are also more valuable sites from bryological point of view, hence in the case of dry rocky grasslands further selection on the basis of indicator species is very important.

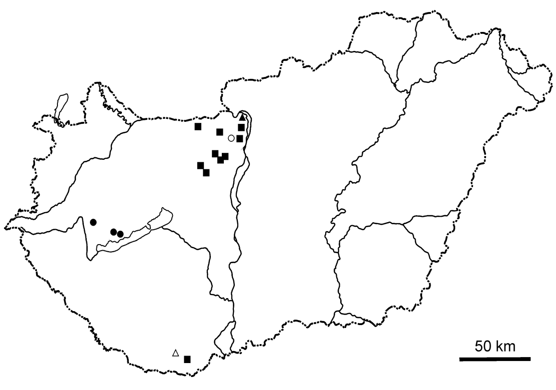

Fig. 1. IBrA sites of dry grassland habitat type.
■ – locality of *Asterella saccata* (Budai Mts: Kecske hill; Gerecse Mts: Kecske-kő at Gyermely; Lóingató hill at Óbarok; Nagy-Teke at Süttő; Turul at Tatabánya, Zuppa at Szár, Pilis Mts: Csúcs hill at Csobánka, Vértes Mts: Szólókő at Csákvár; Tábor hill at Vérteskozma, Villányi Mts: Szársomlyó), ● – loc. of *Pyramidula tetragona* (Balaton Upland: Gulács hill; Szent György hill, Keszthelyi Mts: Tátika hill); ○ – loc. of *Asterella saccata* and *Pyramidula tetragona* (Budai Mts: Remete hill); △ – loc. of *Microbryum floerkeanum* (Villányi Mts: Kövesmáj at Máriagyüd); ▲ – loc. of *Grimmia plagiopodia* (Visegrádi Mts: Kő-hegy hill at Pomáz).

Most of the dry grasslands are parts of the mountain ranges, which belong to national parks or nature protection areas. Many of them are threatened by grazing and mechanical disturbance of wild animals. Large population of deer, wild pig, moufflon are maintained, fed by hunting societies as hunting is a rewarding business in our country. Due to the thin, not stable soil layer trampling, grubbing cause great damage in rocky grasslands.

Saline-alkali grasslands

Continental salt meadows and steppes are rare habitat types and are listed on Annex I of the EU Habitats Directive (Horváth et al., 2003). A characteristic species of the Hungarian saline-alkali areas is *Enthosthodon hungaricus* (Boros, 1924; 1943; 1945), which is also red-listed in Europe. 11 sites could be selected as the known localities of this species. It is frequently accompanied by *Microbryum floerkeanum.* There are 8 saline-alkali sites, where they occur together (Papp & Rajczy, 1999). The latter species can be found in 2 other saline-alkali areas, but it has other localities, as well, where its habitats are roadsides or arable fields (Balaton Upland: Koloska-valley at Balatonfüred; Dunakeszi) and a limestone grassland mentioned before (Papp & Erzberger, 2003). At one site of *Enthosthodon hungaricus* another European red-listed species, *Tortula cernua* was found, too (Papp et al., 2000). This is the only recently existing population of this species in Hungary. In the preservation of these species Hungary has a great responsibility, as the main habitats of these species are the saline-alkaline areas, which are rare in Europe, but can be found in large extension in our country. Altogether 13 sites could be selected (Fig. 2). Most of the sites are situated on the Danube-Tisza Interfluve region, where the elevation ranges between 90–120 m a.s.l. This region has a moderately continental climate with characteristically a high number of sunny hours, high daily and yearly temperature fluctuations as well as relatively low air humidity. The mean yearly sum of the sunny hours is ca. 2000–2100. The mean yearly temperature 10–11 °C. The coldest month is January (-1.5 to -2 °C), the warmest month is July (21–22 °C). The mean yearly temperature fluctuation is considerable, 23–24 °C. The Danube-Tisza Interfluve is one of the driest areas in Hungary (500–600 mm/year). Drought is frequent in summer (Tóth, 1979). Due to the insufficient water regime and high salt-content, alkali areas are covered mainly by halo- and xerophilous vegetation (Tölgyesi, 1979). Plant communities are arranged characteristically in levels in close relation with micro relief, water regime and soil properties. Arable fields and anthropogenic grasslands occupy the highest, sandy or loess areas. At lower elevations wormwood-dominated alkali grasslands (*Artemisio-Festucetum*) appear. The deepest places are covered by the association most heavily affected by salt, *Lepidio-Camphorosmetum annuae* or *Camphorosmetum annuae*. At the littoral zone of alkali lakes the less heavily salt-affected *Lepidio-Puccinellietum limosae* association is found. The above mentioned three European red-listed species appear mainly on bare soil in the transitional zone of *Artemisio-Festucetum* and *Lepidio-Puccinellietum* communities in spring. Grazing plays an important role to preserve the composition and structure of the grasslands, but both overgrazing and lack of management cause considerable changes in the vegetation, which might affect the appearance of bryophytes. Agricultural activity is also a threat in the saline-alkali areas. The cultivated fields are often situated very close to the saline lakes or salt meadows altering the structure of the soil (causing changes in the aeration and water regime), which has drastic effects on the natural habitats (Papp & Rajczy, 2000). In the last years, the agricultural activity and animal keeping has decreased in Hungary. The first could favourable affect the distribution and population size of the red-listed species, but the lack of grazing could cause the reduction of suitable habitats. Although almost all saline-alkali areas are protected and belong to national parks in Hungary, more attention should be paid to adequate treatment for the protection of the unique bryophyte assemblages living here.

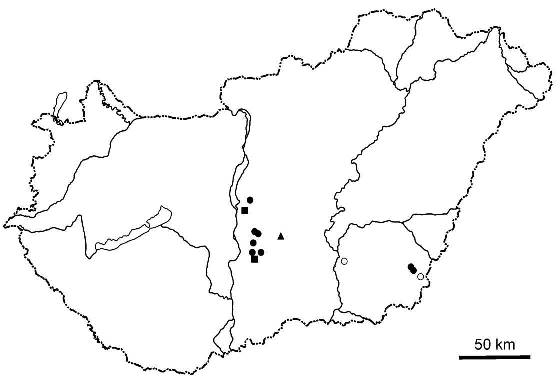

Fig. 2. IBrA sites of saline-alkali grassland habitat type.
○ – locality of *Entosthodon hungaricus* (Békés county: Szikmező at Elek; Csongrád county: Lápis lake at Szentes), ■ – loc. of *Microbryum floerkeanum* (Duna-Tisza Interfluve: Bak-ér at Dömsöd; Miklapuszta), ● – loc. of *Entosthodon hungaricus* and *Microbryum floerkeanum* (Békés county: Peres and Törökhalom at Kétegyháza; Duna-Tisza Interfluve: Apajpuszta; Böddi-szék at Dunatetétlen; Kelemen-szék and Zabszék at Fülöpszállás; Büdös-szék and Kis-rét at Szabadszállás); ▲ – loc. of *Entosthodon hungaricus* and *Tortula cernua* (Duna-Tisza Interfluve: Szappanszék at Fülöpháza).

Loess habitats

Loess habitats are also listed on Annex I of the EU Habitats Directive (Horváth et al., 2003). A characteristic European red-listed moss species of loess cliffs in Hungary is *Hilpertia velenovskyi.* 16 loess cliffs could be designated for the existing populations of this species (Pócs, 1999 and T. Pócs pers. com.). *Pterygoneurum lamellatum* can be found on 5 sites (T. Pócs pers. com.). At one site they live together. On 2 sites of *Hilpertia velenovskyi Tortula brevissima* also occurs (Kürschner & Pócs, 2002). Altogether 20 sites can be selected (Table 6).

In the Pannonian basin loess cliffs are situated mainly along rivers (e.g. Danube, Tisza, Zagyva, Hernád, Bodrog). Due to the erosion of the loess deposits steep vertical cliffs are formed. Additionally huge gorges and cliffs can develop due to secondary erosion at roads, highways, vineyard terraces, vine cellars. The establishment of cryptogamic vegetation on cliffs is highly dependent on the structure and chemical composition of the loess. Aeolian, pale yellow loess deposited during the glacial periods and preserved among semiarid conditions are the best for the formation of well-developed cryptogam assemblages. The near vertical cliffs show desertic character, because of the orography, edaphic and microclimatic conditions. It means at least 7 dry months per year, high insolation and a total rainfall that is less than 150 mm per year (Pócs, 1999; Kürschner & Pócs, 2002).

Naturally, from time to time parts of the vertical loess walls can fall down. This is a natural disturbance and cryptogam communities are adapted to it, they can establish their assemblages again very quickly on the new surfaces. But several walls are situated near houses, cellars, where the anthropogenic influence is high. Pollution, construction with concrete to prevent the walls from collapsing can destroy the suitable habitats for the rare bryophytes.

Wetlands

Wetlands are very threatened habitats in Hungary and they are listed on Annex I of the EU Habitats Directive (Horváth et al., 2003). The extension of these habitat types has been reduced last decades and their water supply has changed unfavourable mainly due to the drier climate of last years. Eutrophication is also a threat factor for these habitats in our country. The European red-listed species have disappeared from our wetlands. For example *Hamatocaulis vernicosus,* a species listed in the Bern Convention and EU Habitats Directive, had 10 large populations in Hungary around 1950–1960, but nowadays not any existing population can be found (Papp et al., 2002). On the basis of the recent populations of European red-listed species only one site could be selected; *Amblystegium radicale* occurs in small quantity in Szőce meadow in the western part of Hungary (Papp & Erzberger, 2003). Hence in the selection of wetland IBrA sites three species protected by law in Hungary and included in the regionally threatened (RT) category of the Red Data Book of European Bryophytes were taken into consideration. *Campyliadelphus elodes* has a small population in the Danube-Tisza Interfluve, while *Pseudocalliergon lycopodioides* and *Drepanocladus sendtneri* live together in two wet meadows in the western part of Hungary (Papp & Erzberger, 2003). Altogether 4 wetland sites could be selected (Fig. 3). The population sizes are very small; it is very doubtful that these species can survive under the recent environmental conditions for a long time in these localities.

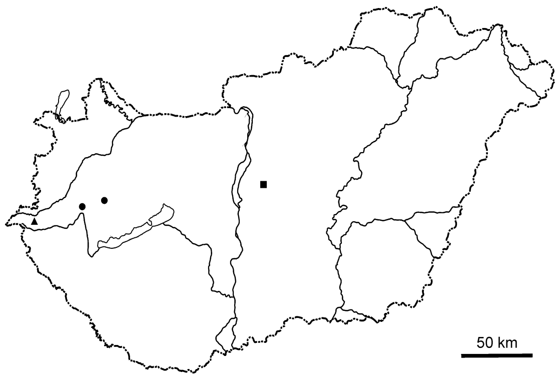

Fig. 3. IBrA sites of wet grassland habitat type.
▲ – locality of *Amblystegium radicale* (Szőce); ● – loc. of *Pseudocalliergon lycopodioides* and *Drepanocladus sendtneri* (Türje, Gyepükaján); ■ – loc. of *Campyliadelphus elodes* (Dabas).

Special habitats

Most of the above mentioned IBrA sites are situated in protected areas, belonging to national parks or nature reserves, but there are some special, not protected habitats, which are also important from a bryological point of view. For example, the recently discovered, only population of *Orthotrichum sprucei* was found on wood attached to the concrete of the inside wall of a sluice chamber along a channel in the Danube-Tisza Interfluve (Erzberger & Papp, 2000). Two populations of *Grimmia plagiopodia* occur on andesite rocks of castle hills. The exposed walls of the Visegrád castle at the Danube river maintain quite a large population (more than 1000 patches, which are ca. 1 cm^2 dense turf of shoots probably growing from the same prothallium) of the species. Two small populations of *Fissidens arnoldii* can be found in millraces of watermills along a stream of the Transdanubian mountain range (Papp et al., 2000). In these cases it is very important to draw attention to the bryophyte rarities living in such special habitats and reconcile the interests of the protection of monuments, historical buildings and the nature conservation to preserve these species. The sites can be seen on Fig. 4.

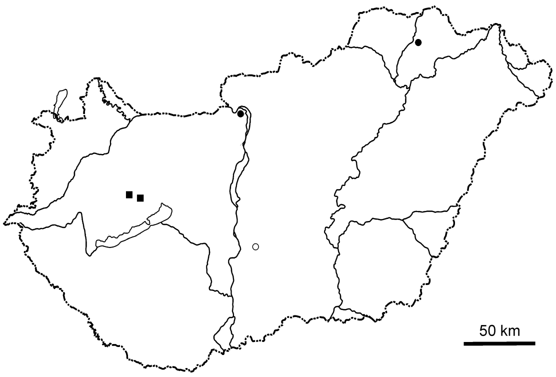

Fig. 4. IBrA sites of special habitats.
■ – watermill with *Fissidens arnoldii* (Bakony Mts: Bánd, Kislőd); ● – castle hill with *Grimmia plagiopodia* (Visegrádi Mts: Visegrád; Zemplén Mts: Boldogkőváralja); ○ – loc. of *Orthotrichum sprucei* (Danube-Tisza Interfluve: Kelemen-szék at Fülöpszállás).

Table 6. IBrAs sites of loess habitats and occurrence of European red-listed species. H – *Hilpertia velenovskyi,* P – *Pterygoneurum lamellatum,* T – *Tortula brevissima.*

	H	P	T
Alsónána, cellars		+	
Bajót	+		
Basaharc	+		
Báta, Csóka-hill	+		
Bölcske		+	
Dunaföldvár, Alsó Öreg-hill	+		
Dunaföldvár, Kálvária-hill	+		
Dunakömlőd, Sánc-hill	+	+	
Kecel, Császártöltés		+	
Kisapostag-Dunaújváros	+		+
Mórágy		+	
Nagyszékely, cellars	+		
Neszmély, Vár hill	+		
Pécel, Vár-hill	+		
Ravazd, Likas Horog	+		
Süttő, Diós-árok gorge	+		
Szekszárd, Szarvas Szurdik gorge	+		
Tokaj, N edge of the town	+		
Tokaj, Nagykopasz hill	+		+
Vértesacsa and Váli gorge	+		

CONCLUSIONS

In Hungary the most important habitats from the point of view of the conservation of European red-listed bryophytes are places with shaded rocks or rocks in streams on forest-covered mountainous areas, which support almost 30% of the existing populations (Table 7). A submediterranean element, *Anomodon rostratus* has the highest number of populations in these habitats. Other species with submediterranean character have also several populations e. g. *Rhynchostegium rotundifolium, Rhynchostegiella teneriffae, Frullania inflata.* A pontic (Caucasian) element, *Taxiphyllum densifolium* can also be found at 4 sites (Table 1). Saline-alkali and dry rocky grasslands and loess cliffs are also very important habitats in the preservation of the European red-listed submediterranean (e .g. *Microbryum floerkeanum, Pyramidula tetragona*) and continental, subcontinental elements (e .g. *Asterella saccata, Entosthodon hungaricus, Hilpertia velenovskyi*). These habitats provide suitable conditions for half of the existing populations of the European red-listed species (Table 7). Wet grasslands are of minor importance nowadays in the preservation of rarities as they are in very bad conditions mainly due to dry climatic periods of last decades. The number of populations of species living on decaying wood and tree barks is also not high. Most of our forests are managed, forestry is a high pressure in these habitats.

Table 7. Quantity of Hungarian populations of European red-listed species in different habitat types.

habitats	number of populations	% of populations
Forest (species on shaded rocks or in streams)	36	29
Saline-alkali grasslands	22	18
loess cliffs	23	18
dry rocky grasslands	17	14
Forest (species on decaying wood or bark of trees)	13	10
wet grasslands	6	5

Hungary has a high responsibility in the preservation of the European red-listed submediterranean and continental, subcontinental elements. These species still can be found in several localities in our country; 80% of the existing populations belong to these groups (Table 8). In the protection of boreal and subboreal elements, on the other hand, Hungary cannot play an important part. Probably due to change of climate, these species have disappeared except some small, isolated populations, which have very doubtful survival chances. However, the existing populations are very valuable, because these species live here at the border of their distributional range.

Table 8. Quantity of Hungarian populations of the different European red-listed flora elements.

European distribution	number of populations	% of populations
submediterranean and/or subatlantic and/or atlantic	51	41
continental, subcontinental, pontic	49	39
temperate zones of Europe	14	11
boreal, subboreal, subarctic-subalpine	11	9

The selection of IBrAs on the basis of the existing localities of European red-listed species is going on. Visiting the earlier known localities and searching for populations of rarities is continuing. For further selection it is inevitable to obtain up-to-date knowledge on the old sites, since the earlier data are usually 50–60 years old. The search for European red listed species in potentially suitable habitats may also increase the number of IBrAs.

The other part of the proposed areas using criterion B would be the localities with high number of indicator species. The identification of indicator species for each habitat type is also an ongoing task. Especially for dry grasslands and wetlands, where the areas selected on the basis of criterion A are not sufficient and do not represent the richness and variety of these habitats in our country, selection according to criterion B is very important. In some habitats the European red-listed species can be regarded as indicators, too (e. g. *Entosthodon hungaricus, Mniobryum floerkeanum* in saline-alkali areas; *Hilpertia velenovskyi* in loess cliffs).

From nature conservation point of view it can be mentioned that most of the recently presented, selected sites are situated in protected areas (national parks, nature reserves), but there are few localities, which are not protected. We would like to draw the attention of nature conservation to these sites, but we also would like to express our opinion that even in protected areas it is necessary to pay more attention to the requirements of bryophyte conservation.

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Lichens in the new Red List of Estonia

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Abstract: The compilation of the current Red List of Estonia took place during 2006–2008; the IUCN system of categories and criteria (vers. 6.1), which is accepted worldwide, was applied. Out of the 1019 lichenized, lichenicolous and closely allied fungal species recorded in Estonia in 2006, 464 species (45.5%) were evaluated while 555 species remained not estimated – in the category Not Evaluated (NE). Of the evaluated species, 213 were assigned to the so-called red-listed categories: Regionally Extinct (RE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) and Data Deficient (DD). 113 of them were classified as threatened (belonging to the categories CR, EN, VU). 251 species were assigned to the category Least Concerned (LC). The full enumeration of the red-listed lichens of Estonia with appropriate category and criteria is presented.

Kokkuvõte: Samblikud Eesti uues punases raamatus

Eesti uue punase raamatu koostamine kestis 2006–2008; kasutati IUCN'i kategooriate ja kriteeriumite laialdaselt tunnustatud süsteemi (versioon 6.1). 1019 samblikuliigist (Eesti 2006. a nimekirja järgi) hinnati 464 liigi (45,5%) ohustatuse seisundit ning 555 liiki jäid hindamata; samblikena on sealjuures tinglikult käsitletud lihheniseerunud ja lihhenikoolseid seeni ning neile süstemaatiliselt lähedasi liike. Hinnatud samblikest 213 liiki kuuluvad nn punastesse kategooriatesse (Regionaalselt hävinud, Äärmiselt ohustatud, Ohustatud, Ohualtid, Ohulähedased ja Puuduliku andmestikuga), neist 113 liiki on ohustatud (kuuluvad kategooriatesse Äärmiselt ohustatud, Ohustatud ja Ohualtid). 251 liigi seisund hinnati väljaspool ohtu olevaks (kategooria Soodsas seisundis). Esitatakse nn punastesse kategooriatesse kuuluvate samblikuliikide täielik loetelu koos rakendatud kriteeriumitega.

INTRODUCTION

The previous Red List of Estonia was compiled ten years ago (Lilleleht, 1998). In this book conventional system of threat categories (Extinct or probably extinct, Endangered, Vulnerable, Rare, Care demanding, Indeterminate) was applied while criteria for defining these categories were fairly vague. Altogether 1318 species or infraspecific taxa were included.

At that time understanding of the composition of the Estonian lichen biota was rather limited, the second checklist of lichenized, lichenicolous and allied fungi of Estonia (Randlane & Saag, 1999) was still under preparation and only the revision of Estonian macrolichens (Trass & Randlane, 1994) had been published. Considering this state of knowledge, only macrolichens were included in the previous Red List of Estonia, altogether 110 species out of the 337 macrolichen taxa known at that time (Randlane, 1998).

The compilation of the current Red List of Estonia took place during 2006–2008. As the knowledge of the composition and distribution of Estonian lichen biota has significantly improved during the last ten years (e.g. Randlane & Saag, 2004; Lõhmus, 2005; Suija, 2005; Jüriado, 2007; Tõrra & Randlane, 2007; Saag, 2008), it appeared reasonable to apply for the first time in Estonia the IUCN system of categories and criteria, which is accepted worldwide. The aim of the article is (1) to summarize regional modifications in application of categories and criteria while assessing lichens and (2) to present – with a brief synopsis – the full list of Estonian lichens included into the red-listed categories.

MATERIAL AND METHODS

Data collection

Lichens were evaluated as a separate, non-systematic group. Besides lichenized taxa, lichenicolous fungi growing on lichens, and a few saprophytic fungi closely related to the lichenized taxa and traditionally treated by lichenologists were also included in the group.

The basis for assessments was the latest (when the workgroup of the Red List of Estonia started in 2006) list of lichenized, lichenicolous and allied fungi of Estonia (Randlane et al., 2006).

For evaluation of lichen species, the main data source was the lichen herbarium of Natural History Museum of the University of Tartu (TU) and herbarium database of the Estonian lichens eSAMBA. Also, the materials from other lichen herbaria of Estonia (ICEB, TALL, TAM) were considered and databases of lichen herbaria B, LD, S and UPS were used. In addition, various literature data (e.g. Ekman et al., 1991; Halonen et al., 2000; Aptroot et al., 2005) and unpublished data of lichen experts and their colleagues were taken into account. All lichen data which were accumulated during the process of assessment were saved in the Information System of Estonian Lichens eSEIS. The first author acted as a member of the workgroup of the Red List of Estonia 2008 and as the coordinator of the lichen expert team. All authors acted as lichen experts.

Application of criteria

The IUCN latest guidelines for the system of red list categories and quantitative criteria, vers. 6.1 (Standards and Petitions Working Group, 2006), was applied in assessing the possible threats to the lichens recorded in Estonia. However, earlier versions of guidelines (IUCN, 2001, 2003) were also considered. The following IUCN categories were used: Regionally Extinct (RE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concerned (LC), Data Deficient (DD), Not Evaluated (NE); categories Extinct (EX), Extinct in the Wild (EW) and Not Applicable (NA) were not used for lichens. Species assigned to either RE, CR, EN, VU, NT or DD are classified as 'red-listed lichens', and species assigned to CR, EN or VU are described as 'threatened' (Gärdenfors, 2005).

All species which have been reliably reported from Estonia until 1950 but not later, and only such species, were classified to the category RE. Criteria A (Population Reduction), B (Geographic Range), C (Small Population Size and Reduction) or D (Very Small or Restricted Population) were used to assign species to the threatened categories CR, EN and VU, criterium E (Quantitative Analysis) was not used due to the insufficiency of data. The taxa which actually did not qualify but were close to be qualified for a threatened category, were included in the category NT. Category DD was applied for such species which had also been evaluated against the criteria A–D, and it emerged that the existing information was still not sufficient to assess the risks of threat for this taxon. Category LC was ascribed to the species which had been evaluated against the criteria and, as a result, did not qualify for any of the red-listed categories. All species which have not been evaluated against the criteria yet belong to the category NE.

In some applied criteria such as C and D1, the number of mature individuals is essential. Delimitation of an individual of a lichen is often a complicated task which may require even special genetic studies. We used these criteria only occasionally and only in such cases where the individuals (sensu Gärdenfors, 2005; Hallingbäck, 2007) had really been counted, e.g. in the cases of *Cladonia norvegica* Tønsberg & Holien and *C. parasitica* (Hoffm.) Hoffm. (Lõhmus & Lõhmus, 2008). Generation time, another parameter difficult to identify for lichens (Scheidegger & Goward, 2002), is important when using criteria A and C1. Different species have been considered to have a generation time of 7 to 33 years (Gärdenfors, 2005). Applying criterium A, we often measured the decline of populations comparing all available data up to 1950 and after 1990, equalizing this period to the minimum of three generations.

RESULTS AND DISCUSSION

1,062 species of lichenized, lichenicolous and allied fungi have been recorded in Estonia by now (Randlane et al., 2007, Suija et al., 2008). The according list from 2006 (Randlane et al., 2006), which was the basis for the assessments, included 1019 species. Of these, 464 species (45.5%) have been evaluated while 555 species remained not evaluated.

All lichenicolous fungi (137) remained, by intention, in the category NE as the distributional data of these taxa are extremely scarce, with two exceptions – *Athelia arachnoidea* (Berk.) Jülich and *Vouauxiella lichenicola* (Linds.) Petr. & Sydow which both were assigned to the Category LC. The species (altogether 48) which had been included in the list of Estonian lichens based on literature data only, without any known herbarium material, were also assigned to NE by choice. A major part of the category NE consists of various microlichens for which the distributional and population data are still insufficient to carry out the evaluation process. A few macrolichens (e.g. species of the *Cladonia chlorophaea* group, some taxa from the genera *Collema, Leptogium* and *Stereocaulon*) which are difficult to identify and therefore lack suitable information also belong to this category.

Of the 464 evaluated species, 251 species were assigned to the category LC and 213 were assigned to the so-called red-listed categories (RE, CR, EN, VU, NT, DD) while 113 species were classified as threatened (belonging to the categories CR, EN, VU) (Tables 1 & 2).

Collema subnigrescens Degel., *Flavoparmelia caperata* (L.) Hale, *Leptogium subtile* (Schrad.) Torss. ja *Bilimbia lobulata* (Sommerf.) Hafellner & Coppins.

In Estonia, in addition to the activities connected with the Red List, the system of legally protected species functions. Since 2004, 51 lichen species are officially protected (divided under the protection categories 1, 2 and 3) (Keskkonnaministri määrus nr 51, 2004; Vabariigi Valitsuse määrus nr 195, 2004). Out of these 51 taxa, 30 belong to the threatened categories of the latest Red List of Estonia, and 19 species are assigned to the category NT; two further protected species, *Hypocenomyce anthracophila* (Ach.) M. Choisy and *Sclerophora pallida* (Pers.) Fr., were evaluated as LC.

Table 1. Distribution of lichen species in the respective categories of Red List of Estonia 2008 (for the abbreviations of categories see Material and Methods)

Categories	RE	CR	EN	VU	NT	DD	LC	NE
No of species included	29	13	32	68	42	29	251	555
% from all evaluated species	6.3	2.8	6.9	14.6	9.0	6.3	54.1	–

Comparison of the data of the current and of the previous red list of Estonian lichens (Lilleleht, 1998; Randlane, 1998) would not be correct as the previous list included macrolichens only, and because the contents of the categories do not coincide. However, some comments might be helpful. There were five species which had been recorded in the previous red list, and which turned out to be misidentifications: *Caloplaca flavescens* (Huds.) J.R. Laundon, *Catapyrenium lachneum* (Ach.) R. Sant., *Heterodermia speciosa* (Wulfen) Trevis., *Nephroma helveticum* Ach. and *Xanthoria lobulata* (Flörke) de Lesd. Two more species – *Dermatocarpon arnoldianum* Degel. and *Usnea scabrata* Nyl. – have been included into other taxa, *Dermatocarpon miniatum* (L.) W. Mann and *Usnea barbata* (L.) F.H. Wigg., respectively. In addition, there were six species which had been included in the previous red list under category 'Extinct or probably extinct' and which have been re-found again: *Cetrelia olivetorum* (Nyl.) W.L. Culb. & C.F. Culb.,

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Table 2. Red-listed lichens of Estonia (for the abbreviations of red list categories and criteria see Material & Methods)

Species name	Category of red list	Criterium	Protection category
Acarospora oligospora (Nyl.) Arnold	RE		
Alectoria sarmentosa (Ach.) Ach.	NT		2
Amygdalaria panaeola (Ach.) Hertel & Brodo	RE		
Anaptychia runcinata (With.) J. R. Laundon	VU	D2	
Arctoparmelia centrifuga (L.) Hale	EN	B1ab(i,iv)	
Arctoparmelia incurva (Pers.) Hale	EN	A2c, B1ab(i,iv)	
Arthonia apatetica (A. Massal.) Th. Fr.	VU	D2	
Arthonia byssacea (Weigel) Almq.	NT		3
Arthonia didyma Körb.	NT		
Arthonia lapidicola (Taylor) Branth. & Rostr.	VU	D2	
Arthopyrenia cinereopruinosa (Schaer.) A. Massal.	RE		
Arthothelium spectabile Flot. ex A. Massal.	VU	D2	
Aspicilia gibbosa (Ach.) Körb.	RE		
Aspicilia xyloxena (H. Magn.) R. Sant. comb. inedit.	RE		
Bacidia biatorina (Körb.) Vain.	EN	B2ab(iii)	2
Bacidia fuscoviridis (Anzi) Lettau	RE		
Bacidia laurocerasi (Delise ex Duby) Zahlbr.	NT		2
Baeomyces carneus Flörke	VU	D2	2
Biatoridium monasteriense J. Lahm ex Körb	NT		2
Bilimbia lobulata (Sommerf.) Hafellner & Coppins	VU	B2ab(iii)	
Bryoria chalybeiformis (L.) Brodo & D. Hawksw.	VU	D2	
Bryoria furcellata (Fr.) Brodo & D. Hawksw.	VU	B1ab(iii)	2
Bryoria intricans (Vain.) Brodo & D. Hawksw.	DD		
Bryoria simplicior (Vain.) Brodo & D. Hawksw.	DD		
Caloplaca atroflava (Turner) Mong.	RE		
Caloplaca biatorina (A. Massal.) J. Steiner	VU	D2	
Caloplaca chalybea (Fr.) Müll. Arg.	RE		
Caloplaca coronata (Kremp. ex Körb.) J. Steiner	VU	D2	
Caloplaca lucifuga G. Thor	NT		
Caloplaca thallincola (Wedd.) Du Rietz	VU	D2	
Caloplaca ulcerosa Coppins & P. James	VU	D2	
Caloplaca verruculifera (Vain.) Zahlbr.	NT		2
Catapyrenium cinereum (Pers.) Körb.	EN	B2ab(iii)	
Cetrelia cetrarioides (Delise ex Duby) W. L. Culb. & C. F. Culb.	VU	B1ab(iii)	
Cetrelia olivetorum (Nyl.) W. L. Culb. & C. F. Culb.	VU	B1ab(iii)	2
Chaenotheca cinerea (Pers.) Tibell	EN	B2ab(iii)	2
Chaenotheca gracilenta (Ach.) J. Mattsson & Middelb.	VU	B2ab(iii)	2
Cladina portentosa (Dufour) Follmann	NT		
Cladonia borealis S. Stenroos	EN	A2bc	
Cladonia brevis (Sandst.) Sandst.	EN	B2ab(iii)	
Cladonia caespiticia (Pers.) Flörke	VU	D2	
Cladonia carneola (Fr.) Vain.	EN	A2bc	
Cladonia cervicornis ssp. *cervicornis* (Ach.) Flot.	DD		
Cladonia coccifera (L.) Willd.	EN	A2bc	
Cladonia convoluta (Lam.) Anders	VU	B2ab(iii)	2
Cladonia decorticata (Flörke) Spreng.	VU	D2	
Cladonia foliacea (Huds.) Willd.	NT		
Cladonia incrassata Flörke	NT		
Cladonia macroceras (Delise) Hav.	NT		
Cladonia macrophylla (Schaer.) Stenh.	EN	A2bc, B2ab(iii)	
Cladonia metacorallifera Asahina	VU	D2	
Cladonia parasitica (Hoffm.) Hoffm.	NT		

Table 2 (continued)

Species name	Category of red list	Criterium	Protection category
Cladonia pocillum (Ach.) Grognot	NT		
Cladonia scabriuscula (Delise) Nyl.	VU	A2bc	
Collema bachmanianum (Fink) Degel.	DD		
Collema limosum (Ach.) Ach.	DD		
Collema nigrescens (Huds.) DC.	VU	B2ab(iii,iv), C1	2
Collema occultatum Bagl.	RE		
Collema parvum Degel.	VU	D2	
Collema subnigrescens Degel.	NT		
Collema undulatum Laurer ex Flot.	VU	D2	
Cyphelium inquinans (Sm.) Trevis.	NT		3
Dermatocarpon leptophyllum (Ach.) K. G. W. Lang	DD		
Dermatocarpon luridum (With.) J. R. Laundon	DD		
Dermatocarpon miniatum (L.) W. Mann	DD		
Dibaeis baeomyces (L. f.) Rambold & Hertel	NT		
Dimerella lutea (Dicks.) Trevis.	VU	B2ab(iii)	2
Diplotomma lutosum (Ach.) Arnold	RE		
Endocarpon psorodeum (Nyl.) Blomb. & Forssell	EN	D1	
Endocarpon pusillum Hedw.	EN	B2ab(iii)	
Eopyrenula leucoplaca (Wallr.) R. C. Harris	EN	B2ab(iii)	
Evernia divaricata (L.) Ach.	VU	A4bc	3
Evernia mesomorpha Nyl.	NT		
Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell	CR	B1ab(iii)+2ab(iii)	1
Flavocetraria nivalis (L.) Kärnefelt & A. Thell	NT		
Flavoparmelia caperata (L.) Hale	EN	B1ab(iii)	2
Fulgensia bracteata (Hoffm.) Räsänen	NT		3
Fulgensia fulgens (Sw.) Elenkin	DD		
Fuscidea cyathoides (Ach.) V. Wirth & Vězda	RE		
Fuscopannaria leucophaea (Vahl) P. M. Jørg.	DD		
Gyalecta ulmi (Sw.) Zahlbr.	VU	B2ab(iii)	2
Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt	RE		
Hypogymnia vittata (Ach.) Parrique	CR	B2ab(iii)	
Lasallia pustulata (L.) Mérat	VU	A2c+3c	3
Lecanora bicincta Ramond	VU	D2	
Lecanora caesiosora Poelt	VU	D2	
Lecanora epibryon (Ach.) Ach.	RE		
Lecanora impudens Degel.	VU	D2	
Lecanora intumescens (Rebent.) Rabenh.	VU	B2ab(iii)	
Lecanora swartzii (Ach.) Ach.	VU	D2	
'Lecidea' erythrophaea Flörke ex Sommerf.	NT		3
Lempholemma isidiodes (Nyl. ex Arnold) H. Magn.	VU	D2	
Lempholemma polyanthes (Bernh.) Malme	RE		
Leptogium cyanescens (Rabenh.) Körb.	DD		
Leptogium gelatinosum (With.) J. R. Laundon	DD		
Leptogium rivulare (Ach.) Mont.	CR	D1	
Leptogium saturninum (Dicks.) Nyl.	NT		3
Leptogium schraderi (Bernh.) Nyl.	VU	D2	
Leptogium subtile (Schrad.) Torss.	VU	D2	
Leptogium tenuissimum (Dicks.) Körb.	DD		
Leptogium teretiusculum (Wallr.) Arnold	VU	B2ab(iii)	2
Lobaria pulmonaria (L.) Hoffm.	NT		3
Lobaria scrobiculata (Scop.) DC.	CR	B2ab(iii)	
Lobothallia radiosa (Hoffm.) Hafellner	NT		
Megalaria grossa (Pers. ex Nyl.) Hafellner	NT		3

Table 2 (continued)

Species name	Category of red list	Criterium	Protection category
Megaspora verrucosa (Ach.) Hafellner & V. Wirth	EN	B2ab(iii)	
Melanelia commixta (Nyl.) A. Thell	CR	B2ab(iv), C1+2a(i)	
Melanelia disjuncta (Erichsen) Essl.	DD		
Melanelia elegantula (Zahlbr.) Essl.	EN	B1ab(iii,iv)	
Melanelia glabra (Schaer.) Essl.	CR	B2ab(iii)	
Melanelia hepatizon (Ach.) A. Thell	EN	B1ab(iii,iv)	
Melanelia septentrionalis (Lynge) Essl.	NT		
Melanelia sorediata (Ach.) Goward & Ahti	DD		
Melanelia stygia (L.) Essl.	VU	A2c	
Melaspilea gibberulosa (Ach.) Zwackh	RE		
Menegazzia terebrata (Hoffm.) A. Massal.	NT		3
Micarea hedlundii Coppins	VU	B2ab(iii)	2
Micarea turfosa (A. Massal.) Du Rietz	RE		
Multiclavula mucida (Pers.) R. H. Petersen	VU	B2ab(iii)	
Multiclavula vernalis (Schwein.) R. H. Petersen	CR	A2a, D1	
Nephroma arcticum (L.) Torss.	RE		
Nephroma bellum (Spreng.) Tuck.	CR	B2ab(iii)	
Nephroma isidiosum (Nyl.) Gyeln.	DD		
Nephroma laevigatum Ach.	VU	A4bc	3
Nephroma parile (Ach.) Ach.	VU	A2bc	3
Nephroma resupinatum (L.) Ach.	EN	A2bc	2
Ochrolechia frigida (Sw.) Lynge	VU	B1ab(iii)	2
Opegrapha atra Pers.	NT		
Opegrapha herbarum Mont.	DD		
Opegrapha ochrocheila Nyl.	VU	D2	
Opegrapha rupestris Pers.	VU	D2	
Opegrapha sorediifera P. James	VU	D2	
Opegrapha viridis (Pers. ex Ach.) Behlen & Desberger	VU	A3c	
Parmelia fraudans (Nyl.) Nyl.	EN	B1ab(i,iv)	
Parmelia omphalodes (L.) Ach.	NT		
Parmeliella triptophylla (Ach.) Müll. Arg.	VU	A2bc, B2ab(iii)	2
Parmelina tiliacea (Hoffm.) Hale	NT		
Peltigera collina (Ach.) Schrad.	CR	D1	2
Peltigera degenii Gyeln.	VU	D2	
Peltigera elisabethae Gyeln.	RE		
Peltigera horizontalis (Huds.) Baumg.	NT		
Peltigera hymenina (Ach.) Delise	NT		
Peltigera lepidophora (Nyl. ex Vain.) Bitter	DD		
Peltigera ponojensis Gyeln.	DD		
Peltigera scabrosa Th. Fr.	EN	B2 ab(iii)	
Peltigera venosa (L.) Hoffm.	EN	B2ab(iv)	
Pertusaria carneopallida (Nyl.) Anzi	RE		
Phaeophyscia chloantha (Ach.) Moberg	RE		
Phaeophyscia endophoenicea (Harm.) Moberg	DD		
Physcia leptalea (Ach.) DC.	VU	A4c	
Physcia magnussonii Frey	VU	D2	
Physconia detersa (Nyl.) Poelt	NT		
Physconia grisea (Lam.) Poelt	NT		
Pilophorus cereolus (Ach.) Th. Fr.	EN	B2ab(iii)	
Placidium pilosellum (Breuss) Breuss	EN	B2ab(iii)	
Placidium squamulosum (Ach.) Breuss	EN	B2ab(iii)	
Polychidium muscicola (Sw.) Gray	DD		
Protopannaria pezizoides (Weber) P. M. Jørg. & S. Ekman	DD		
Protoparmeliopsis achariana (A. L. Sm.) Moberg & R. Sant.	VU	D2	

Table 2 (continued)

Species name	Category of red list	Criterium	Protection category
Protoparmeliopsis macrocyclos (H. Magn.) Moberg & R. Sant.	NT		
Psora decipiens (Hedw.) Hoffm.	NT		3
Punctelia subrudecta (Nyl.) Krog	RE		
Pycnora praestabilis (Nyl.) Hafellner	CR	B2ab(i,ii,iii,iv), D1	
Pycnothelia papillaria Dufour	EN	A2	
Pyrenula laevigata (Pers.) Arnold	VU	B2ab(iii)	2
Pyrenula nitidella (Schaer.) Müll. Arg.	VU	B2ab(iii)	2
Ramalina calicaris (L.) Fr.	VU	A1b	
Ramalina dilacerata (Hoffm.) Hoffm.	DD		
Ramalina elegans (Bagl. & Carestia) Jatta	RE		
Ramalina obtusata (Arnold) Bitter	DD		
Ramalina siliquosa (Huds.) A. L. Sm.	VU	D2	
Ramalina sinensis Jatta	EN	A2	
Ramalina thrausta (Ach.) Nyl.	NT		3
Rhizocarpon badioatrum (Flörke ex Spreng.) Th. Fr.	RE		
Rhizocarpon oederi (Weber) Körb.	RE		
Rinodina interpolata (Stirt.) Sheard	RE		
Sclerophora coniophaea (Norman) J. Mattsson & Middelb.	NT		2
Sclerophora farinacea (Chevall.) Chevall.	VU	B2ab(iii), A3c	2
Sclerophora peronella (Ach.) Tibell	VU	B2ab(iii)	2
Solorina bispora Nyl.	VU	D2	
Solorina saccata (L.) Ach.	NT		2
Solorina spongiosa (Ach.) Anzi	EN	B1ab(iii)	2
Sphaerophorus globosus (Huds.) Vain.	CR	B2ab(iii,iv)	
Squamarina lentigera (Weber) Poelt	EN	B1ab(iii)	2
Stereocaulon condensatum Hoffm.	VU	A2c	3
Stereocaulon evolutum Graewe ex Th. Fr.	RE		
Stereocaulon incrustatum Flörke	DD		
Stereocaulon vesuvianum Pers.	RE		
Thelidium pyrenophorum (Ach.) Mudd	RE		
Thelotrema lepadinum (Ach.) Ach.	NT		3
Toninia sedifolia (Scop.) Timdal	VU	B2ab(iii)	
Toninia verrucarioides (Nyl.) Timdal	DD		
Umbilicaria cinerascens (Arnold) Frey	VU	D2	
Umbilicaria cylindrica (L.) Delise ex Duby	DD		
Umbilicaria decussata (Vill.) Zahlbr.	VU	D2	
Umbilicaria hyperborea (Ach.) Hoffm.	VU	D2	
Umbilicaria nylanderiana (Zahlbr.) H. Magn.	VU	D2	
Umbilicaria polyrrhiza (L.) Fr.	CR	A2bc	
Umbilicaria proboscidea (L.) Schrad.	DD		
Usnea barbata (L.) Weber ex F.H. Wigg	NT		3
Usnea chaetophora Stirt.	EN	B1ab(iii)	
Usnea diplotypus Vain.	NT		
Usnea fulvoreagens (Räsänen) Räsänen	EN	A2bc+3bc	
Usnea glabrata (Ach.) Vain.	CR	A2bc+3bc	
Usnea substerilis Motyka	EN	A2bc+3bc	
Usnea wasmuthii Räsänen	VU	A2bc+3bc	
Verrucaria maculiformis Kremp.	RE		
Vulpicida juniperinus (L.) J.-E. Mattsson & M. J. Lai	DD		
Vulpicida tubulosus (Schaer.) J.-E. Mattsson & M. J. Lai	NT		2
Xanthoparmelia mougeotii (Schaer. ex D. Dietr.) Hale	EN	B2ab(iii)	2
Xanthoria calcicola Oxner	VU	D2	
Xanthoria fallax (Hepp) Arnold	VU	B1ab(i,iv)	
Xanthoria sorediata (Vain.) Poelt	VU	D2	

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The distribution of *Metzgeria violacea* in the Apuseni Mountains (Romanian Western Carpathians)

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Abstract: *Metzgeria violacea* (Ach.) Dumort. was known from three places in Romania. It recently has been found at several localities in the Apuseni Mountains, mostly in deep gorges, on twigs of different woody species. The distribution, ecology and the distinguishing characters from the related species are discussed.

Kokkuvõte: *Metzgeria violacea* levik Apuseni mägedes (Rumeenia Lääne-Karpaadid)

Metzgeria violacea (Ach.) Dumort. oli teada kolmest leiukohast Rumeenias. Hiljuti leiti teda mitmest kohast Apuseni mägedest, enamasti sügavates kuristikes eri puuliikide okstel. Käsiletakse lähedaste liikide levikut, ökoloogiat ja eristustunnuseid.

INTRODUCTION

The simple thalloid hepatic, *Metzgeria violacea* (Ach.) Dumort., before known also under the name of *Metzgeria fruticulosa* (Dicks.) A. Evans, is an oceanic ("atlantic") geographical element.

Its distribution is known from Tierra del Fuego, Valdivia, Argentina and from Peru in the Southern Hemisphere, furthermore from the northern and western part of Europe (Grolle & So, 2003). The records from New Zealand (Campbell, 1961) are erroneous (So, 2002). It was known only from a few localities in the whole Carpathian range, for instance, in Slovakia from the Muran Plateau and from Vihorlat Mts. (Duda, 1962; Peciar, 1960), from Mt. Hoverla in Carpatho-Ukrainia (Boros & Vajda, 1969).

It was first discovered in Romania from the Cibin Mts., Râul Mare Gorge in the Southern Carpathians by Boros & Vajda (1967), confirmed by Gündisch (1977). Later, Goia & Ştefanuţ (2004) recorded the species from the Bihor Mts., Cobleş Valley near Arieşeni. The latter authors also provided a distribution map of the taxon for Romania.

Pócs (2006) recorded a new locality from the Pădurea Craiului near the Vida Lake, mistakenly under the name of the closely related *Metzgeria temperata* Kuwah. The three authors of the current paper collected it again at several localities of the Bihor Mountains, where it seems to be a typical ramicolous element of streamside trees and shrubs in deep, damp, shady gorges. These new records are significant because we are convinced that the species will be more widespread than currently documented, and we predict it will be found from the Romanian Western Carpathians (Apuseni Mts.) at many similar habitats rich in relics and rare plants.

RESULTS & DISCUSSION

Localities of *Metzgeria violacea* in the Apuseni Mountains (Fig. 1)

Bihor Mountains:

Cheile Galbenei, gorge below the bridge, on shady limestone rocks and on decaying wood near the river, at 700 m alt., 46°33'11"N, 22°40'20"E. Coll.: I. Goia & T. Pócs, 06065/G, 8 Sept. 2006;

Cobleş Valley NW of Arieşeni, on spruce roots in small patch ca 1040 m alt, 46°32'29"N, 22°44'07"E. Coll.: I. Goia (Goia 2001, Goia & Ştefanuţ 2004).

Valea Gârda Seacă, on twigs of *Viburnum lantana* along a creek of Izbuc Coteţul Dobreştilor, NW of Dobreşti village, in shady bush, at 763 m alt., 46°28'41"N, 22°48'32"E. Coll.: A. Sass-Gyarmati 06031/G, 13 June 2006.

Cheile Ordâncuşii NE of Gârda, at several points of this deep gorge, seems to be widespread here: along the trail to the entrance of Poarta lui Ionele Cave near a creek, in *Piceo-Fagetum*, on *Picea* and on *Acer pseudoplatanus* twigs and bark, 770 m

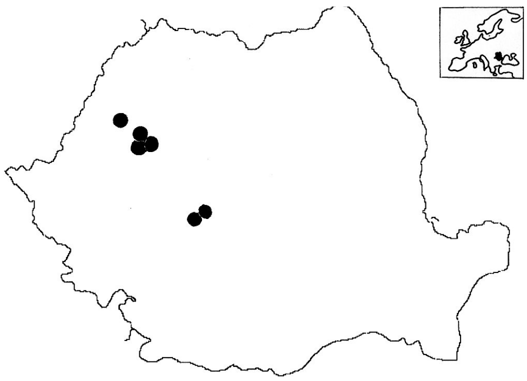

Fig. 1. The distribution of *Metzgeria violacea* (Ach.) Dumort in Romania.

alt, 46°27'59"N, 22°50'18"E. Coll.: A. Sass-Gyarmati 06044/F, 06044/G, 27 June 2006. At the narrowest part of the gorge, on *Salix caprea* twigs along the streamlet, at 830–840 m alt. 46°28'30"N Coll. S. & T. Pócs 07042/E, 20 Apr. 2007. In the upper part of the gorge, on twigs of different shrubs in streamside *Alnetum incanae* and *Petasitetum* stands at 860–870m, 46°28'41–43"N, 22°50'51"E. Coll. Sass-Gyarmati 06045/B, 27 June 2006.

Pădurea Craiului (The Royal Forest) Hills:

Topliţa Valley E of Vida Lake and Luncasprie Village, in streamside *Fageto-Carpinetum*, small patches on bark of *Carpinus betulus,* at 250 m alt., 46°51'47"N, 22°18'56"E. Coll.: T. Pócs & R. Rico 06011//F (Pócs 2006: 11–12 under the name of *Metzgeria temperata*).

The voucher specimens of the above are deposited in CL and in EGR.

Ecology of *Metzgeria violacea*

The ecology of this species is briefly described by Goia & Ştefanuţ (2004), as corticolous or occasionally rupicolous, skiaphilous, mesophilous, micro-mesothermal and moderately acidophilous. Of significance, we add that due to its oceanic distribution and climate requirements in the Apuseni Mountains it is restricted to the relict habitats of narrow gorges or at least to the microclimate of damp valleys and regularly occurs near watercourses, on roots and bark, but mainly on narrow twigs, accompanied by species of *Orthotrichum* and *Ulota.* This seems to prove in the macroclimate of Carpathians its requirement for relatively high air humidity. Its substrate selectivity is low, occurring on the bark of any trees and shrubs, sometimes even on different rocks.

Taxonomy of *Metzgeria violacea*

The taxonomy of this species has historically been very confusing for long time. Morphologically, *Metzgeria violacea* belongs to Subgenus *Biforma* Kuwahara (1978), which is represented by some 10 species worldwide (Kuwahara 1986) and is characterized by two kinds of thallus ends within the same plant. One part of the thallus ends is attenuating, bearing disciform gemmae concentred to the narrow thallus apices (Fig. 2 & 3). Within the same individual are also occurring thallus ends of normal width having obtuse or emarginate apex without gemmae. Three species from this group, the so called *M. temperata-violacea-fruticulosa* complex (Schuster 1992) have oceanic distribution and are sometimes difficult to distinguish from each other. Their synonymy and specific characters were clarified only recently and are provided by Pócs (1993), Paton (1999), Grolle & So (2003), So (2003, 2004). They proved that *M. fruticulosa* is a misapplied name, and *M. consanguinea* belongs to the above named complex.

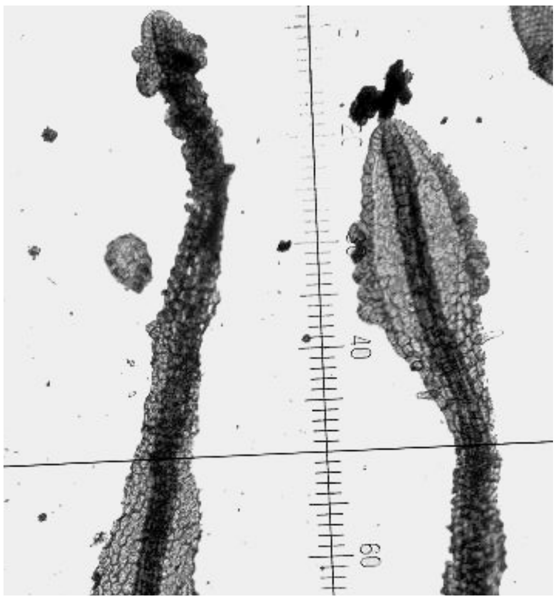

Fig. 2. Attenuated branches bearing gemmae (scale unit 25 μm).

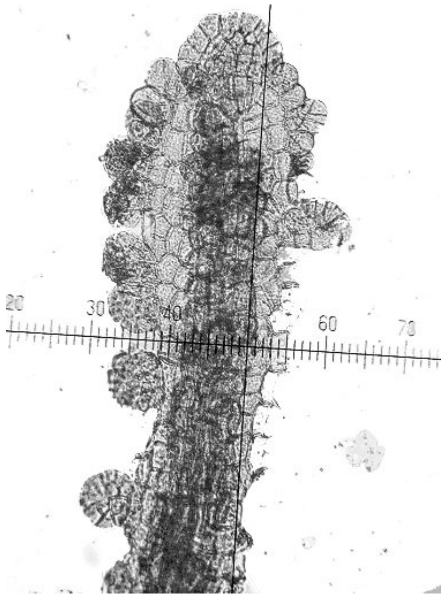

Fig. 3. Branch with costa bearing gemmae (scale unit 8 μm).

Among the European *Metzgeria* species only *M. violacea* turns blue. But we have to be careful with this character, as the bluish colour rarely appears on living plants, in case of full desiccation. The bluish coloration usually appears only several months after the death of the plant, so the green colour in the field may be misguiding. The bluish coloration of some species of *Metzgeria* was largely discussed by Kuwahara (1968), who observed, that the blue color is not bound to any morphological features of the cell or cell content. He recognized the taxonomic significance of blue coloration, which is bound only to two groups of species within this genus. Blue coloration is observed also in other hepatic genera, as it is well known in certain species of the genus *Calypogeia* (e.g. *C. peruviana* Nees et Mont., *C. trichomanis* (L.) Corda = *C. azurea* Stotler & Crotz), where the indigo blue pigment is bound to the oil bodies (Schuster 1969), like in the Andean *Plagiochila longispina* Lindenb. & Gottsche, where in the shoot apexes the blue oil bodies, when disintegrate after their death, stain even the cell walls of the stem cortex (Heinrichs et al., 2000).

We must take in account also the other character, the presence of gemmae on the costa surface (Fig. 3) with reservations, as on certain branches they are present only at the margin, but looking through the whole specimen we definitely find costal surface gemmae too. The most reliable character to distinguish *M. violacea* from the related *M. temperata* is the structure of the costa at the tapering thallus apex, which always has more than 3 epidermal (superficial) cells in *M. violacea* and always only 2 in *M. temperata.* But again, we have to be careful, because this is valid only for the attenuating part of thallus ends, in other parts of the thallus this number in both cases is 2.

However, their distribution is quite different, as there is overlapping only in the distribution of the bipolar temperate *M. violacea* and the hyperoceanic *M. temperate*, which only occurs in western Europe, and *M. consanguinea* is a Pantropical species, which does not occur in Europe.

Key to the species of subgenus *Biforma* occuring in the northern temperate belt

1 – Thallus uniform, lamina without attenuate branches, obtuse or truncate at the apices .... all other subgenera of *Metzgeria*

– Thallus with many attenuate branches bearing gemmae at their apical part (Fig. 2) 2

2 – Thallus with only 2(–3) dorsal and ventral costal cells in the tapered apex.......................... 3

– Costa of attenuating thallus apices with 3–6 dorsal and ventral cell rows on either side, thallus sooner or later turns blue or at least on their apex with bluish tinge; gemmae at the thallus apex in most cases also on both costal surfaces, often forming clusters ....*Metzgeria violacea*

3 – Thallus never turns blue, not even after years in the herbarium, but remains yellowish or dark green; only marginal gemmae at the attenuating thallus apex; lamina 11–18(26) cells wide, median laminal cells 33–58(70) × 25–43 μm .... *M. temperata*

– Thallus sooner or later turns blue or at least on their apex with bluish tinge; gemmae at the thallus apex in most cases also on both costal surfaces, not at thallus margins; lamina 13–28(40) cells wide, median laminal cells 25–43(50) × 18–30(35) μm..........................*M. consanguinea*

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Species richness and distribution ranges of European *Sphagnum*

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Abstract: There are 51 *Sphagnum* species in Europe. *Sphagnum* species richness shows a gradient of decrease from the boreal region towards the north and the south, as well as from west to east to some degree. There is a strong correlation between number of species and number of range restricted species. The most species rich countries (Norway and Sweden) also have most range restricted species. Most species occur in boreal, oceanic and/or alpine areas. Several areas, primarily several countries on the Balkans and Slovakia are identified as probably underexplored for *Sphagnum* species.

Kokkuvõte: Perekonna *Sphagnum* liigirikkus ja levik Euroopas.

Euroopas on 51 turbasambla (*Sphagnum*) liiki. Turbasammalde liigirikkus väheneb boreaalpiirkonnast põhja ja lõuna poole, samuti mõnevõrra läänest ida poole. Liikide koguarvu ja piiratud levikuga liikide arvu vahel on tugev korrelatsioon. Kõige liigirikkamates riikides (Norra ja Rootsi) on ka kõige enam piiratud levikuga liike. Enamus liike esineb boreaalsetes, okeaanilistes ja/või alpiinsetes piirkondades. Paljud kohad, eeskätt mitmed Balkanimaad ja Slovakkia, on turbasammalde poolest väheuuritud.

INTRODUCTION

The importance of recognizing areas that are *Sphagnum* species rich is that the species are ecologically important and dominating large areas, especially mire ecosystems. In addition, as main constituents of peat, they have a direct economic value and are thus subject to human exploitation and depletion.

Sphagnum is a fairly well known genus in Europe, but includes species that show large morphological plasticity and number of taxa recognized has been fluctuating over time. Even today there remains some controversy with the delimitation of some taxa. Flatberg (1994) recognizes, e.g., 5 species in the *S. fallax* complex while Daniels & Eddy (1990) recognize only one and Hill *et al.* (2006) recognize three.

In order to evaluate conservation needs it is necessary to identify species rich areas and areas rich in rare species. However, a species may be rare for several reasons. Rabinowitz (1981), e.g. use three variables that a species can be rare along: habitat requirements, population size and distribution range, and all can be combined. Ideally the rarity of a species should be analyzed along all variables. An attempt in this direction is made for liverworts (Söderström, Séneca & Santos, 2007). However, some of the variables are difficult to score for a large number of species, especially the population sizes for less well known species. This variable was also excluded in Söderström, Séneca & Santos (2007). The variable best known is usually distribution, though many areas are still insufficiently explored bryologically.

This study tries to identify which areas of Europe and Macaronesia are most *Sphagnum* rich and analyzes distribution ranges to see which areas are most rich in globally range restricted species.

METHODS

The geographical units used here follow mainly Brummit (2001) but are adjusted for Europe to follow Söderström, Urmi & Váňa (2002, 2007). Europe and Macaronesia were thus scored with 57 areas (Table 1; see Söderström & Séneca, 2008, for details).

Distributions were registered world-wide for all *Sphagnum* species recognized to occur in Europe and Macaronesia. The taxonomy follows Hill *et al.* (2006) and the distribution was retrieved from a database compiled by us from various sources covering distribution of all European *Sphagnum* taxa worldwide.

Distribution ranges were calculated in a way analogous with diversity in ecological investigations. We used the Shannon-Wiener index (Zar,

Table 1. *Sphagnum* species richness and number of restricted species (H'<0.61) in each area. The abbreviations of the area names are used in some figures

Areas	No. of species	No. of restricted species
Albania (ALB)	1	0
Austria (AUT)	34	3
Azores (AZO)	14	2
Baleares (BAL)	0	0
Belarus (BLR)	36	4
Belgium (BGM)	30	2
Bosnia-Herzegovina (BOS)	19	0
Bulgaria (BUL)	26	0
Canary Is. (CNY)	2	0
Corsica (COR)	1	0
Crete (KRI)	1	0
Crimea (KRY)	1	0
Croatia (CRO)	22	0
Czech Republic (CZE)	34	3
Denmark (DEN)	36	6
Estonia (EST)	37	3
Faeroe Is. (FOR)	21	2
Finland (FIN)	39	5
France (FRA)	34	4
Franz Josef Land (FJL)	0	0
Germany (GER)	36	6
Great Britain (GRB)	34	7
Greece (GRC)	9	0
Hungary (HUN)	24	0
Iceland (ICE)	30	5
Ireland (IRE)	27	6
Italy (ITA)	31	2
Kaliningrad (KAL)	33	3
Latvia (LAT)	37	4
Lithuania (LIT)	36	4
Macedonia (MAK)	11	1
Madeira (MDR)	4	0
Moldova (MOL)	0	0
Montenegro (MNE)	0	0
Netherlands (NET)	29	3
North Caucasus (NCS)	23	0
Norway (NOR)	44	11
Novaya Zemlya (NVZ)	6	0
Poland (POL)	36	3
Portugal (POR)	18	1
Romania (ROM)	27	3
Russia Central (RUC)	35	2
Russia East (RUE)	33	3
Russia North (RUN)	40	6
Russia Northwest (RUW)	35	3
Russia South (RUS)	25	0
Sardinia (SAR)	3	0
Serbia (SER)	18	1
Sicilia (SIC)	5	0
Slovakia (SVK)	22	2
Slovenia (SLO)	29	1
Spain (SPA)	29	3
Svalbard (SVA)	13	3
Sweden (SWE)	42	9
Switzerland (SWI)	29	4
Turkey-in-Europe (TUE)	1	0
Ukraine (UKR)	33	3

1984), which indicates how large chance there is that the next individual you see or catch is a different species, as

$$H' = -\sum p_i \ln p_i$$

where p is the proportion of areas occupied in each region. In this case, the index estimates how large chance there is that the same species occurs in the next region visited.

Range restricted species were defined as the 1/3 of all the species with lowest H'.

Proportion of range restricted species may be used as a measure on the relative importance of an area for range restricted species. However, a restricted species occurring in a species poor area will have a higher impact than a restricted species occurring in a species rich area. To reduce this effect a Rarity Index was created by multiplying the proportion of range restricted species with the absolute number of them as

$$RI = p_r \times n_r$$

where p_r is the proportion of range restricted species occurring in the area and n_r is the number of range restricted species in that region.

RESULTS

Number of species

A total of 51 *Sphagnum* species occur in Europe (Hill et al., 2006). However, there is a large variation in number of species between the different areas (Fig. 1), from 0 in Franz Josef Land, Baleares, Moldova and Montenegro to 44 in Norway.

Species richness (Fig.2) was significantly correlated with the size of the area (Spearman corr. coeff. = 0.670; n = 57; $P < 0.001$).

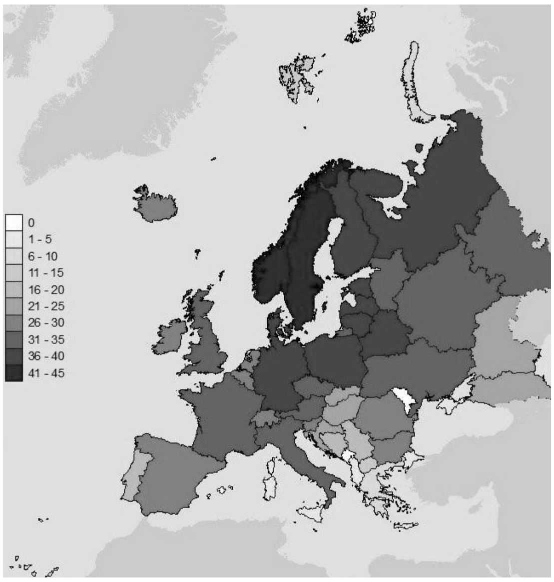

Fig. 1. Number of *Sphagnum* species in different areas of Europe and Macaronesia.

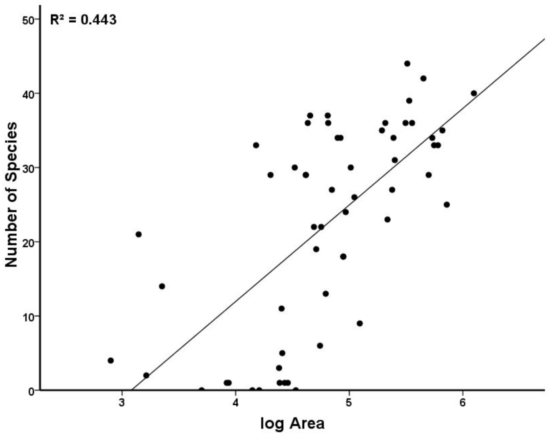

Fig. 2. Relationship between number of *Sphagnum* species and the log $_{10}$ of the size of area.

Number and proportion of range restricted species

The one third most range restricted *Sphagnum* species (17 species) had H'≤1.6. Most of them occur in northwestern Europe (Fig 3). Number of range restricted species is correlated exponentially with species richness (Fig. 4). The number of range restricted species is also correlated with the size of the area (Spearman corr. coeff. = 0.517; n = 57; $P < 0.001$). The linear relationship has a low value of R^2 (Fig. 5) but shows two areas that fall outside the 95% confidence interval for the regression line (Norway and Sweden), indicating that they have more range restricted species than expected from the size of them alone.

Proportion of range restricted species is highest in the Scandinavian Peninsula, British Isles and Svalbard, with over 20% of registered *Sphagnum* species being range restricted (Fig. 6). The values of RI separates these areas more (Fig. 7) and are highest for Norway (2.75) followed by Sweden (1.93), Great Britain (1.44) and Ireland (1.33). The values of RI are exponentially related to the number of species (Spearman corr. coeff. = 0.779; n = 57; $P < 0.001$). They are also related to the size of the area (Spearman corr. coeff. = 0.480; n = 57; $P < 0.001$). Though the

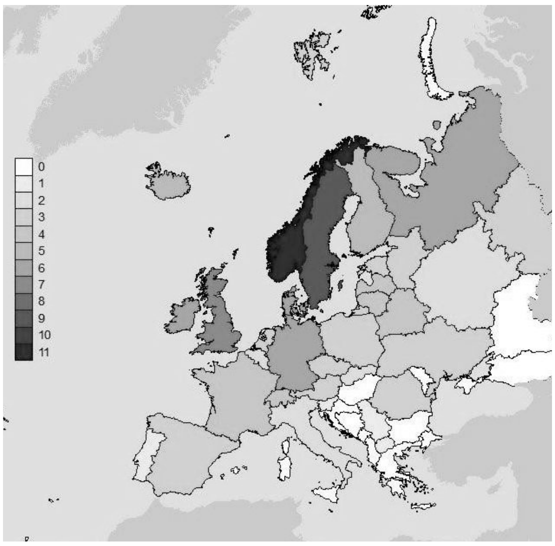

Fig. 3. Number of range restricted *Sphagnum* species in Europe and Macaronesia.

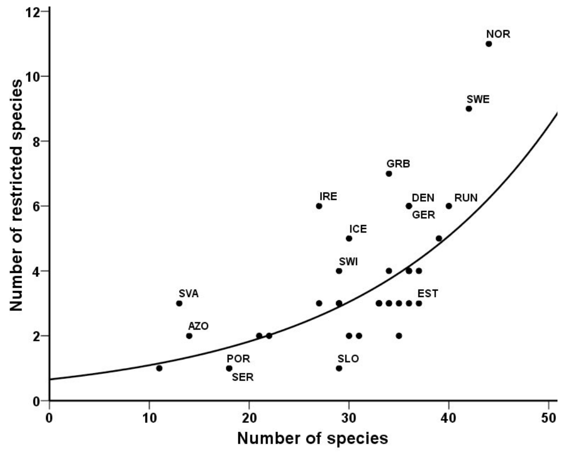

Fig. 4. Relationship between number of range restricted *Sphagnum* species and total number of species. Abbreviations of areas as in Table 1.

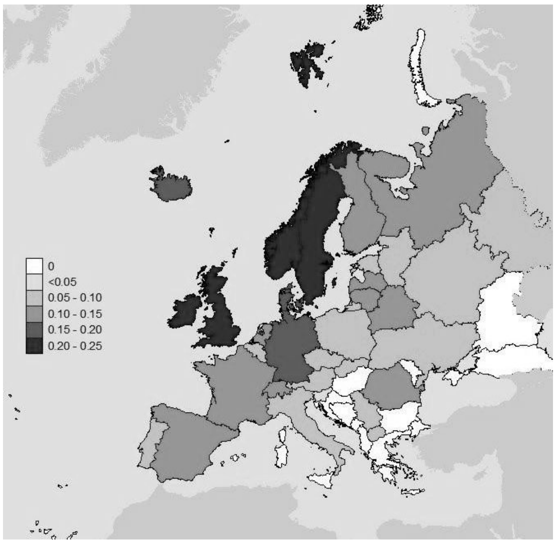

Fig. 5. Proportion of range restricted *Sphagnum* species in Europe and Macaronesia.

linear relationship between these variables is weak (R^2 = 0.093, Fig. 8), it shows four areas (Norway, Sweden, Great Britain and Ireland) lying outside the 95% confidence interval for the regression line.

DISCUSSION

The number of *Sphagnum* species is not uniformly distributed in Europe, as expected.

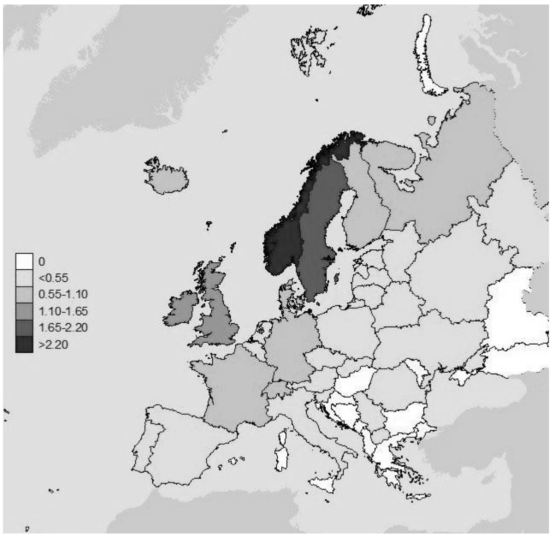

Fig. 6. Rarity Index values for range restricted *Sphagnum* species in Europe and Macaronesia.

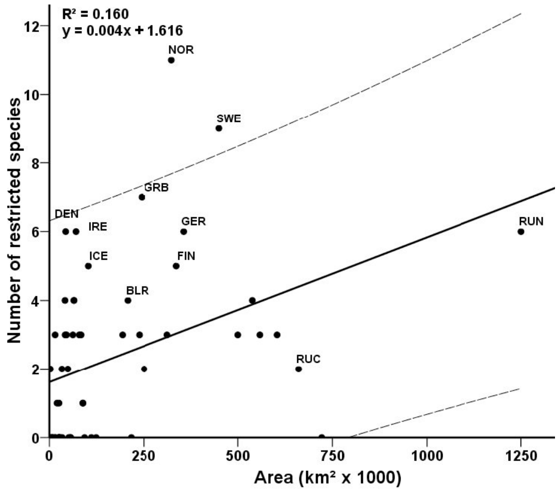

Fig. 7. Relationship between numbers of range restricted *Sphagnum* species and size of area. Dashed lines delimit the 95% confidence interval. Abbreviations of areas as in Table 1.

Three parameters emerge as important for the distribution pattern of the number of *Sphagnum* species: the boreal vegetation belt, the ocean influence and elevation. Fig. 1 clearly shows a gradient of decrease in species richness from the boreal areas towards the north and towards the south. To some degree, a decrease can also be recognized on a west-east gradient which can be

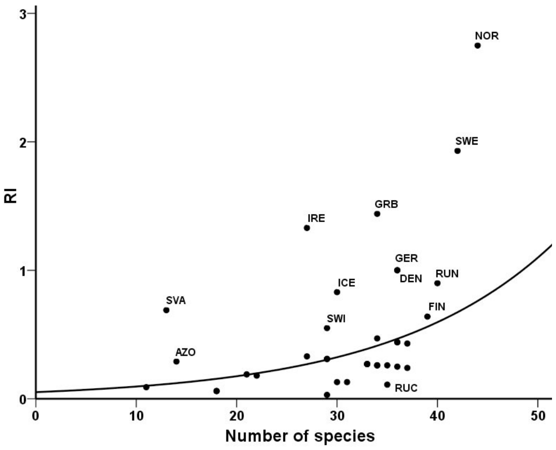

Fig. 8. Relationship between the values of the Rarity Index (RI) for the range restricted and total number of *Sphagnum* species in Europe and Macaronesia. Abbreviations of areas as in Table 1.

related both to a more continental climate and to more uniform topographic conditions.

Some areas do have very few species. With the exception of the Azores archipelago, few *Sphagnum* species occur in Macaronesia. For the Canary Islands this is related to too little precipitation, but for Madeira Island the absence of areas with slow drainage, particularly at higher altitudes, is most likely. Mediterranean areas without high mountains are also species poor, probably mostly due to high summer temperature and few areas with persistent, slow moving water courses.

Although we believe that *Sphagnum* species can be found in all areas in Europe and Macaronesia, we do not expect many species in three of the four areas where we do not have any registered yet. The absence of *Sphagnum* species in Moldova is probably related to poor exploration, but since the area consists mainly of river plains with extensive human land use, not many species will be found. The absence of species in the Baleares and Franz Josef Land is mostly related to climate, the former with a Mediterranean climate without any high mountains and the latter being an arctic desert.

It is also obvious that many areas are less studied than others. Several countries on the Balkan are poorly known bryologically. We expect that at least in Greece (with 9 species reported), Macedonia (11), Albania (1), Montenegro (0), Serbia (18), Bosnia (19) and Croatia (22) the number will increase considerably. We also think the figure for Slovakia (22 reported species) is low considering the varied topography in the area and the much higher number reported from neighboring areas with similar topography.

As for liverworts (Söderström & Séneca, 2008), a better resolution of the distribution data would give a more detailed picture, reflecting the heterogeneity of many areas, as e.g. a differentiation related either to higher elevation and/or oceanic influence in countries as France, Italy, Spain and Portugal.

There is a strong correlation between number of species and number of restricted species in an area. However, this correlation is not linear but rather exponential. This means that when more species are found in a region, a larger proportion of them will be range restricted. This almost follows from the definition of range restricted species as the most widespread occur in a large number of areas and adding species to an area the chance that it is range restricted increases. This trend is so strong among European *Sphagnum* species that it overrides all other trends. Thus the proportion of range restricted species, and even better the RI, is highest in NW Europe, especially in Scandinavia.

According to island biogeography theory number of species is positively correlated with the size of the area. However, even if this relation is significant also in our study, the relation is weak and two areas (Norway and Sweden) have higher number of range restricted species and four areas (Norway, Sweden, Great Britain and Ireland) higher RI than expected from the size alone. Norway and Sweden are also the two most species rich areas and thus Scandinavia appears to be a center for range restricted species in Europe and Macaronesia.

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Diversity and distribution of thelephoroid fungi (Basidiomycota, Thelephorales) in the Sverdlovsk region, Russia

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Abstract: 63 species of the thelephoroid fungi (Basidiomycota) are reported from the Sverdlovsk region (Russia), including fifteen new species for the region. One of them, *Phellodon secretus* is reported for the first time from Russia. This study is based on 931 collections and observations, as well as on literature data. The most frequent species are *Hydnellum aurantiacum*, *H. ferrugineum*, *Sarcodon imbricatus*, *S. squamosus*, *Thelephora palmata*, *Th. terrestris*, *Tomentella bryophila*, *T. ellisii*, *T. ferruginea*, *T. radiosa*, *T. sublilacina*. These species comprise 52% of all observations, but only 17.5% of all species found in the region. Nine species (14.3%) were collected only once, seven species (11.1%) twice, and six species (9.5%) three times, respectively. Some rare species are also infrequently collected in other regions of Russia, viz. *Amaurodon cyaneus*, *A. mustialaensis*, *Hydnellum auratile*, *H. geogenium*, *H. peckii*, *Pseudotomentella flavovirens*, *P. nigra*, *Tomentella galzinii*, *T. viridula*. The highest richness of species was in the southernmost areas of the region, esp. in mixed or broad-leaved forests. Only 4.8% of the total number of the species has been recorded in all biogeographical provinces and 20.6% of species were found only in one province.

Kokkuvõte: Lehternahkiseliste seente (Basidiomycota, Thelephorales) mitmekesisus ja levik Venemaal Sverdlovski oblastis.

Venemaal Sverdlovski oblastis registreeriti 63 seente seltsi lehternahkiselised (Thelephorales) kuuluvat liiki. Liik *Phellodon secretus* on esmasleid Venemaalt. Uuring toetub ühtekokku 931 autori poolt tehtud vaatlusele või kogutud eksemplarile ning lisaks sellele kirjanduse andmetele. Kõige sagedamini esinevad liigid on *Hydnellum aurantiacum*, *H. ferrugineum*, *Sarcodon imbricatus*, *S. squamosus*, *Thelephora palmata*, *Th. terrestris*, *Tomentella bryophila*, *T. ellisii*, *T. ferruginea*, *T. radiosa* ja *T. sublilacina*. Nimetatud liigid moodustavad uuritud eksemplaridest 52%, aga 17,5% kõigist leitud liikidest. Üheksa liiki (14,3%) leiti üks kord, seitse liiki (11,1%) kaks korda ja kuus liiki (9,5%) kolm korda. Nii Sverdlovski oblastis kui ka kogu Venemaal esinevad harva liigid *Amaurodon cyaneus*, *A. mustialaensis*, *Hydnellum auratile*, *H. geogenium*, *H. peckii*, *Pseudotomentella flavovirens*, *P. nigra*, *Tomentella galzinii* ja *T. viridula*. Liigirikkamad olid oblasti lõunapoolsemad laialehised ja segametsad. Ainult 4,8% liikidest on leitud kõigis biogeograafilistes provintsides ja 20,6% liikidest on leitud vaid ühes.

INTRODUCTION

The first records of the thelephoroid fungi in the Sverdlovsk region were published by Stepanova-Kartavenko (1967), who listed 13 species for this region. Kõljalg (1996) studied the diversity of the resupinate thelephoroid fungi in temperate Eurasia including Sverdlovsk region. Also, some additional notes on thelephoroid fungi are included in the recent publications of Shiryaev (2007) and Shiryaev & Stavishenko (2008). In total, 48 species of thelephoroid fungi were known before this sudy.

The main aim of this study was to survey the diversity of thelephoroid fungi in the Sverdlovsk region (Ural, Russia), since no up-to-date lists of the species are available. Even if this list will probably not cover the whole species richness in the study area, it gives basic information for the check-list and red list of the thelephoroid fungi in the Sverdlovsk region. Without such a list it is impossible to make any evaluations of the potentially threatened species. The results of this study, however, are incomplete to make reliable conclusions on the distribution and host preferences of thelephoroid species.

MATERIAL AND METHODS

Sverdlovsk region, with its length of over 700 km from south to north (56°02'–62°01' N) is on the western and eastern slopes of Ural Mountain range which is a bounder between Europe and Asia (Fig. 1). South-western part of region is East-European hills with heights 300–450 m.a.s.l. (Gorchakovsky et al., 1994). The climate is subcontinental with annual precipitation about 600 mm. and mean temperature +1.8 °C. The vegetation is dominated by broad leaved forests (*Quercus robur, Tilia cordata, Acer platanoides, Ulmus laevis, U. scabrum, Corylus avellana, Euonymus verrucosa*) intermixed with conifers

(*Abies sibirica*, *Picea obovata*, *Pinus sylvestris*). Also forest-steppes with xerophilic vegetation on sandy and calcareous soils is found in this area. The Ural Mountains in the southern part of the region are comparatively low, being mostly 250–550 m.a.s.l., and the highest peaks are 600–800 m.a.s.l. The climate is continental, but both the climate and the vegetation are naturally highly dependent on the local relief (altitude, slope orientation). On the western slopes and foothills the precipitation is higher than on the eastern side of the mountains. The western side is covered predominantly with coniferous *Abies sibirica*, *Picea obovata* and few broad-leaved forests with *Tilia cordata*, *Acer platanoides* and the eastern sides are *Pinus sylvestris* dominated forests intermixed with *Larix sibirica*, *Betula* spp. and *Populus tremula*. Northern part is higher, mostly 600–1000 m.a.s.l. and the highest peaks up to 1650 m a.s.l. The climate is cooler and more continental than in southern part. Pine forests are dominated on foothills and spruce with siberian pine (*Pinus sibirica*) on the slopes. The peaks of mountains are covered with alpine vegetation including shrubs of *Juniperus sibirica*, *Pinus sibirica*, *Larix sibirica*, *Betula nana*. Above 1000 m.a.s.l. only mosses and lichens are found. The West Siberian plain in the territory of Sverdlovsk region is 150–300 m.a.s.l. and climate is continental. The area is mostly covered with pine and spruce-birch forests with few *Tilia cordata*, *Ulmus laevis* and *Calluna vulgaris*.

In each collection site all specimens were collected for the further studies except cases where identification was possible on site (species like *Hydnellum ferrugineum*, *Thelephora palmata*, *Th. terrestris*, etc.). However, many sites were visited only once and only in one year.

The list of species below is based mostly on author's collections. Taxa mentioned before this study are marked with citations. The material studied is preserved in the mycological herbarium of the Institute of Plant and Animal, Ural Division of Russian Academy of Science, Ekaterinburg (SVER). For the identifications following keys were used: Nikolaeva, 1961; Corner, 1968; Kõljalg, 1996; Hansen & Knudsen, 1997. The nomenclature of fungi follows *Index Fungorum* (http://www.indexfungorum.org/). Data for the vascular plants, climate and geography are according to Gorchakovsky et al. (1994). The authors of plant species names are

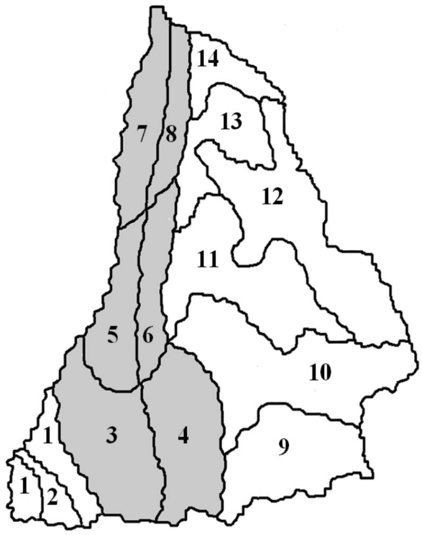

Fig. 1. Biogeographical provinces of Sverdlovsk region.
EAST-EUROPEN HILLS: 1 – P – Perm, 2 – KK – Kungur-Krasnoufimsk
URAL MOUNTAIN RANGE: 3 – Cl – Chusovoy low mountainous, 4 – Bp – Beloyarsk peneplen, 5 – Ks – Kachkanar submountainous, 6 – Nm – Nizhny Tagil middle mountainous, 7 – Kh – Konzhakov high mountainous, 8 – Is – Ivdel submountainous
WEST SIBERIAN PLAIN: 9 – PI – Pishma, 10 – NI – Nitsa, 11 – ST – Sosva-Tura, 12 – PT – Pelym-Tavda, 13 – OU – Ous, 14 – VP – Verch-Pelym
Acronyms (by Gorchakovsky et al., 1994) used in the text.

found in that publication and are not repeated here. In this paper the epithets "spruce" and "*Picea*" refer to *Picea obovata*, "pine" and "*Pinus*" to *Pinus sylvestris*, "birch" to *Betula pendula* or *B. pubescens*, "aspen" or "*Populus*" to *Populus tremula*, "linden" or "*Tilia*" to *Tilia cordata*, "larch" or "*Larix*" to *Larix sibirica*, "oak" or "*Quercus*" to *Quercus robur*, "hazel" or "*Corylus*" to *Corylus avellana* and "fir" or "*Abies*" to *Abies sibirica*, respectively. New fungal species for the region are marked with asterisk (*).

The thelephoroid species are arranged alphabetically and according to the collecting site (biogeographical and administrative area, see fig.1). Rare and species new for Russia are described and illustrated.

RESULTS

Altogether 931 collections and observations were made during this study. In addition more than 400 specimens collected by other collectors were studied as well. Based on these two sets of specimens and observations 63 species of thelephoroid fungi were detected from the Sverdlovsk region. Species found only once, counted 9 (14.3%), twice 9 (14.3%) and three times 17 (27%), respectively. The 35 rare species (1-3 observations) form 55.6% of all the species, whereas 11 most common species (over 10 observations), form 17.5% and the rest (4-9 observations) 26.4%, respectively. The 27 common species comprise 44.4% of all observations.

* Amaurodon cyaneus (Wakef.) Kõljalg & K.H. Larss.
P. Krasnoufimsk area, Sarana, Pudlingovsky, mixed forest: *Picea obovata*, *Pinus sylvestris*, *Acer platanoides*, *Ulmus scabrum*, *Tilia cordata*, *Corylus avellana* on branch of hazel, 11.IX.1977 *A.Sirko* (56°29'N, 57°33'E) SVER(F) 44062.

*Amaurodon mustialaensis (P. Karst.) Kõljalg & K.H. Larss.
P. Krasoufimsk area, "Nizhneirginsk Oak Forest", old grow mixed forest: *Pinus sylvestris, Quercus robur, Acer platanoides, Ulmus scabrum*, on block of oak wood, 15.IX.2000 *A. Shiryaev* (56°50'N, 57°24'E) SVER(F) 44826.

*Amaurodon viridis (Alb. & Schwein.) J. Schröt.
P. Krasnoufimsk area, Garevka, broadleaved forest, on trunk of linden, 10.VIII.2006 *A.Shiryaev* (56°08'N, 57°44'E) SVER(F) 44769; **Cl.** Prigorod area, Visim Nature Reserve, mixed forest: *Abies sibirica*, *Betula pendula*, *Sorbus aucuparia* on branch of fir, 28.VIII.1959 *N.T.Stepanova* (57°24'N, 59°36'E) SVER(F) 43894; Nizhneserginsk area, Nizhnie Sergi, town park, on decaying block of wood *Sorbus aucuparia*, 05.IX.1958 *N.T.Stepanova* (56°38'N, 59°17'E) SVER(F) 43951; **NI.** Alapaevsk area, Mahnevo, on decaying branch of *Populus nigra*, 07.IX.1949 *N.T.Stepanova* (58°26'N, 61°40'E) SVER(F) 43899.

Bankera fuligineoalba (J.C. Schmidt) Coker & Beers ex Pouzar
Wide spread species in the region. **P.** Krasnoufimsk; Achit areas. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Nevyansk; Shalya; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Ekaterinburg surrounds (Stepanova-Kartavenko, 1967); Polevskoi; Sisert areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk; Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Irbit area. **ST.** Gari area. **OU.** Serov area.

Bankera violascens (Alb. & Schwein.) Pouzar
Cl. Prigorod areas, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Ekaterinburg, Nizhne-Isetsk, luxuriant mixed forest: *Picea obovata*, *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, *Tilia cordata*, *Caragana arborescens*, on soil, 08.VIII.1960 *N.T.Stepanova* (56°44'N, 60°43'E) SVER(F) 43800; Sisert area, Dvurechensk, University Biostation, Karasie lake, pine heath forest with some birch bushes, on soil, 05.IX.2003 *A.Shiryaev* (56°33'N, 61°03'E) SVER(F) 44511; **Cl.** Shalya area, Sylva, Shigaevo, close to the brook, herb-rich spruce forest with some pines and hardwoods, on soil, 10.VIII.2007 *A.Shiryaev* (51°21'N, 58°40'E) SVER(F) 44795.

Boletopsis grisea (Peck) Bondartsev & Singer
Cl. Nevyansk area, Tavatui lake, south coast, fairy rich pine heath forest, on sand-stony soil, 02.IX.2003 *A.Shiryaev* (57°05'N, 60°11'E) SVER(F) 44291; Prigorod areas. Visim Natural Reserve (Shiryaev & Stavishenko, 2008). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007). **OU.** Serov area, Vorontsovka, dry pine heath forest, on sandy soil, 22.VIII.1955 *N.T.Stepanova* (59°38'N, 60°12'E) SVER(F) 43990.

Boletopsis leucomelaena (Pers.) Fayod
CI. Nevyansk area, Tavatui lake, eastern coast, spruce-pine heath forest with few *Juniperus communis*, *Tilia cordata*, on stony soil, 11.IX.1960 *N.T.Stepanova* (57°07'N, 60°13'E) SVER(F) 43275; Prigorod areas, Visim Natural Reserve (Shiryaev & Stavishenko, 2008); Nizhneserginsk area, Natural Park "Olenyi ruchyi", mixed forest: *Picea obovata*, *Abies sibirica*, *Betula pendula*, *Tilia cordata*, on calcareous soil, 04.IX.2004 *A.Shiryaev* (56°26'N, 59°20'E) SVER(F) 44294. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

Hydnellum aurantiacum (Batsch.) P. Karst.
Wide spread species in the region. **P.** Krasnoufimsk; Arti areas. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Nevyansk; Shalya; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Polevskoi; Sisert areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk; Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim area (Stepanova-Kartavenko, 1967); Talica area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Irbit area. **ST.** Verkhoturie area. **ST.** Gari area. **OU.** Serov area. **VP.** Ivdel area.

* Hydnellum auratile (Britzelm.) Maas Geest.
CI. Nizhneserginsk area, Nature Park "Olenyi ruchyi", mixed forest: *Pinus sylvestris*, *Juniperus communis*, *Tilia cordata*, *Betula pendula*, *Sorbus aucuparia*, on calcareous soil, 1.X.2000 *A.Shiryaev* (56°26'N, 59°20'E) SVER(F) 44563.

Hydnellum caeruleum (Hornem.) P. Karst.
Syn. *H. compactum* (Pers.) P. Karst.
Wide spread species in the region. **P.** Krasnoufimsk; Achit areas. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Nevyansk; Shalya; Prigorod area, Visim Nature Reserve

(Shiryaev & Stavishenko, 2008). **Bp.** Polevskoi; Sisert areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk; Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim area (Stepanova-Kartavenko, 1967), Talica area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **ST.** Verkhoturie area. **OU.** Serov area.

HYDNELLUM CONCRESCENS (Pers.) Banker
Syn. *H. zonatum* (Batsch) P. Karst.
CI. Nizhneserginsk area, Natural park "Olenyi ruchyi", coniferous forest: *Pinus sylvestris*, *Picea obovata*, *Juniperus communis* with few *Tilia cordata*, *Sorbus aucuparia*, on soil, 1.X.2000 *A.Shiryaev* (56°26'N, 59°20'E) SVER(F) 44561; ibid. (Stepanova-Kartavenko, 1967); Shalya area, Sylva, Shigaevo, southern slope of the hill, coniferous forest: *Pinus sylvestris* with few *Betula pendula*, *Sorbus aucuparia*, on soil, 12.VIII.1966 *N.T.Stepanova* (51°21'N, 58°40'E) SVER (F) 43270; Nevyansk area (Stepanova-Kartavenko, 1967). **Bp.** Beloyarsk (Stepanova-Kartavenko, 1967); **PI.** Talica area, National park "Pripishminsk Bory" (Shiryaev, 2007).

HYDNELLUM FERRUGINEUM (Fr.) P. Karst.
Wide spread species in the region. **P.** Arti area. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Nevyansk; Shalya; Prigorod area, Visim Nature Reserve. **Bp.** Polevskoi; Sisert areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk; Ivdel areas. **Is.** Ivdel area (Stepanova-Kartavenko, 1967). **PI.** Tugulim area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **ST.** Verkhoturie area. **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **PT.** Gari area. **OU.** Serov area.

*HYDNELLUM GEOGENIUM (Fr.) Banker
P. Krasnoufimsk area, Sarana, Petuhovka, mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Acer platanoides*, *Corylus avellana*, on dry soil, 20.VIII.2006 *A.Shiryaev* (56°28'N, 57°37'E) SVER(F) 44381. **CI.** Nizhneserginsk area, Natural park "Olenyi ruchyi", on the open meadows, grass-herb *Picea obovata* forest with *Pinus sylvestris*, *Populus tremula*, *Tilia cordata*, somewhat calcareous ground, 01.IX.2001 *A.Shiryaev* (56°26'N, 59°20'E) SVER(F) 44476.

*HYDNELLUM PECKII Banker
Syn. *H. diabolus* Banker
KK. Krasnoufimsk area, Kriulino, dry coniferous forest: *Pinus sylvestris*, *Picea obovata* with few *Betula pendula*, *Ulmus scabrum*, on sandy-stone soil, 15.IX.1973 *A.Sirko* (56°35'N 57°48'E) SVER (F) 43768. **CI.** Achit area, Korzunovka, mixed forest: *Abies sibirica*, *Picea obovata*, *Acer platanoides*, *Betula pendula*, on soil, 3.IX.2004 *A.Shiryaev* (56°55'N, 58°11'E) SVER(F) 44851. **PI.** Tugulim area, National park "Pripishmisk Bory", Bahmetskoe bog, dry pine heath forest with small eskers, on sandy soil, 30.09.2002 *A.Shiryaev* (57°18'N, 64°28'E) SVER(F) 44562).

HYDNELLUM SCROBICULATUM (Fr.) P. Karst.
P. Krasnoufimsk area, Ayaz, mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Quercus robur*, on reach soil, 10.IX.1951 *N.T.Stepanova* (56°05'N, 57°34'E) SVER(F) 43117. **CI.** Shalya area, Sylva, Shigaevo, southern slope of the hill, coniferous forest: *Abies sibirica*, *Pinus sylvestris* with few *Betula pendula*, *Sorbus aucuparia*, on soil, 10.VIII.2007 *A.Shiryaev* (51°21'N, 58°40'E) SVER(F) 44847; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008).

HYDNELLUM SUAVEOLENS (Scop.) P. Karst.
P. Krasnoufimsk area, Ust-Bugalish, mixed forest: *Picea obovata*, *Quercus robur*, *Populus tremula*, on reach soil, 21.VIII.1996 *A.Shiryaev* (56°16'N, 57°51'E) SVER(F) 44349. **Cl.** Revda area (Stepanova-Kartavenko, 1967); Prigorod areas, Visim Natural Reserve (Shiryaev & Stavishenko, 2008). **Kh.** Severouralsk area, Cumba Mnt., coniferous forest: *Picea obovata*, *Pinus sylvestris* with few *Betula pendula*, on stony soil, 25.VII.1946 *Z.Demidova* (60°09'N, 59°46'E) SVER(F) 43000. **PI.** Tugulim area (Stepanova-Kartavenko, 1967). **NI.** Tavda area, Oshmarka, spruce forest, on sandy soil, 27.08.1973 *N.T. Kartavenko* (58°11'N, 65°00'E) SVER(F) 43067.

PHELLODON CONFLUENS (Pers.) Pouzar
P. Krasnoufimsk area, Nizhneirginsk oak forest, mixed forest: *Quercus robur*, *Pinus sylvestris*, *Acer platanoides*, on reach soil, 19.VIII.1996 *A.Shiryaev* (56°50'N, 57°24'E) SVER(F) 44682; **CI.** Nizhnesergi area, Natural park "Olenyi ruchi", mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Tilia cordata*, *Acer platanoides*, on soil, 03.IX.1973 *A.Sirko* (56°26'N, 59°20'E) SVER(F) 43181; Prigorod areas, Visim Natural Reserve (Shiryaev & Stavishenko, 2008). **PI.** Tugulim area, National Park "Pripishmisk Bory" (Shiryaev, 2007).

PHELLODON MELALEUCUS (Sw. ex Fr.) P. Karst.
Syn. *P.connatus* (Schultz.: Fr.) P. Karst.
P. Krasnoufimsk area, Nizhneirginsk oak forest, mixed forest: *Quercus robur*, *Pinus sylvestris*, on reach soil, 19.VIII.1996 *A.Shiryaev* (56°50'N, 57°24'E) SVER(F) 44402. **KK.** Arti area, Petuhovka, mixed forest: *Pinus sylvestris*, *Abies sibirica*, *Populus tremula*, *Betula pendula*, *Acer platanoides,* on soil, 13.VIII.2002 *A.Shiryaev* (56°23'N, 58°18'E) SVER(F) 44627. **Cl.** Prigorod area, Visim Natural Reserve (Shiryaev & Stavishenko, 2008). **PI.** Kamensk area, Sipaevskoe, mixed *Pinus-Betula* forest-steep, on sandy soil, 29.VIII.1997 *A.Shiryaev* (56°15'N, 61°57'E) SVER(F) 44272; Tugulim area, National Park "Pripishmisk Bory" (Shiryaev, 2007).

PHELLODON NIGER (Fr.) P. Karst.
Cl. Shalya area, Sylva, Shigaevo, mixed forest: *Picea obovata*, *Betula pendula*, *Tilia cordata*, *Sambucus sibirica*, on soil, 10.VIII.2007 *A.Shiryaev* (57°21'N, 58°40'E) SVER(F) 44197; Achit area, Korzunovka,

mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Ulmus scabrum*, on soil, 23.VIII.1965 *N.T.Stepanova* (56°54'N, 58°13'E) SVER(F) 43009; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert area, Dvurechensk, University Biostation, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, *Sorbus aucuparia*, on soil, 04.IX.2003 *A.Shiryaev* (56°35'N, 61°02'E) SVER(F) 44192.

* PHELLODON SECRETUS Niemelä & Kinnunen
New to Russia.

Fruitbodies up to 3.5 cm high and 4 cm in diam., small and fragile, color whitish-ash to mouse-grey, lower surface whitish-pale-gray. Context brownish-grey in KOH. Spines are sharp, regular to 1.2 mm long, pale-grey. Stipe irregular, fragile, very thin, 0.3–2.6 mm in diam. and 6–15 mm long, one or more stipes, mouse-black.

Hyphal system monomytic, CB+, KOH-. Context hyphae with few small amyloid granules, thin-walled, 2.8–4.4(–5.0) μm in diam., hyphae olivaceous in KOH. Stipe hyphae slightly thin-walled, brownish, 3.5–5.3(–5.8) μm in diam. Basidia clavate, 4-spored, without basal clamp, 25–38×5.0–5.8 μm; basidioles clavate, (18–)21–30×4.6–5.2(–5.5) μm. Spores globose, with distinct spines and apiculus, hyaline, thin-walled, guttulate, IKI–, KOH–, 3.0–3.4(–3.8) ×2.5–3.0(–3.4) μm, L=3.3 μm, W=2.9, Q=1.12 (SVER(F) 44622).

The Ural's specimens differ slightly from the description *P. secretus* of Niemelä et al. (2003). In the Finnish material the spore and hyphal size are slightly smaller, but that's showing a rule where mentioned bigger size of the northern and alpine Urals fungal specimens (Stepanova-Kartavenko, 1967) (Fig. 2). However, the differences are very small.

This is rare species, reported only from Finland (Niemelä et al., 2003), but perhaps not rare in the middle and northern boreal pine woodlands of Europe, since also collected from Archangelsk region, Russia (unpubl. data, SVER(F) 43891, *coll. A.Sirko*).

Is. Ivdel area, Ushma, eastern slope of the sandy hill with dry pine forest with few *Betula pendula* and *Juniperus communis*, on soil with needles and woody pieces, 01.IX.1949 *N.T.Stepanova* (61°20'N, 61°01'E) SVER(F) 43092. **OU.** Ivdel area, Ous, heath mixed forest: *Pinus sylvestris*, *P. sibirica*, *Picea obovata*, *Betula pendula*, *Alnus incana*, on soil in the space between fallen pine tree and ground, 15.IX.2000 *A.Shiryaev* (60°49'N, 61°29'E) SVER(F) 44622.

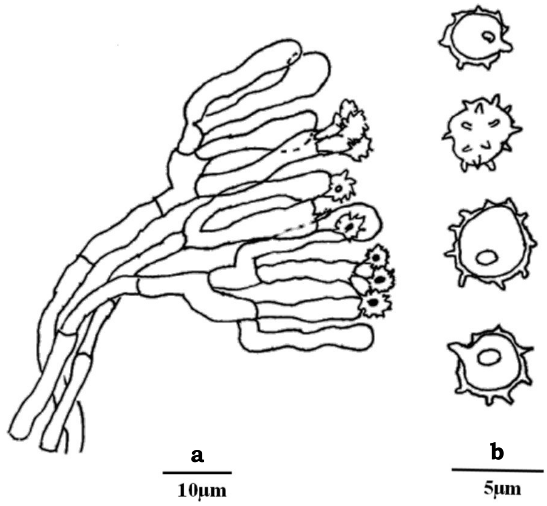

Fig. 2. Hymenial cells (a) with spores (b) of *Phellodon secretus* (SVER(F) 44622).

PHELLODON TOMENTOSUS (L.) Baker
Cl. Shalya area, Sylva, Shigaevo, coniferous forest: *Pinus sylvestris*, *Abies sibirica*, on soil, 1.IX.1997 *A.Shiryaev* (57°21'N, 58°40'E) SVER(F) 44188; Prigorod area, Visim Natural Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert area (Stepanova-Kartavenko, 1967). **Pl.** Tugulim area, Nature Park "Pripishmisk Bory" (Stepanova-Kartavenko, 1967; Shiryaev, 2007). **Nl.** Tavda area, Pokrovka, dry pine forest, on sandy soil, 12.IX.1957 *N.T.Stepanova* (58°06'N, 65°27'E) SVER(F) 43241.

PSEUDOTOMENTELLA FLAVOVIRENS (Höhn. & Litsch.) Svrček
Cl. Nizhneserginsk area, Nature Park "Olenyi ruchyi", mixed luxuriant forest: *Abies sibirica*, *Betula pendula*, *Tilia cordata*, *Sorbus aucuparia*, *Sambucus sibirica*, on birch wood, 3.IX.2004 *A.Shiryaev* (56°29'N, 59°18'E) SVER(F) 43928; Achit area, Korzunovka, mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Ulmus scabrum*, on fallen branch of pine, 23.VIII.1965 *N.T.Stepanova* (56°54'N, 58°13'E) SVER(F) 43007; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008).

PSEUDOTOMENTELLA MUCIDULA (P. Karst.) Svrček
P. Krasnoufimsk area, Sarana, mixed forest: *Abies sibirica*, *Populus tremula*, *Betula pendula*, *Ulmus scabrum*, *Tilia cordata*, on wood of fir, 15.VIII.1977 *N.T.Stepanova* (56°29'N, 57°41'E) SVER(F) 43561. **Cl.** Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Kh.** Severouralsk area, southern slope of the Cumba Mnt., coniferous forest: *Picea obovata*, *Pinus sibirica*, on dead branch of spruce,

04.IX.1954 *A.Sirko* (60°08'N, 59°38'E) SVER(F) 43029.

*PSEUDOTOMENTELLA NIGRA (Höhn. & Litsch.) Svrček

Cl. Nevyansk area, southern cost of Tavatui lake, mixed forest: *Picea obovata*, *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Juniperus communis*, on decayed trunk of pine, 15.IX.2000 *A.Shiryaev* (57°05'N, 60°10'E) SVER(F) 44170.

PSEUDOTOMENTELLA TRISTIS (P. Karst.) M. J. Larsen

Cl. Nevyansk area, southern coast of Tavatui lake, mixed forest: *Picea obovata*, *Pinus sylvestris*, *Betula pendula*, *Juniperus communis*, on decayed trunk of *Juniperus*, 12.IX.1972 *N.T.Stepanova* (57°05'N, 60°10'E) SVER(F) 43326; Prigorod areas, Visim Natural Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert area, Verkh Sisert, mixed moisture forest: *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, *Sorbus aucuparia*, on aspen trunk, VII.1968 *N.T.Stepanova* (56°36'N, 61°03'E) SVER(F) 44102. **PI.** Tugulim area, National Park "Pripishmisk Bory" (Shiryaev, 2007).

SARCODON FENNICUS (P. Karst.) P. Karst.

Cl. Achit area, Korzunovka, mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Ulmus scabrum*, on soil, 21.VIII.1965 *N.T.Stepanova* (56°54'N, 58°13'E) SVER(F) 43006; Prigorod areas, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **PI.** Tugulim area, National Park "Pripishmisk Bory" (Shiryaev, 2007).

SARCODON IMBRICATUS (L.) P. Karst.

P. Krasnoufimsk area, Chernaya rechka, mixed forest: *Picea obovata*, *Quercus robur*, *Acer platanoides*, *Corylus avellana*, on reach soil, 01.IX.1996 *A.Shiryaev* (56°32'N, 57°26'E) SVER(F) 44581. **Cl.** Achit area, Korzunovka, luxuriant mixed forest: *Abies sibirica*, *Picea obovata*, *Tilia cordata*, *Populus tremula*, *Ulmus scabrum*, on soil, 01.IX.2004 *A.Shiryaev* (56°54'N, 58°16'E) SVER(F) 44295; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert area, Dvurechensk, University Biostation, herb-reach mixed forest: *Betula pendula*, *Sorbus aucuparia*, *Pinus sylvestris*, *Populus tremula*, on soil, 17.VIII.1983 *I.Mezentseva* (56°35'N, 61°02'E) SVER(F) 43995. **Kh.** Ivdel area (Stepanova-Kartavenko, 1967). **PI.** Tugulim area, National park "Pripishminsk Bory" (Shiryaev, 2007)

SARCODON LEUCOPUS (Pers.) Maas Geest. & Nannf.

Syn. *S. laevigatus* sensu auct.

P. Krasnoufimsk area, Chernaya rechka, herb-reach mixed forest: *Abies sibirica*, *Picea obovata*, *Pinus sylvestris*, *Ulmus laevis*, *Acer platanoides*, *Populus tremula*, on soil, 12.VIII.2006 *A.Shiryaev* (56°32'N, 57°26'E) SVER(F) 44674. **Cl.** Nevyansk area, southern cost of Tavatui lake, coniferous forest: *Pinus sylvestris*, *Juniperus communis*, on soil, 12.IX.1972 *N.T.Stepanova* (57°05'N, 60°10'E) SVER(F) 43328; ibid., eastern cost, coniferous forest: *Pinus sylvestris*, *Picea obovata*, *Juniperus communis*, on soil, 02.IX.1965 *N.T.Stepanova* (57°07'N, 60°13'E) SVER(F) 43330. **PI.** Tugulim area (Stepanova-Kartavenko, 1967); Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **Is.** Ivdel area (Stepanova-Kartavenko, 1967).

*SARCODON LUNDELLII Maas Geest. & Nannf.

Syn. *Hydnum badium* Pers. ss. auct., *H. subsquamosum* Fr. ss. auct.

Cl. Verchnepishminsk area, Iset, Chertovo gorodishe, dry pine forest with *Betula*, on soil, 12.IX.1965 *L.Kazantseva* (56°56'N, 60°20'E) SVER(F) 43016; Nevyansk area, Tavatui lake, southern coast, herb-reach pine forest with *Juniperus communis*, on sand-stony soil, 28.VIII.1965 *A.Sirko* (57°05'N, 60°10'E) SVER(F) 43018; ibid., eastern coast, dry pine forest with *Vaccinium vitis-idaea*, sand-stony soil, 27.VIII.1965 *A.Sirko* (57°07'N, 60°13'E) SVER(F) 43019.

*SARCODON SCABRIPES (Peck) Banker

Cl. Prigorod area, Visim Natural Reserve, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Sorbus aucuparia*, on soil, 09.IX.2000 *A.Shiryaev* (57°27'N, 59°33'E) SVER(F) 44015. **PI.** Tugulim area, National Park "Pripishminsk Bory", coniferous forest: *Pinus sylvestris*, *P. sibirica* with few *Betula pendula*, *Populus tremula*, *Sorbus sibirica*, on sand-stony soil, 29.IX.2002 *A.Shiryaev* (57°17'N, 64°30'E) SVER(F) 44027.

SARCODON SCABROSUS (Fr.) P. Karst.

Cl. Nizhneserginsk area, National Park "Olenyi ruchyi", mixed forest: *Abies sibirica*, *Tilia cordata*, *Sorbus aucuparia*, on soil, 01.IX.2001 *A.Shiryaev* (56°32'N, 59°18'E) SVER(F) 44813; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008).

SARCODON SQUAMOSUS (Schaeff.) Quel.

P. Krasnoufimsk area, Sarana, Petukhovka, dry grass-herb forest: *Picea obovata*, *Acer platanoides*, *Ulmus scabrum*, *Populus tremula*, *Corylus avellana*, on reach soil, 02.X.1966 *A.Sirko* (56°28'N, 57°35'E) SVER(F) 43822. **Cl.** Prigorod area, Visim Natural Reserve, herb-reach pine forest, on soil, 19.VIII.2000 *A.Shiryaev* (57°28'N, 59°31'E) SVER(F) 44069; Nizhneserginsk area, Nature Park "Olenyi ruchyi", half-open dry pine heath forest, on dry soil, 04.IX.2004 *A.Shiryaev* (56°29'N, 59°16'E) SVER(F) 44391; Nevyansk area, Tavatui lake, southern coast, dry pine forest with *Betula pendula*, *Juniperus communis*, on stony soil, 03.IX.1965 *A.Sirko* (57°28'N, 59°31'E) SVER(F) 44069. **Bp.** Polevskoy area, Kenchurka, dry pine woodland, rocky hilltop, on soil, *I.Kazantseva* 11.IX.1956 (56°16'N, 59°55'E) SVER(F) 44396. **PI.** Kamensk area, Okulovskoye, mixed forest-steep: *Pinus sylvestris*, *Betula pendula*, *Sorbus aucuparia*, *Ulmus minor*, on sandy soil, 10.IX.2007 *A.Shiryaev* (56°10'N, 61°58'E) SVER(F) 44832; Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

SARCODON VERSIPELLIS (Fr.) Nikol.
Cl. Nizhneserginsk area, National Park "Olenyi ruchyi", mixed forest: *Abies sibirica*, *Picea obovata*, *Tilia cordata*, *Betula pendula*, *Sorbus aucuparia*, on soil, 04.IX.2004 *A.Shiryaev* (56°21'N, 59°22'E) SVER(F) 44331; Shalya area, Sylva, Shigaevo, rich spruce grass-herb forest with *Ulmus scabrum*, *Tilia cordata*, on soil, 01.IX.1997 *A.Shiryaev* (57°21'N, 58°40'E) SVER(F) 44136. **PI.** Tugulim area, National park "Pripishminsk Bory" (Shiryaev, 2007).

THELEPHORA ANTHOCEPHALA (Bull.) Fr.
Cl. Prigorod area, Visim Nature reserve, reach-herb mixed forest: *Picea obovata*, *Betula pendula*, *Sorbus aucuparia*, *Tilia cordata*, on soil, 01.IX.1997 *A.Shiryaev* (57°21'N, 59°29'E) SVER(F) 44183. **Bp.** Ekaterinburg, Elmash city park, mixed forest: *Pinus sylvestris*, *Ulmus laevis*, *Padus maacki*, *Acer platanoides*, on soil, 19.VIII.1959 *N.T.Stepanova* (56°53'N, 60°40'E) SVER(F) 43368. **PI.** Talica area, National park "Pripishminsk Bory" (Shiryaev, 2007); Tugulim area, Fominskoye, Gurino lake, village's garden, on soil, *N.T.Stepanova* (57°15'N, 64°21'E) SVER(F) 43219.

THELEPHORA CARYOPHYLLEA (Schaeff.) Pers.
Cl. Visim Nature Reserve in Prigorod areas (Shiryaev & Stavishenko, 2008). **Is.** Ivdel area, Pershino, heath pine forest, on sandy soil, 09.VIII.2007 *A.Shiryaev* (60°40'N, 60°31'E) SVER(F) 44542. **PI.** Talica area, National Park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area, Machnevo, pine forest, on sandy soil and branches, 07.IX.1977 *N.T.Stepanova* (58°26'N, 61°52'E) SVER(F) 43973.

THELEPHORA PALMATA (Scop.) Fr.
Wide spread species in the region. **P.** Krasnoufimsk; Achit areas. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Nevyansk; Shalya; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Polevskoi; Sisert areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk; Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim area (Stepanova-Kartavenko, 1967), Talica area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **ST.** Verkhoturie area. **PT.** Garia area. **OU.** Serov area. **VP.** Ivdela area.

THELEPHORA PENICILLATA (Pers.) Fr.
Syn. *T. mollissima* Pers.
P. Krasnoufimsk area, Ayaz, deciduous forest: *Betula pendula*, *Acer platanoides*, *Quercus robur*, *Tilia cordata*, *Populus tremula*, on twigs of oak, 20.VIII.1945 *N.T.Stepanova* (56°03'N, 57°37'E) SVER(F) 43001. **Bp.** Ekaterinburg, Botanical garden, on base of *Malus* sp., 28.VIII.1949 *N.T.Kartavenko* (56°47'N, 60°36'E) SVER(F) 43000. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

THELEPHORA TERRESTRIS Ehrn.
Wide spread species in the region. **P.** Krasnoufimsk; Arti areas. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Shalya; Nevyansk (Stepanova-Kartavenko, 1967); Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Polevskoi; Sisert; Beloyarsk area (Stepanova-Kartavenko, 1967). **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk; Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim (Stepanova-Kartavenko, 1967), Talica area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **ST.** Verkhoturie area. **PT.** Garia area. **OU.** Serov area. **VP.** Ivdel area.

TOMENTELLA ATRAMENTARIA Rostr.
P. Krasnoufimsk area, Sarana, mixed luxuriant forest: *Abies sibirica*, *Ulmus laevis*, *Tilia cordata*, *Populus tremula*, on rotted branch of fir, 03.IX.1945 *Z.Demidova* (56°30'N, 57°40'E) SVER(F) 43014. **Cl.** Pervouralsk, pine dominated forest, on trunk of birch, 19.VIII.1951 *N.T.Kartavenko* (56°55'N, 59°51'E) SVER(F) 43210; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **OU.** Ivdel area, Ous, mixed forest: *Pinus sylvestris*, *Picea obovata*, *Betula pendula*, *Salix* sp., on decaying log of pine, 10.VIII.2007 *A.Shiryaev* (60°50'N, 61°28'E) SVER(F) 44038. **PI.** Kamensk area, Okulovskoye, *Betula-Populus* forest-steep, on rotted branch of *Cotoneaster melanocarpa*, 09.IX.1970 *A.Sirko* (56°08'N, 61°59'E) SVER(F) 43620; Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007); Talica area, "Pripishminsk Bory", coniferous forest: *Pinus sylvestris*, *Juniperus communis*, on trunk of pine, 16.IX.1952 *N.T.Kartavenko* (56°58'N, 63°43'E) SVER(F) 43286.

TOMENTELLA BADIA (Link) Stalpers
Cl. Nizhneserginsk area, Natural park "Olenyi ruchyi", coniferous forest: *Abies sibirica*, *Pinus sylvestris*, on dead trunk of *Juniperus*, 10.IX.1957 *N.T.Kartavenko* (56°25'N, 59°19'E) SVER(F) 43389; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert area, Dvurechensk, Biostation of University, Carasye lake, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, *Salix* spp., on decaying branch of aspen, 29.VI.1994 *V.Mukhin* (56°32'N, 61°03'E) SVER(F) 44582. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLA BRYOPHILA (Pers.) M.J. Larsen
P. Krasnoufimsk area, Sarana, slope to Ufa river, broad-leaved forest: *Acer platanoides*, *Tilia cordata*, *Populus tremula*, *Corylus avellana*, on dead branch of hazel, 21.IX.1945 *F.Solovyev* (56°29'N, 57°41'E) SVER(F) 43022. **Cl.** Nizhneserginsk area, Natural park "Olenyi ruchyi", coniferous forest: *Abies sibirica*, *Pinus sylvestris*, on dead trunk of fir, 10.IX.1957 *N.T.Kartavenko* (56°25'N, 59°19'E) SVER(F) 43390; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Nm.** Verhnyaya Salda, slope to Isinsky water reservoir, on dead branch of *Sorbus*

aucuparia 22.IX.1969 *I.Kazantseva* (57°58'N, 60°30'E) SVER(F) 43743. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLA CINERASCENS (P. Karst.) Höhn. & Litsch.
P. Krasnoufimsk area, Nizhneirginsk oak forest, mixed forest: *Quercus robur*, *Pinus sylvestris*, *Tilia cordata*, *Betula pendula*, on rotted trunk of oak, 22.VIII.1960 *N.T.Stepanova* (56°50'N, 57°25'E) SVER(F) 43048. **Cl.** Shalya area, Sylva, Shigaevo, top of the hill, mixed luxuriant forest: *Abies sibirica*, *Betula pendula*, *Ulmus laevis*, *Tilia cordata*, *Sorbus aucuparia*, on dead branch of elm, 26.IX.2000 *A.Shiryaev* (57°22'N, 58°43'E) SVER(F) 44850; Prigorod areas, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Ekaterinburg (Stepanova-Kartavenko, 1967). **PI.** Tugulim area (Stepanova-Kartavenko, 1967), Talica area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLA COERULEA (Bres.) Höhn. & Litsch.
Cl. Nizhneserginsk area, Natural park „Olenyi ruchyi", mixed forest: *Abies sibirica*, *Pinus sylvestris*, *Tilia cordata*, *Populus tremula*, on dead trunk of pine, 10.IX.1957 *N.T.Kartavenko* (56°25'N, 59°19'E) SVER(F) 43387; Prigorod areas, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Ks.** Kachkanar area, southern slope of Kachkanar mnt., *Picea* forest, on dead trunk of spruce, 26.VIII.1974 *A.Sirko* (58°46'N, 59°22'E) SVER(F) 43558.

*TOMENTELLA CRINALIS (Fr.) M.J. Larsen
Cl. Shalya area, Sylva, foothill, mixed luxuriant forest: *Abies sibirica*, *Pinus sylvestris*, *Betula pendula*, *Ulmus laevis*, *Tilia cordata*, on dead branch of birch, 01.IX.1957 *Z.Demidova* (57°22'N, 58°43'E) SVER(F) 43047. **Nm.** Serov area, Shaytanka, mixed forest: *Picea obovata*, *Betula pendula*, on dead wood of aspen, IX.1944 *N.T.Kartavenko* (59°25'N, 60°00'E) SVER(F) 43726.

TOMENTELLA ELLISII (Sacc.) Jülich & Stalpers
Wide spread species in the region. **P.** Arti area. **KK.** Krasnoufimsk area. **Cl.** Nizhneserginsk; Shalya; Nevyansk; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert; Beloyarsk areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Sverouralsk; Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **ST.** Verkhoturie area. **OU.** Serov area.

TOMENTELLA FERRUGINEA (Pers.) Pat.
Syn. *T. fusca* (Pers.) J. Schröt.
Wide spread species in the region. **P.** Arti area. **KK.** Krasnoufimsk area. **Cl.** Shalya; Nizhneserginsk (Stepanova-Kartavenko, 1967); Nevyansk (Stepanova-Kartavenko, 1967); Prigorod area, Visim Nature Reserve (Stepanova-Kartavenko, 1967; Shiryaev & Stavishenko, 2008). **Bp.** Sisert; Beloyarsk areas. **Ks.** Kachkanar area. **Nm.** Verkh Salda. **Kh.** Severouralsk (Stepanova-Kartavenko, 1967); Ivdel areas. **Is.** Ivdel area. **PI.** Tugulim area, Nature park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Alapaevsk area (Stepanova-Kartavenko, 1967). **ST.** Verkhoturie area. **OU.** Serov area.

TOMENTELLA FIBROSA (Berk. & M.A. Curtis) Kõljalg
Cl. Shalya area, Natural park "Chusovaya River", 3 km north from Chusovoye, herb-reach mixed forest: *Picea abies*, *Betula pendula*, *Tilia cordata*, on rotted trunk of spruce, 10.VIII.2007 *A.Shiryaev* (57°21'N, 59°12'E) SVER(F) 44800; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007). **OU.** Ivdel area, Ous, slope to river, mixed forest: *Picea obovata*, *Pinus sibirica*, *Betula pendula*, *Sorbus sibirica*, on rotted petioles of *Sorbus*, 10.VIII.2006 *A.Shiryaev* (60°50'N, 61°28'E) SVER(F) 44717.

TOMENTELLA FUSCOCINEREA (Pers.) Donk
P. Besert area, Klenovsky, slope to Bisert river, on fallen branch of *Populus nigra*, IX.1944 *F.Solovyev* (56°50'N, 58°40'E) SVER(F) 43019. **Kh.** Karpinsk area, Konzhakovsky Kamen Mnt., eastern slope, coniferous forest: *Larix sibirica*, *Pinus sibirica*, *Picea obovata*, on dead trunk of larch, VIII. 1952 *N.T.Stepanova* (59°38'N, 59°19'E) SVER(F) 43258. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

*TOMENTELLA GALZINII Bourdot
Cl. Achit area, Korzunovka, herb-reach forest: *Abies sibirica*, *Tilia cordata*, *Populus tremula*, on fallen tree of fir, IX.1960 *N.T.Stepanova* (56°55'N, 58°15'E) SVER(F) 43451; Nizhneserginsk area, Natural Park "Olenyi ruchyi", mixed forest: *Pinus sylvestris*, *Tilia cordata*, *Betula pendula*, *Sorbus aucuparia*, on fallen trunk of aspen, 01.IX.1957 *N.T.Stepanova* (56°26'N, 59°20'E) SVER(F) 43593.

TOMENTELLA LAPIDA (Pers.) Stalpers
P. Krasnoufimsk area, Sarana, slope to Ufa river, broad-leaved forest: *Acer platanoides*, *Tilia cordata*, *Populus tremula*, *Corylus avellana*, on dead branch of hazel, 17.IX.1997 *A.Shiryaev* (56°29'N, 57°41'E) SVER(F) 43021. **Cl.** Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sisert area, Dvurechensk, Biostation University, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, on decaying branch of birch, 25.VII.1998 *E.Brindina* (56°32'N, 61°03'E) SVER(F) 44581. **Kh.** Karpinsk area, Konzhakovsky Kamen Mnt., southern slope, coniferous forest: *Picea obovata*, *Pinus sibirica*, *Larix sibirica*, on decaying trunk of Siberian pine, VIII.1948, *N.T.Stepanova* (59°40'N, 59°23'E) SVER(F) 43271. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLA LATERITIA Pat.
P. Krasnoufimsk area, Nizhneirginsk oak forest, luxuriant herb-reach forest: *Pinus sylvestris*, *Quercus robur*, *Abies sibirica*, *Acer platanoides*, on dead brunch of hazel, 19.VIII.1996 *A.Shiryaev* (56°50'N, 57°24'E) SVER(F) 44403. **Cl.** Prigorod area, Visim Nature

Reserve (Shiryaev & Stavishenko, 2008). **Kh.** Karpinsk area (Kõljalg, 1996). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLA LILACINOGRISEA Wakef.
P. Krasnoufimsk area, Ust-Bugalish, mixed forest: *Picea obovata*, *Quercus robur*, *Populus tremula*, on branch of oak, 21.VIII.1996 *A.Shiryaev* (56°16'N, 57°51'E) SVER(F) 44348. **Cl.** Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Kh.** Ivdel area, Vizhai, mixed forest: *Picea obovata*, *Pinus sylvestris*, *Betula pendula*, on dead branch of pine, VIII.1949 *N.T.Stepanova* (61°17'N, 59°42'E) SVER(F) 43562. **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007). **PT.** Gari area (Kõljalg, 1996).

*TOMENTELLA PILOSA (Burt) Bourdot & Galzin
P. Krasnoufimsk area, Chernaya rechka, herb-reach luxuriant forest: *Abies sibirica*, *Quercus robur*, *Acer platanoides*, *Corylus avellana*, on decaying branch of hazel, 01.IX.1996 *A.Shiryaev* (56°32'N, 57°26'E) SVER(F) 44583. **Cl.** Nevyansk area, southern coast of Tavatui lake, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Sorbus aucuparia*, on decayed trunk of linden, 12.IX.1972 *N.T.Stepanova* (57°05'N, 60°10'E) SVER(F) 43327.

*TOMENTELLA PUNICEA (Alb. & Schwein.) J. Schröt.
P. Krasnoufimsk area, Nizhneirginsk oak forest, herb-reach luxuriant forest: *Quercus robur*, *Pinus sylvestris*, *Populus tremula*, *Acer platanoides*, *Corylus avellana*, *Euonymus verrucosa*, on dead branch of hazel, 19.VIII.1996 *A.Shiryaev* (56°50'N, 57°24'E) SVER(F) 44403; ibid., Ayaz, mixed forest: *Abies sibirica*, *Quercus robur*, on decaying trunk of aspen, 10.VIII.1960 *N.T.Stepanova* (56°05'N, 57°34'E) SVER(F) 43118.

TOMENTELLA RADIOSA (P. Karst.) Rick
Cl. Achit area, Korzunovka, mixed forest: *Abies sibirica*, *Picea obovata*, *Acer platanoides*, *Betula pendula*, on decaying trunk of spruce, 3.IX.2004 *A.Shiryaev* (56°55'N, 58°11'E) SVER(F) 44852. Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Kh.** Severouralsk area, southern slope of the Cumba Mnt., coniferous forest: *Picea obovata*, *Pinus sibirica*, on dead branch of Siberian pine, 04.IX.1954 *A.Sirko* (60°08'N, 59°38'E) SVER(F) 43030; Karpinsk area (Kõljalg, 1996). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLA STUPOSA (Link) Stalpers
Syn. *T. bresadolae* (Brinkm.) Bourdot et Galzin
P. Krasnoufimsk area, Chernaya rechka, herb-reach luxuriant forest: *Abies sibirica*, *Quercus robur*, *Acer platanoides*, *Corylus avellana*, on decaying branch of fir, 01.IX.1996 *A.Shiryaev* (56°32'N, 57°26'E) SVER(F) 44585. **Cl.** Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Sysert area, Dvurechensk, Biostation University, slope to Sysert river, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, *Alnus incana*, on decaying branch of *Alnus*, 26.VII.1998 *E.Brindina* (56°32'N, 61°03'E) SVER(F) 44582. **PI.** Tugulim area (Stepanova-Kartavenko, 1967); Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007). **NI.** Tavda area, Pokrovka, dry pine forest, on trunk of pine, 13.IX.1957 *N.T.Stepanova* (58°06'N, 65°27'E) SVER(F) 43243.

*TOMENTELLA SUBCLAVIGERA Litsch.
Cl. Shalya area, Sylva, Shigaevo, mixed forest: *Pinus sylvestris*, *Picea obovata*, *Betula pendula*, *Tilia cordata*, on dead branch of spruce, 1.IX.1997 *A.Shiryaev* (57°21'N, 58°40'E) SVER(F) 44191.

TOMENTELLA SUBLILACINA (Ellis & Holw.) Wakef.
P. Krasnoufimsk area, Sarana, mixed forest: *Abies sibirica*, *Populus tremula*, *Betula pendula*, *Ulmus scabrum*, *Tilia cordata*, on wood of fir, 15.VIII.1977 *N.T.Stepanova* (56°29'N, 57°41'E) SVER(F) 43559. **Cl.** Nizhneserginsk area, Natural Park "Olenyi ruchyi", mixed luxuriant forest: *Abies sibirica*, *Betula pendula*, *Tilia cordata*, *Populus tremula*, *Sambucus sibirica*, on aspen wood, 2.IX.2004 *A.Shiryaev* (56°29'N, 59°18'E) SVER(F) 43927; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Kh.** Karpinsk area (Kõljalg, 1996). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

*TOMENTELLA SUBTESTACEA Bourdot et Galzin
Cl. Nevyansk area, southern cost of Tavatui lake, mixed forest: *Pinus sylvestris*, *Betula pendula*, *Tilia cordata*, *Populus tremula*, *Juniperus communis*, on decayed trunk of aspen, 15.IX.2000 *A.Shiryaev* (57°05'N, 60°10'E) SVER(F) 44171; Shalya area, Sylva, Shigaevo, mixed forest: *Abies sibirica*, *Populus tremula*, *Ulmus laevis*, *Sorbus aucuparia*, on decaying trunk of *Alnus incana*, 2.IX.1997 *A.Shiryaev* (57°21'N, 58°40'E) SVER(F) 44189.

TOMENTELLA TERRESTRIS (Berk. & Broome) M.J. Larsen
Cl. Nizhneserginsk area, Natural Park "Olenyi ruchyi", mixed luxuriant forest: *Pinus sylvestris*, *Betula pendula*, *Populus tremula*, on pine wood, 3.IX.2004 *A.Shiryaev* (56°29'N, 59°18'E) SVER(F) 43929; Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

*TOMENTELLA VIRIDULA Bourdot & Galzin
P. Krasnoufimsk area, Ayaz, luxuriant deciduous forest: *Acer platanoides*, *Quercus robur*, *Tilia cordata*, *Populus tremula*, *Betula pendula*, on twigs of oak, 23.VIII.1998 *A.Shiryaev* (56°03'N, 57°37'E) SVER(F) 44396.

TOMENTELLOPSIS ECHINOSPORA (Ellis) Hjortstam
P. Krasnoufimsk area, Nizhneirginsk oak forest, mixed forest: *Quercus robur*, *Pinus sylvestris*, *Populus tremula*, on brunch of hazel, 19.VIII.1996 *A.Shiryaev* (56°50'N, 57°24'E) SVER(F) 44407. **Cl.** Prigorod area,

Visim Nature Reserve (Shiryaev & Stavishenko, 2008). **Bp.** Ekaterinburg (Kõljalg, 1996). **PI.** Tugulim area, National Park "Pripishminsk Bory" (Shiryaev, 2007).

TOMENTELLOPSIS ZYGODESMOIDES (Ellis) Hjortstam
P. Krasnoufimsk area, Ust-Bugalish, mixed forest: *Picea obovata*, *Quercus robur*, *Populus tremula*, on decaying trunk of oak, 22.VIII.1996 *A.Shiryaev* (56°16'N, 57°51'E) SVER(F) 44351. **Cl.** Prigorod area, Visim Nature Reserve (Shiryaev & Stavishenko, 2008).

DISCUSSION

The number of species recorded in the 3 biogeographical divisions and 14 provinces of the Sverdlovsk region are presented in Table 1. It should be noted that a low number of provincial records, especially when compared with neighboring provinces, often indicates less intensive research activity and not actual adverse conditions for thelephoroid fungal growth.

About 80% of all species were found in the Ural Mountain Range Division and 15.9% of the species are recorded only here. However, no specimens have been collected in "mountainous" provinces. In the largest Division of the Sverdlovsk region - West Siberian plain - 63.5% of all species were found. This division has no specific species found only here. The East-European Hills Division, the smallest one, with 57% of species and some 8% of "endemic" species with 14.3% common species for both "european" provinces. 85.7% of species found in this division (47.7% of regional) were also recorded in Ural Mountain Range Division and only 48.1% of species were recorded (22.4% of regional) in West Siberian plain.

Table 1. The number of species in the biogeographical provinces of the Sverdlovsk region (A), their percentage of the total (B), and percentage of species recorded in this province only (C).

Province		A	B%	C%
1	P	35	55.6	6.3
2	KK	10	15.9	-
3	Cl	50	79.4	12.7
4	Bp	29	46.0	1.6
5	Ks	9	14.3	-
6	Nm	10	15.9	-
7	Kh	15	23.8	-
8	Is	12	19.0	-
9	PI	33	52.4	-
10	NI	14	22.2	-
11	ST	8	12.7	-
12	PT	4	6.4	-
13	OU	12	19.0	-
14	VP	3	4.8	-

The southern provinces Perm, Chusovoy low mountainous, Beloyarsk peneplen and Pishma, with the highest number of recorded species – close or over 50% of the total – have been studied most intensively. Another reason of the high number of species is that these provinces have higher diversity of mycorrhizal host trees which probably also influence the diversity of thelephoroid species.

The Sverdlovsk region, with its length of over 700 km from south to north and high mountainous altitudes, provides a gradient of several boreal vegetation zones, ranging from the forest-steppe zone in the two southernmost provinces and hemiboreal zone in the one south-westernmost province to alpine areas prevailing in northern areas. Some general observations of the species ranges along this transection can be made, although the uneven collecting effort should be taken into consideration.

Only some 4.8% of the total number of the species has been recorded in all provinces, even if not in the same degree of abundance and frequency throughout the range. Such species include *Hydnellum ferrugineum*, *Thelephora palmata* and *T. terrestris* among others. Excluding two less studied provinces the percentage of widely occurring species is still low - 13%.

About 27% of the total numbers of the species are recorded only in the area comprising the three south-westernmost provinces Perm (P), Chusovoy low mountainous (Cl) and Kungur-Krasnoufimsk (KK). Species recorded in all of these three provinces include *Hydnellum geogenium*, *H. scrobiculatum*, *Tomentella pilosa*, *T. sublilacina*, *Tomentellopsis zygodesmoides*, for instance. The Kungur-Krasnoufimsk province is not well studied and this might be reason why it has no specific taxa found only here.

In comparison, the Chusovoy province (Cl) includes two times more specific species (*Hydnellum auratile*, *Pseudotomentella flavovirens*, *P. nigra*, *Sarcodon lundellii*, *S. scabrosus*, *Tomentella galzinii*, *T. subclavigera*, *T. subtestacea*) than the Perm (P) (*Amaurodon cyaneus*, *A. mustialaensis*, *Tomentella punicea*, *T. viridula*).

The "southern" range includes also the Beloyarsk (Bp) and Pishma (PI) provinces. More than half of species (52.4%) specific to southern areas were found here too (*Bankera violascens*, *Hydnellum peckii*, *Phellodon confluens*, *P. connatus*, *Pseudotomentella tristis*, *Sarcodon fennicus*, *S. scabripes*, *S. versipellis*, *Thelephora anthocephala*, *T. penicillata*, *Tomentella cinerascens*, *T. terrestris*).

Perm province which belongs to the hemiboreal zone share 51% of its species with Ivdel (middle boreal zone), and 43% of its species with Konzhakov (mountainous northern boreal zone and alpine areas).

Four northernmost provinces Konzhakov, Ivdel, Ous and Verkh-Pelym have only one specific species, viz. *Phellodon secretus* which was recorded only from the middle boreal zone. No specific species for northern boreal or alpine areas have been recorded.

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Species richness and range restricted species of liverworts in Europe and Macaronesia

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Abstract: Species richness and range size patterns of European liverworts are analyzed at global scale. At the scale used in the study, species richness decrease from west to east and from the boreal areas towards both south and north. There is a trend that the larger the areas are the more species there are, but this trend is weak and cannot explain much of the patterns. Of the 490 liverwort species occurring in Europe and Macaronesia, 14.5 % have very small distribution ranges (as defined here; H'<1), which is a much lower figure than e.g. Malesia where over 50 % has small distribution ranges. Number of range restricted and very range restricted species is correlated exponentially with number of species. The geographic patterns of species richness and range restriction are not the same as for vascular plants. The more range restricted a liverwort species is in Europe the more it tends to be an oceanic species. Great Britain and France have most range restricted species but Portugal and the Macaronesian Islands have a larger proportion of liverwort species with small distribution ranges. However, the calculated rarity index is low compared with e.g. Malesia due to both lower number of species and lower proportion of range restricted species.

Kokkuvõte: Helviksammalde liigirikkus ja piiratud levikuga liigid Euroopas ja Makaroneesias

Käeolev töö analüüsib Euroopa helviksammalde liigirikkust ja levila suuruse mustreid globaalses skaalas. Uurimuses kasutatud skaalas väheneb liigirikkus läänest itta ja boreaalsest piirkonnast lõuna ja põhja poole. Esineb suundumus, et mida suurem ala, seda rohkem liike, kuid see trend on nõrk ning ei seleta kõiki levikumustreid. 490 Euroopas ja Makaroneesias esinevast helviksamblaliigist on 14,5 protsendil väga väike levila (siin defineeritud kui H'<1), mis on palju väiksem kui näiteks Maleesias, kus üle 50% liikidest on piiratud levikuga. Piiratud ja väga piiratud levikuga liikide arv on eksponentsiaalselt korreleeritud liikide koguarvuga. Liigirikkuse ja piiratud leviku geograafilised mustrid erinevad soontaimede omast. Mida piiratuma levikuga on helviksambla liik Euroopas, seda enam kaldub ta olema okeaaniline. Kõige piiratuma levikuga liigid on Suurbritannias ja Prantsusmaal, kuid Portugalis ja Makaroneesia saartel on kõige suurem hulk väikse levilaga helviksamblaid. Siiski on piiratud leviku indeks seal madalam kui näiteks Maleesias nii väiksema liikide üldarvu kui ka piiratud levikuga liikide madalama osakaalu tõttu.

INTRODUCTION

In Europe, the Mediterranean areas are most species rich and host most endemic vascular plants (Akeroyd & Heywood, 1994). However, those areas are not the most species rich for liverworts (Söderström et al., 2007). It is also a wide-spread opinion that bryophyte generally have wider distribution ranges, especially in boreal and temperate regions, and are therefore not so much in need for conservation. In Europe about 28% of the c. 12,500 vascular plant species are endemic (Akeroyd & Heywood, 1994) while only 9% of the liverworts (4 of 490 species) are endemic.

Liverworts are usually regarded as difficult to find and to identify in the field except for specialists. Although they are widely recognized as an important part of the total biodiversity, their conservation needs have mostly been neglected or assumed to be taken care of through conservation actions directed to other, more easily identified species. However, it is shown that bryophytes (including liverworts) sometimes show different distribution patterns than vascular plants (Pharo *et al.*, 2000). In order to get a good background for the conservation of the European liverworts, patterns of distribution and rarity at several scales must be analyzed.

In this paper the first step is taken to analyze the range sizes of European and Macaronesian liverworts. The aims are to see if there are any large-scale geographic patterns and therefore large units are used to see how widespread the European taxa are on a global scale and which areas of Europe and Macaronesia host most globally range restricted species.

METHODS

Geographical units, species lists and distribution

The geographical units used follow mainly Brummit (2001) and are scored on 3 levels. Level 1 is basically the continents and has 9 units. Level 2 is regions within continents and has 51 units (5 in Europe, 10 in North America, 10 in Africa, etc.). Level 3 are basically countries except that large countries (e.g. Russia) are separated in smaller units and that very small countries are included in a neighbor (e.g. Liechtenstein in Austria and San Marino in Italy). Brummit's (2001) level 3 areas (here named areas) are used but adjusted for Europe to follow Söderström, Urmi & Váňa (2002; 2007). This gives a total of 384 units (57 in Europe). Those areas are clustered in Brummit's level 2 areas (here named regions). Europe and Macaronesia include 7 regions.

Distributions were registered world-wide for all species recognized to occur in Europe and Macaronesia. Söderström, Urmi & Váňa (2002; 2007) was used as base for the taxa and their distribution in Europe. For distribution outside Europe, data was retrieved from a database compiled by us that covers distribution of all European taxa worldwide, registered in level 3 units.

Defining range restricted species

Distribution ranges were calculated in a way analogous with diversity in ecological investigations. The simplest measure is to count the number of known areas a species occur in. This is analogous with species richness in ecology. However, when talking of diversity in ecology one often use other measures including both number of species and their relative abundance. One of the most used diversity index is the Shannon-Wiener index (Zar, 1984) which indicates how large chance there is that the next individual you see or catch is a different species. This index was transformed to estimate how large chance there is to see the same species in the next region visited. The diversity index often uses number of individuals or cover as the abundance measurement. The most obvious here would be to use number of areas in each region. However, as number of areas varies in regions, the only suitable variable to use as abundance variable is the proportion of areas occupied in each region giving the following formula

$$H' = -\sum p_i \ln p_i$$

where p is the proportion of areas occupied in each region.

Range restricted species were defined in 2 ways, the 1/3 of the species with lowest H' (H' ≤ 1.6; 161 species) and all with H' ≤ 1 (70 species). The former is here termed range restricted and the latter very range restricted species.

Defining importance of areas for range restricted species

Proportion of range restricted species may be used as a measure of the relative importance of an area for range restricted species. However, this measure has some unwanted effects. A range restricted species occurring in a species poor area will give a much higher proportion than a range restricted species in a species rich area. Thus, species poor areas will come out as more important just because they are species poor. Therefore, a Rarity Index was created by multiplying the proportion of range restricted species with the absolute number of them as

$$RI = p_r \times n_r$$

where p_r is the proportion of range restricted species occurring in the area and n_r is the number of range restricted species in that region.

None of the variables compared were normal distributed and all correlations were for this reason performed with Spearman correlation test.

RESULTS

Number of species

A total of 484 liverwort species occur in Europe and Macaronesia. However, there is a large variation in number of species between the different areas (Fig. 1). For France 308 species are reported whilst only 9 is known from Moldova and none from the European part of Kazachstan (the latter excluded from the analyses).

From classical island biogeography theory the number of species should be positively related to the size of the area. In this study (Fig. 2) the species richness was significantly correlated with size (Spearman corr. coeff. = 0.459; n = 54; $P < 0.001$).

Number of range restricted species

In this study 29 species (6.0 %) had an H' = 0 and 70 species (14.5 %) had H' < 1. Number of range restricted or very range restricted species

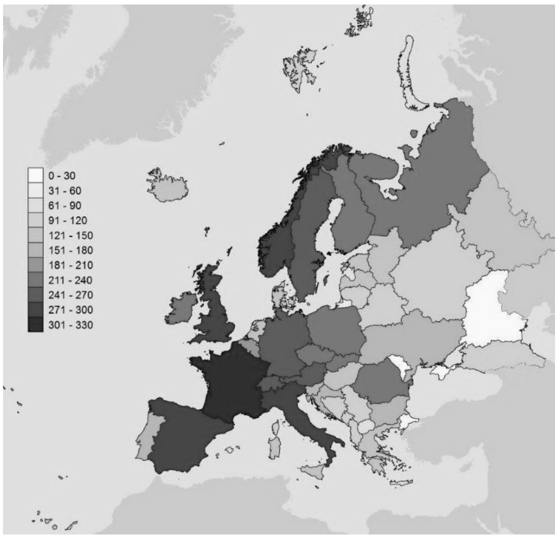

Fig. 1. Number of species of liverworts in various parts of Europe.

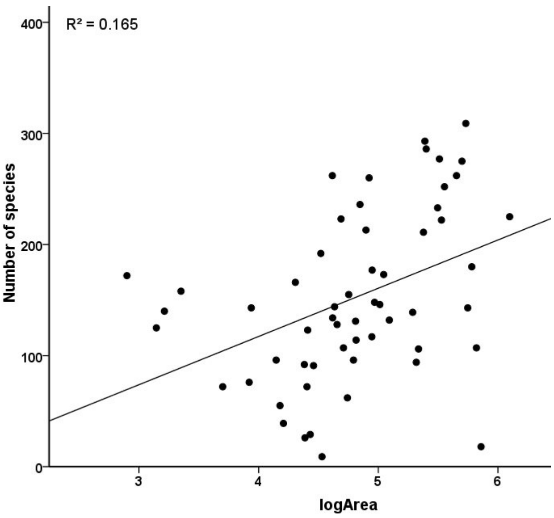

Fig 2. Correlation between number of liverwort species and area (log transformed) in Europe and Macaronesia.

showed no correlation with size of the area. Number of range restricted species (H'<1.6; Fig. 3a) is highly correlated with species richness and number of very range restricted species (H'<1; Fig. 3b) is also correlated with species richness but not so strongly. However, these two relations are not linear but rather exponential (Fig. 4a, b).

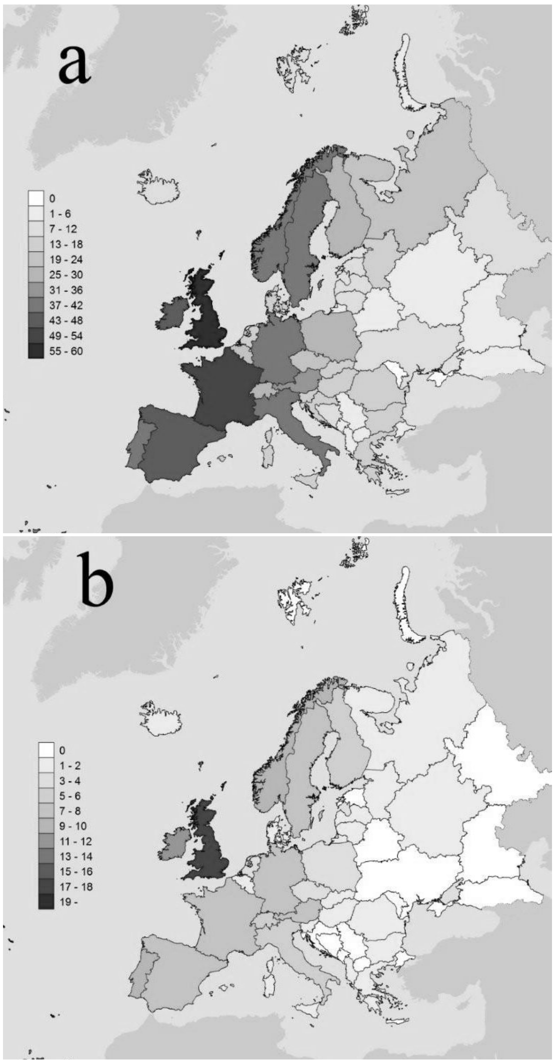

Fig. 3. No of range restricted species (a) and number of very range restricted species (b) in Europe and Macaronesia.

Proportion of range restricted species (Fig. 5) follows about the same pattern as species richness. However, four areas deviated having more range restricted species than the number of species would suggest, i.e. the Macaronesian Islands and Portugal.

Rarity index

Rarity Index (RI; Fig. 6a) has values from 0 (Crimea and Moldova) up to 12.3 for Madeira (11.5 for Great Britain, 11.2 for Azores and 10.3 for

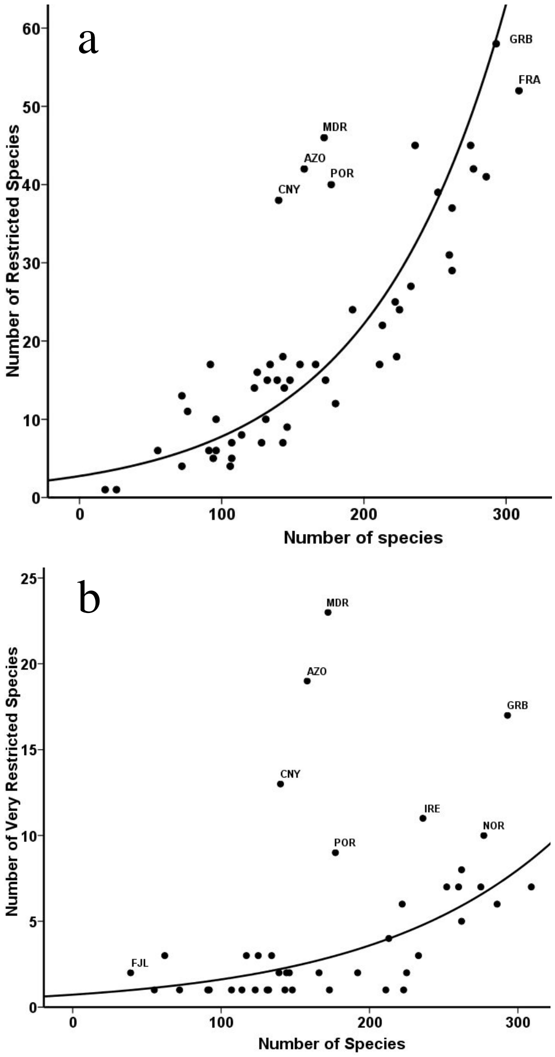

Fig 4. Number of species in relation to (a) number of restricted species, (b) number of very restricted species. Some areas are marked with name (AZO Azores, CNY Canary Is, FJL Franz Josef Land, FRA France, GRB Great Britain, IRE Ireland, MDR Madeira, NOR Norway, POR Portugal).

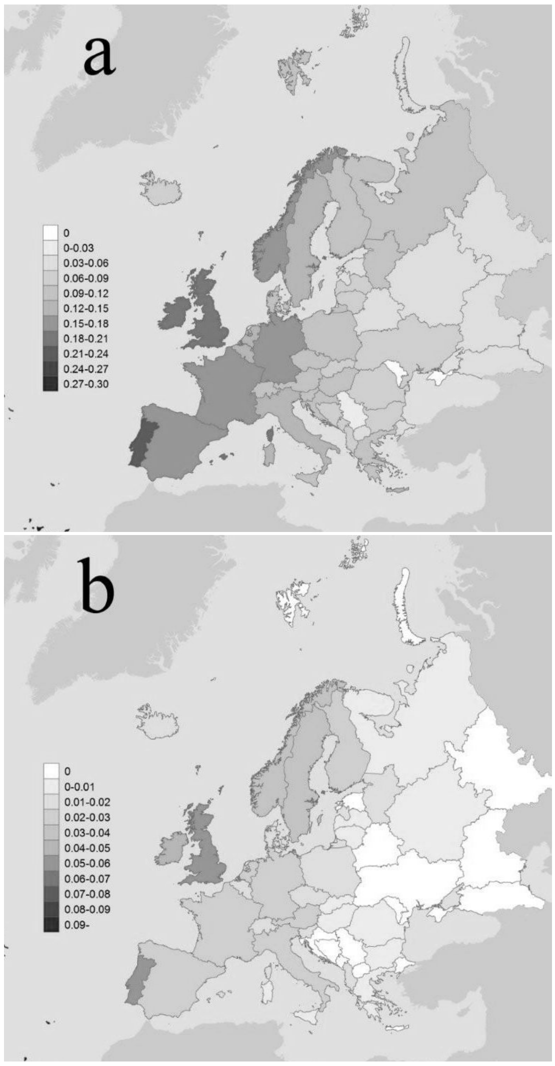

Fig 5. Proportion of range restricted (a) and very range restricted (b) liverwort species in Europe and Macaronesia.

Canary Is.). Calculating Rarity Index for very restricted species (very RI; Fig. 6b) gives values up to 3.08 (Madeira), 2.28 (Azores) and 1.21 (Canary Islands). RI is also strongly correlated with number of species (corr. coeff. = 0.764, n = 57, $P < 0.001$) as is very RI (corr. coeff. = 0.581, n = 57, $P < 0.001$). Also those correlations follow an exponential pattern (Fig. 7a, b).

DISCUSSION

All comparisons in this study show that the liverwort flora of Europe and Macaronesia consists of mainly widespread species and most of the range restricted species occur in very oceanic areas. This distribution pattern does not follow the same pattern as for vascular plants where the highest species richness and most endemism are in the Mediterranean areas (Akeroyd & Heywood, 1994). It is therefore not possible at this scale

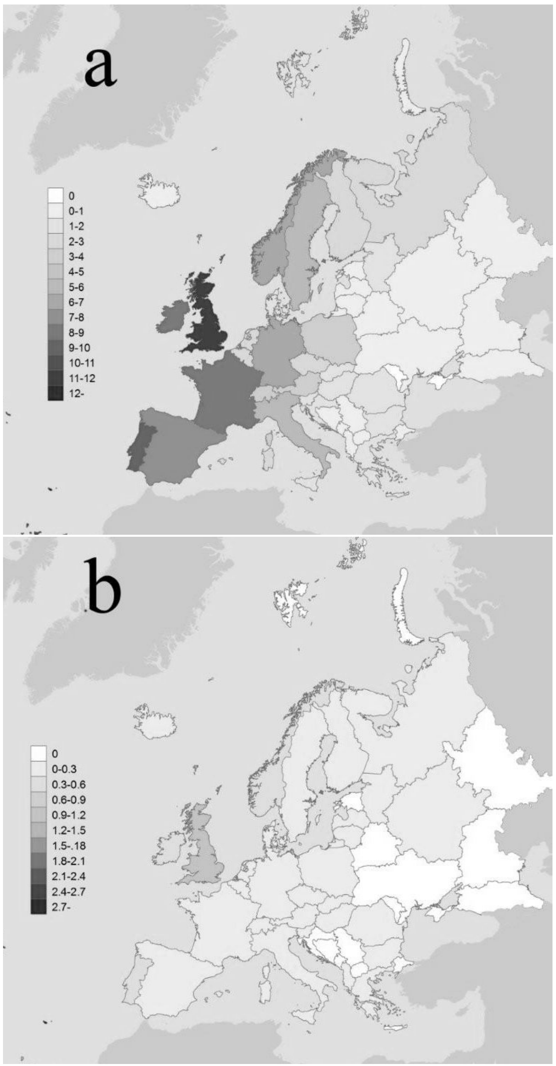

Fig 6. Rarity Index values for fore range restricted (a) and very range restricted (b) liverworts in Europe and Macaronesia.

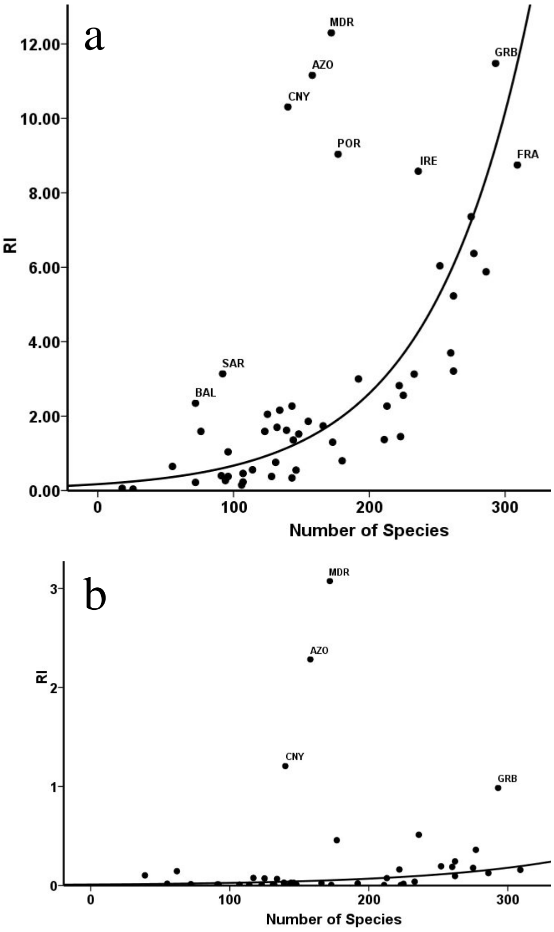

Fig 7. Number of species in relation to (a) rarity index (RI) for range restricted species and (b) RI for very range restricted species. Some areas are marked with name (AZO Azores, BAL Baleares, CNY Canary Is, FRA France, GRB Great Britain, IRE Ireland, MDR Madeira, POR Portugal, SAR Sardinia).

to use patterns in vascular plant biodiversity as a surrogate for patterns in liverwort species richness and rarity. Hepatics are most species rich in oceanic and alpine areas.

The island biogeography theory states that the larger an area is, the more species there should be. This is also true for the European hepatics but the correlation is only weak since large areas as southern and central Russia have much less number of species than expected from their size while smaller areas like Switzerland and Austria do have a higher number than expected. This can be explained in two ways. First, the bryological activity has been, and still is, higher in the Alps than in e.g. southern Russia. Thus, several areas should be expected to have more species than shown here. From our map we expect more species to be found in at least Crimea, Moldova, European Turkey and some areas on Balkan when better explored. However, the different areas also include different vegetation types. Areas with high mountain ranges have more species than surrounding lowland countries. A good example of this is Hungary, a well explored lowland country, compared with the surrounding countries. Austria, Slovakia and Romania all have many more species. However, Croatia does not have many more species although being more mountainous with a larger variation of vegetation types rich in liverworts. We thus predict that many more species will be found in Croatia with increased exploration but we think the low number for Hungary is a reality.

The number of range restricted species is strongly correlated with number of species and shows thus the same pattern with France and Great Britain having the highest number. Number of very range restricted species is also correlated with species richness. However, here France does not separate from neighboring countries. Instead Great Britain alone does have most very range restricted species. Another change is that Portugal does have more very range restricted species than Spain while the opposite occurred when using only range restricted. Thus the more range restricted a species is in Europe, the more it tends to be an oceanic species.

There are only a few analyses on distribution ranges that are directly comparable with this. The European *Sphagnum* flora have even less globally range restricted species than the European liverwort flora (Séneca & Söderström, 2008) with only 11.8 % very range restricted (H'<1) vs. 14.5 % in liverworts but the H' values for the 1/3 most restricted species is almost equal (< 1.61 vs. <1.60). The *Lophoziaceae/Scapaniaceae* complex (a predominantly northern Hemisphere arctic and boreal group but with several range restricted species in the tropics and southern Hemisphere) has 49.5 % of the species with H' < 1 (Söderström & Séneca, 2006) and over 1/3 of the species had H'=0. Comparable data for all hepatic species in a region is available only for Malesia (Söderström & Séneca, 2008). Europe do have a much lower proportion of globally range restricted species than Malesia (51 % with H'<1) and the 1/3 of the species with lowest H' was only H'<0.62 in Malesia. This indicates generally larger distribution ranges in European liverworts than in other areas, but there is no data available for any other boreal areas.

The relationship between number of species and number of range restricted species is not linear but exponential (Fig. 4a), which means that as more species are found a higher proportion of them are range restricted. The picture of very range restricted species is the same but less steeply rising with number of species (Fig. 4b). Four areas, Canary Islands, Azores, Madeira and Portugal, do however have more range restricted species than should be predicted from the number of species alone. Using only very range restricted species the Macaronesian areas deviates markedly from the rest while Portugal, Ireland and Great Britain also have more very range restricted species than expected from number of species. This is visible also when proportion of range restricted species is calculated (Fig. 5).

Three of the areas with the highest rarity index (RI) values (Great Britain, France and Ireland) are also species rich while four areas (Portugal, Canary Is., Madeira and Azores) are not so species rich. When calculating very RI only the three Macaronesian areas (and to some degree Great Britain) remains important. However, the highest RI values for Europe (12.3) is low compared with most areas in Malesia where Borneo have RI=140 and six of the ten areas there have RI over 20 (Söderström & Séneca, 2008).

The map over number of species (Fig. 1) clearly shows an east-west gradient. However, some of the geographic patterns in species richness are hidden since the areas used here (mainly countries) are too heterogeneous. It seems, e.g., that Ukraine is fairly species rich while in fact most of the species are reported from the Ukrainian part of the Carpathian Mts. in the extreme west of the country. An analysis using smaller units would be preferred but at present no more detailed data is available for many of the larger areas.

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Red-listed mosses in the Komi Republic (Russia)

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Abstract: The paper presents data on red-listed mosses of the Komi Republic. 114 taxa of moss species have been suggested for inclusion in the new edition of the Red Data Book of the Komi Republic.

Kokkuvõte: Komi Vabariigi (Venemaa) Punase Raamatu lehtsamblad

On koostatud nimekiri 114 lehtsambla taksonist Komi Vabariigi Punase Raamatu uue versiooni jaoks.

INTRODUCTION

The Komi Republic is situated in the North-East of the European part of the Russian Federation, in the taiga and tundra zones. Its area is approximately 416,000 square kilometers. The relief is predominantly plain. There is an ancient, medium-height elevation, the Timan Ridge, with maximum height of 471 meters. The ridges of the Northern, the Sub-Polar and the Polar Urals stretch in the East. Mount Narodnaya is the highest peak in the Urals (1,900 m). Circa 70% of the Komi Republic is covered with forests, mainly spruce and pine.

The moss flora of the Komi Republic has been studied for over 100 years. The works of Zikendrath (1895, 1900) and Pole (1915) represent the earliest data. The regional bryoflora is now studied by the staff of the Institute of Biology (Komi Scientific Centre, Ural Branch, Russian Academy of Sciences).

The observed increase of human impact on the natural ecosystems has called for urgent action plan for biodiversity conservation. In this connection, the Red Data Book of the Komi Republic, which included 143 moss and 10 liverwort species, was issued in 1998. Additionally, 254 protected areas on 6 million hectares of land (15 % of the total area of the Komi Republic) have been merged into a network of specially protected natural areas. Nowadays bryologists compile the inventory of bryophyte flora of the Komi Republic, with special focus on protected natural areas. As a result, the red list of moss species has been revised. Several species from the former Red Data Book were excluded due to taxonomical changes, uncertain occurrence evidence or increase in the known number of localities. New red list includes 114 moss species. It will make a part of the 2nd edition of the Red Data Book of the Komi Republic.

MATERIALS AND METHODS

The list of taxa is arranged in alphabetic order. Species names correspond to the accepted Check-list of mosses of East Europe and North Asia (Ignatov et al., 2006). We have provided synonyms only to species that differ from the name given in the Red Data Book of the Komi Republic (Taskaev, 1998). Each taxon is referred to one of the following Red List categories (Taskaev, 1998).

Category 2 – vulnerable species: taxa that are likely to be attributed to the Endangered category in the near future provided that the effect of adverse factors continues. Here belong taxa with abundances in all or in the most of populations declining due to intensive use, considerable disturbance of habitats or other changes.

Category 3 – rare species: taxa with small populations that are at risk of becoming vulnerable or endangered. The taxa are restricted to small areas, specific habitat or are sparsely distributed on a vast territory.

Category 4 – species insufficiently known: taxa evidently belonging to one of the preceding categories, however their condition is not known at present.

In addition, care demanding species which are relatively rare and grow in habitats with antropogenic press are listed as an appendix to the Red Data Book.

LIST OF SPECIES

Category 2

Codriophorus fascicularis (Hedw.) Bednarek-Ochyra & Ochyra (*Racomitrium fasciculare* (Hedw.) Brid.)
Cynodontium asperifolium (Lindb. & Arnell) Paris
Dicranum viride (Sull. & Lesq.) Lindb.
Didymodon tophaceus (Brid.) Lisa
Fissidens gracilifolius Brugg.-Nann. & Nyholm (*F. minutulus* Sull.)
Fissidens pusillus (Wilson) Milde
Grimmia unicolor Hook.
Lescuraea patens Lindb. (*Pseudoleskea patens* (Lind.) Kindb.)
Myurella sibirica (Muell. Hal.) Reimers
Pohlia saprophila (Muell. Hal.) Broth.
Tortella inclinata (R.Hedw.) Limpr.

Category 3

Anomodon longifolius (Brid.) Hartm.
Campylophyllum halleri (Hedw.) M. Fleisch. *(Campylium halleri* (Hedw.) Lindb.)
Cinclidium arcticum (Bruch et al.) Schimp.
Cnestrum alpestre (Wahlenb. ex Huebener) Nyholm ex Mogensen.
Cnestrum schistii (F. Weber & D. Mohr) I. Hagen.
Codriophorus acicularis (Hedw.) P. Beauv. (*Racomitrium aciculare* (Hedw.) Brid.)
Cynodontium fallax Limpr.
Dicranum drummondii Muell. Hal.
Discelium nudum (Dicks.) Brid.
Encalypta affinis R. Hedw.
Encalypta brevicolla (Bruch et al.) Ångstr.
Fissidens rufulus Bruch et al.
Fissidens viridulus (Sw.) Wahlenb.
Grimmia mollis Bruch et al. (*Hydrogrimmia mollis* (Bruch et al.) Loeske)
Heterocladium dimorphum (Brid.) Bruch et al.
Lescuraea radicosa (Mitt.) Moenk. (*Pseudoleskea radicosa* (Mitt.) Macoun & Kindb.)
Lescuraea mutabilis (Brid.) Lindb.
Meesia longiseta Hedw.
Myurella tenerrima (Brid.) Lindb.
Neckera pennata Hedw.
Ochyraea norvegica (Bruch et al.) Ignatov & Ignatova (*Hygrohypnum norvegicum* (Bruch et al.) J. J. Amann)
Philonotis marchica (Hedw.) Brid.
Plagiomnium confertidens (Lindb. & Arnell) T. J. Kop.
Pohlia elongata Hedw. var. greenii (Brid.) A.J.Shaw
Pohlia longicollis (Hedw.) Lindb.
Pohlia ludwigii (Spreng. ex Schwaegr.) Broth.
Polytrichastrum formosum (Hedw.) G. L. Sm. (*Polytrichum formosum* Hedw.)
Polytrichastrum sexangulare (Floerke ex Brid.) G.L.Sm. (*Polytrichum sexangulare* Brid.)
Pseudocalliergon trifarium (E.Weber et D.Mohr) Loeske.
Rhynchostegium murale (Hedw.) Bruch et al.
Schistostega pennata (Hedw.) F.Weber & D. Mohr
Sciuro-hypnum ornellanum (Molendo) Ignatov & Huttunen (*Scleropodium ornellanum* (Molendo) Lorenz.)
Sphagnum pulchrum (Lindb. ex Braithw.) Warnst.
Stereodon plicatulus Lindb. (*Hypnum plicatulum* (Lindb.) A. Jaeger)
Ulota curvifolia (Wahlenb.) Lilj.

Category 4

Cynodontium bruntonii (Sm.) Bruch et al.
Dicranodontium denudatum (Brid.) E. Britton
Funaria microstoma Bruch ex Schimp.
Seligeria campylopoda Kindb.
Seligeria donniana (Sm.) Muell. Hal.
Seligeria pusilla (Hedw.) Bruch et al.
Seligeria trifaria (Brid.) Lindb.
Tayloria acuminata Hornsch.

Appendix

Amphidium mougeotii (Bruch et al.) Schimp.
Anomodon viticulosus (Hedw.) Hook. & Taylor
Barbula convoluta Hedw.
Bartramia pomiformis Hedw.
Brachythecium glareosum (Bruch ex Spruce) Bruch et al.
Brachythecium tommasinii (Sendtn. ex Boulay) Ignatov & Huttunen (*Cirriphyllum tenuinerve* (Lindb.) Wijk & Margad., *Cirriphyllum tommasinii* (Sendtn. ex Boulay) Grout)
Bryobrittonia longipes (Mitt.) D. G. Horton
Bryum arcticum (R. Br.) Bruch et al.
Bryum neodamense Itzigs.
Bryum pamirense H.Philib. ex Broth.
Bryum rutilans Brid.

CINCLIDIUM STYGIUM Sw.
CONOSTOMUM TETRAGONUM (Hedw.) Lindb.
DICRANELLA HUMILIS R. Ruthe
DICRANELLA SCHREBERIANA (Hedw.) Hilf. ex H. A. Crum & L. E. Anderson
DIDYMODON RIGIDULUS Hedw.
DISTICHIUM INCLINATUM (Hedw.) Bruch et al.
DITRICHUM PUSILLUM (Hedw.) Hampe
ENCALYPTA CILIATA Hedw.
ENCALYPTA VULGARIS Hedw.
FONTINALIS SQUAMOSA Hedw.
HOMALOTHECIUM SERICEUM (Hedw.) Bruch et al.
HYGROAMBLYSTEGIUM TENAX (Hedw.) Jenn.
HYGROHYPNELLA POLARE (Lindb.) Ignatov & Ignatova (*Hygrohypnum polare* (Lindb.) Loeske
KIAERIA BLYTTII (Broth. et al.) Broth.
KIAERIA FALCATA (Hedw.) I. Hagen
KIAERIA GLACIALIS (Beggr.) I. Hagen
LOESKYPNUM BADIUM (Hartm.) H.K.G.Paul (*Drepanocladus badius* (Hartm.) G. Roth)
MNIUM BLYTTII Bruch et al.
OLIGOTRICHUM HERCYNICUM (Hedw.) Lam. & DC.
ORTHOTHECIUM INTRICATUM (Hartm.) Bruch et al.
ORTHOTHECIUM RUFESCENS (Dicks. ex Brid.) Bruch et al.
ORTHOTRICHUM LAEVIGATUM J. E. Zetterst.
OXYRRHYNCHIUM HIANS (Hedw.) Loeske (*Eurhynchium hians* (Hedw.) Sande Lac.)
PARALEUCOBRYUM LONGIFOLIUM (Hedw.) Loeske
PLAGIOPUS OEDERIANUS (Sw.) H.A.Crum & L.A.Anderson
PLAGIOTHECIUM LATEBRICOLA Bruch et al.
PLATYGYRIUM REPENS (Brid.) Bruch et al.
POHLIA ANDREWSII A. J. Shaw
PSEUDOCALLIERGON LYCOPODIOIDES (Brid.) Hedenäs
PTERIGYNANDRUM FILIFORME Hedw.
RHYNCHOSTEGIUM RIPARIOIDES (Hedw.) Cardot.
SCIURO-HYPNUM GLACIALE (Bruch et al.) Ignatov & Huttunen (*Brachythecium glaciale* Bruch et al.)
SPLACHNUM AMPULLACEUM Hedw.
STEREODON BAMBERGERI (Schimp.) Lindb. (*Hypnum bambergeri* Schimp.)
STEREODON PALLESCENS (Hedw.) Mitt. (*Hypnum pallescens* (Hedw.) P.Beauv.)
STEREODON VAUCHERI (Lesq.) Lindb. ex Broth. (*Hypnum vaucheri* Lesq.)
TAYLORIA TENUIS (Dicks. ex With.) Schimp.
TETRAPLODON PARADOXUS (R. Br.) I. Hagen
THUIDIUM ASSIMILE (Mitt.) A. Jaeger (*T. philibertii* Limpr.)
THUIDIUM DELICATULUM (Hedw.) Bruch et al.
TIMMIA NORVEGICA J.E.Zetterst.
TORTULA HOPPEANA (Schultz) Ochyra (*Desmatodon latifolius* (Hedw.) Brid.)
TORTULA LEUCOSTOMA (R. Br.) Hook. & Grev. (*Desmatodon leucostoma* (R.Br.) Berggr.)
TORTULA MUCRONIFOLIA Schwaegr.
TORTULA PROTOBRYOIDES R.H.Zander (*Pottia bryoides* (Dicks.) Mitt.)
TORTULA TRUNCATA (Hedw.) Mitt. (*Pottia truncata* (Hedw.) Bruch et al.)
TREMATODON AMBIGUUS (Hedw.) Hornsch.
TRICHOSTOMUM CRISPULUM Bruch
ZYGODON VIRIDISSIMUS (Dicks.) Brid.

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NEW ESTONIAN RECORDS

Helotiales, Ascomycota

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Ionomidotis irregularis (Schwein.) E. J. Durand – kurd pigikubi – Jõgevamaa Co., Alam-Pedja Nature Reserve, Utsali, on rotten wood of a deciduous tree, 16 Oct 2007, leg. K. Põldmaa, det. K. Pärtel, TU-104143.

The species is characterised by the comparatively large (to 6 cm diam), black, tough, lobed, irregular or ear-shape apothecia. The shape distinguishes it from other members of the genus. Microsopically the species is easy to recognize due to its septate and lanceolate paraphyses which have acute tips, and the ionomidotic reaction of the apothecial tissues (the exudation of dark purple-brown in 3% KOH solution).

There is published data on the occurrence of *Ionomidotis irregularis* in Europe, North-America and Russian Far East (Zhuang, 1988; Huhtinen, 2007). In Europe the few known specimens originate from Austria, Poland (Zhuang, 1988), Germany and Switzerland (H.-O. Baral, pers. comm.). Only recently was it discovered in Nothern Europe, in an old-growth forest in Finland (Huhtinen, 2007). In Estonia it is among the largest helotiaceous fungi, one of the most extensively studied groups in the country. However, only one dubious earlier record is known from here. The species is mentioned in the list of fungi found during the excursions which followed the European Mycologists Congress held in Tallinn in 1988 (Kalamees & Vaasma, 1989). The record originates from the Nigula Nature Reserve but more precise collection data and a voucher specimen are lacking. The fungus is obviously rare in Estonia and was recently added to the Estonian Red Data List.

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Pezizales, Ascomycota

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Gyromitra fluctuans (Nyl.) Harmaja – Tartumaa Co., Mäksa Comm., Kaagvere, (58°21’15” N 26°52’46” E), on soil, 21 Mai 2008 leg. K. Kalmees, det. B. Kullman (TAA 177865).

Pseudoplectania sphagnophila (Pers.) Kreisel – Tartumaa Co., Mäksa Comm., Kaagvere, (58°21’15” N 26°52’46” E), on soil, 21 Mai 2008 leg. K. Kalmees, det. B. Kullman (TAA 177865).

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Lichens and lichenicolous fungi

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20 new fungal species, 8 of them lichenized and 12 lichenicolous fungi, are recorded first time here. Abbreviations of the distribution regions and frequency classes follow Randlane & Saag (1999). Lichenicolous fungi are indicated with #. The collector names and herbaria are abbreviated as follows: AS = Ave Suija; JM = Jurga Motiejūnaitė; PL = Piret Lõhmus; TU = herbarium of the Natural History Museum of the University of Tartu, Estonia; BILAS = Herbarium of the Institute of Botany, Lithuania.

Adelococcus alpestris (Zopf) Zopf ex Arnold – NW: Rapla Co., Raikküla comm., Jalase Nature Reserve, Lipstu heath (58°59'24"N 24°37'51"E), on thallus and apothecia of *Acarospora glaucocarpa* (Ach.) Körb. growing on limestone, 2 June 2007, leg. & det. AS (TU-42529). Freq.: rr.

Cheiromycina petri D. Hawksw. & Poelt – SE: Tartu Co., ca 2 km NW from the Aravu village (58°14'50"N 27°24'42"E), mature eutrophic boreo-nemoral forest, on *Tilia cordata,* 26 Apr 2006, leg. & det. PL (TU). Freq.: rr. – The taxon belongs to the genus that comprises five lichenized hyphomycete species (Printzen, 2007). It is characterised by bluish-grey hemisphaerical sporodochia, palmately branched multicellular conidia and slightly larger conidiogenous cells than conidial cells (differences from *C. reimeri* Printzen see below). Reported from Canada, Russia (Sakhalin), Turkey, Austria, Norway (Printzen, 2007) and Lithuania (Motiejūnaitė et al., 2008).

Cheiromycina reimeri Printzen – SE: Tartu Co., ca 2 km NW from the village Aravu (58°14'52,8"N 27°24'48,2"E), mature swamp forest with *Alnus glutinosa*, on young *Picea abies*, 21 May 2006, leg. & det. PL (TU). Freq.: rr. – The collection is mixed with *Biatora helvola* Körb. ex Hellb. This recently described species (Printzen, 2007) is similar to *C. petri*, but is clearly distinguishable by the definitely enlarged, more or less globose conidiogenous cells; from *C. flabelliformis* B. Sutton it differs by short terminal branches of the conidia (the latter has 2–5 finger-shaped cells). Until now reported from Russia (Sakhalin) and Turkey.

Dactylospora parasitica (Flörke) Zopf – WIs: Saare Co., Saaremaa island, Pidula park (58°25'16"N 22°09'09"E), on thallus of *Ochrolechia turneri* (Sm.) Hasselrot growing on *Acer platanoides*, 3 July 2007, leg. E. Leppik, det. AS (TU-55214). Freq.: rr.

Epicladonia stenospora (Harm.) D. Hawksw. – SE: Tartu Co., Vara forestry, N edge of the forest square 34 (58°35'N 26°59'E), on squamules of *Cladonia ochrochlora* Flörke, 7 Sept 2006, leg. & det. JM (BILAS-8055). Freq.: rr.

Merismatium decolorans (Rehm ex Arnold) Triebel – NW: Rapla Co., Rapla comm., Tõrma limestone outcrop (59°00'34"N 24°41'37"E), on *Lepraria neglecta* (Nyl.) Lettau growing on mosses, 2 June 2007, leg. & det. AS (TU-40850). Freq.: rr.

Micarea tomentosa Czarnota & Coppins – SE: Tartu Co., Järvselja Virgin Forest Nature Reserve (forest square 226), swamp forest (58°16'46"N 27°19'19"E), snag of *Betula* spp., on well-decayed wood, 7 June 2006, leg. PL, det. JM & PL (TU); Tartu Co., ca 2 km NW from the Siniküla village, protected eutrophic boreo-nemoral forest (58°31'13"N 26°19'20"E), windthrow of *Picea abies*, on wood of decayed root, 7 July 2006, leg. & det. PL (TU). Freq.: rr. – The recently described taxon has similarly to *M. hedlundii* Coppins stalked, whitish and tomentose pycnidia, but differs from it by more brightly coloured and continuous thallus (Czarnota, 2007). In addition, thallus of *M. tomentosa* does not react with K (*M. hedlundii* has dull orange pigment reacting K+ violet within the goniocysts) and has short (meso)condia (on average 3.2 μm in Estonian material). Although the ecology of the two species is similar (for example, both species were found in Siniküla locality in Estonia), *M. tomentosa* is considered to be more rare (Thor & Svensson, 2008). Since now it has been reported from Poland, Slovakia and Sweden (Czarnota, 2007; Thor & Svensson, 2008).

Monodictys anaptychiae (Lindau) D. Hawksw. – NE: Lääne-Viru Co., Mädapea wooded meadow (59°19'N 26°16'E), on *Anaptychia ciliaris* (L.) Körb. on *Quercus robur*, 8 June 2003, leg. & det. AS, ver. D. Hawksworth (TU). Freq.: rr. – This hyphomycete forms superficial dark brown colonies on the thallus of *A. ciliaris*. The conidia of the Estonian specimen are 2–5-celled, 6.4–11 × 5.6–9.6 µm (n=16). The fungus is rare: to date, it has been recorded from scattered localities in Germany (Hawksworth, 1975), Sweden (Wedin, 1993), England (Hawksworth, 1994) and Denmark (Alstrup et al., 2004).

Niesslia cladoniicola D. Hawksw. & W. Gams in Hawksworth – WIs: Hiiu Co., Hõralaid islet (58°53'57"N 23°03'50"E), on *Cladina arbucula* (Wallr.) Hale & W.L. Culb. (infected also with *Taeniolella beschiana* Diederich), 2 July 2007, leg. & det. AS coll. no. 816 (TU-42619). Freq.: rr.

Parmelia submontana Nádv. ex Hale – SE: Võru Co., Haanja Nature Park, eastern part of Vällamägi (57°44'04"N 27°04'05"E), eutrophic boreo-nemoral forest, sevaral thalli on a dried branch of *Corylus avellana*, 6 Oct 2006, leg. PL, det. PL & AS (TU-39231). Freq.: rr. – This species, described more than two decades ago, is very similar to *Parmelia sulcata* Taylor, but is easily recognised by loosely attached, elongated, down-orientated lobes with rolled-down lateral margins and more greenish tinge of the upper thallus surface. For the detailed description of the species characters and ecology see Gauslaa (1999) and Motiejūnaitė et al. (2003). Although *P. submontana* is considered to be a mediterranean/southern central European species (Hale, 1987), it has been reported also from numerous localities in NW Europe (England, Denmark, Norway, Sweden, Lithuania, Poland).

Raciborskiomyces peltigericola (D. Hawksw.) M.E. Barr – WIs: Hiiu Co., Vahtrepa Landscape Reserve, Vohilaid islet (58°55'28"N 23°01'11"E), on *Peltigera* sp. growing on ground, 4 July 2007, leg. & det. AS coll. no. 867 (TU-42623). Freq.: rr.

Reichlingia leopoldii Diederich & Scheid. – SE: Tartu Co., Järvselja Virgin Forest Nature Reserve (forest square 226), old eutrophic boreo-nemoral forest (58°16'45"N 27°19'26"E), on *Alnus glutinosa*, 7 June 2006, leg. PL, det. PL & AS (TU); old swamp forest (58°16'46"N 27°19'19"E), on *A. glutinosa*, 7 June 2006, leg. & det. PL (TU); NE: Ida-Viru Co., Puhatu Nature Reserve, old eutrophic boreo-nemoral forest at the Poruni river (59°10'29"N 27°47'26"E), snag of *A. glutinosa*, on bark, 15 Sept 2007, leg. & det. PL (TU). Freq.: rr. –The lichenized hyphomycete is recognizable in the field by the reddish or chocolate brown conidiophores covering its leprose thallus with *Trentepohlia* photobiont. The species seems to be widespread and common in Central Europe (Austria, Germany, Luxembourg, Switzerland, Poland) but is also found in British Isles and Lithuania (Diederich & Scheidegger, 1996; Kukwa, 2004; Lambley, 2003; Motiejūnaitė & Andersson, 2003).

Rinodina colobina (Ach.) Th. Fr. – WIs: Lääne Co., Harilaid islet (58°14'05"N 23°05'23"E), on worked timber, 1 July 2008, leg. & det. AS coll. no. 881 (TU). Freq.: rr. – The size of the ascospores of the Estonian specimen is 12–21 × 8–10.5 µm (n=11), which matches with the size given in Sheard (1967), but the lower value of the ascospore length is smaller than given in Mayrhofer & Moberg (2002).

Skyttea gregaria Sherwood, D. Hawksw. & Coppins – NE: Ida-Viru Co., Agusalu Landscape Reserve, southern part of Feodori bog, Remniku forestry, forest square 168/15 (59°02'15"N 27°39'36"E), *Polytrichum* forest site type burnt pine forest, on *Mycoblastus fucatus* (Stirt.) Zahlbr., 19 Oct 2007, leg. & det. AS coll. no. 4-72 (TU-42720). Freq.: rr.

Stigmidium cladoniicola Zhurb. & Diederich – NE: Ida-Viru Co., Agusalu Landscape Reserve, Kivinõmme forestry, forest square 124, Riiska bog (59°08'35"N 27°34'58"E), raised bog pine forest, on squamules of *Cladonia digitata* (L.) Hoffm., 2 Aug 2006, leg. & det. AS coll. no. 6 (TU-57779); SE: Tartu Co., Vara forestry, square border between forest squares no. 41 and 34 (58°38'N 26°59'E), on squamules of *Cladonia* sp., 7 Sept 2006, leg. & det. JM (BILAS 8156). Freq.: rr. – This lichenicolous fungus, decribed recently, was known, so far, only from the type locality in Komi Republic, Russia (Zhurbenko & Diederich, 2008). The characters of the specimen TU-57779 match well with the original description: the ascomata have been found only on the basal squamules of *C. digitata*; the ascospores are two-celled, hyaline, mostly biguttulate, 9.6–11.2 × 2.5–4 µm (n=8). The BILAS specimen, however, differs from the description

in the protologue in smaller ascospores: 7.5–8.5 × 2.5–3 µm (9–16.5 × 3–5 µm in Zhurbenko & Diederich, 2008). Thus in spore size it is closer to *S. microcarpum* Alstrup & J.C. David which inhabits moribund parts of *Flavocetraria cucullata* (Bellardi) Kärnefelt & A. Thell (Alstrup, 1993). Therefore the specimen BILAS 8156 is identified as *S. cladoniicola* with some doubt.

Stigmidium fuscatae (Arnold) R. Sant. – WIs: Hiiu Co., Hõralaid islet (58°53'57"N 23°03'50"E), on *Acarospora fuscata* (Schrad.) Th.Fr. growing on granite, 2 July 2007, leg. & det. AS coll. no. 826 (TU-42624). Freq.: rr.

Syzygospora bachmannii Diederich & M.S. Christ. – WIs: Hiiu Co., Hiiumaa Islets Landscape Reserve, Saarnaki islet (58°48'N 23°00'E), on *Cladonia cornuta* (L.) Hoffm. growing on soil, July 2006, leg. J. Liira, det. AS (TU-42625). Freq.: rr.

Taeniolella trapeliopseos Diederich – NW: Harju Co., Väike-Pakri island, meadow (59°19'14"N 23°59'15"E), on *Trapeliopsis flexuosa* (Fr.) Coppins & P. James growing on dried *Juniperus communis*, 28 July 2007, leg. & det. AS coll. no. 8 (TU-42620). Freq.: rr. – The fungus is recorded from Luxembourg (Diederich, 1990), Poland (Kukwa & Czarnota, 2006) and Czech Republic (Šoun et al., 2006).

Thelotrema suecicum (H. Magn.) P. James – SE: Tartu Co., Vara forestry, forest square 105, protected, old eutrophic boreo-nemoral forest (58°32'52"N 26°55'36"E), on *Tilia cordata*, 8 July 2006, leg. & det. PL (TU). Freq.: rr. – This species is very similar to *Thelotrema lepadinum* (Ach.) Ach. in the field as both have apothecia immersed in warts, but apothecia of *T. suecicum* are smaller and ascospores are non-muriform, up to 10-septate (*T. lepadinum* has at least 1–3 longitudinal septa). In Estonian material spores are 6–8 celled, on average 24.6 µm long, but 5 µm broad, i.e. 3 µm narrower than given in the literature (Foucard, 2001). The species is scatterly distributed in the world (Thor & Arvidsson, 1999; Jarman & Kantvilas, 1995, etc.).

Trapeliopsis viridescens (Schrad.) Coppins & P. James – SE: Tartu Co., Vara forestry, forest square 41/12 (58°35'N 26°39'E), old fresh boreal spruce forest, on decaying lying trunk of *Picea abies*, 10 May 2006, leg. PL coll. no. 22, det. JM (TU-39399). Freq.: rr. – This is an uncommon species, probably confined to biologically rich forests.

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