Folia Cryptog. Estonica, Fasc. 41: 1–4 (2005)

EDITORIAL

The 5th Symposium of the International Association for Lichenology LICHENS IN FOCUS

held in Tartu (Estonia) 16–21 August 2004

This was a historical moment, at least for us in the Local Organising Committee – to receive hundreds of lichenologists in our small university town Tartu. It was unbelievable but true – you could meet a lichenologist on every street corner in the center of Tartu during the dinner break, or in the Gunpowder Cellar and Wilde Pub every evening (or perhaps even at night time). The concentration of lichenologists in the population of Tartu (which had somewhat diminished due to the summer holidays) was surely highest of all times, and could be perceived also by eye – blue bags represented the most popular trend among any bags worn at that time in Tartu.

But let's speak through numbers. There were exactly 250 registered participants from 36 countries; six scientific sessions (both oral and poster sessions) took place as well as three discussion sessions; 65 lectures and 153 posters were presented in the following proportions:

I session "Systematics and Evolution" – 11 lectures and 44 posters;

II session "Quality and Quantity: maintaining biological diversity in space and time" – 13 lectures and 34 posters;

III session "Genes, Physiology and Structure" – 14 lectures and 16 posters;

IV session "Contributions of Lichen Ecology to a better understanding of lichens in ecosystems" – 10 lectures and 29 posters;

V session "Lichen Photobionts – physiological, ecological and phylogenetic aspects of their diversity" – 7 lectures and 9 posters;

VI session "Lichen Uses" – 10 lectures and 21 posters.

Furthermore, we listened to the exciting opening lecture by Angela Douglas "Symbiosis: cooperation, slavery or domestification?" and could present everyone's opinion during the discussion sessions **"Translation of phylogenetic analyses into classification"** (convened by Thorsten Lumbsch), **"In search of model organisms"** (convened by Rosmarie Honegger) and **"Phylogenetic methods"** (convened by Francois Lutzoni).

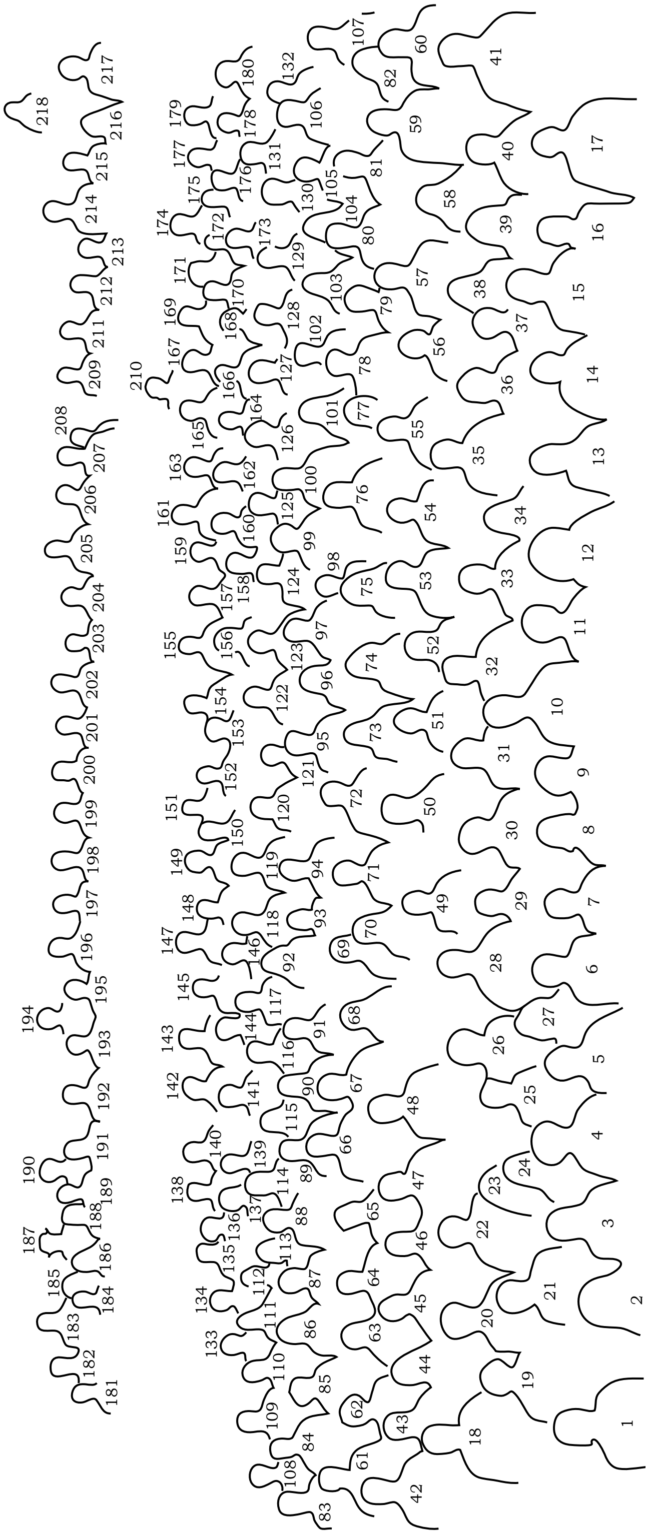
It is a well-known difficulty in preparing any meeting, symposium or congress – how to design the schedule of presentations. Quite normally every participant is eager to introduce his or her latest studies and new results. Some persons are willing to give a lecture and others prefer to prepare posters. The usual opinion is that lecturers belong among Very Important Persons and authors of posters should be students. This time it was different, not *vice versa*, but just different: there were VIPs and students among both categories – the lecturers and the authors of posters. Later several participants of respectable age commented: the significant proportion of young persons among the participants of the symposium was the most striking news of IAL5.

For this thanks are due to the Scientific Committee which consisted of "triumvirates" (Chairman, Convener and Posterman) of every scientific session + conveners of discussion session. Those 21 persons carried out the difficult job of revising abstracts that had been submitted to the symposium, and designed the content of sessions.

The meeting offered us also a good opportunity to introduce our countryside and nature. Altogether 64 persons participated in three excursions which were organised to different parts of Estonia. The participants of the longest, pre-symposium excursion visited Lahemaa and Soomaa National Parks, drove through the Russian old orthodox villages, travelled to the three greatest western islands – Saaremaa, Muhumaa and Hiiumaa. The post-symposium excursion to the eastern and northern parts of Estonia took the participants to the swamp in Endla Nature Reserve, demonstrated the wood-

Participants of the 5th IAL Symposium (August 17, 2004 in Vanemuise Concert Hall)

1. Hiroyuki Kashiwadani (Japan)
2. Kansri Boonpragob (Thailand)
3. Kawinnat Buaruang (Thailand)
4. Kwang Hee Moon (Korea)
5. Fenja Brodo (Canada)
6. Tatiana Makry (Russia)
7. Ave Suija (Estonia)
8. Tiiu Tõrra (Estonia)
9. Palmira Carvalho (Portugal)
10. Mauro Tretiach (Italy)
11. Rui Figuera (Portugal)
12. Elena Molodtsova (Russia)
13. Carolina Cornejo (Switzerland)
14. Laurens B. Sparrius (Netherlands)
15. Lauri Saag (Estonia)
16. Inga Jüriado (Estonia)
17. Åsa Dahlkild (Sweden)
18. Derek Persoh (Germany)
19. Otto L. Lange (Germany)
20. Mark Seaward (UK)
21. Yoshiaki Kon (Japan)
22. Gennadii Urbanavichus (Russia)
23. Irina Urbanavichene (Russia)
24. Svetlana Ektova (Russia)
25. Evgenia Mouchnik (Russia)
26. Susan Will-Wolf (USA)
27. Silvana Munzi (Italy)
28. Mari-Liis Rebane (Estonia)
29. Katrin Kolnes (Estonia)
30. Vagn Alstrup (Denmark)
31. Guido Incerti (Italy)
32. Juri Nascimbene (Italy)
33. Mikhail Piskaryov (Russia)
34. Daniela Csencics (Switzerland)
35. Erast Parmasto (Estonia)
36. Anna Zalewska (Poland)
37. Katarzyna Jando (Poland)
38. Beata Guzow-Krzeminska (Poland)
39. Agniezka Kowalewska (Poland)
40. Eric Steen Hansen (Denmark)
41. Ulf Schiefelbein (Germany)
42. Frank Bungartz (Germany)
43. Irwin Brodo (Canada)
44. Sanja Savic (Sweden)
45. Harrie Sipman (Germany)
46.
47. Jouko Rikkinen (Finland)
48. Thilo Hasse (Germany)
49. Natalia Davydova (Russia)
50. Evgeny Davydov (Russia)
51. Line Balschmidt (Denmark)
52.
53. Piret Lõhmus (Estonia)
54. Evelyn Silvet (Estonia)
55.
56. Bettina Staiger (Germany)
57. Christoph Scheidegger (Switzerland)
58. Alessia Fappiano (Italy)
59. Renato Benesperi (Italy)
60. Andres Saag (Estonia)
61. Roland Moberg (Sweden)
62. Paula de Priest (USA)
63. Lucia Muggia (Italy)
64. Magdalena Opanowicz (Poland)
65.



66. Knut Asbjorn Solhaug (Norway)
67. Per Gerhard Ihlen (Sweden)
68.
69. Asuncion de los Rios (Spain)
70. Nadezhda Alexeeva (Russia)
71. Guillermo Amo de Paz (Spain)
72. Francois Lutzoni (USA)
73. Jolanta Miadlikowska (USA)
74. Jana Kocourkova (Czech Republic)
75. Valerie Hofstetter (USA)
76. Martin Kukwa (Poland)
77. Beata Krzewicka (Poland)
78. Pawel Czarnota (Poland)
79. Paola Adamo (Italy)
80. Paolo Giordani (Italy)
81. Stefano Martellos (Italy)
82. Cecile Gueidan (USA)
83. Rebecca Yahr (USA)
84. Christopher Ellis (UK)
85. Anna Crewe (Sweden)
86. Valerie Reeb (USA)
87. Torbjorg Bjelland (Norway)
88. William Purvis (UK)
89. Cameron Williams (USA)
90. Helga Bültmann Germany)
91.
92. Ljudmilla Martin (Estonia)
93.
94.
95. Bruce McCune (USA)
96. Begona Aguirre-Hudson (UK)
97. Victor Jimenez Rico (Spain)
98. Ruth del Prado (USA)
99. Ineke Beltman (Netherlands)
100. Alexey Zavarzin (Russia)
101. Olga Merkulova (Russia)
102. Christine Keller (Switzerland)
103. Maarja Nõmm (Estonia)
104. Ede Leppik (Estonia)
105. Edit Farkas (Hungaary)
106. Peter Scholtz (Germany)
107. Starri Heidmarsson (Iceland)
108. Imke Schmitt (USA)
109. Zdenek Palice (Czech Republic)
110. Stepanka Bayerova (Czech Republic)
111. Silke Werth (Switzerland)
112. Ondrej Peksa (Czech Republic)
113. Anna Guttova (Slovakia)
114. David Svoboda (Czech Republic)
115. Mahroo Haji Moniri Anbaran (Iran)
116.
117. Tiina Randlane (Estonia)
118. Suzanne Joneson (USA)
119. Alexandro Caruso (Sweden)
120. Heath O'Brian (USA)
121. Shyam Nyatti (Switzerland)
122. Sandra Scherrer (Switzerland)
123. Christof Eichenberger (Switzerland)
124. David Hawksworth (Spain)
125. Jurga Motiejunaite (Lithuania)
126. Holger Thüs (Germany)
127.
128. Milos Bartak (Czech Republic)
129. Ulrik Sochting (Denmark)
130. Alexander Paukov (Russia)
131. Helmut Mayrhofer (Austria)
132. Josef Hajek (Czech Republic)
133. Elisabeth Baloch (Austria)
134. Sabine Wornik (Austria)
135.
136. Alexander Taran (Russia)
137. Svetlana Tchabanenko (Russia)

138. Juliane Blaha (Austria)
139. Irina Mikhailova (Russia)
140. Franc Batic (Slovenia)
141. Margarita Magomedova (Russia)
142.
143. Isao Yoshimura (Japan)
144. Oleg Blum (Ukraine)
145.
146. Jüri Martin (Estonia)
147.
148. Zvonka Jeran (Slovenia)
149. Louise Lindblom (Sweden)
150. Rene Spigelberg Larsen (Denmark)
151. Thomas Nash III (USA)
152. Frank Kauff (USA)
153. Armin Mangold (USA)
154. Mats Wedin (Sweden)
155. Anders Nordin (Sweden)
156. Elfie Stocker-Wörgötter (Austria)
157. André Aptroot (Netherlands)
158. Francoise Rolley (France)
159. Silvia Stofer (Switzerland)
160. Wanaruk Saipunkaew (Thailand)
161. Teuvo Ahti (Finland)
162. Astri Botnen (Norway)
163. Pat Wolseley (UK)
164. Katherine Glew (USA)
165. Christian Printzen (Germany)
166. Scott LaGreca (UK)
167. Tor Tonsberg (Norway)
168. Leena Myllys (Finland)
169. Robert Lücking (USA)
170. Laura Kivistö (Finland)
171. Rosa Perez Perez (Mexico)
172. Heini Hyvärinen (Finland)
173. Heidi Döring (Sweden)
174. Philippe Clerc (Switzerland)
175. Filip Högnabba (Finland)
176. Henrik Hedenås (Sweden)
177. Lucyna Sliwa (Poland)
178. Geir Hestmark (Norway)
179. William Sanders (Spain)
180. Ingrid Berney (Switzerland)
181. Diane Fahselt (USA)
182.
183. Arne Thell (Sweden)
184. Enrica Matteucci (Italy)
185. Elena Pittao (Italy)
186. Paola Crisafulli (Italy)
187. Jacob Garty (Israel)
188. Deborah Isocrono (Italy)
189.
190. Sergio Enrico Favero-Longo (Italy)
191. Lauro Xavier-Filho (Brazil)
192. Mohammad Sohrabi (Iran)
193. Domenico Puntillo (Italy)
194. Pier Luigi Nimis (Italy)
195. Nora Wirtz (Germany)
196. Thorsten Lumbsch (USA)
197. Rikke Reese Naesborg (Sweden)
198. Jan-Eric Mattsson (Sweden)
199. Matthias Schultz (Germany)
200. Tassilo Feuerer (Germany)
201. Anders Tehler (Sweden)
202. Håkan Lättman (Sweden)
203. Orvo Vitikainen (Finland)
204. Emmanuël Sérusiaux (Belgium)
205. Gintaras Kantvilas (Australia)
206. Peter Crittenden (UK)
207. Rikard Sundin (Sweden)
208. Rosmarie Honegger (Switzerland)
209. Michaela Schmull (Germany)
210. Manfred Jennsen (Germany)
211. Elisabeth Lay (USA)
212. Maria Angeles Herrera-Campos (Mexico)
213. Angela Douglas (UK)
214. Fabian Seymour (UK)
215. Jutta Buschbom (Germany)
216. Ana Pintado (Spain)
217. Stefano Loppi (Spain)
218. Alar Suija (Estonia)

land key-habitat, wooded meadow and limestone fields. Another post-symposium excursion was organised to visit the beautiful sites in southern Estonia such as Devonian sandstone cliffs in Taevaskoja, raised bog in Meenikunno and sandy dunes close to Värska. The choice of visited sites turned out to be the most successful – as it can be read from the contribution by Aptroot et al. in the present volume – during these three excursions 30 species of lichens or lichenicolous fungi new to the country were collected!

Contributions presented during IAL5 will be recorded in the various proceedings of the symposium. This volume of Folia Cryptogamica Estonica is only one of them; special volumes or special parts of ordinary volumes of such periodicals as Lichenologist, Environmental Pollution and Journal of Vegetation Science will follow. In this issue you will find 13 papers based on poster presentations, plus a summary of lichenised or lichenicolous taxa new or rare in Estonia, which were found during the excursions or the symposium.

The organisation of the 5th Symposium of the International Association for Lichenology "Lichens in Focus" was a joint effort of the Local Organising Committee, IAL5 Scientific Committee and the IAL Council which served during 2000–2004. The main principles for the organisation of this event as well as numerous small details of even marginal problems were thoroughly discussed and decided first of all by the IAL Council. The Local Organising Committe felt the support of the Council all the time during these four preparatory years. Therefore we would like to express our sincere gratitude to the people who formed this fantastic IAL Council:

Pier Luigi Nimis
Irwin Brodo
Leopoldo Sancho
Francois Lutzoni
Christoph Scheidegger
Martin Grube
Jack Elix
Rosmarie Honegger
Gintaras Kantvilas

The orchids which we received at the IAL dinner are still in blossoms – reminding us of these days in August 2004 that now, in retrospect, seem to have been nothing but pure pleasure.

Tiina Randlane & Andres Saag

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Lichens from islands in the Russian part of the Gulf of Finland

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Abstract: The present paper is based on material from several recent collections made between 1993 and 2003 on islands in the central part of the Gulf of Finland (Gogland, Bolshoy Tuters, Maly Tuters, Seskar, Moschny, Maly, Sommers) and several islands situated near the Russian-Finnish border (Bolshoy Pogranichny and surrounding islands). The list of lichen species includes 170 species and 3 subspecies. *Amandinea cacuminum*, *Buellia badia*, *Caloplaca cerinella*, *C. diphyodes*, *C. microthallina*, *Cladonia borealis*, *C. diversa*, *C. metacorallifera*, *Lecanora marginata*, *L. persimilis*, *L. rimicola*, *L. salina*, *Lepraria caesioalba*, *Melanelia disjuncta*, *Ramalina polymorpha*, *Rhizocarpon richardii*, *Rinodina gennarii*, *Stereocaulon incrustatum* and *S. rivulorum* have been reported for the Leningrad region only from these islands. *Bryoria subcana*, *Cladonia macrophylla*, *Flavocetraria nivalis*, *Melanelia hepatizon*, *M. stygia*, *Neofuscelia pulla*, *Umbilicaria hirsuta*, *U. hyperborea*, *Peltigera scabrosa* and *Ramalina fraxinea* are red-listed in the Leningrad region.

Kokkuvõte: Samblikud Venemaale kuuluvatel Soome lahe saartel.

Töö põhineb aastatel 1993 kuni 2003 Soome lahe keskosa (Suursaar, Suur Tütarsaar, Väike Tütarsaar, Seiskari, Lavansaari, Penisaari, Sommers) ja Vene-Soome piiri lähedastelt saartelt (Paatio jt.) kogutud kollektsioonidel. Samblikuliikide nimekiri koosneb 170 liigist ja 3 alamliigist. Leningradi oblastis on liike *Amandinea cacuminum*, *Buellia badia*, *Caloplaca cerinella*, *C. diphyodes*, *C. microthallina*, *Cladonia borealis*, *C. diversa*, *C. metacorallifera*, *Lecanora marginata*, *L. persimilis*, *L. rimicola*, *L. salina*, *Lepraria caesioalba*, *Melanelia disjuncta*, *Ramalina polymorpha*, *Rhizocarpon richardii*, *Rinodina gennarii*, *Stereocaulon incrustatum* ja *S. rivulorum* leitud ainult nendelt saartelt. *Bryoria subcana*, *Cladonia macrophylla*, *Flavocetraria nivalis*, *Melanelia hepatizon*, *M. stygia*, *Neofuscelia pulla*, *Umbilicaria hirsuta*, *U. hyperborea*, *Peltigera scabrosa* ja *Ramalina fraxinea* kuuluvad Leningradi oblasti punasesse nimekirja.

INTRODUCTION

Many islands situated in the Russian part of the Gulf of Finland have been closed for visiting during the last 60 years due to the Soviet military requirements. Before World War ll this area belonged to Finland and on the largest islands there were several settlements. Nevertheless, neither large-scale agriculture nor forestry have been practised on the islands. Thus the natural complexes and landscape diversity of these territories nearby St. Petersburg have mainly been left undisturbed. During the war civil inhabitants were forced to leave this area. In 1944 the islands became a part of USSR and were included into the so called “border zone”, where access was practically forbidden.

The first notes on richness and uniqueness of the natural complexes of the islands were published by zoologists and botanists who visited these territories in early 1990-s after almost 50-years period of strict protection. Recent inventories of the flora revealed that these islands are extraordinary rich in species and support populations of many red-listed plants (e.g. Glazkova, 2002). The current lichen diversity of the islands remained poorly studied until recently. The lichen flora of Gogland (Hogland) island was investigated by Brenner (1886), but modern detailed review of his collections is still needed. No further inventories of lichens were made on the islands for over a century. In 2002 a list of 120 lichen species collected in 1994 from Bolshoy Tuters island was published by Andreyev (2002). There are also scanty collections of lichens made between 1993 and 2003 on other islands in the central part of the Gulf of Finland (Gogland, Bolshoy Tuters, Maly Tuters, Seskar, Moschny, Maly, Sommers, administratively belonging to Kingiseppsky district of the Leningrad region) and several islands situated near the Russian-Finnish border (Bolshoy Pogranichny and surrounding islands, Vyborgsky district of the Leningrad region).

Here I present the first summary of the lichens found on the remote islands of the Gulf of Finland in recent years. Hopefully this will help to attract lichenologists’ attention to these highly interesting areas.

The islands under consideration are situated between 59°48’–60°32’N and 26°55’–28°25’E (Fig. 1) and differ considerably in their area, height and appearance. Gogland and Bolshoy Tuters are high islands (176 and 56 m a.s.l. respectively), with rocks, cliffs and stone terraces, formed by gneisses, granites, gneisses-granites, quarz-porphyries and quarzite. Sommers island consists of low granite outcrops, so-called "bullheads". In contrast, Maly Tuters, Moschny, Maly and Seskar are low islands (5–15 m a.s.l.); their surface cover consists of moraine and marine deposits of sand, rubble, shingle and gravel. Along with Bolshoy Tuters, they are famous for their dune systems and beach ridges (Glazkova, 2001). Bolshoy Pogranichny and surrounding islands are formed by rocky (predominantly rapakivi granites) ridges up to 20–30 m high. Most of the islands are covered with forests. Pine (*Pinus sylvestris*) forests are prevailing. Spruce forests formed by *Picea abies* and secondary small-leaved forests with *Betula pendula*, *B. pubescens*, *Populus tremula* and *Sorbus aucuparia* are also present. *Alnus glutinosa* stands occur along the seacoast. Broad-leaved trees are mainly restricted to the previous settlements. Various types of meadows and sandy heathlands, as well as fens, raised bogs and transitory bogs can be found on particular islands (Glazkova, 2001; Noskov & Botch, 1999).

MATERIALS AND METHODS

The present paper is based on material from several collections made on the islands between 1993 and 2003 (names of the islands, year of collection and number of samples see in Table 1). In the course of the present studies collections of N. Balashova, E. Glazkova and A. Gaginskaya were revised. The specimens were determined with routine techniques. Secondary compounds of *Cladonia borealis* were analysed according to the standardised TLC method. Herbarium samples are kept at the department of Botany of St. Petersburg State University (LECB). Other records used include list of species for Bolshoy Tuters island published by M. Andreyev; his collections are deposited in the herbaria of Komarov Botanical Institute (LE), Uppsala University (UPS) and Bergen Universiry (BG) (Andreyev, 2002).

RESULTS

A total of 170 species and 3 subspecies are reported for the islands. The majority of these species are common in the Leningrad region. Still, some species identified are of special interest. *Amandinea cacuminum*, *Buellia badia*, *Caloplaca cerinella*, *C. diphyodes*, *C. microthallina*,

Fig. 1. Location of the islands Gogland, Bolshoy Tuters, Maly Tuters, Seskar, Moschny, Maly, Sommers, Bolshoy Pogranichny in the Gulf of Finland.

Table 1. The area of the islands, collector name and year of collection

Russian names	Finnish names	Abbreviations	Area, (km^2)	Collector name, year of collection and number of samples
Gogland	Suursaari	Gog	20.64	N. Balashova, 1993, 12 samples A. Gaginskaya, 2003, 32 samples
Bolshoy Tuters	Suur Tutersaari	BTu	9.2	N. Balashova, 1993, 26 samples M. Andreyev, 1994, 240 samples (Andreyev, 2002)
Maly Tuters	Pieni Tutersaari	MTu	3.0	N. Balashova, 1993, ca 60 samples
Seskar	Seiskari	Ses	4.5	N. Balashova, 1993, 16 samples
Moschny	Lavansaari	Mo	16.5	N. Balashova, 1993, 12 samples
Maly	Peninsaari	Mal	3.5	N. Balashova, 1993, 37 samples
Sommers	Sommers	Som	0.14	E. Glazkova, 1995, ca 50 samples
Bolshoy Pogranichny (and complex of surrounding islands)	Paatio	BPo	9.0	E. Glazkova, 2002, ca 140 samples

Cladonia borealis, *C. diversa*, *C. metacorallifera*, *Lecanora marginata*, *L. persimilis*, *L. rimicola*, *L. salina*, *Lepraria caesioalba*, *Melanelia disjuncta*, *Ramalina polymorpha*, *Rhizocarpon richardii*, *Rinodina gennarii*, *Stereocaulon incrustatum* and *S. rivulorum* have been reported for the Leningrad region only from these islands. *Bryoria subcana*, *Cladonia macrophylla*, *Flavocetraria nivalis*, *Melanelia hepatizon*, *M. stygia*, *Neofuscelia pulla*, *Umbilicaria hirsuta*, *U. hyperborea*, *Peltigera scabrosa* and *Ramalina fraxinea* are red-listed in the Leningrad region (Tzvelev, 2000). The characteristic feature of the territory is the occurrence of oceanic and suboceanic species, such as *Caloplaca scopularis*, *Cladonia ramulosa*, *C. scabriuscula*, *Peltigera hymenina* and *Ramalina polymorpha*.

List of species

The following list is presented in alphabetical order. The nomenclature follows Santesson et al. (2004). Abbreviations of islands see in Table 1. Species mentioned only by Andreyev (2002) and not found in other collections are marked with asterisk (*). Notes on ecology mentioned by M. Andreyev are presented in brackets.

*Acarospora fuscata (Schrad.) Th. Fr. – BTu; (Andreyev: on granite pebbles on the road, granite boulders on dunes).

Amandinea cacuminum (Th. Fr.) H. Mayrhofer & Sheard – MTu; on siliceous pebble.

A. coniops (Wahlenb.) M. Choisy ex Scheid. & H. Mayrhofer – MTu; on siliceous pebble.

A. punctata (Hoffm.) Coppins & Scheid. – Mal, BTu; on bark of deciduous trees (Andreyev: *Padus avium, Quercus robur* near the ruins of old village).

*Aspicilia caesiocinerea (Nyl. ex Malbr.) Arnold – BTu; (Andreyev: on granite rocks and boulders on the coast, granite pebbles on the road).

A. cinerea (L.) Körb. – Som; on siliceous pebble.

Bryoria capillaris (Ach.) Brodo & D. Hawksw. – BTu, Gog; on bark of coniferous trees (Andreyev: *Picea abies* in the young spruce forest).

*B. fuscescens (Gyeln.) Brodo & D. Hawksw. – BTu; (Andreyev: on bark of *Picea abies* in the spruce forest).

B. subcana (Nyl. ex Stizenb.) Brodo & D. Hawksw. – Mal, MTu; on bark of coniferous trees.

*Buellia badia (Fr.) A. Massal. – BTu; (Andreyev: on granite boulders on dunes).

*Caloplaca cerinella (Nyl.) Flagey – BTu; (Andreyev: on bark of *Acer platanoides* near the ruins of old village).

*C. diphyodes (Nyl.) Jatta – BTu; (Andreyev: on granite rocks and boulders on the coast).

C. holocarpa (Hoffm. ex Ach.) A.E. Wade – BTu, BPo; on bark of deciduous trees (Andreyev: *Fraxinus excelsior* near the ruins of old village).

*C. MARINA (Wedd.) Zahlbr. – BTu; (Andreyev: on granite rocks and boulders on the coast).

*C. MICTROTHALLINA (Wedd.) Zahlbr. – BTu; (Andreyev: on granite rocks and boulders on the coast).

*C. SAXICOLA (Hoffm.) Nordin – BTu; (Andreyev: on limestone in the ruined old village).

C. SCOPULARIS (Nyl.) Lettau – Som; on concrete.

CANDELARIELLA AURELLA (Hoffm.) Zahlbr. – Som, BTu; on concrete (Andreyev: on limestone in the ruined old village).

C. CORALLIZA (Nyl.) H. Magn. – MTu; on siliceous pebble.

C. VITELLINA (Hoffm.) Müll. Arg. – BTu, MTu; on siliceous pebbles (Andreyev: on granite rocks and boulders on the coast, granite boulders on dunes).

CETRARIA ACULEATA (Schreb.) Fr. – Mal; on soil.

C. ISLANDICA (L.) Ach. – Som, Mal, BTu, Gog, BPo; on soil (Andreyev: on sand dunes).

C. MURICATA (Ach.) Eckfeldt – Som, Mal; on soil.

C. SEPINCOLA (Ehrh.) Ach. – BPo; on bark of deciduous trees.

*CHAENOTHECA FERRUGINEA (Turner ex Sm.) Mig. – BTu; (Andreyev: on wood in the pine forest).

*CLADONIA AMAUROCRAEA (Flörke) Schaer. – BTu; (Andreyev: on granite rocks in the pine forest).

CLADONIA ARBUSCULA (Wallr.) Flot. ssp. MITIS (Sandst.) Ruoss – Som, BTu; on soil (Andreyev: on sand dunes).

C. ARBUSCULA (Wallr.) Flot. ssp. SQUARROSA (Wallr.) Ruoss – Som, Mal, BTu, Gog; on soil (Andreyev: on sand dunes, granite rocks in the pine forest).

*C. BELLIDIFLORA (Ach.) Schaer. – BTu; (Andreyev: on wood on dunes).

C. BOREALIS S. Stenroos – Mal, Gog; on soil.

C. BOTRYTES (K.G. Hagen) Willd. – BTu, BPo; on soil, (Andreyev: on sand dunes).

*C. CENOTEA (Ach.) Schaer. – BTu; (Andreyev: on wood in the pine forest).

*C. CHLOROPHAEA (Flörke ex Sommerf.) Spreng. – BTu; (Andreyev: on granite rocks in the pine forest).

*C. COCCIFERA (L.) Willd. – BTu; (Andreyev: on granite rocks in the pine forest).

C. CONIOCRAEA (Flörke) Spreng. – Som, BTu, BPo; on soil, wood, (Andreyev: on wood on dunes).

C. CORNUTA (L.) Hoffm. ssp. CORNUTA – BTu, BPo; on soil, (Andreyev: on wood in the pine forest and on sand dunes).

C. CRISPATA (Ach.) Flot. – BTu, BPo; on soil (Andreyev: on wood in the pine forest and on sand dunes).

*C. DEFORMIS (L.) Hoffm. – BTu; (Andreyev: on wood on dunes).

C. DIGITATA (L.) Hoffm. – BPo; on decaying wood.

C. DIVERSA Asperges – Som; on soil.

C. FIMBRIATA (L.) Fr. – Som, BTu, BPo; on soil (Andreyev: on sand dunes).

C. FLOERKEANA (Fr.) Flörke – Som, BTu, BPo; on soil (Andreyev: on wood on dunes).

C. FURCATA (Huds.) Schrad. – Som, Mal, BTu, Gog, BPo; on soil (Andreyev: on sand dunes, granite rocks in the pine forest).

C. GRACILIS (L.) Willd. ssp. GRACILIS – Som, BTu, Gog, BPo; on soil (Andreyev: on granite rocks in the pine forest).

*C. GRACILIS (L.) Willd. ssp. TURBINATA (Ach.) Ahti – BTu; (Andreyev: on wood in the pine forest and on sand dunes).

C. MACILENTA Hoffm. – Som, BTu, Mal; on soil (Andreyev: on wood on dunes and in the pine forest).

C. MACROPHYLLA (Schaer.) Stenh. – BPo; on soil.

C. METACORALLIFERA Asahina – Gog; on soil.

C. PHYLLOPHORA Hoffm. – BTu, Gog, BPo; on soil (Andreyev: on granite rocks in the pine forest).

C. PLEUROTA (Flörke) Schaer. – BTu, Gog, BPo; on soil (Andreyev: on granite rocks and wood in the pine forest).

C. PYXIDATA (L.) Hoffm. – Som, Mal, BTu, BPo; on soil.

*C. PORTENTOSA (Dufour) Coem. – BTu; (Andreyev: on sand dunes).

C. RAMULOSA (With.) J.R. Laundon – Som; on soil.

C. RANGIFERINA (L.) F.H. Wigg. – Som, Mal, BTu, Gog, BPo; on soil (Andreyev: on sand dunes, granite rocks in the pine forest).

*C. REI Schaer. – BTu; (Andreyev: on wood in the pine forest).

C. SCABRIUSCULA (Delise) Nyl. – BTu; on soil.

C. SQUAMOSA Hoffm. – Som, BTu, Gog, BPo; on soil (Andreyev: on granite rocks in the pine forest).

C. STELLARIS (Opiz) Pouzar & Vězda – Mal, BTu; on soil (Andreyev: on sand dunes, granite rocks in the pine forest).

C. SUBULATA (L.) Weber ex F.H. Wigg. – BTu, BPo; on soil (Andreyev: on wood and sand on dunes).

C. TURGIDA Hoffm. – Mal, BTu; on soil (Andreyev: on soil in the young spruce forest, granite rocks in the pine forest).

C. VERTICILLATA (Hoffm.) Schaer. – BTu, BPo; on soil (Andreyev: on sand dunes).

C. UNCIALIS (L.) Weber ex F.H. Wigg. ssp. BIUNCIALIS (Hoffm.) M.Choisy – Som, BTu; on soil.

C. UNCIALIS (L.) Weber ex F.H. Wigg ssp. UNCIALIS – BTu, Gog; on soil (Andreyev: on granite rocks in the pine forest).

FLAVOCETRARIA NIVALIS (L.) Kärnefelt & A. Thell – Mal; on soil.

*HYPOCENOMYCE SCALARIS (Ach.) M. Choisy – BTu; (Andreyev: on wood in the pine forest).

HYPOGYMNIA PHYSODES (L.) Nyl. – Som, Mal, BTu, Gog, Ses, Mo, BPo; on bark of deciduous and coniferous trees, rocky outcrops (Andreyev: on bark of *Alnus* sp., *Picea abies*, wood, granite rocks and boulders, sand – in spruce and pine forests, on the coast, on sand dunes).

H. TUBULOSA (Schaer.) Hav. – Gog; on bark of coniferous trees.

IMSHAUGIA ALEURITES (Ach.) S.L.F. Meyer – Gog; on bark of *Pinus sylvestris*.

LASALLIA PUSTULATA (L.) Mérat – Som, BPo; on siliceous rocks.

LECANORA ALLOPHANA Nyl. – Ses; on bark of deciduous trees.

*L. ARGENTATA (Ach.) Malme – BTu; (Andreyev: on bark of *Alnus* sp. on the coast).

*L. CAMPESTRIS (Schaer.) Hue – BTu; (Andreyev: on granite rocks in the pine forest).

L. CARPINEA (L.) Vain. – Mal, BTu, Gog, Ses, Mo; on bark of deciduous trees (Andreyev: *Acer platanoides, Betula* sp., *Fraxinus excelsior*, *Padus avium*, *Quercus robur*, *Sorbus aucuparia* on the coast and near the ruins of old village).

*L. CHLAROTERA Nyl. – BTu; (Andreyev: on bark of *Quercus robur* near the ruins of old village).

L. DISPERSA (Pers.) Sommerf. – Som, BTu; on concrete (Andreyev: on limestone in the ruined old village).

L. HAGENII (Ach.) Ach. – MTu, BPo; on bark of deciduous trees.

*L. HELICOPIS (Wahlenb.) Ach. – BTu; (Andreyev: on granite rocks and boulders on the coast).

*L. MARGINATA (Schaer.) Hertel & Rambold – BTu; (Andreyev: on granite boulders on dunes).

*L. PERSIMILIS (Th. Fr.) Nyl. – BTu; (Andreyev: on bark of *Alnus* sp. on the coast).

L. POLYTROPA (Ehrh. ex Hoffm.) Rabenh. – BTu, MTu; on siliceous pebbles (Andreyev: on granite pebbles on the road, granite boulders on dunes).

*L. PULICARIS (Pers.) Ach. – BTu; (Andreyev: on bark of *Picea abies*, *Sorbus aucuparia* on the coast).

*L. RIMICOLA H. Magn. – BTu; (Andreyev: on granite boulders on the coast).

L. RUPICOLA (L.) Zahlbr. – Som, BTu, MTu; on siliceous pebbles (Andreyev: on granite boulders on dunes).

*L. SALINA H. Magn. – BTu; (Andreyev: on granite rocks and boulders on the coast).

L. SULPHUREA (Hoffm.) Ach. – MTu; on siliceous pebbles.

L. SYMMICTA (Ach.) Ach. – Ses, BTu, Mo; on bark of deciduous trees (Andreyev: *Alnus* sp., *Betula* sp., *Sorbus aucuparia* on the coast).

*L. VARIA (Hoffm.) Ach. – BTu; (Andreyev: on wood on dunes).

*LECIDEA FUSCOATRA (L.) Ach. – BTu; (Andreyev: on granite boulders on dunes).

L. LAPICIDA (Ach.) Ach. var. PANTHERINA Ach. – Som, BTu, MTu; on siliceous pebbles (Andreyev: on granite rocks and boulders on the coast, granite boulders on dunes, granite pebbles on the road).

*LECIDELLA ACHRISOTERA (Nyl.) Hertel & Leuckert – BTu; (Andreyev: on bark of *Acer platanoides, Betula* sp., *Fraxinus excelsior*, *Quercus robur* near the ruins of old village).

*L. CARPATHICA Körb. – BTu; (Andreyev: on granite rocks in the pine forest).

L. ELAEOCHROMA (Ach.) M. Choisy – Mal, BTu, Gog, Ses; on bark of deciduous trees.

*L. EUPHOREA (Flörke) Hertel. – BTu; (Andreyev: on bark of *Padus avium* near the ruins of old village).

*LEPRARIA CAESIOALBA (de Lesd.) J.R. Laundon – BTu; (Andreyev: on granite boulders in the young spruce forest).

*MELANELIA DISJUNCTA (Erichsen) Essl. – BTu; (Andreyev: on granite rocks and boulders on the coast).

MELANELIA EXASPERATA (De Not.) Essl. – BPo; on bark of deciduous trees.

M. EXASPERATULA (Nyl.) Essl. – Mal, BTu, Gog, Ses, BPo; on bark of deciduous trees and dry twigs of *Picea abies* (Andreyev: on *Alnus* sp. on the coast).

*M. HEPATIZON (Ach.) A. Thell – BTu; (Andreyev: on granite boulders on dunes).

M. OLIVACEA (L.) Essl. – Mal, BTu, Ses; on bark of deciduous trees (Andreyev: on *Alnus* sp., *Sorbus aucuparia* on the coast).

*M. STYGIA (L.) Essl. – BTu; (Andreyev: on granite boulders on dunes).

*NAETROCYMBE PUNCTIFORMIS (Pers.) R.C. Harris – BTu; (Andreyev: on bark of *Alnus* sp., *Betula* sp. on the coast).

NEOFUSCELIA PULLA (Ach.) Essl. – Som, BTu, MTu; on siliceous pebbles (Andreyev: on granite rocks on the coast and in the pine forest, granite boulders on dunes).

*N. VERRUCULIFERA (Nyl.) Essl. – BTu; (Andreyev: on granite rocks and boulders on the coast).

*PACHYPHIALE FAGICOLA (Hepp) Zwackh – BTu; (Andreyev: on bark of *Acer platanoides* near the ruins of old village).

*PARMELIA OMPHALODES (L.) Ach. – BTu; (Andreyev: on granite pebbles on the road).

P. SAXATILIS (L.) Ach. – Som, Mal, BTu, MTu, Gog, Ses, BPo; on siliceous pebbles and rocks (Andreyev: on bark of *Alnus* sp., *Sorbus aucuparia* on the coast, on granite rocks on the coast and in the pine forest, granite boulders on dunes, granite pebbles on the road).

P. SULCATA Taylor – Mal, BTu, Gog, Ses, Mo, BPo; on bark of deciduous trees (Andreyev: on *Sorbus aucuparia* on the coast, *Quercus robur* near the ruins of old village).

PARMELIOPSIS AMBIGUA (Wulfen) Nyl. – Mal, BTu, Mo, BPo; on bark of deciduous and coniferous trees, wood (Andreyev: on wood in the pine forest).

P. HYPEROPTA (Ach.) Arnold – Gog, BPo; on bark of deciduous and coniferous trees.

PELTIGERA APHTHOSA (L.) Willd. – BPo; on soil.

P. CANINA (L.) Willd. – Som, Mal, BTu, BPo; on soil (Andreyev: on soil in the ruined old village).

P. DIDACTYLA (With.) J.R. Laundon – BTu, BPo; on soil.

P. HYMENINA (Ach.) Delise – BPo; on soil.

P. LEUCOPHLEBIA (Nyl.) Gyeln. – Som; on soil.

P. MALACEA (Ach.) Funk – BTu, BPo; on soil.

P. MEMBRANACEA (Ach.) Nyl. – BPo; on soil.

P. NECKERI Hepp. ex Müll. Arg. – Som, Mal, BPo; on soil.

P. POLYDACTYLON (Neck.) Hoffm. – Som, BPo; on soil.

*P. PREATEXTATA (Flörke ex Sommerf.) Zopf – BTu; (Andreyev: on soil in the young spruce forest).

P. RUFESCENS (Weiss) Humb. – Som, Mal, BTu, BPo; on soil.

P. SCABROSA Th. Fr. – BPo; on soil.

*PHAEOPHYSCIA SCIASTRA (Ach.) Moberg – BTu; (Andreyev: on granite pebbles on the road, granite rocks and boulders on the coast).

*PHLYCTIS ARGENA (Spreng.) Flot. – BTu; (Andreyev: on bark of *Alnus* sp. on the coast).

PHYSCIA ADSCENDENS H. Olivier – BTu, Mo, BPo; on bark of deciduous trees.

P. CAESIA (Hoffm.) Fürnr. – MTu, BPo; on siliceous pebbles and rocks.

P. DUBIA (Hoffm.) Lettau – BTu, BPo; on bark of deciduous trees (Andreyev: on *Acer platanoides, Quercus robur* near the ruins of old village, on granite rocks and boulders on the coast, granite boulders on dunes).

*P. LEPTALEA (Ach.) DC. – BTu; (Andreyev: on bark of *Alnus* sp. on the coast).

P. STELLARIS (L.) Nyl. – BTu, Ses, Mo, BPo; on bark of deciduous trees (Andreyev: on *Fraxinus excelsior*, *Quercus robur* near the ruins of old village).

P. TENELLA (Scop.) DC. – Mal, BTu, Ses, Mo; on bark of deciduous trees (Andreyev: on *Quercus robur* near the ruins of old village, on granite rocks and boulders on the coast).

PLATISMATIA GLAUCA (L.) W.L. Culb. & C.F. Culb. – Mal, BTu, Gog, BPo; on bark of deciduous and coniferous trees, rocky outcrops (Andreyev: on bark of *Picea abies* in spruce forests, wood on dunes).

*PORPIDIA CRUSTULATA (Ach.) Hertel & Knoph – BTu; (Andreyev: on granite boulders on dunes).

*P. FLAVOCAERULESCENS (Hornem.) Hertel & A.J. Schwab – BTu; (Andreyev: on granite boulders in the young spruce forest).

*PROTOPARMELIA BADIA (Hoffm.) Hafellner – BTu; (Andreyev: on granite boulders on dunes).

PROTOPARMELIOPSIS MURALIS (Schreb.) M. Choisy – MTu, BPo; on siliceous pebbles and wood.

PSEUDEVERNIA FURFURACEA (L.) Zopf – Mal, BTu, Gog, BPo; on bark of deciduous and coniferous trees (Andreyev: on *Picea abies* in the spruce forest, on wood and granite rocks and boulders in the pine forest and on dunes).

RAMALINA FARINACEA (L.) Ach. – Mal, BTu, BPo; on bark of deciduous trees (Andreyev: on *Alnus* sp. on the coast).

RAMALINA FRAXINEA (L.) Ach – Mal; on bark of deciduous trees.

*R. POLLINARIA (Westr.) Ach. – BTu; (Andreyev: on bark of *Alnus* sp., *Sorbus aucuparia* on the coast, bark of *Quercus robur* near the ruins of old village).

R. POLYMORPHA (Liljeblad) Ach. – Som; on siliceous rocks.

RHIZOCARPON DISTINCTUM Th. Fr. – Som, BTu, MTu; on siliceous pebbles (Andreyev: on granite pebbles on the road).

R. GEOGRAPHICUM (L.) DC. – Som, BTu; on siliceous pebbles (Andreyev: on granite rocks on the coast and in the pine forest).

R. GRANDE (Flörke) Arnold – MTu; on siliceous pebble.

*R. LECANORINUM Anders – BTu; (Andreyev: on granite rocks on the coast and in the pine forest, granite boulders on dunes).

*R. RICHARDII (Lamy ex Nyl.) Zahlbr. – BTu; (Andreyev: on granite rocks and boulders on the coast).

*RINODINA GENNARII Bagl. – BTu; (Andreyev: on limestone in the ruined old village).

*R. PYRINA (Ach.) Arnold – BTu; (Andreyev: on bark of *Quercus robur* near the ruins of old village).

*R. SOPHODES (Ach.) A. Massal. – BTu; (Andreyev: on bark of *Sorbus aucuparia* on the coast).

*SCHAERERIA FUSCOCINEREA (Nyl.) Clauzade & Cl. Roux – BTu; (Andreyev: on granite rocks on the coast and in the pine forest).

SCOLICIOSPORUM CHLOROCOCCUM (Graewe ex Stenh.) Vězda – BTu, Gog; on bark of deciduous and coniferous trees (Andreyev: *Alnus* sp., *Picea abies*, *Sorbus aucuparia* on the coast).

*S. UMBRINUM (Ach.) Arnold – BTu; (Andreyev: on granite rocks and boulders on the coast).

SPHAEROPHORUS FRAGILIS (L.) Pers. – BPo; on rocks.

STEREOCAULON ALPINUM Laurer – Mal; on soil.

*S. INCRUSTATUM Flörke – BTu; (Andreyev: on sand dunes).

*S. RIVULORUM H. Magn. – BTu; (Andreyev: on sand dunes).

*S. SAXATILE H. Magn. – BTu; (Andreyev: on sand dunes).

*S. TOMENTOSUM Fr. – BTu; (Andreyev: on sand dunes).

*TEPHROMELA ATRA (Huds.) Hafellner – BTu; (Andreyev: on granite rocks and boulders on the coast, granite boulders on dunes).

*TREMOLECIA ATRATA (Ach.) Hertel – BTu; (Andreyev: on granite rocks and boulders on the coast, granite boulders on dunes).

TUCKERMANNOPSIS CHLOROPHYLLA (Willd.) Hale – Mal, BTu, Gog, Ses, Mo, BPo; on bark of deciduous and coniferous trees (Andreyev: *Picea abies* in the spruce forest).

UMBILICARIA DEUSTA (L.) Baumg. – Som, Mal, BTu, Gog, BPo; on siliceous rocks (Andreyev: on granite boulders on sand dunes).

U. HIRSUTA (Sw. ex Westr.) Hoffm. – Gog, BPo; on siliceous rocks.

*U. HYPERBOREA (Ach.) Hoffm. – BTu; (Andreyev: on granite boulders in the young spruce forest).

U. POLYPHYLLA (L.) Baumg. – Som, BTu; on siliceous rocks (Andreyev: on granite boulders on dunes).

*U. TORREFACTA (Lightf.) Schrad. – BTu; (Andreyev: on granite boulders on dunes).

USNEA HIRTA (L.) Weber ex F.H. Wigg. – Mal, Gog; on bark of coniferous trees.

*VERRUCARIA MAURA Wahlenb. – BTu; (Andreyev: on granite rocks and boulders on the coast).

VULPICIDA PINASTRI (Scop.) J.-E. Mattsson & M.J. Lai – Ses, Mo, BPo; on bark of deciduous and coniferous trees, wood.

XANTHOPARMELIA CONSPERSA (Ach.) Hale – Som, BTu, MTu, Ses, BPo; on siliceous pebbles and rocks (Andreyev: on granite boulders on dunes).

X. SOMLOËNSIS (Gyeln.) Hale – BTu, BPo; on siliceous pebbles and rocks (Andreyev: on granite boulders on dunes).

XANTHORIA CANDELARIA (L.) Th. Fr. – BTu, BPo; on siliceous rocks, wood (Andreyev: on granite boulders on dunes).

X. ELEGANS (Link) Th. Fr. – BPo; on siliceous rocks.

X. PARIETINA (L.) Th. Fr. – Som, Mal, BTu, MTu, Ses, Mo, BPo; on siliceous pebbles and rocks, concrete, bark of deciduous trees (Andreyev: *Fraxinus excelsior, Padus avium, Sorbus aucuparia* near the ruins of old village, on granite rocks and boulders on the coast).

X. POLYCARPA (Hoffm.) Th. Fr. ex Rieber – Mal, BTu, MTu, Gog, Ses, Mo, BPo; on bark of deciduous trees, dry twigs of *Picea abies,* wood (Andreyev: on bark of *Alnus* sp. on the coast, *Quercus robur* near the ruins of old village, wood on dunes).

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New or interesting lichens and lichenicolous fungi found during the 5th IAL Symposium in Estonia

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Abstract: Altogether 74 species of lichens and lichenicolous fungi found during IAL5 (Estonia, August 2004) are listed; 30 of them are new to the country. New lichens: *Absconditella celata, A. delutula, A. sphagnorum, Bacidia adastra, B. caligans, Bacidina chloroticula, Cladonia monomorpha, Dirina massiliensis f. sorediata, Lecanora subcarpinea, Lecidella flavosorediata, Micarea anterior, M. lutulata, M. micrococca, Ramonia* aff. *nigra, Rinodina degeliana, Thelocarpon lichenicola, Trapelia involuta, Verrucaria bryoctona, V. dolosa*. New lichenicolous fungi: *Arthonia digitatae, A. galactinaria, Cercidospora macrospora, Cornutispora lichenicola, Marchandiomyces aurantiacus, Merismatium heterophractum, Phoma epiphyscia, Pronectria xanthoriae, Telogalla olivieri, Trichonectria anisospora, T. hirta.*

Kokkuvõte: IAL5 sümpoosioni ajal Eestist leitud uued ning huvipakkuvad samblikud ja lihhenikoolsed seened.

Rahvusvahelise Lihhenoloogide Assotsiatsiooni 5nda sümpoosioni ajal 2004. a-l leiti Eestist 74 haruldast või seni leidmata taksonit. Eestile uued samblikuliigid on (19) on: *Absconditella celata, A. delutula, A. sphagnorum, Bacidia adastra, B. caligans, Bacidina chloroticula, Cladonia monomorpha, Dirina massiliensis f. sorediata, Lecanora subcarpinea, Lecidella flavosorediata, Micarea anterior, M. lutulata, M. micrococca, Ramonia* aff. *nigra, Rinodina degeliana, Thelocarpon lichenicola, Trapelia involuta, Verrucaria bryoctona, V. dolosa*. Eestile uued lihhenikoolsed seened (11) on: *Arthonia digitatae, A. galactinaria, Cercidospora macrospora, Cornutispora lichenicola, Marchandiomyces aurantiacus, Merismatium heterophractum, Phoma epiphyscia, Pronectria xanthoriae, Telogalla olivieri, Trichonectria anisospora, T. hirta.*

INTRODUCTION

Lichenological field trips and symposia which have been arranged in Estonia and attended by colleagues from other countries have always been very generous in new floristic data. In 1989, several Swedish lichenologists visited the western part of the country and presented then 317 taxa, 75 of them new to Estonia (Ekman et al., 1991). Two years later, our Swedish colleagues Göran Thor and Anders Nordin investigated wooded meadows in West-Estonia and some localities in the vicinity of Tartu and identified 16 new species (Thor & Nordin, 1998). The XIV Symposium of Baltic Mycologists and Lichenologists which took place in the south-eastern part of Estonia in 1999 was not an exception either: 43 rare lichen and lichenicolous fungus species, 17 of which were previously unknown from the country, were reported (Halonen et al., 2000).

The present paper contains notes on 74 lichenized and lichenicolous fungi found during the 5th IAL symposium "Lichens in Focus". As a well-entrenched tradition, the number of new species was high again – 30. Most of the specimens were collected during three excursions to different parts of Estonia; however, some interesting taxa were also found in Tartu where the symposium took place.

The longest, five days lasting pre-symposium excursion covered various parts of the mainland and western islands of Estonia. 23 participants visited natural forests in Lahemaa National Park and clint forest in northern Estonia, broadleaved deciduous forest and wooded meadow in western Estonia, and a raised bog in Soomaa National Park in south-western part. Thereafter the trip continued in the islands Muhumaa, Saaremaa (Fig. 1) and Hiiumaa. Different forest types, alvars, oak wood and sandy dunes were visited. Beside these, some places with cultural implications e.g. Kaali meteorite crater and the medieval castle in Kuressaare (both in Saaremaa), Kuremäe orthodox nunnery and Palmse estate (both on the mainland) were included into the excursion program as well.

The most popular trip (30 participants), two days lasting post-symposium excursion took place in the eastern and northern part of Estonia. The tour consisted of a trip to the raised bog in Endla Nature Reserve, visits to a forest stand with old aspens and to a wooded meadow (both near Rakvere), and a stop in a karst field in Kostivere (Fig. 2). A short visit to Sagadi manor house and Museum of Forestry in Lahemaa National Park was also arranged.

19 participants of the one-day post-symposium excursion were taken to South-Estonia. The longer lichenological stops were arranged on the high sandstone banks of the primeval valley of Ahja River, on a raised bog and on the sandy dunes in Värska close to the border of Russia. In addition, a visit to Setu Farm Museum was a tourist event of the day.

Fig. 1. Participants of IAL5 pre-symposium excursion on Atla alvar, island Saaremaa (photo I. Jüriado).

Fig. 2. Karst field in Kostivere, northern part of Estonia (photo I. Jüriado).

Localities
(see also Fig. 3)

1. Lääne-Virumaa, Oandu forest trail (59°33’45”N 26°00’39”E). Spruce forest on peat soil with scattered deciduous trees. 11 Aug 2004.
2. Ida-Virumaa, coast near Ontika (59°26’39”N 27°19’22”E). Deciduous, broad-leaved clint forest. 12 Aug 2004.
3. Ida-Virumaa, Kuremäe cloister (59°11’56”N 27°32’03”E). Trees along footways. 12 Aug 2004.
4. Pärnumaa, Soomaa National Park, Riisa bog (58°29’23”N 24°59’33”E). Raised bog and spruce forest. 13 Aug 2004.
5. Pärnumaa, Koonga community, Nedrema wooded meadow (58°32’45”N 24°04’23”E). Woodland with scattered deciduous trees. 13 Aug 2004.
6. Saaremaa, Muhu Island, Tupenurme cliffs (58°38’45”N 23°13’10”E). Inland limestone cliffs, ca 2 m high. 13 Aug 2004.
7. Saaremaa, Vilsandi National Park, Atla alvar (58°17’06”N 21°54’46”E). Limestone fields. 14 Aug 2004.
8. Saaremaa, Sõrve Peninsula, Lõo alvar (58°06’09”N 22°10’50”E). Coastal limestone fields. 14 Aug 2004.
9. Saaremaa, Kaali Meteorite Crater (58°27’21”N 22°39’48”E). Park around crater lake. 14 Aug 2004.
10. Hiiumaa, Kõpu peninsula, Rebastemäe Nature Track (58°55’22”N 22°15’02”E). Spruce and pine forest on steep sand dunes, alt. ca 70 m. 15 Aug 2004.
11. Hiiumaa, Pihla-Kaibaldi Nature Reserve (58°58’24”N 22°39’51”E). Kaibaldi heath pine forest and inland dunes. 15 Aug 2004.
12. Tartumaa, nature trail N of the city along Emajõgi river (58°25’20”N 26°40’32”E). Riverine deciduous and coniferous forest. 19 Aug 2004.
13. Tartu, parks in city center (58°23’N 26°43’E). 22 Aug 2004.
14. Tartu, Aleksandri Street (59°22’45”N 26°43’49”E). Deciduous trees along the street. 20 Aug 2004.
15. Jõgevamaa, Tooma village near the border of Endla Nature Reserve (58°52’19”N

26°16'16"E). Trees along footpath. 22 Aug 2004.
16. Jõgevamaa, Endla Nature Reserve, Männikjärve bog trail (58°52'21"N 26°14'56"E). Raised bog and spruce forest. 22 Aug 2004.
17. Lääne-Virumaa, around Emumäe tower, alt. 166 m (58°56'17"N 26°22'23"E). Coniferous forest. 22 Aug 2004.
18. Ida-Virumaa, Oonurme village, Kautvere (key habitat site) (59°10'28"N 26°57'36"E). Coniferous forest with scattered aspen trees. 22 Aug 2004.
19. Lääne-Virumaa, Rakvere town (59°21'03"N 26°21'11"E). Deciduous trees. 23 Aug 2004.
20. Lääne-Virumaa, Mädapea wooded meadow (59°19'31"N 26°15'60"E). Woodland with scattered deciduous trees. 23 Aug 2004.
21. Lääne-Virumaa, Lahemaa National Park, Sagadi manor (59°32'11"N 26°05'11"E). Trees in the vicinity of Museum of Forestry. 23 Aug 2004.
22. Harjumaa, Kostivere karst field (59°26'07"N 25°06'45"E). 23 Aug 2004.
23. Põlvamaa, N of Põlva, Taevaskoja along Ahja river (58°06'34"N 27°03'06"E). Forest dominated by *Pinus sylvestris* and *Picea abies*. 22 Aug 2004.
24. Põlvamaa, SE of Värska on Russian border, Mustoja kame field (57°53'40"N 27°42'40"E). Sand dunes with sparse pine forest and small open sand patches. 22 Aug 2004.
25. Põlvamaa, Meenikunno raised bog (57°56'23"N 27°19'40"E). 22 Aug 2004.
26. Põlvamaa, Värska, yard of Setu Farm Museum (57°56'34"N 27°38'57"E). 22 Aug 2004.

LIST OF SPECIES

New species to Estonia are typed in **bold;** all changes in frequency classes (Randlane & Saag, 1999) are indicated with → and are also typed in **bold**.

Abbreviations and symbols: # = lichenicolous fungus; + non-lichenized species. Frequency classes: rr = very rare (1–2 localities); r = rare (3–5); st r = rather rare (6–10). Collectors: AA = Andre Aproot; AS = Ave Suija; ES = Emmanuel Sérusiaux, HS = Harrie Sipman; HT = Holger Thüs; IJ = Inga Jüriado; JK = Jana Kocourková; LS = Laurens Sparrius; LSaag = Lauri Saag; MK = Martin Kukwa; PC = Paweł Czarnota, ZP = Zděnek Palice, TR = Tiina Randlane. Herbaria: ABL = Adviesbureau voor Bryologie en Lichenologie, the Netherlands; B = Botanischer Garten und Botanisches Museum Berlin-Dahlem, Zentraleinrichtung der Freien Universität Berlin, Germany; GPN = Gorce National Park, Poland; Herb. Palice = private herbarium of Zděnek Palice, Czech Republic; Herb. Sparrius = private herbarium of Laurens Sparrius, the Netherlands; Herb. Thüs = private herbarium of Holger Thüs, Germany; LG = Université de Liège, Belgium; PRM = Mycological Department of National Museum, Prague, Czech Republic; TU =

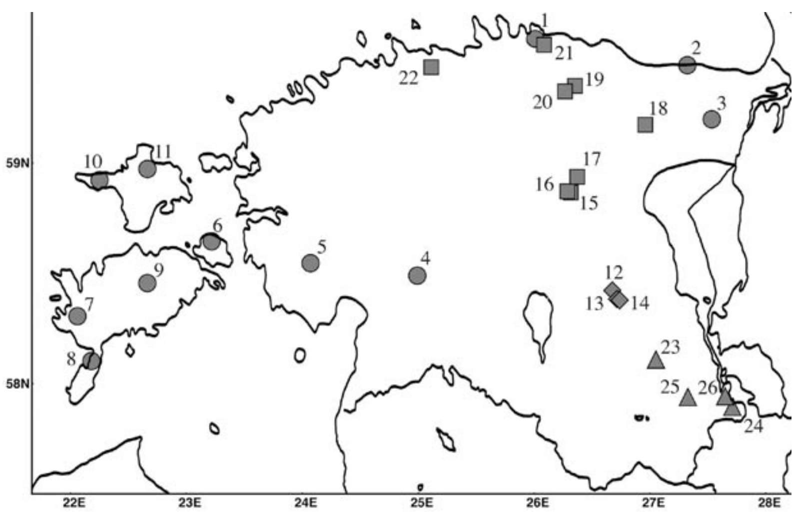

Fig. 3. Location of the sampling points:
- ● – pre-symposium excursion;
- ■ – post-symposium excursion lasting two days
- ▲ – post-symposium excursion of one day;
- ◆ – Tartu, during symposium.

University of Tartu, Estonia; UGDA-L = lichen herbarium of Gdansk University, Poland.

Absconditella celata Döbbeler & Poelt – 23: on lying decaying trunks of *Picea abies* and on decaying wood of bridge over brook, JK (PRM); 25: on wood, cutting flat of stump, ZP (Herb. Palice). Freq.: rr.

Absconditella delutula (Nyl.) Coppins & H. Kilias – 16: on wood, MK (UGDA-L). Freq.: rr.

Absconditella lignicola Vězda & Pišút – 23: on decaying wood of bridge over brook; in spruce forest, on lying decaying trunk of *Picea abies*, JK (PRM). Freq.: rr. – This is the second locality, earlier record from the same region (Halonen et al., 2000).

Absconditella sphagnorum Vězda & Poelt – 4: on peat, LS (Herb. Sparrius), TR (TU); 25: on *Sphagnum* cf. *magellanicum*, JK (PRM). Freq.: rr. – This species is more or less restricted to patches of dead *Sphagnum* in raised bogs in the Northern Hemisphere. It probably lives partly as saprob. The species is visible as minute (0.1–0.3 mm diam.) flesh-coloured, marginate apothecia on dry, decaying *Sphagnum* which then has more or less the same colour.

Agonimia globulifera Brand & Diederich – 7: on calcareous soil with *Fulgensia bracteata*, LS (Herb. Sparrius, TU). Freq.: rr. – This is the second record from Estonia. Steffen Boch (Germany) found *Agonimia globulifera* two months earlier from another alvar in Saaremaa rather close to this locality (Nõmm et al., 2005).

Anisomeridium biforme (Borrer & Sowerb.) R.C. Harris – 20: on *Quercus robur*, LS (Herb. Sparrius). Freq.: rr. – This is the second locality, so far was recorded in south-western region of Estonia (Randlane & Saag, 2004).

Anisomeridium polypori (Ellis & Everh.) M.E. Barr – 12: on *Quercus robur*, AA (ABL); 13: on *Salix* sp., AA (ABL); 16: on *Ulmus* sp., ES (LG). Freq.: rr → **r**. – Known until now from two localities in western islands and north-western region of Estonia (Randlane & Saag, 2004), probably overlooked.

Arthonia muscigena Th. Fr. – 18: on *Populus tremula*, LS (Herb. Sparrius). Freq.: rr. – Earlier was known from only one locality in western islands (Randlane & Saag, 2004).

Arthonia digitatae Hafellner – 23: on *Cladonia digitata* on bark of *Pinus sylvestris*, JK (PRM). Freq.: rr. – The species seems to be known until now only from Austria (Hafellner 1999), Luxemburg (Sérusiaux et al. 2003) and the Czech Republic (Kocourková & Boom, 2005).

Arthonia galactinaria Leight. – 22: on *Lecanora dispersa* agg. on concrete, MK (UGDA-L). Freq.: rr.

Arthrorhaphis aeruginosa R. Sant. & Tønsberg – 23: on squamules of *Cladonia polydactyla* and *C. digitata* growing at base of *Picea abies*, JK (PRM); 24: on *C. phyllophora*, JK (PRM). Freq.: rr. – The fungus is easily recognized by the characteristic deep blue-green pigmentation of basal squamules of the host species (Santesson & Tønsberg, 1994).

Bacidia adastra Sparrius & Aptroot – 13: on *Malus* sp., AA (ABL, TU). Freq.: rr. – This species was found on a few fruit trees in the urban environment. It is only recently described taxon (Sparrius & Aptroot, 2003) which may have been overlooked as it is often sterile. The samples collected in Estonia are unfortunately sterile. The species should belong to the genus *Bacidina* mainly by the characteristics of the fruit-bodies.

Bacidia biatorina (Körb.) Vain. – 18: on *Populus tremula*, LS (Herb. Sparrius), HS (B). Freq.: r. – Previously reported from three localities in Pärnumaa, south-western region of Estonia (Randlane & Saag, 2004).

Bacidia caligans (Nyl.) A.L. Sm. – 13: botanical garden, on *Pyrus* sp., AA (ABL, TU). Freq.: rr. – This species should belong to the genus *Bacidina* (Ekman, 1996 : 125; Santesson et al., 2004), however, no valid combination has been made.

Bacidia incompta (Borrer ex Hook.) Anzi – 23: on rotten wood of bridge over brook, JK (PRM). Freq.: r. – Previously known from three scattered localities (Randlane & Saag, 2004).

Bacidina chloroticula (Nyl.) Vězda & Poelt – 12: on *Betula* sp. and *Quercus robur*, AA (ABL), LS (Herb. Sparrius, TU); 13: on *Quercus robur*, LS (Herb. Sparrius); 25: on wood, cutting flat of stump, ZP (Herb. Palice). Freq.: r. – *B. chloroticula* is mainly found in disturbed, artificial habitats on both acid rock, wood and bark. All collected specimens have the characteristic grey to dark green, areolate to coarsely granular thallus; however, specimens collected on bark (loc. 12 & 13) deviate from typical *B. chloroticula* by the rather dark, reddish brown pigmentation of the excipulum. The specimen collected on wood (loc. 25) has distinctive colourless excipulum.

Biatora chrysantha (Zahlbr.) Printzen – 18: on *Populus tremula*, MK (UGDA-L), PC (GPN). Freq.: rr → **r**. – Until now only two localities were known from north- and south-western regions of Estonia (Randlane & Saag, 2004).

Buellia schaereri De Not. – 20: on *Quercus robur*, LS (Herb. Sparrius). Freq.: r. – Previously known from four scattered localities (Randlane & Saag 2004).

Calicium pinastri Tibell – 24: on peeling bark of young *Pinus sylvestris*, ZP (Herb. Palice). Freq.: rr → **r**. – Earlier only two localities were known in south-eastern and -western regions (Randlane & Saag, 2004).

Caloplaca obscurella (Körb.) Th. Fr. – 13: on *Ulmus* sp., LS (Herb. Sparrius). Freq.: rr. – Only one record from western islands was known before (Randlane & Saag, 2004).

Cercidospora macrospora (Uloth) Hafellner & Nav.-Ros. – 22: on *Lecanora muralis* on granite stone, AS (TU), MK (UGDA-L). Freq.: rr. – *C. macrospora* was lately found also from Kadakalaid islet near Hiiumaa (Jüriado & Suija, unpubl.)

Cladonia monomorpha Aptroot, Sipman & Herk – 24: on acid soil, AA (ABL), IJ (TU), ZP (Herb. Palice). Freq.: rr. – A recently described species (Aptroot et al., 2001) which has been confused with *Cladonia pyxidata*. The latter species is generally more southern growing predominantly on boulders, not on open sandy soils. *C. monomorpha* is morphologically distinct by large bullate plates on the cups, both on the inside and outside.

Cladonia polydactyla (Flörke) Spreng. – 16: on *Betula* sp., AS (TU); 23: on *Pinus sylvestris*, AA & IJ (TU) and on rotten stump, JK (PRM, sub *Arthrorhaphis aeruginosa*); 25: on the shore of a lake, on wood of *Pinus sylvestris*, JK (PRM). Freq.: r → **st r**. – *C. polydactyla* has earlier been found from three scattered localities in Estonia (Randlane & Saag, 1999). However, the species might be overlooked and confused with *C. digitata* and *C. coniocraea* which can grow in rather similar habitats.

Clypeococcum hypocenomyces D. Hawksw. – 20: on *Hypocenomyce scalaris* on wood, MK (UGDA-L). Freq.: r. – Previously reported from north-eastern and south-eastern regions of Estonia (Randlane & Saag, 2004).

Cornutispora lichenicola D. Hawksw. & B. Sutton – 23: on *Cladonia digitata* at the base of *Pinus sylvestris*, JK (PRM) Freq.: rr.

Cyphelium tigillare (Ach.) Ach. – 16: on wooden footpath in Männikjärve bog, AS (TU). Freq.: r → **st r**. – Five scattered localities were known before (Randlane & Saag, 2004).

Dirina massiliensis Durieu & Mont. f. sorediata (Müll. Arg.) Tehler – 6: on soft limestone, LS (Herb. Sparrius), TR (TU). Freq.: rr. – The genus *Dirina* has a predominantly Mediterranean distribution in Europe while the sorediate form of *D. massiliensis* occurs also in northern Europe. It favours shaded overhangs and vertical walls of basic (natural and artificial) rock and also occurs on acid rock near the coast with direct influence of salt spray making the substratum pH slightly higher (Tehler, 1983). The record in Estonia is the north-easternmost record ever. It occurs at slightly higher latitudes only in Norway (Botnen & Tønsberg 1988) and in Scotland, and is distributed more eastern only in Bulgaria, Yemen (Socotra) and along the Mediterranean coast (Tehler, 1983).

Gyalecta truncigena (Ach.) Hepp. – 18: on *Populus tremula*, ES (LG), PC (GPN). Freq.: r. – Earlier known from four scattered localities (Randlane & Saag, 2004).

Illosporiopsis christiansenii (B. L. Brady & D. Hawksw.) D. Hawksw. – 13: on *Physcia tenella* on *Quercus robur*, LS (Herb. Sparrius); 15: on *P.* cf. *stellaris* on *Malus domestica*, MK (UGDA-L); 22: on *P. tenella* on hard wood, LS (Herb. Sparrius), on *P. dubia* over granitic boulder in meadow, PC (GPN) and on *P.* cf. *stellaris* on *Malus domestica*, MK (UGDA-L). Freq.: r → **st r**. – Until now, the species was known only from three localities in Estonia (Randlane & Saag, 2004).

Lecanora subcarpinea Szatala – 5: on *Quercus robur*, LS (Herb. Sparrius); 13: on *Populus tremula* AA (ABL), LS (Herb. Sparrius); 20: on *Quercus robur*, LS (Herb. Sparrius). Freq.: r. – This species is widespread in central and southern Europe (e.g. Lumbsch et al., 1997; Wirth, 1995; van Herk & Aptroot, 2004), however, not recorded from northern Europe. It is similar to *Lecanora carpinea*, but has fewer and smaller apothecia and a P+ yellow disc margin additional to the C+ orange reaction of the disc pruina. The thallus is bright white and therefore rather conspicuous. It occurs mostly on acid and neutral bark of well-lit trees.

Lecidea hypopta Ach. – 23: on *Pinus sylvestris*, AA (ABL). Freq.: r. – This is the fourth record from Estonia, before was known from western islands only (Randlane & Saag, 2004).

Lecidella flavosorediata (Vězda) Hertel & Leuckert – 3: on *Quercus robur*, LS (Herb. Sparrius, TU); 12: on *Populus tremula* AA (ABL); 13: on *Quercus robur*, LS, on *P. tremula*, AA (ABL); 20: on *Quercus robur*, LS (Herb. Sparrius) and on *Betula* sp., MK (UGDA-L). Freq.: r. – This sorediate and usually sterile species is rather common in northern Europe on well-lit, acid bark, but much overlooked. It was found on wayside oak trees in parkland, in a community with predominantly crustose species: *Haematomma ochroleucum, Lecanora expallens, Melanelia glabratula, Pertusaria coccodes, Phlyctis argena and Pyrrhospora quernea. Lecidella flavosorediata* is similar in appearance to *Pyrrhospora quernea*, but has a darker green, fine soredia (+/- isidiate in *Pyrrhospora*) on a grey areolate thallus (yellowish or absent in *Pyrrhospora*).

Lecidella subviridis Tønsberg – 16: on *Picea abies*, MK (UGDA-L). Freq.: rr → **r**. – Earlier two records were from western islands and south-eastern region of Estonia (Randlane & Saag, 2004).

Lepraria atlantica Orange – 23: on sandstone rock, LSaag (TU). Freq.: rr. – This is the second record from Estonia (Jüriado et al., 2002). TLC: atranorin & porphyrilic acid.

Leptogium gelatinosum (With.) J.R. Laundon – 8: on calciferous soil, LS (Herb. Sparrius). Freq.: r. – The species occurs in western islands and north-eastern region of the mainland (Randlane & Saag, 1999).

Leptogium plicatile (Ach.) Leight. – 22: on limestone, HS (B). Freq.: rr. – *L. plicatile* was considered extinct in Estonia, the only known record is from the end of 19th century in the north-eastern region of the mainland (Randlane & Trass, 1994).

Lopadium disciforme (Flot.) Kullh. – 18: on trunk of old *Populus tremula*, ES (LG). Freq.: r. – This is the fourth locality of this species in Estonia (Randlane & Saag, 2004).

Marchandiomyces aurantiacus (Lasch) Diederich – 15: on *Physcia tenella* on *Malus domestica*, MK (UGDA-L); 19: on *Physcia* sp. on *Acer platanoides*, MK (UGDA-L); 20: on *P. tenella* on *Quercus robur*, MK (UGDA-L). Freq.: r. – This species was recently found also from Kadakalaid islet near Hiiumaa (Jüriado & Suija, unpubl.).

Melanelia elegantula (Zahlbr.) Essl. – 20: on *Quercus robur*, LS (Herb. Sparrius). Freq.: rr. – This species was recorded as doubtful in Estonia, known only according to the literature data (Mereschkowsky, 1913).

Melanelia septentrionalis (Lynge) Essl. – 12: on *Betula* sp., AA (ABL) Freq.: r → **st r**. – This is the sixth record of the species, previously has been reported also from Tartu (Trass & Randlane, 1994).

Merismatium heterophractum (Nyl.) Vouaux – 23: on *Lecanora* sp. on twigs of *Pinus sylvestris*, JK (PRM). Freq.: rr.

Micarea anterior (Nyl.) Hedl. – 20: on rotting wood of a fallen deciduous tree, PC (GPN). Freq.: rr. – A rare lignicolous species reported only from a few European countries: Sweden and Finland (Coppins, 1983), Komi Republic in Russia (Hermansson et al., 1998), Germany (Wirth, 1995) and Czech Republic (Palice, 1999) and recently from Poland (Czarnota, in press). *M. anterior* is inconspicuous, epixylic lichen forming in the most cases only stipitate pycnidia and probably for this reason it is overlooked during field work or mistakenly identified as a non-lichenized fungus. In many respects darker specimens of *M. anterior* are very similar to *M. misella* (Nyl.) Hedl., and moreover they sometimes grow together. In the Estonian case the two species are growing also together, but *M. misella* forms only stipitate pycnidia, whose walls react K+ violet. *M. anterior* produces a lot of small pale brownish apothecia. The brown tinge in epithecium and narrow excipulum is still present after KOH and moreover the species has also small 2–(3)septate ascospores. This species may be difficult to recognize due to a few other lignicolous species and unidentified facultative lichenicolous fungus growing together with it.

Micarea lutulata (Nyl.) Coppins – 11: on shingle on sandy plane, AS & IJ (TU). Freq.: rr. – *M. lutulata* was recently found also from Vohilaid islet near Hiiumaa (Jüriado & Suija, unpubl.).

Micarea micrococca (Körb.) Gams ex Coppins – 1: on rotten wood, LS (Herb. Sparrius); 10: on *Pinus sylvestris*, LS (Herb. Sparrius); 16: on *P. sylvestris* and *Picea abies*, PC (GPN); 18: on *Populus tremula*, PC (GPN). Freq.: r. – This species has been included in *M. prasina* s. lato a few times, but recently it was distinguished from *M. prasina* s. str. by the presence of methoxymicareic acid while *M. prasina* produces micareic acid. There are also some ecological differences between the species: *M. micrococca* mainly grows on bark of many tree species, in forests and also small woods, even near industrial regions and seems to be more acidophilic than *M. prasina* which occurs in most cases on soft wood of decaying stumps within larger, shaded woodlands. The morphological variability of *M. micrococca* seems to be quite large. Typical specimens have whitish or cream-coloured apothecia but some others have dark gray or even blackish fruit-bodies and could be similar to *M. melanobola.* For this reason the two species and also the whole *M. prasina* group seem to need more taxonomical study based on molecular analyses. The species is surely widespread in Europe, but mostly treated as synonym of *M. prasina*.

Micarea nitschkeana (J. Lahm ex Rabenh.) Harm. – 16: on wood of fallen pine log within pine bog forest, PC (GPN); 24: peeling bark of young *Pinus sylvestris*, ZP (Herb. Palice) Freq.: st r. – The species was not recorded in the southern part of Estonia until now (Randlane & Saag, 2004).

Peltigera scabrosa Th. Fr. – 24: on acid soil, AA (ABL). Freq.: rr. – This is the second locality of the species in Estonia, previously known only from the island Aegna on the northern coast of the mainland (Trass & Randlane, 1994).

Phaeopyxis punctum (A. Massal.) Rambold, Triebel & Coppins – 18: on *Cladonia ochrochlora* on *Populus tremula*, MK (UGDA-L). Freq.: r. – This lichen parasite, restricted to *Cladonia* species, was previously known from three scattered localities (Randlane & Saag, 2004; Suija, unpubl.).

Phaeosporobolus usneae D. Hawksw. & Hafellner – 23: on *Pseudevernia furfuracea* on *Pinus sylvestris*, JK (PRM); 25: on shore of a lake, on *Usnea filipendula* on bark of *P. sylvestris*, JK (PRM); on *P. furfuracea* on *Betula pubescens,* JK (PRM). Freq.: rr → **r**. – Although *P. usneae* is a widespread species (Hawksworth & Hafellner, 1986), the taxon was recorded from Estonia only once before (Randlane & Saag, 2004).

Phoma epiphyscia Vouaux – 15: on *Xanthoria parietina* on *Malus domestica*, MK (UGDA-L). Freq.: rr.

Pronectria xanthoriae Lowen & Diederich – 15: on *Xanthoria parietina* on *Malus domestica*, MK (UGDA-L). Freq.: rr.

Ramonia aff. nigra Coppins – 18: on trunk of old *Populus tremula*, ES (LG). Freq.: rr. – The material is scanty but definitely a *Ramonia* with dark brown apothecia and muriform ascospores; still, these are much too small to be the spores of *R. nigra*.

Rinodina degeliana Coppins – 20: mixed with *Scoliciosporum chlorococcum* on *Betula* sp., MK (UGDA-L). Freq.: rr. – TLC: atranorin and zeorin were found as major substances.

+ Sarea difformis (Fr.) Fr.– 23: on resin of *Picea abies*, JK (PRM). Freq.: r. – This is the fourth locality in Estonia (Randlane & Saag, 2004).

Scoliciosporum sarothamni (Vain.) Vězda – 13: on *Quercus robur*, AA (ABL); 16: on twigs of *Picea abies*, PC (GPN); 20: on branches of *Quercus robur*, MK (UGDA-L); 23: on *P. abies*, AA (ABL). Freq.: r → **st r**. – The species was known from three localities before (Randlane & Saag, 2004); probably overlooked.

Staurothele frustulenta Vain. – 22: on limestone, HT (Herb. Thüs). Freq.: rr → **r**. – This is the third locality of the species in Estonia (Randlane & Saag, 2004).

Steinia geophana (Nyl.) Stein – 2: on clay, LS (Herb. Sparrius); 25: on wood, cutting flat of stump, ZP (Herb. Palice). Freq.: rr → **r**. – This ephemeral lichen species has been reported only once before in Estonia (Randlane & Saag, 2004).

\# STIGMIDIUM XANTHOPARMELIARUM Hafellner – 26: on *Xanthoparmelia conspersa* on granite boulder, JK (PRM) Freq.: rr. – This is the second record of the species (Randlane & Saag, 2004).

\# SYZYGOSPORA PHYSCIACEARUM Diederich – 17: on *Physcia tenella* on *Sorbus aucuparia*, PC (GPN); 20: on *Physcia* sp. on *Quercus robur*, MK (UGDA-L); 22: on *P. stellaris* on *Malus domestica*, MK (UGDA-L). Freq.: rr → **r**. – This fungus was previously reported from two localities (Randlane & Saag, 2004).

\# TAENIOLELLA BESCHIANA Diederich – 23: on *Cladonia polydactyla* on rotten stump, JK (PRM); 25: on squamules of *C. polydactyla* on wood of *Pinus sylvestris* at bank of lake, JK (PRM). Freq.: rr → **r**. – The species was until now known from three scattered localities (Randlane & Saag, 2004; Suija, unpubl.).

\# **TELOGALLA OLIVIERI (Vouaux) Nik. Hoffmann & Hafellner** – 15: on thallus of *Xanthoria parietina* on twigs of *Malus domestica*, PC (GPN), MK (UGDA-L); 21: on *X. parietina* on *Acer platanoides*, MK (UGDA-L). Freq.: rr.

THELIDIUM DECIPIENS (Nyl.) Kremp. – 9: on soft limestone, LS (Herb. Sparrius). Freq.: r. – This perithecioid lichen has been previously known from three localities in Estonia (Randlane & Saag, 2004), probably it has been overlooked.

\+ **THELOCARPON LICHENICOLA (Fuckel) Poelt & Hafellner** – 23: on lying decaying trunks of *Picea abies*, JK (PRM). Freq.: rr.

TRAPELIA INVOLUTA (Taylor) Hertel – 11: on limestone shingle, AS (TU). Freq.: rr.

TRAPELIA PLACODIOIDES Coppins & P. James – 8: on humus rich soil with *Candelariella vitellina*, LS (Herb. Sparrius); 24: on granite boulder in pine forest, AA (ABL), IJ & LSaag (TU); on granite boulder in pine forest, JK (PRM). Freq.: rr → **r**. – The species was known from two scattered localities before (Randlane & Saag, 2004; Suija, unpubl.), probably has been overlooked.

TRAPELIOPSIS GLAUCOLEPIDEA (Nyl.) Gotth. Schneid. – 24: on peat/humus among roots of eradicated tree, ZP (Herb. Palice). Freq.: rr. – Czarnota and Kukwa (2004) mentioned the occurrence of this species in Estonia, Tartumaa.

\# TREMELLA LICHENICOLA Diederich – 23: on *Mycoblastus fucatus* on *Betula* sp., AA (ABL). Freq.: rr → **r**. – The species was known until now from two localities (Randlane & Saag 2004).

\# TREMELLA PHAEOPHYSCIAE Diederich & M.S. Christ. – 14: on *Phaeophyscia orbicularis* on *Acer platanoides*, PC (GPN); 21: on *P. orbicularis* on *A. platanoides*, MK (UGDA-L); 22: on *P. orbicularis* on *Malus domestica*, MK (UGDA-L). Freq.: rr → **r**. – Until now, only one locality (in Tartu) was known (Randlane & Saag, 2004).

\# TREMELLA RAMALINAE Diederich – 20: on *Ramalina fraxinea* on *Betula* sp., MK (UGDA-L). Freq.: rr. – This is the second record from Estonia (Halonen et al., 2000).

\# **TRICHONECTRIA ANISOSPORA (Lowen) van den Boom & Diederich** – 23: on *Hypogymnia physodes* and on *H. tubulosa* on branches of *Picea abies* and *Pinus sylvestris*, JK (PRM). Freq.: rr. – Until now the species has been known only on *H. physodes; H. tubulosa* represents a new host species for this fungus.

\# **TRICHONECTRIA HIRTA (Bloxam) Petch.** – 24: on *Cladonia phyllophora, Placynthiella icmalea* and on other dead lichens on plant debris and twigs lying on ground, JK (PRM). Freq.: rr.

VERRUCARIA BRYOCTONA (Th. Fr.) Orange – 22: on calciferous soil, LS (Herb. Sparrius, TU). Freq.: rr.

VERRUCARIA DOLOSA Hepp – 16: on asbestos pipe under a bridge over a little creek in forest, HT (Herb. Thüs); 17: at the +/- shaded, bottom parts of granitic boulders, HT (Herb. Thüs). Freq.: rr. – This species is easily recognized by its superficial perithecia, a thin thallus and rather small elongated ascospores (16–18 × 4–7 µm). Its outer appearance is quite similar to some morphs of *V. muralis* but the almost "sessile" perithecia and its microscopical features make *V. dolosa* one of the few *Verrucaria* species that are rather easy to identify.

VERRUCARIA VIRIDULA (Schrad.) Ach. – 9: on soft limestone, LS (Herb. Sparrius). Freq.: rr → **r.** – This is the third record of this species in Estonia (Randlane & Saag, 2004).

\# XANTHORIICOLA PHYSCIAE (Kalchbr.) D. Hawksw. – 20: on *Xanthoria parietina* on *Quercus robur*, MK (UGDA-L). Freq.: rr. – The species has been recorded from Estonia only once, from island Saaremaa (Randlane & Saag, 2004). The infection of this hyphomycete is easily recognized through the host apothecia which are turned black.

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Ecological analysis of lichens in the Teberda State Biosphere Reserve (North-Western Caucasus, Russia)

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Abstract: The distribution and general ecology of 389 species of lichens are recorded for ca 694 km^2 of mountainous terrain in the Teberda State Biosphere Reserve located on the northern side of the Great Caucasus mountain range. 56 taxa are documented for the first time for North Caucasus, 36 for Caucasus and 3 for Russia (*Aspicilia szechenyi*, *Bacidina delicata*, *Rhizocarpon carpaticum*). There are more crustose species (48,7%) than foliose (31,4%) or fruticose species (19,8%). Corticolous lichens were found on 24 tree species, the greatest biodiversity being recorded on *Abies nordmanniana*, *Acer platanoides*, *Pinus sylvestris* and *Fagus orientalis*.

Kokkuvõte: Teberda Riikliku Biosfääri Kaitseala (Loode-Kaukasus, Venemaa) samblike ökoloogiline analüüs.

Käsitletakse Teberda Riikliku Biosfääri Kaitseala 389 samblikuliigi levikut ja põhilisi ökoloogilisi nõudlusi. Proovid koguti umbes 694 km^2 suuruselt mägiselt maastikult Suur-Kaukasuse aheliku põhjaküljel. 56 taksonit mainitakse esmakordselt Põhja-Kaukasuse, 36 Kaukasuse ja 3 Venemaa jaoks. Sagedasemad on kooriksamblikud (48,7%), vähemsagedased leht- (31,4%) ja põõsassamblikud (19,8%). Epifüütseid samblikke leiti 24 puuliigil, suurim oli bioloogiline mitmekesisus forofüütidel *Abies nordmanniana*, *Acer platanoides*, *Pinus sylvestris* ja *Fagus orientalis*.

INTRODUCTION

The Great Caucasus is a huge mountain area on the border between Europe and Asia. Its rich flora and varied vegetation are very attractive for naturalists and scientists. The complicated and dramatic history of the area and the harsh alpine environment are favorable to nature protection, with several large national reserves on the northern slopes of the Great Caucasus (North-Osetia, Kabardino-Balkaria, Teberda, and the Caucasian Reserve in the Krasnodar region) were established in the 20th century.

The lichen flora of Teberda Reserve, although one of the richest in the Great Caucasus, has attracted relatively little attention with only 79 species known before our investigations (Barhalov, 1983; Novruzov & Onipchenko, 1985; Onipchenko, 1987; Vorobyova & Onipchenko, 1994). The investigation of lichens in this region is part of an integrated study of biodiversity which has been carried out in this mountain region since 1936.

The present study has two primary objectives: first, to provide a floristic account of the lichens and increase our knowledge of lichens in the Teberda Reserve; second, to indicate the salient features of ecological distribution of the species.

THE STUDY AREA

The Teberda State Biosphere Reserve is located on the northern side of the Great Caucasus mountain range (Fig. 1). The main section of the reserve occupies the upper reaches of the Teberda river valley between 41°35'–41°55' E, and 43°13'–43°28' N, and has a total area of ca 694 km^2. Elevations inside the reserve range from 1259 m to 4046 m a.s.l.; about 83% of the reserve's territory lies above 2000 m a.s.l. and can be considered to be truly alpine. Siliceous rocks predominate in the reserve, but local outcrops of limestone exist two km to the north of the reserve boundary (Tushinskii, 1957).

The climate of different parts of the reserve varies considerably due to the two main factors: elevation and distance from the Great Caucasus Range, which forms the southern boundary of the reserve. Overall, the mean annual temperature decreases by 0.5–0.6 °C per 100 m increase in altitude. Precipitation increases with altitude up to about 2200–2500 m. On the whole, the climate of the Teberda Reserve is temperate-continental. In the region of the town of Teberda, the average annual temperature is +1,2 °C, the average relative humidity is 79%, and the average annual rainfall is 1400 mm.

The total number of vascular plant species found in the Teberda Reserve is ca 1150 (Vorobyova & Onipchenko, 2001); 35% of the reserve is forested, 28% is covered with meadows, and more than 10% is occupied by glaciers (Pavlov, 2004). There are more than 100 tree species in the reserve, the most frequent being *Pinus sylvestris*, *Betula litwinowii*, *Abies nordmanniana*, *Picea orientalis* and *Fagus orientalis* (Kononov, 1957). Vegetation units (life zones) are based on the altitudinal zonation of the northwestern Caucasus proposed by Kuznetsov (1909). Six altitudinal belts have been recognized in the Teberda Reserve: middle forest (1250–1600 m a.l.s), upper forest (1600–2000 m), subalpine (2000–2500 m), alpine (2500–3200 m), subnival (3200–3400 m) and nival (from 3200–3800 m).

Fig. 1. Location of Teberda Reserve in Caucasus area.

MATERIAL AND METHODS

24 canyons with a total length of about 150 km at elevations ranging from 1259 to 3800 m a.s.l. were investigated. About 2000 specimens of lichens were collected in the different altitudinal belts and plants communities between 2000–2003. Some data from the literature were also interpreted (Barhalov, 1983; Novruzov & Onipchenko, 1985; Vorobyova & Onipchenko, 1994; Onipchenko et al., 1999; Onipchenko, 2002). For an ecological summary we report lichen species by growth forms, substrate groups, and distribution on tree species. Epiphyte samples were collected from branches, trunks and bases of trees to a height of 2 m; for these analyses only trees with 20 specimens or more were sampled.

Subnival and nival belts were combined into one because of the small number of lichen samples and species represented.

The collected specimens have been deposited in the herbarium of the Biological Faculty of the Moscow State University (MW) and in the Herbarium of the Polar-Alpine Botanical Garden-Institute (KPABG).

The names of taxa are given according to the latest lichen checklist of Austria (Hafellner & Türk, 2001) and authors' abbreviations are according to Kirk and Ansell (1992).

RESULTS AND DISCUSSION

The full list of lichens in the Teberda Reserve (Appendix 1) consists of 389 species, distributed in 125 genera, 45 families, 11 orders, 3 subclasses and one class – *Ascomycetes* (Kirk et al., 2001). 56 taxa are documented for the first time for North Caucasus, 36 for Caucasus, and 3 for Russia (*Aspicilia szechenyi, Bacidina delicata, Rhizocarpon carpaticum*).

Growth forms of lichens

Three growth forms of lichens are distinguished: crustose, foliose and fruticose; the first group includes also effigurate, squamulose and peltate taxa (Oksner, 1974). Crustose species (e.g. *Aspicilia caesiocinerea, Bellemerea alpina, Candelariella vitellina, Lecanora intricata, Rhizocarpon geographicum*) predominate in the investigated territory (189 species or 48,7%); this is usual for all lichen floras of arctic, mountain and arid areas (Urbanavichus, 1998). They play an important role at all elevations, but show the maximum species diversity (89 species or 45,2%) in the upper forest belt (Fig. 2). A wide variety of microhabitats creates favorable conditions here for different species of all growth forms. In the alpine and nival belts crustose lichens predominate over other growth forms (Table 1). The rigorous conditions of these altitudes are evidently less favorable for foliose and fruticose lichens and vascular plants.

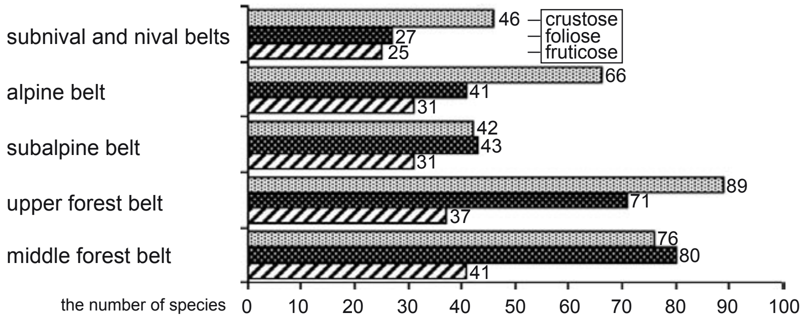

Fig. 2. The distribution of fruticose, foliose and crustose lichen species in different altitude belts.

Table 1. Percentage of crustose, foliose and fruticose lichens in the different altitude belts.

Altitude belt	crustose	foliose	fruticose
middle forest	38,6	40,6	20,8
upper forest	45,2	36,0	18,8
subalpine	36,2	37,1	26,7
alpine	47,8	29,7	22,5
subnival and nival	46,9	27,6	25,5

There are 123 species (31,6%) of foliose lichens (e.g. *Brodoa atrofusca, Melanelia glabra, Physcia aipolia, Physconia distorta, Umbilicaria cylindrica*) in the reserve. This group is more sensitive to environmental factors than crustose lichens (Golubkova, 1977) and predominates in the middle forest belt where a milder climate persists.

Fruticose lichens (e.g. *Allocetraria madreporiformis, Bryoria nadvornikiana, Cetraria islandica, Cladonia pyxidata*) are the least numerous (77 species or 19,8%) in all altitudinal belts.

In general, the percentage of crustose lichens of the total lichen flora increases with altitude whereas the percentage of foliose lichens falls (Makryi, 1990), but our studies do not support this to date (Fig. 2); foliose lichens are much better known than crustose lichens in the Teberda Reserve, thus evidently many crustose taxa have yet to be reported. Further inquiry is needed to show the real picture. However, species richness of all growth forms tends to decrease with altitude. This phenomenon is probably connected with the smaller diversity of substrates in the upper belts as well as the rigorous environmental conditions.

Substrate preferences

Substrate is the most tangible element of all environmental conditions influencing lichens. The type and properties of substrate have a great impact on ecology, distribution and taxonomy of lichens (Brodo, 1974).

Five substrate groups of lichens are distinguished in this study: corticolous (on bark of trunks and branches of trees), saxicolous (directly attached to the rock), terricolous (on soil), muscicolous (on bryophytes) and lignicolous (on lignum) species. Although some lichens regularly colonize a wide variety of substrates, most species tend to reveal a distinct preference for a single substrate type (284 species or 73,1%). This tendency is especially well developed among corticolous and saxicolous species of crustose lichens.

Corticolous species (e.g *Arthonia radiata, Arthothelium ruanum, Bacidia subincompta, Biatora vernalis, Bryoria subcana*) form the biggest substrate group in the Teberda Reserve (174 species, 44,8%). Their distribution is controlled by the distribution of tree species, being absent above the limit of trees and bushes (Fig.3). Otherwise, crustose species predominate on a wide variety of deciduous trees (*Acer platanoides, A. trautvetteri, Alnus incana, Berberis vulgaris, Betula litwinowii, B. pendula, Carpinus betulus, Corylus avellana, Crataegus monogyna, Fagus orientalis, Fraxinus excelsior, Malus sylvestris, Padus avium, Populus alba, P. tremula, Quercus robur, Rosa* spp., *Salix* spp., *Sorbus aucuparia, Ulmus glabra*) and outnumber species on coniferous trees (*Abies nordmanniana, Juniperus communis, Picea orientalis, Pinus sylvestris*).

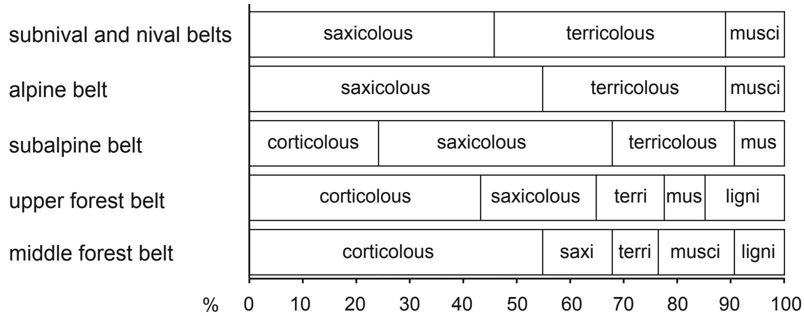

Fig. 3. The distribution of substrate groups of lichens in different altitude belts.

However, the greatest numbers of lichens where found on *Abies nordmanniana* (67 species), *Pinus sylvestris* (51), *Acer platanoides* (46) and *Fagus orientalis* (43), which are the most numerous trees in the Teberda Reserve (Table 2).

Most of the species (239 species, or 61,6%) are typical epiphytes (mainly species of *Lecanora, Ramalina* and *Usnea*). However, many facultative epiphytes which often grow on other types of substrates (e.g. *Cladonia fimbriata* and *C. pyxidata*) also occur on trees.

133 species (34,2%) found on rock (e.g. *Cornicularia normoerica, Lecanora intricata, Lecanora polytropa*) are all acidophilous as only siliceous rocks occur in the research area (see above, Study Area). Since this group, mainly crustose, will prove to be the most biodiverse, further investigation is obviously necessary. The percentage of saxicolous lichens increases with altitude and reaches a maximum in the alpine belt (Fig. 3).

The 90 terricolous species (23%) found in the Teberda Reserve (e.g. *Cetraria islandica, Peltigera canina, P. lepidophora, Pertusaria geminipara, Phaeorrhiza nimbosa, Physconia muscigena*) are mostly fruticose. The percentage of terricolous lichens increases with altitude (Fig. 3).

Muscicolous lichens (71 species, 18,2%; e.g. *Fuscopannaria praetermissa, Lepraria cacuminum, Peltigera leucophlebia, Physconia muscigena*) are mainly foliose and maintain a more-or-less constant percentage along the altitudinal gradient (Fig. 3).

The lowest number of species are lignicolous (50 species, 12,8%; e.g. *Absconditella lignicola, Alectoria sarmentosa*). As in the case of the corticolous species, the distribution of lignicolous

Table 2. Occurrence of corticolous lichens on different tree species

Tree species	Number of lichen species
conifers	
Abies nordmanniana	67
Juniperus communis	9
Picea orientalis	7
Pinus sylvestris	51
deciduous	
Acer platanoides	46
Acer trautvetteri	17
Alnus incana	26
Berberis vulgaris	3
Betula litwinowii	23
Betula pendula	22
Carpinus betulus	6
Corylus avellana	11
Crataegus monogyna	5
Fagus orientalis	43
Fraxinus excelsior	17
Malus sylvestris	10
Padus avium	18
Populus alba	6
Populus tremula	8
Quercus robur	14
Rosa spp.	2
Salix spp.	26
Sorbus aucuparia	14
Ulmus glabra	4

species is restricted by the range of forests (Fig. 3). All growth forms were present among lignicolous lichens almost in equal numbers.

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APPENDIX

The list of lichens in the Teberda Reserve

Abbreviations of substrate: B – bryophytes, L – lignum, R – rock, S – soil, Abi – *Abies nordmanniana,* AceP – *Acer platanoides,* AceT – *Acer trautvetteri,* Aln – *Alnus incana,* Ber – *Berberis vulgaris,* BetL – *Betula litwinowii,* BetP – *Betula pendula,* Car – *Carpinus betulus,* Cor – *Corylus avellana,* Cra – *Crataegus monogyna,* Fag – *Fagus orientalis,* Fra – *Fraxinus excelsior,* Jun – *Juniperus communis,* Mal – *Malus sylvestris,* Pad – *Padus avium,* Pic – *Picea orientalis,* Pin – *Pinus sylvestris,* PopA – *Populus alba,* PopT – *Populus tremula,* Que – *Quercus robur,* Ros – *Rosa* spp., Sal – *Salix* spp., Sor – *Sorbus aucuparia,* Ulm – *Ulmus glabra.*

Range of altitudes where the species were collected is given in the brackets. The literature data are added as well. Species new to Russia are marked by ***, to Caucasus – by **, and to North Caucasus – by *. Species in the Red Data Book of Russia (Takhthadjan, 1988) are given in **bold**.

**Abrothallus prodiens (Harm.) Diederich & Hafellner – on thallus of *Hypogymnia physodes* (1450).

**Absconditella lignicola Vězda & Pišut – on L (2000).

Acarospora atrata Hue – on R (2400).

Acarospora molybdina (Wahlenb.) Trevis. – on R (2000) (Novrusov & Onipchenko, 1985).

Acarospora rufa (Vain.) H. Magn. – on R (2000) (Novrusov & Onipchenko, 1985).

Acarospora smaragdula (Wahlenb.) A. Massal. – on R (3850).

Acarospora veronensis A. Massal. – on R (2700).

Alectoria sarmentosa (Ach.) Ach. – on AceP and Pic, on L (1500–1700).

Allocetraria madreporiformis (Ach.) Kärnefelt & A. Thell – on S (2750–3151).

**Amandinea cacuminum (Th. Fr.) H. Mayrhofer & Sheard – on R (2050–2600).

Amandinea punctata (Hoffm.) Coppins & Scheid. – on B and R, on BetP, Cra, Cor, Abi, (2700).

**Amygdalaria panaeola (Ach.) Hertel & Brodo – on R (1600).

Anaptychia ciliaris (L.) Körb. – on L, on Aln, Fra, Cor, BetP, Sor, Fag (1300–1600).

Arthonia radiata (Pers.) Ach. – on AceP and Cor (1350–1500).

Arthothelium ruanum (A. Massal.) Körb. – on AceP and Fag (1500–1600).

*Arthrosporum populorum A. Massal. – on Ulm and AceP (1350).

Aspicilia caesiocinerea (Nyl. ex Malbr.) Arnold – on R (1600–3850).

Aspicilia cinerea (L.) Körb. – on R (1700–2400).

Aspicilia desertorum (Kremp.) Mereschk. – on R (2700).

*Aspicilia laevata (Ach.) Arnold – on R (2000).

Aspicilia maculata (H. Magn.) Oxner – on R (2000) (Novruzov & Onipchenko, 1985).

*Aspicilia simoënsis Räsänen – on R (2400).

Aspicilia sphaerospora (Tomin) Oxner – on R (2000) (Novruzov & Onipchenko, 1985).

***Aspicilia szechenyi (Vain.) Hue – on R (2000–3850).

Aspicilia verrucigera Hue – on R (2000–2800).

Bacidia herbarum (Stizenb.) Arnold – on S (2500).

**Bacidia subincompta (Nyl.) Arnold – on Abi (2000).

***Bacidina delicata (Larbal. ex Leight.) V. Wirth & Vězda – on Fra (1350).

Bellemerea alpina (Sommerf.) Clauzade & Cl. Roux – on R (1560–2800).

Bellemerea cupreoatra (Nyl.) Clauzade & Cl. Roux – on R (2000).

*Biatora vernalis (L.) Fr. – on AceP (1500).

Brodoa atrofusca (Schaer.) Goward – on R (2000–3850).

Brodoa intestiniformis (Vill.) Goward – on R (1800–3850).

Bryocaulon divergens (Ach.) Kärnefelt – on S (2800–3050).

Bryonora castanea (Hepp) Poelt – on S (2850).

Bryoria bicolor (Ehrh.) Brodo & D. Hawksw. – on B and R (1300–2700).

Bryoria chalybeiformis (L.) Brodo & D. Hawksw. – on AceP, on L and S (1500–2030).

Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw. – on L, on Pic, Pin (1550–1800).

Bryoria implexa (Hoffm.) Brodo & D. Hawksw. – on Abi, Pin, AceP (1500–2700).

Bryoria nadvornikiana (Gyeln.) Brodo & D. Hawksw. – on Sal, Fag, Abi, Pin, on R, B, L (1400–2750).

Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw. – on R, B, S (2980–3050).

Bryoria subcana (Nyl. ex Stizenb.) Brodo & D. Hawksw. – on Fag (1500–1600).

Bryoria trichodes (Michx.) Brodo & D. Hawksw. – on Fag, Pin (1400–1500).

Buellia aethalea (Ach.) Th. Fr. – on R (2000).

*Buellia chloroleuca Körb. – on L (1600).

Buellia disciformis (Fr.) Mudd. – on Fag and Pin (1600–2000).

Buellia erubescens Arnold – on L, on Abi (1900–2000).

Buellia griseovirens (Turn. & Borr. ex Sm.) Almb. – on Pin (1800).
*Buellia insignis (Naegeli ex Hepp) Th. Fr. – on Pin, S, B (1800, 3000–3050).
**Buellia leptocline (Flot.) A. Massal. – on R (2600).
**Buellia miriquidica Scheid. – on R (2700–3850).
Buellia papillata (Sommerf.) Tuck. – on S (3060).
**Buellia pulverulenta (Anzi) Jatta – on thallus of *Physconia muscigena* (3050).
Buellia schaereri De Not. – on Abi (2000).
Buellia vilis Th. Fr. – on S (2700).
Calicium adaequatum Nyl. – on Fag (1400).
Caloplaca ammiospila (Wahlenb.) H. Olivier – on S (3060).
Caloplaca arenaria (Pers.) Müll. Arg. – on R (1300, 3050–3060).
Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr. – on Aln, Ulm, Fra, AceP, AceT, Sal, Pad, BetL (1300–2000, 3050).
*Caloplaca crenularia (With.) J.R. Laundon – on R (2700).
**Caloplaca epithallina Lynge – on R, on the tallus of a lichen (1560–2000).
Caloplaca ferruginea (Huds.) Th. Fr. – on Jun, on S (2050–2800).
Caloplaca herbidella (Hue) H. Magn. – on AceP, Fag, Sor, Abi (1500–2000).
Caloplaca holocarpa (Hoffm.) Wade – on PopT (1600–2000).
**Caloplaca hungarica H. Magn. – on Pin (1600).
Caloplaca jungermanniae (Vahl) Th. Fr. – on S, B (1900, 3050).
**Caloplaca nivalis (Körb.) Th. Fr. – on S (3000).
Caloplaca saxicola (Hoffm.) Nordin – on R (2400) (Novruzov & Onipchenko, 1985).
*Caloplaca tiroliensis Zahlbr. – on S (2600).
Calvitimela armeniaca (DC.) Hafellner – on R (2700).
Candelaria concolor (Dicks.) Stein – on Aln, Ber, Que, AceP (1300–1350).
Candelariella aurella (Hoffm.) Zahlbr. – on Que, BetL (1300–2000).
Candelariella coralliza (Nyl.) H. Magn. – on R (2400–2600).
**Candelariella lutella (Vain.) Räsänen – on AceP, Cor (1350).
Candelariella reflexa (Nyl.) Lettau – on Mal, Cra, BetL (1300–2000).
Candelariella vitellina (Hoffm.) Müll. Arg. – on Aln, BetL, on R (1300–3850).
Candelariella xanthostigma (Ach.) Lettau – on AceP, BetL, Sal, Abi (1650–2000).
Carbonea vitellinaria (Nyl.) Hertel – on thallus of *Candelariella* (2700–3100).
Carbonea vorticosa (Flörke) Hertel – on R (3050).
Catapyrenium cinereum (Pers.) Körb. – on S (3080–3850).
Cetraria aculeata (Schreb.) Fr. – on R, S (2400–3150).
Cetraria ericetorum Opiz – on S (2950).
Cetraria islandica (L.) Ach. – on S (1800–3150).
Cetraria laevigata Rassad. – on S (2700).
Cetraria muricata (Ach.) Eckfeldt – on S (2800–2900).
**Cetraria odontella (Ach.) Ach. – on R (3000).
Cetrelia cetrarioides (Duby) W.L. Culb. & C.F. Culb. – on R, S (1550–2000).
Cetrelia olivetorum (Nyl.) W.L. Culb. & C.F. Culb. – on B (1450).
Chaenotheca furfuracea (L.) Tibell – on Abi (1450).
Chrysothrix candelaris (L.) J.R. Laundon – on Fag, Abi (1400–1600).
Cladonia amaurocraea (Flörke) Schaer. – on S (2000–2400).
Cladonia arbuscula (Wallr.) Flot. – on S (2630).
Cladonia cariosa (Ach.) Spreng. – on S (3050).
Cladonia cenotea (Ach.) Schaer. – on S, L (1400–2000).
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng. – on S, B (1400–2700).
Cladonia coniocraea (Flörke) Spreng. – on S, L (1450–2630).
Cladonia cornuta (L.) Hoffm – on S (2000–2750).
Cladonia crispata (Ach.) Flot. – on S (2000, 3000).
Cladonia digitata (L.) Hoffm. – on Pin (1800).
Cladonia ecmocyna (Ach.) Leigth. – on S (2200, 3050).
Cladonia fimbriata (L.) Fr. – on S, L, B (1500–2800).
Cladonia furcata (Huds.) Schrad. – on S (2000–2900).
Cladonia gracilis (L.) Willd. – on S (1800–2900).
Cladonia macilenta Hoffm. – on S, L (1600–2050).
Cladonia macroceras (Delise) Hav. – on S (2750–2900).
Cladonia mitis Sandst. – on S (2000–2800).
Cladonia ochrochlora Flörke – on S (1300–1600, 2100).
Cladonia phyllophora Hoffm. – on S (1800–2900).
Cladonia pleurota (Flörke) Schaer. – on S (1600–2600).
Cladonia pocillum (Ach.) Grognot – on S (2630–3050).

Cladonia pyxidata (L.) Hoffm. – on S, B, on Abi, Jun (1300–3850).
Cladonia ramulosa (With.) J.R. Laundon – on R (2000).
Cladonia rangiferina (L.) Weber ex F.H. Wigg. – on S (1800, 3050).
Cladonia squamosa Hoffm. – on L (1850).
Cladonia stellaris (Opiz) Pouzar & Vězda – on S (2950–3000).
Cladonia symphycarpia (Flörke) Fr. – on S (1450–2400).
Cliostomum corrugatum (Ach.: Fr.) Fr. – on Abi (1600).
**Cliostomum leprosum (Räsänen) Holien & Tønsberg – on Abi (1500).
Collema auriforme (With.) Coppins & J.R. Laundon – on R (2920).
Collema flaccidum (Ach.) Ach. – on R, B, on Fra, AceT, Sal (1350–1650).
Collema furfuraceum (Arnold) Du Rietz – on Jun, AceT (1350–1650).
Collema fuscovirens (With.) J.R. Laundon – on Fra (1350).
Collema tenax var. ceranoides (Borrer) Degel. – on S (2100).
Collema undulatum Laurer ex Flot. – Teberda (Jatta, 1900).
Cornicularia normoerica (Gunnerus) Du Rietz – on R (2050–2700).
Dendriscocaulon umhausense (Auersw.) Degel. – on AceP, AceT (1500–1600).
Dermatocarpon arnoldianum Degel. – on R (1600–2800).
Dermatocarpon intestiniforme (Körb.) Hasse – on R (2000–3850).
Dermatocarpon luridum (With.) J.R. Laundon – Teberda (Jatta, 1900).
Dermatocarpon miniatum (L.) W. Mann – on R (1300–2620).
Dermatocarpon rivulorum (Arnold) Dalla Torre & Sarnth. – on R (2800) (Novruzov & Onipchenko, 1985).
Dimelaena oreina (Ach.) Norman – on R (2000–2500).
Diploschistes muscorum (Scop.) R. Sant. – on B, S (2800–3050).
Diploschistes scruposus (Schreb.) Norman – on R (2000).
Evernia divaricata (L.) Ach. – on AceP, Sal, Abi, Pic (1400–2000).
Evernia prunastri (L.) Ach. – on PopT, Fra (1400).
Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell – on S (2750–3150).
Flavocetraria nivalis (L.) Kärnefelt & A. Thell – on S (3150).
Flavoparmelia caperata (L.) Hale – on Que, BetP, Sal, Mal, B (1250–2200).
Flavopunctelia soredica (Nyl.) Hale – on BetP (1300).
Fuscidea cyathoides (Ach.) V. Wirth & Vězda – on R (2700).
Fuscopannaria leucophaea (Vahl) P.M. Jørg. – on B (2200–3050).
Fuscopannaria mediterranea (Tav.) P.M. Jørg. – on S, on thallus of *Lobaria scrobiculata* (1500–2000).
Fuscopannaria praetermissa (Nyl.) P.M. Jørg. – on B (1400).
Heterodermia speciosa (Wulfen) Trevis. – on Sal, B, S (1350–2000).
Hypocenomyce scalaris (Ach.) M. Choisy – on Pin (1500).
Hypogymnia austerodes (Nyl.) Räsänen – on B, L (1400–2000).
Hypogymnia bitteri (Lynge) Ahti – on BetL (1900).
Hypogymnia physodes (L.) Nyl. – on BetP, BetL, AceP, Sor, Fag, Pin, B, L (1300–2200).
Hypogymnia tubulosa (Schaer.) Hav. – on Abi, BetL (2000–2050).
Hypogymnia vittata (Ach.) Parrique – on Abi, on B (1500–1700, 2600).
Hypotrachyna laevigata (Sm.) Hale – on Abi (1500).
Hypotrachyna revoluta (Flörke) Hale – on Fag (1500).
Icmadophila ericetorum (L.) Zahlbr. – on L, B (1800–2400).
Imshaugia aleurites (Ach.) S.L.F. Meyer – on Pin (1800).
Lasallia pensylvanica (Hoffm.) Llano – on R (1750–1800).
Lecania cyrtella (Ach.) Th. Fr. – on Fag, PopA (1300–1350).
**Lecania cyrtellina (Nyl.) Sandst. – on PopA (1300).
*Lecania fuscella (Schaer) Körb. – on Fag (1350).
Lecania naegelii (Hepp) Diederich & van den Boom – on Pad (1900).
Lecanora albella (Pers.) Ach. – on Cra (1300).
Lecanora allophana Nyl. – on Fag, Aln, PopT, (1300–2050, 3850).
Lecanora argentata (Ach.) Malme – on Ros, Fag, Pin (1300–1600).
**Lecanora cadubriae (A. Massal.) Hedl. – on Pin (1900).
Lecanora campestris (Schaer.) Hue – on L (1850–2400).

Lecanora carpinea (L.) Vain. – on AceP, Fag, Aln, Pad, Pin, Abi (1500–2000).
Lecanora cenisia Ach. – on R (2700).
Lecanora chlarotera Nyl. – on Aln, PopT, Fag, Sor, Pin, Abi, on L (1300–2000).
Lecanora dispersoareolata (Schaer.) Lamy – Teberda (Jatta, 1900).
Lecanora frustulosa (Dicks.) Ach.– on R (2000–2800) (Novruzov & Onipchenko, 1985).
**Lecanora fuscescens (Sommerf.) Nyl. – on Fag (1700).
Lecanora glabrata (Ach.) Malme – on Carp, Fag, Pad, Abi (1350–2000).
Lecanora hagenii (Ach.) Ach. – on B, S (2500).
Lecanora hieroglyphica Poelt – on R (2000) (Novruzov & Onipchenko, 1985).
Lecanora intricata (Ach.) Ach. – on R (1700–3050).
*Lecanora intumescens (Rebent.) Rabenh. – on Que, Pop, AceP, AceT, Fra (1300–2000).
*Lecanora laatokkaensis (Räsänen) Poelt – on R (2600).
*Lecanora leptyrodes (Nyl.) Degel. – on Que, AceP, Pad, Abi (1300–2000).
Lecanora muralis (Schreb.) Rabenh. – on R (1300–3000).
Lecanora polytropa (Hoffm.) Rabenh. – on R (a single finding – on L) (1400–3850).
Lecanora populicola (DC.) Duby – on Aln (1300).
Lecanora rugosella Zahlbr. – on Pop, Fag (1550, 3850).
Lecanora rupicola (L.) Zahlbr. – on R (1700–2000, 2800).
*Lecanora saligna (Schrad.) Zahlbr. – on Aln, Pin, L (1600–2000).
Lecanora subcarpinea Szatala – on Ulm, AceT, Pic, Abi (1300–1500).
*Lecanora subintricata (Nyl.) Th. Fr. – on Pin (1800).
Lecanora symmicta (Ach.) Ach. – on Abi (1600).
Lecanora varia (Hoffm.) Ach. – on Pin, BetL (1800–2200).
Lecidea artrobrunnea (Ramond ex Lam. & DC.) Schaer – on R (2400–2500, 3850).
Lecidea auriculata Th. Fr. – on R (2000–2100, 3850).
Lecidea ecrustacea (Anzi ex Arnold) Arnold – Teberda (Jatta, 1900).
Lecidea lapicida (Ach.) Ach. – on R (2000, 2700–3850).
Lecidea promiscens Nyl. – on R (2400–2500).
Lecidea tessellata Flörke – on R (2050).
Lecidella carpathica Körb. – on R (2100, 2700).
Lecidella elaeochroma (Ach.) M. Choisy – on Aln, Ros, AceP, Sor, Pad, Carp, Que, Ber (1300–1900).
Lecidella euphorea (Flörke) Hertel – on BetP, BetL, PopA, Fag, Pin, Jun (1300–2050).
Lecidella laureri (Hepp) Körb. – on Carp, Sor, Pad, Abi, Pin (1350–2000).
Lecidella stigmatea (Ach.) Hertel & Leuckert – on R (2800).
Lecidoma demissum (Rutstr.) Gutth. Schneid. & Hertel – on S, B (2000–2900).
*Lempholemma polyanthes (Bernh.) Malme – on S (1450).
**Lepraria cacuminum (A. Massal.) Loht. – on S (2200).
**Lepraria caesioalba (de Lesd.) J.R. Laundon – on S, B and plant remains (2200–3100).
**Lepraria jackii Tønsberg– on Sal (1400).
Lepraria lobificans Nyl. – on Abi (1450).
Leptogium burnetiae C.W. Dodge – on Fra, Fag, AceT (1350–1650).
Leptogium cyanescens (Rabenh.) Körb. – on B (1600).
Leptogium hildenbrandii (Garov.) Nyl. – on Fag (1550–2000).
Leptogium saturninum (Dicks.) Nyl. – on BetL, AceP, Pad, S (1500–2000).
Leptogium teretiusculum (Wallr.) Arnold – on Fra, Sal (1350).
Letharia vulpina (L.) Hue – on Pin (1860–2200).
Lobaria amplissima (Scop.) Forss. – on Fag, AceP (1400–1600).
Lobaria pulmonaria (L.) Hoffm. – on Sal, Fa, AceP, AceT, Abi (1350–1650).
Lobaria scrobiculata (Scop.) DC. – on Bet, B (1500).
Lobothallia alphoplaca (Wahlenb.) Hafellner – on R (2000) (Novruzov & Onipchenko, 1985).
Megaspora verrucosa (Ach.) Hafellner & V. Wirth – on B, S (2750).
Melanelia commixta (Nyl.) A. Thell – on R (2000).
Melanelia disjuncta (Erichsen) Essl. – on R (2700).
Melanelia elegantula (Zahlbr.) Essl. – on Fag (1800–2000).
Melanelia exasperata (De Not.) Essl. – on AceP, BetP, BetL, Sal, Pad, Pin, Abi (1350–2000).
Melanelia exasperatula (Nyl.) Essl. – on Aln, Que, Sal, AceP, BetP, BetL, Sor, Pin, Abi, B, L (1300–3050).
Melanelia glabra (Schaer.) Essl. – on Aln, Que, Sal, AceP, Fra, Ulm, Cor, Fag, BetP, BetL, Sor, Abi (1250–1900).

Melanelia hepatizon (Ach.) A. Thell – on R (2000–3100).
Melanelia infumata (Nyl.) Essl. – on S (3150).
Melanelia olivacea Essl. – on Aln (1500).
Melanelia stygia (L.) Essl. – on R, B, S (1800–2750).
Melanelia subargentifera (Nyl.) Essl. – on PopA, BetP, Cor, Jun, B (1300–1350).
Melanelia subaurifera (Nyl.) Essl. – on Cra, AceP, B (1300–3050).
**Micarea bauschiana (Körb.) V. Wirth & Vězda – on L (2000).
Micarea peliocarpa (Anzi) Coppins & R. Sant. – on Pin (1900).
Micarea prasina Fr. – on Abi (1600–2000).
Micarea sylvicola (Flot.) Vězda & V. Wirth – on R (2000–2700).
**Miriquidica deusta (Stenh.) Hertel & Rambold – on R (3150, 3850).
Miriquidica garovaglii (Schaer.) Hertel & Rambold – on R (2700).
**Miriquidica nigroleprosa (Vain.) Hertel & Rambold – on R (3150).
Mycobilimbia berengeriana (A. Massal.) Hafellner & V. Wirth – on Abi (1600).
Mycocalicium subtile (Pers.) Szatala – on L (1500).
Myxobilimbia lobulata (Sommerf.) Hafellner – Teberda (Jatta, 1900).
Naetrocymbe punctiformis (Pers.) R.C. Harris – on Abi (2000).
Neofuscelia delisei (Duby) Essl. – on R (1400–2450).
Neofuscelia verruculifera (Nyl.) Essl. – on R (1400).
Nephroma bellum (Spreng.) Tuck. – on AceP, Abi, on S (1600–2500).
Nephroma parile (Ach.) Ach. – on Jun, AceP, BetL, B, S (1350–2650).
Nephroma resupinatum (L.) Ach. – on Fag, AceP, AceT, B, L (1250–2000).
Ochrolechia pallescens (L.) A. Massal. – on AceP (1300).
Ochrolechia szatalaensis Vers. – on Sor (2000).
Opegrapha varia Pers. – on AceP (1500).
Ophioparma ventosa (L.) Norman – on R (2700–2800).
Pannaria conoplea (Ach.) Bory –on AcerT, B, S (1400–2000).
Parmelia omphalodes (L.) Ach. – on R, B, S (1400, 2750–2800).
Parmelia saxatilis (L.) Ach. – on Fag, Abi, Pin, L, R, S (1450–2800).
Parmelia submontana Nádv. ex Hale – on Fag (1500).
Parmelia sulcata Taylor – on AceP, AceT, BetP, BetL, Fra, Aln, Sal, Pad, Cra, Abi, Pin, Jun (1300–2300).
Parmeliella triptophylla (Ach.) Müll. Arg. – on BetP, B (1500).
Parmeliopsis ambigua (Wulfen) Nyl. – on L (1500–2000).
Parmeliopsis hyperopta (Ach.) Arnold – on L (1500–2000).
Parmotrema chinense (Osbeck) Hale & Ahti – on R (2000) (Novruzov & Onipchenko, 1985).
Parmotrema stuppeum (Taylor) Hale – on Sal (1350).
Peltigera aphthosa (L.) Willd – on S (1400–2000).
Peltigera canina (L.) Willd. – on S, B (1250–2650).
Peltigera degenii Gyeln. – on S, B (1900–2000).
Peltigera elisabethae Gyeln. – on S (1500–1550).
Peltigera horizontalis (Huds.) Baumg. – on L, S (1450–2000).
Peltigera lepidophora (Nyl. ex Vain.) Bitter – on S (1450).
Peltigera leucophlebia (Nyl.) Gyeln. – on S, B (2800–3150).
Peltigera malacea (Ach.) Funck – on S, B (1800–2900).
Peltigera membranacea (Ach.) Nyl. – on S, B (1600–2650).
Peltigera polydactylon (Neck.) Hoffm. – on L, B, S (1250–2000).
**Peltigera ponojensis Gyel. – on S, B (1400–2050).
Peltigera praetextata (Flörke ex Sommerf.) Zopf – on S, B, L (1600–2200).
Peltigera rufescens (Weiss) Humb. – on S, B, L (1300–3050).
**Peridiothelia fuliguncta (Norman) D. Hawksw. – on Aln (1300).
Pertusaria albescens (Huds.) M. Choisy & Werner – on AceP, Fag, Abi, Pic, Pin (1300–2000).
Pertusaria amara (Ach.) Nyl. – on AceP, Fag, Sal, Abi (1300–1800).
Pertusaria coccodes (Ach.) Nyl. – on Fag and Abi (1600–1700).
Pertusaria coronata (Ach.) Th. Fr. – on Abi (1500–1700).
**Pertusaria geminipara (Th. Fr.) C. Knight – on S (2950).
Pertusaria leioplaca DC. – on B, Fag (1300–1700).
*Pertusaria servitiana Erichsen – on Abi, L (1500).

Phaeophyscia ciliata (Hoffm.) Moberg – on AceP, Sal, Pad, Pin (1350–1900).

Phaeophyscia endococcina (Körb.) Moberg – on R, B (1300–2400).

Phaeophyscia nigricans (Flörke) Moberg – on Aln (1300).

Phaeophyscia orbicularis (Neck.) Moberg – on Ulm, Aln, Cor, Que, Pin, B (1250–1500).

Phaeophyscia pusilloides (Zahlbr.) Essl. – on Sal (1300).

Phaeorrhiza nimbosa (Fr.) H. Mayrhofer & Poelt – on S, B (1900, 2600–2950).

Phlyctis argena (Spreng.) Flot. – on Abi (1450–1500).

Physcia adscendens (Fr.) H. Olivier – on Aln, Ma, Sal, Pad, Abi (1300–2000).

Physcia aipolia (Ehrh. ex Humb.) Fürnr. – on R, on Ulm, Aln, PopA, PopT, Fra, AceP, Cor, Sal, BetP, BetL, Pad, Fag, Sor, Abi (1250–3850).

Physcia caesia (Hoffm.) Fürnr. – on R (2400).

Physcia dubia (Hoffm.) Lettau – on R and S (2000–2200).

Physcia stellaris (L.) Nyl. – on Mal, Cor, Aln, Sor, BetL, Abi, Pin (1300–2000).

Physcia tenella (Scop.) DC. – on Mal, Fag, BetL, PopT, Abi (1300–2050)

Physcia tribacia (Ach.) Nyl. – on Mal, on R (1300).

Physconia distorta (With.) J.R. Laundon – on B, on Ulm, Aln, PopA, PopT, Fra, AceP, Cor, Sal, BetP, BetL, Pad, Fag, Sor (1250–1900).

Physconia enteroxantha (Nyl.) Poelt – on B (1500).

Physconia muscigena (Ach.) Poelt – on R, B (1350–3850).

Physconia perisidiosa (Erichsen) Moberg – on B, Que, Fag, AceP, Pad (1250–1900).

Placidium lachneum (Ach.) Breuss – on S (3080–3150).

Placynthiella dasaea (Stirt.) Tønsberg – on Betp, Abi (1300–1600).

Placynthiella icmalea (Ach.) Coppins & P. James – on L (1650–1900).

Placynthiella uliginosa (Schrad.) Coppins & P. James – on B (3150).

Platismatia glauca (L.) W.L. Culb. & C.F. Culb. – on Abi (1500–2300).

Pleopsidium flavum (Bellardi) Körb. – on R (2500–2600).

Pleurosticta acetabulum (Neck.) Elix & Lumbsch – on R (2000).

Porpidia crustulata (Ach.) Hertel & Knoph – on R (1400–2000).

Porpidia macrocarpa (DC.) Hertel & A.J. Schwab – on R (2700, 3850).

Protopannaria pezizoides (Web.) P.M. Jørg. – on B, S (1400–3100).

Protoparmelia badia (Hoffm.) Hafellner – on R (2800).

**Pseudephebe minuscula (Nyl ex Arnold) Brodo & D. Hawksw. – on R, B, S (2600–3000).

Pseudephebe pubescens (L.) M. Choisy – on R (2200–3000).

Pseudevernia furfuracea (L.) Zopf – on BetP, Aln, Sor, Sal, Pin, Abi (1300–2200).

Psora decipiens (Hedw.) Hoffm. – on S (2850–3080).

**Pycnora praestabilis (Nyl.) Hafellner – on L (1600–2000).

Ramalina dilacerata (Hoffm.) Hoffm. – on AceT (1500).

Ramalina farinacea (L.) Ach. – on R, on AceP, Sal, Abi, Pic (1400–1600).

Ramalina fastigiata (Pers.) Ach. – on Abi, AceT (1500).

Ramalina fraxinea (L.) Ach. – on BetL, BetP (1600–2000).

Ramalina obtusata (Arnold) Bitter – on Abi (1300–1500).

Ramalina pollinaria (Westr.) Ach. – on R, B, S, on AceP, Fag (1250–1900).

Ramalina polymorpha (Lilj.) Ach. – on R (2300).

Ramalina sinensis Jatta – on AceP, AceT, Sal, Cor, Pad (1300–1900).

Ramalina thrausta (Ach.) Nyl. – on Abi (1500).

***Rhizocarpon carpaticum Runem. – on R (2700–3850).

Rhizocarpon geographicum (L.) DC. – on R (1560–3850).

Rhizocarpon macrosporum Räsänen – on R (2500).

Rhizocarpon obscuratum (Ach.) A. Massal. – on R (3150) (Novruzov & Onipchenko, 1985).

Rhizocarpon polycarpum (Hepp) Th. Fr. – on R (1800–2750).

Rhizocarpon viridiatrum (Wulfen) Körb. – on R (2000) (Novruzov & Onipchenko, 1985).

Rhizoplaca chrysoleuca (Sm.) Zopf – on R (2000–2700).

Rhizoplaca melanophthalma (DC.) Leuckert & Poelt – on R (2500–2700).

Rinodina exigua (Ach.) Gray –on Pin, Pad, L (1500–1900).

**Rinodina interpolata (Stirt.) Sheard – on R (2400).

Rinodina laevigata (Ach.) Malme – on Abi (2000).

**Rinodina olivaceobrunnea C.W. Dodge & G.E. Baker – on plant remains (3150).

Rinodina pyrina (Ach.) Arnold –on Abi, L (1900–2000).

*Rinodina septentrionalis Malme – on Sal (1500–2000)

*Schaereria fuscocinerea (Nyl.) Clauzade & Cl. Roux – on R (2700).

Scoliciosporum chlorococcum (Stenh.) Vězda – on Mal, Sor, Abi, on L (1300–1600).

Scoliciosporum umbrinum (Ach.) Arnold – on Pin (1600).

Solorina crocea (L.) Ach. – on S (2850–2950, 3850).

Solorina saccata (L.) Ach. – on S (2850–3150).

Squamarina lentigera (Weber) Poelt – on R (3150) (Novrusov & Onipchenko, 1985).

Staurothele frustulenta Vain. – on R (2050).

Stereocaulon alpinum Laurer – on S, B (2050–3160).

Stereocaulon nanodes Tuck. – on R (3850).

Sticta sylvatica (Hudson) Ach. – on Abi (2000).

Strigula stigmatella (Ach.) R.C. Harris – on Abi, on L (2000)

Thamnolia vermicularis (Sw.) Schaer. – on S (2750–2950).

**Thelidium pyrenophorum (Ach.) Mudd – on R (2200).

Toninia sedifolia (Scop.) Timdal – Teberda (Jatta, 1900).

Trapeliopsis granulosa (Hoffm.) Lumbsch – on L, B, S (1400–1900, 3000).

Tuckermannopsis chlorophylla (Willd.) Hale – on AceP, Abi, L (1450–1700).

Umbilicaria cylindrica (L.) Delise ex Duby – on R (1500–3850).

Umbilicaria decussata (Vill.) Zahlbr. – on R (2000–3150).

Umbilicaria deusta (L.) Baumg. – on R (1600–3150).

Umbilicaria hirsuta (Sw. ex Westr.) Hoffm. – on R (2500).

Umbilicaria hyperborea (Ach.) Hoffm. – on R (2400–2700).

Umbilicaria leiocarpa DC. – on R (2700).

Umbilicaria nylanderiana (Zahlbr.) H. Magn. – on R (2000).

Umbilicaria polyphylla (L.) Baumg. – on R (2700–3000).

Umbilicaria proboscidea (L.) Schrad. – on R (2000–2700).

Umbilicaria subglabra (Nyl.) Frey – on R (2000).

Umbilicaria vellea (L.) Hoffm. – on R (1300–3000).

Usnea caucasica Vain. – on Sor (1600–1700).

Usnea cavernosa Tuck. – on Abi, Pin, AceP, L, B (1300–2000).

**Usnea chaetophora Stirton – on Abi (1600).

Usnea filipendula Stirton – on AceP, L (1500–1650).

Usnea florida (L.) F.H. Wigg. – on Que, BetL, Pin, Abi, L (1350–2000).

Usnea fulvoreagens (Räsänen) Räsänen – on BetP, Pin (1300–2000).

Usnea glabrata (Ach.) Vain. – on Abi, Sor, BetL, L (1400–2050).

Usnea glabrescens (Nyl. ex Vain.) Vain. – on Aln, Pin, L (1500–2500).

Usnea lapponica Vain. – on AceP, Sal, Pin (1500–2200).

Usnea prostrata Vain. – on AceP (1500).

Usnea scabrata Nyl. – on AceP, Abi, Pin (1500–2000).

Usnea subfloridana Stirt. – on L, BetL, Abi, Pin (1400–2000).

Verrucaria dolosa Hepp – on R (2000).

Verrucaria funckii (Spreng.) Zahlbr. – on R (2050).

Verrucaria nigrescens Pers. – on R (1300–3850).

Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai – on L, Pin, Abi, BetL (1800–2200).

Xanthoparmelia conspersa (Ehrh. ex Ach.) Hale – on L, S, Pin (1300–2400).

Xanthoparmelia somloënsis (Gyeln.) Hale – on L, B (1300–3850).

**Xanthoria ectaneoides (Nyl.) Zahlbr. – on R (2200–2400).

Xanthoria elegans (Link) Th. Fr. – on R, B, S (1250–2850).

Xanthoria fallax (Hepp) Arnold – on B, Que (1300).

Xanthoria parietina (L.) Th. Fr. – on Aln (1300).

*Xanthoria sorediata (Vain.) Poelt – on R (2500–2700).

Xanthoria ulophyllodes Räsänen – on R, Aln, Fra, PopA, Pin (1250–1500).

Xylographa parallela (Ach.: Fr.) Behlen & Desberg – on L (1900–2000).

**Xylographa vitiligo (Ach.) J.R. Laundon – on L (1500–2000).

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Lichens from Uummannaq, Qilakitsoq and Qaarsut, Central West Greenland

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Abstract: A total of 177 taxa of lichens are reported from three localities in the Uummannaq area in Central West Greenland. *Aspicilia myrinii* is reported as new to Greenland. Northern extensions of 13 species in West Greenland are presented. Geology, climate and vegetation of the localities are briefly treated.

Kokkuvõte: Kesk-lääne Gröönimaa (Uummannaq, Qilakitsog ja Qaarsut) samblikud.

Esitatakse Kesk-lääne Gröönimaa Uummannaqi piirkonna kolme kogumisala 177 samblikutaksoni leiuandmed. *Aspicilia myrinii* on esmasleid Gröönimaalt. Andmetest nähtub 13 Lääne-Gröönimaa liigi ulatuslik levik põhja suunas. Lühidalt peatutakse piirkonna geoloogial, kliimal ja taimkattel.

INTRODUCTION

The lichen flora of Uummannaq Ø and two additional lowland localities situated at the north coast of Nuussuaq Peninsula, viz. Qilakitsoq and Qaarsut (Fig. 1), was investigated by the author in July 1989 and July 2003. Uummannaq covers an area of c. 12 square kilometres. The town, Uummannaq, is located at the southern point of the island. A 1170 m high mountain, Hjertefjeldet, occupies the central part of the island (Fig. 2). A small bay, Spraglebugt, occurs at the western side of the island just north of Uummannaq. All parts of the island except the uppermost and steepest slopes of Hjertefjeldet were studied by the author. Qilakitsoq and Qaarsut are separated from Uummannaq by the channel, Sarqarput. The distance between Uummannaq and the two localities is 8 km and 16 km, respectively. The former, now abandoned village, Qilakitsoq, is primarily known because of the rare find of some well-preserved, more than 500 year old mummies now deposited at the Greenland national museum in Nuuk. The author investigated the gneissic foreland near the graves. Qaarsut is a settlement with c. 250 inhabitants. The author studied its surroundings, in particular the coastal lowland and the lowest level of the mountains, which rise more or less steeply to altitudes about 2000 m in the central part of Nuussuaq.

J. Vahl visited the Uummannaq District in 1834 (Branth & Grønlund, 1888), E. Vanhöffen in 1892 (Darbishire, 1897). The first publications list only about twenty species, most of them very common and widely distributed Greenland lichens. A more complete survey of the lichen flora of Uummannaq has not been published so far, but a number of recent publications contain informations about lichens collected in the area including the surroundings of the previous mining town, Maarmorilik (Breuss & Hansen, 1988; Hansen, 1990a, 1990b, 1991, 1995; Hansen & Poelt, 1987; Hansen et al., 1987a, 1987b; Leuckert et al., 1987; Moberg & Hansen, 1986; Thomson, 1997).

Localities and geology

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

1. Uummannaq. 70°41´N, 52°08´W. Alt. 0–200 m (Fig. 2). 15–19 July 1989, 27 July 1989 & 22–23 July 2003. Archaean gneiss ("Uummannaq gneiss") with layers of amphibolite (Escher & Stuart Watt, 1976).
2. Qilakitsoq. 70°36´N, 52°13´W. Alt. 0–100 m. 28 July 1989. Archaean gneiss.
3. Qaarsut. 70°44´N, 52°39´W. Alt. 0–300 m. 24–29 July 2003. Archaean gneiss and scattered occurrences of amphibolite. The locality is distincly influenced by Tertiary basalts and Cretaceous sediments derived from surrounding rock formations.

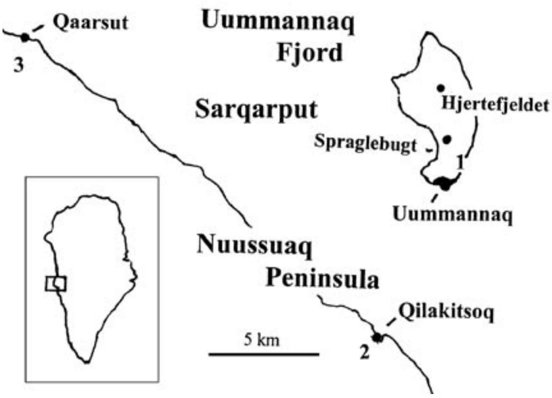

Fig. 1. Location of investigation area in Central West Greenland. 1 – Uummannaq Ø; 2 – Qilakitsoq; 3 – Qaarsut. The small Greenland map shows the situation of the investigation area.

Climate

The Uummannaq area has a low arctic and oceanic climate. The mean temperature of the warmest month, July, is 8°C at Uummannaq, whereas the mean temperature of the coldest month, March, is –17°C according to measurements made by Asiaq/Grønlands Forundersøgelser. The annual precipitation is 120 mm (2000).

MATERIAL AND METHODS

Lichens were collected at numerous sample plots at the three localities situated in the Uummannaq area. The collected material, a total of 630 specimens of lichens, was studied with Zeiss light microscopes. Selected specimens of *Bryoria* and *Stereocaulon* were identified by means of TLC. The material is deposited at the Botanical Museum, University of Copenhagen (C).

RESULTS AND DISCUSSION

About 100 lichens have been reported from the Uummannaq area prior to the present investigation by Hansen and different co-authors (see Introduction). Floristically Uummannaq Ø and Nuussuaq Peninsula are more similar to the

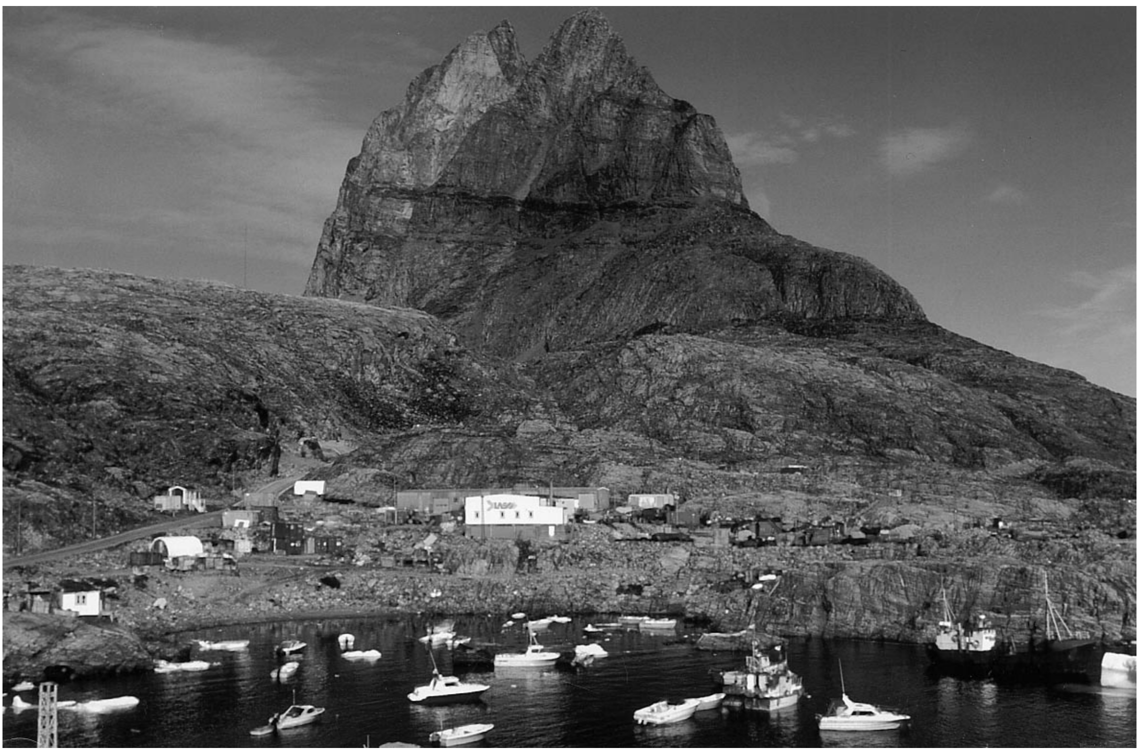

Fig. 2. Rocky hills just north of Uummannaq town. Hjertefjeldet (= Uummannaq Fjeld) with distinct black bands of amphibolite is seen in the background.

northernmost part of Disko and Svartenhuk Peninsula than to the inland area between the two big peninsulas. Thus the surroundings of Maarmorilik are richer in lichens with affinity to more or less calciferous substrates than, for example, Uummannaq Ø (Hansen, 1990a, 1991). Selected, mostly rare species of particular interest reported from the investigation area, but not found during the trips in 1989 and 2003, are listed together with the references in the following.

Caloplaca anchon-phoeniceon Poelt & Clauzade (Hansen et al., 1987a)
Caloplaca cacuminum Poelt (Hansen et al., 1987a)
Caloplaca celata Th. Fr. (Hansen et al., 1987a)
Caloplaca fulvolutea (Nyl.) Jatta (Hansen et al., 1987a)
Caloplaca insularis Poelt (Hansen et al., 1987a)
Caloplaca paulii Poelt (Hansen et al., 1987a)
Caloplaca saxifragarum Poelt (Hansen et al., 1987a)
Caloplaca xanthostigmoidea (Räsänen) Zahlbr. (syn. *Caloplaca epiphyta* Lynge) (Hansen et al., 1987a)
Catapyrenium cinereum (Pers.) Körb. (Breuss & Hansen, 1988)
Catapyrenium daedaleum (Kremp.) Stein. (Breuss & Hansen, 1988)
Glypholecia scabra (Pers.) Müll. Arg. (Hansen & Poelt, 1987)
Involucropyrenium waltheri (Kremp.) Breuss [syn. *Catapyrenium waltheri* (Kremp.) Körb.] (Hansen & Poelt, 1987)
Lecidea ileiformis Fr. (Hansen & Poelt, 1987)
Megaspora verrucosa (Ach.) Hafellner & Wirth [syn. *Pachyospora verrucosa* (Ach.) A. Massal.] (Hansen, 1991)
Melanolecia transitoria (Arnold) Hertel (Hansen & Poelt, 1987)
Placidium norvegicum (Breuss) Breuss (syn. *Catapyrenium norvegicum* Breuss) (Breuss & Hansen, 1988)
Phaeophyscia kairamoi (Vain.) Moberg (Moberg & Hansen, 1986)
Psora globifera (Ach.) A. Massal. (Hansen, 1991)
Psora vallesiaca (Schaer.) Timdal (Hansen, 1991)
Sagiolechia protuberans (Ach.) A. Massal. (Hansen et al., 1987)
Schadonia fecunda (Th. Fr.) Vězda & Poelt (Hansen & Poelt, 1987)

General remarks on the lichen vegetation

Uummannaq Ø is characterized by a fairly diverse terricolous lichen vegetation in spite of the relatively simple geological conditions prevailing on the island. Moist heath mosaics with dominating *Cassiope tetragona*, *Phyllodoce coerulea* and *Salix herbacea* occur in places with a moderate to prolonged snow cover during winter. *Cetrariella delisei, Cladonia borealis*, *C. mitis*, *C. trassii*, *Cetraria islandica*, *Ochrolechia frigida*, *Peltigera malacea*, *Psoroma tenue* and *Stereocaulon alpinum* are common lichens in this snow-patch-like heath type. A related, but somewhat drier heath vegetation with *Cassiope*, *Empetrum hermaphroditum* and *Vaccinium uliginosum* covers the thin soil layer near Qilakitsoq. However, proper snow-patches dominated by *Salix herbacea*, *Solorina crocea* and *Pertusaria oculata* also occur at this locality. *Bryoria nitidula*, *Cladonia bellidiflora*, *C. cyanipes* and *C. sulphurina* are among the most typical lichens in this gneissic area. *Empetrum*, *Vaccinium* and *Salix glauca* form a lichen-rich community on many, more or less exposed rocks on Uummannaq Ø. *Alectoria nigricans*, *Cetraria islandica*, *C. muricata* and *Sphaerophorus globosus* are commonly found at these sites. Wind exposed rocks with a thin snow cover in winter sometimes hold a dry *Dryas integrifolia-Vaccinium heath* with *Alectoria nigricans*, *A. ochroleuca*, *Cetraria muricata*, *Flavocetraria cucullata*, *F. nivalis* and *Thamnolia vermicularis*. These lichens also occur abundantly in open places in the extensive *Betula nana* heath at Spraglebugt and in a steppe-like *Carex rupestris-Artemisia borealis* community occurring on south-facing slopes on the island. *Caloplaca tiroliensis*, *Candelariella placodizans*, *Cetraria muricata*, *Physconia muscigena* and *Psora rubiformis* are additional species occurring in the last-mentioned community. Dry *Dryas-Carex rupestris* heaths with well-developed *Alectoria ochroleuca* and *Flavocetraria nivalis* occur commonly in the vicinity of Qaarsut. *Bryoria nitidula* and *Flavocetraria cucullata* are the dominant lichen species in mixed *Vaccinium-Dryas* heaths around this settlement. *Cassiope*, *Empetrum*, *Betula nana* and *Rhododendron lapponicum* are occasional dwarf shrubs in the heath mosaics occurring at Qaarsut. Their content of lichens is comparable with that of Uummannaq. However, *Protopannaria pezizoides* was not found at Uummannaq. At Qaarsut it grows on moist soil in these dwarf shrub heaths. Some moist depressions near Spraglebugt just north of Uummannaq are covered by, for example, *Arctocetraria nigricascens*, *Arthrorhaphis alpina* and *Lecanora geophila*.

A few corticolous lichens, for example, *Leptogium saturninum* and *Melanelia septentrionalis*, have previously been reported from Maarmorilik (Alstrup, 1982; Hansen, 1991). *Lecanora fuscescens* was collected at Qaarsut, only. The comparatively cold climatic conditions prevailing in the Uummannaq area evidently do not favour the development of extensive scrubs with a corticolous lichen flora of the type known from more southern parts of Greenland.

Ornithocoprophilous saxicolous lichens are of great importance at all of the three localities, indicating the very rich bird life of the area. Guano of ravens and different sea birds, in particular gulls, manures exposed rocks and thus favours lichens such as *Candelariella vitellina*, *Dimelaena oreina*, *Lecidea atrobrunnea*, *Phaeophyscia sciastra*, *Physcia caesia*, *P. dubia*, *Rhizoplaca melanophthalma*, *Umbilicaria arctica*, *U. decussata* and *Xanthoria elegans*. *Umbilicaria decussata* is sometimes the dominant lichen on north- and east-facing rocks on Uummannaq Ø, while *Xanthoria elegans* dominates in the lichen communities on south-facing rocks. The basal part of the rocks is occasionally covered by *Xanthoria sorediata*. *Umbilicaria vellea* occurs abundantly on overhanging rocks and in places with percolating water. The lowest, west-facing amphibolite band on Hjertefjeldet holds the following lichens: *Dimelaena oreina*, *Physcia caesia*, *Pseudephebe minuscula*, *Rhizocarpon geminatum*, *Rhizoplaca melanophthalma*, *Umbilicaria hyperborea*, *Xanthoria elegans* (dominant) and *X. sorediata*. A similar sociation (without *Dimelaena oreina* and *Xanthoria sorediata*) occurs at Qilakitsoq. Here *Usnea sphacelata* was found growing on a gneissic rock. The nitrophilous sociation is quite common at Qaarsut (Fig. 3), but differs in the abundant occurrence of *Melanelia infumata*. At this locality *Xanthoria elegans* binds gravel in the same way as at, for example, Qeqertarsuaq on Disko (Hansen, 1999). Somewhat exposed, horizontal gneissic rock faces

Fig. 3. Top of bird rock at Qaarsut. The mouse-grey thalli of *Umbilicaria decussata* have distinct reticulate ridges. They are surrounded by pale yellowish white thalli of *Rhizoplaca melanophthalma*.

at Qaarsut support species such as *Calvitimela armeniaca*, *Dimelaena oreina*, *Sporastatia testudinea* (infected by *Rhizocarpon pusillum*), *Umbilicaria decussata* and *U. lyngei*.

Gneissic rocks are much wider distributed in the Uummannaq area than rocks composed of amphibolite and accordingly contain more lichen species than the latter. *Acarospora molybdina*, *Caloplaca alcarum* and *Lecanora contractula* form a characteristic sociation on gneissic seashore rocks manured by, for example, gulls. It is widely distributed in coastal areas in Greenland (Hansen et al., 1987a). A south-facing gneissic rock at the east side of Uummannaq Ø is covered by *Lecanora intricata*, *Rhizocarpon geminatum* (dominant, infected by *Caloplaca castellana*), *Umbilicaria hyperborea*, *U. torrefacta* and *U. virginis*. A blackish lichen sociation with *Arctoparmelia incurva*, *Orphniospora moriopsis, Pseudephebe minuscula* and *Umbilicaria hyperborea* occurs on gneissic rocks at a somewhat higher level (alt. 100 m a.s.l.) in this area. Another dark coloured community occurring more or less commonly at Uummannaq consists of the following lichens: *Allantoparmelia alpicola*, *Arctoparmelia incurva*, *Ophioparma ventosa*, *Orphniospora moriopsis*, *Pseudephebe minuscula* (dominant), *Rhizocarpon inarense*, *Sphaerophorus fragilis*, *Umbilicaria hyperborea* and *U. lyngei*. A horizontal rock just north of Uummannaq also holds a greyish to black coloured association with *Melanelia hepatizon, Parmelia saxalis*, *Sphaerophorus fragilis*, *Umbilicaria hyperborea* and *U. lyngei*.

Annotated list of lichens

The following list of lichens is based on the author´s collections. The list cannot be considered representative as regards genera such as *Aspicilia*, *Verrucaria* and a number of lecideoid microlichens, which have been neglected during the present investigation. Nomenclature follows Santesson et al. (2004) with some exceptions. Numbers 1, 2, 3 indicate the three localities listed above. Annotations are given as regards the substrate of the lichens and presence of apothecia (ap.) or perithecia (pe.); "st." means that the specimens is sterile. The asterisk * in front of the name indicates that the collection represents a northern range extension of the taxon in West Greenland. The frequency is mentioned, where it was possible to estimate it. Collections which have been distributed previously from herbarium C as part of "Lichenes Groenlandici Exsiccati" (LGE) are stated by their numbers. Selected references are cited.

ACAROSPORA MOLYBDINA (Wahlenb.) A. Massal. – 1. On gneissic seashore rocks; ap.

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

A. RHIZOBOLA (Nyl.) Alstrup – 1, 3. On soil; ap.

* A. VERONENSIS A. Massal. – 2. On gneissic rocks; ap.

ALECTORIA NIGRICANS (Ach.) Nyl. – 1, 2, 3. On soil; st.

A. OCHROLEUCA (Hoffm.) A. Massal. – 1, 2, 3. On soil; st. LGE 910.

ALLANTOPARMELIA ALPICOLA (Vain.) Essl. – 1, 2. On gneissic rocks; st.

* AMANDINEA CONIOPS (Wahlenb.) M. Choisy ex Scheid. & H. Mayrhofer – 1. On gneissic rocks; ap.

ARCTOCETRARIA NIGRICASCENS (Nyl.) Kärnefelt & A. Thell – 1. On soil; st. LGE 356.

ARCTOPARMELIA INCURVA (Pers.) Hale – 1, 2, 3. On gneissic rocks; st.

ARCTOPELTIS THULEANA Poelt – 1. On gneissic rocks manured by birds; ap. The species is common on Disko and Nuusuaq Peninsula, but very rare outside this area (Hansen, 1997).

ARTHRORHAPHIS ALPINA (Schaer.) R. Sant. – 1, 2, 3. On soil; st.

A. CITRINELLA (Ach.) Poelt – 1. On soil; st.

ASPICILIA MASTRUCATA (Wahlenb.) Th. Fr. – 1, 2, 3. On rocks composed of gneiss and amphibolite; st.

A. MYRINII (Fr.) Hafellner – 1. On gneissic rocks; ap. New to Greenland.

* BAEOMYCES CARNEUS Flörke – 1, 3. On soil and plant debris; st.

BRODOA OROARCTICA (Krog) Goward – 3. On siliceous rocks; st.

BRYOCAULON DIVERGENS (Ach.) Kärnefelt – 1. On soil; st.

BRYONORA CASTANEA (Hepp) Poelt – 1, 2, 3. On mosses and plant debris; st.

BRYORIA CHALYBEIFORMIS (L.) Brodo & D. Hawksw. – 1. On soil; st.

* B. LANESTRIS (Ach.) Brodo & D. Hawksw. – 3. On gneissic rocks; st.; rare. Thallus contains fumarprotocetraric acid (TLC).

B. NITIDULA (Th. Fr.) Brodo & D. Hawksw. – 1, 2, 3. On soil; st. LGE 360, 908.

Buellia papillata (Sommerf.) Tuck. – 1, 3. On soil; ap.

Caloplaca alcarum Poelt – 1, 3. On *Lecanora contractula* on seashore rocks composed of gneiss and amphibolite; rarely on old bones; ap.

C. ammiospila (Wahlenb.) H. Olivier – 1, 2, 3. On plant debris, mosses and soil; ap.

C. castellana (Räsänen) Poelt – 1, 3. On *Placynthium asperellum* and *Rhizocarpum geminatum* on gneissic rocks; ap.

C. cerina (Ehrh. ex Hedw.) Th. Fr. – 1, 2, 3. On mosses, plant debris and old bones; ap.

C. citrina (Hoffm.) Th. Fr. – On old bones; ap. Previously reported from a few localities in South-, West- and North Greenland (Hansen et al., 1987a).

C. epithallina Lynge – 1, 3. On *Dimelaena oreina* and *Rhizoplaca melanophthalma* on gneissic rocks; ap.

C. fraudans (Th. Fr.) H. Olivier – 2. On gneissic rocks; ap.

C. jungermanniae (Vahl) Th. Fr. – 1, 2. On plant debris; ap.

C. tetraspora (Nyl.) H. Olivier – 1, 3. On plant debris; ap.

C. tiroliensis Zahlbr. – 1, 2, 3. On mosses and plant debris; ap.; common.

C. tominii L.I. Savicz – 3. On calciferous soil; st.

Calvitimela armeniaca (DC.) Hafellner – 1, 3. On gneissic rocks; ap.

Candelariella aurella (Hoffm.) Zahlbr. – 3. On old bone; ap.

C. dispersa (Räsänen) Hakul. – 3. On *Placynthium asperellum* on gneissic rocks; st.

C. placodizans (Nyl.) H. Magn. – 1, 2, 3. On soil; ap.

C. terrigena Räsänen – 1. On soil rich in humus; st.

C. vitellina (Hoffm.) Müll. Arg. – 1, 3. On gneissic rocks; ap.

C. xanthostigma (Ach.) Lettau – 1. On plant debris; st.; rare.

Cetraria islandica (L.) Ach. – 1, 2, 3. On soil; st. LGE 359.

C. muricata (Ach.) Eckfeldt – 1, 2, 3. On soil; st.

Cetrariella delisei (Bory ex Schaer.) Kärnefelt & A. Thell – 1, 2, 3. ; st.; common. LGE 368.

Chaenotheca furfuracea (L.) Tibell – 2. On plant debris and mosses; st.

Cladonia amaurocraea (Flörke) Schaer. – 1, 2, 3. On soil rich in humus; st.; common.

C. bellidiflora (Ach.) Schaer. – 1, 2. On soil and plant debris; ap.

C. borealis S. Stenroos – 1, 2, 3. On soil rich in humus; ap.

C. cariosa (Ach.) Spreng. – 1. On soil; ap.

C. chlorophaea (Flörke ex Sommerf.) Spreng. – 1, 2, 3. On soil and mosses; st.

C. cornuta (L.) Hoffm. – 1, 2. On soil rich in humus and on mosses; st.

C. cyanipes (Sommerf.) Nyl. – 2. On soil rich in humus; st.

C. gracilis (L.) Willd. – 1, 2. On soil rich in humus; ap.

C. luteoalba Wheldon & A. Wilson – 2. On plant debris; st.

C. macroceras (Delise) Hav. – 1, 3. On soil; st.

C. macrophylla (Schaer.) Stenh. – 2. On soil rich in humus; ap.

* C. macrophyllodes Nyl. – 1, 2. On soil and mosses; st.

C. mitis Sandst. – 1, 2, 3. On soil; st.; common.

C. phyllophora Hoffm. – 1. On soil rich in humus; st.

C. pleurota (Flörke) Schaer. – 1, 2. On soil rich in humus and on plant debris; st.

C. pocillum (Ach.) Grognot – 1, 3. On soil; st.

C. pyxidata (L.) Hoffm. – 1, 2, 3. On soil rich in humus; st.; common.

C. stygia (Fr.) Ruoss – 2. Among mosses on soil; st.

C. sulphurina (Michx.) Fr. – 1, 2. On soil rich in humus; st.

* C. trassii Ahti – 1, 2. On soil rich in humus; ap.

Collema undulatum Laurer ex Flot. var. granulosum Degel. – 1. On calciferous soil; st.

Dactylina ramulosa (Hook.) Tuck. – 3. On soil, mosses and plant debris; st. LGE 909

Dimelaena oreina (Ach.) Norman – 1, 2, 3. On rocks composed of gneiss and amphibolite; ap.

* Euopsis pulvinata (Schaer.) Vain. – 1. On gravel; ap.

Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell – 1, 2, 3. On soil; st.; common. LGE 907.

F. nivalis (L.) Kärnefelt & A. Thell – 1, 2, 3. On soil; st.; common. LGE 906.

Fulgensia bracteata (Hoffm.) Räsänen – 3. On plant debris and mosses on calciferous soil; ap.; rare.

Fuscopannaria praetermissa (Nyl.) P.M. Jørg. – 1. On mosses on calciferous soil; st.

Hypogymnia austerodes (Nyl.) Räsänen – 1, 3. On plant debris and mosses; st.

H. subobscura (Vain.) Poelt – 3. On plant debris; st.

Lecanora argopholis (Ach.) Ach. – 1, 3. On rocks composed of gneiss and amphibolite; ap.

L. cenisia Ach. – 1. On gneissic rocks; ap.

L. chloroleprosa (Vain.) H. Magn. – 1, 2. On gneissic rocks; st.

L. contractula Nyl. – 1, 2. On seashore rocks composed of gneiss and amphibolite; rarely on old bones; ap.

L. epibryon (Ach.) Ach. – 1, 3. On soil, mosses and plant debris; ap.

L. fuscescens (Sommerf.) Nyl. – 3. On dead twigs of *Salix glauca*; ap.

L. geophila (Th. Fr.) Poelt – 1. On soil rich in humus; st.

L. hagenii (Ach.) Ach. var. fallax Hepp. – 1, 2, 3. On plant debris and old bone; ap.

L. intricata (Ach.) Ach. – 1. On gneissic rocks; ap.

L. polytropa (Ehrh. ex Hoffm.) Rabenh. – 1, 2, 3. On rocks composed of gneiss and amphibolite; ap.; common.

Lecidea atrobrunnea (Ramond ex Lam. & DC.) Schaer. – 1, 3. On gneissic rocks; ap.

L. lapicida (Ach.) Ach. var. pantherina Ach. – 3. On gneissic rocks; ap.

L. tessellata Flörke – 1, 3. On gneissic rocks; ap.

Lecidella wulfenii (Hepp) Körb. – 1. On soil rich in humus; ap.

Leprocaulon subalbicans (I.M. Lamb) I.M. Lamb & A.M. Ward – 1, 2, 3. On mosses.

Lichenomphalia hudsoniana (H.S. Jenn.) Redhead et al. – 2. On mosses.

Lopadium coralloideum (Nyl.) Lynge – 3. On soil; ap.

Melanelia disjuncta (Erichsen) Essl. – 1, 2, 3. On gneissic rocks; st.

M. hepatizon (Ach.) A. Thell – 1, 3. On gneissic rocks; st.

M. infumata (Nyl.) Essl. – 1, 3. On gneissic rocks manured by birds; rarely on twigs (*Salix glauca*); st. LGE 905.

Micarea assimilata (Nyl.) Coppins – 1. On soil; ap.

Miriquidica atrofulva (Sommerf.) A.J. Schwab & Rambold – 1, 2. On gneissic rocks rich in iron minerals; st.

M. garovaglii (Schaer.) Hertel & Rambold – 1, 3. On gneissic rocks; st.

M. nigroleprosa (Vain.) Hertel & Rambold – 1. On gneissic rocks; st.

Myxobilimbia lobulata (Sommerf.) Hafellner – 1, 3. On soil and mosses; ap.

Ochrolechia frigida (Sw.) Lynge – 1, 2, 3. On soil, plant debris and mosses; ap.; common.

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

* O. inaequatula (Nyl.) Zahlbr. – 1. On mosses; st.

O. lapuënsis (Vain.) Räsänen – 1, 2, 3. On plant debris; st.

Ophioparma ventosa (L.) Norman – 1, 2. On gneissic rocks; ap.

Orphniospora moriopsis (A. Massal.) D. Hawksw. – 1, 2. On gneissic rocks; ap.

Parmelia omphalodes (L.) Ach. – 1, 2, 3. On mosses; st.

P. saxatilis (L.) Ach. – 1, 2, 3. On gneissic rocks and mosses; st.

P. sulcata Taylor – 2. On gneissic rocks; st.

Parmeliella triptophylla (Ach.) Müll. Arg. – 3. On mosses; st.

Peltigera didactyla (With.) J.R. Laundon – 1, 2. On soil and mosses; st. The species is infected by *Illosporium carneum*.

P. lepidophora (Nyl. ex Vain.) Bitter – 3. On soil; st.; rare.

P. leucophlebia (Nyl.) Gyeln. – 2. On mosses; st.

P. malacea (Ach.) Funck – 1, 2, 3. On soil and mosses; st.

P. rufescens (Weiss) Humb. – 1, 2, 3. On soil and mosses; st.

P. scabrosa Th. Fr. – 1, 2, 3. On soil and mosses; st.

Pertusaria coriacea (Th. Fr.) Th. Fr. – 1, 3. On soil, mosses and plant debris; st.

P. dactylina (Ach.) Nyl. – 2. On soil; st.

P. geminipara (Th. Fr.) C. Knight ex Brodo – 1, 2. On mosses and plant debris; st.

P. oculata (Dicks.) Th. Fr. – 1, 2, 3. On soil and mosses; ap.

Phaeophyscia constipata (Norrl. & Nyl.) Moberg – 1. On mosses and soil; st.; rare.

P. endococcina (Körb.) Moberg – 1. On gneissic rocks and on mosses; ap.

P. sciastra (Ach.) Moberg – 1, 3. On gneissic rocks and on mosses; ap.

Physcia caesia (Hoffm.) Fürnr. – 1, 2, 3. On gneissic rocks and old bones; st.

P. dubia (Hoffm.) Lettau – 1, 3. On gneissic rocks and old bones; st.

* P. tenella (Scop.) DC. – 1, 3. On gneissic rocks and dead twigs; st.; rare.

Physconia muscigena (Ach.) Poelt – 1, 2, 3. On soil, mosses, planr debris and gneissic rocks; ap.; common.

Placidium lachneum (Ach.) de Lesd. – 1, 3. On calciferous soil and mosses; pe.

Placynthium asperellum (Ach.) Trevis – 1, 2, 3. On gneissic rocks; ap.

Pleopsidium chlorophanum (Wahlenb.) Zopf – 1, 2, 3. On rocks composed af amphibolite and gneiss; ap.

* Polychidium muscicola (Sw.) Gray – 1. On plant debris; st.

Porpidia flavocaerulescens (Hornem.) Hertel & A.J. Schwab – 2, 3. On gneissic rocks; ap.

Protopannaria pezizoides (Weber) P.M. Jørg. & S. Ekman – 3. On soil; ap.

Protoparmelia badia (Hoffm.) Hafellner – 1, 3. On gneissic rocksmanured by birds; ap.

Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw. – 1, 2, 3. On rocks and stones composed of amphibolite and gneiss; st.; common.

P. pubescens (L.) M. Choisy – 2. On gneissic rocks; rare.

Psora rubiformis (Ach.) Hook – 1, 3. On calciferous soil and mosses; ap.

Psoroma tenue Henssen var. boreale Henssen – 1, 2, 3. On soil, mosses and plant debris; ap. Recently reported as overlooked, but widespread, arctic-alpine lichen (Jørgensen, 2004). The taxon is common in more northern parts of Greenland.

Rhizocarpon bolanderi (Tuck.) Herre – 1. On gneissic rocks; st.; rare.

R. disporum (Nägeli ex Hepp) Müll. Arg. – 1. On gneissic rocks; ap.

R. eupetraeoides (Nyl.) Blomb. & Forssell – 1. On gneissic rocks; ap.

R. geminatum Körb. – 1, 3. On rocks composed of amphibolite and gneiss; ap. LGE 902.

R. geographicum (L.) DC. – 1, 3. On gneissic rocks; ap.

R. grande (Flörke) Arnold – 1. On gneissic rocks; ap.

R. inarense (Vain.) Vain. – 1, 2, 3. On gneissic rocks; ap.; common.

* R. jemtlandicum (Malme) Malme – 1, 3. On rocks composed of amphibolite and gneiss; ap.

R. praebadium (Nyl.) Zahlbr. – 1. On gneissic rocks; ap.

R. pusillum Runemark – 1, 3. On *Sporastatia testudinea* on gneissic rocks; ap.

R. superficiale (Schaer.) Vain. – 1, 3. On gneissic rocks; ap.

Rhizoplaca melanophthalma (DC.) Leuckert & Poelt – 1, 3. On gneissic rocks manured by birds; also on rocks composed of amphibolite; ap.

Rinodina turfacea (Wahlenb.) Körb – 1, 2. On soil and plant debris; ap.

Solorina bispora Nyl. – 1. On calciferous soil; ap.

S. crocea (L.) Ach. – 2. On soil; ap.

S. spongiosa (Ach.) Anzi – 3. On calciferous soil; ap.

Sphaerophorus fragilis (L.) Pers. – 1, 2. On gravelly soil and gneissic rocks; st.

S. globosus (Huds.) Vain. – 1, 2. On soil and mosses; st.

Sporastatia polyspora (Nyl.) Grummann – 1, 3. On gneissic rocks; ap.

S. testudinea (Ach.) A. Massal. – 1, 3. On rocks composed of amphibolite and gneiss; ap.

Stereocaulon alpinum Laurer – 1, 2, 3. Among mosses on soil; ap.; common.

* S. arcticum Lynge – 1, 2. On soil; st. LGE 355.Thallus contains atranorin and stictic acid (TLC)

S. arenarium (L.I. Savicz) I.M. Lamb – 1, 2, 3. On mosses or less gravelly soil; st.; common.

S. botryosum Ach. – 2. On gneissic rocks; st.

S. glareosum (L.I. Savicz) H. Magn. – 1, 2. On soil; st.

Thamnolia vermicularis (Sw.) Schaer. var. subuliformis (Ehrh.) Schaer. – 1, 2, 3. On soil and mosses; common. LGE 911.

Tremolecia atrata (Ach.) Hertel – 1, 2, 3. On gneissic rocks; ap.

Umbilicaria arctica (Ach.) Nyl. – 1, 2, 3. On gneissic rocks manured by birds; ap.; common.

U. decussata (Vill.) Zahlbr. – 1, 2. On bird rocks composed of amphibolite and gneiss; ap. LGE 354, 904.

U. hyperborea (Ach.) Hoffm. – 1, 2, 3. On rocks composed of amphibolite and gneiss; ap.; common.

U. lyngei Schol. – 1, 2, 3. On gneissic rocks; ap.; common.

U. proboscidea (L.) Schrad. – 1, 2, 3. On gneissic rocks; ap.

U. torrefacta (Lightf.) Schrad. – 1. On gneissic rocks; st.

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

U. VIRGINIS Schaer. – 1, 2, 3. On gneissic rocks; ap.

USNEA SPHACELATA R. Br. – 2. On gneissic rocks; st.; rare.

XANTHORIA BOREALIS R. Sant. & Poelt – 1, 3. On gneissic rocks manured by birds; rarely on soil and mosses; ap.

X. ELEGANS (Link) Th. Fr. – 1, 2, 3. On bird rocks composed of amphibolite and gneiss, rarely on mosses and old bones; ap.; common. LGE 903.

X. SOREDIATA (Vain.) Poelt – 1, 3. On vertical faces of gneissic rocks manured by birds; st.

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Influence of environmental factors on the local-scale distribution of cyanobacterial lichens: case study in the North Urals, Russia

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Abstract: Distribution and frequency of 11 cyanobacterial lichen species on *Populus tremula* trunks were studied in the mountain taiga of the North Urals. Within an area of 150×200 m, all aspen trunks were registered, and a range of environmental variables (including characteristics of tree stand, herbs, dwarf-shrubs and mosses; 30 variables in total) were noted within a circle of 6 m diameter around each tree. This study suggests the environmental variables to be of small importance for spatial distribution of the lichens on a local scale. However, the abundance of the species was shown to depend on size and vitality of their host trees, reaching maximal values in oldest damaged trees.

Kokkuvõte: Keskkonnategurite mõju tsüanobaktereid sisaldavate samblike levikule lokaalskaalas: pilootprojekt Põhja-Uuralitest, Venemaalt.

Põhja-Uuralite mägitaigas uuriti 11 tsüanobaktereid sisaldava samblikuliigi levikut ja sagedust haava (*Populus tremula*) tüvedel. 150×200 m alal registreeriti kõik haavatüved, ja 6 m läbimõõduga ringides ümber iga puu märgiti üles rida keskonna muutujaid (sealhulgas puistu karakteristikud, taimed, puhmad ja samblad; kokku 30 muutujat). Uurimusest tuleneb, et samblike ruumilise leviku jaoks lokaalskaalas on keskkonna muutujad vähese tähtsusega. Ometi sõltus liikide ohtrus peremeespuude suurusest ja elujõulisusest, saavutades suurima väärtuse vanimatel vigastatud puudel.

INTRODUCTION

Cyanobacterial lichens are a rather specific group of lichens from both physiological and ecological points of view. Many of them are highly sensitive to any kind of ecosystem disturbances and are suggested as being indicators of ecological continuity, or old-growth forest indicators (Gauslaa, 1994, Kuusinen, 1996, Sillett & McCune, 1998, etc.). Among cyanolichens, there is a range of rare and endangered species included to Red lists of many European countries. Use of cyanolichens as biological indicators as well as necessity of their conservation require better understanding of environmental factors influencing their distribution in different spatial scales, from a forest patch up to the species distribution area as a whole.

Factors determining distribution of lichen species at different spatial levels can be very different, for example, climate parameters, altitude, and regional air quality are responsible for the lichen distribution at regional scale, and forest vegetation parameters are of the highest importance at subregional spatial scale (Will-Wolf et al., 2004).

Our investigations were carried out in one of few old-growth forests left in the North Urals. Continental climate of the Ural Mountains together with high level of industrialization of the region does not advantage high diversity and abundance of epiphytic cyanolichens. Hot spots of cyanolichen diversity can be found in mountain taiga under conditions of higher humidity and low level of any kind of human activity though even these habitats are unfavorable for cyanolichens. Under these conditions, all relationships between lichens and environment are expected to be more pronounced. Our study was aimed to assess the importance of environmental factors for the distribution and frequency of cyanolichens on the local scale (few hectares within more or less homogeneous tree stand).

MATERIAL AND METHODS

The study was carried out in the mountain taiga of the North Ural near the village of Kytlym (Sverdlovsk region, 59°28'N, 59°14'E). The climate is moderately continental, with an annual average precipitation of 492 mm. The mean annual temperature is –0.2°C; mean January and July temperatures are –16.4°C and 13.9°C, respectively. The duration of the frost-free period is 96 days (Reference book…, 1965, 1968).

The area belongs to the middle taiga phytogeographical subzone (Kolesnikov et al., 1973). The sample plot was established in the lower part (460 m a.s.l.) of the western slope of Pervyi Bugor mountain (931 m a.s.l.). The tree stand was composed by *Picea obovata, Abies sibirica, Pinus sibirica, Populus tremula,* and *Betula pubescens* with an average age of 120 years. The soil was well-drained, deep and rocky, and was classified as brown forest mountain soil (Firsova, 1977). In the understorey vegetation, *Vaccinium myrtillus, Oxalis acetosella, Calamagrostis obtusata, Pleurozium schreberi,* and *Hylocomium splendens* dominated.

Populus tremula was selected as a phorophyte for studying cyanolichens because of high water capacity of its bark (Barkman, 1958) which is advantageous for cyanolichens. Within an area of 150×200 m, all aspen trees with diameter at breast height (DBH) of at least 30 cm were registered (182 trees). On all registered trunks, the frequencies of cyanolichens were recorded using a sample grid of 10 units adapted to fit half the circumference of each trunk (Herzig & Urech, 1991). The grid was placed sequentially on the basal (0–0.5 m above ground) halves of the trunks and on those at 1.0–1.5 m above ground. Thus, species frequency on the trunk ranged from 0 to 40. For species growing out of quadrates, only presence was recorded.

The following parameters were noted for each tree: DBH, class of vitality [1 – healthy, 2 – damaged (parasitic fungi or mechanical damages), 3 – dead], and inclination (measured with an inclinometer). Age of 45 healthy trees was determined with an increment borer. Obtaining of accurate age estimates for damaged aspens was problematic because of decaying of heartwood.

A range of environmental variables was registered within a circle of 6 m diameter around each tree: 1) tree stand characteristics (basal area of coniferous and deciduous trees, total basal area, and crown parameters); 2) density of young growth in three height classes: < 50 cm, 50–100 cm, and >100 cm; 3) density of shrubs and trees of undergrowth in three height classes: < 50 cm, 50–100 cm, and >100 cm; 4) characteristics of understorey vegetation [abundance and number of herb and dwarfshrub species, total cover of bryophytes, total cover of herbs and dwarf-shrubs, average height of lowest and tallest herb and dwarf-shrub layers, the share of three dominant species (*Calamagrostis obtusata, Oxalis acetosella,* and *Vaccinium myrtillus)*].

To estimate canopy cover above sample trees, 8 digital pictures of crowns were taken around each tree: at 4 cardinal points in circles of 0.5 m and 1 m radius around the tree (the camera was placed at the 1 m height from the ground). The percentage of open sky area (ratio of number of pixels that fall on the open sky to the total number of pixels) and the index of crown density (ratio of number of pixels that fall on the boundary sky/crown to the number of pixels that fall on the crown) were calculated in color images using SIAMS Photolab software (developed by SIAMS, Ekaterinburg, http://siams.com).

To determine ecological indices of the sites (indices of insolation, moistening, soil acidity, continentality, soil fertility, and thermal regime), Ellenberg's indicator values scale (Ellenberg et al., 1991) was used. Each species of the herb and dwarf-shrub layer was referred to one of ecological groups. Indices were calculated as weighted averages of Ellenberg's indicator values.

To determine bark acidity, samples of upper layer (1–2 mm) were collected from four cardinal points of 80 model aspen trees at 1–1.5 m height. Model trees were selected to allow for the balanced model of 2-way ANOVA (tree vitality and tree DBH as independent factors). In the laboratory, bark samples were cleaned from bryophytes and lichens under dissecting microscope and were ground with a laboratory mill. One gram of the powder was suspended in 25 ml of distillated water in stoppered vials, placed to a shaker for 30 min and then left for 30 min. After this, pH was measured with standard glass electrode without filtration.

RESULTS AND DISCUSSION

Sample tree and site characteristics

Sample aspens varied significantly in their size (Table 1). Age of model healthy trees ranged between 53 and 130 years. Pearson correlation coefficient between age and DBH was 0.66 at $p<0.05$; the mean DBH corresponds to the age of about 80 years. The age of largest damaged trees

Table 1. Some characteristics of the sample plot

Variables	Mean	SE	CV (%)	Min	Max
DBH of aspen trees (cm)	80.57	1.88	31.54	32.50	145.00
Total basal area of tree stand (m^2/ha)	41.42	1.47	48.07	0.00	108.61
% open sky: 0.5 m from the trunk	0.22	<0.01	26.33	0.07	0.48
% open sky: 1 m from the trunk	0.24	<0.01	25.34	0.10	0.47
Index of insolation	5.07	0.03	8.62	3.60	5.88
Index of moistening	5.60	0.01	3.53	5.03	6.05
Bryophyte cover (%)	55.57	1.68	40.99	10.00	95.00
Cover of herb and dwarf-shrub layer (%)	68.57	0.79	15.57	40.00	86.00
Average bark pH per trunk	6.10	0.05	7.62	4.40	6.77
Minimal pH value per trunk	5.69	0.07	11.49	4.19	6.64
Maximal pH value per trunk	6.49	0.04	5.79	4.82	7.09

can probably exceed 150 years. Healthy trees prevailed among aspens; 40.7% of aspens had different signs of damage (fruit bodies of fungi, mainly *Phellinus tremula,* mechanical injuries, frost splits, etc.), and only one tree was dead.

Bark pH was found to vary in great extent both between and within sample trees. Range within the same trunk sometimes reached 2.2 units, so we had to treat minimal, maximal and average pH values for each trunk as separate variables (Table 1). Two-way ANOVA (*SS* III, DBH and vitality as fixed factors) revealed significant contribution of DBH to the variability of maximal pH values ($F = 5.5$, $df=4, 63$, $p<0.01$); bark pH smoothly rose with the increase of tree size (Fig. 1). Bark of damaged trees tended to be slightly more acid (difference was not significant, $F = 2.57$, $df=1, 63$, $p=0.11$). For the variability of minimal pH values, DBH was not found to be an important factor; tree vitality, on the contrary, contributed significantly ($F = 4.4$, $df=1, 63$, $p<0.05$). Acidification of the bark of damaged trees might probably be explained by activity of parasitic fungi secreting acidic substances though this question needs special investigations. High variability of pH values within the same trunk is most probably due to “dripzone effect” (Goward & Arsenault, 2000). For example, acid leachates from neighbouring coniferous trees can cause acidification of aspen bark

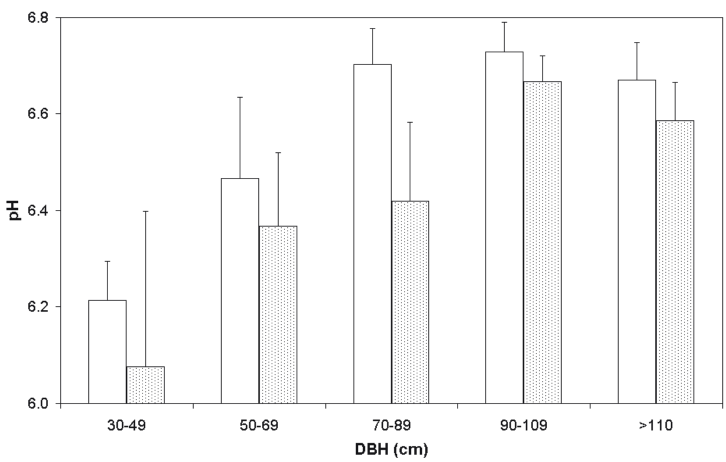

Fig. 1. Maximal values of bark pH (from 4 measurements) *vs* aspen DBH (means ± SE). White bars – healthy trees, dotted bars – damaged trees.

which in turn leads to the inoculation of aspens by acidophytic lichens that are generally not typical for this phorophyte, such as *Hypogymnia physodes* and *Vulpicida pinastri*. Generally, the range of pH values at the sample plot (4.19–7.09) corresponds to values found for aspen trunks in middle and southern boreal forests of Finland (Kuusinen, 1994).

Mean values of the total basal area and crown cover indicate rather close tree stand. Basal area was the most variable among environmental parameters registered; crown characteristics were more stable (Table 1). Cover of bryophytes also varied in a great extent indicating differences in soil moistening. Though variation coefficients of ecological indices were low, actual range of ecological factors can be rather high: for example, minimal found value of insolation index (3.6) corresponds to shadowed habitats while maximal value (5.88) falls between half-shadowed and half-opened habitats (Ellenberg et al., 1991). Thus, within the more or less homogeneous local tree stand, some heterogeneity of environmental factors exists which can be of importance for distribution and abundance of epiphytic lichens.

Table 2. List of species under study and their frequencies

Species	No of findings	% of *P. tremula* trunks colonized
Collema subflaccidum Degel.	5	2.74
Leptogium intermedium (Arnold) Arnold	1	0.55
L. saturninum (Dicks.) Nyl.	12	6.59
Lobaria pulmonaria (L.) Hoffm.	17	9.34
Nephroma parile (Ach.) Ach.	18	9.89
N. resupinatum (L.) Ach.	16	8.79
Pannaria pezizoides (Weber) Trevis.	10	5.49
Peltigera aphthosa (L.) Willd.	6	3.30
P. canina (L.) Willd.	24	13.19
P. polydactylon (Neck.) Hoffm.	6	3.30
P. praetextata (Sommerf.) Zopf	5	2.76

Cyanolichen species composition

A total of 11 cyanolichen species were found on the 182 aspens sampled (Table 2). Most of them, especially *Nephroma* species and red-listed species *Lobaria pulmonaria,* have been often mentioned as indicators of old-growth forests in Eurasia and North America (Rose, 1976, Kuusinen, 1996, Kondratyuk et al., 1998, Sillett & McCune, 1998, etc.). At 60.18% of investigated aspen trunks, at least one cyanolichen species was found. However, the share of trunks inoculated by individual species proved to be very low and in most cases did not exceed 10%. *Leptogium intermedium,* which was found on a single aspen tree, was excluded from the further analysis.

Frequency of cyanolichens *vs* site characteristics

Factor analysis was applied to reduce the total variation of measured environmental variables to three independent factors that were interpreted respectively as site insolation, soil fertility and canopy openness (Table 3). Interpretation of factor 1 and factor 3 looks at the first glance very similar: both of them reflect light conditions. The difference seems to be in the following: factor 1 includes parameters of grass and dwarf-shrub layer thus reflecting light regime over the 6 m diameter sample plot while factor 3 includes mainly the crown parameters which were registered within 1 m from the trunk and hence reflects insolation of the sample trunk. Factor loadings of parameters of the host trees, undergrowth trees and young growth were negligible. Three extracted factors explained 45% of the total variance.

At the next step of analysis, Spearman rank order correlation coefficients were calculated between lichen frequencies and the factors extracted (Table 4). *Peltigera* species and *Collema subflaccidum* did not show any dependency from the factors extracted; for the rest of species, significant correlation with at least one factor was revealed. Frequency of four cyanolichen species negatively correlated with site insolation (though correlation was extremely weak). The most probable, this is not the low site insolation which favors development of cyanolichens, but accompanying higher ambient humidity. Besides,

Table 3. Factor loadings of site and phorophyte variables (marked with * loadings are >0.5)

Variables	Factor 1 Site insolation	Factor 2 Soil fertility	Factor 3 Canopy openness
Phorophyte data			
DBH	-0.24	0.00	-0.33
Vitality	-0.23	-0.06	-0.06
Inclination	-0.31	-0.02	-0.03
Tree stand characteristics			
Basal area of coniferous trees	-0.29	0.11	-0.40
Basal area of decidious trees	0.35	0.03	-0.41
Total basal area	0.02	0.11	-0.62*
% open sky:			
0.5 m from the trunk	0.17	0.04	0.81*
1 m from the trunk	0.10	0.05	0.80*
Crown density:			
0.5 m from the trunk	-0.04	-0.23	-0.68*
1 m from the trunk	-0.04	-0.26	-0.68*
Density of young growth			
height < 50 cm	-0.13	0.35	-0.10
height 50–100 cm	-0.28	0.13	0.11
height >100 cm	-0.46	0.02	0.30
Density of shrubs and trees of undergrowth			
height < 50 cm	0.19	-0.22	-0.15
height 50–100 cm	0.19	0.00	0.28
height >100 cm	-0.16	-0.03	0.17
Understorey vegetation			
Abundance of herb and dwarf-shrub species	0.30	0.64*	0.31
Number of herb and dwarf-shrub species	0.24	0.77*	0.25
Cover of bryophytes	-0.07	-0.58*	0.33
Cover of herb and dwarf-shrub layer	0.67*	0.14	0.32
Mean height of the lowest herb layer	0.69*	-0.02	0.15
Mean height of the tallest herb layer	0.72*	0.34	0.11
The share of:			
Calamagrostis obtusata	0.66*	-0.12	-0.07
Oxalis acetosella	-0.69*	0.52*	-0.17
Vaccinium myrtillus	-0.07	-0.89*	-0.12
Site indices (based on Ellenberg's indicator values scale)			
Index of insolation	0.82*	-0.40	0.07
Index of moistening	0.73*	0.09	0.30
Index of soil acidity	0.61*	0.66*	0.05
Index of continentality	0.28	-0.76*	0.01
Index of soil fertility	0.01	0.90*	0.14
Index of thermal regime	0.06	-0.15	-0.20
% of variation explained	16	16	13

Table 4. Spearman rank order correlation coefficients for correlation between lichen frequencies and environmental data (* – p<0.05, ** – p<0.01, *** – p<0.001)

Species	Factor 1 Site insolation	Factor 2 Soil fertility	Factor 3 Canopy openness
Collema subflaccidum	0.04	0.09	-0.11
Leptogium saturninum	-0.23 **	0.04	-0.16 *
Lobaria pulmonaria	-0.19 **	0.12	-0.10
Nephroma parile	-0.16 *	0.10	-0.06
N.resupinatum	-0.28 ***	0.06	-0.09
Pannaria pezizoides	-0.04	0.15 *	-0.10
Peltigera aphthosa	0.106	-0.003	0.074
P. canina	-0.111	0.062	-0.002
P. polydactylon	0.013	0.026	0.008
P. praetextata	-0.021	0.075	-0.090

site insolation has been reflecting history of the plot: for instance, high insolation means previously happened tree-fall which was followed by rapid development of light-demanding forbs and deciduous young growth. Epiphytic lichens inoculated the sample trunk at least tens of years ago, so looks probable that lichen occurrence correlates not with present-day but with previous-day environment.

Rather unexpected was the absence of correlation of lichen frequency with canopy openness (excluding for *Leptogium saturninum),* i.e. with light regime of the microhabitat. As in the case of site insolation, the effect of trunk insolation hardly can be separated from that of other factors, especially, from water relations. Crown parameters significantly affect amount of water passing down as stemflow. Epiphytic gelatinous cyanolichens often grow in rain-tracks; however, presence and pattern of rain-tracks can not be predicted from our data on crown cover and density.

Multiple linear stepwise regression analysis (ridge regression) showed that environmental variables accounted for a very low (<20%) part of variability of cyanolichen species frequency (Table 5). For different species, from 6 to 15 site variables were included to the model; so extracting of one or two major factors was not possible. Integral parameters (number of cyanolichen species per trunk and total frequency of cyanolichens) were found to be “more predictable” on the base of collected site characteristics.

Discriminant analysis was applied to data on presence/absence of lichen species (without quantitative information on frequency). The results confirmed the conclusion of the multiple regression analysis: frequency of correct predictions of presence/absence of lichen species was extremely low and ranged from 16 to 66%.

Table 5. Results of ridge step-wise regression analysis (*df1* is a number of variables included to the model, *df2* is *df* Error)

	Adjusted *R2*	*df1*	*df2*	*F*	*p*
Collema subflaccidum	0.036	7	179	1.99	0.059
Leptogium saturninum	0.140	12	174	3.52	<0.001
Lobaria pulmonaria	0.151	11	175	4.01	<0.001
Nephroma parile	0.052	6	180	2.71	0.015
N. resupinatum	0.180	12	174	4.40	<0.001
Pannaria pezizoides	0.119	9	177	3.79	0.001
Peltigera aphthosa	0.046	6	174	2.45	0.027
P. canina	0.139	9	171	4.24	<0.001
P. polydactylon	0.033	7	173	1.89	0.074
P. praetextata	0.063	7	173	2.72	0.010
Peltigera spp. (total frequency)	0.097	7	173	3.77	<0.001
Total frequency of cyanolichens	0.214	15	171	4.38	<0.001
No of cyanolichen species	0.345	13	173	8.52	<0.001

Thus, predictive power of collected environmental data is very low. This means that at the few hectares spatial scale heterogeneity of site characteristics seems not to influence significantly the occurrence of cyanolichens.

Relationship between phorophyte parameters and frequency of cyanolichen species

The dependency of lichen community composition on such trunk parameters as size (i.e. tree age), inclination and vitality is of wide knowledge (Barkman, 1958; Kalgutkar & Bird, 1968; Bates, 1992, etc.). However, as indicated above, phorophyte parameters showed very weak correlation with factors extracted, and their influence on lichen occurrence was not adequately analysed. Because of this, two-way ANOVA was used to estimate contribution of tree DBH and vitality to the overall variability of lichen frequency [5 groups of DBH × 2 vitality classes (healthy and damaged)]. To assess influence of tree inclination, one-way ANOVA was used (number of observations did not allow three-way ANOVA).

For *Lobaria pulmonaria, Nephroma resupinatum* and *Peltigera aphthosa* DBH was found to contribute significantly to the variability of frequencies (Table 6). Frequency of *L. pulmonaria* and *N. resupinatum* was higher on larger trunks (Fig. 2). Tree vitality was also of high importance for these species, especially for *N. resupinatum,* which was found on damaged trees only. Combination of the factors (DBH + vitality) was highly significant for three species mentioned above, and also for *Nephroma parile* and for the total frequency of *Peltigera* species.

Most cyanolichen species had a similar pattern of response to phorophyte parameters: their frequency increased with an increase of tree size and with lowering of its vitality thus reaching maximal values on the largest damaged trunks. The only exception was *Peltigera* species (Fig. 2) that showed maximal frequency on small-sized

Table 6. Results of ANOVA (*SS* III) for the lichen frequencies (*df* Error= 170 in all cases)

Species	Sources of variation			
	DBH	Tree vitality	DBH + vitality	Tree inclination
	df=4	*df*=1	*df*=4	*df*=2
	F *p*	*F* *p*	*F* *p*	*F* *p*
Collema subflaccidum	1.59 0.179	1.91 0.169	0.12 0.883	1.56 0.186
Lobaria pulmonaria	5.68 <0.001	7.63 0.006	4.22 0.016	5.65 <0.001
Leptogium saturninum	1.30 0.271	3.86 0.051	1.80 0.169	1.01 0.406
Nephroma parile	1.86 0.120	2.69 0.103	1.46 0.235	2.47 0.046
N. resupinatum	3.72 0.006	8.46 0.004	7.57 0.001	3.79 0.006
Pannaria pezizoides	1.29 0.275	1.59 0.210	1.08 0.343	1.34 0.258
Peltigera aphthosa	2.57 0.040	1.35 0.246	6.52 0.002	3.80 0.005
P. canina	1.53 0.197	0.99 0.322	0.67 0.511	2.01 0.095
P. polydactylon	0.52 0.719	0.61 0.436	2.05 0.131	1.45 0.219
P. praetextata	0.44 0.782	0.82 0.366	0.97 0.380	0.44 0.782
Peltigera spp. (total frequency)	0.65 0.626	0.06 0.806	1.10 0.334	2.96 0.021

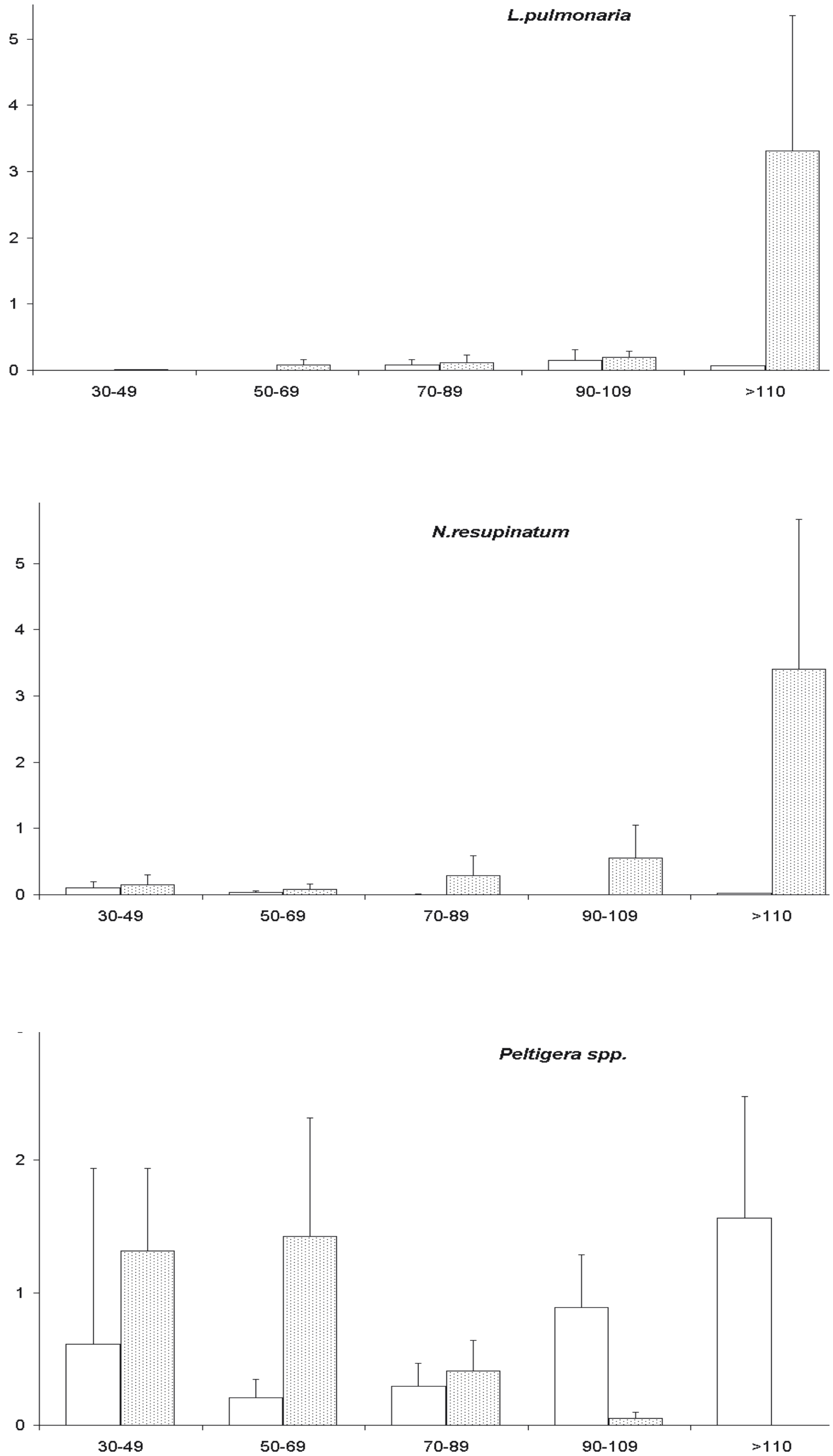

Fig. 2. Frequencies of cyanolichens *vs* DBH of host trees (means ± SE). Axes: X – DBH (cm), Y – lichen frequency. White bars – healthy trees, dotted bars – damaged trees.

damaged trunks. Making comparisons with successional stages, we may suggest different patterns of epiphytic successions on bases of healthy and damaged trunks. We suppose that reason for this difference can be in relationships between *Peltigera* species and characteristics of successively changing epiphytic bryophyte communities. This relationship can include, first, direct moss-lichen competition and, second, indirect influence of bryophytes on *Peltigera* species through changes in the water regime of microhabitat.

Frequencies of three species (*Lobaria pulmonaria, Nephroma resupinatum,* and *Peltigera aphthosa)* were influenced by inclination of trunks: the highest frequency was found on trunks with inclination more than 15°.

Thus, preferred habitats for the majority of studied cyanolichens are large trees that were shown to have highest values of bark pH. However, we failed to reveal statistically significant correlation between frequency of cyanolichens and bark pH. The only exception was *Nephroma resupinatum* which showed significant correlation with minimal pH value per trunk (Spearman rank order correlation coefficient –0.26, $p < 0.05$). Thus, pH values, at least in the range found in this study, hardly can be regarded as an important factor for the growth of cyanolichens.

CONCLUSIONS

This study suggests low probability to predict both presence and frequency of cyanolichens from the data on the range of environmental variables within small (few hectares) relatively homogeneous tree stand. This is in contrast to results on larger scales where authors usually manage to reveal major factors influencing lichen species distribution (forest type, macroclimate, air pollution, etc.). Spatial scale of our study causes relatively low range of variability of environmental factors, and within this range the factors seem not to be limiting for cyanolichens (except for the size of host tree). Impossibility to extract major factors that are responsible for the lichen distribution causes low predictive power of collected variables. Besides, low frequency of studied cyanolichen species makes the obtaining of statistically significant results very difficult.

Another reason of failure to find clear dependency between lichen distribution and site characteristics is in not taking in the account reproductive potential of lichens studied (number of propagules produced, distance of propagule dispersion, success of survival, etc.). However, biological features like limited dispersion ability, which was mentioned for most of lichen species studied (Scheidegger, 1995; Zoller et al., 2000), can be of high importance in defining patterns of lichen distribution within a small area and can mask significance of ecological factors. Simply stated, lack of propagules can cause absence of lichens even in the most favorable environment.

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Lichens from the Khorasan Province, Iran

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Abstract: Lichens were investigated in 13 localities of the Khorasan province (NE Iran). 39 infrageneric taxa in 22 genera of 14 families were identified. Two genera and nine species are new to Iran, 21 species are new to the province.

Kokkuvõte: Iraani Khorasani provintsi samblikud.

Khorasani provintsis (Iraani kirde-osas) koguti 13 kohas samblikke. Määrati 39 liiki ja liigisisest taksonit 14 sugukonna 22 perekonnast. 2 perekonda ja 9 liiki on uued Iraani, 21 liiki Khorasani provintsi jaoks.

INTRODUCTION

Iran, with a surface area of ca 1,645,000 km², is located in the southwest of Asia between 25°–40°N. The knowledge of Iranian lichens is still very scarce, which also produces a deep gap in our understanding of Iranian vegetation. In comparison with 275 published Floras of flowering plants in different parts of Iran, not even an exhaustive catalogue is available for lichens. So far, the most comprehensive reference to Iranian lichens is a survey of 248 species compiled by Szatala (1957). The present paper, devoted to the lichens of the Khorasan province, is a contribution to a better knowledge of the lichen flora of this large and ecologically diverse country.

MATERIALS AND METHODS

Survey area

The Khorasan province is located in the northeast of Iran, between 30°21'–38°17'N and 55°28'–61°30'E (Fig. 1). This area is transitional between the Siberian region and the desert area. Four climate types can be distinguished: cold-montane; temperate-montane; temperate semi-desert and hot-dry desert. The survey area is located in two different geological zones called Alborz and East-Southeastern, with expansion over 800 miles from north to south, and over 200 miles from east to west. Khorasan is distinguished by the presence of regular and symmetrical mountain ranges, the fold structures occurring as successive rows of ridges, each row being provided with local names; altitude ranges between 300 and more than 3000 m (Parsa, 1978).

Fig. 1. The location of the Khorasan province in Iran.

Materials and identification of lichens

825 samples of lichens were collected by the first author from different parts of the Khorasan province in 2002–2003. Due to the inadequacy of literature and absence of reference material concerning Iran, only part of them could be identified. The original samples are stored in FUMH, duplicates in B.

Identifications were made using some keybooks, separate papers and websites: Giordani et al. (2003), Goward et al. (1994), Heidmarsson (2000), Magnusson (1929), Mc Cune (2002), Nash et al. (2002), Nimis & Martellos (2004), Poelt & Vezda (1981), Poelt & Wirth (1968), Purvis et al. (1992), Szatala (1957), and Wetmore (2003). Morphology and chemistry were studied using standard microscopes and the current reagents (Purvis et al., 1992).

RESULTS

Two varieties and 37 species in 22 genera and 14 families were identified from the Khorasan province. The genera *Farnoldia* Hertel and *Placidium* A. Massal. are new to Iran. 10 infrageneric taxa are new to Iran, 22 taxa are new to the Khorasan province.

Annotated list of the lichens found in the Khorasan province, Iran

Numbers indicate voucher specimens deposited in FUMH. Species marked with * are new to Iran, and those marked with ** are new to Khorasan.

Acarospora cervina A. Massal. – 1436c.
**A. stapfiana (Müll. Arg.) Hue – 1429a.
**A. strigata (Nyl.) Jatta – 1519.
*Anaptychia roemeri Poelt – 1506a.
A. ulotrichoides (Vain.) Vain. – 1463.
**Aspicilia candida (Anzi) Hue – 1408.
**Caloplaca alociza (A. Massal.) Mig. – 1497a.
*C. chalybeia (Fr.) Müll. Arg. – 1496a.
**C. transcaspica (Nyl.) Zahlbr. – 1420.
Candelariella aurella (Hoffm.) Zahlbr. – 1497b.
*Collema auriforme (With.) Coppins & J.R. Laundon – 1435a.
**Dermatocarpon miniatum (L.) W. Mann – 1432a.
*D. miniatum var. cirsodes (Ach.) Zahlbr. – 1470a
**D. miniatum var. complicatum (Lightf.) Hellb. – 1470a.
**Diplotomma venustum Körb. – 1496a.
**Endocarpon pusillum Hedw. – 1433b.
*Farnoldia jurana (Schaer.) Hertel – 1528a.
*Fulgensia subbracteata (Nyl.) Poelt – 1434a.
**Glypholecia scabra (Pers.) Müll. Arg. – 1455.
Lecanora agardhiana Ach. – 1534.
**L. crenulata Hook.– 1420.
**L. marginata (Schaer.) Hertel & Rambold – 1532b.
**L. muralis (Schreb.) Rabenh. – 1469a.
*Neofuscelia perrugata (Nyl.) Elix – 1436a.
*Placidium pilosellum (Breuss) Breuss – 1523.
**Psora decipiens (Hedw.) Hoffm. – 1433a.
Rhizocarpon geminatum Körb. – 1436a.
**R. geographicum (L.) DC. – 1436a.
**R. lecanorinum Anders – 1663.
**R. viridiatrum (Wulfen) Körb.; (11); 1436c.
**Rhizoplaca melanophtalma (Ramond) Leuckert & Poelt – 1471.
Rinodina bischoffii (Hepp) A. Massal. – 1522.
**Squamarina cartilaginea (With.) P. James – 1653.
**S. lentigera (Weber) Poelt – 1537.
**Toninia candida (Weber.) Th. Fr. – 1492.
*T. diffracta (A. Massal.) Zahlbr. – 1453a.
*T. physaroides (Opiz) Zahlbr. – 1480a
**T. sedifolia (Scop.) Timdal. – 1480a.
Xanthoria elegans (Link.) Th. Fr. – 1491.

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Lichens in the Red Data Books in Russia

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Abstract: Legal aspects of lichen conservation through red-listing in Russia are described in the paper. A compilation of the list of officially protected lichen taxa in Russia is made for the first time. It includes 29 species included in the Red Data Book of the Russian Federation and 368 currently accepted taxa (species, subspecies, and varieties) from regional Red Data Books. Progress and problems of redlisting as a basis for lichen conservation in the Russian regions are discussed.

Kokkuvõte: Samblikud Venemaa Punases Raamatus

Kirjeldatakse samblike kaitse õiguslikke aspekte, mis avalduvad Venemaa punaste nimekirjade koostamise kaudu. Esmakordselt on kokku liidetud Venemaal ametlikult kaitstavate samblike loendid. Saadud nimestik sisaldab 29 liiki Vene Föderatsiooni Punasest Raamatust ja 368 taksonit (liiki, alamliiki, varieteeti) regionaalsetest punastest raamatutest. Arutletakse punaste nimekirjade ja samblike kaitse aluste üle.

INTRODUCTION

Lichen conservation is a complex scientific and environmental task aimed at preserving the diversity of lichen taxa. Red Lists is an important political tool and attract people's attention to threatened organisms. Red-listed species are often monitored and inventoried. This is also true for the Russian Federation (as it was for the former Soviet Union). Red Data Books of different levels are compiled here in order to express the concern of the scientific community for the fate of certain taxa and propose necessary actions to preserve these elements of biological diversity. However, the redlisting process in Russia differs from that accepted in most other countries. The reason behind this difference is that Russian Red Lists normally function as legal documents naming the species to be protected either in the whole country (in the case of the Red Data Book of the Russian Federation) or at the regional level (by means of the Red lists and/or the Red Data Books of regions of the Russian Federation). Thus the Red Lists in Russia are a combination of scientific paper and legal act. The latter allows to regulate protection of rare species and to ensure preservation of rare species' habitats (Zavarzin et al., 2003).

Redlisting is regulated by the Federal Law "On the Red Data Book of the Russian Federation" or by the regional laws or regulations on regional Red Data Books. Usually the authorized group of good standing researchers, who submit their proposals to the responsible agencies, performs drafting of national and regional Red lists. The agencies (Federal Ministry of Natural Resources or respective regional authorities) evaluate the proposals before approving the lists. After the lists are approved they are to be adopted either by the Government of Russia (in case of Federal Red Data Book) or by the regional administration (in case of regional Red Data Book or Red List). When the lists are adopted they are published in a form of the Red Data Book with description of species, their biology, distribution in the area, limiting factors and necessary conservation measures. The laws usually set the period of up to 10 years for the Red lists to be revised. It is also required that the Red list is distributed over to state institution, private stakeholders and public as soon as the list is adopted, however, electronic forms of the Red lists are still not considered to be valid.

In practice the redlisted species are protected by the government, and their populations or individuals as well as their habitats must not be directly or indirectly destroyed. If the destruction happens the responsible person or organization is a subject for different administrative penalties. Furthermore, registered populations of redlisted species are an important requirement for establishing of protected area or introduction of restrictions on economic use of the certain area. Redlisted species are always priority objects for environmental monitoring and important part of every Environmental Impact Assessment.

However, generally low knowledge of redlisted species, absence of readily available guidebooks for species identification as well as week law enforcement in Russia do not allow the easy use of the legal opportunities presented by the Red lists. This is especially true for such groups of organisms as invertebrates, bryophytes, algae, and lichens.

MATERIAL AND METHODS

This paper is based on analysis of literature data – published Red Data Books and Red Lists of the whole Russian Federation (Red Data Book of RSFSR, 1988) as well as of its separate regions. Respective publications containing data about lichens for the following regions (Fig. 1) were used:

1. **Central Federal District:** Belgorod region (Moutchnik, 2003), Lipetsk region (Moutchnik, 2003), Moscow region (Zubakin & Tikhomirov, 1998), City of Moscow (Samojlov & Morozov, 2001), Ryazan region (Kazakova, 2002), Smolensk region (Kruglov, 1997), Tambov region (Usova et al., 2002), Tver region (Sorokin, 2002).
2. **North-Western Federal District:** Arkhangelsk region and Nenets autonomous district (Andreev, 1995), Republic of Karelia (Ivanter & Kuznetsov, 1995), Republic of Komi (Taskaev, 1998), Leningrad region (Tsvelev, 2000), Murmansk region (Konstantinova, Koryakin, Makarova, 2003).
3. **Northern Caucasus Federal District:** Republic of Adygeja (Kozmenko, 2000), Republic of Dagestan (Abdurakhmanov, 1998), Republic of Kabardino-Balkaria (Ivanov, 2000), Krasnodar region (Nagalevsky, 1994), Republic of Northern Osetia-Alania (Komzha et al. 1999).
4. **Privolzhsky Federal District:** Republic of Bashkortostan (Solomesha, 2002), Kirov region (Dobrinsky, Korytin, 2001), Perm region and Komi-Perm autonomous district (Bolshakov & Gorchakovsky, 1996[1]), Saratov region (Michurin & Shlyakhtin, 1996), Republic of Tatarstan (Shepovskikh, 1995), Republic of Udmurtia (Tuganaev, 2001).
5. **Urals Federal District:** Khanty-Mansy autonomous district (Vasin, 2003), Yamalo-Nenets autonomous district (Dobrinsky, 1997), Sverdlovsk region (Bolshakov & Gorchakovsky, 1996).
6. **Siberian Federal District:** Republic of Altaj (Krasnoborov & Sidelnikov, 1996), Republic of Buriat (Bojkov, 2002), Chita region and Agin'-Buriat autonomous district (Ostrovsky, 2002), Kemerovo region (Krasnoborov, 2000), Republic of Khakassia (Krasnoborov, 2002), Novosibirsk region (Krasnoborov et al. 1998), Republic of Tyva (Krasnoborov, 1999).
7. **Far East Federal District:** Khabarovsk region (Voronov, 2000), Republic of Sakha (Yakutia) (Isaev, 2000).

RESULTS

LICHENS IN THE RED DATA BOOK OF THE RUSSIAN FEDERATION

The currently functioning Red Data Book of the Russian Federation was approved and published in 1988 and contains 29 species of lichens (Red Data Book of RSFSR, 1988)[2]. All taxa in this Red Data Book are distributed between five Red List categories (Table 1) with lichen species being mainly placed in categories 2 and 3. Presently used categories are not corresponding to those of IUCN, however, a tendency to find the ways of adjusting national and international categories is becoming more and more clear (Zavarzin & Moutchnik, 2005). The second edition of the Red Data Book of the Russian Federation devoted to the threatened plants, fungi and lichens is to be published in 2005.

Many of the nationally redlisted lichen taxa are found in the Far East of Russia and just a few could be found in the rest of the territory (Table 2). However, due to the extremely uneven knowledge of lichen diversity in different regions of Russia it is hard to verify whether populations of these taxa are really threatened and so narrowly localized or not. This problem could be solved through analysis of the data gathered for regional Red Data Books.

LICHENS IN THE REGIONAL RED LISTS AND RED DATA BOOKS IN RUSSIA

Following the nationwide activities the redlisting process has started recently in most regions of the Russian Federation. Analysis of the state of populations[3] in the regions of Russia and identification of threatened species are essential for at-the-site preservation of species populations

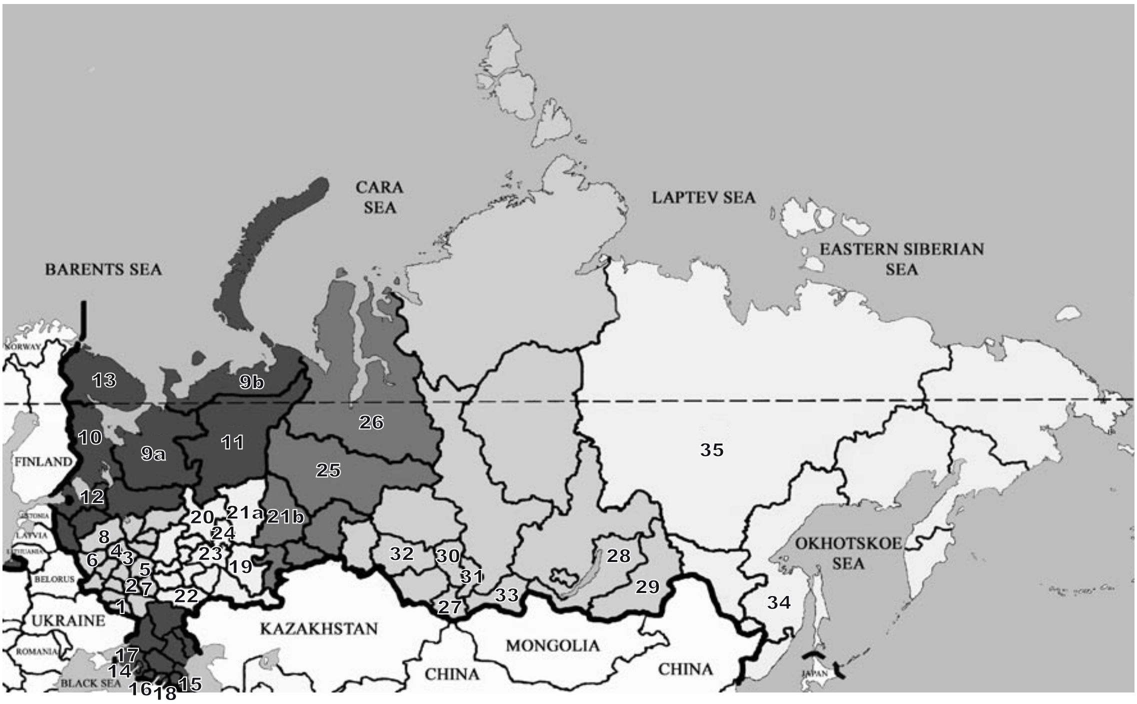

Fig.1. Map of the administrative division of the Russian Federation.
— — — Polar circle

Numbers (following those in Table 2) refer to the regions of Russia where Red Data Books contain lichenised taxa.

I. Central Federal District:
1 – Belgorod region;
2 – Lipetsk region;
3 – Moscow region;
4 – city of Moscow;
5 – Ryazan region;
6 – Smolensk region;
7 – Tambov region;
8 – Tver region.

II. North-Western Federal District:
9a – Archangel region;
9b – Nenets autonomous district;
10 – Republic of Karelia;
11 – Republic of Komi;
12 – Leningrad region;
13 – Murmansk region.

III. Northern Caucasus Federal District:
14 – Republic of Adygeja;
15 – Republic of Dagestan;
16 – Republic of Kabardino-Balkaria;
17 – Krasnodar region;
18 – Republic of Northern Osetia (Alania).

IV. Privolzhsky Federal District:
19 – Republic of Bashkortostan;
20 – Kirov region;
21a – Perm region and Komi-Perm autonomous district;
22 – Saratov region;
23 – Republic of Tatarstan;
24 – Republic of Udmurtia.

V. Urals Federal District:
21b – Sverdlovsk region
25 – Khanty-Mansy autonomous district;
26 – Yamalo-Nenets autonomous district.

VI. Siberian Federal District:
27 – Republic of Altaj;
28 – Republic of Buriat;
29 – Chita region and Agin'-Buriat autonomous district;
30 – Kemerovo region;
31 – Republic of Khakassia;
32 – Novosibirsk region;
33 – Republic of Tyva.

VII. Far East Federal District:
34 – Khabarovsk region;
35 – Republic of Sakha (Yakutia).

Table 1. Categories of wild plant taxa used in the Red Data Book of the Russian Federation (1988)

Categories	Description of the categories used
0 – Possibly extinct	Taxa, previously known from the territory of Russia, but without viable populations registered for at least 50 years, though the possibility of their findings is not totally excluded.
1 – Facing extinction	Taxa that have declined to critical numbers (in terms of organisms and/or localities) to the extent that they can get extinct in the nearest future.
2 – Decreasing in numbers	Taxa with steadily decreasing numbers of individuals or localities so that under the existing pressures they will be the subjects for Category 1, including: a) taxa that are declining due to the changes in environmental conditions and habitat destruction; b) taxa that are declining because of the overexploitation by humans and require special conservation measures (e.g. medicinal, decorative plants, etc.)
3 – Rare	Taxa with naturally low density and small area of distribution or sporadically distributed over large areas and which require special protective measures, including: a) endemic taxa with small areas of distribution; b) taxa with large areals but sporadically distributed and having small populations; c) taxa with strong requirements for specific and rare habitats; d) taxa with large areals but present in Russia at the limits of distribution; e) taxa with limited areal with the part of it being in Russia.
4 – Of undetermined status (=Data deficient)	Taxa assumed to be threatened and thus requiring special protective measures but having insufficient data to be assigned to one of the previous categories.
5 – Restored or restoring	Taxa that are restoring their numbers and/or area of distribution under natural or artificially maintained conditions and that will soon reach the point when further protective measures will not be necessary.

including lichens. 62 out of 89 regions of Russia (so called "Subjects of the Russian Federation") have compiled and published their regional Red Data Books[4] by the year 2004. These books cover redlisted species of animals, vascular plants, bryophytes, algae, fungi and lichens.

Species of lichens are included in 35 of these regional Red lists covering 40 regions of about a billion of hectares (924 370 thousands ha), i.e. 54,1% of the territory of Russia (Fig. 1). The number of protected lichen species varies from 1 in Saratov region to 77 in the Republic of Karelia. The total number of lichen taxa (species, subspecies, and varieties) included in the Red Data Books is 368[5] (Table 2).

Most of the lichen taxa are categorized as 3 (Rare) or 4 (Data deficient). Seven lichens from the Red Data Book of the Russian Federation (1988) are absent in the regional Red Data Books. These are: *Cladonia graciliformis* Zahlbr., *C. vulcani* Savicz, *Icmadophila japonica* (Zahlbr.) Rambold & Hertel, *Stereocaulon exutum* Nyl., *S. saviczii* Du Rietz, *Teloschistes flavicans* (Sw.) Norm., and *Umbilicaria esculenta* (Mioshi) Minks. These species, with the exception of *S. saviczii*, will be included in the Red List of Primorje region which is still not published. *S. saviczii* should be protected in the Kamchatka region where the Red List contains only animal taxa so far.

DISCUSSION

Despite of certain positive trends in redlisting of lichens (e.g. increasing number of inventories prior to compilation of Red lists and involvement of experienced lichenologists into revision of proposals for the Red lists), some serious problems exist in Russia. The overall low level of knowledge about the lichen diversity in many regions of Russia is clearly visible when comparing lists of lichens and higher plants from the Red Data Books. The majority of Red lists contain only large foliose and fruticose lichens (Table 2). Along with the lack of modern floristic studies obvious mistakes are not uncommon. For example, *Parmelia sulcata* is listed in the Red Data Book of Archangelsk region or *Phaeophyscia nigricans* is included into Red Data Books of Moscow and Riazan regions, though it is obvious that these species are quite common in those areas. *Nephroma laevigatum* is protected in Kirov region even though it is hard to imagine the presence of this oceanic species in the quite continental part of Russia.

Furthermore, the term "rare lichen" in Russia is also subjective, mainly because different regions of the Russian Federation have been unevenly explored in terms of lichen diversity. Taking into account the ongoing process of lichen diversity inventories it is essential to distinguish at least three different groups of regionally rare lichens:

(1) "constitutively rare" meaning that the taxon is scarcely spread in the whole area of distribution due to its ecological requirements;
(2) taxon that is present in the region at the limit of its distribution, but which is common in some neighbouring regions;
(3) taxon associated with rare biotopes especially sensitive to anthropogenic impact.

A serious problem is arising from the lack of detailed description of criteria for assigning lichens to different categories in the regional Red Data Books in Russia. Analysis of lichenological papers that present more or less reliable data on lichen density in the regions indicates that most of the authors use only subjective measures even for this criterion. Usually species are ranked as "rare", "scarce", "average" or "abundant" [see for examples all issues of the Handbook of Lichens of the USSR (Russia), 1971–2003; Shustov, 1989; Makryi, 1990; Dudoreva & Ahti, 1996; Krivorotov, 1997; Hermansson, Kudriavtseva, 1997; Poriadina, 1998; Urbanavichene & Urbanavichus, 1998; Zhurbenko, 2000; Pystina, 2000; Vedeneev, 2001 and others]. Only a few researchers indicate exact number of localities where the species was found as a criterion for a specific rank. For example, Budaeva (2001) ranks as rare only taxa encountered at 3 to 5 locations in the region. Kataeva (2002) considers species with less than 4 localities as demanding regional conservation efforts.

Possible solutions could be found in the enhancement of regional floristic studies especially in protected areas and adoption of the system of IUCN criteria (2001) for analyzing the state of lichen populations prior to compiling regional Red Data Books in Russia (Zavarzin & Moutchnik, 2005).

Due to their biology lichens are special objects for conservation. The relatively small size, the ability for vegetative propagation, and the low pressure from direct use by people help to reduce the potential danger of decrease of their populations. On the other hand, often narrow substrate and biotope affiliation coupled with high sensitivity to environmental quality make the task of lichen conservation very difficult. As there is no possibility to preserve lichens in botanical gardens or arboretums, the only way left is to maintain viable populations through protecting biotopes and developing networks of protected areas. In our opinion this is the most effective approach to be introduced in Russia and therefore the redlisting efforts in the Russian regions have to be always focused on ensuring the establishment and maintenance of the effective network of protected areas. The Red Data Books can be used as a powerful legal tool in this case.

Remarks

[1] This Red Data Book covers two federal districts of Russia: Perm region and Komi-Perm autonomous district belonging to the Privolzhsky Federal District, and Sverdlovsk region being within Urals Federal District.

[2] One of the species – *Parmelia borisorum* – is not considered to be an independent taxon and is currently included in *Melanelia tominii.*

[3] The term "population" is used in a geographic sense meaning all organisms of a certain taxon in a certain region.

[4] Regional Red Data Books follow the same categories that are used in the Red Data Book of Russian Federation (Table 1). However, they may contain additional categories depending upon the needs and necessities of the region.

[5] Except for 85 species belonging the region-specific category "demanding biological monitoring" in the Red Data Book of Murmansk region, and for 7 taxa currently treated as synonyms (these 7 taxa are also included in Table 2 but are marked by "!").

Table 2. Lichen species included into the Red Data Books of the regions of the Russian Federation (see Fig 1 for explanation of numbers)**.** Lichen species protected at the national level (included in the Red Data Book of Russian Federation, 1988) are marked **in bold**. Species that have been synonymised but are treated here still as separate taxa are marked with !.

Lichen species	Red Data Books of the Subjects of the Russian Federation																																		
	I								II					III					IV						V		VI						VII		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Acarospora sinopica (Wahlenb.) Körb.								+																											
Acrocordia gemmata (Ach.) A.Massal.											+																								
Adelolecia kolaënsis (Nyl.) Hertel & Rambold (as Lecidea conferenda Nyl.)								+																											
Alectoria sarmentosa (Ach.) Ach.												+																							
A. sarmentosa ssp. vexillifera (Nyl.) D.Hawksw.										+			+																						
Amygdalaria pelobotryon (Wahlenb.) Norman													+																						
Anaptychia ciliaris (L.) Körb.							+			+	+																								
A. runcinata (With.) J.R.Laundon								+																											
Arctocetraria andrejevii (Oxner) Kärnefelt & A.Thell											+																								
A. nigricascens (Nyl.) Kärnefelt & A.Thell													+																						
Arctoparmelia centrifuga (L.) Hale												+																							
A. incurva (Pers.) Hale												+																							
A. subcentrifuga (Oxner) Hale													+																						
Arthonia arthonioides (Ach.) A.L.Sm.											+																								
A. incarnata Th.Fr. ex Almq.													+																						
A. leucopellaea (Ach.) Almq.											+																								
A. ligniariella Coppins											+																								
A. ruana A.Massal. [as Arthothelium ruanum (A.Massal.) Körb.]														+																					
Asahinea chrysantha (Tuck.) W.L.Culb. & C.F.Culb.													+																						
A. scholanderi (Llano) W.L.Culb. & C.F.Culb.																					+				+			+	+					+	+
Aspicilia canina Räsänen										+																									
A. laevata (Ach.) Arnold								+																											

A. protuberans Räsänen									+																							
Aspilidea myrinii (Fr.) Hafellner [as Aspicilia myrinii (Fr.) Stein.]									+																							
Bacidia incompta (Borrer ex Hook.) Anzi										+																						
B. polychroa (Th.Fr.) Körb. [as B. acerina (Ach.) Arnold]							+																									
Belonia russula Körb. & Nyl.																																
Brodoa intestiniformis (Vill.) Goward									+		+																					
Bryoria bicolor (Ehrh.) Brodo & D.Hawksw.									+			+															+					
B. capillaris (Ach.) Brodo & D.Hawksw.																											+					
B. chalybeiformis (L.) Brodo & D.Hawksw. (as B. intricans (Vain.) Brodo & D.Hawksw.)											+																					
B. fremontii (Tuck.) Brodo & D.Hawksw.									+	+		+																		+	+	+
B. fuscescens (Gyeln.) Brodo & D. Hawksw.[6]			+										+			+								+								
B. implexa (Hoffm.) Brodo & D.Hawksw.																						+										
B. nadvornikiana (Gyeln.) Brodo & D.Hawksw.											+	+																				
B. nitidula (Th.Fr.) Brodo & D.Hawksw.												+																				
B. smithii (Du Rietz) Brodo & D.Hawksw.									+	+																						
B. subcana (Nyl. ex Stizenb.) Brodo & D.Hawksw.											+																					
Buellia geophila (Flörke ex Sommerf.) Lynge (as B. triphragmia (Nyl.) Arnold)									+																							
Calicium abietinum Pers.										+																						
C. adaequatum Nyl.												+																				
C. lenticulare Ach.									+	+																						
C. quercinum Pers.									+																							
C. viride Pers.													+			+																
Caloplaca decipiens (Arnold) Blomb. & Forssell									+																							
C. sinapisperma (Lam. & DC.) Maheu & Gillet									+																							
Cetraria aculeata (Schreb.) Fr.		+																														
C. ericetorum Opiz							+																									
C. islandica (L.) Ach.	+		+			+																+										
C. odontella (Ach.) Ach.											+																					

Table 2 (continued)

Lichen species	Red Data Books of the Subjects of the Russian Federation																																		
	I								II					III					IV						V		VI							VII	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
C. sepincola (Ehrh.) Ach. (as Tuckermanopsis sepincola (Ehrh.) Hale)		+					+																												
C. steppae (Savicz) Kärnefelt (as Cornicularia steppae Savicz)							+											+													+		+		+
Cetrariella delisei (Bory ex Schaer.) Kärnefelt & A.Thell												+																							
C. fastigiata (Delise ex Nyl.) Kärnefelt & A.Thell																													+						
Cetrelia alaskana (C.F.Culb. & W.L.Culb.) W.L.Culb. & C.F.Culb.																												+							+
! C. cetrarioides (Del. ex Duby) W.L. Culb. & C.F.Culb.[7]								+																											
C. olivetorum (Nyl.) W.L.Culb. & C.F.Culb.										+	+		+																						
Chaenotheca brachypoda (Ach.) Tibell														+																					
C. cinerea (Pers.) Tibell														+																					
C. chlorella (Ach.) Müll.Arg.											+																								
C. gracilenta (Ach.) J.Mattsson & Middelb. [as Cybebe gracilenta (Ach.) Tibell]										+	+			+																					
C. gracillima (Vain.) Tibell										+	+		+																						
C. hispidula (Ach.) Zahlbr.											+																								
C. laevigata Nádv.											+																								
C. phaeocephala (Turner) Th.Fr.											+																								
C. stemonea (Ach.) Müll.Arg.										+																									
C. subroscida (Eitner) Zahlbr.											+																								
Chaenothecopsis consociata (Nádv.) A.F.W.Schmidt														+																					
C. haematopus Tibell											+																								
C. vainioana (Nádv.) Tibell											+																								
C. viridialba (Krempelh.) A.F.W.Schmidt														+																					
Cladonia acuminata (Ach.) Norrl.		+																																	
C. amaurocraea (Flörke) Schaer.																							+												

C. arbuscula (Wallr.) Flot. ssp. arbuscula	+			+										
C. bellidiflora (Ach.) Schaer.						+	+							
C. botrytes (K.G.Hagen.) Willd.	+			+										
C. caespiticia (Pers.) Flörke							+							
C. cariosa (Ach.) Spreng.	+			+	+									
C. cenotea (Ach.) Schaer.	+													
C. crispata (Ach.) Flot.	+													
C. deformis (L.) Hoffm.	+	+			+							+		
C. digitata (L.) Hoffm.		+			+							+		
C. ecmocyna Leight.													+	
C. floerkeana (Fr.) Flörke												+		
C. foliacea (Huds.) Willd.	+	+	+							+				
C. furcata (Huds.) Schrad.	+			+										
C. gracilis (L.) Willd.	+													
C. incrassata Flörke		+			+		+							
C. kanewskii Oxner														+
C. luteoalba Wheldon & A. Wilson														
C. macilenta Hoffm. ssp. macilenta				+								+		
C. macroceras (Delise) Hav.					+									
C. macrophylla (Schaer.) Stenh.								+						
C. magyarica Vain.	+	+												
C. nipponica Asahina														+
C. phyllophora Hoffm.												+		
C. pleurota (Flörke) Schaer.												+		
C. polycarpoides Nyl.											+			
C. portentosa (Dufour) Coem.												+		
C.rangiferina (L.) F.H.Wigg.	+													
C. rangiformis Hoffm.		+			+							+		
C. scabriuscula (Delise) Nyl.									+					
C. stellaris (Opiz) Pouzar & Vězda		+		+	+							+		

Table 2 (continued)

Lichen species	Red Data Books of the Subjects of the Russian Federation																																		
	I								II					III					IV						V		VI							VII	
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C. subrangiformis Sandst.	+																																		
C. subulata (L.) Weber ex F.H.Wigg.	+																																		
C. symphycarpia (Flörke) Fr.	+	+																																	
C. turgida Hoffm.				+																															
C. verticillata (Hoffm.) Schaer. [as C. cervicornis (Ach.) Flot. ssp. verticillata (Hoffm.) Ahti]	+	+					+																												
Cliostomum corrugatum (Ach.:Fr.) Fr.											+																								
C. leprosum (Räsänen) Holien & Tønsberg											+																								
Coccocarpia palmicola (Spreng.) Arv. & D.J.Galloway [as C. cronia (Tuck.) Vain.]																											+	+	+						
C. erythroxyli (Spreng.) Swinscow & Krog																												+	+						
Collema auriforme (With.) Coppins & J.R.Laundon		+																																	
C. bachmanianum (Fink) Degel.												+																							
C. crispum (Huds.) Weber ex F.H.Wigg.	+									+																									
C. cristatum (L.) Weber ex F.H.Wigg.	+																																		
C. curtisporum Degel.													+																						
C. fragrans (Sm.) Ach.											+																	+							
C. fuscovirens (With.) J.R.Laundon [as C. tunaeforme (Ach.) Ach.]		+																																	
C. furfuraceum (Arnold) Du Rietz											+	+												+											
C. limosum (Ach.) Ach.			+																					+											
C. nigrescens (Huds.) DC.										+	+		+												+										
C. occultatum var. populinum (Th.Fr.) Degel.											+																								
C. polycarpon Hoffm.										+																									
C. subflaccidum Degel.											+																	+							
C. subnigrescens Degel.												+													+										
Cyphelium inquinans (Sm.) Trevis.											+																								

C. karelicum (Vain.) Räsänen										+	+																							
! Dendriscocaulon umhausense (Auersw.) Degel.[8]																												+	+					
Dermatocarpon deminuens Vain.										+																								
D. meiophyllizum Vain.										+																								
D. miniatum (L.) W.Mann.		+																																
Dimerella lutea (Dicks.) Trevis.											+																							
Endocarpon adscendens (Anzi) Müll.Arg.										+																								
E. psorodeum (Nyl.) Blomb. & Forssell										+			+																					
E. pusillum Hedw.										+																								
Evernia divaricata (L.) Ach.										+	+	+	+						+	+														
E. mesomorpha Nyl.	+			+																														
E. prunastri (L.) Ach.				+																				+										
Flavocetraria nivalis (L.) Kärnefelt & A.Thell												+							+															
Flavoparmelia caperata (L.) Hale												+	+																					
Flavopunctelia soredica (Nyl.) Hale																			+				+											
Fuscopannaria ahlneri (P.M.Jørg.) P.M.Jørg.																													+					
F.confusa (P.M. Jørg.) P.M.Jørg.											+																							
Gonohymenia nigritella (Lettau) Henssen [as Lichinella nigritella (Lettau) Moreno]																													+					
Graphis scripta (L.) Ach.																																		
Gyalecta flotowii Körb.								+					+																					
G. kukriensis (Räsänen) Räsänen										+																								
G. ulmi (Sw.) Zahlbr.								+																										
Heppia solorinoides (Nyl.) Nyl.																													+					
Heterodermia japonica (M.Sato) Swinscow & Krog																												+						
H. speciosa (Wulfen) Trevis.										+	+									+														
Hypogymnia austerodes (Nyl.) Räsänen										+	+																							
H. bitteri (Lynge) Ahti			+								+																							
H. hypotrypa (Nyl.) Rass. [as H. hypotrypella (Asahina) Rass.]																																		+
H. pseudophysodes (Asahina) Rass.																												+						

Table 2 (continued)

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H. pulverata (Nyl. ex Cromb.) Elix																												+							
H. submundata (Oxner) Rass.																												+							
H. tubulosa (Schaer.) Hav.				+																			+												
H. vittata (Ach.) Parrique											+																								
Hypotrachyna revoluta (Flörke) Hale												+																							
H. sinuosa (Sm.) Hale																												+							
Icmadophila ericetorum (L.) Zahlbr.	+																																		
Imshaugia aleurites (Ach.) S.L.F.Meyer			+					+															+												
Lecanora albescens (Hoffm.) Branth & Rostr.		+																																	
L. cenisea Ach.								+																											
L. hypopta (Ach.) Vain.								+																											
L. mughicola Nyl.														+																					
L. subcarnea (Lilj.) Ach.													+																						
L. sulphurea (Hoffm.) Ach.										+																									
Lecidea albofuscescens Nyl.										+																									
L. lapicida (Ach.) Ach.								+																											
L. leprarioides Tønsberg											+																								
L. plana (J.Lahm.) Nyl.								+																											
Leptochidium albociliatum (Desm.) M. Choisy										+																									
Leptogium asiaticum P.M.Jørg.																												+	+						
L. brebissonii Mont.																												+							
L. burnetiae C.W.Dodge																			+								+		+	+	+		+	+	
L. cyanescens (Rabh.) Körb.											+														+						+	+	+		
L. issatschenkoi Elenk.												+																							
L. hildenbrandii (Garov.) Nyl.																		+										+	+					+	

L. lichenoides (L.) Zahlbr.			+					+				+												+											
L. rivulare (Ach.) Mont.											+		+																						
L. saturninum (Dicks.) Nyl.																								+											
L. schraderi (Bern.) Nyl.	+																																		
L. subtile (Schrad.) Torss.												+																							
L. tenuissimum (Dicks.) Körb.											+																								
L. teretiusculum (Wallr.) Arnold											+																								
Letharia vulpina (L.) Hue														+			+	+																	
Lichenomphalia hudsoniana (H.S.Jenn) Red-head et al. [as Omphalina hudsoniana (H.S.Jenn) H.E.Bigelow]										+			+												+	+		+							
Lobaria amplissima (Scop.) Forssell														+	+		+	+																	
L. hallii (Tuck.) Zahlbr.											+																								
L. isidiosa (Müll.Arg.) Vain.																											+	+							
L. linita (Ach.) Rabenh.													+																						+
L. meridionalis Vain.																											+				+				
L. orientalis (Asahina) Yoshim.														+														+							
L. retigera (Bory) Trevis.																											+	+	+	+	+		+	+	
L. pulmonaria (L.) Hoffm.			+			+		+		+	+	+	+	+	+	+	+	+	+	+	+			+		+		+	+					+	
L. scrobicalata (Scop.) DC.										+	+	+												+				+	+						
L.virens (With.) J.R. Laundon														+																					
Lobothallia radiosa (Hoffm) Hafellner		+																																	
Masonhalea richardsonii (Hook.) Kärnefelt																												+	+						
Melanelia commixta (Nyl.) A.Thell												+																							
M. exasperata (De Not.) Essl.		+					+																												
M. exasperatula (Nyl.) Essl.							+						+																						
M. fuliginosa (Fr. ex Duby) Essl.										+				+									+		+										
M. glabra (Schaer.) Essl.	+																																		
M. hepatizon (Ach.) A.Thell												+																							
M. olivacea (L.) Essl.		+					+																+												

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M. septentrionalis (Lynge) Essl.							+																												
M. sorediata (Ach.) Goward & Ahti												+																							
M. stygia (L.) Essl.												+																							
M. subargentifera (Nyl.) Essl.											+																								
M. subaurifera (Nyl.) Essl.													+																						
M. tominii (Oxner) Essl. (as Parmelia borisorum Oxner)																																			+
Menegazzia terebrata (Hoffm.) A.Massal.			+					+		+		+		+			+							+			+	+		+				+	
! Micarea kivakkensis Vain.[9]										+																									
M. tuberculata (Sommerf.) R.A.Anderson								+																											
Microcalicium ahlneri Tibell											+																								
Miriquidica deusta (Stenh.) Hertel & Rambold										+																									
Mycobilimbia lurida (Ach.) Hafellner &Türk [as Lecidea lurida (Ach.) DC.]										+			+																						
Myelochroa metarevoluta (Asahina) Elix & Hale																												+							
Neofuscelia loxodes (Nyl.) Essl.												+																							
N. pulla (Ach.) Essl.		+										+				+																			
N. pulla var. delisei Duby.										+																									
N. ryssolea (Ach.) Essl.																			+																
Nephroma arcticum (L.) Torss.												+																							
N. bellum (Spreng.) Tuck.										+		+																							
N. helveticum Ach.										+			+																						
N. isidiosum (Nyl.) Gyeln.											+																								
N. laevigatum Ach. non auct.										+										+															
N. parile (Ach.) Ach.																								+											
N. resupinatum (L.) Ach.												+								+				+											

Nephromopsis komarovii (Elenk.) Wei (as Cetraria komarovii Elenk.)																											+	+	+				+	+
Normandina pulchella (Borrer) Nyl.																												+	+					
Ochrolechia pallescens (L.) A.Massal.													+																					
Opegrapha atra Pers.														+																				
Ophioparma lapponica (Räsänen) Hafellner & R.W.Rogers [as O. ventosa (L.) Norman var. lapponica Räsänen]										+																								
Pannaria conoplea (Ach.) Bory											+																	+						
P. rubiginosa (Ach.) Bory																									+									
Parmelia fraudans (Nyl.) Nyl.												+																						
P. saxatilis (L.) Ach.								+																										
P. sulcata Taylor									+																									
Parmeliella triptophylla (Ach.) Müll.Arg.												+																						
Parmelina quercina (Willd.) Hale			+					+																	+			+						
P. tiliacea (Hoffm.) Hale								+		+	+																							
Parmeliopsis ambigua (Wulfen) Nyl.				+																														
P. hyperopta (Ach.) Arnold							+																											
Peltigera aphthosa (L.) Willd.			+					+																										
P. canina (L.) Willd.				+			+																											
P. collina (Ach.) Schrad.												+	+																					
P. degenii Gyeln.										+		+																						
P. elisabethae Gyeln.											+																							
P. horizontalis (Huds.) Baumg.			+																					+										
P. leucophlebia (Nyl.) Gyeln.																							+											
P. malacea (Ach.) Funck		+																																
P. neckeri Hepp ex Müll.Arg.	+																																	
P. ponojensis Gyeln.	+																																	
P. praetextata (Flörke ex Sommerf.) Fr.	+																																	
P. rufescens (Weiss) Humb.				+																														
P. scabrosa Th.Fr.												+																						

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P. venosa (L.) Hoffm.			+							+	+																								
Peltula radicata Nyl.																													+						
P. zabolotnoji (Elenk.) Golubk.																													+						
Pertusaria hemisphaerica (Flörke) Erichsen										+	+																								
P. pseudophlyctis Erichs.														+																					
P. raesaenenii Erichsen													+																						
P. sommerfeltii Fr.														+			+																		
Phaeocalicium compressulum (Szatala) A.F.W.Schmidt											+																								
P. populneum (Brond ex Duby) A. F.W.Schmidt										+	+																								
Phaeophyscia endophoenicea (Harm.) Moberg											+																								
P. hirsuta (Mereschk.) Moberg											+																								
P. hispidula (Ach.) Moberg																									+										
P. kairamoi (Vain.) Moberg										+	+		+																						
P. nigricans (Flörke) Moberg			+		+			+																											
P. pyrrophora (Poelt) D.D.Awasthi & M.Joshi																												+							
Phylliscum demangeonii (Moug. & Mont.) Nyl.										+																									
Physcia caesia (Hoffm.) Fürnr.																							+												
Physconia detersa (Nyl.) Poelt	+										+																								
P. perisidiosa (Erichsen) Moberg																							+												
Placolecis opaca (Fr.) Hafellner																													+						
P. cribellans (Nyl.) Räsänen																													+						
Platismatia glauca (L.) W.L.Culb. & C.F.Culb.	+	+					+																												
Pleopsidium flavum (Bellardi) Körb.		+																																	
Pleurosticta acetabulum (Neck.) Elix & Lumbsch			+					+				+																							
Polychidium muscicola (Sw.) Gray		+																																	

Protopannaria pezizoides (Weber) P.M.Jørg. [as Pannaria pezizoides (Web.) Trev.]												+																					
Protoparmelia badia (Hoffm.) Hafellner								+																									
P. nephaea (Sommerf.) R.Sant.										+																							
Protoparmeliopsis muralis (Schreb.) M.Choisy [as Lecanora muralis (Schreb.) Rabenh.]				+			+																										
Pseudevernia furfuracea (L.) Zopf	+	+					+				+		+																				
Psilolechia clavulifera (Nyl.) Coppins											+																						
Psora globifera (Ach.) A.Massal.										+																							
P. rubiformis (Ach.) Hook.													+																				
Psoroma hypnorum (Vahl.) Gray										+																							
Punctelia subrudecta (Nyl.) Krog																												+					
Pycnothelia papillaria (Ehrh.) Dufour										+																							
Pyrenocarpon flotowianum (Hepp.) Trevis.										+																							
Pyrrhospora elabens (Fr.) Hafellner								+																									
Pyxine endochrysoides (Nyl.) Degel. [as Pyxine sorediata (Ach.) Mont.]																											+	+	+	+	+		
! Ramalina asahinana Zahlbr.[10]														+																+	+	+	
R. baltica Lettau												+								+													
R. calicaris (L.) Fr.											+	+																					
R. dilacerata (Hoffm.) Hoffm.			+					+		+		+																					
R. elegans (Bagl. & Carestia) Jatta																				+													
R. evernioides Nyl.														+			+																
R. farinacea (L.) Ach.	+			+			+																		+								
R. fastigiata (Pers.) Ach.																								+									
R. fraxinea (L.) Ach.		+								+		+		+									+	+									
R. obtusata (Arnold) Bitter													+							+													
R. pollinaria (Westr.) Ach.		+					+																										
R. roesleri (Hochst. ex Schaer.) Hue										+	+												+										
R. sinensis Jatta																																+	+
R. subfarinacea (Nyl. ex Cromb.) Nyl.										+																							

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R. thrausta (Ach.) Nyl.										+	+	+	+							+															
Rhizocarpon grande (Flörke) Arnold								+																											
R. hochstetteri (Körb.) Vain.								+																											
R. petraeum (Wulfen) A.Massal. (as R. concentricum auct.)										+																									
R. postumum (Nyl.) Arnold								+																											
Sclerophora coniophaea (Norman) J. Mattsson & Middelb.											+																								
Sphinctrina anglica Nyl.											+																								
S. turbinata (Pers.:Fr.) De Not.											+																								
Stenocybe major Nyl.											+																								
Stereocaulon arenarium (Savicz) I.M.Lamb																													+						
S. capitellatum H.Magn.										+																									
S. dactylophyllum Flörke										+			+																		+	+			
S. symphycheilum I.M.Lamb										+																							+		
Sticta arctica Degel.																																			+
S. fuliginosa (Hoffm.) Ach.																											+								
S. limbata (Sm.) Ach.																											+			+				+	
S. nylanderiana Zahlbr.											+																+				+	+			
S. sylvatica (Huds.) Ach.																											+				+				
S. wrightii Tuck.										+																									
Synalissa symphorea (Ach.) Nyl.										+																									
Tholurna dissimilis (Norman) Norman										+			+																						
Tornabenia atlantica (Ach.) Kurok.														+	+		+																		
Trapeliopsis viridescens (Schrad.) Coppins & P.James											+																								
Tuckermannopsis chlorophylla (Willd.) Hale	+																						+												

T. ciliaris (Ach.) Gyeln.											+		+																						
Tuckneraria laureri (Kremp.) Randlane & A.Thell [as Nephromopsis laureri (Krempelh.) Kurok. or Cetraria laureri Krempelh.]											+								+						+		+		+	+	+	+	+		
Umbilicaria deusta (L.) Baumg.								+																+											
U. hirsuta (Sw. ex Westr.) Hoffm.												+																							
U. hyperborea (Ach.) Hoffm.								+				+												+											
U. krascheninnikovii (Savicz) Zahlbr.																																			+
U. polyphylla (L.) Baumg.								+																+											
U. polyrrhiza (L.) Ach.												+																							
U. proboscidea (L.) Schrad.												+																							
U. pulvinaria (Savicz) Frey[11]																													+						
Usnea articulata (L.) Hoffm.														+			+																		
U. barbata (L.) Weber ex F.H.Wigg																				+					+										
U. cavernosa Tuck.																								+											
! U. distincta Motyka[12]														+																					
! U. extensa Vain.[13]										+																									
U. filipendula Stirt.			+																				+												
U. florida (L.) Weber ex F.H.Wigg.			+			+								+	+	+	+	+	+	+				+											
! U. foveata Vain.[14]																									+										
U. fulvoreagens (Räsänen) Räsänen			+																																
U. glabrata (Ach.) Vain.			+							+																									
U. glabrescens (Nyl. ex. Vain.) Vain.			+										+																						
U. hapalotera (Harm.) Mot.																									+										
U. hirta (L.) Weber ex F.H.Wigg.	+		+	+	+		+																												
U. lapponica Vain.			+																																
U. longissima Ach.										+	+																	+							
U. subfloridana Stirt.		+	+				+																												
U. wasmuthii Räsänen																			+																
Varicellaria rhodocarpa (Körb.) Th.Fr.										+																									

Table 2 (continued)

Lichen species	Red Data Books of the Subjects of the Russian Federation																																		
	I								II					III					IV						V		VI							VII	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Verrucaria margacea (Wahlenb.) Wahlenb.								+																											
V. onegensis Vain.										+																									
Vulpicida juniperinus (L.) J.-E. Mattsson & M.J.Lai												+							+																
Xanthoparmelia camschadalis (Ach.) Hale																						+													
X. conspersa (Ach.) Hale													+																						
X. somloënsis (Gyeln.) Hale													+																						
Xanthoria calcicola Oxner		+																																	
X. candelaria (L.) Th.Fr.																							+												
X. fallax (Hepp) Arnold	+		+																																

Remarks

[6] In two regional Red Data Books (of Republic of Adygeja and of Krasnodar region) this species is listed under *Bryoria jubatus* (L.) Brodo & D. Hawksw.

[7] *Cetrelia cetrarioides* is currently treated as a synonym to *C. olivetorum* (see e.g. Santesson et al., 2004). However, we prefer to maintain the chemical species here as separate taxa.

[8] *Dendriscocaulon umhausense* is currently treated as *Lobaria amplissima* (see e.g. Santesson et al., 2004). However, the taxon is redlisted in two regions of Russia under this name which is used also here.

[9] *Micarea kivakkensis* Vain. is considered to be conspecific with *Catillaria contristans* (Nyl.) Zahlbr. (see e.g. Kotlov, 2004) which is a rather widespread lichen. This taxon was included into the officially adopted list of threatened species of the Republic of Karelia presumably due to its original description from the Karelian locality.

[10] *Ramalina asahinana* is often synonymized with *R. sinensis*; however, both taxa are included in the Red Data Book of Novosibirsk Region and Red Data Book of the Republic of Khakassia. We also prefer to keep these two taxa separate. Furthermore, *R. asahinana* is misspelled in the Red Data Book of Republic of Adygeja and is included there as "*Ramalina asahina* Zahlbr." while *R.sinensis* is mentioned in the latter publication as a synonym.

[11] *Umbilicaria pulvinaria* was originally mentioned as *Gyrophora pulvinaria* by Savicz (1911: 256) and was described later under the same name (Savicz, 1914). The taxon needs revision.

[12] *Usnea distincta* is not reported for Russia in the recent treatment of the genus (Handbook of the Lichens of Russia, Vol. 6, 1996), but is mentioned there as a potential synonym of *U. glabrescens* (p. 86). However, the taxon is included into the Red Data Book of the Republic of Adygeja and therefore is kept in the list of officially protected lichen species. Presumably should be treated as *U. glabrescens*.

[13] *Usnea exstensa* is treated as a separate species in the recent treatment of the genus in Russia (Handbook of the Lichens of Russia, Vol. 6, 1996: 78–79) and is redlisted in the Republic of Karelia. According to other authors (e.g. Santesson et al., 2004) the taxon is a synonym of *U. glabrescens*.

[14] *Usnea foveata* is treated as a separate species in the recent treatment of the genus in Russia (Handbook of the Lichens of Russia, Vol. 6, 1996: 82–83) and is redlisted in Khanty-Mansy autonomous district. According to other authors (e.g. Santesson et al., 2004) the taxon is a synonym of *U. barbata*.

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Lithophilous lichens of Middle Urals

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Abstract: The list of 194 lichen species spatially connected with rocky outcrops at Middle Urals is presented. The differences in species composition and specificity, taxonomic spectra are shown for the rock types under consideration. The groups of rarity and pollution sensitivity are segregated within epilithic lichens.

Kokkuvõte: Kesk-Uurali litofiilsed samblikud.

Esitatakse Kesk-Uurali kaljupaljandite samblike nimekiri, mis sisaldab 194 liiki. Käsitletakse erinevat tüüpi kivisubstraatide lihhenofloora liigilise koosseisu iseärasusi. Epiliitsete samblike hulgas on eristatud erineva haruldus- ja saastetundlikkus-astmega rühmad.

INTRODUCTION

The lithophilous lichen flora of Middle Urals has never been thorougly studied and only a few data on lichen biodiversity on rocks are available for this territory (Ryabkova, 1998; Kotlov, 2003; Paukov & Trapeznikova, 2003).

Middle Urals lay between latitudes 55°54' and 59°15'N (Fig. 1) (Urals and ..., 1968). It is a less elevated part of Ural mountains but it bears a high complexity in the aspects of geology and vegetation. The outcrops of limestone, ultramafic, basic and acidic rocks situated mainly at the river banks are equally ubiqiutous here. Limestone is a sedimental rock type that consists of about 95% of calcium carbonate and 5% of calcium-magnesium carbonate. The acidity rate of silicate rocks is often estimated indirectly by comparison of content of SiO_2 (weak acid) and some additional components which may influence on pH. Serpentines and pyroxenites are the ultramafic rocks which contain about 41% of SiO_2 and 36–42% of MgO. Basalts are the basic rocks which contain up to 50% of SiO_2, 16% of Al_2O_3, 9% of CaO and 6% of MgO. Acidic rocks – granites – consist of 72% of SiO_2 and 14% of Al_2O_3 (Voitkevich et al., 1990).

The highest relative altitude is 878 metres (Katchkanar mountain) that is almost twice as low as neighbouring mountains of Northern Urals so there is no altitudinal zonation seen within Middle Urals. Climatic conditions on the outcrops vary from rather cool and wet from a seepage water on the northern slopes to dry and hot with temperatures rising above 60 °C at the southern slopes. Coniferous forests with pine (*Pinus sylvestris* L.) and fir (*Picea obovata* Ledeb.) is the dominant vegetation with birch forests and steppe patches are on the south.

Middle Urals is a territory with high concentration of metallurgical factories. Main pollut-

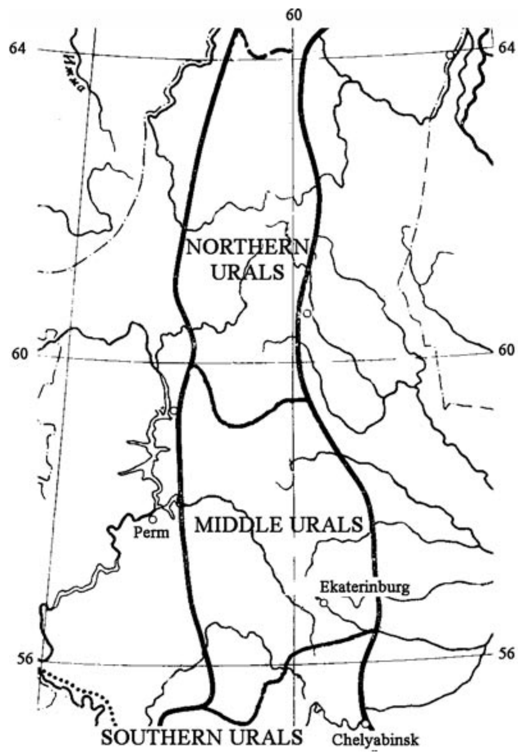

Fig. 1. The location of Middle Urals within the Ural mountains.

ants are heavy metals (Cu, Pb, Fe and others) and sulphur dioxide. Car exhaust gases are the major pollutants in Ekaterinburg that result in high concentration of nitrogen oxides, formaldehyde, phenol and lead in the air.

The aims of this study were to reveal the lichen biodiversity of the territory, to compare species richness and composition on different rocks and to evaluate the possibility to delimit pollution sensitivity groups within the lithophilous lichens.

MATERIAL AND METHODS

Lichens spatially connected with rocky outcrops and growing directly on rock, plant debris, soil and mosses have been collected at the banks of rivers Bagaryak, Iset, Sysert, Pyshma, Serga, Chusovaya, Ufa, Rhezh, Neiva, Tagil, Tura and on mountains such as Uktus, Volchikha, Shunut and others. Different types of rocks, e.g. limestones, basalts, serpentines, pyroxenites, dunites, gabbro, granites and diorites have been studied. Attention has also been payed to artificial stones and concrete in towns and villages. The term “lithophilous lichens” was interpreted here as the species not growing directly on rock only but as all species occuring in these habitats. Many of them are not obligately epilithic (e.g. *Caloplaca cerina* var. *chloroleuca* (Sm.) Th. Fr., *Endocarpon pusillum* Hedwig etc.).

List of lichens was compiled for every rock type separately. Sørensen coefficient was calculated to evaluate the similarity of such species lists. Delimitation of categories of rare species was made using the following criteria: 1) lichens with a single known locality and rare within it (category rr1); 2) lichens with a single locality but abundant there (category rr2); 3) lichens known from two or three distant localities and rare within them (category rr3).

The affinity groups of lichen families to substrate type were derived from the ranks of families counted on the number of species recorded on the certain rock type (e.g. *Parmeliaceae* with 15 species on pyroxenite was graded to the rank 1, *Lecanoraceae* with 10 species was graded to the rank 2, *Physciaceae* with 8 species was graded to the rank 3). Using the highest ranks for particular family the segregation of affinity groups was made. The term “acidofilic” is used for the families which have highest ranks on granite, "neutrofilic" are the families with highest ranks on ultramafics and basalt as the intermediate rocks in SiO_2 content. "Basifilic" family is the one with highest ranks on limestone, and species of which had not been found on granite. Some additional groups were also segregated.

Species on granite were used to delimit groups of sensitivity to air pollution. Six points with granite outcrops in different parts of Ekaterinburg and 50 km NW from the town were selected. The location of inner points of species distribution in the town together with the quantity of specimens found were the criteria for delimitation of sensitivity groups of lithophilous lichens. Three groups were delimited: tolerant – species abundant in the centre of the town; moderately tolerant – species growing only in the town periphery (the park zone) and non-polluted zone; sensitive – species collected only in the non-polluted territory.

RESULTS AND DISCUSSION

194 species of lithophilous lichens are known from the Middle Urals. Total species number on different rocky outcrops vary from 82 species on limestone and serpentine to 69 species on granite (Table 1). Only 11 species (6% of total) are amphitolerant growing on all rock types while

Table 1. Lichen species quantity on different rock types

	Limestone	Serpentine	Pyroxenite	Basalt	Granite
	no SiO_2	41% SiO_2	41% SiO_2	50% SiO_2	72% SiO_2
Total number of species	82	82	70	78	69
Number of species specific to the rock type	47	14	6	15	22
Specificity index = (Specific/Total)	0,57	0,17	0,09	0,19	0,32

the others appear to be selective. Limestone is a substrate with the highest percentage of specific lichens – 57% of all taxa recorded on limestone have not been recorded elsewhere. Granites (incl. diorites) have the second highest percentage of specific species – 32%. Ultramafics and basalt are rather poor in specific lichens (less than 20% of recorded species). The most chemically deviating rocks bear the most specific flora while the substrates with the intermediate values of SiO_2 concentration have a lot of species which are able to migrate there either from granite or from limestone. The data on the serpentine flora of higher plants (Kruckeberg, 1954; Proctor & Woodell, 1971) are different and imply that the pH rather than availability of metal ions is a key factor determining lichen species distribution on different rocks.

A dendrogram based on the Sørensen's index shows the similarity of lichen floras on different types of rocks (Fig. 2). Ultramafics (serpentine and pyroxenite) and basalt are rather similar in their species composition while flora of limestone is the most deviating.

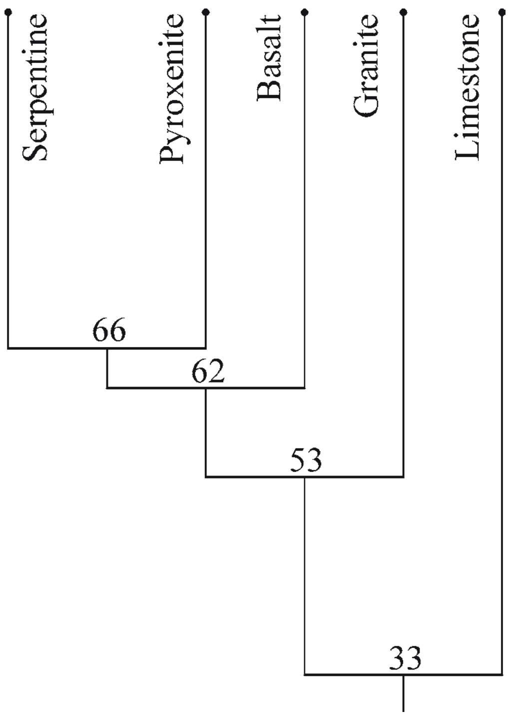

Fig. 2. Similarity dendrogram of the species composition of lichens on different rocks. Numbers are the Sørensen similarity indexes of the linkage.

Taxonomic analysis of lichen biodiversity on different rocks revealed the affinity of different lichen families to a particular substrate group (Table 2). *Physciaceae* and *Lecanoraceae* are the amphitolerant families with a high number of species on every substrate. *Porpidiaceae* and *Rhizocarpaceae* are acidophilic families with the biggest number of species on granite. *Parmeliaceae* has the affinity to neutral and acidic rocks. This is different from *Teloschistaceae* which is widespread on limestone, basalt and ultramafics. *Collemataceae* is a basifilic family that is very usual on limestone and have not been found on granite. According to our data for the same territory, these affinities of the families including also epiphytic lichens are not necessarily concordant with the affinities for different bark types segregated by the acidity. *Teloschistaceae*, *Lecanoraceae* and *Parmeliaceae* are concordant while *Physciaceae* is more acidophilic on rocks.

50 species are rare in the region. *Acarospora oligospora* (Nyl.) Arnold, *Melanelia panniformis* (Nyl.) Essl., *Micarea sylvicola* (Flotow) Vězda & V. Wirth, *M. tuberculata* (Sommerf.) R. A. Anderson, *Miriqiudica leucophaea* (Rabenh.) Hertel & Rambold, *Toninia opuntioide*s (Vill.) Timdal and others belong to the first category of rare species. *Bacidia herbarum* (Stizenb.) Arnold, *Heterodermia speciosa* (Wulfen) Trevis., *Trapelia placodioides* Coppins & P. James are the species of the second category. *Caloplaca chrysodeta* (Vainio et Räsänen) Dombr., *Cetrelia olivetorum* (Nyl.) W.L. Culb. & C.F. Culb., *Flavoparmelia caperata* (L.) Hale, *Phlyctis argena* (Sprengel) Flot., *Sarcogyne privigna* (Ach.) Anzi are the examples of the third category of rare species.

Granite is a substrate with a biggest percentage of rare species (28% of total) (Table 3). The discrepancy between the poorest lichen flora and the biggest number of rare species can probably be explained by microclimatic conditions on this substrate. Granite outcrops are situated under the forest canopy within the studied territory. The surface of this stone is permanently cold so arctic and hypoarctic species are common on this substrate. Rare steppe lichens (*Cladonia pocillum* (Ach.) Grognot, *Fulgensia bracteata* (Hoffm.) Räsänen) occur mainly on limestone (the most xeric substrate) or on the southern slopes of other rock types.

Table 2. Taxonomic spectrum of lichen flora on different rocks. Numbers (1–26) are the ranks of families counted on the number of species recorded on the certain rock type. Highest ranks (1–5) for the particular family are in **bold**.

	Substrate					
Family	Limestone	Serpentine	Pyroxenite	Basalt	Granite	Affinity
Physciaceae	**3**	**1**	**3**	**2–4**	**5–6**	Amphitolerant
Lecanoraceae	**4**	**2**	**2**	**5**	**2**	Amphitolerant
Porpidiaceae	12–16	12–13	6–8	9–13	**3–4**	Acidophilic
Rhizocarpaceae	-	14–26	6–8	9–13	**3–4**	Acidophilic
Parmeliaceae	9–11	**3–4**	**1**	**1**	**1**	Calciphobous
Hymeneliaceae	12–16	**3–4**	**5**	**2–4**	7–10	Neutrophilic
Teloschistaceae	**1**	**5**	**4**	**2–4**	13–22	Basi-neutrophil.
Collemataceae	**2**	9–11	9–10	7	-	Basifilic

Granite outcrops are common within Ekaterinburg and suburbs. It gives a good possibility to estimate changes of biodiversity of epilithic lichens in the town and delimit sensitivity groups of species on this substrate. Granite of the central part of the town is characterized by the poorest lichen biodiversity (17 species only, some of them are included into the tolerant group). The most usual species are: *Acarospora fuscata* (Schrad.) Arnold, *Aspicilia cinerea* (L.) Körb., *Caloplaca crenularia* (With.) J.R. Laundon., *Candelariella vitellina* (Hoffm.) Müll. Arg., *Lecanora dispersa* (Pers.) Sommerf., *Lecanora muralis* (Schreb.) Rabenh., *L. polytropa* (Hoffm.) Rabenh., *Physcia caesia* (Hoffm.) Fürnr., *Porpidia crustulata* (Ach.) Hertel & Knoph, *Scoliciosporum umbrinum* (Ach.) Arnold. Some lichens known from the centre of the city with the one specimen only are not included into this group. 25–29 lichen species are recorded on different outcrops in the periphery of Ekaterinburg. Moderately tolerant lichens with an inner distribution border in a town periphery are: *Dibaeis baeomyces* (L.) Rambold & Hertel, *Diploschistes scruposus* (Schreb.) Norman, *Phaeophyscia sciastra* (Ach.) Moberg, *Polysporina simplex* (Davies) Vězda, *Rhizocarpon grande* (Flörke) Arnold, *R. obscuratum* (Ach.) A. Massal., *Stereocaulon tomentosum* Fr. and *Umbilicaria deusta* (L.) Baumg. The latter was recorded in the town on granite in 1995 but has not been found later. The group of sensitive lichens include: *Arctoparmelia centrifuga* (L.) Hale, *Bryoria simplicior* (Vain.) Brodo & D. Hawksw., *Cetrelia olivetorum* (Nyl.) W.L. Culb. & C.F. Culb., *Lepraria rigidula* (de Lesd.) Tønsberg, *Melanelia panniformis* (Nyl.) Essl., *Parmelia fraudans* (Nyl.) Nyl., *Porpidia cinereoatra* (Ach.) Hertel & Knoph. Granites outside the town bear the most diverse lichen biota that includes 67 species. *Caloplaca crenularia* and *Lecanora dispersa* have not yet been found on granite in the non-polluted territory. *Melanelia disjuncta* (Erichsen) Essl. and *M. infumata* (Nyl.) Essl. were found outside the town only on granites, and regarded as sensitive. Inside the town they were found on different substrate (pyroxenite). It may reflect the possible changes of the rock chemistry as have been previously reported in Sweden (Arup et al., 1989).

Some rare fruticose and foliose lichens as the most susceptible group to anthropogenic stress

Table 3. Number of rare species on different rock types

	Limestone	Serpentine	Pyroxenite	Basalt	Granite
Number of rare species	18	8	3	8	19
Percentage of rare species of total number of species on the rock type	22	10	4	10	28

are in need of protection. These species are: *Bryoria simplicior*, *Cetrelia olivetorum*, *Collema crispum* (Hudson) F.H. Wigg., *C. flaccidum* (Ach.) Ach., *C. glebulentum* (Nyl. ex Crombie) Degel., *Flavoparmelia caperata*, *Heterodermia speciosa*, *Leptogium lichenoides* (L.) Zahlbr., *Melanelia panniformis*, *Peccania coralloides* (A. Massal.) A. Massal., *Solorina saccata* (L.) Ach. and *Umbilicaria rossica* (Dombr.) Golubk. Some of them grow on the territory of "Olenyi ruchyi" national park and Visim state biospheric reserve both situated within the Middle Urals. Nevertheless, the forest fires and tourist activities still leave the possible threat to these species.

CONCLUSIONS

The biodiversity of lithophilous lichens of the Middle Urals is rather high. This is caused mainly by the substrate and microclimatic diversity that gives suitable sites for acidofilic and basifilic lichens and a possibility for both steppe and arctic lichens to occur. Limestone and granite which bear the most specific flora are very valuable substrates for the conservation of rare species. Atmospheric pollution and recreation are the most deleterious factors for lithophilous lichens in the studied area. The segregated sensitivity groups can be used as an alternative way for monitoring lichens especially in polluted sites where epiphytic lichens are poorly developed.

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APPENDIX

The list of lichens of Middle Urals

Abbreviations of substrates: bas. – basalt, concr. – concrete, gr. – granite, limest. – limestone, pyr. – pyroxenite, serp. – serpentine.

Rr1, rr2, rr3 are the rarity groups described in Material and Methods.

Acarospora badiofusca (Nyl.) Th. Fr. – bas.

A. fuscata (Schrad.) Arnold – serp., pyr., bas., gr.

A. glaucocarpa (Wahlenb.) Körb. – limest.

A. macrospora (Hepp) Bagl. – limest.

A. nitrophila H. Magn. – serp., pyr., bas.

A. oligospora (Nyl.) Arnold – serp.; rr1.

Amandinea punctata (Hoffm.) Coppins & Scheid. – serp., bas.

Anema jenisejensis H. Magn. – limest.

Arctoparmelia centrifuga (L.) Hale – gr.

Arthonia lapidicola (Taylor) Branth & Rostr. – concr.; rr1.

Aspicilia cinerea (L.) Körb. – serp., pyr., bas., gr.

A. contorta (Hoffm.) Krempelh. – limest., serp., pyr.

A. contorta ssp. hoffmanniana S. Ekman & Fröberg – serp., pyr., bas.

A. desertorum (Krempelh.) Mereschk. – serp., pyr.; rr1.
A. lapponica (Zahlbr.) Oxner – serp., pyr., bas.
A. moenium (Vain.) Thor &Timdal – concr., limest.
A. cf. perradiata (Nyl.) Hue – bas.
A. simoënsis Räsänen – serp., bas.
A. cf. supertegens Arnold – bas.
A. cf. verrucigera (Hue) Zahlbr. – serp., pyr., bas., gr.
A. transbaicalica Oxner – bas.
Bacidia herbarum (Stizenb.) Arnold – mosses on serp.; rr2.
B. inundata (Fr.) Körb. – serp.; rr1.
Bacidina arnoldiana (Körb.) V. Wirth & Vězda – limest.; rr1.
Baeomyces rufus (Huds.) Rebent. – gr.
Bellemerea cupreoatra (Nyl.) Clauzade & Cl. Roux – serp., pyr., bas., gr.
Bryoria simplicior (Vain.) Brodo & D. Hawksw. – gr.; rr1.
Buellia leptocline (Flot.) A. Massal. – bas.; rr1.
Caloplaca arenaria (Pers.) Müll. Arg. – serp., bas.
C. cerina var. chloroleuca (Sm.) Th. Fr. – debris on limest.
C. chrysodeta (Vain. & Räsänen) Dombr. – limest.; rr3.
C. cirrochroa (Ach.) Th. Fr. – limest.
C. crenularia (With.) J.R. Laundon – gr.
C. diphyodes (Nyl.) Jatta – bas.; rr1.
C. dolomiticola (Hue) Zahlbr. – limest.
C. flavovirescens (Wulfen) Dalla Torre & Sarnth. – serp., pyr., bas., limest.
C. grimmiae (Nyl.) H. Olivier – On *Candelariella vitellina.*
C. holocarpa (Ach.) A.E. Wade – serp., pyr., bas.
C. jungermanniae (Vahl.) Th. Fr. – debris on limest.; rr1.
C. lactea (Massal.) Zahlbr. – limest.
C. saxicola (Hoffm.) Nordin – limest., bas.
C. subpallida H. Magn. – bas., serp., pyr.
C. variabilis (Pers.) Müll. Arg. – limest.
C. vitellinula (Nyl.) H. Olivier – serp., bas., limest.
Candelariella medians (Nyl.) A.L. Sm. – limest.; rr1.
C. vitellina (Ehrh.) Müll. Arg. – gr., serp., pyr., bas., limest.
Catapyrenium sp. – limest.
Cetrelia olivetorum (Nyl.) W.L. Culb. & C.F. Culb. – gr.; rr3.
Chromatochlamys muscorum (Fr.) H. Mayrhofer & Poelt – moss on pyr.; rr1.
Chrysothrix chlorina (Ach.) J.R. Laundon – gr., serp.
Cladonia acuminata (Ach.) Norrl. – soil on limest.
C. amaurocraea (Flörke) Schaer. – soil on serp.
C. chlorophaea (Flörke) Spreng. – soil on serp., pyr., gr., bas.
C. coniocraea (Flörke) Spreng. – soil on serp., gr.
C. pocillum (Ach.) Grognot – soil, moss on limest.
C. pyxidata (L.) Hoffm. – soil, moss on gr., serp., pyr., limest., bas.
C. ramulosa (With.) J.R. Laundon – gr.
Clauzadea monticola (Schaer.) Hafellner & Bellem. – limest.; rr1.
Collema auriforme (With.) Coppins & J.R. Laundon – moss on limest.
C. crispum (Huds.) F.H. Wigg. – limest.; rr2.
C. cristatum (L.) F.H. Wigg. – serp., bas., limest.
C. flaccidum (Ach.) Ach. – serp., bas., limest.; rr2.
C. fuscovirens (With.) J.R. Laundon – limest.
C. glebulentum (Nyl. ex Cromb.) Degel. – limest.; rr1.
C. polycarpon Hoffm. – serp., pyr., limest.
C. tenax (Sw.) Ach. – soil on serp., pyr., limest., bas.
Dermatocarpon miniatum (L.) W. Mann. – serp., bas.
Dibaeis baeomyces (L.) Rambold & Hertel – serp., pyr., gr.
Dimelaena oreina (Ach.) Norman – bas., gr.
Diploschistes muscorum (Scop.) R. Sant. – moss on limest., serp.
D. scruposus (Schreb.) Norman – gr., pyr., bas.
Diplotomma alboatrum (Hoffm.) Flot. – limest.; rr1.
Endocarpon pusillum Hedw. – soil on limest., serp.
Evernia mesomorpha Nyl. – serp., pyr., bas.
Flavoparmelia caperata (L.) Hale – pyr.; rr3.
Flavopunctelia soredica (Nyl.) Hale – bas.
Fulgensia bracteata (Hoffm.) Räsänen – limest.; rr1.
Fuscopannaria leucophaea (Vahl) P.M. Jørg. – serp.; rr1.
F. praetermissa (Nyl.) P.M. Jørg. – serp.; rr1.
Gyalidea fritzei (B. Stein) Vězda – gr.; rr1.
Heterodermia speciosa (Wulfen) Trevis. – moss on serp., pyr.; rr2.

Hypogymnia physodes (L.) Nyl. – gr., serp., pyr., bas.
Lecania erysibe (Ach.) Mudd – limest.
L. turicensis (Hepp) Müll. Arg. – limest.
Lecanora campestris (Schaer.) Hue – serp., pyr., gr., bas.
L. crenulata Hook. – limest.
L. dispersa (Pers.) Sommerf. – serp., pyr., gr., bas.
L. frustulosa (Dicks.) Ach. – serp., pyr., bas., limest.
L. intricata (Ach.) Ach. – pyr., gabbro.
L. muralis (Schreb.) Rabenh. – gr., serp., pyr., bas., limest.
L. polytropa (Hoffm.) Rabenh. – serp., pyr., gr., bas.
L. cf. xanthostoma Cl. Roux ex Fröberg – limest.
Lecidea atomaria Th. Fr. – serp., pyr.; rr1.
Lecidella carpathica Körb. – serp., pyr., bas., limest.
L. stigmatea (Ach.) Hertel & Leuckert – gr., serp., pyr., bas., limest.
Lepraria incana (L.) Ach. – serp., pyr., bas.
L. membranacea (Dicks.) Vain. – serp., pyr., bas., gr., limest.
L. rigidula (de Lesd.) Tønsberg – gr.
Leptogium lichenoides (L.) Zahlbr. – limest.; rr1.
Leptogium sp. – limest.
L. tenuissimum (Dicks.) Körb. – soil on serp., bas.
Lichinella stipatula Nyl. – serp., pyr., bas.
Melanalia olivacea (L.) Essl. – pyr.
M. disjuncta (Erichsen) Essl. – gr., pyr., bas.
M. exasperatula (Nyl.) Essl. – serp., pyr.
M. infumata (Nyl.) Essl. – pyr., gr., serp., bas.
M. panniformis (Nyl.) Essl. – gr.; rr1.
M. subargentifera (Nyl.) Essl. – serp.
M. tominii (Oxner) Essl. – pyr., bas.
Micarea erratica (Körb.) Hertel, Rambold & Pietschm. – serp., gr.
M. lapillicola (Vain.) Coppins & Muhr – pyr.
M. sylvicola (Flot.) Vězda & V. Wirth – gr.; rr1.
M. tuberculata (Sommerf.) R.A. Anderson – gr.; rr1.
Miriqiudica leucophaea (Rabenh.) Hertel & Rambold – gr.; rr1.
Mycobilimbia carneoalbida (Müll. Arg.) Printzen – moss on limest.
M. microcarpa (Th. Fr.) Brunnb. – moss on limest.
M. sabuletorum (Schreb.) Hafellner – moss on limest.
M. tetramera (De Not.) Vitik. et al. – moss on limest.
Parmelia fraudans Nyl. – pyr., bas., gr.
P. saxatilis (L.) Ach. – gr.; rr1.
P. sulcata Tayl. – gr., serp., pyr., bas., limest.
Peccania coralloides (A. Massal.) A. Massal. – limest.; rr1.
Peltigera lepidophora (Vain.) Bitter – soil on serp., bas.
P. rufescens (Weiss) Humb. – soil on limest., bas.
Peltula cf. euploca (Ach.) Poelt – serp.
Pertusaria albescens (Huds.) M. Choisy & Werner – serp., gr.
Phaeophyscia constipata (Norrl. & Nyl.) Moberg – moss on limest., serp.
P. nigricans (Flörke) Moberg – serp.
P. sciastra (Ach.) Moberg – gr., serp., pyr., bas., limest.
Phlyctis argena (Spreng.) Flot. – limest.; rr3.
Physcia adscendens (Fr.) H. Olivier – pyr.
Ph. caesia (Hoffm.) Fürnr. – gr., serp., pyr., bas., limest.
Ph. dubia (Hoffm.) Lettau – gr., serp., pyr., bas.
Ph. sp. – bas.; rr1.
Physconia detersa (Nyl.) Poelt – serp., pyr., bas.
Ph. muscigena (Ach.) Poelt – serp., pyr., bas.
Ph. perisidiosa (Erichsen) Moberg – limest., serp.
Placynthiella icmalea (Ach.) Coppins & P. James – gr.
P. uliginosa (Schrad.) Coppins & P. James – gr.
Placynthium nigrum S. Gray – limest.
Polysporina simplex (Davies) Vězda – gr., bas.
Porpidia cinereoatra (Ach.) Hertel & Knoph – gr., serp.
P. crustulata (Ach.) Hertel & Knoph – serp., pyr., gr., bas., limest.
P. aff. glaucophaea (Körb.) Hertel & Knoph – gabbro; rr2.
P. macrocarpa (DC.) Hertel & A.J. Schwab – gr.
P. cf. soredizodes (Lamy ex Nyl.) J.R. Laundon – gr.; rr1.
P. tuberculosa (Sm.) Hertel & Knoph – bas.; rr1.
Protoblastenia rupestris (Scop.) J. Steiner – limest.
Protopannaria pezizoides (Weber) P.M. Jørg. & S. Ekman – soil on gr.
Psora elenkinii Rass. – limest.
Ramalina pollinaria (Westr.) Ach. – serp.
Rhizocarpon badioatrum (Spreng.) Th. Fr. – gr., pyr., bas.

R. grande (Flörke) Arnold – gr., serp., pyr., bas.
R. obscuratum (Ach.) A. Massal. – gr., pyr.
R. cf. plicatile (Leighton) A. L. Sm. – gr.; rr1.
R. subgeminatum Eitner – gr.; rr1.
Rhizoplaca chrysoleuca (Sm.) Zopf – bas.
Rinodina bischofii (Hepp) A. Massal. – limest.
R. calcarea (Hepp) Arnold – limest.
R. confragosa (Ach.) Körb. – serp., pyr., bas.
R. milvina (Wahlenb.) Th. Fr. – serp., pyr., limest.
Sarcogyne privigna (Ach.) Anzi var. calcicola H. Magn. – limest.; rr3.
S. regularis Körb em. Oxner – limest.
Scoliciosporum umbrinum (Ach.) Arnold – serp., pyr., gr., bas.
Solorina saccata (L.) Ach. – soil on limest.; rr1.
Staurothele fuscocuprea (Nyl.) Zschacke – bas.; rr1.
Stereocaulon saxatile H. Magn. – gabbro.
S. tomentosum Fr. – gr., pyr.
Thyrea cf. confusa Henssen – limest.
Toninia opuntioides (Vill.) Timdal – limest.; rr1.
T. cinereovirens (Schaer.) A. Massal. – serp.; rr2.
Trapelia coarctata (Sm.) M. Choisy – gr.
T. cf. involuta (Taylor) Hertel – bas.; rr1.
T. cf. obtegens (Th. Fr.) Hertel – gr.; rr1.
T. placodioides Coppins & P. James – gr, bas.; rr2.
Tuckermannopsis sepincola (Ehrh.) Hale – pyr., gr.
Umbilicaria deusta (L.) Baumg. – gr., pyr.
U. rossica (Dombr.) Golubk. – bas.; rr1.
Verrucaria caerulea DC. – serp.
V. calciseda DC. – limest.
V. hydrela Ach. – pyr. in springs.
V. cf. leightonii A. Massal. – concr.
V. muralis Ach. – serp., pyr.
V. cf. mutabilis Borr. – limest.
V. nigrescens Pers. – limest., concr.
V. cf. viridula (Schrad.) Ach. – serp.
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai – gr., pyr.
Xanthoparmelia camtschadalis (Ach.) Hale – soil on limest.; rr1.
X. conspersa (Ach.) Hale – pyr., gr., serp., bas.
X. somloënsis (Gyeln.) Hale – pyr., gr., serp., bas., limest.
X. tinctina (Maheu & A. Gillet) Hale – gr., pyr.
Xanthoria elegans (Link) Th. Fr. – bas., serp., pyr., limest.
X. fallax (Hepp) Arnold – pyr., bas., limest.
X. sorediata (Vain.) Poelt – serp., pyr., bas., limest.

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Distribution patterns of primary and secondary species in the genus *Vulpicida*

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Abstract: World-wide distribution maps are presented for all six *Vulpicida* species as well as for the groups of primary and secondary species separately. Taxa which usually bear apothecia (*V. canadensis, V. juniperinus* and *V. viridis*) are treated as primary species; the status of secondary species is assigned in this paper to the sorediate taxon (*V. pinastri*) as well as to these two species (*V. tilesii* and *V. tubulosus*) that probably reproduce mainly vegetatively by the fragments of thalli. There are two north-american endemics and one eurasian taxon among primary species, and two circumboreal taxa plus one european taxon among secondary species. The idea that the ancestor of *Vulpicida* may have had a circumpolar distribution, and later speciation processes took place in Eurasia as well as in North America may explain the contemporary distribution patterns of *Vulpicida* species. The shape of pycnidiospores (differing in two north-american endemics and other four species) supports the speculation that the former taxa have evolved apart from the latter, which probably developed somewhere in Eurasia, and some of them (*V. pinastri, V. tilesii*) have distributed secondarily to North America.

Kokkuvõte: Rebasesamblike (*Vulpicida*) primaarsete ja sekundaarsete liikide levikumustrid.

Esitatakse kõigi kuue *Vulpicida* liigi levikukaardid, samuti eraldi koondkaardid primaar- ja sekundaarliikide leviku kohta. Liike, mis tavaliselt moodustavad apoteetsiume, käsitletakse primaarliikidena (*V. canadensis, V. juniperinus* ja *V. viridis*); sekundaarliigi staatus on selles töös antud sorediossele taksonile (*V. pinastri*) ning neile kahele liigile (*V. tilesii* ja *V. tubulosus*), mis tõenäoliselt paljunevad vegetatiivselt talluse tükkide abil. Primaarsete liikide hulgas on kaks põhja-ameerika endeemi ja üks euraasia takson ning sekundaarsete liikide hulgas kaks tsirkumboreaalset ning üks euroopa takson . Idee, et rebasesamblike eellane võis olla levinud tsirkumpolaarselt ja edasine liigiteke toimus nii Euraasias kui ka Põhja-Ameerikas, seletaks *Vulpicida* liikide tänapäevast levikumustrit. Püknidiospooride kuju (erinev kahel põhja-ameerika endeemil ja ülejäänud neljal liigil) toetab seisukohta, mille kohaselt põhja-ameerika liigid arenesid eraldi ülejäänutest; viimaste areng toimus tõenäoliselt kusagil Euraasias ning osa neist (*V. pinastri, V. tilesii*) võisid uuesti levida Põhja-Ameerikasse.

INTRODUCTION

The heterogeneous group of cetrarioid lichens (fam. Parmeliaceae, Ascomycota) including about 150 species from more than 20 genera comprises eight genera in which both primary and secondary species are represented – *Allocetraria, Cetrelia, Cetreliopsis, Platismatia, Tuckermanella, Tuckneraria, Tuckermannopsis* and *Vulpicida* (Randlane & Saag, 2004). World-wide distribution maps for four of them, mainly Asian genera (*Allocetraria, Cetrelia, Cetreliopsis* and *Tuckneraria*), were presented lately (Randlane & Saag, 2004) while the distribution of three further, mainly North American genera, *Platismatia, Tuckermanella* and *Tuckermannopsis*, will be analysed in another paper.

Here we focus on the distribution of species from the genus *Vulpicida: V. canadensis* (Räsänen) J.-E. Mattsson & M. J. Lai, *V. juniperinus* (L.) J.-E. Mattsson & M. J. Lai, *V. pinastri* (Scop) J.-E. Mattsson & M. J. Lai, *V. tilesii* (Ach.) J.-E. Mattsson & M. J. Lai, *V. tubulosus* (Schaerer) J.-E. Mattsson & M. J. Lai, and *V. viridis* (Schwein.) J.-E. Mattsson & M. J. Lai.

Genus *Vulpicida* was described and thoroughly characterized more than ten years ago (Mattsson & Lai, 1993; Mattsson, 1993). Six cetrarioid taxa with intensely yellow coloured foliose or subfruticose thallus were incorporated in this unit. The main diagnostic character of the genus is the presence of pinastric and vulpinic acids in the medulla. Broadly clavate asci and broadly ellipsoid to subglobose ascospores are also of importance. Still, phylogenetic analyses based on morphological (*s. lat.*) characters (Mattsson, 1993; Saag et al., 2002) reveal that *Vulpicida* is not quite homogenous: it includes two separate clades which anatomically differ in the shape of pycnidiospores (citriform in North-American endemics *V. canadensis* and *V. viridis* and sublageniform in other four species). Analyses using molecular characters (Saag et al., 2002; Mattsson & Articus, 2004) group the species inside the genus differently. As only four species of the six have been sequenced till now, the topography of cladograms can be changed in future analyses.

Both primary and secondary species are represented in the genus.

The concept of species pairs was first and clearly formulated by Du Rietz in 1924 who used the term "Artenpaaren" for indicating the phenomenon that pairs of lichen species exist which differ from each other in just one character – having or lacking soredia (or isidia). He also drew attention to the fact that sorediate and usually sterile taxa have a different ecology and distribution from their nonsorediate fertile allies (Mattsson & Lumbsch, 1989). Hale (1965) pointed out that sorediate species often have a wider distribution than their fertile counterparts. Poelt (1970, 1972) expanded the species pair concept and suggested that to every sorediate taxon corresponds a nonsorediate one, considering that sorediate taxa represent evolutionary dead ends. It was also pointed out that all taxa with sexual reproduction appear to be quite rare with very restricted distribution. Still, this is not the absolute rule. For example, two primary *Allocetraria* species (*A. madreporiformis, A. stracheyi*) have spread from the probable speciation centre of the genus in Asia to North America. Furthermore, if several sorediate cetrarioid lichens occur extensively on two, three or even four continents, then isidiate species are clearly less successful in their distribution. For example, of cetrarioid isidiate taxa which evidently have evolved in Asia (*Allocetraria isidiigera, Cetrelia braunsiana, C. isidiata* and *Tuckneraria togashii*), all four have "stayed" in this continent (Randlane & Saag, 2004).

In *Vulpicida* one sorediate species (*V. pinastri*) is known, and three taxa which usually bear apothecia (*V. canadensis, V. juniperinus* and *V. viridis*). They can be treated as secondary and primary species, respectively. However, it is not as simple as it seems to distinguish between primary and secondary species using the presence of apothecia *versus* soredia or isidia only. In *Vulpicida* there are some species which lack vegetative propagules of reproduction but for which apothecia have been observed occasionally only. Both such taxa (*V. tilesii* and *V. tubulosus*) grow on the ground – differently from the other species in the genus which are epiphytic – and presumably reproduce through the fragmentation of thalli. In this paper we assign the status of secondary species to the sorediate taxon (*V. pinastri*) as well as to these two species (*V. tilesii* and *V. tubulosus*) that probably reproduce mainly vegetatively by the fragments of thalli.

MATERIAL AND METHODS

Distribution maps were compiled using the computer program DMAP. Both herbarium and literature data were used as sources for the localities. The materials from the following herbaria were taken into consideration: B, GZU, H, LD, LE, TU, UPS, and the collections of Irina Skirina, Vladivostok (from the Far East of Russia). Data of the checklists published on the internet (Feuerer, 2004) were accounted only in exceptional cases, when no other data were available. The literature sources for distribution data of each lichen species are listed below.

Vulpicida canadensis: Brodo et al., 2001; Mattsson, 1993; Nash III et al., 2002.

V. juniperinus: Azuaga & Gomez-Bolea, 1996, 2000; Barkhalov, 1983; Biazrov et al., 1989; Davydov, 2001; Fadeyeva et al., 1997; Feuerer, 2004; Hermansson et al., 1998; Himelbrant et al., 2001; Kotlov, 1995; Kurokawa, 2003; Martellos & Nimis, 2001; Mattsson, 1993; Randlane & Saag, 1999; Randlane et al., 2001; Santesson et al., 2004; Scholz, 2000; Urbanavichene, 1998; Wei, 1991; Zavarzin et al., 1999.

V. pinastri: Azuaga & Gomez-Bolea, 2000; Barkhalov, 1983; Biazrov et al., 1989; Brodo et al., 2001; Davydov, 2001; Diederich & Sérusiaux, 2000; Fadeyeva et al., 1997; Feuerer, 2004; Gorbatch, 1973; Hafellner & Türk, 2001; Hermansson et al., 1998; Himelbrant et al., 2001; Kopatchevskaya, 1986; Kotlov, 1995; Kurokawa, 2003; Makarova, 1998; Makarova et al., 2002; Mattsson, 1993; Motiejunaite, 1999; Piterans, 2001; Pisút et al., 1996; Poryadina, 2001; Randlane & Saag, 1999; Santesson et al., 2004; Sorokina, 2001; Suppan et al., 2000; Urbanavichene, 1998; Vězda & Liska, 1999; Wei, 1991; Zhuravleva & Zhigunov, 2002; Zhurbenko & Vechov, 2001.

V. tilesii: Biazrov et al., 1989; Brodo et al., 2001; Davydov, 2001; Glew, 2004; Hermansson et al., 1998; Kotlov, 1994, 1995; Mattsson, 1993; Urbanavichene, 1998.

V. tubulosus: Fadeyeva et al., 1997; Hafellner & Türk, 2001; Martellos & Nimis, 2001; Mattsson, 1993; Pisút et al., 1996; Randlane & Saag, 1999; Santesson et al., 2004; Suppan et al., 2000; Vězda & Liska, 1999.

V. viridis: Brodo et al., 2001; Mattsson, 1993.

RESULTS

Vulpicida canadensis (Fig. 1) is endemic to western North America and is distributed in Canada (British Columbia, Alberta), Mexico (Baja California) and USA (Washington, Idaho, Montana, Oregon, California) only. The lichen grows on bark and wood of mainly conifers (*Pinus, Pseudotsuga, Picea, Abies*) in open and relatively dry sites.

Fig. 1. World distribution of *Vulpicida canadensis* – on the western coast of North America (● – after Mattsson, 1993; ○ – complemented).

V. juniperinus (Fig. 2) is distributed mainly in northern Europe (Estonia, Finland, Norway, Russia, Sweden), but known also from a few isolated sites in subalpine areas of central or southern Europe (Andorra, Germany, Italy, Spain, United Kingdom), and sparsely in Asia (China, Georgia, India, Japan, Mongolia, Russia, South Korea). The species has become today very rare in southern Fennoscandia, in one of its main distribution regions (Thell et al., 2004). It is an epiphyte that is mainly restricted to *Juniperus communis* in Europe and to *Pinus pumila* in Asia; occasionally grows also on *Betula* or on calcareous soil (Randlane et al., 2001).

V. pinastri (Fig. 3) is a circumboreal lichen which occurs in subalpine, subarctic and boreal zones of North America (Canada, Greenland, USA), Europe (Andorra, Austria, Belgium, Bulgaria, Byelorussia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romenia, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom) and Asia (Armenia, China, Georgia, Japan, Kazakhstan, Mongolia, Russia, Turkey). It grows mainly on branches and trunks of coniferous trees (e.g. *Abies*, *Juniperus, Larix, Picea, Pinus*, in Europe preferably on *Pinus sylvestris*) and on deciduous trees with acidic bark (e.g. *Alnus, Betula, Populus* etc.), occasionally also on lignum, siliceous rocks and soil.

V. tilesii (Fig. 4) is an arctic-alpine species distributed mainly in the north-western part of North America (Canada, Greenland, USA) and northern part of Asia (Kazakhstan, Mongolia, Russia); in Europe only a few localities are known from its very eastern areas (Russia). It is a terricolous lichen occurring on exposed, periodically wet calciferous soil (Mattsson, 1993).

V. tubulosus (Fig. 5) has a disjunct distribution area, being found abundantly on the Baltic Isles and adjacent territories (Estonia, Finland, Norway, Sweden, Russia), and in the alpine regions of Central Europe (Austria, Czech Republic, France, Germany, Italy, Poland, Romania, Slovenia, Slovakia, Spain, Switzerland). The northernmost localities are known from Torne Lappmark in Sweden (≈ 68°N), where it is partly extinct (Santesson et al., 2004).

V. viridis (Fig. 6) occurs in the south-eastern part of North America (USA), close to the Atlantic coast. The species is endemic to this area; recent findings of this taxon in Russian

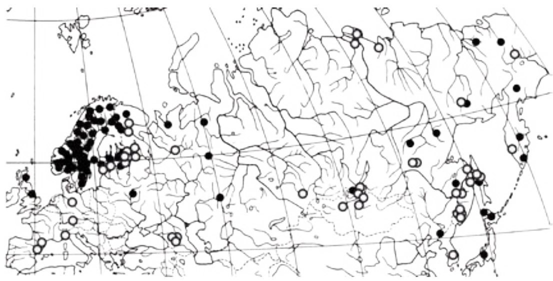

Fig. 2. World distribution of *Vulpicida juniperinus* (● – after Mattsson, 1993; ○ – complemented).

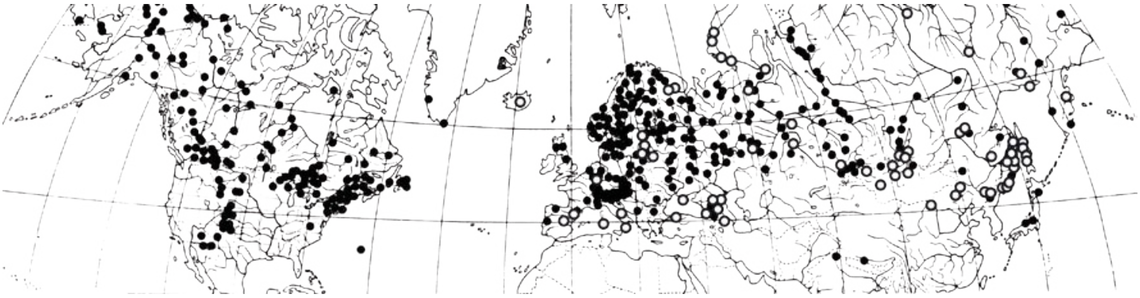

Fig. 3. World distribution of *Vulpicida pinastri* (● – after Mattsson, 1993; ○ – complemented).

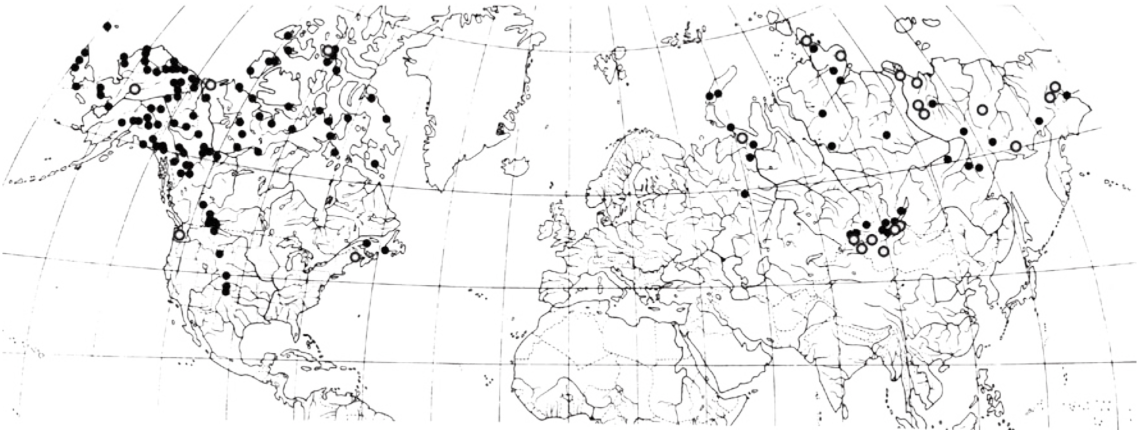

Fig. 4. World distribution of *Vulpicida tilesii* (● – after Mattsson, 1993; ○ – complemented).

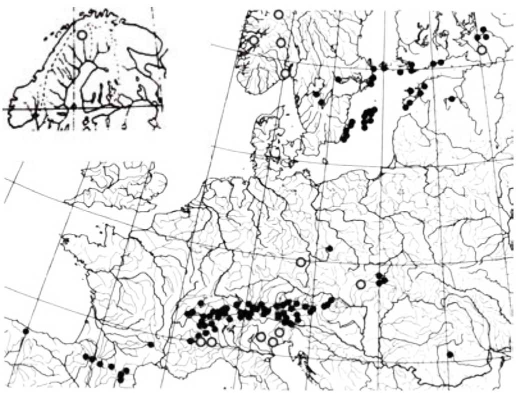

Fig. 5. World distribution of *Vulpicida tubulosus* (● – after Mattsson, 1993; ○ – complemented).

Fig. 6. World distribution of *Vulpicida viridis* – on the eastern coast of North America (after Mattsson, 1993).

Far East, Primorye region, close to the Pacific coast (Tchabanenko, 2002; Randlane et al., 2004) turned out to be misidentifications. It is an epiphytic lichen which mainly grows in humid conditions on *Chamaecyparis thyoides* (in bogs along the north-eastern coastal plain) or mature trees of *Quercus* in the south (Brodo et al., 2001).

DISCUSSION

None of the primary species (*V. canadensis, V. juniperinus* and *V. viridis*) occurs simultaneously in Europe, Asia and North America. *V. juniperinus* has the widest distribution area of the three, occurring abundantly in Europe and scarcely in wide territories of Asia. Two other primary taxa, *V. canadensis* and *V. viridis* have rather restricted distribution areas; although they are both endemic to North America, their distributions do not overlap.

All primary species are predominantly epiphytic, however, *V. juniperinus* can occasionally grow also on soil.

Among the secondary species, the distribution area of the sorediate *V. pinastri* is the widest, covering North America, Europe and a major part of Asia. *V. tilesii* has also rather a wide distribution in North America and northern Asia (with only a few localities in the very eastern part of Europe). The third secondary species, *V. tubulosus,* has a restricted and disjunct distribution area, with both parts of its distribution only in Europe.

Epiphytic and epigeic lichens are present among secondary species of *Vulpicida*. The epiphytic *V. pinastri* shows the widest ecological amplitude growing on various tree species, lignum, and rarely on rocks or soil.

The distribution patterns of primary (Fig. 7) and secondary species of *Vulpicida* (Fig. 8) do not refer unambiguously to the biodiversity or speciation centres of the genus. If secondary taxa and especially sorediate lichens usually occur on different continents, then primary species are either too specialized (to the substratum, ecological conditions etc.) or unable to cross the wide distances between the continents. In this genus there are two north-american endemics and one eurasian taxon among primary species, and two circumboreal taxa plus one european

Fig. 7. Distribution patterns of primary *Vulpicida* species.

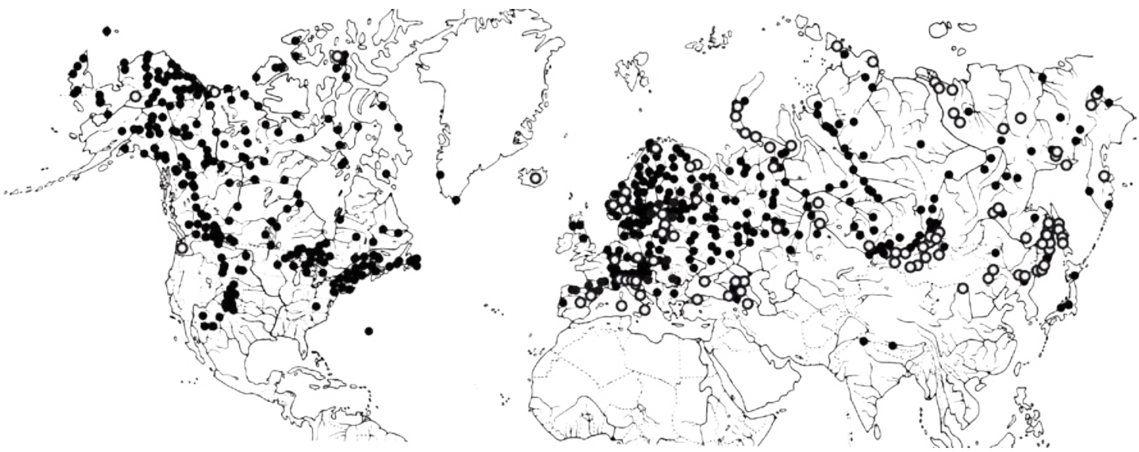

Fig. 8. Distribution patterns of secondary *Vulpicida* species.

taxon among secondary species. The idea that the ancestor of *Vulpicida* may have had a circumpolar distribution (Mattsson 1993), and later speciation processes took place in Eurasia as well as in North America may explain the contemporary distribution patterns of *Vulpicida* species. The shape of pycnidiospores which differs in two north-american endemics (citriform) and other four species (sublageniform) supports the speculation that the former taxa have evolved apart from the latter, probably somewhere in Eurasia, and some of them (*V. pinastri, V. tilesii*) have distributed secondarily to North America.

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Some lichens have incomplete distribution ranges in the Aegean (Greece)

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Abstract: An investigation of the epiphytic lichen flora on two comparable islands in the Aegean Sea (Greece) showed that some of the common species are present on one of the islands but absent from the other. This suggests that they failed to colonize all suitable habitats in the region and that insular isolation has a similar reducing effect on lichen diversity as it has for other organism groups. Further observations, which support dispersal restrictions, are that vegetative diaspore frequency deviates from that in continental areas, and that chemical strains of *Pseudevernia furfuracea* occupy separate ranges. A list of 208 epiphytic lichens encountered on the islands Ikaria and Naxos is appended.

Kokkuvõte: Mõnede samblike levik on Egeuse piirkonnas (Kreeka) lünklik.

Kahe Egeuse meres asuva Kreeka saare samblike uurimine näitas, et mõned tavalised liigid ühel saartest esinevad, teisel mitte. See tekitab arvamuse, et nad pole suutnud asustada kõiki selle regiooni sobivaid substraate ja et saareline eraldatus vähendab samblike mitmekesisust samuti nagu teistelgi organismirühmadel. Edasised, leviku piiranguid toetavad uuringud näitavad vegetatiivsete diaspooride sageduse erinevust sellest, mis mandriosas on tavaline, ja et hariliku karesambliku (*Pseudevernia furfuracea)* erinevad keemilised rassid on erineva levikuga. Lisatud on Ikaria ja Naxose saarte epifüütsete samblike nimestik, mis koosneb 208 liigist.

INTRODUCTION

For a long time it is known that islands have a reduced flora and fauna. This is commonly explained by difficult access and increased risk for extinction because of the small population sizes. Lichens, however, as spore-producing organisms, are supposed to be easily dispersed, and their presence or absence to be determined by the availability of suitable habitats rather than geographical connections or other forms of easy access. Indeed, Hayward & Hayward (1986) conclude in an investigation of island lichen biota that the number of species present is correlated with the availability of different habitats. However, there are also indications that spatial isolation might play a role in lichen diversity. Warren (2003) reports that increasing distance reduces genetic exchange, and Degelius (1986) concludes that the remote island of Anholt is mainly colonized by late immigrants. He gives no further interpretation of his observation but it bears the suggestion that other species have been unable to reach the island.

An ongoing project to inventory the lichen flora of individual islands in the Aegean See, Greece, by the first two authors (Sipman & Raus, 1995, 1999, 2002) provided an opportunity to test the effect of insular isolation on lichen diversity. The Aegean Sea, situated between the mainland of Greece and Turkey, contains many islands, remains of a submersed mountain system (Higgins & Higgins, 1996). These share a Mediterranean, rather arid climate, but differ considerably as to the availability of bedrock. Some are exclusively composed of limestone, others have large intrusions of granite or metamorphic rocks, while a few have volcanic rocks. Consequently the total lichen diversity of the islands is much influenced by the available rock substrate. The epiphytic substrates, however, show much less variation, because the number of available tree species is very restricted (Appendix 1). Moreover, epiphytic lichens tend to be unspecialized and grow on a wide range of tree species. Thus the epiphytic diversity seems to be less influenced by geological differences between the islands and more suitable for a study of insular effects.

For an estimation whether islands have an impoverished lichen flora, it would seem most suitable to compare them with an equally sized continental area. However, the adjacent continental areas of the Aegean are very mountainous and exceed the islands considerably in altitudinal range. Also the climate is different from the islands, which have a pronounced maritime climate. This makes considerable differences in lichen flora probable. Therefore a comparison between two islands with comparable size and elevation, situated close enough to assure a climatic similarity, seemed more appropriate to investigate isolation effects. When there is an impoverishment, it is unlikely that it has exactly the same effect in two islands, but it is more probable that some species are absent from one island and other species absent from the other island.

MATERIAL AND METHODS

Epiphytic lichen inventories were available for two islands, Naxos, coordinates 37°03' N, 25°28' E and area 428 km^2, and Ikaria, coordinates 37°35' N, 26°10' E and area 255 km^2 (Fig. 1), situated in the central part of the Aegean sea and about 60 km apart from each other.

The epiphytic lichens of Naxos were studied in detail by the third author during three months in 1995 (Scharlau, 1996). The island is largely covered by mountains reaching to about 900 m elevation and composed of various rock types, including limestone, granite and gneiss. Trees are available mainly in cultivated areas in the higher valleys and on the mountain slopes. The author investigated 304 individual trees belonging to 22 phorophytes (Appendix 1) in 55 localities. In total some 4000 observations of 148 taxa were made (Appendix 2).

Ikaria is very similar to Naxos, and differs mainly in shape. It is elongated rather than rounded and W-E-oriented, so that clouds from the sea driven by the prevailing northerly winds (called "meltémia") have a stronger effect.

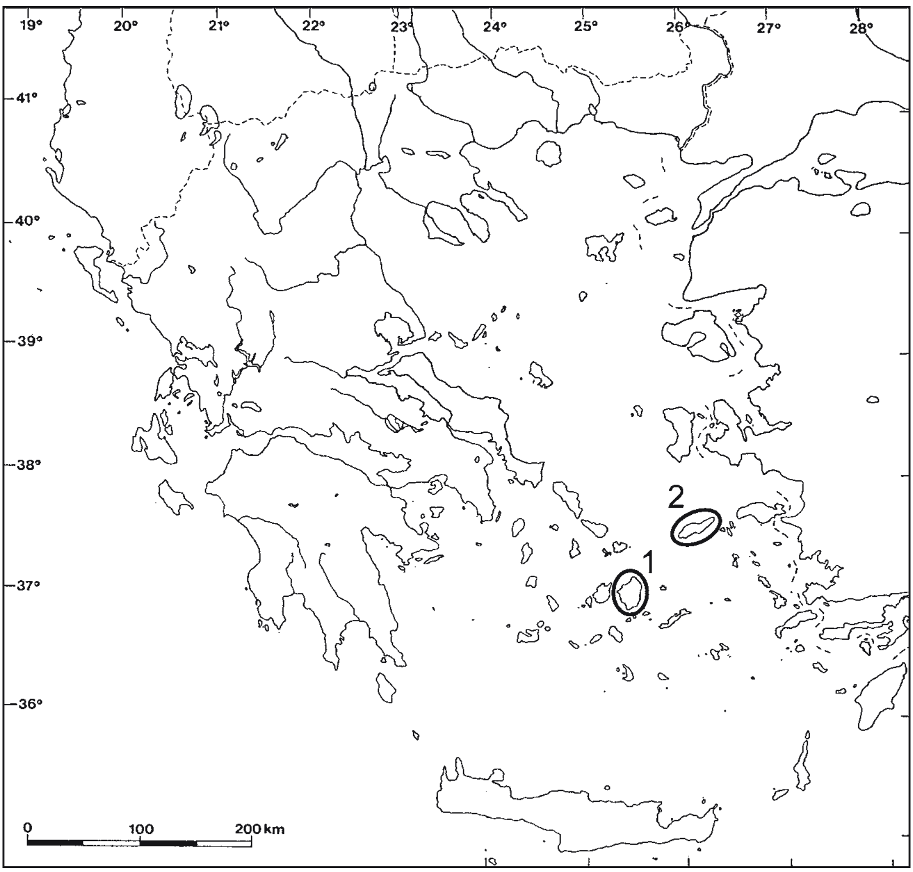

Fig. 1. The Aegean sea with the investigated islands. 1 – Naxos; 2 – Ikaria.

It was surveyed by the first two authors, who made a lichen inventory of all available habitats in 44 localities during two weeks in 2002, including 18 phorophytes (Appendix 1). Some 650 epiphytic records of 147 taxa were gathered (Appendix 2).

Vouchers of the encountered lichens are preserved in B, some in ATHU. A small number of records was omitted because of incomplete identification, usually caused by poor state of the material: 37 from Ikaria and 38 from Naxos.

RESULTS AND DISCUSSION

As Appendix 2 shows, there are 87 taxa shared by both islands. Naxos has in addition 61 species not observed on Ikaria, and Ikaria has 60 species not observed on Naxos. This suggests considerable floristic differences. However, the differentiating species are usually uncommon and may have been missed by accident on one of the islands. When taking into account only the 70 commonest species (3 or more records from Ikaria or over 40 from Naxos), and leaving aside taxa where identification problems might have caused observation differences, 8 taxa remain, which are evidently present on one of the islands and absent from the other (Table 1). It concerns common and widespread species in the Mediterranean, which must have had sufficient nearby diaspore sources to reach the islands. Therefore the only explanation for their uneven distribution seems to be insular isolation. They evidently reached one of the islands, but failed to reach the other, although suitable habitats are surely present.

Another way by which an effect of insular isolation might become visible, is the frequency of means for vegetative reproduction. For long-range dispersal they may be disadvantageous, because the propagules are larger and probably less easily dispersed over wider distances than most ascospores.

An evaluation of the 208 listed taxa demonstrates that 71 or about 34% are vegetatively reproducing by means of soredia, blastidia, granules or isidia. A comparison with a study of a mainland area (Giralt, 1996) shows that only 40 out of 180 species, or 22 %, produce vegetative diaspores. A possible explanation is that the vegetatively reproducing species disperse themselves over long distances by ascospores, and that the vegetative diaspores serve for short-distance dispersal, enabling the species to build a strong population quickly once the first individual has become established. This is indicated by the high number of sorediate species in Table 1.

A remarkable distribution was found for two chemical strains of *Pseudevernia furfuracea* on Ikaria, var. *ceracea* and var. *olivetorina* (Fig. 2). The species is found only above 700 m, and the island has two areas reaching above this level, separated by a pass of about 500 m of altitude. The physodic acid-containing race was found only on the eastern part, and the olivetoric acid-containing race only in the west. Allopatric distribution for the races is unusual, as they have been shown always to be indistinguishable by ecology or distribution so far (e.g. Culberson et al., 1977). It suggests that both areas have been colonized in two separate events and that the populations have been unable to spread across the pass.

Table 1. List of species common on one of the islands Ikaria and Naxos, but absent from the other. Numbers of observations and presence of vegetative reproduction (sor = sorediate) in brackets.

Only observed on Ikaria 5 out of 59 frequent species:	Only observed on Naxos 3 out of 49 frequent species:
Bryoria capillaris (3; sor)	*Caloplaca aegatica* (79)
Hyperphyscia adglutinata (3; sor)	*Collema multipunctatum* (43)
Hypogymnia tubulosa (5; sor)	*Melanelia glabra* (88)
Lecanora expallens (5; sor)	
Pyrrhospora quernea (3; sor)	

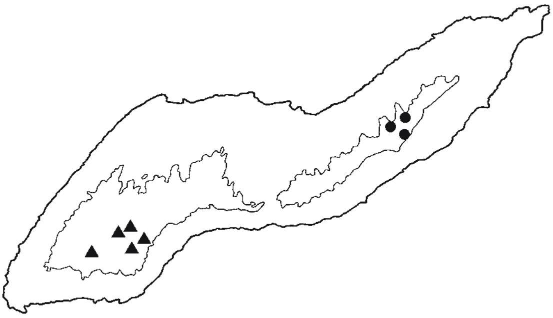

Fig. 2. Distribution of the chemotypes of *Pseudevernia furfuracea* on Ikaria. Dots – physodic acid-strain; triangles – olivetoric acid-strain. Thin line: 500 m contour.

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APPENDIX 1

The investigated phorophytes (27 species); IK = Ikaria; NA = Naxos.

Acer sempervirens – NA; *Alnus glutinosa* – NA; *Arbutus unedo* – IK; *Castanea sativa* – IK, NA; *Ceratonia siliqua* – IK, NA; *Crataegus monogyna* – IK, NA; *Cupressus sempervirens* – IK, NA; *Erica arborea* – NA; *Erica manipuliflora* – IK, NA; *Ficus carica* – IK, NA; *Juglans regia* – NA; *Juniperus oxycedrus* subsp. *macrocarpa* – IK, NA; *Malus domestica* – IK; *Morus nigra* – IK, NA; *Nerium oleander* – NA; *Olea europaea* – IK, NA; *Phillyrea latifolia* – IK; *Pinus brutia* – IK; *Pinus halepensis* – NA; *Pistacia lentiscus* – NA; *Platanus orientalis* – NA; *Prunus cerasifera* – IK; *Pyrus spinosa* – IK, NA; *Quercus coccifera* – IK, NA; *Quercus ilex* – IK, NA; *Quercus ithaburensis* subsp. *macrolepis* - NA; *Quercus pubescens* – IK, NA.

APPENDIX 2

The epiphytic lichen taxa (208), with indication of island (IK = Ikaria, NA = Naxos), number of records in brackets and collecting numbers of selected vouchers.

Acrocordia gemmata (Ach.) A. Massal. – IK (3): 48924, 49152; NA (9): 270.

Agonimia octospora Coppins & P. James – IK (5): 48943.

Anaptychia ciliaris (L.) Körb. – IK (7): 48728, 48854; NA (61): 96.

Anisomeridium biforme (Borrer) R.C. Harris – NA (1): 362.

Arthonia cinnabarina (DC.) Wallr. – IK (1): 49197.

Arthonia ligniaria Hellb. – IK (1): 48942.

Arthonia patellulata Nyl. – IK (1): 48939a (cf.); NA (1).
Bacidia auerswaldii (Stizenb.) Mig. – NA (4).
Bacidia circumspecta (Vain.) Malme – NA (12): 258, 238a.
Bacidia crozalsiana (H. Olivier) Zahlbr. – NA (1): 381.
Bacidia rosella (Pers.) De Not. – IK (2): 49226a; NA (89): 215.
Bacidia rubella (Hoffm.) A. Massal. – IK (5): 48910; NA (26): 250.
Bacidia subincompta (Nyl.) Arnold – NA (12): 238.
Bacidina phacodes (Körb.) Vězda – NA (13): 251.
Bactrospora patellarioides (Nyl.) Almq. – IK (2): 48921; NA (3).
Biatorella ochrophora (Nyl.) Arnold – NA (9): 283.
Bryoria capillaris (Ach.) Brodo & D. Hawksw. – IK (5): 48746, 49179.
Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw. – IK (1): 49006.
Buellia erubescens Arnold – IK (1): 48971a.
Buellia griseovirens (Sm.) Almb. – IK (3): in 48994, in 48810.
Buellia schaereri De Not. – IK (1): 48912.
Calicium glaucellum Ach. – IK (1): 48974.
Calicium salicinum Pers. – NA (1): 372.
Calicium viride Pers. – IK (1): 48987.
Caloplaca aegatica Giralt, Nimis & Poelt – NA (79): 330.
Caloplaca alnetorum Giralt, Nimis & Poelt – NA (112): 227.
Caloplaca cerina (Hedw.) Th. Fr. – IK (2): 49055, 49625; NA (49): 230.
Caloplaca cerinella (Nyl.) Flagey – NA voucher nr. 301.
Caloplaca cerinelloides (Erichsen) Poelt – IK (2): in 48468, in 49015; NA (67): 283.
Caloplaca ferruginea (Huds.) Th. Fr. – IK (2): 49015. 49587; NA (42): 235.
Caloplaca flavocitrina (Nyl.) H. Olivier – IK (2): 49227, in 48910; NA (15): 210.
Caloplaca flavorubescens (Huds.) J.R. Laundon var. quercina (Flagey) Giralt, Nimis & Poelt – IK (10): 47791, 48434.
Caloplaca haematites (St.-Amans) Zwackh – IK (4): 48466, 48471; NA (215): 34.
Caloplaca herbidella (Hue) H. Magn. – IK (4): 48717, 48864; NA (3): 307.
Caloplaca holocarpa (Ach.) A.E. Wade – NA (3).
Caloplaca hungarica H. Magn. – IK (3): 48972, 48997.
Caloplaca lobulata (Flörke) Hellb. – NA (2): 295.
Caloplaca obscurella (Körb.) Th. Fr. – IK (4): 48469; NA (9): 289.
Candelariella aurella (Hoffm.) Zahlbr. – NA (1).
Candelariella reflexa (Nyl.) Lettau – IK (1): 49127.
Candelariella viae-lactae G. Thor & V. Wirth – NA (1).
Candelariella vitellina (Hoffm.) Müll. Arg. – IK (1): 49017; NA (59): 32.
Candelariella xanthostigma (Ach.) Lettau – NA (6): 308.
Catapyrenium psoromoides (Borrer) R. Sant. – NA (4): 354.
Catillaria chalybeia (Borrer) A. Massal. – IK (5): 49231a, 48398; NA (44): 105.
Catillaria mediterranea Hafellner – NA (1): in 291.
Catillaria nigroclavata (Nyl.) Schuler – IK (3): 49204.
Catillaria praedicta Tretiach & Hafellner – IK (2): 47790, in 49313; NA (24): 314.
Catinaria atropurpurea (Schaer.) Vězda & Poelt – IK (1): 48939; NA (6): 297.
Cetraria aculeata (Schreb.) Fr. – NA (1).
Cetraria chlorophylla (Willd.) Vain. – IK (4): 48744, 48999.
Cladonia chlorophaea (Sommerf.) Spreng. – IK (2): 48806, 48857a; NA (6): 394.
Cladonia fimbriata (L.) Fr. – IK (1): 49121.
Cladonia foliacea (Huds.) Willd. – NA (2).
Cladonia glauca Flörke – NA (2).
Cladonia pocillum (Ach.) O.J. Richter – NA (9).
Cladonia pseudopityrea Vain. – IK (1): 48979; NA (4): 365.
Cladonia pyxidata (L.) Hoffm. – IK (9): 48718, 48805; NA (16): 12.
Cladonia rangiformis Hoffm. – NA (5): 107, 107a.
Collema flaccidum (Ach.) Ach. – NA (10): 306.
Collema furfuraceum (Arnold) Du Rietz – IK (2): 48927; NA (5): 392.
Collema multipunctatum Degel. – NA (43): 202.
Collema nigrescens (Huds.) DC. – IK (6): 48928, 49030; NA (157): 204.
Degelia atlantica (Degel.) P.M. Jørg. & P. James – IK (1): 49027.
Degelia plumbea (Lightf.) P.M. Jørg. & P. James – IK (2): 49014; NA (2): 159.
Dimerella pineti (Ach.) Vězda – IK (1): 48926.
Diploicia canescens (Dicks.) A. Massal. var. canescens – IK (2): in 48922, in 48900; NA (5): 169.

Diploschistes muscorum (Scop.) R. Sant. – IK (1): 49133.

Diplotomma alboatrum (Hoffm.) Flot. – IK (1): in 48467; NA (55): 256.

Diplotomma pulverulentum (Anzi) D. Hawksw. – NA (1).

Dirina ceratoniae (Ach.) Fr. – IK (1): in 47792.

Evernia prunastri (L.) Ach. – IK (16): 48729, 48743; NA (71): 249.

Fuscopannaria olivacea (P.M. Jørg.) P.M. Jørg. – IK (6): 48865, 48930; NA (45): 35.

Gyalecta truncigena (Ach.) Hepp – IK (1): 49232b; NA (1).

Gyalideopsis anastomosans P. James & Vězda – NA (1).

Hafellia disciformis (Fr.) Marbach & H. Mayrhofer – IK (1): 49190a.

Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt – IK (4): 48426, 48436.

Hypogymnia farinacea Zopf – IK (1): 49003; NA (1): 390.

Hypogymnia physodes (L.) Nyl. – IK (5): 48730, 48966; NA (3): 369.

Hypogymnia tubulosa (Schaer.) Hav. – IK (18): 48715, 48722.

Lecania cyrtella (Ach.) Th. Fr. – NA (4): 250.

Lecania koerberiana J. Lahm – NA (12): 293.

Lecania naegelii (Hepp) Diederich & van den Boom – IK (4): 49132a, 49312; NA (39): 255.

Lecanora allophana Nyl. – NA (1): 225.

Lecanora argentata (Ach.) Malme – NA (399): 33.

Lecanora carpinea (L.) Vain. – NA (12): 261.

Lecanora chlarotera Nyl. – IK (15): 48467, 48473 (4 not chemically tested); NA (400): 207.

Lecanora dispersa (Pers.) Sommerf. – IK (5): 49311.

Lecanora expallens Ach. – IK (14): 48913, 49194 (7 uncertain).

Lecanora hageni (Ach.) Ach. – IK (1): in 49194; NA (104): 268, 245.

Lecanora horiza (Ach.) Linds. – IK (10): 47788, 48433.

Lecanora hybocarpa (Tuck.) Brodo – IK (6): 48429, 48872.

Lecanora leuckertiana Zedda – IK (1): 48906.

Lecanora sambuci (Pers.) Nyl. – NA (1).

Lecanora strobilina (Spreng.) Kieff. – NA (34): 210.

Lecanora symmicta (Ach.) Ach. – IK (4): 48973, 49191; NA (12): 226.

Lecidella elaeochroma (Ach.) M. Choisy – IK (26): 48428, 48470; NA (592): 34-1, 34-2, 219.

Lepraria nivalis J.R. Laundon – IK (7): 48719, 48808; NA (49): 213.

Lepraria vouauxii (Hue) Kukwa – IK (1): 48925.

Leprocaulon microscopicum (Vill.) Gams – IK (5): 48944, 49131; NA (15): 56.

Leptogium brebissonii Mont. – IK (1): 48852.

Leptogium cyanescens (Rabenh.) Körb. – NA (2): 305.

Leptogium gelatinosum (With.) J.R. Laundon – NA (5): 378.

Leptogium tenuissimum (Dicks.) Körb. – NA (2): 386.

Leptogium teretiusculum (Wallr.) Arnold – IK (2): 48875, in 49146; NA (27): 269, 388.

Lobaria amplissima (Scop.) Forssell – IK (2): 49035, 49154.

Lobaria pulmonaria (L.) Hoffm. – IK (4): 48848, 49153; NA (2): 364.

Lobaria scrobiculata (Scop.) Nyl. – IK (1): 48853.

Melanelia glabra (Schaer.) Essl. – NA (88): 4.

Melanelia glabratula (Lamy) Essl. – NA (24): 205.

Melanelia subaurifera (Nyl.) Essl. – IK (1): 48742.

Micarea lithinella (Nyl.) Nyl. – IK (1): 49159a.

Micarea prasina Fr. – IK (2): 48953, in 48949.

Mycocalicium subtile (Pers.) Szatala – NA (3): 340.

Nephroma laevigatum Ach. – IK (5): 48860, 48946; NA (3): 155.

Normandina pulchella (Borrer) Nyl. – IK (2): 48850, in 49131; NA (1): 368.

Ochrolechia androgyna (Hoffm.) Arnold – IK (6): 48868, 48983; NA (97): 216, 277.

Ochrolechia balcanica Verseghy – NA (19): 252.

Ochrolechia parella (L.) A. Massal. – IK (10): 48724, 48881; NA (140): 229.

Ochrolechia subviridis (Høeg) Erichsen – IK (9): 48726, 48809.

Ochrolechia turneri (Sm.) Hasselrot – IK (1): 49602a.

Opegrapha atra Pers. – NA (9): 350, 352.

Opegrapha celtidicola (Jatta) Jatta – NA (10): 346.

Opegrapha culmigena Lib. – NA (10).

Opegrapha niveoatra (Borrer) J.R. Laundon – NA (1): 273.

Opegrapha ochrocincta Werner – NA (3): 347.

Opegrapha varia Pers. – IK (1): 49229; NA (41): 231.

Pachyphiale carneola (Ach.) Arnold – IK (3): 48871, 48940.

Pannaria rubiginosa (Ach.) Bory – IK (1): 48851.
Parmelia saxatilis (L.) Ach. – IK (15): 48716, 48721; NA (16): 234.
Parmelia sulcata Taylor – IK (3): 48803, 48948; NA (28): 214.
Parmelina pastillifera (Harm.) Hale – IK (3): 48720, 48862; NA (12).
Parmelina quercina (Willd.) Hale – IK (1): 49591; NA (41): 235.
Parmelina tiliacea (Hoffm.) Hale – IK (8): 49592; NA (334): 2, in 325.
Parmotrema chinense (Osbeck) Hale & Ahti – IK (13): 48733, 48739; NA (16): 235.
Peltigera collina (Ach.) Schrad. – IK (1): 49124.
Peltigera hymenina (Ach.) Delise – NA: 362.
Peltigera neckeri Müll. Arg. – NA (2): 362.
Pertusaria albescens (Huds.) M. Choisy & Werner – IK (16): 48727, 48735; NA (175): 10, 162, 300.
Pertusaria amara (Ach.) Nyl. – IK (1): 48810.
Pertusaria coccodes (Ach.) Nyl. – IK (6): 48879, 48932; NA (6): 260.
Pertusaria dalmatica Erichsen – NA (16): 240.
Pertusaria graeca Erichsen – IK (12): 48723, 48807; NA (23): 124.
Pertusaria hemisphaerica (Flörke) Erichsen – IK (1): 49434; NA voucher nr. 216.
Pertusaria heterochroa (Müll. Arg.) Erichsen – IK (3): in 48736, 48917.
Pertusaria hymenea (Ach.) Schaer. – IK (9): 48423, 48878; NA (238).
Pertusaria leioplaca DC. – NA (32).
Pertusaria ophthalmiza (Nyl.) Nyl. – IK (1): 49436.
Pertusaria pertusa (Weigel) Tuck. – IK (18): 48725, 48736; NA (187): 93.
Pertusaria rhodiensis Erichsen – NA (22): 303.
Pertusaria werneriana Boqueras – IK (2): 48427, 49201.
Phaeophyscia orbicularis (Neck.) Moberg – IK (5): 49316, 49601; NA (83): 271.
Phlyctis agelaea (Ach.) Flot. – IK (3): 48957, 49202, in 49197; NA (28): 496.
Phlyctis argena (Spreng.) Flot. – IK (15): 48424, 48880; NA (96): 92.
Physcia adscendens (Fr.) H. Olivier – IK (6): 48465, 48919; NA (309): 97.
Physcia aipolea (Humb.) Fürnr. – IK (1): 49599; NA (150): 215.
Physcia biziana (A. Massal.) Zahlbr. var. biziana – IK (8): 48464, 48908; NA (260): 7.
Physcia biziana (A. Massal.) Zahlbr. var. leptophylla Vězda – IK (1): 48903; NA (10): 37.
Physcia leptalea (Ach.) DC. – IK (6): 49040, 49119; NA (334): 122, 278, 133.
Physcia tenella (Scop.) DC. – IK (11): 48425, 48902; NA (101): 158.
Physconia enteroxantha (Nyl.) Poelt – IK (2): 49237a, in 48425; NA (32): 36.
Physconia grisea (Lam.) Poelt – IK (1): 49237; NA (18): 332.
Physconia perisidiosa (Erichsen) Moberg – IK (4): 48421, 49012; NA (31): 212.
Physconia servitii (Nádv.) Poelt – IK (9): 48422, 48437; NA voucher nr. in 215, in 224.
Physconia subpulverulenta (Szatala) Poelt – IK (6): 48861, 48963; NA voucher nr. 224.
Physconia venusta (Ach.) Poelt – IK (1): 49011; NA (83): 3, in 224.
Placynthiella icmalea (Ach.) Coppins & P. James – IK (2): 48975.
Placynthiella uliginosa (Schrad.) Coppins & P. James – IK (1): 48991.
Platismatia glauca (L.) W.L. Culb. & C.F. Culb. – IK (1) obs. Pirintsos; NA (2): 229.
Pleurosticta acetabulum (Neck.) Elix & Lumbsch – IK (2): 48968, in 48950; NA (33): 228.
Porina aenea (Wallr.) Zahlbr. – NA (3): 263.
Pseudevernia furfuracea (L.) Zopf var. ceratea (Ach.) D. Hawksw. – IK (3): 48745.
Pseudevernia furfuracea (L.) Zopf var. furfuracea – IK (5): 49000; NA (2): 231.
Pyrenula chlorospila Arnold – IK (1): 49232a; NA (1): 364.
Pyrrhospora lusitanica (Räsänen) Hafellner – IK (1): in 49188.
Pyrrhospora quernea (Dicks.) Körb. – IK (8): 48984, 49165.
Ramalina canariensis J. Steiner – IK (2): 48431, in 48912; NA (76): 101, 73.
Ramalina farinacea (L.) Ach. – IK (3): 48430, 48858; NA (51): 121.
Ramalina fastigiata (Pers.) Ach. – IK (18): 48432, 48438; NA (173): 100.
Ramalina fraxinea (L.) Ach. var. calicariformis (Nyl.) Hue – IK (1): 48945; NA (37): 99.
Ramalina fraxinea (L.) Ach. var. fraxinea – NA (31): 98.
Rinodina boleana Giralt & H. Mayrhofer – NA (4): 341.
Rinodina capensis Hampe – IK (7): 49308, 49584; NA (13): 289.
Rinodina colobina (Ach.) Th. Fr. – NA (2): 393.
Rinodina nimisii Giralt & H. Mayrhofer – NA (1): 333.

Rinodina oleae Bagl. – IK (1): in 48716; NA (126): 348.
Rinodina pyrina (Ach.) Arnold – NA (8): 275.
Rinodina septentrionalis Malme – NA (46): 281.
Schismatomma decolorans (Sm.) Clauzade & Vězda – IK (2): 48920.
Scoliciosporum chlorococcum (Stenh.) Vězda – IK (2): 48996, 49203.
Scoliciosporum sarothamni (Vain.) Vězda – IK (2): 49167, in 49190; NA (29): in 333.
Staurolemma omphalarioides (Anzi) P.M. Jørg. & Henssen – IK (2): 49031, 49236; NA (2): 329.
Strigula mediterranea Etayo – NA (4): 321.
Teloschistes flavicans (L.) Norman – IK (1): 48855.
Tephromela atra (Huds.) Hafellner – IK (9): 48955, 49143; NA (149): 8.
Thelenella modesta (Nyl.) Nyl. – NA (4): 385.
Thelopsis isiaca Stizenb. – IK (1): 47792; NA (1): 343.
Tornabea scutellifera (With.) J.R. Laundon – NA (8): 228.
Trapeliopsis granulosa (Hoffm.) Lumbsch – IK (1): in 49188.
Usnea articulata (L.) Hoffm. – IK (3): 48747, 48845; NA (3): 230-1.
Usnea cornuta Körb. – IK (5): 49177, 49186, 49430; NA (5): 230-2.
Usnea esperantina P. Clerc – IK (2): 49432a, in 48730.
Usnea flammea Stirt. – IK (1): 48748; NA (2).
Usnea glabrescens (Vain.) Vain. – IK (2): 48749, 49185.
Usnea scabrata Nyl. – IK (1): 48849.
Usnea wirthii P. Clerc – IK (2): 49428, in 49186.
Waynea stoechadiana (Abbassi Maaf & Cl. Roux) Cl. Roux & P. Clerc – IK (1): 48905.
Xanthoria parietina (L.) Th. Fr. – IK (13): 48435, 49232; NA (488): 1.

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Lichens from Golestan National Park (Iran)

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Abstract: 41 lichen species belonging to 28 genera are reported from Golestan National Park (Iran). 3 genera and 11 species are new to the lichen flora of Iran.

Kokkuvõte: Golestani Rahvuspargi (Iraan) samblikud.

Esitatakse Golestani Rahvuspargi (Iraan) samblike nimekiri, mis sisaldab 41 liiki 28 perekonnast, koos leiuandmetega. 3 perekonda ja 11 liiki on uued Iraani samblikeflooras.

INTRODUCTION

This paper is a contribution to a better knowledge of the lichen flora of Iran. It reports several species which were found in the Golestan National Park (province of Golestan). Golestan National Park is one of the UNESCO's designated reserves and the first Iranian national park. The area, with 91.895 hectares, is located in the northeast of Iran between three provinces; Golestan, Khorassan, and Semnan. The most outstanding feature of the area lies in its extremely different climatic conditions, which vary from temperate subhumid in the west to cold-arid and cold-semiarid in the south and the east of the park, with an annual precipitation ranging from ca 150 to ca 1000 mm. The complex of geomorphologic, geologic, hydrologic, and climatic conditions provide a wide range of biotopes leading to high biodiversity.

Although, there are some reports on the lichen flora of northern Iran (Buhse, 1860; Müller, 1892; Steiner, 1896, 1910, 1916; Szatala, 1940, 1957; Oxner, 1946; Weber, 1965; Riedl, 1979), the only records from Golestan are those of a few species cited by Hertel (2001) and Seaward et al (2004). The present paper is the first devoted to a better knowledge of the poorly known lichen flora of the Park.

MATERIAL AND METHODS

The samples were collected between 20–21 June 2003 in three different zones in the southeast of Golestan National Park: Almeh, Golzar, and Sharleg (Fig. 1).

The samples were numbered, and stored in paper envelopes. A stereomicroscope, light microscope, and usual colour tests were used in the identification. The main reference texts were: Clauzade & Roux (1985), Magnusson (1929, 1940), Nimis (1993), Orange *et al* (2001), Timdal (1991), Wirth (1987). The samples are kept in the private herbarium of Mohammad Sohrabi (hb. M. Sohrabi), all duplicates kept in the TSB herbarium. New records are marked with *.

LIST OF TAXA

Acarospora cervina A. Massal. – Golestan National Park, Almeh zone, 850 m; saxicolous. 20 June 2003, Sohrabi 2507.

*Acarospora laqueata Stizenb. – Golestan National Park, Sharleg zone, 750 m; saxicolous. 21 June 2003, Sohrabi 2592.

Anaptychia ciliaris (L.) Körb. ex A. Massal. – Golestan National Park, Golzar camping, 600 m; corticolous on *Quercus* sp. 21 June 2003, Sohrabi 2479.

Anaptychia crinalis (Schrad.) Vězda – Golestan National Park, Golzar camping, 600 m; corticolous on *Quercus* sp. 21 June 2003, Sohrabi 2481.

Anaptychia ulothrichoides (Vain.) Vain. – Golestan National Park, Sharleg zone, 750 m; corticolous on *Quercus* sp. 21 June 2003, Sohrabi 2596.

*Aspicilia emiliae Aggr. – Golestan National Park, Golzar camping, 600 m; saxicolous. 21 June 2003, Sohrabi 2497.

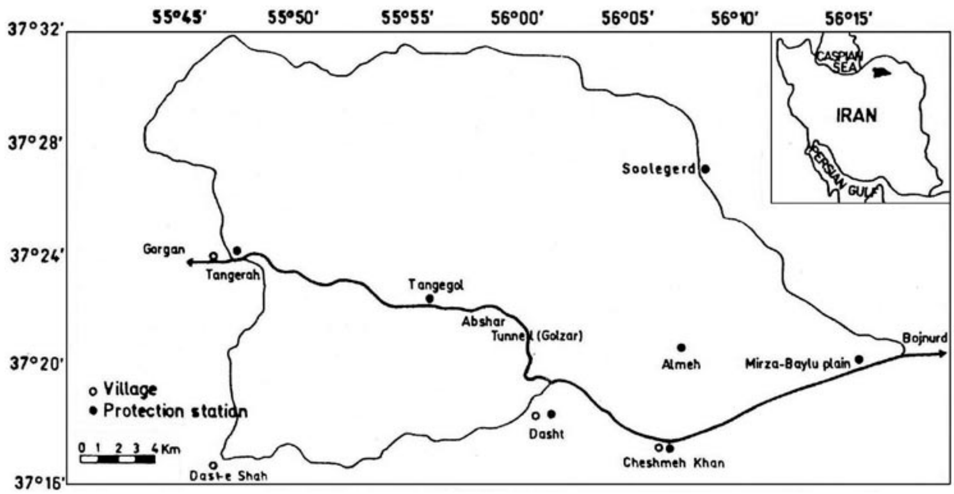

Fig. 1. Location of Golestan National Park.

*Biatorella ochrophora (Nyl.) Arnold – Golestan National Park, Golzar camping, 600 m; corticolous on *Pyrus* sp. 21 June 2003, Sohrabi 2484.

Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr. – Golestan National Park, Golzar camping, 600 m; lignicolous, on *Quercus* sp. 21 June 2003, Sohrabi 2478.

Caloplaca persica (J. Steiner) M. Steiner & Poelt – Golestan National Park, Almeh zone, 850 m; lignicolous, on *Pyrus* sp. 20 June 2003, Sohrabi 2500.

Candelariella vitellina (Hoffm.) Müll. Arg. – Golestan National Park, Almeh zone, 850 m.; saxicolous, lignicolous on *Juniperus*. 20 June 2003, Sohrabi 2507.

Cladonia pocillum (Ach.) Grognot – Golestan National Park, Sharleg zone, 750 m; terricolous. 21 June 2003, Sohrabi 2584.

Collema auriforme (With.) Coppins & J.R. Laundon – Golestan National Park, Almeh zone, 850 m; saxicolous, or muscicolous. 20 June 2003, Sohrabi 2525.

Collema fuscovirens (With.) J.R. Laundon – Golestan National Park, Almeh zone, 850 m; saxicolous or on calcareous rock under trees. 20 June 2003, Sohrabi 2525

Collema fuscovirens (With.) J.R. Laundon – Golestan National Park, Sharleg zone, 750 m; saxicolous or on calcareous rock under trees. 21 June 2003, Sohrabi 2578.

Diploschistes diacapsis (Ach.) Lumbsch – Golestan National Park, Sharleg zone, 750 m; terricolous. 21 June 2003, Sohrabi 2582.

Diplotomma venustum Körb. – Golestan National Park, Sharleg zone, 750 m; saxicolous. 21 June 2003, Sohrabi 2583.

Evernia prunastri (L.) Ach. – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2495.

Lecanora flotowiana Körb. – Golestan National Park, Almeh zone, 850 m; lignicolous, on *Quercus* sp. 20 June 2003, Sohrabi 2499.

Lecanora hagenii (Ach.) Ach. – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2486.

Lecanora muralis (Schreb.) Rabenh. – Golestan National Park, Sharleg zone, 750 m; saxicolous, on calcareous rock. 21 June 2003, Sohrabi 2589.

Melanelia glabra (Schaer.) Nyl. – Golestan National Park, Golzar camping, 600 m. corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2483.

Melanelia subargentifera (Nyl.) Essl. – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2487.

Parmelina tiliacea (Hoffm.) Hale – Golestan National Park, Golzar camping, 600 m;

corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2493.

*Peccania terricola H. Magn. – Golestan National Park, Almeh zone, 850 m; terricolous, on soil and in crevices of rocks. 20 June 2003, Sohrabi 2506, 2529.

Peltigera rufescens (Weiss) Humb. – Golestan National Park, Sharleg zone, 750 m; terricolous. 21 June 2003, Sohrabi 2586.

*Pertusaria albescens (Huds.) M.Choisy & Werner – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2482, 2491.

*Phlyctis argena (Spreng.) Flot. – Golestan National Park, Golzar camping, 600 m. corticolous, on *Acer* sp. 21 June 2003, Sohrabi 2492.

Physcia adscendens (Fr.) H. Olivier – Golestan National Park, Almeh zone, 850 m; corticolous, on *Quercus* sp. 20 June 2003, Sohrabi 2500.

Physcia tenella (Scop.) DC. – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2485.

Physcia tribacia (Ach.) Nyl. – Golestan National Park, Almeh zone, 850 m; corticolous, on *Quercus* sp. 20 June 2003, Sohrabi 2504.

Physconia grisea (Lam.) Poelt – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2480.

Physconia perisidiosa (Erichsen) Moberg – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2481.

*Pleurosticta acetabulum (Neck.) Elix & Lumbsch – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2484.

*Ramalina fraxinea (L.) Ach. – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2478, 2490.

Ramalina pollinaria (Westr.) Ach. – Golestan National Park, Golzar camping, 600 m; corticolous, on *Quercus* sp. 21 June 2003, Sohrabi 2494.

Rhizocarpon geographicum (L.) DC. – Golestan National Park, Sharleg zone, 750 m; saxicolous. 21 June 2003, Sohrabi 2579.

Rhizoplaca chrysoleuca (Sm.) Zopf – Golestan National Park, Almeh zone, 850 m; saxicolous. 20 June 2003, Sohrabi 2521.

Toninia cinereovirens (Schaerer) A. Massal. – Golestan National Park, Sharleg zone, 750 m. Saxicolous, in fissures of rocks. 21 June 2003, Sohrabi 2580.

*Toninia taurica (Szatala) Oxner – Golestan National Park, Sharleg zone, 750 m; saxicolous, in fissures of rocks. 21 June 2003, Sohrabi 2594.

*Verrucaria marmorea (Scop.) Arnold – Golestan National Park, Sharleg zone, 750 m; saxicolous. 21 June 2003, Sohrabi 2595.

*Xanthoria fulva (Hoffm.) Poelt & Petutschnig – Golestan National Park, Golzar camping, 600 m; corticolous, on *Acer* sp. 21 June 2003, Sohrabi 2486, 2488.

ACKNOWLEDGEMENTS

I am most grateful to Prof. P. L. Nimis, (Trieste, Italy) for confirmation of my identifications. I especially want to thank Prof. Mansouri and Mis. Shimi (Center of International Research and Collaboration – ISMO) and Dr. Ali Tavili (Teheran University) and all people who helped me in various ways during my research in different parts of Iran. This study was financially supported by ISMO.

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Chemical constituents from lichens for pharmaceutical and industrial uses

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Abstract: Some pharmaceutical and industrial uses of lichen metabolites from both cultured isolates and the thalli of lichens are reported. 5-propylresorcinol and bis(2,4-dihydroxy-5-propylphenyl)methane are the anti-tyrosinase active constituents of mixture of *Protousnea* spp. Since tyrosinase is an enzyme producing melanin pigments, the anti-tyrosinase activity might be effective in whitening the facial skin. Both the activity and cytotoxicity of some synthetic resorcinol derivatives were tested. Furthermore, the inhibitory activities of confluentic acid and its synthetic analogues on liver monoamine oxidases were screened. New compounds, arthoniafurone A and B, and cinnabarinol, were obtained from the cultured isolate of *Arthonia cinnabarina*. These novel metabolites showed cytotoxicity against U937 human leukemia cells. Other novel substances panaefluoroline A, B, and C were obtained from the medium where cultured isolate of *Amygdalaria panaeola* was grown. These substances are significant regarding their structures and also their fluorescent characters, which were stable both in water and in organic solvents over one year. The metabolites of cultured mycobionts may be one of new natural resources for developing of fluorescent agents.

Kokkuvõte: Samblikuained farmaatsia ja tööstuse tarbeks.

Tutvustatakse nii samblikutallustest eraldatud samblikuainete kui söötmel kasvatatud mükobiontidest saadud ainete kasutusvõimalusi farmaatsias ja tööstuses. 5-propüülresorsinool ja bis(2,4-dihüdroksü-5-propüülfenüül)metaan on türosinaasivastase toimega ained perekonna *Protousnea* liikides. Kuna türosinaas on ensüüm, mis katalüüsib melaniinsete pigmentide teket, siis türosinaasivastase toimega ained võiksid olla kasulikud näonaha pleegitamisel. Kontrolliti veel mõnede sünteetiliste resorsinooli derivaatide bioaktiivsust ja tsütotoksilisust. Uuriti konfluenthappe ja selle sünteetiliste analoogide inhibeerivaid omadusi maksa monoamiini oksidaaside suhtes. *Arthonia cinnabarina* kultuurist eraldati uued ühendid arthoniafuroon A ja B ning tsinnabarinool. Need ained ilmutasid tsütotoksilisust inimese leukeemia U937 rakkude suhtes. Söötmest, millel oli kasvatatud *Amygdalaria panaeola* kultuuri, eraldati veel kolm uut ühendit – panaefluoroliin A, B, ja C. Need ained on tähelepanuväärsed nii oma struktuuri ja kui ka fluorestseeruvate omaduste poolest, mis säilusid nii vees kui orgaanilistes lahustites üle aasta. Kultuuris kasvatatud mükobiontidest eraldatavad ained võivad olla üheks uute looduslike fluorestseeruvate ühendite allikaks.

INTRODUCTION

Lichens, symbiotic associations of algal and fungal partners, produce many characteristic phenolic compounds such as depsides, depsidones, benzoquinones, naphthquinones, anthraquinones, xanthones, biphenyls and dibenzofuranes (Huneck & Yoshimura, 1996), which are considered to be biosynthesized by the mycobionts, fungal partners (Culberson, 1969). We are interested in primary and secondary metabolites of lichens and for this reason we performed both structural elucidation of novel metabolites and screened their possible applications in the pharmaceutical field (Takahashi et al., 1974, 1979, 1981; Watanabe et al., 1986; Kinoshita et al., 1993, 1994a, 1994b, 2002, 2003; Matubara et al., 1994, 1997, 1998, 1999; Yamamoto et al., 2002b). As a result of our search of secondary metabolites in cultured lichen mycobionts, we surprisingly isolated some novel metabolites, which had never been found in intact lichen thalli from nature. New secondary compounds were recently found in cultured isolates of lichens under stress conditions, for example under osmotic stress – if 10% sucrose was supplemented to the nutrient medium (Kon et al., 1997; Miyagawa et al., 1993, 1994, 1997; Tanahashi et al., 1997; Yamamoto et al., 1996).

A major objective of the present study is to determine the chemical structures of hitherto unknown secondary lichen compounds isolated from aposymbiotically grown lichen fungi (Yamamoto et al., 1996, 2002a, 2002b; Kinoshita et al., 2003). A further aim of these investigations is to compare past and new reports about pharmaceutical and industrial uses of lichen metabolites from both cultures and the thalli.

MATERIAL AND METHODS

Plant materials

Protousnea spp. mixture [*P. dusenii* (DR.) Krog, *P. malacea* (Stirt.) Krog and *P. magellanica* (Mont.) Krog] was collected in Tierra del Fuego in 1990; the specimens are kept in Department of Biological Production Science, Faculty of Bioresource Sciences, Akita Prefectural University, Japan. *Arthonia cinnabarina* (DC.) Wallr. was collected in 1995 in Japan; the specimen is in the harbarium of the Natural History Museum and Institute, Chiba, Japan. *Amygdalaria panaeola* (Ach.) Hertel & Brodo was collected in Finland in 1990; the specimen is in Hattori Botanical Laboratory, Kochi Branch, Kochi, Japan.

All lichens were identified by Dr I. Yoshimura, Hattori Botanical Laboratory, Kochi Branch, Kochi, Japan.

Chemical material

Isolated confluentic acid used by the authors of this paper is from Asahina Collection which is stored in the Department of Pharmacognosy and Phytochemistry, Meiji Pharmaceutical University, Japan.

Methods

The inhibition assay on MAO-A and MAO-B was performed according to the method reported by Kagaya et al. 1996.

RESULTS

In search of new biologically active compounds, we found some secondary metabolites of lichens that could be potential sources for pharmaceutical and industrial uses.

PHARMACEUTICAL USES

Anti-tyrosinase active substances

Natives in the island of Tierra del Fuego have used the extract of lichen mixtures of *Protousnea* spp. as a skin conditioner to whiten the facial skin. We reported earlier that the anti-tyrosinase active constituents of those are 5-propylresorcinol (Fig. 1, substance 1) and bis(2,4- dihydroxy-5-propylphenyl)methane (Fig. 1, substance 2) (Kinoshita et al., 1994a). Since tyrosinase is an enzyme producing melanin pigments, the anti-tyrosinase activity might be effective in whitening the facial skin.

In an additional study to find out more details about the structure-activity interrelationship, some synthetic resorcinol derivatives were prepared. The elongation of the alkyl chain of resorcinol from methyl to nonyl showed an increase of the activity. Moreover, 4-alkylresorcinols, non-natural and synthetic analogues, and also arbutin (Fig. 1, substance 3), which have been used as a component of cosmetics to cause whitening effects of the skin, were prepared and tested for their biological activities. Our experiments demonstrated that the activity of 4-alkylresorcinols, for example 4-methylresorcinol (substance 4), was stronger than those of 5-alkylresorcinols (5-methylresorcinol, substance 5) and also of a natural diphenylmethane, bis(2,4-dihydroxy-5-methylphenyl)methane (substance 6) (Matsubara et al., 1997) (Figs 1–2).

In a new test series we screened both the activity and cytotoxicity of those compounds. As a conclusion, 4-alkylresorcinols showed inhibition of melanin production and cytotoxicity effects were visible in cultured B-16 mouse melanoma cells at concentrations from 10 mM to 1.2 mM. Among the tested compounds, substance 4 showed a comparatively stronger activity with a slightly weaker cytotoxicity at 80 μM (Matsubara et al., 1998). It was noticed that the difference in the position and the length of the alkyl group in resorcinol derivatives affected both the anti-tyrosinase activity and the cytotoxicity. Such findings may be useful for understanding the chemical background of recorcinol derived compounds and their applications in skin care.

Monoamine oxidase (MAO) inhibitors

MAO is located in the outer mitochondrial membrane and exists in two forms, type A and B

(MAO-A and MAO-B). Endo et al. (1994) reported that confluentic acid, isolated from a Brazilian plant, showed a selective inhibitory effect on MAO-B. Confluentic acid (Fig. 3, substance 7) was first isolated form the lichen, *Lecidea confluens* (Weber) Ach. and is a depside comprising two alkylresorcinolic acid units. We examined the inhibitory activities of some lichen compounds and their synthetic analogues on liver MAO to determine the role of confluentic acid (Kinoshita et al., 2002). We have since found that the synthetic 6-alkyl-α-resorcinolic acids had no activity, but 5-heptyl-3-methoxyphenol showed activity (56%) at a concentration of 2.5 X 10^{-5} g/ml. These findings indicated that the presence of a carboxylic acid group was not essential for the biological activity.

Mouse liver MAO is a mixture of MAO-A and B. We have now tested confluentic acid and the synthetic compounds 1-(2,4-dihydroxyphenyl)-1-heptanone (substance 8) and 1-(4-hydroxy-2-methoxyphenyl)-1-heptanone (substance 9) for their activity on MAO-A and MAO-B, respectively (Fig. 3). It has previously been reported that MAO-B inhibitors can be used effectively in combination with L-DOPA (L-dihydroxyphenylalanine) for the treatment of Parkinson's disease. The inhibitory activity of compound 8 on MAO-B was found to be much stronger than that of compound 9. Thus methylation of *ortho*-phenolic group of 8 decreased its activity. Among various synthetic analogues the heptanone 8 showed the strongest and most selective activity against MAO-A and B, and it had almost the same potency as natural confluentic acid (Table 1).

Cytotoxicity against cancer cells

Some aposymbiotically grown lichen mycobionts (cultured without the algal partner) can synthesize novel and extraordinary chemical constituents. We successfully cultured the isolate of *Arthonia cinnabarina* derived from its spores. New compounds, arthoniafurone A (substance 10) and B (substance 11), and cinnabarinol (substance 12), were obtained from the culture (Fig. 4) (Yamamoto et al., 2002b). These novel metabolites showed cytotoxicity against U937 human leukemia cells. The concentration of 50% effective dose of substance 10 was <30μM, that of substance 11 was <30μM, and of 12 was 25μM.

INDUSTRIAL USES

Cultured isolate of *Amygdalaria panaeola* was obtained from the thallus fragment. The medium, on which the mycobiont grew, showed yellowish green fluorescence under a fluorescent lamp. Novel fluorescent substances, panaefluoroline A (13), B (14), and C (15), were first isolated to determine their structures (Fig. 5) (Kinoshita et al., 2003).

As mentioned already, these fluorescent pigments could not be detected in the natural lichen thallus by HPLC analysis. Moreover, polyketides like depsides or depsidones were not isolated and could not be detected in the culture medium by TLC. However, fluorescent compounds were isolated from the medium of cultured isolate. These results suggest that the biosynthetic pathway of the cultured mycobiont, *Amygdalaria panaeola*, may be changed by stress under variable culture conditions.

Anyway, the obtained novel compounds are significant regarding their structures and also their fluorescent characters, which were stable both in water and in organic solvents over one year. The metabolites of cultured mycobionts may be one of new natural resources for developing fluorescent agents.

AKNOWLEDGEMENTS

We wish to thank Emeritus Professor of Tokyo University, Shoji Shibata, for his encouragement and suggestion.

Table 1 Inhibition of monoamine oxidases (MAO-A and MAO-B) by confluentic acid and its analogues.

	Confluentic acid (7)	1-(2,4-dihydroxy-phenyl)-1-heptanone (8)	1-(4-hydroxy-2-methoxy-phenyl)-1-heptanone (9)
MAO-A(IC_{50}, μM)	25	70	>100
MAO-B(IC_{50}, μM)	1.4	2.4	16
Ratio (A/B)	18	29	>6.3

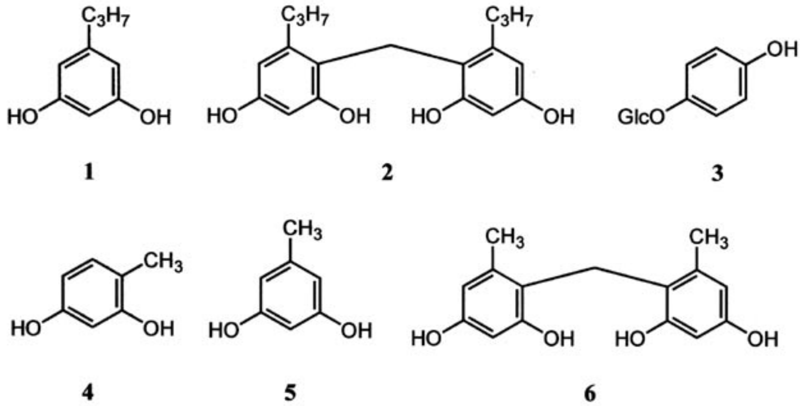


Fig. 1. Structures of 5-propylresorcinol (1), bis(2,4-dihydroxy-6-propylphenyl)-methane (2), arbutin (3), 4-methylresorcinol (4), 5-methylresorcinol (5) and bis(2,4-dihydroxy-6-methylphenyl)methane (6).

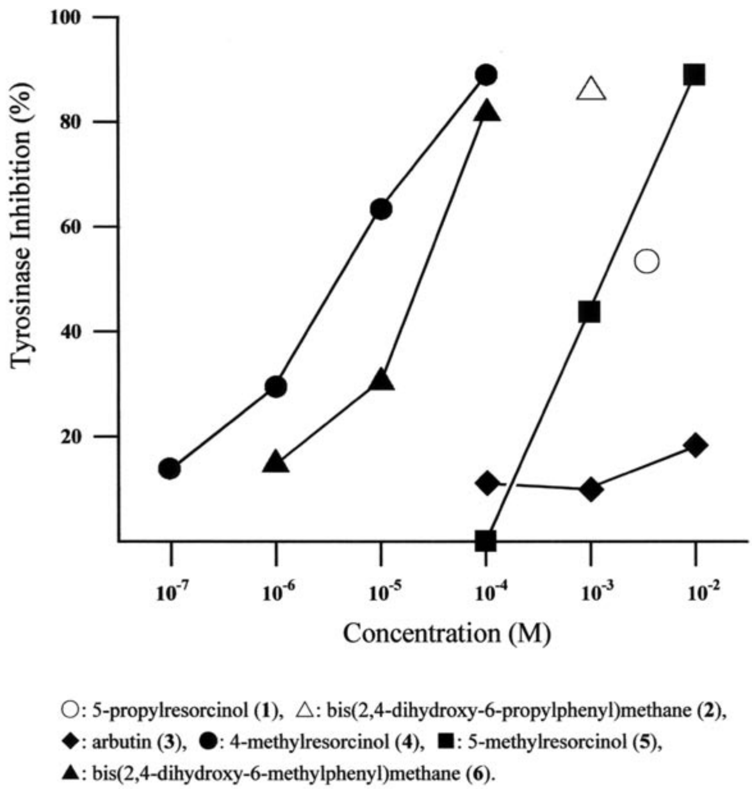
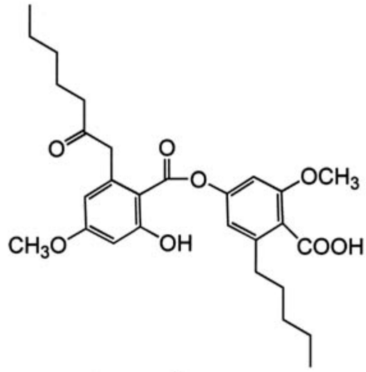


Fig. 2. Anti-tyrosinase activities of resorcinol derivatives and arbutin.



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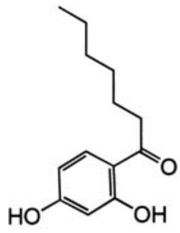

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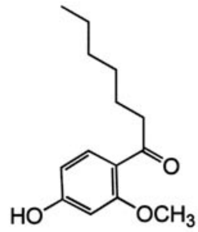

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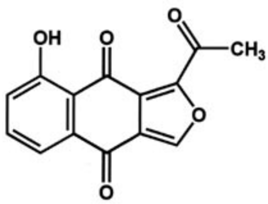
Fig. 3. Structures of inhibitors of monoamine oxidases – confluentic acid (7), and its analogues, 1-(2,4-dihydroxyphenyl)-1-heptanone (8) and 1-(4-hydroxy-2-methoxyphenyl)-1-heptanone (9).



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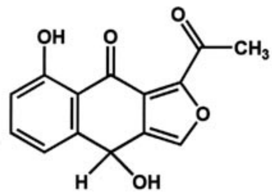

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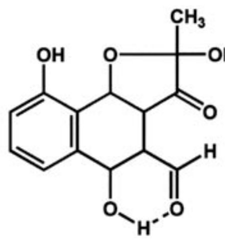
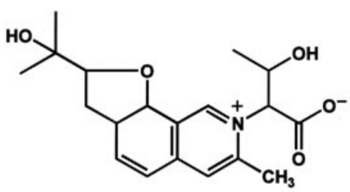
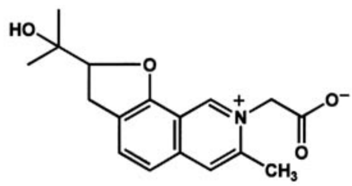


12

Fig. 4. Structures of new compounds arthoniafurone A (10), B (11) and cinnabarinal (12).



13



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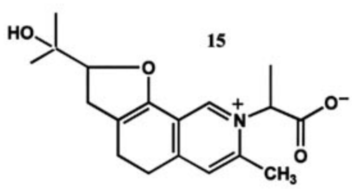

Fig. 5. Structures of other novel substances panaefluoroline A (13), B (14) and C (15).

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A preliminary phylogeographic study of *Flavopunctelia* and *Punctelia* inferred from rDNA ITS-sequences

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Abstract: A preliminary phylogeny of the genera *Flavopunctelia* and *Punctelia* is presented. Genus and species delimitations have been investigated using ITS rDNA-sequencing of populations from different continents. Current genus delimitations of *Flavopunctelia*, *Punctelia* and *Parmelia* are confirmed and the species status of recently resurrected *Punctelia ulophylla* is confirmed. The status of three cryptic species, *Flavopunctelia soredica*, *Punctelia perreticulata* and *P. stictica* is discussed. *Flavopunctelia borrerioides* and *Punctelia perreticulata* are reported from China for the first time.

Kokkuvõte: Esialgne ülevaade perekondade *Flavopunctelia* ja *Punctelia* fülogeograafiast rDNA ITS-sekventside põhjal.

Esitatakse perekondade *Flavopunctelia* ja *Punctelia* esialgne fülogeneesi rekonstruktsioon. Perekondade ja liikide eraldamist on uuritud erinevatelt kontinentidelt pärinevate populatsioonide ITS rDNA sekventside alusel. Senine perekondade *Flavopunctelia*, *Punctelia* ja *Parmelia* piiritlemine on leidnud kinnitust, samuti liigi *Punctelia ulophylla* staatus. Arutletakse kolme krüptilise liigi, *Flavopunctelia soredica*, *Punctelia perreticulata* ja *P. stictica* staatuse üle. Teatatakse liikide *Flavopunctelia borrerioides* ja *Punctelia perreticulata* esmasleidudest Hiinas.

INTRODUCTION

The genus *Punctelia* Krog was segregated from *Parmelia* Ach. on differences in pseudocyphellae ontogeny, secondary chemistry and phytogeography (Krog, 1982). The genus, originally including 22 species, was subdivided into two distinct subgenera: *Punctelia* subgenus *Punctelia*, characterized by unciform spermatia and atranorin as a a major cortical substance, and *Punctelia* subgenus *Flavopunctelia* Krog characterized by bifusiform spermatia and usnic acid as a major cortical substance. Spermatial shape has been considered to be of great importance in genus delimitations (Kärnefelt, 1998). Based on spermatial and additional chemical characters, *Flavopunctelia* (Krog) Hale was recognized as a separate genus composed of four species (Hale, 1984); two additional species have been discovered in *Flavopunctelia* (Elix & Adler, 1987; Kurokawa, 1999) as compared with 30 species which constitute *Punctelia* today (Crespo et al., 2004; Egan, 2003; Elix & Johnston, 1988; Galloway & Elix, 1994; Kurokawa, 1999; Sérusiaux, 1983, 1984; Wilhelm & Ladd, 1992). Both *Flavopunctelia* and *Punctelia* have a temperate to subtropical distribution and reach their highest diversity in South- and North-America and in Africa (Krog, 1982). DNA-investigations support that *Flavopunctelia* and *Punctelia* are sister groups and that *Parmelia* Ach. may be the sister group of the two genera (Blanco et al., 2004, Thell et al., 2004). Populations of *Flavopunctelia* and *Punctelia* species, of which some are represented by collections from different continents, are analysed here, together with some *Parmelia* species, using nuclear ITS rDNA-sequences. Genus and species delimitations are studied and discussed.

MATERIALS AND METHODS

The material was collected by the authors and collegues during recent travels, resulting in 20 new sequences from the ITS1-5.8S-ITS2 rDNA region that were submitted to the NCBI GenBank (http://www.ncbi.nlm.nih.gov, Table 1). Eleven sequences were downloaded from the

Table 1. Specimens used in the study, extraction numbers (LD), sample-IDs and GenBank accession numbers

Species	Extr.	Sample-ID	GenB. acc.
Flavoparmelia caperata	555	Estonia, Tartumaa, Ahunapalu,Thell 9906 (TUR)	AF451750*
Flavopunctelia borrerioides	1521	China, Yunnan Prov., 29 Oct 2002, van Herk (ABL)	AY773129
Flavopunctelia flaventior	1285	Germany, Bavaria, Dachau, Feuerer s. n. (HBG)	AF251420*
Flavopunctelia flaventior	1517	China, Yunnan Prov., Aptroot 56024 (ABL)	AY773126
Flavopunctelia flaventior	1520	China. Yunnan Prov., Aptroot 560101 (ABL)	AY773127
Flavopunctelia soredica	1518	U. S. A., New York, Aptroot 50612 (ABL)	AY773128
Parmelia ernstiae	858	Germany, Schleswig-Holstein, Feuerer & Thell (HBG)	AF410834*
Parmelia ernstiae	965	Sweden, Scania, Eslöv, Thell 0101 (HBG)	AF247007*
Parmelia saxatilis	518	Chile, Magallanes, Feuerer 29542 (HBG)	AF410672*
Parmelia saxatilis	534	Finland, Regio aboënsis, Ruissalo, Thell 9926 (TUR)	AF410835*
Parmelia submontana	-	Spain, Hoya Redonda (MAF 3729)	AY037000*
Parmotrema crinitum	1273	Yemen, Socotra, Schultz 14297c (HBG)	AY251442*
Punctelia borreri	945	Italy, Trentino-Alto Adige, Feuerer & Thell s. n. (HBG)	AY773113
Punctelia borreri	959	Italy, Abruzzo, Tretiach 34124 (HBG)	AF451769*
Punctelia borreri	960	Italy, Friuli-Venezia-Giulia, Gambera 34126 (HBG)	AY773114
Punctelia borreri	1338	Kenya, Kakamega Forest Nat. R., Killmann (priv. herb.)	AY773110
Punctelia borreri	1339	Kenya, Kakamega Forest Nat. R., Killmann (priv. herb.)	AY773111
Punctelia borreri	1506	China, Yunnan Prov., Aptroot 56028 (ABL)	AY773115
Punctelia perreticulata	1286	U. S. A., Missouri, Osage Co., Ladd 23798 (HBG)	AY773123
Punctelia perreticulata	1331	China, Yunnan Prov., Yunlong, Aptroot 56005 (ABL)	AY773124
Punctelia perreticulata	1505	China, Yunnan Prov., Aptroot 56094 (ABL)	AY773122
Punctelia stictica	1020	Venezuela, La Culata, 31 Oct 1995, Feuerer s. n. (HBG)	AY773125
Punctelia stictica	1340	Kenya, Kakamega Forest Nat. R., Killmann (priv. herb.)	AY773112
Punctelia stictica	1609	Peru, Pisac, 20 Sept 2003, Thell & Feuerer s. n. (HBG)	AY773119
Punctelia subpraesignis	1310	Argentina, B. Aires, Adler & Protomastro s. n (BAFC)	AY267010*
Punctelia subrudecta	944	Germany, Schleswig-Holstein, Feuerer & Thell (HBG)	AY773116
Punctelia subrudecta	958	Italy, Venezia-Giulia, Gambera 34128 (dupl. HBG)	AY773117
Punctelia subrudecta	1509	Germany, Eifel, Aptroot 55416 (ABL)	AY773118
Punctelia ulophylla	956	The Netherlands, Gelderland, Aptroot 44450 (ABL)	AY773120
Punctelia ulophylla	957	The Netherlands, Prov. Utrecht, Sipman 43579 (HBG)	AY251726*
Punctelia ulophylla	1507	Belgium, Liege, Aptroot 57873 (ABL).	AY773121

*Sequences downloaded from the GenBank

same GenBank, of which 10 have appeared in earlier publications (Adler et al., 2004; Molina et al., 2004; Thell et al., 2002, 2004). The laboratory work was performed at the Department of General Botany and Botanical Garden, University of Hamburg.

Minute fragments of the fresh collections were ground with sterile plastic pestels. Total

DNA was extracted using the DNEasy Plant Mini Kit from Qiagen as described in Thell et al. (2004). ITS standard primers, ITS 4 and ITS 5, were used (White et al., 1990)

Ready To Go PCR beads (in 0.2 ml tubes) from Pharmacia Biotech Inc. were dissolved in 11.8 µl distilled water, 0.35 µl of a 16µM concentration of each of the primers ITS5 and ITS4 (White et al., 1990). The ITS fragments were amplified with a Perkin-Elmer Gene Amp PCR System 9700 thermal cycler. 12.5 µl of the concentrated DNA extractions were added to the solution, resulting in final reaction volumes of ca. 25 µl. The PCR started with 2 minutes at 95°C, followed by a 30–35 cycle schedule using a denaturation temperature of 95°C for 1 min., an annealing temperature of 60°C for 1 min., and an extension temperature of 72°C for 1 min.

The PCR products were purified with QIAquick PCR purification kit, and diluted in 30 µl of the enclosed elution buffer. A 25 cycle sequencing PCR, with a denaturation temperature of 96° C for 10 seconds, an annealing temperature of 50° C for 5 seconds, and an extension time of 60° C for 4 minutes, was performed to amplify the DNA-fragments prior to the sequencing procedure. 12 µl deionized water including 30–90 ng of the purified PCR-product and 3.2 pmol of the primers ITS1LM (Myllys, 1999) and ITS4 were added to 8 µl BigDye Terminator Cycle Sequencing Ready Reaction Kit with AmpliTaq Polymerase FS from Perkin Elmer according to the accompanying protocol. The sequences were produced using an automatic sequencer, ABI Prism 377 from Perkin-Elmer.

The phylogenetic analyses of the manually aligned ITS sequences were done with PAUP version 4.0b (Swofford, 1998). Trees were searched by using the heuristic option, with TBR branch swapping, 1000 replicates of random addition sequence order, and branches collapsed if the maximum length is zero. Gaps in the alligned sequences were treated as missing characters. Bootstrap analyses with 1000 replicates were done, using the same settings as in the heuristic search. Bootstrap support values of 60 or above are marked in the cladogram above the branches (Fig. 1). Large surveys of Parmeliaceae phylogeny were consulted when selecting the outgroup (Crespo et al., 2001; Thell et al., 2004)

RESULTS AND DISCUSSION

Results from the phylogeny analysis

The aligned matrix was composed of 520 nucleotide long sequences, including the gaps. Of the 163 variable characters, 114 were parsimony informative. The phylogeny was based on parsimony analysis using PAUP 4.0b. The analysis resulted in 12 shortest trees of length 328 (RI = 0,834; CI = 0,668). Bootstrap consensus (Fig. I) was identical to strict consensus of the 12 most parsimonious trees, except for some branching orders of the *Punctelia* subclades (Fig. 1. I–V).

Genus and species delimitations

Present genus delimitations are supported in the analysis, where *Parmelia* and *Flavopunctelia* are strongly supported, with bootstrap values of 94 and 100 respectively. *Punctelia* has a more moderate support, 75, of the three ingroup genera, and the clade is divided into five subclades (Fig. 1, I–V). Four of these subclades, however, constitute single species, and two of these species constitute monophyletic clades, *P. subrudecta* (Nyl.) Krog and *P. ulophylla* (Ach.) van Herk & Aptroot (Fig. 1, subclades II–III), both having a bootstrap support value at least 99. *Flavopunctelia soredica* (Nyl.) Hale*, Punctelia perrecticulata* (Räs.) G. Wilh. & Ladd and *P. stictica* (Duby) Krog appear as cryptic species (Fig. 1, subclades IV–V). The bootstrap support for the largest subclade (Fig. 1, I) is rather strong, 75. At the adjacent node of the tree, however, an even stronger monophyletic clade is identified, composed of *P. borreri* (Sm.) Krog, the *P. perreticulata*-samples collected in China, *P. subpraesignis* (Nyl.) Krog. African *P. borreri* and the Chinese *P. perreticulata* are not supported as separate species by ITS-sequences (Wilhelm & Ladd, 1987).

The number of cryptic species have increased rapidly in recent years becuse they are revealed by DNA-techniques. How to taxonomically treat these morphologically and chemically more or less identical but genetically different species is currently under constant review. Cryptic species are most frequently discovered by ITS-sequences, but the results should preferrably be confirmed by a second or third gene, such as mitochondrial SSU (Crespo et al., 2001) or GAPDH (Myllys et al., 2002). On the contrary,

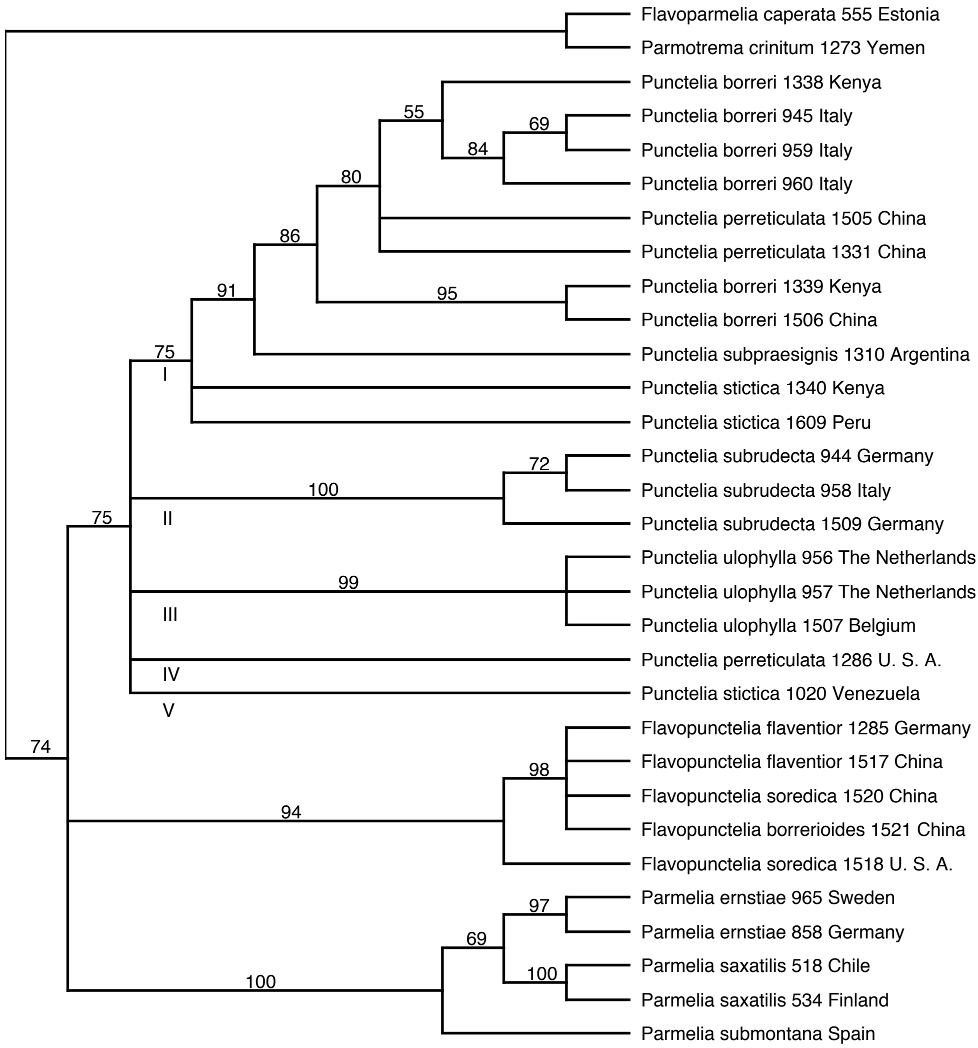

Fig. 1. Phylogeny of *Flavopunctelia, Parmelia* and *Punctelia* based on ITS rDNA-sequences. Bootstrap consensus, identical to strict consensus from 12 most parsimonious trees. Bootstrap support values of 60 or above are indicated above the branches, and the five subclades (I–V) of *Punctelia* below the branches.

ITS-sequences do not always separate formerly accepted morphological species (Grube & Kroken, 2000).

Punctelia ulophylla – a successfully resurrected taxon

Punctelia ulophylla was resurrected only recently (van Herk & Aptroot, 2000), based on detailed morphological observations and co-occurrence in Western Europe with *P. subrudecta.* Although the species was formerly described as a variety, it was rarely mentioned, and was not thought to merit much attention between the many other varieties and forms described in *Parmelia* s. lat. However, it has now been widely reported, mainly from Western Europe, but also from Northern Europe (Gauslaa, 2000) and Central Europe (Truong & Clerc, 2003). Crespo et al. (2004) confirmed its status as a separate species and even found it to be only distantly related to

P. subrudecta, which is confirmed here by our results. It is surprising how such a common and well-recognizable macrolichen has remained unnoticed for so many years. Even more surprising is the current reluctence of some authors to accept this fact, even including the unexplained citation of *P. ulophylla* as a synonym of *P. subrudecta* in Santesson et al. (2004).

Flavopunctelia borrerioides and *Punctelia perreticulata* – new to China

Among the material cited are two species which are new to China, namely *Flavopunctelia borrerioides* Kurok. and *Punctelia perreticulata.*

Flavopunctelia borrerioides was described by Kurokawa (1999) from Peru and Mexico and more recently has been reported from India by Divakar et al. (2003). It differs from the common *F. flaventior* (Stirton) Hale, with which it occurs, by the conspicuous rounded laminal pseudocyphellae developing into soredia, giving it the aspect of *Punctelia borreri* (hence the name). Our specimen from China and an additional one from South Africa (leg. C.M. van Herk, in ABL) suggest that this is a widespread subtropical species.

Punctelia perreticulata was recently reported (Aptroot, 2003) to be the most common and widespread sorediate *Punctelia* in North- and Central America (Egan & Aptroot, 2004). It is therefore not surprising that it is also present in Asia, as our specimen from China shows.

Notes on the cryptic species

Punctelia perreticulata is a species mainly distinguished by atranorin in the upper cortex and sorediate pseudocyphellae. The lower side is ivory to tan towards the centre and lecanoric acid in the medulla is the major secondary metabolite. It has been treated as a synonym of *P. subrudecta* by Krog (1982) and Nimis (1993), a view not supported in the cladogram, which contradicts a conspecific habit of the two species (Fig. 1). Alternatively, Whilhelm & Ladd (1987), who studied corticolous populations from the interior highlands of the USA, considered *P. perreticulata* to be a distinct species, distinguished by a strongly fovelate-reticulate upper surface compared with the occasionally somewhat ridged upper surface of *P. subrudecta*. Adler & Ahti (1996) also considered *P. perreticulata* as a distinct species, mainly differring from *P. subrudecta* in shape and length of spermatia: European studied specimens of *P. perreticulata* were all saxicolous, had a strongly foveolate upper surface, and 7 µm long, filiform spermatia. Specimens form Argentina were characterized by longer, 9–11 µm, spermatia, whereas those from the USA were mostly corticolous and supplied with an even upper surface (Adler & Ahti, 1996; Aptroot, 2003; Egan & Aptroot, 2004). The Chinese specimens of *P. perreticulata* are corticolous and have 9–12 µm long spermatia similar to the North-American material. Adler & Ahti (1996) concluded that *P. perreticulata* is a species with an unusually wide infraspecific geographic variation. On the contrary, Longán et al. (2000) prefer a narrow species concept for samples with long spermatia. The present analysis, comparing samples from China and the USA only, supports the view that several species may be accumulated in *P. perreticulata*, compared with the circumscription by Adler & Ahti (1996).

Punctelia stictica (Duby) Krog is characterized by a light to dark brown upper surface with secondarily sorediate pseudocyphellae, with granular to isidioid soredia, the underside brown to black towards the centre, with gyrophoric acid as the major medullary metabolite and long filiform spermatia (Adler, 1996). It is also a widely distributed, cosmopolitan species, reported from North- and South-America, Africa and Europe, growing mostly on rocks in very different climates and altitudes, but found also on soil and trunks (Adler, 1996). Both *P. perrecticulata* and *P. stictica* are very widely distributed and have wide ecological amplitudes. Apart from *P. perreticulata*, the cryptic habit of *P. stictica* is, however, not supported by any hitherto known morphological, chemical or anatomical traits, which, on the other hand, is the definition of being cryptic. Furthermore, the *P. stictica* samples do not group according to geographic origin (Fig. 1)

Finally, the *Flavopunctelia soredica* sample from the USA (New York) constitutes a sister group to the single *F. borrerioides* sample, the two *F. flaventior* samples and the *F. soredica* sample from China. Interestingly, in this preliminary study based on a single DNA-fragment, populations of the three possibly cryptic species correlate with DNA according to their geographical origins.

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Secondary chemistry of lichen-forming ascomycetes: culture experiments with isolates of *Xanthoparmelia* species from Australia

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Abstract: Sterile cultured isolates of different *Xanthoparmelia* species from Australia were analyzed and their chemistry compared with their voucher specimens. Isolates produced the same major and satellite substances as typically formed in lichen thalli, such as usnic, salazinic and consalazinic acids in *Xanthoparmelia cheelii*, *X. tasmanica* and *X. antleriformis*. Norlobaridone, loxodin, usnic acid and, surprisingly, divaricatic acid, which was never before reported for that lichen were found in voucher specimens and cultures of *X. flavescentireagens*. Many of the cultured fungi produced additional compounds and traces of various other secondary metabolites, which are either closely related to the major substances and/or parts of a chemosyndrome and precursors. *X. flavescentireagens* produced different secondary compounds, depending on the composition of the culturing media.

Kokkuvõte: Samblikke moodustavate kottseente sekundaarsete ainete keemia: Austraaliast pärit koldsamblike (*Xanthoparmelia*) isolaatide kultuuris kasvatamise katsed.

Analüüsiti Austraaliast pärit *Xanthoparmelia* liikide steriilseid kultuuri viidud isolaate ning võrreldi nende samblikuaineid samade liikide lihheniseerunud eksemplaride ainetega. Isolaadid tootsid samu põhi- ja kõrvalaineid, mis tavaliselt moodustuvad nende samblike talluses, nt usniin-, salatsiin- ja konsalatsiinhappeid liikides *Xanthoparmelia cheelii*, *X. tasmanica* ja *X. antleriformis*. Sambliku *X. flavescentireagens* tõendeksemplarides ja kultiveeritud isolaatides leiti norlobaridooni, loksodiini, usniinhapet ja üllatuslikult ka divarikaathapet, mida sellest samblikust varem määratud pole. Paljudest kultuuri viidud seentest leiti lisaaineid ning erinevate metaboliitide jälgi, mis on tihedalt seotud põhiainetega ja/või kemosündroomi osade ja eelkäijatega. *X. flavescentireagens* tootis kultuuri koostisest sõltuvalt erinevaid sekundaaraineid.

INTRODUCTION

Lichen forming ascomycetes produce a wide range of secondary metabolites such as depsides, depsidones and dibenzofurans (Culberson, 1969), some of which are potentially useful, biologically active compounds. Antiviral, antibiotic, antitumor, photoprotective, but also allergenic and enzyme inhibitory effects have been recognized (e.g. Rancan et al., 2002; Yamamoto et al., 1993). Lichen substances can also be produced by cultured mycobionts, depending on the culture conditions, composition of the nutrient media and stress parameters such as osmotic and temperature stress or exposure to high light intensities (Tanahashi et al., 1997; Stocker-Wörgötter & Elix, 2002; Yamamoto et al., 1987). The biosynthesis of secondary metabolites in the cultured mycobionts may differ from the production in intact thalli. Possible causes for these differences can be osmotic conditions, nutrient supply, culture age, culture conditions or the presence of a photobiont (Molina et al., 2003).

Lichen thalli are known to be frequently inhabited by parasitic, endo- and epiphytic fungi. Therefore, chemical or genetic analyses are often required for identification of sterile cultured isolates (Yamamoto, 1990; Stocker-Wörgötter, 2001).

The genus *Xanthoparmelia* (Vain.) Hale, a segregate of *Parmelia* Ach., occurs mainly in southern Africa, Australia and New Zealand. In comparison, only few species are known from the northern hemisphere. *Xanthoparmelia* is one of the most dominant groups of saxicolous lichens in very warm, semi-arid regions, where its representatives frequently grow in open habitats.

Xanthoparmelia thalli are foliose to subcrustose, loosely to very tightly adnate, and their upper surface is pale yellow-green to grey-green. Common secondary compounds in the genus *Xanthoparmelia* are usnic, salazinic, consalazinic, norstictic and protocetraric acid, loxodin, norlobaridone and chemically closely related minor substances (Elix, 1994).

In general, representatives of Parmeliaceae reveal highly variable and complex chemical profiles (including many biologically active compounds) and thus are exciting subjects for culturing and chemical investigations.

The objective of this investigation was to screen culture conditions and their influence on the formation of secondary compounds in sterile cultured isolates of Australian *Xanthoparmelia* species, and to compare them with lichen substances contained in the original thalli.

MATERIAL AND METHODS

Lichen specimens

Xanthoparmelia antleriformis (Elix) Elix & Johnst. was collected S of Morton National Park near Nerriga in New South Wales, Australia, 35°05'S, 150°09'E, 700 m; *X. cheelii* (Gyeln.) Hale and *X. flavescentireagens* (Gyeln.) D.J. Galloway: Brindabella Range, Mt Majura, Australian Capital Territory (ACT), 35°14'S, 149°11'E (Fig. 1); *X. tasmanica* (Hook.f. & Taylor) Hale: Brindabella Range, summit of Mt Aggie, ACT, 43 km WSW of Canberra, 35°28'S, 148°48'E, 1490 m.

List of culture media

Different culturing media were used. LBM+B [Lilly-Barnett-Medium with bark extract (Lilly-Barnett, 1951)] contains glucose as a carbohydrate source, agar, asparagine, thiamine, biotin and different mineral nutrients (Mg, K, Fe, Zn, Mn) and additionally bark extract prepared by the method of Esser (1976).

MIX [MIX-Medium (Stocker-Wörgötter, 2002)] contains glucose, malt, yeast extract, agar, peptone and NaCl.

MS [Murashige-Skoog-Medium modified (Stocker-Wörgötter, 2001)] consists of sucrose, mannitol, malt, caseine, agar and the Murashige mineral salts.

MY [Malt-Yeast-Medium (Yamamoto, 1990)] is composed of malt, yeast extract and agar.

PDA [Potato-Dextrose-Agar (Sigma P-2182)] is an extract of potatoes, glucose and agar.

S2% [Sabouraud-2%-Glucose-Agar (Fluka 84086)] and S4% [Sabouraud-4%-Glucose-Agar modified (Stocker-Wörgötter, 2001)] contain polypeptone, glucose and agar.

Mycobiont isolations

The Yamamoto-method (modified after Yamamoto, 1990) was used for the isolation of the symbionts from selected *Xanthoparmelia* species. Small thallus fragments were washed in bidistilled water containing a drop of Tween 80, then homogenized in sterile water with a mortar and pestle. The suspension was filtered through two sieves (500 and 150μm mesh size). Fragments (160–200 μm size) of the washed and homogenized lichen material were transferred with bamboo sticks into tubes containing MS-medium. The tubes were kept in darkness (covered by aluminium foil) for about 3 months until small colonies had formed. The fungal colonies were homogenized for subculturing on the different media as described above.

Isolates were kept in a culture chamber with a 14 h/20°C:10 h/10°C day-night cycle and a light intensity of 50-100 μE m-2s-1.

Chemical analyses

For the chemical analyses, sterile cultures of the mycobionts (c. 1.0–1.5 cm) were cut out of the agar plates and freeze-dried at –42°C for at least 12 h. Dried cultures and small pieces of the original lichen thalli were extracted in methanol for 4 h; the extracts were transferred to HPLC vials. The secondary compounds of the thalli and mycobiont cultures were observed by HPLC using a Merck-Hitachi system with two pumps, a DAD (photodiode array detector; 190–800 nm wavelength) and a computer system. Two solvent systems were used: (A) 1% aqueous orthophosphoric acid and methanol in the ratio 7:3, and (B) methanol. The run started with 100% A and was raised to 58% B within 15 min, then to 100% B after a further 15 min, followed by isocratic elution in 100% B for a further 10 min. The spectra were identified by means of a spectrum library (comparisons with reference substances), and chemical data of Huneck and Yoshimura (1996). TLC was performed using the standardized method with 3 solvent systems (Culberson & Ammann, 1979; Culberson & Kristinsson, 1969).

RESULTS

Cultures

Isolates of the different *Xanthoparmelia* spp., when grown on the same media (Fig. 2–4), differ in color, growth rate and growth form. They all produce brown pigments. Protruding hyphae cause a velvet appearance. The *Xanthoparmelia cheelii* isolate (Fig. 3) forms more hyphae that dip into the medium than the other species.

Depending on the composition of the nutrient media, isolates of the same species vary in their growth rates, colouration and also in their developmental patterns. Figures 5–10 show isolates of *X. flavescentireagens* growing on various test media. Pigments leak into the medium and darkly stain it, particularly on MIX and S2%.

In general, the *Xanthoparmelia* isolates show a high increase of biomass on all tested media, except on S4% where slow growth was recorded (Fig. 10).

Chemistry of the voucher specimens and their cultured mycobionts

The chemical profiles of the selected lichens and their response to different media were compared. Isolates of *Xanthoparmelia tasmanica*, *X. cheelii* and *X. antleriformis* showed best growth on MS, whereas the isolate of *X. flavescentireagens* revealed no preference for a particular nutrient medium. Qualitatively, the chemical profile (types of secondary metabolites) did not change, but quantitative differences (major, minor, traces) were found on different media. Table 1 gives an overview of the chemical analyses.

Xanthoparmelia tasmanica

The HPLC and TLC data revealed that the thallus contained salazinic acid (major), usnic acid (minor) and a small amount of consalazinic acid (Fig. 11).

The mycobiont grown on MS produces salazinic acid (major), usnic acid (minor) and has additional minor compound conorlobaridone.

Tab. 1. Results of the chemical analyses of *Xanthoparmelia* spp. and its cultured isolates

Species	Source of substances	Quantity of substances		
		major	minor	low quantities/traces
X. tasmanica	thallus (Fig. 11)	salazinic acid	usnic acid	consalazinic acid
	isolate (MS) (Fig. 12)	salazinic acid	usnic acid, conorlobaridone	consalazinic acid, unknown
X. cheelii	thallus (Fig. 13)	salazinic acid	usnic acid	consalazinic acid, norstictid acid, protocetraric acid
	isolate (MS) (Fig. 14)	salazinic acid, usnic acid	conorlobaridone	unknowns
X. antleriformis	thallus (Fig. 15)	salazinic acid	usnic acid	consalazinic acid, norstictic acid, protocetraric acid
	isolate (MS) (Fig. 16)	salazinic acid	usnic acid	consalazinic acid, conorlobaridone, unknowns
X. flavescentireagens	thallus (Fig. 17)	usnic acid, norlobaridone	loxodin, divaricatic acid	
	isolate (MS)			usnic acid, nor-lobaridone, loxodin, divaricatic acid
	isolate (MIX)		norlobaridone	
	isolate (PDA)	norlobaridone	usnic acid	loxodin, divaricatic acid
	isolate (MY)			conorlobaridone
	isolate (LBM+B) (Fig. 18)	2´O-methylsubdivaricatic acid	norlobaridone, usnic acid	loxodin, divaricatic acid, conorlobaridone
	isolate (S2%)	norlobaridone	loxodin, usnic acid	conorlobaridone
	isolate (S4%)	norlobaridone	loxodin, usnic acid	conorlobaridone

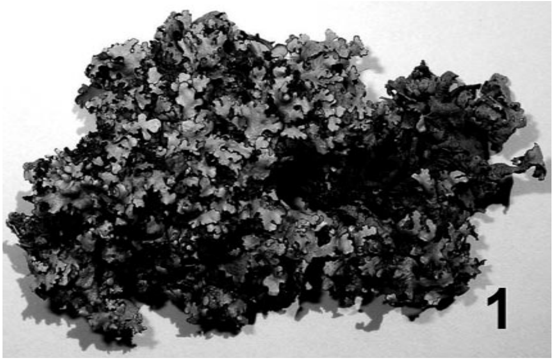


Fig. 1. Thallus of *Xanthoparmelia flavescentireagens.*

There are also traces of consalazinic acid and another unknown (UK) substance (Fig. 12).

XANTHOPARMELIA CHEELII

The voucher specimen contains salazinic acid (major), usnic acid (minor) and traces of consalazinic acid, norstictic acid and protocetraric acid (Fig. 13).

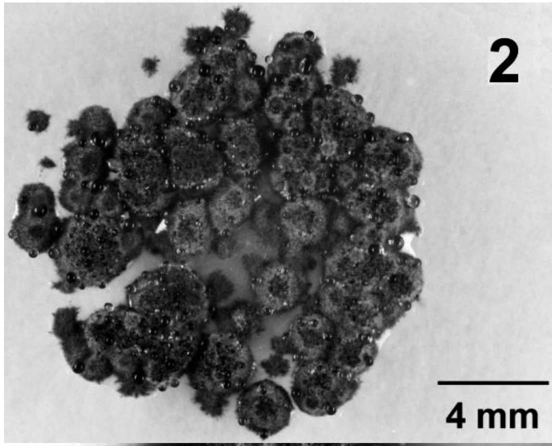
The cultured mycobiont produces the two major substances (salazinic and usnic acid), and conorlobaridone as another minor compound (Fig. 14). There are also several peaks of unidentified trace substances.

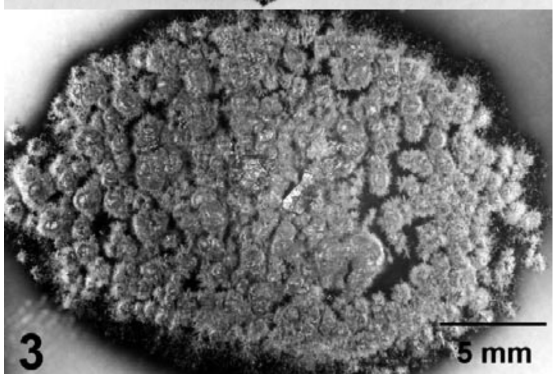
XANTHOPARMELIA ANTLERIFORMIS

Salazinic acid (major) and usnic acid (minor) and a small quantity of consalazinic acid can be found both in the thallus and the cultured mycobiont. Additionally, the lichen thallus forms traces of norstictic acid and protocetraric acid; in contrast the mycobiont in culture produces traces of conorlobaridone and different additional unknown compounds (Fig. 15, 16).

XANTHOPARMELIA FLAVESCENTIREAGENS

The thallus contains usnic acid and norlobaridone as major metabolites, and loxodin and divaricatic acid as minor compounds (Fig. 17). The mycobiont grown on MS produces the same substances, but only a trace quantity of them. However, when grown on MIX, the mycobiont only forms norlobaridone. When cultured on PDA the mycobiont produces this substance as a major compound, usnic acid as a minor compound, and there are traces of loxodin and divaricatic acid. The extract of the mycobiont on LBM+H (Fig. 18) shows a depside, probably 2`-O-methylsubdivaricatic acid (major), norlobaridone (minor), usnic acid (minor), a small amount of loxodin and divaricatic acid, and a trace of conorlobaridone. On MY, the mycobiont did not produce any major lichen substances, except a trace of conorlobaridone. On S2% and





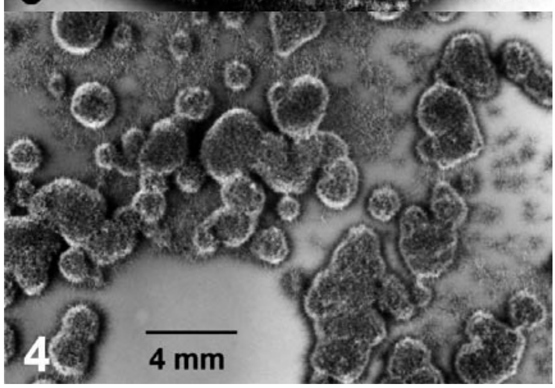
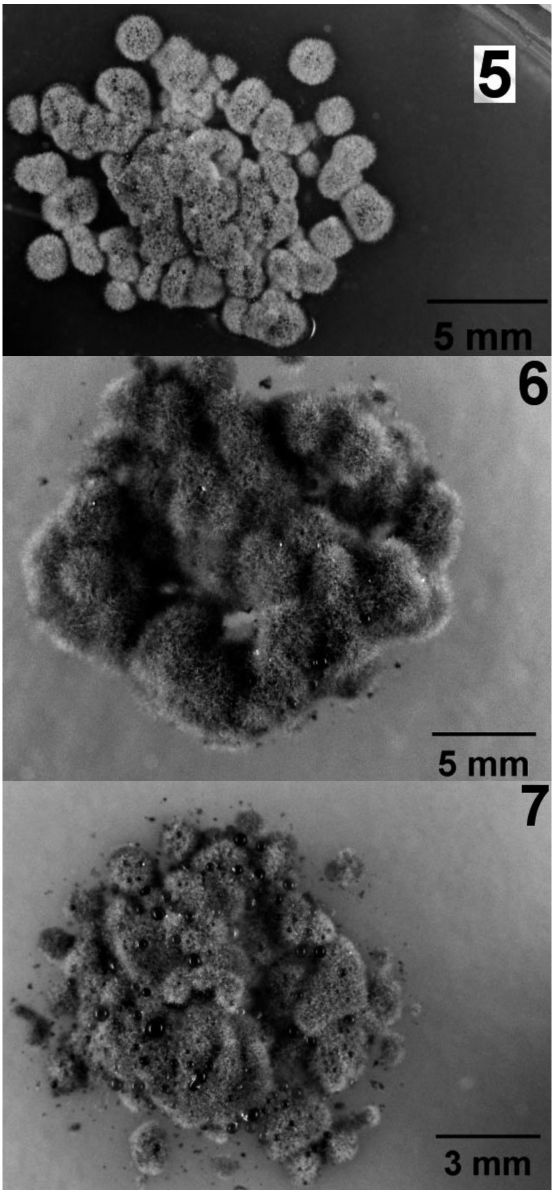


Fig. 2. Isolate of *X. tasmanica* cultured on MS medium.

Fig. 3. Isolate of *X. cheelii* cultured on MS medium.

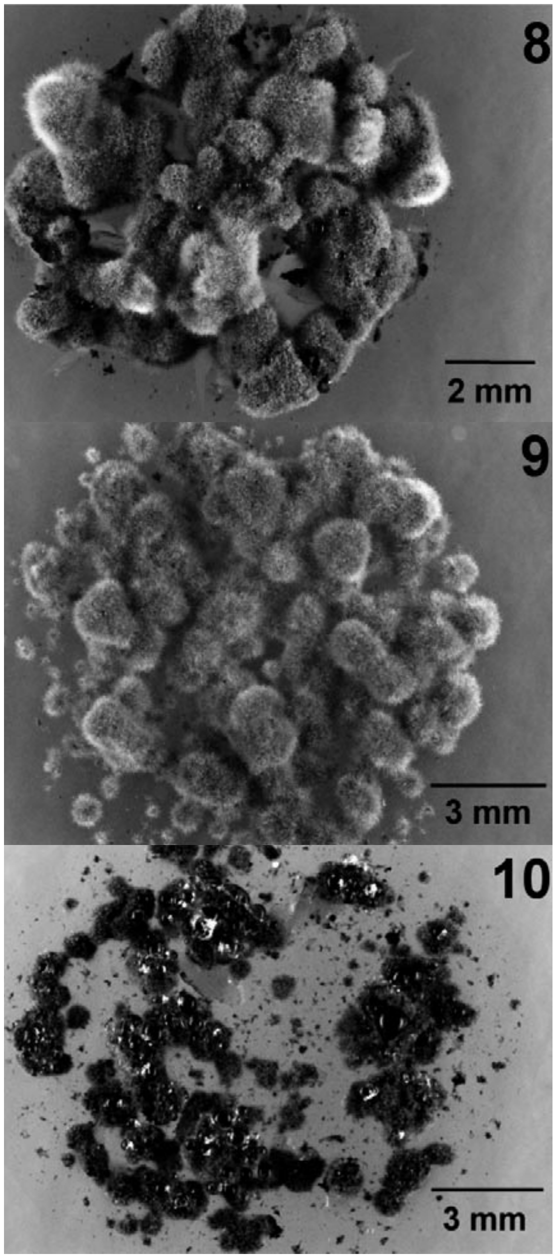
Fig. 4. Isolate of *X. antleriformis* cultured on MS medium.



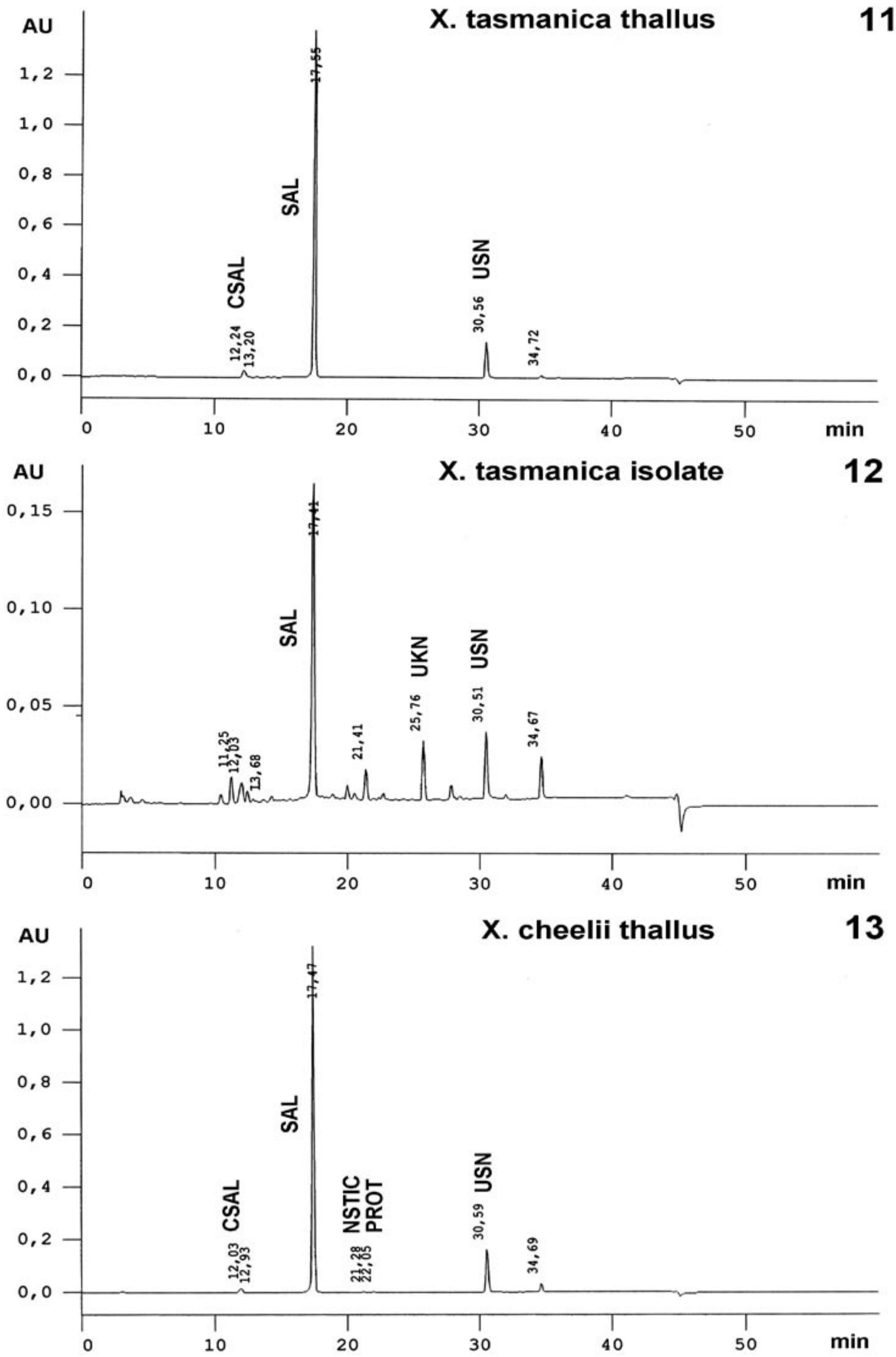
S4% the mycobiont produced norlobaridone (major), loxodin (minor), divaricatic acid (minor), usnic acid (minor), and also a trace of conorlobaridone.

Figs 19–22 show UV-spectra of prominent substances, as found in *Xanthoparmelia* spp. (salazinic acid, usnic acid, norlobaridone and divaricatic acid).

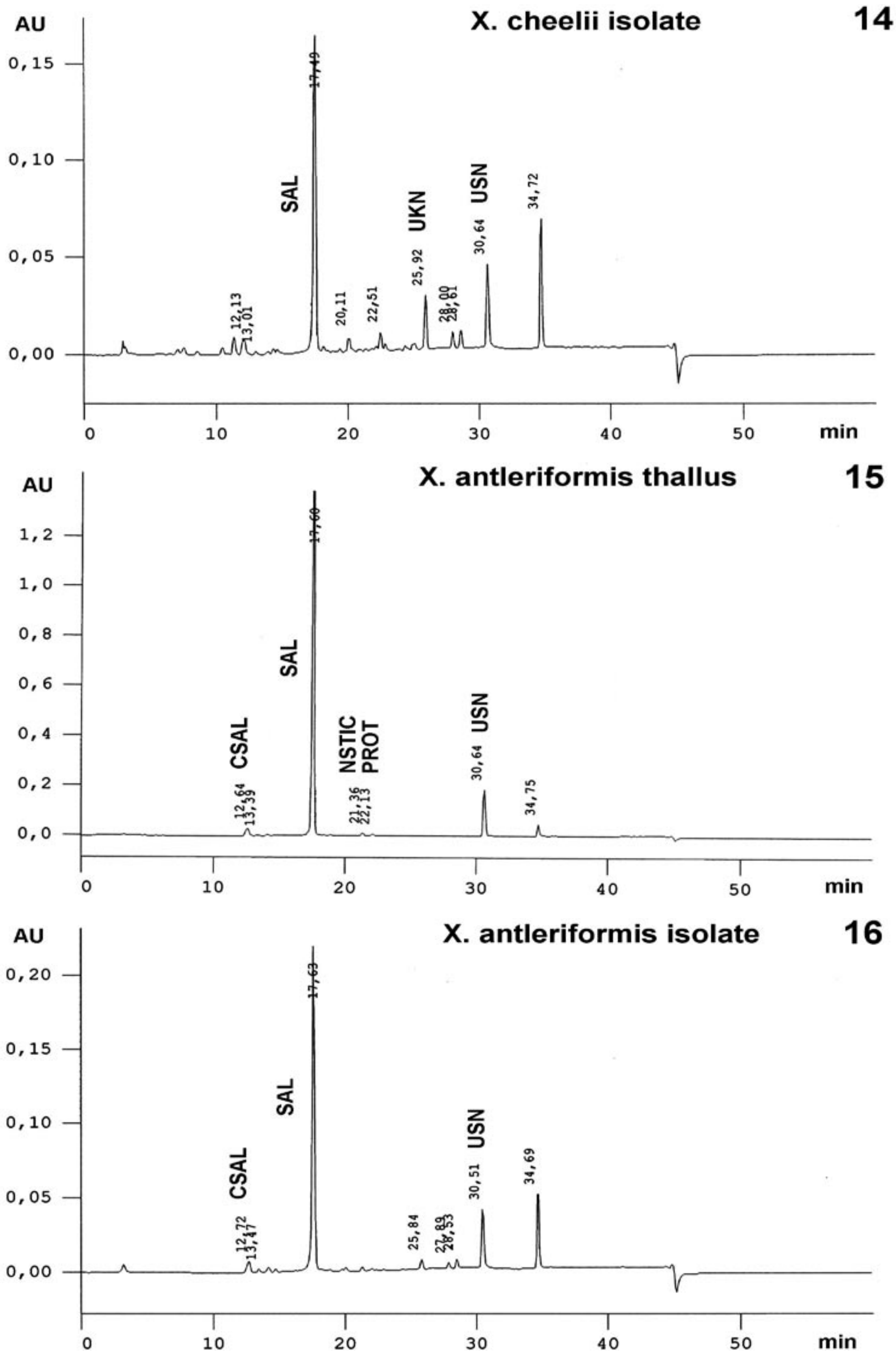
Extracts of the culture media show that the mycobionts had released only a small quantity



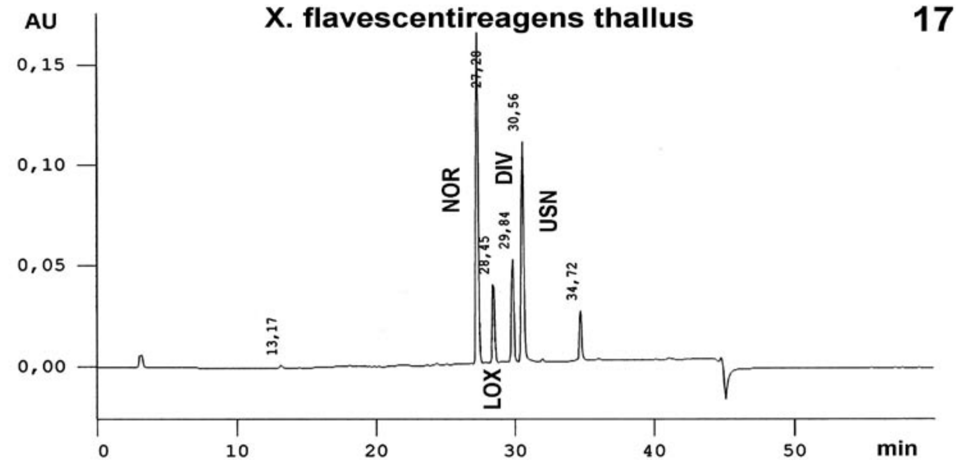
Figures 5–10: Sterile cultured isolate of *X. flavescentireagens* grown on different media:
Fig. 5. MIX medium;
Fig. 6. PDA medium;
Fig. 7. LBM+B medium;
Fig. 8. MY medium;
Fig. 9. S2% medium;
Fig. 10. S4% medium.

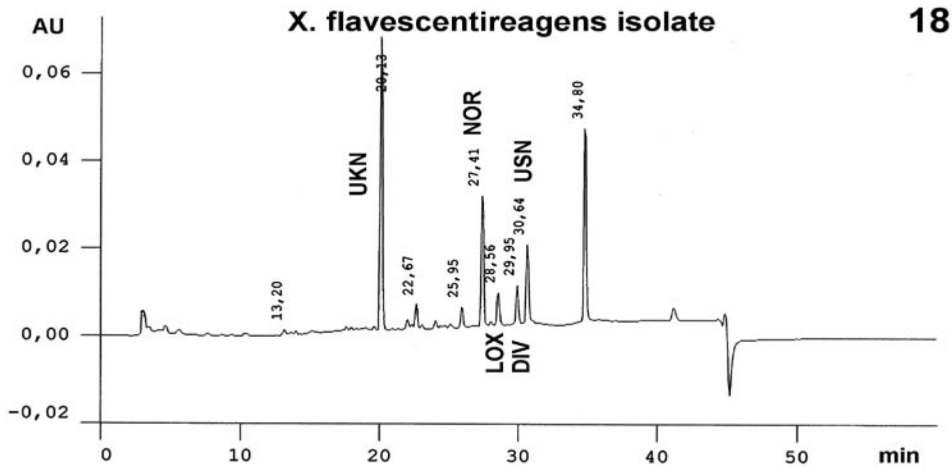


Figs 11–13. HPLC chromatograms of secondary compounds produced by thalli (T) and sterile cultured isolates (I) of *Xanthoparmelia* spp.:
Fig. 11. *X. tasmanica* (T); **Fig. 12.** *X. tasmanica* (I) grown on MS medium; **Fig. 13.** *X. cheelii* (T).



Figs 14–18. HPLC chromatograms of secondary compounds produced by thalli (T) and sterile cultured isolates (I) of *Xanthoparmelia* spp.: **Fig. 14.** *X. cheelii* (I) grown on MS medium; **Fig. 15.** *X. antleriformis* (T); **Fig. 16.** *X. antleriformis* (I) grown on MS medium.





Figs 17–18. HPLC chromatograms of secondary compounds produced by thalli (T) and sterile cultured isolates (I) of *Xanthoparmelia* spp.:
Fig. 17. *X. flavescentireagens* (T); **Fig. 18.** *X. flavescentireagens* (I) grown on LBM+B medium.

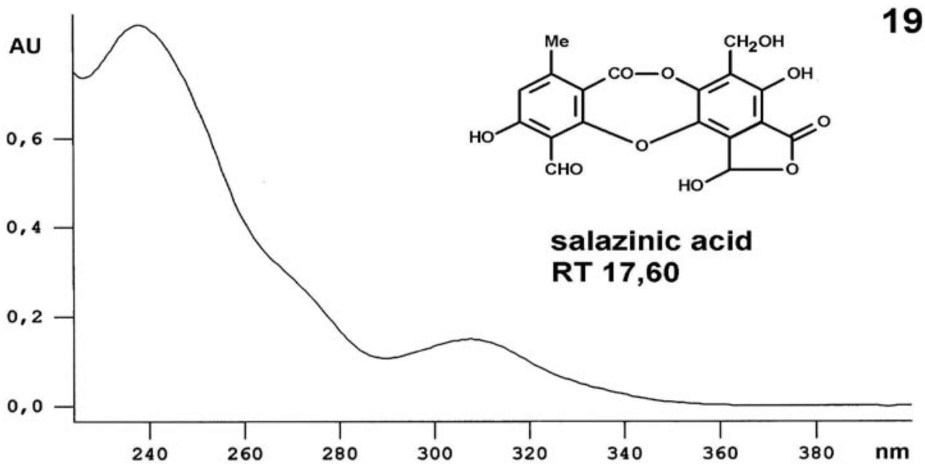
of substances into the medium, probably chemically related metabolites of norlobaridone and traces of several unidentifiable compounds. Depending on the type of medium and/or the species (e.g. *X. flavescentireagens*, *X. antleriformis*), pigments were released into the medium. Obviously, these pigments were not solubilized in methanol and therefore could not be detected in HPLC analyses.

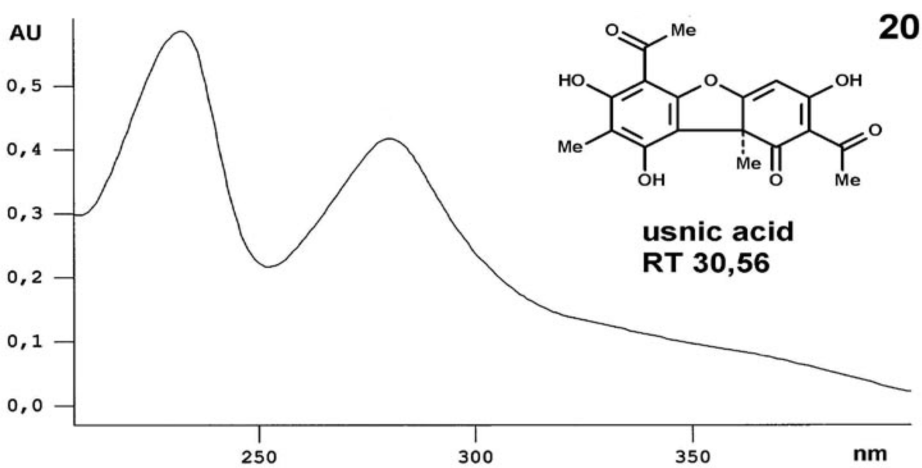
DISCUSSION

Most of the cultured mycobionts produced the same major substances as the voucher specimens, but cultured isolates often showed considerable chemosyndromic variation in the composition of satellite compounds and precursors (e.g. conorlobaridone, 2`-O-methylsubdivaricatic acid). Due to the very low contents, these traces were often difficult to identify, because the spectra showed a high background noise. One explanation for the differences in the production of secondary compounds in voucher specimens and cultures could be that the aposymbiotically grown mycobionts represent juvenile and deviate developmental stages that have been grown under "artificial" lab conditions considerably different to the ones parent thalli experience in their natural environment (Molina et al., 2003).

The cultured isolates of the different *Xanthoparmelia* species exhibited similar growth forms, probably because they are representatives of the same genus and closely related to each other. Mostly, the cultured isolates showed increased growth rates on nutrient rich media. The only exception is S4%, obviously a less than optimal substrate, since all *Xanthoparmelia* isolates grew much more slowly on this medium than on S2%. In general, the production of lichen substances by cultured isolates also depended on the composition of the nutrient media.

However, high growth rates on one medium do not necessarily mean that the culture also produces high quantities of secondary compounds, as can be seen in the cultured isolates of *X. flavescentireagens* grown on MY or MIX. A negative correlation was found between fast growth on nutrient-rich media and production of secondary compounds. Our results indicate that mycobionts exhibiting low growth rates favour the polymalonate pathway. Further essential parameters include environmental factors such as temperature shifts, increased light intensities and various other stress factors (Tanahashi et al., 1997; Stocker-Wörgötter & Elix, 2002; Yamamoto et al., 1987). The impact of these factors could be tested in further investigations. Our study showed that the cultured fungal isolates responded to physiological stress, such as reduced and altered nutrient content of the artificial media. Seasonal changes and alternating day-night cycles in the natural environment can only be partly simulated in the





Figs 19–20: UV-spectra: **Fig. 19.** salazinic acid; **Fig. 20.** usnic acid.

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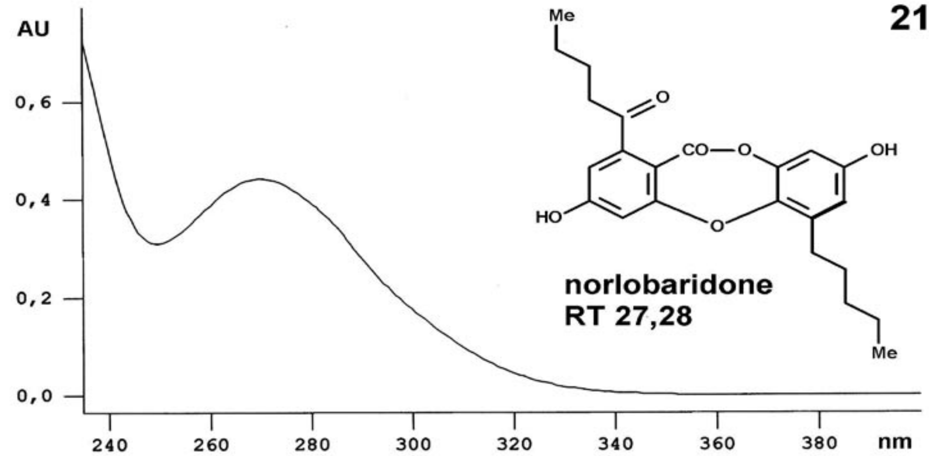

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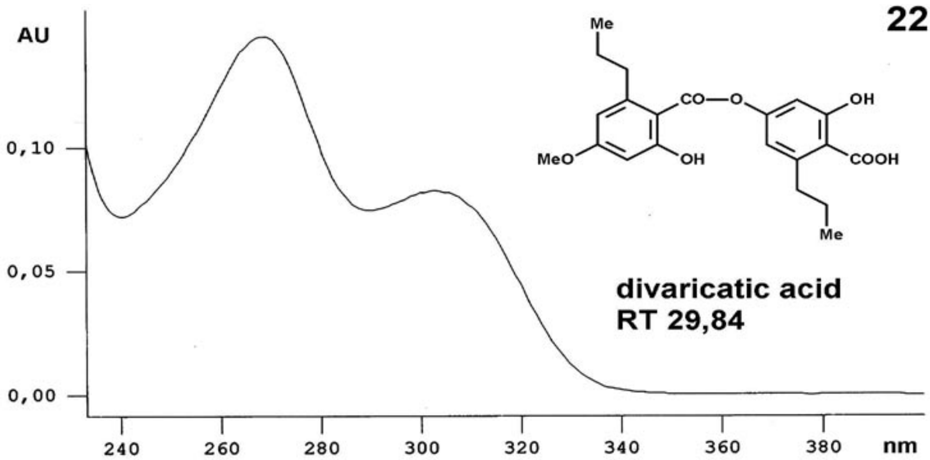

Figs 21–22: UV-spectra: **Fig. 21.** norlobaridone; **Fig. 22.** divaricatic acid.

culture chamber (i.e. by exposing the cultures to a 14 h/20°C:10 h/10°C day-night cycle). The detection of divaricatic acid in the original thallus and the culture of *X. flavescentireagens* was very surprising, as this compound has not been previously described from this species (Elix, 1994; Elix, *pers. comm.*).

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NEW ESTONIAN RECORDS

Lichens and lichenicolous fungi

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Eleven new species of lichens and lichenicolous fungi and one new variety are reported here. Abbreviations of distribution regions and frequency classes follow Randlane & Saag (1999). All cited material is deposited in the lichenological herbarium of University of Tartu (TU).

Agonimia globulifera Brand & Diederich – WIs: Saaremaa, Tagamõisa, Tammese, alvar (58°25,5'N, 21°59,7'E), on calcareous pebbles and soil over mosses in Sedo-Scleranthenea, 24 July 2004, leg. S. Boch T31/B11.5. Freq.: rr. – This only recently described species (Sérusiaux et al., 1999) is known from northern and western Europe in lowland areas. It has been confused with *Agonimia gelatinosa*, which is a mountainous-boreal species. *A. globulifera* differs from this species by the thallus possessing numerous shiny, black sterile globules (young fruiting bodies). The common *A. tristicula* has a distinct squamulose thallus, no globules and larger ascospores, 2 per ascus.

Arthonia farinacea (H. Olivier) R. Sant. – NW: Raplamaa, Märjamaa comm., Niidiaia wooded meadow with oaks (58°53'N 24°28'E), on soralia of *Ramalina farinacea* on *Quercus robur*, 14 July 2004, leg. & det. A. Suija No. 45. Freq.: rr.

Didymellopsis collematum (J. Steiner) Grube & Hafellner – WIs: Hiiumaa, Kadakalaid islet (58°59'N 23°00'E), limestone bank in the northern coast, on *Collema* sp. on ground mosses, 6 July 2004, leg. A. Suija & I. Jüriado No. 609, det. A. Suija. Freq.: rr.

Endococcus protoblasteniae Diederich – WIs: Hiiumaa, Vohilaid islet (58°55'N 23°02'E), eastern coast, on *Protoblastenia rupestris* on limestone shingle, 7 July 2004, leg. A. Suija & I. Jüriado No. 657, det. A. Suija. Freq.: rr. – This species has been previously reported from Luxemburg (Sérusiaux et al., 1999) and Sweden (Santesson et al. 2004).

Fellhaneropsis vezdae (Coppins & P. James) Sérus. & Coppins – SW: Pärnumaa, Surju comm., Sigaste (58°13'2"N 24°48'18"E), spruce and ash dominating eutrophic paludified forest, on *Alnus glutinosa*, 10 July 2003, leg. & det. M. Nõmm. Freq.: rr. – The species is recorded in Norway, Sweden and Lithuania and is not found in Finland and Latvia (Motiejúnaité, 1999; Piteráns, 2001; Santesson et al., 2004).

Monodictys fuliginosa Etayo – NE: Ida-Virumaa, Oonurme forestry, q. 82/8, (59°08'45"N 26°57'17"E), *Oxalis myrtillus-Vaccinium uliginosum* type aspen forest with some *Picea abies* and *Betula pendula*, on thallus of *Lobaria pulmonaria* on *Populus tremula*, 23 Jan 2004, leg. I. Jüriado, det. A. Suija. Freq.: rr. – This inconspicuous hyphomycete, restricted to *L. pulmonaria* has been recorded from Spain and Scotland (Etayo & Diederich, 1996), Canary islands (Etayo, 1996) and Russia (Hermansson et al., 1998; Zhurbenko, 2001).

Naeterocymbe fraxini (A. Massal) R.C. Harris – NE: Jõgevamaa, Tabivere comm., Sortsi (58°34'27"N 26°25'12"E), birch and spruce dominating eutrophic paludified forest, on *Alnus incana*, 16 Sept 2003, leg. & det. M. Nõmm. Freq.: rr. – The species is recorded in Norway and Sweden, not found in Finland, Latvia and Lithuania (Motiejúnaité, 1999; Piteráns, 2001; Santesson et al., 2004).

Phacopis fusca (Triebel & Rambold) Diederich – WIs: Saaremaa, Muhu island, at the edge of Raugi wooded meadow (58°39'N 23°17'E), on *Xanthoparmelia* sp. on granite, 29 May 2004, leg. & det. A. Suija; Hiiumaa, Vohilaid islet, alvar (58°55'N 23°02'E), on *Xanthoparmelia* sp. (infected also with *Lichenostigma cosmopolites*) on granite, 7 July 2004, leg. I. Jüriado & A. Suija No. 632, det. A. Suija. Freq.: rr.

Pronectria robergei (Mont. & Desm.) Lowen – NW: Raplamaa, Kõnnumaa Landscape

Reserve, near Lalli village, former gravel quarry (58°53'N 25°00'E), on *Peltigera* sp. (infected also with *Graphium aphthosae* and *Corticifraga fuckelii*) on soil, 1 Oct 2003, leg. & det. A. Suija No. 13. Freq.: rr.

SARCOSAGIUM CAMPESTRE (Fr.) Poetsch & Schied. – SE: Võrumaa, Karula National Park, near to the Pautsjärve reservation, former gravel quarry (57°41'N 26°29'E), on *Peltigera* sp. (infected also with *Graphium aphthosae*) and on soil mosses, 24 Aug 2003, leg. & det. A. Suija (TU-26822). Freq.: rr. – *Sarcosagium campestre* is one of a few ephemeral lichens. The life-cycle of this species has been described by Gilbert (2004) in detail. According to his field observations, the fruit-bodies of *S. campestre* are detected in rather short period in a year, from the late summer to the beginning of spring.

SPHAERELLOTHECIUM ARANEOSUM (Arnold) Zopf var. CLADONIAE Alstrup & Zhurb. – WIs: Hiiumaa, Vohilaid islet (58°55'N 23°02'E), alvar in central part of the islet, on *Cladonia symphycarpia* on soil, 7 July 2004, leg. I. Jüriado & A. Suija No. 626, det. A. Suija. Freq.: rr. – This a while ago described taxon (Zhurbenko & Alstrup, 2004) is rather easily noticed through the dark net-like mycelium bound with fruit-bodies on primary squamules of various *Cladonia* species growing on soil.

THELIDIUM MINUTULUM Körb. – NW: Raplamaa, Kädva, Kädva stream (58°54'N 25°05'E), on inundated stones, 15 July 2004, leg. A. Suija No. 56, det. H. Thüs. Freq.: rr. – *Thelidium minutulum* was repeatedly reported from European watercourses, e.g. by Gilbert (1996) from British limestone creeks, by Keller (2000) on gneiss from the fluvial mesic Zone in the river Teigitsch in Austria and also on schist in the fluvial mesic zone of the small river Wisper in Germany (Thüs, 2002: p. 191). Certainly it is a species with a very wide ecological amplitude and will be found in other habitats in Estonia also.

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