



Abh. Ber. Naturkundemus. Görlitz	Band 79 Heft 1	S. 131 – 140	2007
--	-------------------	--------------	------

ISSN 0373-7586

Biodiversity of lichens and lichenicolous fungi of Mt Bol'šoj Thač (NW Caucasus) and its vicinity

VOLKER OTTE

University of Potsdam and State Museum of Natural History, Görlitz

Abstract

The Bol'šoj Thač region (Russian Federation: Republic of Adygea) is characterised by a remarkably high diversity of its lichen flora. With more than 400 taxa of lichens and lichenicolous fungi being reported so far, it contains an important part of the lichens known from the NW Caucasus Mts. A considerable number of species was documented for the NW Caucasus, in some cases for the entire Caucasus, for the first time, among them several first records for the territory of the Russian Federation. Due to the presence of wood stands hardly influenced by forestry measures and the absence of air pollution, the Bol'šoj Thač region has a model character for natural European forest ecosystems. The area represents a refuge for lichen species that have, due to environmental pollution and forestry, disappeared from large regions within Europe. Ten of the eleven lichen species of the Red Data Book of Russia that are known from the Caucasus have been found in the study area, that comes up to 24 % of Russia's Red Data Book lichens. Due to the relatively low elevation compared with the Caucasian Biosphere Reserve, biogeographical peculiarities of the Caucasus are well represented. For the preservation of the taxa that are remarkable from the ecological and biogeographical points of view, virgin forest stands in moist valleys are of special importance.

Zusammenfassung

Biodiversität der Flechten und flechtenbewohnenden Pilze des Berges Bol'šoj Thač (NW Kaukasus) und seiner Umgebung – Die Flechtenflora im Umfeld des Berges Bol'šoj Tchač (Russische Föderation: Republik Adygea) zeichnet sich durch eine große Vielfalt aus. Mit bisher dokumentierten über 400 Taxa von Flechten und lichenicolen Pilzen umfaßt sie einen bedeutenden Teil der aus dem NW-Kaukasus überhaupt bekannten Sippen. Eine beträchtliche Zahl von Arten konnte erstmals für den NW-Kaukasus bzw. Kaukasus nachgewiesen werden, darunter verschiedene Erstnachweise für das Gebiet der Russischen Föderation. Durch das Vorhandensein forstlich wenig oder nicht beeinflusster Waldbestände unter Absenz von Schadstoffeinträgen besitzt das Gebiet Modellcharakter für natürliche europäische Waldökosysteme. So finden sich zahlreiche in Europa durch Immissionseinflüsse und forstwirtschaftliche Eingriffe großräumig zurückgegangene Sippen. Im Gebiet sind 10 der 11 aus dem Kaukasus bekannten Flechtenarten des Roten Buches der Russischen Föderation vertreten, bzw. 24 % aller Rotbuchflechten Rußlands. Durch die im Vergleich zum Kaukasischen Biosphärenreservat relativ geringe Höhenlage sind auch biogeographische Besonderheiten des Kaukasus gut repräsentiert. Für die Erhaltung der ökologisch und biogeographisch besonders bemerkenswerten Sippen sind vor allem ursprüngliche Waldbestände in feuchten Tälern von Bedeutung.

Резюме

Биоразнообразие лишайников и лихенофильных грибов г. Большой Тхач (сев.-зап. Кавказ) и своих окрестностей – Район г. Бол. Тхач (Российская Федерация: Республика Адыгея) характеризуется высоким разнообразием своей лихенофлоры. До сих пор более чем 400 таксонов лишайников и лихенофильных грибов были найдены, это является значительной частью всей известной лихенофлоры северо-западного Кавказа. Многие виды были найдены в первый раз на северо-западном Кавказе или Кавказе, в том числе виды, которые до сих пор не были известны из России. В результате присутствия лесов не подверженных влиянию или находящихся под небольшим влиянием лесопользования, при одновременном отсутствии загрязнения воздуха, район г. Бол. Тхач является модельным для природных европейских лесных экосистем. Многие из представленных здесь видов лишайников исчезли из большинства регионов Европы в результате загрязнения окружающей среды и лесопользования. В районе г. Бол. Тхача были найдены 10 из 11 известных с Кавказа краснокнижных лишайников России, это 24 % всех краснокнижных лишайников Российской Федерации. Из-за относительно малой высоты н. у. м. в сравнении с Кавказским Заповедником, в окрестностях г. Бол. Тхач биogeографические особенности Кавказа хорошо представлены. Наиболее важным для сохранения видов, примечательных с точки зрения экологии и биogeографии, являются нетронутые леса во влажных долинах.

Keywords: World Nature Heritage, Western Caucasus, nature protection

1. Introduction

The studies presented below were initiated in 1997 when the question of protecting the Bol'soj Thaç region became pressing. They provided basic information on the significance of protecting this area from a lichenological point of view. After the foundation of the Bol'soj Thaç Nature Park they were continued. In the meantime the results regarding species composition have been published in detail in a number of papers. The aim of the paper presented here is to discuss these results mainly focussing on the importance of the considered area for the preservation of lichenological biodiversity on a larger scale and the measures that are necessary to guarantee this preservation.

2. Materials and methods

The study area comprises the surroundings of Mt Bol'soj Thaç in the NW Caucasus (Russian Federation: Republic of Adygea, 44°02'40"N – 40°26'E) (Fig. 1). The field work was carried out during excursions, each of them lasting about 3 weeks in the years 1997 – 1999, 2001 – 2005 and 2007. They mainly took place in the summer months (usually between June and September), but in May in 2004. The basic study sites are shown in Fig. 2; they are characterised in detail in OTTE (2001, 2004, 2007a).

The collected material was deposited in GLM and in the author's own herbarium, respectively. The determination methods are described in detail by OTTE (2007a).

The appendix of this volume contains a complete list of the lichens and lichenicolous fungi observed in the study area; for author citations of the taxa mentioned here in the text, see there.

The importance of the area for the preservation of lichenological biodiversity was estimated regarding the regional and the European scale based on literature studies considering rareness and endangerness of the species. Necessities for protection measures are derived from the occurrence of the according taxa.

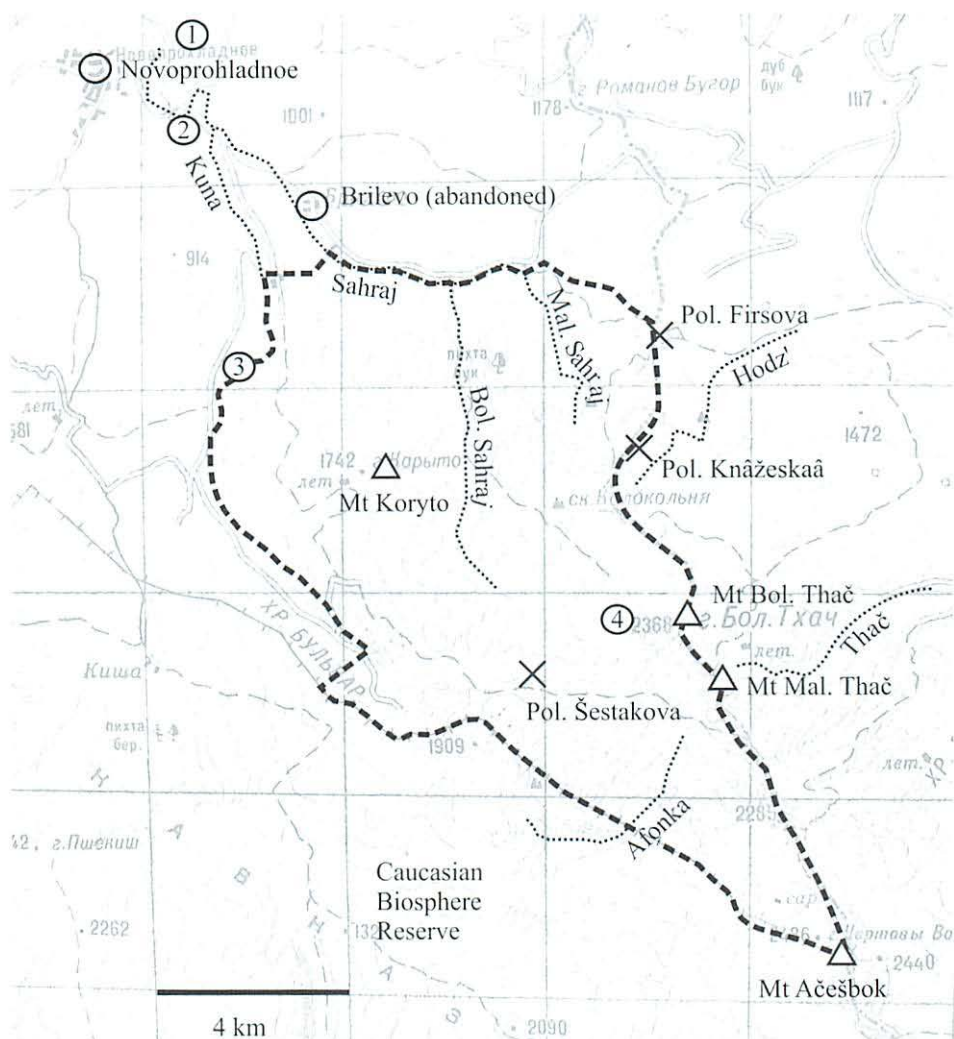


Fig. 1 Location of the study area (circle)

3. Results

3.1. Biodiversity

At present, more than 400 lichen species and a number of lichenicolous fungi have been documented in the study area (OTTE 2001, 2004, 2007a, b; see appendix). Quantitatively, that comes up to 75 % of the species number of lichens that was reported by KRIVOROTOV (1995) for the whole NW Caucasus based on historical data and his own collections. Qualitatively, many taxa were found that were not previously known from the NW Caucasus (OTTE 2004, 2007a, b). Among them are also first records for Russia. In only a few cases was it possible to clarify the latter question due to the lack of a checklist. However, the most recent issues of the Russian Lichen Flora allow an estimation regarding taxa of the families considered there. They also show that many species were not as yet known from the Caucasus (see below).



- ① Mt Šibaba
- ② rapids »Man'kin Šum«
- ③ rocks »Krasnye Skalki«
- ④ refuge »Vetrennyj«
- border of the nature park »Bol'shoj Thač«
- rivers
- Pol. = meadow (Polâna)

Fig. 2 The study area with the main study sites. Map background: Topografičeskaâ Karta Krasnodarskij Kraj, Respublika Adygeâ 1 : 200 000. 439 CĖVKF, Moskva 1996.

3.2. Red Data Book species

Among the species of lichens and lichenicolous fungi found in the study area there are a number of taxa that have been included in Red Data Books. These are

a) from the Red Data Book of the Russian Federation (Krasnaâ Kniga Rossii 2005):

Leptogium burnetiae: in the lower mountain belt widespread on tree trunks covered with bryophytes,

Leptogium hildenbrandii: margins of the meadow Polâna Firsova, on *Populus tremula*; along Sahraj valley, on tops of hills and ridges in thermophile oak stands (e.g. Mt Šibaba near Novoprohladnoe),

Lobaria amplissima: in forest stands that are not or only weakly affected by forestry, especially in the middle mountain belt (beech belt) on old deciduous trees,

Lobaria pulmonaria: in forest stands that are not or only weakly affected by forestry, from the middle mountain belt (beech belt) to the upper montane belt (fir belt) and occasionally up to the subalpine belt on old deciduous trees (in and above the fir belt on *Acer trautvetteri*),

Menegazzia terebrata: in deciduous forests, particularly in moist valleys on *Alnus incana*, also in beech forests that are not or only weakly influenced by forestry,

Nephromopsis laureri: 1 record (headwaters of the river Thač, on *Betula*),

Parmotrema arnoldii: 1 record (Afonka valley),

Parmotrema reticulatum [sub *Rimelia* r.]: 2 records: valley of the river Mal. Sahraj, on *Fagus*; above rapids »Man'kin Šum« 2 km E of the village Novoprohladnoe, on *Carpinus*,

Pyxine soredata: valleys of the rivers Mal. Sahraj and Bol. Sahraj, on *Fagus*, rare,

Usnea florida: preferably in the lower mountain belts (oak belt and beech belt) on twigs of deciduous trees, widespread.

It is remarkable that this includes 10 of 11 (or 91 %) of all Russian Red Data Book lichens that are known to occur in the Caucasus (except for the Black Sea coast and the steppe foreland) or 10 of 42 = 24 % of the Russian Red Data Book lichens altogether.

b) Furthermore from the Red Data Book of Adygeâ (Krasnaâ Kniga Respubliki Adygeâ 2000):

Chaenothecopsis consociata: 1 record (valley of the river Afonka),

Cybebe gracilentia [sub *Coniocybe* g.]: 1 record (valley of the river Hodz'),

Lecanora mughicola: 1 record (clapboards of the refuge Vetrennyj),

Melanelia fuliginosa: in the mountain forests widespread on deciduous trees, also on *Abies*,

Ramalina fraxinea: on deciduous trees, scattered, e.g.: below the meadow Polâna Knâžeskaâ, on *Acer trautvetteri* and *Sorbus aucuparia*; near the refuge Vetrennyj on *Salix*; ridge between Mt Afonka and Mt Malyj Thač, on *Acer trautvetteri*,

Ramalina sinensis [sub *R.* »*asahina*« = *R. asahinana*]: widespread in the lower and middle mountain forest belt of the study area, preferably on twigs of deciduous trees,

Usnea articulata: in the fir belt widespread on branches and twigs of *Abies*.

Krasnaâ Kniga Respubliki Adygeâ (2000) also mentions *Usnea distincta* Motyka. According to Opredelitel' lišajnikov Rossii (1996) this is probably a synonym of *U. glabrescens* that is widespread in the lower and middle mountain belts of the study area.

Furthermore, »*Bryoria jubatus* (L.) Brodo & D. Hawksw.« is mentioned in Krasnaâ Kniga Respubliki Adygeâ (2000), and »*Brioria jubatus* (L.) Ach.« in Krasnaâ Kniga Respubliki Adygeâ (1997). This probably means *Alectoria jubata* (L.) Ach., which is a nomen ambiguum and has therefore been declared as a nomen rejicendum (BRODO & HAWKSWORTH 1977, JØRGENSEN et al. 1994, GREUTER et al. 2000). *Alectoria jubata* auct. p. p. is synonym to *Bryoria fuscescens*; a species that is common in the coniferous forests of the upper mountain belt of the study area.

3.3. Further rare, endangered or otherwise remarkable species

Besides the species that are explicitly considered as endangered and declared as protected by the Red Data Books of Russia or Adygeâ, the study area shelters a high number of lichen occurrences which are to be considered as remarkable in a larger scale.

On the one hand, due to the absence of anthropogenic pollutants (Umweltbundesamt 1997) with a \pm neutral pH of the precipitation (see PUČIK & MOROZOVA 1994 regarding the Teberda Reserve, which is situated 125 km ESE of the study area), a considerable number of lichens can be observed that have disappeared or become extremely rare in large regions of Europe due to air pollution. These are namely species sensitive to acidification, particularly lichens with cyanobacteria such as e.g. *Collema flaccidum*, *C. furfuraceum*, *C. nigrescens*, *C. fasciculare*, *C. fragrans*, *C. subflaccidum*, *Leptogium cyanescens*, *L. saturninum* and the Red Data Book species of the genus *Leptogium* (Ach.) Gray mentioned above, *Nephroma helveticum*, *N. parile*, *N. resupinatum*, *Pannaria conoplea*, *P. rubiginosa*, *Degelia plumbea*, *Parmeliella triptophylla*, furthermore other neutrophilous and subneutrophilous epiphytes such as *Anaptychia ciliaris*, *Bacidia incompta*, *B. rosella*, *Caloplaca flavorubescens*, *Gyalecta ulmi*, *G. truncigena*, *Sclerophora nivea* as well as further epiphytes sensitive to immissions of pollutants such as *Melanelia exasperata*, *Ochrolechia pallescens*, *Pyrenula laevigata*, *Phaeophyscia ciliata*, *Rinodina polyspora* and namely the genera *Bryoria* Brodo & D. Hawksw. and *Usnea* Dill. ex Adanson that are well represented in the area with many species, including the Red Data Book species mentioned above.

On the other hand there are »indicators of ecological continuity« (ROSE 1976, 1992) in the remnants of forest stands that have not or only slightly been influenced by forestry, where at least some old trees from the ancient stock have survived. Besides the Red Data Book species of the genus *Lobaria* (Schreber) Hoffm. mentioned above these are *L. scrobiculata* as well as *Sticta sylvatica* and *S. fuliginosa*. Our observations in the region outside the vicinity of Mt Bol'shoj Thač have shown that this is not the typical situation in the NW Caucasus. In most of the places large areas of the forests have been cut down and now consist of coppice-like woodland where the only old trunks are those of fruit trees, which have been spared. In the oak forest belt a similar situation can also be encountered in the Thač region; cohesive stands without human impact are nearly lacking, but on single old trees peculiarities such as e.g. *Bactrospora dryina* and *Caloplaca lucifuga* can be found.

Many species that can still be found (in part more or less frequently) in the study area have become so rare and endangered in Europe that they have been included into the Red Data Book of Macrolichens of the European Union (SERUSIAUX 1989). These are *Bryoria smithii*, *B. kuemmerleana*, *Cetraria sepincola*, *Degelia plumbea*, *Flavopunctelia soredica*, *Fuscopannaria praetermissa*, *F. saubinetii*, *Hypogymnia austerodes*, *Hypotrachyna*

endochlora, *Lobaria amplissima*, *L. scrobiculata*, *Nephroma helveticum*, *Nephromopsis laureri*, *Pannaria conoplea*, *P. rubiginosa*, *Parmeliella parvula*, *Parmotrema arnoldii*, *P. stippeum*, *Peltigera venosa*, *Phaeophyscia kairamoi*, *Punctelia perreticulata*, *Pyxine sorediata*, *Ramalina obtusata*, *R. roesleri*, *R. sinensis*, *R. thrausta*, *Sticta fuliginosa*, *S. sylvatica*, *Usnea articulata* and *U. longissima*.

A considerable number of species has evidently hitherto not been observed anywhere else in Caucasia. In the recently published 8th volume of the Russian Lichen Flora (Opredelitel' lišajnikov Rossii 2003), which contains the families Bacidiaceae, Mycobilimbiaceae, Rhizocarpaceae and Trapeliaceae, and in the 9th volume (Opredelitel' lišajnikov Rossii 2004) dealing with the Fuscideaceae and Teloschistaceae, and that traditionally consider the whole former Soviet territory, *Bacidia circumspecta*, *B. fraxinea*, *B. subincompta*, *Bilimbia lobulata*, *Caloplaca cerinelloides*, *C. chrysophthalma*, *C. latzelii*, *C. lucifuga*, *Cliostomum corrugatum*, *Toninia alutacea*, *Mycobilimbia carnealbida*, and *Rhizocarpon atroflavescens*, which were found in Bol'shoj Thač region, had not been previously mentioned from the Caucasus. They are also lacking in BARHALOV'S (1983) Caucasian lichen flora. Furthermore, according to the cited volume of the »Opredelitel«, *Trapelia corticola*, *Caloplaca latzelii* and *Caloplaca lucifuga* seem to have not been known before from the whole of Russia. For the majority of the families it was not possible to judge this question with this topicality. Until now *Bacidia suffusa* was only known from eastern North America (see OTTE 2007b).

Remarkable findings are also among the lichenicolous fungi. According to Žurbenko (in litt.) *Taeniolella punctata* and *Vouauxiomyces truncatus* are first records for Russia.

Finally, there is a number of species that are remarkable from a biogeographical point of view. As was pointed out by OTTE (2004, 2007a), the Bol'shoj Thač region houses several lichens whose global distribution is concentrated on the eastern sides of Eurasia and North America respectively, and which are absent or very rare in Europe. These are namely *Phaeophyscia rubropulchra*, *Ph. erythrocardia*, *Pyxine sorediata*, *Lecanora thysanophora*, *Myelochroa aurulenta*, *M. metarevoluta*, *Ramalina conduplicans*, *Bacidia suffusa*. Most of them are not known elsewhere in the NW Caucasus.

4. Discussion

Constitutional features causing the high biodiversity of the lichen flora of the study area are doubtlessly the diverse natural conditions: the diversity of stands in a submeridional mountain area that contains several altitudinal belts from oak forests in the lower montane belt via montane beech and fir forests up to subalpine pine and birch woodlands and open alpine grasslands (see OTTE 2007c in this volume). The high diversity of species is also supported by the diversity of rock substrata (limestone and siliceous rocks) and certainly the oceanic climate conditions due to the proximity to the Black Sea.

On a smaller scale of consideration, the diversity of human utilisation (several kinds of forestry, fruit orchards, pastures) contributes to the lichen diversity as well.

Compared with similar regions in Europe, most noteworthy is the fact that the high lichen diversity is documented not only for historical times, but also contemporarily. The coincidence of virgin forests with unpolluted environments is a very remarkable feature of the study area that enables the occurrence of a high number of lichens that are threatened in Europe. Compared with Europe it is of special interest that even in the deciduous forest belt

(viz. down to the beech belt) there are some stands with only limited or absent human impact in Bol'šoj Thač region. This explains the often abundant occurrence of lichens highly threatened in Europe in the study area. In Europe the very few virgin forest remnants that are situated south of the boreal zone and below the upper montane belt are more or less under influence of pollutants. Even in the famous Białowieża virgin forest reserve in eastern Poland, which is situated rather remotely from sources of environmental pollutants, many sensitive lichens have totally disappeared, and others have become less vital due to the wide-ranging air pollution in Europe (CIEŚLIŃSKI & TOBOLEWSKI 1988). That makes the forests of the study area all that more important for the preservation of the biodiversity of Europe's lichens and a unique model region for the study of unaffected cryptogamic vegetation of European type. As was shown by PETERSSON et al. (1995) in undisturbed compared with anthropogenically disturbed boreal coniferous forest systems of Scandinavia, the epiphytic cryptogamic synusia hold a central role in the functionality of natural forest ecosystems. There are few chances to study such questions in deciduous forest systems in Europe due to the lack of undisturbed deciduous forests, but the Bol'šoj Thač region offers this opportunity.

Particular attention should be given to the lichenicolous fungi. They often specifically depend on certain host lichens and are therefore rarer and more threatened than the lichens themselves. The rich lichen flora of the study area supports a remarkable diversity of lichenicolous fungi which have been only partly identified as yet.

The most remarkable floristic element in the lichen flora of Bol'šoj Thač region consists of the species with an »eastern distribution affinity« lacking or very rare in Europe and mainly occurring in East Asia and/or eastern North America. Their distribution pattern is accurately that of the so-called »Tertiary relicts« among the vascular plants. This pattern is interpreted differently (e.g., JÄGER 1968, MEUSEL & JÄGER 1989: ecogeographical vs. the conventional historical explanations). The occurrences of lichens of this global distribution type in the study area are concentrated in moist valleys of the lower montane belt (see OTTE 2004, 2007a and discussion there). This belt is well represented in the Bol'šoj Thač region; a fact that must be pointed out because according to AKATOVA (2004), who studied the bryophyte flora of the Caucasian Reserve, the biogeographically remarkable elements are strongly under-represented there compared with arctic-alpine species due to the extension of the Caucasian Reserve predominantly in the upper mountain belts.

Altogether, from a lichenological point of view, the vicinity of Mt Bol'šoj Thač must be considered as a very valuable part of the World Heritage Site Western Caucasus. The protection of undisturbed woodlands in moist valleys seems particularly important.

5. Acknowledgements

Kristin Meier (Potsdam) is thanked for the improvement of the English, two unknown reviewers are thanked for some corrections and for proposals for improvements in the manuscript and Kathrin Wiegand (Staatliches Museum für Naturkunde Görlitz) for graphic design assistance.

6. References

- AKATOVA, T. V. (2004): Listostebel'nye mhi Kavkazskogo zapovednika (Zapadnyj Kavkaz). – Avtoreferat dissertacii, RAN, Glavnyj botaničeskij sad im. N. V. Cicina. Moskva, 20 pp.
- BARHALOV, Š. O. (1983): Flora lišajnikov Kavkaza. – Elm, Baku, 338 pp.
- BRODO, I. M. & D. L. HAWKSWORTH (1977): *Alectoria* and allied genera in North America. – *Opera Bot.* **42**: 1 – 164
- CHIEŚLIŃSKI, S. & Z. TOBOLEWSKI (1988): Porosty (Lichenes) Puszczy Białowieskiej i jej zachodniego przedpola. – *Phytocoenosis* **1**: 1 – 216
- GREUTER, W., J. MCNEILL, F. R. BARRIE, H.-M. BURDET, V. DEMOULIN, T. F. FILGUEIRAS, D. H. NICOLSON, P. C. SILVA, J. E. SKOG, P. TREHANE, N. J. TURLAND & D. L. HAWKSWORTH (2000): International Code of Botanical Nomenclature (St. Louis Code) adopted by the Sixteenth International Botanical Congress St Louis, Missouri, July-August 1999. Electronic version of the original English text, last updated April 20, 2003. – [<http://www.bgbm.fu-berlin.de/iapt/nomenclature/code/SaintLouis/0000St.Luistitle.htm>] (last access 19 December, 2005)
- JÄGER, E. (1968): Die pflanzengeographische Ozeanitätsgliederung der Holarktis und die Ozeanitätsbindung der Pflanzenareale. – *Feddes Repert.* **79**: 157 – 335
- JORGENSEN, P. M., P. W. JAMES & C. E. JARVIS (1994): Linnæan lichen names and their typification. – *Bot. J. Linn. Soc.* **115**: 261 – 405
- Krasnaâ Kniga Respubliki Adygeâ (1997): Informacionnyj bûlleten'. – Ed. by Ministerstvo ohrany okružaûšej sredy i prirodnyh resursov RA. Majkop, 20 pp.
- Krasnaâ Kniga Respubliki Adygeâ (2000): Ed. by Ministerstvo ohrany okružaûšej sredy i prirodnyh resursov RA. Majkop.
- Krasnaâ Kniga Rossii (2005): Perečen' ob'ektov rastitel'nogo mira, zanesennyh v Krasnuû Knigu Rossijskoj Federacii [<http://www.redbook.ru/article414.html>]
- KRIVOROTOV, S. B. (1995): Lišajniki i lišajnikovye gruppirovki severo-zapadnogo Kavkaza i predkavkaz'â. Florističeskij i êkologičeskij analiz. – Krasnodar, 204 pp.
- MEUSEL, H. & E. J. JÄGER (1989): Ecogeographical differentiation of the Submediterranean deciduous forest flora. – *Plant Syst. Evol.* **162**: 315 – 329
- Opredelitel' lišajnikov Rossii (1996): Vol. 6. – Nauka, Sankt-Peterburg, 203 pp.
- (2003): Vol. 8. – Nauka, Sankt-Peterburg, 278 pp.
- (2004): Vol. 9. – Nauka, Sankt-Peterburg, 338 pp.
- OTTE, V. (2001): Flechten und Moose im Gebiet des Bolschoi Tchatsch (NW-Kaukasus) – eine erste Übersicht, ergänzt durch einige von D. Benkert bestimmte Pezizales. – *Feddes Repert.* **112** (7 – 8): 565 – 582
- (2004): Flechten, Moose und lichenicole Pilze aus dem nordwestlichen Kaukasus – erster Nachtrag. – *Feddes Repert.* **115** (1 – 2): 155 – 163
- (2007a): Flechten, lichenicole Pilze und Moose aus dem Nordwest-Kaukasus – zweiter Nachtrag. – *Herzogia* **20**: 221 – 237
- (2007b): *Bacidia suffusa* (Lichenes: Bacidaceae) in Adygeya (Caucasus), the first record outside America. – *Abh. Ber. Naturkundemus. Görnitz* **78** (2): 141 – 145
- (2007c): Vegetation and flora of vascular plants in the vicinity of Mt Bol'soj Thač (NW Caucasus) and the effects of human interference. – *Abh. Ber. Naturkundemus. Görnitz* **79** (1): 85 – 95

- PETTERSSON, R. B., J. P. BALL, K.-E. RENHORN, P.-A. ESSEEN & K. SJÖBERG (1995): Invertebrate communities in boreal forest canopies as influenced by forestry and lichens with implications for passerine birds. – *Biol. Conserv.* **74**: 57 – 63
- PUČIK, M. L. & O. V. MOROZOVA (1994): Kislótnost' atmosferynh osadkov v Teberdinskom Gosudarstvennom zapovednike. – In: Kavkazskij Gosudarstvennyj Biosfernyj Zapovednik (ed.): Itogi i perspektivy ekologičeskogo monitoringa v zapovednikah. Materialy naučnoj konferencii posvásennoj 70-letiu organizacii Kavkazskogo zapovednika. Soči: 138 – 139
- ROSE, F. (1976): Lichenological indicators of age and environmental continuity in woodlands. – In: BROWN, D. H., D. L. HAWKSWORTH & R. H. BAILEY (eds): *Lichenology: Progress and Problems.* – London: 279 – 307
- ROSE, F. (1992): Temperate forest management: its effects on bryophyte and lichen floras and habitats. – In: BATES, J. W. & A. M. Farmer (eds): *Bryophytes and Lichens in a Changing Environment.* – Oxford: 211 – 233
- SERUSIAUX, E. (1989): Liste Rouge des Macrolichens dans la Communauté Européenne. – Liège.
- Umweltbundesamt (1997): Daten zur Umwelt. Der Zustand der Umwelt in Deutschland. – Ausgabe 1997, Berlin, 570 pp.

Manuscript accepted: 20 September 2007

Author's address:

Dr Volker Otte
Universität Potsdam
Inst. f. Biochemie und Biologie
Lehrstuhl für Biozönoseforschung und Spezielle Botanik
Maulbeerallee 1
14469 Potsdam
email: Volker.Otte@uni-potsdam.de