Problems in conservation of fungal diversity in Bulgaria and prospects for estimating the threat status of microscopic fungi

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Abstract. Recent activity and current problems in conservation of fungal diversity in Bulgaria are discussed. The need for complex investigation, conservation, and monitoring of fungal diversity is presented. A preliminary red list of smut fungi in Bulgaria (as an example for redlisting of microscopic fungi), evaluated with IUCN criteria, is proposed, including 16 species: two Regionally Extinct (RE) (*Ustilago bulgarica* and *Doassansia punctiformis*), four Critically Endangered (CR) (*Entyloma urocystoides, Urocystis aquilegiae, Microbotryum holostei,* and *M. jehudanum*), three Endangered (EN) (*Schizonella intercedens, Sporisorium schweinfurthianum,* and *Urocystis leimbachii*), two Vulnerable (VU) (*Microbotryum violaceo-verrucosum* and *Thecaphora thlaspeos*), and five Data Deficient (DD) (*Entorrhiza casparyana, Entyloma corydalis, Schizonella cocconii, Urocystis eranthidis,* and *U. junci*). Information about their distribution, threats, and conservation actions is also given.

Key words: Bulgaria, conservation of fungi, fungal diversity, redlisting of microscopic fungi, smut fungi, threat status of microscopic fungi

Conservation of fungi in Bulgaria and the gap in biodiversity legislation

Contemporary knowledge of fungal diversity in Bulgaria is based on a hundred years of investigations (Denchev & Bakalova 2002). To date, the total number of recorded slime moulds, fungus-like and fungal species in Bulgaria is approximately 5220, including myxomycetes (>50); oomycetes, hyphochytrids, chytrids, and zygomycetes (>180); nonlichenized ascomycetes (>970); lichen-forming ascomycetes and lichenicolous species (929); basidiomycetes proper (about 1600); smut fungi (119); rust fungi (376); and anamorphic fungi (over 1000) (Denchev 2002, 2003; Denchev *et al.* 2005; Mayrhofer *et al.* 2005; etc.).

There are 3900 species of vascular plants in Bulgaria (Petrova 2001). If the fungus:plant ratio of 5.3:1, proposed by Hawksworth (1998, 2001), is applied, the total fungal diversity of Bulgaria might be estimated at 20 670 species. Inventories of fungus-like organisms and fungi thus clearly lag seriously behind those of animals and plants (Denchev 2002; Denchev *et al.* 2005).

Unfortunately Bulgaria lacks a specific document (law or decree) regulating the collection, purchase, sale, and export of wild fungi. The absence of such a document, which should serve as a normative base for future conservation of fungi, is a serious problem.

Collecting of fungi in Bulgaria is thus absolutely free and uncontrolled, and has greatly escalated since 1990 (Denchev & Bakalova 2002).

Fungi were omitted from the ***Biodiversity Act,*** published in 2002, and are not treated as part of Bulgaria's biodiversity because they do not fit in the terminology in common use, i.e. they are not a component of the terms *plants*, *flora*, *animals*, and *fauna.* In the whole document, there is no place where the words *fungi* and *fungal diversity* are used. There are no fungal species in the appendixes to the ***Act,*** which include lists of protected species and/or species restricted to a regulated regime of use.

The place of fungi in the natural world is of exclusive importance for correct understanding of their uniqueness, and requires correct terminology. The problem is closely related to study of fungal diversity, and to practical conservation, including work on norms and regulations. Similar terminological

problems exist at a European level in European Conservation Legislation.

Biodiversity must be divided not only into plant and animal, but also into fungal diversity. Therefore, two sets of analogous terms are needed:

- **plant diversity / fungal diversity / animal diversity**
- **flora / mycota / fauna**

Abandonment of the term 'flora' in relation to fungi is long overdue (cfr Hawksworth 2003: 40: "Never use terms such as 'plants', 'microorganisms', or 'flora' in relation to fungi"): it should be replaced by the term 'mycota' (as proposed by Barr 1983).

During the last six years, the following activities conserve fungal diversity were carried out by Bulgarian mycologists:

- In 2000 a *Red list and threat status of Bulgarian macromycetes* (Gyosheva *et al.* 2000) was published. The list includes 19 ascomycetes and 106 basidiomycetes. In that list five threat categories were applied – extinct, endangered, vulnerable, rare, and indeterminate. The main purpose of that preliminary list was to initiate important research in fungal conservation and to accelerate proposals for legal measures to conserve fungal diversity.
- Surveys for macromycetes were carried out in some protected areas (Fakirova *et al.* 2000, 2002; Gyosheva & Denchev 2000; Gyosheva 2003; etc.).
- Within the framework of the project *Red lists of plants and fungi in Bulgaria* (2003-2005), assigned by the Ministry of Environment and Water of Republic of Bulgaria, a contemporary *Red list of fungi in Bulgaria* was prepared. It includes 215 species. In that list, current IUCN Red Data Book Categories (IUCN 2001, 2003a, b) were put into practice for the fungi. Establishment of a new and contemporary *Red list of fungi in Bulgaria* is an extremely important and promising step for fungal conservation in Bulgaria.
- Work has begun on a *Red Data Book of Republic of Bulgaria. Vol. 1. Plants and fungi* (2004-2007). It will help legitimize conservation of fungal diversity in Bulgaria.
- In May 2004, a *Workshop on current problems of investigation and conservation of the biodiversity in Bulgaria* was held in Sofia. Mycologists from the Bulgarian Mycological Society took a part in that symposium with an oral presentation entitled *Fungal diversity in Bulgaria – current status of the investigation, conservation, and rational utilization* (Denchev *et al.* 2005). During that workshop the new *National Biodiversity Conservation Plan* (2005-2010) was discussed. The Bulgarian Mycological Society proposed that this *Action Plan* should aim for: (1) amendments and supplements to the *Biodiversity Act* which to correct omissions about fungi, and (2) development of a *Regulation on the wild fungi* for the *Biodiversity Act*. Later both proposals were accepted in the new NBCP. They will be tasks of great importance for Bulgarian mycologists.
- A *Framework for development of a National Biodiversity and Protected Areas Monitoring System in Bulgaria* was created and published (Gospodinov *et al.* 2005). For the first time, fungi will be included by the Ministry of Environment and Water in a monitoring system at national level.

Delimitation of fungi into micromycetes and macromycetes

Dividing fungi into two groups, macromycetes and micromycetes, is too arbitrary. Some authors include within the macromycetes not only basidiomycetes proper, cup fungi, and truffles (cfr Kirk *et al.* 2001) but also parasitic discomycetes of Rhytismatales, different members of pyrenomycetes, and other groups of ascomycetes, even members of Clavicipitales, etc. 'Macromycetes' is not a taxonomic term, and its arbitrary nature generates practical problems in investigation and conservation of fungal diversity. Current practice in Bulgaria is the curious situation where total fungal diversity is interpreted by governmental institutions and NGOs as diversity of only macromycetes. Many practical problems in carrying out inventories of other taxonomical groups of fungi and fungus-like organisms have arisen as a result.

Rossman (1994, 1997) highlighted the urgent need in a defined geographical region for an all-taxa biodiversity inventory of fungi closely related to assessment of the site's other biodiversity.

In conclusion, both study and conservation of fungal diversity in a particular country and within a particular site, should be carried out to reach a full picture of all fungi and fungus-like organisms, instead of concentrating only on the arbitrarily-defined 'macromycetes'.

There are practical difficulties in assessing the status of some groups, e.g. anamorphic fungi, but the long-term aim should be for a full assessment and full conservation of fungal diversity (Denchev 2002, 2003, in press; Denchev & Bakalova 2002; Denchev *et al.* 2005).

Assessing the threat status of microscopic fungi in Bulgaria based mainly on experience from studies on smut fungi

All fungal diversity is an invaluable genetic resource and therefore, the threat status of microscopic fungi must also be subject to assessment (Denchev 2002, 2003; Denchev & Bakalova 2002). Conservation of microscopic fungi is not a new idea and has already been discussed by many authors (Vánky & Harada 1989; Simay 1991; Helfer 1993; Foitzik 1996; Vánky 2004; etc.).

Conservation of microscopic fungi could be realized in different ways. Up to 1986, about 11 500 microscopic fungi, or less than 1 % of their potential number, had been grown *ex situ* in culture collections (Staines *et al.* 1986). Unfortunately, the keeping in a good condition of such collections needs well equipped laboratories and all year financing, which can be afforded only by a small number of countries. Furthermore, pure culture maintenance of many obligate parasites, such as rust fungi, laboulbeniomycetes etc., is impossible or extremely difficult in practice. Cultivation of some other groups, such as smuts, VAM-fungi etc., is possible but very difficult in practice, and not always successful (Rossman 1997). Moreover, even those species, which could be cultivated and preserved in a col-

lection, have restricted genetic diversity: an insignificant part of the real genetic diversity of each of those species in nature (Rossman 1997).

The best strategy for conservation of microscopic fungi is their conservation *in situ* – in their natural habitats, together with the other organisms (Rossman 1997).

Some microscopic fungi are already represented in national red lists, e.g., *A provisional red list of British fungi* (Ing 1992), included 50 species of rust fungi and 13 species of smut fungi; *A provisional red list of phytoparasitic fungi (Erysiphales, Uredinales & Ustilaginales) of Germany* (Foitzik 1996), includes 23 species of powdery mildew, 143 species of rust fungi, and 127 species of smut fungi; etc.

The problems that exist in assessing the threat status of microscopic fungi are similar to those for macroscopic fungi; i.e. a correct taxonomic base; an advanced stage of inventory; accumulation of distribution data; an adequate estimation of threats; etc. A further and very important precondition for assessment of parasitic fungi is their parasitic specialization.

Among the downy mildews, rust fungi, smut fungi, etc. there are species with wider (family), and others, with narrow (genus) specialization.

It is possible for a parasite to have a narrow specialization and for the host to be rather wide-spread in the country. On the other hand, the narrow specialization may be on a host(s) with a limited or even local distribution. In this case, both the host and parasite species may be evaluated as critically endangered species possessing extent of occurrence estimated as less than 100 km2 and/or as species known from a single location. As a result, the parasite as well as the host, must be regarded as organisms requiring conservation.

A parasite may alternatively have a wide specialization but some of its hosts may be rare for the country. For instance, *Puccinia calcitrapae* DC. is a wide-spread rust fungus in Bulgaria, known as a parasite on a large number of *Centaurea* spp. (24 species). However, some hosts, for example *Centaurea immanuelis-loewii* Deg., *C. parilica* Stoj., and *C. kernerana* Janka subsp. *gheorghieffii* (Hal.) Dost. are vulnerable in Bulgaria (Denchev 1995a; Apostolova & Denchev 1997).

Another example among smut fungi is *Schizonella melanogramma* (DC.) J. Schröt. which parasitizes many species of *Carex*. Attacked plants are usually sterile, i.e. without generative organs. *Schizonella melanogramma* is widely distributed in Bulgaria and Europe but *Carex rupestris* All. is among its Bulgarian hosts (Denchev 1993, 2001). This is an endangered plant species in Bulgaria known only from 2 localities in the Rila Mts and Pirin Mts. Because of the biology of *S. melanogramma,* it may be a factor in reducing the population of *Carex rupestris* in Bulgaria.

A given parasitic species may or may not therefore attack threatened or near threatened plant species. In the latter case, the parasite could be an important factor in control of the number as well as the limitation of host distribution. It may even affect survival of the host population. Such a parasite attacking threatened plants may be a wide-spread species, but it may also be an endangered or vulnerable species. An example from Bulgaria is *Urocystis aquilegiae* (Cif.) Schwarzman, a *Critically Endangered* (CR) species at regional and European level, on *Aquilegia aurea* Janka, a Balkan endemic and *Near Threatened* (NT) species for Bulgaria.

In the most complicated case (in conservation terms) of a fungus/host combination, e.g., a combination of a threatened parasitic species on a threatened plant species, an interesting question arises: should the parasite be destroyed or should it be protected together with the host species (cfr Helfer 1993)? The latter is surely the better conservation strategy.

Another question, very often posed, is "should microscopic fungi which can be recognized by only a few specialists in the country, be included in a red list"? The answer should undoubtedly be affirmative. A red list assesses the level to which an organism is threatened with extinction. It is not a measure of the ease with which it can be identified in the field. Organisms which are difficult or impossible to identify in the field should never be excluded from red-lists for this reason. There is a similar situation with threatened macroscopic fungi, i.e., there are many macroscopic fungi, including those in many national red lists, which are difficult to distinguish in field conditions and which can be identified only by a small number of mycologists but not, for example, by an officer responsible for the management of a protected area. Regardless of the ease with which they can be identified, all organisms can only be protected by habitat conservation. The aim in assessing the threatened species of microscopic fungi is rather to protect their sites and their host plants in nature, as well as certain specific habitats. Protection of such microscopic fungi can be realized only together with protection of threatened species of plants and other taxonomic groups of organisms in the same site or habitat(s).

A preliminary red list of smut fungi in Bulgaria

The list, proposed here, includes 16 species, as follows: two Regionally Extinct (RE) species, nine threatened species (four Critically Endangered (CR), three Endangered (EN), and two Vulnerable (VU) species), and five Data Deficient (DD) species. Their status evaluation is based on the IUCN criteria (IUCN 2001, 2003a, b). The DD species will receive the same degree of attention as threatened species until their conservation status can be assessed. They are species known in taxonomic terms, but without enough information about distribution, current conservation status, and possible threats. A Data Deficient listing does not imply that a taxon is not threatened (cfr IUCN 2003b).

At present, there is no intention to include these species in the new version (2005) of the *Red list of fungi in Bulgaria.* The aim is simply to stimulate assessment of the conservation status of parasitic and other microscopic fungi and to establish the practice of their redlisting in Bulgaria and the Balkan Peninsula. An obstacle in applying the IUCN criteria is the absence of similar evaluations of microscopic fungi conservation status in other Balkan Peninsula countries: another indication that such studies are overdue.

Ustilago bulgarica Bubák

Status: **Regionally Extinct** (**RE**).

Global status: probably globally **Extinct** (? **EX**).

Distribution: collected in Bulgaria in 1907 in Sadovo and described as a new species (Bubák 1910) (lectotype in PRM 795 563 !, sel. by Denchev 1993; isolectotypes in Sydow, Sydow, Ust., no. 386). This species has not been collected again in Bulgaria since 1907.

General distribution: Europe (Bulgaria) and Asia (Kazakhstan – Schwarzman 1960; two collections from 1943, 1956).

Habitat: a parasite on *Sorghum bicolor* (L.) Moench.

Threats: unknown.

Conservation actions: none.

References: Bubák (1910), Denchev (1993, 2001).

Doassansia punctiformis G. Winter

Status: **Regionally Extinct** (**RE**).

Distribution: collected in Bulgaria in 1900 and reported for this country in 1903 (Bubák 1903, as *Doassansia peplidis* Bubák – holotype in BPI 178 531 !). This species has not been recorded since 1903. The habitat was situated on land near a spa (Haskovo Spa). That area has subsequently been built-up and its character has totally changed. All attempts to find this species again have been unsuccessful.

General distribution: Europe (Bulgaria, France, Portugal) and Australia.

Habitat: a parasite on *Peplis alternifolia* Bieb.

Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, recreation, transport), (ii) pollution (agricultural and domestic land pollution).

Conservation actions: none.

References: Bubák (1903), Denchev (2001).

Entyloma urocystoides Bubák

Status: **Critically Endangered** (**CR**) – CR B2ab(iii).

Distribution: a single locality in Black See coast (Silistar).

General distribution: Europe.

Habitat: a parasite on *Corydalis.*

Threats: habitat loss and degradation (tourism, recreation, human settlement, transport).

Conservation actions: the locality is in Silistar Protected Area.

References: Denchev (1991a, 2001).

Urocystis aquilegiae (Cif.) Schwarzman

Status in Bulgaria and Europe: **Critically Endangered** (**CR**) – CR B1ab(iii)+2ab(iii).

Distribution: a single locality in the Pirin Mts (Bayuvi Doupki).

General distribution: Europe (Bulgaria), Asia, North America. In Europe known only from Bulgaria.

Habitat: a parasite on *Aquilegia aurea* Janka.

Threats: habitat loss and degradation (tourism, recreation).

Conservation actions: the locality is in Pirin National Park.

References: Hinkova (1962); Denchev (2001).

Microbotryum holostei (de Bary) Vánky

Status: **Critically Endangered** (**CR**) – CR B2ab(iii).

Distribution: a single locality in Mt Lyulin.

General distribution: Europe.

Habitat: a parasite on *Holosteum umbellatum* L.

Threats: (i) habitat loss and degradation – agriculture (livestock breeding, wood plantations) and infrastructure development (human settlement, tourism, recreation), (ii) pollution (agricultural and domestic land pollution).

Conservation actions: none.

References: Denchev (1991b, 2001).

Microbotryum jehudanum (Zundel emend. Denchev) Vánky (incl. *M. moenchiae-manticae* (Lindner) Vánky; cfr Denchev 1997a)

Status: **Critically Endangered** (**CR**) – CR B2ab(iii).

Distribution: a single locality in the eastern Rhodopes (Mezek).

General distribution: Europe (Serbia, Bulgaria), Asia (Israel).

Habitat: a parasite on *Moenchia erecta* (L.) P. Gaertner, B. Meyer & Scherb.

Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, transport), (ii) pollution (agricultural and domestic land pollution).

Conservation actions: none.

References: Denchev (1997a, 2001).

Schizonella intercedens Vánky & A. Nagler

Status: **Endangered** (**EN**) – EN B2ab(iii).

Distribution: Northeast Bulgaria (Koshov, distr. Rouse), Znepole region (Mt Zemenska Planina).

General distribution: Europe.

Habitat: a parasite on *Carex michelii* Host.

Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, recreation, transport), (ii) pollution (agricultural and domestic land pollution).

Conservation actions: one of the localities is in Rousenski Lom Natural Park.

References: Zwetko *et al.* (2004).

Sporisorium schweinfurthianum (Thüm.) Vánky

Status: **Endangered** (**EN**) – EN B2ab(iii).

Distribution: Black Sea coast (Sinemorets), Valley of River Strouma (Kulata).

General distribution: S. Europe, Africa, Asia.

Habitat: a parasite on *Imperata cylindrica* (L.) Beauv.

Threats: (i) habitat loss and degradation – agriculture (farming) and infrastructure development (tourism, recreation, human settlement, transport), (ii) pollution (agricultural and domestic land pollution).

Conservation actions: none.

References: Denchev (1991a, 2001).

Urocystis leimbachii Oertel

Status: **Endangered** (**EN**) – EN B2ab(iii).

Distribution: Znepole region(Slivnitsa), Valley of River Strouma (Moursalevo).

General distribution: Europe, Asia, N. Africa.

Habitat: a parasite on *Adonis vernalis* L.

Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, transport), (ii) pollution (agricultural and domestic land pollution).
Conservation actions: none.
References: Denchev (2001).

Microbotryum violaceo-verrucosum (Brandenburger & Schwinn) Vánky
Status: **Vulnerable** (**VU**) – VU B2ab(iii).
Distribution: West Frontier Mts (Mt Osogovo), Valley of River Strouma (Kresnensko Defile), Pirin Mts (Sinanitsa), the Rhodopes (eastern – Golyamo Kamenyane).
General distribution: Europe, North Africa (Morocco).
Habitat: a parasite on *Silene bupleuroides* L. subsp. *bupleuroides, S. gallinyi* Heuffel ex Reichenb., *S. italica* (L.) Pers. *subsp. italica.*
Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, recreation, transport), (ii) pollution (agricultural and domestic land pollution).
Conservation actions: none.
References: Denchev (1995b, 1997b, 2001).

Thecaphora thlaspeos (G. Beck) Vánky (Syn. *Tothiella thlaspeos* (G. Beck) Vánky)
Status: **Vulnerable** (**VU**) – VU B2ab(iii).
Distribution: Northeast Bulgaria (Draganovo, distr. Veliko Turnovo), Znepole region (Tsurven Dol, Zlogosh, distr. Kyustendil), the Rhodopes (central – Asenova Krepost).
General distribution: Europe.
Habitat: a parasite on Brassicaceae (*Alyssum, Erysimum*).
Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, transport), (ii) pollution (agricultural and domestic land pollution).
Conservation actions: none.
References: Denchev (1991a, 2001).

Entorrhiza casparyana (Magnus) Lagerh.
Status: **Data Deficient** (**DD**).
Distribution: a single locality in the Rila Mts (Rila monastery).
General distribution: Europe, North America, New Zealand.
Habitat: a parasite on *Juncus.*
Threats: habitat loss and degradation (tourism, recreation).
Conservation actions: the locality is in the Rila Monastery Natural Park.
References: Denchev (1991a, 2001).

Entyloma corydalis de Bary
Status: **Data Deficient** (**DD**).
Distribution: a single locality in Black See coast (Silistar).
General distribution: Europe.
Habitat: a parasite on *Corydalis.*
Threats: habitat loss and degradation (human settlement, tourism, recreation, transport), domestic land pollution.
Conservation actions: the locality is in Silistar Protected Area.
References: Denchev (1991a, 2001).

Schizonella cocconii (Morini) Liro
Status: **Data Deficient** (**DD**).
Distribution: a single locality in Thracian Lowland (Gorni Voden, distr. Plovdiv).
General distribution: Europe.
Habitat: a parasite on *Carex.*
Threats: (i) habitat loss and degradation – agriculture (farming, livestock breeding) and infrastructure development (human settlement, tourism, recreation, transport), (ii) pollution (agricultural and domestic land pollution).
Conservation actions: none.
References: Denchev (1993, 2001).

Urocystis eranthidis (Pass.) Ainsw. & Sampson
Status in Bulgaria: **Data Deficient** (**DD**).
Distribution: a single locality in Sofia.
General distribution: Europe, Asia, North America.
Habitat: a parasite on *Eranthis hyemalis* (L.) Salisb. (hort.).
Threats: infrastructure development.
Conservation actions: none.
References: Denchev (1991a, 2001).

Urocystis junci Lagerh.
Status in Bulgaria: **Data Deficient** (**DD**).
Distribution: a single locality in in the Rila Mts (Gruncharsko Lake).
General distribution: Europe, Asia, North America, New Zealand.
Habitat: a parasite on *Juncus filiformis* L.
Threats: habitat loss and degradation (tourism, recreation), domestic land pollution.
Conservation actions: the locality is in Rila National Park.
References: Hinkova (1960); Denchev (2001).

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