Fungal diversity and conservation in the Mediterranean area: Recent advances in the inventory of Greek macromycetes

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Abstract. New and interesting records of macrofungi are reported in the framework of a detailed inventory on selected ecosystems of Greece and they are further evaluated on the basis of existing pertinent data. Various types of habitats were investigated consisting mainly of conifer, oak and beech forests and their mycofloristic wealth is presented. In addition, information is provided on taxa which could be considered as rare and/or endangered in conjunction with notes on conservation priorities.

Key words: check-list, Greece, macrofungi, mushrooms, mycoflora

Introduction

Fungal conservation has attracted the attention of mycologists from the early 1980s, when reports started to appear on the prominent decrease of certain groups of macrofungi in some countries (Arnolds 1988; Fellner 1993). Systematic mapping in selected regions revealed essential information on the geographical distribution of macrofungi and showed the very limited occurrence of many species (Krieglsteiner 1991; Nauta & Vellinga 1992), hence the need to protect these sites.

Today, there is a great need for accurate information on the ranges of habitat types, substrates and host specificity of species in different parts of Europe, preferably in a semi quantitative form. This information may be gathered by mycocoenological and autecological studies as well as during annotated floristic and geographical investigations. Special attention should be paid to experimental studies on the impact of various anthropogenic factors on the mycoflora, such as may affect the different types of forest and grassland management, or from the threats of air pollution and urban development.

Nowadays, the evidence for the extinction/losses of macrofungi is biased towards central, western, and northern Europe because of the more detailed studies and the attention this group of organisms has received, whereas for the southern and eastern regions of the continent data are scarce and fragmentary. This lack of reliable information on the distribution of fungi in Europe means that any conclusions drawn about decline are at most tentative and may even be misleading. Several species that have been included in Red-Lists seem to have their main distribution in more southern regions; e.g. *Boletus queletii, B. regius, B. satanas, Gomphus clavatus, Hericium erinaceus, Hydnellum caeruleum, H. ferrugineum, Hygrophorus pudorinus, H. russula, Lactarius mairei, Phellodon niger, Tricholoma aurantium.* In Italy, Spain and France, fungal diversity has been more extensively studied in comparison to other Mediterranean countries. As one might expect, a high species diversity is demonstrated throughout this area, and regional inventories have been published while Red-Lists are under preparation (Perini *et al.* 1993; Venturella *et al.* 1997; Ivancevic 1998; Redeuilh *et al.* 1999).

The current mycofloristic situation in Greece

The geomorphological, biogeographical and climatological conditions in Greece, in conjunction with the high plant diversity and endemism, contribute towards a conservative estimation for the existence of 30 000 fungal species including

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6000-7000 macromycetes. Until now, the total number of the recorded fungal species in Greece is approx. 3500, among which 1800 represent mushrooms.

However, the total number of fungi reported above represents a draft estimation since it does not include recent data on the diversity of microfungi; calculations were based on the Fungus-Host Index for Greece (Pantidou 1973).

Actually, the most adequately surveyed groups belong to the plant pathogenic fungi, to the Homobasidiomycetes, and to the larger ascomycetes. For example, 230 species of Aphyllophorales s. lat. have been recorded out of an estimated total of 550; 580 recorded species of Agaricales out of 2400; 50 recorded species of gasteromycetes out of 150; 20 recorded species of jelly fungi out of 200; 70 recorded species of Pezizales out of 150; and 15 recorded species of Xylariales out of 300; calculated number of species was inferred following Rossman (1994) and Hawksworth (2001), and our own estimations.

As regards macromycetes, pertinent knowledge was very poor until the 1990s (Zervakis *et al.* 1998, 1999). However, significant progress on their inventory and mapping has been accomplished during the last decade and it has resulted in an increase of *ca* 100% of the number of the recorded species.

Novel and interesting records from various ecosystems of Greece

Special attention was drawn to typical Mediterranean ecosystems and largely under-explored regions of continental Greece and Aegean islands (Zervakis 2001). A detailed inventory of macrofungi was carried out during the last six years for the following ecosystems:

a. A typical *Abietion cephalonicae* phytosociety in Mt. Taygetos (southern Peloponnissos, alt. 800-1400 m) dominated by *Abies cephalonica* J.W. Loudon and *Pinus nigra* Arnold subsp. *pallasiana* (Lamb.) Holmboe. This area is representative of the chorological type of southern Greece (Peloponnissos and south-central Greece), it presents a weak mid-mediterranean to sub-mediterranean climate (Zervakis *et al*. 2002a).

b. The deciduous oak forests of central Peloponnissos (alt. 200-900 m) are classified within the para-Mediterranean *Quercetalia pubescentis* phytosociety (*Quercion confertae* suballeance), which extends throughout continental Greece, presenting a weak mid-mediterranean to sub-mediterranean bioclimatic type. *Quercus frainetto* Ten. is the dominant species often forming mixed groups (as well as hybrids) with *Q. pubescens* Willd. (Zervakis *et al*. 2002b).

c. The southernmost beech forest in the Balkan Peninsula (Mt. Oxya, Sterea Hellas, central Greece), which consists of mixed *Fagus sylvatica* L. and *F. moesiaca* (K. Malý) Czecz. trees (1300-1800 m) and the adjacent alpine region (Dimou *et al.* 2002).

d. The *Abies cephalonica* forests of the east side of Mt. Oxya (850-1300 m) intermixed at lower altitudes mainly with *Castanea sativa* Miller, *Quercus* spp., and *Pinus nigra* (authors' unpubl. data).

e. Various other regions in continental Greece (Nafpaktia Mts., Mt. Parnitha, Mt. Dirfi, Mt. Oiti, Mt. Ossa, Mt. Pilion, Mt. Tymfi, etc.) and in the Aegean islands (Andros, Naxos, Agios Efstratios, Kythira, Crete, etc.) (authors' unpubl. data).

All collected specimens are deposited in the herbarium at the authors Institutes (NAGREF-IK and LGAM-AUA), while a photographic archive is also maintained.

During this extensive investigation over 800 macromycete species were recorded, among which more than 200 constituted first records for Greece, while a great number were detected on new host/substrata or ecosystems (e.g. Dimou *et al.* 2002; Polemis *et al.* 2002; Zervakis *et al.* 2002a, b; and authors' unpubl. data). In addition, thirty-eight genera were recorded for the first time:

Amphinema P. Karst., *Amylocorticium* Pouzar (Mt. Taygetos), *Antrodiella* Ryvarden & I. Johans. (Mt. Oxya on conifers), *Athelia* Pers. (Mt. Taygetos, Evvoia), *Botryobasidium* Donk (Mt. Taygetos), *Botryohypochnus* Donk (Mt. Oxya, Nafpactia), *Byssocorticium* Bondartsev & Singer (Mt. Oxya), *Ceratobasidium* D.P. Rogers (Naxos), *Ceriporia* Donk (Evvoia), *Crustomyces* Jülich (Mt. Oxya), *Colus* Cavalier & S□chier (Cyclades, Evvoia, Fthiotida), *Cylindrobasidium* Jülich (Evrytania), *Dentipellis* Donk (Mt. Oxya), *Diplomitoporus* Domanski (Mt. Oxya on conifers), *Endoptychum* Czern. (Mt. Oxya), *Exidiopsis* (Bref.) A. Moeller (Mt. Oxya on conifers), *Faerberia* Pouzar (Mt. Taygetos), *Fayodia* Kühner (Mt. Taygetos), *Fibulomyces* Jülich (Mt. Kallidromo), *Galeropsis* Velen. (Mt. Oxya), *Geoglossum* Pers. (Mt. Taygetos), *Gloeocystidiellum* Donk (Nafpactia), *Gyrophragmium* Mont. (Messinia, Andros), *Leucocoprinus* Pat. (Athens), *Leucocortinarius* (J.E. Lange) Singer (Mt. Oxya), *Litschaurella* Oberw. (Mt. Taygetos), *Mycenastrum* Desv. (Mt. Oxya, Mt. Dirfi in conifers, Nafpactia), *Mycoaciella* J. Erikss. & Ryvarden (Andros), *Myxarium* Wallr. (Cyclades), *Oxyporus* (Bourdot & Galzin) Donk (Mt. Oxya), *Phaeomarasmius* Scherff. (Nafpactia on *Carpinus orientalis* Miller), *Phlebiella* P. Karst. (Arkadia and Evvoia), *Physisporinus* P. Karst. (Mt. Oxya), *Porostereum* Pilat (Messinia), *Simocybe* P. Karst. (Andros, Naxos), *Sistotrema* Fr. (Mt. Taygetos), *Thelephora* Ehrh. & Willd. (Mt. Oxya on soil), *Vararia* P. Karst. (Agios Efstratios), *Veluticeps* Hjortstam & Telleria (Mt. Taygetos) (Dimou *et al.* 2002; Polemis *et al.* 2002; Zervakis *et al.* 2002a, b; and authors' unpubl. data).

In addition, of significant ecological and/or taxonomic interest were the following findings classified within the respective groups:

a. Wood-inhabiting fungi: *Ceriporia purpurea* (Fr.) Donk, Kotsikia (Evvoia) on pine construction-wood, and on *Laurus nobilis* L. (Andros island); *Ceriporia viridans* (Berk. & Broome) Donk, Gardiki (Fthiotida) on *Abies cephalonica; Crustomyces subabruptus* (Bourdot & Galzin) Jülich, Mt. Oxya

on *Fagus sylvatica; Cylindrobasidium laeve* (Pers.) Chamuris, Proussos (Evrytania) on *Platanus orientalis* L.; *Fibulomyces mutabilis* (Bres.) Jülich, Mt. Kallidromo (Fthiotida) on *Pinus* sp.; *Galeropsis madagascariensis* Singer, Gardiki (Fthiotida) on grassy soil under *Alnus glutinosa* (L.) Gaertner and *Platanus orientalis* mixed stands; *Gloeocystidiellum leucoxanthum* (Bres.) Boidin, Mt. Oxya on *Fagus sylvatica; Gloeocystidiellum luridum* (Bres.) Boidin, Nafpactia on *Carpinus orientalis; Hyphoderma argillaceum* (Bres.) Donk, Nafpactia on *Junglans regia* L.; *Hypoxylon fuscum* (Pers.) Fr., Nafpactia on *Carpinus orientalis; Oligoporus fragilis* (Fr.) Gilb. & Ryvarden, Mt. Taygetos and Mt. Oxya on *Abies cephalonica; Oxyporus corticola* (Fr.) Ryvarden, Mt. Oxya on *Fagus sylvatica; Pleurotus dryinus* (Pers.) P. Kumm., Mt. Oxya on *Fagus sylvatica; Phlebia lilascens* (Bourdot) J. Erikss. & Hjortstam, Vovoussa (Ioannina) on *Fagus sylvatica; Podofomes pyrenaicus* F. Rath, Mt. Parnitha on *Abies cephalonica; Porostereum spadiceum* (Pers.) Hjortstam & Ryvarden, Kampos (Messinia) on *Olea europaea* L.; *Sistotrema brinkmannii* (Bres.) J. Erikss., Mt. Taygetos on *Pinus nigra; Tomentella badia* (Link) Stalpers, Nafpactia on *Castanea sativa; Tubulicrinis calothrix* (Pat.) Donk, Nafpactia on *Abies cephalonica.*

b. Secotioid fungi recorded in dry regions with warm weather, whose occurrence is rarely recorded: *Endoptychum agaricoides* Czern., Mt. Oxya at high elevations and in manured soils; *Galeropsis madagascariensis; Gyrophragmium dunalii* (Fr.) Zeller.

c. Macrofungi which are particularly abundant in burned regions and/or appear in large numbers after fires (e.g. Mt. Taygetos, conifers forest): *Geopyxis carbonaria* (Alb. & Schwein.) Sacc., *Gyromitra infula* (Schaeff.) Quĕl., *Helvella leucomelaena* (Pers.) Nannf., *Morchella conica* Pers., *Peziza violacea* Pers., *Plicaria trachycarpa* (Curr.) Boud., *Coprinus angulatus* Peck, *Faerberia carbonaria* (Alb. & Schwein.) Pouzar, *Fayodia maura* (Fr.) Singer, *Galerina vittiformis* (Fr.) Singer, *Lyophyllum sphaerosporum* Kühner & Romagn., *Pholiota highlandensis* (Peck) Quadr. & Lunghini, *Psathyrella pennata* (Fr.) Konrad & Maubl.

d. Taxa associated with *Cistus* spp. and other typical plants of the Mediterranean flora (located mainly in the islands of Andros and Naxos) (Polemis *et al*. 2002; authors' unpublished data): *Marasmius anomalus* Peck var. *microsporus* (Maire) Antonín on stems of *Phoeniculum vulgare*; *Marasmius corbariensis* (Roum.) Singer on leaves of *Olea europaea; Hebeloma album* Peck, *H. cistophilum* Maire, *Lactarius cistophilus* Bon & Trimbach and *L. tesquorum* Malençon associated with shrubs of the genus *Cistus; Peniophora tamaricicola* Boidin & Malençon on *Tamarix* spp. and on *Pistacia lentiscus* L.; *Ceriporiopsis gilvescens* (Bres.) Domański on *Nerium oleander* L.; *Aleurodiscus cerussatus* (Bres.) Höhn. & Litsch. var. *minor* Pilat on *Juniperus phoenicea* L. and *Cistus* sp.; *Crepidotus luteolus* (Lambotte) Sacc. and *Dacryomyces lacrymalis* (Pers.) Sommerf. on *Nerium oleander; Hyphodontia sambuci* (Pers.) J. Erikss. on *Juniperus oxycedrus* L. subsp. *macrocarpa* (Sm.) Ball, *Euphorbia acanthothamnos* Heldr. & Sart. ex Boiss., *Thymus capitatus* (L.) Hoffmanns & Link, *Genista acanthoclada* DC.; *Byssomerulius corium* (Pers.) Parmasto on *Nerium oleander, Myrtus communis* L., *Tamarix* sp., *Pistacia lentiscus; Polyporus meridionalis* (A. David) H. Jahn on *Erica arborea* L.; *Peniophora lycii* (Pers.) Höhn. & Litsch. on *Tamarix* sp., *Genista acanthoclada, Pistacia lentiscus,* and *Calycotome villosa* (Poiret) Link.

Final considerations and concerns

On the basis of the recently obtained information (it might still be considered incomplete since there are inadequate data from past research studies, let alone from detailed inventories), a number of macrofungi could be considered as rare for Greece, e.g. *Battarraea stevenii* (Libosch.) Fr., *Calvatia pachyderma* (Peck) Morgan, *Clitocybe phyllophila* (Pers.) P. Kumm., *Clitocybula lacerata* (Lasch) Singer, *Crepidotus sphaerosporus* (Pat.) J.E. Lange, *Daedaleopsis confragosa* (Bolton) J. Schröt., *Dentipellis fragilis* (Pers.) Donk, *Endoptychum agaricoides* Czern., *Geastrum coronatum* Pers., *Gyroporus cyanescens* (Bull.) Quél., *Hohenbuehelia chevalieri* (Pat.) Pegler, *Hysterangium marchii* Bres., *Lactarius tabidus* Fr., *Laxitextum bicolor* (Pers.) Lentz, *Leucocortinarius bulbiger* (Fr.) Singer, *Macrocystidia cucumis* (Pers.) Joss., *Melanoleuca humilis* (Pers.) Pat., *Myriostoma coliforme* (Dicks.) Corda, *Panus rudis* Fr., *Pleurotus cornucopiae* (Paulet) Rolland, *Porodaedalea conchata* (Pers.) Fiasson & Niemelä, *Pulveroboletus auriporus* (Peck) Singer, *Resupinatus striatulus* (Pers.) Murrill, *Russula nigricans* (Bull.) Fr., *Tephrocybe rancida* (Fr.) Donk, *Tomentella ferruginea* (Pers.) Pat., *Tulostoma fimbriatum* Fr., *Trichaptum biforme* (Fr.) Ryvarden, *Tricholoma colossum* Fr., *Xerula xeruloides* (Bon) Dörfelt, etc.

In Greece, human intervention has not yet caused the adverse effects it has in other European countries; however, it constitutes the main reason for high level concerns as regards macromycetes existence and disribution. Fungi considered to be in an endagered state are those growing in agricultural fields with cereal crops, in swamps, bogs and lake-sides, in fire-susceptible forests or areas undergoing logging, in coastal ecosystems, as well as the wood-rotting species growing in old forests. Appropriate measures for the conservation of the mycoflora include the prohibition of grazing (at least at vulnerable sites of particular biodiversity value), strict enforcement of existing laws concerning building activities within forest regions, intensification of fire-prevention measures, and establishment of protected areas where any anthropogenic activity should be minimized. In addition, of great need is the establishment of a national law regulating harvest of wild mushrooms, since there is a lack of any type of pertinent legislation in Greece.

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The extent of novelty discovered in recent monographic generic revisions and studies of species in particular habitats varies from 0-96 %.Â I 'Fungal diversity' and 'fungi' in this contribution, unless otherwise qualified, refer to all organisms traditionally studied by mycologists. regardless of the kingdoms in which some are now classified; i.e. including chromistan fungi, lichen-forming fungi, slime-moulds, and yeasts. much discussion and research as to the numbers of fungi that may be present on Earth, The 1990 estimate was based on.Â In general macromycetes are less host-specific than microfungi, but the numbers in a particular area compared to plants are pertinent to overall extrapolations. Studying macromycetes in pine-oak forests in Mexico, Cifuentes Blanco et al.