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Mycodiversity in Greece

Abstract

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Research on fungal biodiversity and conservation has been fragmentary and inadequate in Greece. Large gaps exist in our knowledge, despite the ecological importance and value of this region. The geographic position, the variety of landscapes and climatic conditions, the distinct topography and geology combined to create a multitude of habitats for living organisms. As concerns fungi in particular, the large number of host plants, many of which are endemic, provides an additional clue for the alleged existence of a particularly rich mycoflora. Based on scarce and rather ancient literature data, the number of fungal species is about 2,500. In contrast, relatively recent, but still limited, interest in macromycetes contributed at establishing an estimate of 935 species, of which 815 belong to Basidiomycota and 120 to larger Ascomycota. However, these figures represent only a small fraction of the existing mycodiversity as it is also evidenced from relevant detailed studies in other European countries, and from the rate of recording new species for Greece. The need for intensifying this type of work and producing an inventory of the fungal biota is here emphasized. The acquisition and evaluation of new data, first in selected representative ecosystems, could eventually contribute at accomplishing the goal of mapping the Greek mycoflora. Of great priority is also the issue of conservation, and protection of sites which are rich in macrofungi, but nowadays they are rapidly deteriorating.

Introduction

Greece covers an area of 132,000 km^2, is situated in the southernmost part of the Balkan peninsula, and belongs to the Mediterranean zone of the Palearctic biogeographical region. It is characterized by a large climatic diversity, varied landscapes with high mountains and extensive coastline (ca. 15,000 km), with many islands in the Archipelagos of the Aegean and Ionian Sea.

Greece hosts one biological diversity (genetic, population, species, habitats, communities, ecosystems) among the richest in Europe. This wealth is mainly due to:

- The biogeographical position of Greece at the crossing of three continents: Europe, Asia and Africa. The European characteristic prevail in most taxa, but in the sense of a Mediterranean and Balkan European sub-division.
- The high geomorphological diversity of Greece, as evidenced by the large number of islands, the rapid landscape change from marine to alpine, the extensive compartmentaliza-

tion of Greece by numerous caves, rivers, rivulets, gorges, valleys, peninsulas etc. This diversity has promoted the geographical isolation of populations and has triggered endemism.
- The complex geological and ecological history of Greece shaped up by tectonic, eustatic, climatic and biotic interactions.
- The relatively mild human interference as compared to that of northern Europe (e.g. absence of heavy industrial activities, low pollution). Continuous human presence has occurred in the area for millennia, always interacting with the natural resources. Actually, many practices, especially in agriculture, are believed to have increased certain factors of biodiversity by expanding habitat heterogeneity. These trends have changed significantly only in the last few decades.

The number of recorded species and subspecies in Greek flora, as well as the number of endemic and rare plants is in constant change (Phitos & al. 1995). It was calculated to be ca. 6,308 (Strid & Tan 1991), and this is one of the greatest number of taxa recorded within all the other European countries of similar and even larger area (e.g. Denmark with ca. 1,300 and Great Britain with ca. 1,800). The most recent figure regarding the number of endemic taxa is 1,275, i.e. 20.21% of the total Greek flora, and is the highest figure for any country or territory of a comparable extention in Europe and in the Mediterranean area (e.g. mainland Spain has 501 endemic species and Morocco has 536 endemic species) (Phitos & al. 1995). Another interesting aspect of endemism is the genetic differentiation of populations, which is also high in Greece and is mainly attributed to the following reasons: i. the absence of any negative effect of the Pleistocene glaciation period; ii. the very active geological history which resulted in the fragmentation of the country and the creation of isolated areas, islands and habitats with special ecological characters; iii. the enrichment of the native flora through plant migration from the "Central Aegean" and "South Aegean" east-west route, and the "Alpine" north-south route.

Twenty-five groups of habitat types (according to the CORINE classification and Directive 92/43 of the European Union) are represented in Greece, the most important of which are: coastal (dunes, rocky habitats, wetlands, etc.), phrygana and maquis (characteristic of Mediterranean ecosystems, covering about 40% of the country in lowland areas and in thermo- and mesomediterranean zones, with poor soils and dry or semi-dry climate), forest (Mediterranean biotopes with deciduous oaks and sclerophyllous shrubs, and mountain biotopes with *Abies cephalonica* Loudon of southern Greece whereas northern Greece is mainly characterized by the presence of *Fagus sylvatica* L. and *Abies borisii-regis* Mattf.), meadow and grassland habitats (xerophilous therophytic communities, dry grasslands on limestone or siliceous soils, sub-nitrophilous communities and perennial grasses, wet meadows, sub-alpine and alpine meadows, etc.), inland, rocky habitats, with cliffs and screes (with plant communities which colonize the rock crevices, ledges or screes and have a significant diversity and a high degree of endemism), etc.

Fungal diversity in Greece

Data on the diversity of the mycoflora in Greece are very scarce and fragmentary, covering mainly fungi of phytopathological importance and macrofungi. Existing figures produce a total of about 2,500 recorded species. Indicative of the lack of research in this domain is the fact that in other European countries of equivalent or even smaller extention (e.g. United Kingdom or Switzerland) many more fungal species have been described so far (12,000 and 10,000, respectively), out of a conservative estimate of about 70,000 described and an estimated world total of 1,500,000 species (Wilson 1988, Hawksworth 1991, Hawksworth 1993). If such an estimate of the total number of fungal species existing in Greece is attempted on the basis of the respective available figure for vascular plants, then more than 25,000 species are expected to occur. Moreover taking into account, the existing large variety of habitat conditions together with the very limited relevant studies accomplished so far, it is rather easy to confirm this estimate of species yet to be discovered, many of them are anticipated to be endemic for similar reasons as for plants.

The synopsis of the mycoflora of Greece goes back to Maire & Politis (1940), followed by the comprehensive fungus-host index of Pantidou (1973). During the last half of the century, many researches studies were published contributing data on the occurrence, distribution and host-range of plant pathogenic fungi (mainly *Oomycetes*, *Erysiphales*, *Helotiales*, *Hypocreales*, *Uredinales*, *Ustilaginales* and *Aphyllophorales*), of parasites of invertebrates (mainly *Ascomycetes* and *Heterobasidiomycetes*) and of saprophytic and mycorrhizal fungi (*Pezizales* and *Basidiomycota*) from the activities of the Benaki Phytopathological Institute, the Universities of Athens, Thessaloniki and Patras, the Agricultural University of Athens, the National Agricultural Research Foundation, foreign collaborating Institutions, etc. However, no special work has so far been dedicated and very few or no data are available concerning the diversity of the soil mycoflora (very diverse including *Mucorales*, *Oomycetes*, dematiaceous *Hyphomycetes*, *Coelomycetes*), the vescicular mycorrhizal fungi (*Endogonales*, *Glomales*), the entomopathogenic fungi (*Entomophthorales*, *Trichomycetes*, *Laboulbeniomycetes*), the leaf-litter microfungi, the hypogeous fungi (*Basidiomycetes*, *Ascomycetes*), the yeasts (*Endomycetales*), the aquatic fungi (*Hyphomycetes*), the Chytridiomycetes, the lichen-forming fungi, etc. Hence, relevant information is practically non-existent for an immense range and size of organisms, despite their significant ecological role; and is opposed to the knowledge which has been accumulated so far at an international level for some of these categories, like Aphyllophorales sensu lato, dematiaceous and aquatic *Hyphomycetes*, *Endomycetales*, *Heterobasidiomycetes* and macrolichens (Rossman 1994).

Although no organized and official biodiversity initiative has been undertaken until now through the collaboration of the Greek mycologists and under the auspices of the State, emphasis is being lately given on the occurrence of macrofungi (Diamandis & Minter 1983, Pantidou & Gonou 1984, Avtzis & Diamandis 1988, Diamandis & Perlerou 1994, Zervakis & Balis 1996). It was until very recently that two research projects (significant but low in budget) were undertaken by the author with the funding of the Greek General Secretariat of Research and Technology and the National Agricultural Research Foundation aiming at establishing an inventory of the Greek macrofungi. The overall aim is to increase the knowledge of the Greek mycoflora as regards taxonomical, ecological, chorological, and biodistribution aspects. The need to realize such a program has become necessary because Greece (but this holds true for other Mediterranean countries as well) has no formal check-list of fungi, not to mention mycological maps or red data lists. This initiative has already produced a check-list of Basidiomycotina, mainly Homobasidiomycetes: 811 species, assigned to 214 genera, and 58 families (Zervakis & al.

1998). Moreover, 77 species of macrofungi belonging to Ascomycetes (assigned to 17 families and 42 genera) have already been reported as occuring in Greece (Zervakis & Dimou, unpublished data), which, if they are added to the number of recent-unreported records, raise the total number of fungal species in Greece to over 900.

As regards Myxomycetes, very few data were available until recently, i.e. 58 species (Lado 1993). However, during the last few years an intensive effort yielded many more records and increased the total number of known species to 138 (Ing & Zervakis, unpublished data).

These figures quoted above are only indicative of the current state of knowledge, and are constantly increasing through on-going research work. However, the efficiency of such a program could still be improved by the evaluation and computer processing of the data in existing herbaria-libraries, which would significantly facilitate the development of the mapping project.

According to relevant literature, the regions of Greece that are relatively better investigated as regards the occurrence of macrofungi include many of the existing protected national parks (NP) as well as some mountain areas of particular biodiversity value: Mt. Parnitha (NP) and Attiki, Mt. Olympos (NP), northern Peloponnese (Chelmos, Vitina), Mt. Mainalon, Mt. Ossa, Mt. Grameni Oxia, Mt. Pilion, Mt. Holomontas, Protected Forest of Fracto, Samaria (NP), and Andros. In contrast, very few data exist for the Aegean islands, Crete, Ionian islands, Peloponnese, Thrace, Epirus and large areas of Macedonia. In addition, more fungal records originate from biotopes with prominent plant-host species such as: *Abies cephalonica* Loudon, *A. borisii-regis* Mattf., *Castanea sativa* Mill., *Cupressus sempervirens* L., *Fagus orientalis* Lipsky, *F. sylvatica* L., *Juniperus oxycedrus* L., *Picea abies* Karst., *Pinus brutia* Ten., *P. halepensis* Mill., *P. nigra* Arn., *Platanus orientalis* L., *Populus alba* L., *P. nigra* L, *Prunus* sp. pl., *Quercus coccifera* L., *Q. conferta* Kit., *Q. ilex* L., *Q. pubescens* Willd., *Salix alba* L., *Cistus laurifolius* L., *Carpinus betulus* L., *Juglans regia* L., etc.

Actual threats to the maintenance of fungal biodiversity include air pollution, agricultural practices which lead to a fast and irreversible loss of poorly managed pastures and their associated fungi in meadows or inside the forest, forest exploitation putting mainly at risk old-grown forests with their characteristic wood-inhabiting fungi, uncontrolled grazing, recreation facilities which jeopardize the existence of coastal ecosystems, expansion of towns and uncontrolled building activities, etc. Special care needs also to be taken on the issue of edible mushroom hunting, which in certain areas of Greece has evolved into a significant problem for the conservation of the local mycoflora.

About 300 species of macrofungi are considered to be endangered throughout Europe, on the basis of published national and regional lists (Ing 1993). They are arranged in four categories depending on the degree and geographical extent of endangerment. The evidence of losses is biased towards central, western and northern Europe, since no red data list for fungi is available for most of the Mediterranean countries. This striking absence of information means that any conclusions drawn about decline are at most tentative and could be completely misleading. Interpretation of relevant data from central Europe is risky as many species from that area may in fact have their main distribution in more southern regions; e.g. *Cantharellus lutescens* Fr., *Tricholoma atrosquamosum* (Chev.)

Sacc. and *T. aurantium* (Schaeff.: Fr.) Ricken, which appear to be threatened in many northern countries, are quite common in Italy or Greece.

In the absence of any red list for the Greek fungi and based on the available occurrence data (Zervakis & al. 1998), the following remarks could be expressed in relation with the provisional European red list of endangered macrofungi (Ing 1993): species like *Boletus regius* Krombh., *Gomphus clavatus* (Fr.) Gray, *Hygrophorus pudorinus* Fr., *Hygrophorus russula* (Fr.) Quel. and *Tricholoma aurantium* (Scaeff.: Fr.) Ricken could not be classified in the categories with widespread losses, but instead in groups C and D with widespread, but scattered, populations, fewer extinctions, low-level concern and mainly at the edge of geographical range. In contrast others like *Cyathus stercoreus* (Schw.) de Toni, *Ganoderma pfeifferi* Bres., *Ganoderma resinaceum* Boud.: Pat., *Geastrum coronatum* Pers.: Pers., *Mutinus caninus* (Huds.: Pers.) Fr., *Lentinellus vulpinus* (Fr.) Kuhner & Maire and *Tulostoma brumale* Pers.: Pers. fit better into the high-level concern groups, i.e. A and B with widespread losses, rapidly declining population, several national extinctions, medium to high-level concern, since they are very scarce in Greece. Many more taxa could be accommodated in either one of the four mentioned groups, and it is of apparent importance and urgency to progress with the task of inventorying the Greek fungal biota before proceeding with more demanding tasks such as mapping and red data lists.

Conservation of the Greek fungi

Greece participates to most international conventions on environmental protection issues and has undertaken specific international commitments towards the protection and conservation of its natural heritage. Along this line of action and to contribute towards the *in situ* conservation 10 National Parks, 19 Aesthetic Forests and 51 protected National Monuments were established in 1971. Today, a total of up to 696,000 ha (3.6% of the surface of Greece) have been designated under various conservation categories. In addition, recent specific protection measures were taken through the application of the "Natura 2000" project including 264 regions (corresponding to about 16% of the country's area), by creating a network of important habitats and by protecting particular sites of high conservation priority to the EU.

Other measures which could contribute to the *in situ* conservation of fungal communities are: national environmental planning with regard to biodiversity conservation, the establishment of additional protected ecosystems (Peloponnese does not have any, despite possessing the richest in number of plant species ecosystems!); development of occurrence and habitat maps for terrestrial and coastal ecosystems, together with development of inventories, red data lists and distribution maps at the species level.

Ex situ conservation includes the establishment of fungal Culture Collections and Herbaria functioning in modern facilities with specialised personnel, improvement of the existing infrastructure, allocation of increased funding for increased functionality, evaluation of existing biological material, promotion of integration between *ex situ* and *in situ* protection.

In general, the mentioned above actions should be complemented with increased awareness, collaboration and information-sharing among scientists, local people and authorities;

evaluation of land use plans, economic activities (mainly tourism and agriculture), existing policies and legal framework towards biodiversity conservation; additional funding and re-direction of existing financial resources; inclusion of biodiversity-related issues in planning sustainable development.

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