The mycoflora of the chestnut ecosystems in Greece

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Abstract
Chestnut (*Castanea sativa* Mill.) forests in Greece occupy 33 000 ha of mostly mountainous land and are considered to be wild, native ecosystems. They are managed mainly for timber production. One of the secondary products is edible mushrooms, which in recent years have been harvested on a heavy commercial scale in several parts of the country. Chestnut coppice ecosystems, as well as old-growth chestnut forests, make excellent habitats for a rich mycoflora. The main objective of the present study was to survey the fungal biodiversity in chestnut ecoystems because 1) the mycoflora comprises one of the main components in these ecosystems, 2) the results could be fed into conservation policy. Nearly 170 species of parasitic fungi of chestnut and macrofungi (Basidiomycotina and Ascomycotina), classified as mycorrhizal, saprotrophic and wood decay fungi, are discussed in this paper.

Keywords: chestnut, mycoflora, biodiversity, sustainable management, *Castanea sativa*

1 Introduction

Chestnut (*Castanea sativa* Mill.) forests in Greece occupy 33 000 ha of mostly mountainous land, extending from 400 to 1000 m in altitude and are considered to be wild, native ecosystems (National Forest Survey 1992). They are managed mainly for timber production by coppicing. Rotation is short (20–25 years), but there is a tendency to prolong it to 30 or 40 years because of market demand for large-dimension timber. One of the secondary products is edible mushrooms, which in recent years have been harvested on a heavy, commercial scale in several parts of the country. These forests also maintain a good variety of wildlife because of their remoteness, density and nutritious nuts.

There is no clear evidence yet on whether the commercial harvest of edible mushrooms has a negative effect on fungal biodiversity. Recent research in Europe has shown that the decline in populations of mycorrhizal fungi over the last three decades is due to the alteration of forest habitats by agricultural and urban development rather than commercial harvesting (Arnolds 1988, 1991). Wild mushrooms and their commercial harvest are now, however, receiving more attention in several European countries and in the USA, since there is concern about the sustainability of their populations. Small-scale studies of the impact of edible mushroom picking have concluded that careful harvesting does not reduce fruiting (Egli *et al.* 1990), but these have not adequately addressed the impact of large-scale commercial mushroom harvesting. Whether edible mushroom harvesting is sustainable for long periods of time or across landscapes is a complex question (Pilz and Molina 1998).

Commercial mushroom harvesting is a rather new activity in Greece which is starting to attract more companies every year hoping to achieve high profits. Other European countries, including Portugal, Yugoslavia, Russia, are faced with the same problem (ECCF Annual Report 1997). The European Council for the Conservation of Fungi (ECCF) and also individual governments are deeply concerned and have imposed legislation in an effort not only to prevent or control commercial harvesting, but also to control amateur mushroom picking.

Over the last 20 years the Greek State Forest Service has shown increasing interest in creating natural forest reserves. This has increased the area covered by old, natural forests and among these are chestnut forests. In these old-growth forests human interference is minimal, which means they act as natural banks for biodiversity (DIAMANDIS and PERLEROU 1994). Because the chestnut coppice managerial form is based on clear cutting and short rotation, there has been concern about whether such management may have an impact on the conservation of fauna and flora, including the mycoflora. The aims of this work were: 1) to record and study the mycoflora because it comprises a main component in the ecosystem, and 2) to use the data in planning an appropriate, long-term conservation policy.

2 Materials and methods

For the last 18 years collections have been carried out in chestnut coppices and natural, old chestnut forests in several parts of the country as illustrated in Figure 1. Collections were taken from eight sites which have been regularly visited on an annual basis in the fall immediately after the first rains. Macrofungi belonging to Basidiomycotina and Ascomycotina were collected, as well as parasitic fungi attacking chestnut. Chestnut coppice forests are usually very dense and shady so that the understory is suppressed. Only on Mount Athos is there a well-defined understory consisting of *Ilex aquifolium,* sporadic *Abies borisii regis* and in some areas *Tillia* sp. In this particular location, care was paid to identify the substratum of each carpophore precisely. Those specimens classified as mycorrhizal were collected only in pure chestnut stands. The recording of microfungi lags far behind the recording of macrofungi, and the former are, therefore, excluded from the present work.

The specimens were identified to species level based on their macro- and micromorphological feature sets. Co-ordinates of the actual habitat of each record were taken using a portable GPS. Dry specimens of all the identified species were deposited in the fungal herbarium at the Forest Research Institute, Thessaloniki.

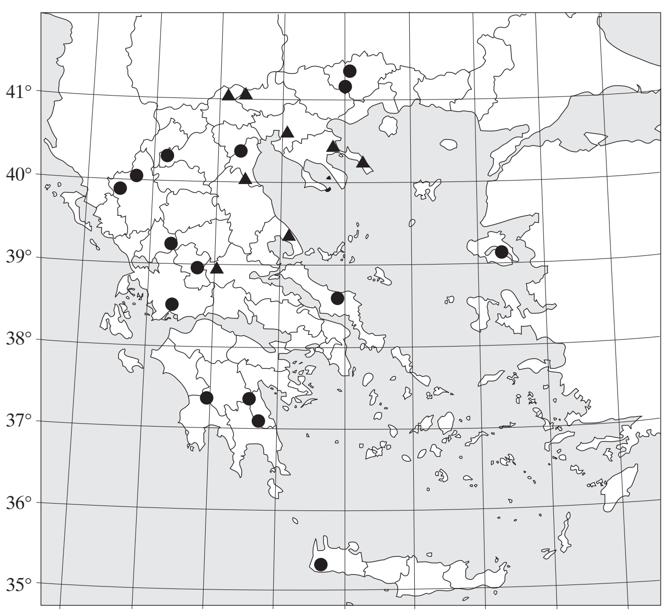

Fig. 1. Chestnut *(C. sativa)* distribution in Greece.
● Areas surveyed for mycoflora
▲ Areas not surveyed

3 Results

As can be seen in Table 1, 168 species, mostly Basidiomycotina and Ascomycotina and a few parasitic fungi of chestnut, have been found so far in chestnut ecosystems. This survey is being continued. All the recorded species are listed in Table 1 in alphabetical order and classified into four major groups according to their nutritional status: parasitic, mycorrhizal, saprotrophic and wood decay.

Among parasitic fungi, *Cryphonectria parasitica* and *Phytophthora cambivora* cause two of the most destructive diseases of chestnut, namely blight and ink disease respectively. Chestnut blight has spread throughout the country, while ink disease is more or less localized. *Armillaria mellea* (*sensu stricto*), *Armillaria gallica* (TSOPELAS 1997), *Melanconis modonia, Microsphaera castanae, Mycosphaerella castanicola* and *Mycosphaerella maculiformis* also cause damage to chestnut, while *Cryphonectria radicalis* has attracted a lot of attention due to its weak pathogenicity.

56 mycorrhizal fungi were found widely spread in all pure chestnut surveyed sites, while 57 saprotrophic and soil fungi were found, but only at some sites (Fig. 2). The mycorrhizal group includes some highly valued edible species. *Amanita caesaria, A. rubescens, Boletus edulis*, *B. aereus*, *Cantharellus cibarius, Craterellus cornucopioides*, *Hydnum repandum, H. rufescens* and others grow in both chestnut coppice and natural forests and fruit abundantly. Wood decay fungi comprised 46 species, with the most common being *Stereum hirsutum. Fistulina hepatica,* which is considered parasitic and grows on standing, old-growth trees, and *Laetiporus sulphureus* were found mostly in natural forests and less often in coppice forests. Carpophores of *Coriolus versicolor, Phellinus torulosus, Lycoperdon pyriforme, Mycena inclinata, Tremella mesenterica* and *Xylaria hypoxylon* were found in fairly high densities at all sites (coppice and old forest).

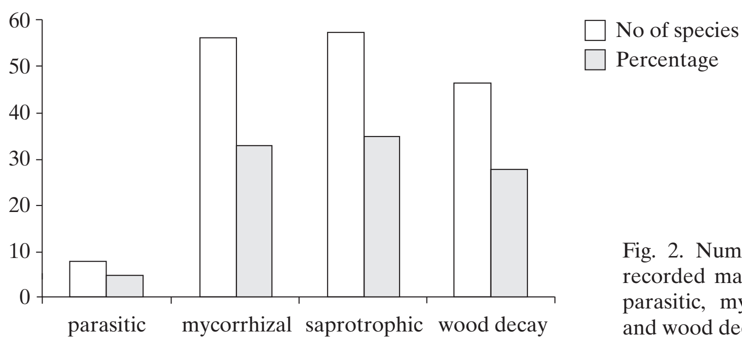

Fig. 2. Number and percentage of recorded macrofungi as classified in parasitic, mycorrhizal, saprotrophic and wood decay.

Table 1. Mycoflora of chestnut coppice and old-growth forests from 8 sites in Greece (Fig. 1), recorded during the period 1982–2000.

Scientific name of fungus Nutritional status: parasitic	Substratum *C. sativa*
Armillaria gallica Marx. & Romagn.	roots
Armillaria mellea (Vahl. ex Fr.) Kummer	roots
Cryphonectria parasitica (Murr.) Barr.	bark
Melanconis modonia Tulasne	bark
Microsphaera alphitoides Griffon & Maubl.	leaves
Mycosphaerella castanicola Kleb.	leaves
Mycosphaerella maculiformis (Pers. ex Fr.) Schroeter	leaves
Phomopsis endogena (Speg.) Cif.	bark
Phytophthora cambivora (Perti) Buism.	roots

Table 1 continued.

Scientific name of fungus Nutritional status: mycorrhizal	
Amanita caesarea (Scop. ex Fr.) Quél.	*Hydnum repandum* Fr.
Amanita citrina (Schaeff.) S.F. Gray	*Hydnum rufescens* Fr.
Amanita citrina var. *alba* (Gillet) Gilbert	*Hygrophorus hypothejus* (Fr. ex Fr.) Fr.
Amanita fulva (Schaeff.) Secr.	*Hygrophorus russula* (Fr.) Quél.
Amanita gemmata (Fr.) Gillet	*Hygrophorus unicolor* Gröger
Amanita muscaria (L. ex Fr.) Hooker	*Inocybe geophylla* var. *lilacina* Gillet
Amanita pantherina (D.C. ex Fr.) Secr.	*Laccaria amethystea* (Bull. ex Merat) Murr.
Amanita phalloides (Vaill. ex Fr.) Secr.	*Laccaria laccata* (Scop. ex Fr.) Cke.
Amanita porphyria (Alb & Schw. ex Fr.) Mlady	*Lactarius chrysorrheus* Fr.
Amanita rubescens (Pers. ex Fr.) S.F. Gray	*Lactarius piperatus* (Scop. ex Fr.) S.F. Gray
Amanita virosa Secr.	*Lactarius vellereus* (Fr.) Fr.
Boletus aereus Bull. ex Fr.	*Lactarius zonarius* (Bull. ex St. Amans) Fr.
Boletus appendiculatus Schaeff. ex Fr.	*Lactarius volemus* (Fr. ex Fr.) Fr.
Boletus edulis Bull. ex Fr.	*Lepista nuda* (Bull. ex Fr.) Cooke
Boletus inpolitus Fr.	*Paxillus involutus* (Batch ex Fr.) Fr.
Boletus piperatus Bull. ex Fr.	*Pisolithus arhizus* (Pers.) Rausch.
Boletus rhodopurpureus Smotlacha	*Russula atropurpurea* (Krombh.) Britz.
Boletus satanas Lenz.	*Russula brunneoviolaceae* Crawsh.
Boletus satanoides Smotlacha	*Russula delica* Fr.
Cantharellus cibarius Fr.	*Russula fragilis* (Pers. ex Fr.) Fr.
Cortinarius anomalus f. *lepidopus* (Cke.) Lge.	*Russula lepida* (Fr. ex Fr.) Fr.
Cortinarius bulliardii (Fr.) Fr.	*Russula nigricans* (Bull. ex Mérat) Fr.
Cortinarius pseudosalor Lge.	*Russula virescens* (Schaeff. ex Zantedschi) Fr.
Cortinarius purpurascens (Fr.) Fr.	*Tricholoma acerbum* (Bull. ex Fr.) Quél.
Cortinarius trivialis Lge.	*Tricholoma albobrunneum* (Pers. ex Fr.) Kummer
Cratellelus cornucopioides (L. ex Fr.) Pers.	*Tricholoma aurantium* (Schaeff. ex Fr.) Rick.
Hebeloma crustuliniforme (Bull. ex St. Amans) Quél.	*Tricholoma squarrulosum* Bres.
Hebeloma sinapizans (Paulet ex Fr.) Gillet	*Tricholoma ustale* (Fr. ex Fr.) Kummer

Scientific name of fungus Nutritional status: saprotrophic	Substratum
Agaricus arvensis Schaeff. ex Secr.	soil
Albatrellus cristatus (Pers. ex Fr.) Kotl. & Pouz.	soil
Aleuria aurantia (Fr.)Fuckel	soil
Astraeus hygrometricus (Pers.)Morg.	soil
Cantharellula cyathiformis (Bull. ex Fr.)Kummer	soil
Ciboria americana	cupule
Ciboria batschiana (Zopf)Buchwald	cupule
Clitocybe clavipes (Pers. ex Fr.)Kummer	soil
Clitocybe infudibuliformis (Schaeff. ex Weinm.)Quél.	soil
Clitocybe nebularis (Fr.)Kummer	soil
Collybia butyracea (Bull. ex Fr.)Kummer	leaf litter
Collybia erythropus (Pers. ex Fr.)Kummer	leaf litter
Collybia fusipes (Bull. ex Fr.)Quél.	leaf litter
Coprinus cinereofloccosus Orton	soil
Coprinus comatus (Mull. ex Fr.)S.F. Gray	soil
Coprinus lagopus (Fr.)Fr.	horse dung
Coprinus picaceus (Bull. ex Fr.)S.F. Gray	leaf litter
Cryphonectria radicalis (Schw. ex Fr.)Barr.	bark
Dasyscyphus virgineus S.F. Gray	twig
Entoloma clypeatum (L.)Kummer	soil
Entoloma papillatum (Bresadola)Dennis	soil
Helvella lacunosa Afz. ex Fr.	leaf litter
Hygrocybe conica (Scop. ex Fr.)Kummer	soil
Hygrocybe nigrescens (Quél.)Kühn.	soil
Hypoxylon fragiforme (Pers. ex Fr.)Kickx	bark
Lacrymaria velutina (Pers. ex Fr.)Konrad & Maubl.	soil

Scientific name of fungus Nutritional status: saprotrophic	Substratum
Lepiota cristata (A.& S. ex Fr.)Kummer	soil
Lepiota leucothites (Vitt.)Orton	soil
Lepiota mastoidea (Fr.)Kummer	soil
Leucopaxillus giganteus (Sow. ex Fr.)Sing.	soil
Lycoperdon atropurpureum Vittad.	soil
Lycoperdon perlatum Pers.	soil
Lyophyllum decastes (Fr. ex Fr.)Sing.	soil
Macrolepiota procera (Scop. ex Fr.)Sing.	soil
Marasmius oreades (Bull. ex Fr.)Fr.	soil
Marasmius rotula (Scop. ex Fr.)Fr.	bark
Morcella conica Swartz ex Pers.	soil
Morchella esculenta Pers. ex St. Amans	soil
Mycena crocata (Schrad. ex Fr.)Kummer	leaf litter
Mycena epipterygia (Scop. ex Fr.)S.F. Gray	litter
Mycena fibula (Bull. ex Fr.)Kühn	moss
Mycena olida Bres.	bark
Mycena picta Lge.	leaf litter
Mycena rosea (Bull.)Sacc. et Palla Costa	leaf litter
Nolanea farinolens Orton	soil
Omphalina galericolor (Romagn.)Bon	soil
Panaeolus ater (Lge.) Kühn. & Romagn.	dung
Peziza proteana var. *sparasoides* (Boud.)Korf	soil
Phallus impudicus Pers.	soil
Psathyrella multipedata Peck	soil
Psathyrella spintrigera (Fr.)Konrad & Maubl.	soil
Ramaria botrytis (Fr.)Rick.	soil
Rutstroemia firma (Pers.)Karst.	bark
Rutstroemia sydowiana (Rehm)White	leaf litter
Scleroderma geaster Fr.	soil
Sphaerobolus stellatus Tobe ex Pers.	cupule
Stropharia aeruginosa (Curt. ex Fr.) Quél.	soil

Scientific name of fungus Nutritional status: wood decay	
Coniophora arida (Fr.) Karst.	*Mycena inclinata* (Fr.) Quél.
Coprinus micaceus (Bull. ex Fr.) Fr.	*Mycena leucogala* Cke.
Coriolus hirsutus (Wulf. ex Fr.) Quél.	*Mycena polygramma* (Bull. ex Fr.) S.F. Gray
Coriolus versicolor (L. ex Fr.) Quél.	*Mycena praecox* Vel.
Crepidotus variabilis (Pers. ex Fr.) Kummer	*Omphalotus olearius* (D.C. ex Fr.) Sing.
Crucibulum laeve (Bull. ex DC) Kambly	*Oudemansiella longipes* (Bull. ex St. Amans) Maire
Daedalea quercina L. ex Fr.	*Oudemansiella radicata* (Relh. ex Fr.) Sing.
Diatrype disciformis (Hoffm. ex Fr.) Fr.	*Panellus stipticus* (Bull. ex Fr.) Fr.
Exidia glandulosa Fr.	*Peniophora meridionalis* Boidin
Exidia truncata Fr.	*Peniophora quercina* (Fr.) Cke.
Fistulina hepatica Schaeff. ex Fr.	*Phanerochaete sordida* (Karst.) Erikss. & Ryv.
Hymenochaete rubiginosa (Dicks. ex Fr.) Lév.	*Phellinus torulosus* Pers.
Hypholoma capnoides (Fr. ex Fr.) Kummer	*Phlebiopsis roumeguerii* (Bres.) Jül. & Stalpers
Hypholoma elongatum (Pers. ex Fr.) Ricken	*Schizophyllum commune* Fr.
Hypholoma fasciculare (Hubs. ex Fr.) Kummer	*Skeletocutis percandida* (Malenc. & Bert.) Keller
Hypholoma sublateritium (Fr.) Quél.	*Stereum gausapatum* (Fr.) Fr.
Hypoxylon nummularium Bull. ex Fr.	*Stereum hirsutum* (Wild. ex Fr.) S.F. Gray
Kuehneromyces mutabilis (Schaeff. ex Fr.) Sing. & Smith	*Trechispora farinacea* (Pers. ex Fr.) Liberta
Laetiporus sulfureus (Fr.) Murr.	*Trechispora vaga* (Fr.) Liberta
Lycoperdon pyriforme Schaeff. ex Pers.	*Tremella foliacea* Pers. ex Fr.
Meripilus giganteus (Pers. ex Fr.) Karst.	*Tremella mesenterica* Retz. ex Hook.
Mycena alkalina (Fr.) Kummer	*Vuilleminia comedens* (Nees) Maire
Mycena galericulata (Scop. ex Fr.) S.F. Gray	*Xylaria hypoxylon* (L. ex Hook.) Grev.

4 Discussion

It is well established that the overall role of the mycoflora (parasitic, mycorrhizal, saprotrophic and wood decay) contributes to the balance and normal function of healthy, natural ecosystems. Work done mainly in the 2nd half of the 20th century has shown that human activity and interference with the natural environment may threaten fungal biodiversity and even cause the extinction of some species (ARNOLDS 1988, 1991, PARKS and SCHMITT 1997).

The mycorrhizal group is represented here by quite a large number of species. It may well be interesting to study the effect of coppicing (clear cutting in short rotation) on the species structure and also on the population sustainability of chestnut mycoflora. Chestnut stumps sprout in the growing season following clear cutting and the fast developing, dense, young stand will close its canopy in two years. Thus it will be interesting to study whether or not the mycorrhizal fungi attached to the roots of living stumps can survive and whether there is an impact on carpophore production in the next fruiting period. Coppicing is a traditional management system and has been applied in Greek chestnut forests for centuries. It is unfortunate that there has been no previous, systematic work done on the mycoflora of these natural forests in Greece making a comparison of past and present data impossible. As far as wood decay fungi and also saprotrophic and soil macrofungi are concerned, coppicing may favour them because of the large amounts of biomass which accumulate on the forest floor after clear felling and during the two thinning operations carried out in the 20- to 25-year rotation.

A large number of visitors are attracted to the chestnut coppice forests for recreation, nut collecting and mushroom picking, especially in the autumn. Wild, edible mushrooms are picked traditionally in Greece by the rural population without any obvious sign of threat to this natural resource. In recent years, however, commercial harvesting has become a growing activity, and dried or otherwise preserved mushrooms are being exported to Italy and Central European countries. The long-term impact of such commercial harvesting should be investigated and management and protection measures, if necessary, should be imposed (MOLINA *et al.* 1993).

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