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Ecology – remediation of water and soils

DIVERSITY OF MICROFUNGI ON FAGACEAE IN ULUDAG FORESTS

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ABSTRACT

Forests ecosystems are sources of oxygen and wood products, also they prevent soil erosion, improve water and air quality, serve as homes for wildlife; and therefore, they preserve and increase biodiversity. Forests can host a diverse community of fungal species with various effects on their host trees. In this research, trees of Fagaceae family of Uludag forests of Bursa province were investigated between the years of 2002 and 2008. By microscopic examination we identified 38 microfungi species in 27 genera belongs to Ascomycota and 1 microfungus species in 1 genus belongs to Basidiomycota. The taxa belong to 15 families: Botryosphaeriaceae, Diaporthaceae, Diatrypaceae, Dothioraceae, Erysiphaceae, Gnomoniaceae, Incertae sedis, Melanconidaceae, Microstromataceae, Nectriaceae, Pseudovalsaceae, Rhytismataceae, Trichosphaeriaceae, Valsaceae and Xylariaceae. The distribution of species by trophic groups revealed a dominance of xylotrophic species. With this study, fungal diversity of Fagaceae family in Uludag forests was identified and included in the mycobiota of Turkey.

Keywords: ecology, microfungus, fagaceae, Bursa, Turkey.

AIMS AND BACKGROUND

Forest ecosystems are complex and functional systems that are formed by organisms like plants, animals and microorganisms and physical factors like soil, water, light

* For correspondence.

and temperature. Forest ecosystems, as 'host of biodiversity', provide sustainability for life on earth. These important resources of life are effected by biotic and abiotic factors. They are exposed to attack by forest pests and fungi, which are among the most important forest damage agents[1].

Fungi are the main decomposers and recyclers of the organic matters, symbiotic partners, element converters, foods of invertebrate and vertebrate animals and indicator of the soil biological productivity as well as pathogens and parasites of the organisms in forest ecosystems[2]. They are particularly important in the breakdown and recycling of cellulose and hemicelluloses and important in the degrading lignocellulose. They attack trees and other plants, so this process is resulting with declining productivity of forests, also death of trees. In this point, identification of the organisms in a habitat becomes more of an a issue to understand the advantages and disadvantages of these organisms[3].

Bursa, the fourth largest province of Turkey, is situated in the Marmara region of Turkey, located in A_2 (A) and B_2 (B) according to the David grid square system[4]. The city encompasses 11403 km^2 and is bordered by Yalova in the north, Balikesir and Kutahya in the south, Bilecik in the east, and Balikesir in the west (Fig. 1). Bursa is in the Mediterranean climate belt according to Yesilkonak, Inegol, Keles and Bursa meteorology stations; it is also in the sub-Mediterranean climate belt according to Sarialan and Zirve meteorology stations (Fig. 2).

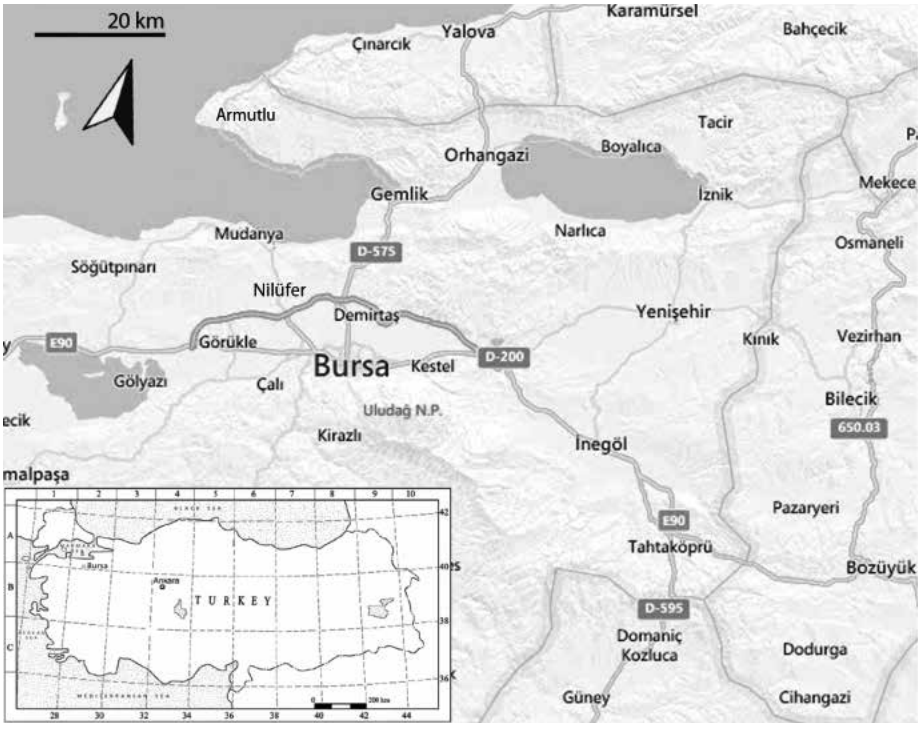

Fig. 1. A map of Turkey, with a grid system, and Bursa province

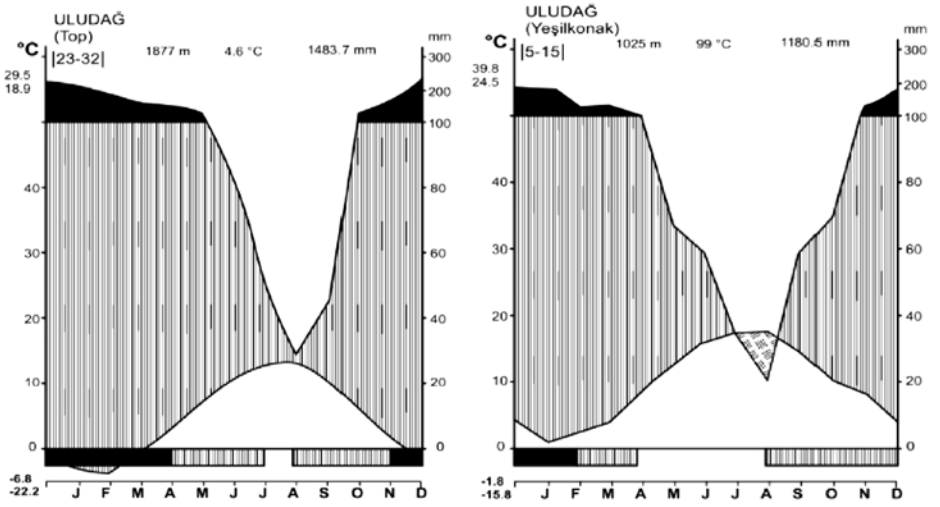

Fig. 2. Climate diagrams for Uludag-Top and Uludag-Yesilkonak (redrawn from Refs 5 and 6 for Uludag-Yesilkonak after Ref. 7, respectively)

Uludag forests are located at Uludag and the mountain is bordered by Nilüfer stream in the west and south, Inegol and Bursa in the east and north. The soil structure of the Uludag forests changes with elevation: it is deposited on the bedrock and ranges from terra rossa at lower elevations to podzol-like brown forest soil at higher elevations[8]. Surface soils at elevations greater than 1000 m contain rich, dark organic detrital material in especially densely forested areas. Soils are often acidic[9].

The region has traces of three separate Phytogeographic zones: Euro-Siberian (63%), Mediterranean (32%) and Irano-Turanian (6%). Six bioclimatic zones are found on Uludag Mountain and National Park: *Lauretum* (0–350 m), *Castanetum* (350–700 m), *Fagetum* (750–1100 m), *Pinetum* (1100–1400 m), *Abietum* (1400–2050 m) and *Alpinetum* (2050–2543 m) (Ref. 10). The *Fagetum, Pinetum*, *Abietum* and *Alpinetum* zones harbor some of the endemic elements of the vegetation.

The Fagaceae family has a worldwide distribution; nevertheless, it is widely distributed across the Northern hemisphere and especially most abundant in temperate and subtropical parts of this region. There is one tropical and one south temperate *Nothofagus* genus. Genus level diversity is concentrated in Southeast Asia where most of the extant genera are thought to have evolved before migrating to Europe and North America. *Fagus*, *Castanea* and *Quercus* are the important genera of the family[11,12].

Our study area possesses eight species of the Fagaceae family: *C. sativa* M i l l., *Fagus orientalis* L i p s k y, *Quercus cerris* L., *Quercus frainetto* T e n., *Quercus hartwissiana* S t e w., *Quercus petraea* (Mattuschka) L i e b l., *Quercus robur* L. and Q*uercus trojana* P. B. W e b b. The present study is based on specimens collected from Fagaceae members of Uludag forests.

Identification of fungi on tree species of Uludag forests is the initial step to protect the first national park of Turkey and this is also important for forest reserve. The aim of the study is to determine the microfungi diversity on trees of Fagaceae family in Uludag forests and to make a contribution to the mycobiota of Turkey.

EXPERIMENTAL

The material for this study was collected from Uludag forests and its surroundings in 2002 and 2008. During the field study morphological and ecological properties of the samples were recorded and they were photographed. Then the fungal materials were taken to the laboratory, and macroscopic and microscopic measurements were performed. Using the overall data, obtained from the field and laboratory, they were identified with the help of Refs 13–27. The systematics of the taxa is in accordance with Refs 28 and 29. The samples are kept at Uludag University, Arts and Science Faculty, Department of Biology, Bursa, Turkey.

RESULTS AND DISCUSSION

This research was carried out within the boundaries of Uludag forests of Bursa province in 2002 and 2008. In this study, 38 microfungi species of Ascomycota (4 classes, 10 orders, 14 families, 27 genera and 38 species) and 1 microfungus species of Basidiomycota (1 class, 1 order, 1 family, 1 genus and 1 species) were determined (Table 1).

F. orientalis was the common substratum for the fungi within the Fagaceae with 27 fungi species. The others are *Q. frainetto* (7 species), *Q. robur* (5 species), *Q. petraea* (3 species), *Q. cerris* (3 species) and *Q. hartwisiana*, *Q. trojana, C. sativa*, (1 species), respectively. Big part of the fungi were found on only one substratum; however five of them were found on more than one substratum, these were: *B. nummularia* on *F. orientalis*, *Q. cerris*, *Q. frainetto* and *Q. petraea*; *D. decorata* on *F.orientalis* and *Q. frainetto*; *D. quercina* on *Q. cerris*, *Q. petraea* and *Q. robur*; *A.errabunda* on *F. orientalis*, *Q. robur* and *Q. trojana; R. croceola* on *F. orientalis* and *Q. frainetto.*

All species, except *A. errabunda* and *M. album* were found on died specimens. *A. errabunda, C. oreades*, *E. alphitoides*, *M.album*, *P. desolationis* and *P. roboris* were found on leaves. Meanwhile, the other species were found on bare wood or branches of the trees.

Table 1. List of the identified species of Fagaceae family in Uludag forests

Species	Habitat
1	2
Ascomycota	
Annulohypoxylon cohaerens (P e r s.) Y. M. Ju, J. D. Rogers & H. M. Hsieh	on the shell of dry branches of *F. orientalis*
A. multiforme (F r.) Y. M. Ju, J. D. Rogers & H. M. Hsieh	on dry branches of *F. orientalis*
Anthostoma decipiens (DC.) Nitschke	on the shell of dry branches of *F. orientalis*
A. turgidum (P e r s.) Nitschke	on dry and thick branches of *F. orientalis*
Apiognomonia errabunda (R o b e r g e ex D e s m.) Höhn	on alive leaves of *F. orientalis*, *Q. robur* subsp. *robur* and *Q. trojana*
Asterosporium asterospermum (P e r s.) S. Hughes	on dry branches of *F. orientalis*
Biscogniauxia nummularia (B u l l.) Kuntze	on the trunk and branches of dried trees of *F. orientalis* (from root neck to top of tree); on dried truks of *Q. cerris* subsp. *cerris*; on dried logs of *Q. frainetto*; on the trunk and thick branches of *Q. petraea* subsp. *petraea*
Brachysporium dingleyae S. Hughes	on dry thin branches of *Fagus orientalis*
Camarosporium oreades (D u r i e u & M o n t.) Sacc.	on leaves of *Q. robur* subsp. *robur*
Cheirospora botryospora (M o n t.) Berk. & Broome	on dry and thin branches of *F. orientalis*
Colpoma quercinum (P e r s.) Wallr.	on dry and thin branches of *Q. frainetto*
Coryneum japonicum (S a c c.) B. Sutton	on the shell of dry branches of *Q. hartwisiana*
C. megaspermum Syd. & P. Syd.	on the shell of dry branches of *F. orientalis*
Cytospora pustulata Sacc. & Roum.	on dry branches of *F. orientalis*
C. salicis (C o r d a) Rabenh.	on dry branches of *Fagus orientalis*
Diaporthe macrostoma Nitschke	on dry branches of *F. orientalis*
Diatrype disciformis (H o f f m.) Fr.	on dry branches of *F. orientalis*
D. stigma (H o f f m.) Fr.	on dry branches of *F. orientalis*
Diatrypella decorata Nitschke	on dry and thin branches of *F. orientalis* and *Q. frainetto*
D. pulvinata Nitschke	on dry branches of *C. sativa*
D. quercina (P e r s.) Cooke	on the shell of dry branches of *Q. robur* subsp. *robur* and *Q. petraea* subsp. *petraea*; on dry branches of *Q. cerris* subsp. *cerris*
Dothiorella dryophila Sacc. & Briard	on dry and thin branches of *Q. cerris* subsp. *Cerris*
Erysiphe alphitoides (G r i f f o n & M a u b l.) U. Braun & S. Takam.	on leaves of *Q.petraea* subsp. *ibrica*
Eutypa flavovirens (Pers.) Tul. & C. Tul.	on dry, thin/thick branches and bare wood of *Q. frainetto*

to be continued

Continuation of Table 1

1	2
Eutypella quaternata (P e r s.) Rappaz	on dry and thick branches of *F. orientalis*
E. stellulata (F r.) Sacc.	on dry branches of *F. orientalis*
E. ventricosa (F u c k e l) Sacc.	on branches of *F. orientalis*
Leucostoma persoonii (N i t s c h k e) Höhn.	on dry and thick branches of *F. orientalis*
Melanconium bicolor Nees	on dry and thick branches of *F. orientalis*
M. stromaticum Corda	on dry and thick branches of *F. orientalis*
Metasphaeria canadensis (De Not) Sacc.	on bare wood of *F. orientalis*
Microdiplodia iliceti Sacc.	on bare wood and dry branches of *Q. frainetto*
Nectria peziza (T o d e) Fr.	on bare wood of *F. orientalis*
Phoma desolationis Speg	on leaves of *F. orientalis*
P. quercicola Sacc. & Briard	on dry and thin branches of *Q. frainetto*
Phyllactinia roboris (G a c h e t) Blummer	on leaves of *Q. robur* subsp. *robur*
Roscoepoundia croceola (S a c c.) Kuntze	on dry branches of *F. orientalis*; on the shell of trunk and thick branches of *Q. frainetto*
Volutella ciliata (A l b. & S c h w e i n.) Fr.	on dry and thick branches of *F. orientalis*
Basidiomycota	
Microstroma album	on alive leaves of *Q. robur*

Genera represented by single species were *Apiognomonia*, *Asterosporium*, *Biscogniauxia*, *Brachysporium*, *Camarosporium*, *Cheirospora*, *Colpoma*, *Diaporthe*, *Dothiorella*, *Erysiphe*, *Eutypa*, *Leucostoma*, *Metasphaeria*, *Microdiplodia*, *Microstroma*, *Nectria*, *Phyllactinia*, *Roscoepoundia* and *Volutella*; genera represented more than one species were *Annulohypoxylon*, *Anthostoma*, *Coryneum*, *Cytospora*, *Diatrype*, *Diatrypella*, *Eutypella*, *Melanconium* and *Phoma*.

Only a few studies have been carried out about fungi on Fagaceae in Turkey. Reference 30 is reported *Cryphonectria parasitica* (M u r r i l l) M. E. Barr and *Pseudomassaria chondrospora* (C e s.) Jacz. on *C. sativa* in Küre Mountains; Reference 31 reported *Botryosphaeria castanea* (S c h w.) Sacc., *Ceratocystis castanea* (V a n i n et S o l o v.), *Ceratophorum helicosporum* (S a c c.) Sacc., *Cylindrosporium castanicola* (D e s m a z.) Berl., *Cylindrium clandestinum* Sacc., *Nectria viridescens* Booth and *Phomopsis castanea* Woronidin on *C. sativa* in Rize province; Reference 32 reported *Taeniolella breviuscula* (B e r k. & M. A. C u r t i s) S. Hughes on *C. sativa* in Giresun province.

Fungi on *F. orientalis* were reported from Giresun province, Istranca Mountains, Kure Mountains and Rize province. *Cryptodiaporthe galericulata* (T u l. & C. T u l.) Wehm., *Curvularia lunata* (W a n k e r) Boedijn, *Helicomyces scandens* Morgan, *Pithomyces chartarum* (B e r k. & M. A. C u r t i s) M. B. Ellis and *Sporidesmium hormiscoides* Corda were found on *F. orientalis* in Giresun province; *Discosia artocreas* Tode: Fr. and *Melanomma fascidulum Sacc.* were found on *F. orientalis* in Istranca Mountains; *Biscogniauxia nummularia* (B u l l.) Kuntze, *Glonium inter-*

ruptum Sacc., *Lophiotrema spiraeae* (P e c k) Sacc., *Melogramma campylosporum* Fr., *Xylaria carpophila* (P e r s.) Fr. and *Xylaria longipes* Nitschke were found on *F. orientalis* in Küre Mountains; *Ceratocystis fagi* (W. L o o s) Moreau, *Dasyscyphus cerinus* (P e r s.) Fuckel, *Melanopsamma carpatica* Petr., *Metasphaeria vulgaris* Feltgen, *Mycosphaerella fagi* (A u e r s.) Lindau, *Naemospora croceola* Sacc., *Xylaria carpophila* (P e r s.) Fr. and *Zignoëlla inflata* (Ellis)Sacc. were found on *F. orientalis* in Rize province[30–33].

Cucurbitaria pontica Savul. et Sandu-Ville was found on *Q. cerris* in Karaman province and *Camarosporium oreades* Sacc. was found on *Q. cerris* in Istranca Mountains[33,34].

Eutypa acharii Tul. & C. Tul., *Lophiosphaera fuckelii* Sacc. and *Melanomma fusicladium* (S a c c.)Sacc were found on *Q. petraea* in Rize province; *Botryosphaeria stevensii* Shoemaker was found on *Q. petraea* in Istranca Mountains[31,33].

Fungi on *Q.robur* were investigated in Karaman province and Istranca Mountains. *Aposphaeria peregrina* P. Karst., *Apiognomonia quercina* (Kleb.) Höhn. and *Didymella analepta* Sacc. were reported on *Q. robur* in Karaman province; *Apiognomonia errabunda* (R o b e r g e ex D e s m.) Höhn. and *Coccomyces coranatus* (S c h u m a c h.) De Not. were reported on *Q. robur* in Istranca Mountains[33,34].

Fungi on *Q. trojana* were only found in Karaman province and these were: *Phyllosticta associata* Bubák, *Seimatosporium discozioides* (E l l i s & E v e r h.) Shoemaker and *Phoma innumerabilis* Thüm. (Ref. 34).

Cryptovalsa sparsa Ellis & Everh. was found on *Q. hartwisiana* in Rize province[31].

There are various studies to identify fungi on Fagaceae in the world. *Phytophthora cinnamomi* was reported as a cause of the root disease factor of Chinkapin trees (*Castanea pumila*), European Chestnut (*C. sativa*) and the Asiatic species of *Castanea* (Ref. 35). 80 fungi species was found on *Q. robur* L. with many disease symptoms like leaves with atrophy and necrotic areas, dead branches, dead water sprouts, local necrotic areas in bark and phloem, local discolorations inside sapwood, dead trees[36]. It is reported[37] that certain species of endophytic fungi at a dormant situation can be stimulated in case of feeding activity of certain gall insects in the leaves of *Q. robur* L.. The most frequently isolated fungi[38] on *C. sativa* were *Amphiporthe castanea*, *Pezicula cinnamomea*, *Coryneum modonium*, and *Phomopsis* sp. In Ref. 39 are reported Fomitopsis pinicola, Ganoderma adspersum, Inonotus hispidus and Ustulina deusta growth within the reaction zone of the Fagus sylvatica and they found the breaching mechanisms to reaction zone of these fungi all different. 47 fungal taxa[40] were isolated from living, senescent, freshly fallen, and decomposing leaves and identified 15 species as phyllosphere fungi on *Fagus crenata*. 234 species were identified[41] on collected epigeous fruitbodies of both ectomycorrhizal (ECM) and saprobic fungi in an old-growth *Quercus ilex* L.; 166 species representing 84 genera of aphyllophoraceous fungi growing on *F. sylvatica* was given as a list[42].

The identified species were analysed in terms of trophic structure and were categorised in 3 groups: xylotroph, lignotroph and phyllotroph (Table 2). 30 species were

identified as xylotroph (the fungi that develop both on alive and dead branches and bodies of trees and on poured dry branches and fallen trees); 6 species were identified as phyllotroph (the fungi that develop on alive and fallen leaves) and 3 species were identifed as lignotroph (the fungi that develop on bare wood).

Table 2. Assessment of the identified species in terms of trophic structure

Species	Trophic structure	Species	Trophic structure
Annulohypoxylon cohaerens	xylotroph	*d. quercina*	xylotroph
a. multiforme	xylotroph	*dothiorella dryophila*	xylotroph
anthostoma decipiens	xylotroph	*erysiphe alphitoides*	phyllotroph
a. turgidum	xylotroph	*eutypa flavovirens*	xylotroph
apiognomonia errabunda	phyllotroph	*eutypella quaternata*	xylotroph
asterosporium asterospermum	xylotroph	*e. stellulata*	xylotroph
biscogniauxia nummularia	xylotroph	*e. ventricosa*	xylotroph
brachysporium dingleyae	xylotroph	*leucostoma persoonii*	xylotroph
camarosporium oreades	phyllotroph	*melanconium bicolor*	xylotroph
cheirospora botryospora	xylotroph	*m. stromaticum*	xylotroph
colpoma quercinum	xylotroph	*metasphaeria canadensis*	lignotroph
coryneum japonicum	xylotroph	*microdiplodia iliceti*	lignotroph
c. megaspermum	xylotroph	*microstroma album*	phyllotroph
cytospora pustulata	xylotroph	*nectria peziza*	lignotroph
c. salicis	xylotroph	*phoma desolationis*	phyllotroph
diaporthe macrostoma	xylotroph	*p. quercicola*	xylotroph
diatrype disciformis	xylotroph	*phyllactinia roboris*	phyllotroph
d. stigma	xylotroph	*roscoepoundia croceola*	xylotroph
diatrypella decorata	xylotroph	*volutella ciliata*	xylotroph
d. pulvinata	xylotroph		

CONCLUSIONS

Forest ecosystems have a significance within terrestrial ecosystems. They provide a range of services. Forest trees hold the soil firmly and protect it from erosion and floods. They regulate the local, regional and global climate. They have great effect on the cycling of carbon, water, and nutrients. Forest plants and animals alter soil characteristics by adding organic matter. Forest ecosystems are important biodiversity repositories with the greatest assemblage of species found in any terrestrial ecosystem[43]. Reduction of tree population of a forest is defined as forest deterioration. It is important to recognise and follow all the elements of forests to protect it. In this study, we present 39 microfungi species found on Fagaceae of Uludag forests. This study contributes to mycological knowledge in Turkey and creates a significant source for further studies.

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