ECOLOGIA BALKANICA

2013, Vol. 5, Issue 1 June 2013 pp. 87-96

Macrofungal Communities in Hyrcanian Forests, North of Iran: Relationships with Season and Forest Types

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Abstract. The identification of macrofungal genera and species was carried out according to the macroscopic and microscopic characteristics of the specimens, as well as their characteristic responses to some chemical reagents. This study was conducted to identify the forest floor of macrofungal in *Parrotia-Carpinetum* and planted stands of *Cupressus sempervirens* and *Alnus subcordata* in North of Iran (Gorgan, Shast Kalate) during 2010-2011. For this purpose, all macrofungal in the area (0.6 ha in separated stands, three plots) were collected. Measurements were made from slide preparations stained with cotton blue- lacto- phenol contains 100 ml. Lacctophenol, 2ml 2% aqueous solution of cotton blue, by Olympus light microscope. The results show that 35 species were found which were classified into 21 genera from 16 families. Up to 54% of the species were classified into *Parrotia-Carpinetum*, 26% *Alnus subcordata* and 20% *Cupressus sempervirens*. In wet season 30 species of macrofungal and 13 species in dry season were collected. In spring season 12 species, one species in summer season, 23 species in fall season and 7 species in winter season were found.

Key Words: Macrofungi, Agaric, Ecosystem, Macroscopic, Season, Forest stands.

Introduction

Fungi play a vital role in ecosystem functions and have big influence on humans and human-related activities (MUELLER & BILLS, 2004). They are the second largest group of ground creatures (CANNON & HOWKSWORTH, 1995) found in every ecosystem. It is estimated that there are 1.5 million species of fungi, but only about 69 000 species have been studied including, 46,124 species of Basidiomycetes, Ascomycetes. Macroscopic fungi with specific fruiting organs and size, big enough, to be visible by the naked eye, grow on the ground or underground (SAREMI *et al.*, 2005). Although fungi are extremely diverse, they are often ephemeral and cryptic, rendering inventorization difficult (MUELLER *et al.*, 2004a).

Understanding the variation in fungal populations in time and space is important because of its relevance to questions of biodiversity and the roles fungi play in regulating populations of other organisms and ecosystem processes (LODGE & CANTRELL, 1995). HUTTON & RASMUSSEN (1970), compared fungi that were cultured from surfaces of leaves of 20 tree species in

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moist forest at Fort Clayton, Panama Canal Zone. Although their methods were unclear as to the replication within plant species and their presentation of data make certain analyses difficult, one surprising pattern is suggested by their data. A total of 36 types of fungi were isolated, of which 12 were present only in the rainy season, 12 were present only in the dry season, and 12 were found in both seasons. Three to four fungal species were cultured from leaf surfaces on each tree in the rainy season, although this is probably an underrepresentation of the total epiphyllic mycota. Such a large seasonal turnover in fungal epiphylls was unexpected.

Disturbances induce changes in the environment and the abundance of different substrates, resulting in changes in fungal communities through time, and variation over the landscape. Severe disturbances, as well as the slight daily variations in rainfall, profoundly affect populations of fungal decomposers and their influence on plant nutrient availability (LODGE & CANTRELL, 1995). Some species of agaric fungi are known to live in canopies of rain forests, but fruiting may be rare and confined to the wet season. Disturbances from seasonal changes in rainfall and tree falls to hurricanes can differentially affect fungal species. HUTTON & RASMUSSEN (1970), found in Panama that 8 of the 23 species they sampled had no epiphyllous fungi in common between the rainy and dry seasons and 10 plant species had only one epiphyllous fungus common to both seasons. Epigeous sporocarp productivity greatly increases after the first rains of fall; many species produce sporocarps only during fall (RICHARDSON, 1970).

Hypogenous sporocarp productivity at lower elevations in the Pacific Northwest generally peaks in the spring and fall, although sporocarps of several species either persist through summer and winter, or are produced during these seasons (FOGEL, 1976; HUNT & TRAPPE, 1987; LUOMA, 1991). Numerous studies have successfully used sporophore abundance to assess ectomycorrhizal fungus community composition (MILLER, 1982a; BILLS *et al.*, 1986; VILLENEUVE *et al.*, 1989; NANTEL & NEUMANN, 1992; PALMER *et al.*, 1994). The results produced by these studies appear to correspond well with plausible explanations. NANTEL & NEUMANN (1992) found that the strongest niche dimension of ectomycorrhizal communities was stand composition, but within the range of a stand, fungal assemblages differed in relation to edaphic characteristics.

Predictive equations of forest mushroom yields are quite complex given the dynamics that influence ectomycorrhizal fungal communities. Numerous interactive factors come into play, before and during the autumn fruiting period, including environmental (rainfall, air and soil temperatures, evapotranspiration, relative humidity, and water deficits or excesses), silvicultural (tree species, stand age, density and distribution, canopy cover), ecological (community composition, competitive interactions, reproductive strategies), landscape (altitude, aspect, slope) and anthropogenic (timber removal, controlled burns, wildlife management, grazing, introduced species) (MARTÍNEZ DE ARAGÓN *et al.*, 2007).

The forest tree species, which is host to associated fungal symbionts, influences the fungal community and fungal species richness through host specificity (MOLINA *et al.*, 1992). Each host tree species can only form an ectomycorrhizal symbiosis with a recognized group of fungal species. Therefore the composition of ectomycorrhizal fungi is limited by the range of fungal symbionts recognized by a given host tree under the existing ecological conditions, and the diversity of host trees present in the forest stand. Forest age also has an effect upon succession, diversity and production of certain forest fungi (KALAMEES & SILVER, 1988; SMITH *et al.*, 2002; BONET *et al.*, 2004), and aspect has been shown to influence habitat for some species (BONET *et al.*, 2004).

Human intervention has played a significant role because forest management tools (clearings, pruning, species selection, fire, fertilization) can modify density, canopy cover, primary productivity, basal

area, understory plant communities, soil conditions and soil microbial communities. These modifications in turn alter microclimates responsible for the succession and fruiting of numerous fungal species (OHENOJA, 1988; FERNÁNDEZ DE ANA *et al.*, 1989; TERMORSHUIZEN, 1993; EGLI & AYER, 1997; HERNÁNDEZ & FERNÁNDEZ, 1998).

It is well known that fungal fruiting is a seasonal event that depends on meteorological factors, especially temperature and rainfall. High rainfall and mild temperatures in summer are normally considered to favour the formation of carpophores by the fungal mycelium (ARNOLDS, 1981). Many authors have tried to find direct relations between fungal fruiting and weather patterns. It has been demonstrated that an important condition is a wet period after a dry one (BECKER, 1956; HEIM, 1969), and that excess water in the soil inhibits carpophore production (BUJAKIWICZ, 1969).

Both vegetative communities and animals influence the macrofungal habitat in the forest ecosystem (CRABTREE *et al.*, 2010; HUSTAD *et al.*, 2011), especially the core giant panda habitat, and in turn, the macrofungi are the essential decomposers that maintained regional ecological balance for plants and animals living. The diversity of the macrofungal community reflects the environmental conditions in the region. The data suggests that despite the lagged sporophore peak compared with the highest temperature, macrofungal diversity was positively related to the temperature in the area. More Arbuscular mycorrhizal (AM) fungal biomas and spores were produced during the wet season than during the dry season. The different types of organic matter had similar influence on the amount of AM biomass but the species composition was varied with the types of organic matter. In wet season nine species of AM spores and in dry season ten species of AM spores were found. In dry season *Scutellospora nigra* was found which was different from wet season (VAIDYA *et al.*, 2007).This study was conducted to identify the forest floor of macrofungal in natural stands (*Parrotia persica* and *Carpinus betulus*) and planted stands (*Cupressus sempervirens* and *Alnus subcordata*) in North of Iran (Gorgan, Shast Kalate) during 2010-2011.

Material and Methods

Site Description. This investigation was carried out in Shast Kalate (Bahram Nia) forest, experimental forest of Gorgan University of Agricultural Sciences and Natural Resources, a virgin mixed deciduous forest covering an area of about 1 713.3 ha and located in the north of Iran (36°43´ to 36°48′ N and 54°21′ to 54°24′ E), with an average annual precipitation of about 649 mm, and an altitude ranging from 210 to 995 m above sea level (Fig. 1). The study region has an average temperature of 12°C and average humidity of 76.5%. The aforementioned site is a permanent plot for long term studies, established on brown forest soil with mostly sandstone as bedrock (KARIM *et al.*, 2012).

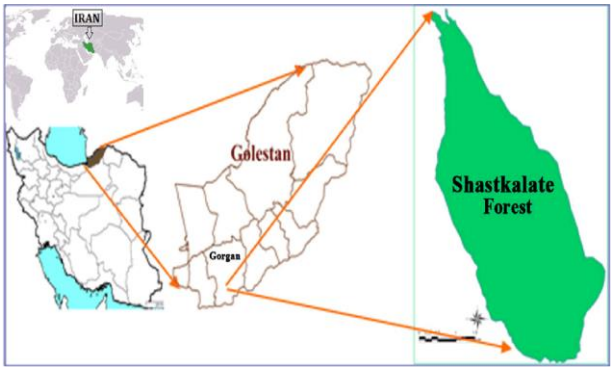

Fig. 1. Indicative map of the study area (KARIM *et al.*, 2012).

Identification. Macrofungal identification through the comparison of relevant information is essential (LI *et al.*, 2012). The identification of microfungal genera and species was carried out according to the macroscopic and microscopic characteristics of the specimens, as well as their characteristic responses to some chemical reagents (SMITH *et al.*, 1979; WEI, 1979; MOSER, 1983; SINGER, 1975; HUANG, 1998; MAO, 1998, 2000; DIYABALANAGE *et al.*, 2008; OUZOUNI *et al.*, 2009). This study was conducted to identify the forest floor of macrofungal in *Parrotia-Carpinetum* and planted stands of *Cupressus sempervirens* and

Alnus subcordata in North of Iran (Gorgan, Shast Kalate) during 2010-2011. For this purpose, all macrofungal in the area (0.6 ha in separated stands) were collected. Measurements were made from slide preparations stained with cotton blue- lacto-phenol contains 100 ml. Lacctophenol, 2ml 2% aqueous solution of cotton blue, by Olympus light microscope (BH2) (SMITH *et al.*, 1979; MOSER, 1983; SINGER, 1986).

Results

The results show that 35 species were found in the three assessment plots, which were classified into 21 genera (especially genera from Basidiomycetes) from 16 families. Maximum macrofungal were observed at Psathyrellaceae (two genera and six species). Minimum macrofungal (one species and one genus) in Amanitaceae, Cantharellaceae, Coprinaceae, Geastraceae, Hygrphoraceae, Paxillaceae, and Sclerodermataceae were found (Table 1). All macrofungal classified to *Agaricales, Boletales, Cantharellales, Geastrales,* and *Russulales* genera. The maximum of fungal species in *Agaricales* genera were found and distributed in *Parrotia-Carpinetum*, *Cupressus sempervirens* and *Alnus subcordata* stands (Fig. 2). The maximum number of macrofungal in *Parrotia-Carpinetum* (five species and two genera), *Alnus subcordata* (three species, two genera) and *Cupressus sempervirens* (four species and two genera) were found in the Psathyrellaceae family (Fig.3). Up to 54% of the species were classified into *Parrotia persica - Carpinus betulus* (twenty seven species), 26% *Alnus subcordata* stand (eleven species) and 20% *Cupressus sempervirens* (ten species) (Fig.4). In wet season 30 species of macrofungal and 13 species in dry season were found. In spring season 12 species, one species in summer season, 23 species in fall season and 7 species in winter season were observed. In addition to, maximum fungal (43.8%) collected in *Parrotia-Carpinetum* stand in the fall season (Fig. 5).

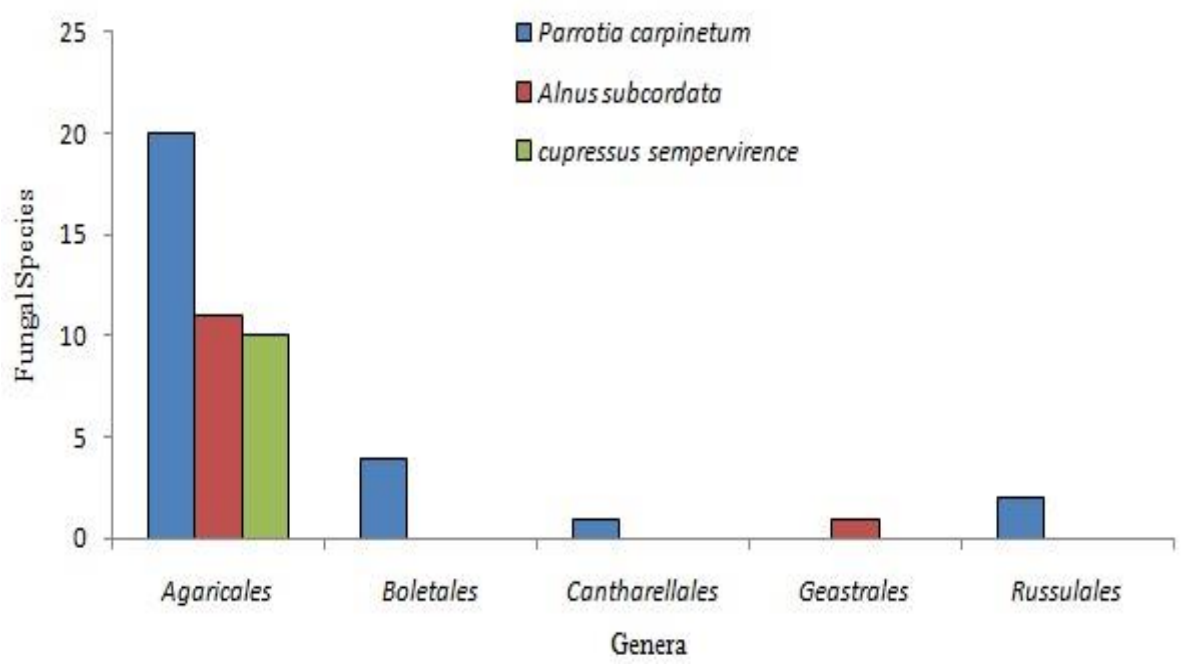

Fig. 2. Frequency of macrofungal species in relation to number of plots in which they were found.

Table 1. Total individual species density of macrofungi in the three plots. Legend:*= Macrofungal species, Pp = *Parrotia persica*; Cb = *Carpinus betulus*; Ag = *Alnus subcordata*.

N	Species name	Family	Genera	Pp	Cb	Ag	Spring	Summer	Fall	Winter
1	*Agaricussilvicola*	Agaricaceae	Agaricales	*					*	
2	*Agaricus xanthodermus*	Agaricaceae	Agaricales	*		*			*	
3	*Agrocybe praecox*	Strophariaceae	Agaricales	*		*	*		*	
4	*Agaricus semiorbicularis*	Strophariaceae	Agaricales	*		*	*			
5	*Amanita rubescens*	Amanitaceae	Agaricales	*					*	
6	*Cantharelluse cibarius*	Cantharellaceae	Cantharellales	*					*	
7	*Clitocybe gibba*	Tricholomataceae	Agaricales	*		*			*	
8	*Clitocybe vibecina*	Tricholomataceae	Agaricales			*			*	
9	*Collybia confluens*	Tricholomataceae	Agaricales		*				*	
10	*Clitocybe dryophila*	Tricholomataceae	Agaricales	*			*			
11	*Coprinus atramentarius*	Psathyrellaceae	Agaricales	*	*	*	*		*	
12	*Clitocybe disseminates*	Psathyrellaceae	Agaricales	*			*			
13	*Clitocybe lagopides*	Psathyrellaceae	Agaricales	*	*	*	*			
14	*Clitocybe micaceus*	Psathyrellaceae	Agaricales		*				*	
15	*Geastrum triplex*	Geastraceae	Geastrales			*	*			
16	*Gymnopilus spectabilis*	Strophariaceae	Agaricales	*						*
17	*Hebeloma sinapizans*	Strophariaceae	Agaricales	*					*	
18	*Hygrocybe unguinosa*	Hygrphoraceae	Agaricales	*						*
19	*Laccaria amethystea*	Hydnangiaceae	Agaricales	*						*
20	*Laccaria laccata*	Hydnangiaceae	Agaricales	*			*		*	
21	*Lepiota cristata*	Agaricaceae	Agaricales		*				*	
22	*Lepiota naucina*	Agaricaceae	Agaricales	*	*	*			*	
23	*Micromphale brassicolens*	Marasmiaceae	Agaricales	*		*	*		*	*
24	*Mycena foetidum*	Marasmiaceae	Agaricales		*		*			
25	*Mycena polygramma*	Mycenaceae	Agaricales		*				*	
26	*Mycena pura*	Mycenaceae	Agaricales		*				*	
27	*Panaeolus sphinctrinus*	Coprinaceae	Agaricales	*						*
28	*Paxillus involutus*	Paxillaceae	Boletales	*			*			
29	*Psathyrella candolleana*	Psathyrellaceae	Agaricales	*	*	*	*	*	*	*
30	*Psathyrella vernalis*	Psathyrellaceae	Agaricales	*						*
31	*Russula delica*	Russulaceae	Russulales	*					*	
32	*Russula heterophylla*	Russulaceae	Russulales	*					*	
33	*Scleroderma verrucosum*	Sclerodermataceae	Boletales	*					*	
34	*Xerocomus badius*	Boletaceae	Boletales	*					*	
35	*Xerocomus chrysenteron*	Boletaceae	Boletales	*					*	

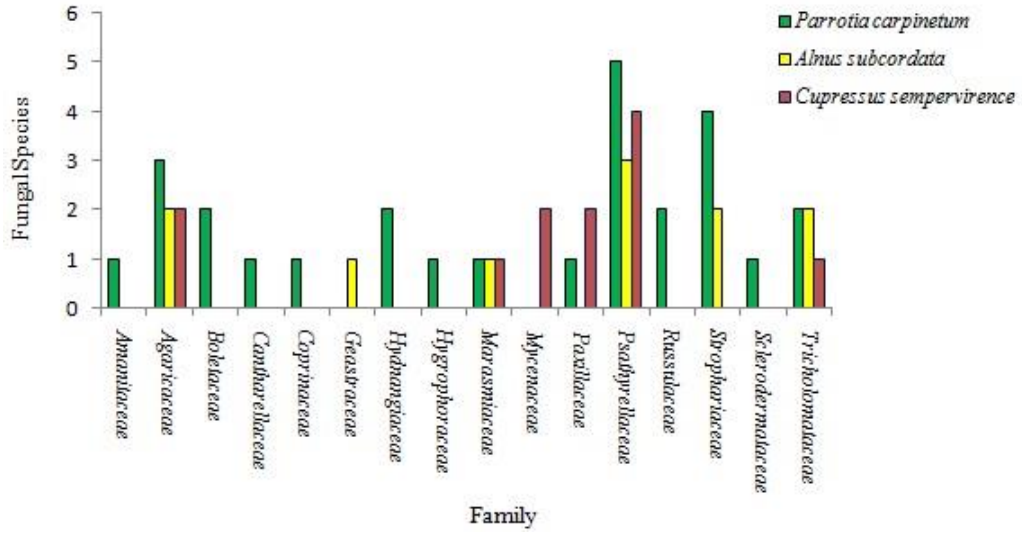

Fig. 3. Number of macrofungal species recorded in different families.

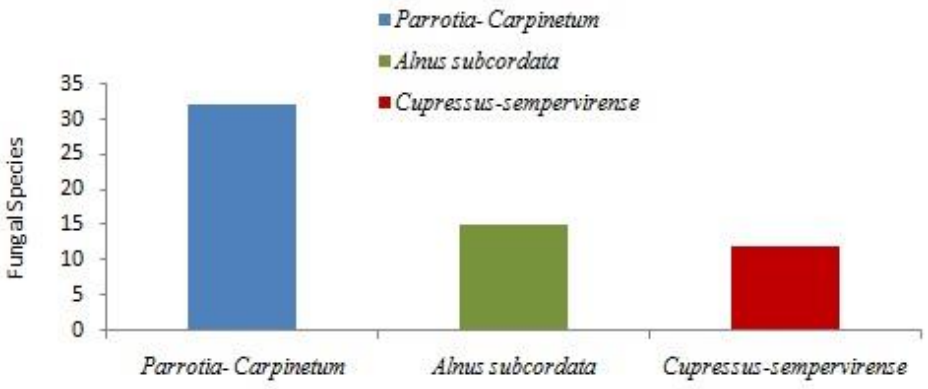

Fig. 4. Distribution of macrofungal species in relation to all forest stands: *Parrotia persica- Carpinus betulus; Cupressus sempervirens* and *Alnus subcordata*.

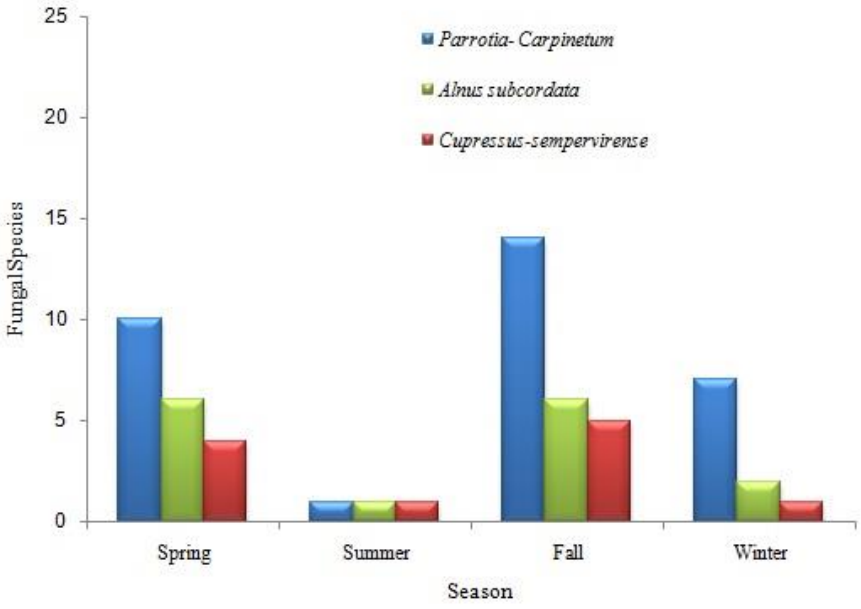

Fig. 5. Collected of macrofungal species in relation to time in season different; spring, summer, fall and winter.

Discussion

Understanding how fungal populations and communities are spatially and temporally distributed is fundamental to estimating their diversity. Such information is also useful in determining how fungal populations affect the abundance and distribution of other organisms and ecosystem processes at the landscape level (LODGE & CANTRELL, 1995). As discussed by BILLS *et al.* (1986), it is difficult to determine the adequate sampling area required to capture the fungal species diversity of a particular vegetation type. Changes in forest composition due to succession, disturbance, or timber harvesting will produce changes in sporocarp abundance and diversity, because ectomycorrhizal fungi that rely on carbohydrates from their tree hosts (HARLEY & SMITH, 1983) produce most sporocarps. However, quantitative data of macrofungal diversity have been used to determine whether mushroom species follow the ecological rule that the local abundance of a species is related to the size of its geographic range (GASTON, 1994; JOHNSON, 1998). In a natural ecosystem different processes could become prominent at different stages of the seasonal cycle, and the changes in the patterns observed might, therefore, have reflected temporal changes in the overall ecosystem functioning (KRIVTSOV *et al.,* 2004). This study has demonstrated that natural stands and *Cupressus sempervirens – Alnus subcordata* plantations provide a habitat for diverse macrofungal communities, which vary markedly in composition from site to site. The results of this research showed that number of macrofungal species was found to be correlated with temperature, moisture, and organic matter is consistent with the results (WALKER & MILLER, 2000; KARIM *et al.,* 2011; FISCHER, 2007). Frequency of macrofungal species in relation to forest stands was varied, *Parrotia persica - Carpinus betulus* (54%), *Alnus subcordata* plantations (26%) and *Cupressus sempervirens* plantations (20%). This is may be related to tree diversity (FISCHER, 2007), not human effects (FERRIS *et al.,* 2000), exist of litterfall, high decomposition of foliage. This results in consistent with the results of HUMPHREY *et al.,* 2000; LAGANA *et al.,* 2000; MCLAUGHLIN, 1997; BADER *et al.,* 1995; LAGANA *et al.,* 1998.Disturbances from seasonal changes in rainfall and tree falls to hurricanes can differentially affect fungal species. Temperature and moisture are essential factors in distribution of macrofungal. The maximum of macrofungal species were found in wet season. In finally, fungi are extremely diverse, they are often ephemeral and cryptic, rendering inventorization difficult (MULLER *et al.,* 2004) However, knowledge of biodiversity at the community and species level is essential to monitor the effectiveness of, or the need for reservation, and also to follow the effects of natural or artificial disturbance (PACKHAM *et al.,* 2002). The data on fungi diversity and distribution are limited and fragmentary, the consensus is that certain patterns are robust and are worthy of future consideration.

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Received: 29.12.2012
Accepted: 10.03.2013