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Macrofungal diversity in moist temperate forests of Garhwal Himalaya

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Abstract

The present investigation was carried out in different moist temperate forests of Garhwal Himalaya. The fruiting bodies of macrofungi were collected from these forests between July 2008 and September 2009. Frequent field visits and collections were made within the elevation range of 550-2500 msl in the districts Pauri, Tehri, Chamoli and Rudraprayag. As a result of an extensive field survey and microscopic study in laboratory, 40 taxa belonging to 11 families were identified. Two families and 2 taxa belonged to class- Ascomycetes viz: Family-Helvellaceae and Morchellaceae, and nine families and 38 taxa to class-Basidiomycetes viz: Family-Agaricaceae, Amanitaceae, Boletaceae, Cantharellaceae, Coprinaceae, Ganodermataceae Hydnagiaceae, Lycoperdaceae and Russulaceae. Some macrofungi are also being used as medicine viz: *Morchella esculenta, Hydnum repandum*, *Agaricus campestris, Cantharellus cibarius*, *Coprinus comatus* and *Ganoderma lucidum*.

Keywords: Diversity, Macrofungal diversity, moist temperate forests, Garhwal Himalaya

Introduction

Fungi are some of the most important organisms in the world, because of their vital role in ecosystem function, influence on humus and human-related activities (Mueller & Bill, 2004). Fungi are not only beautiful but play a significant role in the daily life of human beings besides their utilization in industry, agriculture and medicine (Cowan, 2001; Chang & Miles, 2004). Macrofungi need moisture to develop. The peak mushrooms and macrofungi season for each region is different for each ecological climate (Arora, 1991). The number of fungi recorded in India exceeds 27,000 species, the largest biotic community after insects (Sarbhoy e*t al*., 1996).

The Garhwal Himalaya represents one of the most fascinating and characteristic vegetation of the Indian sub-continent. Marked variations are noticeable both in the quality and quantity of vegetation with respect to the different latitudinal, altitudinal and habitat conditions. Moreover, the Garhwal Himalaya consists of widest range of altitudes (*ca* 350 to 7817 m asl), having contrast climatic conditions *viz.*, warm humid Terai belt on the one hand and on the other cold desert at Tibetan border. Due to these factors, differing magnitudes of habitats give rise to several microclimatic pockets thus high diversity of flora grows and exists in this region. Because it's climatic condition, plant distributions and field features Garhwal Himalaya if very suitable for the growth of macrofungi. Several workers have studied diversity of mushrooms earlier in many parts of the country. Although lot of studies have addressed the taxonomic diversity of higher plants and cryptogams (Gairola *et al*., 2010, 2011a, 2011b, 2011c, 2011d; Sharma *et al*., 2010a, 2011) but very few studies have addressed diversity of macrofungal flora of the Garhwal Himalaya (Bhatt, *et al*., 1989, 1990, 1995,2007a, 2007b, 2003; Bhatt, *et al*., 1999, 2000; Das, *et al.*, 2005; Prasad, *et al*., 2000; Moncalvo, *et al.,* 2004; Semwal, *et al.,* 2005, 2006a, 2006b, 2007; Vishwakarma, 2010; Vishwakarma *et al*., 2011). Keeping the aforesaid facts in view the present study was undertaken in the Garhwal Himalaya to determine the macrofungal diversity in the region and provide important information on the macrofungi flora of Garhwal Himalaya.

Study area

The Garhwal Himalaya lying between the latitudes 29° 31'9" N and 31° 26'5" N and longitudes 77° 33'5" E and 80° 6'0" E with a total area of 29,089 km^2 is the most frequented and best known part of the Himalaya, starting from the foothills in the south, it covers all three sections of the Himalaya *i.e*. outer Shiwalik, the lesser Himalaya comprising linear mountain ranges and the Great Himalaya covering about 40,000 km. of snowfields. Administratively, Garhwal Himalaya comprises seven districts namely, Chamoli, Dehradun, Haridwar, Pauri, Rudraprayag, Tehri and Uttarkashi (Fig.1).

The climate is temperate (montane) between 2000 and 3200 m asl. The average precipitation in the region is 1500 mm varying from 600 to 3000 mm. Most of the precipitation as much as 75 % in the region is received during monsoon months (between June and September). The range of climatic conditions in this region is extremely variable because of considerable variation in altitudes. The climatic factors *i.e*. precipitation, temperature, relative humidity and wind, in association with elevation (valleys or mountain ranges from foot hills to montane zones), proximity of Great Himalaya, slope aspects, vegetation, etc. causes variations at local or even at micro levels (Sharma *et al*., 2010b). Variations are also observed in the soil characteristics. The nature, colour and texture of soil vary with the slope, vegetation and topography. The most common features of the soils include coarse and sandy nature, usually less fertile. Generally In densely forested areas, the soil is black with thick layer of humus and litter (Sharma *et al*., 2010c). The

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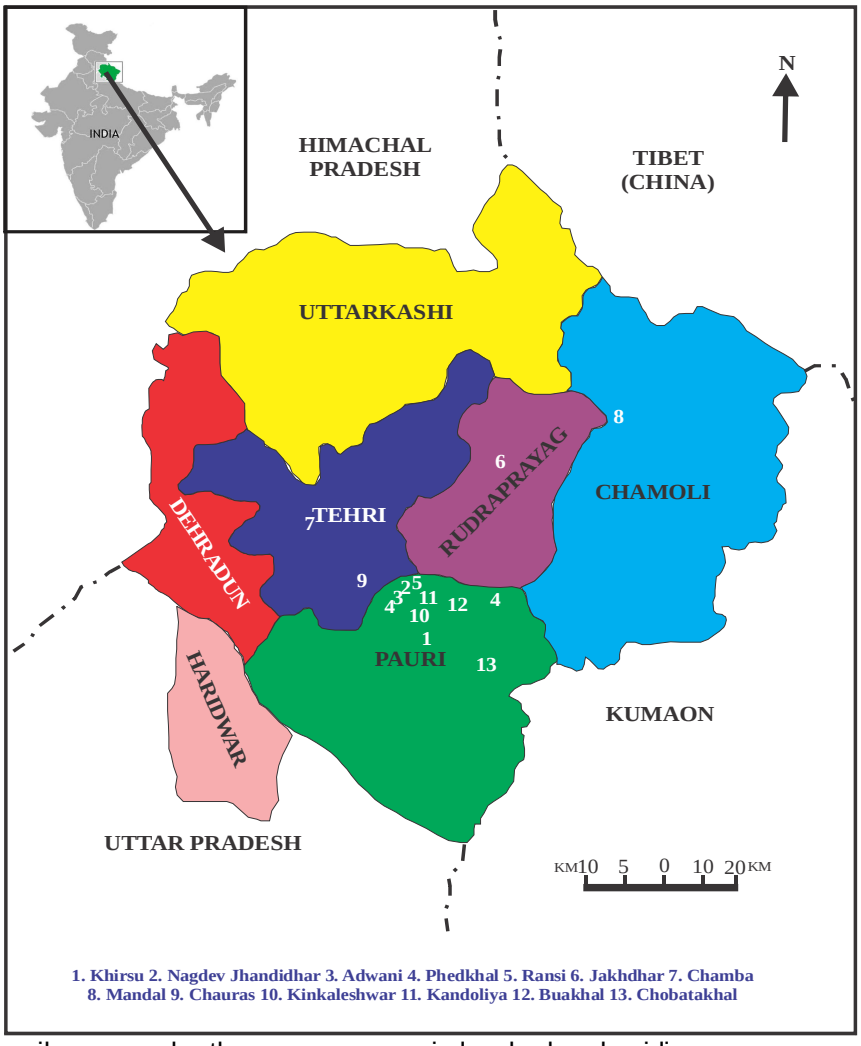
Fig. 1. Map of the study area showing collection sites.



soil cover under the gymnosperms is leached and acidic. Whereas, in the valleys with the xerophytic or shrubby vegetation, the soil cover is very thin (Gaur, 1982).

In the study area, the forests are dominated by *Pinus roxburghii* (Chir pine) from 1200 to 2200 m asl, *Pinus wallichiana, Quercus leuchotrichophora, Rhododendron arboreum, Myrica esculenta, Lyonia ovalifolia*, and *Quercus floribunda* (Banj oak) from 1400 to 2400 m asl, *Abies pindrow* (Silver fir) from 2000 to 3000 m asl, *Picea morinda* (Spruce) from 2000 to 3200 m asl, *Cupressus torulosa* (Himalayan Cypress) from 2000 to 3000 m asl, *Cedrus deodara* (Deodar) from 2500 to 3000 m asl, *Quercus semecarpifolia* (Kharsu oak) and *Betula utilis* (Birch) from 2500 to 3200 m asl. Some mixed hardwoods found on the sheltered valleys, often in scattered areas at the elevation of 2000 to 3000 m asl forming the mixed humid deciduous forests. Some other common tree species of the region are *Acer caesium* (Kanjula), *Acer pictum* (Gud-papri), *Alnus nepalensis* (Uteest), *Buxus wallichina (*Papri), *Aesculus indica* (Pangar), *Corylus jacquemontii (Bhotia badam), Juglans regia* (Akhrot), *Rhus punjabensis* (Amlara) and *Ulmus wallichiana* (Mairu). Usually pine forests of the region are dry and have poor ground flora, some common montane shrubs are *Abelia triflora, Berberis aristata, B. asiatica, B. chitria, Coriaria nepalensis, Cotoneaster* spp., *Daphne paparacea, Indigofera gerardiana, Inula capa, Lindera pulcherrima, Lonicera spp. Machillus* spp., *Myisine africana, Rubus* spp., *Sarococca saligna, Sorbus* spp., *Spirarea* and *Strobianthes* spp. etc. There is gradual change in the composition of vegetation with reference to altitude, slope, humidity, etc. Forest floor in montane region have gregarious growth of ferns, like *Asplenium, Dipteris, Dryopteris, Polypodium*, etc. It is in the montane humid forests that epiphytic orchid's ferns, lycopodes saprophytes, like *Monotropa uniflora* and semiparasites such as *Orobanche* spp., *Boschniakia himaliaica* are often present in shady places.

Material and methods

The extensive field trips were conducted between July 2008 and September 2009 in different localities of the Garhwal Himalaya to collect the samples of macrofungi. During the field surveys, the macrofungal samples (fruiting bodies) were collected with a great care to avoid damage to the base and other parts of the samples. Macroscopic characteristics such as shape, size, colour, colour change on bruising or ageing, taste, odour, spore deposition of the fresh specimens and ecological characteristics viz., nature of forest, tree composition association, physiographic factors (altitudinal range, slope, aspect) and edapho-climatic status from the selected site were noticed. Fungal fruiting bodies (sample) were recorded followed by photographed in their natural habitats. Samples were kept in separate paper bags to avoid mixing and were taken to the laboratory. Macro-and microscopic investigations and micro-chemical reactions were carried out on the collected samples. Collected specimens were dried, preserved in paper or polythene bags and numbered (Atri & Saini, 2000; Atri *et al*., 2003). Identification was made on the basis of critical observations of the specimens and perusal of relevant literature (Arora, 1986; Hesler & Smith, 1979; Singer, 1986; Moller, 1950, 1952; Kuo, *2003;* Natarajan & Raman, 1983; *Natarajan et al., 2005;* Orton & Watling, 1979; Lincoff, 1981; Phillips, 1991; Watling & Gregory, 1980). All the identified and un-identified specimens were deposited in the Herbarium, Department of Botany & Microbiology, HNB Garhwal University, (GUH) Srinagar Garhwal, Uttarakhand, India.

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Result

As a result of the present study, following 40 macrofungal taxa belonging to 11 families were identified. All the taxa were listed along with relevant information about their habitat, locality (district wise), collection date, collection number and edibility (Arora, 1986; Kriegar, 1967; Phillips, 1991; Lincoff, 1981; Miller, 1981).

Class- Ascomycetes

Family- Helvellaceae

Helvella crispa Fr. Under conifers, Pauri Garhwal, Nagdev-Jhandidhar forest, 8 July 2008, Coll. No. MPV/ RPB- 130, Edible.

Family- Morchellaceae

Morchella esculenta Pers. ex St. Amans, On ground, Pauri Garhwal, Nagdev-Jhandidhar forest, 2 July 2009, Coll. No. MPV/ RPB- 250, Medicinal and Edible.

Class- Basidiomycetes

Family- Agaricaceae

Agaricus arvensis Schaeff. ex Fr. In Pastured land, Pauri Garhwal, Khirsu forest, 10 July 2009, Coll. No. MPV/ RPB- 258, Edible.

Agaricus campestris L. ex Fr. In field associated with grasses, especially with *Cynodon*, Pauri Garhwal, Khirsu forest, 18 July 2009, Coll. No. MPV/RPB -263, Medicinal and Edible.

Agaricus abruptibulbus Peck, In broadleaved forest, Pauri Garhwal, Phedkhal, 16 July 2008, Coll. No. MPV/RPB-140, Poisonous.

Agaricus augustus Fr. In mixed broadleaved forest, Pauri Garhwal, Khirsu forest, 25 July 2009, Coll. No. MPV/RPB-269, Edible.

Agaricus micromegathus Peck, Associated with grasses, especially with *Cynodon*, along road side, in lawns, pastures, field and other grassy or open areas, Pauri Garhwal, Ransi forest, 20 July 2008, Coll. No. MPV/RPB-152, Edible.

Agaricus silvicola (Vittadini) Sacc. In mixed broadleaved forest, Pauri Garhwal, Khirsu Forest, 28 July 2009, Coll. No. MPV/RPB -278, Edible.

Agaricus silvaticus Schaeff. ex Secr. In mixed wood, Pauri Garhwal, Adwani forest, 20 July 2008, MPV/RPB -159, Edible.

Agaricus placomyces Peck In mixed broadleaved forest, Rudraprayag, Jakhdhar forest, 31 July 2009, Coll. No. MPV/ RPB -282, Poisonous.

Agaricus xanthodermus Genev. Under trees and hedges, on lawns, grasses, along road and paths, Pauri Garhwal, Khirsu forest, 29 July 2008, Coll. No. MPV/RPB -165, Poisonous.

Chlorophyllum molybdites (Meyer ex Fr.) Mass. In pastureland, garden, or on rich soil, also in mixed forest, Tehri Garhwal, Chamba, 3 August 2009, Coll. No. MPV/RPB-288, Poisonous.

*Lepiota cristata (*A. & S.) Fr. In mixed broadleaved forest, Pauri Garhwal, Khirsu Forest, 3 August 2008, Coll. No. MPV /RPB -169, Poisonous.

Lepiota clypeolaria (Bull. ex Fr.) Kummer On ground in mixed woods, Chamoli, Mandal, 8 August 2009, Coll. No. MPV /RPB -292, Poisonous.

Leucocoprinus cretaceus (Bull. ex Fr.) Locq. on compost heap, among grass on road side, Pauri Garhwal, Adwani forest, 12 August 2008, Coll. No. MPV /RPB -173.

Macrolepiota procera (Scop. ex Fr.) Singer, In open woods and at their edges, in old pastures, Pauri Garhwal, Khirsu forest, 20 August 2008, Coll. No.MPV /RPB -178, Edible.

Macrolepiota rhachodes (Vittadini) Singer, on ground, under trees (particularly conifers), along roads and other disturbed places, Pauri Garhwal, Chauras Campus, near University gate Srinagar, 12 August 2009, Coll. No. MPV /RPB -298, Edible.

Macrolepiota dolichaula (Berkeley & Broome) Pegler & Rayner In mixed woods, old pastures, on open grassy area, Pauri Garhwal, Khirsu forest, 25 August 2008, Coll. No. MPV/RPB -183.

Family- Amanitaceae

Amanita hemibapha (Berk. & Br.)Sacc. In mixed broadleaved forest, Pauri Garhwal, Khirsu forest, 18 August 2009, Coll. No. RPB/MPV -305, Edible.

Amanita pseudoporphyria Hongo In mixed broadleaved forest, Pauri Garhwal, Khirsu forest, 29 August 2008, Coll. No. RPB/MPV-186.

Family- Boletaceae

Strobilomyces floccopus (Vahl. ex Fr.) Karst. In mixed broadleaved forest, Pauri Garhwal, Keinkaleshwar, 23 August 2009, Coll. No. MPV/RPB -310, Edible.

Phylloporus rhodoxanthus (Schw.) Bres. In hardwoods, especially oaks, Mycorrhizal with hardwoods, Pauri Garhwal, Phedkhal, 29 August 2008, Coll. No. MPV/ RPB/SJ -190.

Family- Cantharellaceae

Cantharellus cibarius Fr. In broadleaved forest, Pauri Garhwal, Adwani forest, 27 August 2009, Coll. No. MPV /RPB/SJ - 315, Medicinal and Edible.

Family- Coprinaceae

Coprinus comatus (Mull. ex Fr.) S.F. Gray, On lawns, wood chips, disturbed soil, along roadsides, Chamoli, Mandal, 30 August 2009, MPV/ RPB -325, Medicinal and Edible.

Coprinus lagopus (Fr.) Fr. On compost-heap, sometimes on dung, Pauri Garhwal, Khirsu Forest, 2 September 2008, Coll. No. MPV/RPB -192.

Coprinus disseminatus (Pers. ex Fr.) S.F. Gray, on old stumps or dead wood or on soil near buried wood, Rudraprayag, Jakhdhar forest, 3 September 2009, Coll.No. MPV/ RPB-336.

Coprinus plicatilis (Curt. ex Fr.) Fr. Growing on lawns and other grassy places, Pauri Garhwal, Ransi, 5 September 2008, Coll. No. MPV/RPB -195.

Psathyrella candolleana (Fr.)Maire & Werner, Around old hardwood stumps, or buried wood, Pauri Garhwal, Adwani forest, 8 September 2009, Coll. No. MPV/RPB -340, Edible.

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Family- Ganodermataceae

Ganoderma lucidum Leys ex Fr. On living hardwoods (especially oaks), usually near the base of the tree, Chamoli, Mandal, 8 September 2008, Coll. No.MPV/RPB-198, Medicinal

Family- Hydnagiaceae

Laccaria amethystina Cooke, In mixed broadleaved forest and Mycorrhizal with hardwoods, Pauri Garhwal, Khirsu forest, 12 September 2008, MPV/ RPB/SJ -205.

Hydnum repandum L.ex Fr. In broadleaved forest, Pauri, Garhwal, Phedkhal, 12 September 2009, Coll. No. MPV/RPB- 348, Medicinal and Edible.

Family- Lycoperdaceae

Lycoperdon perlatum Pers. On ground, Pauri Garhwal, Kandolia, 12 September 2009, Coll. No. MPV/RPB -352, Poisonous.

Family- Russulaceae

Lactarius corrugis Peck In broadleaved forest, Pauri Garhwal, Keinkaleshwar, 16 September 2009, Coll. No. MPV/RPB/SJ -362, Edible.

Lactarius hygrophoroides var. *hygrophoroides* Berk. & Curt. On humicolous soil in temperate mixed broad leaved forests, Pauri Garhwal, Bhuakhal, 20 September 2008, Coll. No. MPV/RPB/SJ -209, Edible.

Lactarius volemus (Fr.) Fr. var. *volemus* On humicolous in both conifer mixed broad leaved and temperate mixed broad leaved forests, Pauri Garhwal, Nagdev-Jhandidhar, 21 September 2009, Coll. No. MPV/RPB/SJ -369, Edible.

Lactarius subindigo Verbeken & E. Horak On humicolous soil, in mixed coniferous forests, Phedkhal, 25 September 2008, Coll. No. MPV/RPB/SJ -215.

Lactarius yazooensis Hesler & Smith, On humicolous soil in mixed and broad leaved forests, Adwani Forest, 26 September 2009, Coll. No. MPV/RPB/SJ -372

Russula albida Peck, In mixed broadleaved forest, Pauri Garhwal, Chobattakhal, 25 September 2008, RPB/MPV/SJ -222.

Russula pseudolepida Singer, On humicolous soil in broad leaved forests, Pauri Garhwal, Phedkhal, 28 September 2008, RPB/MPV/SJ -230.

Russula flocculosa Burlingham, On humicolous soil in broad leaved forests, Pauri Garhwal, Adwani, 29 September 2009, Coll. No. RPB/MPV/SJ -380.

Discussion

In the present study, 40 macrofungal taxa belonging to 11 families were reported. Two taxa belonged to Class-Ascomycetes and 38 to Class- Basidiomycetes. The study area supports very rich macrofungi flora, which grow in various habitats, e.g. Pine forest, Cedrus forest, mixed broadleaved forest, meadows and evergreen shrubs. These habitats provide very suitable conditions for members of these macrofungi (Vishwakarma, 2010; Vishwakarma et al., 2011). The most common species in the study area were *Agaricus silvicola*, *A. placomyces*, *A. xanthodermus*, *Chlorophyllum molybdites, Lepiota clypeolaria*; *Macrolepiota dolichaula, Amanita hemibapha*; *Strobilomyces floccopus*, *Phylloporus rhodoxanthus*, *Lactarius subindigo, L. yazooensis*, *Coprinus comatus*, *C. disseminatus* and *Cantharellus cibarius* Fr. These species are cosmopolitan in distribution and are found in coniferous and mixed broadleaved forests.

Eighteen out of the 40 macrofungi taxa, which were recorded from the study area are considered edible. These are *Helvella crispa*, *Morchella esculenta, Agaricus arvensis, A. campestris*, *A. augustus, A. micromegathus*, *A. silvicola, Macrolepiota procera*, *M. rhachodes, Amanita hemibapha*, *Strobilomyces floccopus, Cantharellus cibarius, Coprinus comatus, Psathyrella candolleana, Hydnum repandum, Lactarius corrugis, L. hygrophoroides* var. *hygrophoroides* and *L. volemus* var. *volemus*. There are also seven poisonous macrofungi taxa in the study area. These are *Agaricus abruptibulbus, A. placomyces, A. xanthodermus, Chlorophyllum molybdites, Lepiota cristata, L. Clypeolaria* and *Lycoperdon perlatum*. Six out of the 40 macrofungi taxa viz: *Morchella esculenta, Hydnum repandum*, *Agaricus campestris, Cantharellus cibarius*, *Coprinus comatus* and *Ganoderma lucidum* have medicinal properties (Vishwakarma et al., 2011). Despite the number of poisonous macrofungi in the area, the local inhabitants do not have enough knowledge about poisonous mushrooms and there are no records of poisonings.

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