Journal of Agricultural Technology 2011 Vol. 7(5): 1375-1387
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Seasonal production of epigeal fungal sporocarps in mixed and pure fir (*Abies pindrow*) stands in Kashmir forests

Muzafer A. Beig, Gh. Hassan Dar*, Nisar A. Khan and Nadeem A. Ganai

Division of Plant Pathology, S.K. University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir, (191 121) India.

Muzafer A. Beig, Gh. Hassan Dar, Nisar A. Khan and Nadeem A. Ganai (2011) Seasonal production of epigeal fungal sporocarps in mixed and pure fir (*Abies pindrow*) stands in Kashmir forests. Journal of Agricultural Technology 7(5): 1375-1387.

The studies were conducted to assess the seasonal variation in epigeal fruiting pattern through spring, summer and autumn, and to establish the base-line inventory of macrofungi of Kashmir forests in Western Himalaya. Two forests viz., Gulmarg and Pahalgam of Kashmir, consisting of 9 sites from each forest having either pure or mixed fir (*Abies pindrow*) stand, were surveyed for epigeal macrofungi in 2008 and 2009. A total of 1,439 sporocarps belonging to 66 macrofungal species (43 genera) were collected during the survey from the selected sites, out of which 36 species were mycorrhizal in nature. Much species diversity was noticed in *Russula* (13%), *Amanita* (11%), *Suillus* (9%) and *Hebeloma* (7%). The sporocarp production was 14% higher in year 2008 than 2009. Twenty five macrofungal species were observed in both the years whereas 25 species occurred exclusively in 2008 and only 16 macrofungal species exclusively in 2009. Of the 25 species noticed in both the years 60% were mycorrhizal in nature. Twenty seven macrofungal species were noticed in both the forests and 21 species appeared in more than one season. Hitherto unreported macrofungi, *Clitocybe eccentrica* Peck. and *Leucoagaricus nympharum* (Kalchbr.) Bon. were new records from India and *Panaeolus campanulatus* (Bull. ex. Fr.) a new report from Jammu & Kashmir State. The epigeal macrofungal dry biomass yield of 1,800 g ha^{-1} $year^{-1}$ was observed from both the forests surveyed and varied from season to season with highest aggregate yield recorded in autumn (921.5 g ha^{-1}) and less in summer (309.5 g ha^{-1}). Gulmarg forest exhibited much diversity in macrofungal biomass than Pahalgam forest. In Gulmarg and Pahalgam forests, an average dry sporocarp biomass of 2,132.5 and 1,467.0 g ha^{-1}, respectively, was recorded from both mixed and pure stands in three seasons with maximum biomass in autumn and minimum in summer. The sporocarp biomass production was more in pure fir forest stands (1,903 g ha^{-1}) than mixed stands (1,697 g ha^{-1}). The study revealed prevalence of great macrofungal diversity and specie richness in Western Himalayan forests and their proper exploration may be of immense future use.

Key words: Fir, India, macrofungal diversity, mycorrhiza, seasonal production

* Corresponding author: Gh. Hassan Dar; e-mail: ghasandar@gmail.com

Introduction

The mountainous range of Western Himalaya possesses rich forest biodiversity owing to the wide variation in agro-climatic conditions, altitude, plant species, etc. The State of Jammu & Kashmir falls in the mountainous range of Western Himalaya and has abundant temperate forests, mostly dominated by conifers. These coniferous forests presumably possess great diversity not only in plant species but also in macrofungi. Only some selected pockets of these forests have been surveyed that too in unsystemic manner. However, the dwindling forest cover due to anthropogenic activities across the State has unnoticeably led to the loss of many rare fungal species. In J&K State no base-line data about the macrofungal diversity is available, except some stray reporting of hitherto unrecorded macrofungi (Dar *et al.,* 2009 c,e 2010 a). The ability of conifers to grow over a wide range of habitats and over long periods is linked with the high level of ectomycorrhizal fungal diversity. Ectomycorrhizal fungi, with a few exceptions, belong to either ascomycota or basidiomycota, and most species produce macroscopic sporocarps in the form of mushrooms, truffles, etc. Besides, many macrofungi observed in these forests are either edible or medicinal mushrooms or wood rotting fungi. These fungal species vary in their abundance and phenology of fruiting as well as in nutritional value of their sporocarps (Luoma, 1988; Luoma *et al.,* 1991). Various biotic and abiotic factors influence the sporocarp production of macrofungi (Villeneuve *et al.,* 1991). Sporocarps are non-uniform in distribution varying from a few scattered fruiting bodies to concentrated clusters of numerous fruit bodies (North *et al.,* 1997; States and Gaud, 1997; Water *et al.,* 1997). The documentation of existing fruiting patterns is critical to the interpretation of changes that may result from several manipulations. The practical way to compare the relative functional importance of species of macrofungi, especially ectomycorrhizal ones, in an ecosystem is by estimating the sporocarp production. Most of the macrofungal species producing hypogeous/ epigeal sporocarp are thought to be ectomycorrhizal (Trappe, 1962; Castellano *et al.,* 1989; Beig *et al.,* 2008 a,b). Fogel (1976) was first to analyze the seasonal distribution of hypogeous sporocarps quantitatively through sporocarp dry weight, number for individual species and population. Sporocarp formation varies both in space and time, and depends on a range of external factors. The aim of present investigation was to generate base-line information on prevailing macrofungi, including ectomycorrhiza, of Western Himalayan forests and to study the seasonal variation in epigeal fruiting pattern/production/distribution in Kashmir forests.

Materials and methods

The present study was conducted in two forests of J&K State viz., Gulmarg forest (Jehlum Valley Division) in district Baramulla and Pahalgam forest (Lidder Division) in district Anantnag during the years 2008 and 2009. These forests lie at an altitudinal range of 2000 to 3500 m masl. These forests are approximately 60 and 95 km away from the capital city Srinagar on western and north-eastern side of the city, respectively. Vegetation is classified as temperate deciduous dominated by conifers. The experimental sites were selected on the basis of their dense forest plantation and road connectivity. Both pure fir stand and fir (*Abies pindrow*)-dominated mixed stands (comprising of several conifers like pine, deodar, etc. but dominated by fir) were chosen for the collection of epigeal sporocarps. Eighteen study sites, nine from each forest, were selected. The details of experimental area with respect to location, type of forest, temperature, soil type, pH, organic matter, nitrogen and phosphorus contents, etc. were recorded. At each selected plantation site approximately 0.2 ha area was explored during active growth period, except the period when the area was snow-clad (December to February). Difficulty was that small proportions of macrofungi were visible on a single visit. Hence, repeated surveys were done during March to November in all the sampling sites. The sporocarps were collected in polybags during active growth seasons viz., spring (March-May), summer (June-August) and autumn (September-November). The exposed sporocarps of each species were collected and analyzed in laboratory for their identity. The fungi represented a mixture of young, mature and old fruiting bodies. The sporocarps were identified upto species level on the basis of critical observations of the specimen and with the help of available literature and authentic keys (Phillips, 1981; Pacioni, 1985). Photographs were taken using digital Nikon camera. Standard methods were followed for the collection, preservation and macro- and micro-scopic studies of macrofungi (Atri *et al.,* 2003). Efforts were made to establish the relationship of sporocarps/sporophores with plant root by careful digging of soil and tracing their connection with host plant roots as per the methods of Young (1940) and Zak (1971) for their mycorrhizal association. The sporocarps were stored at 4°C for further studies. The sporocarps were oven-dried to a constant weight at 60$\pm$°C before estimating their biomass on dry weight basis. The total sporocarp biomass was estimated at the end of growing season. The sporocarps and sporophores of macrofungi were preserved in the Mycology and Forestry Section, Division of Plant Pathology, SKUAST-K, Shalimar, Srinagar (J&K).

Results and discussion

The soils at the selected sites in Gulmarg and Pahalgam forests were in the textural class of loam to clay loam, with organic carbon content varying from 0.96 to 1.11%, total nitrogen 0.092 to 0.113%, total phosphorus 0.039 to 0.050%, pH 5.8 to 6.8 and soil temperature 7.6 to 16.9°C (Table 1).

Table 1. Details of forest areas surveyed with the physico-chemical properties of soil.

Forest areas surveyed	Physico-chemical properties of soil at the surveyed sites					
	Soil Texture	Organic Carbon (%)	Total N (%)	Total P (%)	pH (1:2)	Soil Temperature (°C)
Gulmarg (J.V. Division)	Clay loam - loam	1.03-1.06	0.092-0.102	0.039-0.040	5.9-6.8	7.9-16.9
Pahalgam (Lidder Division)	Loam	0.96-1.11	0.108-0.113	0.045-0.050	5.8-6.5	7.6-15.2

A total number of 1,439 sporocarps belonging to 66 macrofungal species were collected during two year-survey from the selected sites, out of which 36 species (54.5% of the total) were mycorrhizal in nature. Of the macrofungi observed, 79% were basidomycetous fungi and the rest ascomycetous fungi. The abundance of macrofungi was uniformly high within fir-tree canopy, declined rapidly around 10 m from the base of the trees and non-uniformly low beyond 15 m. Baring six species, all the other collected macrofungi were epigeal in nature (Table 2).

Table 2. The species of epigeous macrofungi collected from Gulmarg and Pahalgam forest areas during two study years along with their mycorrhizal status, yearly presence and dry biomass.

Macrofungal species	Mycorrhizal status	Host	Presence* 2008	Presence* 2009	Season in which noticed	Dry biomass (g $ha^{-1}year^{-1}$)	% of total biomass	Site of first collection Location	Site of first collection Altitude (m masl)
Amanita porphyria	Yes	*A. pindrow*	1	0	Su, Au	53	0.73	Gulmarg	2,653
A. excels	No	*P. wallichiana*	0	1	Au	41	0.56	Aru	2,350
A. inauratia	Yes	*A. pindrow*	1	0	Au	33	0.45	Pahalgam	2,130
A. citrina	No	*P. wallichiana*	0	1	Sp, Su	87	1.20	Tangmarg	2,232
Amanita sp.	No	*A. pindrow*	1	0	Su	32	0.44	Baisaran	2,438
Aleuria aurantia	No	Broad leaved trees	1	1	Sp	39	0.54	Tangmarg	2,232
Auricularia judae	No	Broad leaved trees	1	1	Sp	135	1.87	Tangmarg	2,232
Bovista nigrescens	No	*C. deodara*	1	1	Sp, Su	223	3.09	Aru	2,350
Boletus rhodoxanthus	Yes	*A. pindrow*	1	0	Au	174	2.41	Babareshi	2,310
B. edulis	Yes	*P. wallichiana*	1	1	Au	102	1.41	Gulmarg	2,653
Canthralleus cibrius	Yes	*P. wallichiana* & *A. pindrow*	1	1	Su, Au	156	2.16	Aru	2,350
Cortinarius sp.	Yes	*A. pindrow*	1	1	Au	255	3.60	Pahalgam	2,150
Clavridelphus ligula	No	*P. helpenses*	1	1	Su	123	1.70	Gulmarg	2,653
Clitocybe eccentrica	No	Conifer woods	1	0	Su, Au	13	0.18	Pahalgam	2,150
C. flaccida	No	*A. pindrow*	1	0	Sp, Su	115	1.59	Tangmarg	2,232
C. geotropha	Yes	*P.wallichiana*	1	0	Au	82	1.13	Tangmarg	2,232
Coprinus disseminatus	No	Broad leaved trees	1	1	Sp, Su	182	2.52	Pahalgam	2,150
Crucibulum lavea	No	*C. deodara*	1	0	Sp	63	0.87	Baisaran	2,438
Hebeloma crustuliniforme	Yes	*P. wallichiana*	0	1	Au	120	1.66	Pahalgam	2,150
H. cylindorosum	Yes	*P. helpenses*	1	1	Au	208	2.88	Pahalgam	2,150

Hebeloma sp.	Yes	*A. pindrow*	0	1	Su, F	80	1.11	Tangmarg	2,232
Gyromitra sp.	No	Mixed forests	0	1	Sp	42	0.58	Babareshi	2,310
Hygrophorus sp.	Yes	*P. wallichiana*	1	0	Au	152	2.11	Aru	2,350
H. camrophyllus	Yes	*A. pindrow*	0	1	Au	40	0.55	Gulmarg	2,653
Helvella crispa	No	*P. wallichiana*	1	1	Su, Au	215	2.98	Babareshi	2,310
Herrecium corraloides	No	Broadleaved trees	0	1	Sp	195	2.70	Babareshi	2,310
Humaria hemispherica	No	Broadleaved trees	0	1	Sp	90	1.25	Pahalgam	2,150
Inocybe rimosa	Yes	*P. helpenses*	1	0	Su, Au	123	1.70	Babareshi	2,310
I. fastigata	Yes	*P. helpenses*	0	1	Au	42	0.58	Babareshi	2,310
Lactarius torminosus	Yes	*P. wallichiana*	1	0	Au	62	0.86	Aru	2,350
Laccaria laccatta	Yes	*A. pindrow*	0	1	Su, Au	58	0.80	Tangmarg	2,232
Lepoita cristata	No	*A. pindrow*	1	1	Su	123	1.70	Baisaran	2,438
L. clypeloria	No	*A. pindrow*	0	1	Su	15	0.20	Aru	2,350
Leucoagaricus nympharum	Yes	Conifer forests	1	0	Su	17	0.23	Tangmarg	2,232
Lycoperdon perlatum	Yes	*P. wallichiana*	1	1	Su	205	2.84	Gulmarg	2,653
Mycena sp.	No	Broadleaved trees	1	0	Sp, Su	315	4.37	Pahalgam	2,150
Morchella vulgaris	No	Mixed forests	0	1	Sp	213	2.95	Gulmarg	2,653
M. esculenta	No	Mixed forests	1	1	Sp	156	2.16	Gulmarg	2,653
Marasimus androceium	No	Broadleaved trees	1	0	Sp, Su	78	1.08	Babareshi	2,310
Panaeolus campanulatus	No	Broadleaved trees	1	0	Sp, Su	12	0.16	Pahalgam	2,150
Paxina barlae	No	*C. deodara*	1	0	Sp	35	0.48	Tangmarg	2,232
Pezziza exogelatinosa	No	*C. deodara*; *P. wallichiana*	1	0	Sp	42	0.58	Gulmarg	2,653
Pisolithus tinctorius	Yes	*A. pindrow*; *P. wallichiana*	1	1	Su, Au	78	1.08	Aru	2,350
Ramaria invalli	Yes	*P. wallichiana*	1	1	Au	289	4.01	Gulmarg	2,653
R. flava	Yes	*A. pindrow*	1	1	Su, Au	99	1.37	Tangmarg	2,232
Rhizopogon vulgaris	Yes	*A. pindrow*	1	1	Au	142	1.97	Tangmarg	2,232
Russula brevipes	Yes	*P. helpenses*	0	1	Au	101	1.40	Pahalgam	2,150
R. densifolia	Yes	*P. wallichiana*	1	0	Au	169	2.34	Pahalgam	2,150
R. sardonia	Yes	*A. pindrow*	1	0	Au	123	1.70	Babareshi	2,310
R. lutea	Yes	*P. wallichiana*	1	1	Su	165	2.29	Babareshi	2,310
R. emetica	Yes	*A. pindrow*	1	0	Au	191	2.65	Aru	2,350
Russula sp.	Yes	*A. pindrow*	1	0	Su, Au	45	0.62	Pahalgam	2,150
Scleroderma citrinum	Yes	*C. deodara*	0	1	Su, Au	50	0.69	Gulmarg	2,653
Suillus placidus	Yes	*P. wallichiana*	1	1	Au	242	3.36	Tangmarg	2,232
S. cavipes	Yes	*P. wallichiana*	0	1	Su, Au	98	1.36	Tangmarg	2,232
S. granulatus	Yes	*A. pindrow*	1	1	Au	91	1.26	Babareshi	2,310
S. luteus	Yes	*A. pindrow* & *P. wallichiana*	1	1	Au	192	2.66	Pahalgam	2,150
Sarcosypha austrica	No	*C. deodara*	1	0	Sp, Su	68	0.94	Tangmarg	2,232
Sepultaria sumneriania	No	*C. deodara*	1	1	Sp	72	1.00	Gulmarg	2,653
Strobilurus sp.	No	*C. deodara*	1	0	Sp	12	0.16	Aru	2,350
Tricholoma terreum	Yes	*A. pindrow*	1	1	Au	90	1.25	Tangmarg	2,232
T. portentosum	Yes	*P. wallichiana*	0	1	Su	21	0.29	Gulmarg	2,653
Tulostoma brumalae	No	*C. deodara*	1	1	S, Su	111	1.54	Pahalgam	2,150
Tarzetta catinus	No	Broadleaved trees	1	0	Sp	89	1.23	Aru	2,350
Tuber sp.	No	*P. wallichiana*	1	0	Au	47	0.65	Aru	2,350
Thelephora terrestris	Yes	*A. pindrow*	1	1	Au	68	0.94	Tangmarg	2,232
Total : 66						**7,199**			,

*refer to occurrence during 2008 and 2009 (1= collected, 0 = not collected); + Present, - Absent; Sp: Spring; Su: Summer & Au: Autumn

The hypogeal macrofungal species observed were *Bovista nigrescens, Pisolithus tinctorius*, *Rhizopogon vulgaris, Scleroderma citrinum, Tuber* sp. and *Tulostoma brumalae.* Four genera viz., *Russula*, *Amanita*, *Suillus* and *Hebeloma* comprized of 40% of the total species noticed. Maximum species diversity was noticed in *Russula* (13%), *Amanita* (11%) and *Suillus* (9%) and *Hebeloma* (7%). These findings are in agreement with Bonet *et al*. (2004) in a 3 year study at Central Pyrenees collected 9,073 sporocarps and classified them into 164 different taxa, of which 144 taxa belonging to 34 genera were ectomycorrhizal in nature. They observed that out of the total number of sporocarps collected, four genera comprised of 62% and seven species 47%, with most frequently encountered species as *Tricholoma imbricatum*, *Hebeloma edurum, Inocybe* sp., *Hebeloma* sp., *Cortinarius* sp., *Hygrophorus* sp., *Russula*

sp., *Lactarius* sp. and *Ramaria* sp. Similarly Dar *et al.* (2009 a,b,d, 2010 b), while reporting some new macrofungi from J&K forests, including some *hitherto* unrecorded from India, have speculated that owing to the presence of dense coniferous forest and variable physiography in J&K State rich diversity of macrofungi is expected. Vare *et al.* (1996) reported one hundred fifty two species associated with *P. sylvestris* in Finnish Lapland, 90 of them were ectomycorrhizal while Salo (1979) observed 107 species in 18 plots of 150 m^2 each on fertilized- and peat-lands, in which *P. sylvestris* was the dominant tree species. Vogt *et al.* (1981) found one hypogeous fungus species compared to 49 epigeous species in a study of mycorrhizal dynamics in an *Abies* stand.

During survey, the sporocarp production was observed to be 14% higher in year 2008 than year 2009. Higher sporocarp production in 2008 may be ascribed to the favourable agro-climatic conditions especially higher and timely precipitation and congenial temperature from April to October in 2008 (mean precipitation: 314 mm and mean temperature: 22.3°C). The year 2009 with mean precipitation of 236 mm and mean temperature of 24.6°C was comparatively drier and slightly warmer than 2008 which probably may have affected the species diversity and sporocarps production by individual macrofungal species. The findings are in agreement with Mihali (1995) who during two year study in 1992 and 1993 observed 83 macromycetous species that produced 817 fruiting bodies in beech stand at Jalna, Slovak Republic.

Twenty five macrofungal species were of common occurrence in both the years whereas 25 macrofungal species were observed exclusively in 2008 and 16 species exclusively in 2009. Of the 25 macrofungal species of common occurrence, 60% species were mycorrhizal in nature (Table 2). Our finding are in agreement with Trappe (1987), Trappe and Luoma (1992) and Smith and Read (1997) who reported that the fungi which are always present on the forest floor have mycorrhizal associations for vital existence of most vascular plants and facilitate the uptake of water, nitrogen, phosphorus and other minerals to the plant.

On an average, dry sporocarp biomass yield of 1,800 ha^{-1} $year^{-1}$ was recorded from both the forests surveyed. The epigeal macrofungal biomass yield varied from season to season with highest aggregate yield observed in autumn (921.5 g ha^{-1}) and less in summer (309.5 g ha^{-1}). Maximum abundance of fruiting bodies in these two years was observed in *Mycena* sp. (315 g ha^{-1}) followed by *Ramaria invalli* (289 g ha^{-1}), *Cortinarius* sp. (255 g ha^{-1}), *Suillus placidus* (242 g ha^{-1}) and *Bovista nigrescens* (223 g ha^{-1}). The mycorrhizal fructification was low in 2009, obviously attributed to the prevalence of dryness for longer periods. However, a keen observation revealed that rich macrofungal fructification appeared soon after good precipitation (within 7-10 days). Our

results corroborate with O'Dell *et al.* (1999) who in eight mixed *Tsuga heterophylla* and *Pseudotusga menziesii* stands in Pacific Northwest, USA found the majority of collected fungal species in two sampled autumns. Ohenoja (1993) also observed that the sporocarp production not only varies considerably between different years in the same locality but also between different plots of the same aspect in the same year.

During survey, it was noticed that Gulmarg forest possessed much diversity in sporocarp biomass than Pahalgam forest (Table 3).

Table 3. Seasonal dry sporocarps biomass production (g ha^{-1}) in mixed and pure fir stands in Gulmarg and Pahalgam forests in different seasons (mean of 2 years data).

Forest area	Type of stand	Sporophore biomass (g ha^{-1})			
		Spring	Summer	Autumn	Total
Gulmarg	Mixed fir stand	642	418	980	2040
	Pure fir stand	711	342	1172	2225
	Average	676	380	1076	2132.5
Pahalgam	Mixed fir stand	420	220	714	1354
	Pure fir stand	502	258	820	1580
	Average	461	239	767	1467.0

In Gulmarg, average dry sporocarp biomass of 2132.5 g ha^{-1} was recorded in both mixed and pure stands in three seasons with maximum biomass recorded in autumn. While in Pahalgam an average dry sporocarp biomass of 1,467.0 g ha^{-1} was recorded during active growth seasons with maximum biomass production in autumn and minimum in summer. Further, the sporocarp biomass production was more in pure fir forest stands (1,903 g ha^{-1}) than mixed stands (1,697 g ha^{-1}). Irrespective of the forest areas, the maximum number of macrofungal species was observed in autumn season than spring and summer (Table 4). Of the 66 macrofungal species observed, 27 were noticed in both the forests and 21 species appeared in more than one season. Further, eight species observed in both the forests appeared in more than one season. The species which occurred in both Gulmarg and Pahalgam forests were *Amanita excelsa, Bovista nigrescens, Boletus edulis, Canthralleus cibrius, Cortinarius* sp., *Clitocybe geotropha, Coprinus disseminatus, Hebeloma crustuliniforme, Herrecium corraloides, Hygrophorus camrophyllus*, *Inocybe rimosa, I. fastigata, Lepoita cristata, Lycoperdon perlatum, Mycena* sp., *Morchella vulgaris, M. esculenta, Marasimus androceium, Ramaria flava, R. invalli, Russula brevipes, R. emetica, R. lutea, Suillus cavipes, S. granulatus, Tuber* sp. and *Thelephora terrestris*.

Table 4. The number of macrofungal species observed in various seasons in Gulmarg and Pahalgam forests during two years (2008 & 2009).

Forest	Spring	Summer	Autumn
Gulmarg	16 (+4)*	14 (+12)	23 (+8)
Pahalgam	12 (+5)	11 (+9)	25 (+4)

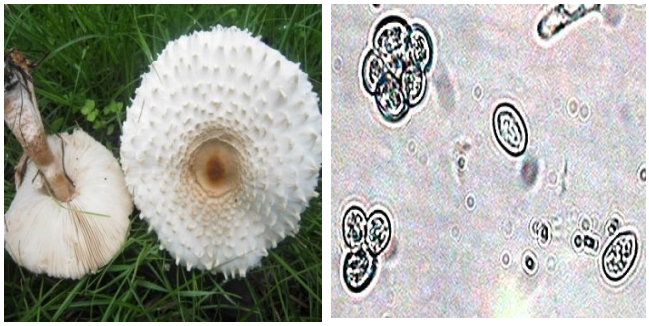
*The figures in brackets indicate the number of species which appeared in more than one season.

Irrespective of forest areas, 22 macrofungal species were observed in spring season during both the years which were mostly non-mycorrhizal in nature and yielded dry sporocarps biomass of 569 g ha^{-1} in both mixed and pure stands in the selected sites.

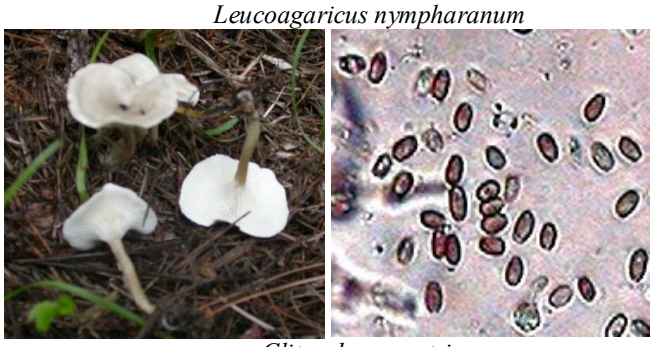
The species noticed in this season were *Amanita citrina, Aleuria aurantia, Auricularia judae, Bovista nigrescens, Clitocybe flaccida, Coprinus disseminatus, Crucibulum lavea, Gyromitra* sp., *Herrecium corraloides, Humaria hemispherica, Mycena* sp., *Morchella vulgaris, M. esculenta, Marasimus androceium, Paxina barlae, Panaeolus campanulatus, Pezziza exogelatinosa, Sarcosypha austrica, Sepultaria sumneriania, Strobilurus* sp., *Tulostoma brumalae* and *Tarzetta catinus.* Of the above species, nine continued to appear in summer season also. In summer season 29 macrofungal species namely *Amanita porphyria, A. citrina, Amanita* sp., *Bovista nigrescens, Canthralleus cibrius, Clavridelphus ligula, Clitocybe eccentrica, C. flaccida, Coprinus disseminatus, Hebeloma* sp., *Helvella crispa, Inocybe rimosa, Laccaria laccata, Lepoita cristata, Lepoita clypeolaria, Leucoagaricus nympharum, Lycoperdon perlatum, Mycena* sp., *Marasimus androceium, Panaeolus campanulatus, Pisolithus tinctorius, Ramaria flava, Russula* sp., *R. lutea, Suillus cavipes, Sarcosypha austrica, Scleroderma citrinum, Tricholoma portentosum* and *Tulostoma brumalae* were collected. These species gave dry sporocarp biomass yield of 309.5 g ha^{-1} in both the experimental areas. Of the macrofungi observed during summer 12 species also appeared in autumn. In autumn season, 36 macrofungal species were observed which were mostly mycorrhizal in nature and yielded dry sporocarp biomass of 921.5 g ha^{-1} in both mixed and pure stands. These were *Amanita porphyria, A. excelsa, A. inauratia, Boletus rhodoxanthus, B. edulis, Canthralleus cibrius, Cortinarius* sp., *Clitocybe eccentrica, Clitocybe geotropha, Hebeloma crustuliniforme, H. cylindorosum, Hebeloma* sp., *Hygrophorus* sp., *H. camrophyllus, Helvella crispa, Inocybe rimosa, I. fastigata, Lactarius torminosus, Laccaria laccata, Pisolithus tinctorius, Ramaria invalli, R. flava, Rhizopogon vulgaris, Russula* sp., *R. brevipes, R. densifolia, R. sardonia, R. emetica, Scleroderma citrinum, Suillus placidus, S. cavipes, S. granulatus, S. luteus, Tricholoma terreum, Tuber* sp. and *Thelephora terrestris*. Most of these fungi were observed under the

canopy of trees. The macrofungal diversity and richness decreased with increasing disturbance intensity. The macrofungal diversity and sporocarp biomass production in both the forests was remarkable in forest stands with fir predominance (1.902.5 g biomass ha^{-1} yr^{-1}) rather in mixed fir-dominated stands (1.697 g ha^{-1} yr^{-1}). Fogel (1981) and Ohenoja (1993) reported that the sporocarp production not only considerably varied between years in the same locality but also between plots of the same aspect or age class in the same year. The variation in the occurrence and dominance of spring, summer and fall macrofungal fruiting species may be attributed to the variations in annual weather conditions and emphasized on the necessity of collecting samples for several years to adequately characterize the sporocarp composition and production of fruiting fungi in a given site. Fogel and Hunt (1979) observed peak in total sporocarp dry weight in initial fall season but noticed greatly reduced fruiting in spring. Vare *et al.* (1996) reported that the variation in annual sporocarp production from 0 to 940 kg fresh weight/ha has been reported in mixed pine plots. O'Dell *et al*. (1999) found that in eight mixed *Pseudotsuga menziesii* stands of Pacific Northwest (USA), the majority of fungal species in single stands fruited only in one of two sampled autumns.

During survey two *hitherto* unreported macrofungi viz., *Clitocybe eccentrica* Peck. and *Leucoagaricus nympharum (*Kalchbr.) Bon. from India and one unreported macrofungus *Panaeolus campanulatus* (Bull. ex. Fr.) from Jammu & Kashmir State (Fig. 1) were observed (Bilgrami *et al.,* 1982, 1991, Jammaludin *et al*., 2004, Sorbhay *et al.,* 1996). These are briefly described.



Leucoagaricus nympharanum



Clitocybe eccentrica

Panaeolus campanulatus

Fig.1. *Hitherto* unreported macrofungi from India and J&K State**.** (The inset figures show the spores of respective macrofungi).

Clitocybe eccentrica **Peck.:** Found growing gregariously and in clusters on decayed wood in coniferous forests of Pahalgam Kashmir during late summer to autumn; cap 1-6 cm, initially convex, became flat or shallowly vase-shaped, dry, smooth, white to pale brown, usually changed colour markedly as it dried out and margins frequently in-rolled; gills ran down to stem, fairly crowded and initially white and then changed to buff with age; stipe 3-5 cm long, more or less equal, dry; smooth or finely hairy above, densely hairy at the extreme base with white rhizomorphs attached; flesh thin and pale; spores elliptical, smooth, inamyloid and measured 4.5-6.0 x 2.5-3.5 µm in size.

***Leucoagaricus nympharum (*Kalchbr.) Bon.:** Observed in late spring to summer as saprobe on soil and decayed woods in conifer-dominated forest areas of Tangmarg, Kashmir; cap 4.0-10.0 cm wide, convex, dry, white, smooth with radial fibres/scales; centre of cap slightly depressed, light brown to dark brown in colour; gills free, initially white to cream, turned light brown with age; stipe 4.0-9.0 cm, slightly rough, brittle, initially dull white and turned light brown to dark brown, partial veil membranous; annulus present, fixed and cuff-like; context soft, fragile; spores ellipsoid, smooth, thick-walled without apical germ pore and measured 5.5-11.5 x 3.0-7.5 µm in size.

***Panaeolus campanulatus* Bull. ex. Fr. (Syn. *Panaeolus papilionaceus, P. retirugis, P. sphinctrinus, Agaricus calosus*):** Found singly or in small groups in pasture lands and under broad-leaved trees in late spring to summer in Pahalgam forests of Kashmir; cap 1.0-5.0 cm across, obtusely conical to bell shaped, hemispherical when young, later became campanulate with age; margins adorned with white tooth-like partial veil fragments when young, reddish-brown towards centre which was slightly viscid in wet weather; flesh thin and buff; stipe 7-11 cm, much longer than cap diameter, gray-brown, paler toward apex, fibrous and pruinose; gills adnate, crowded with one or two tiers of intermediate gills, pale-gray when young, acquired mottled black appearance with age; spores more or less elliptical with an apical pore, smooth and measured 12-18 x 7-10 µm in size.

Acknowledgement

The authors are highly grateful to the Department of Science and Technology, Government of India, New Mehrauli Road, New Delhi for providing financial grant for the conduct of present research.

References

Atri, N. S., Kaur, A. and Kaur, H. (2003). Wild Mushrooms-Collection and Identification. Chambaghat, Solan, Himachal Pradesh, India.

Beig, M. A., Dar, G. H., Ganai, N. A. and Khan, N. A. (2008a). Mycorrhizal biodiversity in Kashmir forests and some new records of macrofungi from J&K state. Applied Biological Research 10: 26-30.

Beig, M. A., Dar, G. H. and Ganai, N. A. (2008b). Some Hitherto unrecorded macrofungi from India. Journal of Mycology and Plant Pathology 38:158-160.

Bilgrami, K.C., Jammaludin and Rizvi, M. A. (1982). Fungi of India Part I and II, Today's and Tomorrow's Printers and Publishers, New Delhi, India, 268p.

Bilgrami, K. C., Jammaludin and Rizvi, M. A. (1991). The Fungi of India, Today's and Tomorrow's Printers and Publishers, New Delhi, India, 278p.

Bonet, J. A., Fischer, C. R. and Colinas, C. (2004). The relationship between forest age and aspect on the production of sporocarps of ectomycorrhizal fungi in *Pinus sylvestris* forests of the Central Pyrenees. Forest Ecology and Management 203:157-175.

Castellano, M. A., Molina, R. (1989). Mycorrhizae. In: The Biological Component: Nursery Pests and Mycorrhizae, Vol. 5. The Container Tree Nursery Manual. (eds. T.D. Landis, R.W. Tinus, S.E. McDonald and J. P. Barnett) Agricultural Handbook 674. USDA Forest Service, Washington, DC, USA, p. 101–167.

Dar, G. H., Beig, M. A., Ganai, N. A., Khan, N. A. and Ahangar, F. A. (2009a). Hitherto unreported Pezizales from Jammu and Kashmir. Journal of Mycology and Plant Pathology 39(2):244-246.

Dar, G. H., Beig, M. A., Ganai, N. A., Qazi, N. A. (2009b). Hitherto unreported Agaricales from Jammu and Kashmir. Journal of Mycology and Plant Pathology 39(1):35-38.

Dar, G. H., Beig, M. A. and Ganai, N. A. (2009c). Diversity of ectomycorrhizal fungi of various forests in district Baramulla (Jammu & Kashmir). Indian Journal of Forestry 31:137-140.

Dar, G. H., Beig, M. A. and Ganai, N. A. (2009d). Hitherto unreported macrofungi from India. Applied Biological Research 11:59-62.

Dar, G. H., Beig, M. A. and Ganai, N. A. (2009e). Biodiversity of ectomycorrhizal fungi of Pahalgam forests (Jammu & Kashmir). Indian Journal of Forestry 33(3): 373-376.

Dar, G. H., Beig, M. A., Qazi, N. A. and Ganai, N. A. (2010a). Hitherto unreported macrofungi from Jammu and Kashmir. Indian Journal of Forestry 33(1):445-446.

Dar, G. H., Ganai, N. A., Beig, M. A., Ahangar, F. A. and Sofi, T. A. (2010b). Biodiversity of macrofungi from conifer dominated forests of Kashmir, India. Journal of Mycology and Plant Pathology 40:169-171.

Fogel, R. (1976). Ecological studies of hypogeous fungi. II. Sporocarp phenology in a western Oregon Douglas-fir stand. Canadian Journal of Botany 54:1152–1162.

Fogel, R. M. (1981). Quantification of sporocarps produced by hypogeous fungi. In: The Fungal Community, its Organization and Role in the Ecosystem. (eds. D. T. Wicklow, G. C. Carroll), Marcel, Dekker, New York, USA, 553-568.

Fogel, R. M. and Hunt, G. (1979). Fungal and arboreal biomass in a Western Oregon Douglas-fir ecosystem: distribution patterns and turnover. Canadian Journal of Forestry Research 9: 245-256.

Jammaludin, Bilgrammi, K. C. and Ojha, B. M. (2004). Fungi of India 1989-2001, Scientific Publishers, Jodhpur, Rajasthan, India, 326p.

Hintikka, V. (1988). On the macromycetes flora in oligotrophic pine forest of different ages in South Finland. Acta Botanica Fennica 136:89-94.

Luoma, D. L. (1988). Biomass and community structure of sporocarps formed by hypogeous ectomycorrhizal fungi within selected forest habitats of the H.J. Andrews Experimental Forest. Ph.D. thesis. Oregon State University, Corvallis, Oregon, USA.

Luoma, D. L., Frenkel, R. E. and Trappe, J. M. (1991). Fruiting of hypogeous fungi in Oregon Douglas-fir forests: seasonal and habitat variation. Mycologia 83:335–353.

Mihali, I. (1995).Abundancia a distribúcia plodníc húb(prebierkovej [Abundance and distribution of fruiting bodies of fungi in terms beech]. v podmienkach prebierkovej buciny. Forestry 41 : 218–223. 41:218-223.

North, M., Trappe, J. M. and Franklin, J. (1997). Standing crop and animal consumption of fungal sporocarps in Pacific Northwest. Forest Ecology 78:1543-1554.

O'Dell, T. E., Ammariati, J. F. and Schreiner, E. G. (1999). Species richness and abundance of ectomycorrhizal basidomyctes sporocarps on a moisture gradient in the *Tusga heterophylla* zone. Canadian Journal of Botany 77:1699-1711.

Ohenojo, E. (1993). Effect of Weather Condition on the Larger Fungi at Different Forest Sites in the Northern Finland in 1976-1988. Vol. A243. Acvta University Oulu, Finland, 69p.

Pacioni, G. (1985). Mushrooms and Toad stools. Macdonald and Co. Publishers, Maxwell house, London, UK, 512p.

Phillips, R. (1981). Mushrooms. Pan Books, London, 288p.
Salo, K. (1979). Mushroom and mushroom yield on transitional peatlands in Central Finland. Annuals of Botanica Fennicia 16:181-192.
Smith, S. E. and Read, D. J. (1997). *Mycorrhizal Symbiosis*, 2nd edn. Academic Press Ltd., London, UK.
Sorbhay, A. K., Varshney, J. L. and Agarwal, D. K. (1996). Fungi of India (1982-1992). CBS Publishers and Distributors, New Delhi, India, 350p.
States, J. S., Gaud, W. S. (1997). Ecology of hypogeous fungi associated with ponderosa pine: Patterns of distribution and sporocarp production in some Anzona forests. Mycologia 89:7l2 721.
Trappe, J. M. (1962). Fungus associates of ectotrophic mycorrhizae. The Botanical Review 28: 538–606.
Trappe, J. M. (1987). Phylogenetic and ecologic aspects of mycotrophy in the angiosperms from an evolutionary standpoint. In: Ecophysiology of VA Mycorrhizal Plants, (ed G. R. Safir), CRC Press, Boca Rotan, Florida, USA, 2–25.
Trappe, J. M., Luoma, D. L. (1992). The ties that bind: fungi in ecosystems. In: The Fungal Community: Its Organization and Role in the Ecosystsem, 2nd edn. (eds. G. C. Carroll, D. T Wicklow), Marcel Dekker, New York, USA, 17–27.
Vare, H., Ohenoja, E. and Ohtonen, R. (1996). Macrofungi of oligotrophic Scots pine forests in northern Finland, Karstenia 36:1-18.
Villeneuve, N., FLe Tacon and Bouchard, D. (1991). Survival of inoculated *Laccaria laccata* in competition with native ectomycorrhizal fungi and effects on the growth of out-planted Douglas fir seedlings. Plant and Soil 135:95-107.
Vogt, K. A., Edmonds, R. L. and Grier, C. C. (1981). Biomass and nutrient concentrations of sporocarps produced by mycorrhizal and decomposer fungi in *Abies amabilis* stands. Oecologia 50:170-175.
Water, J. R., McKelvcy, K. S., Luomr, D. L. and Zabel, C. J. (1997). Truffle production in old-growth and mature fir stands in northeastern California. Forest Ecology and Management 96:155-166.
Young, H. E. (1940). Mycorrhiza and growth of Pinus and Araucaria: The influence of different species of mycorrhizae forming fungi on seedling growth. Journal of Australian Agricultural Science 6:21-25.
Zak, B. (1971). Characterization and classification of mycorrhizae of Douglas-fir. *Pseudotsuga menziesii* + *Rhizopogon vinicolor*. Canadian Journal of Botany 49:1079-1084.

(Received 23 February 2011; accepted 8 August 2011)