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Diversity and Distribution of Macrofungi in the Valley of Flowers National Park

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ABSTRACT: This paper presents first records of one hundred and six species of macrofungi belonging to sixty genera from the Valley of Flowers National Park. Out of these 106 species, eight species belong to seven genera (*viz. Daldinia* Ces. & De Not., *Geoglossum Pers.*, *Helvella* L., *Hypoxylon* Bull., *Morchella* Dill. ex Pers., *Trichoglossum* Boud and *Xylaria* Hill ex Schrank) of four families (*viz.* Geoglossaceae Corda, Helvellaceae Fr., Morchellaceae Rchb. and Xylariaceae Tul. & C. Tul.) of Ascomycota, and ninety eight species belong to fifty three genera (*viz. Auricularia* Bull., *Antrodia* Karst., *Astraeus* Morgan, *Bjerkandera* Karst., *Bovista* Pers., *Calocera* (Fr.) Fr., *Chaetoderma* Parmasto, *Clavulinopsis* Overeem, *Coltricia* Gray, *Cristinia* Parm., *Daedalea* Pers., *Daedaleopsis* Schröt., *Favolus* Fr., *Flavodon* Ryv., *Fomes* (Fr.) Fr., *Fomitopsis* Karst., *Ganoderma* Karst., *Gloeophyllum* Karst., *Heterobasidion* Bref., *Hexagonia* Fr., *Inonotus* Karst., *Irpex* Fr., *Junghuhnia* Corda, *Laetiporus* Murr., *Lentinus* Fr., *Lenzites* Fr., *Lycoperdon* Pers., *Microporus* Beauv., *Nigroporus* Murr., *Oxyporus* (Bourdot & Galzin) Donk, *Peniophora* Cooke, *Phanerochaete* Karst., *Phellinus* Quél., *Phlebiopsis* Jülich, *Phylloporia* Murr., *Polyporus* (Pers.) Gray, *Poria* Pers., *Postia* Fr., *Pycnoporus* Karst., *Rigidoporus* Murr., *Schizophyllum* Fr., *Schizopora* Velen., *Scleroderma* Pers., *Scopuloides* (Massee) Höhn. & Litsch., *Serpula* (Pers.) Gray, *Skeletocutis* Kotl. & Pouzar, *Spongipellis* Pat., *Stereum* Hill ex Pers., *Trametes* Fr., *Tremella* Pers., *Trichaptum* Murr., *Tubulicrinus* Donk and *Xylobolus* Karst.) of twenty five families (*viz.* Astraeaceae Zeller ex Jülich, Atheliaceae Jülich, Auriculariaceae Fr., Bondarzewiaceae Kotl. & Pouzer, Clavariaceae Chevall., Coniophoraceae Ulbr., Dacrymycetaceae Schröt, Fomitopsidaceae Jülich, Ganodermataceae (Donk) Donk, Gloeophyllaceae Jülich, Hapalopilaceae Jülich, Hymenochaetaceae Imazeki & Toki, Lycoperdaceae Chevall., Meripilaceae Jülich, Meruliaceae Karst., Peniophoraceae Lotsy, Phanerochaetaceae Jülich, Polyporaceae Fr. Ex Corda, Schizophyllaceae Qŷel., Schizoporaceae Jülich, Sclerodermataceae Corda, Steccherinaceae Parmesto, Stereaceae Pilat, Tremellaceae Fr. and Tubulicrinaceae Jülich) of Basidiomycota.

Keywords: Natural World Heritage Site; Western Himalaya; Valley of Flowers National Park and Macrofungi.

INTRODUCTION: The macrofungi includes fungi with the macroscopic fructifications. Macrofungi are categorized into fleshy fungi (mushrooms), polypores, jelly fungi and puffballs etc. Fungi are eukaryotic heterotrophs lacking photosynthetic capacity and gain nutrition by absorption.[1] They reproduce both by asexual and sexual reproduction. The macrofungi produce the visible fruiting bodies (ascomata in case of ascomycota and basidioma in case of basidiomycota) for their reproduction. The ascomata and basidioma play a significant role in the taxonomy of macrofungi. A large number of these fungi are edible and medicinally important and are considered as one of the important non-wood forest products (NWFP) collected world over and used for subsistence purpose as well as sold on local markets and elsewhere.[2]

The dead wood inhabiting fungi cause decay/degradation of wood by acting on cellulose and lignin which are the two main components of wood. When both cellulose and lignin are utilized by the fungus, leaving a whitish residue, it is called white rot and when just cellulose is utilized, leaving a brown residue consisting of remaining chemically modified (demethylated) lignin, it is called brown rot.[3 & 4] Since the brown rot fungi also grow on saprophytes on standing dead wood, a large industry has evolved worldwide to develop and produce chemicals to prevent wood decay. Brown rot fungus cultures are used in the laboratory testing of wood preservatives before they are brought to the market. Brown rot fungal enzymes involved in hemicellulose degradation have been studied for bioindustrial applications.[5]

Fungi accounts for 1.5 million species including about 20,000 species of lichens and are the second largest biotic community after insects in the world.[6 & 7] About 27,000 species of macrofungi have been recorded so far from India.[8] In spite of the massive floristic studies undertaken by various workers to explore the macrofungal diversity of N.W. Himalaya in the past, certain pockets of the biodiversity rich Himalaya such as the Valley of Flowers Nationa Park have remained unexplored. Keeping in view the outstanding universal values of this world heritage site and in contrast to the insufficient data available on the geographical distribution, taxonomy & diversity of macrofungi in this National Park, the efforts were initiated to describe & preserve the macrofungi of this area and 106 species of macrofungi have been collected & described for their geographical distribution, taxonomy and diversity.

The review of literature reveals that no studies on macrofungal flora have been conducted in this park and efforts were made during the present study for exploring the macrofungal diversity of this area.[13, 14, 15 & 16.]

MATERIAL AND METHODS:

Study Area – Valley of Flowers National Park: The Valley of Flowers was incidentally explored by British Mountaineers Frank S. Smythe and R.L. Holdsworth during their expedition in 1932 for ascent to Mount Kamet.[9] The Valley of Flowers established as National Park by Government of India in 1982 is a Natural World Heritage site inscribed by UNESCO in 2005 under criteria vii (to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance) and criteria x (to contain the most important and significant natural habitats for *in-situ* conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation). This national park spreads over an area of 87.5 Km², of which 63.58 Km² is under perpetual snow, 18.63 Km² is under alpine meadow and 5.29 Km² is under sub-alpine forest.[10] The park is under core zone of Nanda Devi Biosphere Reserve and situated between 30°41' -30°48' N latitude & 79°33'-79°46'E longitude in North Western Himalaya with an altitude range of 3,200m – 6,675m, providing a great diversity of landscape and microhabitats. It is bounded by Gauri Parvat (6,500m) and Rataban (6,126m) in the East, Kunthkhal (4,430m) in the West, Saptshring (5,038m) in the South and Nilgiri Parvat (6,479m) in the North. River Pushpawati originates from the left bank of Tipra glacier and flows down through the park to drain into river Alaknanda which is a tributary of river Ganges. The climate of the park is moist temperate and alpine type annually with short period of cool summers and long period of severe winters.

This park accounts for 13 species of mammals including snow leopard (*Panthera uncia*), blue sheep (*Pseudois nayaur*), himalayan musk deer (*Moschus chrysogaster*), Asiatic black bear (*Selenarctos thibetanus*), serow (*Namorhaedus sumatrensis*), Himalayan tahr (*Hemitragus jemlahicus*) and forty one species of birds. The flora of the park accounts for 521 species of vascular plants including 499 Angiosperms, 4 Gymnosperms and 18 Pteridophytes.[11,12] The characteristic tree species in the park are maple **(***Acer cappadocicum***)**, walnut (*Juglans regia*), hazelnut (*Corylus jacquemontii*), spruce (*Picea smithiana*), blue pine (*Pinus wallichiana*), birch (*Betula utilis*), rhododendron (*Rhododendron arboretum*), fir (*Abies pindrow*), chestnut (*Aesculus indica*) and oak (*Quercus semecarpifolia*).

Experimental: The specimens were collected from various habitats and substrates during the months September-October in 2014. A total of 345 specimens were collected from nine microhabitats of the park namely Pairra (*c* 3200m), Nagtal (*c* 3300m), Baminidhaur (*c* 3450m), Semar (*c* 3500m), Bistoli (*c* 3500m), Kundaliyasain (*c* 3500m), Drunager (*c* 3550m), Sewachand (*c* 3600m) and Tiprakharak (*c* 3700m). The field data such as texture, size, colour and macroscopic features have been recorded in the field data book during the excursions.[17] A hand lens (20 X), knife, and a saw were the tools used while collecting the specimens. The collected specimens were placed in paper packets of suitable size and a paper slip containing the field data such as collection number, details of collection site, host/substrate and altitude in meters, the date of collection & name of the legator was placed in each paper packet. The fragile specimens were placed in card boxes of suitable size. The fresh specimens were observed for morphological investigations and sun dried at the camping site, placed in the paper bags along with paper slip containing field data and naphthalene balls to avoid insects attack.

The following mountants/stains were used for the taxonomic investigations pertaining to different groups of macrofungi during the present study:

1. ***Amann's Lactophenol:*** It was used for mounting of microscopic structures and composed of 20g Phenol, 20ml Lactic acid, 40ml Glycerol and 20ml distilled water.

2. ***Glycerine:*** It was used for mounting of microscopic structures and composed of 2ml Glycerine in distilled water to make 100ml.
3. ***Potassium hydroxide:*** It was used for microchemical tests and softening of the study materials and composed of 5g KOH in distilled water to make 100ml.
4. ***Melzer's Iodine:*** It was used to test amyloidity of the sporulating structures and composed of 22g Chloral hydrate , 5g Iodine, 0.5g Potassium iodide and 20ml distilled water.
5. ***Distilled water:*** It was used for observing the natural colour of the microcopic structures.
6. ***Erythrosine B in ammonia:*** It was used for observing septation in spores & mycelium and composed of 1g Erythrosine B, 10ml Ammonia and 90ml distilled water.
7. ***Phloxine:*** It was used to stain and observe septaion in spores & mycelium and composed of 1g Phloxine and distilled water to make 100ml.
8. ***Cotton blue:*** It was used to stain the cytoplasm of the fungal cells & also to observe cyanophilly of the microscopic structures and composed of 0.01g Cotton blue in 100ml Lactic acid.
9. ***Lugol's iodine:*** It was used to check amyloidity and composed of 5g Iodine, 10g Potassium Iodide and 100ml distilled water.
10. ***Congo red:*** It was used to stain ascus wall, paraphyses, ascospores & excipular tissues and composed of 2% Congo red or 1% Congo red in 50% ammonia.
11. ***Potassium hydroxide-phloxine-glycerine:*** It was used to stains the cytoplasm bright pink & for clarity of the septa and walls. The thin sections were placed in 2% KOH on the slide, to which a drop of 1% aqueous phloxine was added after 10-15 minutes the sections were transferred to a drop of 50% glycerine (slightly acidified) and then the cover slip was placed on it.
12. ***Sulfobenzaldehyde:*** It was used to stain gloeocystidia and composed of 1.5ml distilled water, Sulphuric acid 5.0ml and 4.5ml benzaldehyde.

RESULTS AND DISCUSSION: A total of 106 species of macrofungi collected and described for their geographical distribution, taxonomy & diversity have been given in Table 1 and Table 2.

Table 1: Macrofungi of the Valley of Flowers National Park.

Family/Genera/Species	Substratum		
	Soil	Wood	
		Angiospermous	Gymnospermous
1. ***Geoglossum Pers.***	√		
1. ***G. fallax*** Durand	√		
2. ***Trichoglossum*** Boud	√		
2. ***T. farlowii*** (Cooke) Durand	√		
3. ***Helvella*** L.	√		
3. ***H. compressa*** (Snyder) Weber	√		
4. ***Morchella*** Dill. ex Pers.	√		
4. ***M. Conica*** Pers.	√		
5. ***M. deliciosa*** Fr.	√		
5. ***Daldinia*** Ces. & De Not.		√	√
6. ***D. concentrica*** Ces & de Not.		√	√
6. ***Hypoxylon*** Bull.		√	√
7. ***H. ferrugineum*** Otth		√	√
7. ***Xylaria*** Hill ex Schrank		√	√
8. ***X. hypoxylon*** (L.: Fr.) Grev.		√	√
8. ***Astraeus*** Morgan		√	
9. ***A. hygrometricus*** (Pers.) Morgan		√	
9. ***Cristinia*** Parm.		√	√
10. ***C. helvetica*** (Pers.) Parm.		√	√
10. ***Auricularia*** Bull.		√	√
11. ***A. auricula-judae*** Schroet.		√	√
12. ***A. polytricha*** (Mont.) Sacc.		√	√
11. ***Heterobasidion*** Bref.		√	√
13. ***H. annosum*** (Fr.) Bref.		√	√
14. ***H. insulare*** (Murr.) Ryv.		√	√
12. ***Clavulinopsis*** Overeem	√		
15. ***C. subtilis*** (Pers.) Corner	√		
13. ***Serpula*** (Pers.) Gray			√
16. ***S. lacrymans*** (Wulfen) Schröt.			√
14. ***Calocera*** (Fr.) Fr.		√	
17. ***C. viscosa*** (Pers.) Fr.		√	
15. ***Daedalea*** Pers.		√	√
18. ***D. stereoides*** Fr.		√	√
19. ***D. quercina*** (L.) Pers.		√	√
16. ***Fomitopsis*** Karst.		√	√
20. ***F. dochmia*** Ryv.		√	√
17. ***Postia*** Fr.		√	
21. ***P. guttulata*** (Peck) Jülich		√	

18 ***Ganoderma*** Karst.		√	√
22. ***G. applanatum*** Karst.		√	√
23. ***G. lucidum*** Karst.		√	√
19. ***Gloeophyllum*** Karst.		√	√
24. ***G. subferrugineum*** (Berk.)		√	√
20. ***Spongipellis*** Pat.		√	√
25. ***S. dilectans*** (Peck.) Murr.		√	√
21. ***Bjerkandera*** Karst.		√	√
26. ***B. adusta*** (Willd.) Karst.		√	√
22. ***Coltricia*** Gray	√	√	√
27. ***C. cinnamomea*** (Jacq.) Murr.		√	√
28. ***C. perennis*** (L.:Fr.) Murr.	√		
23. ***Inonotus*** Karst.		√	√
29. ***I. dryadeus*** (Pers.) Murr.		√	
30. ***I. tabacinus*** (Mont.) Cunn.		√	√
24. ***Phellinus*** Quél.	√	√	√
31. ***P. allardii*** (Bres.) Ahmad		√	√
32. ***P. caryophylli*** (Racib.) Cunn.		√	√
33. ***P. fastulosus*** (Lev.) Ryv.		√	√
34. ***P. ferruginosus*** (Schrad.) Pat.		√	√
35. ***P. gilvus*** (Schw.) Pat.		√	√
36. ***P. johnsonianus*** (Murr.) Ryv.		√	√
37. ***P. linteus*** (Berk. & Curtis) Teng		√	√
38. ***P. merrillii*** (Murr.) Ryv.		√	√
39. ***P. pini*** (Brot.) Bond. & Sing.		√	√
40. ***P. robustus*** (Karst.) Bourd		√	√
41. ***P. sanfordii*** (Lloyd) Ryv.		√	√
42. ***P. torulosus*** (Pers.) Bourd.		√	√
43. ***P. xeranticus*** (Berk.) Pegler		√	√
25. ***Phylloporia*** Murr.		√	√
44. ***P. ribis*** (Schumach.) Ryv.		√	√
26. ***Bovista*** Pers.	√		
45. ***B. bovistoides*** Ahmad	√		
27. ***Lycoperdon*** Pers.	√		
46. ***L. elongatum*** Berk.	√		
47. ***L. perlatum*** Pers.	√		
48. ***L. pussillum*** Batsch. ex Pers.	√		
28. ***Antrodia*** Karst.		√	√
49. ***A. xantha*** (Fr.) Ryv.		√	√
29. ***Rigidoporus*** Murr.		√	√
50. ***R. ulmarius*** (Sowerby) Imazeki		√	√
30. ***Scopuloides*** Höhn. & Litsch.			√
51. ***S. hydnoides*** Hjortstam & Ryv.			√
31. ***Peniophora*** Cooke		√	√
52. ***P. pithya*** (Pers.) J. Erikss.		√	√
32. ***Phanerochaete*** Karst.		√	√
53. ***P. flavidoalba*** (Cooke) Rattan		√	√
33. ***Phlebiopsis*** Jülich		√	√
54. ***P. roumeguerei*** Jülich & Stalpers		√	√
34. ***Daedaleopsis*** Schröt.		√	√
55. ***D. confragosa*** (Bolton) Schröt.		√	√
35. ***Favolus*** Fr.		√	√
56. ***F. tenuiculus*** Beauv.		√	√
36. ***Fomes***(Fr.) Fr.			√
57. ***F. fomentarius*** (L.) Kickx			√

37. ***Hexagonia*** Fr.		√	√
58. ***H. sulcata*** Berk.		√	√
38. ***Laetiporus*** Murr.			√
59. ***L. sulphurous*** (Bull.) Murr.			√
39. ***Lentinus*** Fr.		√	√
60. ***L. fasciatus*** Berk.		√	√
40. ***Lenzites*** Fr.		√	√
61. ***L. adustus*** Mass.		√	√
62. ***L. betulina*** (L.:Fr.) Fr.		√	√
63. ***L. palisotii*** (Fr.) Sacc.		√	√
41. ***Microporus*** Beauv.		√	√
64. ***M. affinis*** Kuntze		√	√
65. ***M. xanthopus*** (Fr.) Kuntze		√	√
42. ***Nigroporus*** Murr.		√	√
66. ***N. vinosus*** (Berk.) Murr.		√	√
43. ***Polyporus*** (Pers.) Gray		√	√
67. ***P. biformis*** Fr.			√
68. ***P. conchoids*** (Mont.) Lloyd		√	√
69. ***P. durus*** (Timm) Kreisel		√	
70. ***P. grammocephalus*** Berk.			√
71. ***P. hirsutus*** Wulf. ex Fr.		√	√
72. ***P. xeranticus*** Berk.		√	√
44. ***Poria*** Pers.		√	√
73. ***P. fulviseda*** Bres.		√	√
74. ***P. lenta*** Overh. & Lowe.		√	√
75. ***P. leucoplaca*** (Berk.) Cooke		√	√
45. ***Pycnoporus*** Karst.		√	√
76. ***P. coccineus*** (Fr.) Bond. & Sing.		√	√
46. ***Skeletocutis*** Kotl. & Pouzar		√	√
77. ***S. amorpha*** (Fr.) Kotl. & Pouzar		√	√
78. ***S. lenis*** (Karst.) Niemela		√	
47. ***Trametes*** Fr.		√	√
79. ***T. carbonaria*** Overh.		√	√
80. ***T. cervina*** (Schwein.) Bres.		√	√
81. ***T. gibbosa*** (Pers.:Fr.) Fr.		√	√
82. ***T. versicolour*** (L.:Fr.) Pilat		√	√
48. ***Trichaptum*** Murr.		√	√
83. ***T. abietinum*** (Dicks.) Ryv.		√	√
84. ***T. biforme*** (Fr.) Ryv.		√	√
85. ***T. fuscoviolaceum*** (Ehrenb.) Ryv		√	√
49. ***Schizophyllum*** Fr.		√	√
86. ***S. commune*** Fr.:Fr.		√	√
50. ***Schizopora*** Velen.		√	√
87 ***S. paradoxa*** (Schrad.) Donk		√	√
51. ***Oxyporus*** Donk		√	√
88. ***O. corticola*** (Fr.) Ryv.		√	√
52. ***Scleroderma*** Pers.	√		
89. ***S. areolatum*** Ehrenb.	√		
90. ***S. bovista*** Fr.	√		
91. ***S. dictyosporum*** Pat.	√		
92. ***S. nitidum*** Berk.	√		
53. ***Flavodon*** Ryv.		√	√
93. ***F. flavus*** (Klot.) Ryv.		√	√
54. ***Irpex*** Fr.		√	√
94. ***I. flavus*** Klotzsch			√
95. ***I. lacteus*** (Fr.) Fr.		√	√

96. ***I. Vallereus*** Berk. & Broome		√	√
97. ***I. zonatus*** Berk.		√	√
55. ***Junghuhnia*** Corda		√	√
98. ***J. collabens*** (Fr.) Ryv.		√	√
56. ***Chaetoderma*** Parmasto		√	√
99. ***C. luna*** (Romell ex Rogers &		√	√
57. ***Stereum*** Hill ex Pers.		√	√
100. ***S. acanthophysatum*** Rehill		√	√
101 ***S. hirsutum*** (Willd.) Pers.		√	√
102. ***S. petaloides*** Berk.		√	
58. ***Xylobolus*** Karst.		√	√
103. ***X. frustulatus*** (Pers.) Boidin		√	√
104. ***X. subpileatus*** Berk. & Curtis		√	√
59. ***Tremella*** Pers.		√	√
105. ***T. foliacea*** Pers.		√	√
60. ***Tubulicrinus*** Donk			√
106. ***T. umbricula*** Cunn.			√

Table 2: Diversity of Macrofungi in the Valley of Flowers National Park.

No. of families reported	29
No. of genera reported	60
No. of genera reported for the first time from the area	51
No. of species reported No. of species reported for the first time from the area	106

The dominant family of macrofungi in the Valley of Flowers National Park is Polyporaceae Fr. Ex Corda followed by Hymenochaetaceae Imazeki & Toki, Steccherinaceae Parmesto, Stereaceae Pilat, Fomitopsidaceae Jülich, Xylariaceae Tul. & C. Tul., Lycoperdaceae Chevall., Geoglossaceae Corda, Hapalopilaceae Jülich, Meripilaceae Jülich, Phanerochaetaceae Jülich, Schizoporaceae Jülich,Sclerodermataceae Corda, Morchellaceae Rchb., Auriculariaceae Fr., Bondarzewiaceae Kotl. & Pouzer, Ganodermataceae (Donk) Donk, Helvellaceae Fr., Astraeaceae Zeller ex Jülich, Atheliaceae Jülich, Clavariaceae Chevall., Coniophoraceae Ulbr.,Dacrymycetaceae Schröt, Gloeophyllaceae Jülich, Meruliaceae Karst., Peniophoraceae Lotsy, Schizophyllaceae Qǿel., Tremellaceae Fr. and Tubulicrinaceae Jülich.

The corticolous species (81) of macrofungi are dominant over terricolous (36) species in NDBR. Out of the 81 species of corticolous fungi, 8 species grow on angiospermic wood whereas 7 species grow on gymnospermic wood however 66 species grow both on angiospermic and gymnospermic wood.

CONCLUSION: Macrofungal diversity of this area accounts for first records of one hundred and six species belonging to sixty genera. Eight species belong to seven genera of four families of Ascomycota, and ninety eight species belong to fifty three genera of twenty five families of Basidiomycota.

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