

A COMPREHENSIVE ANALYSIS AND STATUS OF BOLETALES FROM PAKISTAN

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Abstract

Study on taxonomy and diversity of Boletes mushrooms from Pakistan is neglected irrespective of their great diversity in coniferous forests of Himalayan range of Pakistan. Boletes are economically important due to their ectomycorrhizal status, edibility and medicinal values. There is need to enlist data, explore more diversity as well as to conserve these fungi. This study enlist the Boletes fungi data from Pakistan which showed total eighty-eight species that have been reported from Pakistan belonging to thirty-nine genera and fourteen families of order Boletales. Most dominant family is Boletaceae with twenty-one reported genera while dominant genus is *Suillus* belongs to Suillaceae family with fifteen species. Thirteen species have been reported that were first time described from Pakistan as new to Science species. Species described previously by old names have been replaced here by current names using Index Fungorum and their old names have also been mentioned as synonyms for clarity. All taxa are enlisted here alphabetically. First checklist of this group of fungi was published in 2013 but it was preliminary and much work on order Boletales was done after this. Before 2011, all species of this group reported from Pakistan has many confusions because these were identified only by morphological analysis. For some taxa identification method is still unknown because it was not mentioned in literature and for some there were even no pictures as proof. After 2011, there was progress towards molecular analysis of boletes fungi. Doubtful things are mentioned in the results. This is a second and more comprehensive report of this group of fungi describing their habit, habitat, host tree, publication status, economic importance, identification method etc. It has been compiled following an extensive survey of literature, references, GenBank data, MycoBank data, Index Fungorum and consultation with different specialists. Bibliography of reported species from Pakistan has also been enlisted.

Keywords: Boletales, Himalaya, GenBank, Hymenium, Taxonomy, Molecular Phylogeny.

INTRODUCTION

Bolete mushrooms (Basidiomycetes, Agaricomycetidae, Agaricomycotina, Boletales) are distinguished by developing their spores in small pores. They do not have gills, which is basic feature of agarics mushrooms. Boletes are considered as safe mushrooms for human consumption. These mushrooms have colorful caps, pores and thick stems. Most species produce large fleshy mushrooms (difficult to dry) with a central stipe. In most of species, flesh that is bruised or cut turned blue as a result of the oxidation of pulvinic acid derivatives (Nelson, 2010). These fungi are traditionally united by a “boletoid” habit; a combination of having fleshy sporocarps with a tubular–poroid hymenophore and nearly all grow on the ground along the trees. Some members are not fleshy, some are parasitic too.

Phylogeny and Systematics of Boletales

The order Boletales was first proposed by Gilbert (1931) to include all above ground fungi with fleshy and putrescent fruit bodies (basidiocarps) and a tubulate hymenophore (the spore producing surface). The classification of the order Boletales was initially based on the morphology of macrocharacters, then combining the morphology of macro- and microscopic characters with anatomical and biochemical criteria. Singer (1981) classified the Boletales in the kingdom Fungi, division Basidiomycota, class Basidiomycetes, order Agaricales and suborder Boletineae, with three families, six subfamilies and 33 genera; this classification was based on their poroid or sublamellate hymenophore. Later in 1986, Singer grouped them into one family, the Boletaceae, and six subfamilies in the order Agaricales. Recent revisions have resulted from the integration of molecular characters and phylogenetic analyses with morphological data. According to the 2008 (10th) edition of the *Dictionary of the Fungi*, the Boletales comprise 17 families, 96 genera, and 1316 species (Kirk et al. 2008) and till that the number is increasing day by day. Currently, the Boletales has been divided into six suborders, approximately 19 families, grouping taxa with different fruit body morphology including poroid, gilled, resupinate, hypogeous and epigeous gasteroid forms (Kretzer et al. 1996, Hibbett et al. 1997, Kretzer & Bruns 1997, Bruns et al. 1998, Binder 1999, Hughey et al. 2000, Grubisha et al. 2001,2002, Binder & Bresinsky 2002a,b, Binder & Hibbet 2002,2004,2006, Li et al. 2009, Dentinger et al. 2010, Kibby 2011, Sarwar & Khalid 2013, Wu et al. 2014, 2016, Cui et al. 2016, Sarwar & Khalid 2014 a, b, Sarwar et al. 2011, 2012, 2014, 2015, 2016, 2018 a, b, Naseer et al. 2019, Han et al. 2020, Diama et al. 2021, Sarwar et al. 2021a, b, Aman et al. 2022, Raza et al. 2022).

Molecular dating suggests that Boletes diverged from the Agaricales 189 million years ago (Feng et al. 2012). Several molecular phylogenetic studies, using different barcode markers, reveal that the Boletes is monophyletic (Binder & Bresinsky 2002a, Bresinsky et al. 1999, Bruns et al. 1998, Grubisha et al. 2001, Hughey et al. 2000, Kretzer & Bruns 1999, Jarosch 2001, Binder & Hibbett 2002) while Agaricales is the sister group of boletes. Five major groups which have been classified as suborders (Agerer 1999, Binder & Bresinsky 2002a, Besl & Bresinsky 1997, Gilbert 1931) are currently recognized within the Boletales: Boletineae, Paxillineae, Sclerodermatineae, Suillineae, and Coniophorineae (Binder & Hibbett 2006). Currently accepted taxonomy suggests that there is much diversity in fruiting body of this group (Binder & Bresinsky 2002a, Binder & Hibbett 2002, Jarosch & Besl 2001).

Nuclear large subunit (Nuc-LSU) rDNA has been widely sampled in Boletes and appears to provide adequate resolution of terminal groups within the suborders (Binder 1999, Binder & Bresinsky 2002a, b, Jarosch 2001). There is ongoing debate over generic concepts in the Boletes (Watling 2001) and the phylogenetic interpretation of certain morphological and anatomical characters, such as spore ornamentation, hymenophoral trama type, spore print color, and stipe ornamentation (Bresinsky 1996, Pegler & Young 1981, Singer 1986, Smith & Thiers 1971). Many of these characters have been emphasized in generic delimitations, but now appear (on the basis of molecular

phylogenies) to have evolved repeatedly (Binder 1999, Binder & Fischer 1997, Binder & Besl 2000, Bresinsky et al. 1999). The ITS region has become a popular tool for molecular ecology of fungal taxa (Horton & Bruns 2001). Again, extensive ITS data sets from across the Boletales are not yet available, which limits both molecular ecological studies and species-level systematics (Badotti et al. 2017, Frank et al. 2020).

Economic importance of Boletales

The boletes, like other macrofungi are an important part of any forest ecosystem because they almost always form ectomycorrhizae with a variety of green plant symbionts. In this role, they are an integral part of all forest systems since they are intimately involved with such basic processes as nutrient cycling, nutrient uptake, and decomposition of organic matter. These fungi are mostly found in symbiotic association with roots of economically important higher plants in Himalayan Moist Temperate forests of the World including Pakistan. Many species in this group of mushrooms are found as edible and of medicinal importance, but there is scarce literature regarding mycochemical analysis of these fungi. Boletes are important food source as they are low in lipids, calories and high in vegetable proteins, vitamins and minerals. Boletes typically make up a large portion of the visible mycobiota during the rainy seasons (Hongo 1984), and are consumed by many forest animals (Bruns 1984). Boletes are a source of food for humans, with some species among the most prized choice edibles (Sanmee et al. 2010). Recent research has suggested that boletes may have even been a part of the human diet in the Magdalenian period, about 18,000 to 12,000 years ago (Power et al. 2015). Boletes are efficient at heavy metal uptake from the environment (Malinowska et al. 2004), a promising avenue for environmental bioremediation (Elekes & Busuioc 2011). Pigments may be extracted from boletes to make dyes for fabrics (Bessette et al. 2000), an environmentally friendly alternative to typical commercial dyes (Durán et al. 2002, Velíšek & Cejpek 2011).

Available data on Boletales in Pakistan

The knowledge about the species diversity and distribution of Boletales in Pakistan is still scarce despite of the fact that there is great diversity of these mushrooms in diversity rich areas of Pakistan. Information is scattered in many papers, a checklist and a PhD dissertation. Even for species known to be common data about their distribution are deficient. Individual separate published papers usually do not provide sufficient information to make possible any further judgment of the findings about diversity of whole group.

The same holds also for the voucher specimens if there are any at all. Since boletes are among the most economically important fungal groups, intensive research is needed on bolete data compilation in the country for any further project which will involve boletes. This report aims to provide information about some findings that are not in the previous checklists i.e., some new species, new records or their associations (Sarwar & Khalid 2013, Hernández-Restrepo et al. 2016, Sarwar & Khalid 2014 a, b, Sarwar et al. 2011, 2012, 2014, 2015, 2016, 2018 a, b, Naseer et al. 2019, Diama et al. 2021, Sarwar et al. 2021a, b, Aman et al. 2022, Raza et al. 2022).

Short description of Pakistani's Boletales research

Previously there were few attempts to study bolete diversity of Pakistan by some scientists including pioneer mycologist Dr. Sultan Ahmad and some other scientists. Literature till 1997 (Murrill 1924, Ahmad 1952, 1956, 1962, 1969, 1980, Shibata 1992, Yoshimi & Hagiwara 1992, Murakami 1993, Iqbal & Khalid 1996) shows that all Pakistani mycologists had just highlighted only few species from different areas of Pakistan that are enlisted in book "FUNGI OF PAKISTAN" (Ahmad et al. 1997) with their distribution, habitat and collector name but no morphological and molecular description of those taxa available in literature. Molecular work of boletes was started in Pakistan during 2011 (Sarwar et al. 2011). Literature is available regarding many other bolete taxa from Pakistan (Gardezi 2003, Razaq & Shahzad 2004, Sultana et al. 2011, Sarwar & Khalid 2013, 2014 a, b, Sarwar et al. 2011, 2012, 2014, 2015, 2016, 2018 a, b, Hernández-Restrepo et al. 2016, Naseer et al. 2019, Dima et al. 2021, Sarwar et al. 2021a, b, Aman et al. 2022, Raza et al. 2022).

Ecology of Pakistani Boletales

In Pakistan, boletes have been found mainly in coniferous forests in moist temperate regions (Ahmad et al. 1997, Sultana et al. 2011, Sarwar & Khalid 2013, 2014 a, b, Sarwar et al. 2011, 2012, 2014, 2015, 2016, 2018 a, b, Hernández-Restrepo et al. 2016, Naseer et al. 2019, Dima et al. 2021, Sarwar et al. 2021a, b, Aman et al. 2022, Raza et al. 2022).

The reason for non/less occurrence of boletes in provinces other than Khyber Pakhtunkhwa may be due to less exploration of these sites and non-favourable weather and climatic conditions for these mushrooms as well as non-availability of their mycorrhizal host trees. The evergreen forests of conifers frequently mixed with oak and deciduous broad-leaved trees fall within this category.

Their undergrowth is rarely dense, and consists of both evergreen and deciduous species. These forests occur between 1500 m and 3000 m elevation. Rainfall ranges between 650–750 mm or sometimes to about 1500 mm annually. Average aerial humidity is 57% and the mean daily temperature peak in June is 12.5°C dropping to a minimum of 3°C in January (Siddiqui 1997). These coniferous forests are divided into a lower and an upper zone, in each of which definite species of conifers and/or oaks dominate.

In the lower zone, *Cedrus deodara* Loudon, *Pinus wallichiana* A.B. Jacks., *Picea smithiana* Boiss., and *Abies pindrow* Royle are the main conifer species in order of increasing altitude, with *Quercus incana* Roxb. at lower altitudes and *Q. dilatata* Royle above 2130 m. In the upper zone *Abies pindrow* and *Q. semecarpifolia* Sm. are the dominant tree species. There may be pockets of deciduous broad-leaved trees, mainly edaphically conditioned, in both the zones. *Alnus* spp. colonize new gravels and sometimes *Pinus wallichiana*, does the same (Siddiqui 1997).

MATERIALS AND METHODS

Basis of report

This review report is based on available literature data, after consulting all publications available until nowadays. The taxa are presented in alphabetical order, followed by author names, species habitat, molecular data, available description/notes, available photographs, distribution and the literature. For some taxa some information was not found in literature.

Data resources

This work was completed by using data resources like checklists (Sarwar & Khalid 2013, Aman et al. 2022, Raza et al. 2022), GenBank, MycoBank, Index Fungorum, published papers by Pakistani researchers, Fungi of Pakistan online database (www.fungiofpakistan.com) and *Fungi of Pakistan* book (Ahmad et al. 1997).

Synonyms treatment

Because several species have been published under different names, a thesaurus of synonyms is separately listed with references to the correct names used in the main list. A list of excluded records, providing reasons for their exclusion, is also appended.

Nomenclature and classification

Index Fungorum was used for taxonomic positions. Nomenclature and classification followed Watling (2008) and Kirk et al. (2008). Species treatment and nomenclature also follow recent monographs and particular articles on boletes. The author's names were abbreviated according to Kirk & Ansell (1992).

Data Entries

Published genera reported from Pakistan are listed alphabetically. In comprehensive way, data was compiled according to the recent classification and habitat, distribution, illustration, economic importance are provided with references. Synonyms with full publication details; 3) misapplied names, data on habitat, seasonality, and associated species, distribution, abbreviated references to relevant descriptions and illustrations as well as any additional notes.

Distribution and Frequency

The entry for each accepted taxon includes basic data on distribution within the Pakistan and for each of these, frequency is indicated as tabulated form. In fact, apart from a few species which are visibly common, all taxa in the report could easily have been marked 'data deficient'. The problem lies in the lack of fungal recorders, the lack of specialists, limited resources to reach in diversity rich disputed areas and the lack of funding for research. It is not yet possible to tell, for example, whether a 'rare' fungus is genuinely rare, or whether it only produces fruitbodies rarely. Similarly, it is not clear whether a species not seen for many years is genuinely 'extinct'.

Descriptions and Illustrations

Abbreviated references are given to relevant descriptions and illustrations. In the main, the references have been selected from standard published works. References are clearly neither comprehensive nor complete, nor should the descriptions and illustrations necessarily be taken as 'recommended'. They are included simply as a helpful starting point to discover more about the taxon listed. Some of the species with problems are mentioned because previous publications related to those do not provide sufficient information to make possible any further judgment of the findings.

Economic Importance

Mostly boletes are mycorrhizal, some are edible while some have medicinal value as well. Economic importance was mentioned by following literature available i.e., Listed by Homola & Mistretta (1977), Luo et al. (2012), Zhang et al. (2014), Wang et al. (2022), and all other available literature.

Tabulated Data presentation

Once compiled data in text form was also presented in tabulated form for better understating and further revision/additions.

RESULTS

Reported species of Boletales from Pakistan

Total eighty eight (88) species of boletes have been described from Pakistan belonging to thirty nine (39) genera and thirteen (13) families of order Boletales (Table 1)

Tab 1: Boletales taxa reported from Pakistan (bold taxa as new species from Pakistan)

Sr. No	Family name	Genus name	Genus Synonyms	Species
1	Boletaceae Chevall.	<i>Aureoboletus</i> Pouzar	<i>Sinoboletus</i> M. Zang	<i>A. gentilis</i> (Quél.) Pouzar
		<i>Boletus</i> L.	<i>Ceratomyces</i> Murrill <i>Dictyopus</i> Quél. <i>Notholepiota</i> E. Horak <i>Oedipus</i> Bataille, Bull <i>Suillus</i> P. Micheli <i>Tubiporus</i> P. Karst. <i>Xerocomopsis</i> Reichert	<i>B. edulis</i> Bull.
				<i>B. himalayensis</i> S. Jabeen, S. Sarwar & A. N. Khalid
				<i>B. pakistanicus</i> Sarwar and Khalid
				<i>B. reticulatus</i> Schaeff.
		<i>B. subvelutipes</i> Peck.		
		<i>Butyriboletus</i> D. Arora & J.L. Frank		<i>B. appendiculatus</i> (Schaeff.) D. Arora & J.L. Frank= (Synonym) <i>Boletus appendiculatus</i> Schaeff.
<i>Caloboletus</i> Vizzini		<i>C. calopus</i> (Pers.) Vizzini= (Synonym) <i>Boletus calopus</i> Pers.		
<i>Chalciporus</i> Bataille		<i>Ch. piperatus</i> (Bull.) Bataille		

		<i>Cyanoboletus</i> Gelardi, Vizzini & Simonini		C. macroporus Sarwar, Naseer & Khalid <i>C. pulverulentus</i> (Opat.) Gelardi, Vizzini & Simonini
		<i>Hortiboletus</i> Simonini, Vizzini & Gelardi		H. kohistanensis A. Naseer., S. Sarwar & A.N. Khalid <i>H. rubellus</i> (Krombh.) Simonini, Vizzini & Gelardi= (Synonym) <i>Boletus fraternus</i> Peck <i>Boletus rubellus</i> Krombh.
		<i>Leccinellum</i> Bresinsky & Manfr. Binder		<i>L. crocipodium</i> (Letell.) Della Magg. & Trassin.
		<i>Leccinum</i> Gray	<i>Krombholzia</i> P. Karst. <i>Krombholziella</i> Maire <i>Trachypus</i> Bataille	<i>L. scabrum</i> (Bull.) Gray= (Synonym) <i>Krombholziella oxydabilis</i> (Singer) Šutara; <i>Krombholziella scabra</i> (Bull.) Maire <i>L. ustale</i> (Berk.) E. Horak, <i>L. versipelle</i> (Fr. & Hök) Snell
		<i>Neoboletus</i> Gelardi, Simonini & Vizzini		<i>N. luridiformis</i> (Rostk.) Gelardi, Simonini & Vizzini= (Synonym) <i>Boletus erythropus</i> Pers.; <i>Boletus luridiformis</i> Rostk.
		<i>Phylloporus</i> Quél.		<i>Ph. brunneiceps</i> N.K. Zeng, Zhu L. Yang & L.P. Tang <i>Ph. rhodoxanthus</i> (Schwein.) Bres.
		<i>Porphyrellus</i> E.-J. Gilbert		<i>P. porphyrosporus</i> (Fr. & Hök) E.-J. Gilbert= (Synonym) <i>Porphyrellus psedoscaber</i> Secr. ex Singer
		<i>Pseudoboletus</i> Šutara		<i>P. parasiticus</i> (Bull.) Šutara= (Synonym) <i>Xerocomus parasiticus</i> (Bull.) Quél.
		<i>Rubroboletus</i> Kuan Zhao & Zhu L. Yang		<i>R. lupinus</i> (Fr.) Costanzo, Gelardi, Simonini & Vizzini= (Synonym) <i>Boletus lupinus</i> Fr. R. himalayensis Sarwar & Khalid
		<i>Strobilomyces</i> Berk.	<i>Eriocorys</i> Quél.	<i>S. longistipitatus</i> D. Chakr., K. Das & S. Adhikari <i>S. strobilaceus</i> (Scop.) Berk.
		<i>Suillellus</i> Murrill	<i>Cupreoboletus</i> Simonini, Gelardi & Vizzini <i>Exsudoporus</i> Vizzini, Simonini & Gelardi	<i>S. luridus</i> (Schaeff.) Murrill= (Synonym) <i>Boletus luridus</i> Schaeff. <i>S. queletii</i> (Schulzer) Vizzini, Simonini & Gelardi= (Synonym) <i>Boletus queletii</i> Schulzer
		<i>Tylophilus</i> P. Karst.	<i>Leucogyroporus</i> Snell <i>Phaeoporus</i> Bataille <i>Rhodobolites</i> Beck	<i>T. felleus</i> (Bull.) P. Karst. <i>T. pseudoscaber</i> Secr. ex A.H. Sm. & Thiers

			<i>Rhodoporus</i> Quél.	<i>T. sultanii</i> S. Sarwar, Khalid & Niazi
		<i>Xanthoconium</i> Singer		<i>X. separans</i> (Peck) Halling & Both= (Synonym) <i>Boletus separans</i> (peck.) halling
		<i>Xerocomellus</i> Štara		<i>X. chrysenteron</i> (Bull.) Štara= (Synonym) <i>Xerocomus chrysenteron</i> Bull.; <i>Boletus chrysenteron</i> Bull.
				<i>X. dryophilus</i> (Thiers) N. Siegel, C.F. Schwarz & J.L. Frank= (Synonym) <i>Xerocomus dryophilus</i> (Thiers) Singer
				<i>X. fulvus</i> Sarwar, Ahmad & Khalid
				<i>X. pakistanicus</i> Sarwar and Khalid =(Synonym) <i>Boletus pakistanicus</i>
		<i>Xerocomus</i> Quél.	<i>Versipellis</i> Quél.	<i>X. ferrugineus</i> (Schaeff.) Alessio <i>X. indicus</i> Singer <i>X. subtomentosus</i> (L.) Quél.
		<i>Veloporphyrellus</i> L. D. Gómez & Singer		<i>V. latisporus</i> J. Khan & S. Ullah
2	Coniophoraceae Ulbr.	<i>Coniophora</i> DC.= (Synonym) <i>Coniophorella</i> P. Karst.	<i>Coniophorella</i> P. Karst.	<i>C. arida</i> (Fr.) P. Karst.
		<i>Gyrodontium</i> Pat.= (Synonym) <i>Boninohydnum</i> S. Ito & S. Imai		<i>G. sacchari</i> (Spreng.) Hjortstam
3	Diplocystidiaceae Kreisel	<i>Astraeus</i> Morgan	<i>Diploderma</i> Link	<i>A. hygrometricus</i> (Pers.) Morgan
4	Gastrosporiaceae Pilát	<i>Gastrosporium</i> Mattir.= (Synonym) <i>Leucorhizon</i> Velen.	<i>Leucorhizon</i> Velen.	<i>G. simplex</i> Mattir.
5	Gomphidiaceae Maire ex Jülich	<i>Chroogomphus</i> (Singer) O.K. Mill.	<i>Brauniellula</i> A.H. Sm. & Singer	<i>C. helveticus</i> (Singer) M.M. Moser
				<i>C. pakistanicus</i> M. Kiran and A.N. Khalid
				<i>C. pruinus</i> M. Kiran and A.N. Khalid
				<i>C. roseolus</i> Y.C. Li and Zhu L. Yang
				<i>C. rutilus</i> (Schaeff.) O.K. Mill.
		<i>Gomphidius</i> Fr.	<i>Agaricus</i> subgen. <i>Gomphus</i> Fr. <i>Gomphus</i> (Fr.) Weinm. <i>Leucogomphidius</i> Kottl. & Pouzar	<i>G. glutinosus</i> (Schaeff.) Fr.

6	Gyroporaceae Manfr. Binder & Bresinsky= (Synonym) Gyroporaceae Locq.	<i>Gyroporus</i> Quél.	<i>Coelopus</i> Bataille <i>Leucobolites</i> Beck <i>Leucoconius</i> Beck <i>Suillus</i> P. Karst.	<i>G. castaneus</i> (Bull.) Quél.
7	Hygrophoropsidaceae Kühner	<i>Leucogyrophana</i> Pouzar		<i>L. mollusca</i> (Fr.) Pouzar
8	Paxillaceae Lotsy.	<i>Gyrodon</i> Opat.	<i>Anastomaria</i> Raf. <i>Campbellia</i> Cooke & Masee <i>Gilbertiella</i> R. Heim <i>Gilbertina</i> R. Heim <i>Pseudogyrodon</i> Heine m. & Rammeloo <i>Rodwaya</i> Syd. & P. Syd. <i>Uloporus</i> Quél.	<i>G. lividus</i> (Bull.) Sacc.
		<i>Hydnomerulius</i> Jarosch & Besl		<i>H. pinastris</i> (Fr.) Jarosch & Besl = (Synonym) <i>Leucogyrophana pinastris</i>
		<i>Melanogaster</i> Corda		<i>M. durissimus</i> Cooke
9	Rhizopogonaceae Gämum. & C.W. Dodge	<i>Rhizopogon</i> Fr.	<i>Anthracophlous</i> Mattir. ex Lloyd <i>Hysteromyces</i> Vittad. <i>Splanchnomyces</i> Corda <i>Trappeindia</i> Castellano, S.L. Mill., L. Singh bis & T.N. Lakh.	<i>R. flavus</i> Petch, Ann. R. bot <i>R. obtectus</i> (Spreng.) R. Rauschert
10	Sclerodermataceae Corda	<i>Pisolithus</i> Alb. & Schwein.	<i>Durosaccum</i> Lloyd <i>Endacinus</i> Raf. <i>Eudacnus</i> Raf. <i>Lycoperdodes</i> Haller <i>Pisocarpium</i> Link <i>Pisomyces</i> Fr. <i>Polypora</i> Pers. <i>Polysaccum</i> F. Desp. & DC.	<i>P. arhizus</i> (Scop.) Rauschert <i>P. tinctorius</i> (Mont.) E. Fisch.= <i>Polysaccum tinctorium</i> Mont.
		<i>Scleroderma</i> Pers.	<i>Actigea</i> Raf. <i>Actinodermium</i> Nees <i>Caloderma</i> Petri <i>Goupilia</i> Mérat <i>Lycoperdastrum</i> P. Micheli <i>Mycastrum</i> Raf. <i>Neosaccardia</i> Mattir. <i>Nepotatus</i> Lloyd <i>Phlyctospora</i> Corda	<i>S. areolatum</i> Ehrenb. <i>S. bovista</i> Fr. <i>S. cepa</i> Pers. <i>S. chevalieri</i> Guzmán <i>S. citrinum</i> Pers. <i>S. dictyosporum</i> Pat. <i>S. flavidum</i> Ellis and Everh. <i>S. sinnamariense</i> Mont. <i>S. verrucosum</i> (Bull.) Pers.

			<i>Pirogaster</i> Henn. <i>Pompholyx</i> Corda <i>Sclerangium</i> Lév. <i>Stella</i> Masee <i>Sterrebekia</i> Link <i>Veligaster</i> Guzmán	
11	Serpulaceae Jarosch & Bresinsky	<i>Serpula</i> (Pers.) Gray		<i>S. lacrymans</i> (Wulfen) J. Schröt.
12	Suillaceae Besl & Bresinsky	<i>Suillus</i> P. Gray	<i>Boletopsis</i> Henn. <i>Boletus</i> sect. <i>Viscipellis</i> Fr. <i>Cricunopus</i> P. Karst. <i>Euryporus</i> Quéf. <i>Gastrosuillus</i> Thiers <i>Gymnopus</i> (Quéf.) Quéf. <i>Ixocomus</i> Quéf. <i>Mariaella</i> Šutara <i>Peplopus</i> (Quéf.) Quéf. <i>Pinuzza</i> Gray <i>Rostkovites</i> P. Karst. <i>Solenia</i> Hill <i>Viscipellis</i> (Fr.) Quéf.	<i>S. americanus</i> (Peck) Snell= (Synonym) <i>Suillus sibiricus</i> (Singer) Singer <i>S. bovinus</i> (L.) Roussel <i>S. brevipes</i> (Peck) Kuntze <i>S. collinitus</i> (Fr.) Kuntze <i>S. flavidus</i> (Fr.) J. Presl <i>S. granulatus</i> (L.) Roussel <i>S. grevillei</i> (Klotzsch) Singer <i>S. himalayensis</i> B. Verma and M. S. Reddy <i>S. luteus</i> (L.) Roussel <i>S. marginielevatus</i> S. Sarwar, A. N. Khalid and B. M. Dentinger <i>S. placidus</i> (Bonord.) Singer <i>S. triacicularis</i> B. Verma and M.S. Reddy <i>S. tomentosus</i> Singer <i>S. viscidus</i> (L.) Roussel <i>S. quercinus</i> Sarwar, Naseer & Khalid
13	Tapinellaceae C. Hahn. = (Synonym) Tapinellaceae Locq	<i>Pseudomerulius</i> Jülich <i>Tapinella</i> E.-J. Gilbert	<i>Agaricus</i> trib. <i>Tapinia</i> Fr. <i>Serpula</i> sect. <i>Tapinella</i> (E.-J. Gilbert) Zmitr. <i>Tapinia</i> (Fr.) P. Karst.	<i>P. aureus</i> (Fr.) Jülich <i>T. atrotomentosa</i> (Batsch) Šutara <i>T. panuoides</i> (Fr.) E.-J. Gilbert

Species reported within each genus of different bolete families from Pakistan

1. Species of different genera of family Boletaceae from Pakistan

Mostly boletes which has been reported from Pakistan fall in this family. Twenty one (21) different genera and forty (40) species of this family have been reported from Pakistan.

1.1 *Aureoboletus* Pouzar

Only one species of this genus has been reported from explored areas of Pakistan, so this is rare genus or not yet fully explored.

1.1.1 *Aureoboletus genitilis* (Qué.) Pouzar

Habitat: on ground in small groups

Distribution: Dichal nala, forests of Mushkin, Astore District.

Economic importance: Edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2013).

Comments: Figure is not clear; molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.2 *Boletus* L.

1.2.1 *Boletus edulis* Bull.

Habitat: Solitary or in small groups, on soil.

Distribution: Hunza valley, District Gilgit; Shogran, Sharhan, Pakistan

Economic importance: Edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2013).

Comments: Figure is not clear, molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.2.2 *Boletus himalayensis* S. Jabeen, S. Sarwar and A. N. Khalid

Habitat: on soil, solitary

Distribution: under *Cedrus deodara*, *Quercus baloot* and *Pinus wallichiana*, Kalam, Malakand, Swat District, Kalam; Mashkun; Hazara Division, Mansehra, Sharan (Kaghan Valley), Khyber Pakhtunkhwa, Pakistan.

Economic importance: Not known

Identification method: Both morphological and molecular analysis

MycoBank Number MB 820806

GenBank number: for ITS KJ131225; for LSU MF288904

Figures: Available

Reference: Sarwar et al. (2018).

1.2.3 *Boletus pakistanicus* Sarwar and Khalid

Habitat: on soil, Solitary as well as in groups

Distribution: under *Pinus wallichiana*, Khanspur, Ayubia; Nathia gali, Khyber Pakhtunkhwa, Pakistan.

Economic importance: Not known

Identification method: Both morphological and molecular analysis

Mykobank Number: MB 564279

GenBank Number: JQ178324.

Figures: Available

Reference: Sarwar & Khalid (2014a).

1.2.4 *Boletus reticulatus* Schaeff.

Habitat: on soil, solitary

Distribution: Dichal nala, District Astore, Pakistan.

Economic importance: Edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2013), Aman et al. (2022)

Comments: Figure is not clear and seems related to *Leccinum* species; this species needs further confirmation by more collections and molecular analysis

1.2.5 *Boletus subvelutipes* Peck.

Habitat: on soil, solitary

Distribution: under mixed coniferous forests, Shogran, Khyber Pakhtunkhwa, Pakistan.

Economic importance: Edibility unknown/poisonous

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in *Fungi of Pakistan* Book, figure, morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.3 *Butyriboletus* D. Arora and J.L. Frank

1.3.1 *Butyriboletus appendiculatus* (Schaeff.) D. Arora and J.L. Frank

Habitat: on soil, solitary

Distribution: under mixed coniferous forests near broadleaved trees, Kund, Kaghan Valley, Khyber Pakhtunkhwa, Pakistan.

Economic importance: Edible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: Only enlisted in *Fungi of Pakistan* Book, figure morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.4 *Caloboletus* Vizzini

1.4.1 *Caloboletus calopus* (Pers.) Vizzini

Habitat: on soil, solitary

Distribution: under *Pinus wallichiana*, Rawalpindi (Punjab), Pakistan.

Economic importance: inedible

Identification method: only morphological

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in *Fungi of Pakistan* Book, figure, morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.5 *Chalciporus* Bataille

1.5.1 *Chalciporus piperatus* (Bull.) Bataille

Habitat: Usually in groups, on soil

Distribution: under conifers and broad leaved trees, Dichal nalla, District Astore; Shogran, Sharan, Pakistan

Economic importance: edible, but unpalatable

Identification method: only morphological

Figures: available

Reference: Razaq & Shahzad (2013)

Comments: Figure is not clear and seems related to *Suillus* species; this species needs further confirmation by more collections and molecular analysis

1.6 *Cyanoboletus* Gelardi, Vizzini and Simonini

1.6.1 *Cyanoboletus macroporus* Sarwar, Naseer & Khalid

Habitat: on soil, solitary

Distribution: under *Quercus semicarpifolia*, Swat, Sultanr, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: Both morphological and molecular

MycoBank Number: MB837538

GenBank Number: MW045557

Figures: Available

Reference: Sarwar et al. (2021a)

1.6.2 *Cyanoboletus pulverulentus* (Opat.) Gelardi, Vizzini and Simonini

Habitat: on soil, solitary

Distribution: under *Abies pindrow*, Sharan, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in *Fungi of Pakistan* Book, figure, morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.7 *Hortiboletus* Simonini, Vizzini and Gelardi

1.7.1 *Hortiboletus kohistanensis* A. Naseer., S. Sarwar and A.N. Khalid

Habitat: on soil, solitary

Distribution: under *Quercus incana*, Toa, Swat Valley, Khyber Pakhtunkhwa, Pakistan.

Economic importance: not known

Identification method: Both morphological and molecular

MycoBank Number: MB 824504

GenBank Number: MG988193

Figures: available

Reference: Naseer et al. (2019)

1.7.2 *Hortiboletus rubellus* (Krombh.) Simonini, Vizzini and Gelardi

Habitat: on soil, solitary

Distribution: under *Pinus wallichiana*, *Quercus incana*, *Quercus baloot*, *Quercus* spp., Murree, Hazara, Khaira gali, Khanspur, Ayubia, Swat, Kalam, Jetkot, Lamati, Dir, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible but not recommended

Identification method: Both morphological and molecular

GenBank Number: KJ802928, KJ802929, KX907539

Figures: available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Sarwar et al. (2016), Aman et al. (2022)

1.8 *Leccinellum* Bresinsky and Manfr. Binder

1.8.1 *Leccinellum crocipodium* (Letell.) Della Magg. And Trassin.

Habitat: on soil, solitary/in groups

Distribution: under oaks. Mushkin, District Astore, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: available

Reference: Razaq & Shahzad (2017)

Comments: Figure is not clear and seems related to *Suillus* species; this species needs further confirmation by more collections and molecular analysis

1.9 *Leccinum* Gray

1.9.1 *Leccinum scabrum* (Bull.) Gray

Habitat: on soil, solitary

Distribution: under mixed forest, Dichal nala (Dashkin), District Astore, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: available

Reference: Razaq & Shahzad (2017)

Comments: this species needs molecular analysis

1.9.2 *Leccinum ustale* (Berk.) E. Horak

Habitat: on soil, solitary

Distribution: under mixed forest, Murree, Punjab, Pakistan.

Economic importance: edibility not known

Identification method: only morphological

Figures: not available

Reference: Ahmad et al. (1997), Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in *Fungi of Pakistan* Book and some checklists; figure is not available; this species needs further confirmation by more collections and molecular analysis

1.9.3 *Leccinum versipelle* (Fr. and Hök) Snell

Habitat: on soil, solitary

Distribution: under mixed forest, Dichal nala (Dashkin),

District Astore, Khyber Pakhtunkhwa, Pakistan.

Economic importance: mildly toxic

Identification method: only morphological

Figures: available

Reference: Razaq & Shahzad (2017)

Comments: Molecular data is not available

1.10 *Neoboletus* Gelardi, Simonini and Vizzini

1.10.1 *Neoboletus luridiformis* (Rostk.) Gelardi, Simonini and Vizzini

Habitat: on ground, solitary

Distribution: under conifers, broadleaved trees and herbs; Dungagali, Khanspur, Ayubia; Nathiagali; Malakundi, Sharan (Kaghan valley), Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility on choice but not recommended

Identification method: Both morphological and molecular analysis

GenBank Number: KJ802930, KJ802931, KM199730

Figures: Available

Reference: Iqbal & Khalid (1996), Sarwar et al. (2016)

1.11 *Phylloporus* Qué.

1.11.1 *Phylloporus brunneiceps* N.K. Zeng, Zhu L. Yang and L.P. Tang

Habitat: on ground, solitary

Distribution: under *Quercus incana*; Toa, Shangla/ Swat boundary, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: Both morphological and molecular analysis

GenBank Number: KY679591, KY679592 & KY679593

Figures: Available

Reference: Naseer et al. (2017)

1.11.2 *Phylloporus rhodoxanthus* (Schwein.) Bres.

Habitat: on ground, solitary

Distribution: under broadleaved trees; Sharan, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: not available

Figures: Not available

Reference: Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in some checklists; figure, morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.12 *Porphyrellus* E.-J. Gilbert

1.12.1 *Porphyrellus porphyrosporus* (Fr. and Hök) E.-J. Gilbert

Habitat: on ground, solitary/Abundantly

Distribution: under mixed coniferous trees; Hunza, Gilgit, Shogran, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: available

Reference: Ahmad et al. (1997), Razaq & Shahzad (2017), Aman et al. (2022)

Comments: Figure is not clear; this species needs further confirmation by more collections and molecular analysis

1.13 *Pseudoboletus* Šutara

1.13.1 *Pseudoboletus parasiticus* (Bull.) Šutara

Habitat: not known

Distribution: not known.

Economic importance: parasitic

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in some checklists; figure and morphological description is not available; this species needs further confirmation by more collections and molecular analysis

1.14 *Rubroboletus* Kuan Zhao and Zhu L. Yang

1.14.1 *Rubroboletus lupinus* (Fr.) Costanzo, Gelardi, Simonini and Vizzini

Habitat: on soil

Distribution: Kamalban forest, Khannian, Kaghan Valley Pakistan.

Economic importance: edible

Identification method: not known

Figures: Not available

Reference: Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in some checklists; figure and morphological description is not available; this species needs further confirmation by more collections and molecular analysis

1.14.2 *Rubroboletus himalayensis* Sarwar & Khalid

Habitat: on ground

Distribution: Changla gali, Murree, Punjab, Pakistan

Economic importance: not known

Identification method: morphological and molecular

Mycobank Number: MB 831169

GenBank Number: MK391936, MK391937

Figures: available

Reference: Sarwar et al. (2021 b)

1.15 *Strobilomyces* Berk.

1.15.1 *Strobilomyces longistipitatus* D. Chakr., K. Das and S. Adhikari

Habitat: on soil, solitary

Distribution: under *Abies pindrow*, Takht, Shangla; Kund Bangla, Mansehra, Khyber Pakhtunkhwa, Pakistan

Economic importance: not known

Identification method: both morphological and molecular

GenBank Number: MK518062, MK518063, MK518064, MK518065

Figures: available

Reference: Ullah et al. (2019)

1.15.2 *Strobilomyces strobilaceus* (Scop.) Berk.

Habitat: on soil, solitary

Distribution: under *Betula*, Malakundi, Kashmir

Economic importance: edible

Identification method: not known

Figures: not available

Reference: Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in some checklists; figure and morphological description is not available; this species needs further confirmation by more collections, morphological and molecular analysis

1.16 *Suillellus* Murrill

1.16.1 *Suillellus luridus* (Schaeff.) Murrill

Habitat: on soil

Distribution: in mixed woods, under conifers; Sudhan Gali, Hajinpir, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible but not recommended

Identification method: not available

Figures: not available

Reference: Ahmad et al. (1997), Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in some checklists; figure, morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

1.16.2 *Suillellus queletii* (Schulzer) Vizzini, Simonini and Gelardi

Habitat: on soil

Distribution: in mixed conifers, Muree, Punjab; Sharan, Khyber Pakhtunkhwa, Pakistan

Economic importance: edible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Only enlisted in some checklists; figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

1.17 *Tylopilus* P. Karst.

1.17.1 *Tylopilus felleus* (Bull.) P. Karst.

Habitat: on soil in small groups

Distribution: under mixed coniferous trees; Lashtang forest (Dashkin), District Astore, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: available

Reference: Razaq & Shahzad (2017), Aman et al. (2022)

Comments: figure is not clear; this species needs further confirmation by more collections and molecular analysis

1.17.2 *Tylopilus pseudoscaber* Secr. ex A.H. Sm. and Thiers

Habitat: on soil, solitary

Distribution: under *Abies pindrow*, *Pinus wallichiana*; Khaira gali, Nathiagali, Sharan, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: both morphological and molecular

GenBank Number: KJ775785

Figures: available

Reference: Sarwar et al. (2014)

1.17.3 *Tylophilus sultanii* S. Sarwar, Khalid and Niazi

Habitat: on soil, solitary

Distribution: under *Pinus wallichiana*; Ayubia, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: both morphological and molecular

MycoBank Number: MB 802339

GenBank Number: KJ775786

Figures: available

Reference: Sarwar et al. (2014)

1.18 *Xanthoconium* Singer

1.18.1 *Xanthoconium separans* (Peck) Halling and Both

Habitat: on soil, solitary to gregarious

Distribution: under conifers; Sudhan gali, Las Dana; Rahimabad, Gilgit, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: available

Reference: Razaq et al. (2014), Aman et al. (2022)

Comments: figure is not clear; this species needs further confirmation by more collections and molecular analysis

1.19 *Xerocomellus* Šutara

1.19.1 *Xerocomellus chrysenteron* (Bull.) Šutara

Habitat: on soil

Distribution: under conifer, Malakandi, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: morphological

Figures: not available

Reference: Ahmad et al. (1997), Sultana et al. (2011), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: only enlisted in some checklists, figure is not available, morphological description is short; this species needs further confirmation by more collections and molecular analysis

1.19.2 *Xerocomellus dryophilus* (Thiers) N. Siegel, C.F. Schwarz and J.L. Frank

Habitat: on soil, solitary to gregarious

Distribution: under oaks; Hullar, Samani, Azad Jammu and Kashmir

Economic importance: edible but not choice

Identification method: only morphological

Figures: not available

Reference: Gardezi (2003), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: only enlisted in some checklists, figure is not available; this species needs further confirmation by more collections and molecular analysis

1.19.3 *Xerocomellus fulvus* Sarwar, Ahmad and Khalid

Habitat: on soil, solitary

Distribution: under under *Cedrus deodara*, Swat, Ushu, Kalam, Khyber Pakhtunkhwa, Pakistan.

Economic importance: Not Known

Identification method: Both morphological and molecular analysis

MycoBank Number: MB815528

GenBank Number: KU163374

Figures: Available

Reference: Hernández-Restrepo et al. (2016).

1.20 *Xerocomus* Qué.

1.20.1 *Xerocomus ferrugineus* (Schaeff.) Alessio

Habitat: on ground, solitary

Distribution: under wood, locality not known.

Economic importance: edibility not known

Identification method: not known

Figures: Not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: only enlisted in some checklists, figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

1.20.2 *Xerocomus indicus* Singer

Habitat: on ground, solitary

Distribution: under *Saccharum ravennae*, Ladhar, Haripur District, Khyber Pakhtunkhwa, Pakistan

Economic importance: edibility not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: only enlisted in some checklists, figure and morphological description is not available; this species needs further confirmation by more collections and molecular analysis

1.20.3 *Xerocomus subtomentosus* (L.) Qué.

Habitat: on soil, in small groups

Distribution: under broadleaved trees and mixed woods, Dashkin (panote col), Astore, Gilgit; Kaghan Valley, Khyber Pakhtunkhwa, Pakistan

Economic importance: edible

Identification method: only morphological

Figures: available

Reference: Sultana et al. (2011), Sarwar & Khalid (2013), Razaq & Shahzad (2016), Aman et al. (2022)

Comments: Figure is not clear and seems related to *Suillus* species; this species needs further confirmation by more collections and molecular analysis

1.21 *Veloporphyrellus* L.D. Gómez and Singer

1.21.1 *Veloporphyrellus latisporus* J. Khan & S. Ullah

Habitat: on loamy moist soil under *Pinus roxberghii* among the mosses

Distribution: Chawga, Shangla district, Khyber Pakhtunkhwa, Pakistan

Economic importance: Not known

Identification method: both morphological and molecular

GenBank Number: MZ079120, MZ079121, MZ079122, MZ079123

Figures: available

Reference: Khan et al. (2021)

2. Species of different genera of family Coniophoraceae from Pakistan

Data showed that only two genera and three species of this family have been reported from Pakistan.

2.1 *Coniophora* DC

2.1.1 *Coniophora arida* (Fr.) P. Karst.

Habitat: on wood

Distribution: Khyber Pakhtunkhwa, Pakistan

Economic importance: inedible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

2.1.2 *Coniophora fusispora* (Cooke & Ellis) Cooke

Habitat: on wood

Distribution: Khyber Pakhtunkhwa, Pakistan

Economic importance: inedible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections and molecular analysis

2.2 *Gyrodontium* Pat.

2.2.1 *Gyrodontium sacchari* (Spreng.) Hjortstam

Habitat: on wood

Distribution: Khyber Pakhtunkhwa, Pakistan

Economic importance: inedible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

3. Species of different genera of family Diplocystidiaceae from Pakistan

Only one genus and one species has been reported yet from Pakistan belonging to this family.

3.1 *Astraeus* Morgan

3.1.1 *Astraeus hygrometricus* (Pers.) Morgan

Habitat: on ground, solitary as well as in groups

Distribution: under conifers, among grasses, Shedandi, Margala hills, Murree, Punjab; Khabbal Paien, Mansehra; Kaghan Valley, Khyber Pakhtunkhwa; Makeen, Wana, Birmal, South Waziristan Agency, Pakistan.

Economic importance: inedible

Identification method: only morphological

Figures: Available

Reference: Ahmad (1978), Yousaf et al. (2014), Badshah et al. (2015)

Comment: No molecular data available.

4. Species of different genera of family Gasterosporiaceae from Pakistan

Data shows that only one genus and one species has been reported. There is no image and full description of this species.

4.1 *Gastrosporium* Mattir.

4.1.1 *Gastrosporium simplex* Mattir.

Habitat: at the base of *Cynodon dactylon*

Distribution: Ladhar, Sheikhpura, Panjab

Economic importance: as an ecological indicator

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

5. Species of different genera of family Gomphidiaceae from Pakistan

Only two genera and six species of this family have been reported from different areas of Pakistan.

5.1 *Chroogomphus* (Singer) O.K. Mill.

5.1.1 *Chroogomphus helveticus* (Singer) M.M. Moser

Habitat: on ground

Distribution: under mixed conifers, Khanspur, Ayubia, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Kiran et al. (2020), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

5.1.2 *Chroogomphus pakistanicus* M. Kiran and A.N. Khalid

Habitat: gregarious on soil

Distribution: under mixed conifers, Kumrat valley, District Dir (Upper), Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: both morphological and molecular

Mycobank Number: MB829715

GenBank Number: MK509771, MK509772

Figures: Available

Reference: Kiran et al. (2020)

5.1.3 *Chroogomphus pruinosus* M. Kiran and A.N. Khalid

Habitat: gregarious on soil

Distribution: under mixed conifers, Kumrat valley, District Dir (Upper), Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: both morphological and molecular

Mycobank Number: MB829714

GenBank Number: MK509768, MK509769, MK509770

Figures: Available

Reference: Kiran et al. (2020)

5.1.4 *Chroogomphus roseolus* Y.C. Li and Zhu L. Yang

Habitat: solitary, on soil

Distribution: under *Pinus wallichina*, Khanspur, Ayubia, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: both morphological and molecular

GenBank Number: LT576117

Figures: Available

Reference: Razaq et al. (2016)

5.1.5 *Chroogomphus rutilus* (Schaeff.) O.K. Mill

Habitat: on soil

Distribution: under conifers, Shogran, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Kiran et al. (2020), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

5.2 *Gomphidius* Fr.

5.2.1 *Gomphidius glutinosus* (Schaeff.) Fr.

Habitat: not known

Distribution: under conifers, Shogran, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

6. Species of different genera of family Gyroporaceae from Pakistan

Only one genus and species has been reported from Pakistan.

6.1 Gyroporus Qué.

6.1.1 Gyroporus castaneus (Bull.) Qué.

Habitat: solitary, on soil

Distribution: under *Quercus incana*, Shawar Valley, Swat, Khyber Pakhtunkhwa, Pakistan.

Economic importance: Edibility on choice but not recommended

Identification method: both morphological and molecular

Figures: Available

Reference: Davoodian et al. (2018)

Comment: Molecular data is not available in GenBank

7. Species of different genera of family Hygrophoropsidacea from Pakistan

Data shows that only one genus and one species has been reported from Pakistan. Image and full description of this species is not available.

7.1 Leucogyrophana Pouzar

7.1.1 Leucogyrophana mollusca (Fr.) Pouzar

Habitat: on substrate

Distribution: different areas of Pakistan

Economic importance: not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

8. Species of different genera of family Paxillaceae reported from Pakistan

Only three genera and three species have been reported from Pakistan. Description and figures available for one taxon while for other two taxa, data is not available.

8.1 Gyrodon Opat.

8.1.1 Gyrodon lividus (Bull.) Sacc.

Habitat: on soil, in groups

Distribution: among grasses, Mushkin, District Astore, Khyber Pakhtunkhwa, Pakistan.

Economic importance: Edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2017), Aman et al. (2022)

Comments: This species needs further confirmation by more collections and molecular analysis

8.2 *Hydnomerulius* Jarosch & Besl

8.2.1 *Hydnomerulius pinastri* (Fr.) Jarosch & Besl

Habitat: on substarte

Distribution: different areas of Pakistan

Economic importance: not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

8.3 *Melanogaster* Corda

8.3.1 *Melanogaster durissimus* Cooke

Habitat: not available

Distribution: Pakistan

Economic importance: not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

9. Species of different genera of family Rhizopogonaceae reported from Pakistan

From Pakistan, only one genus and two species of this family have been reported.

9.1 *Rhizopogon* Fr.

9.1.1 *Rhizopogon flavus* Petch.

Habitat: semi hypogeous, in groups

Distribution: under *Cedrus deodara*, deciduous trees, Mashkun, Swat district, Qaldara, Malakand; Shogran, Sharan, Kaghan, Khyber Pakhtunkhwa, Pakistan.

Economic importance: inedible

Identification method: morphological

Figures: Available

Reference: Ahmad et al. (1997), Yousaf et al. (2014)

Comments: Molecular data is not available

9.1.2 *Rhizopogon obtextus* (Spreng.) R. Rauschert

Habitat: on soil, common

Distribution: under pines, Naran, Kaghan Valley, Pakistan.

Economic importance: not known

Identification method: only morphological

Figures: not available

Reference: Sultana et al. (2015).

Comments: figure and molecular data is not available, morphological description is short; this species needs further confirmation by more collections and both morphological and molecular analysis

10. Species of different genera of family Sclerodermataceae reported from Pakistan

Uptill now, two genera and eleven species of this family have been reported.

10.1 *Pisolithus* Alb. and Schwein.

10.1.1 *Pisolithus arhizus* (Scop.) Rauschert

Habitat: on soil, litter and near water canals

Distribution: under *Eucalyptus* sp., different areas of Khuzdar, Balochistan; different areas of Karachi, Sindh.

Economic importance: Edible when young

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2004), Yousaf et al. (2014), Aman et al. (2022)

Comments: Molecular data is not available

10.1.2 *Pisolithus tinctorius* (Mont.) E. Fisch

Habitat: sandy soil, on ground

Distribution: near the root zone of *Eucalyptus* trees in Karachi University Campus, Karachi, Sindh, Pakistan; Sangla Hill, District Nankana Sahib, Punjab

Economic importance: medicinal and good sources of dye

Identification method: morphological

Figures: available

Reference: Razzaq & Shahzad (2004), Awan et al. (2022)

Comments: Molecular data is not available

10.2 Scleroderma Pers.

10.2.1 Scleroderma areolatum Ehrenb.

Habitat: on soil, solitary

Distribution: under conifers as well as broad leaved trees, Khanspur, Ayubia; Shogran, Khyber Pakhtunkhwa, Pakistan.

Economic importance: not Edible

Identification method: only morphological

Figures: Available only in line drawing

Reference: Yousaf et al. (2012), Sarwar & Khalid (2013), Sultana et al. (2015), Aman et al. (2022)

Comments: Molecular data and original figure is not available

10.2.2 Scleroderma bovista Fr.

Habitat: on soil, in groups

Distribution: under *Cedrus deodara* in grass, Murree, Punjab, Kalam, Swat; Ughi forest, Mansehra; Khanspur, Ayubia, Nadi Bunglow; Khyber Pakhtunkhwa, Dashkin, Rama, Astore, Pakistan.

Economic importance: Edible when young

Identification method: morphological

Figures: Available

Reference: Ahmad et al. (1997), Yousaf et al. (2012), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Molecular data is not available

10.2.3 Scleroderma cepa Pers.

Habitat: not known

Distribution: Not known.

Economic importance: not known

Identification method: not known

Figures: Not available

Reference: Ahmad et al. (1997), Yousaf et al. (2012), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

10.2.4 *Scleroderma chevalieri* Guzmán

Habitat: on soil, in groups

Distribution: under *Abies pindrow*, Nathia Gali, Khyber Pakhtunkhwa, Pakistan.

Economic importance: not known

Identification method: only morphological

Figures: Available in line drawing only

Reference: Yousaf et al. (2012), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Original figure and molecular data is not available; this species needs further confirmation through more collections and molecular analysis

10.2.5 *Scleroderma citrinum* Pers.

Habitat: on soil

Distribution: among grass, Lashtang forest, Lahore, Punjab, Pakistan.

Economic importance: poisonous

Identification method: only morphological

Figures: not available

Reference: Sarwar & Khalid (2013), Razaq et al. (2014)

Comments: Figure, detailed morphological description and molecular data is not available; this species needs further confirmation through more collections, morphological and molecular analysis

10.2.6 *Scleroderma dictyosporum* Pat.

Habitat: on sandy soil, solitary

Distribution: among grass, Naran, Kaghan valley, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: only morphological

Figures: Available in line drawing form

Reference: Yousaf et al. (2012), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: Original figure and molecular data is not available; this species needs further confirmation through more collections and molecular analysis

10.2.7 *Scleroderma flavidum* Ellis and Everh.

Habitat: on soil

Distribution: Shogran, Kaghan valley, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Sultana et al. (2015), Aman et al. (2022)

Comments: Figure, morphological and molecular data is not available; this species needs further confirmation through more collections, morphological and molecular analysis

10.2.8 *Scleroderma sinnamariense* Mont.

Habitat: not known

Distribution: Mansehra, Kaghan valley, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

10.2.9 *Scleroderma verrucosum* (Bull.) Pers.

Habitat: on ground

Distribution: under conifers, Margalla hills, Changla gali, Murree, Nathia gali, Mansehra, Kaghan valley, Swat, Gokina Chowki, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Sultana et al. (2015), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

11. Species of different genera of family Serpulaceae from Pakistan

Only one genus and one species has been described from Pakistan. No image and description available for this species.

11.1 *Serpula* (Pers.) Gray

11.1.1 *Serpula lacrymans* (Wulfen) J. Schröt.

Habitat: not available

Distribution: Pakistan

Economic importance: not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

12. Species of different genera of family Suillaceae from Pakistan

Only one genus of this family has been reported with fifteen species.

12.1 *Suillus* P. Gray

12.1.1 *Suillus americanus* (Peck) Snell

Habitat: on soil, in groups as well as solitary

Distribution: under *Abies pindrow*, *Pinus wallichiana*, *Salix alba*, Khaira Gali Nathiagali, Kuzagali, Banjoosa (AJK), Batakundi, Pirchinasi, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: both morphological and molecular

GenBank Number: JN119748-54

Figures: Available

Reference: Sarwar et al. (2011), Sarwar & Khalid (2014b)

12.1.2 *Suillus bovinus* (L.) Roussel

Habitat: on ground, solitary

Distribution: under conifers, Mushkin forests, District Astore, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2016).

Comments: Molecular data is not available; this species needs molecular analysis

12.1.3 *Suillus brevipes* (Peck) Kuntze

Habitat: on ground, solitary

Distribution: under *Quercus incana*, Khanspur, Ayubia, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility on choice

Identification method: only morphological

Figures: Available

Reference: Sarwar et al. (2011), Sarwar & Khalid (2014b)

Comments: Molecular data is not available; this species needs more collections and molecular analysis

12.1.4 *Suillus collinitus* (Fr.) Kuntze

Habitat: on ground, solitary

Distribution: under *Pinus wallichiana*, Khanspur, Ayubia, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibile

Identification method: both morphological and molecular

Figures: Available

Reference: Sarwar et al. (2011), Sarwar & Khalid (2014b)

12.1.5 *Suillus flavidus* (Fr.) J. Presl

Habitat: on ground, solitary

Distribution: under *Pinus wallichiana*, Khanspur, Ayubia, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibile

Identification method: both morphological and molecular

Figures: Available

Reference: Sarwar et al. (2012)

Comment: Molecular data is not available in GenBank

12.1.6 *Suillus granulatus* (L.) Roussel

Habitat: on ground, solitary

Distribution: under *Pinus wallichiana*, *Abies pindrow*, mixed conifers, Murree, Punjab; Khanspur, Ayubia; Malakundi, Pirchinasi, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: both morphological and molecular

Figures: Available

Reference: Sarwar & Khalid (2014b)

Comment: Molecular data is not available in GenBank

12.1.7 *Suillus grevillei* (Klotzsch) Singer

Habitat: on ground, solitary

Distribution: under mixed conifers, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2013), Aman et al. (2022)

Comments: figure, morphological and molecular data is not available; this species needs further confirmation by more collections, morphological and molecular analysis

12.1.8 *Suillus himalayensis* B. Verma and M. S. Reddy

Habitat: on ground, solitary/scattered

Distribution: under mixed conifers, Chattar plain, Mansehra; Sharan (Kaghan valley); Khanspur, Ayubia; Khyber Pakhtunkhwa, Pakistan.

Economic importance: not known

Identification method: both morphological and molecular

GenBank Number: KR056819, KR056820, KR056821

Figures: Available

Reference: Sarwar et al. (2018).

12.1.9 *Suillus luteus* (L.) Roussel

Habitat: on ground, along sides of canals

Distribution: Dashkin, Astore, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2016), Aman et al. (2022)

Comments: Molecular data is not available; this species needs more collections and molecular analysis

12.1.10 *Suillus marginielevatus* S. Sarwar, A. N. Khalid and B. M. Dentinger

Habitat: on ground, solitary

Distribution: under *Quercus incana*, *Pinus wallichiana*; Khaira Gali, Nathia gali, Sharan (Kaghan valley), Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: both morphological and molecular

MycoBank MB 807713

GenBank Number: KJ361512; KJ361513; KP792120; KP792121

Figures: Available

Reference: Sarwar et al. (2015).

12.1.11 *Suillus placidus* (Bonord.)

Habitat: on ground

Distribution: in mixed conifers with *Juglans regia*, *Pinus wallichiana* and *Abies pindrow*; Dungagali, Nathiagali, Sharan, Khyber Pakhtunkhwa; Mushkin forest, Dhirkot (AJK), Pakistan.

Economic importance: edible

Identification method: morphological

Figures: not available

Reference: Ahmad et al. (1997), Razaq & Shahzad (2016), Aman et al. (2022)

Comments: figure and molecular data is not available; morphological description is short, this species needs further confirmation by more collections, morphological and molecular analysis

12.1.12 *Suillus triacicularis* B. Verma and M.S. Reddy

Habitat: on ground, solitary

Distribution: under *Pinus wallichiana*; Batrasi, Mansehra, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edibility not known

Identification method: both morphological and molecular

GenBank Number: KM677929

Figures: Available

Reference: Sarwar et al. (2015).

12.1.13 *Suillus tomentosus* Singer

Habitat: on ground, in groups

Distribution: in coniferous forest, under *Abies pindrow*, *Pinus wallichiana* and herbaceous vegetation; Nathiagali Dungagali, Ayubia; Malakundi, Khyber Pakhtunkhwa, Pakistan.

Economic importance: edible but acidic feeling

Identification method: only morphological

Figures: Available

Reference: Ahmad et al. (1997), Sarwar & Khalid (2014b), Aman et al. (2022)

Comments: molecular data is not available; this species needs molecular analysis

12.1.14 *Suillus viscidus* (L.) Roussel

Habitat: on ground, in groups

Distribution: under conifers; Mushkin forests, Astore, Pakistan.

Economic importance: edible

Identification method: only morphological

Figures: Available

Reference: Razaq & Shahzad (2016), Aman et al. (2022)

Comments: molecular data is not available; this species needs molecular analysis

12.1.15 *Suillus quercinus* Sarwar, Naseer & Khalid

Habitat: on ground

Distribution: under *Quercus incana* (Fagales, Fagaceae), Toa Valley, Swat District, Khyber Pakhtunkhwa, Pakistan

Economic importance: Not known

Identification method: both morphological and molecular

Mycobank Number: MB 835423

GenBank Number: MT361744, MT361745, MT361746

Figures: available

Reference: Dima et al. (2021)

13 Description of species of different genera of Tapinellaceae

Only two genera and three species have been reported belonging to this family.

13.1 *Pseudomerulius* Jülich

13.1.1 *Pseudomerulius aureus* (Fr.) Jülich

Habitat: not available

Distribution: Pakistan

Economic importance: not known

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular description is not available; this species needs further confirmation by more collections, morphological and molecular analysis

14. *Tapinellaceae* C. Hahn. *Tapinella* E.-J. Gilbert

14.1 *Tapinella* E.-J. Gilbert

14.1.1 *Tapinella atrotomentosa* (Batsch) Šutara

Habitat: not known

Distribution: Lahore, Punjab, Pakistan.

Economic importance: inedible

Identification method: not known

Figures: not available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular description is not available; this species needs further confirmation by more collections, morphological and molecular analysis

14.1.2 *Tapinella panuoides* (Fr.) E.-J. Gilbert

Habitat: not known

Distribution: Patriata, Shogran, Khyber Pakhtunkhwa; Lahore, Punjab, Pakistan.

Economic importance: poisonous

Identification method: not known

Figures: not Available

Reference: Ahmad et al. (1997), Aman et al. (2022)

Comments: figure, morphological and molecular description is not available; this species needs further confirmation by more collections, morphological and molecular analysis

Species number with in each genus reported from Pakistan

From Pakistan till February 2023 thirty nine (39) genera of boletes mushrooms have been reported (Table 2). Most dominant genus is *Suillus* which has fifteen reported species from Pakistan. Second dominant genus is *Scleroderma* with nine reported species from Pakistan. All other genera need mush attention regarding their exploration from unexplored areas.

Tab 2: Species number with in each genus reported from Pakistan

Sr. No.	Genus reported from Pakistan	Number of reported species from Pakistan
1	<i>Aureoboletus</i>	1
2	<i>Boletus</i>	5
3	<i>Butyriboletus</i>	1
4	<i>Caloboletus</i>	1
5	<i>Chalciporus</i>	1
6	<i>Cyanoboletus</i>	2
7	<i>Hortiboletus</i>	2
8	<i>Leccinellum</i>	1
9	<i>Leccinum</i>	3
10	<i>Neoboletus</i>	1
11	<i>Phylloporus</i>	2
12	<i>Porphyrellus</i>	1
13	<i>Pseudoboletus</i>	1
14	<i>Rubroboletus</i>	2
15	<i>Strobilomyces</i>	2
16	<i>Suillellus</i>	2
17	<i>Tylopilus</i>	3
18	<i>Xanthoconium</i>	1
19	<i>Xerocomellus</i>	4
20	<i>Xer ocomus</i>	3
21	<i>Veloporphyrillus</i>	1
22	<i>Coniophora</i>	2
23	<i>Gyrodontium</i>	1
24	<i>Astraeus</i>	1
25	<i>Gastrosporium</i>	1
26	<i>Chroogomphus</i>	5
27	<i>Gomphidius</i>	1
28	<i>Gyroporus</i>	1
29	<i>Leucogyrophana</i>	1
30	<i>Gyrodon</i>	1
31	<i>Hydnomerulius</i>	1
32	<i>Melanogaster</i>	1
33	<i>Rhizopogon</i>	2
34	<i>Pisolithus</i>	2
35	<i>Scleroderma</i>	9
36	<i>Serpula</i>	1
37	<i>Suillus</i>	15
38	<i>Pseudomerulius</i>	1
39	<i>Tapinella</i>	2

Data about reported Ectomycorrhizal morphotypes of Boletes from Pakistan

Data about ectomycorrhizae of these fungi is very scarce from Pakistan. Only few ECMs of these mushrooms have been reported with conifers in Himalayn Moist Temperate forests of Pakistan (Sarwar et al. 2012, 2018). As there are fruiting bodies reported so it is obvious that ectomycorrhizal boletes have belowground ECMs. There is need to focus regarding this mycorrhizal group for afforestation and reforestation programs because mycorrhizal mycelia can be used as inoculums with nursery plants for their better growth.

CONCLUSION

This diversity rich region needs further exploration to widen the nutritional and medicinal base of the rural population who depend on the mushrooms through conservation, cultivation and commercialization activities. The rich diversity of mushrooms offers huge socio-economic potentials. However, they need to be properly documented for optimum application. The biggest threats to biodiversity are habitat fragmentation and degradation, the introduction of non-native species, overexploitation, pollution and disease (GOP 2000). Effective methods should implement to stop genetic erosion and encourage the rehabilitation of degraded ecosystem in mega biodiversity regions. Efforts are initiating to protect and save biodiversity both by ex-situ and in-situ conservation (GOP 2000). There are number of edible fungi that are still being collected from the forest for human consumption and research is required to domesticate new species. There is a need for developing superior strains of cultivated mushrooms using available germplasm. Alternatively systems have to be developed for commercial/industrial scale mycelia multiplication for extracting industrial/ medicinal important metabolites/compounds. Amongst the vast number of living forms very little attention has been paid to conservation of fungal biodiversity. Many fungal species are on threat due to loss of natural habitats, soil and air pollution, expansion of mono-cropping and loss of genetic diversity. For the smooth functioning of this terrestrial ecosystem, the conservation of mushroom diversity is critical. Keeping in view this enormous mushroom treasure it is the high time to fully conserve this biodiversity. And hence a timely research regarding isolation, identification and characterization of the existing mushroom flora is essential. Biotechnological tools can be employed in order to achieve the in situ and ex situ conservation of many of the mushroom species.

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