MUSHROOM BIODIVERSITY IN INDIA: PROSPECTS AND POTENTIAL

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ABSTRACT

Mushrooms are an important and integral component of the ecosystem. Status of Indian Agaricales was reviewed first by Sathe and Rahalkar making 1825 as the base and then by Manjula in 1983, providing a very exhaustive list of Agricoid fungi from India and Nepal. The systematics of Agaricales can be divided in to three phases: Phase I (1825-1899), Phase –II (1900-1969) and Phase-III (1970-onwords). The following groups became active in phase III; Natarajan and his group in South India, Sathe and his Co Workers, in South West India, Kapoor and associates in and around Delhi, Rawala and his students, Saini and Atri and their students in North India, Lakhanpal and his co-worker, Kaul and his associates and Upadhyay *et. al* at DMR Solan in the Himalayan region. A family wise exploration which began with family Boletaceae in 1976 culminated in family wise monographic treatment of Boletaceae, Amanitaceae, Russulaceae and Morels.

Keywords: Agaricales, systematic, Boletaceae, Amanitaceae, Russulaceae, morels

Mushrooms are the macro or larger fungi which possess fleshy, subfleshy, or sometimes leathery, umbrella like fructifications, which bear their spore producing surface either on lamellae (gills) or lining the tubes, opening out by means of pores. Usually the lamellate members are called 'mushrooms' or toadstools' depending upon whether they are edible or poisonous and the tube bearing poroid members, as boletes. Mushrooms are seasonal fungi, which occupy diverse niches in nature in the forest ecosystem. They predominantly occur during the rainy season and also during spring when the snow melts.

Mushrooms have been by far most extensively studied in most of the countries of the world in the West. Though many papers compilations and treatments have been published periodically, "The Agaricales in Modern Taxonomy" by Singer [1] is still the most standard treatment. A new revised systematic treatment of all the fungi including mushrooms has been presented by Kirk *et al.* [2] in the "Dictionary of Fungi" based on molecular characters. Mutational rearrangements and placement least challenge the content given by Singer. Many other regional compendia and lists have been published periodically from different parts of the world.

Indian fungi has a chequered history, it was leisure past time for British amateurs, the pioneers in the investigations. Mushrooms, therefore, have a beleaguered history with gaps and punctuations. One of the reasons may be the lack of communication facilities and unapproachable destinations which are now comparatively easily accessible. The first list on Indian Fungi was published by Butler and Bisby [3], and then revised by Vasudeva [4]. Several additional lists appeared in between culminating with the fungi of India by Bilgrami *et al.* [5]. Status of Indian Agricales was reviewed first by Sathe and Rahalkar [6] making it as the base and then by Manjula [7], providing a very exhaustive list of Agaricoid and Boletoid fungi from India and Nepal. This is so far the best list which enumerates 538 valid genera and 20 families in the Agaricales. This list has been recently updated by Natrajan *et al.* [8]. The systematics of Agaricales can be divided into three phases; Phase I (1825-1899), Phase II (1900-1969) and Phase III (1970-onwards). The main key player in the first phase was Berkeley [9, 10, 11, 12, 13]. But Fries[14] appears to be the first to report and describe *Lentinus alopecinus* Fr. ex Fr. and *L. sajor-caju* Fr. from India. In 1855, he reported *L. molliceps*, Fr. and *Marasmius korthalsii* Fr. from Nicobar Islands [15]. Montagne [16] reported *Trogia belangeri* (Mont.) Fr. (as *Agaricus crepidotus*), T. *montagnei* Fr. (as *Cantherellus aploruitus* Mont.) *Xerotus pessotteitii* Lev. from Nilgiri hills (as *Agaricus catervarius* Lev.), *Lentinus javanicus* L. (as *L. decaisneanus* Lev.) from Bombay and *L. pergameneus* Lev., the type of which was deposited in Paris with the remarks "Herb de Canddle, Indes".

Berkeley made major notable contributions to the field of Agaricology in India [9, 10, 11, 12, 13]. He dealt with 159 species of mushrooms collected from Assam, Darjeeling, Sikkim, Calcutta, Masulipatnam and Madhya Pradesh. Cooke [17] recorded nine mushroom species from Bombay, Andaman, Island, Saharanpur, Madras and Nepal. Henning [18, 19]

described 72 species of mushrooms Bose and associates [20] added nearly 34 mushroom species to the Indian records. Similarly Ginai [21] recorded two species of *Coprinus* from Punjab, Benerji [22] listed 180 species of hymenomycates from Calcutta and suburbs which included 41 agarics belonging to 14 genera. Ghosh and Pathak [23] described three species of *Macrolepiota* from Lucknow (UP).

In the second phase Massee [24] recorded 32 species of mushrooms. The following groups became active in the III Phase: Natrajan and his group in South India, Sathe and co-workers, in South-West India, Kapoor and associates in and around Delhi, Rawla and his students, Saini and Atri and their students in North India, Lakhanpal and his co-workers, Kaul and his associates and Upadhyay *et al.* at DMR Solan in the Himalayan region.

The Himalayas represent the loftiest chain of mountain in the world. Himachal Pradesh is situated between 30° 22'-33° 12' N and 75° 47'-79° 04' E in the North-Western Himalayas along the northern border of India. It has a entirely mountainous terrain with altitude varying from 300 m to 7000 m. Physiographically it is characterized with hilly terrain with an intricate mosaic of hills, valleys, mountain range and snow clad peaks. It possesses a rugged topography with rich temperate flora. The forests vary from to tropical to alpine pastures. The vegetation predominantly consists of pine species, (*Pinus roxburghii, P. wallichiana and P. gerardiana*), high altitude conifers (*Picea smithiana, Abies pindrow, Abies specabilis), Taxus baccata, Cedrus deodara* and *Quercus incana, Q. leucotrichophora and Q. semecarpifolia*. These forests serve a congenial habitat for all sorts of fungi, especially mushrooms.

On the North-western Himalayan mycoflora, the prominent publications have been by Watlilng and Gregory [25], Hongo [26], Horak [27], Kaul and Kachroo [28], Abraham *et al.* [29], Saini and Atri [30-33], Saini *et al.* [34] Rawla and Sarwal [35], Sharma and Lakhanpal [36], Lakhanpal *et al.* [37-39], Sharma [40], Bhatt [41], Kumar [42], Shad [43-44], Kaisth [45], Sharma [46-48], Chaturvedi [49], Thakur[50], Lakhanpal and Shad [51-52], Lakhanpal *et al.* [53], Bhatt and Lakhanpal [54-56], Sagar and Lakhanpal 57], Kumar *et al.* [58], Lakhanpal [59], Lakhanpal *et al.* [60]. From a survey of mushroom in the N.W. Himalayas Lakhanpal and his associates recorded agarics belonging to 300 species, 59 genera and 15 families of Agaricales. This survey provides an inventory of the species occurring in the Himalaya, a list of species of mushrooms, which enter into mycorrhizal relationship with forest trees; and a list and description of non-conventional edible species discovered during the surveys.

Watlling and Gregory [25] presented a comprehensive list of 119 taxa from Jammu and Kashmir. Abraham [62] published a list of agarics with ecological notes from Kashmir Himalayas reporting 250 species. Lakhanpal reviewed exploratory work on the Himalayans agarics and concluded that the taxa recorded are least commensurate with the vastness and diversity in the mountainous range [62]. Atri and Saini [63] reviewed the work on Russulaceous fungi the world over and reported the Indian contribution, Atri and Saini [64] published the checklist of Indian Russulaceous wherein 48 species of *Lactarius* and 67 taxa of *Russula* have been listed. Saini and Atri [65] reviewed exploratory work on mushrooms from Punjab and listed 94 taxa spread over 24 genera. Gupta *et al.* [66] reviewed Indian work on Agaric systematics. While working on the taxonomy of the genus from North West India, Gupta [67] made 261 collections falling in 66 taxa, which include 4 new species. From South Indian region, excluding Kerala, Natarajan [68] reported 457 species of agarics spread over 76 genera. Work on mushrooms from Kerala has been reviewed by Bhawani Devi [69]. Patil *et al.* [70] listed 212 species of agarics spread over 63 genera from Maharashtra. Verma *et al.* [71] listed 95 additional species of mushrooms.

The wild mushroom seem to have been traditionally consumed by man since very early times, but these were then probably considered a food in wilderness, which now have come to occupy a very popular place in the modern dietic regimen because of its nutritive value.

AGARICALES

A systematic survey of mushrooms and toadstools of N.W. Himalayas was started in 1976 and has been carried through all these years [36, 72, 73]. Since Agaricales is a large assemblage of mushrooms and toadstools, comprising more than 20 families [13], instead of initiating work on all families, it was decided to begin family wise survey, starting with the family Boletaceae [36, 40, 46, 72, 73].

In the family Boletaceae 7 genera and 57 species were recorded. The seven genera recorded are *Austroboletus* (1), *Boletus* (37), *Gyproporus* (2), *Leccinum* (6), *Strobilomyces* (3), *Suillus* (5)and *Tylopilus* (3).This work included 5 new species and an equal number of new varieties. The work on Boletaceae was compiled into a monograph: Mushrooms of India-Boletaceae [73]. The systematics was supplemented with data on 22 edible species in Boletaceae, *Boletus edulis* being the species of choice. Majority of the species were new records for India and *B. hoarkii* sp. nov. was designated as a new species. About 22 species of boletes were observed to form mycorrhiza with different predominant conifer tree species, especially with *C. deodara, P. wallichiana, A. pindrow and P. smithiana.*

In 1981, the mushroom exploration was extended to the families Amanitaceae, Russulaceae and Cantharellaaceae. The collections were primarily made from Shimla and adjoining areas. In these collections the genus *Amanita* in Amanitaceae was represented by 12 species; genus *Lactarius* and *Russula* in Russulaceae by 14 and 22 species, respectively and genus *Cantharellus* and *Craterellus* by 5 and 2 species respectively [41,74-76]. In 1983, work was extended to different parts of Himachal Pradesh and 6 more species in Amanitaceae were collected bringing the total number to 18 in the N.W. Himalayas and 25 in India [42]. This resulted in the publication of "Amanitaceae of India" [77]. This work included 4 taxa new to science, 13 species were mycorrhizal with different trees species. Out of this only *Amanita caesaria* and *A. vaginata* were reported to be edible and consumed locally by the people. Typical *A. muscaria* was not recorded however; only *A. muscaria var. flavivolvata w*as recorded. Similarly the exploration was also intensified on Russulaceae and Cantharellaceae [41].

The family *Cantharellaceae* was represented by 2 genera *Cantharellus* and *Craterellus* with 5 and 2 species, respectively and out of which one species each is new to science. *Cantharellus cibrarius* and *C. minor* and *Cratellus cornucopoides* are edible species and the former two are also mycorrhizal with *Cedrus deodara.* In the family Russulaceae, the genus *Lactatius* is represented by 14 species and *Russula* by 22 species and these include 4 species in the former and 5 new species in the latter. On the family Russulaceae very extensive work has been carried out at Punjabi University, Patiala by Saini and Atri [30-34, 63-65, 78-89]. They described 50 species of *Russula* from H.P. in addition to Watling and Gregory[25] and Rawla and Sarwal, [35]. Bhatt *et al.* [90] described 4 species of *Russula* from Uttrakhand. Eleven taxa are reported to be mycorrhizal with different trees species and 13 species are observed to be edible in literature out of which only *Lactarius delicious*, *L. sanguifluus* and *Russula brevipes* are the most favoured ones in the Himalayan region. A monograph on Russulaceae and *Cantharellus* has been prepared but not yet published (Bhatt and Lakhanpal, unpublished).

The systematic work was further extended to families Agaricaceae, Hygrophoraceae, Pluteaceae and Tricholomatatceae (Lakhanpal [91]; Kumar [42]). In the family Agaricaceae 6 genera have been recorded: *Agaricus, Cystoderma, Lepiota, Macrolepiota, Leucoagaricus* and *Leucocoprinus.* The last two were unrecorded from N.W. Himalaya earlier. In the genus *Agaricus* 8 species are reported from N.W. Himalayas [18, 25, 92-96]. Lakhanpal [91] and Kumar [42] described 4 species in this genus from Himachal Himalaya; *Agaricus angustus* Fr., *A. arvensis* Schaeff. *A. campestris* L.ex Fr. And *A. placomyces* Peck. Atri and his student have described around 25 species in the genus from different parts of Punjab and Dhancholia and Bahukhadi [97] described two species from Garhwal Himalayas in Utrakhand.

The genus *Cystoderma* was so far unrepresented from N.W. Himalayas. One species, *C. amianthinum* (Fr.) Fayod, has now been reported in the genus from N.W. Himalaya [91, 42]. The species is mycorrhizal with *Cedrus deodara.*

No. species in the genus *Lepiota* was so far known from N.W. Himalaya. The two species known from the Himalayan region are from Eastern Himalayas. Lakhanpal [91] and Kumar [42] recorded three species in this genus: *L. acutesquamosa* (Weinon) Kummer, *L. clypeolaria* (Bull ex Fr.) Kummer and *L. cristata* (Fr.) Kummer, The last two are mycorrhizal with *Cedrus deodara.*

The genus *Leucocoprinus* is represented by *L.cepaestipes* (Sow. ex Fr.) Pat and a new species *Leucocoprinus* sp. nov. and in the genus *Leucoagaricus,* only one species, *L. rubrotinctus* (Peck) Singer has been recorded. *M. procera* (Scop. ex Fr.) Singer a new species, *Macrolepiota sp.* Nov., *A. angustus and Leucoagaricus rubrotinctus* are new records

from India. *A. arvensis, C. amianthium, L. acutesquamosa, L. clypeolaria, L. cepaestipes* have been recorded for the first time from N.W. Himalaya and *A. campestris* and *L. cristata* have been recorded for the first time from Himachal Pradesh.

In the family Hygrophoraceae, only two genera *Hygrophorus* and *Hygrocybe* were represented in the N.W. Himalayas. Kumar [42] also recorded *Camerophyllus* for the first time. In *Hygrophorus* the following taxa have been described: *H. ebureneus* (Bull. ex Fr.) Fr., *H. pudorinus* (Fr.) Fr., *H. pudorinus* var. *fragrans* (Murr.) Hesler and a new variety in *H. pustulatus*. Earlier only two species in the genus were known. In *Hygrocybe* only one species was known so far from N.W. Himalaya i.e. *H. psittacina* (Schaeff. ex Fr.) Kummer. Kumar [42] described 3 more species: *H. conica* (Scop ex Fr.) Kummer and H. *calopus* sp. nov. which forms mycorrhiza with *Q. incana.*

The genus *Camerophyllus* has been found to be represented by one species *C. pratensis* (Pers. ex Fr.) Kummer, and is recorded for the first time. Earlier it was known only from Maharashtra. Only one species *Gomphidius maculates* (Scop. ex Fr.) has been reported in the family Gomphidiaceae [91]. However, earlier Watling and Gregory [25] reported *Gomphus clavatus* (Pers. ex Fr.) S.F. Gray in the family Gomphidiaceae from Kashmir.

In the first family Pluteaceae, out of the three genera recorded from India, two are represented in the N.W. Himalaya. These are *Pluteus* and *Volvariella*. Out of the 6 species of *Pluteus* in India, 5 are represented in the Himalayan region but only one i.e. *Pluteus cervinus* (Schaeff. ex Fr.) Kummer in N.W. Himalaya [25, 42]. In the genus *Volvariella,* only *V. volvacea* (Bull. Ex Fr.) Singer was so far known from N.W. Himalayas [19]. Lakhanpal *et al.* [38] described *V. bombycina* (Schaeff, ex, Fr.) Singer from H.P. collected on the living decorticated trees of *Picea smithiana* (7000-9000 ft.). It was a low temperature loving species and could be cultured easily. Lakhanpal [91] and Kumar [42] respectively listed and described *V. pussila* (Pers. ex Fr.), Kumar [42] described a new species of *Volvariella,* apparently which was collected on soil, associated with *C. deodara.* Natrajan *et al.* [8] list two additional species in *Pluteus* and 12 in the genus *Volvariella.*

In the family Pleurotaceae,the genus *Pleurotus* is represented by 6 species, all collected from Jammu & Kashmir (Watling and Gregory)[25]as: *P. dryinus* (Pers. ex Fr.) Kummer, *P. ostreatus* (Kaul and Kachroo[28], *P. membranaceus* Massee and *P. fossulatus* (*Cooke*) Sacc. Lakhanpal [91] recorded *P. ostreatus* from Himachal Pradesh and Chaturvedi [49] conducted experimental trials on its cultivation.

In the genus *Lentinus* only two species are known from N.W. Himalayas, *L. strigosus* (Schwein) Fr. and *L. tigrinus* (Watling and Gregory [25], Lakhanpal [91], Natrajan *et al.* [8] treat these two genera in Polyporaceae listing two species in *Lentinus* and three in *Pleurotus.*

The family Tricholomataceae is one of the largest families of the Agricales with its members distributed far and wide and occupying a variety of ecological niches. Out of the 98 genera reported from all over the world, 41 genera are represented in India as well (Manjula, [7], However, Natrajan *et al.* [8] reported 34 genera in this family from 1984-2002. Twenty five genera have been reported from the Himalaya and only 5 from N.W. Himalaya. These genera are: *Armillaria, Tricholoma, Collybia, Leucopaxillus* and *Melanoleuca.* Kumar [42] recorded in addition to these, 8 more genera from N.W. Himalayas. These are: *Asterophora, Clitocybe, Lepista, Mycena, Oudmansiella, Tricholomopsis, Laccaria* and *Marasmius.* Lakhanpal [91] has also recorded these and two additional genra i.e. *Lyophyllum* and *Flammulina* from N.W. Himalaya.

So far only *A. mellea* (Vahl. Ex Fr.) Kummer, and *A. obscura* (Pers. ex Secr.) Romagn are known from Himalaya. We have recorded only *A. mellea* from Himachal Pradesh. Similar has been the case with the genus *Asterophora* in which only one species *A. lycoperdoides* (Bull ex Mirat) Ditmat ex Fr. was for the first time recorded from India by Kumar *et al.* [98], which was collected growing gregariously on the carpophores of *Russula.*

The genus *Clitocybe* hitherto unrecorded from N.W. Himalayas, is known to be represented by four species (Kumar, [42]; Lakhanpal, [91]). *C. clavipes* Fr.) Kummer, *C. dilatata* Pres. ex Karsten, *C. gibba* (Fr.) Kummer and *C. squamulosa* (Fr.) Kummer. All the four have been seen to form mycorrziza. Only three species in the genus *Collybia* are so far known from N.W. Himalaya. Out of these *C. peronata* (Boltr. exFr.) Kummer was recorded from Mussoorie (U.P.) by Hennings

[19]. The other two were recorded by Watling and Gregory [25] from Kashmir viz. *C. dryophila* (Bull ex Fr.) Kummer and *C. fuscopurpurea* (Pers ex Fr.) Kummer. In the genus *Laccaria, L. laccata* (Scop. ex Fr.) Cooke, and *L. amethysta* (Bull ex Gray) Murrill (earlier known from Nilgiri hills) has been recorded from N.W. Himalaya. The fungus has gained much prominence in the last few decades being a good mycorrhizal species, which forms mycorrhizal associations with many trees. In the genus *Lepista*, only one species, *L, nuda* (Bull. Ex Fr.) Cooke, has been recorded from N.W. Himalaya [42, 91] which is mycorrhizal with *Quercus semicarpifolia.*

In the genus *Leucopaxillus,* four species have been reported from N.W. Himalaya [25]; *L. albissimus* (peck) Singer var. *piceinus* Peck) Singer and Smith, *L. laterarius* (Peck) Singer and Smith, *L. amarus* (A&S ex Fr.) Kuhn, *L. rosebrulles* (Murr.) Singer and Smith and *L. giganteus* (Sow, ex Fr.).The genus *Marasmius* surprisingly has been reported to be represented by just one species in the N.W. Himalaya, *M. cohaerens* (A&S. ex Fr.) Cke & Quel. Kumar *et al.* [99] reported a new species, *M. ellipsoidosporus* and a new record *M. siccus* (Schw.) Fr. from H.P.

In the genus *Melanoleuca* two species *M. subpulverulenta* (Pers. ex Fr.) Singer and *M. melanoleuca* (Pers. ex Fr.) Murr. were so far known from Kashmir Himalaya [25, 42] recorded *M. alboflavida* (Pk.) Murrill from H.P. for the first time. The genus *Mycena* is so far represented by five species in the N.W. Himalayas: *M. aetites* (Fr.) Quel., *M. atrocyanea* (Fr.) Gillet, *M. golericulata, M. epiterygia* (Scop. ex Fr.) Kummer. The last two have been reported from Himachal Pradesh [42, 91]. The genus *Oudemansiella,* is observed to be represented only by one species i.e. *O. radicata* (Relh.) ex Fr.) Singer from N.W. Himalayas [42, 91].

Tricholoma, a widely distributed and represented genus the world over, has only *T. terreum* (Bull. ex Fr.) Kummar recorded from N.W. Himalaya [25]. Two more species have been now recorded from N.W. Himalayas. These are: a new species of *Tricholoma* and *T. virgatum* (Fr. ex Fr.) Kummer. The latter has been observed growing in mycorrhizal association with *C. deodara* [42, 91].

The genus *Tricholomopsis* is so far represented by two species from India, one from U.P. [92] and other from eastern Himalaya (*T. rutilana)* [92(a)]. Kumar [42] and Lakhanpal [91] recorded *T. rutilans* (Schaeff. ex Fr.) Singer and *T. sulphureoides* (Peck) Singer from N.W. Himalaya for the first time. In the genus *Flammulina* only *F. velutipes* (Curt ex Fr.) Karst. has been reported so far from Indian and Himalaya. The genus *Lyophyllum* isrepresented by four species in India. Lakhanpal [91] recorded *L. decastes* (Fr. Ex Fr.) Singer from HP. In the genus *Resupinatus* Watling and Gregory [25] recorded *R. applicatus* from Kashmir and in the genus *Xeramphalina,* out of the three species recorded from India and Himalaya, *X. aurara* Horak and *X. campanella* (Batsch. ex Fr.) Maire, have been recorded from N.W. Himalaya [25].

SYSTEMATICS OF MORELS

The genus *Morchella* (Ascomycetes) commonly known as morels and 'Guchhi' in the Indian market has been investigated for different aspects of morel biology (Shad [44]; Lakhanpal and Shad [100], Shad and Lakhanpal [101], Thakur [102], Rana, [103], Lakhanpal *et al.* [60]. All the six classical species viz. *M. angusticeps, M. conica, M. crassipes, M. deliciosa, M. esculenta* and *M. semilibra* have been collected and described from the Himalayan region. In addition *M. tibelica* and *M. simlensis* sp. nov have been recorded from HP. The polymorphism and genetic analysis in the species *Morchella* has been assessed at molecular level [60].

Similar studies have been conducted on the taxonomy, ecology, physiology and nutritional requirements, ethnic uses and analysis of nutritive components [104]. On *Helvella crispa, Gyromitra esculenta* among members of *Ascomycotina, Lactarius delicious, L. sanguifluus, Macrolepiota procera* and *Russula brevipes* among gilled members and *Boletus edulis, B. erythropus, B. horakii, Cantharellus cibarius, Hydnum repandum, Ramaria botrytoides* and *Sparassis crispa* among the non-gilled members of Basdiomycotina. These mushrooms can be exploited for cultivation as they are already accepted for consumption by local people.

Nutraceutical potential of morels has been investigated [60]. Nutraceutical attributes of morels compare favourably with the mushroom species listed above. They are even a better source of polysaccharides, crude fibre, nucleic acids, minerals especially Se, Zn, K, Cu, Na, and Ca, Vitamin (B_1, B_2, C, A, D and K; proteins and all the essential amino acids. They are free from cholesterol. Hence they are of good nutraceutical use.

Ethnomycological studies were initially conducted on morels and some other mushrooms: *Lactarius delicious, L. sanguifluus, Amanita veginata, Russula brevipes, Sparassis crispa, Hydnum repandum*, specie of *Clavaria, Macrolepiota procera* etc. [45, 104-106]. The general myths are almost the same for all these mushrooms. Even the recipes are similar but the varieties are more. Previously most of these mushrooms were dried for use in winter months by the local inhabitants when most of the areas in HP are snow bound. Now the use is declining with the ready availability of vegetables and other crops.

The ecological data was collected from forest lying in the outer, middle and inner ranges (Tara Devi, Glan and Jakhu Forests) and also along a gradient with altitude varying from 6000-10,000 ft. msl. (Narkanda forest).The studies were aimed at (i) to determine the distribution/occurrence of particular species of fungi in different elevational/vegetational zones (ii) to identify the species of fungi entering into mycorrhizal association with particular species of trees, and (iii) to quantify fruiting phenlogy of different species of fungi.

Cultivation technology was developed for two mushrooms. Cultivation of *Lentinula edodes* (Shitake) was achieved for the first time in India on local sawdust substitutes [107, 108]. Similarly package of practices was developed for the first time for *Calocybe indica* [109, 110].

The research on ectomycorrhiza at HP University during the last three decades has been carried out on almost all the dominant conifer species: *P. roxburghii, P. wallichiana, P. gerardiana, Cedrus deodara, Abis pindrow, Picea smithiana* and *Taxus baccata*. In addition studies on the mycorrhiza of Oak, *Rhododendron arboreum, Monotropa,* Orchids, *Aesculus indica* and Apple has also been carried out [72, 102, 106, 111, 113]. The survey of mushroom that enters into mycorrhizal synthesis with different species of conifers provided the specific mushroom species for *in-vitro* myconhizal synthesis which has been achieved successfully.

III. HYPOGEOUS FUNGI

Truffle and truffle like Fungi are virtually unknown in India except *Tuber indicum* Cooke & Massee. There have been no systematic explorations. The author has recorded the following genera from N.W. Himalaya: *Astreus hygrometricus*, (Pers.) Margan, *Gauteria trabuti* (Chatin) Pat., *Histerangium membranaceum* Vitt., *Melanogaster broomeianus* Berk., *Rhizopogon rubescens* Var. *Ochra ceous* A.H. Smith, *Tuber mesentricum* and *Trappeinda himalayasis* [112, 114].

These are least representative of the vast Himalayan ranges with so great diversity of vegetation and climate. These need to be explored more intensively and extensively. Nevertheless, a small and humble beginning has been made for enthusiasts to pursue further.

It is clear that mushroom diversity so presented, holds great promise and potential for exploration, experimentation and amelioration of the environment. It demands great interest, commitment and of course, encouragement from living fossils-the systematics.

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