Original Research Article

Distribution of Boleteceous Mushrooms in India, Some New Records from Sal Forest of Central India

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A B S T R A C T

An account of Boleteceous mushrooms reported from different part of India is given. Total 84 species of Boletaceae were compiled from literature with records of habitat, distribution and references. Boletus spp. are the most common (37 species) followed by Strobilomyces (9 species), Tylopilus (7 species), Boletellus (6 species), Xerocomus (5 species), Suillus (3 species), Chalciporus, Retiboletus and Pulveroboletus (2 species each), Australoboletus, Borofutus, Hemileccinum, Hortiboletus, Leccinum, Octaviania, Phylloporus, Retiboletus, Rhodactina, Suillellus, Xerocomellus (one species each). Among Indian states, Himachal Pradesh and Sikkim represent the most boletes mushroom (16 species each) followed, Meghalaya (13), West Bengal (11), Madhya Pradesh and Uttarakhand (7 each), Jammu & Kashmir (5) Chhattisgarh and Kerala (4) and rest of states showed 3 or less number of species. Six species of boletes namely: Boletellus ananas, B. chrysenteroides, B. dissiliens, B. pseudochrysenteroides, B. corneri and Boletus edulis were recorded for the first time from sal forest of central India (Chhattisgarh and Madhya Pradesh). These fungi are known to form ectomycorrizal association with sal trees.

Key words
Agaricomycetes, Basidiomycota, Boletes, distribution, ecto-mycorrhiza, edible mushroom

Introduction

Basidiomycetes places in family Boletaceae are mushrooms which are primarily characterized by developing their spores in small pores, instead of gills, as are found in agarics. Among these mushrooms, Boletus edulis which is also known as the king mushroom is of high demand by mushroom hunters. Typical members of the family are generally known as boletes. These are a relatively safe group of mushrooms for human consumption, as none of these are known to be deadly poisonous to adults. These are little confused with deadly mushrooms, like various Amanita agarics, which are the most poisonous mushrooms in the world. Due to absence of gills boletes can be easily distinguished from gilled mushrooms. These are also easily recognized having colorful caps, pores and thick stems. Most species in Boletaceae produce large fleshy mushrooms 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). Boletes were first described by the French botanist François Fulgis Chevallier in 1826 in a family, distinct from...
Agaricaceae. According to the Dictionary of the Fungi (Kirk et al., 2008), 35 genera are recognized in boletaceae, which collectively contain 787 species. In the comprehensive work of (Wu et al., 2014), seven major clades at subfamily level and 59 generic lineages were uncovered, including four new subfamilies (Austroboletoideae, Chalciporoideae, Leccinoideae, and Zangioideae) and 22 new potential genera have been described. Boletes are found worldwide, on every continent except Antarctica. These fungi are well-known reported from temperate regions of northern hemisphere; newer research has also shown significant diversity in tropical and southern hemisphere regions as well. A large number of boletes are delicious or at least edible. On the other hand poisonous or inedible species also exist, however, such as the unpalatable bitter species, for example Boletus calopus and Tylopilus felleus (bitter bolete). Some orange-capped species of Leccinum are also inedible. Several guidebooks recommend avoiding all red-pored boletes, but both B. erythropus (Neoboletus luridiformis) and Suillellus luridus are edible when well-cooked. Some of the boletes genera were separated based on basidiospores morphology, for example Boletellus have olive brown elongate to fusoid with longitudinally grooves and winged basidiospores (almond like) while Boletus have smooth spores (Pegler and Young, 1981).

The present article reports distribution of 84 boletaceous mushroom in different states of India. Six boletes (Boletellus ananas, B. chrysenteroides, B. dissiliens, B. pseudochrysenteroides, B. corneri and Boletus edulis) were also reported for the first time from sal forest of central India.

Materials and Methods

Specimens of bolete mushrooms were collected from sal forest of Madhya Pradesh and Chhattisgarh states in rainy seasons from forest floor under sal trees. Some parts of collected samples were preserved in 70% alcohol just after collection for microscopic study. The fruit bodies of fungi were dried under the sun or in the wooden box lighted with 100W electric bulb. Microscopic slides were prepared by using stain, mountant, clearing and softening chemicals. Micro slides were observed under advanced research microscope (Leica, Germany) using 5x, 10x, 20x, 40x objectives and 10x and 15x eyepieces. Observations under phase contrast and dark field were also made whenever required. Photomicrography was done with the help of a digital camera (make, Leica) attached to the advanced microscope. Identification of fungi have been done with the help of published literature, monographs, books, keys, etc. (Ahmad 1950; Berkeley 1851a; b: 1852a; b; 1854a; Bhavanidevi and Nair 1983; Chaouhan et al., 2010; Cunningham, 1942; Dar et al., 2010; De, 2006; Harsh and Bisht, 1983, 1985; Kumar and Sharma, 2011; Lakanpal and Sagar, 1989; Lakanpal, 1996; Murrill, 1909; Pyasi et al., 2011; Shajahan and Samajpati, 1995; Sharma et al., 1978; Sharma and Lakanpal, 1988; Singer and Singh, 1971; Singer, 1948; Singer and Singh, 1971; Tiwari et al., 2013; Verma et al., 2008; Wu et al., 2014, 2015; Zang et al., 2001).

Results and Discussion

Taxonomic description

Boletellus ananas (M.A. Curtis) Murrill (Figure 1-6)

≡Boletus ananas M.A. Curtis

Pileus, convexo-plane, dry, dull crimson to rose red, often fading to pale fawn drab, finely tomentose, cracking in to large floccose squamules, 60-75mm in diameter and 22 mm
thick. Margin far exceeding the pores and covering them as a false veil, then splitting radially and stellately, appendiculate. Stem, central, 120 x 12 mm, subcylindric, base often enlarged and villous with thick white mycelium, tomentose, tan buff or buff-white, base and apex of pinkish shade. Flesh, 10 mm thick at the centre of the pileus, 4-5 mm halfway to the margin, creamish white with patches con-colorous with the pileus patches, soft to touch.

Hymenium, yellow, pores 1/mm, angular, pore tube 12mm long, yellow. Basidiospores, vinaceous chocolate brown, boletoid, longitudinally striate in the hyaline exospores, slightly curved, oblique main striae disappearing at the ends of the spore apiculate, 17.0-21.0 x 7.5-9.0µm. Basidia, long clavate, 41.5-53.0 x 12.5-15.0µm, sterigmata 3.5-5.5µm. Cystidia, ventricose with obtuse wide apex, some with a subcylindric appendage, thin walled, hyaline. Tramal hyphae, hyaline thick-walled septate, 5.0-7.5µm wide.

Collections examined
In humus of *Shorea robusta*, Nagadand forest, Sarguja, Chhattisgarh, 22/9/2011, Tropical Forest Research Institute TF 3196.

*Boletellus chrysenteroides* (Snell) Snell (Figures 7-10)

= *Boletus chrysenteroides* Snell

Cap 4-11cm, convex to broadly convex with age, dry, finely velvety to nearly bald; sometimes becoming cracked with age; dark brown to nearly black at first, becoming medium brown or eventually pale brown. Stem, 2-10cm long; up to 1.5cm thick; more or less equal, at first punctuated by brownish, *Leccinum*-like scabers that later become aggregated into hairy or sub-scaly clusters that sometimes approximate the appearance of reticulation; yellowish to brownish at first, becoming reddish to purplish red in the mid-portion with age. Pore surface: bright to dull yellow, becoming olive yellow; bruising slowly blue and eventually brown; pore 1-2/mm round to angular, tubes up to about 1cm deep. Flesh pale yellow to whitish, or with age reddish in the mid-portion of the stem and around damaged areas; changing to bluish or blue when sliced.

KOH reaction, black on cap, brownish on flesh, iron salts olive on flesh. Spore print, olive-brown. Basidiospores 10-17 x 5-8µm; longitudinally twisted-grooved; ellipsoid; yellow in KOH. Pileipellis a trichoderm; terminal elements often cystidioid, with sub-terminal elements sometimes somewhat inflated.

Collection examined
On soil surface in sal forest of Chada, Dindori, Madhya Pradesh, 25/07/2017, Tropical Forest Research Institute, TF 4041.

*Boletellus corneri* Klofac & Krisai (Figures 11-15)

=*Boletellus fallax* (Corner) Watling

Pileus convex, pale rose red to pinkish brown, bearing rough angular cracks on its dorsal surface exposing white creamy flesh, bearing yellow angular pore tubes 3-5 mm long. Stalk long 9-15 x 1-1.5cm, hard, characteristically bent, red rose to faint pink may be pinkish yellow with white mycelial tufts base. Spores 12.5-20 x 5-10µm, boletoid, round to elongate, oblong with small apicules, longitudinally striated with slender ridges 7-10 in side view. Basidia 27.5-40 x 8.75-12.5µm, sterigmata 4, (2.5-3.5µm long). Cystidia 45-160 x 12.5-15.5µm ventricose with prolong base 3.5-6.0µm wide and a projecting neck with obtuse to sub capitata apex 3-9µm wide.
**Collection examined**

On forest floor of sal, Amarkantak, Madhya Pradesh, 23/08/2011, Mycology Herbarium, Tropical Forest Research Institute, Jabalpur TF 2649.

**Boletellus dissiliens** (Corner) Pegler & T.W.K. Young (Figures 16-21)

≡*Boletus dissiliens* Corner

Pileus: 45 mm pale pinkish buff cap, yellow cyanescence flesh, yellow, dull pinkish tan, sub-tomentose, dry, cracking into large flag patches, margin at first greatly extending the pores, covering them as a veil, splitting radically, stellately. Stem: 70 mm long, solid and 8 mm wide near the apex, 12 mm at base, at the thickened base villose with the white mycelium, hard, concolourous with the pileus, apex pallid. Pore tube: 5 mm long, sinuato adnate, ventricose, golden yellow then brownish ochraceous, cyanescence: pore angular, concolours, cyanescence. Flesh: 6 mm thick in the centre of the pileus. 3-4 mm halfway to the margin, white, pale yellowish over the tube. Basidia 40-41 x 9-14.5µm, pyriform, sterigmata, 5.0-5.25µm. Cystidia: 41.5 x 17.68µm Basidiospores: olive brown in mass, ellipsoid boletoid, almond shape, rather coarsely striate with ridges, 13.5-17.5 x 5.5 - 8.5µm.

**Collection examined**

Growing under *Shorea robusta* tree, Amarkantak, Madhya Pradesh, 25/07/2017, Tropical Forest Research Institute TF 3986.

**Boletus edulis** Bull. (Figures 29-30)

≡*Leccinum edule* (Bulliard) Gray ≡*Dictyopus edulis* (Bulliard) Forquignon

Sporocarp small to medium sized. Pilus 5-3cm. diam., convex when young, broadly convex with age; surface dry, viscid when wet, glabrous, smooth, uneven colour brown, margin regular, smooth, incurved when young. Tubes 4-9 mm deep, adnexed but depressed around the stipe, violaceous grey when young. Pores minute, round, stuffed when young, pinkish brown to pale brown in age, unchanging on bruising.
Fig. 1-6 *Boletellus ananas* (1-2) Habit, fruitbody near sal tree (3) cystidia (4) hyphae (5) basidia with developing basidiospores on sterigmata (6) basidiospores

Fig. 7-10 *Boletellus chrysenteroides* (7) habit, (8) sporophore showing pore surface, stipe and volva (9) basidiospores and hyphae and (10) basidiospores
Fig.11-15 *Boletellus corneri* (11) fruitbody under sal tree (12) fruitbody pore surface, stioe and vulva (13) basidia with developing basidiospores (14) cystidia (15) basidiospores
**Fig.16-21** *Boletellus dissiliens* (16) habit (17-18) sporphores under sal tree (19) hyphae (20) basidia with developing basidiospores (21) basidiospores

**Fig.22-28** *Boletellus pseudochrysenteroides*. (22-24) habit (showing pileus, stem and pore surface covered with veil) (25) basidium (26) basidium attached with developing basidiospores and cystidia (27-28) basidiospores
Fig. 29-30 *Boletus edulis* (28) sporophore and (29) basidiospores
**Fig.31** Distribution of Boletaceous mushroom fungi in India

![Distribution of Boletaceous mushroom fungi in India](image)

**Table.1** Distribution of Boletaceous mushrooms in India

| S.N. | Species                                      | Habitat                                      | Distribution                                                                 | Reference                                      |
|------|----------------------------------------------|----------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------|
| 1.   | *Austroboletus olivaceoglutinosus* K. Das & Dentinger | On soil associated with *Tsuga dumosa*       | Sikkim                                                                      | Das and Dentinger (2015)                      |
| 2.   | *Boletellus ananas* (M.A. Curtis) Murrill    | In humus of sal forest and on base of *Holigarna arnottiana* | Nagadand, Sarguja, Chhattisgarh and Thiruvananthapuram, Kerala               | This article                                  |
|      |                                              |                                              |                                                                              | Vrinda, Pradeep (2014)                        |
| 3.   | *Boletellus chrysenteroides* (Snell) Snell   | On soil surface in sal forest                | Chada, Dindori, Madhya Pradesh                                             | This article                                  |
| 4.   | *Boletellus corneri* Klofac & Krisai         | On forest floor of sal                       | Amarkantak, Madhya Pradesh                                                 | This article                                  |
| 5.   | *Boletellus dissiliens* (Corner) Pegler & T.W.K. Young | On ground near base of sal tree               | Nagadand, Sarguja, Chhattisgarh                                             | This article                                  |
| 6.   | *Boletellus emodensis* (Berk.) Singer = *Boletus emodensis* Berk. | On forest soil                                | Khasi Hills, Meghalaya; Darjeeling, West Bengal and Sikkim                 | Berkeley (1851a,b; 1852; 1854)                |
| 7.   | *Boletellus pseudochrysenteroides* A.H. Sm. & Thiers | Growing under *Shorea robusta* tree           | Amarkantak, Madhya Pradesh                                                 | This article                                  |
| 8.   | *Boletus aestivalis* Fr.                     | On ground in forest                          | Himachal Pradesh                                                            | Lakanpal and Sagar                            |
| No. | Species                          | Distribution Notes                                                                 | References |
|-----|----------------------------------|--------------------------------------------------------------------------------------|------------|
| 9   | *Boletus alexandri* Sagar & T.N. Lakh. | On ground in forest; Himachal Pradesh                                               | Lakhanpal (1996) |
| 10  | *Boletus alutaceus* Morgan =*Boletus alutaceus* var. *similensis* T.N. Ladh. & Sagar | On brunt soil, and on forest ground; ectomycorrhizal with *Ficus benghalensis*     | Lakhanpal (1996) |
| 11  | *Boletus areolatus* Berk.         | Open pastures; Kala-Panee, Khasi Hills, Meghalaya                                   | Berkeley (1852a) |
| 12  | *Boletus chrysenteron* Fries     | Ecto-mycorrhizal with *Holigarna arnotiana*                                         | Vrinda, Pradeep (2014) |
| 13  | *Boletus cinerascens* Schwein., =*Boletus cyanescens* Bull. =*Gyroporus cyanescens* (Bull.) Quél. | On open places of earth; Darjeeling, West Bengal                                   | Berkeley (1851b) |
| 14  | *Boletus craspedius* Massee      | On soil under oak forest; Kumaon, Uttarakhand                                      | Harsh and Bisht, (1982b) |
| 15  | *Boletus delphinus* Hook.f. =*Boletus delphinus* Berk. | On soil; Darjeeling, West Bengal                                                   | Berkeley (1851a) |
| 16  | *Boletus dissiliens* Corner      | On soil under oak forest; Kumaon, Uttarakhand                                      | Harsh and Bisht, (1982b) |
| 17  | *Boletus edulis* Bull.           | Mycorrhizal on sal, growing on humicolic soil in coniferous forest and under *Syzygium cumini*; coniferous forest; on dead wood logs | This article |
|     |                                  | Amarkantak-Achanakmar, Madhya Pradesh and Chhattisgarh and Chishoti, Kishtwar, J&K; forest of Khunti, Jharkhand; Nagaland; Assam | Kumar and Sharma (2011b) |
|     |                                  |                                                                                      | Srivastava *et al.*, (2012) |
|     |                                  |                                                                                        | Ao *et al.*, (2016) |
|     |                                  |                                                                                        | Sarma *et al.*, (2010) |
| 18  | *Boletus emodensis* Berk.        | On the ground; Darjeeling, West Bengal                                              | Berkeley (1851a) |
| 19  | *Boletus fallax* Corner          | On forest floor of sal forest; Darjeeling, West Bengal                              | Pyasi *et al.*, (2012) |
| 20  | *Boletus formosus* Corner        | Growing in coniferous mixed and broad leaved forest; Dugga, Bhadarwah, Jammu & Kashmir | Kumar and Sharma (2011b) |
| 21  | *Boletus frostii* J.L. Russell   | On soil in pasture and deodar tree; Chail, Simla, Himachal Pradesh                 | Sharma *et al.*, (1978) |
| 22  | *Boletus furfuraceus* Berk.      | On clay-banks; Moflong, Khasi Hills, Meghalaya                                     | Berkeley (1852a) |
| 23  | *Boletus gigas* Berk.            | On soil and copses of *Andromeda* and Birch; Khasi Hills, Meghalaya and Lachen river, Sikkim | Berkeley (1852a); Horak (1980) |
| 24  | *Boletus gracilis* Peck.         | On soil rich in humus mixed forest; Chambaghata, Solan, Himachal Pradesh            | Sharma *et al.*, (1978) |
| 25  | *Boletus granulatus* L.          | Growing on humicolic soil in scattered coniferous forest; Dugga, Bhadarwah, Jammu & Kashmir | Kumar and Sharma (2011b) |
| 26  | *Boletus griseus* Frost          | On soil; Kandaghat, Solan, Himachal Pradesh                                         | Sharma *et al.*, (1978) |
| 27  | *Boletus hongoi* T.N. Ladh. & Sagar | On ground in forest; Himachal Pradesh                                              | Lakhanpal (1996) |
| No. | Species                                    | Habitat/Location                                                                 | Additional Information |
|-----|--------------------------------------------|---------------------------------------------------------------------------------|------------------------|
| 28. | *Boletus illudens* Peck                    | On grassland                                                                     | De (2006b)             |
| 29. | *Boletus lahanpalii* K. Das, D. Chakr., Baghela, Sanjay K. Singh & Dentinger | On soil, associated with *Larix griffithiana*                                   | Das *et al.*, (2015)   |
| 30. | *Boletus luridus* Schaefl                  | Growing on humicolous soil in scattered mixed forest                            | Bhadarwah, Jammu & Kashmir; Kumar and Sharma (2011b) |
| 31. | *Boletus niveus* Jullien ex Vill.           | On soil, mixed forest                                                           | Kandaghat, Solan, Himachal Pradesh; Sharma *et al.*, (1978) |
| 32. | *Boletus parvulus* (Paulet) Lév.           | On soil rich in humus mixed forest                                               | Chambaghat, Solan, Himachal Pradesh; Sharma *et al.*, (1978) |
| 33. | *Boletus pusillus* Berk. ≈ *Suillus pusillus* Kuntze | On ground                                                                       | Moflong, Khasi Hills, Meghalaya; Berkeley (1854a) |
| 34. | *Boletus rhodoxanthes* (Krombh) Kallenb.    | From moist humus soil under conifer dominated forest                            | Gulmarg, Kashmir; Dar *et al.*, (2010) |
| 35. | *Boletus rubripes* Thiers                  | Growing under *Picea spinulosa* Forest                                           | North district, Dombang valley, Sikkim; Das (2013a) |
| 36. | *Boletus scaber* Bull.                     | On soil                                                                         | Himachal Pradesh; Sharma *et al.*, (1978) |
| 37. | *Boletus scrobiculatus* Berk.              | On soil in open places and rotten wood                                           | Moflong, Khasi Hills, Meghalaya, Darjeeling, West Bengal; Berkeley (1852a) Horak (1980) |
| 38. | *Boletus squamatus* Berk. ≈ *Boletellus squamatus* (Berk.) Singer | In woods                                                                       | Myrung, Khasi Hills, Meghalaya; Berkeley (1852a) |
| 39. | *Boletus subaeastivalis* Sagar & T.N. Lakh. | Growing among plant debris                                                      | Himachal Pradesh; Lakhanpal (1996) |
| 40. | *Boletus thiersii* T.N. Lakh. & Sagar      | On clear soil                                                                   | Himachal Pradesh; Lakhanpal (1996) |
| 41. | *Boletus ustalis* Berk.                    | On rotten tree trunk                                                            | Darjeeling, West Bengal; Berkeley (1851a) |
| 42. | *Boletus variipes* Peck ≈ *Boletus variipes var. variipes* Peck | Growing solitary or gregariously in angiosperms forest soil                      | Shimla, Himachal Pradesh; Lakhanpal and Sagar (1989) |
| 43. | *Boletus vermiculosus var. thindii* T.N. Lakh. & Sagar | Associated with *Quercus* sp.                                                   | Himachal Pradesh; Lakhanpal (1996) |
| 44. | *Boletus verrucarius* Berk. ≈ *Boletellus verrucarius* (Berk.) Singer | On ground                                                                       | Sikkim; Berkeley (1854a) |
| 45. | *Boletus spp.*                             | On ground and in moist deciduous forest                                         | Namakkal, Tamil Nadu; Shimoga, Karnataka; Raja *et al.*, (2011) Swapan *et al.*, (2008) |
| 46. | *Borofutus dhakanus* Hosen & Zhu L. Yang   | Under sal and deciduous forest                                                  | Koderma, Jharkhand; Parihar *et al.*, (2014) |
| 47. | *Chalciporus piperatus* (Bull.) Bataille ≈ *Boletus piperatus* Bull.             | Ectomycorrhizal on sal, growing solitary in sal forest                          | Balibhasa, West Bengal; Shajahan and Samajpati (1995) |
| 48. | *Chalciporus rubinellus* (Peck) Singer ≈ *Boletus rubinellus* Peck               | growing gregariously on ground in coniferous forests and amongst grasses under tree, | Mandi, Himachal Pradesh and Jodhpur, Rajasthan; Lakhanpal and Sagar (1989); Chaouhan *et al.*, (2010) |
| 49. | *Hemileccinum subglabripes*                | On soil                                                                         | Moflong, Khasi Hills; Berkeley (1854a) |
| No. | Species                                                                 | Location                                                                 | Habitat                                                                 | Author(s) and Year(s) |
|-----|-------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------|
| 50. | *Hortiboletus indorubellus* K. Das, D. Chakr., Baghela, S.K. Singh & Dentinger | Meghalaya                                                               | On ground in forest, under *Betula alnoides*                         | Das *et al.* (2016)   |
| 51. | *Leccinum ustale* (Berk.) E. Horak ≡ *Boletus ustalis* Berk.            | Meghalaya                                                               | On soil                                                                 | Berkeley (1851a,b); Horak (1980) |
| 52. | *Octaviania longiana* S. Ahmad                                           | Meghalaya                                                               | On ground amongst grasses                                             | Ahmad (1950)          |
| 53. | *Phylloporus septocystidiatus* C.K. Pradeep & K.B. Vrinda              | Meghalaya                                                               | In tropical forest under *Hopea parviflora* and *Xanthophyllum arnottianum* | In Pradeep *et al.* (2015) |
| 54. | *Pulveroboletus fragicolor* (Berk.) Singer ≡ *Phaeogyroporus fragicolor* (Berk.) E. Horak ≡ *Boletus fragicolor* Berk. | Meghalaya                                                               | From mountain                                                          | Berkeley (1852a) Horak (1980) |
| 55. | *Pulveroboletus shoreae* Singer & B. Singh                               | Meghalaya                                                               | Ectomycorrhizal on sal, growing solitary in sal forest                | Singer and Singh, 1971; Shajahan and Samajpati (1995) |
| 56. | *Retiboletus kauffmanii* (Lohwag) N.K. Zeng & Zhu L. Yang = *Boletus kauffmanii* Lohwag | Meghalaya                                                               | Under *Lithocarpus* sp., broadleaf forest                              | Chakraborty *et al.* (2017) |
| 57. | *Retiboletus ornatipus* (Peck) Manfr. Binder & Bresinsky                | Meghalaya                                                               | On ground                                                              | Das (2013b)           |
| 58. | *Rhodactina himalayensis* Pegler & T.W.K. Young                         | Meghalaya                                                               | On soil under leaf litter, in association with roots of sal            | Pegler and Young (1989) |
| 59. | *Strobilomyces echinocephalus* Gelardi & Vizzini                       | Meghalaya                                                               | Growing in *Quercus semecarpifolia* and wild *Punica granatum* forest  | Kour *et al.* (2013)  |
| 60. | *Strobilomyces floccopus* (Fr.) Karsten                                | Meghalaya                                                               | On broad-leaved or coniferous woods                                    | Vrinda, Pradeep (2014) |
| 61. | *Strobilomyces kalimpongensis* Bose                                     | Meghalaya                                                               | On dead wood                                                           | Bose (1946)           |
| 62. | *Strobilomyces mollis* Corner                                           | Meghalaya                                                               | Growing on humicolous soil under *Pinus roxburghii* and *P. wallichiana.* | Kour *et al.* (2013); Lakhunpal (1996) |
| 63. | *Strobilomyces montosus* Berk.                                         | Meghalaya                                                               | On soil                                                                | Berkeley (1851a,b)    |
| 64. | *Strobilomyces nigricans* Berk.                                         | Meghalaya                                                               | On soil                                                                | Berkeley, 1852        |
| 65. | *Strobilomyces polypiramis* Hook. f.                                    | Meghalaya                                                               | On rotten wood and soil                                                | Horak (1980)          |
| 66. | *Strobilomyces strobilaceus* (Scop.) Berk.                             | Meghalaya                                                               | Grows in association with coniferous trees                             | Ao *et al.* (2016)    |
| 67. | *Strobilomyces velutipes*                                               | Meghalaya                                                               | On ground                                                              | Lloyd (1925)          |
| Number | Species                                      | Habitat                                      | Location                                      | Reference                                      |
|--------|---------------------------------------------|----------------------------------------------|-----------------------------------------------|------------------------------------------------|
| 68.    | Strobilomyces indicus Lloyd                 | Growing in leaf litter                       | Southern Rajasthan                            | Doshi and Mohammad (2015)                      |
| 69.    | Suillus luridus (Schaeff.) Murrill ≡Boletus luridus Schaeff. | On ground under Andromeda (Pieris sp.) and Betula | Lachen, Sikkim and Meghalaya                  | Berkeley, 1852); (Horak, 1980)                 |
| 70.    | Suillus luteus (L.) Roussel ≡Boletus luteus L. | On elephant dung                            | Assam                                         | Sarma et al., (2010)                          |
| 71.    | Suillus furfuraceus (Berk.) E. Horak ≡Boletus furfuraceus Berk. | On ground, semi evergreen and moist deciduous forest | Amarkantak, Madhya Pradesh                     | Dwivedi et al., (2012)                         |
| 72.    | Tylopilus areolatus (Berk.) Henn. ≡Boletus areolatus Berk. | Growing in open pasture                      | Kala-Panee, Khasi Hills, Meghalaya           | Berkeley (1852b); Manjula (1983)               |
| 73.    | Tylopilus chromapes (Frost) A.H. Sm. & Thierr ≡Boletus chromapes Frost | Growing on grassland                         | West Bengal                                   | De (2006b)                                    |
| 74.    | Tylopilus himalayanus D. Chakr., K. Das & Vizzini | Under Pinus sp. in mixed forest and under Cedrus deodara in coniferous forest | East District, Upper Chandmari, Sikkim and Champawat and Pauri, Uttarakhand | Chakraborty et al., (2018)                     |
| 75.    | Tylopilus indecisus (Peck) Murrill           | Growing on soil under oak forest             | Kumaon, Uttaralhand                           | Harsh and Bisht, (1982b)                       |
| 76.    | Tylopilus neofelleus Hongo                  | Under Castanopsis sp. in temperate broadleaf forest | East district, Fambonglo WLS, Sikkim         | Chakraborty et al., (2018)                     |
| 77.    | Tylopilus plumbeoviolaceus (Snell & E.A. Dick) Snell & E.A. Dick ≡Boletus plumbeoviolaceus Snell & E.A. Dick | On ground in a pasture surrounded by Cedrus deodara forest | Kullu, Himachal Pradesh                       | Sharma and Lakhnanpal (1988)                   |
| 78.    | Tylopilus pseudoballouli K. Das, D. Chakr & Vizzini | Under Quercus spp.                           | South District, Maenam WLS, Sikkim           | Chakraborty et al., (2018)                     |
| 79.    | Xerocomellus chrysenteron (Bull.) Sutara ≡Xerocomus chrysenteron (Bull.) Quél. | On ground, semi evergreen and moist deciduous forest; sub-tropical semi-evergreen forests | Amarkantak, Madhya Pradesh Nagaland           | Dwivedi et al., (2012); Ao et al., (2016)      |
| 80.    | Xerocomus bakshii Singer & B. Singh         | On soil connected with roots of Pinus roxburghii | Dehradun, Uttarakhand                         | Singer and Singh, (1971)                       |
| 81.    | Xerocomus delphinus (Hook. f.) Manjula      | On open places of earth                      | Darjeeling, West Bengal                       | Berkeley (1951b); Manjula (1983)              |
| 82.    | Xerocomus doodhcha K. Das, D. Chakr., Baghela, S.K. Singh & Dentinger | On ground in broadleaf forest, of Lithocarpus pachyphyllus | Sikkim                                         | Das, et al., (2016)                           |
| 83.    | Xerocomus indicus Singer                    | -                                            | from India                                    | Butler and Bisby (1960); Singer (1948)        |
| 84.    | Xerocomus longistipitatus K. Das, A. Parihar, D. Chakr. & A. Baghela | On soil under under Lithocarpus sp., broadleaf forest | Rabangla, alt. 1985m, Sikkim                 | Chakraborty et al., (2017)                     |
Stipe central 4-6 x 1-2cm across, bulbous at base or almost parallel, pale greyish violet in apical part, whitish brown at base, reticulate in the upper half, base sub-radiating, flesh firm, white unchanging. Basidia 26-28 x 5-7µm clavate, 4-spored, hyaline. Pleurocystidia scattered 36-42 x 6-9µm, narrowly fusoid ventricose, smooth, thin walled; cheilocystidia similar to pleurocystidia. Hyphae 7-10µm wide; subcutis composed of interwoven hyphae, stipe cuticle of loosely interwoven clavate to ventricose, thin-walled, clamp-connection absent. Basidiospores olive brown, 5-2.5 x 2-1.2µm, ellipsoid, subfusiform, smooth walled, hilum distinct.

**Collection examined**

Mycorrhizal on sal, Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012, Mycology Herbarium, Tropical Forest Research Institute, Jabalpur TF 2786.

Total 84 species of family boletaceae reported from India were compiled and presented in Table 1 including 37 species of *Boletus* excluding two unidentified species. The next common genus is *Strobilomyces* represented by 9 species followed by *Tylopilus* (7 species), *Boletellus* (6 species), *Xerocomus* (5 species each), and *Suillus* (3 species) *Chalciporus* and *Pulveroboletus* (2 species each). *Austroboletus malacensis* var *autroboletus* was reported from *Quercus* sp., *Pinus wallichiana* and *Cedrus deodara* forest, Jammu & Kashmir (Kumar and Sharma, 2011b); *Chalciporus piperatus*, an ectomycorrhizal fungus from sal forest, West Bengal (Shajahan and Samajpati, 1995) while *Chalciporus rubinellus* was reported from coniferous forests of Mandi, Himachal Pradesh (Lakhanpal and Sagar, 1989) and Jodhpur, Rajasthan (Chauhan et al., 2010). *Octaviania asterosperma* and *Octaviania longiana* were reported from Rohtak (Cunningham, 1942; Ahmad, 1950). *Pulveroboletus shoreae*, an ectomycorrhizal bolete with sal, was reported from Dehradun, Uttarakhand and Gidhani, West Bengal (Singer and Singh, 1971; Shajahan and Samajpati, 1995) and *Rhodactina himalayensis* from Uttar Pradesh (Pegler and Young, 1989). *Tylopilus areolatus*, and *Tylopilus chromapes* were reported from Meghalaya (Berkeley, 1852b; Manjula, 1983) and West Bengal (De, 2006b) while *Tylopilus indecisus* and *Tylopilus plumbeoviolaceus* were reported from Uttaralhand (Harsh and Bisht, 1982b) and Himachal Pradesh (Sharma and Lakhanpal, 1988). *Xerocomus bakshii*, *X. delphinus* and *X. indicus* were also reported from India (Berkeley, 1951b; Butler and Bisby, 1960; Singer, 1948; Singer and Singh, 1971; Manjula, 1983).

There is no record of occurrence of bolataceae in Andhra Pradesh, Maharashtra and Karnataka but local communities in these states and also of Goa, Kerala and Tamil Nadu cultivate popular edible mushrooms including Boletaceae which are safe for human consumption (www.maria-online.com (Boletus). Along with other popular edible mushrooms the ectomycorrhizhal boletes also reported from Western Ghats (Maharashtra, Karnataka, Goa, Kerala and Tamil Nadu) (www.nzdl.org/gsdlmod?).

Fungi accommodated in family Boletaceae were reported from different places of India, a list of 82 species is presented in Table 1. Boletaceous mushroom fungi were distributed in Himachal Pradesh followed by Meghalaya, West Bengal, Uttarakhand, Madhya Pradesh, Chhattisgarh, Sikkim, Jammu and Kashmir, Kerala, Nagaland, Uttar Pradesh, Haryana and Rajasthan (Figure 31). *Boletellus ananas* reported from Kerala growing under *Holigarna arnottiana* (Vrinda and Pradeep, 2014) for the first time it is being reported from sal forest of CG. This species is earlier
reported growing beside old log of *Pinus* and oaks in South Carolina (Murrill, 1909) and also as forming ecto-mycorrhizal associations with eucalypts in Australia (Gardner and Malajczuk 1988). Other places of distribution include Malaya, Singapore, Borneo, Kinabalu and Mesilau (Corner, 1972; Mayor et al., 2008; McNabb, 1967; Yeh et al., 1982; Zhishu, 1993). Although this mushroom is used as a food in Mexico (Boa, 2004) but another field guide listed it as inedible or not recommended for eating (Bessette et al., 2007).

*Boletellus chrysenteroides*, probably ectomycorrhizal and reported to be associated with oaks and eastern hemlock and often found growing near well decayed oak stumps, usually growing alone. This fungus is widely distributed in North Carolina, USA, Aylmer and Ontario in Canada (Snell, 1936, 1941) and also for the first is being reported from Madhya Pradesh and Chhattisgarh. However, *Boletellus corneri* was earlier reported as *Boletus fallax* from sal forest of Amarkantaka, Madhya Pradesh (Pyasi et al., 2012). This mushroom is reported to be distributed in Malaya (Singapore) (Corner, 1972). *Boletellus dissiliens* was reported growing on soil or ground near base of Myrtaceae and Fagaceae and distributed in Singapore and Australia (Corner, 1972). *Boletellus pseudochrysenteroides* is reported mycorrhizal with hardwoods of beech and oaks and distributed in USA (Illinois, Michigan and Arizona) (Smith and Thiers, 1971).

Genus *Boletus* is very common amongst mushroom of family boletaceae and out of 50 known species from world 37 species are reported from India (Table 1). *Boletus edulis* was reported growing on humicolous soil in coniferous forest of Jammu & Kashmir (Kumar and Sharma 2011b). It was reported as forming ectomycorrhizal association with sal, *Syzygium cuminii* and growing on dead wood logs in Madhya Pradesh, Chhattisgarh, Jammu & Kashmir, Jharkhand, Nagaland and Assam (Kumar and Sharma, 2011b; Srivastava et al., 2012; Ao et al., 2016; Sarma et al., 2010). The present article reports it for the first time sal forest of Madhya Pradesh and Chhattisgarh. *Boletus lakhanpalii* is recently reported from Sikkim (Das et al., 2015). Besides sal, other known tree species reported in literature under which this mushroom can grow and form ectomycorrhizal associations includes, *Hopea ponga*, *H. parviflora*, *Vateria indica*, and *Diospyros malabarica*. *B. edulis* is distributed worldwide and also reported from moist deciduous forests of India as well as in the forests of Arunachal Pradesh (Adhikary et al., 1999).

*Austroboletus olivaceoglutinosus* forming ecto-mycorrhizal association with *Tsuga dumosa* in forest of Sikkim (Das and Dentinger, 2015), it is the only species of the genus reported from India. Genus *Chalciporus* is represented by two species in India, *C. piperatus* which form ectomycorrhiza with sal in forest of West Bengal (Shajahan and Samajpati, 1995) and the another species, *C. rubinellus* is reported growing gregariously in coniferous forests and amongst grasses under tree from Mandi, Himachal Pradesh and Jodhpur, Rajasthan (Lakhanpal and Sagar, 1989; Chaouhan et al., 2010). *Hemileccinum subglabripes* is the only species under this genus recorded from Moflong, Khasi Hills, Meghalaya (Berkeley, 1854a). The species was earlier known as *Pulveroboletus flavipes* and *Boletus flavipes*. One species of *Leccinum*, *L. ustale* was reported from Khasi mountain, Meghalaya and from Sikkim (Berkeley 1851a, b; Horak, 1980) the species was earlier known as *Boletus ustalis*. *Octaviania longiana* was the only species of boletes reported from Rohtak, Haryana (Ahmad, 1950) while *Phylloporus*
septocystidiatus is reported from tropical forest under Hopea parviflora and Xanthophyllum arnottianum from Palode, Thiruvanthapuram, Kerala (in Pradeep et al., 2015). Two species of Pulveroboletus, namely P. fragicolor and P. shoreae were reported India. P. fragicolor is reported from Nunklow, mountain Khasi, Meghalaya (Berkeley, 1852a; Horak, 1980). P. shoreae was reported to form ectomycorrhizal association with sal in forest at Dehradun, Uttarakhand (Singer and Singh, 1971) and the species is growing solitary in sal forest of Gidhani, West Bengal (Shajahan and Samajpati, 1995). Two species of Retiboletus, R. kauffmanii earlier known as Boletus kauffmanii was reported from broadleaf forest under Lithocarpus sp., from Maenam, Sikkim (Chakraborty et al., 2017) while second species was R. ornatipus which also occurred in Sikkim (Das, 2013b). One species, Rhodactina himalayensis was recorded growing in leaf litter and in association with sal trees in a forest of Uttar Pradesh (Pegler and Young, 1989).

Stroblomyces species have wide distribution from north to southern India and nine species have been reported including some recent reports. S. echinocephalus occur under Quercus semecarpifolia and wild Punica granatum forest and S. mollis grew on humicolous soil under Pinus roxburghii and P. wallichiana in Jammu and Kashmir (Kour et al., 2013; Lakhanpal, 1996). S. floccopus was reported from broad-leaved forests or coniferous woods from Thiruvananthapuram, Kerala (Vrinda and Pradeep, 2014). S. kalimpongensis occur on dead wood in Kolkata, West Bengal (Bose, 1946). S. montosus and S. nigricans were reported from Khasi Hills, Meghalaya and Darjeeling, West Bengal (Berkeley, 1851a, b; 1852). S. polypyramis was found on rotten wood and soil in Darjeeling, West Bengal and Sikkim (Horak, 1980). S. strobitaceus was recently reported growing in association with coniferous trees in Nagaland (Ao et al., 2016). S. velutipes was reported from Mussoorie, Uttarakhand and Saharanpur, Uttar Pradesh (Lloyd, 1925).

Suillellus luridus, earlier known as Boletus luridus was reported growing in leaf litter in forest of Southern Rajasthan (Doshi and Mohammad, 2015). Three species of Suillus were reported from Sikkim, Meghalaya, Assam and Madhya Pradesh including S. furfuraceus grew under Pieris and Betula, S. luteus on elephant dung and S. spraguei from semi evergreen and moist deciduous forest (Berkeley, 1852; Dwivedi et al., 2012; Horak, 1980; Sarma et al., 2010).

Seven species of genus Tylopilus were reported from northern and north eastern India these include: T. areolatus grew in open pasture at Khasi Hills in Meghalaya (Berkeley, 1852b; Manjula, 1983), T. chromapes from grassland of West Bengal (De, 2006b), T. himalayanus from Pinus sp. and Cedrus deodara forests of Sikkim and Uttarakhand; T. neofelleus grew under Castanopsis sp. and T. pseudoballoui under Quercus spp., Sikkim (Chakraborty et al., 2018). T. indecisus collected from soil surface under oak forest of Kumaon, Uttarakhand (Harsh and Bisht, 1982b) and T. plumbeoviolaceus from pasture surrounded by Cedrus deodara forest Himachal Pradesh was reported (Sharma and Lakhanpal, 1988).

Xerocomellus chrysenteron was recorded from semi evergreen and moist deciduous forest of Amarkantak, Madhya Pradesh and Nagaland (Dwivedi et al., 2012; Ao et al., 2016). X. bakshii was connected with roots of Pinus roxburghii in forest at Dehradun, Uttarakhand (Singer and Singh, 1971). X. delphinus was recorded from open places of earth from Darjeeling, West Bengal (Berkeley, 1951b; Manjula, 1983). Two
species were recently described from Sikkim; *X. doodhcha* from broadleaf forest of *Lithocarpus pachyphyllus* and *X. longistipitatus* from the soil under *Lithocarpus* sp. (Das, et al., 2016; Chakraborty et al., 2017). *Xerocomus indicus* was also recorded from India (Butler and Bisby, 1960; Singer, 1948).

Total 84 species of Boletaceae were recorded from India. *Boletus* species are the most common followed by *Strobilomyces*, *Tylopilus*, *Boletellus*, *Xerocomus*, *Suillus*, *Chalciporus*, *Retiboletus* and *Pulveroboletus*. The most common bolete mushroom representing state is Himachal Pradesh in India followed by Sikkim, Meghalaya, West Bengal, Madhya Pradesh, Chhattisgarh and Kerala. *Boletellus ananas*, *B. chrysenteroides*, *B. dissiliens*, *B. pseudochrysenteroides*, *B. corneri* and *Boletus edulis* were recorded for the first time from Sal forest of Central India (Chhattisgarh and Madhya Pradesh).

**Acknowledgement**

The authors are thankful to Dr. G. Rajeshwar Rao, Director, Tropical Forest Research Institute, Jabalpur for providing the research facilities. The work presented was conducted under project ID No. 224/TFRI/2016/Patho-1(22) funded by Indian Council of Forestry Research & Education (ICFRE), Dehradun.

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How to cite this article:

Verma R. K. and Vimal Pandro. 2018. Distribution of Boletaceous Mushrooms in India, Some New Records from Sal Forest of Central India. *Int.J.Curr.Microbiol.App.Sci.* 7(06): 1694-1713. doi: [https://doi.org/10.20546/ijcemas.2018.706.201](https://doi.org/10.20546/ijcemas.2018.706.201)