

## 6. TAXONOMIC INVESTIGATIONS

Two investigated genera, namely *Lentinus* Fr. (Order: Polyporales) and *Pleurotus* (Fr.) P. Kumm. (Order: Agaricales) belong to class Agaricomycetes of phylum Basidiomycota. A key to the segregation of individual genus with respective order in parenthesis is given below:

### Key to the investigated Genera

Basidiocarps centrally to excentrically stipitate, tough and coriaceous; hyphal construction dimitic with either skeletal or binding hyphae along with generative hyphae..... *Lentinus* (Order : Polyporales, Family: Polyporaceae)

Basidiocarps pleurotoid; soft and fleshy when fresh, hyphal system monomitic.....*Pleurotus* (Order – Agaricales, Family: Pleurotaceae)

To begin with the diagnosis of the order Polyporales to which the investigated genus *Lentinus* Fr. belongs has been given followed by the check list to the species of *Lentinus* documented from India. A key to the presently investigated species of the genus followed by taxonomic and cultural characteristics of the individual species has been given in the ongoing account in the sequence of segregation of respective taxon in the key.

### 6.1. Order Polyporales Gäumann. *Vergleichende Morphologie der Pilze* : 503 (1926).--**A Diagnosis and taxonomic studies undertaken**

The order includes some polypores as well as many corticioid fungi and a few agarics (mainly the genus *Lentinus* Fr.). Species within the order are saprotrophic, most of them wood - rotters. Those of economic importance include several important pathogens of forest and avenue trees and a few species that cause damage by rotting structural timber. Some of the Polyporales are commercially cultivated and marketed for use as food items or in traditional Chinese medicine.

**HABIT AND DISTRIBUTION:** The order is cosmopolitan and contains around 1800 species worldwide (Kirk *et al.*, 2008). All species in the Polyporales are saprotrophs, most of them wood - rotters. They are typically found on living or on dead attached or fallen wood.

**DEVELOPMENT:** All species show gymnocarpic mode of development.

**STATISTICS:** German mycologist Ernst Albert Gäumann proposed this order in 1926 to accommodate species within the phylum Basidiomycota producing basidiocarps showing a gymnocarpous mode of development. As such, the order included ten families, namely Brachybasidiaceae, Corticiaceae, Clavariaceae, Cyphellaceae, Dictyolaceae, Fistulinaceae, Polyporaceae, Radulaceae, Tulasnellaceae and Vuilleminiaceae, representing a mix of poroid, corticioid, cyphelloid, and clavarioid fungi. However, the order was not widely adopted by Gäumann's contemporaries but most mycologists and reference works preferred to use the artificial order Aphyllorphorales for polypores and other "non-gilled fungi". Molecular research, based on cladistic analysis of DNA sequences, has resurrected and redefined the order Polyporales (Hibbet, 2006; Binder *et al.*, 2005). In the present work the concepts as adopted by Kirk *et al.* (2008) in the latest version of "Dictionary of Fungi" has been followed.

**Family Polyporaceae (Fr.) Fr. *Epicr.*, p. 408 (Polyporei, as ordo) - 1838; Corda, *Icon. Fung.*, 3 : 49 (1839). ----- A Diagnosis**

Polyporaceae is a family of bracket fungi belonging to the Basidiomycota. The flesh of their fruiting bodies varies from soft to very tough. Most members of this family have their hymenium (fertile layer) in vertical pores on the underside of the caps, but some of them have gills (e.g., *Lentinus* Fr., *Panus* Fr.) or gill-like structures (Daedaleopsis). Carpophores small to large. Pileus convex to depressed, usually fleshy but especially in age become fleshy tough, pilose squamose or fibrillose or

glabrous. Hymenophore reduced and venose to lamellate or tubular, never free, stipe central to excentric or even lateral or absent, solid, continuous with the pileus. Partial veil present or absent. Spore print white to cream, occasionally pink when fresh. Spores oblong to cylindrical, at times arcuate or allantoid, hyaline, thin walled, inamyloid. Hymenophore edge sterile, crowded with hyphal endings or differentiated cheilocystidia. Pleurocystidia present or absent. Hymenophoral trama regular to irregular often intermixed, never bilateral. Pileus context fleshy to leathery inamyloid; hyphal system monomitic or dimitic with skeletal or binding hyphae. Clamp connections usually numerous.

**DEVELOPMENT:** Gymnocarpic

**HABIT AND HABITAT:** Pleurotoid, clitocyboid or polyporoid. Habitat on wood, living as well as dead, also on living or dead roots or immersed wood, rarely on grass roots, charcoal etc.

As during the present investigations only genus *Lentinus* Fr. of this family was studied for taxonomic, nutritional and nutraceutical attributes, hence its diagnosis followed by checklist of Indian species and key to the investigated taxa is given

## **Genus *Lentinus* Fr. *Syst. Orb. Veg.* : 77 (1825) ----- A Diagnosis**

### **Synonyms**

*Agaricus* Fr. 'subtribe.' *Lentiscyphi* Fr., *Syst. Mycol.* **1** : 174 (1821).

*Scleroma* Fr., *Epicrasis* : 387 (1838).

*Panus* Fr., *Epicrasis Systematis Mycologici* . 396 (1838)

*Lentodium* Morgan. *Journ. Cincinn. Soc. Nat. Hist.* **18** : 36 (1895).

*Pocillaria* P. Browne ex Earle in *Bull. Bot. Gard.* **5** : 416 (1909).

*Lentodiellum* Murr. *Mycologia* **7** : 216 (1915).

*Lentinopanus* (Pilát) Pilát. *Ann. Mycol.* **39** : 72 (1941).

*Cryptomphalina* Heim. *Rev. Mycol.* **30** : 234 (1966).

## **Generic Diagnosis**

Basidiocarps solitary or caespitose, tough, persistent, xeromorphic, lignicolous, rarely graminicolous; agaricoid with a lamellate hymenophore. Pileus coriaceous, first convex, then depressed to umblicate-cyathiform or even infundibuliform, sometimes flabelliform, surface dry, fibrillose - squamulose, radially striate, mostly dull colored except in young stages. Lamellae decurrent, at times intervened, rarely furcated, moderately spaced to densely crowded; edges entire, denticulate or coarsely serrate. Stipe mostly central, sometimes lateral to much reduced, solid, continuous with pileus. Context tough fibrous, mostly thin, sometime fleshy consisting of dimitic hyphal construction; with generative hyphae bearing clamp connections; skeletal hyphae with thick walls branched or unbranched. Spore print white to cream. Spores elongate cylindrical, sometimes ovoid to ellipsoid, hyaline, thin walled, smooth, aporous, inamyloid. Basidia tetrasporic. Lamellae edges always sterile, either with emergent skeletal elements, chielocystidia or both. Pleurocystidia absent or more rarely present and appearing metuloidal. Hymenophoral trama either initially regular then becoming irregular. Pileipellis mostly undifferentiated, forming a repent epicutis of radially parallel hyphae, sometimes trichodermial.

**HABIT AND HABITAT:** Lentinoid, on wood.

**DEVELOPMENT OF THE CARPOPHORE:** Species of the genus *Lentinus* Fr. exhibit gymnocarpic development with the hymenophore developing externally on the primordium and remaining so throughout the development.

**DISTRIBUTION:** Cosmopolitan, mostly in tropics and rarely in temperate regions.

**LIMITS:** The genus *Lentinus* Fr. can be distinguished from its closely related genus *Pleurotus* (Fr.) P. Kumm. by its dimitic hyphal system with either skeletal or binding hyphae along with generative hyphae and firm and persistent texture. In *Pleurotus* (Fr.) P. Kumm. the hyphal system is monomitic, and the texture of basidiocarps is soft fleshy and soon decaying, never persistent.

**STATISTICS:** In genus *Lentinus* Fr. 40 species are known the world over (Kirk *et al.*, 2008). As compared from India 40 species have been documented from time to time (Butler and Bisby, 1931; Vasudeva, 1960; Bilgrami *et al.*, 1979, 1991; Purkayastha and Chandra, 1985; Manimohan and Leelavathy, 1995; Sarbhoy *et al.*, 1996; Jamaluddin *et al.*, 2004; Manimohan *et al.*, 2004; Kumar and Manimohan, 2005 and Natarajan *et al.*, 2005). Upon scrutiny of the latest authentic literature (Pegler, 1983; Manjula, 1983) and Mycobank record, out of total 40 species reported to have been documented from India, 24 are valid species while 16 are invalid species which stands deleted from Indian record. A revised check list of valid and species recommended for exclusion from the Indian record of *Lentinus* Fr. is given below.

### **Check list of *Lentinus* Fr. species recorded from India**

#### **List of included species**

1. *L. alopecinus* (Fr.) Fr. *Epicrasis* 392 (1838).

Fries (1838) documented its occurrence from India. As pointed out by Pegler (1983), it was the earliest species described from "India Orientalis" with very brief original description for which neither type nor any another material is available. *L. alopecinus* (Fr.) Fr. is a valid species in MycoBank.

2. *L. connatus* Berk. *Hooker Journ. Bot.* 1 : 145 (1842).

Bose (1920) documented this species on dead wood from Howrah (West Bengal). It is a valid species and was also documented from time to time from different localities including Dehradun in Uttar Pradesh (now Uttarakhand), Maharashtra and Assam by different workers (Pegler, 1983; Manjula, 1983). Present collection has been made from Chandigarh in Punjab.

3. *Lentinus badius* Berk. *Lon. Journ. Bot.* **6** : 491 (1847).

In his World monograph Pegler (1983) has enlisted the collection of *L. badius* (Berk.) Berk. from Darjeeling (West Bengal), Khasia Hills (Sikkim) and Manipur in India which accounts for its valid documentation. This is a valid species in MycoBank.

4. *L. lepideus* (Fr.:Fr.)Fr. *Syst. Orb. Veg.* **78** (1825).

Its occurrence has been reported from Chakrata (Deoban, Kanam) in Uttar Pradesh (now Uttrakhand) and Kullu (Munaki and Bushahar Division) in Himachal Pradesh (Pegler, 1983 ; Bakshi, 1955). It exists as a legitimate species in MycoBank.

5. *L. sajor-caju* (Fr.) Fr. *Epicrasis Syst. Mycol.* 393 (1838).

Pegler (1983) in his World monograph on *Lentinus* has enlisted its occurrence from Seram in West Bengal and Assam. Bose (1920) documented it on dead wood from Hoogly district of West Bengal. Butler & Bisby (1960) in Fungi of India has also reported its occurrence from South Andaman Islands (Cooke described it as *L. exilis* Klotzsch from Annamalai in Kerela). Presently this species was collected from Renuka Lake (Sirmour) in Himachal Pradesh. It exists as a legitimate species in MycoBank.

6. *L. squarrosulus* Mont. *Ann. Sci. Nat. Bot.* **18** : 21 (1842).

It is one of the most widely distributed species in India which has been documented from number of localities including Madras (Natarajan and Manjula, 1978), Khandala, Maharashtra by Theissen (1911) as *L. subnudus* Berk., Calcutta in West Bengal by Bose (1920) as *L. subnudus* Berk. and Banerjee (1947) as *Lentinus curreyanus* Sacc. & Cub. Present collection has been documented from Palampur in Himachal Pradesh. It exists as a valid species in Mycobank.

7. *L. strigosus* Fr. *Sys. Orb. Veg.* **77** (1825).

Murrill (1924) and Watling and Gregory (1980) documented it from Sonamarg (Kashmir). Abraham (1991) reported it from Kashmir. It is also known from number of other localities in India (Pegler, 1983). Berkeley (1851) described it as *L. lecomtei* Fr. from Tonglo in Sikkim. It exists as a legitimate species in MycoBank.

8. *L. subdulcis* Berk. *Hooker Journ. Bot. and Kew Misc.* **3** : 46 (1851).

Pegler (1983) in his World monograph of *Lentinus* has listed its occurrence from Darjeeling (West Bengal) and Ootacamund in Tamil Nadu. There is no record for this species in MycoBank, although it is a validly described species (Pegler, 1983).

9. *L. tigrinus* (Bull.) Fr. *Syst. Orb. Veg.* **78** (1825).

Lloyd (1904 - 1919) listed its occurrence from India. Other reports of its occurrence are by Watling and Gregory (1980) from Sarband and Abraham (1991)

from Anant Nag and Srinagar in Jammu and Kashmir. It exists as a valid species in MycoBank.

**10. *L. velutinus* Fr. *Linn.* **5** : 510 (1830).**

Currey (1874) and Lloyd (1904 - 1919) documented the occurrence of this species from Bengal in India. Pegler (1983) in his World monograph on *Lentinus* reported its occurrence from Dehradun in Uttar Pradesh (now Uttarakhand) and Kodaikanal in Tamil Nadu. Berkeley (1851) described this species as *L. hookerianus* Berk. from Darjeeling in West Bengal, Banerjee (1943) described it as *L. blepharodes* Berk. from Calcutta and Hennings (1900) as *L. melanophyllus* Lév from Bilaspur in Madhya Pradesh. It exists as valid species in the MycoBank.

**11. *L. villosus* Klotzsch *Linn.* **8** : 479 (1833).**

This species was reported by Lloyd (1904 - 1919) for the first time from India. Manjula (1983) listed it as synonym of *L. crinitus* Berk. and recommended the exclusion of *L. villosus* Klotzsch from the Indian records. However, *L. crinitus* Berk. has been listed as synonym of *L. swartzii* Berk. by Pegler (1983). *L. villosus* Klotzsch being a valid species stands restored to the list of Indian species of *Lentinus* Fr. It exists as a legitimate species in the MycoBank.

**12. *L. polychrous* Lév. *Ann. Sci. Nat. Bot.* **2** : 175 (1844).**

Pegler (1983) in his World monograph on *Lentinus* listed the occurrence of this species from Bihar, West Bengal and Andhra Pradesh. Natarajan and Manjula (1978) and Manimohan *et al.* (2004) described it from Tamil Nadu. Berkeley (1854) and Banerjee (1947) described it as *L. praerigidus* from Bihar and West Bengal, respectively. It exists as a valid species in Mycobank.

**13. *L. cladopus* Lév. *Ann. des Sci. Nat. Bot.* **2** : 174 (1844).**

This species was reported by Natarajan (1978) and Natarajan and Raman (1980) from Madras in TamilNadu. Pegler (1983) has also listed it from Cochin in Kerela. Presently, this species was documented from Palampur in Himachal Pradesh on *Albizia chinensis* Benth. It exists as a valid species in MycoBank.

**14. *L. tuber-regium* (Fr.) Fr. *Syn. gen. Lent.* : **10** (1836).**

It was reported to occur in Trichur (Kerela) by Pegler (1983) and Pathak and Gupta (1982) from Uttar Pradesh. It exists as a legitimate species in the World Monograph of *Lentinus* by Pegler (1983). It exists as a valid species in MycoBank.

**15. *L. prolifer* (Pát. & Har.) Pegler *Kew Bull. Addit. Ser.* **6** : 40 (1977).**

Natarajan and Raman (1981) documented this species from Madras in Tamil Nadu. It exists as a valid species in MycoBank.

16. *L. caespiticola* var. *asiaticus* Manim. & Leelav. *Mycol. Res.* **99** (4) : 451 (1995).

Manimohan and Leelavathy (1995) documented it for the first time from Kerala. It exists as a valid species in MycoBank.

17. *L. giganteus* Berk. Hooker *Journ. Bot.* **6** : 493 (1847).

Joseph *et al.* (1995) and Manimohan *et al.* (2004) documented this species for the first time from India. It exists as a valid species in MycoBank.

18. *L. dicholamellatus* Manim. *Mycotaxon* **90**(2): 312 (2004).

This species was documented from Tamil Nadu by Manimohan *et al.* (2004). It exists as a valid species in MycoBank.

19. *L. torulosus* Fr. (Pers.:Fr.) Llyod. *Mycol. Writ.* 4, Lett. **47**:13 (1913).

Atri *et al.* (2010) documented this species for the first time from Bhadrol (Palampur) in Himachal Pradesh. Pegler (1983) in his World monograph has treated it as a legitimate species. It exists as a valid species in MycoBank.

20. *L. similis* Berk. & Broome. *Journ. Linn. Soc. Bot.* **14** : 43 (1873).

Pegler (1983) in his World monograph reported the occurrence of this species from Khasia Hills West Bengal, Nagarhole Game Sanctuary (Coorg District) in Karnataka, Nilgiri Hills, Ootacamund and Tinnevely in Tamil Nadu. It exists as a legitimate species in MycoBank.

21. *L. candidus* Graff. *Philipp. Journ. of Sci. Bot.* **8** : 302 (1913).

Lloyd (1898 - 1925) documented it from India. *L. candidus* Graff. has been treated as the synonym of *L. connatus* Berk. by Pegler (1983). In view of this Manjula (1983) deleted it from Indian record. However, in MycoBank's opinion this species is currently in use and is a valid species.

22. *L. glabratus* Mont. *Ann. Sci. Nat. Bot.* **17** : 128 (1842).

This species was documented from Raj Mahal Hills (North Bengal) by Currey (1874). Although *L. glabratus* Mont. is a valid species but the collection assigned to *L. glabratus* Mont. from India has been assigned to *L. squarrosulus* Mont. (Pegler, 1983 ; Manjula, 1983). However, in MycoBank's opinion, this species is currently in use and hence is a valid species for inclusion in Indian record.

23. *L. hookerianus* Berk. *Hook. Journ. Bot. and Kew Misc.* **3** : 45 (1851).

Berkeley (1856) documented this species from Darjeeling (West Bengal) on dead wood. Pegler (1983) has also enlisted a collection made on July 18, 1977 by Samajpati from Calcutta in his World monograph. Although a validly described species, Manjula (1983) listed *L. hookerianus* as synonym of *L. velutinus* Fr. and

recommended its exclusion from the Indian record. However, in Mycobank's opinion this species is currently in use and hence is a valid species for inclusion in Indian record.

**24. *L. blepharodes* Berk. *Jour. Lin. Soc. Bot.* **10** : 301 (1869).**

Lloyd (1904 - 1919) recorded it from Botanic Garden of Saharnpur in Uttar Pradesh and Banerjee recorded it on dead tree of *Cocos nucifera* from Calcutta in West Bengal. Pilát in Index of Fungi by Petrak (1950) made a new combination *L. velutinus* Fr. var. *blepharodes* (Berk. and Curtis) Pilát. Later Pegler (1983) treated *L. blepharodes* (Berk. and Curtis) Pilát as the synonym of *L. velutinus* Fr. in his World monograph of *Lentinus*. In view of this Manjula (1983) deleted *L. blepharodes* Berk. from the Indian records however, it exists as a valid species in MycoBank.

**List of excluded species from Indian records**

**1. *L. coadunnatus* Hook. *Hooker Journ. Bot.* **3** : 45 (1851).**

Berkeley (1856) documented it from Darjeeling on dead wood. Lloyd (1904 - 1919) equated this species with *L. subnudus*. Pegler (1983) relegated it to the level of synonym of *L. squarrosulus* Mont. as a consequence of which *L. coadunnatus* Hook. stands deleted from the Indian record. This species does not exist in Mycobank record.

**2. *L. curreyanus* Sacc. & Cub. *Syll. Fung.* **5** : 586 (1887).**

Banerjee (1947) reported it from Calcutta (West Bengal) on dead wood. Pegler (1983) recognized this species as synonym of *L. squarrosulus* Mont. as a consequence of which Manjula (1983) recommended this species for exclusion from the Indian record. In MycoBank's opinion it exists as the synonym of *L. squarrosulus* Mont.

**3. *L. decaisneanus* Lév. *Bull. Ann. Sci. Nat. Bot.* **5** : 120 (1846).**

Banerjee (1947) recorded its occurrence from Calcutta (West Bengal). This is not a valid species as Pegler (1983) in his World monograph of the genus treated *L. decaisneanus* Lév as the synonym of *L. connatus* Berk. Hence *L. decaisneanus* Lév stands deleted from the Indian records. It exists as a synonym of *L. connatus* Berk. in MycoBank record.

**4. *L. exilis* Klotzsch ex Fr. *Syn. Gen. Lent.* **10** (1836).**

Cooke (1881) recorded it from Andaman Islands for the first time from India. Pegler (1983) treated *L. exilis* Klotzsch ex Fr. as the synonym of *L. sajor-caju* (Fr.) Fr. because of which Manjula (1983) deleted this species from the Indian records. In MycoBank's opinion, this species is listed as synonym of *L. sajor-caju* (Fr.) Fr.

**5. *L. hepaticus* Berk. *Hooker Journ. Bot. and Kew Misc.* **3** : 45 (1851).**

This species was recorded by Berkeley (1856) from Darjeeling (West Bengal) on tree trunk. Pegler (1983) assigned the collection of this species to *Collybia* (Fr.)

Kumm., hence being a dubious name *L. hepaticus* Berk. has been excluded as it do not belong to *Lentinus* Fr. In view of this *L. hepaticus* Berk. stands deleted from the Indian record (Manjula, 1983).

**6. *L. inquinans* Berk. *Hooker Journ. Bot. and Kew Misc.* **6** : 132 (1854).**

From India Pegler (1983) has listed its occurrence from Changa - Chelling in Sikkim; Manipur; Khashi hills of Assam; Tista bridge in Hora and Darjeeling in West Bengal. It is a synonym of *L. badius* (Pegler, 1983) which was described by Berkeley (1854) as *L. inquinans* Berk. because of which it stands excluded from Indian list of *Lentinus* species (Manjula, 1983). In MycoBank record this species exists as a synonym of *L. badius* (Berk.) Berk.

**7. *L. javanicus* Lév. *Ann. Sci. Nat. Bot.* **5** : 118 (1846).**

Its occurrence has been documented from Dehradun in Uttar Pradesh (now Uttarakhand), Assam and Bombay in Maharashtra by Pegler (1983) in his World monograph. *L. javanicus* Lév. is an invalid species which is listed as the synonym of *L. connatus* Berk. In view of its present status *L. javanicus* Lév. has been excluded from the Indian record (Manjula, 1983). This species exists as the synonym of *L. connatus* Berk. in MycoBank record.

**8. *L. lecomtei* Fr. *Syst. Orb. Veg.* **77** (1825).**

Berkeley (1851, 1876) reported it from Tonglo in Sikkim Himalaya and Gulmarg in Kashmir, Darjeeling in West Bengal. It is also reported from Ootacamund in Tamil Nadu (Pegler, 1983). All the above collections of *L. lecomtei* Fr. has been identified to be those of *L. strigosus* Fr., in view of which *L. lecomtei* Fr. stands excluded from Indian record (Manjula, 1983). In Mycobank opinion this species is recognized as a synonym of *L. strigosus* Fr.

**9. *L. melanophyllus* Lév. *Ann. Sci. Nat. Bot.* **2** : 175 (1844).**

Its occurrence has been listed from India on *Shorea rubusta* Gaertn. from Bilaspur in Madhya Pradesh by Hennings (1901). Manjula (1983) recognized it to be a synonym of *L. velutinus* Fr. however, Pegler (1983) in his World monograph on *Lentinus* enlisted it in the list of synonym of *L. ciliatus* Lév.

**10. *L. molliceps* Fr. *Nova Acta R. Soc. Sci. Upsal.* **1** : 38 (1851).**

It has been enlisted to occur in Nicobar Islands (Fries, 1855). Although Manjula (1983) has recognized it as a valid species and listed it under Indian species of *Lentinus* Fr., however, Pegler (1983) in his World monograph on *Lentinus* Fr. treated *L. molliceps* Fr. as the synonym of *L. squarrosulus* Mont. In view of this *L. molliceps* Fr. has been excluded from the Indian records. This species exists as synonym of *L. squarrosulus* Mont. in MycoBank's opinion.

**11. *L. nepalensis* Berk. *Hooker Journ. Bot. and Kew Misc.* **6** : 131 (1854).**

It was recorded by Berkeley (1856) from Nangki in East Nepal. It was not documented from any part of India. This is not a valid species and is a synonym of *L.*

*velutinus* Fr. (Pegler, 1983, Manjula, 1983). In view of its present status *L. nepalensis* Berk. stands deleted from the Indian records. In MycoBank's opinion it exists as synonym of *L. velutinus* Fr.

**12.** *L. nicobarensis* Reichardt. *Apaud Frenzi Reise der Österreich Freg. Novara. Bot. 1* : 143 (1870).

It has been recorded to grow on rotten trunks in Nicobar Islands (Petch, 1916). This is not a valid species. Pegler (1983) and Manjula (1983) treated *L. nicobarensis* Reichardt. as the synonym of *L. sajour-caju* (Fr.) Fr. In view of its present status *L. nicobarensis* Reichardt. stands deleted from the Indian records. It exists as a synonym of *L. sajour-caju* (Fr.) Fr. in MycoBank record.

**13.** *L. pergameneus* Lév. *Ann. Sci. Nat. Bot. 5* : 117 (1846).

It has been listed from India by Lèvèillè (1846). Its type at Paris has been marked as "Herb. De Candole, Indes" (Butler & Bisby, 1960). Although Manjula (1983) treated *L. pergameneus* Lév as a valid species and recognized its type documented by Lèvèillè (1846) as authentic record. Contrary to the treatment of Manjula (1983), in his World monograph of *Lentinus*, Pegler (1983) relegated it to the status of synonym of *L. squarrosulus* Mont. In view of this *L. pergameneus* Lév. stands excluded from the Indian records. This species exists as a synonym of *L. squarrosulus* Mont. in MycoBank record.

**14.** *L. praerigidus* Berk. *Hooker Journ. Bot. and Kew Garden Misc. 6* : 132(1854).

It has been reported from Sone River in Bihar by Berkeley(1856), on logs of *Shorea robusta* Gaertn. by Banerjee (1947) from Calcutta in West Bengal and on *Terminalia paniculata* Roth. and *Vateria indica* Linn. (Anonymous, 1950). This is not a valid species. Pegler (1983) treated this species as the synonym of *Lentinus polychrous* Lév which has been documented from Chota Nagpur (Maharashtra); Bankwara and Calcutta (West Bengal) and Nanda Hills (Andhra Pradesh) in India. Manjula (1983) recognized *L. polychrous* Lév instead of *L. praerigidus* Berk. In Mycobank's opinion this species is a synonym of *L. polychrous* Lév.

**15.** *L. revelatus* Berk. *Hooker Lon. Journ. Bot. 6* : 492 (1847).

Cooke (1881) recorded it from Andaman Islands on fallen stumps of *Cocos nucifera* L. and on dead stump of tree. Lloyd (1898 - 1925) and Banerjee (1947) reported it from Calcutta in West Bengal. Pegler (1983) enlisted *Lentinus revelatus* Berk. as the synonym of *L. connatus* Berk. In view of the above *L. revelatus* Berk. stands excluded from the Indian records (Manjula, 1983). It exists as a synonym of *L. connatus* Berk. in MycoBank record.

**16.** *L. cochleatus* (Pers.:Fr.) Fr. *Syst. Orb. Veg. 78* (1825).

Trivedi (1972) documented it from Nagpur. Pegler (1983) has excluded it from World monograph of *Lentinus* and instead has recognized it as *Lentinellus cochlentus* (Pers.:Fr.) Karst. Hence this species stands deleted from Indian record. In

MycoBank record, this species exists as a synonym of *Lentinellus cochleatus* (Pers.) P. Karst.

During the present survey six taxa of *Lentinus* Fr., namely *Lentinus sajor-caju* (Fr.) Fr., *L. connatus* Berk., *L. torulosus* (Pers. : Fr.) Lloyd, *L. cladopus* Lév, *L. squarrosulus* Mont. var. *squarrosulus* Mont. and *L. squarrosulus* Mont. var. *mangoensis* var. nov have been collected and identified taxonomically. A key to their segregation is given below. In the text individual description has been arranged in the sequence of segregation in the key given below.

**Key to the taxa of *Lentinus* Fr. investigated**

- 1. Pileus context dimitic, consisting of branched skeletal hyphae and generative hyphae, hyphal pegs normally present.....2
- 1' Pileus context dimitic consisting of unbranched skeletal hyphae and generative hyphae; hyphal pegs absent/present.....5
- 2. Pileus surface floccose to recurved fibrillose; pileocystidia present.....3
- 2'. Pileus surface smooth; pileocystidia absent.....4
- 3. Pileus 9 - 9.5cm broad, convex when young with depressed center, umbilicate to deeply infundibuliform at maturity, pale yellow to yellowish white; fleshy, flesh upto 0.8cm thick; spores 5 – 8 X 2.4 – 3.2 µm.  
.....*L. squarrosulus* var. *squarrosulus*
- 3'. Pileus 3 – 3.5 cm broad, depressed at the center, white to pale yellow; flesh thin up to 0.2 cm thick; spores 4.4 – 6.5 X 2.2 – 3 µm.  
.....*L. squarrosulus* var. *mangoensis*
- 4. Basidiocarp in caespitose clusters, stipes of two or more basidiocarps arising from a single base; pileus convex to depressed, surface white; stipe without annular ridge, blackish at base.....*L. cladopus*
- 4' Basidiocarp hard rigid not arising in caespitose clusters, gregarious depressed, pileus deeply infundibuliform to cyathiform, stipe short, yellowish later turning brownish gray at maturity, central to excentric with annular ridge.  
.....*L. sajor-caju*
- 5. Pileus reddish purple, fading from center to ochraceous brown along the thin involute lobed margin; stipe central to excentric; spores 4.98 - 6.74 X 3.3 µm, elliptical, pleurocystidia present.....*L. torulosus*
- 5' Pileus white when fresh, yellowish white when dried, depressed in the center to finally obliquely infundibuliform to fang shaped with excentric stipe; spores 5.63 - 8 × 1.6 - 2.4 µm; pleurocystidia absent .....*L. connatus*

## TAXONOMIC INVESTIGATIONS

1. *Lentinus squarrosulus* Mont. var. *squarrosulus* Mont. *Ann. Sci. Nat. Bot.* ser. 2, **18** : 21 (1842). Plates - 2 & 3

### Synonyms

- L. lucochrous* Lèv. *Ann. Sci. Nat. Bot.* ser. 3, **2** : 174(1846).  
*L. pergamenus* Lèv. *Ann. Sci. Nat. Bot.* ser. 3, **5** : 117(1846).  
*L. subnudus* Berk. Hooker, *Lond. Journ. Bot.* **6** : 492 (1847).  
*L. inconspicuus* Hooker, *Lond. Journ. Bot.* **6** : 494 (1847).  
*L. coadunatus* Hooker. Apud Berk. *Hooker Journ. Bot.* **3** : 5(1851).  
*L. wilkesii* Berk. & Curt. *Amer. Journ. Sci. Arts.* ser. 2, **11**: 93 (1851).  
*L. molliceus* Fr. *Nova Acta R. Soc. Sci., Upsal.* ser. **1** : 38(1885).  
*L. multiformis* Berk. & Br. *Journ. Linn. Soc., Bot.* **14** : 42(1873).  
*L. cretaceous* Berk. & Br. *Journ. Linn. Soc., Bot.* **14** : 42(1873).  
*L. caespitosus* Currey. *Trans. Linn. Soc., Bot.* ser. 2, **1** : 120 (1875).  
*L. manipularis* Berk. & Br. *Journ. Linn. Soc., Bot.* **14** : 43(1873).  
*L. lobatus* Berk. & Br. *Journ. Linn. Soc., Bot.* **14** : 44(1873).  
*L. hygrometricus* Berk. *Journ. Linn. Soc., Bot.* **16** : 49 (1877).  
*L. curreyanus* sacc. *Cub., Syll. Fung.* **5** : 586 (1887).  
*L. babianus* Pát. *Journ. Bot.* **4** : 15 (1890).  
*L. melanopus* Pát. *Bull. Soc. Mycol. Fr.* **8** : 47 (1892).  
*L. rivae* Bres. *Annuar. Bot. Roma.* **6** : 177 (1896).  
*L. subtigrinus* P. Henn. *Engl. Bot. Jahrb.* **25** : 502 (1898).  
*L. crenulatus* Masee *Bull. Soc. Misc. Inf. Kew.* **121** : (1898).  
*L. ramosii* Lloyd. *Mycol. Writ.* **7** : 1197 (1923).  
*L. piperatus* Beeli. *Bull. Soc. Bot. Belg.* **60** : 161 (1928).  
*L. ledermannii* Pilát. *Ann. Mycol.* **34** : 112 (1936).  
*L. tigrinus* (Bull.: Fr.) var. *squarrosulus* (Mont.) Pilát. *Ann. Mycol.* **34** : 130 (1936).  
*Pleurotus squarrosulus* (Mont.) Singer. *Sydowia.* **15** : 45 (1961).

### Morphological details

Fructification 4.5 - 7.5 cm in height (Figs. 2/A ; 3/A). Pileus 9 - 9.5 cm in diameter, convex when young with depressed center, umbilicate to deeply infundibuliform at maturity, tough coriaceous on drying; surface dry, pale yellow (2A3) to yellowish white (4A2), margin irregular, splitting at maturity, involute; scales recurved fibrillose to floccose fibrillose over the entire pileus surface; cuticle fully peeling; fleshy, flesh up to 8 mm thick, unchanging; pileal veil scaly; taste sweet and odour mushroomy. Lamellae deeply decurrent, unequal, slightly intervened,

crowded up to 5 mm broad, tough, orange white (5A2); gill edges smooth; spore deposit pale yellow (2A3) to creamish. Stipe central or eccentric, 4 - 4.6 cm long, 0.3 - 0.6 cm broad, concolorous with the pileus, fleshy, tough, cylindrical to slightly tapering downwards, solid; stipe surface covered by floccose fibrils over the entire surface.

### **Microscopical details (Plate - 2 &3)**

Spores 5 - 8 X 2.4 - 3.22  $\mu\text{m}$  (Q = 2.3  $\mu\text{m}$ ) thin walled, cylindrical with granular contents (Figs. 2/C; 3/C); inamyloid, cystidioles present on the sides of lamellae. Gill edges sterile with abundant cystidiform hairs measuring 17.70 - 40.25 X 2.42 - 4  $\mu\text{m}$  having clamp connections (Fig. 3/E), sometimes branched, inamyloid. Pleurocystidia 16.1 - 37.8 X 2.42 - 6.44  $\mu\text{m}$  in size. Clavate - ventricose to fusiform with or without tip, mucronate (Fig. 3/D). Pileus cuticle an epicutis of radially arranged 2.42 - 4.83  $\mu\text{m}$  broad hyphae with clamp connections, bovista type binding hyphae measuring 1.6 - 7.2  $\mu\text{m}$  in width producing numerous lateral branches present in the context (Figs. 2/E ; 3/C). Gill trama inamyloid, interwoven. Hyphal pegs numerous extending beyond the basidial layer, made up of thin walled hyaline hyphae arising directly from the trama (Fig. 2/D). Stipe formed of septate generative hyphae (Fig. 3/F) and aseptate binding hyphae.

### **Molecular characterization**

The sequence of 683 bp ITS region of the fungus showed 99 % identity with the *Lentinus squarrosulus* strain 7-4-2. ITS 1, 5.8S rRNA gene and ITS 2, complete sequence and 28S rRNA gene, partial sequence. Phylogenetic tree was constructed with the Mega 4 software. The amplification of the ITS-regions and the phylogenetic relationship of this species with other related species of *Lentinus* investigated is shown in Plate – 24 & 25. In the tree, sequences of reference strain were obtained

from the NCBI GenBank. The newly generated sequence has been submitted at GenBank (accession number JQ868748).

**COLLECTION EXAMINED:** Palampur (H.P.) (1200 m), growing on dead stump of *Albizia chinensis* Sapan Kumar, PUN 4151, November 2009.

### **Remarks**

This species of *Lentinus* Fr. is quite close to *L. sajor-caju* (Fr.) Fr. (Pegler, 1977). It is characterized by caespitose habit, umbilicate coriaceous carpophores with sweet mushroomy taste, deeply decurrent intervened lamellae, pale cream spore deposit, floccose fibrillar stipe and dimitic hyphal system with bovista type binding hyphae. These diagnostic features are in conformity with the details given by Pegler (1977) for *L. squarrosulus* Mont. Earlier record of this fungus in India was by Montagne (1842) and Natarajan and Manjula (1978). This species is edible and consumed in many parts of world including some African countries.

### **Culture Characteristics (Plate - 2)**

Growth of mycelium started on the second day of inoculation of the tissue in petriplate containing potato dextrose agar (solid Medium). To begin with mycelium was white and growth was in concentric manner with irregular margins forming a thin mat (Fig. 2/F). Towards maturity the mycelial mat became denser. On the sixth day of inoculation noticeable change in colour occurred in the form of appearance of light brown patch on the mycelial mat. This patch extended in a uniform manner from center towards the periphery (Fig.2/F). As the culture became older, its diameter also increased. On the eighth day of inoculation the dark brown patch covered the entire petriplate. On overall basis the mycelium was observed growing @ 1.8 cm/day on an average daily basis.

No specific odour was found to occur in all the stages of the growth of this fungus. Hyphal construction was found to be dimitic. Generative hyphae were prominently clamped.

**CULTURE DEPOSITION :** Culture deposited at Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10949.

**2. *Lentinus squarrosulus* Mont. *Ann. Sci. Nat. Bot.* ser. 2, **18** : 21 (1842).**

**var. *mangoensis* var.nov.**

**Plates - 4 & 5**

### **Morphological details**

Fructifications 4.5 - 9 cm in height (Figs. 4/A; 5/A). Pileus 3 – 5.5 cm in diameter, with depressed center, tough on drying; surface dry, white to pale yellow (2A3), margin irregular, not splitting at maturity, involute; scales appressed fibrillose, dense in the center, recurved fibrillose to floccose fibrillose over the entire pileus surface; cuticle fully peeling; fleshy, flesh up to 0.2 cm thick, unchanging, pileal veil scaly; taste sweet and odour mushroomy. Lamellae deeply decurrent, unequal, slightly intervened, crowded, up to 0.3 cm broad, tough, whitish when young, yellowish white at maturity; gill edges serrated; spore print white. Stipe central to eccentric, 4.5 - 8 cm long, 0.2 - 0.4 cm broad, concolorous with the pileus, fleshy, tough at maturity, leathery, equal throughout, solid, stipe surface covered by appressed fibrillose scales similar to that on the pileus.

### **Microscopical detail**

Spores 4.4 – 6.5 X 2.2 - 3  $\mu\text{m}$  (Q = 2.19  $\mu\text{m}$ ) thin walled, cylindrical with granular contents (Figs. 4 /C; 5/C); inamyloid. Basidia 11.8 – 28.1 X 3 – 5  $\mu\text{m}$ ; cystidioles present on the sides of lamellae. Gill edges sterile with abundant cystidiform hairs measuring 11.8 – 22.2 X 4.5 – 5.2  $\mu\text{m}$  having clamp connections, sometimes branched, inamyloid (Fig. 5/D). Pleurocystidia 11.8 – 23.2 X 3.70 – 4.4  $\mu\text{m}$  in size,

clavate to fusiform, mucronate (Fig. 5/E). Pileus cuticle an epicutis of radially arranged 2.2 - 4.3  $\mu\text{m}$  broad hyphae with clamp connections. Gill trama inamyloid, interwoven. Hyphal pegs numerous extending beyond the basidial layer (Fig. 4/ D). Stipe formed of septate generative with abundant caulocystidia measuring 3.7 – 4.5  $\mu\text{m}$  in breadth. Stipe hyphae thick walled, clamped 3.7  $\mu\text{m}$  broad.

Pileus hyphae thick walled, clamped, 2.9 – 3.70  $\mu\text{m}$  in breadth. Caulocystidia abundant on stipe surface (Fig. 4/F); Stipe hyphae thick walled; dimitic measuring 3.70 – 6.00  $\mu\text{m}$  in thickness.

### **Molecular characterization**

It is a close variant of *L. squarrosulus* Mont. The sequence of 600 bp ITS region of the fungus showed 94 % identity with the *L. squarrosulus* strain 7-4-2. ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. Phylogenetic tree was constructed with the Mega 4 software. The amplification of the ITS-regions and phylogenetic relationship of this species with other *Lentinus* species investigated is shown in Plate – 24 & 25. In the tree, sequences of the reference strain were obtained from the NCBI GenBank. The newly generated sequence has been submitted in GenBank (accession number JQ868747).

### **Remarks**

The presently examined collection falls in the overall taxonomic limits of *L. squarrosulus* Mont. But from the type variety it differs in having narrower pileus measuring 3 – 5.5 cm in diameter, thin flesh measuring upto 0.2 cm in thickness, larger stipe measuring up to 4.5 - 8 cm in length and spores measuring 4.4 – 6.5 X 2.2 – 3  $\mu\text{m}$  as compared to 10 cm broad pileus, upto 0.8 cm thick flesh, shorter stipe

measuring 1.2 – 5 cm in length and larger spores measuring 5.5 – 7.5 X 1.7 – 3 µm in *L. squarrosulus* var. *typica*. Besides the molecular sequence of this variety exhibit only 94 % homology with the genomic sequence of the type variety available in the GenBank. In view of the variation encountered in the macroscopic, microscopic and molecular sequencing details, a new variety namely *L. squarrosulus* var. *mangoensis* var. nov. has been proposed to accommodate this collection.

**COLLECTION EXAMINED:** Bhadrol (H.P.) (850m), growing on dead stump of *Mangifera indica* Sapan Kumar, PUN 4710, November, 2009.

### **Culture Characteristics**

Growth of the mycelium started on the second day of inoculation of the tissue in potato dextrose agar medium in petriplate. To begin with mycelium was white and concentric in arrangement with irregular margins forming a thin mat. Towards maturity the mycelial mat became denser. On the fifth day of inoculation a change in colour was observed in the form of appearance of light brown cottony patch starting from the center of the mycelial mat (Fig. 4/G). This patch extended in a uniform manner from center towards the periphery and assumed a characteristic shape at maturity. It took eight days for the mycelium to cover the entire petriplate. On overall basis the mycelium was observed growing @ 1.7 cm/day on an average daily basis. No particular odour was there in all the stages of the growth of this fungus. Hyphal construction was dimitic. Generative hyphae were prominently clamped.

**3. *Lentinus cladopus* Lèv. *Sci. Nat. Bot.* ser. 3, 2 : 174(1844).**

**Plates - 6 & 7**

### **Synonyms**

*L. inocephalus* Lèv *Champ. Exot.* 173 (1844).

*L. ramosipes* Har. & Pát. *Bull. Mus. Hist. Nat.* **15**: 88 (1909).

### **Morphological details**

Basidiocarp caespitose, stipes of two or more basidiocarps arising from a single base (Figs. 6/A & B; 7/A). Pileus 2 - 5 cm in diameter, coriaceous, convex to

depressed; surface white, smooth, translucent, moist, margin entire. Lamellae short decurrent, of four lengths, thin, pale cream to pale yellowish, 2 mm wide; edges entire. Stipe 2 - 8 cm long, equal, firm, solid, slender, concolorous with the pileus, blackening in the base.

### **Microscopic details**

Spores 6.7 - 8.6 x 3.6 - 4.6  $\mu\text{m}$  (Q=1.86) elongated ellipsoid to subcylindric, hyaline, thin walled, with occasional guttulate contents (Figs. 6/C; 7/B). Basidia small, measuring 16 – 17.5 x 4 - 4.5  $\mu\text{m}$ , clavate cylindrical, bearing four sterigmata (Fig. 7/C) ; gill edges sterile; cheilocystidia abundant, measuring 19 – 30  $\mu\text{m}$ , clavate, hyaline, sinuous and thin walled (Fig. 6 /D). Cystidiform hairs measuring 46 - 64 x 1.7 – 4  $\mu\text{m}$ , elongated thin walled (Fig. 7/D). Pleurocystidia absent. Hyphal pegs abundant, extending beyond the basidial layer, elongated. Hymenophoral trama irregular, composed of interwoven hyphae. Dimitic hyphal construction with thick walled skeletal hyphae and prominently clamped generative hyphae (Fig. 7/E&F). Caulocystidia prominent on the stipe surface (Fig. 6/E).

### **Molecular characterization**

A single band of ~651 bp was obtained when the ITS region of the fungus was amplified (Plate-24). The sequence of 645 bp ITS region of the fungus showed 99 % identity with the *Lentinus cladopus* strain VKMK05, ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. Phylogenetic tree was constructed with the Mega 4 software. The phylogenetic relationship of this species with other related species is shown in Plate-25. In the tree, sequences of reference strain for the purpose of comparison were obtained from the NCBI GenBank. The newly generated sequence was submitted at GenBank (accession number JQ868754).

**COLLECTION EXAMINED:** Palampur (1200m), Himachal Pradesh growing in groups on dried *Albizia chinensis*, Sapan Kumar, PUN 3948, September, 2009.

## Remarks

*Lentinus cladopus* Lév has a worldwide distribution. This species closely resembles with *Lentinus squarrosulus* Mont. with similar distribution and some authors regard one as the form of other. From India it has been documented from Kerela by Natarajan (1977). *Lentinus cladopus* Lév remain distinctive by virtue of a compound fructification with two or many stipes emerging from a common base. It has thin and glabrous pileus and stipe and very thin context (Pegler, 1983). Another *Lentinus* Fr. species with forking stipe is *L. concinnus* Berk. but it differs by having scales on the pileus surface and inflated generative hyphae. It is an edible species which is consumed worldwide.

## Culture Characteristics

Mycelium of this fungus grows at a fast rate. Growth of the mycelium started on the second day of inoculation of the tissue in petriplates containing Potato Dextrose Agar (solid Medium) and it reached upto 1 cm in diameter on the third day. On the fourth day of inoculation the diameter of mycelium reached upto 2 cm. The mycelial colony was smooth with irregular margins and concentric orientations. As culture grew older it became denser and its diameter also increased. On the seventh day the colony attained 7 cm diameter. It took nine days for the mycelium to cover the entire petriplate (Fig. 6/F). The mycelium was recorded growing @ 1.5 cm on an average daily basis. Initially the color of the mycelium was white which became blackish brown toward the end of 5<sup>th</sup> day of inoculation. The blackish brown patch extended uniformly from center to the periphery. At maturity entire white mycelium changed into blackish brown in appearance. No specific odor was noticed during all the stages of the growth of this fungus. Hyphal construction was found to be dimitic. Generative hyphae were prominently clamped.

**CULTURE DEPOSITION :** Culture deposited at Microbial Type Culture Collection and GeneBank, Institute of Microbial Technology (IMTECH) under MTCC No. 10948.

**4. *Lentinus sajor-caju* (Fr.) Fr., *Epicrasis*. 393 (1838).**

**Plates - 8 & 9**

**Synonyms**

- Agaricus sajor-caju* Fr., *Syst. Mycol.* 1:175 (1821); Rumpf., *Herb. Amboin.* **6**: 125, pl. 56/1 (1750).  
*L. exilis* Klotzsch ex Fr., *Syn. Gen. Lent.* 10 (1836).  
*L. dactyliophorus* Lév. *Ann. Sci. Nat., Bot. ser.* 3, **2** :174 (1844).  
*L. tanghiniae* Lev., *Mycologia.* **5** :119 (1846).  
*L. stenophyllus* H.W. Reichardt. *Verh. Zool. - Bot. Ges., Wien* **16** : 375 (1866).  
*L. nicobarensis* H.W. Reichardt apud Fenzl, *Reise Oesterreich. Freg. Novara. Bot.* **1** :143, pl. 23/1 (1870).  
*L. irregularis* Currey. *Trans. Linn. Soc., Bot. ser.* **1** : 121, pl. 19/14-15 (1876).  
*L. glandulosus* Ces. *Atti Acc. Sci. fisich. Matem. Napoli.* **8** : 3 (1879), non P. Henn. (1900).  
*L. murray* Kalchbr. MacOwan apud Kalchbr. *Grevillea* **9** : 136 (1881).  
*L. woodii* Kalchbr. *System. Bot. and Mycol.* 136.  
*L. tenupies* Sacc. & Paoletti. *Atti R. 1<sup>st</sup>. Venet. Sci., Lett. Ed Arti ser.* **6** (6) : 392, pl. 5/3 (1888).  
*L. bonii* Pat. *Bull. Soc. Mycol. Fr.* **8** : 48 (1892).  
*L. bukobensis* P. Henn. *Ngl. Bot Jahrb.* **17** : 32 (1893).  
*L. annulifer* Seynes, *Rech. Champ. Congo Fr.* 25 (1897).  
*Panus exilis* (Klotzsch ex Fr.) Bres. *Bull. Soc. Bot. Belg.* **59** : 110 (1927).  
*L. inopus* 'Lèv.' *Petra, Mycoth. Gen.* 437 (1912).  
*L. macgregorii* Graff. *Philipp. Journ. Sci. Bot.* **9** : 241 (1914).  
*L. elmerianus* Lloyd, *Mycol. Writ.* **7** : 1106, p1187/2021  
*L. nigroglabratus* Lloyd, *System. Bot. & Mycol.* 1198, pl. 244/2448 (1923).  
*Armillaria dactyliophora* (Lév.) Beeli. *Bull. Soc. Bot. Belg.* **59** : 110 (1927).  
*L. sajor-caju* var. *densifolius* Pilat. *Ann. Mycol.* **34** : 128 (1936).  
*Panus dactyliophorus* (Lév) Singer. *Sydowia.* **5** : 462 (1951).  
*Pleurotus sajor-caju* (Fr.) Singer. *Lilloa.* **22** : 27 (1951).  
*Pleurotus geesteranus* Singer. *Sydowia.* **15** : 45 (1961).

**Morphological details**

Fructification 2.5 - 7cm in height, hard, rigid, gregarious (Figs. 8/A, B ; 9/A).  
Pileus to 5 - 14 cm in diameter, depressed; deeply infundibuliform to cyathiform, coriaceous surface yellowish white (4A2), turning brownish grey (8F3) at maturity, bearing appressed brownish (8F3) squamules towards the center. Pileus surface dry with radiating striations; margin regular, splitting; veil absent along the pileus margin;

fleshy, flesh up to 0.1 cm thick, white, unchanging on exposure to air; taste and odour mild. Lamellae yellowish white (4A2), turning dark at maturity, deeply decurrent, extending down on to the stipe, narrowly crowded (up to 0.1 cm apart from each other), ventricose, unequal, lamellae in 4 tiers, edges denticulate; spore print white (1F1). Stipe yellowish white (4A2), turning dark at maturity, short, central to eccentric, 1.5 - 2.5 cm long, 2.2 - 3 cm in breadth, equal throughout, solid, appressed squamules similar to those on pileus present on the stipe surface as well, flesh white underneath, concolorous with the pileus but not tomentose or hairy. Annulus present, inserted at the apex of the stipe, hard.

### **Microscopic details**

Spores (5.5) 5.6 - 8.9 (9.2) x 2.41 - 3.3  $\mu\text{m}$  (Q = 2.92), cylindrical, inamyloid, thin walled, curved, hyaline, smooth (Figs. 8/C ; 9/B). Basidia club shaped 14.49 - 19.32 x 3.22 - 4.83  $\mu\text{m}$ , four spored (Fig. 9/A) ; sterigmata 1.61  $\mu\text{m}$  long; gill edges heteromorphous with cystidiform septate hairs on the gill edges measuring 16.1 - 37.03 x 4.02 - 4.83  $\mu\text{m}$ , prominently clamped at the base (Fig. 9/D). Pleurocystidia absent. Pileus cuticle thick measuring 16.1 - 25.76  $\mu\text{m}$ , consisting of thick walled, radiating hyphae. Pileus context consisting of dimitic hyphal system with branched thick walled binding hyphae and clamped generative hyphae measuring 3.22 - 4.83  $\mu\text{m}$ ; gill trama irregular hyaline containing interwoven thin walled generative hyphae measuring 1.61 - 3.22  $\mu\text{m}$  in breadth with prominent clamp connections. Hyphal pegs 49 - 85 x 3.22 - 4.83  $\mu\text{m}$  in size (Figs. 8/D ; 9/E). Stipe cuticle 8.05 - 12.88  $\mu\text{m}$  thick with thick walled parallel running hyphae. Stipe context with thick walled clamped generative hyphae measuring 4 - 8  $\mu\text{m}$  in breadth.

## **Molecular Characterization**

A single band of ~600 bp was obtained when the ITS region of the fungus was amplified (Plate-24). The sequence of 595 bp ITS region of the fungus showed 99% identity with the *Lentinus sajor-caju* strain JN849390 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. Mega 4 software used for the construction of phylogenetic tree. The phylogenetic relationship of this species with other related species is shown in Plate-25. In the tree, sequences of reference strain were obtained from the NCBI GenBank. The newly generated sequence has been submitted at GenBank (accession number JQ868751).

**COLLECTION EXAMINED :** Renuka Lake, Nahan (Sirmour), (672 mts.) growing gregarious on dead part of stem of *Bauhinia variegata*, Sapan Kumar, PUN 4153, August, 2008.

**Remarks :** *Lentinus sajor-caju* (Fr.) Fr. is a common mushroom of the Paleotropical forests, with the distribution extending from equatorial and Southern Africa to South- East Asia and down to the north East corner of Australia (Pegler, 1983). From India it is reported earlier from West Bengal by Nair and Kaul (1980). It is a deeply infundibuliform mushroom with in-rolled pileal margin. This species is reported to be edible when it is young. It is consumed in Vietnam (Joly and Perreau, 1977). Corner (1981) described it from Malaysia as ‘the vegetable that grows from wood’. On drying and at maturity its colour changes to yellowish brown and the carpophore finally becomes rigid and hard. At maturity this species can be recognized by cyathiform pileus and the presence of rigid annulus, which represents the diagnostic characters of the mushroom. It is also an edible species of genus *Lentinus*.

## **Culture Characteristics**

The mushroom tissue was inoculated aseptically in petriplates containing potato dextrose agar medium (PDA). The inoculated petriplates were incubated at  $27 \pm 1$  °C.

It took eleven days for the mycelium to cover the petriplate. At the initial stages of the growth the growing margins of the mycelium were found to be irregular (Fig. 8/E), but the overall growth was in concentric manner. The mycelium grew @ 1.3 cm/day on an average basis. At the initial stages of the growth the general appearance and color of the mycelium was white. But with maturity during 7<sup>th</sup> – 8<sup>th</sup> day of growth gradually the color changed from white to light brown and then to yellowish brown. The change in colour does not occur in a uniform manner but it occurred in patches and by 11<sup>th</sup> day of incubation almost entire mycelial mat became yellowish brown with scattered whitish patches (Fig. 8/F). Finally the upper surface of the mat gave a rough variegated appearance due to these changes in the general appearance.

To begin with the mycelial mat was thin, smooth, concentric but with advancement towards maturity, the mycelial mat became thick and dense. Finally the mycelial mat appeared leathery with regular margins and concentric pattern of growth. No specific odour was noticed during culturing. Hyphal construction was found dimitic and generative hyphae were prominently clamped.

**CULTURE DEPOSITION:** Culture deposited in Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10945.

**5. *Lentinus torulosus*** (Pers.:Fr.) Lloyd, *Mycol. Writ. Lett.* **47** : 13 (1913).

**Plates - 10 & 11**

### **Synonyms**

- Agaricus flabelliformis* Schaeffer, *Fung. Bav. Palat., Regensb.* **1** : 20, pl. 43 – 44 (1762).
- A. carneotomentosus* Batsch, *Elench. Fung.* **90**, pl. 8/33 (1783).
- A. torulosus* Pers.: Fr., *Syst. Mycol.* **1** : 181 (1821).
- A. conchatus* (Bull.: Fr.) Bull. *Herb. Fr.* 298 (1786).
- L. inconstans* (Pers.: Fr.) Fr., *Syn. Gen. Lent.* **12** (1836).
- Panus torulosus* (Pers.: Fr.) Fr. *Epicrisis.* 397 (1838).
- P. monticola* Berk. *Hooker Journ. Bot. & Kew Misc.* **3** : 46 (1851).
- P. vaporarius* Baglietto. *Comm. Soc. Critt. Itl.* **2** : 264 (1865).
- L. percomics* Berk. & Br. *Journ. Linn. Soc. Bot.* **14** : 42 (1873).

- L. divisus* Schulzer. *Verh. Zool. – Bot. Gesell. Wien.* **28** : 426 (1879).  
*L. bresadolae* Schulzer. *Hedwigia* **24** : 141 (1885).  
*P. flabelliformis* (Schaeffer) Quél. *Fl. Mycol.* 325 (1881).  
*L. carneotomentosus* (Batsch) Schroet. *Apud Cohn, Pilze Schles.* **1** : 554 (1889).  
*L. obconicus* Peck in Bull. *Torrey Bot. Cl.* **33** : 215 (1906).  
*P. carneotomentosus* (Batsch) Ricken, *Blatterpilze.* 88 (1915).  
*P. torulosus* var. *conchatus* (Bull.:Fr.)Kauffm., *Agar. Mich.* 47 (1918).  
*Lentinopanus chonchatus* (Bull.:Fr.) Pilát. *Ann. Mycol.* **39** : 73 (1941).

### **Morphological details**

Pileus up to 13 cm in diameter, tough depressed, surface reddish purple, fading from center to ochraceous brown along the thin involute lobed margin (Fig. 10/A,B ; 11/A); scaly, scales whitish, radially arranged, appressed fibrillose in the center. Taste mildly bitter. Lamellae deeply decurrent, crowded, ventricose, 0.2 cm broad in the center, lamellulae of four lengths, edges entire. Stipe central to excentric, 2.5 cm in length and 1.7 cm in breadth, strigose, light pale, concolorous with the pileus, sometime sub bulbous to even tapering at the base, solid.

### **Microscopic details**

Carpophore context homoiomerous; hyphal system dimitic, generative hyphae thin walled branched with prominent large clamp connections (Fig. 11/C) ; skeletal hyphae thick walled (Fig. 11/B). Spores 4.9 - 6.8 X 3.3  $\mu\text{m}$  (Q=2.04) broad, ellipsoidal, thin walled, having some oil droplets (Figs. 10/C; 11/B). Pleurocystidia 24 - 35.20 X 4.8 - 6.8 $\mu\text{m}$ , abundant often clavate to sinusoidal and constricted with rounded to tapered apex, becoming thick walled metuloidal from the base (Figs. 10/B). Lamellae edges sterile with abundant cheilocystidia. Cheilocystidia 24.15 - 40 X 4.8 - 8.0  $\mu\text{m}$ , elongated clavate to sinusoidal and even constricted, some clamped, thick walled with scanty contents (Figs. 10/D, E ; 11/E). Pileus cuticle of radially arranged parallel running hyphae, impregnated with incrustations. Pileus context irregular, few of the hyphae arranged in a radiate manner. Hymenophoral trama, similar in structure to the pileus context (Fig.10/C).

## **Molecular characterization**

A single band of ~600 bp was obtained on amplification of the ITS region of the fungus (Plate-24). The sequence of 235 bp ITS region of the fungus showed 98 % identity with the *Lentinus torulosus* strain 175098 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. Phylogenetic tree has been constructed using Mega 4 software is shown in Plate-25. In the tree, sequences of reference strain for making comparison were obtained from the NCBI GenBank. The newly generated sequence was submitted at GenBank (accession number JQ868753).

**COLLECTION EXAMINED:** Bhadrol, Palampur Himachal Pradesh (850m) growing in caespitose clusters on dried *Pinus* tree stump, Sapan Kumar, PUN 3904, July 29, 2009.

**Remarks :** *Lentinus torulosus* (Pers. : Fr.) Lloyd is a large fleshy species, often distinguished by basidiomes with excentric stipe typically growing in caespitose clusters on stumps, tree roots and fallen branches. Sometime it is also reported to grow solitary and may have central stipe (Pegler, 1983). The species is characterized by tough, lobed, depressed pileus, sinusoidal chielocystidia, metuloidal pleurocystidia and short and strigose stipe. It is commonly found in central Europe (Pilát, 1935), the British Isles and Scandinavia, and in North Eastern states of North America (Murrill, 1915). *L. torulosus* is probably more widely known under the name *Panus chonchatus*. Atri *et al.* (2010) recorded it for the first time from India and it is an edible fungus.

## **Culture Characteristics**

*Lentinus torulosus* has a unique growth pattern. It is a slow growing fungus as compared to other *Lentinus* Fr. species studied. The mycelium has been recorded growing @ 0.5 cm on an average daily basis with colony showing irregular margin all around (Fig. 10/F). On the sixth day of inoculation mycelium at the center became

thick and formed small protuberances. Usually 3 - 4 protuberances emerged from one point. On the ninth day the protuberance reached upto 5 cm in length. Normally out of 3 - 4 protuberances only one reached upto 5 cm in length and rest were abortive (Fig. 10/G). Overall the mat appeared thin with smooth concentric aggregation of hyphae except in the center where the mat was thick and protuberances are formed (Plate & Fig. 10F, G). Colour of the mycelium and the protuberances remained white throughout the growth period. No specific odour was found to occur in all the stages of the growth of this fungus. Hyphal construction was found to be dimitic with generative hyphae prominently clamped.

**CULTURE DEPOSITION:** Culture deposited in Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10947.

**5. *Lentinus connatus* Berk. Hooker. Lond. Journ. Bot. 1:145(1842).**

**Plates - 12& 13**

**Synonyms**

- L. javanicus* Lèv. *Ann. Sci.Nat., Bot. Ser. 3, 5* : 118 (1846).
- L. revelatus* Berk. *Hooker Lond. Journ. Bot. 6* : 492 bis (1847).
- L. infundibuliformis* Berk. & Br. *Journ. Linn. Soc., Bot. 14* : 42 (1875).
- L. beccarianus* ces. *Atti Acc. Sci. Fis. Mat. Napoli. 8* : 3 (1879).
- Panus fendleri* Cooke ex P. Henn. *Engl. Bot. Jahrb. 44* : 34 (1894).
- L. variabilis* Holtermann. *Mykol. Unters. Trop. :* 91, pl. 10/1a – e (1898).
- L. fendleri* (Cooke) Schum. & Lauterb., *Fl. Deut. Schutz. Sudsee:* 53 (1900).
- L. eradicatus* Pat. *Agric. Prat. Pays chauds. 1* : 264 (1901).
- Panus spathulatus* Masee. *Bot. Tidsskr. 24* : 365 (1902).
- P. ochraceus* Masee. *Bull. Misc. Inf. Kew. :* 92 (1906).
- L. candidus* Graff. *Philipp. Journ. Sci. Bot. 8* : 302, pl. 8 (1913).
- Panus murinus* Bres. *Hedwigia 56* : 289 (1915).
- L. sajor-caju* (Fr.) Fr. var. *Javanicus* (Lèv) Pilat. *Ann. Mycol. 34* : 138 (1936).
- Panus javanicus* (Lèv.) Corner. *Beih. Nova Hedw. 69* : 92 (1981).

**Morphological details**

Fructifications 4 - 12 cm in height, lentinoid (Figs. 12/A;13/A). Pileus 2.5 - 13 cm in diameter, white when fresh, yellowish white when dried, depressed in the center to finally obliquely infundibuliform to fang shaped with eccentric stipe; grayish

brown to dark brown (6F4); scaly, scales small, isolated, appressed to finally recurved fibrillose, concentrically to radially arranged, slightly darker than the colour of the pileus; margin irregularly incised, incurved in young carpophores. Lamellae deeply decurrent, unequal, crowded with lamellulae of 5 - 6 lengths, up to 4 mm broad, yellowish white, normal, edges smooth, at places the persistent veil remnants were observed sticking to the gill edges. Stipe eccentric, 3 - 4.5 cm long, 0.3 - 1 cm broad, white, tapering downwards, solid, scaly, at places persistent whitish tomentose veil was observed sticking to the stipe surface, velar elements floccose, hyphae thick walled, branched or even unbranched, 2.4 - 4.83  $\mu\text{m}$  in diameter.

### **Microscopical details**

Spores 5.63 - 8  $\times$  1.6 - 2.4  $\mu\text{m}$  (Q = 2.97), hyaline, inamyloid, ovoid, cylindrical with curved tapered apiculus, apical pore absent (Figs. 12/D; 13/B). Basidia 16 - 21  $\times$  2.4 - 4.83  $\mu\text{m}$ , clavate, cylindrical, tetrasporic (Figs. 13/C). Lamellae edges sterile with numerous sterile cystidioles measuring 16 - 43.47  $\times$  2.42 - 4.83  $\mu\text{m}$ , hyaline, thin walled, clavate (Fig. 13/E). Pleurocystidia absent. Carpophore context homoiomerous; hyphal construction dimitic, composed of thin walled highly branched clamped generative hyphae measuring 3.22 - 8  $\mu\text{m}$  in diameter and thick walled unbranched skeletal hyphae ranging from 3.32 - 9.66  $\mu\text{m}$  in diameter (Figs. 12/E;13/F,G). Hyphoid elements forming hyphal pegs in the hymenium which originates from the hymenophoral trama in scattered fascicles. Pileus cuticle a cutis of radially tangled hyphal elements measuring 3.22 - 4.83  $\mu\text{m}$  in diameter with emerging pilocystidial elements (Fig. 13/D).

### **Molecular characterization**

Molecular sequencing of *L. connatus* has been attempted for first time. For this purpose a single band of ~663 bp was obtained on amplification of the ITS region

of the fungus (Plate-24). The sequence of 636 bp ITS region of the fungus showed 95 % identity with the *Lentinus squarrosulus* strain VKMK03 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. The phylogenetic relationship of this species with other related species has been shown in Plate-25. In the tree, sequences of the reference strain were obtained from the NCBI GenBank. The newly generated sequence has been submitted at GenBank (accession number JQ868752).

**COLLECTION EXAMINED:** Chandigarh (250 m), growing gregariously on dead stem of *Mangifera indica*, Sapan Kumar, June 17, 2008, PUN 3905.

**Remarks:** *Lentinus connatus* Berk. was originally described by Berkeley (1842) from Philippine. It is reported to form caespitose clusters on dead and decaying wood. It is a common species of South East Asia and has been reported to extend Southwards into the South Pacific islands (Pegler, 1983). From India it has been reported from Uttar Pradesh, Dehradun (Butler, 1903), Assam (Bagchee, 1952) and Bose (1920) from Howrah in West Bengal. The Basidiome of this species grows on an erect lateral to centrally attached elongate stipe. This species can be identified on the basis of leathery carpophore and concentric scales on the pileus surface. Carpophore in young stages is white and soft but at maturity it becomes hard and yellowish with rigid subcylindric stipe. It is closely related to *L. anthocephalus* Lév, of equatorial Africa from which it differs in having densely crowded sublinear lamellae, a much longer stipe and slightly narrower spores. The diagnostic characters are in agreement with the details given by Pegler (1977) for this species. *Lentinus connatus* is also an edible species.

### **Culture Characteristics**

In the initial stages mycelium growth was quite slow. After two days of inoculation of the tissue in petriplates containing potato dextrose agar (solid medium),

the mycelium grew @ 0.8 cm on an average daily basis but later on the rate of mycelium growth was at faster rate. The entire petriplate was covered with mycelium on 11<sup>th</sup> day of inoculation. The average growth rate of the mycelium observed was 1.1cm/day, which was slower as compared to the growth of *Lentinus sajor-caju* (1.3 cm/day) under similar culture conditions. Initially the color of the mycelium was white (Fig. 12/F) but with age and maturity the color changed from white to blackish brown. The browning started from the center of petriplate. By the end of 7<sup>th</sup> day patches of thin and thick mycelium became clearly visible on petriplates. The change in color was not uniform. The patches became apparent after 6<sup>th</sup> day of inoculation and by eighth day these patches became more prominent (Fig. 12/F). To begin with the mycelial mat was thin smooth and concentric and with maturity it became thick, patchy and dense with regular margins and concentric pattern throughout. No specific odour was noticed at all the stages of the growth of this fungus. Hyphal construction was found to be dimitic. Generative hyphae were prominently clamped.

**CULTURE DEPOSITION:** Culture deposited in Microbial Type Culture Collection and GenBank, Institute of Microbial Technology (IMTECH) under MTCC no. 10946.

## **6.2. Order Agaricales** Clements. *Genera of fungi*, pp. 102, 1909; *Rea, Brit. Bas.*, pp. XI. 1922. -A **Diagnosis and taxonomic studies undertaken**

Order Agaricales comprises the gilled mushrooms with 33 families, 413 genera, and over 13000 described species. This order was first proposed in "North American Flora" without a diagnosis, but its meaning was equivalent to the Hymenomycetes of Clements classification (1909). Singer (1986) used this order in his latest monograph entitled, "Agaricales in Modern Taxonomy" which was amended to contain all of Clements Agaricales, Gastromycetales and Aphyllophorales of Rea's classification (1922). The order Agaricales with its type family Agaricaceae and the type genus *Agaricus* was accepted by modern taxonomist in their treatment in all subsequent publications. Under this order Singer (1986) retained Polyporaceae, sensu stricto as one of the family and recognized 230 genera and 5658 species spread over 17 families. Instead of erecting smaller orders, Singer (1986) divided the order Agaricales into 3 suborders namely, Agaricineae, Boletineae and Russulineae. Hawksworth *et al.* (1995) in the *Dictionary of Fungi* accepted almost all the families recognized by Singer (1986) except Boletaceae, Bondarzewiaceae, Cortinariaceae, Russulaceae and Polyporaceae, which have been elevated as orders and stands as independent orders, namely Boletales, Bondarzewiales, Cortinariales, Russulales and Polyporales, respectively. Kirk *et al.* (2008) treated Podaxaceae as synonym of Agaricaceae; Crepidotaceae as synonym of Cortinariaceae; Amanitaceae as synonym of Pluteaceae and Hygrophoraceae as synonym of Tricholomataceae. Besides these, four families recognized earlier namely Galeropsidaceae, Richoniellaceae, Secotiaceae and Torrendaceae by Hawksworth *et al.* (1995) are not listed in the new version of the 'Dictionary of Fungi' by Kirk *et al.* (2008).

**DIAGNOSIS:** Basidiocarp annual, never effused - resupinate but always pileate at maturity. Pileus 0.1 - 0.50 cm in diameter, membranous, soft fleshy to tough leathery, never ligneous. Hymenophore inferior, generally distinct, typically lamellate but also tubular, venose or smooth. Stipe typically present and central, sometimes excentric, lateral or absent, sometimes replaced by a pseudostipe; sometimes sclerotia, pseudosclerotia or rizomorphs present. Velar structures at times present and persisting into maturity as a volva, annulus, cortina, or pileal and stipe squamules at maturity. Context formed by a monomitic hyphal system, with the inflated generative hyphae, with or without clamp connections; or heteromerous with embedded sphaerocytes (Russulaceae). Basidiospores 2 – 45 um long, very variable in form, hyaline or pigmented, smooth or ornamented, ballistosporic, producing a spore print. Chlamydospores, oidia and conidia occasionally produced. Basidia holobasidious, clavate to cylindric, typically tetrasporic also mono, bi and trisporic. Hymenophore edge continuous, fertile heteromorphous or sterile. Cystidia frequently present leptocystidioid, metuloidal, gloeocystidioid or pseudocystidioid. Hymenophoral trama regular, bilateral, irregular or intermixed. Pileal surface, undifferentiated, or specialized as an epicutis, epithelium or trichodermium. Development gymnocarpic, hemiangiocarpic or pseudoangiocarpic. Worldwide terrestrial, parasitic and saprophytic on plant material, rarely animals, also coprophilous, carbonicolous, mycorrhizal and never truly aquatic.

**DISTRIBUTION:** Agarics are ubiquitous, being found across all continents. Most are terrestrial, their habitats including all types of woodland and grassland, varying largely from one genus to another. The members of Agaricales are cosmopolitan in distribution. They grow on wide variety of habitats from an open grassy lawn to deep forests. The members of Agaricales may be parasitic on the roots

of trees, herbaceous plants, shrubs, etc., also on trunks of trees, on stems of herbaceous plants and shrubs, even on twigs and leaves of living plants or their fruits; saprophytic on all kinds of plant debris, even on animal debris (hides, bones, hairs), often very specialized as to species and organ of the host, on dung, on scattered organic matter, on sand, rocks, on living trees, pavement, etc., on naked earth in pastures, meadows, steppes, tundras, deserts, gardens, roadsides, greenhouses; on various artificial matter such as some plastics, sawdust, wooden structures, charcoal heaps, ropes, clothing, etc., in close connection with stands of mosses such as *Sphagnum*, *Polytrichum*, etc., in symbiosis with conifers, in association with termitaria, etc. In all zones and continents, altitudes and plant communities, but very rarely truly aquatic.

**DEVELOPMENT:** The development is mostly hemiangiocarpic, very rarely gymnocarpic.

**STATISTICS:** Singer (1986) recognized 230 genera and 5658 species spread over 17 families in order Agaricales. In the latest version of 'Dictionary of Fungi' Kirk *et al.*, (2008) recognized 33 families, 413 genera, and over 13000 described species on worldwide basis. The presently investigated genus *Pleurotus* (Fr.) P. Kumm. belongs to family Pleurotaceae, the diagnosis of which is given in the ongoing account.

**Family Pleurotaceae Kühner.** *Bull. Mens. Soc. Linn. Lyon.* **49:** 184 (1980).

Pleurotaceae is a family of small to medium sized mushrooms which have white spores and Pleurotoid habit. The family contains 6 genera including *Pleurotus* (Fr.) P. Kumm. and 94 species (Kirk *et al.*, 2008).

**CHARACTERISTICS:** Fruit body pileate, mostly stipitate, fleshy or sometimes tough textured. Stipe excentric to lateral. Pileus surface grayish or with blue or lilac tints, smooth. Hyphal system monomitic or dimitic, hyphae sometimes gelatinized, with clamp connections, not staining in iodine. Hymenium lamellar, veil sometimes present. Basidia clavate, usually with four sterigmata, often accompanied by thick walled encrusted cystidia. Basidiospores hyaline, cylindrical, smooth or faintly punctuate, thin walled and varied in size.

**DISTRIBUTION:** Widespread in tropical and temperate zones.

The diagnosis of *Pleurotus* (Fr.) P. Kumm. is given below

**Genus *Pleurotus* (Fr.) P. Kumm. *Syst. Myc.* 1 : 178 (1821) - A Diagnosis**

**Synonyms**

*Omphalotus* Fayod. *Annl. Sci. Nat. Bot.* Ser. 7, **9** : 338 (1889).

*Nothopanus* Singer. *Mycologia*. **36** : 364 (1944).

*Lampteromyces* Singer. *Mycologia*. **39** : 79 (1947).

*Pleurocybella* Singer. *Mycologia*. **39** : 81 (1947).

**GENERAL CHARACTERS:** Basidicarps pleurotoid sessile to shortly stalked, lignicolous. Pileus normally smooth; margin at first incurved. Veil present or absent. Gills decurrent, rarely dichotomous, edges entire. Flesh thick to very thin, fleshy to subhygrophanous or watery mucilaginous, often becoming tough with loss of hydrature and maturity. Spores white or pale pinkish in mass, smooth, inamyloid, multi - guttulate or not, globose, ellipsoid or cylindrical, rarely subballantoid, inamyloid. Basidia short to long. Cheilocystidia present or absent. Pleurocystidia present in few species. Hyphae monomitic or dimitic, rarely branched; generative hyphae more or less inflated or not, becoming thick walled in some species, clamped, except in a few species.

**HABIT AND HABITAT:** Pleurotoid, on wood.

**DEVELOPMENT:** Gymnocarpous.

**LIMITS:** The other two closely related genera of *Pleurotus* (Fr.) P. Kumm. are *Panus* Fr. and *Lentinus* Fr. The main distinctive feature among these is the hyphal system, which is monomitic in *Pleurotus* (Fr.) P. Kumm. species whereas in *Panus* Fr. and *Lentinus* Fr. it is found to be dimitic or amphimitic with either skeletal or binding hyphae along with generative hyphae and firm, tough and persistent texture as compared to fleshy texture in *Pleurotus* (Fr.) P. Kumm.

**STATISTICS:** The world over *Pleurotus* (Fr.) P. Kumm. is known by 20 species (Kirk *et al.*, 2008). From Indian point of view, 21 species of this genus have been reported which includes large number of synonyms and excluded species (Jandaik, 1997; Natarajan *et al.*, 2005; Manjula 1983; Jammaludin *et al.*, 2004; Jandaik and Kapoor, 1975; Vasudeva, 1960 and Bilgrami *et al.*, 1979). However, upon scrutiny of latest authentic literature and MycoBank record, out of the total 21 species reported to occur in India, only 12 are valid species which are legitimate and are listed in MycoBank. As many as 9 are either invalid or synonyms of the legitimate species and hence stands deleted from the Indian record. The check list of valid and excluded species of *Pleurotus* from Indian point of view is given below.

## **Check List of *Pleurotus* species recorded from India**

### **List of included species**

1. *Pleurotus anserinus* Sacc. *Syll. Fung.* **5** : 361 (1887).

Berkeley (1856) recorded this species on the dead wood from Jalapahar, Darjeeling in West Bengal. It exists as a legitimate species in MycoBank.

2. *P. dryinus* (Pers.:Fr.)Kumm. *Der Führer die Pilzkunde*.104 (1871).

Berkeley (1856) documented this species from Avantipur in Jammu & Kashmir and Abraham (1991) reported it from Kashmir. It is treated as a valid species in MycoBank.

3. *P. membranaceus* Masee. *Bull. Misc. Inf. Royal Botanical Gardens Kew*, 151 (1901).

Masee (1898) documented it from Poona in Maharashtra and Watling and Gregory (1980) reported it from Jammu and Kashmir. Abraham (1991) documented it from Kashmir. It is a valid species in MycoBank.

4. *P. ostreatus* (Jacq.) Kumm. *Führer in die Pilzkunde*. 105 (1871).

Murrill (1924) documented it for the first time from Sonmarg in Kashmir. Subsequent reports of its occurrence are from Khasia Hills, Assam (Berkeley, 1854), Uttar Pradesh (Ghosh *et al.*, 1974), Sikkim (Bose and Bose, 1940), Mumbai, Maharashtra (Moses, 1948) and Kashmir (Kaul and Kachroo, 1974). *P. ostreatus* (Jacq.) Kumm. exists as a valid species in MycoBank.

5. *P. sapidus* Quélet. *Compt. Rend. Assoc. Franç. Avancem. Sci.* **11** : 338 (1883).

Graham (1915) recorded it from Madhya Pradesh. Manjula (1983) and Watling and Gregory (1989) recognized *P. sapidus* Quélet. as synonym of *P. cornucopiae* (Páulet ex Pers.) Rolland. Manjula (1983) suggested for its exclusion from the Indian records. However, *P. sapidus* Quélet exists as an independent species in the MycoBank. Presently collected material from Palampur (Himachal Pradesh) has been identified as *P. sapidus* Quélet.

6. *P. sajor-caju* (Fr.) Singer. *Lilloa* **22** : 271 (1951).

Cooke (1881) recorded this species from South Andaman Islands. The another authentic record for its occurrence are from West Bengal (Bose, 1920), Foot Hills of Himalayas (Jandaik and Kapoor, 1975 ; Jandaik, 1976) and from Kottayam (Kerala) by Sathe and Daniel (1980). Presently the collection of this species has been made from Palampur (Himachal Pradesh) on *Albizia chinensis* Benth.

7. *P. cornucopiae* (Páulet:Pers.) Rolland. *Comptes rendus de l'Association française pour l'Avancement* **13** : 278 (1885).

Graham (1915) described this species as *P. sapidus* (Schulz-apud) Kalchbr. from Madhya Pradesh and Abraham (1991) documented it from Kashmir, it is now listed as the synonym of *P. cornucopiae* (Páulet:Pers.) Rolland by Watling and Gregory (1989), however *P. sapidus* is not there in the list of synonym of *P. cornucopiae* (Páulet:Pers.) Rolland in the MycoBank and it exists as a legitimate species.

8. *P. platypus* (Cooke & Masee) Sacc. *Syll. Fung.* **9** : 47 (1891).

It has been documented by Watling and Gregory (1980) from Jammu and Kashmir. Natarajan (1978) confirmed the identification of the material belonging to *P. platypus* (Masee) Sacc. which was wrongly identified by Jandaik and Kapoor (1975a) as *P. sajor-caju* (Fr.) Fr. Marimuthu *et al* (1991) recorded it from silk cotton tree in Tamil Nadu. *P. platypus* (Cooke & Masee) Sacc. is a legitimate species in MycoBank.

9. *P. cystidiosus* O.K. Miller. *Mycologia* **6** : 889 (1969).

Natarajan and Raman (1984) documented this species from Tirunelveli in Tamil Nadu. Presently this species has been documented on *Mangifera Indica* from Baradari Gardens (Patiala) in Punjab. The presently worked out collection has been identified as *P. cystidiosus* O.K. Miller ssp. *abalonus* O.K. Miller based upon its close resemblance with this variety of *P. cystidiosus*. It is a legitimate species in MycoBank.

10. *P. pulmonarius* (Fr.) Quél. *Mémoires de la Société d'Émulation de Montbéliard* **5** : 113 (1872).

Chaktavarty and Purkayastha (1976) recorded this species from Sebanipur in West Bengal. Present collection has been documented from Palampur in Himachal Pradesh on the tree of *Albizia chinensis*. It exists as an independent species in Mycobank. Although the present collection is typical of *P. pulmonarius* (Fr.) Quél. based upon its gross taxonomic features but varied molecular sequence from the sequence of the type species available in GenBank, has led us to recognize new variety which has been named as *P. pulmonarius* (Fr.) Quél var. *indica* var. nov.

11. *P. fossulatus* Cooke. *Revisio Generum Plantarum* **3** : 464 (1898).

Masee, (1899) recorded *P. cretaceous* Masee which was subsequently identified as *P. fossulatus* Cooke by Pegler (1976). Watling and Gregory (1980) collected it from Jammu and Kashmir. Puri *et al.* (1981) reported it from Dehradun in Uttar Pradesh (now Uttrakhand). Abraham (1991) documented it from Kashmir. It exists as a valid species in MycoBank.

12. *P. cretaceous* Masee. *Bull. Misc. Inf. Royal Botanical Gardens Kew.* 165 (1899).

Graham (1915) recorded it growing on wood in Madhya Pradesh. Pegler (1976) enlisted this species as the synonym of *Pleurotus fossulatus* Cooke based upon which Manjula (1983) recommended its exclusion from Indian record. In MycoBank's opinion, this species is currently in use and hence is a valid species for inclusion in Indian record.

## List of excluded species

1. *P. ulmarius* (Bull.) P. Kumm. *Führer die Pilzkunde*. **1** : 105(1871).

Singh and Mehrotra (1974) recorded it from Uttar Pradesh. *P. ulmarius* (Bull.) P. Kumm. is documented as a synonym of *Hypsizygous ulmarius* (Bull.) Redhead and hence stands deleted from the list of Indian records.

2. *P. flabellatus* (Berk. & Br.) Sacc. *Syll. Fung.* **5** : 369 (1887).

It is one of the most common species of *Pleurotus* which has been documented from West Bengal (Bose, 1920), Sikkim (Banerjee, 1944) in Assam, Mysore in Karnataka (Pegler, 1976), Katra forest in Jammu and Kashmir (Watling and Gregory, 1980) and Tirunelveli in Tamil Nadu (Natarajan and Raman, 1981), Khasi Hills in Meghalaya (Shajahan *et al.*, 1988) and Kashmir (Abraham, 1991). In MycoBank's opinion it is a synonym of *P. djamor* (Rumph. ex Fr.) Boedijn and hence stands excluded from Indian record.

3. *P. subpalmatus* (Fr.) Gillet. *Les Hyménomycètes* 343 (1876).

Hennings (1901) recorded it growing on the ground, perhaps on roots from Aringadh, Mussoorie in Uttar Pradesh (now Uttrakhand) to be that of *Rhotodus palmatus* (Bull.) Maire. *P. subpalmatus* (Fr.) Gillet. is treated as a synonym of *Rhotodus palmatus* (Bull.) Maire in the Mycobank record and hence is deleted from Indian records of *Pleurotus* species.

4. *P. eöus* (Berk.) Sacc. *Syll. Fung.* **5** : 361 (1887).

Berkeley (1856) reported it growing on dead tree trunks in open places in Sikkim. Singh and Rajarathnam (1977) documented it from Karnataka. Roy and Samajpati (1980) reported this species from Bankura in West Bengal. In MycoBank's opinion it is treated as a synonym of *P. djamor* (Rumph. ex Fr.) Boedijn, hence is deleted from Indian record.

5. *P. ninguidus* (Berk.) Sacc. *Syll. Fung.* **5** : 361 (1887).

Berkeley (1850) recorded it growing on dead timber from Sikkim. *P. ninguidus* is treated as a synonym of *P. djamor* (Rumph. ex Fr.) Boedijn in the MycoBank and hence stands deleted from Indian record.

6. *P. fimbriatus* (Bolt.) Gillet. *Les Hyménomycètes ou Description De Tousl Champignons Qui Croissent En France*, 341 (1876).

Graham (1915) documented this species from Madhya Pradesh. This collection actually belonged to *Pleurocollybia lignatitidis* Gillet., because of which Manjula (1983) recommended the exclusion of *P. fimbriatus* (Bolt.) Gillet. from the Indian records.

7. *P. verrucarius* (Berk.) Sacc. *Syll. Fung.* **5**: 351 (1887).

Berkeley (1856) recorded it growing on dead wood from Darjeeling in West Bengal. Manjula (1983) transferred this collection to *L. badius* Berk. and recommended the exclusion of *L. verrucarius* (Berk.)Sacc. from Indian record. This species is listed as the synonym of *Lentinus inquinans* Berk. in MycoBank record

8. *P. parsonii* (Stev.). *Kew Bull.* **19** : 31 (1964).

Dhancholia and Sinha (1988) recorded this species from Cuttuck in Orrisa. This species has no record in MycoBank as an independent species and hence stands excluded from Indian records.

9. *P. hapalosclerus* (Berk.) Sacc. *Syll. Fung.* **5** : 1887.

Berkeley (1856) documented it growing on the trunks in Darjeeling. It was described as *P. apalosclerus* (Berk.) Sacc. in the original description. Pegler (1976) identified this collection as *Armellaria mellea* Sing. based upon which Manjula (1983) recommended the exclusion of *P. hapalosclerus* (Berk.) Sacc. from the Indian records.

Presently five species of *Pleurotus* (Fr.) P. Kumm. namely, *Pleurotus sapidus* Kalchb., *Pleurotus cystidiosus* O.K.Miller subsp. *abalonus* (Han, Chen & Cheng.) G.J.Zervakis, *P. floridanus* Singer, *P. pulmonarius* (Fr.) Quél. var. *indica* var. nov. and *P. sajor-caju* (Fr.) Singer collected from the wild have been taxonomically described based upon classical and molecular techniques. A key to their determination is given below:

1. Fructifications 8 – 12 cm in height; cheilocystidia present on the gill edges .....2
- 1'. Fructifications smaller, not beyond 3 cm in height; cheilocystidia absent on gill edges.....4
2. Basidiospores large sized, 8.5 – 16.6 X 4 – 6.64 µm.....3
- 2'. Basidiospores smaller, 5.6 – 8 X 2.4 – 4 µm.....*P. sapidus*
3. Pileus greyish brown bearing brownish to purplish squammules ; mycelium forms toxocyst representing coremia in culture.... *P. cystidiosus* ssp. *abalonus*
- 3'. Pileus white, lemon yellow to light yellowish brown on drying; mycelium do not form toxocyst in culture..... *P. floridanus*
4. Fructification pulmonariform; white to whitish grey; stipe greyish white, excentric and without any hairy tomentum at the base. ....*P.pulmonarius* var. *indica*

- 4'. Fructification stout, shell like, pleurotoid, grey to brownish grey, stipe rudimentary to almost none, yellowish white, hairy tomentose towards the base..... *P. sajor-caju*

In the text the description of individual taxon has been arranged in the sequence of its segregation in the key above.

**1. *Pleurotus sapidus* Kalchb. *Comptes Rendus De Association Française Pour. Avancement Des Sciences* **11** : 338 (1883).**

**Plates - 14 & 15**

**Synonyms**

*Agaricus sapidus* Schulzer Kalchbrenner. *Icon. Sel. Hymenomyc. Hung.* 1873.

*Agaricus sapidus* Schulzer. *Verhandlungen Der Zoologisch - Botanischen Gesellschaft Wien* **30** : 492 (1881).

*Dendrosarcus sapidus* (Schulzer) Kuntze. *Revisio Generum Plantarum* **3** : 464 (1898).

**Morphological details**

Fructifications up to 8 – 11 cm in height, pleurotoid (Figs. 14/A; 15/A). Pileus up to 11 cm in diameter, depressed; surface yellowish white (4A2), smooth, scales absent, dry; veil absent; fleshy, flesh up to 0.3 cm thick, white, unchanging on exposure to air; taste and odour mild. Lamellae yellowish white (4A2), decurrent, extending down on to the stipe, subdistant (up to 0.3 cm apart from each other), unequal, divided into four tiers, ventricose, gill edges smooth, spore print white (1F1). Stipe yellowish white (4A2), eccentric to lateral, 7.4 cm long, 1.2 cm broad, almost equal throughout, solid, concolorous with the pileus, smooth.

**Microscopical details**

Spores 5.6 – 8.05 x 2.4 – 4.02  $\mu\text{m}$  (Q = 2.0), oblong, elliptical, inamyloid (Figs. 14/B ; 15/B). Basidia 13.7 – 16.1 x 7.2 - 8.05  $\mu\text{m}$  ; sterigmata upto 1.61  $\mu\text{m}$  long; gill edges heteromorphous. Cheilocystidia club shaped to versiform with elongated tip, 22.54 - 45.08 x 4.83 – 7.24  $\mu\text{m}$  (Fig. 14/C ; 15/E), pleurocystidia

clavate, 16.1 – 19.32 x 3.22 – 4.83 µm. Pileocystidia, abundant, elongated. Pileus elements clamped septate (Fig. 15/F); hymenophoral trama having interwoven hyphal elements. Stipe hyphae with thick walls and clamped, 3.20 - 4.02 µm in breadth. Hyphal system monomitic with prominently clamped hyphae (Fig. 14/E ; 15/D)

### **Molecular characterization**

The sequence of 675 bp ITS region of the fungus showed 99% identity with the *Pleurotus sapidus* strain S047 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. The amplification of ITS-region and the phylogenetic relationship of this species with other related species has been shown in Plate-24 & 26. In the tree, sequence of the reference strain was obtained from the NCBI GenBank. The newly generated sequence has been submitted in GenBank (accession number JQ868741).

**COLLECTION EXAMINED:** Himachal Pradesh, Thakurdwara, Palampur (950m), growing gregariously on *Grevillea robusta*, Sapan Kumar, Sept. 16, 2009, PUN 4148.

### **Remarks**

*Pleurotus sapidus* is a widely distributed species throughout the world. This species is characterized by pleurotoid basidiocarps growing in caespitose clusters. It is a wood decaying fleshy edible species which is being consumed in many parts of the world. Earlier it was reported from Madhya Pradesh (M.P.) by Graham (1915) and is an edible species consumed worldwide.

### **Culture Characteristics**

Growth of mycelium started on the second day of inoculation of the tissue on the solid medium (P.D.A.). The colony diameter reached up to 1.2 cm on second day. Mycelium growth was in concentric manner with regular margins. It took 9 days after inoculation for the mycelium to cover the diameter of a petriplate. The mycelium was noted growing @ 1.1 cm on an average daily basis. During the entire stages of growth

the color of the mycelium was white. To begin with the mycelial mat was thin, smooth and concentric but later on it became dense and cottony (Fig. 14/F). Finally the mat attained leathery consistency with almond like fragrance as in case of *P. floridanus*. Hyphal construction was found to be monomitic with prominently clamped generative hyphae.

**CULTURE DEPOSITION :** Culture deposited in Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10943.

2. *Pleurotus cystidiosus* O.K.Miller **subsp. abalonus** (Han, Chen & Cheng.) G.J.Zervakis *Mycol.* **90**(6) : 1063 - 1074(1998).

**Plates - 16&17**

**Nomen anamorphosis:** *Antromycopsis macrocarpa* (Ellis & Everh) Stalpers, Seifert & Samson.

#### **Morphological details**

Fructification up to 9.2 cm in height, pleurotoid (Figs. 16/A ; 17/A). Pileus up to 10.5 cm in diameter, depressed; surface grayish brown (8F3) bearing brownish to purplish squamules, dry; veil absent; fleshy, flesh up to 0.3 cm thick, white; unchanging on exposure to air; taste and odour mild. Lamellae yellowish white (4A2), decurrent, extending down on to the stipe, subdistant, lamellae up to 0.4 cm apart from each other, unequal, divided into two tiers, ventricose, gill edges wavy, spore print white (1F1). Stipe grayish brown (8F3), lateral, 4.5 to 6.5 cm long, 2.2 to 3 cm broad, tapering downwards, solid, flesh white underneath.

#### **Microscopic details**

Spores 8.5 - 14.5 x 4.5 - 6.64  $\mu\text{m}$  (Q = 2.18), oblong, elliptical, inamyloid (Figs. 16/E ; 17/B). Basidia 33.2 – 50.0 x 5.0 - 8.30  $\mu\text{m}$ ; sterigmata 3.3 - 8.3  $\mu\text{m}$  long. Pleurocystidia 36.5 - 43 X 4.9 - 8.3  $\mu\text{m}$ , clavate to ventricose, abundant (Fig. 17/D); cheilocystidia clavate to pyriform, club shaped, 16 - 22.5 x 5 - 8  $\mu\text{m}$  (Fig. 17/F); gill edges heteromorphous. Hymenophoral trama formed of interwoven hyphal elements.

Pileus cuticle hyphal with scattered to aggregated clavate to cylindrical pileocystidia measuring 24.15 - 32 x 4.83 – 7.3  $\mu\text{m}$  (Fig. 17/E). Clamp connections present in the hyphal elements of pileus; hymenophoral trama having interwoven hyphal elements. Hyphal construction monomitic with prominently clamped generative hyphae (Figs. 16/F ; 17/C).

### **Molecular Characterization**

A single band of ~600 bp was obtained on amplification of the ITS region of the fungus (Plate-24). The sequence of 514 bp ITS region of the fungus showed 92% identity with the *Pleurotus cystidiosus* strain ACCC 51280 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. The phylogenetic relationship of the presently investigated species with other related species has been shown in Plate-26. In the tree, sequences of reference strain were obtained for ascertaining the relatedness from the NCBI GenBank. The newly generated sequence has been submitted in GenBank (accession number GU947713).

**COLLECTION EXAMINED:** Baradari Gardens (250m), Patiala, Punjab, India, growing in caespitose clusters on *Mangifera indica*, Sapan Kumar, PUN 3949, June 6, 2008.

### **Remarks**

This species is widely distributed in central Argentina, United States, Indiana, Brown Country, Hoosier. From India it was reported by Natarajan and Raman (1984) from Tamil Nadu. This species is characterized by abundant clavate pileocystidia; oblong-elliptical non-amyloid spores; short pyriform infrequent cheilocystidia; and complete absence of a veil. These characters are reinforced by the unique black-headed coremia, which are produced in abundance in culture. In addition, this fungus

produces abundant chlamydospores with thick brown walls but no coremia (synnemata). Kaufert (1936) reported the sporophores of this mushroom from a "fire-scarred red gum (*Liquidambar styraciflua* L.) in Mississippi and five isolates from Louisiana on fire-scarred *Quercus nuttallii* where the coremioid asexual stage caused a white rot of the sapwood similar to that has been reported on red maple. Current isolate has been documented from *Mangifera indica* and is an edible species.

### **Culture characteristics**

After 4 days of inoculation of the fresh tissue at 25 °C, irregular mycelial growth started on the entire inoculated tissue. At first, a large amount of hyaline, aerial mycelium was observed which in due course become whitish. Coremia formation started in the form of small protuberances on the entire tissue simultaneously (Fig. 16/B). Initially tiny watery droplets having blackish color appeared on the white stalk which after 3 days of protuberance appearance terminated into distinct capitate structure called toxocyst (Fig. 16/C), which is a characteristic feature of *P. cystidiosus* subsp. *abalonus*. In the hyphae prominent clamp connections were observed (Fig. 16/F). Growth of mycelium was cottony and irregular. Coremial spores measured from 7.77 - 10.81 µm (Fig. 16/D). Optimum temperature for mycelial growth was recorded at 25 ±1 °C. There was no coremia formation below 15 °C. With maturity in the fourth week emergence of disagreeable putrid odour from culture plate became quite prominent.

**CULTURE DEPOSITION :** Culture deposited in Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10940.

3. *Pleurotus floridanus* Singer. *Pap. Mich. Acad. Sci.* **32** : 134 (1946).

Plates - 18 & 19

### Synonyms

- Agaricus allochrous* Pers., *Mycologia Europaea* **3** : 38 (1828).  
*Pleurotus allochrous* (Pers.) Sacc. & Traverso Saccardo, *Sylloge Fungorum* **20** : 447 (1911).  
*Pleurotus salignus* var. *allochrous* (Pers.) Sacc. & Trotter Saccardo. *Sylloge Fungorum* **21** : 66 (1912).  
*Pleurotus columbinus* Quél. *Fungi tridentini* **1** : 10 (1881).  
*Pleurotus columbinus* Quél. *Enchiridion Fungorum in Europa media et praesertim in Gallia Vigentium*: 148 (1886).  
*Dendrosarcus columbinus* (Quél.) Kuntze. *Revisio Generum Plantarum* **3** : 463 (1898).  
*Pleurotus ostreatus* f. *columbinus* (Quél.) Pilát. *Atlas des Champignons de Europe II*. 120 (1935).  
*Crepidopus ostreatus* (Jacq.) Gray. *A Natural Arrangement of British Plants* **1** : 616 (1821).  
*Dendrosarcus ostreatus* (Jacq.) *Revisio Generum Plantarum* **3** : 463 (1898).  
*Agaricus salignus* Pers. *Synopsis Methodica Fungorum* 478 (1801).

### Morphological details

Basidiocarp clitocyboid, lentinoid to pleurotoid usually gregarious up to 12 cm in height (Figs. 18/A,B ; 19/A). Pileus 10 - 15 cm in diameter, surface flattened, shell shaped, white (4A1), lemon yellow to light yellowish brown on drying, margin irregular, thin, usually recurved on drying; flesh up to 3 mm in thickness, unchanging; gills deeply decurrent, forming anastomosing ridges on the stipe (Fig. 18/19), subdistant, unequal, 4 mm broad, yellowish white, smooth; spore deposit light cremish white to almost white. Taste and odour mild. Stipe usually small, typically lateral to occasionally eccentric, 3.5 cm long, 1 cm broad, yellowish white, tapering downwards, solid, often woolly tomentose at the base where several fruitbodies are joined; veil absent.

### **Microscopical details**

Spores 9 - 16.6 X 4 - 6  $\mu\text{m}$  (Q = 2.6), elongate, ellipsoid, hyaline, inamyloid (Figs. 18/C ; 19/C). Basidia 29.9 - 46.5 X 5.8 - 9.2  $\mu\text{m}$ , clavate, hyaline, thin walled, tetrasporic (Fig. 19/B); sterigmata 3.3 - 6.64  $\mu\text{m}$  long; gill edges fertile with occasional cheilocystidia. Cheilocystidia 21.6 - 26.6 X 5.8 - 8.3  $\mu\text{m}$ , narrowly clavate to fusoid ventricose with tapering tip (Fig. 19/D). Pileus surface composed of radially arranged pileocystidia measuring 28.2 - 43.16 X 7.5 - 8.3  $\mu\text{m}$ ; context homoiomerous; gill trama interwoven. Stipe cuticle composed of filamentous hyphae many of which forms aggregates of adhering components resulting in scruffiness, some of the surface scales 3.3 - 4.2 in diameter. Clamp connections present in pileus tramal context and stipe surface hyphae (Figs. 18/E). Hyphal system monomitic.

### **Molecular Characterization**

The sequence of 600 bp ITS region of the fungus showed 99% identity with the *Pleurotus floridanus* Singer strain dd08070 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. The amplification of the ITS-region and the phylogenetic relationship of this species with the other related species is shown in Plate-24&26. In the tree, sequences of reference strain were obtained from the NCBI GenBank. The newly generated sequence has been submitted in GenBank (accession number JQ868739).

**COLLECTION EXAMINED:** Punjab, Baradari Gardens, Patiala (251m), growing gregariously on Banyan tree, Sapan Kumar, July 7, 2008, PUN - 3894.

### **Remarks**

The present collection was made from *Ficus benghalensis* L. stump. This species is characterized by clitocyboid, lentinoid to pleurotoid usually gregarious basidiocarps which becomes lemon yellow to light yellowish brown on drying. The stipe of the carpophore is usually small, typically lateral to occasionally eccentric,

yellowish white, solid with woolly tomentum at the base where several fruit bodies are joined. On the basis of its macroscopic and microscopic features this collection has been identified as *P. floridanus* Singer. It has wide distribution and is reported to grow in USA, Florida, East countries and South Western Argentina (Nobles, 1948).

### **Culture Characteristics**

Growth of the mycelium started on a day after inoculation of the tissue in petriplate containing Potato Dextrose Agar (solid Medium) incubated at  $28 \pm 1$  °C. It reached upto 1 cm in diameter at the end of second day of inoculation. Mycelium appeared in concentric manner with regular margins. With time culture became denser but the rate of growth was slow (Fig. 18/F). It took 11 days after inoculation for mycelium to cover the petriplate (Fig. 18/F). On overall basis the mycelium was observed growing @ 0.8 cm/day. During the entire growth period of this fungus the color of the mycelium remained white.

To begin with the mycelial mat was thin but in due course of time it became cottony dense and finally leathery. The culture emitted a peculiar almond odour when smelled. Hyphal construction was found to be monomitic with prominently clamped generative hyphae (Fig. 18E).

**CULTURE DEPOSITION :** Culture deposited in Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10941.

**4. *Pleurotus pulmonarius* (Fr.) Quèl. *Mém. de la Soc. Émul. de Montbéliard* 5 : 113 (1872).**

**var. *indica* var nov.**

**Plates – 20 & 21**

### **Morphological details**

Fructification up to 3 cm in height, pleurotoid, pulmonariform to labelliform, soft when young hard on drying (Figs. 20/A ; 21/A). Pileus 6 - 7 cm in diameter, depressed; surface whitish to brownish grey (5D2) in the center, dry; margin inrolled

when young, irregular, splitting at maturity; cuticle fully peeling; veil absent; fleshy, flesh up to 0.3 cm thick, white; unchanging on exposure; taste and odour mild. Lamellae yellowish white (4A2), decurrent, extending down on to the stipe, subdistant to close (up to 0.4 cm apart from each other), ventricose, gill edges smooth, spore print white (1A1). Stipe grayish white (8F3), excentric, 2 cm long, 1 cm broad; solid, equal in diameter throughout, smooth, annulus absent, solid, concolorous with the pileus.

### **Microscopical details**

Spores (6.64) 6.6 – 11 (11.9) x 2.49 – 3.32  $\mu\text{m}$  (Q = 2.56), cylindrical, oblong, elliptical, hyaline, not dextrinoid or amyloid, thin walled, smooth (Figs. 20/C ; 21/B). Basidia 24.9 – 33.2 x 4.9 – 6.6  $\mu\text{m}$ , tetrasterigmatic (Figs. 20/B ; 21/C). Pleurocystidia club shaped, 11.27 – 35.42 x 3.22 – 8.05  $\mu\text{m}$ , resembling basidioles (Fig. 21/D); cheilocystidia absent. Pileus cuticle with scurfy surface, 22 – 36  $\mu\text{m}$  thick (Fig. 21/E). Cuticle composed of thick walled, septate hyphae, lying parallel to each other, 4 - 8  $\mu\text{m}$  broad. Gill trama homoiomerous, consisting of interwoven generative thin and thick walled hyphal elements measuring 3.22 – 4.83  $\mu\text{m}$  in width (Fig. 20/D). Stipe cuticle 16 – 24  $\mu\text{m}$  thick, context composed of clamped 4.83  $\mu\text{m}$  broad hyphae, hyphal construction monomitic (Fig. 21/F), generative hyphae with clamps.

### **Molecular characterization**

The sequence of 639 bp ITS region of the fungus showed 94% identity with the *Pleurotus pulmonarius* voucher HMAS86396 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. The amplification of ITS-regions and the phylogenetic relationship of this species with other related species is shown in Plate-24 & 26. In the tree, sequences of reference strain were obtained from

the NCBI GenBank. The newly generated sequence has been submitted in GenBank (accession number JQ868740).

**COLLECTION EXAMINED:** Palampur, Himachal Pradesh (1200 m) growing in caespitose clusters on dead branch of *Albizia chinensis* tree, Sapan Kumar, PUN 4149, October 6, 2009.

### **Remarks**

This species is characterized by pulmonariform to flabelliform fruitbodies which are soft when young and hard on drying. The pileipellis in *P. pulmonarius* (Fr.) Quél is thinner with whitish to brownish gray pileus, lateral stipe and sweet aeromatic odour. In its gross morphological detail it comes quite close to *P. ostreatus* which possesses stouter carpophores with excentric stipe, thicker pileipellis, darker pileus color and fungal odour (Chakravarty and Purkayastha, 1976). Although the sequencing data of the presently examined collection exhibit 94% homology with the sequence of this species available in the GenBank but macroscopic and microscopic observations of this collection are in complete conformity with the details given by Watling and Gregory (1989) for *P. pulmonarius* (Fr.) Quél.

But the varied molecular sequence of the presently investigated taxon from the sequence of the type species available in the GenBank has led us to name a new variety *P. pulmonarius* var. *indica* var. nov. to accommodate this collection.

### **Culture Characteristics**

On the third day of inoculation of the tissue on the solid medium the mycelium started growing in concentric manner with regular margins and reached a diameter of 3.0 cm. With maturity the culture became denser. After seventh day of inoculation the mycelium covered the petriplate fully with diameter of the colony reaching up to 8 cm. On overall basis the mycelium was recorded growing @ 1.23 cm on an average daily basis. To begin with the mat was smooth and thin but in due course it became

dense and cottony (Fig. 20/ E). The overall colour of the mycelium remained white. The culture was recorded to emit sweet smell throughout the growth period. Hyphal construction was monomitic with prominently clamped generative hyphae.

**CULTURE DEPOSITION:** Culture deposited in Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology (IMTECH) under MTCC No. 10942.

**5. *Pleurotus sajor-caju*. Singer, *Lilloa* **22** : 2711(1949)**

**Plates - 22 & 23**

**Synonyms**

- Lentinus annulifer* De Seynes, *Recherches pour servir à histoire naturelle et à la flore des champignons de Congo Français* **1** : 25 (1897).  
*Lentinus bonii* Pat. Patouillard, *N.T. Bulletin de la Société Mycologique de France* **8** : 48 (1892).  
*Lentinus bukobensis* Henn. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* **17** : 32 (1893)  
*Pocillaria dactyliophora* (Lév.) Kuntze. *Revisio Generum Plantarum* **2** : 866 (1891)  
*Armillaria dactyliophora* (Lév.) Beeli. *Bulletin de la Société Royale de Botanique de Belgique* **59** : 110 (1927).  
*Lentinus dactyliophorus* Lév., *Annales des Sciences Naturelles, Botanique* **2** : 174 (1844).  
*Lentinus exilis* Klotzsch ex Fr. *Synopsis generis Lentinorum*: **10** : (1836)  
*Pocillaria exilis* (Klotzsch ex Fr.) Kuntze. *Revisio Generum Plantarum* **2** : 866 (1891).  
*Panus exilis* (Klotzsch ex Fr.) Bres. *Bulletin de la Société Royale de Botanique de Belgique* **38** : 153 (1899).  
*Pocillaria glandulosa* (Ces.) Kuntze. *Revisio Generum Plantarum* **2** : 866 (1891).  
*Lentinus glandulosus* Ces. *Atti dell'Accademia di Scienze fisiche e matematiche, Napoli* **8** : 3 (1879).  
*Lentinus irregularis* Curr. *Transactions of the Linnaean Society of London* **1** : 121 (1876).  
*Pocillaria irregularis* (Curr.) Kuntze. *Revisio Generum Plantarum* **2** : 866 (1891).  
*Lentinus murrayi* (Kalchbr. & MacOwan). *Grevillea* **9** : 136 (1881).  
*Pocillaria murrayi* (Kalchbr. & MacOwan) Kuntze. *Revisio generum plantarum* **2** : 866 (1891).  
*Lentinus nicobarensis* Reichardt Fenzl. *Reise der Österr. Fregatte Novara* **1** : 143(1870).  
*Pocillaria nicobarensis* (Reichardt) Kuntze. *Revisio Generum Plantarum* **2** : 866 (1891).  
*Lentinus stenophyllus* Reichardt. *Verhandlungen der Zoologisch-Botanischen Gesellschaft Wien* **16** : 375 (1866).  
*Lentinus tanghiniae* Lév. *Annales des Sciences Naturelles, Botanique* **5** : 119 (1846).  
*Pocillaria tanghiniae* (Lév.) Kuntzel *Revisio Generum Plantarum* **2** : 866 (1891).  
*Lentinus tenuipes* Sacc. & Paol. *Atti dell'Istituto veneto Scienze* **6** : 392 (1888).

### **Morphological details**

Fructification up to 3 cm in height, stout, fleshy white shell like, pleurotoid, caespitose (Figs. 22/A; 23/A). Pileus up to 14 cm in diameter; surface grey to brownish grey when young to brownish (5C2) at maturity, smooth, scales absent on the pileus surface, dry; veil absent; margin inrolled depressed, flesh up to 0.3 cm thick, white, unchanging on exposure; taste and odour mild. Lamellae yellowish white (4A2), decurrent, extending down on to the stipe, subdistant (up to 0.3 cm apart from each other), unequal, divided into three tiers, ventricose, gill edges smooth, spore print white (1F1). Stipe rudimentary to almost none, yellowish white (4A2), excentric, up to 2 cm long, 2 cm broad, almost equal throughout, solid, smooth, hairy tomentose towards the base, flesh white underneath.

### **Microscopical details**

Spores (6.44) 7.24 – 9.66 (11.27) x 2.49 – 4.15  $\mu\text{m}$  (Q = 2.54), oblong, elliptical, bean shaped, smooth, inamyloid (Figs. 22/C ; 23/B). Basidia 16.1 – 22.54 x 4.02 - 4.83  $\mu\text{m}$ , club shaped, tetrasporic, tetra-sterigmatic (Figs. 22/B ; 23/C); sterigmata 2.41 – 4.02  $\mu\text{m}$  long; gill edges heteromorphous. Hymenophoral trama irregular (Fig. 23/E). Pleurocystidia and cheilocystidia absent. Pileus cuticle 60 – 112  $\mu\text{m}$  thick, with thin hyphae forming a scurfy layer over the pileus surface. Pileus context composed of elongated, branched, septate hyphae measuring 2.22 – 4.83  $\mu\text{m}$  in breadth; pileocystidia small 2.49 - 4.98 X 2.49  $\mu\text{m}$ . Gill trama consisting of interwoven generative hyphal elements measuring 2.2 – 4.8  $\mu\text{m}$  in width. Hyphal pegs present. Stipe cuticle 12 – 20  $\mu\text{m}$  thick: context composed of calmped, septate, hyphae measuring 4.83 – 6.44  $\mu\text{m}$  in breadth (Fig. 23/E), hyphal construction monomitic, generative hyphae with clamps.

### **Molecular characterization**

The sequence of 670 bp ITS region of the fungus showed 100 % identity with the *Pleurotus sajor-caju* strain S049 ITS 1, 5.8S rRNA gene and ITS 2, complete sequence; and 28S rRNA gene, partial sequence. The amplification of ITS-region and the phylogenetic relationship of this species with other related species is shown in Plate- 24&26. In the tree, sequences of reference strain were obtained from the NCBI GenBank. The newly generated sequence has been submitted in GenBank (accession number JQ868742).

**COLLECTION EXAMINED:** Himachal Pradesh, Palampur (1200 m), growing gregariously on *Albizia chinensis*, Sapan Kumar, Nov. 10, 2009, PUN - 4150.

### **Remarks**

The species can be identified by white shell like, pleurotoid, caespitose, basidiocarps with pileus having grey to brownish grey surface with inrolled, yellowish white margins. Stipe small to rudimentary with hairy tomentum at the base. This species is widely distributed in countries like Nigeria, Spain, etc. Earlier from India it is reported by Nair and Kaul (1980).

### **Culture Characteristics**

Growth of mycelium started from a day after inoculation on PDA. On the second day of inoculation mycelial diameter reached up to 1.3. It took 7 days after inoculation for the mycelium to cover the complete diameter of petriplate. The mycelium was recorded growing @ 1.2 cm growing on an average daily basis. In the beginning the mycelial mat was thin and appeared concentric but with maturity it became dense and cottony (Fig. 22/F). The mycelium remained white throughout the growth period and emitted fragrant odour. Hyphal construction was found to be monomitic and the generative hyphae were prominently clamped.

**CULTURE DEPOSITION:** Culture deposited in Microbial Type Culture Collection and GeneBank, Institute of Microbial Technology (IMTECH) under MTCC No. 10944.