

Taxonomy and Diversity of *Ganoderma* from the Western parts of Maharashtra (India)

Bhosle S^{1*}, Ranadive K², Bapat G¹, Garad S¹, Deshpande G¹ and Vaidya J⁶

¹Department of Botany, University of Pune, Pune – 411 007, India

²Waghire college Saswad, Tal- Purandhar, Maharashtra (India) ranadive.kiran@gmail.com

Bhosle S, Ranadive K, Bapat G, Garad S, Deshpande G, Vaidya J (2010). Taxonomy and Diversity of *Ganoderma* from the Western parts of Maharashtra (India). *Mycosphere* 1(3), 249–262.

Ganoderma is the genus from order Aphyllophorales with more than 300 species. The type species, *Ganoderma lucidum* is medicinally important and many other species are worked out for various medicinal properties. Only 9 valid species have been reported from India but the present study reports 15 species and 3 varieties of *G. lucidum*, of which one variety remains unidentified. The species are each described and the fruit bodies, spore and cutis are illustrated.

Key words – Aphyllophorales – Ganodermataceae – Maharashtra – medicinal mushroom – Western Ghats

Article Information

Received 8 July 2010

Accepted 5 October 2010

Published online 30 October 2010

*Corresponding author: Shekhar Bhosle – e-mail – srbhosle@gmail.com

Introduction

Ganoderma is largest genus in order aphyllophorales with more than 300 species. It is known to cause root or butt rot of the hardwood trees, and also known as medicinally important mushroom in the Asian continent.

Karsten in 1881 established the genus *Ganoderma* with the type species *G. lucidum* and number of species has been described in the genus thereafter. The genus *Ganoderma* was divided in two sub-genus, *Ganoderma* and *Elfvigia* by Karsten in 1889 (Steyaert, 1980). The sub-genus *Elfvigia* was based on the name *Boletus applanatus* and the section was dedicated to the species with non-laccate pileated fruit body.

Different taxonomic characters were used for identification by various authors, namely Murill (1902, 1903), Atkinson (1908), Coleman (1927), Corner (1947). Steyaert (1972, 1980) worked extensively on the genus from nearly each continent of the world. He created many new species or transferred many names

to this genus and also removed several synonyms.

Ryvarden (1995) questioned the morphology of *Ganoderma*. He studied 53 specimens of *G. lucidum* from Norway for the morphological variations. He concluded in judging the following morphological characters.

- Shape and size of basidiocarp are doubtful and at least 3-5 collections should be examined.
- Colour of pileus and stipe changes with age and should be carefully considered.
- Pore size is a valuable taxonomic character as it is constant.
- Colour of pore surface and context changes over time so specimens of different age should be examined.
- Hyphal system is of less help as majority species of *G. lucidum* group has Trimitic hyphal system (but latter on Ryvarden (2000) reported 15 species from *lucidum* group with dimitic hyphal system).

- f. Size and shape of apical pilear cells (cutis/dermal elements) is another reliable and constant character and valuable for taxonomic separation of species in at least *lucidum* group.
- g. Basidiospore may vary in size and shape and hence should be used carefully.

Ryvarden (1995) concluded that 1–2 collections are insufficient to describe a species unless there are striking microscopic characters coupled with distinct macromorphological features. Gottlieb and Wright (1999a,b) carried out their studies using the macro and micro-morphology, of the subgenus *Ganoderma* and *Elfvigia* respectively.

Recently, modern methods like isoenzyme analysis were used for phylogenetic studies. Park et al. (1994), Gottlieb et al. (1995, 1998), and Gottlieb & Wright (1999a) used this technique to discrete the species of *Ganoderma*. Smith & Sivasithamparam (2000) studied isoenzymes of five Australian species using Cellulose acetate gel electrophoresis (CAGE) and Polyacrylamide gel electrophoresis (PAGE). Moncalvo et al. (1995a,b) and Moncalvo et al. (1995c) used ribosomal DNA sequencing as tool for analyzing phylogenetic relationship in *Ganoderma lucidum* complex. Hseu et al. (1996) used RAPD – Polymerase chain reaction (PCR) and internal transcribed spacer (ITS) sequences to differentiate the isolates of *G. lucidum* complex.

Moncalvo & Ryvarden (1997) published a world list of *Ganoderma* species. The study considered the species described in last 200 years listing 386 names for Ganodermataceae as whole. There are 322 species listed in the CABI Bioscience Fungal names database. The database of Stalpers and Stegehuis available on CBS Website lists 316 names in *Ganoderma*.

In India, Bakshi (1971) contributed to the study of this genus, describing five species. Bilgrami et al. (1991), recorded seven species of *Ganoderma* in list, ‘Fungi of India’. Whereas some species are reported in different databases/checklists of various states, (<http://thallsvr.tn.nic.in/envis/CheckListFungi.html>, www.punjabenvironment.com/bd_list.htm).

Material and Methods

Collection of the samples was done from various locations from Pune University campus, City and the surrounding area. (Table 1)

For the morphological details thin, hand sections were taken from the cutis, context and from the tube layer of each sample respectively. Spores were isolated from a block of tube layer, technique described by Steyaert (1972). To loosen the hyphae, the sectioned material was treated with 10% KOH, washed with water and stained with 1% phloxine. These sections were again washed with water and finally stained with cotton blue. Lactoglycerine (50%) was used as mounting media. All the preparations were semi permanent. The slides were observed under Bausch and Lomb compound microscope having a combination of 10X eyepiece and 10X, 45X and oil immersion (i.e.100X), objectives.

The spores were observed under Olympus BX–40 at 100X objective with phase contrast and the dermis sections at 40X objective of the same. Photographs were taken using Olympus BX–40 attached with photomicrography unit.

Results

An artificial key was prepared to differentiate the collected species. For the segregation and assignment of correct taxonomic identity to the samples, keys of different authors *viz.* Bakshi, (1971), Steyaert (1972, 1980), Ryvarden & Johansen (1980), Gilbertson & Ryvarden (1986), Gottlieb & Wright (1999 a,b) and Ryvarden (1995, 2000) were used.

Key to the species of *Ganoderma*

1. Pileus non laccate; generally astipitate
.....2 (*G. applanatum* complex)
- 1*. Pileus laccate; stipitate.....
.....5 (*G. lucidum* complex)
2. Cutis trichodermis type..... 3
- 2*. Cutis other than trichodermis type..... 4
3. Spore (6) 7–11 × (4)5–7µm; tube layer single *G. lipsiense*

- 3*. Spore 7–8 × 5–6 μm; tube layer multiple (4–8).....*G. Applanatum*
4. Cutis anamixodermis; spore 7–10 × 4–7 μm.....*G. Testaceum*
- 4*. Cutis similar to plecodermis; spore 5–7 × 4–5 μm.....*G. philippi*
5. Hyphal system Dimitic..... 6
- 5*. Hyphal system Trimitic..... 12
6. Spore index = 1.2..... 7
- 6*. Spore index ≥ 1.3..... 8
7. Hymenodermis type speroid pedunculate (26–40 × 6–8 μm); pores angular 3 mm⁻¹ ...
.....*G. stipitatum*
- 7*. Hymenodermis type diverticulate (40–46 × 9–12 μm); pores circular 5 mm⁻¹.....
.....*G. orbiformum*
8. Cutis type claviform..... 9
- 8*. Cutis type diverticulate..... 10
9. Cutis 37–40 μm; context up to 5mm; spore index 1.3.....*G. recinaceum*
- 9*. Cutis 30–33 μm; context 15–20mm; spore index 1.6.....*G. chalceum*
10. Cutis size more than 45 μm..... 11
- 10*. Cutis up to 30 μm; spore index 1.3; context 5mm; pores 5–8 mm⁻¹.....
.....*G. multiplicatum*.
11. Cutis 45–52 μm; spore index 1.2; context 5 mm thick.....*G. perzonatum*
- 11*. Cutis 50–60 μm; spore index 1.5; context 8–13 mm thick.....*G. multicornum*
12. Spore ornamentation not distinctly rugose..... 13
- 12*. Spore ornamentation distinctly rugose .. 15
13. Cutis type claviform..... 14
- 13*. Cutis type sheproid pedunculate.....
.....*G. sessiliforme*
14. Context 10mm; cutis claviform (33.3–41.6 × 6.6–8.3 μm); spore ≤ 8 μm; pores angular 4 mm⁻¹.....*G. curtisii*
- 14*. Context 5mm; cutis diverticulate (20–38 × 8.3–9 μm); spore ≥ 8 μm; pores circular 5 mm⁻¹.....*G. praelongum*
15. Spore index ≥ 1.5; cutis ≤ 30 μm long; context layer ≤ 5 mm.....
.....*G. lucidum var. Unidentified*
- 15*. Spore index ≤ 1.5; cutis ≥ 30 μm long; context layer ≥ 5 mm..... 16.
16. Spore index = 1.5, spore up to 8 μm; cutis [40-50(60)×8.3–10]; context layer 5–7 mm.....
.....*G. lucidum var. lucidum*
- 16*. Spore index = 1.6, spore up to 10 μm; cutis [35–42 × 6–8.5]; context layer 9 mm.....
.....*G. lucidum var. capense*.

Description of Species

Ganoderma applanatum (Pers.) Pat., *Hyménomyc. Eur.* (Paris): 143 (1887)
= *Boletus applanatus* Pers., *Obs. Mycol.* 2:2. 1799.

Basidiocarp sessile, woody to corky, applanate, up to 40cm diameter, 1.5–5cm thick at base, shelf like. Upper surface pale grey to dark brown, crustose with concentric zonation, sulcate, covered with layer of chocolate, brown spore appearing dusty. Margin 1 to 10 mm, thick, sterile, rounded, turning brown on drying (Fig. 1a). Pore surface: whitish, milky to coffee, rough. Pore 4–5 per mm, spherical to ovoid. Tube multi layer, 4–8 layers in perennial specimen separated by layer. Context thick, purplish brown, shining. Cutis type trichodermis. Hyphal system trimitic, generative hyphae, 3.3–4.1 μm diameter, pale yellow with clamp connection; skeletal hyphae 5.8 to 6.6 μm diameter, dark brown; binding hyphae 7.5 μm diameter, dark brown. Basidiospore 7–8 × 5–6 μm, pale yellow. SI: 1.3 (Fig. 3a).

Material examined – On dead stump of *Phoenix sylvestris*, Government nursery GA – 2(PUC).

Geographical distribution – Forest region of USA. Canada, Germany, Austria, India, Nepal, Pakistan.

Ganoderma chalceum (Cooke) Steyaert, *Bull. Jard. Nat. Belg.* 37: 481, (1967).

= *Polyporus chalceus* Cooke, *Trans. Proc. Bot. Soc. Edinb.* 13: 135, 1878.

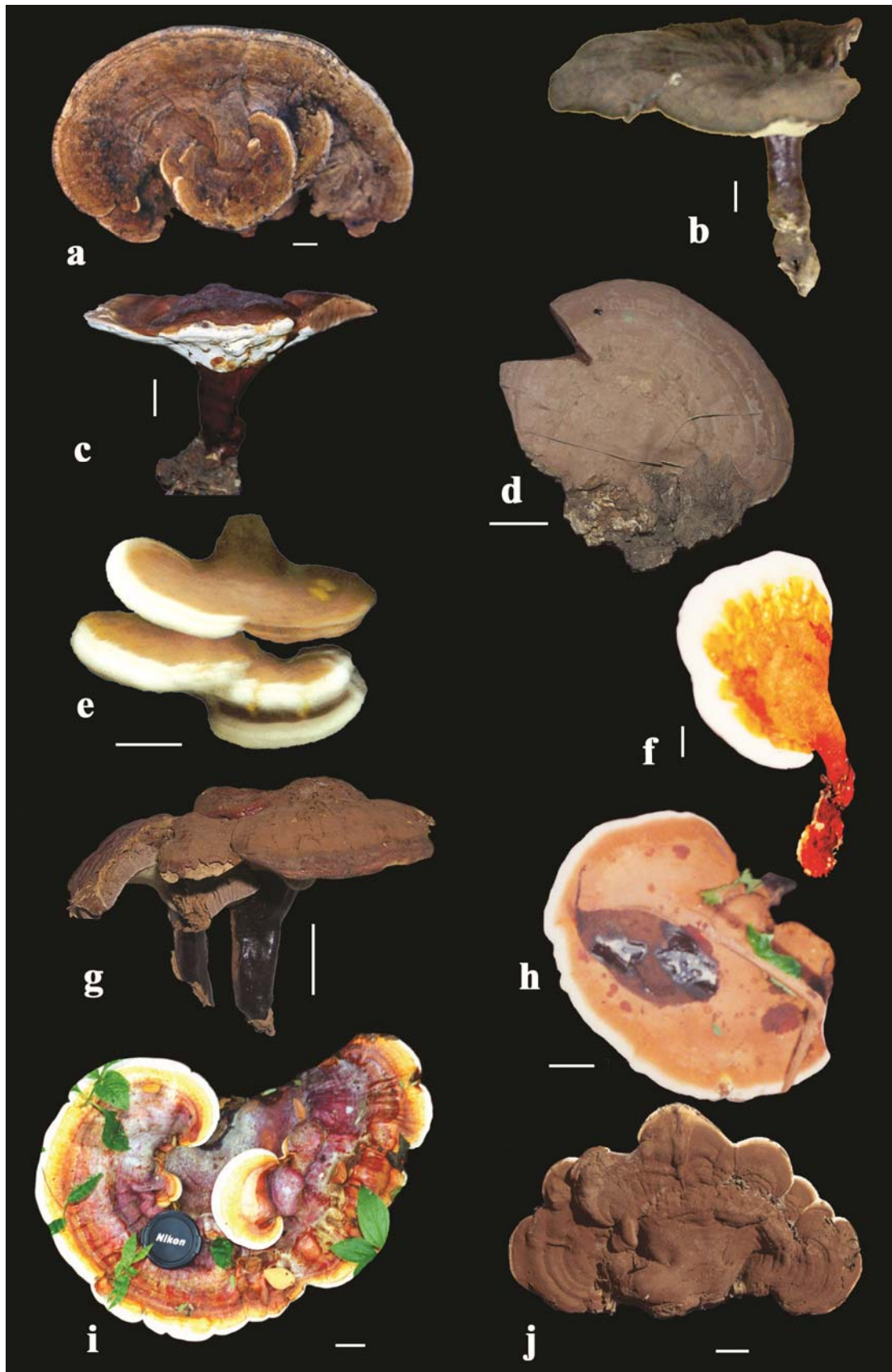


Fig. 1 – Basidiocarp of study Samples (bar = 2 cm). **a.** *Ganoderma applanatum* (GA-2); **b.** *G. chalceum* (GA-39); **c.** *Ganoderma curtisii* (GA-18); **d.** *G. lipsiense* (GA-19) **e.** *G. lucidum* var. *capense* (GA-6); **f.** *G. lucidum* var. *lucidum* (GA-13); **g.** *G. lucidum* var. *unidentified* (GA-38); **h.** *G. multicornum* (GA-28); **i.** *G. multiplicatum* (GA-27); **j.** *G. multiplicatum* (GA-12).

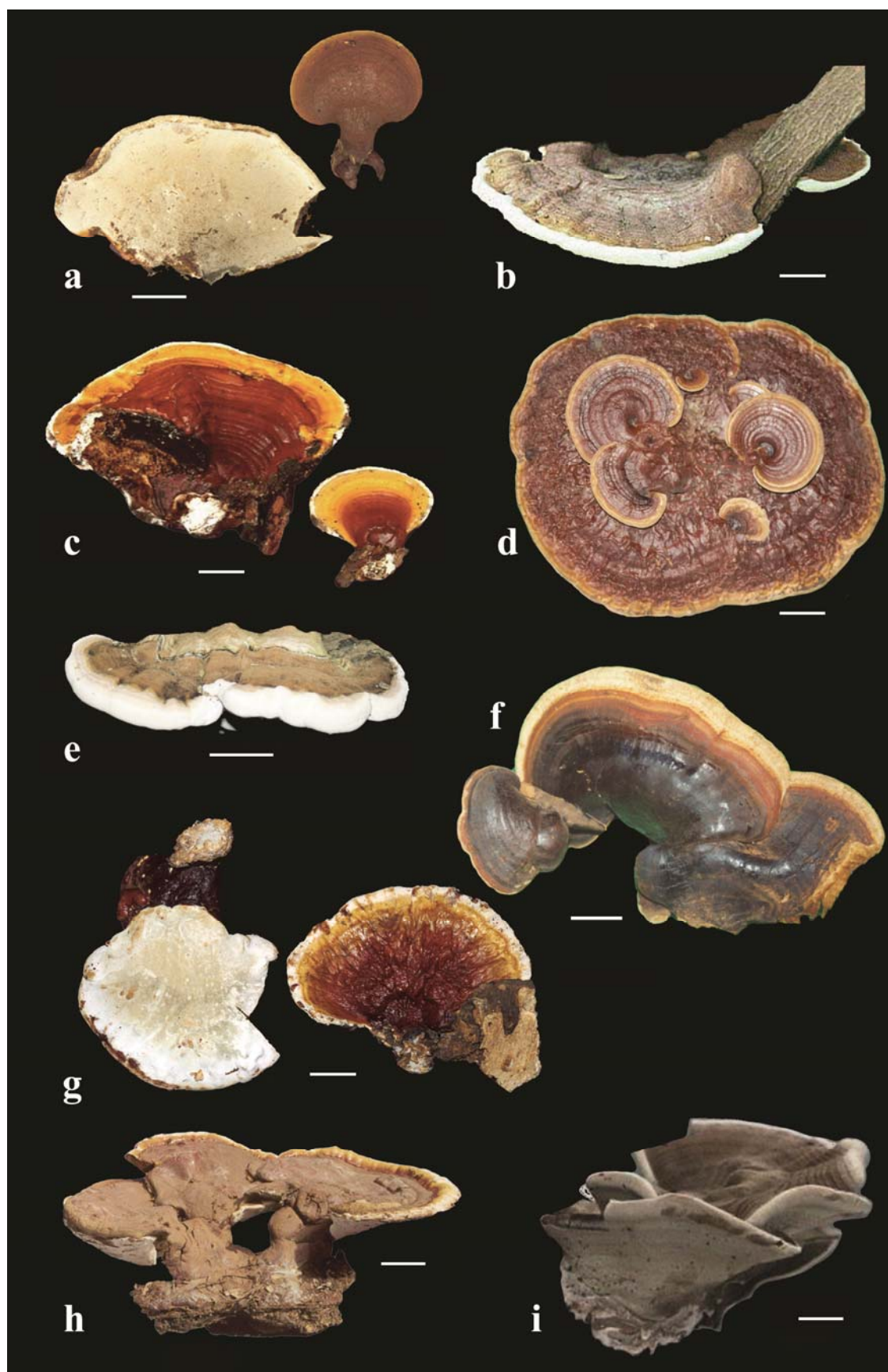


Fig. 2 – Basidiocarp of study Samples (bar = 2cm). **a.** *Ganoderma orbiformum*; **b.** *G. perzonatum*; **c.** *G. praelongum*; **d.** *G. praelongum*; **e.** *G. philippii*; **f.** *G. resinaceum*; **g.** *G. sessiliforme*; **h.** *G. stipitatum*; **i.** *G. testaceum*

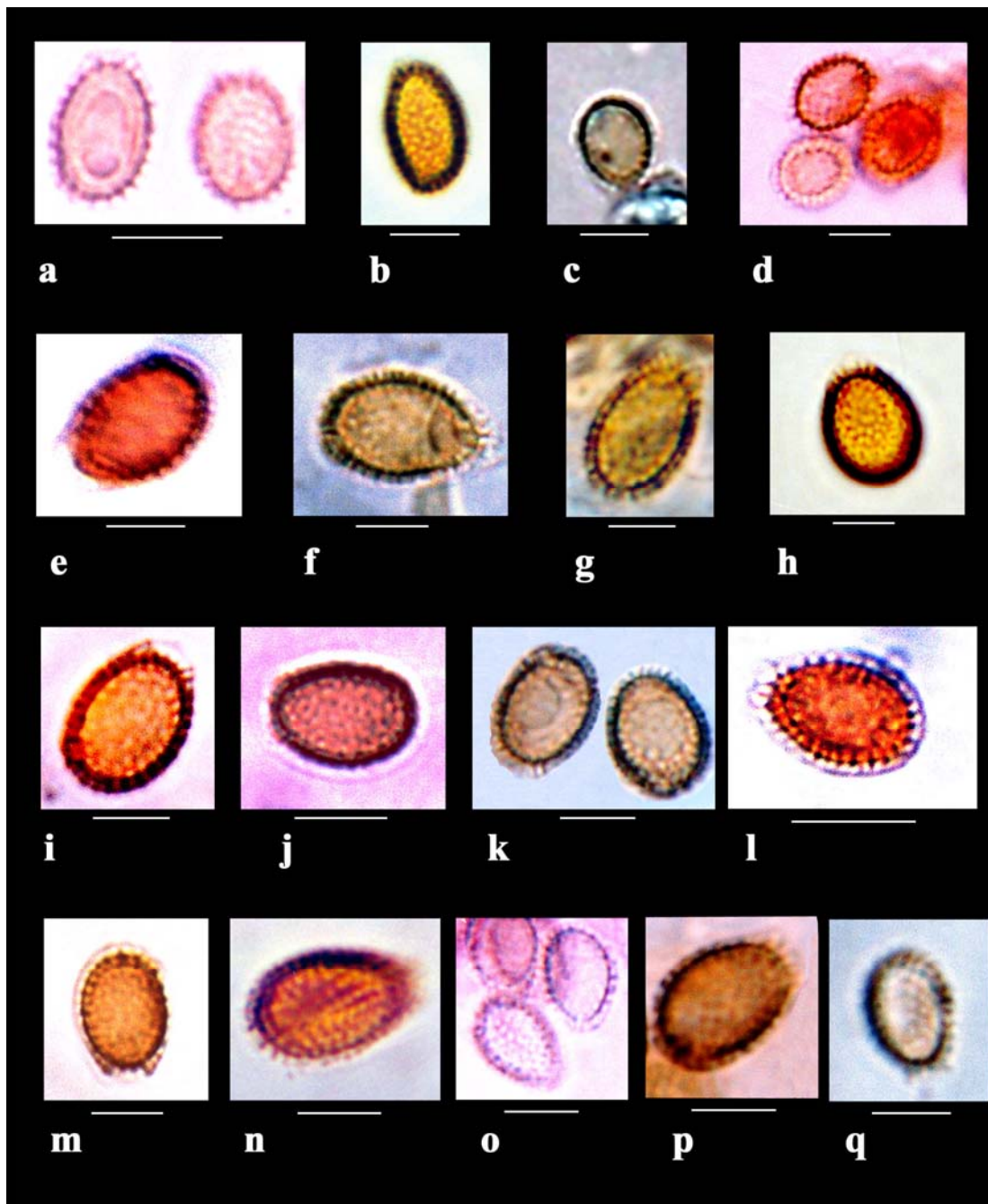


Fig. 3 – Spores of *Ganoderma* species (bar = 5 μ m). **a.** *Ganoderma applanatum*; **b.** *G. chalconum*; **c.** *G. curtisii*; **d.** *G. lipsiense*; **e.** *G. lucidum* var. *capense*; **f.** *G. lucidum* var. *lucidum*; **g.** *G. lucidum* var. *unidentified*; **h.** *G. multicornum*; **i.** *G. multiplicatum*; **j.** *G. orbiformum*; **k.** *G. perzonatum*; **l.** *G. philippi*; **m.** *G. praelongum*; **n.** *G. resinaceum*; **o.** *G. sessiliforme*; **p.** *G. stipitatum*; **q.** *G. testaceum*

Basidiocarp corky, annual, 14–17 \times 3–5 cm. Upper Surface reddish brown, laccate, highly sulcate, with crust Margin hard, acute, 2mm thick, creamish yellow, sterile (Fig. 1b). Pore Surface coffee colour. Pore minute, 3–5 per mm angular. Tube unstratified concolourous to pore surface, 4–13 mm long. Context coffee coloured, fibrous, up to 15mm wide and more than 20mm at base. Cutis type claviform with various types, 29.1–32.8 \times 5–5.5 μ m, (Fig. 4a). Hyphal System dimitic, generative hyphae

3.5 μ m diameter, hyaline, thin walled with clamps; skeletal hyphae 7.5 μ m diameter, brown.

Basidiospore – 5–6.6 \times 9.1–10 μ m, ellipsoid, yellowish brown. SI 1.6 (Fig. 3b).

Material examined – On unknown dead stump, Shivajinagar, Pune city (GA – 39).

Geographical Distribution – Panatropic species, reported from numerous countries in Africa and Asia (China), with wider distribution.

Ganoderma curtisii (Berk.) Murill, *North. Am. Fl.* 9:120 (1908).

= *Polyporus curtisii* Berkeley, Hook. *Journ. Bot.* 1: 101–102 (1849).

Basidiocarp subsessile to stipitate, laccate. Upper surface flabellate, upper surface variegated from ochraceous buff to carbo brown, usually laccate. Margin slightly thick, dull brown (Fig. 1c). Pore surface brownish. Pore angular, 4 per mm. Tube 10 mm thick, ochraceous-tawny. Context 10mm thick, milky coffee ochraceous buff to ochraeous tawn near tube layer with one or several dark brown zones, thin or thick laccate line, originating from stipe and run parallel to upper surface. Cutis type claviform type diverticulate at base, 33.3–41.6 × 6.6–8.3 μm (Fig. 4b). Hyphal System trimitic, generative hyphae 2.5 μm diameter, yellowish; skeletal hyphae 5 μm diameter, brown; binding hyphae 3.3 μm diameter, yellowish brown. Basidiospore 6–7.5 × 5–5.8 μm, ellipsoid, brown. SI 1.3 (Fig. 3c).

Material examined – *Gliricidia sepium*, Range Hill (GA–18) (PUC).

Geographical distribution – many places in U.S.A.

Ganoderma lipsiense (Batsch) Atk. *Ann. Mycol.* 6:189.(1908).

= *Boletus lipsiensis* Batsch, Elench. *Fung. Contin. Prima*, 183–187, 1796.

Basidiocarp hard, dimidiate, medium, appanate woody. Upper Surface slightly zonate, pulverulent glabrous, tuberous, rugose solitary, crust, rigid, up to 1mm thick, reddish grey or cinnamon. Margin hard, obtuse, slightly thick and lobate, cinnamon to grayish white or slightly yellowish (Fig. 1d). Pore Surface milky coffee. Pore minute, 5–6 per mm. Tube unstratified concolourous to pileus, 4–13 mm long. Context reddish brown, sub ferrugineous to coccoa coloured, corky, tough, thin, up to 30 mm wide. Cutis type, trichodermis. Hyphal System trimitic, generative hyphae 3.3 μm diameter, yellow; skeletal hyphae 5 μm diameter, brown; binding hyphae 5.8 μm diameter, brown. Basidiospore: 6–11 × 4–5 μm, ovoid to broadly ellipsoid. SI 1.3 (Fig. 3d).

Material examined – On living tree of *Casuarina equisetifolia*, Government Nursery (GA – 19, GA – 20) (PUC).

Geographical Distribution – U.S.A.

Ganoderma lucidum var. *capense* Lloyd, *Mycol. Writ.* V, *Lett.* 63:10.1916.

= *Polyporus capensis* Lloyd, *Mycol. Writ.* V, *Lett.* 63:10, 1916.

= *G. capense* (Lloyd) Teng, *Ckungo–Kuo Ti Chen – Chun.* p. 760. Science Press. Perking. 1963. [Reprint: *Fungi of China. Mycotaxon Ltd.* Ithaca, N.Y. P. 327.1996.]

Basidiocarp 7–12 × 11–19 × 1.5 cm, woody to corky, sub sessile to laterally stipitate with 2–3 cm in length, reniform. Upper Surface laccate, dark reddish, purplish, yellowish towards margin, brittle, soft. Margin blunt, rounded, brown white (Fig. 1e). Pore surface creamish to milky coffee. Pore 5 per mm, rounded. Tube 2–9 mm, white turning brown when brushed and with age. Context 9 mm wide, brown without horny deposition. Cutis type thick walled claviform type with diverticulate at base, 35–42 × 6–8.5 μm (Fig. 4c). Hyphal System trimitic, generative hyphae 3.3 μm diameter, hyaline, thin walled, with clamp connection; skeletal hyphae 5.8 to 7.5 μm diameter, brown coloured, thick walled; binding hyphae 5 to 7.5 μm diameter, brown colour. Basidiospore 8.3–10 × 6.6 μm, yellowish brown. SI 1.6 (Fig. 3e).

Material examined – On dead stump of *Pongamia pinnata*, Elis Garden (GA – 6) (PUC).

Geographical distribution – South-East Africa, China.

Remarks – refer to the Table 1, for relevant information pertaining to this variety.

Ganoderma lucidum (Curtis: Fr.) P. Karst. var. *lucidum*, *Rev. Mycol.* 3 (9): 16–18.1881.

= *Boletus lucidus* W. Curtis, *Flora londinensis* f. 4, pl. 224, 1781

Basidiocarp laterally stipitate or eccentric, 12–14 × 8–9 × 1.6 cm, laccate, brittle, stipe reddish black, 7–10 cm long. Upper surface radially sulcate, semidull dark reddish brown. Margin thin, yellowish to brown (Fig. 1f). Pore surface cream-turning ochraceous. Pore 4–5 per mm, round to irregular. Tube 5–7 mm long, cream to ochraceous. Context almost as thick as tube, thickening towards the base of the stem. Cutis Type thick walled claviform, 40–50 × 8.3–10 μm, (Fig. 4d). Hyphal system trimitic, generative hyphae 2.5–3 μm diameter, thin walled, hyaline; skeletal hyphae 5–5.8 μm

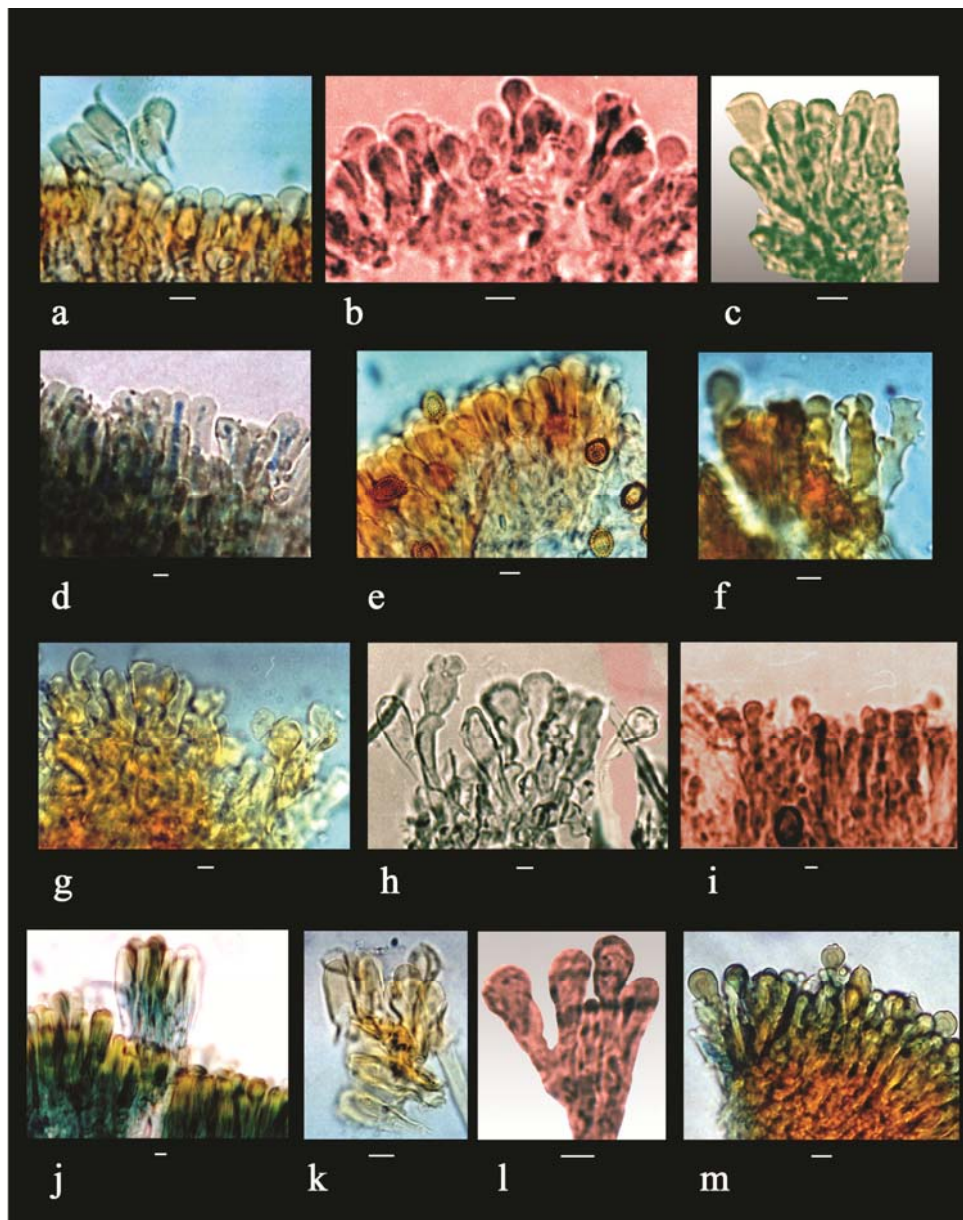


Fig. 4 – Cutis of *Ganoderma* species (bar=5 μ m). **a.** *Ganoderma chalconum*; **b.** *G. curtisii*; **c.** *G. lucidum* var. *capense*; **d.** *G. lucidum* var. *lucidum* **e.** *G. lucidum* var. unidentified; **f.** *G. multicornum*; **g.** *G. multiplicatum*; **h.** *G. orbiformum*; **i.** *G. perzonatum*; **j.** *G. praelongum*; **k.** *G. resinaceum*; **l.** *G. sessiliforme*; **m.** *G. stipitatum*.

diameter, thick walled, yellowish green. Basidiospore 7–8.5 \times 5–6 μ m, chamois, rugose, obovate. SI 1.5 (Fig. 3f).

Material examined – On living tree of *Citrus aurantium*, Pimple dhumal, Pune.(GA – 13).

Geographical distribution – Finland, Europe, USA, India, Kenya, Tanzania, Ghana, China, Japan, Korea and other South East Asian countries.

Remarks – refer to the Table 1, for relevant information pertaining to this variety.

Ganoderma lucidum (Curtis: Fr.) P. Karst. *Rev. Mycol.* 3 (9): 16– 18. 1881. Var. unidentified

Basidiocarp laterally stipitate or eccentric, 4–7 \times 3– 8 \times 1 cm, laccate, brittle, stipe reddish brown, 5–7 cm long and 1cm diameter. Upper surface laccate, sulcate, semidull dark reddish brown. Margin 2 mm in thickness, sterile, yellowish to reddish brown (Fig. 1g). Pore surface yellowish cream. Pore 6 per mm, irregular. Tube 3–5mm long, unstratified, whitish brown. Context 2mm thick, coffee colour, thickening towards the base of the stem.

Table 1 Comparison of varieties of *Ganoderma lucidum* from the present study.

Character	<i>G. lucidum</i> var. lucidum ^a	<i>G. lucidum</i> var. lucidum	<i>G. lucidum</i> var. capense	<i>G. lucidum</i> var. unidentified
Sample code		GA-13	GA-6	GA-38
Spore Index	1.4-1.5	1.5	1.6	1.3
Spore size	(8) 9-12(13) × 6-9 μm	7-8.5 × 5-6 μm	8.3-10 × 6.6-7.2 μm	6.6-7.5 × 8.3-9.1 μm
Cutis type	Claviform vera	Claviform vera	Claviform	Claviform vera
Cutis size	63-85 × 10 μm	40-50(60) × 8.3-10 μm	35-42 × 6-8.5 μm	22.5-25.8 × 5-5.8 μm
Tube layer	15-20 mm	5-7 mm	2-9 mm	3-5 mm
Pores per mm ^b	4-6	4-5	5	6
Context layer ^b	15-20 mm	5-7 mm	9 mm	2-5 mm
Stipe type ^b	Eccentric or centric or lateral	Lateral	Lateral to subsessile	Lateral sometimes centric
Stipe length ^b	Up to 10 cm	8-9 cm	2-3 cm	3-8 cm

^aDescription of type species as per Gottlieb and Wright (1999a)

^bCharacters mentioned as stable for *Ganoderma lucidum* by Ryvarden (1995)

Cutis Type thick walled claviform, 22.8–25.8 × 5–5.8 μm, (Fig. 4f). Hyphal system: trimitic, generative hyphae 2.5–3 μm diameter, thin walled, hyaline; binding hyphae 4.1 μm, thin walled, yellowish; skeletal hyphae 7.9 μm diameter, thick walled, yellowish brown. Basidiospore: 6.6–7.5 × 8.3–9.1 μm, rugose, obovate. *SI*: 1.3 (Fig. 3h).

Material examined – On dead stump of *Artocarpus integrifolia*, Off Bhandarkar Institute Road, Pune. (GA-38).

Geographical distribution – Throughout the temperate zones of the northern hemisphere. From the Pacific shores of the USA and Canada, through temperate Europe to the Pacific shores of Asia and Japan. Also in the mountains of Central Africa above the 1500 m level.

Remarks – refer to the Table 1, for the justification about the proposition of this variety.

Ganoderma multicornum Ryvarden. *Mycologia* 92(1): 180–191 (2000).

Basidiocarp laccate, annual, sub sessile to laterally stipitate, semi circular, 17 × 8 × 3 cm slightly contracted at base, shiny when fresh. Upper Surface slightly sulcate and zonate, reddish black. Margin soft, obtuse, thick creamish white sterile (Fig. 1h). Pore Surface creamish brown. Pore very small, 5–6 per mm, angular. Tube indistinctly stratified, up to 5 mm long, chocolate colour. Context cocoa coloured, bicoloured, upper side faint and

lower dark coloured, fibrous, thin, 8–13 mm wide. Cutis type diverticulate type, 50–65 × 4.5–6 μm (Fig. 4g). Hyphal System dimitic, generative hyphae 3–5 μm diameter, hyaline, thin walled, clamps present; skeletal hyphae 15 μm diameter, yellowish brown, thick walled dichotomously branched towards upper surface. Basidiospore 5.5–7.5 × 9.1–10 μm, ellipsoid, truncate at apex, brown. *SI* 1.5 (Fig. 3i).

Material examined – On dead stump of probably *Azadirachta indica*, Government Nursery (GA-28) (PUC).

Geographical Distribution – Venezuela.

Ganoderma multiplicatum (Mont.) Pat., *Bull. Soc. Mycol. Fr.* 5:74, 1889.

= *Polyporus multiplicatus* Mont. *Ann. Sci. Nat. Bot. Ser.* 41:128, 1854.

Basidiocarp perennial, pileate, stipitate, dimidiate, laccate 17–18 × 11–5 × 1.5–2 cm. Upper surface concentrically sulcate, brown of chestnut (Fig. 1i,j). Pore surface creamy white at first later ochraceous to pale brown. Pore round, 5–8 per mm. Tube 3 mm thick snuff brown. Context 5 mm, snuff brown, shiny. Cutis type diverticulate, 28–30.8 × 14 μm, (Fig. 4h). Hyphal system dimitic, generative hyphae 3.8 μm diameter, thin walled, hyaline with clamp connection; skeletal hyphae 5.8–7.5 μm diameter, thick walled, yellowish green colour. Basidiospore 7–9 × 5–7 μm, brown ellipsoid, truncate. *SI* 1.3 (Fig. 3j).

Material examined – On dead stump of *Holoptelea integrifolia* (GA-12); live standing

tree of *Tamarindus indica* (GA-27) Pulgate., Government Nursery (PUC).

Geographical distribution - Pan tropical species originally described from Venezuela, but in America also reported from Brazil and French Guyana (Steyaert 1980), China, New Guinea and Egypt.

Ganoderma orbiformum (Fr.) Ryvarden, *Mycologia*. 92(1), 187, 2000.

= *Polyporus orbiformis* Fr., *Epicrisis Mycol* p. 463, 1838.

Basidiocarp 14 × 12 × 5cm, biannual or perennial, pileate, dimidiate to sessile, corky, laccate. Upper surface flat to concave, sulcate, glabrous, laccate, deep reddish to chestnut brown becoming dark by age. Margin cream white (Fig. 2a). Pore surface creamy white in fresh specimen later ochraceous to pale brown. Pore 5 per mm, round. Tube dark brown, 10mm thick, without stratification. Context umber colour, up to 10 mm thick. Cutis type diverticulate, 40–46 × 9–12 μm (Fig. 4i). Hyphal system dimitic, generative hyphae 3.3–5 μm diameter, pale yellow with clamp; skeletal hyphae 5–6.6 μm diameter, pale brown, thick walled. Basidiospore 8.3–10 × 6.6–7.5 μm, pale brown, ellipsoid truncate. SI: 1.2 (Fig. 3k).

Material examined – On living or dead tree of *Leucaena leucocephala*, Teacher's Quarters (GA-15) (PUC).

Geographical distribution – Tropical species originally described from Guinea in Africa, but also known from Bonin Island, Puerto Rico, Brazil and Venezuela but also reported from Venezuela and Japan.

Ganoderma perzonatum Murrill, *North Am Fl.* 9: 121, 1908.

Basidiocarp annual, pileate, dimidiate, 21–25 × 17–19 × 2.5–3 cm. shortly stipitate, woody semicircular. Upper surface glabrous, laccate, sulcate, bay to cinnamon, powder of deposited basidiospore (Fig. 2b). Pore surface greyish brown. Pore circular, 5 per mm. Tube 1 cm long, brown, without zonation. Context 5mm thick, ochraceous brown, darker zone above tube. Cutis type diverticulate, 45–51 × 6–10 μm (Fig. 4j). Hyphal system dimitic, generative hyphae 3.3–4.1 μm diameter,

hyaline, thin walled, with clamp connection; skeletal hyphae 5–6.6 μm diameter, yellowish brown, thick walled. Basidiospore 8.3–9.8 × 6.6–8.3 μm, oblong, ellipsoid, truncate, yellowish brown. SI: 1.2 (Fig. 3l).

Material examined – On living tree of *Tamarindus indica*, Main gate, (GA-3) (PUC).

Geographical distribution – Cuba.

Ganoderma philippi (Bres. and Henn.) Bres., *Iconographia Mycologica* 21:1014. 1932.

= *Fomes philippi* Bres. and Henn., *Saccardo Syll. Fung.* IX: 180.1891.

Basidiocarp 10 × 15 × 6 cm, sessile, non-laccate, applanate, dimidiate pileus crust thin; brittle Upper surface dull brown, milky coffee near the margin, concentrically sulcate, glabrous. Margin thin lobate, sterile, brown at old age (Fig. 2e). Pore Surface greyish brown to dull brown. Pore circular, 4 per mm. Tube concolourous, with context 13–15 mm thick. Context soft, shiny, 7–15 mm thick, cinnamon. Cutis type similar to plecodermis. Hyphal system trimitic, generative hyphae 5–58 μm diameter, thin walled, clamps connection; skeletal hyphae 6.6–7.5 μm, brown; binding hyphae 6.6 μm diameter, yellowish brown. Basidiospore 5–7 × 4.5 μm, brown, ovoid or obpyriform, smooth. SI 1.4 (Fig. 3m).

Material examined – On the dead stump of *Albezzia lebbeck*, Elis garden (GA-4) (PUC).

Geographical distribution – Burma, Malaysia, Singapore, Indonesia, India.

Ganoderma praelongum Murrill, *North American, Flora* 9:121.1908.

Basidiocarp corky, orbicular dimidiate to flabelliform flat, rarely umbonate to stipitate, 14.5 × 10 × 20 cm. Upper surface glabrous, sulcate, laccate, bay to brownish. Margin thin, sterile, cream to ochraceous, acute to sulcate, rarely blunt (Fig. 2c,d). Pore: 5 per mm. Tubes: 3 mm long, hazelnut, darkening when brushed. Context: 5 mm long, soft, without melanoid deposition. Cutis thick walled diverticulate, 20–38 × 8.3–9 μm (Fig. 4l). Hyphal system: trimitic, generative hyphae 3.3 μm, diameter, skeletal hyphae 5 μm diameter, thick walled, brown; binding hyphae 6.6 μm diameter, yellowish brown. Basidiospore: ovoid, semirugose brown, 8–10 × 6.7 μm. SI –1.3 (Fig. 3o).

Material examined – on living tree of *Leucaena latisiliqua* (GA-8) and *Delonix regia* (GA-37) Pulgate, Pune.

Geographical distribution – USA, West Indies, France, Belgium, Chekoslovakia, Portugal, Italy, Bulgaria, Israel, Iran, India, Pakistan, Venezuela, Brasil, Morocco, Kenya, South Africa, Cuba.

Ganoderma resinaceum Boudier, *Bull. Soc. Mycol. Fr.* 5: 72, 1889.

Basidiocarp woody, stipitate, dimidiate, 14–16 × 35–41 × 4–9 cm, slightly bent, eccentric, stipe up to 5 cm. Upper surface bay to wine coloured, slightly zonate, laccate, glabrous when fresh, often covered with cinnamon powder of deposited basidiospores. Margin 1–1.5 mm, sterile, creamish white, thin, acute (Fig. 2f). Pore surface creamish brown. Pore angular, 3–4 per mm. Tube 3 mm brown, unstratified. Context 5 mm, ochraceous brown, slightly zonate. Cutis type claviform, 37.5–40.6 × 4.1–5 μm (Fig. 4m). Hyphal system dimitic, generative hyphae 3.8–4.5 μm diameter, thin walled, hyaline with clamp connection; skeletal hyphae up to 7.5 μm diameter, thin walled, brownish yellow, dichotomously branched. Basidiospore 7.5×10–10.8 μm, oblong, ellipsoid, truncate, pale yellow. SI 1.3 (Fig. 3p).

Material examined – On unknown dead stump, Elis Garden, (GA-36). (PUC).

Geographical distribution – Mostly cosmopolitan, reports from Europe, Central, South and North America, China.

Ganoderma sessiliforme Murrill, *Bull. N.Y. Bot. Garden* 8:149.1912.

Basidiocarp 9–11 × 6 × 5 cm, stipitate, laccate, corky to woody, dimidiate, sometimes conchate to flabelliform, thickening towards the margin. Upper Surface sulcate, brittle, rugose, reddish brown. Margin thick, coffee colour (Fig. 2h). Pore surface yellowish white. Pore: 3–4 per mm. Tube 5 mm in long, hazelnut. Context 3–6 mm, pale yellow, horny deposition monostratified. Cutis type spheroid pendunculate, 28–30 × 4.1–8.3 μm (Fig. 4n). Hyphal System trimitic, generative hyphae 2.5 μm diameter, by line clamp connection; skeletal hyphae 5 μm diameter, pale yellow, thick walled; binding hyphae 5–5.8 μm diameter, pale yellowish, thick walled. Basidiospore: 6.8

× 4–5 μm, semirugose, globose, brown. SI: 1.4 (Fig. 3q).

Material examined – On dead stump of *Pongamia pinnata*, Karnala wild life sanctuary, Panvel (GA-21).

Geographical distribution – Mexico.

Ganoderma stipitatum (Murrill) Murrill, *North Am. Fl.* 9: 122, 1908.

= *Fomes stipitatum* Murrill, *Bull. Torrey Bot. Cl.* 30:229, 1903.

Basidiocarp 5–13 × 10 × 1–2.5 cm, laccate, stipitate, lateral/centric, biannual, pileate, laterally stipitate. Upper surface flat, sulcate, glabrous, laccate, reddish to chestnut. Margin thin, 1 mm, creamish to dull brown (Fig. 2i). Pore surface milky coffee. Pore angular, 3 per mm. Tube 10 mm thick, concolourous to context. Context fibrous up to 10 mm thick, bay colour with melanoid deposition. Cutis type spheroid pendunculate, 26–40 × 6–8 μm (Fig. 4o). Hyphal system: dimitic, generative hyphae 3.3 to 4.1 μm diameter, hyaline, thin walled, clamp connection; skeletal hyphae 5–5.8 μm diameter, thick walled, brown. Basidiospore: 7–10 × 6–8 μm diameter, oblong, ellipsoid, truncate at apex. SI 1.2 (Fig. 3r).

Material examined – On living tree of *Tamarindus indica*, Pune University campus GA-7).

Geographical distribution – Widespread in the neotropics from Nicaragua, Costa Rica, Surinam, Bolivia, Brazil, Perus and Venezuela (Steyaert 1972).

Ganoderma testaceum (Lev.) Pat. *Bull. Soc. Myc. France* 5: 67. 1889.

= *Polyporus testaceus* Lev., Champ. Mus. Paris, *Ann. Sci. Nat.* 3, ser. V: 126, 1846.

Basidiocarp sessile to subsessile, non-laccate, flabelliform to dimidiate, 12 cm, in radius. Upper Surface concentrically sulcate, ferruginous to tawny to mummy brown, with age becoming hard. Margin thin to thick, rounded to subacute (Fig. 2j). Pore surface cream to white yellowish. Pore circular, 4 per mm. Tube 10–20 mm, thick, chestnut to bay concolourous with context. Context 2–5 mm, shining, deposits of melanoid substance. Cutis type anamixodermis. Hyphal System: trimitic, generative hyphae 3–4 μm, diameter, hyaline,

Table 2 List of different *Ganoderma* species identified from India.

Bakshi (1971)	Bilgrami et al. (1991)	Others	Present Study
<i>G. applanatum</i>	<i>G. adspermum</i>	<i>G. ahmadii</i> ^c	<i>G. applanatum</i>
<i>G. australe</i>	<i>G. annulare</i>	<i>G. flexipes</i> ^b	<i>G. chaliceum</i>
<i>G. colossum</i>	<i>G. applanatum</i>	<i>G. multiplicatum</i> ^d	<i>G. curtisii</i>
<i>G. lucidum</i>	<i>G. australe</i>	<i>G. resinaceum</i> ^e	<i>G. lipsiense</i>
<i>G. philippi</i>	<i>G. colossum</i>	<i>G. tornatum</i> ^a	<i>G. lucidum</i> var. <i>capense</i>
	<i>G. leucophaeum</i>		<i>G. lucidum</i> var. <i>lucidum</i>
	<i>G. lucidum</i>		<i>G. lucidum</i> var. unidentified
	<i>G. philippi</i>		<i>G. multicornum</i>
			<i>G. multiplicatum</i>
			<i>G. orbiformum</i>
			<i>G. perzonatum</i>
			<i>G. philippi</i>
			<i>G. praelongum</i>
			<i>G. resinaceum</i>
			<i>G. sessiliforme</i>
			<i>G. stipitatum</i>
			<i>G. testaceum</i>

^a Bakshi, (1958) and Chakravorti, (1931) as reported in Steyaert (1972).

^b Joshi (1949) as reported in Steyaert (1972).

^c Bakshi (1949) as reported in Steyaert (1972).

^d Steyaert 1980.

^e Bose (1934) as reported in Steyaert (1980).

Table 3 Comparative account of the species, *G. praelongum* and *G. resinaceum*.

Characters	<i>G. praelongum</i> [*]	<i>G. resinaceum</i> [#]
Hyphal System	Trimitic	Dimitic
Basidiocarp size	3–4 × 10 × 20 cm	5–6 × 16 × 30–35 cm
Stipe size (length × diameter)	10–14 × 2–4 cm	3–5 × 2–4 cm
Cutis	Diverticulate	Claviform
Cutis size	20–38 × 8.3–9 µm	37.5–40.6 × 4.1–5 µm
Pores per mm	5	3–4
Spore size	8–10 × 6.7 µm	7.5 × 10–10.8 µm
Stipe type	Centric or lateral	Eccentric

^{*}Species description as per Gottlieb and Wright (1999a).

[#]Species description as per Ryvarden (2000).

with clamp; skeletal hyphae 5–6 µm diameter, yellowish brown; binding hyphae 6 µm diameter, yellowish brown. Basidiospore: 7–10 × 4–7 µm, ovoid, brown. SI 1.2 (Fig. 3s).

Material examined – On living tree of *Peltophorum ferrugineum*, Near Lonavala Railway Station (GA–22).

Geographical distribution – Southern Brazil, Guyana, Bolivia, Columbia, Cuba and USA.

Discussion:

In all, 15 species of *Ganoderma* are described in the present study. As per the study *Tamarindus indica* and *Leucaena latisiliqua* were found to be most susceptible hosts. The plantation of *Leucaena latisiliqua* from the Pune University campus was most susceptible

and showed high incidence of infection causing threat to the plantation.

Distribution of the *Ganoderma* species

The species are well distributed except for species like *viz. G. perzonatum*, *G. sessiliformae* and *G. multicornum* are restricted to specific locations. The overall count of valid species described by various authors from India is nine (Table 2). *G. lucidum*, *G. applanatum* and *G. philippi*, *G. multiplicatum* and *G. resinaceum* has been previously reported.

Bilgrami et al. (1991) reported *G. annulare*, *G. adspermum* and *G. australe* from India, and Bakshi (1958, as in Steyaert, 1972) reported *G. tronatum* but all these species are the synonym of *G. australe* (Moncalvo and Ryvarden, 1997).

Bilgrami et al., (1991) also reported *G. leucophaeum* and *G. applanatum* but *G. leucophaeum* was considered as synonym of *G. applanatum* (Moncalvo & Ryvarden, 1997).

G. resinaceum has been reported from India (Bose 1934, as in Steyaert 1980), he considered *G. praelongum* as its synonym, so did Moncalvo & Ryvarden (1997). Gottlieb and Wright (1999a) rejected the synonymy of *G. praelongum* with *G. resinaceum* and continued as separate species. Ryvarden (2000) separated *G. resinaceum* as species with dimittic hyphal system, continuing the synonymy. The present study accepts the argument of Gottlieb & Wright (1999a) since the specimens showed variation in their characters (Table 3) and hence both the species are reported here separately.

G. multiplicatum was reported by Steyaert (1980), from India but did not confirmed due to insufficient material. Joshi (1949, as in Steyaert, 1972) reported *G. flexipes* and Bakshi (1949, as in Steyaert, 1972) reported *G. ahmadii* from India, both these names are continued and are accepted by Moncalvo & Ryvarden (1997), but were not observed in the present study.

G. orbiformum was considered as invalid name by Moncalvo and Ryvarden (1997), but latter Ryvarden (2000) separated the same species under dimittic hyphal system. Similarly *G. perzonatum* was considered as synonym of *G. purvulum* and *G. chalceum* of *G. cupreum* (Moncalvo & Ryvarden, 1997), but latter these species (*G. perzonatum* and *G. chalceum*) were separated under the dimittic hyphal system (Ryvarden, 2000). Even recently Smith and Sivasithamparam (2003) considered *G. cupreum* with priority and synonym to *G. chalceum*, wherein they have not considered the dimittic hyphal system described by Ryvarden (2000), who separated the species from *G. cupreum*.

G. lipsiense was considered as nomen ambiguum by Moncalvo & Ryvarden (1997) but the species was reconsidered under the sub genus *Elfvindingia* by Gottlieb & Wright (1999b). *G. testaceum* was considered poorly known taxa and was placed under the sub genus *Ganoderma* by Moncalvo & Ryvarden (1997), but later Gottlieb & Wright (1999b) reconsidered the original characters placed the species

back to the subgenus *Elfvindingia* as individual species.

G. multicornum, was described as new species by Ryvarden (2000) with dimittic hyphal system and with only type locality, present study reports a new locality for the species from India.

Understanding the taxonomic status of *Ganoderma* in India, it is confirmed that till date 9 valid species have been reported from India of which 5 species are reported in the present study viz. *Ganoderma lucidum*, *G. Applanatum*, *G. philippi*, *G. multiplicatum*, *G. resinaceum*. 10 species are reported for the first time from India viz. *G. chalceum*, *G. curtisii*, *G. lipsiense*, *G. multicornum*, *G. orbiformum*, *G. perzonatum*, *G. praelongum*, *G. Sessili-formae*, *G. stipitatum*, *G. testaceum*. Total three varieties of *G. lucidum* are reported out of which one is unidentified (Table 1).

Thus in nutshell, there is an urgent need to examine all materials deposited in herbaria, under the genus *Ganoderma*. The work facilitates in understanding species diversity of *Ganoderma* from the Indian subcontinent.

Acknowledgment

The authors are thankful to Department of Science and Technology for the financial assistance. We are very much thankful to Prof. M.R. Walher, Principal, Waghire College Saswad, Maharashtra (India) for his encouragement. We are also thank to the Prof. G.S Chinchankar, Head, Department of Botany, University of Pune and Dr. P.K. Jite, Mycology Lab. Department of Botany, University of Pune and Dr. V.D. Ranade, Ex Head, Department of Botany, Abasaheb Garware College, Karve road, Pune, for their constant encouragement.

References

- Atkinson, GF. 1908 – Observations on *Polyporus lucidus* Leys. And some of its allies from Europe and North America. Botanical Gazette 46, 321–338.
- Bakshi BK. 1971 – The Polyporaceae (On Trees and Timber). Indian Council of Agriculture Research New Delhi. 58–62.
- Bilgrami KS, Jamaluddin S, Rizwi MA. 1991 – Fungi of India: List and References.

- 2ndedn. Today and Tomorrows Printers and Publishers, New Delhi-110005.
- Coleman LC. 1927 – Structure of spore wall in *Ganoderma*. Botanical Gazette 83, 48–60.
- Corner EJH. 1947 – Variation in the size and shape of spores, basidia and cystidia in Basidiomycetes. New Phytologist 46, 195–228.
- Gilberston RL, Ryvarden L. 1986 – North American Polyporaceae. Volume I. Fungiflora – Oslo – Norway. 1–636.
- Gottlieb AM, Wright JE. 1999a – Taxonomy of *Ganoderma* from southern South America: subgenus *Ganoderma*. Mycological Research 103, 661–673.
- Gottlieb AM, Wright JE. 1999b – Taxonomy of *Ganoderma* from southern South America: subgenus *Elfvigia*. Mycological Research 103, 1289 – 1298.
- Gottlieb AM, Saidman BO, Wright JE. 1995 – Characterization of six isoenzymatic systems in Argentine representatives of two groups of *Ganoderma*. Proceedings of Contributed Symposium, 59A, B 5th International Mycological Congress (eds. PK Buchanan, RS Hseu and JM Moncalvo), 25 – 29.
- Gottlieb AM, Saidman BO, Wright JE. 1998 – Isozymes of *Ganoderma* species from southern South America. Mycological Research 102, 415–426.
- Hseu RS, Wang HH, Wang HF, Moncalvo JM. 1996 – Differentiation and grouping of Isolates of the *Ganoderma lucidum* complex by random amplified polymorphic DNA-PCR compared with grouping on basis on the internal transcribed spacer sequences. Applied and Environmental Microbiology 62, 1354–1363.
- Moncalvo JM, Ryvarden L. 1997 – A nomenclatural study of the Ganodermataceae. Synopsis Fungorum 11. Fungiflora – Oslo –Norway. 1–114.
- Moncalvo JM, Wang HF, Hseu RS. 1995a – Phylogenetic relationships in *Ganoderma* inferred from the internal transcribed spacers & 25s ribosomal DNA sequences. Mycologia 87, 223–238.
- Moncalvo JM, Wang HF, Hseu RS. 1995b – Gene phylogeny of *Ganoderma lucidum* complex based on ribosomal sequences comparison with traditional taxonomic characters. Mycological Research 99, 1489–1499.
- Moncalvo JM, Wang HF, Wang HH, Hseu RS. 1995c – The use of ribosomal DNA sequence data for species identification and phylogeny in the Ganodermataceae. Proceedings of Contributed Symposium, 59A, B 5th International Mycological Congress (eds. PK Buchanan, RS Hseu and JM Moncalvo). 31–44.
- Murrill WM. 1902 – The Polyporaceae of North America. I. The genus *Ganoderma*. Bulletin of the Torrey Botanical Club. 29, 599–608.
- Murrill WM. 1903 – The Polyporaceae of North America. IV. The genus *Elfvigia*. Bulletin of the Torrey Botanical Club. 30, 296–301.
- Park DS, Sung JM, Kim YS, Yoo YB, Ryu YJ, Cha DY. 1994 – Analysis of Interspecific Allozyme variation within genus *Ganoderma* by polyacrylamide Gel Isoelectric Focusing RDA. Journal of. Agriculture 36, 212–221.
- Ryvarden L. 1995 – Can we trust morphology in *Ganoderma*? Proceedings of Contributed Symposium, 59A, B 5th International Mycological Congress (eds. PK Buchanan, RS Hseu and JM Moncalvo). 19–24.
- Ryvarden L. 2000 – Studies in neotropical polypores 2: a preliminary key to neotropical species of *Ganoderma* with a laccate pileus. Mycologia. 92, 180–191.
- Ryvarden L, Johansen I. 1980 – A preliminary polypore flora of East Africa. Oslo, Fungiflora, 630
- Smith BJ, Sivasithamparam K. 2000 – Isozymes of *Ganoderma* species from Australia. Mycological Research 104, 952–961.
- Smith BJ, Sivasithamparam K. 2003 – Morphological studies of *Ganoderma* (Ganodermataceae) from the Australasian and Pacific region. Australian Systematic Botany. 16, 487–503.
- Steyaert RL. 1972 – Species of *Ganoderma* and related genera mainly of the Bogor and Leiden herbaria. Persoonia. 7, 55 – 118.
- Steyaert RL. 1980 – Study of some *Ganoderma* species. Bull. Jard. Bot. Nat. Belg. Bull. Nat. Plantenium Belg. 50, 135–186.