

## The genus *Ganoderma* (Basidiomycota) in Iran

MOHAMMAD FATA MORADALI<sup>1\*</sup>, GHORBAN ALI HEDJAROUDE<sup>1</sup>,  
HOSSEIN MOSTAFAVI<sup>2</sup>, MEHRDAD ABBASI<sup>3</sup>,  
SHIRIN GHODS<sup>1</sup> & ABBAS SHARIFI-TEHRANI<sup>1</sup>

\*fmoradali@excite.com

<sup>1</sup>Plant Protection Dept., Faculty of Horticultural Science & Plant Protection  
Agriculture & Natural Resources College, Tehran University,  
Karaj, Iran

<sup>2</sup>Organic Chemistry & Biochemistry Dept., Faculty of Chemistry  
Tabriz University, Tabriz, Iran

<sup>3</sup>Plant Pest & Diseases Research Institute  
Tehran, Iran

**Abstract** — The genus *Ganoderma* was investigated in Iran. Based on micro- and macromorphology and host relationships, descriptions are made and a key to the identification of the Iranian species provided. Seven species of *Ganoderma* were found in Iran, viz. the three non-laccate species *G. applanatum*, *G. adspersum*, and *G. colossus* and the four laccate species *G. lucidum*, *G. resinaceum*, *G. tsugae* and *G. manoutchehrii*.

**Key words** — basidiocarp, morphology, taxonomy, basidiospore, *Elfvigia*

### Introduction

The genus *Ganoderma* P. Karst. has been known for over 100 years and was introduced by Karsten (1881) based on *Polyporus lucidus*. On the basis of the unique feature of the double-walled basidiospore, Patouillard (1889) described in or transferred into *Ganoderma* a number of species and published a monograph accepting 48 species. He distinguished also the species with globose or subglobose spores as section *Amauroderma*.

Many species belonging to the genus *Ganoderma* were reported by Patouillard (1889), Boudier & Fischer (1894), Boudier (1895), Murrill (1902, 1908) and other taxonomists. Boudier & Fischer (1894) and Boudier (1895) described *G. valesiacum* Boud. from conifers in Europe. Murrill (1902, 1908) published a synopsis of the species occurring in North America. He described seven new temperate species including *G. tsugae*, *G. sessile* Murrill, *G. zonatum*

Murrill, *G. sulcatum* Murrill, *G. oregonense* Murrill, *G. sequoiae* Murrill and *G. nevadense* Murrill, along with 10 others from tropical areas. The identification of *Ganoderma* was by then mainly based on host specificity, geographical distribution, and macromorphological features of the fruitbody, including the color of the context and the shape of the margin of the pileus and whether the fruit body was stipitate or sessile. Murrill (1902, 1908) considered primary taxonomic characters to be host specificity, geographical distribution, and macromorphology of the fruiting body. Atkinson (1908), Ames (1913), Haddow (1931), Overholts (1953), Steyaert (1972, 1975, 1977, 1980), Bazzalo & Wright (1982), and Corner (1983) conducted the identification of *Ganoderma* species by morphological features from a geographically restricted set of specimens. Haddow (1931) and Steyaert (1980) emphasized the basidiospore and hyphal characteristics as key features for the taxonomy of this group. Steyaert (1961a,b, 1962, 1967a, b, 1972, 1980) also investigated the world taxa while evaluating the value of both macro- and micromorphological features and described several new taxa most of which he later reduced to synonymy.

According to Ryvar den (1991), the genus is in a state of taxonomic chaos. Different authors use diverse criteria for the taxonomy of these fungi. This lack of unifying criteria contributed to the difficulty of harmonizing the taxonomy of this group. Recent workers have used characters other than morphology to determine relationships within the genus. These have included, in the first instance cultural and mating characters (Adaskaveg & Gilbertson 1986), isozyme studies (Hseu 1990, Gottlieb & Wright 1999), and more recently ribosomal DNA sequence and cladistic methods (Moncalvo et al. 1995) to infer natural relationships. With the development of cladistic methods to reconstruct phylogeny, the possible resolution of some of these problems appears close to hand.

The family *Ganodermataceae* was erected for polypores having a double-walled basidiospore (Donk 1964). Two kinds of basidiocarps producing this type of basidiospore have been distinguished: those with a shiny (laccate), yellowish or reddish-brown to black pilear surface, and those with a dull (non-laccate), grey-brown to black pilear surface (Moncalvo 2000). The genus *Elfvíngia* P. Karst. was created to accommodate non-laccate *Ganoderma* taxa with *Boletus applanatus* as the type species (Karsten 1889). Modern authors such as Corner (1983) and Ryvar den (1991) treat *Elfvíngia* as a subgenus of *Ganoderma*.

Seven species of *Ganoderma* have been previously recorded from Iran (Steyaert 1972; Saber & Minassian 2000; Moradali et al. 2004; Arefipour et al. 2002, 2004). They are re-described here in more details based on macro- and micromorphological features (Table 1). Their distributions throughout Iran are shown in Figure 1.



Figure 1- Biogeographical vegetation domain of *Ganoderma* species for Iran: *G. lucidum* (\*); *G. resinaceum* (+); *G. tsugae* (★); *G. applanatum* (▲); *G. adspersum* (◆); *G. colossus* (⊙); *G. manoutchehrrii* (⊗).

## Materials and methods

In this study we examined herbarium specimens from Herbarium of the Ministry of Jihad-e Keshavarzi (IRAN) and newly collected materials from Northern Iran.

Basidiospores were observed by light microscopy, using 3% KOH, Melzer's reagent and Lactophenol. Spore length and width were determined by ocular micrometer for 20 spores from the fruitbody. Sections of the cutis and tube layer were obtained with a freezing microtome and their elements were observed by using 3% KOH, Melzer's reagent and Lactophenol. Pigments covering the elements of cutis were washed by Acetone solvent. Amyloid or non-amyloid reaction was observed in Melzer's reagent (Kirk et al. 2001, where the recipe can be found). Drawings were made with a drawing tube on a Zeiss microscope.

**Table 1-** The *Ganoderma* species reported from Iran

Name	Geographical origin	Host/substrate	Reference
<i>G. lucidum</i>	Shast-Klateh	-	Arefipour et al. 2004
	Astara	<i>Parrotia persica</i> <i>Fagus orientalis</i> <i>Alnus</i> sp.	Saber et al. 2000
	Golestan	<i>Fagus</i> sp.	Arefipour et al. 2002
<i>G. resinaceum</i>	Tonekabon	wood	Moradali et al. 2004
	Lahijane	<i>Quercus</i> sp. <i>Parrotia persica</i>	Saber et al. 2000
	Bandar-e-Anzali	<i>Robinia pseudoacacia</i>	Saber et al. 2000
	Rasht	<i>Populus</i> sp.	
	Tonekabon	wood	Moradali et al. 2004
<i>G. tsugae</i>	Gilan	Conifer	Saber et al. 2000
<i>G. applanatum</i>	Golestan	<i>Fagus</i> sp.	Arefipour et al. 2002
	Shast-Klateh	-	Arefipour et al. 2004
	Drazno	-	
	Ahvaz	-	Saber et al. 2000
	Chalous	-	
	Golestan	-	
	Tonekabon Dohezar	Wood Wood	Moradali et al. 2004
<i>G. adspersum</i>	Astara	-	Saber et al. 2000
	Dohezar	<i>Ulmus</i> sp.	Saber et al. 2002
	Dohezar	Wood	Moradali et al. 2004
<i>G. colossus</i>	Kish Island	<i>Ficus benghalensis</i>	Saber et al. 2000
	Ahvaz	<i>Ziziphus spina-christi</i>	
<i>G. manoutchehrrii</i>	Ramsar	<i>Acacia</i> sp.	Steyaert 1972

**Key to *Ganoderma* species of Iran**

- 1a. Cutis a hymenoderm; context pale, white to pale brown or brown ..... 2
- 1b. Cutis a characoderm; context dark brown ..... 5
  - 2a. (1a) Basidiocarp laccate and context white to pale or dark brown; without chlamydospores ..... 3
  - 2b. Basidiocarp non-laccate, context yellowish to buff; chlamydospores 8.0-12.5 x 13-19.5 µm ..... ***G. colossus***
- 3a. (2a) Context dark cinnamon brown; basidiospores 6.7-11.5 x 5.7-7.6 µm ..... ***G. resinaceum***
- 3b. Context white to pale brown or yellowish; basidiospores longer than 9 µm ..... 4

- 4a. (3b) Context white to brownish; carpophore brownish orange to black; on coniferous trees; basidiospores 9-11 x 6-8  $\mu\text{m}$  ..... *G. tsugae*  
 4b. Context pale brown to yellowish; carpophore reddish brown to black; on angiosperms; basidiospores 10.5-13.4 x 6.7-9.6  $\mu\text{m}$  ..... *G. lucidum*  
 5a. (1b) Basidiocarp non-laccate, with or without hyaline hyphae in cutis ..... 6  
 5b. Basidiocarp laccate with hyaline hyphae in cutis ..... *G. manoutchehrui*  
 6a. (5a) Cutis with hyaline hyphae; basidiospores 8.6-10.5 x 5.7-7.6  $\mu\text{m}$  ..... *G. adspersum*  
 6b. Cutis without hyaline hyphae; basidiospores 7.6-11.5 x 5.7-6.7  $\mu\text{m}$  ..... *G. applanatum*

### Taxonomy

*Ganoderma applanatum* (Pers.) Pat. Hyménomyc. Eur. (Paris): 143, 1887 Figs. 2-3

= *Boletus applanatus* Pers., Obs. Mycol. 2: 2, 1800 ('1799').

= *Polyporus applanatus* (Pers.) Wallr., Fl. Crypt. Germ. 2: 591, 1833.

= *Elfvigia applanata* (Pers.) P. Karst., Bidr. Känn. Finl. Nat. Folk 48: 334, 1889.

= *Polyporus megaloma* Lév., Anns Sci. Nat. (Bot.) III 5: 128, 1846.

= *Polyporus leucophaeus* Mont., Syll. Crypt. p. 157, 1856.

**Key characters** — Basidiocarp perennial, woody, typically sessile, up to 35 x 26 x 9 cm, fan-shaped to slightly convex, usually solitary but also connected with each others; margin rounded early and becoming narrowed at maturity; surface a hard crust, brown to grey brown, dull grey, irregular, often furrowed, nodulose and zonate, often dusted with brown spores, crust thick, of characodermis type with irregular hyphal elements; context up to 6.0 cm thick, brown to dark brown, veined with white mycelia, tough, corky; pore 4-5 per mm, pore surface at first white, becoming grey-brown at maturity and quickly bruising brown when injured, fading to pale yellowish-buff when dried, most specimens with several tube layers (up to 6 layers) separated by thin layers of brown tissue.

Basidiospores ovoid to broadly ellipsoid, with a truncate apex, thick and double-walled, brown, spinulose, 5.7-6.7 x 7.6-10.5-11.5  $\mu\text{m}$ . Hyphal system trimitic with hyaline, thin-walled, septate, clamped generative hyphae, 1-2  $\mu\text{m}$  in diam., skeletal hyphae golden brown, thick-walled, aseptate, very long, 4-6  $\mu\text{m}$  in diam. and binding hyphae profusely branched, thinner and lighter than the skeletal, aseptate, limited growth, 1-4  $\mu\text{m}$  in diam.

**Habitat** — This species grows solitary or in small groups almost always on fallen logs of both hardwood and conifers, but also on living trees as a weak parasite, penetrating through injured tissue and causing a white rot.

**Material examined**- On fallen logs of hardwood, Kotra, Tonekabon, Mazandaran, April 21, 2003 (IRAN 1538 F); on fallen logs of hardwood, Dohezar forest, Tonekabon, April 21, 2003 (IRAN 1527 F); on fallen logs of hardwood, Mazoben, Kotra, Tonekabon, July 21, 2003 (IRAN 1528 F); on fallen logs, Namak-Abroud forest, Chalous, Mazandaran, July 30, 2003 (IRAN 2100 F).

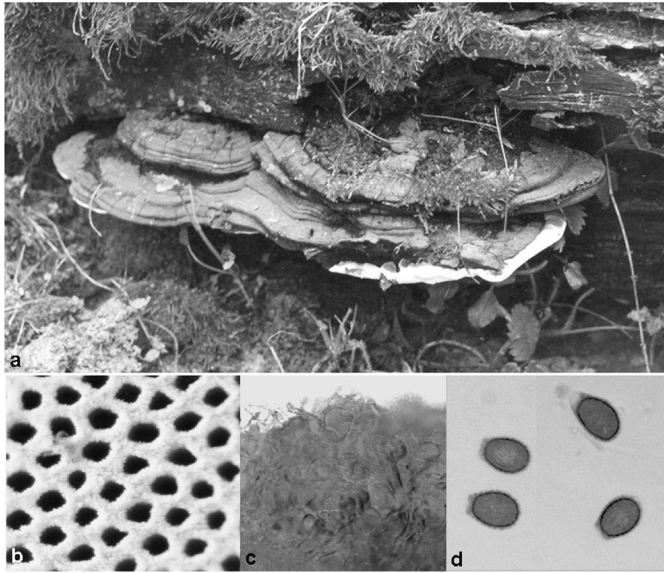


Figure 2- Macro- and micromorphological characteristics of *Ganoderma applanatum*.  
a, basidiocarp; b, pore surface; c, cutis elements; d, basidiospores

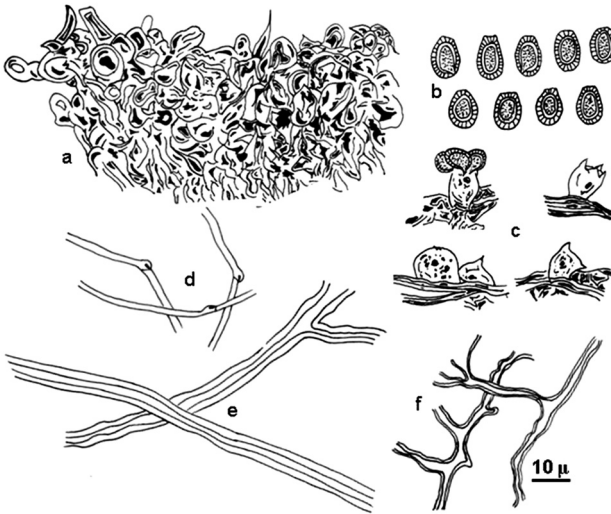


Figure 3- Basidiocarp characteristics of *Ganoderma applanatum*.  
a, cutis elements; b, basidiospores; c, basidia;  
d, generative hyphae; e, skeletal hyphae; f, binding hyphae

*Ganoderma adpersum* (Schulzer) Donk, Proc. Ned. Akad. Wet., C 72: 273, 1969.

Figs. 4-5

= *Polyporus adpersus* Schulzer, Flora 61: 11, 1878.

= *Polyporus linhartii* Kalchbr., in Linhart, Fung. Hong. no. 252, 1884.

= *Ganoderma linhartii* (Kalchbr.) Z. Igmándy, Acta Phytopath. Acad. Sci. Hung. 3: 237, 1968.

= *Ganoderma europaeum* Steyaert, Bull. Jard. Bot. Brux. 31: 70, 1961.

**Key characters** — Basidiocarp perennial, woody, sessile, dimidiate, up to 17 x 16 x 6 cm; pileus brown to dark brown; very hard when dry, zoned with concentric sulcate rings, somewhat cracking when dry, surface a hard crust, cutis 0.9-1.5 mm thick, of characodermis type with irregular hyphal elements also with hyaline hyphae that branch off in the cutis; context relatively thin, up to 4.0 cm thick, dark brown, corky; pore 4-5 per mm, pore surface whitish grey to light brown, fading to pale yellowish-buff when dried; tube layer with lighter color than context, clearly differentiated from the context, without distinct separating context zones between each tube layer and tubes, whitish, up to 1.5 cm thick.

Basidiospores ovoid, with a rounded or truncate apex, thick and double-walled, brown, spinulose, 5.7-6.7-7.6 x 8.6-9.6-10.5  $\mu\text{m}$ . Hyphal system trimitic with hyaline, thin-walled, septate, clamped generative hyphae, 1-3  $\mu\text{m}$  in diam., skeletal hyphae golden brown, thick-walled, aseptate, very long, 4-8  $\mu\text{m}$  in diam. and binding hyphae profusely branched, thinner and lighter than the skeletal hyphae aseptate, limited growth, 2-5  $\mu\text{m}$  in diam.

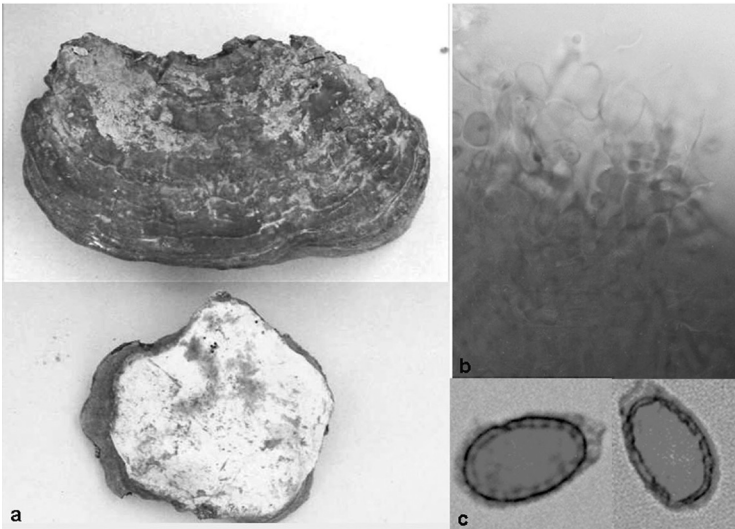


Figure 4- Macro- and micromorphological characteristics of *Ganoderma adpersum*.  
a, basidiocarp; b, cutis elements; c, basidiospores



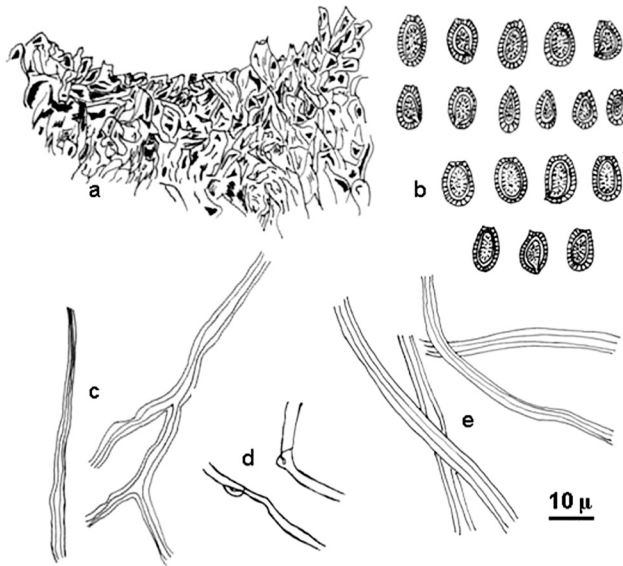


Figure 5 - Basidiocarp characteristics of *Ganoderma adpersum*.  
 a, cutis elements; b, basidiospores; c, binding hyphae; d, generative hyphae; e, skeletal hyphae

The basidiocarps of *G. applanatum* and *G. adpersum* are sometimes similar to each other. However, the differences between them is clearly seen in their spore dimensions and micromorphology of the cutis, the basidiospores of *G. applanatum* being the smaller. Also there are hyaline hyphae that branch off in the cutis of *G. adpersum*. According to Steyaert's study on the Iranian specimens of *G. adpersum*, it is quoted that they have smaller spores and thinner context than in European specimens (Saber 1973). The context in these specimens is brown and they have white hyphae whereas European specimens have a red context and no white hyphae (Saber 1973). According to Steyaert (Saber 1973), the existence of white hyphae is caused by a facultative parasite, that this species is subject to in the climatic conditions of northern Iran. This difference can arise from their geographical distribution, habitat and behaviour of organisms in each geographical region.

**Habitat** — This species grows on fallen logs of hardwoods causing a white rot. It has been collected in northern Iran on *Gleditschia caspica*, *Prunus spinosa*, *Citrus aurantium*, *Diospyros kaki*, *Mespilus germanica*, but also on living trees of *Quercus* spp., *Acer* spp. and *Fagus orientalis* (Saber et al. 2000).

**Material examined**- On fallen log of hardwood tree, Dohezar forest, Tonekabon, Mazandaran, April 22, 2003 (IRAN 1539 F); on dry wood, Gorgan and shamoshak forest, Golestan province, Nov. 2003 (IRAN 311 F).



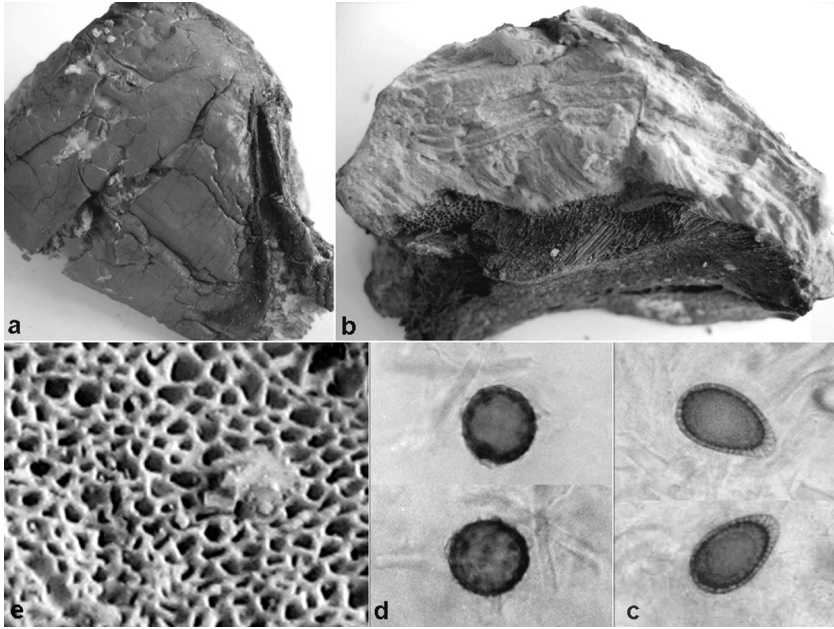


Figure 6 – macro – and micromorphological characteristics of *Ganoderma colossus*.  
a, basidiocarp; b, context and tube layer; c, basidiospores; d, chlamydospores; e, pore surface

***Ganoderma colossus*** (Fr.) C.F. Baker, Fung. Malay. no 425, 1918.

= *Polyporus colossus* Fr., Nova Acta Soc. Sci. Upsal. III 1: 56, 1851.

= *Dendrophagus colossus* (Fr.) Murrill, Bull. Torrey Bot. Club 32: 473, 1905.

= *Tomophagus colossus* (Fr.) Murrill, Torrey 5: 197, 1905.

= *Ganoderma obockense* Pat., Bull. Soc. mycol. Fr. 3: 119, 1887.

= *Polyporus hollandii* Masee, Bull. Misc. Inf. Kew 1901: 163, 1901.

Fig. 6

**Key characters** — Basidiocarp dimidiate, bulky, up to 35 cm in radius and 9 cm thick; pileus tender, soft and upper surface dull to somewhat shiny, yellowish to buff; cutis very thin, dark dull yellow, scaling off easily, of hymeniodermis type with club-shaped elements, about 40  $\mu\text{m}$  long and 7-8  $\mu\text{m}$  thick at the apex; context usually two third of the thickness of the basidioma, chamois; pore surface white at first and dark buff at maturity and when dried; tube layer up to 3.0 cm thick, buff.

Basidiospores ovoid, chamois, double-walled, echinulate with 1  $\mu\text{m}$  long spines along the spore side and up to 4  $\mu\text{m}$  long at the apex, 8-9.7-12.5 x 13-16.3-19.5  $\mu\text{m}$ .

Chlamydospores globose, covered with short, stump spines or ridges, chamois, 16-18-21  $\mu\text{m}$ , located irregularly in context; hyphal system dimitic with hyaline, thin-walled, septate, clamped generative hyphae, strongly branched

in the context, 2-4  $\mu\text{m}$  in diam. and skeletal hyphae pale yellow, thick-walled, aseptate, 3-5  $\mu\text{m}$  in diam.

**Habitat** — This species was collected on *Ficus benghalensis* and on an unknown tree in Kish Island, and on *Ziziphus spina-christi* in Ahvaz, Khuzestan province, both areas situated in southern Iran (Saber & Minassian 2000).

**Material examined**- On *Ziziphus spina-christi*, Ahvaz, Khuzestan, Nov. 1999 (IRAN 10927 F); on *Ficus benghalensis*, Kish Island, Oct. 1997 (IRAN 10560 F).

***Ganoderma lucidum*** (Curtis) P. Karst., Revue mycol., Toulouse 3(9): 17, 1881

Fig. 7-9

= *Boletus lucidus* Curtis, Fl. Lond. 2: pl. 216, 1781.

= *Polyporus lucidus* (Curtis) Fr., Syst. Mycol. 1: 353, 1821.

= *Placodes lucidus* (Curtis) Quél., Enchir. Fung. p. 170, 1886.

**Key characters** — Basidiocarp sessile, dimidiate or stipitate either centrally, excentrically or laterally, and then usually reniform, with different sizes, up to 20 x 14 x 1.5 cm; upper surface radially and concentrically plicate, usually irregular, sometimes warty, laccate, shiny, pale red, reddish brown to blackish brown; margin usually thick, sometimes acute, white in actively growing specimens, and turning yellowish, orange, and reddish brown from the extreme outline inward; stem lateral, vertical, cylindrical, usually long, slender, up to 3 cm thick and 27 cm long, reddish black to almost black, laccate, brilliant, and often but not always with a stem; cutis thin, shiny, a hymenoderm with club-shaped elements originating from the ends of skeletal hyphae, arranged in a palisade-like hymenium, up to 10.5 x 62  $\mu\text{m}$ , amyloid in Melzer's reagent or non-amyloid, these elements are covered by a thick layer of a lacquer pigments that dissolve in a hot solution of 5% KOH and acetone; context creamy white to ochraceous brown, corky, about 1.0 cm thick; tube layer about 1.0 cm thick; tube layer darker than context, about 7.0 mm thick; pore surface white at first and turning greyish when mature and dried; pores more or less rounded, somewhat irregular, 4-6 per mm.

Basidiospores ovoid, double-walled, with a rounded or truncate apex, brown, echinulate comparatively few, long and thick, 6.7-8.6-9.6 x 10.5-12.4-13.4  $\mu\text{m}$ . Hyphal system trimitic with hyaline, thin-walled, septate, clamped generative hyphae, 1-3  $\mu\text{m}$  in diam., skeletal hyphae golden brown, thick-walled, aseptate, very long, 3-7  $\mu\text{m}$  in diam. and binding hyphae profusely branched, thinner and lighter than the skeletal, aseptate, limited growth, 2-4  $\mu\text{m}$  in diam.

**Habitat** — At the base of trunks and on roots of hardwoods, rarely on conifers. Specimens of this species were collected on *Buxus hyrcana*, *Acacia dealbata*, *Pterocarya fraxinifolia*, *Quercus* sp., *Albizia* sp., *Casuarina* sp., *Platanus* sp. (Saber 1973 Saber & Minassian 2000 Saber & Esmailii-Taheri 2004).

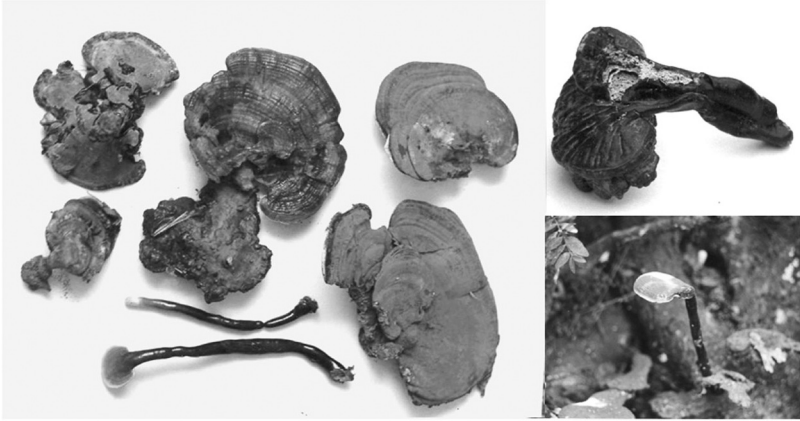


Figure 7- Basidiocarp characteristics of *Ganoderma lucidum*

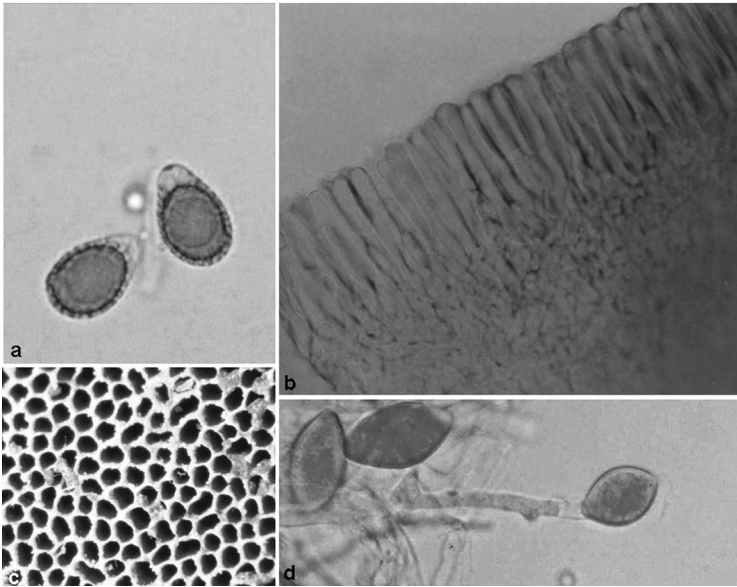


Figure 8- Micromorphological characteristics of *Ganoderma lucidum*.  
a, basidiospores; b, cutis elements; c, pore surface; d, chlamydospores

**Material examined-** On fallen hardwood trunk, Dohezar forest, Tonekabon, Mazandaran, July, 2003 (IRAN 1540 F); on fallen hardwood trunk, Dohezar forest, Tonekabon, Mazandaran, April, 2003 (IRAN 1541 F); on fallen hardwood trunk, Mazoben, Kotra, Tonekabon, Mazandaran, July, 2003 (IRAN 2099 F); on *Carpinus betulus*, Gavsar, Tonekabon, Mazandaran, August 19, 1971 (IRAN 6722 F); on wood, Tonekabon, Mazandaran, summer, 1970 (IRAN 6721 F).

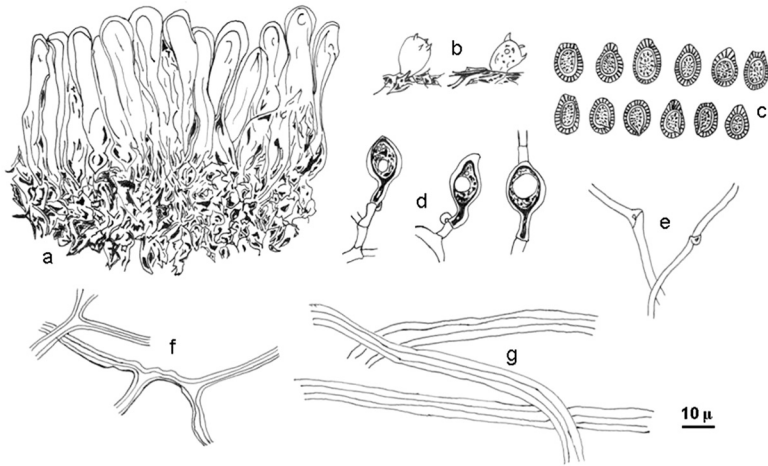


Figure 9 - Basidiocarp characteristics of *Ganoderma lucidum*.  
 a, cutis elements; b, basidia; c, basidiospores; d, chlamydospores;  
 e, generative hyphae; f, binding hyphae; g, skeletal hyphae

***Ganoderma resinaceum*** Boud. in Patouillard, Bull. Soc. mycol. Fr. 5: 72, 1889

Figs. 10-11

= *Ganoderma chaffangeonii* Pat., Bull. Soc. mycol. Fr. 5: 74, 1889.

= *Ganoderma sessile* Murrill, Bull. Torrey Bot. Club 29: 604, 1902.

= *Polyporus polychromus* Copel., Ann. Mycol. 2: 507, 1904.

= *Ganoderma polychromum* (Copel.) Murrill, N. Am. Fl. 9: 119, 1908.

= *Ganoderma praelongum* Murrill, N. Am. Fl. 9: 121, 1908.

= *Ganoderma argillaceum* Murrill, N. Am. Fl. 9: 122, 1908.

= *Ganoderma subperforatum* G.F. Atk., Bot. Gaz. 46: 337, 1908.

= *Ganoderma platense* Speg., Bol. Acad. Nac. Cienc. Córdoba 28: 363, 1926.

**Key characters** — Basidiocarp dimidiate to reniform, substipitate to long stipitate, usually laterally, sometimes centrally stipitate; pileus very variable in size, up to 26 x 13 x 5 cm, often very irregular in shape; upper surface appanate, concave or more or less infundibuliform, smooth, irregularly rugose, concentrically sulcate and radially rugose or strongly tuberculose, shiny laccate, reddish brown or light reddish brown in maturity, central zone yellowish brown and very light in young specimens, may have a thick white margin when these are not mature, gradually turning yellow, red, brown and finally black from the margin toward the base; stem very short to long, lateral or central, slender to thick, black, laccate, brilliant; cutis thin, 100 μm, shiny black, a hymenoderm with club-shaped elements originating from the ends of the skeletal hyphae, arranged in a palisade-like hymenium, up to 22 x 57 μm, amyloid in Melzer's reagent; context corky, cinnamon brown in the upper parts

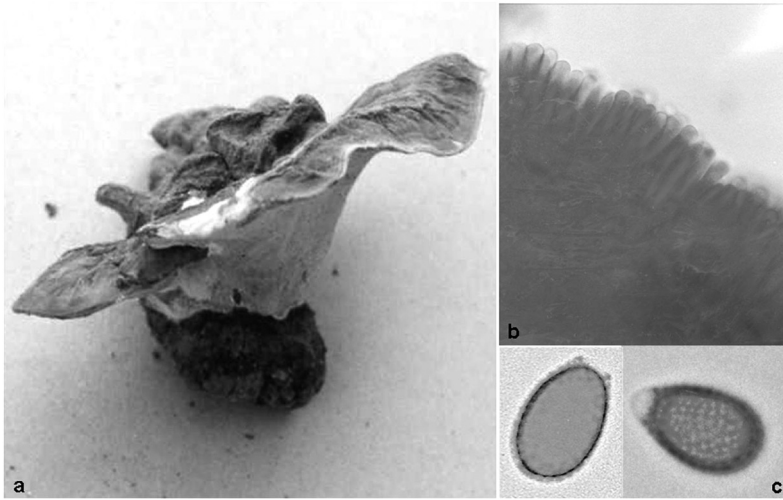


Figure 10- Macro- and micromorphological characteristics of *Ganoderma resinaceum*.  
a, basidiocarp; b, cutis elements; c, basidiospores

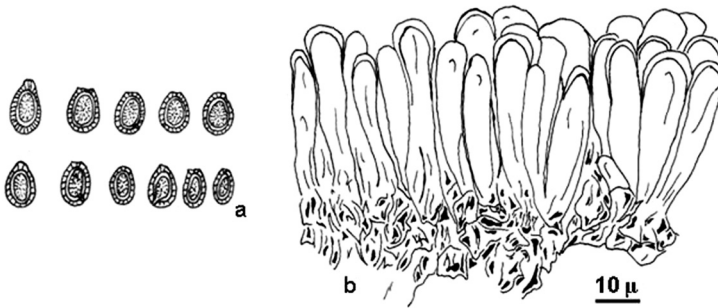


Figure 11 - Basidiocarp characteristics of *Ganoderma resinaceum*.  
a, basidiospores; b, cutis elements

but with zone closed to tube layer cacao brown; tube layer slightly lighter than context, about 4-15 mm thick; pore surface white at first turning greyish when mature and dried; pores rounded, somewhat irregular, 4-6 per mm.

Basidiospores ellipsoid, double-walled, with a rounded or truncate apex, chamois, with short, thin, closely packed spines, thus appearing smooth when observed at 400 x, 5.7-6.7-7.6 x 6.7-11.5  $\mu$ m. Hyphal system trimitic with hyaline, thin-walled, septate, clamped generative hyphae, 1-5  $\mu$ m in diam., skeletal

hyphae golden brown, thick-walled, aseptate, very long, mostly unbranched or with one or two distal branches besides some lateral swellings, 3-7  $\mu\text{m}$  diam. and binding hyphae branched, thinner and lighter than the skeletal hyphae, aseptate, limited growth, much branched, 2-4  $\mu\text{m}$  in diam.

**Habitat** — On trunks and fallen logs of hardwoods and conifers. *Quercus* sp., *Robinia pseudoacacia* and *Populus* sp. are its hosts in Iran (Saber & Minassian 2000).

**Material examined**- On fallen trunk, Gisum Park, Gilan, Iran, June 21, 1991 (IRAN 10685 F).

*Ganoderma tsugae* Murrill, Bull. Torrey Bot. Club 29: 601, 1902 Fig. 12  
= *Polyporus tsugae* (Murrill) Overh., Ann. Mo. Bot. Gard. 2: 714, 1915.

**Key characters** — Basidiocarp reniform or flabelliform, stipitate or narrowed to an almost sessile base, corky; pileus variable in size, up to 20 x 30 x 5 cm, brownish orange to blackish, shiny laccate, paler on the margin, sometimes with a brown coating of spores, azonate or somewhat zonate or sulcate on the margin; stem when present usually lateral, sometimes central with color as in the pileus or more shining, 3-5 cm; cutis thin, shiny red, a hymenoderm; context tough and watery when fresh, white or nearly so throughout but usually slightly brownish next to the tube, 0.5-2.5 cm thick; pore surface white to brown, tube layer 0.5-1 cm thick; pores 4-6 per mm.

Basidiospores ovoid, double-walled, with a truncate apex, light brown, apparently echinulate, 6-8 x 9-11  $\mu\text{m}$ . Hyphal system trimitic with hyaline, thin-walled, septate, clamped generative hyphae, 1-3  $\mu\text{m}$  in diam., skeletal hyphae pale brown, thick-walled, aseptate, 4-6  $\mu\text{m}$  in diam. and binding hyphae branched, thinner and lighter than the skeletal, aseptate, 2-4  $\mu\text{m}$  in diam.

**Habitat** — On logs and living trees of conifers.

**Material examined**- On conifer, Gisom-Rezvanshahr, Gilan province, July 1997 (IRAN 10843 F); on wood, 10 Km Fuman to Masuleh, Gilan province, May 1996 (IRAN 10782 F).

*Ganoderma manoutchehrii* Steyaert, Persoonia 7(1): 71, 1972

This species was described by Steyaert (1972) based upon a single specimen on *Acacia* sp., collected from Ramsar (Northern Iran). The holotype was not available for us to check. We also visited type locality of above species several times to find topotype but no specimen was found.



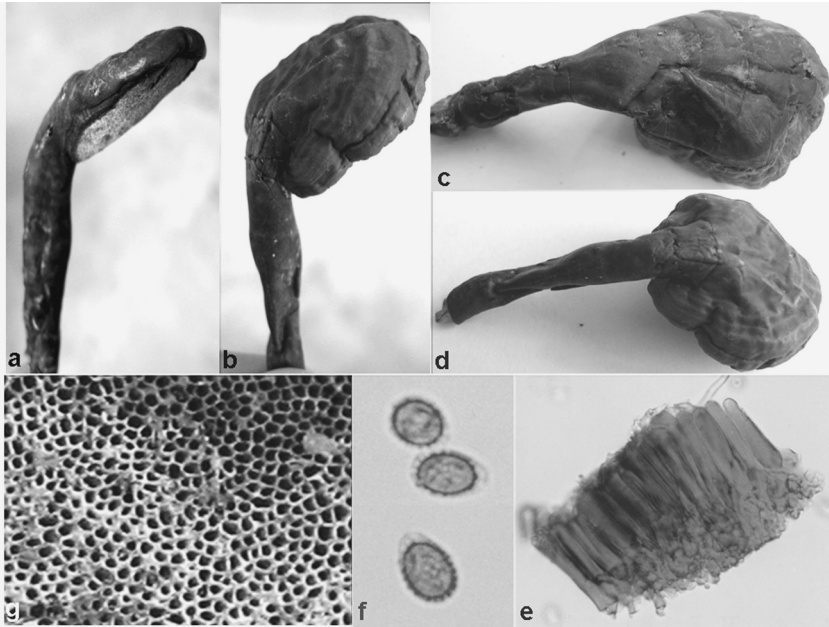


Figure 12- macro- and micromorphological characteristics of *Ganoderma tsugae*.  
a-d, basidiocarp; e, cutis elements; f, basidiospores; g, pore surface

## Discussion

Identifications of *Ganoderma* species were traditionally based on a combination of micro- and macromorphological studies and host relationship. More recently, cultural and mating type studies, together with molecular taxonomy added new insight into the taxonomy of this difficult group, resolving partly the taxonomical chaos of *Ganoderma*. Distributions of the *Ganoderma* species especially through Middle East and Asia in combination with their host relationship are still poorly known.

In the present work we investigated collections of *Ganoderma* species from Iran and introduced them based on micro- and macromorphology and host relationships and also provide a key for their identification. Seven *Ganoderma* species are reported from Iran, two of which belong to subgenus *Elfvigia* (P. Karst.) Imazeki (non-laccate species, *G. applanatum*, *G. adspersum*, and four species belong to subgenus *Ganoderma* (laccate species, *G. lucidum*, *G. resinaceum*, *G. tsugae*, *G. manoutchehrrii*) and one species, *G. colossus*, that does not belong to above mentioned subgenera (This species was once placed in its own genus, *Tomophagus* Murrill. Although most authors consider *Tomophagus*



as a synonym of *Ganoderma*, recent data from molecular studies would support the recognition of the genus).

Most authors consider *Elfvigina* to be a subgenus of *Ganoderma* including non-laccate species, the laccate species being referred to as subgenus *Ganoderma*. The species belonging to subgenus *Ganoderma* have a hymenodermis or characodermis type cutis; many of them are stipitate or variably sessile or stipitate (see *G. resinaceum* for instance). Members of subgenus *Elfvigina* have a cutis and are mostly sessile. *Ganoderma applanatum* is the type species of *Elfvigina* and along with *G. adspersum*, form the core species in the *G. applanatum-adspersum* complex. *Ganoderma applanatum* possibly has a northern distribution (Ryvarden & Gilbertson 1993). *Ganoderma applanatum* and *G. adspersum* spread in temperate and humid areas of Iran that includes the southern margin of the Caspian Sea. In northern Iran with its temperate and humid climate the growth of some *Ganoderma* species is favored. In this area there are dense and temperate forests of *Alnus subcordata*, *Pterocarya fraxinifolia*, *Celtis caucasica*, *Quercus sessiliflora*, *Q. castaneifolia*, *Carpinus betulus*, *Fagus orientalis*, *Gleditschia caspica*, *Betula pendula*, and *Populus caspica*.

*Ganoderma colossus* was collected from southern subtropical areas of Iran growing on deciduous trees. This species has in contrast to other non-laccate species a hymenoderm.

*G. manoutchehrui* was described on the basis of a collection originating from Iran (Steyaert 1972). This species has not been collected during this study, although we specifically search for in the type locality.

Host specificity has been used to circumscribe *Ganoderma* taxa. In the northern temperate regions *G. valesiacum*, *G. carnosum* Pat., *G. tsugae* and *G. oregonense* have been distinguished from *G. lucidum* based on their host relationships, and all appear to be restricted to conifers. *Ganoderma tsugae* was originally described from North America on Conifer, and have been reported from East Asia (China and Japan) on *Picea*, *Pinus*, *Tsuga*, and *Abies*, more rarely on *Acer* and *Betula*.

Among the studied specimens IRAN 6722 F, IRAN 6721 F are Eurasian specimens of *G. lucidum*. They differ from Asian specimens in the amyloid reaction of cutis elements in Melzer's reagent. However, amyloid reaction of the cutis is not usually a stable character and may vary considerably with age and development, and consequently, has to be used with caution in the taxonomy of this genus (according to personal communications with Dr. Ryvarden). They differ also both in the size and ornamentation of their basidiospores. The Eurasian specimens have smaller basidiospores than Asian specimens (4.8-5.7-6.7 x 6.7-7.6-9.6 µm) and the spines are more delicate, plentiful and smaller than in other specimens. It is important that in the first observation such spores

be very like *G. resinaceum* ones. With regard to such differences we can agree that such specimens belong to *G. lucidum* complex reported from Iran and that molecular studies can help us to more precise identification.

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