The identity of Ganoderma applanatum (Basidiomycota)

Article *in* Taxon · August 2008

DOI: 10.1002/tax.573024

2 authors, including:

Otto Miettinen
University of Helsinki
135 PUBLICATIONS **3,075** CITATIONS

The identity of *Ganoderma applanatum* (*Basidiomycota*)

Tuomo Niemelä & Otto Miettinen*

*Botanical Museum, University of Helsinki, P.O. Box 7, 00014 Helsinki, Finland. *otto.miettinen@helsinki.fi (author for correspondence)*

A proposal was recently made (Redhead & al. in Taxon 55. 2006) to conserve the name *Boletus applanatus* Pers., and a neotype was selected for it. However, two externally almost indistinguishable species occur in Europe: *Ganoderma applanatum* (Pers.) Pat. as commonly understood, and *G. adspersum* (Schulzer) Donk. In this paper we examine the selected neotype of *Boletus applanatus* and determine that it conforms to the current European concept of *G. applanatum* rather than to the superficially similar *G. adspersum*.

KEYWORDS: *Basidiomycota, Ganoderma*, nomenclature, typification

INTRODUCTION

Ganoderma P. Karst. is taxonomically one of the most difficult genera among polypores. Difficulties arise from the high number of species names (many of them synonyms)—a consequence of the variability in basidiocarp morphology, striking colours, and scantiness of species-specific microscopic characteristics. The genus is distributed widely from the tropics to the temperate forests. DNA-based analyses of *Ganoderma* (Gottlieb & al., 2000; Smith & Sivasithamparam, 2000; Hong & Jung, 2004; Kaliyaperumal & Kalaichelvan, 2008; Moncalvo & Buchanan, 2008) show its species-richness and heterogeneity. The names *G. applanatum* (Pers.) Pat. and *G. lucidum* (Curtis : Fr.) P. Karst., in particular, have been used worldwide, and often misused.

Redhead & al. (2006) recently made a proposal to conserve *Boletus applanatus* Pers. 1800 against *B. lipsiensis* Batsch 1786, which we fully support. The two names have commonly been considered to refer to the same species. The identity of *Ganoderma applanatum* is important because it and related species are serious decayers of forest and park trees (Schwarze & al., 2000; Tsopelas & al., 2000; Sankaran & al., 2005; Paterson, 2006), and the genus has economic value due to supposed medicinal properties (Dai & Bau, 2007).

Both these names were described from Europe. They have been widely used, *G. applanatum* with very variable species concepts and *G. lipsiense* (Batsch) G.F. Atk. more exactly for a common European taxon. For this reason we use the name *G. lipsiense* below, until the identity of *G. applanatum* becomes explained. In order to clarify the taxonomy of *B. applanatus*, Redhead & al. (2006) selected a neotype for it. In this paper we check that the neotype specimen matches *G. lipsiense* rather than superficially similar species such as *G. adspersum* (Schulzer) Donk, a European species externally almost indistinguishable from *G. applanatum*, and aged, dull specimens of the otherwise laccate species *G. pfeifferi* Bres.

MATERIALS AND METHODS

Spores were measured in Cotton Blue as explained in Miettinen & al. (2006). A minimum of 30 spores were measured from each specimen, with an accuracy of 0.1 µm. The multilayer structure of the *Ganoderma* spore wall has resulted in different methods of spore measurement. We measured spores from the surface of the outer, transparent wall layer, including the turgid vesicular appendix at the spore's distal end. The latter collapses during spore maturation, reducing spore length by 1–2 µm. For comparison, a smaller amount of spores were measured from the pigmented inner wall. This gives less variable and more reliable readings, but is not the standard way of measuring. The following symbols are used for spore measurements: L = mean length, W = mean width, Q = L/W (average length divided by average width), Q' = length/width ratio of individual spores, n = number of spores measured from given number of specimens, for instance 90/3 meaning 90 spores measured from 3 specimens. In presenting the variation of spore size and Q', the whole range is given in parentheses. The 90% range excluding the extreme 5% of values from both ends is given without parentheses. In case the 5% limit falls between two values, the one further from the median was chosen to represent the 5% tail. Whenever the figures within and outside parentheses are identical, parentheses are omitted.

In order to avoid mistaken inclusion of other *Ganoderma* species, only basidiocarps from European collections were selected for measurements, supplemented by two specimens from temperate Asia (Table 1); subtropical–tropical and New World materials were omitted. The neotype of *B. applanatus* is preserved in herbarium L, the others

Table 1. Specimens examined microscopically of *Ganoderma adspersum*, *G. applanatum*, and *G. pfeifferi*. All specimens from H, except the neotype of *G. applanatum*.

Ganoderma adspersum	
Austria	Wien, angiosperm, 29.II.2008, *Miettinen 12384.1*
Belgium	Fiége, Herve, *Tilia*, 27.I.1965, *Leval & Demoulin s.n.*
Croatia	Zagreb, *Quercus*, 9.X.1969, *Tortić 192-96*
Czech Republic	Bohemia, Žatec, *Acer saccharinum*, 15.VIII.1973, *Niemelä 483*
Turkey	Sakarya, Sapança, *Prunus*, 20.VI.1981, *Kurtto 3112a*
Ganoderma applanatum	
China	Jilin, Changbai, deciduous tree, 26.VIII.2005, *Miettinen 10549.1*
Finland	Uusimaa, Vantaa, *Salix caprea*, 24.VIII.1984, *Saarenoksa 35184*; Koillismaa, Taivalkoski, *Populus tremula*, 19.VII.1995, *Nissinen 217*; Kittilän Lappi, Aakenus, *Populus tremula*, 29.VIII.2000, *Niemelä 6824*
Germany	Hessen, Giessen, *Abies alba*, 9.IX.1975, *Hupke s.n.*
Sine loco	"*Polyporus fomentarius* var. *applanatus*, Herb. Persoon, no. 393" (L 910.263–520, new numbering L 0009227), neotype
Ganoderma pfeifferi	
Slovakia	Kremnické Pohorie, *F. sylvatica*, 4.VIII.1973, *Niemelä 496b*
Sweden	Göteborg, *Fagus sylvatica*, 2.VIII.1985, *Nordin 9729*

in H. The neotype sheet contains an envelope with two basidiocarp pieces inside; these are clearly parts of a single specimen, as their broken surfaces match with each other.

RESULTS

Spore size measurements are presented in Table 2, which shows that spore sizes, especially their mean values, differ clearly between the two species, *G. lipsiense* and *G. adspersum*. If sizes of individual spores are plotted (Fig. 1), the two species cluster separately, even though the largest spores of *G. lipsiense* are slightly larger than the smallest spores of *G. adspersum*. Spores of the neotype of *G. applanatum* clearly agree with those of what we call *G. lipsiense*, supporting the synonymy of the two names. Hence the name *G. applanatum* will be used below. Spores of *G. pfeifferi* are clearly larger than those of *G. applanatum* (Table 2).

Other microscopic differences were sought between *G. applanatum* and *G. adspersum*, but in vain. For instance, the obscure hyphal structure of the upper pileus crust gave no clue for separation of the two species. In contrast, the palisade of clavate thick-walled cells on the shiny, or with age dull crust of *G. pfeifferi* clearly differentiates this species.

DISCUSSION

Redhead & al. (2006) in their proposal to conserve *B. applanatus* listed over 50 books and papers in which the name *G. applanatum* has been used, but failed to mention that a great deal of these have collective or unclear species concepts (including *G. adspersum* and/or other extra-European species), e.g., Bourdot & Galzin (1927), Pilát (1942), Bondartsev (1953), and Lindsey & Gilbertson (1978) among the major manuals. Redhead & al. (2006) did not mention possible confusion of *G. applanatum* and *G. adspersum*.

Jahn (1963) may have been the first mycologist to

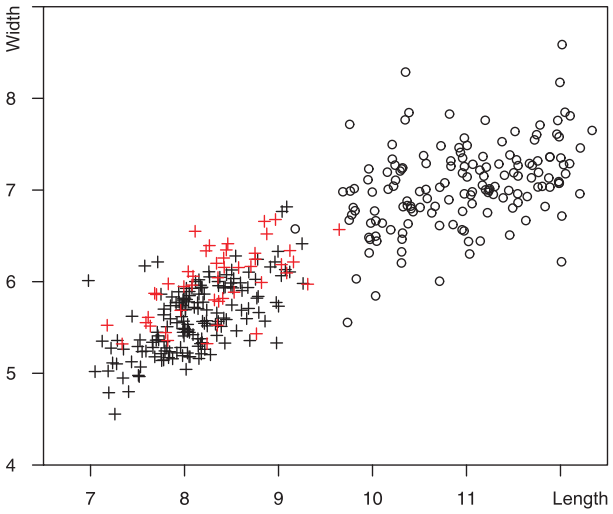

Fig. 1. Size of individual spores of *Ganoderma applanatum* (+; red-colour symbols from the neotype) and of *G. adspersum* (o), the outer spore wall included in the measurements. The points have been jittered, i.e., moved randomly within 0.05 µm around the original value along both axes.

Table 2. Measurements of spores of *Ganoderma adspersum*, *G. applanatum*, and *G. pfeifferi*.

Spore measurements with the outer wall and expanded vesicular apex included							
Species/specimen	**Length**	**L**	**Width**	**W**	**Q'**	**Q**	**n**
Ganoderma adspersum	**(9.2–)9.8–12.0(–12.3)**	**10.95**	**(5.6–)6.3–7.8(–8.6)**	**7.05**	**(1.3–)1.4–1.7(–1.9)**	**1.55**	**150/5**
Kurtto 3112a	10.6–12.1(–12.3)	11.37	(6.6–)6.8–7.6(–7.7)	7.21	1.5–1.7	1.58	30
Leval 27.I.1965	(9.7–)9.8–11.8(–12.0)	10.58	(5.6–)6.0–7.7(–8.2)	6.77	1.4–1.7(–1.8)	1.56	30
Miettinen 12384.1	(9.8–)10.0–12.0	10.87	(6.6–)6.7–7.8(–8.3)	7.32	1.3–1.7	1.49	30
Niemelä 483	(9.2–)9.7–11.2(–12.0)	10.29	(6.0–)6.2–7.7(–8.6)	6.94	(1.3–)1.4–1.6(–1.7)	1.48	30
Tortić 192-96	(10.0–)11.0–12.2	11.65	(5.8–)6.2–7.8	7.02	(1.4–)1.5–1.8(–1.9)	1.66	30
Ganoderma applanatum	**(7.0–)7.3–9.0(–9.6)**	**8.17**	**(4.6–)5.1–6.3(–6.8)**	**5.69**	**(1.2–)1.3–1.6(–1.7)**	**1.43**	**205/6**
Neotype	(7.2–)7.6–9.2(–9.6)	8.35	(5.3–)5.4–6.7(–7.3)	6.03	(1.2–)1.3–1.5(–1.6)	1.39	45
Hupke 9.9.1975	(7.0–)7.1–9.1(–9.3)	8.16	(5.0–)5.1–6.4(–6.8)	5.79	(1.2–)1.3–1.5	1.41	30
Miettinen 10549.1	(7.5–)7.7–9.0	8.25	(5.0–)5.2–6.0	5.51	1.4–1.6(–1.7)	1.50	30
Niemelä 6824	(7.2–)7.4–9.0(–9.3)	8.11	(4.8–)5.1–6.0(–6.2)	5.49	(1.2–)1.4–1.6	1.48	40
Nissinen 217	(7.7–)7.8–9.0(–9.1)	8.24	(5.4–)5.5–6.2(–6.3)	5.85	1.3–1.5	1.41	30
Saarenoksa 35184	(7.0–)7.2–8.4(–9.0)	7.81	(4.6–)4.8–6.2(–6.8)	5.43	1.2–1.6	1.43	30
Ganoderma pfeifferi	**(10.6–)11.0–13.0(–13.5)**	**11.92**	**(7.2–)7.9–9.2(–9.8)**	**8.49**	**(1.2–)1.3–1.5(–1.6)**	**1.40**	**60/2**
Niemelä 496b	(11.5–)11.6–13.1(–13.5)	12.20	(7.9–)8.0–9.1(–9.4)	8.54	(1.3–)1.4–1.5(–1.6)	1.43	30
Nordin 9729	10.6–12.6(–13.0)	11.64	(7.2–)7.7–9.2(–9.8)	8.43	(1.2–)1.3–1.5	1.38	30
Spore measurements with the outer wall and expanded vesicular apex excluded							
Species/specimen	**Length**	**L**	**Width**	**W**	**Q'**	**Q**	**n**
Ganoderma adspersum	**(7.2–)8.0–9.7(–10.3)**	**8.73**	**(5.2–)5.7–7.2(–7.8)**	**6.33**	**(1.2–)1.3–1.5(–1.6)**	**1.38**	**94/3**
Miettinen 12384.1	(8.3–)8.4–10.0(–10.2)	9.11	6.2–7.2	6.58	(1.2–)1.3–1.5	1.39	34
Niemelä 483	(7.7–)7.9–9.6(–10.3)	8.55	(5.2–)5.5–6.8(–7.8)	6.13	1.2–1.6	1.38	30
Tortić 192-96	(7.2–)8.0–9.1(–9.3)	8.47	5.8–6.8(–6.9)	6.26	1.2–1.4(–1.5)	1.35	30
Ganoderma applanatum	**(5.9–)6.3–7.6(–8.0)**	**6.92**	**(4.5–)4.6–5.6(–6.0)**	**5.07**	**(1.2–)1.3–1.5(–1.6)**	**1.37**	**107/3**
Neotype	(5.9–)6.2–7.6(–8.0)	6.96	4.5–5.6(–6.0)	5.12	(1.2–)1.3–1.5(–1.6)	1.36	47
Miettinen 10549.1	(6.3–)6.7–7.6(–7.7)	7.09	4.7–5.3(–5.8)	5.06	1.3–1.5	1.40	30
Saarenoksa 35184	(6.0–)6.2–7.3(–7.4)	6.68	4.5–5.5(–5.8)	4.95	1.3–1.4(–1.5)	1.35	30

Combined statistics for each species are printed in bold. L = mean spore length, W = mean width, Q' = length/width ratio of individual spores, Q = L/W (average length divided by average width), n = number of spores measured.

clearly show that there are two separate but similar European species, *G. applanatum* and *G. adspersum*. While describing *Ganoderma europaeum* Steyaert—a later synonym of *G. adspersum* (Donk, 1969)—Steyaert (1961) did not clearly distinguish it from *G. applanatum*. Only later (Steyaert, 1967) did he explain and illustrate species differences in colour.

Ganoderma's multi-layered spore wall with hyaline outer surface and soon-collapsing vesicular apex leads to ambiguity in published spore dimensions unless the method of measurement is explained. In spite of these obstacles the difference in spore size between *G. applanatum* and *G. adspersum* is clear enough to be reliable.

Recent molecular studies (Smith & Sivasithamparam, 2000; Hong & Jung, 2004; Kaliyaperumal & Kalaichelvan, 2008; Moncalvo & Buchanan, 2008) clearly show that the number of species in *Ganoderma* is much higher than traditionally thought. The immediate challenge is to clarify nomenclature by typifying all existing names, and selecting representative recent collections for molecular analyses, collected from areas where species were first described. Only in this way can the present serious nomenclatural complexities be solved.

ACKNOWLEDGEMENTS

We thank Dr. Gerard Thijsse in herb. L for allowing the author O.M. to study the neotype of *B. applanatus*. Prof. Pertti Uotila (H) kindly arranged funding for O.M.'s visit to the Leiden herbarium, and the Ministry of Environment (Finland) funded the work via project YM 131/5512/2002.

LITERATURE CITED

Bondartsev, A.S. 1953. *Trutovye Griby Evropeyskoy Chasti SSSR i Kavkaza*. Izdatel'stvo Akad. Nauk SSSR, Moskva & Leningrad.

Bourdot, H. & Galzin, A. 1927. *Hyménomycètes de France. Hetérobasidiés – Homobasidiés Gymnocarpes*. Marcel Bry, Sceaux.

Dai, Y.C. & Bau, T. 2007. *Illustrations of Edible and Medicinal Fungi in Northeastern China.* Science Press, Beijing.

Donk, M.A. 1969. Notes on European polypores 4, on some species of *Ganoderma*. *Proc. Kon. Ned. Akad. Wetensch., Ser. C, Biol. Med. Sci.* 72: 273–282.

Gottlieb, A.M., Ferrer, E. & Wright, J.E. 2000. rDNA analyses as an aid to the taxonomy of species of *Ganoderma*. *Mycol. Res.* 104: 1033–1045.

Hong, S.G. & Jung, H.S. 2004. Phylogenetic analysis of *Ganoderma* based on nearly complete mitochondrial small-subunit ribosomal DNA sequences. *Mycologia* 96: 742–755.

Jahn, H. 1963. Mitteleuropäische Porlinge (*Polyporaceae* s. lato) und ihr Vorkommen in Westfalen. *Westfälische Pilzbriefe* 4: 1–143.

Kaliyaperumal, M. & Kalaichelvan, P.T. 2008. *Ganoderma australe* from southern India. *Microbiol. Res.* 163: 286–292.

Lindsey, J.P. & Gilbertson, R.L. 1978. Basidiomycetes that decay aspen in North America. *Biblioth. Mycol.* 63: 1–406.

Miettinen, O., Niemelä, T. & Spirin, W. 2006. Northern *Antrodiella* species, the identity of *A. semisupina*, and type studies of related taxa. *Mycotaxon* 96: 211–239.

Moncalvo, J.-M. & Buchanan, P.K. 2008. Molecular evidence for long distance dispersal across the Southern Hemisphere in the *Ganoderma applanatum–australe* species complex (*Basidiomycota*). *Mycol. Res.* 112: 425–436.

Paterson, R.R.M. 2006. *Ganoderma* disease of oil palm. A white rot perspective necessary for integrated control. *Crop Protect.* 26: 1369–1376.

Pilát, A. 1942. *Polyporaceae*. Pp. 473–624 in: Kavina, C. & Pilát, A. (eds.), *Atlas des Champignons de l'Europe*, sér. B, fasc. 42–48. Privately published, Praha.

Redhead, S.A., Ginns, J. & Moncalvo, J.-M. 2006. (1739) Proposal to conserve the name *Boletus applanatus* against *B. lipsiensis* (*Basidiomycota*). *Taxon* 55: 1029–1030.

Sankaran, K.V., Bridge, P.D. & Gokulapalan, C. 2005. *Ganoderma* diseases of perennial crops in India, an overview. *Mycopathologia* 159: 143–152.

Schwarze, F.W.M.R., Engels, J. & Mattheck, C. 2000. *Fungal Strategies of Wood Decay in Trees.* Springer, Berlin.

Smith, B.J. & Sivasithamparam, K. 2000. Internal transcribed spacer ribosomal DNA sequence of five species of *Ganoderma* from Australia. *Mycol. Res.* 104: 943–951.

Steyaert, R.L. 1961. Genus *Ganoderma* (*Polyporaceae*), taxa nova 1. *Bull. Jard. Bot. État Bruxelles* 31: 69–83.

Steyaert, R.L. 1967. Considérations générales sur le genre *Ganoderma* et plus spécialement sur les espèces européennes. *Bull. Soc. Roy. Bot. Belgique* 100: 189–211.

Tsopelas, P., Angelopoulos, A., Gonou-Zagou, Z. & Kapsanaki-Gotsi, E. 2000. *Ganoderma australe* (Fr.) Pat. a new pathogenic fungus of willow (*Salix alba*) in Greece [abstract]. P. 275 in: Hellenic Society for Biological Sciences (ed.), *Proceedings of the 22nd Congress of the Hellenic Society of Biological Sciences, 25–28 May, Skiathos, Greece*.