Mycol Progress (2011) 10:389–398
DOI 10.1007/s11557-010-0701-6

REVIEW

Three new species of *Lentinus* from northern Thailand

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Received: 15 June 2010 / Revised: 22 July 2010 / Accepted: 23 July 2010 / Published online: 12 August 2010

Abstract There have been few studies on the taxonomy and biodiversity of the genus *Lentinus* in Thailand, which is a genus of edible mushrooms. Recently, collections from 17 sites in northern Thailand yielded 47 specimens of *Lentinus* sensu lato. Three were shown to be new species of *Lentinus* sensu stricto and *Lentinus roseus, L. concentricus* and *L. megacystidiatus* are introduced in this paper. The new species are described and illustrated with line drawings and are justified and compared with similar taxa. Furthermore, ITS sequence data do not match closely with any species presently lodged in GenBank.

Keywords Biodiversity · Edible fungi · Taxonomy · Tropical fungi

Taxonomic novelties *Lentinus roseus* Karunarathna, K.D. Hyde & Zhu L. Yang, sp. nov.
Lentinus megacystidiatus Karunarathna, K.D. Hyde & Zhu L. Yang, sp. nov.
Lentinus concentricus Karunarathna, K.D. Hyde & Zhu L. Yang, sp. nov.

Introduction

Tropical regions have the potential to be one of the richest sources of fungal species, and Thailand is no exception. The macrofungi of the Mushroom Research Centre and surrounding areas in northern Thailand are presently being studied (Le et al. 2007; Sanmee et al. 2008; Kerekes and

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Desjardin 2009; Wannathes et al. 2009a, b). *Lentinus* (Fr.) Quel' is a cosmopolitan genus with an estimated 63 species (Kirk et al. 2008) which are able to survive over a wide temperature range, are abundant in the tropics, and are frequently found in temperate regions (Pegler 1983). Species of *Lentinus* are normally wood-decaying basidiomycetes and have decurrent lamellae, dimitic tissues in the basidiome, and hyaline, ellipsoid to cylindric spores. Species in the subgenus *Lentinus* have hyphal pegs (Corner 1981; Pegler 1983). Generally, the basidiomes are xeromorphic with a tough, firm texture when dry and have a long life span, but in Thailand they fruit only early in the summer rainy season (Sysouphanthong et al. 2010). Traditionally, *Lentinus* has been placed in the agaric family Tricholomataceae because species possess a lamellate hymenophore and white spore print (e.g., Miller 1973).

A close relationship has long been observed between *Lentinus* and certain polypores (Corner 1981; Pegler 1983; Singer 1986). *Lentinus* has been grouped under the family Polyporaceae based on the presence of dimitic and amphimitic hyphal systems (Moser 1978; Kühner 1980; Pegler 1983; Singer 1986). Moreover, hyphal pegs, fascicles of sterile hyphae coming out from the hymenium surface, are some of the common features present in some genera of the Polyporaceae and in *Lentinus* subg. *Lentinus* (Pegler 1983; Corner 1981).

Recent research (e.g., Redhead and Ginns 1985; Hibbett and Vilgalys 1991, 1993; Hibbett and Thorn 1994; Hibbett et al. 1993) has elucidated the *Lentinus–Pleurotus–Panus* complex; it has shown that *Lentinus* sensu Pegler is polyphyletic, with *Lentinus* subg. *Lentinus* sensu Pegler monophyletic and belonging to the Polyporales (Hibbett and Vilgalys 1991; Kruger and Gargas 2004). *Panus* Fr., *Pleurotus* Fr., and *Neolentinus* Redhead & Ginns are also monophyletic, with *Pleurotus* belonging to the Agaricales (Fleming 1994; Hibbett and Thorn 1994). These genera have been treated differently by Corner (1981), Kühner (1980), Pegler (1975, 1983) and Singer (1986). Two brown rot genera, *Neolentinus* Redhead & Ginns, and *Heliocybe* Redhead & Ginns, were separated from *Lentinus* which otherwise comprises white rot species (Gilbertson 1980; Redhead and Ginns 1985). Here, *Lentinus* will be used to mean *Lentinus* subg. *Lentinus* sensu Pegler (1983), which is essentially equivalent to *Lentinus* sensu Corner (1981). Molecular studies support the view that *Lentinus* is derived from the Polyporales (Pegler 1983) and suggest that *Polyporus arcularius* Batsch : Fr. is a closely related outgroup (Hibbett and Vilgalys 1991, 1993). *Panus* sensu stricto is characterized by the skeletal hyphae, the radial trama, and the purplish pigment of the young basidiomes but absence of metuloides and gloeocystidia are an abnormal feature. Species of *Lentinus* sensu lato are found on fallen tree trunks and decaying timber.

Thailand is rich in species of *Lentinus* (e.g., *L. badius* (Berk.) Berk., *L. squarrosulus* Mont.,*L. polychrous* Lev., *L. cladopus* Lev., *L. strigosus* (Schwein.) Fr., *L. velutinus* Fr., *L. similis* Berk. & Broome and *L. connatus* Berk.) based on the records by Pegler (1983), but no systematic study of the genus has been undertaken so far.

Wild mushrooms are one of the higher valued non-timber forest products in northern Thailand. They provide locals with seasonal food, medicine and an alternative income (Sysouphanthong et al. 2010). The richness of wild mushrooms is also one bio-indicator of ecosystem health. The cultivated, non-mycorrhizal mushrooms, such as *Agaricus* spp., *Auricularia* spp., *Lentinula edodes*, *Pleurotus sajor-caju* (Fr.) Singer, *Pleurotus* spp., and *Volvariella* spp. are available throughout the year in markets of northern Thailand; however, edible wild mushrooms can only be found in the wet season from June to September (Sysouphanthong et al. 2010). In *Lentinus*, almost all the members are edible except those which have a tough texture. It is therefore important to try to introduce members of this genus as commercial species. Although there are many studies on cultivated and wild edible mushrooms in the northern hemisphere and their nutritional value (Aletor 1995; Latiff et al. 1996; Manzi et al. 1999, 2001; Demirbas 2000), there is little information available concerning the taxonomy, biodiversity and potential to introduce *Lentinus* species from northern Thailand for cultivation. Scientific information on wild mushrooms is essential for the introduction of new species for the table. As part of a study to assess the biodiversity, taxonomy and potential for cultivation of *Lentinus* species in northern Thailand, we discovered three new species. The objective of this paper is to introduce these three new species.

Materials and methods

Sample collection

Sites in northern Thailand were in Chiang Mai and Chiang Rai Provinces and are listed with details in Table 1.

Morphological character examination

Macro-morphological characters were described based on fresh material, and documented by photographs. Color designations (e.g., 4B5) are from Kornerup and Wanscher (1978), while the color names with the first letters capitalized (e.g., Grayish yellow) are from Ridgeway (1912). Specimens were dried and placed in plastic bags separately, and then deposited in the Herbarium of Mae Fah Luang University (MFLU). For micro-morphological examination, sections were cut with a razor blade from

Table 1 *Lentinus* species from Thailand

No.	List of species	Collection site
1	*Lentinus badius* (Berk.) Berk.	DCD; Pegler 1983
2	*L. squarrosulus* Mont.	KL; Pegler 1983
3	*L. polychrous* Lev.	BU; Pegler 1983, SE; Pegler 1983, KKC; Pegler 1983, ST; Pegler 1983
4	*L. cladopus* Lev.	CL; Pegler 1983, CCM; Pegler 1983
5	*L. tigrinus* (Bull.: Fr.) Fr.	HWY; this paper, PT; this paper, MS; this paper
6	*L. megacystidiatus* sp. nov.	PT; this paper
7	*L. concenticus* sp. nov.	MRC; this paper
8	*L. roseus* sp. nov.	HS; this paper, KK; this paper

DCD Doi Chiang Dao Nat. Park; *KL* Bangkok, Puckdeedindan; Khao Luon; *BU* Bung; *SE* Seiracha; *KKC* Khao Kai Chiang; *ST* Sri-tan; *CL* Cangwat Lamphun; *CCM* Cangwat Chiang Mai

MRC THAILAND, Chiang Mai Province, Mae Taeng District, Ban Pha Deng, Mushroom Research Centre, 19°17.123′N, 98°44. 009′E, elevation 900 m, rainforest dominated by *Castanopsis armata*, *Erythrina* sp, and *Dipterocarpus* sp.

PT THAILAND, Chiang Mai Province., Mae Taeng District, Ban Pha Deng, Pathummikaram Temple, forest trail, 19°06.288′N, 98°44.47.3′E, elevation 1,050 m, rainforest dominated by *Castanopsis armata*, and *Dipterocarpus* sp.

HWY THAILAND, Chiang Mai Province, Mae Teng District, Highway 1095 at 22 km marker, 19°07.57′N, 98°45.65′E, elevation 750 m, xeric broad-leaf forest (*Dipterocarpus* spp. + *Tectona grandis*) with *Pinus kesiya*.

MS THAILAND, Chiang Mai Province, Mae Taeng, Ban Mae Sae village, on Highway 1095 near 50 km marker, 19°14.599′N, 98°39.456′E, elevation 962 m, rainforest dominated by *Castanopsis armata, Castanopsis* sp., *Pinus* sp., *Lithocarpus* sp.

HS THAILAND, Chiang Mai Province, Mae Taeng District, Hot Spring National Park, Pong Duad Pa Pae 40 kms off Chiangmai. 35 kms from the Highway Route No 1095: Mae Malai-Pai and turn right for 6.5 kms, humid montane rainforest with *Quercus*, *Castanopsis*, *Lithocarpus echinops*.

KK THAILAND, Chiang Rai Province, Tambon Mae Korn and Tambon Huay Chompoo, Muang District, Khun Korn Waterfall, 19°51–54′N, 99°35.39′E, elevation 1,208 m, moist upper mixed deciduous forest (Royal Forest Department, 1962).

MFLU THAILAND, Chiang Rai Province, Thasud, Muang District, Mae Fah Luang University park, 18°05′59.1″N, 102°40′02.9″E, elevation 488 m, dominated by *Dipterocarpus* sp., *Ficus* sp., and *Tabebuia chrysantha*.

dried specimens and mounted on slides in 5% KOH and Congo red, and then observed, measured and illustrated under a compound microscope (Zeiss Axioskop 40, Germany). In the description of the basidiospores: *n* indicates the number of spores which were measured; L^m is the mean spore length over a population of spores; W^m the mean spore width over a population of spores; Q the length/width ratio (L/W) of a spore in side view; **Q** the average Q of all spores measured.

DNA extraction, PCR and sequencing

Dried mushroom samples were used to extract genomic DNA. Genomic DNA was extracted using a Biospin Fungus Genomic DNA Extraction Kit (Bio Flux) according to the instructions of the manufacturer. DNA concentrations were estimated visually in agarose gel by comparing band intensity with a DNA ladder 1,000 bp (Transgen Biotech).

The PCR reactions were performed in a 50 μl volume (0.3 mM primers (ITS1:5′TCC GTA GGT GAA CCTTGC GG 3′) and ITS4:5′TCCTCCGCTTATTGATATGC3′(White et al. 1990); 10–20 ng DNA template, 1×buffer, 0.2 mM dNTPs, 1.5 units Taq and sterile water). The thermal cycles consisted of 94C° for 3 min, followed by 30–35 cycles at 94C° for 1 min, 52C° for 50 s and 72C° for 1 min, with a final extension step of 72C° for 10 min. The PCR products were verified by staining with ethidium bromide on 1% agarose electrophoresis gels stained with ethidium bromide in 1×Tris-boric acid EDTA buffer. ITS 1 and ITS 4 were used to sequence both strands of the DNA molecules at the International Fungal Research and Development Centre, and The Research Institute of Resource Insects, the Chinese Academy of Forestry, China.

Phylogenetic analysis

The taxa information and GenBank accession numbers in molecular work are listed in Table 2. Sequences for each strain were aligned using Clustal X (Thompson et al. 1997). Alignments were manually adjusted to allow maximum sequence similarity. Gaps were treated as missing data. Phylogenetic analysis were performed using PAUP* 4.0b10 (Swofford 1998). Ambiguously aligned regions were excluded from all analyses. Trees were inferred using the heuristic search option with TBR branch swapping and 1,000 random sequence additions. Maxtrees were unlimited, branches of zero length were collapsed and all multiple parsimonious trees were saved. Clade stability of the trees resulting from the

Table 2 Taxon information and GenBank accession numbers in molecular work

Taxa	Resource and herbarium accession number	DNA extract material	GenBank accession numbers (ITS)
Pleurotus ostreatus	GenBank		EU520193 (Unpublished data)
Lentinus squarrosulus	GenBank		GQ849475 (Unpublished data)
Lentinus squarrosulus	GenBank		AB478883 (Sotome et al. 2009)
Lentinus tigrinus	GenBank		GQ849476 (Unpublished data)
Lentinus tigrinus	GenBank		FJ755219 (Unpublished data)
Lentinus tigrinus	GenBank		EU543989 (Unpublished data)
Lentinus tigrinus	GenBank		DQ056860 (Unpublished data)
Lentinus tigrinus	GenBank		AF516521 (Krueger 2002)
Lentinus tigrinus	GenBank		AF516520 (Krueger 2002)
Lentinus tigrinus	GenBank		AF516519 (Krueger 2002)
Lentinus tigrinus	GenBank		AF516518 (Krueger 2002)
Lentinus tigrinus	GenBank		AF516517 (Krueger 2002)
Lentinus tigrinus	GenBank		AY218419 (Unpublished data)
Lentinus polychrous	GenBank		AB478882 (Sotome et al. 2009)
L. concentricus sp. nov.	MFLU08 1375	Dried sample	(new sequence in this study)
L. megacystidiatus sp. nov.	MFLU08 1388	Dried sample	(new sequence in this study)
Polyporus lepideus	GenBank		GU731572 (Unpublished data)
Polyporus tricholoma	GenBank		AF518753 (Krueger 2002)
Polyporus squamosus	GenBank		DQ267123 (Unpublished data)

parsimony analyses were assessed by bootstrap analysis with 1,000 replicates, each with 10 replicates of random stepwise addition of taxa (Felsenstein 1985). Trees were figured in Treeview.

Taxonomy

1. Lentinus roseus Karunarathna, K.D. Hyde & Zhu L. Yang, sp. nov.

(Figs. 1a–f and 2b)

MycoBank: 518240

Pileus 5–5.5 cm latus, coriaceus, profunde cyathiformis, centro pallide alboluteolo, marginem versus fuscatum ipsum pallide roseum, siccus, estriatus, ezonatus. Lamellae profunde decurrentes, lamellulis 5 seriebus. Stipes 1.5–2 cm longus, 0.5–0.7 cm latus, centralis fusiformis. Basidiosporae 5–7(9) μm longae 3–4(6) μm, latae ellipsoideae ad elongatae. Basidia 18–24 μm longa, 5–7 μm lata, anguste clavata, sterigmatibus 4. Cheilocystidia 19–37 μm longa, 5.5–8 μm lata clavata, hyalina, parietate tenui. Metuloids 36–45(60) μm longa, 9–15 μm lata, clavata, hyalina, apice late rotundato.

Holotype THAILAND, Chiang Mai Province, Mae Taeng District, Hot Spring National Park, Pong Duad Pa Pae, 40 kms off Chiangmai, 35 kms from the Highway Route No 1095: Mae Malai-Pai and turn right for 6.5 kms, humid montane rainforest with *Quercus*, *Castanopsis*, *Lithocarpus echinops*, 05 July 2008, Samantha C. Karunarathna (MFLU08 1376).

Etymology roseus, in reference to the rose color of the mature fruiting body.

Description Basidiomes relatively small (Fig. 2b). Pileus 5–5.5 cm in diameter, leathery, deeply cyathiform, when seen from above rounded flabelliform; margin eroded; surface pale yellow cream (4A3) at centre, darker towards margin and there reddish grey (11B2), not changing on bruising, dry, neither striate nor zonate. Lamellae deeply decurrent, with 5 tiers of lamellulae, 0.5 mm wide, reddish grey (11B2) close to pileus margin, pale yellow cream (4A3), towards stipe in old and young specimens, with entire edge. Stipe 1.5–2×0.5–0.7 cm, central, 1.5–2×5 mm at apex, expanding towards base 1.5–2×7 mm attached to a discoid base, solid, fusiform, yellowish white (4A2), floccose, leathery, solid, with white cottony context. Generative hyphae (Fig. 1f) 4–5 μm diameter, inflated with a slightly thickened wall, more or less radially parallel but frequently branching and with large clamp connections. Skeletal hyphae (Fig. 1e) 5–6 μm in diameter, hyaline, very thick walled with only a very narrow lumen, typically unbranched. Basidiospores (Fig. 1a) 5–7(−9)×3–4 (−6) μm (n=40, L^m=5.93 μm, W^m=3.72 μm, Q=1.36–1.85, **Q**=1.59), ellipsoid to elongate, occasionally broadly ellipsoid or rarely subglobose, hyaline, thin walled, with few contents. Basidia (Fig. 1c) 18–24×5–7 μm, elongate clavate, bearing 4 sterigmata. Cheilocystidia

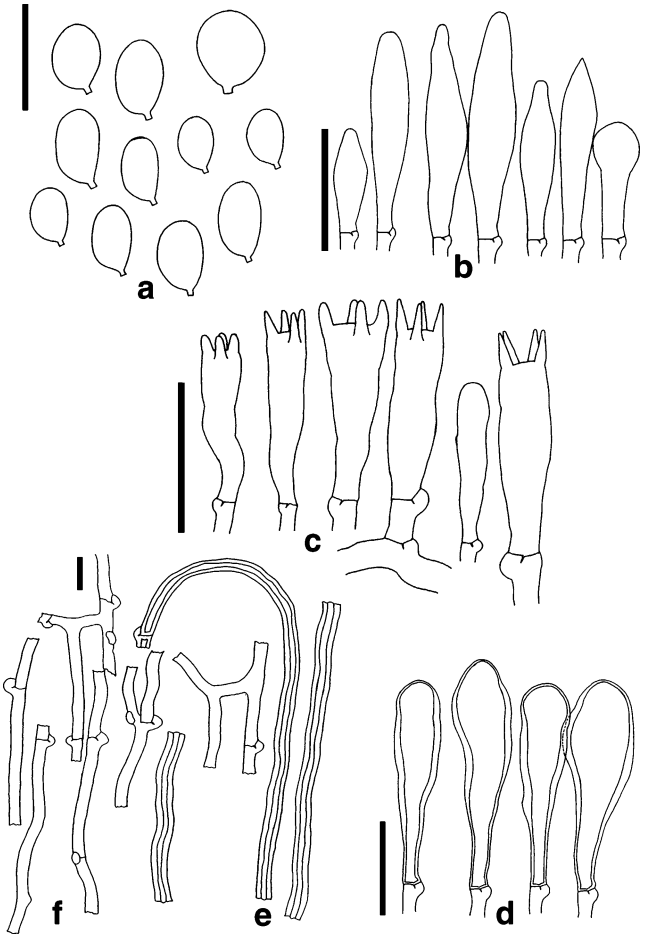

Fig. 1 *Lentinus roseus* (MFLU08 1376) **a** Basidiospores, **b** cheilocystidia, **c** basidia, **d** metuloids, **e** skeletal hyphae, **f** generative hyphae. *Scale bars* (**a**–**d**) 20 μm, (**e**,**f**) 10 μm

(Fig. 1b) 19–37×5.5–8 μm, clavate, hyaline, thin walled. Metuloids (Fig. 1d) abundant to occasional on both sides and edges of the lamellae, 36–45(−60)×9–15 μm, mostly clavate with a broadly rounded apex, thick walled, hyaline. Clamp connections are prominent in generative hyphae.

Habitat Clustered on rotten wood, in a forest with *Quercus*, *Castanopsis* and *Lithocarpus echinops* and in moist upper mixed deciduous forest

Additional specimen examined THAILAND, Chiang Rai Province, Tambon Mae Korn and Tambon Huay Chompoo, Muang District, Khun Korn Waterfall, 19°51–54′N, 99° 35.39′E, elevation 1,208 m, moist upper mixed deciduous forest (Royal forest Department, 1962), 22 July 2009, Sam T-09 (MFLU10 0145).

Distribution Only known from northern Thailand.

Notes This new species is distinguished by its relatively small basidiomes with a leathery, deeply cyathiform and pink pileus, large, clavate metuloids mostly with a broad rounded apex, ellipsoid to elongate basidiospores with a hyaline thin wall, a dimitic hyphal system with very thick walled unbranched skeletal hyphae. In many aspects, it bears superficial resemblance to *Lentinus sajor-caju* (Fr.) Singer. *Lentinus sajor-caju* (Fr.) Singer, however, has larger basidiomes with a whitish cream to mottled gray pileus, an annulate stipe and relatively narrower basidiospores. *Lentinus roseus* also bears superficial resemblance with *L. strigosus* (Schwein.) Fr. and *L. torulosus* (Pers.: Fr.) Lloyd. *Lentinus strigosus* differs from *Lentinus roseus* in having whitish to pallid ochraceous, more brownish basidiomes, and the pileipellis is a trichodermial epicutis, whereas *L. roseus* has characteristic rose basidiomes and the pileipellis is not a trichodermial epicutis. *Lentinus torulosus* differs from *L. roseus* in having narrowly clavate pleurocystidia with an obtusely rounded apex, whereas *L. roseus* lacks pleurocystidia (Corner 1981; Pegler 1983). *Lentinus roseus* forms clusters of basidiomes on dead and decaying wood. Initially, the young fruiting bodies are whitish pink, and they become pink with maturity.

2. Lentinus megacystidiatus Karunarathna, K.D. Hyde & Zhu L. Yang, sp. nov.

(Figs. 2c–d and 3a–g)

MycoBank: 518277

Pileus 0.6–2 cm latus, tenuis, convexus, coriaceus, umbilicatus ad infundibuliformis. Lamellae arcuatae, profunde decurrentes confertae. Stipes centralis, rarissime lateralis, cylindricus. Basidiosporae 6–8 μm longae, 3–4 μm latae, ellipsoideae ad cylindricae. Basidia 18–24 μm longa, 5–7 μm lata clavata, sterigmatibus 4. Cheilocystidia 19–35 μm longa, 4–6.5 μm lata, inflate clavata. Sclerocystidia dispersa 37–52 μm longa, 10–16 μm lata pariete incrassato (ad 3 μm), hyalino vel pallide brunneo.

Holotype THAILAND, Chiang Mai Province, Mae Taeng District, Ban Pha Deng Village, Pathummikaram Temple, forest trail, 19°06.288′N, 98°44.473′E, elevation 1050 m., rainforest dominated by *Castanopsis armata* and *Dipterocarpus* sp., 15 July 2008, Samantha C. Karunarathna (MFLU08 1388)

Etymology megacystidiatus, in reference to the very large sclerocystidia of the taxon.

Description Basidiomes very small (Figs. 2c–d). Pileus 0.6–2 cm in diameter, thin, convex, coriaceous, umbilicate to infundibuliform; margin inflexed, entire, thin at first reflexed, involute at maturity; surface grayish orange (5B4), dry, uniformly velutinous to slightly long-hispid or subsquamulose furfuraceous, zonate, densely ciliate; hairs dark

Fig. 2 **a** Basidiomes of *Lentinus concentricus* (MFLU08 1375), **b** basidiomes of *L. roseus* (MFLU08 1376), **c,d** basidiomes of *L. megacystidiatus* (MFLU08 1388). *Scale bars (***b**) 50 mm, (**c**,**d**) 30 mm

brown (6F7). Lamellae arcuate, deeply decurrent, up to 0.25 mm wide, crowded with 6 tiers of lamellulae, grayish orange (5B4), with entire edge. Stipe 0.2–1.4 cm×2–4 mm, central, excentric, rarely lateral, cylindrical, slender, solid, yellowish brown (5E8), uniformly and persistently velutinous, with dark brown (6F7) hairs; context 2–3 mm, white in color, consisting of a dimitic hyphal system with generative and skeletal hyphae. Generative hyphae 5–6 μm diameter, hyaline, very thin walled, frequently branched, with prominent clamp connexions. Skeletal hyphae 9–10 μm diameter, hyaline with a thickened wall, unbranched or with an occasional short, lateral branch, either terminal or intercalary in origin. Basidiospores (Fig. 3a) 6–8×3–4 μm (n=40, L^m=6.37 μm, W^m=3.6 μm, Q=1.50–2.16, **Q**=1.76), ellipsoid to cylindrical, occasionally broadly ellipsoid or even subglobose, hyaline, thin walled, with few contents. Basidia (Fig. 3b) 18–24×5–7 μm, clavate, bearing 4 sterigmata. Cheilocystidia (Fig. 3d) 19–35×4–6.5 μm, narrowly clavate, to utriform, hyaline, thin-walled with some contents. Sclerocystidia (Fig. 3c) scattered, 37–52×10–16 μm, with a thickened, hyaline or pale brown wall up to 3 μm thick. Hairs on the pileus (Fig. 3e) dense, 8–10 μm in diameter, with a thickened pale brown wall up to 4 μm thick. Clamp connections are prominent in generative hyphae.

Habitat On dead wood, in clusters, in rainforest dominated by *Castanopsis armata*, *Dipterocarpus* sp., *Ficus* sp. and *Tabebuia chrysantha*.

Additional specimen examined THAILAND, Chiang Rai Province., Thasud, Muang Dist., Mae Fah Luang University Park, 18°05′59.1″N, 102°40′02.9″E, elevation 488 m., dominated by *Dipterocarpus sp*., *Ficus sp*., and *Tabebuia chrysantha*. 18 June 2009, BJP 021 (MFLU10 0151).

Distribution Only known from northern Thailand.

Notes This new species is characterized by its small, grayish orange basidiomes and very large, 37–52×10–16 μm, scattered, clavate sclerocystidia with a broadly rounded apex. In some aspects *Lentinus megacystidiatus* bears superficial resemblance to *L. strigosus* (Schwein.) Fr. but *L. strigosus* differs in having pallid ochraceous to brownish basidiomes and cylindric, subclavate or subventricose metuloids with an obtusely rounded apex (Corner 1981; Pegler 1983). *Lentinus megacystidiatus* also bears superficial resemblance to *L. torulosus* (Pers.: Fr.) Lloyd, which has very large, clavate cheilocystidia, 24–60×7–16 μm, whereas *L. megacystidiatus* has moderate sized (19–35×4–6.5 μm), narrowly clavate, cheilocystidia (Corner

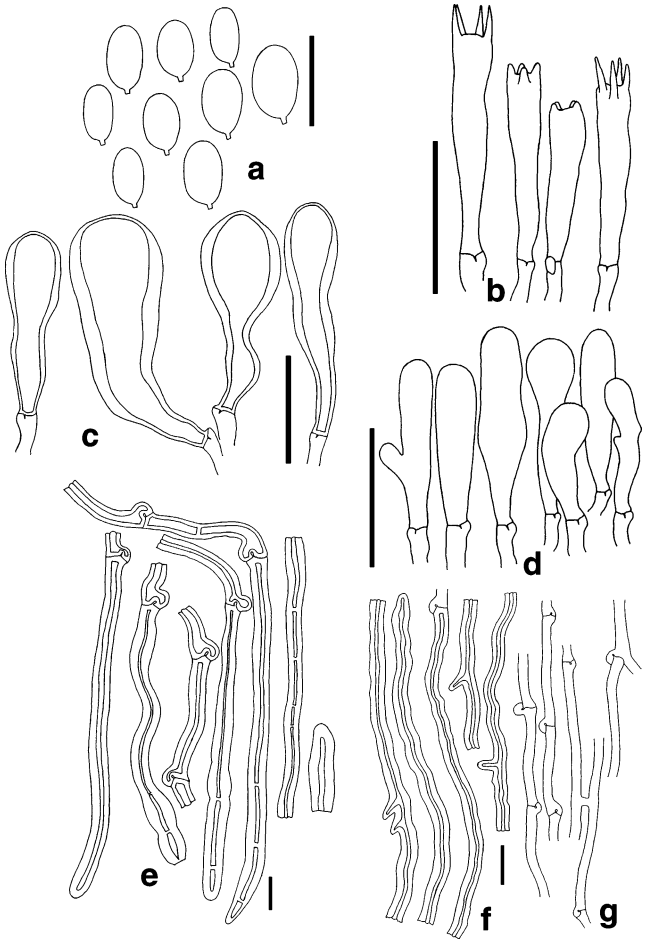

Fig. 3 *Lentinus megacystidiatus* (MFLU08 1388). **a** Spores, **b** basidia, **c** sclerocystidia, **d** cheilocystidia, **e** hairs on the pileus, **f** skeletal hyphae, **g** generative hyphae. *Scale bars* (**a**–**d**) 20 μm, (**e**–**g**) 10 μm

1981; Pegler 1983). *Lentinus megacystidiatus* forms clusters of basidiomes on dead and decaying wood.

3. Lentinus concentricus Karunarathna, K.D. Hyde & Zhu L. Yang, sp. nov.

(Figs. 2a and 4a–e)

MycoBank: 518249

Pileus 6.5–7 cm diam., tenuis, centro profunde umbilicatus, velutinus, mollis, zonatus. Lamellae profunde decurrentes, lamellulis 5 seriebus confertis. Stipes 4–4.5 mm longus, 5–6 mm latus, cylindricus. Basidiosporae 5–7 μm longae, 2.5–4 μm latae ellipsoideae ad cylindricae. Basidia 19–25 μm longa, 5–6.5 μm lata, sterigmatibus 4. Cheilocystidia 20–30 μm longa, 5–7 μm lata, anguste clavata, aliquot appendicibus apicalibus (10–12 μm longis), hyalina, parietate tenui. Pagina pilei pilis 5–5.5 μm diam.

Holotype THAILAND, Chiang Mai Province, Mae Taeng District, Ban Pha Deng, Mushroom Research Centre, 19° 17.123′N, 98°44.009′E, elevation 900 m, rainforest dominated by *Castanopsis armata*, *Erythrina* sp, and *Dipterocarpus* sp., 15 July 2008, Samantha C. Karunarathna (MFLU08 1375)

Etymology concentricus, in reference to the prominent concentric zonations on the pileus surface.

Description Basidiomes medium-sized to large (Fig. 2a). Pileus 6.5–7 cm in diameter, thin, with deeply umbilicate centre, when seen from above circular, yellowish brown-clay (5D5) at margin, yellowish brown (5E8) towards centre, surface from centre to margin velvety, soft, concentrically zonate, with brownish grey (6F8) hairs at margin; hairs grayish orange (5B4) towards centre. Lamellae deeply decurrent, 0.5 mm broad, with 5 tiers of lamellulae, pompeian yellow (5C6) when young and old, with entire edge. Stipe 4–4.5×5–6 mm, cylindric, solid, leathery, dry, yellowish brown-clay (5D5) when young, raw umber (5F8) when old, surface velvety/velutinous, short/soft hairs; brownish grey color (6F8); with white context up to 2 mm thick at the disk, consisting of a dimitic hyphal systems with skeletal hyphae

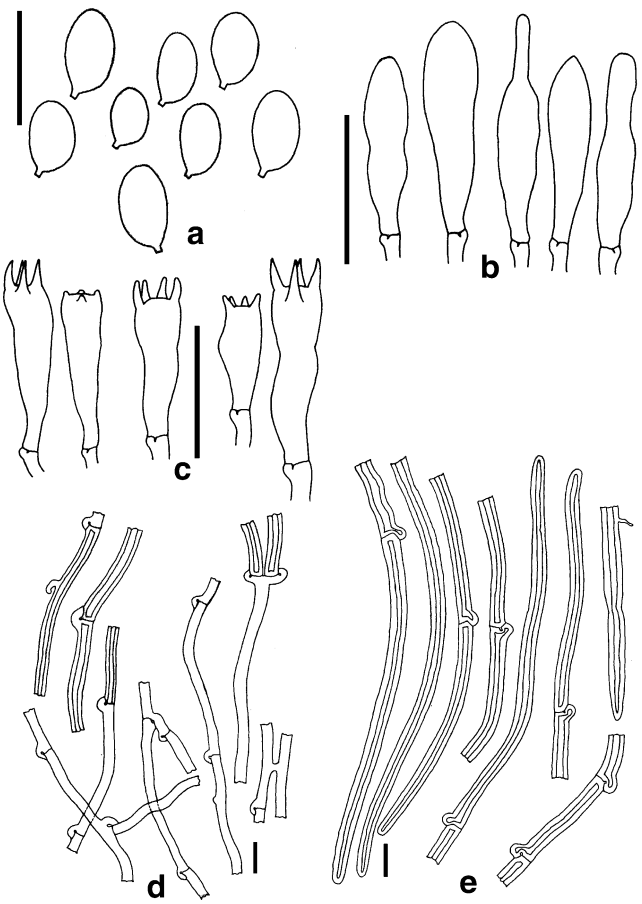

Fig. 4 *Lentinus concentricus* (MFLU08 1375). **a** Spores, **b** cheilocystidia, **c** basidia, **d** generative hyphae and skeletal hyphae, **e** hairs on the pileus. *Scale bars* (**a**–**c**) 20 μm, (**d**,**e**) 10 μm

(Fig. 4d). Generative hyphae (Fig. 4d) 3–4 μm diameter, not inflated, hyaline, thin-walled, frequently branched, with clamp connections. Skeletal hyphae 3–4.5 μm diameter, sinuous, cylindric, hyaline, with a thickened wall and narrow lumen, unbranched. Diameter of hairs on the surface of pileus 5–5.5 μm. Basidiospores (Fig. 4a) 5–7×2.5–4 μm (n=20, L^m=6.78 μm, W^m=3.75 μm, Q=1.5–2.4, **Q**=1.8) ellipsoid to cylindrical, occasionally broadly ellipsoid or even subglobose, hyaline, thin-walled, with few contents. Basidia (Fig. 4c) 19–25×5–6.5 μm, clavate, bearing 4 sterigmata. Lamella edge sterile with crowded cheilocystidia. Cheilocystidia (Fig. 4b) 20–30×5–7 μm, narrowly clavate, some with apical excrescence (10–12 μm long) hyaline, thin-walled. Sclerocystidia absent. Hairs on the pileus (Fig. 4e) dense, 5–10 μm in diameter, with a thickened pale brown wall up to 4 μm thick.

Habitat On dead wood, in cluster, in rainforest dominated by *Castanopsis armata*.

Distribution Only known from northern Thailand.

Notes This new species is characterized by its yellowish brown-clay, velvety, concentrically zonate, leathery, solid, dry and hard small basidiomes, absence of sclerocystidia and 19–25×5–6.5 μm, clavate basidia. The prominent zonation of the pileus is the main characteristic feature of *Lentinus concentricus*. In some aspects it bears superficial resemblance to *Lentinus fasciatus* Berk. which differs in having off-whitish to pale ochraceous basidiomes and abundant clavate or fusoid, 22–32×4–9 μm sclerocystidia on the sides of the lamellae (Corner 1981; Pegler 1983). *Lentinus concentricus* also bears a superficial resemblance to *Lentinus bertieri* (Fr.) Fr. and *Lentinus ciliatus* Lév. *Lentinus bertieri* differs from *L. concentricus* in having narrowly clavate basidia, 13.5–17×3.5–4.5 μm and *Lentinus ciliatus* also differs in having narrowly clavate basidia, 16–20×4–5.5 μm and 19–32×4–8 μm clavate to fusoid sclerocystidia (Corner 1981; Pegler 1983).

Results and discussion

We collected 47 *Lentinus* specimens from 17 sites in northern Thailand, belonging to 8 species of *Lentinus* sensu lato: *L. connatus, L. polychrous, L. similis*, *L. tigrinus, L. velutinus* and three new species. In this paper, three new species are fully described and illustrated with line drawings. We investigated the position of *L. concentricus* and *L. megacystidiatus*, based on phylogenetic analyses of the nrITS sequences (Fig. 5). The results from these analyses are preliminary as the nrITS region is very variable and it is not the best region to use for phylogenetic inference (Bruns 2001). A multi-gene phylogeny of *Lentinus* is needed based on a sampling of a wide range of species. The morphological data, however, support the

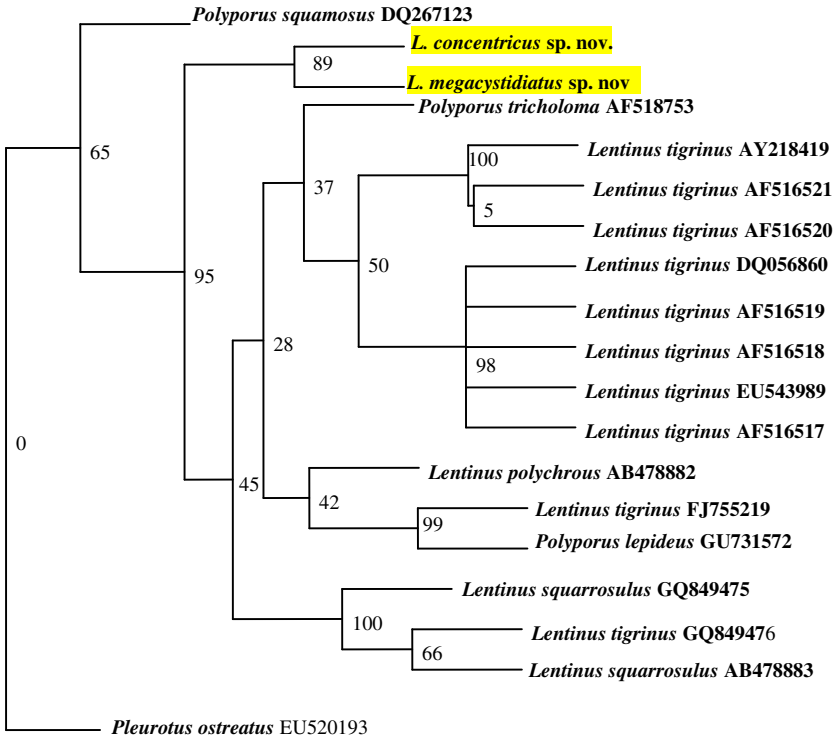

Fig. 5 Maximum parsimony phylogram showing phylogenetic relationships among two new *Lentinus* species *L. concentricus* (MFLU08 1375) and *L. megacystidiatus* (MFLU08 1388) with some selected *Lentinus* sensu stricto and *Polyporus* species based on ITS sequences. Data were analyzed with random addition sequence, unweighted parsimony and gaps were treated as missing data. Values above the branches are parsimony boostrap (≥50%).The tree is rooted with *Pleurotus ostreatus* (EU520193)

introduction of the new species. *Lentinus concentricus* and *L. megacystidiatus* are positioned, with high bootstrap support, in the same clade as *L. tigrinus*. This group is in need of further phylogenetic research, and it has to be seen whether the genus *Lentinus* should be maintained as a separate genus.

The main focus of this paper has been on biodiversity and taxonomy; however, it is worth noting that basidiomes of most *Lentinus* species are potentially edible and cultivatable. In most countries, there is a well-established consumer acceptance for cultivated mushrooms (e.g., *Agaricus bisporus, Auricularia* spp., *Pleurotus* spp., *Lentinula edodes* and *Volvariella volvacea*) (Sanmee et al. 2003). *Pleurotus tuber-regium* and *L. squarrosulus* are popular throughout central Africa as a source of food (Watling 1993), while Chin (1981) stated that *Lentinus sajor-caju* and *Lentinus strigosus* are edible. *Lentinus sajor-caju* is also widely sold at the local markets in Thailand. Mushrooms have been shown to have great potential for anti-oxidant activity (Yang et al. 2002; Vattem et al. 2004; Mau et al. 2005). Burkill (1966) stated that *Lentinus subnudus* is an edible species. *Pleurotus giganteus*, locally referred to as "Uru Paha" in Sri Lanka, is one of the largest of edible mushrooms, and has been treated as a special food since ancient times as mentioned in Buddhist literature (Udugama and Wickramaratna 1991; Berkeley 1847). Furthermore, *Pleurotus tuber-regium* is a very valuable medicine against diarrhea (Burkill 1966). It is also possible that the three new species described in this study are likely to be edible and may be cultivated and may eventually reach the table. Our future studies will attempt to cultivate these taxa.

Acknowledgements We are grateful to Phongeun Sysouphanthong for his help in collecting and suggestions, Sitthisack Phoulivong, Natchanun Phunthanateerakul, Pheng Phengsintham, Bang Feng and Liping Tang are gratefully acknowledged for their valuable discussions. Dr Jan Frits Veldkamp (L) is thanked for providing the Latin diagnosis. We wish to acknowledge the help with field work provided by Kobeke Van de Putte, Michael Pilkington, Putarak Chomnunti, Jian Kui-Liu and Thida Win Ko Ko. Kanjana Niraphai (MFLU) is thanked for her assistance in the herbarium. This study was financially supported by the project "Value added products from Basidiomycetes: Putting Thailand's biodiversity to use" (BRN049/2553). Study in China was supported by a grant from the Ministry of Science and Technology of the People's Republic of China (2008FY110300).

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