
A review of genus *Lepiota* and its distribution in east Asia

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Lepiota is a large genus comprising saprobic species growing under trees on the forest floor or in grasslands and occurs as solitary or gregarious fruiting bodies; there is a high diversity of species in tropical and temperate regions. This study provides a review of the general characteristics and differences of *Lepiota* from related genera, presents the infrageneric classification, discusses phylogenetic studies, and its significance. Several sections of *Lepiota* are diverse and distributed in Asia, and a part of this review provides a preliminary list of *Lepiota* species in countries of east Asia.

Key words – Asia – Agaricales – distribution – diversity – Lepiotaceous fungi.

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Introduction to lepiotaceous fungi

Mushroom genera with white spores such as *Chamaemyces*, *Chlorophyllum*, *Coniolepiota*, *Cystolepiota*, *Eriocybe*, *Lepiota*, *Leucoagaricus*, *Leucocoprinus*, and *Macrolepiota* are called lepiotaceous fungi and they show varied forms and morphological characters (Vellinga 2004 a,b). Historically mycologists characterised and defined these lepiotaceous taxa mostly from Europe (Bon 1993, Fries 1821). Candusso & Lanzoni (1990) studied the lepiotaceous fungi including some herbaria material from Europe and estimated there were 156 species belonging to seven genera. The main characters of this group are thus mostly based on the characters of temperate species with a few considerations from tropical species (Vellinga 2001). Studies of tropical lepiotaceous taxa are less. Pegler (1972) provided a revision of *Lepiota* species

from Sri Lanka and Manjula (1983) carried out a study in India; these studies also included *Macrolepiota* and *Leucocoprinus*. However, most of mycologists did not accept a narrow definition lepiotaceous fungi. The presently accepted characters of lepiotaceous fungi are mostly derived from the literature by Vellinga (2001), Vellinga & Huijser (1993, 1998), Vellinga & Noordeloos (2001) and main characters are as follows.

Basidiomata: The fruiting bodies can be solitary to gregarious, rarely in fairy rings; the basidiomata vary from tiny to large and from pluteoid (free lamellae, context of pileus discontinuous with context of stipe and the stipe is longer than width of pileus) or collybioid (pileus not umbilicate, not conical; free or adnate lamellae, tough context and context of pileus continuous with context of

stipe). The persistence of basidiomata is dependent on their size.

Pileus: Pileus can be less than 5 mm and up to 40 cm diameter, paraboloid, campanulate or umbonate, planoconvex to planoconcave; the covering of the pileus can be smooth, granulose, with patches, squamules or pyramidal spines, and ranges from white, grey to almost black, pink, purplish, yellow, orange, to olivaceous and a wide variety of browns.

Lamellae: Lamellae are always free, moderately crowded to crowded, ventricose to distinctly ventricose, white to sulfur-yellow or pale green, sometimes deep pink.

Stipe: Stipe is always hollow, cylindrical with a wider base or bulbous; a membranous, annulus is present in all taxa of *Leucoagaricus*, *Leucocoprinus*, *Macrolepiota* and *Chlorophyllum*.

Annulus: Annulus is usually present in all genera, the shapes are membranous or cuff-like with or without flaring part; some species of *Lepiota*, *Chamaemyces*, *Coniolepiota*, *Cystolepiota* and *Eriocybe* have an annular zone with fibrils or squamules on the stipe which are same as the structures on the pileus covering.

Context: Context of pileus is usually dull; context of stipe is shiny.

Smell and Taste: The smell and taste varies and is very distinctive or less distinctive in different species and may be sweet, fruity, rubber-like, soapy, or fungoid-astringent.

Spore print: Spore print is white to cream or pale yellow, rarely pale pink; it is dull green in *Chlorophyllum* species.

Colour reactions: In *Lepiota* species might develop orange tinges with age; several groups of species in *Leucoagaricus* turn red when touched. Chemical reactions include a red-brown or a green reaction with ammonia or KOH or a colour change with iron salts.

Spores: Spores show a range of size and shapes among species or genera such as ellipsoid-ovoid in most genera, spurred or fusiform in some *Lepiota* species, with a germ pore in *Chlorophyllum*, *Leucocoprinus* and *Macrolepiota*, and some *Leucoagaricus* species; and spores are ellipsoid and finely verrucose in *Melanophyllum*. The spore wall of most species turn red-brown in Melzer's reagent, blue in Cotton blue and red in Congo red; in *Leucoagaricus*, *Leucocoprinus*, *Macrolepiota* and *Chlorophyllum*, and a few *Lepiota* species the inner spore wall turns pink in cresyl blue.

Basidia: Basidia are 4-spored, in a few species 2-spored; mostly narrowly clavate, but in *Leucocoprinus* relatively wide and heteromorphous.

Cheilocystidia and pleurocystidia: Cheilocystidia are present in most species, with the exception of some *Cystolepiota* species; pleurocystidia are absent in most species, but present in some *Leucoagaricus* species and in *Chamaemyces*. The cheilocystidia are clavate, utriform, sphaeropedunculate to irregular and with or without apical crystals, without or with apical excrescence, and in some cases a septum is present; generally the cystidia are hyaline.

Trama: There are two kinds of hymenophoral trama in lepiotaceous fungi; a regular trama is present in some genera such as *Chamaemyces*, *Cystolepiota*, *Lepiota* and *Melanophyllum*, and a more irregular, often trabecular trama is present in *Leucoagaricus*, *Leucocoprinus*, *Macrolepiota* and *Chlorophyllum*.

Pileus- and stipe covering: The structure of the pileus covering is very important, it can be a cutis, a hymeniderm, an epithelium, a trichoderm or variations on any of those. The covering can be of velar origin or part of the pileipellis.

Veils: A universal and a partial veil are always present.

Introduction to genus *Lepiota*

Lepiota (Pers.: Fr.) S.F. Gray is a large and diverse genus of white-spored *Agaricales* which commonly occur in the tropics (Dennis 1952). The genus *Lepiota* belongs to the family *Agaricaceae* (Singer 1986, Kirk et al. 2008) and the classification of the genus is shown in Fig 1. The first definition of *Lepiota* was given by Fries (1821) and this definition included *Cystolepiota*, *Leucoagaricus*, *Leucocoprinus* and *Macrolepiota*. Many mycologists divided *Lepiota* into different sections according to characters concerning the spores and the pileus covering (e.g. Bon 1993; Candusso & Lanzoni 1990, Vellinga 2001). The current divisions and characterizations of the genus are mostly based on European collections and studies. In addition, a few mycologists have studied *Lepiota* in Asia, e.g. Pegler (1972) revised genus *Lepiota* in Sri Lanka and nine sections were present, and Manjula (1983) gave a revised list of *Lepiota* from India and Nepal and five section were found comprising *Stenosporae*, *Ovisporae*, *Cristata*, *Echinatae* and *sericellae*. However, *Lepiota* species in these and many other studies also included species from the other genera in the family, such as *Coniolepiota*, *Cystolepiota*, *Leucoagaricus* and *Leucocoprinus*. The currently accepted definition of *Lepiota* is provided by Vellinga (2001) and the classification of *Lepiota* species is mostly based on morphology and anatomy of spores and cheilocystidia, and the structure of the pileus covering.

General characteristics of *Lepiota*

Lepiota was based on *Agaricus* sect. *Lepiota* Persoon (Persoon 1797). The type species of *Lepiota* was not indicated at that time and *L. procera* (Scop. : Fr.) Gray (= *Macrolepiota procera* (Scop. : Fr.) Singer) was considered to be type by Earle (1909), but *M. procera* is not presently included in *Lepiota*. Another species, *Agaricus colubrinus* Bull. (current name = *L. clypeolaria* (Bull. : Fr.) P. Kumm.) was also suggested to be type species of *Lepiota* (Singer 1946), and this is now the accepted type of the genus.

Vellinga (2001) provided a definition for the genus based on macro- and microcharacters. Characteristic macrochara-

acters for *Lepiota* include pluteoid basidiomata with a persistent universal veil and a pileus surface that in most species is squamulose. The lamellae are free and white to cream, the annulus or annular zone presents the remnants of the partial veil and the spore print is white to cream. Typical microcharacters in *Lepiota* are ellipsoid, fusiform or spurred basidiospores in most species, which are smooth or minutely rough in a few species. The walls are hyaline, dextrinoid, congophilous, cyanophilous, not metachromatic in Cresyl blue or, rarely, with a pink inner wall in Cresyl blue (Vellinga 2001), and the spore walls swell slightly or do not swell in ammonia (NH_3 (aq)) and acetic acid (CH_3COOH (aq)); spores are mostly binucleate, although uninucleate in a few species. Cheilocystidia are present in most species. Pleurocystidia are rarely present. The hymenophoral trama is regular. The pileus covering is a trichoderm, a cutis, a hymeniderm or an epithelium and clamp-connections are present in most species. Some figures of tropical species of *Lepiota* are given in Fig 2.

(1) Section *Lepiota*

Members of this section are characterized by fusiform-amygdaliform basidiospores with convex abaxial and convex adaxial sides, or with a straight abaxial side, in combination with a pileus covering made up of long cylindrical elements with or without short clavate elements at the base and with clamp-connections (Vellinga 2001). Candusso and Lanzoni (1990) divided this section into 2 subsections, species with subamygdaliform basidiospores belong to subsection *Latisporinae* Bon with *Lepiota latispora* Kühner ex Wasser as the type species. Species with largely ellipsoid or fusiform basidiospores were placed in subsection *Lepiota*. The taxonomy of this section does not include *Lepiota cortinarius* J.E. Lange which was placed in section *Stenosporae* because of the long fusiform basidiospores and slightly spurred base. However, section *Lepiota* is not divided into subsections in the present classification and *Lepiota cortinarius* is presently considered to be a member of this section based on morphology and molecular data (Vellinga 2001, 2003).

Domain: Eukaryota
 Kingdom: Fungi
 Phylum: Basidiomycota
 Subphylum: Agaricomycotina
 Class: Agaricomycetes
 Subclass: Agaricomycetidae
 Order: Agaricales
 Family: Agaricaceae
 Genus: *Lepiota*, *Leucoagaricus*, *Leucocoprinus*, *Macrolepiota*,
Chlorophyllum, *Cystolepiota*, etc.

Fig. 1 – Classifications of *Lepiota* and related genera of lepiotaceous fungi (Kirk et al. 2008).

General classification and division of genus *Lepiota*

Key to sections of genus *Lepiota*

- 1. Pileus covering a trichoderm or a cutis 2
- 1. Pileus covering not a trichoderm or a cutis 3
- 2. Basidiospores spurred, or with straight base.....(3) Sect. *Stenosporae*
- 2. Basidiospores ellip not spurred, or without straight base 4
- 3. Pileus covering a hymeniderm and basidiospores ovoid or spurred.....(5) Sect. *Lilaceae*
- 3. Pileus covering not a hymeniderm..... 5
- 4. Basidiospores ellipsoid, fusiform-amygdaliform with straight or convex abaxial side and suprahilar depression..... (1)Sect. *Lepiota*
- 4. Basidiospores ellipsoid to ovoid; annulus present or as annular zone.....(2)Sect. *Ovisporae*
- 5. Pileus covering a cutis made up of articulate and cylindrical, repent to ascending elements; clamp connection absent; basidiospores ellipsoid to ovoid (4)Sect. *Fuscovinaceae*
- 5. Pileus with acute squamules; pileus covering made up of globose to ellipsoid elements in agglutinated chains; basidiospores ellipsoid, or spurred (6)Sect. *Echinatae*

(2) Section *Ovisporae* (J.E. Lange) Kühner

This section includes species with ellipsoid to oblong spores, a trichoderma pileus covering made up of long elements with or without short clavate elements at the base of these long elements and having clamp-connections. Two subsections are separated by structures of elements of the pileus covering. Species whose pileus covering is made up of long erect elements with short clavate elements belong to the subsection *Felininae* Bon while species whose pileus covering are made up of long erect elements without short clavate elements belong to subsection *Helveolinae* Bon & Boiffard (Candusso & Lanzoni 1990, Vellinga 2001)

(3) Section *Stenosporae* (J.E. Lange) Kühner

The species in this section are distinguished from other groups in having cylindrical spores with a spurred base, the pileus covering is a cutis or a trichoderm made up of long erect and slender elements and with clamp connections (Vellinga 2001). There are two forms of pileus covering (cutis and trichoderm) in this section but it is not divided into subsections.

(4) Section *Fuscovinaceae* Bon and Candusso

This section comprises species only *Lepiota fuscovinacea* (J.E. Lange) Kühner, a species without clamp-connections, with articulate and cylindrical elements in the pileus covering, and ovoid basidiospores (Candusso and Lanzoni 1990, Vellinga 2001).



Fig. 2 – Some species of *Lepiota* in tropical Asia.

(5) Section *Lilaceae* M. Bon

Species in this section are characterized by a hymeniderm pileus covering which is made up of tightly packed clavate to narrowly clavate elements, and by subglobose to ellipsoid or spurred basidiospores (Vellinga 2001). Candusso and Lanzoni (1990) put *Lepiota cristata* (species with spurred spores and hymenodermal pileus covering) into Section *Stenosporae*, but Vellinga (2001) put every species with hymenodermal pileus covering into Section *Lilaceae*; this is supported by phylogenetic studies based on molecular characters (Vellinga 2003).

(6) Section *Echinatae* Fay.

Species in this section are characterized by a pileus covering with acute squamules, made up of globose to ellipsoid elements in agglutinated chains, transient to long and coloured hyphae on the pileus surface; basidiospores are dextrinoid and rarely not reacting with Melzer's Regent, ovoid to ellipsoid, ovoid or cylindrical with a spurred base; clamp-connections are present or rarely absent (Vellinga 2001). This section has been recognized at genus level as *Echinoderma* (Locq. ex Bon) Bon.

Phylogenetic studies of *Lepiota*

Phylogenies of the genera in family Agaricaceae were presented by Vellinga (2004b) and Vellinga et al. (2011). Some of the main findings of these studies are: *Leucoagaricus* and *Leucocoprinus* form together one large monophyletic clade, while *Lepiota*, *Cystolepiota* and *Melanophyllum* also form together one monophyletic clade. The phylogeny of the genus *Lepiota* and its satellite genera was the subject of a study by Vellinga (2003), using evidence from nrITS and LSU sequences. Four clades could be recognized: Clade (I) is characterized by a trichodermal pileus covering with fusiform, penguin-shaped and broadly fusiform to ellipsoid spores, accommodating species from sect. *Lepiota* and *Ovisporae*. In clade (II) are species with 2 types of pileus covering, trichodermal and a cutis pileus covering and the spores are ellipsoid or spurred spores, comprising species from sect. *Stenosporae* and sect. *Ovisporae*. In clade (III), species with hymenidermal pileus

covering with variable spore shape of sect. *Lilaceae* M. Bon. The fourth clade is not monophyletic based on ITS-data and species in this group are in sect. *Echinatae* Fay., but in a phylogenetic tree based on ITS and LSU data, sect. *Echinatae* Fay. is split into 2 subclades.

Significance: toxicity, medical application and cultivation of *Lepiota*

Many *Lepiota* species are reported to be poisonous, with only a few species eaten. However, *Leucoagaricus americanus*, *Leucoagaricus leucothites*, *Macrolepiota* species and *Chlorophyllum rachodes* are noted as good edible species (e.g. Arora 1986; Marshall 2008; Fischer & Bessette 1992; Christensen 1972, 1992). Boa (2004) gave a global overview of the use and importance to humans of wild mushrooms; *Macrolepiota procera*, *M. madirokenlensis*, *M. mastoidea* and *Chl. rachodes* are economically important edible fungi, and some edible or medicinal species are *L. aspera*, *L. grassei*, *L. henningsii*, and *L. magnispora*. Some species that are reported to be edible are sometimes toxic when eaten in different regions; this includes species such as *Leucoagaricus americanus*, *L. clypeolaria* and *Chl. rachodes* (Boa 2004; Christensen 1972, 1992, Fischer & Bessette 1992, Marshall 2008). It is not clear whether these are the same species or if they are wrongly identified or whether species have different properties depending on where they grow. Many species of *Lepiota* are poisonous as they contain amatoxins (cyclopeptides) as in species of *Amanita*, *Pholiotina*, and *Galerina*, these toxins are generally considered the world's most toxic substance in mushrooms (Benjamin 1995). For *Amanita* species the genes encoding for these major toxins have been discovered and described (Hallen et al. 2007), but the genes and the pathways in the other genera are not known yet. The amatoxins from *Lepiota* species have been implicated in human and animals poisonings which ended in hepatic failure and death (e.g. Wieland 1986; Bettin et al. 1993; Haines et al. 1986; Khelil et al. 2010; Bresinsky & Besl 1985; Enjalbert et al. 2002).

Most toxic *Lepiota* species (Table 1) belong to sections *Ovisporae* and *Stenosporae* (Gérault & Girre 1975, 1977). Because of possible confusion with those species consum-

Table 1 *Lepiota* species reported as poisonous or edible.

Species	Edible	Poisonous
<i>L. aspera</i> (Pers.) Quél.	+	
<i>L. clypeolaria</i> (Bull.) P. Kumm.	+	
<i>L. brunneoincarnata</i> Chodat & Martin		+
<i>L. brunneolilacea</i> Bon & Boiffard		+
<i>L. castanea</i> Quél.		+
<i>L. clypeolarioides</i> Rea		+
<i>L. elaiophylla</i> Vellinga & Huijser		+
<i>L. felina</i> (Pers. : Fr.) Karsten		+
<i>L. fulvella</i> Rea (<i>L. boudieri</i>)		+
<i>L. friesii</i> (Lasch) Quél.	+	
<i>L. grassei</i> R. Heim	+	
<i>L. griseovirens</i> Maire		+
<i>L. helveola</i> Bres.		+
<i>L. henningsii</i> Sacc. & P. Syd.	+	
<i>L. josserandii</i> Bon & Boiffard		+
<i>L. kuehneri</i> Huijism. ex Hora		+
<i>L. langei</i> Locq.		+
<i>L. ochraceofulva</i> Orton		+
<i>L. pseudohelveola</i> Kühner ex Hora		+
<i>L. subincarnata</i> J.E. Lange		+
<i>L. ventriospora</i> D.A. Reid	+	

Note: + = present as edible or poisonous

ption of any *Lepiota* species is generally not recommended.

There are no reports on cultivation efforts of *Lepiota* species; however, some *Macrolepiota* species are cultivated (Coetzee et al. 1980; Manz 1971; Gbolagade et al. 2006; Jones et al. 2004). Gbolagade et al. (2006) studied the effect of different nutrient sources on biomass production of *M. procera* in submerged liquid cultures by comparing mycelial dry weight of *M. procera* in different nutrient sources; fruitbodies were not produced in these media. Jones et al. (2004) cultivated *M. gracilentia* by using a growth medium, composed of a sterilized mixture of composted straw, rice bran, gypsum, urea and calcium carbonate; this substrate produced fruitbodies well.

Distribution of *Lepiota* in South- and Southeast Asia

Kirk et al. (2008) estimated that there are 400 *Lepiota* species worldwide, and though it was speculated that in tropics the *Leucoagaricus/Leucocorpinus* clade is more

species rich than *Lepiota*, and that *Lepiota* species are more numerous in temperate regions (Vellinga 2004a), many species have been reported from eastern Asia. Interpretation of these names and reports are hampered by the fact that many early reports only give a few sentences per species, modern type studies have not been carried out for all taxa, and literature is not always easily accessible, European names have been used, and even in very recent literature, *Leucoagaricus* species have been included in the genus *Lepiota* s. str. (e.g. Pegler 1972; Kumar et al. 2009; Wang & Yang 2005). We present an overview of *Lepiota* species reported from eastern Asia in Table 2, which is meant as a first attempt to compile the available data; probably some reports and literature has not been included; *Cystolepiota*, *Coniolepiota*, *Macrolepiota* and *Leucoagaricus* taxa are not treated here. We were unable to find any records for Bangladesh, Cambodia, Laos, and Myanmar.

The earliest study from India was started by Berkeley (1850, 1852, 1854) and all *Lepiota* species were placed in *Agaricus* at this

time, and for this reason, some reports of *Lepiota* are not verified. The next study was carried out by Masee (1912) and he described four new species from India, *Lepiota mimica*, *L. punicea*, *L. flavophylla* and *L. sericea*. Other substantial studies were from South India and Nepal, with many species being described and illustrated (Natarajan and Manjula, 1983) 14 species and two varieties of *Lepiota* were described and illustrated and all species were new records for India; Manjula (1983) gave a revised list and a key to 30 species Indian species of *Lepiota*; Rawla and Arya (1991) described *Lepiota sulphurea* and *L. nainitala* as new species from north-west India; six species of *Lepiota* have been recorded from Nepal (Adhikari 1990, 1991; Manandha & Adhikari, 1994). Natarajan et al. (2005) provided a checklist of Indian Agarics and Boletes, this included 18 species. Kumar & Manimohan (2009) recently studied 22 *Lepiota* taxa from Kerala state, and they recorded eight new species and one new variety; however, several of these clearly belong to *Leucoagaricus*; because of the absence of clamp connections and the structure of the pileus covering; these have not been included in Table 2.

Other substantial studies were in Sri Lanka; Berkeley (1847) who first studied *Lepiota* from Sri Lanka and Berkeley and Broome (1871) studied materials from Gardner and Thwaites. Over thirty years later, Petch (1910, 1917) revised fungi of Sri Lanka and described *L. viridiflava* as new species to Sri Lanka, and Petch & Bisby (1950) gave the checklist of *Lepiota* at that time. The connected study of *Lepiota* was done again by Pegler (1972) who studied the type collections of the species described by Berkeley & Broome (1871) and he recorded 53 species from Sri Lanka, many of them belonging to other genera than *Lepiota*; it also appeared that several of Berkeley & Broome's species had to be accommodated in unrelated genera such as *Pluteus* or *Amanita*. After Pegler's study it seems that no mycologist worked on *Lepiota* in Sri Lanka.

The study of *Lepiota* in Indonesia is poor. A few studies of the genus were done by Hennings (1900a,b; 1901) and three new species were described to Indonesia which are

L. aurantiaca, *L. verrucosa* and *L. celebica*, and Boedijn (1940) recorded *L. flavophylla* and *L. oenopoda* from the region. Twenty species of *Lepiota* with spurred spores were studied in Papua New Guinea; those species are included sections *Echinatae*, *Stenosporae* and *Lilaceae* (Horak 1980).

For the close area of Indonesia, Singapore, *L. semivestita*, *L. carneorubra*, *L. ochracea*, *L. ferruginosa* and *L. albida* were reported (Masee 1914). Some *Lepiota* species are known from the Philippines by Copeland (1905) and 4 species were reported; Graff (1914) provided 7 species and 2 new species; Mendoza and Leus-Palo (1934, 1938) published *L. americana* as edible species and they revised 12 species of Philippine *Lepiota*.

Very few *Lepiota* species are known from Vietnam (Kiet 1998; Yang 2000). Yang (2000) studied the type collections of the species described by Patouillard (1892, 1907, 1917), and only *Lepiota demangei* is clearly a *Lepiota* species, all others are accommodated in *Leucoagaricus*, *Leucocoprinus* or *Micropsalliota*.

Several reports of macrofungi in Thailand have been carried out (Chandrasrikul 1996; Chandrasrikul et al., 2008; Ruksavong et al. 2001; Soyong 1994; Høiland K, Schumacher 1982), but the lepiotaceous fungi have rarely been studied and are poorly known. Some mycologists have studied Basidiomycota in general, and have reported a few lepiotaceous species, such as *Lepiota cristata*, *L. clypeolaria*, *L. cortinarius*, and *L. pseudo-lveola* (Chandrasrikul 1996; Chandrasrikul et al. 2008; Ruksawong & Flegel 2001, Soyong 1994). Sysouphanthong et al. (2011a,b) illustrated 15 species of *Lepiota* section *Stenosporae* and *Lepiota* in northern Thailand and 5 species were described as new for science. However, relatively little attention has been given to the distribution and diversity of the lepiotaceous fungi in Thailand.

In the area of Northeast Asia, there are many species of *Lepiota* recorded an described as new from Japan (e.g. Hongo 1956a, 1956b, Hongo 1958, Hongo 1959, Hongo 1965, Hongo 1973, Imai 1938, Kasuya & Knudsen 2003). *Lepiota grangei* and *L. cristata* are listed from Korea (Kim et al., 1998; Wojewoda et al. 2004). Yang et al.

Table 2. Distribution of *Lepiota* s. str. in South Asia and Southeast Asia per country

Species	Country											
	CN	ID	IN	JP	NP	Ko	Ph	SG	SL	TH	VN	PN
<i>L. adusta</i> (Horak) E. Horak												+
<i>L. alba</i> Beeli	+											
<i>L. albida</i> Masee								+				
<i>L. albocitrina</i> Pat. [probably in <i>Leucoagaricus</i> , see Yang 2000]											+	
<i>L. alopochroa</i> (Berk. & Br.) Sacc.		+							+	+		+
<i>L. altissima</i> Masee	+	+										
<i>L. anax</i> (Berk.) Sacc.		+										
<i>L. apalochroa</i> (Berk. & Br.) Sacc.		+							+	+		
<i>L. aspera</i> (Pers.) Quél. (<i>L. acutesquamosa</i> (Weinm.) P. Kumm.)	+			+	+					+		+
<i>L. atrata</i> E. Horak												+
<i>L. atosquamulosa</i> Hongo	+			+								
<i>L. attenuata</i> J.F. Liang & Zhu L. Yang	+											
<i>L. aureofulvella</i> Sysouphanthong et al.										+		
<i>L. aurola</i> E. Horak												+
<i>L. azalearum</i> (Murril) Dennis	+											
<i>L. babruka</i> Kumar & Manim.		+										
<i>L. boudieri</i> Bres.	+											
(<i>L. fulvella</i> Rea; <i>L. fulvella</i> f. <i>gracilis</i> J.E. Lange)												
<i>L. brevipes</i> Murrill		+										
<i>L. brevipes</i> var. <i>distincta</i> Kumar & Manim.		+										
<i>L. bichroma</i> E. Horak												+
<i>L. brunneoincarnata</i> Chodat & Martín	+											
<i>L. calcarata</i> (Horak) E. Horak												+
<i>L. candida</i> Copeland							+					
<i>L. carneorubra</i> Masse								+				
<i>L. castanea</i> Quél.	+	+		+	+					+		+
<i>L. catenariocystidiata</i> Wang & Yang	+											
<i>L. celebica</i> Henn.			+									
<i>L. ceramogenes</i> (Berk. & Br.) Sacc.		+								+		
<i>L. cf. hispida</i> (Lasch.) Fr.		+										
<i>L. chichuensis</i> W.F. Chiu	+											
<i>L. cinnamomea</i> Hongo	+											
<i>L. citrophylla</i> (Berk. & Br.) Sacc.	+	+							+	+		
<i>L. clypeolaria</i> (Bull. : Fr.) P. Kumm.	+	+		+						+		
<i>L. cortinarius</i> J.E. Lange	+									+		
<i>L. crepusculata</i> E. Horak												+

Table 2 continued. Distribution of *Lepiota* s. str. in South Asia and Southeast Asia per country

Species	Country											
	CN	ID	IN	JP	NP	Ko	Ph	SG	SL	TH	VN	PN
<i>L. cristata</i> (Bolt. : Fr.) P. Kumm.	+	+		+	+	+	+			+		
<i>L. cristata</i> var. <i>macrospora</i> Zhu L. Yang	+											
<i>L. cristatanea</i> J.F. Liang & Zhu L. Yang	+											
<i>L. deliciolum</i> (Berk.) Sacc.		+										
<i>L. demangei</i> Pat.											+	
<i>L. disseminata</i> E. Horak												+
<i>L. echinacea</i> J.E. Lange		+										
<i>L. elaiophylla</i> Vellinga & Huijser		+										
<i>L. elata</i> Copel.							+					
<i>L. epicharis</i> (Berk. & Br.) Sacc.	+	+							+			
<i>L. erminea</i> (Fr.) Gillet	+	+			+							
<i>L. erythrogramma</i> (Berk. & Br.) Sacc. (<i>L. alborussea</i> (Berk. & Broome) Sacc.)	+	+							+			
<i>L. erythrosticta</i> (Berk. & Broome) Sacc.		+							+	+		+
<i>L. exocarpi</i> Cleland												+
<i>L. felina</i> (Pers.) P. Karst.	+				+						+	
<i>L. felinoides</i> var. <i>macrospora</i> W. F. Chiu	+											
<i>L. ferruginosa</i> Massee								+				
<i>L. flavophylla</i> Massee			+		+				+			
<i>L. fraterna</i> E. Horak												+
<i>L. friesii</i> (Lasch) Quél.					+							
<i>L. fusc squamea</i> Peck	+						+					
<i>L. fuscovinacea</i> F.H. Møller & J.E.Lange	+											
<i>L. grangei</i> (Eyre) J.E. Lange						+				+		+
<i>L. cf. griseorubescens</i> Dennis	+											
<i>L. griseovirens</i> Maire		+								+		
<i>L. helveola</i> Bres.	+											
<i>L. hispida</i> Lasch							+					
<i>L. hystrix</i> F.H. Møller & J.E.Lange	+											
<i>L. ianthinosquamosa</i> Pegler	+	+										
<i>L. ignivolva</i> Bousset & Joss.	+											
<i>L. implana</i> (Berk.) Sacc. [probably an <i>Amanita</i> species]		+										
<i>L. infelix</i> E. Horak										+		+
<i>L. insimulata</i> E. Horak	+											+
<i>L. jacobi</i> Vellinga & Knudsen	+											
<i>L. leontoderes</i> (Berk. & Br.) Sacc.		+							+			
<i>L. lepidophora</i> (Berk. & Br.) Sacc.		+							+			
<i>L. leprica</i> (Berk. & Br.) Sacc.									+			

Table 2 continued. Distribution of *Lepiota* s. str. in South Asia and Southeast Asia per country

Species	Country											
	CN	ID	IN	JP	NP	Ko	Ph	SG	SL	TH	VN	PN
<i>L. roseoalba</i> P. Henn.			+									
<i>L. sanguinea</i> Sathe & Deshp.		+										
<i>L. semivestita</i> Masee								+				
<i>L. shixingensis</i> Bi & Li	+											
<i>L. shveta</i> Kumar & Manim,		+										
<i>L. magnispora</i> Murrill (<i>L. ventriosospora</i> D. Reid)	+			+								
<i>L. mammosa</i> Henn.			+									
<i>L. manilensis</i> Copeland.							+					
<i>L. metulispora</i> (Berk. & Broome) Sacc.	+	+							+	+		
<i>L. micropholis</i> (Berk. & Br.) Sacc.	+								+			
<i>L. microspila</i> Berk.												+
<i>L. microcarpa</i> Sysouphanthong et al.										+		
<i>L. microspora</i> Masee		+										
<i>L. montosa</i> (Berk.) Sacc. [probably an <i>Amanita</i> species]		+										
<i>L. murinocapitata</i> Dennis [probably in <i>Leucoagaricus</i>]		+										
<i>L. nainitala</i> Rawla		+										
<i>L. nigricans</i> Pat.											+	
<i>L. nirupama</i> Kumar & Manim.		+										
<i>L. nivalis</i> W.F. Chiu	+											
<i>L. ochracea</i> Masee								+				
<i>L. oenocephala</i> (Berk. & Br.) Sacc.									+			
<i>L. oreadiformis</i> Velen.	+											
<i>L. pardalota</i> (Berk. & Br.) Sacc.									+			
<i>L. papillata</i> Sysouphanthong et al.										+		
<i>L. parvannulata</i> (Lasch) Fr.	+	+										
<i>L. philipinensis</i> Mendoza							+					
<i>L. phlyctaenodes</i> (Berk. & Br.) Sacc.	+	+							+			
<i>L. plumbicolor</i> (Berk. & Br.) Sacc.		+							+			
<i>L. poliochloodes</i> Vellinga & Huijser										+		
<i>L. pongduadensis</i> Sysouphanthong et al.										+		
<i>L. pselliophora</i> (Berk. & Br.) Sacc.									+			
<i>L. pseudoasperula</i> (Knudsen) Knudsen		+										
<i>L. pseudohelveola</i> Kuehner ex Hora (<i>L. pseudolilacea</i> Huijsman)										+		
<i>L. pulcherrima</i> P.W. Graff							+					

Table 2 continued. Distribution of *Lepiota* s. str. in South Asia and Southeast Asia per country

Species	Country												
	CN	ID	IN	JP	NP	Ko	Ph	SG	SL	TH	VN	PN	
<i>L. punicea</i> Masee		+											
<i>L. purpurata</i> (G. Stev.) E. Horak													+
<i>L. pyrrhaes</i> (Berk. & Br.) Sacc.		+							+				
<i>L. spiculata</i> Pegler	+												
<i>L. squamatula</i> E. Horak													+
<i>L. squamulosa</i> B. Tolgor & Yu Li	+												
<i>L. subamanitifformis</i> Dennis	+	+											
<i>L. subgracillis</i> Kühner	+												
<i>L. subincarnata</i> J.E. Lange (<i>L. josserandii</i> Bon & Boiff.)	+	+											
<i>L. subclypeolaria</i> (Berk. & M.A. Curtis) Sacc.		+											
<i>L. subrufa</i> Natarajan & Manjula		+											
<i>L. sulphopenita</i> P.W. Graff										+			
<i>L. sulphurea</i> Rawla		+											
<i>L. thiersii</i> Sundberg		+											
<i>L. thrombophora</i> (Berk. & Br.) Sacc.	+	+								+			
<i>L. verrucosa</i> Henn.				+									
<i>L. viridiflava</i> Petch										+			
<i>L. xanthophylla</i> P.D. Orton		+											
<i>L. zalkavriitha</i> Kumar & Manim.		+											

Note: CN = China, ID = India, IN = Indonesia, JP = Japan, Ko = North and South Korea, Ph = Philippines, SG = Singapore, SL = Sri Lanka, TH = Thailand, VN = Vietnam, PN = Papua New Guinea .

(2005) gave a list of species diversity of Lepiotoid fungi in China and they provided 50 species of *Lepiota.*, and in recent years several new species have been described, and type collections restudied (Liang 2007; Liang & Yang 2011; Liang et al. 2011). In addition, Liang et al. (2009) studied the population structure of *Lepiota cristata* in China by using three genes. Some other studies are those by Wang & Yang (2005, 2006), and a more general overview by Mao (2000). All species review are present in Table 2

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