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**Studies on *Amanita* (Basidiomycetes: Amanitaceae) in Northern Thailand**


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Specimens of the genus *Amanita*, collected from northern Thailand and deposited in the fungal herbarium of Chiang Mai University and some overseas herbaria were studied. Twenty-five taxa, including eighteen new to Thailand, are described briefly. A key to species is provided. The new records for Thailand are *A. alboflavescens*, *A. avellaneosquamosa*, *A. chepangiana*, *A. clarisquamosa*, *A. flavipes sensu lato*, *A. fritillaria*, *A. fuliginea*, *A. hongoi*, *A. japonica*, *A. manginiana sensu* W.F. Chiu, *A. obsita*, *A. ovalispora*, *A. pseudoporphyrina*, *A. rubrovolvata*, *A. sinensis*, *A. sinocitrina*, *A. subglobosa*, and *A. virgineoides*. A type study of *A. pudibunda* is included. *Amanita frostiana sensu* R. Heim is proposed to be properly diagnosed as *A. rubrovolvata*.

**Key words:** Agaricales, southeast Asia, taxonomy

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## Introduction

The forests in northern Thailand have a high diversity of *Agaricales* (Nuytinck *et al.*, 2006; Le *et al.*, 2007a,b), but knowledge of species in the genus *Amanita* Pers., many of which are ectomycorrhizal with forest trees, is limited; and only a few species have been reported from Thailand in the literature (Heim, 1962; Høiland and Schumacher, 1982; Chansri- kul *et al.*, 1984; Soyong, 1994; Rachabun- ditayasathan, 1996; Chansri- kul, 1998; Ruksawong and Flegel, 2001). Two taxa covered in this paper were originally described from Thailand: *A. pudibunda* and *A. siamensis*. The presence of two previously reported taxa is confirmed: *A. princeps* and *A. sculpta*. Three previously reported taxa (*A. angustilamellata*, *A. mira* and *A. hemibapha*) may be present and are phenetically similar to taxa that were collected and revised in preparation of this paper.

## Materials and methods

For four years (1999-2002), *Amanita* taxa

growing in forests dominated by members of the *Dipterocarpaceae*, *Fagaceae*, or *Pinaceae* were surveyed during the rainy season in five provinces (Chiang Mai, Chiang Rai, Nakhon Panom, Phayao, and Sakhon Nakhon) of northern and northeastern Thailand. Colour names were coded according to Petersen (1996). Basidiocarps were placed in size categories following Bas (1969). Microscopic data is presented in the format of Yang (1997), for the most part. The specimens of Thai collectors were deposited in the fungal herbarium of the Department of Biology, Faculty of Science, Chiang Mai University (CMU).

Throughout this paper, when stipe length is given and length of the stipe's bulb is not, it should be assumed that bulb length is included in stipe length.

Additional material collected by, or communicated to, Roger Heim (deposited in PC) and collected by David Arora (deposited in SFSU and the private herbarium of Tulloss) was reviewed and is reported using the same format, with the exception of the type study of

*A. pudibunda*, which was carried out according to the methods of, and is reported using the notation of, Tulloss *et al.* (1992) as amended by Tulloss (1993, 1994, 1998b, 2000) and restated by Tulloss and Lindgren (2005). Format of the type study conforms to that of Tulloss (1994) in order to maintain Tulloss' type studies in a constant format for purposes of comparison.

Words describing spore shapes are used according to the definitions of Bas (1969): A spore is 'globose' if its length/width ratio (Q) falls between 1 and 1.05; 'subglobose' if its Q falls between 1.05 and 1.15; 'broadly ellipsoid' if its Q falls between 1.15 and 1.3; 'ellipsoid' if its Q falls between 1.30 and 1.6; 'elongate' if its Q falls between 1.6 and 2; 'cylindric' if its Q falls between 2 and 3; and 'bacilliform' if its Q falls above 3.

Biometric variables used in Tulloss' type study are defined most recently in (Tulloss and Lindgren, 2005) and on the *Amanita* Studies web site (Tulloss, 2007b). The letter 'R' represents the length of a pileus radius.

Unless otherwise stated, determinations of material were based on: (1) protologs; (2) monographs or monographic-style works of Corner and Bas (1962), Bas (1969), Yang (1997), and Tulloss *et al.* (2001); and (3) additional keys such as Tulloss (2007a).

National Park names are abbreviated as follows: DLNP (Doi Luang National Park), DSPNP (Doi Suthep-Pui National Park), and KCNP (Khun Chae National Park). Herbarium codes follow Holmgren, Holmgren and Barnett (1992) with the exception of the following: HKAS—Herbarium of Cryptograms, Kunming Institute of Botany, Academia Sinica, Kunming, Yunnan Province, China. RET—personal herbarium of Tulloss. Abbreviations in author citations follow Kirk and Ansell (1992) with the exception of 'E.-J. Gilbert', in which case we use the author's initials in the order in which they appear on the vast majority of his publications including his *magnum opus* (Gilbert, 1940-41).

Names used for supraspecific taxa in *Amanita* follow Corner and Bas (1962) and Bas (1969) as modified by Yang (1997).

We take this opportunity to emphasize the importance of including modern Asian sources when researching *Amanita* in Asia. An over-

emphasis on European and North American literature has led unavoidably to misdetermination of endemic taxa. This tendency should become a thing of the past. We strongly recommend (Yang, 1997) and other works of Yang and his co-authors as models for modern, Asian, mycological work in the genus *Amanita*. The encounter with an unfamiliar *Amanita* should lead to its being worked up as if it were an undescribed taxon. The chances are that it will be endemic and, often, new to science.

## Results

Organized by section, the species now recognized for northern Thailand are as follows—with newly reported taxa marked by an asterisk (\*):

<i>Amanita</i> [subg. <i>Amanita</i> ] sect. <i>Amanita</i>	<i>A. affin. mira</i> <i>A. obsita</i> * <i>A. rubrovolvata</i> * <i>A. siamensis</i> <i>A. sinensis</i> * <i>A. subglobosa</i> * <i>A. chepangiana</i> *
<i>Amanita</i> sect. <i>Caesareae</i>	<i>A. hemibapha sensu lato</i> <i>A. princeps</i>
<i>Amanita</i> sect. <i>Vaginatae</i>	<i>A. affin. angustilamellata</i> <i>A. ovalispora</i> * <i>A. pudibunda</i>
<i>Amanita</i> [subg. <i>Lepidella</i> ] sect. <i>Amidella</i> <i>Amanita</i> sect. <i>Lepidella</i>	<i>A. avellaneosquamosa</i> * <i>A. clarisquamosa</i> * <i>A. alboflavescens</i> * <i>A. hongoi</i> * <i>A. japonica</i> * <i>A. sculpta</i> <i>A. virgineoides</i> *
<i>Amanita</i> sect. <i>Phalloideae</i>	<i>A. fuliginea</i> * <i>A. manginiana sensu W.F. Chiu</i> * <i>A. pseudoporphyria</i> *
<i>Amanita</i> sect. <i>Validae</i>	<i>A. flavipes sensu lato</i> * <i>A. fritillaria</i> * <i>A. sinocitrina</i> *

There are strong climatic and vegetational links between the Thai region of study and other upland regions of southern and eastern Asia. With the exception of *A. pudibunda* and the recently described *A. siamensis*, the species in this list were originally described from Japan, China, Indonesia, peninsular Malaya, Nepal, and Singapore. The habitats from which these species were described include the same families of mycorrhizal trees associated with the species in Thailand (*e.g.*, Tulloss and Bhandary, 1992; Yang, 1997; Bhatt *et al.*, 2003). In the cited countries combined, there are approximately 125 named taxa of *Amanita*

known at this writing (Yang, 1997, 2005; Tulloss, 2005). Therefore, it seems very likely that some previously described *Amanita* taxa would be found in northern Thailand.

We expect that additional undescribed *Amanita* taxa will be found in the region of study. For example, given the size of *Amanita* sect. *Vaginatae* regionally (Yang, 1997; Tulloss, 2005) and worldwide (Tulloss and Yang, 2007a), it is unlikely that the count of taxa for northern Thailand in that section will remain as low as three species in the face of continued exploration and study of herbarium material.

Not surprisingly, given the close geographic proximity, 84% of *Amanita* taxa recorded for northern Thailand also occur in southern and southwestern China (Yang, 1997; Yang *et al.*, 2000; Yang *et al.*, 2001). However, in China there appears to be much greater diversity of *Amanita* than in northern Thailand, probably due to the more diverse vegetational types especially at higher elevations.

All members of *Amanita* play an important role in forest ecology in northern Thailand, due to mycorrhizal associations with trees. In this regard, more taxa are reported herein from possible association with taxa of *Fagaceae* (22 or 88% of reported taxa) than with taxa of *Dipterocarpaceae* (10 or 40%). Only 5 reported taxa (20%) are known from possible association with a member of the *Pinaceae*. In the region of study, mixed *Fagaceae/Pinaceae* forests at higher elevations and dry *Dipterocarpaceae* forests at lower elevations require more extensive collecting in the future; and their *Amanita* taxa should be compared with collections from other areas of southeast Asia.

A number of the available collections were not in a good state of preservation or for another reason bore atypical spores. Throughout the paper, we provide spore measurements from other sources in the 'Notes' sections of our descriptions in order to provide additional support for future workers in southeast Asia.

### **Key to known *Amanita* species of northern Thailand**

1. Basidiospores amyloid (*Amanita* subg. *Lepidella*)..... 2
1. Basidiospores inamyloid (*Amanita* subg. *Amanita*)..... 14

2. Margin of pileus short striate, appendiculate at first; stipe base bearing thick, membranous, saccate volva with distinct layers (three to five) ranging from floccose to farinose adjacent to pileipellis to membranous on exterior (*Amanita* sect. *Amidella*).... 3
2. Margin of pileus non-striate, appendiculate only in sect. *Lepidella*; universal veil friable, submembranous, or membranous, sometimes limbate, but never saccate ..... 4
3. Pileus whitish sometimes covered only with cream to yellowish brown farinose to floccose patches representing the lower level of the universal veil, when upper layers are present they may be fibrillose (browning on exposure) or membranous (white to sordid); basidiospores (8.5-)9-11(-12) × (4.5-)5-6.5(-7) μm, with Q = (1.35-)1.5-1.88(-2.5) ..... ***A. avellaneosquamosa***
3. Pileus whitish, with volval remnants brown or brownish, patchy, fibrillose, rarely with membranous universal veil outer layer present; basidiospores (10-)11-12.5(-16) × (7-)7.5-8 (11) μm, with Q = (1.15-)1.44-1.63(-2.07)..... ***A. clarisquamosa***
4. Margin of pileus appendiculate (*Amanita* sect. *Lepidella*)..... 5
4. Margin of pileus non-appendiculate..... 9
5. Volval remnants on pileus floccose to squamulose; context of basidiocarp white, becoming yellow to lemon-chrome when cut; basidiospores 8-10.5(-11) × 5-6(-6.5) μm, with Q = 1.47-1.78(-2) ..... ***A. alboflavescens***
5. Volval remnants on pileus as conic to subconic warts; context of basidiocarp not becoming yellow or lemon-chrome when cut; basidiospores differing in range of size or range of Q..... 6
6. Pileus reddish brown with chocolate coloured conic volval remnants; lamellae white when young, turning pinkish to violet when mature; context white, turning pinkish to purplish when cut; basidiospores (8-)9-11(-11.5) × (8-)9-10.5(-11) μm, with Q = 1-1.04(-1.08) ... ***A. sculpta***
6. Pileus and volval remnants not so deeply pigmented; lamellae white to cream, unchanging; context white, unchanging; basidiospores differing in range of size or range of Q ..... 7
7. Pileus white to brownish, with brown or pinkish brown volval remnants; basidiospores 7-9(-10) × (5.5-)6.5-7(-8) μm, with Q = (1.06-)1.12-1.25(-1.36); basal septa of basidia lacking clamps ..... ***A. hongoi***
7. Pileus grey to greyish or white, with similarly coloured volval remains; 95% of basidiospores having Q exceeding 1.25; basal septa of basidia often bearing clamps ..... 8

8. Pileus and universal veil grey or greyish; basal bulb of stipe slender, radicating; basidiospores  $8\text{-}9\text{-}(11.5) \times (4.5\text{-})5.5\text{-}6.5\text{-}(7.5) \mu\text{m}$ , with  $Q = 1.34\text{-}1.64\text{-}(2)$ .....  
.....**A. japonica**
8. Pileus and universal veil white; basal bulb of stipe not slender, not radicating; basidiospores  $(7.5\text{-})8\text{-}9 \times (5\text{-})6\text{-}7 \mu\text{m}$ , with  $Q = (1.11\text{-})1.25\text{-}1.47\text{-}(1.69)$  .....  
.....**A. virgineoides**
9. Volval remnants limbate, membranous, mostly present on basal bulb of stipe (*Amanita* sect. *Phalloideae*).....  
.....10
9. Volval remnants floccose, subconic or granular, or patch-like, mostly present on pileus (*Amanita* sect. *Validae*).....12
10. Pileus dark brown to blackish over umbo, paler toward margin; annulus grey, persistent; basidiospores  $7\text{-}8.5\text{-}(10) \times (6.5\text{-})7\text{-}8\text{-}(9.5) \mu\text{m}$ , with  $Q = 1\text{-}1.06\text{-}(1.11)$ .....**A. fuliginea**
10. Pileus differently coloured; annulus not grey, although sometimes sordid white; basidiospores globose to elongate.....11
11. Pileus pallidly sordid to grey; annulus white, persistent; basidiospores  $(5\text{-})7\text{-}8\text{-}( ) \times (4\text{-})5\text{-}6\text{-}(7) \mu\text{m}$ , with  $Q = (1.20\text{-})1.27\text{-}1.71\text{-}(1.89)$ .....  
.....**A. pseudoporphyria**
11. Pileus greyish brown; annulus white to sordid white, fragile; basidiospores  $(5.5\text{-})6\text{-}7 \times 5\text{-}6\text{-}( ) \mu\text{m}$ , with  $Q = 1\text{-}1.20\text{-}(0.50)$ .....**A. manginiana sensu** W.F. Chiu
12. Stipe with marginate bulbous base; basidiospores  $(6.5\text{-})7\text{-}8\text{-}(9) \times 6.5\text{-}7.5\text{-}(8.5) \mu\text{m}$ , with  $Q = 1\text{-}1.06\text{-}(1.1)$ .....**A. sinocitrina**
12. Stipe without marginate basal bulb; 95% of basidiospores having  $Q$  equal to or greater than 1.06.....  
.....13
13. Pileus olivaceous buff to honey-yellow, paler toward margin, decorated with yellow floccose to patch-like volval remnants; basidiospores  $(6.5\text{-})7\text{-}8\text{-}(9) \times (5\text{-})5.5\text{-}7\text{-}(8) \mu\text{m}$ , with  $Q = 1.06\text{-}1.38\text{-}(1.47)$  .....  
.....**A. flavipes sensu lato**
13. Pileus greyish brown (sometimes distinctly paler at margin) covered with dark brown to fuscous volval remnants as powder or small warts; volval remnants on upper surface of stipe bulb powdery in broken rings; basidiospores  $(6.5\text{-})7\text{-}9\text{-}(10) \times (5\text{-})5.5\text{-}7\text{-}(8.5) \mu\text{m}$ , with  $Q = 1.06\text{-}1.43\text{-}(1.56)$  .....**A. fritillaria**
14. Basidiocarps developing eccentrically in primordium; hence, stipe usually with bulbous base (*Amanita* sect. *Amanita*).....15
14. Basidiocarps developing centrally in primordium; stipe totally elongating and, hence, without bulbous base.....20
15. Basidial clamps absent or infrequent; basidiocarps often small to medium-sized.....16
15. Basidial clamps present and common; basidiocarps usually medium-sized to large; occasionally small .....  
.....9
16. Annulus present (at least until broken by expanding pileus).....17
16. Annulus lacking from prior to expansion of basidiocarp.....18
17. Pileus reddish orange, paler toward margin; volval remnants red to orange to yellow; basidiospores  $(6.5\text{-})7\text{-}8\text{-}(9) \times (6.5\text{-})7\text{-}8\text{-}(8.5) \mu\text{m}$ , with  $Q = 1\text{-}1.06\text{-}(0.24)$ ..  
.....**A. ubrovolvata**
17. Pileus greenish yellow to olivaceous buff, volval remnants cinnamon buff; basidiospores  $(9\text{-})9.5\text{-}11.5\text{-}(3) \times (5\text{-})5.5\text{-}7\text{-}(8) \mu\text{m}$ , with  $Q = (1.38\text{-})1.53\text{-}1.88\text{-}(93)$ ....  
.....**A. siamensis**
18. Pileus greyish brown, paler toward margin, volval remnants farinose; upper part of bulbous base covered with greyish brown, farinose volval remnants; basidiospores  $(5.5\text{-})6.5\text{-}7 \times 5.5\text{-}6.5\text{-}(7) \mu\text{m}$ , with  $Q = 1\text{-}1.07\text{-}(1.14)$ .....**A. obsita**
18. Pileus cinnamon buff with yellowish pyramidal warts; upper part of bulbous base with scattered yellow volval remnants; basidiospores  $(7\text{-})8\text{-}9 \times 7\text{-}8\text{-}(9) \mu\text{m}$ , with  $Q = 1\text{-}1.05\text{-}(0.22)$ .....**A. affinis mira**
19. Volval remnants on pileus dirty white to cream; pileus brownish to tea-brown, darker over disc; upper part of bulb on stipe base covered with whitish floccose volval remnants; basidiospores  $(7.5\text{-})8\text{-}10\text{-}(11) \times (6.5\text{-})7\text{-}8.5\text{-}(9) \mu\text{m}$ , with  $Q = (1.05\text{-})1.1\text{-}1.32\text{-}(1.33)$ .....**A. subglobosa**
19. Volval remnants on pileus dark grey; pileus brownish grey; upper part of bulb and stipe base covered with grey floccose volval remnants; basidiospores  $9.5\text{-}12.5\text{-}(13.5) \times 7\text{-}9\text{-}(5) \mu\text{m}$ , with  $Q = (1.22\text{-})1.27\text{-}1.50\text{-}(0.56)$ .....**A. sinensis**
20. Membranous annulus present; clamps present and common (*Amanita* sect. *Caesareae*).....21
20. Annulus lacking; clamps usually rare or absent (*Amanita* sect. *Vaginatae*) .....23
21. Pileus bearing bright colours such as yellow, orange or red over disc, paler or differently coloured toward margin; annulus some shade of yellow, orange or red; stipe bearing yellow, orange or red fibrils or patches; basidiospores  $(7.5\text{-})8\text{-}11\text{-}(13.5) \times (5.5\text{-})6\text{-}7\text{-}(9) \mu\text{m}$ , with  $Q = (1.16\text{-})1.31\text{-}1.5\text{-}(1.81)$  .....  
.....**A. hemibapha sensu lato**
21. Pileus lacking orange, red or yellow regions (or with minimal pigmentation only over disc); basidiospores with lower  $Q$  values.....23
22. Pileus dominantly white; basidiospores  $9\text{-}11\text{-}(13) \times (7\text{-})8\text{-}10.5\text{-}(1) \mu\text{m}$ , with  $Q = (1\text{-})1.04\text{-}1.2\text{-}(1.33)$  .....  
.....**A. chepangiana**
22. Pileus brownish over disc, paler toward margin; basidiospores  $(9\text{-})9.5\text{-}11\text{-}(13) \times 9\text{-}11\text{-}(13) \mu\text{m}$ , with  $Q = 1\text{-}1.08\text{-}(0.22)$ .....**A. princeps**
23. Pileus white, bearing a layer of plentiful remains from inner surface of volva; basidiospores  $(6.5\text{-})6.8\text{-}10.4\text{-}(10.5) \times (5.1\text{-})5.2\text{-}7.4\text{-}(7.9) \mu\text{m}$ , with  $Q = (1.25\text{-})1.27\text{-}1.65\text{-}(1.74)$ .....**A. pudibunda**

23. Pileus greyish brown to ash-grey, not bearing such volval remains; basidiospores have 95% of Q values less than 1.38.....24
24. Pileus greyish brown; basidiospores (9-)9.5-11(-12) × (8-)9-11(-11.5) μm, with Q = 1-1.04(-1.14) .....  
..... *A. affin. angustilamellata*
24. Pileus ash-grey; basidiospores (8-)9-10.5(-13.5) × (6-)7-9(-10) μm, with Q = (1.09-)1.15-1.37(-1.7) .....  
..... *A. ovalispora*

***Amanita* [subgenus *Amanita*] section *Amanita***  
*Amanita* affin. *mira* Corner & Bas, Persoonia 2: 290 (1962).

*Basidiocarps* small. *Pileus* 4-5 cm wide, cinnamon-buff, paler toward margin, plane with depressed centre, with margin striate (approx. 0.5 R), non-appendiculate, with volval remnants as yellowish pyramidal warts (ca. 1 × 1 mm). *Lamellae* free, subcrowded, white to whitish, thin; lamellulae truncate. *Stipe* 6.5-8 × 0.5-0.6 cm, cream, tapering upward, with apex slightly expanded, hollow, with 1.3 cm wide solid subbulbous base, with yellow warts on upper surface of bulb; context white to whitish. *Exannulate*.

*Basidia* 28-35 × 7-13 μm, clavate, 4-spored; sterigmata 2.5-4.5 μm long; basal septa without clamps. *Basidiospores* [32/1/1] (7-)8-9 × 7-8(-9) μm [Q = 1-1.05(-1.22), Q = 1.05 ± 0.05], globose to subglobose, rarely broadly ellipsoid, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate.

*Habitat*: Solitary on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 28 September 1999, R. Sanmee (CMU ecmu0016).

*Notes*: While this species seems similar to *A. mira*, it differs in pigment of the pileus and stipe and in having larger spores than have been reported for that species (Corner and Bas, 1962; Yang, 1997). In particular, Corner and Bas describe the species as having a pileus that is orange or red-orange over the disc with a gradual transition toward a more yellowish pigmentation on the margin. In age, the pileus darkens considerably according to the protolog, becoming 'dingy fuliginous olive or bistre from the centre outward'. It is probable that ecmu0016 is a specimen of an undescribed species, which requires further collecting and study.

The most recent detailed treatment of *A. mira* is by Yang (1997). The true *A. mira* is

known from Singapore and southwestern China.

***Amanita obsita*** Corner & Bas, Persoonia 2: 292 (1962).

*Basidiocarps* very small to small. *Pileus* 2.5-3 cm wide, convex to plane, concave, greyish brown, darker over disc, paler toward striate (0.4-0.5R) margin, non-appendiculate, slightly depressed in centre, with volval remnants farinose. *Lamellae* white, free, subcrowded, 0.3-0.4 cm broad; lamellulae truncate. *Stipe* 2.5-3 × 0.2-0.3 cm, brownish, equal, apex slightly expanded, subbulbous at base, with bulb 0.4-0.5 cm wide and with upper part decorated with greyish brown farinose material in few irregular rings; context white. *Exannulate*.

*Basidia* 28-34 × 8-10 μm, clavate, 4-spored; sterigmata 3-5.5 μm long; basal septa without clamps. *Basidiospores* [30/1/1] (5.5-)6.5-7 × 5.5-6.5(-7) μm [Q = 1-1.07(-1.14), Q = 1.05 ± 0.05], globose to subglobose, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate.

*Habitat*: Solitary on ground in forest dominated by *Shorea*.

*Material examined*: THAILAND, Chiang Rai Prov., Ban Mae Sard, 11 July 1999, R. Sanmee, S. & P. Lumyong, B. Dell (CMU e0162).

*Notes*: The material cited from Ban Mae Sard is a rather good match to the protolog of the present species. *Amanita farinosa* Schwein. is somewhat similar to *Amanita obsita*; however, the former has a brownish grey pileus and slightly larger, broadly ellipsoid spores (Corner and Bas, 1962; Tulloss *et al.*, 1995; Yang, 1997; Yang, 2000; Tulloss, 2007c). For comparative purposes, spore measurements from the protolog are provided: 5.8-6.7 × 5.2-6.1 μm (in preserved material) and 6.5-7.5(-8) × 6-7(-7.5) μm (in fresh material). Previous to this report, *A. obsita* was known from Singapore (protolog).

***Amanita rubrovolvata*** S. Imai, Botanical Magazine (Tokyo) 53: 392 (1939).

*Basidiocarps* small. *Pileus* 2.2-4.2 cm wide, convex, plano-convex to plane, reddish orange over disc, paler (straw-yellow to yellow) toward margin, densely covered with reddish orange floccose volval remnants, with volval remnants also sometimes as floccose patches, with margin striate (approx. 0.5 R) and non-

appendiculate. *Lamellae* free, white to whitish, crowded; lamellulae truncate, approximately 17/cm. *Stipe* 4-5.5 × 0.3-0.5 cm, pale yellow to yellow with concolourous pulverulence, tapering upward, with 0.7-0.9 cm wide bulbous base, with volva present as ring around upper part of bulb; context white to whitish, hollow in mature specimens. *Annulus* ascending, superior to median, membranous, pale yellow, with orange margin. Spore print white to cream.

*Basidia* 25-44 × 10-14 μm, clavate, 4-spored, rarely 2-spored; sterigmata 3-4(-5.5) μm long; basal septa without clamps. *Lamella trama* bilateral. *Subhymenium* with (1-) 2-3 layers of globose to subglobose, ellipsoid, or doliform inflated cells (6-22 × 5-18 μm). *Basidiospores* [90/3/3] (6.5-)7-8(-9) × (6.5-)7-8 (-8.5) μm [Q = 1-1.06(-1.24), Q = 1.04 ± 0.04], globose to subglobose, rarely broadly ellipsoid, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate. *Volva* with remnants on pileus comprising more or less vertically arranged elements: inflated cells fairly abundant, globose to subglobose (14-50 × 12-40 μm) to ellipsoid (16-44 × 12-26 μm) to ovoid (20-46 × 12-24 μm), single and terminal, or in chains of 2-3, thin-walled, colourless, hyaline; hyphae abundant, 2-6 μm wide, thin-walled, colourless, hyaline. *Volva* with remnants on stipe base and upper bulb made up of irregularly arranged elements—inflated cells abundant, globose to subglobose (12-30 × 10-24 μm) to long-ellipsoid to subfusiform (30-50 × 8-12 μm), often in chains of 4-6 cells.

*Habitat*: Gregarious on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Sun Gu, 29 July 2000, R. Sanmee, S. & P. Lumyong (CMU 2215); *ibid.*, 11 July 2002, R. Sanmee, S. & P. Lumyong, R. Kodsueb (CMU 4527); *ibid.*, 3 July 2002, R. Sanmee, Z.L. Yang, S. & P. Lumyong, B. Dell, K.D. Hyde (CMU 45138).

*Notes*: The eastern North American *A. frostiana* Peck has been reported from Thailand, but this appears to be in error. The latter species resembles *A. rubrovolvata* slightly, but has short striations at the margin of a yellow-orange pileus, slightly larger spores, a volva that is yellow from the button stage onward, common basidial clamps, and other differences (Tulloss *et al.*, 1995, 2007d; Yang, 1997). There follows a translation of the description

Heim (1962: 149) gave for his Thai material of '*Amanita frostiana*':

*Basidiocarps* small. *Pileus* 25-35 mm wide, orangish citrine yellow, very fragile, quickly becoming planar, then centrally depressed; context white, membrane-like (except, possibly, over stipe); margin profoundly striate-sulcate; volval remnants covering disc as orange tomentum and away from disc as soft orange warts. *Lamellae* free, cream, with serrate and farinose edge; lamellulae not described. *Stipe* 50-70 × 3-4 mm, colour ranging from whitish at base to cream in mid-portion to yellowish at apex, narrowing upward, flaring at apex, farinose in upper part; bulb globose, 8 mm wide, pronounced; annulus simple, thin, membranous, citrine, subsuperior to submedian, fugacious; volval remnants present on bulb as orange-raspberry warts ('pustules') arranged in few broken rings above widest point. *Odour* lacking. *Taste* insipid.

*Basidiospores* 7.1-8.2 × 6.8-7.3 μm, [approx. Q = 1.1], inamyloid, smooth; apiculus at least sometimes proportionately narrow; contents not recorded; white in deposit. [N.B.: Heim's spore drawings do not illustrate spores in lateral view. Therefore, measurements made only from lateral views of spores may produce greater lengths and a slightly different value of Q.]

*Habitat*: On ground, in old *Dipterocarpus* forest, ca. 1200 m elev.

*Collection cited by Heim*: THAILAND, Chiang Mai Prov., DSPNP, *s.d.* R. Heim Th. 47 (location of deposit unknown, mat'l. possibly lost).

In his protolog of the species *A. subfrostiana* Zhu L. Yang (1997), the author provided a thorough description of both his new species and *A. frostiana*. The Thai material of Heim differs from both and more strongly suggests *A. rubrovolvata*, which we propose is the correct determination for it. Unfortunately, Heim's southeast Asian material in PC has often not been maintained in preservation. Bottles once containing a specimen in liquid now may contain useless dried lumps. *Amanita pudibunda*, below, is a welcome exception. Also, Heim is said to have kept material from the herbarium in several apartments around Paris. The last communication on this subject from PC to Tulloss indicated that some exsiccata, notebooks, paintings, etc. were missing.

For comparative purposes, spore measurements for *A. rubrovolvata* from (Yang, 1997) are provided: [300/15/15] (7-)7.5-9(-11) × (6.5-)7-8.5(-10.5) μm [Q = 1-1.1(-1.23), Q = 1.06 ± 0.04].

The most recent detailed treatment of *A. rubrovolvata* is by Yang (1997) who reported the species from southwestern China. It was originally described from Japan. It has been reported from as far north as Korea (Kim *et al.*, 1993), as far west as Nepal (Tulloss and H.R. Bhandary, unpub. data) and northern India (Bhatt *et al.*, 2003; Semwal *et al.*, 2007), and as far south as southern peninsular Malaya (Corner and Bas, 1962).

*Amanita siamensis* Sanmee *et al.*, Mycotaxon 88: 225 (2003).

*Basidiocarps* medium-sized. *Pileus* 7.5-9.5 cm wide, convex to plano-convex, with low broad umbo, greenish yellow to olivaceous buff, with a greyish brown disc; volval remnants farinose or as floccose patches, cinnamon buff; margin striate (0.2-0.4R), slightly reflexed at maturity, non-appendiculate; context white, unchanging. *Lamellae* free, white, crowded, with edge farinose; lamellulae truncate to subtruncate. *Stipe* 9-15 × 1-1.5 cm, subcylindric or slightly tapering upward, with apex slightly expanded, greenish yellow to olivaceous, densely covered with cinnamon buff, farinose, squamules; context white; bulb at stipe base subglobose, 1.5-2.5 cm wide. *Annulus* membranous, easily broken during expansion of pileus, upper surface white with fine subradial striations, lower surface cinnamon buff, with edge cinnamon buff viewed from above. Spore print white.

*Basidia* 36-48 × 9.5-14.5 μm, clavate, 4-spored; sterigmata 4-7.5 (-9.5) μm long; basal septa without clamps. *Basidiospores* [60/2/1] (9-)9.5-11.5(-13) × (5-)5.5-7(-8) μm [Q = (1.38-)1.53-1.88(-1.93), Q = 1.62 ± 0.15], elongate, sometimes ellipsoid, inamyloid, colourless, hyaline, thin-walled, smooth; apiculus small.

*Habitat*: Gregarious on ground in a forest dominated by *Fagaceae*. Presently known only from the type locality.

*Material examined*: THAILAND, Chiang Mai Prov., Khun Chang-Kian, 11 June 2002, R. Sanmee, P. Lumyong, S. Lumyong, R. Kodsueb & W. Chitrong (CMU 4528, **holotype**; HKAS 41153, **isotype**).

*Notes*: Since its original publication, the present species has not been encountered again. Of east Asian taxa, *A. rufoferruginea* Hongo is somewhat similar to the present species. However, it can be distinguished from *A. siamensis* by its having yellowish brown basidiocarps with reddish brown volva remnants on the pileus and stipe, and globose to subglobose basidiospores (Hongo, 1966; Imazeki *et al.*, 1988; Imazeki and Hongo, 1995; Yang, 1997).

*Amanita sinensis* Zhu L. Yang, Bibliotheca Mycologica 170: 23 (1997).

*Basidiocarps* medium to large. *Pileus* 12-14 cm wide, convex to plane, margin striate (0.15-0.25R), non-appendiculate, brownish grey, darker at centre, paler toward margin, volval remnants as fibrillose, floccose patches, dark grey, diminishing in size toward margin, with margin of mature cap upturned. *Lamellae* free, white to dirty white, crowded, thick; lamellulae truncate. *Stipe* 9-11 × 1.2-1.5 cm, brownish grey, slightly tapering upward, with ovoid bulb farinose; context white to whitish. *Annulus* white, membranous, apical. Spore print white to cream.

*Lamella trama* bilateral. *Mediostratum* ca. 40 μm wide, consisting of ellipsoid to fusiform cells, 10-20 μm wide, mixed with abundant, branching hyphae, 2-8 μm wide; vascular hyphae rare. *Lateral strata* comprising long ellipsoid to fusiform cells. *Subhymenium* 30-50 μm thick, with 3-4 layers of globose to subglobose to pyriform cells, 8-24 × 8-18 μm. *Basidia* 44-68 × 9-16 μm, clavate, 4-spored; sterigmata 4-9 μm long; basal septa often bearing clamps. *Basidiospores* [33/1/1] 9.5-12.5(-13.5) × 7-9(-9.5) μm [Q = (1.22-)1.27-1.5(-1.56), Q = 1.39 ± 0.09], broadly ellipsoid to ellipsoid, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate. *Lamella edge* sterile, as somewhat gelatinized strip, 160 μm wide in side view, made up of ovoid to subglobose (12-20 × 10-20 μm) to ellipsoid (28-30 × 12-14 μm) to clavate (30-34 × 10-12 μm) to fusiform (35-40 × 8-10 μm) cells in chains of 2-4, thin-walled, colourless. *Volval remnants* on pileus with plentiful inflated cells subglobose to broadly ellipsoid to elongate-ellipsoid, 20-80 × 20-40 μm.

*Habitat:* Subgregarious. Terrestrial under *Pinus kesiya* Royle ex Gordon.

*Material examined:* THAILAND, Phayao Prov., DLNP-Jumpathong, 28 May 2000, S. & P. Lumyong and students (CMU 2135).

*Notes:* The colour and habit of *A. sinensis* are unusual for a taxon in sect. *Amanita*. In the field, the general appearance suggests a species of sect. *Lepidella* (e.g., *A. griseofarinosa* Hongo). However, simply testing the spores for amyloidity can quickly resolve such a confusion.

Spore measurements from the protolog are provided for comparative purposes: [140/5/4] (8-)9.5-12.5(-13.5) × 7-8.5(-9.5) [Q = (1.14-)1.25-1.53(-1.63); Q = 1.38 ± 0.09].

The most recent detailed treatment of the present species is its protolog. The material cited therein is from southwestern China. More recently, Oda *et al.* (2000) have reported *A. sinensis* from Japan and Nepal.

*Amanita subglobosa* Zhu L. Yang, Bibliotheca Mycologica 170: 18 (1997). (Fig. 1)

*Basidiocarps* medium-sized. *Pileus* 3-5 cm wide, convex to plane, brownish to tea-brown, darker over disc, volval remnants as subpyramidal warts, 1-2 mm wide, up to 1.5 mm high, dirty white to cream, scattered; margin short striate (0.15-0.3 R), non-appendiculate; context white. *Lamellae* free, white; lamellulae truncate. *Stipe* 5-7 × 0.4-1.3 cm, white, equal, with apex slightly expanded, bulb at stipe base subglobose, ca. 0.8-2.5 cm wide, with juncture of stipe and bulb surrounded with whitish floccose ring of volva. *Annulus* white, submembranous.

*Lamella* trama bilateral. *Subhymenium* 2-3 layers of subglobose to cuneiform to pyriform to broadly clavate cells, 6-20 × 4-15 μm. *Basidia* 36-48 × 9-13 μm, clavate, 4-spored; sterigmata 2.5-5 μm long; basal septa often bearing clamps. *Basidiospores* [60/1/1] (7.5-)8-10(-11) × (6.5-)7-8.5(-9) μm [Q = (1.05-)1.1-1.32(-1.33), Q = 1.19 ± 0.07], subglobose to broadly ellipsoid, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate. *Lamella edge* as sterile and somewhat gelatinized strip, 120-190 μm wide in side view, made up of globose to subglobose (6-16 μm wide), ovoid (16-18 × 10-12 μm) to clavate (18-26 × 10-14 μm) to bacilliform (20-25 × 8-10 μm) cells in chains of 4-8, thin-walled,

colourless. *Volval remnants* on pileus made up of irregularly arranged elements: filamentous hyphae fairly abundant, 3-6 (-8) μm wide, hyaline, thin-walled, with septa sometimes bearing clamps; inflated cells abundant to very abundant, globose to subglobose to ovoid to ellipsoid to (occasionally) fusiform, 18-60 × 8-44 μm, often in short chains, thin-walled, colourless. *Annulus* dominantly comprising irregularly arranged, filamentous hyphae (2-9 μm wide) mixed with abundant inflated cells (globose to subglobose to ellipsoid to clavate to fusiform, often in terminal chains, sometimes single and terminal, 14-88 × 8-52 μm, colourless, hyaline, thin-walled); clamps common.

*Habitat:* Solitary on ground in a forest with *Castanopsis*, *Quercus*, and species of *Dipterocarpaceae*.

*Material examined:* THAILAND, Chiang Mai Prov., DSPNP-1 km from Phra-Tard-Doi-Suthep Temple, 13 July 2002, R. Sanmee (CMU 45179, CMU 45180).

*Notes:* *Amanita kwangsiensis* Y.C. Wang (= *A. sychnopyramis* f. *subannulata* Hongo) and *A. parvipantherina* Zhu L. Yang *et al.* are somewhat similar to *A. subglobosa*, but they both lack clamps; and, in addition, the former has much smaller, globose to subglobose spores, and (Yang, 1994; Yang, 1997; Yang *et al.* 2004). Rarity or lack of clamps is common in pantherinoid taxa.

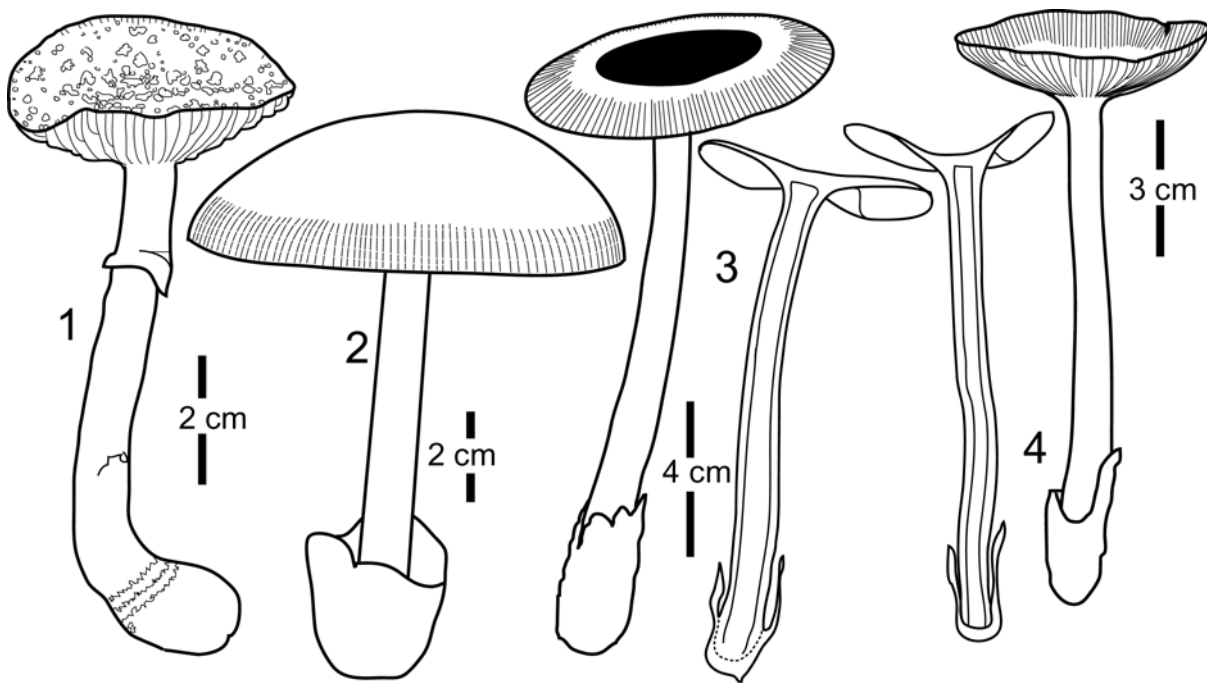
For comparative purposes the spore measurements from the protolog are provided: [110/4/3] (8.5-)9.5-12(-15) × (6.5-)7-9.5(-12.5) μm, [Q = (1.1-)1.18-1.44(-1.62); Q = 1.31 ± 0.09].

The most recent detailed treatment of the present species is provided by Yang (2005). The most recent detailed treatment in English is its protolog (southwestern Chinese material). A description of this taxon based on collections from northern India has appeared recently (Semwal *et al.*, 2007). *Amanita ibotengutake* T. Oda, C. Tanaka & Tsuda (2002), described from Japan, is strikingly similar to *A. subglobosa* (Yang, 2005, 2007a); it is said to be distinguishable on the basis of molecular phylogeny.

#### *Amanita section Caesareae* Singer

All of the known taxa of this section from southeast Asia are assignable to the rather large group of species presently called *Amanita* stirps *Hemibapha* (Tulloss, 1998a, 2007a). Many taxa of this stirps are still to be





**Figs 1-4.** *Amanita* species, habit illustrations; cross-sections not to scale. **1.** *A. subglobosa*, (CMU 45180). **2.** *A. chepangiana*, (CMU 2132). **3.** *A. affinis angustilamellata*, (CMU 45151). **4.** *A. ovalispora*, (CMU e0195).

described; and this situation is certainly the case in southeast Asia. A key to known taxa of this stirps for the world is maintained by Tulloss (2007a). One as yet undetermined taxon from Thailand collected by D. Arora appears in that key denoted by alphanumeric code—‘Thai 3’.

*Amanita chepangiana* Tulloss & Bhandary, Mycotaxon 43: 25 (1992). (Fig. 2)

*Basidiocarps* medium to large. *Pileus* 6-13 cm wide, convex to plane, white, dry, glabrous, with margin striate (0.2-0.4R) and non-appendiculate. *Lamellae* free, white, crowded; lamellulae truncate. *Stipe* 8-14 × 1-1.5 cm, white, slightly tapering upward, apex slightly expanded, stuffed with white cottony material or hollow, with bulb absent; context white. *Annulus* white, membranous, apical to subapical. *Volva* 4-6 × 2.5-5 cm, white, membranous, saccate. Spore print white to cream.

*Basidia* 38-54 × 12-14 μm, clavate, 4-spored; sterigmata 2.5-6 μm long; basal septa often bearing clamps. *Basidiospores* [185/6/5] 9-11(-13) × (7-)8-10.5(-11) μm [Q = (1-) 1.04-1.2 (-1.33), Q = 1.12 ± 0.06], globose, subglobose to broadly ellipsoid, rarely ellipsoid, inamyloid, colourless, hyaline, thin-walled,

smooth, with large prominent apiculus, with contents guttulate.

*Habitat*: Solitary or gregarious on ground in forest of *Fagaceae* and *Dipterocarpaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 9 May 2000, R. Sanmee (CMU 2016) – Chiang Mai Prov., DSPNP-1 km from Phra-Tard-Doi-Suthep Temple, 13 July 2002, R. Sanmee & Z.L. Yang (CMU 45191) – Chiang Mai Prov., KCNP-no loc., 27 May 2000, R. Sanmee, S. & P. Lumyong (CMU 2118) – Phayao Prov., Doi Puya, 27 May 2000, S. & P. Lumyong and students (CMU 2132, CMU 2126).

*Notes*: The original material of *A. chepangiana* was collected in association with *Shorea* (Tulloss and Bhandary, 1992).

There have been newspaper accounts of poisonings by *A. verna* (Bull. : Fr.) Lam. in Thailand (*e.g.*, Dailynews, Bangkok, 30 May 2000); and it is sometimes reported that this mushroom is the leading cause of death from mushroom ingestion in Thailand, Laos, and Cambodia. *Amanita verna* is apparently restricted to Europe and western Asia; however, there are deadly species known from eastern Asia that are macroscopically similar to *A. verna*—*A. exitialis* Zhu L. Yang & T.H. Li (Yang *et al.*, 2001; Zhang *et al.*, 2005), *A. oberwinklerana* Zhu L. Yang & Yoshim. Doi (1999), and *A. subjunquillea* var. *alba* Zhu L. Yang (1997). In at least some parts of Thailand, one or more of

these species goes under the local name of 'hed kai kao teen ton'. Because of the presence of these deadly species, it is important to be able to distinguish the poisonous white species of sect. *Phalloideae* from the very common, edible *A. chepangiana* (with the local name 'hed kai kao').

*Amanita verna* (Breitenbach and Kränzlin, 1995; Neville and Poumarat, 2004) and its Asian look-alikes can be segregated from *A. chepangiana* by characters observable in the field, by their lacking striations along the pileal margin and having a bulb at the stipe base with a comparatively short limbate (not saccate) volva. If appropriate reagents are available, all species of section *Phalloideae* can also be segregated from all species of stirps *Hemibapha* by the amyloid reaction of a pile of spores scraped from a spore print. Under a microscope, specimens of all species of section *Phalloideae* will also be found to lack clamps at the bases of basidia in contrast with all taxa of stirps *Hemibapha*.

The most recent detailed description of the present species was published by Yang (1997); in his description he corrects several mistakes made in the protolog of *A. chepangiana*.

For comparative purposes, spore measurements from (Yang, 1997) are provided: [120/4/4] (8.5-)10-13(-16) × (7.5-)8.5-11(-11.5) μm [Q = (1.04-) 1.09-1.33 (-1.52), Q = 1.19 ± 0.08].

The species was originally described from Nepal; Yang's material is from south-western China. The species has repeatedly been reported from as far north as Korea under the misapplied name *Amanita caesarea* var. *alba* Gillet (Yang, 1997, 2000) or *A. hemibapha* subsp. *alba* Kim *et al. nom. inval.* (1993).

*Amanita hemibapha* (Berk. & Broome) Sacc. *sensu lato*, *Sylloge Fungorum* 5: 13 (1887).

The following is a general description that probably covers several taxa that may or may not have been recognized in the literature. More work is necessary in order to separate them.

*Basidiocarps* medium to large. *Pileus* 5-16 cm wide, convex to plane, concave, margin striate (0.3-0.4R), non-appendiculate, orange-red over centre, paler toward curry-yellow margin, glabrous, viscid when wet. *Lamellae*

free, creamy to yellow, crowded (approx. 7 lamellae/cm); lamellulae truncate. *Stipe* 6-19 × 0.6-3 cm, equal or slightly tapering upwards, apex slightly expanded, yellow to pale yellow, bearing pale orange fibrillose zones below annulus, stuffed with white to yellowish cottony material or hollow, with bulb absent; context white, creamy, or yellowish. *Annulus* yellow to pale orange, thin, membranous, apical, pendant, easily collapsing. *Volva* 2-6 × 1.5-2.5 cm, white, saccate, membranous. Spore print white.

*Basidia* 44-68 × 11-13 μm, clavate, 4-spored; sterigmata 3-4.5 μm long; basal septa often with clamps. *Basidiospores* [279/9/7] (7.5-)8-11(-13.5) × (5.5-)6-7(-9) μm [Q = (1.16-)1.31-1.5(-1.81), Q = 1.41 ± 0.09], ellipsoid, sometimes broadly ellipsoid, rarely elongate, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate.

*Habitat*: Gregarious on ground in forests of *Dipterocarpaceae* and *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Quinine Garden, 17 May 2000, R. Sanmee (CMU 2001) – Chiang Mai Prov., DSPNP-Sun Gu, 11 May 2002, R. Sanmee (CMU 4525) – Chiang Mai Prov., DSPNP-1 km from Phra-Tard-Doi-Suthep Temple, 13 July 2002, R. Sanmee & Z.L. Yang (CMU 45183) – Chiang Mai Prov., DSPNP-Huay Kog Ma, 28 August 2002, R. Sanmee (CMU 45252) – Chiang Mai Prov., KCNP–no loc., 27 May 2000, R. Sanmee, S. & P. Lumyong (CMU 2121) – Chiang Mai Prov., Khun Chang Kian, 11 June 2002, S. Lumyong (CMU 4523) – Phayao Prov., Doi Kum Phra, 27 May 2000, S. & P. Lumyong and students (CMU 2123).

*Notes*: Brightly coloured taxa of *Amanita* stirps *Hemibapha* make up one of the most popular groups of wild edible mushrooms in northern Thailand. The local name is 'hed kai laung'.

Worldwide, there are many taxa in stirps *Hemibapha* (Corner and Bas, 1962; Yang, 1997; Tulloss, 1998a; 1998b, 2007a; Tulloss *et al.*, 2001). They vary in colour, bruising reactions, size, and spore characters; many have a pronounced umbo and rather long marginal striations. However, the basidiocarps of some, including *A. hemibapha sensu stricto* [known with greatest confidence from Sri Lanka and southern India (Berkeley and Broome, 1871; Vrinda *et al.*, 2005; Tulloss, 2007g)], may often lack an umbo. In our Thai collections, a dominantly yellow entity of stirps *Hemibapha* is more plentiful than a red one. Chansrikul *et al.* (1984) and Rachabundi-

tayasathan (1996) reported two taxa in Thailand—*A. hemibapha* subsp. *javanica* Corner & Bas (1962) [= *A. javanica* (Corner & Bas) T. Oda *et al.* (1999)], a predominantly yellow to orange-yellow entity and *A. hemibapha* subsp. *similis* (Boedijn) Corner & Bas (1962) [= *A. similis* Boedijn (1951)], a brown-capped entity having a yellow stipe decorated with orange fibrillose patches. A species of the same stirps with a completely bright orange-red cap is depicted on the worldwide web in a photograph labelled '*Amanita caesarea* [sic] (Thailand)' by Taylor Lockwood (2004); this photograph strongly suggests *A. caesareoides* Lj. N. Vassiljeva, presently known from northern India to eastern Siberia.

The present entry uses the name *A. hemibapha* in a broad sense—covering the brightly coloured taxa (of whatever rank they may be assigned) of stirps *Hemibapha* in Thailand. *Amanita chepangiana*, above, and *A. princeps*, below, are both taxa of stirps *Hemibapha* that lack the bright colours of taxa treated within the present entry; moreover, the two cited species have spores tending to be more nearly globose or subglobose than spores of many of the brightly coloured taxa.

***Amanita princeps*** Corner & Bas, *Persoonia* 2: 297 (1962).

*Basidiocarps* medium to large. *Pileus* 8–15 cm wide, convex to plane, concave, brownish, darker over disc, paler toward a striate margin (0.2–0.4R), non-appendiculate, glabrous, viscid when wet. *Lamellae* free, white, approx. 1.2 cm broad, crowded, averaging 6–7 per cm; lamellulae truncate. *Stipe* 8–23 × 1.5–2.5 cm, slightly tapering upward, white to whitish, stuffed with white cottony material or hollow; bulb absent; context white, moist. *Annulus* white, apical, membranous, thin, easily collapsed. *Volva* saccate, 4–8 × 2–3.5 cm, membranous, white to whitish. Spore print white.

*Basidia* 33–58 × 9–17(–25) μm, clavate, 4-spored; sterigmata (2.5–)4–7 μm long; basal septa often with clamps. *Basidiospores* [90/3/3] (9–)9.5–11(–13) × 9–11(–13) μm [Q = 1–1.08(–1.22), Q = 1.06 ± 0.05], globose to subglobose, rarely broadly ellipsoid, inamyloid, colourless, hyaline, thin-walled, smooth, with large and prominent apiculus, with contents guttulate.

*Habitat*: Solitary or gregarious on ground under *Castanopsis*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Quinine Garden, 17 May 2000, R. Sanmee (CMU 2000) – *ibid.*, 6 June 2002, R. Sanmee & R. Kodsueb (CMU 4504).

*Notes*: *Amanita princeps* is a common edible wild mushroom in northern Thailand during the rainy season. The local name is 'hed kai kao'.

The current species was originally described from Singapore. It seems to be common in tropical China (Yang *et al.*, 2001; Yang 2005, 2007b).

### ***Amanita* section *Vaginatae* (Fr.) Quél.**

*Amanita* affin. *angustilamellata* (Höhn.) Boedijn, *Sydowia* 5: 318 (1951). (Fig. 3)

*Basidiocarps* medium-sized. *Pileus* 3.5–9.5 cm wide, convex to umbonate-convex to plane, often subumbonate or lacking an umbo, with margin long striate (0.4–0.5R), non-appendiculate, greyish brown, darker at disc, paler toward margin, glabrous. *Lamellae* free, white to whitish, subcrowded, thick; lamellulae truncate. *Stipe* 10–14 × 0.5–1 cm, slightly tapering upward, apex slightly expanded, white to brownish, bearing grey to greyish fibrils; context white, hollow. *Exannulate*. *Volva* 2.5–4 × 1–2 cm, white, with very pale greyish tinge, saccate, membranous.

*Basidia* 42–62 × 13–16 μm, clavate, 4-spored; sterigmata 4.5–7 μm long; basal septa without clamps. *Basidiospores* [151/5/5] (9–)9.5–11(–12) × (8–)9–11(–11.5) μm [Q = 1–1.04(–1.14), Q = 1.04 ± 0.03], globose to subglobose, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate.

*Habitat*: Solitary or gregarious on ground in forests including *Dipterocarpaceae* or *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 24 July 1999, R. Sanmee (CMU e0209) – Chiang Mai Prov., Doi Saked, Huay Hong Krai, 6 July 2002, R. Sanmee, Z.L. Yang & K.D. Hyde (CMU 45151) – Chiang Mai Prov., KCNP-no loc., 10 July 1999, R. Sanmee, S. & P. Lumyong & B. Dell (CMU e0152) – Chiang Mai Prov., Sanpathong, Mae Wang, 5 October 2002, S. & P. Lumyong, R. Sanmee (CMU 45265) – *ibid.*, 8 December 2002, S. & P. Lumyong, R. Sanmee (CMU 45333).

*Notes*: FH 4712 is sole syntype and, therefore, lectotype of the present species; and it is in good condition (Zhu L. Yang, pers. comm.) except that the base of the stipe and the

volva were not collected. The present day understanding of the taxon is based largely on the protolog, the drawing von Höhnel deposited with his exsiccatum (FH), and interpretations by subsequent authors—Boedijn (1951), Corner and Bas (1962) and Yang (1997). A brief summary of current knowledge of the present species is maintained by Tulloss (2007e).

Z.L. Yang (pers. corresp.) generously provided us with his unpublished data on the spores of the type. They are included here for comparative purposes: [35/1/1]11-14(-15) × (10-) 10.5-13 (-14.5) μm, Q = 1-1.1 (-1.15), Q = 1.05 ± 0.04.

The region of interest is not at all thoroughly explored, and species of sect. *Vaginatae* are among the undetermined exsiccata awaiting further research. In the present case, at least three concerns remain as open issues with regard to determination of the Thai material here listed as *A. affin. angustilamellata*. The original drawing of von Höhnel shows the length:breadth ratio of the lamellae to be in the range of 6.5-6.75 while the same ratio taken from the habit illustration accompanying the present description is 2.9. Tulloss' on-line summary [based largely on the descriptions of von Höhnel, Boedijn, and Yang (1997)] mentions that the saccate volva of *A. angustilamellata* is attached only at the very base of the stipe. This character is also shown in Corner's watercolour of the present species (Corner and Bas, 1962; Tulloss, 2007e). The habit on Thai material examined shows a more extensive region of volval attachment to the stipe. Spore measurements (possibly affected by the quality of preservation of the Thai material?) are not a close match to those reported from the type (e.g., ranges of spore length in the two data sets are nearly disjunct). Additional, well-annotated and illustrated collections of material considered to be *A. angustilamellata* are very much needed from sites throughout the supposed range of the species, in order to get a more definitive understanding of it.

*Amanita angustilamellata* has been previously reported from Indonesia (protolog), Singapore (Corner and Bas, 1962), and southwestern China (Yang, 1997).

*Amanita ovalispora* Boedijn, Sydowia 5: 320 (1951). (Fig. 4)

*Basidiocarps* medium-sized. *Pileus* 4-5 cm wide, convex to plane, glabrous, viscid, dark grey at centre, paler (e.g., ash-grey) toward nonappendiculate, striate (0.4-0.6 R) margin. *Lamellae* free, white, crowded; lamellulae truncate. *Stipe* 8-10.5 × 0.6-0.8 cm, slightly tapering upward, with apex slightly expanded, white, fibrillose to floccose; context white, hollow. *Exannulate*. *Volva* saccate, 2.5-3 × 1.5-2 cm, membranous, white to dirty white.

*Basidia* 33-50 × 12-15 μm, clavate, 4-spored; sterigmata 2.5-5 μm long; basal septa without clamps. *Basidiospores* [120/4/4] (8-)9-10.5(-13.5) × (6-)7-9(-10) μm [Q = (1.09-) 1.15-1.37(-1.7), Q = 1.3 ± 0.13], broadly ellipsoid to ellipsoid, rarely subglobose or elongate, inamyloid, colourless, hyaline, thin-walled, smooth, with contents guttulate.

*Habitat*: Solitary on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 20 July 1999, R. Sanmee, S. & P. Lumyong (CMU e0195) – *ibid.*, 24 July 1999, R. Sanmee (CMU e0211) – *ibid.*, 9 May 2000, R. Sanmee, S. & P. Lumyong (CMU 2036) – Chiang Mai Prov., Chiang Mai Univ., Ang Kaew, 27 July 2002, R. Sanmee, Z.L. Yang & H.Y. He (CMU 45238).

*Notes*: The most recent detailed treatment of this taxon is by Yang (1997) who described southwestern Chinese material. In the same work, Yang provides a useful comparison to *A. pseudovaginata* Hongo.

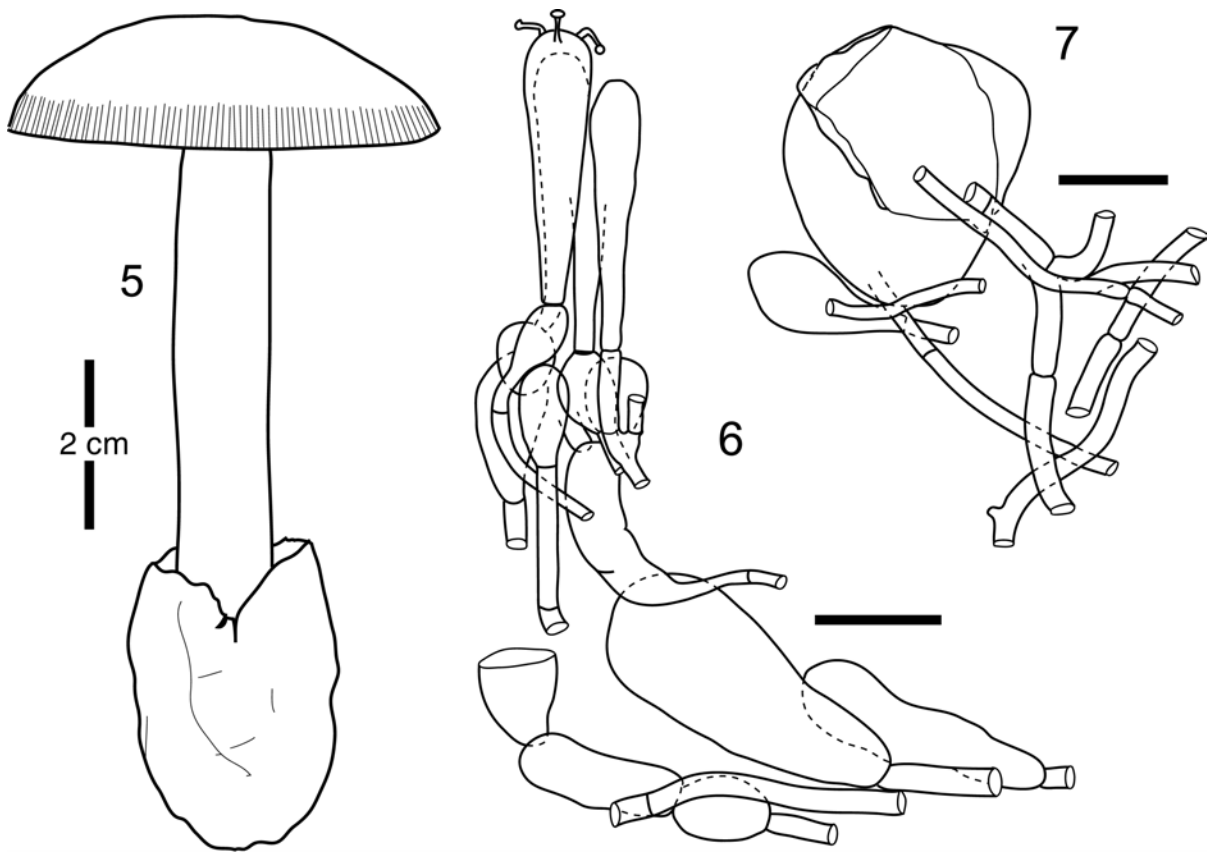
This species is often called *A. vaginata* (Bull. : Fr.) Lam. in the Thai literature; however, *A. vaginata* is a European and west Asian species that has globose basidiospores (e.g., Breitenbach and Kränzlin, 1995). Unfortunately, the latter species is poorly understood, and its name is misapplied throughout the world.

The current species was originally described from Indonesia.

*Amanita pudibunda* R. Heim ex R. Heim, Revue de Mycologie 30: 235 (1965).

= *Amanita pudibonda* [sic] R. Heim, Revue de Mycologie 27: 146 (1962) *nom. inval.* (Lacking Latin diagnosis.) (Figs 5-7)

*Pileus*: 35-45 mm wide, white, gibbous to convex at first, then convex to pulvinate, flat over disc, with tomentose to farinose surface decoration; context white; margin short striate (faint, but 0.25R in preserved material),



**Figs 5-7.** *A. pudibunda* (holotype). Scale bars on microscopic anatomy indicate 20  $\mu\text{m}$ . **5.** Habit. **6.** Elements of hymenium and subhymenial tree. **7.** Elements of universal veil from stipe base.

farinose, slightly incurved at least at first; *universal veil* not described in original descriptions, but depicted as scattered irregular fragments, probable source of surface decoration reported with microanatomical characters (below).

*Lamellae*: spacing from stipe not noted, crowded as preserved, white with flesh-coloured tint in mass, white in side view, rather broad, rather thick and fleshy, with smooth and concolourous edge; *lamellulae* not described.

*Stipe*: 80-100  $\times$  9-12 mm, white, narrowing upward evenly, having series of concolourous rings or broken rings in apical third (fragile, white, farinose), pulverulent, with pulverulence easily lost below apical third, quickly becoming nearly smooth below, with subtle browning below apical portion (from handling?); *context* white, with ample central cylinder (width not recorded); *universal veil* as saccate volva, ample, with limb of roughly even height to slightly bilobate, membranous, rather thick, whitish with pinkish brown spots, 32  $\times$  20 mm, 2 mm thick as preserved,

apparently lacking *limbus internus* in preserved state.

*Odour* subtle, agreeable; *taste* sapid.

*Macrochemical tests*: none reported.

*Pileipellis*: comprising colourless suprapellis (445-450  $\mu\text{m}$  thick) and subpellis (235 $\pm$   $\mu\text{m}$  thick) with hyphae having brown tinted walls, overall 680-685  $\mu\text{m}$  thick, overlaid by nearly uniform layer from inner surface of universal veil (see below); suprapellis comprising gelatinized matrix including loosely interwoven, narrow, filamentous, undifferentiated hyphae seeming to curve up into matrix from subpellis; subpellis with filamentous, undifferentiated hyphae up to 9.6  $\mu\text{m}$  wide, branching, often constricted at septa, ungelatinized; vascular hyphae not observed. *Pileus context*: filamentous, undifferentiated hyphae 4.8-14.4  $\mu\text{m}$  wide, branching, plentiful; acrophysalides narrowly clavate, plentiful to dominant, with many subradially arranged, up to 145  $\times$  32  $\mu\text{m}$  or larger, with walls thin or commonly up to 0.8  $\mu\text{m}$  thick, terminal or occasionally in chains; vascular hyphae 6.4-

12.8  $\mu\text{m}$  wide, scattered, sinuous, orange-brown.

*Lamella trama*: bilateral;  $w_{cs} = 30\text{-}35 \mu\text{m}$ ; subhymenial base including plentiful inflated cells (clavate to broadly clavate to elongate to ovoid, thin-walled, apparently all intercalary, up to  $73 \times 30 \mu\text{m}$ ), with angle of divergence from shallow to  $60^\circ$  or more; central stratum containing plentiful partially inflated intercalary segments up to  $14.4 \mu\text{m}$  wide; filamentous, undifferentiated hyphae  $2.1\text{-}6.4 \mu\text{m}$  wide, branching, often with granular contents; terminal, divergent inflated cells occasional, of the same form as intercalary cells of subhymenial base; vascular hyphae not observed. *Subnymenium*:  $w_{st\text{-}near} = 70\text{-}90 \mu\text{m}$ ;  $w_{st\text{-}far} = 95\text{-}100 \mu\text{m}$ ; as branching structure comprising short uninflated and partially inflated hyphal segments and small inflated cells, with  $10\text{-}30 \mu\text{m}$  between bases of largest basidia/-oles and subhymenial base, with  $45\text{-}50 \mu\text{m}$  between bases of shortest basidia/-oles and subhymenial base, with basidia arising from cells of all types, least frequently from inflated cells. *Basidia*:  $39\text{-}61 \times 8.0\text{-}11.6 \mu\text{m}$ , 4-sterigmate; clamps not observed. *Universal veil*: *On pileus, lower surface, attached to pileipellis*: nearly uniform layer  $20\text{-}50 \mu\text{m}$  thick of brownish walled partially gelatinized elements, with all types of elements often having granular contents (see description of pileipellis, above); filamentous, undifferentiated hyphae up to  $7.2 \mu\text{m}$  wide, branching; inflated cells (up to  $47 \times 11.2 \mu\text{m}$  or larger), collapsed, narrowly clavate to allantoid, possibly in chains. *On stipe base, exterior surface*: as rather dense layer to depth of up to  $85 \mu\text{m}$ ; filamentous, undifferentiated hyphae  $1.0\text{-}8.0 \mu\text{m}$  wide, branching, dominantly fasciculate and often in rather broad fascicles, also appearing singly, interwoven in open lattice, but denser than in interior, with many partially gelatinized; inflated cells not observed; vascular hyphae  $3.2 \mu\text{m}$  wide, scattered to rare, fragmented. *On stipe base, interior*: filamentous, undifferentiated hyphae  $3.2\text{-}11.2 \mu\text{m}$  wide, branching, plentiful, often fasciculate, thin-walled, with septa occasionally constricted, very loosely interwoven in open lattice, with tip cells sometimes slightly expanded; inflated cells plentiful to locally dominating, thin-walled, up to  $105 \times 79 \mu\text{m}$ , occasionally irregularly clavate, usually

broadly ellipsoid to subglobose; vascular hyphae  $3.2\text{-}15.2 \mu\text{m}$  wide, scattered, sinuous; clamps not observed. *On stipe base, inner surface*: partially gelatinized in some regions, very similar to dark layer on pileipellis surface, from comparatively thin to up to  $110 \mu\text{m}$  thick; filamentous, undifferentiated hyphae  $2.4\text{-}9.6 \mu\text{m}$  wide, with some intercalary segments up to  $14.4 \mu\text{m}$  wide, frequently branching, dominating, densely interwoven, with almost all in fascicles, frequently septate, with yellow granular contents in 20%  $\text{NH}_4\text{OH}$ , with dark brown pigment apparently restricted to cell walls; inflated cells apparently terminal (singly or in short chains), narrowly clavate or allantoid (up to  $123 \times 32 \mu\text{m}$ , thin-walled) to pyriform or subglobose (up to  $43 \times 40 \mu\text{m}$  or larger, with walls up to  $1.6 \mu\text{m}$  thick), plentiful, often with granular contents as in hyphae; vascular hyphae not observed. *Stipe context*: longitudinally acrophysalidic; filamentous, undifferentiated hyphae  $2.4\text{-}9.6 \mu\text{m}$  wide, branching, plentiful; acrophysalides dominating, thin-walled, up to  $298 \times 32 \mu\text{m}$ ; vascular hyphae not observed.

Basidiospores:  $[20/1/1]$   $(6.5\text{-})6.8\text{-}10.4$   $(-10.5) \times (5.1\text{-})5.2\text{-}7.4(-7.9) \mu\text{m}$ , ( $L = 8.7 \mu\text{m}$ ;  $W = 6 \mu\text{m}$ ;  $Q = (1.25\text{-})1.27\text{-}1.65(-1.74)$ ;  $Q = 1.46$ ), hyaline, colourless, with walls very slightly thickened ( $< 0.5 \mu\text{m}$ ), smooth, inamyloid, broadly ellipsoid to ellipsoid to elongate; apiculus sublateral; contents multiguttulate; colour in deposit unknown.

*Habitat*: In humus of old *Dipterocarpus* forest, 1200 m elev.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP, [5] December 1957, R. Heim [Th.] 57 (PC, **holotype**).

*Notes*: Heim (1962: 148) states that this species was most closely related to the varieties of *Amanita annulatovaginata* Beeli (from the Republic of Congo) due to the presence of fragile decoration on the upper stipe (suggestive of an annulus) and the shape and size of the spores. However, the gracile African species was not reported to have, and from its illustrations does not appear to have, the curious covering of volval material that *A. pudibunda* bears on its pileus; and there seems little reason to judge the two taxa to be closely related phenetically.

Yang (pers. corresp.) has suggested to Tulloss that this taxon might well be placed in

sect. *Amidella* except for its inamyloid spores. Weak amyloid reaction in spores of one collection of *Amidella* was reported by Bas (1969: 342) as Yang noted. Yang (pers. corresp.) also reports that he has reviewed dried material that seems to belong to sect. *Amidella* with the exception of having inamyloid spores.

This species is known only from a single specimen. The holotype of *A. pudibunda* is preserved in liquid. Generally speaking, Tulloss found the tissues to be in very good condition. Parts of the collection data in brackets do not appear on the herbarium label in PC. 'Th.' stands for the name of the actual collector.

New material of *A. pudibunda* with good notes on its fresh state and in condition to support molecular studies is very much needed.

***Amanita* [subgenus *Lepidella*] section *Amidella* (E.-J. Gilbert) Konrad & Maubl.**

*Amanita avellaneosquamosa* (S. Imai) S. Imai in Ito, Mycological Flora of Japan 2(5): 250 (1959).

*Basidiocarps* medium-sized. *Pileus* 4-9 cm wide, convex to plane, slightly depressed in centre, margin striate (0.25-0.35R), non-appendiculate when collected, whitish, with volval remnants cream to yellowish brown, farinose or floccose small patches. *Lamellae* free, white to whitish, subcrowded; lamellulae truncate. *Stipe* 5-7 × 0.7-2 cm, slightly tapering upward, white to cream, decorated with white farinose to floccose material; context white to whitish. *Annulus* fugacious. *Volva* 2-3 × 1.5-3 cm, yellowish brown, saccate, membranous. *Odour* strong, unpleasant (possibly due to decay). Spore print white.

*Basidia* 40-50 × 8-14 μm, 4-spored; sterigmata 3-5 μm long; basal septa without clamps. *Basidiospores* [109/3/3] (8.5-)9-11(-12) × (4.5-)5-6.5(-7) μm [Q = (1.35-)1.5-1.88(-2.5), Q = 1.74 ± 0.19], ellipsoid to elongate, rarely cylindrical, amyloid, colourless, hyaline, thin-walled, smooth; apiculus small.

*Habitat*: Solitary on ground in forests of *Fagaceae* and *Pinaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPSP-Suan Sone, 11 June 1999, R. Sanmee, S. & P. Lumyong (CMU e0051) – Chiang Mai Prov., DSPSP-Sun Gu, 29 July 2000, S. & P. Lumyong, R. Sanmee (CMU 2220) – Chiang Mai Prov., KCNP, 27 May 2000, S. & P. Lumyong, R. Sanmee (CMU 2119).

*Notes*: Species of sect. *Amidella* represent notable exceptions to the belief that the presence of truncate lamellulae in an *Amanita* correlates with the presence of inamyloid spores (Tulloss and Yang, 2007b). *Amanita volvata* (Peck) Lloyd (a North American taxon) is similar to *A. avellaneosquamosa* but differs by pinkish to red-brown staining after injury to the context, having a fibrillose-floccose inner layer of volval remnants (made up of abundant, fusiform, broadly clavate to ellipsoid, loosely and irregularly arranged inflated cells) almost always remaining in part or whole on the pileus, having a thicker subhymenium with (2-) 3-4 (-5) layers of inflated cells, and having somewhat larger spores. This is according to Yang (2000), who reported the present species from southwestern China (Yang, 1997). This species was reported from northern India as *A. volvata* according to Bhatt *et al.* (2003).

The present species differs from *A. clarisquamosa*, below, by having more elongate spores (higher average Q), having a volval sac that is often more laterally compressed, longer marginal striations on the pileus, less crowded lamellae, and smaller spores—as reported by Yang (1997).

For comparative purposes, the spore measurements from Yang's description of material from southwestern China are provided: [110/4/2] (8-)9-11(-12) × 5.5-6.5(-7) μm [Q = (1.33-)1.43-1.87(-2), Q = 1.65 ± 0.14]. In addition Tulloss' spore measurements from material of China, Japan, and northern India are as follows: [125/5/5] (5.8-)7-10.5 (-11.8) × (4-)4.8-6.5(-7.8) μm [Q = (1.28-)1.38-1.91(-2), avg. Q per specimen = 1.48-1.71; Q = 1.61 ± 0.16].

*Extralimital habitat*: India: At 1900<sup>±</sup>-3250 m elev., in forest of *Quercus leucotrichophora* A. Camus and *Rhododendron arbo-reum* Sm., with scattered *Cedrus deodara* (Roxb. ex Lambert) G. Don. or under *Pinus roxburghii* Sarg. or in mixed forest including *Abies pindrow* (Royle ex D. Don) Royle, *Picea smithiana* (Wall.) Boiss., *Pinus wallichiana* A.B. Jacks., *Q. dilatata* Royle, *Q. semecarpifolia* Sm. [latter known to be mycorrhizal with current species (Kumar *et al.*, 1990)], and *Taxus*. Japan: At ca. 300 m elev., in evergreen forest with *Castanopsis* and some *Abies* and *Pinus*.

*Extralimital material examined:* CHINA, Jiangsu Prov., Nanjing, Ling-ku-sze Woods, 14 July 1936 S.C. Li 112 (CUP-CH) – INDIA, Himachal Pradesh, Shimla, Narkanda, Hattoo Peak, 20 August 1986, T.N. Lakhnopal & A. Kumar *s.n.* (HPUB 4430 (*n.v.*); BPI 71990) – Uttarakhand, Mussooree, 21 September 1964 C. Bas 4442 (L) – Uttarakhand, Pauri Garhwal, Dandapani, 8 August 2001, K.C. Semwal & R.P. Bhatt 378 (GUH; RET) – JAPAN, Chiba Pref., Kiyosumi, 25 August 1983 C. Bas 9002 (L) – Shiga Pref., Seta-chô, 2 October 1949, T. Hongo 6 (herb. T. Hongo).

The current species has been reported previously from Japan (protolog), southwestern China (Yang, 1997), and northern India (Bhatt *et al.*, 2003).

*Amanita clarisquamosa* (S. Imai) S. Imai *in* Ito, Mycol. Fl. Jap. 2: 250 (1959).

Field notes for the single collection available were limited. The description is largely based on the description of Yang (1997).

*Pileus* 7 cm wide, convex at first, planar when expanded, slightly depressed over disc, white to whitish, slightly yellow-brownish over disc, viscid (or tacky), decorated with grey-brown, brownish to brown, irregular, membranous to fibrillose volval remains, with margin shortly and lightly striate (0.1-0.15R) and often appendiculate; context white, 4-6 mm thick over stipe, thinner toward margin, not or indistinctly discolouring. *Lamellae* free to nearly free, 5-8 mm broad, white, tending to become greyish, grey-brownish, brownish or chocolate brown when dried slowly or in humid environment, crowded to moderately crowded, with edge finely floccose, greyish to brownish; lamellulae truncate to rounded truncate, with 0-2 between each pair of lamellae. *Stipe* 12 × 1.2-1.8 cm, nearly cylindrical or tapering slightly toward apex, with whitish ground colour under grey-brown scales or flocculence; context white to whitish; basal bulb lacking. *Volva* saccate, fleshy, 4-5 cm high, 3.5-4 cm wide, 2-9 mm thick, adhering to stipe surface, with outer surface white to sordid white, with inner surface whitish, with limbus internus placed high on limb and somewhat difficult to distinguish. *Annulus* fragile or ephemeral, often remaining as grey-brown scales on upper portion of stipe. *Odour* and *taste* not conspicuous. Spore deposit 'white'.

*Basidia* 4-sterigmate; basal septa without clamps. *Basidiospores* [34/3/1] (10-)11-12.5(-16) × (7-)7.5-8(-11) µm, [Q = (1.15-)1.44-1.63

(-2.07), Q = 1.52 ± 0.17], amyloid, broadly ellipsoid to ellipsoid, occasionally elongate, rarely cylindrical, colourless, hyaline, thin-walled; apiculus small, cylindrical, sublateral.

*Habitat:* In mixed forest including *Pinus* and *Castanopsis*.

*Material examined:* THAILAND, Chiang Mai Prov., Om Koi, 12 September 1999, D. Arora 99281 (RET; SFSU).

*Notes:* Our material conforms well to the description of the present species by Yang (1997) as well as with unpublished data of Tulloss. For comparison to *A. avellaneosquamosa*, see observations under that species. In Arora 99-281, 'giant spores' were present—probably spores from basidia with less than 4 sterigmata. Bhatt *et al.* (2003) note that this species has been reported in northern India as *A. peckiana* Kauffman. Tulloss' spore data for *A. clarisquamosa* (using notation of the present paper) based on collections from India are as follows: [150/7/3] (7-)10-12(-15) × (5.5-)6-7(-9) µm, [Q = (1.18-)1.45-1.77(-1.88), avg. Q per specimen = 1.50-1.69, Q = 1.59 ± 0.13].

*Extralimital habitat:* India: At 1850-2800<sup>±</sup> m elev., on slope in pure *Abies pindrow* forest or on N slope in coniferous forest including *A. pindrow*, *Picea smithiana*, and *Pinus wallichiana* or scattered on rich humus under *Myrica esculenta* Buch.-Ham. ex D. Don, *Quercus leucotrichophora*, and *Rhododendron arboreum*.

*Extralimital material examined:* INDIA, Himachal Pradesh, Narkanda, 6 August 1964, C. Bas 4066 (L) – *ibid.*, 11 August 1964 C. Bas 4118 (L) – Uttarakhand, Garhwal, Dandapani, 20 September 1993, V.K. & R.P. Bhatt *s.n.* (GUH M-20168; RET).

The current species has been reported previously from Japan (protolog), southwestern China (Yang, 1997), and northern India (Bhatt *et al.*, 2003).

*Amanita section Lepidella sensu Bas (1969)*

*Amanita alboflavescens* Hongo, *Memoirs of the Shiga University, Natural Science* 20: 50 (1970).

*Basidiocarps* medium-sized. *Pileus* 6 cm wide, convex to plane, pale yellow, volval remnants floccose to squamulose, yellowish to brownish, becoming lemon-chrome when touched, margin non-striate, appendiculate. *Lamellae* free, whitish, cream to yellowish, edges serrate, crowded; lamellulae nearly truncate. *Stipe* 12 × 0.9-1.2 cm, slightly tapering



upward, apex slightly expanded, yellowish, floccose to squamulose, with ovoid, bulbous base 2.2 cm wide; context white. *Annulus* yellowish, apical, floccose-membranous. *Volva* yellowish, floccose-felted, fugacious. Spore print white to cream.

*Basidia* clavate, 4-spored, sterigmata 5-6.5  $\mu\text{m}$  long. *Basidiospores* [30/1/1] 8-10.5 (-11)  $\times$  5-6(-6.5)  $\mu\text{m}$  [Q = 1.47-1.78 (-2), Q = 1.66  $\pm$  0.12], ellipsoid to elongate, rarely cylindrical, amyloid, colourless, hyaline, thin-walled, smooth; apiculus small.

*Habitat*: Solitary on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 25 May 2000, S. & P. Lumyong, R. Sanmee (CMU 2113).

*Notes*: The North American species, *A. crassifolia* Bas *nom. prov.*, is similar to *A. alboflavescens*, but the former has thicker lamellae and common clamps (Bas, 1969). The Thai *A. alboflavescens* specimen is in poor condition, and no clamps were observed. According to Yang's observation of Chinese specimens, *A. alboflavescens* has no clamps.

Tulloss (2000) has expressed the view that some yellow-staining North American species belonging to sect. *Lepidella* are apparently specimens of non-yellowing taxa that have been infected by one or more pathogens. Bas considered the possibility that *A. crassifolia* was an unusual specimen of *A. subsolitaria* (Murrill) Murrill; and Tulloss (2007f) now states this to be the case. This situation suggests that *A. alboflavescens* should be investigated for the cause of its yellowing reaction. If the variability of spore width (and, consequently, of spore shape) reported in the above description and these notes is supported by examination of additional collections, this may be further evidence of a nongenetic factor's having an effect on the basidiocarps of *A. alboflavescens*. Corner (1947) observed that spore width of a given species is usually less variable than spore length of that species; and, based on Tulloss' nearly 30 years of research on the genus, this appears to be true in *Amanita*.

Since the Thai material may not have typical spores, for purposes of comparison, we provided three other sources of data. In its protolog, the spores of the present species were described as follows: '8-12  $\times$  4.5-6.5  $\mu\text{m}$ ' (esti-

mated Q = 1.82). Yang (1997: 159) provides the following data from a southwestern Chinese collection: [33/1/1] (7.5-)8-10.5(-11.5)  $\times$  (4.5-) 5-6  $\mu\text{m}$  [Q = (1.52-)1.58-1.91(-2.3), Q = 1.72  $\pm$  0.14]. Tulloss' spore measurements from a Chinese collection are as follows: [55/3/1] (7.7-)8-10.3(-11)  $\times$  (3.6-)4-5.5(-6)  $\mu\text{m}$  [Q = (1.4-)1.62-2.24(-2.39), avg. Q per specimen = 1.88-2, Q = 1.92  $\pm$  0.21].

*Extralimital material examined*: CHINA, Yunnan Prov., Lu Feng, 2 August 2002, D. Arora 02-149 (RET, SFSU).

*Amanita alboflavescens* was originally described from Japan. In addition to China, it has been reported from Korea (Kim *et al.*, 1993).

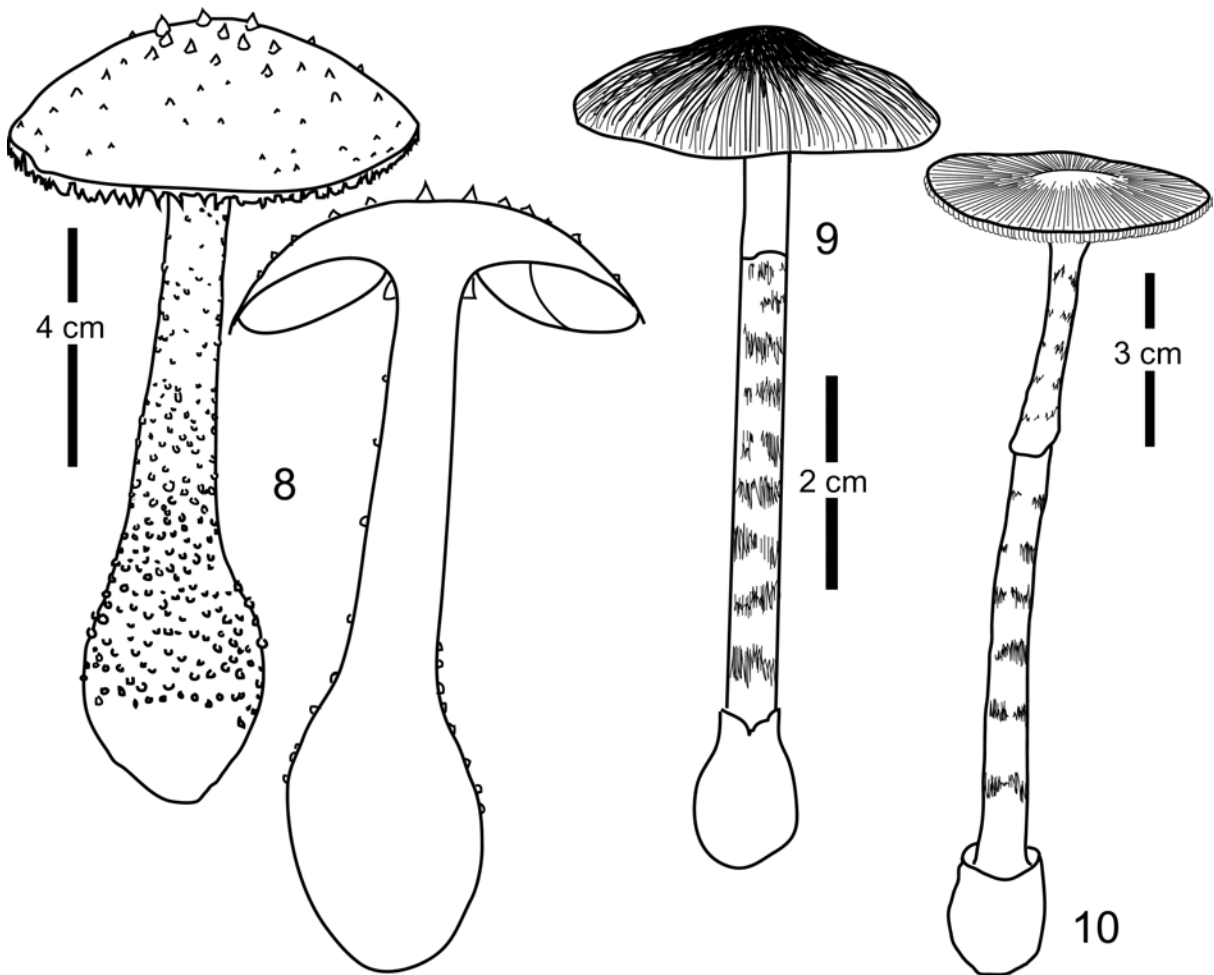
*Amanita hongoi* Bas, Persoonia 5: 410 (1969).  
(Fig. 8)

*Basidiocarps* medium to large. *Pileus* 5-8 cm wide, convex to plano-convex; margin non-striate, appendiculate, brownish to dull yellowish over centre, paler toward margin (whitish to pale brown), dry; volval remnants as conic warts 1.5-4 mm high, 1.5-3.5 mm wide, whitish to dull yellowish to brownish, diminishing in size (with colour paler) towards margin. *Lamellae* free, close to crowded, white to cream, up to 2.5 cm broad; lamellulae attenuate. *Stipe* 7-16  $\times$  1-2 cm, with apex often brownish, floccose to squamulose, with base clavate-bulbous, 2.5-7.5 cm wide, sometimes splitting longitudinally, dirty white to reddish, with conic volval warts on at least upper part of bulbous base if not also on lower stipe and more of bulb. *Annulus* fragile, with upper surface white and radially striate, with lower surface white to dirty white, verrucose. Context white, unchanging, solid.

*Basidia* 53-63  $\times$  11-14  $\mu\text{m}$ , clavate, 4-spored; sterigmata 4-7  $\mu\text{m}$  long; basal septa without clamps. *Basidiospores* [123/4/2] 7-9 (-10)  $\times$  (5.5- 6.5-7(-8)  $\mu\text{m}$  [Q = (1.06-) 1.12-1.25 (-1.36), Q = 1.19  $\pm$  0.07], subglobose to broadly ellipsoid, rarely globose or ellipsoid, amyloid, colourless, hyaline, thin-walled, smooth.

*Habitat*: Gregarious on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., Khun Chang Kian, 29 July 2002, Z.L. Yang, R. Sanmee, S. & P. Lumyong (CMU 45216) – Chiang Mai



**Figs 8-10.** *Amanita* species, habit illustrations; cross-sections not to scale. **8.** *A. hongoi*, (CMU 45216). **9.** *A. fuliginea*, (CMU 45215). **10.** *A. sinocitrina*, (CMU 45230).

Prov., 50 km S of Om Koi, ca. Lahu village, 11 September 1999, D. Arora 99-280 (RET; SFSU).

*Notes:* This species is somewhat similar to *Amanita castanopsis* Hongo. However, the basidia of the latter have common clamp connections on their basal septa; and *A. castanopsis* has elongate spores (Hongo, 1974; Yang, 1997; Yang and Doi, 1999).

For comparative purposes, spore measurements from the protolog are provided: [20/1/1] (7-)8-10(-11.5) × 7-9(-10) μm [Q = 1-1.2, Q = 1.1].

*Amanita hongoi* was originally described from Japan. It has been reported from Korea and China (Kim *et al.*, 1993; Yang, 2005)

*Amanita japonica* Hongo *ex* Bas, *Persoonia* 5: 399 (1969).

Because of lack of data on the single collection obtained in the region of study, the following macroscopic description is excerpted

from the monograph of Bas (1969).

*Basidiocarps* 'medium-sized, slender'. *Pileus* '55-80 mm wide, convex then plane, with appendiculate, non-sulcate margin, dry, at first moderately dark grey to pale buffy grey ['drab-grey' to 'light drab' of Ridgway (1912)], felted-subflocculose, rather densely set with somewhat paler, floccose-felted, subpyramidal, adnate warts, up to about 2 mm wide and 1.5 mm high; later coloured surface of cap breaking up into vaguely delimited, thin patches between which whitish flesh showing, in which case every pale wart situated at centre of a minutely radially fibrillose, practically circular, darker grey spot; warts and spots diminishing in size and less distinct towards margin'. *Lamellae* 'close to subdistant, nearly free, sometimes with slight decurrent teeth, rather broad, 7-8 mm broad, subventricose, white, with subflocculose edge'; lamellulae 'subtruncate to attenuate'. *Stipe* 80-170 × 7-15 mm,

attenuate upward, with fusiform-rooting to subclavate base up to 25 mm wide, solid, white, floccose, with flocculose-pulverulent to small, vague, scale-like, pale buffy grey ('light drab' of Ridgway) remnants of volva on lower half, with fugacious floccose-fibrillose remnants of white ring at top. Flesh soft. Taste and smell indistinct'.

*Basidia* bearing clamps. *Basidiospores* [23/1/1] 8-9(-11.5) × (4.5-)5.5-6.5(-7.5) μm [Q = 1.34-1.64(-2), Q = 1.52 ± 0.14], colourless, hyaline, thin-walled, smooth, amyloid, ellipsoid to elongate; apiculus sublateral; contents granular to guttulate.

*Habitat*: On ground under *Quercus* and *Dipterocarpaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., Om Koi, 1999 D. Arora s.n. (RET; SFSU).

*Notes*: The single specimen available is not in good condition, and the spore size and value of Q are probably somewhat depressed because of its condition prior to, or during, drying. Nevertheless, clamps were not difficult to find in the stipe context. Among Asian taxa, *A. japonica* is most similar to *A. miculifera* Bas & Hatan. (Bas & Hatanaka, 1984) and *A. griseoverrucosa* Zhu L. Yang. According to Yang (1997), *A. miculifera* differs from *A. japonica* in having a conic to flattened-conic pileus with volval remains in the form of friable warts, a stipe with a notably radicating basal bulb, larger spores, and a disordered microscopic structure in volval remnants. Its authors placed *A. miculifera* in Bas' stirps *Virgineoides*, not with *A. japonica* in Bas' stirps *Solitaria*. *Amanita griseoverrucosa* has a much less strongly rooting bulb, lighter coloured volval remnants on the pileus, and no clamps (Yang, 2004). *Amanita eijii* Zhu L. Yang (2002a) is a recently described species of stirps *Solitaria* that should be compared with the present species. Yang's species is distinguished among other things by its often larger basidiocarp, becoming pinkish to brownish in part after *in situ* aging or cutting, an annulus that is membranous or submembranous and sometimes persistent with fibrils largely free from the undersurface attaching that surface to the stipe, distinctly reflexed scales (with volval material on their tips) arranged in incomplete or complete rings on the lower portion of the stipe and the upper part of its bulb, and slightly

longer and significantly broader spores with Q = 1.36 ± 0.08.

Spore measurements from southwestern Chinese material of *A. japonica* (Yang, 1997) are provided for purposes of comparison: [70/2/2] (7.5-)8.5-10.5 × (5-)5.5-7 μm [Q = (1.31-)1.36-1.67(-1.81), Q = 1.52 ± 0.1].

*Amanita japonica* was originally described from Japan.

*Amanita sculpta* Corner & Bas, *Persoonia* 2: 255 (1962).

*Basidiocarps* large to very large, taking on a dark wine colour when dried. *Pileus* 10-22 cm wide, convex to plane, margin non-striate, appendiculate, reddish brown, decorated with chocolate brown, 6-13 mm high, 6-12 mm wide, conic warts; mature cap margin upturned, warts easily breaking off. *Lamellae* free, crowded, white when young, turning pinkish to violet when mature, up to 2 cm broad; lamellulae truncate. *Stipe* 28-35 × 2.5-4 cm, equal with bulbous base, 5.5-6.5 cm wide, reddish brown, fibrillose, floccose to squamulose, with somewhat recurved squamulose warts around stipe base. Context solid, white, turning pinkish to purplish when cut or bruised. Spore print white.

*Lamella trama* bilateral. *Subhymenium* 40-48 μm thick, with 2-3 layers of subglobose, ovoid, or doliform cells, 13-24 × 10-15 μm. *Basidia* 40-60 × 12-17 μm, clavate, 4-spored; sterigmata 4-7 (-9) μm long; basal septa without clamps. *Basidiospores* [30/1/1] (8-)9-11(-11.5) × (8-)9-10.5(-11) μm [Q = 1-1.04(-1.08), Q = 1.02 ± 0.02], globose to subglobose, amyloid, colourless, hyaline, thin-walled, smooth; apiculus small. *Volval* remnants on pileus comprising inflated cells, subglobose, ovoid, ellipsoid to pyriform, 24-130 × 16-80 μm, thin-walled, colourless, or sometimes with yellow-brown content; filamentous hyphae fairly abundant, 2.5-8(-12) μm wide; vascular hyphae rare, ca. 4 μm wide.

*Habitat*: Solitary on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 30 July 1999, S. & P. Lumyong, R. Sanmee (CMU 0031) – Chiang Mai Prov., DSPNP-Quinine Garden, 9 July 2002, Z.L. Yang & R. Sanmee (CMU 45160) – Nakohn Panom Prov., loc. unkn., in market, July 1999, D. Arora 99-185 (RET; SFSU).

*Notes:* This species has a thick, submembranous, floccose-arachnoid, disrupting, pale dingy vinaceous ring (Corner and Bas, 1962). Annuli of the specimens cited above were fugacious. This species is similar to the North American *A. westii* (Murrill) Murrill as noted by Bas (1969) and Tulloss and Lewis (1994).

For purposes of comparison, spore measurements from southwestern Chinese material (Yang, 1997) are provided: [70/2/2] (7.5-)8-11(-15.5) × (7.5-)8-10.5(-14.5) μm [Q = 1-1.1(-1.13), Q = 1.05 ± 0.03].

*Amanita sculpta* was originally described from North Borneo and Singapore.

*Amanita virgineoides* Bas, Persoonia 5: 435 (1969).

*Basidiocarps* medium to large. *Pileus* 7-13.5 cm wide, convex to plane, margin non-striate, appendiculate, white, densely covered with white conic to subconic warts, 1-3 mm high, easily removed when touched. *Lamellae* free, white, crowded, 10 lamellae/cm, approx. 0.9 cm broad; lamellulae attenuate. *Stipe* 14-19 × 1.5-2 cm, equal with bulbous base 4-4.5 cm wide, white, covered with white squamules. Context white, solid. *Annulus* white, membranous, descending, fragile, soon falling to pieces. Spore print white.

*Lamella trama* bilateral. *Subhymenium* 2-3 layers of subglobose, ellipsoid, cuneiform to broadly pyriform cells, 8-22 × 6-15 μm. *Basidia* 32-48 × 9.5-12 μm, clavate, 4-spored; sterigmata 3-5 μm long; basal septa often with clamps. *Basidiospores* [30/1/1] (7.5-)8-9 × (5-)6-7 μm [Q = (1.11-)1.25-1.47(-1.69), Q = 1.35 ± 0.11], broadly ellipsoid to ellipsoid, infrequently subglobose, amyloid, colourless, sometimes guttulate, hyaline, thin-walled, smooth. *Volval remnants on pileus* comprising irregularly arranged elements: inflated cells fairly abundant to abundant, ellipsoid to subglobose, 16-48 × 13-36 μm, thin-walled, colourless, filamentous hyphae, 3-6 μm wide.

*Habitat:* Solitary or gregarious. Terrestrial in forest of *Fagaceae*.

*Material examined:* THAILAND, Chiang Mai Prov., DSPNP-Quinine Garden, 6 June 2002, R. Sanmee, R. Kodsueb, W. Chittrong & W. Bhilabut (CMU 4502).

*Notes:* The present species is somewhat similar to *A. eijii*, however the pinkish staining of lamellae and trama of the latter are not seen in *A. virgineoides*. Moreover, *A. eijii* has larger

spores (Yang, 2002a). See notes under *A. japonica*, above.

Data from a larger sampling of spores (Yang, 1997) based on southwestern Chinese material is provided for comparison: [160/7/6] (7.5-)8-10(-11.5) × (5.5-)6-7.5(-8.5) μm [Q = (1.07-)1.18-1.5(-1.67), Q = 1.34 ± 0.11].

*Amanita virgineoides* was originally described from Japan. It has been reported from Korea (Kim *et al.*, 1993).

### *Amanita section Phalloideae (Fr.) Quél.*

*Amanita fuliginea* Hongo, The Journal of Japanese Botany 28: 69 (1953). (Fig. 9)

*Basidiocarps* medium-sized. *Pileus* 3-4 cm wide, umbonate-convex to plane, margin non-striate, non-appendiculate, dark brown to blackish over umbo, paler toward margin, appearing innately fibrillose, with broad low umbo, glabrous. *Lamellae* free, white, 0.4 cm broad, subcrowded; lamellulae attenuate. *Stipe* 7 × 0.5 cm, equal, slightly tapering upward, apex slightly expanded, dirty white, decorated with grey or brownish grey fibrils or squamules, subbulbous at base, approx. 1 cm wide, solid; context white. *Annulus* grey, apical, membranous. *Volva* limbate, white, membranous, 1.5 cm from bottom of bulb to upper edge of limb.

*Basidia* 31-35 × 11-15 μm, clavate, 4-spored; sterigmata 4-5.5 μm long; basal septa without clamps. *Basidiospores* [30/1/1] 7-8.5(-10) × (6.5-)7-8(-9.5) μm [Q = 1-1.06 (1.11), Q = 1.04 ± 0.04], globose to subglobose, amyloid, colourless, hyaline, thin-walled, smooth.

*Habitat:* Solitary on ground in forest of *Fagaceae*.

*Material examined:* THAILAND, Chiang Mai Prov., Khun Chang Kian, 29 July 2002, P. Lumyong (CMU 45215).

*Notes:* This mushroom is similar to *A. elephas* Corner & Bas, but the latter has a white ring and smaller subglobose to broadly ellipsoid spores (Corner and Bas, 1962).

Concerning *A. fuliginea*, Yang (2007c) writes, "This species is deadly poisonous. Many disasters have happened in central China in the last few years due to people's eating this mushroom."

Spore measurements from southwestern Chinese material (Yang, 1997) are supplied for comparative purposes: [30/1/1] (7.5-)8-10 (-11) × (6.5-)7-9.5 (-10) μm [Q = 1-1.13(-1.21), Q =

1.07 ± 0.05].

*Amanita fuliginea* was originally described from Japan.

*Amanita manginiana sensu* W.F. Chiu, Science Reports of National Tsing Hua University, Series B, Biological & Psychological Sciences 3: 166 (1948).

*Basidiocarps* medium-sized to large. *Pileus* 9-13 cm wide, convex to plane, greyish brown, appearing innately fibrillose, glabrous, subviscid; margin smooth, non-striate, non-appendiculate. *Lamellae* free, cream, crowded, averaging 9 per cm; lamellulae attenuate. *Stipe* 12-13.5 × 2-2.5 cm, white, slightly tapering upward; context white, solid. *Annulus* white, apical, membranous, fragile, soon falling to pieces. *Volva* 5-6 × 3-4 cm, limbate, membranous, white.

*Basidia* 29-36 × 8-11 μm, clavate, 4-spored; sterigmata 3.5-4.5 μm long; basal septa without clamps. *Basidiospores* [30/1/1] (5.5-)6-7 × 5-6(-7) μm [Q = 1-1.2 (-1.5), Q = 1.16 ± 0.13], globose, subglobose, broadly ellipsoid, sometimes ellipsoid, amyloid, colourless, hyaline, thin-walled, smooth.

*Habitat*: Solitary on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., Khun Chang-Kian, 11 June 2002, R. Sanmee (CMU 4530).

*Notes*: *Amanita manginiana sensu* W.F. Chiu is an edible species known in China (Yang, 1997), but until now unknown in Thailand. According to the original description of Hariot and Patouillard (1914) and the coloured illustrations published by Gilbert (1941), *A. manginiana* Har. & Pat. differs from *A. manginiana sensu* W.F. Chiu by its castaneous brown pileus with castaneous brown fimbriate pileal margin, and a brownish limbate volva on the stipe's bulb (Yang, 1997).

For comparative purposes, spore measurements from southwestern Chinese material (Yang, 1997) are provided: [200/9/5] (5.5-)6-8 (-9) × (4.5-)5-7 (-7.5) μm [Q = (1-)1.07-1.3(-1.44), Q = 1.20 ± 0.07].

The current species was reported previously from China and Japan (Yang and Doi, 1999; Yang, 2005).

*Amanita pseudoporphyria* Hongo, The Journal of Japanese Botany 32: 141 (1957).

*Basidiocarps* medium-sized to large. *Pileus* 5-10 cm wide, grey to pale grey or pale greyish brown, pigment more concentrated over disc in older material, smooth, with margin nonstriate and sometimes bearing fragments of annulus. *Lamellae* white, adnexed, sometimes yellowish in age; lamellulae plentiful, of diverse lengths, unevenly distributed, rounded truncate to subtruncate (with narrow tooth along pileus context) to attenuate. *Stipe* 10-20 × 1-1.6 cm, white, cylindrical; context white, stuffed; bulb subfusiform, white. *Annulus* very thin, membranous, skirt-like, apical, with floccose underside occasionally separable. *Volva* thin, white, limbate, with distance from bottom of bulb to top of limb 1.9-5 cm.

*Basidia* 4-sterigmate; basal septa without clamps. *Basidiospores* [40/2/2] (5-)7-8(-9) × (4-)5-6(-7) μm [Q = 1.19-1.62(-1.88), Q = 1.35 ± 0.13], broadly ellipsoid to ellipsoid, rarely elongate, colourless, hyaline, thin-walled, smooth, amyloid; apiculus cylindrical; contents guttulate.

*Habitat*: On ground in forest of *Dipterocarpaceae*; in one case, with forest dominated by young trees.

*Material examined*: THAILAND, Chiang Mai Prov., Hang Dong, 20 August 1995, D. Arora *s.n.* (RET; SFSU) – Sakhon Nakhon Prov., Poo Pan, August 1998, D. Arora 98-43 (RET; SFSU).

*Notes*: Bhatt *et al.* (2003) proposed that *A. indica* R.P. Bhatt, Locq. & T.N. Lakh. (Kumar *et al.*, 1990) is a synonym of the present species. The species is eaten in the Thai provinces from which material is reported. Arora (pers. comm.) reports market names for this species that he transliterated as 'hed mahn ung', 'hed man', and 'hed lai'.

For comparative purposes, spore measurements from plentiful southwestern Chinese material (Yang, 1997) are provided: [405/16/12] (6-)7-9(-10.5) × (4.5-)5-6.5(-7.5) μm [Q = (1.09-)1.21-1.58(-1.8), Q = 1.39 ± 0.11].

*Amanita pseudoporphyria* was originally described from Japan. In addition to China (Yang, 1997; 2005), this species has been reported from northern India (Bhatt *et al.*, 2003) and Korea (Kim *et al.*, 1993).

#### *Amanita section Validae (Fr.) Quél.*

*Amanita flavipes* S. Imai *sensu lato*, Botanical Magazine (Tokyo) 47: 428 (1933).

*Basidiocarps* small to medium-sized.

*Pileus* 3.5-5.5 cm wide, umbonate-convex to plane, olivaceous buff to honey-yellow, paler toward margin, non-striate, non-appendiculate, volval remnants as floccose patches, yellow, diminishing toward margin. *Lamellae* white to cream, free, subcrowded, 12-13 lamellae/cm; lamellulae attenuate. *Stipe* 6-7 × 1.5-2 cm, yellowish, slightly tapering upward, floccose, bulbous at base, 1.2-1.3 cm wide, upper part of bulb sometimes decorated with yellowish, floccose patches or occasionally with yellowish, floccose ring; context white to whitish, hollow. *Annulus* yellowish, median, sometimes ascending, membranous, thin, persistent.

*Basidia* 30-40 × 11-12 μm, clavate, 4-spored; sterigmata 3-5 μm long; basal septa without clamps. *Basidiospores* [90/3/2] (6.5-)7-8(-9) × (5-)5.5-7(-8) μm [Q = 1.06-1.38 (-1.47), Q = 1.2 ± 0.09], subglobose to broadly ellipsoid, sometimes ellipsoid, amyloid, colourless, hyaline, thin-walled, smooth.

*Habitat*: Subgregarious on ground in forest of *Fagaceae*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Sun Gu, 11 June 2002, S. & P. Lumyong, R. Sanmee (CMU 4529) – *ibid.*, 3 July 2002, R. Sanmee (CMU 45111).

*Notes*: Tulloss *et al.* (2001) proposed that *A. watlingii* Ash. Kumar & T.N. Lakh. is a taxonomic synonym of *A. flavipes*.

Comparative spore measurements are found in two recent papers. Spores from southwestern Chinese material come from (Yang, 1997): [210/8/6] (6.5-)7-9(-10) × (5-)5.5-7 (-8.5) μm [Q = (1.06-)1.2-1.48(-1.56), Q = 1.31 ± 0.07]. Very similar spore measurements from Indian and Pakistani material can be found in Tulloss *et al.* (2001).

This species has been reported to have one of the most extended ranges known for an Asian *Amanita* species—extending from Japan (protolog) and Korea in the northeast and Thailand in the south to northwestern Pakistan in the west (Kim *et al.*, 1993; Yang, 1997; Tulloss *et al.*, 2001; Tulloss, 2005). This range description may need to be revised because Zhang *et al.* (2004) reported the presence of genetically and morphologically distinguishable taxa within *A. flavipes sensu lato*.

*Amanita fritillaria* (Berk.) Sacc., Sylloge Fungorum 9: 2 (1891).

*Basidiocarps* medium-sized. *Pileus* 6-9.5 cm wide, convex to plane, greyish brown;

margin non-striate, non-appendiculate; volval remnants as floccose patches, dark brown to fuscous, diminishing in size and frequency toward margin. *Lamellae* free, crowded, approx. 17-21 lamellae/cm, white; lamellulae attenuate. *Stipe* 7-12.5 × 0.5-1.5 cm, slightly tapering upward, paler brown, decorated with greyish brown fibrils, subbulbous at base, 1.5-2 cm wide; upper part of bulb decorated with blackish brown, floccose warts in one or more rings; context white to whitish. *Annulus* greyish brown, membranous, apical. Spore print white.

*Basidia* 33-37 × 7-11 μm, clavate, 4-spored; sterigmata 3.5-4.5 μm long; basal septa without clamps. *Basidiospores* [160/5/5] (6.5-)7-9(-10) × (5-)5.5-7(-8.5) μm [Q = 1.06-1.43(-1.56), Q = 1.22 ± 0.11], broadly ellipsoid, sometimes subglobose or ellipsoid, amyloid, colourless, hyaline, thin-walled, smooth.

*Habitat*: Solitary or gregarious on ground in forests including *Fagaceae*, *Dipterocarpaceae*, and *Pinus*.

*Material examined*: THAILAND, Chiang Mai Prov., DSPNP-Huay Kog Ma, 30 July 1999, S. & P. Lumyong, R. Sanmee (CMU 0038) – *ibid.*, 9 May 2000, S. & P. Lumyong, R. Sanmee (CMU 2050) – Chiang Mai Prov., DSPNP-Quinine Garden, 6 June 2002, R. Sanmee (CMU 4503) – Chiang Mai Prov., Khun Chang Kian, 14 June 2002, R. Sanmee & R. Kodsueb (CMU 4562) – Chiang Mai Prov., Sanpathong, Mae Wang, 5 October 2002, R. Sanmee, S. & P. Lumyong (CMU 45270) – Phayao Prov., DLNP-Jamphong, 28 May 2000, S. & P. Lumyong & students (CMU 2136).

*Notes*: Yang (2004, 2005) regards *Amanita spissacea* S. Imai (1933) as a synonym of *A. fritillaria*.

For comparative purposes spore measurements from plentiful southwestern Chinese material (Yang, 1997) are provided: [395/23/17] 7-9(-12) × 5.5-7(-8.4) μm, [Q = (1.03-)1.18-1.4 (-1.54); Q = 1.28 ± 0.07].

*Amanita fritillaria* was originally described from northern India. In addition to China, this rather common species has been reported from Singapore (Corner and Bas, 1962), Japan (*e.g.*, as *A. spissacea*), and Korea (Kim *et al.*, 1993, as *A. spissacea*).

*Amanita sinocitrina* Zhu L. Yang, Zuo H. Chen & Z.G. Zhang, Mycotaxon 79: 275 (2001). (Fig. 10)

*Basidiocarps* medium-sized. *Pileus* 4-5 cm wide, convex to plano-convex, greyish brown, darker over disc, appearing innately fibrillose, with low umbo, becoming depressed at centre; margin non-striate, non-appendiculate;

context cream. *Lamellae* free, crowded, white to cream; lamellulae attenuate. *Stipe* 8-12 × 0.4-0.7 cm, dirty white, tapering upward, with apex slightly expanded, decorated with greyish brown fibrils; marginate, bulbous base ca. 1-1.3 cm wide. *Annulus* dirty white, membranous.

*Lamella trama* bilateral. *Subhymenium* ca. 20-40 μm thick, with 2-4 layers of globose to subglobose, ellipsoid to pyriform cells, 7-38 × 7-20 μm. *Basidia* 22-36 × 9-12 μm, clavate, 4-spored; sterigmata 2.5-4(-5) μm long; basal septa without clamps. *Basidiospores* [30/1/1] (6.5-)7-8(-9) × 6.5-7.5(-8.5) μm [Q = 1-1.06 (-1.1), Q = 1.03 ± 0.03], globose to subglobose, amyloid, colourless, hyaline, thin-walled, smooth.

*Habitat*: Solitary on ground in *Castanopsis* forest.

*Material examined*: THAILAND, Chiang Mai Prov., Khun Chang-Kian, 29 July 2002, Z.L. Yang & H.Y. He (CMU 45230).

*Notes*: *Amanita sinocitrina* is rather similar to *A. bulbosa* var. *citrina* (Schaeff.) Gillet (≡ *A. citrina* (Schaeff.) Pers.). However, *A. sinocitrina* differs from *A. bulbosa* var. *citrina* by its differently coloured pileus with somewhat darker coloured volval remnants, smaller basidia, and significantly smaller spores (Chen *et al.*, 2001).

Spore measurements from the protolog are provided for comparative purposes: [135/6/5] (5.5-)6-7.5(-8) × (5-)5.5-7(-7.5) μm, [Q = 1-1.15(-1.2); Q = 1.08 ± 0.05].

## Discussion

### *A few words on Amanita poisonings*

*Amanita* is important as a food source for local people in northern Thailand (Sanmee *et al.*, 2003; Dell *et al.*, 2005). At least six species are edible (*A. chepangiana*, *A. hemibapha sensu lato*, *A. princeps*, *A. manginiana sensu* W.F. Chiu, *A. pseudoporphyria* and *A. sinensis*) and three (*A. princeps*, *A. chepangiana*, and *A. hemibapha sensu lato*) are very common in northern Thai markets during the wet season (July to September).

On the other hand, one must have concern over ingestion of toxic species of *Amanita* in the region of study. Care must be taken to avoid confusion of comestible and toxic species of *Amanita* when they are being

collected in the wild for food. Each rainy season in Thailand, there is a risk of consuming poisonous mushrooms because, unlike in parts of Western Europe, there is no reliable system for the certification of fungal identification in rural or city markets.

There are reports in newspapers each year of poisonings: (a) Dr. Vivatth Koviriyakamon, Public Health of Loei Province, released numbers of victims of mushroom poisoning—60 people in 1999, 27 people in 2000 (one death) and 84 people in 2001 (Dailynews, Bangkok, June, 10 2002); (b) Dr. Ittiphon Sungkaeng, Public Health of Yasothorn Province, warned people to be careful about collecting wild mushrooms since in 2001 there were three deaths in Ubonrachathanee Province because of mistaken identification of a deadly *Amanita* or ‘hed rangok hin’ in the local language (Dailynews, Bangkok, July, 8 2003); (c) the Ministry of Public Health released the number of victims of life-threatening mushroom poisoning during January to July of 2003 as 132 (7 deaths) (Dailynews, Bangkok, September, 10 2003). Mention of an additional poisoning can be found in the notes on *A. chepangiana* (*Amanita* sect. *Caesareae*), above. In spite of poisonings attributed to the genus, *Amanita* species remain popular table mushrooms for people in northern Thailand.

The single species containing amatoxins that was found in this study is *A. fuliginea* of sect. *Phalloideae*. A number of toxic species previously reported from Thailand were *not* found during the present study: *A. muscaria* (L. : Fr.) Lam., *A. pantherina* (DC. : Fr.) Krombh., *A. phalloides* (Fr. : Fr.) Link, *A. verna* and *A. virosa* (Fr.) Bertill. (Soytong, 1994; Rachabunditayasathan, 1996; Chansrikul, 1998; Chaiear *et al.*, 1999). Recent studies in eastern and southern Asia (*e.g.*, northern India, north-western Pakistan, and south-western China) have demonstrated that collections identified in the past under the cited names were misidentified (*e.g.*, Yang, 1997, 2002; Yang and Doi, 1999; Yang and Lee, 2001; Bhatt *et al.*, 2003). Hence, the Thai reports need re-examination.

With regard to amatoxins, in the notes on *A. chepangiana*, above, we list a set of white species of sect. *Phalloideae* from the group called ‘destroying angels’ in English. Since the

listed species are present to the west and north of the study area, they may also occur in Thai forests, particularly in association with species of *Fagaceae* or *Pinaceae*. Based on data from India and China (Bhatt *et al.*, 2003; Yang, 2005) and using the same reasoning, the deadly poisonous *A. subjunquillea* S. Imai (1933) (perhaps previously determined as '*A. phalloides*') is likely to occur in Thailand.

With regard to the Pantherine Syndrome (Benjamin, 1995) in Thai amanitas, *A. subglobosa* is one of the muscarioid taxa of sect. *Amanita* and should be suspected of harboring toxins similar to those of *A. muscaria* and *A. pantherina*.

With regard to the so-called 'amino-acid poisoning' recently documented in species of sect. *Lepidella* such as *A. smithiana* Bas (Tulloss and Lindgren, 1992; Pelizzari *et al.*, 1994; Benjamin, 1995), all taxa in sect. *Lepidella* should be suspect unless there is convincing ethnomycological and/or toxicological evidence to the contrary. This type of poisoning can cause life-threatening shutdown of both the kidney and liver. At least one species of sect. *Amidella* (*A. proxima* Dumée) has been reported to cause serious poisonings in Europe (Neville and Poumarat, 2001) with symptoms similar to those seen in *A. smithiana* intoxications.

Sufficient evidence from other regions of the world suggest that species of sect. *Validae* should be suspected of containing a heat-labile hemolytic compound causing gastrointestinal distress if eaten without cooking (*e.g.*, Benjamin, 1995). Commonly, populations that regularly eat species of this section have a long ethnomycological history that teaches them never to eat their familiar species of sect. *Validae* raw.

Inquiries among local people who loving eating *Amanita* indicate that they will not renounce eating this genus, so there is a need for more public education concerning use of *Amanita* as food.

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