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NOTULAE AD FLORAM AGARICINAM NEERLANDICAM – XXXIX
Bolbitius

EEF ARNOLDS

Holthe 21, 9411 TN Beilen, The Netherlands

A key is provided to the European taxa of *Bolbitius*, mainly based on a revision of material from the Netherlands and adjacent regions. The nomenclature and morphological variation of *B. titubans* and *B. reticulatus* are discussed. The new combination *B. titubans* var. *olivaceus* is proposed. Full descriptions are given of the critical species *B. demangei* and *B. lacteus*. *Bolbitius ferrugineus* is described as a new species, based on material from southern Italy.

In this paper some taxonomic and nomenclatural problems in the genus *Bolbitius* are discussed and a key to the recognized species in Europe is given. No recent monograph or critical revision of *Bolbitius* in Europe is available and current species concepts vary strongly from author to author. The descriptions given in this paper and in Flora agaricina neerlandica vol. 6 (Arnolds, in prep.) are based on newly collected material and on studies of herbarium specimens, mainly from the Nationaal Herbarium Nederland, Universiteit Leiden branch (L) and the Nationaal Herbarium Nederland, Wageningen university branch (WAG). Most collections studied originate from the Netherlands. In addition a new species, *Bolbitius ferrugineus*, is described, based on a collection from Italy.

KEY TO THE SPECIES OF BOLBITIUS IN EUROPE

1. Spores 9.5–16.0(–16.5) × 5.5–11.0 µm, on average 10.4–14.0 × 6.5–9.7 µm, rather thick-walled (0.5–1.8 µm), vividly orange-brown to rusty-brown; basidiocarps growing on dung, soil or litter, not on wood.
   2. Pileus bright yellow, olive-yellow or olive-brown ..... *B. titubans*
   2. Pileus without bright yellow or olivaceous colours but whitish, pink, orange or violaceous grey.
      3. Pileus whitish or cream-coloured and small, up to 15(–20) mm broad; spores (10.0–)10.5–14.0(–14.5) × (5.5–)6.0–7.5 µm, on average 11.5–12.4 × 6.6–6.8 µm ..... 2. *B. lacteus*
      3. Pileus with pink, orange or violaceous grey colours, at least when young, and larger, 30–80 mm broad.
         4. Pileus violaceous grey; spores (9.5–)10.5–13.0 × (5.5–)6.5–7.0(–7.5) µm, on average 11.1–11.7 × 6.5–6.8 µm, not or slightly flattened 3. *B. demangei*
         4. Pileus pink, pale orange or flesh-coloured when young, discolouring ochraceous or brownish; spores 11.5–16.0(–16.5) × 8.5–11.0 × 6.5–9.5 µm, on average 13.2–14.0 × 8.7–9.7 × 7.4–8.2 µm, distinctly flattened.

5. Pileus pale pink or pale orange at first, gradually fading to brownish
4. *B. coprophilus*

5. Pileus more intensely coloured, flesh-coloured at first
(*B. incarnatus*, see notes on *B. coprophilus*)

1. Spores (6.5–)7.0–12.0(–12.5) × (3.5–)4.0–5.5(–6.5) µm, on average (7.9–)8.3–9.9 × (4.1–)4.5–5.2 µm, thin-walled (< 0.5 µm), pale yellow-brown to brownish orange; basidiocarps growing in forests, often on decayed wood, occasionally on soil.
   6. Pileus whitish, pinkish, grey, brown, often with violaceous or olivaceous tone; basidiocarps usually on wood; pileipellis made up of clavate elements intermixed with trichodermal hyphae of short, cylindrical elements; clamp-connections absent or rare ..... 5. *B. reticulatus*
   6. Pileus orange-brown; basidiocarps on soil; pileipellis only made up of clavate elements; clamp-connections numerous ..... 6. *B. ferrugineus*

NOTES AND DESCRIPTIONS OF THE ACCEPTED TAXA

1. **Bolbitius titubans** (Bull.: Fr.) Fr. — Fig. 1

Bolbitius titubans (Bull.: Fr.) Fr., Epicrisis (1838) 254.

KEY TO THE VARIETIES

1. Pileus entirely bright lemon yellow to egg-yellow at first, becoming beige to brown in broad marginal zone when maturing, retaining bright yellow colour at centre; surface usually smooth, occasionally rugulose to reticulate with yellow veins, concolorous with background ..... 1a .var. *titubans*
1. Pileus ochre yellow, olivaceous yellow to olive-brown at first, becoming brownish in broad marginal zone on maturing, retaining yellowish or greenish colour at centre; surface often rugulose to reticulate with veins darker than background, occasionally smooth ..... 1b. var. *olivaceus*

1a. **Bolbitius titubans** (Bull.: Fr.) Fr. var. **titubans**

Bolbitius titubans (Bull.: Fr.) Fr. var. *titubans*, Epicrisis (1838) 254.

Agaricus titubans Bull., Herb. France (1789) pl. 425, fig. 1; *Agaricus titubans* Bull.: Fr., Syst. mycol. 1 (1821) 304; *Pluteolus titubans* (Bull.: Fr.) Quél., Fl. mycol. France (1888) 83.; *Bolbitius vitellinus* ssp. *titubans* (Bull.: Fr.) Konr. & M., Ic. sel. Fung. 2 (1932) pl. 171, fig. 2; *Bolbitius vitellinus* var. *titubans* (Bull.: Fr.) Bon & Courtec., Doc. mycol. 18 (69) (1987) 37. — *Agaricus vitellinus* Pers., Syn. meth. Fung. (1801) 402; *Agaricus vitellinus* Pers.: Fr., Syst. mycol. 1 (1821) 303; *Bolbitius vitellinus* (Pers.: Fr.) Fr., Epicrisis (1838) 254; *Pluteolus vitellinus* (Pers.: Fr.) Quél., Fl. mycol. France (1888) 83. — *Agaricus fragilis* L., Spec. Pl. (1753) 1175; *Bolbitius fragilis* (L.) Fr. Epicrisis (1838) 254; *Pluteolus vitellinus* var. *fragilis* (L.) Quél., Fl. mycol. France (1888) 83; *Bolbitius vitellinus* ssp. *fragilis* (L.) Konrad & Maubl., Ic. sel. Fung. 2 (1932) pl. 171. fig. 1; *Bolbitius vitellinus* var. *fragilis* (L.) Bon & Courtec., Doc. mycol. 18 (69) (1987) 37.

Bolbitius titubans var. *titubans* is a common and well-characterized agaric, in general better known with the name *Bolbitius vitellinus*. Both names *Agaricus titubans* and *A. vitellinus* were sanctioned by Fries but the former name has priority since it is based on the oldest name, viz. *Agaricus titubans* Bull. (Herb. France: 425, 1789).

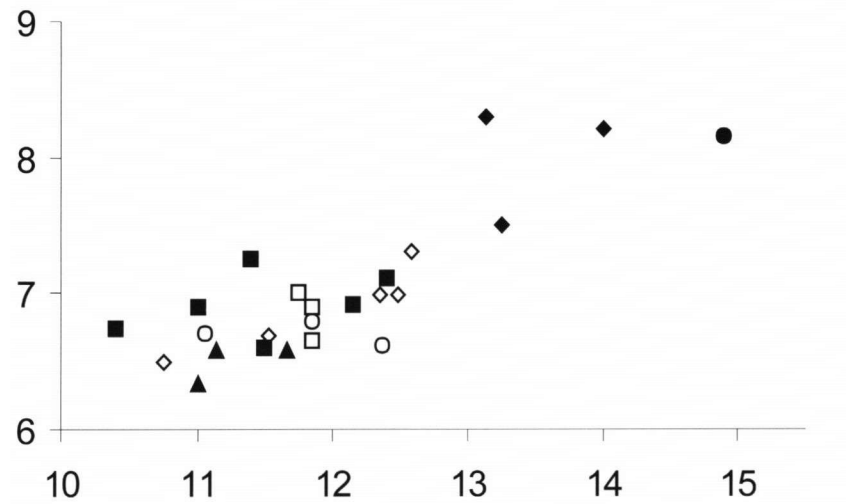

Fig. 1. Average spore size (at least 10 spores measured in side-view) in basidiocarps of *Bolbitius titubans* var. *titubans* with pileus less than 25 mm broad (■); *B. titubans* var. *titubans* with pileus broader than 25 mm (◇); *B. titubans* var. *olivaceus* (□); *B.* spec. aff. *titubans* var. *olivaceus* (●); *B. lacteus* (○), *B. demangei* (▲) and *B. coprophilus* (◆).

Many authors distinguish two or three taxa (species, subspecies or varieties) within *Bolbitius titubans*. For instance, Moser (1983) distinguished var. *vitellinus* with a deep yellow pileus, white stipe and spores measuring 12–13 × 6–7 µm, var. *titubans* with a lemon-yellow, deeply striate pileus, yellowish stipe and spores measuring 13–15 × 7–9 µm and var. *fragilis* with a lemon-yellow pileus striate at margin only, yellowish stipe and spores measuring 9–12 × 6–7 µm. Watling (1982) and Bon (1992) distinguished *B. titubans* and *B. vitellinus* as different species. *B. titubans* sensu stricto is said to be characterized by small basidiocarps with strongly striate, bright yellow pileus and yellow stipe; *B. vitellinus* by larger basidiocarps with the pileus striate at margin only and a white stipe. Cetto (1989) and Courtecuisse & Duhem (1994) described these two taxa as varieties of a single species. On the other hand, Enderle et al. (1985) argued that all three taxa are only phenotypic variants of a single species without taxonomic relevance. Their opinion was shared by Ryman & Holmåsen (1984), Gerhardt (1997) and others.

On the basis of extensive studies of collections from the Netherlands I support the view that there is only one, variable species. The size of the basidiocarps is quite variable indeed with an expanded pileus ranging from 10–65 mm diameter. This variation can be explained by differences in nutrient status of the substrate (Enderle et al., 1985). Large basidiocarps were usually collected from heaps of dung or wood chips, small basidiocarps from dead grass remains or manured soil. Similar variation is found in other coprophytic species, for instance in *Psilocybe semiglobata* (Batsch: Fr.) Noordel. with a pileus size ranging from 3–30 mm.

It is true that in general the pileus of smaller basidiocarps is paler yellow and stronger striate than the pileus of larger basidiocarps, but this is a normal phenomenon

among agarics. No correlation between yellow colours on the stipe and the size of basidiocarps was found. The spore size showed considerable variation with a minimum size of (8.5–)9.5–11.5 × 6.0–7.5 μm, on average 10.4 × 6.7 μm (collection *Arnolds 7114*, WBS) and a maximum of 10.5–15.0 × 6.0–9.0 μm, on average 12.5 × 7.3 μm (collection *P.B. Jansen 82-240*, L) (Fig. 1). However, a continuous range of collections with intermediate spore size exist. Spore size is correlated neither with the size of basidiocarps (Fig. 1), nor with any other morphological character. Conclusively, there is no reason to distinguish several (intraspecific) taxa on the basis of morphological characters.

A complete description of *B. titubans* var. *titubans* will be published in Flora agaricina neerlandica vol. 6 (Arnolds, in prep.).

1b. **Bolbitius titubans** var. **olivaceus** (Gillet) Arnolds, *comb. nov.*

Basionym: *Bolbitius vitellinus* var. *olivaceus* Gillet in Rea, Brit. Basidiomyc. (1922) 497.

Synonyms: *Bolbitius variicolor* G.F. Atk., Studies Amer. Fungi (1900) 164.; *Mycena variicolor* (G.F. Atk.) Murrill, N. Amer. Fl. 10 (1917) 191; *Bolbitius vitellinus* var. *variicolor* (G.F. Atk.) Krieglst., Beitr. Kenntn. Pilze Mitteleuropas 7 (1991) 62.

Bolbitius titubans var. *olivaceus* is often regarded as a separate species under the well-known, correct name *B. variicolor*, for instance by Watling (1982), Furrer-Ziogas (1990), Courtecuisse & Duhem (1992). *Bolbitius variicolor* is said to differ in (1) duller colours of the pileus, ranging from olive-brown to olivaceous yellow or brownish yellow when young; (2) the pileus surface that is often darker brown radially rugulose or reticulate at centre; and (3) regular occurrence in fascicles of several basidiocarps. Basidiocarps combining all these features are quite characteristic and illustrated by e.g. Cetto (1979), Enderle et al. (1985), Furrer-Ziogas (1990), Ludwig (2000, pl. 14, fig. 5.5A). However, the darker veins on the pileus are lacking in many collections with olivaceous colours, as illustrated by Breitenbach & Kränzlin (1995) and Ludwig (2000, pl. 14, fig. 5.5B). On the other hand, large basidiocarps of *B. titubans* var. *titubans* may have a bright yellow pileus with conspicuous concolorous, radial veins, occasionally even with darker brown veins. Such collections have been depicted by Dähncke (1993: 586, as *B. vitellinus*) and by Courtecuisse & Duhem (1994: pl. 1309, as *B. variicolor*).

Both var. *olivaceus* and var. *titubans* may occur fasciculate on large, homogeneous substrates, such as soil mixed with dung and on wood chips. On excrements *B. titubans* var. *olivaceus* grows solitary, like var. *titubans*.

The microscopic characters of var. *olivaceus* are identical with var. *titubans*. The average spore sizes of the collections studied are indicated in Fig. 1. A collection made by Huijsman in 1938 near Domburg with macroscopical characters of var. *olivaceus* differs in very large spores: (13.0–)14.0–17.5 × 8.0–10.0 × 7.5–9.0 μm, av. 14.9 × 9.1 × 8.2 μm. It may represent in fact a different taxon. Unfortunately the exsiccatum is in bad condition, heavily damaged by moulds.

Krieglsteiner (1991) reduced *B. variicolor* to a variety of *B. vitellinus*. His suggestion was accepted by e.g. Breitenbach & Kränzlin (1995) and Ludwig (2000). In view of the described variation I follow this proposal. In fact the only remaining difference with *B. titubans* var. *titubans* is the duller pileus colour with olivaceous tones in the former taxon. Such a taxon was described before by Gillet (Rea, 1922) with the short

diagnosis: "Differs from the type in its *olivaceous colour*. Horse dung." No authentic herbarium material could be traced but there is little doubt that this variety is identical with *B. variicolor*. The epithet *olivaceus* has priority in the rank of variety, as Watling (1982) suggested before.

For a concise description of *B. titubans* var. *olivaceus* and full references to other descriptions and plates one is referred to Flora agaricina neerlandica vol. 6 (Arnolds, 2003).

2. **Bolbitius lacteus** J.E. Lange — Fig. 1, 2

Bolbitius lacteus J.E. Lange, Fl. agar. dan. 5, Appendix (1940) II.

Excluded — *Bolbitius lacteus* sensu Watling & Knudsen, Svampe 4 (1981) 78. (= *B. reticulatus* var. *pluteoides*); *Bolbitius lacteus* sensu Watling, Nordic J. Bot. 3 (1983) 265. (= *B. reticulatus* var. *pluteoides*); *Bolbitius lacteus* sensu Bon, Mushr. Toadst. (1987) 261. (= *Conocybe apala* (Fr.: Fr.) Arnolds var. *albipes* (Otth) Arnolds (= *C. albipes* (Otth) Hauskn. = *C. lactea* J.E. Lange).

Pileus 8–15(–20) mm, conico-convex at first, then plano-convex to flattened, milk white (K. & W. 1A1/A2) with cream-coloured (2A2) centre at first, then from the margin becoming isabella to pale brown, centre retaining pale colour, smooth, then sulcate-striate up to 3/4 of the radius, viscid, soon deliquescent. Lamellae, L = 24–34, l = 1–3, free, crowded, segmentiform, very thin, whitish at first then brownish orange to orange-brown, with white fimbriate edge, occasionaly weeping hyaline droplets, soon deliquescent. Stipe 27–50 × 1–2(–3) mm, cylindrical, fistulose fragile, white to cream-coloured, entirely pruinose-flocculose. Context submembranaceous, fragile, in pileus white, in stipe pale yellow. Smell and taste weak, not distinctive. Spore print not recorded.

Spores (10.0–)10.5–14.0(–14.5) × (5.5–)6.0–7.5 μm, on average 11.5–12.4 × 6.6–6.8 μm, Q = (1.5–)1.6–1.9, av. Q = 1.7–1.8, not to distinctly flattened, in front-view ellipsoid- to ovoid-oblong, in side-view ellipsoid-oblong to subamygdaliform, rarely subphaseoliform, orange-brown in alkali (6C8, 6D8), fairly thick-walled (0.5–1.0 μm) with central to slightly eccentric germ pore, 1.7–2.5 μm wide. Basidia 17.5–25 × 10.5–13 μm, clavate, 4-spored, often surrounded by pseudoparaphyses. Lamella edge heterogeneous. Cheilocystidia 23–37 × 11–18 μm, clavate, utriform or broadly lageniform with neck 6.0–7.5 μm broad. Pleurocystidia absent. Pseudoparaphyses broadly clavate to spherical, 10–22 μm broad, often difficult to find in older basidiocarps. Hymenophoral trama subregular, made up of slender, cylindrical hyphae, 4.0–12 μm broad. Pileipellis an epithelioid hymeniderm, made up of clavate cells, 28–50 × 10–22 μm, with thin hyaline wall, covered by a thin gelatinous layer, not well visible in exsiccata. Pileocystidia absent. Stipitipellis a dry cutis of slender, hyaline hyphae, 2.0–6.0 μm broad, with clusters of caulocystidia. Caulocystidia 13–50 × 6.5–13 μm, subcylindrical, clavate, utriform or broadly lageniform, sometimes in short chains or with irregular projections. Clamp-connections not seen.

Habitat & distribution — Saprotrophic, solitary or in small groups, on dead culms of grasses or on soil, in grasslands on dry, calcareous, loamy soil and along forest edges. Rarely collected in the Netherlands but probably often overlooked. July–Sept. Also recorded from Denmark, Germany and Italy.

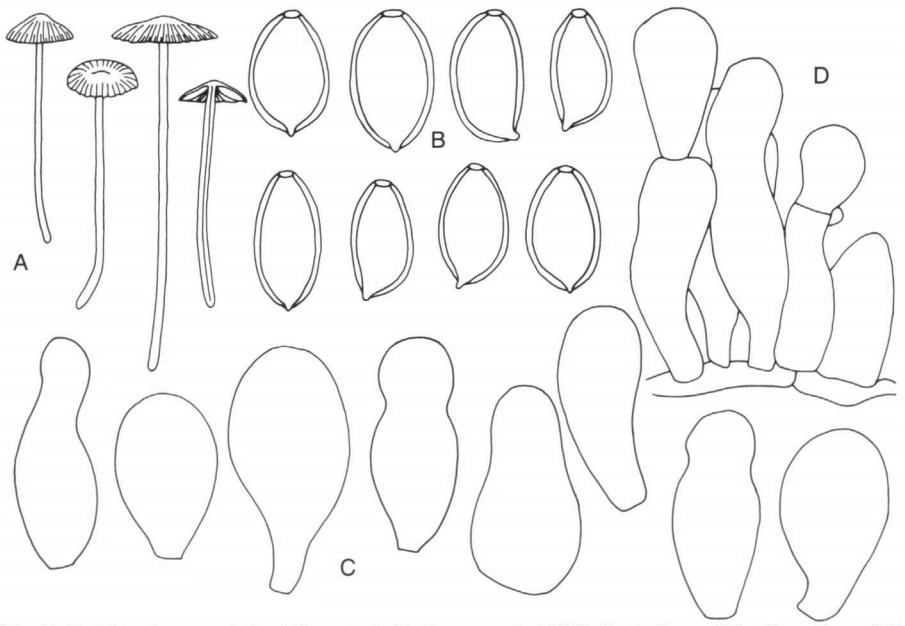

Fig. 2. *Bolbitius lacteus*. A. basidiocarps (× 1); B. spores (× 1500); C. cheilocystidia; D. caulocystidia (all × 1000). (A–D from *E. Arnolds 01-5*).

Collections examined. THE NETHERLANDS: prov. Drenthe, Beilen, Holthe, 'Schepping', 5.IX.2000, *Arnolds 00-77* (L); prov. Flevoland, Lelystad, 'Jagersveld', 11.X.1982, *P.B. Jansen 82-241* (L); prov. Limburg, Wittem, Nijswiller, 21.VII.2001, *Arnolds 01-5* (L). — GERMANY: Eifel, Gerolstein, 'Felsenhof', 15.IX.1990, *P.B. Jansen 90-173* (L).

Bolbitius lacteus is a little-known species and subject of both taxonomic and nomenclatural confusion. After its introduction by Lange (1940) it was not redescribed until Watling & Knudsen (1981) and Watling (1983), based on a single collection from Denmark. Watling claimed that his material agrees with the original diagnosis in every way, but in fact it differs considerably in spore size (Watling 8.5–10.0(–11.0) × 5.0–6.0(–6.5) μm; Lange 10.5–11.5 × 6.0–6.3 μm). Moreover the collection was not made in grassland, as Lange did, but in a shady place under *Sambucus nigra*. In my opinion *B. lacteus* sensu Watling is identical with *B. reticulatus* var. *pluteoides*. Several Dutch collections, labelled as *Bolbitius lacteus*, appeared also to belong to *B. reticulatus* var. *pluteoides*. The two taxa can be easily separated by differences in spore size and colour and thickness of the spore wall, and usually also by habitat. *B. reticulatus* var. *pluteoides* occurs in forests, usually on decayed wood but sometimes on soil, whereas *B. lacteus* grows on dead grass remains or soil in meadows and roadside verges.

In nomenclatural respect *Bolbitius lacteus* has been confused with *Conocybe apala* (Fr.: Fr.) Arnolds, until recently better known as *C. lactea* J.E. Lange. *C. apala* is placed by some authors in the genus *Bolbitius*, for instance by Bon in (1992). The plate of *B. lacteus* in Bon (1987) erroneously represents *Conocybe apala*, readily recognized by the elongated, campanulate pileus and microscopically by the lecythiform cheilocystidia.

Future research may reveal that *Bolbitius lacteus* is only a variant of *B. titubans* with very small and pale basidiocarps, as suggested also by Enderle et al. (1985). The investigation of more collections is needed to clarify this relationship.

3. **Bolbitius demangei** (Quél.) Sacc. & D. Sacc. in Sacc. — Fig. 1, 3, 4

Bolbitius demangei (Quél.) Sacc. & D. Sacc. in Sacc., Syll. Fung. 17 (1905) 74.
Pluteolus demangei Quél. in Assoc. Fr. Avanc. Sci. (1901): 495.

Pileus 30–70 mm broad, ovoid at first, then conico-convex, soon plano-convex to flattened, not hygrophanous, pale to dark violaceous grey, becoming sulcate-striate up to centre, smooth or wrinkled-rugulose around centre, viscid when moist. Lamellae, L = 35–52, l = 1–3, crowded, free, segmentiform, thin, white or pale yellow at first, then greyish brown ('dark café-au-lait'). Stipe 50–100 × 3–5 mm, gradually thickened to base, up to 8 mm thick, fistulose, fragile, white or pale yellow, pruinose-floccose. Context fragile, in pileus submembranous. Smell and taste not recorded. Spore print not recorded.

Spores (9.5–)10.5–13.0 × (5.5–)6.5–7.0(–7.5) μm, av. 11.1–11.7 × 6.5–6.8 μm, Q = 1.6–2.0, av. Q = 1.7–1.8, not or slightly flattened, in frontal view ellipsoid-oblong to ovoid-oblong, in side-view ellipsoid-oblong to subamygdaliform, brownish orange in ammonia, rather thick-walled (0.5–1.0 μm), with central to slightly eccentric

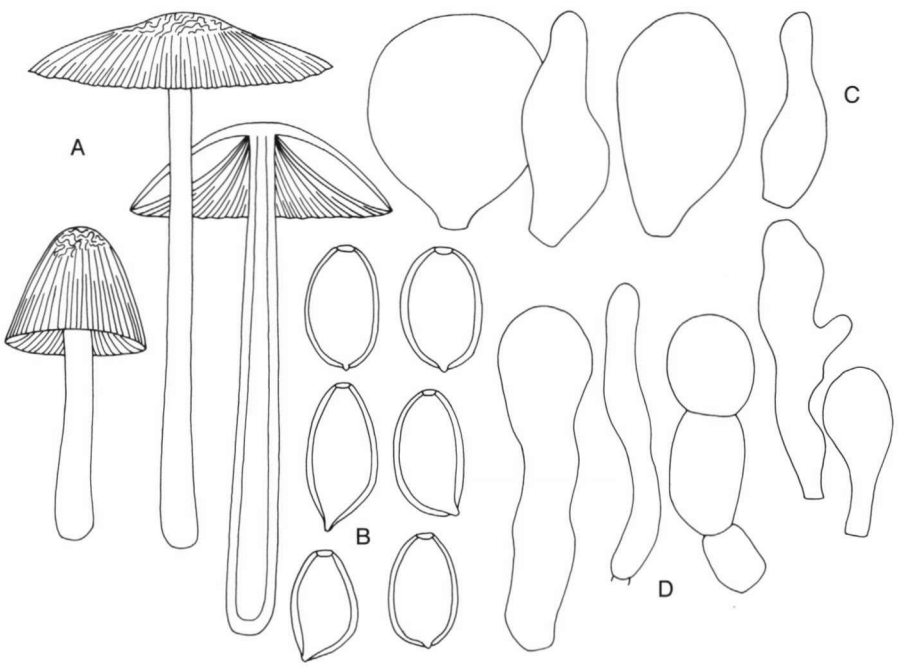

Fig. 3. *Bolbitius demangei*. A. basidiocarps (× 1); B. spores (× 1500); C. cheilocystidia; D. caulocystidia (all × 1000). (A–D from *J. Daams 71-41*).

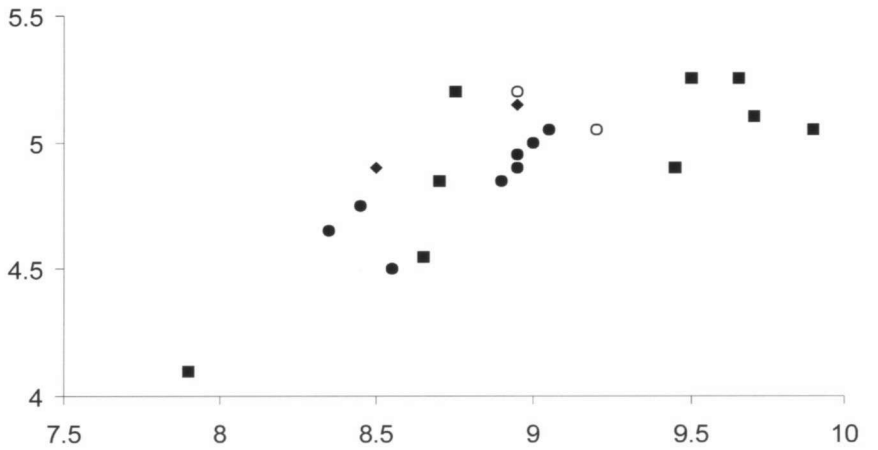

Fig. 4. Average spore size (at least 10 spores measured in side-view) in basidiocarps of *Bolbitius reticulatus* f. *reticulatus* (o); *B. reticulatus* var. *reticulatus* f. *aleuriatus* (■); *B. reticulatus* var. *pluteoides* (●); *B. ferrugineus* (◆).

germ pore, 1.2–2.0 μm wide. Basidia 16–21 × 9.0–11 μm, 4-spored, surrounded by pseudoparaphyses. Lamella edge sterile. Cheilocystidia 30–52 × 9.0–28 μm, broadly clavate, utriform or lageniform with neck 4.0–10 μm broad. Pleurocystidia absent. Pseudoparaphyses 13–17 × 11–13 μm, spheropedunculate. Hymenophoral trama made up of subcylindrical hyphae, 4.0–10 μm broad, with thin, hyaline wall. Pileipellis an epithelioid hymeniderm, made up of clavate elements, sometimes furcate, 26–52 × 6.5–12 μm, hyaline, thin-walled. Pileocystidia absent. Stipitipellis a cutis, made up of slender hyphae, 2.0–5.0 μm broad, with thin, hyaline wall, with clusters of caulocystidia. Caulocystidia 24–54 × 4.0–13 μm, variable, subcylindrical, clavate or lageniform with neck 4.0–5.0 μm broad, often irregular with some projections, thin-walled, hyaline. Clamp-connections absent.

Habitat & distribution — Saprotrophic, subgregarious, in the Netherlands on straw-rich substrate in unheated glasshouses with cucumber cultures, not yet found outside buildings. Very rare in the Netherlands, probably introduced from other regions. June. Also recorded from France (Vosges) and Argentina (Singer & Digilio, 1952; Guzman, 1977).

Collections examined. THE NETHERLANDS: 's Graveland, glasshouse Steenvoorde, 22.VI.1971, *J. Daams 71-141* (L, as *B.* cf. *aleuriatus*); ibidem, 12.VII.1971, *J. Daams 71-46* (L, as *B. reticulatus*).

The collections mentioned above were initially identified by the collector J. Daams as *Bolbitius reticulatus* or *B. aleuriatus* in view of the violaceous grey colour of the pileus. However, they differ clearly from these taxa in much more robust basidiocarps and considerably larger, in particular broader, spores. The spores in *B. reticulatus* measure (6.5)7.0–12.0(–12.5) × (3.5–)4.0–5.5(–6.5) μm, on average (7.9–)8.4–9.9 × (4.1–)4.5–5.2 μm. The Dutch collections fit the original diagnosis of *Pluteolus demangei* Quél. well. The latter species is described from dung in a roadside verge in France

(Vosges) and has a lilac brown, 30–40 mm broad pileus and spores of 12.0–14.0 µm in length. The stipe in *P. demangei* is said to be white at first, then becoming pink below. A pink colour was not observed in the studied collections.

Some authors suggest that *Bolbitius demangei* may be identical with *B. coprophilus* (Enderle et al., 1985). However, both colours of the young basidiocarps and the size and shape of spores are quite different in the studied collections. Spores in *B. coprophilus* are clearly flattened and measure 11.5–16.0(–16.5) × 8.0–11.0 × 6.5–9.5 µm, av. 13.2–14.0 × 8.7–9.7 × 7.4–8.2 µm. A plate by Narducci & Petrucci (1994) under the name of *B. demangei* represents in my opinion *B. incarnatus* Hongo, which is probably a variant of *B. coprophilus* with strongly pigmented pileus (see notes on *B. coprophilus*).

4. **Bolbitius coprophilus** (Peck) Hongo

Bolbitius coprophilus (Peck) Hongo, Mem. Fac. Educ. Shiga Univ. Nat. Sci. 9 (1959) 82.
Pluteolus coprophilus Peck, Rep. N.Y. St. Mus. nat. Hist. 45 (1893) 59. — *Bolbitius radians* Morgan, J. Cinc. Soc. Nat. Hist. 18 (1895) 36.

Bolbitius coprophilus is a species growing on dung, compost and decaying plant material, characterized by its pale pink pileus, at least when young and fresh. The collections from the Netherlands differ from *B. titubans*, *B. lacteus* and *B. demangei* not only in colour of the basidiocarps, but also in larger spores, measuring 11.5–16.0(–16.5) × 8.5–11.0 × 6.5–9.5 µm, on average 13.2–14.0 × 8.7–9.7 × 7.4–8.2 µm, which are distinctly flattened and have a clearly eccentric germ pore. However, Rald & Strandberg (1991) reported smaller spores, fitting into the range of *B. titubans*, viz. 12.5–13.75 × 7.5–8.75 µm. A full description of *B. coprophilus* will be published in Flora agaricina neerlandica (Arnolds, 2003).

Bolbitius coprophilus has been described and illustrated in recent years from various European countries, e.g. by Daams (1967) from the Netherlands, Watling (1982) from Great-Britain, Hübsch (1985) and Gerhardt (1997) from Germany, Rald & Strandberg (1991) from Denmark and Hausknecht & Zuccherelli (1993) from Italy. In the Netherlands it has only been observed in glasshouses so far, where it may occur in large quantities in places (Daams, 1967). In Germany, Denmark and Italy it was recorded from gardens and other places in open air. According to Gerhardt (1997: 318) it is common in Berlin. *Bolbitius coprophilus* has been probably introduced in Europe, possibly from North-America from which it was originally described.

Bolbitius incarnatus Hongo was originally described from Japan. In Europe it has been recorded from Italy (Moser & Cetto, 1987; Cetto, 1989). It was also described and illustrated under the incorrect name *B. demangei* by Narducci & Petrucci (1994) (see description of *B. demangei* above). *B. incarnatus* is said to be different from *B. coprophilus* in the considerably darker, flesh-coloured pileus, but it may be identical with the latter species. More research is required.

5. **Bolbitius reticulatus** (Pers.: Fr.) Ricken — Fig. 4

Bolbitius reticulatus (Pers.: Fr.) Ricken, Blätterpilze 1 (1915) 68.
Agaricus reticulatus Pers., Syn. meth. Fung. (1801) 341; *Agaricus reticulatus* Pers.: Fr., Syst. mycol. 1 (1821) 238; *Pluteolus reticulatus* (Pers.; Fr.) Gillet, Champ. France (1878) pl. 373; *Pluteolus aleuriatus* (Fr.: Fr.) P. Karst. var. *reticulatus* (Pers.: Fr.) J.E. Lange, Dansk bot. Ark. 9 (6) (1938) 49.

— *Agaricus aleuriatus* Fr., Observ. mycol. 1 (1801) 49; *Agaricus aleuriatus* Fr.: Fr., Syst. mycol. 1 (1821) 238; *Pluteolus aleuriatus* (Fr.: Fr.) P. Karst, Ryssl. Finl. Skand. Halføns Hattsvamp. (1879) 428; *Bolbitius aleuriatus* (Fr.: Fr.) Singer, Lilloa 22 (1951 '1949') 490; *Bolbitius reticulatus* var. *aleuriatus* (Fr.: Fr.) Bon, Doc. mycol. 20 (78) (1990) 39; *Bolbitius reticulatus* f. *aleuriatus* (Fr.: Fr.) Enderle, Ulmer Pilzfl. 4 (1996) 50. — *Bolbitius pluteoides* M.M. Moser, Fung. rar. Ic. col. 7 (1978) 27.

KEY TO THE VARIETIES AND FORMAE OF BOLBITIUS RETICULATUS

1. Basidiocarps usually small: pileus 5–17 mm, stipe 15–45 × 0.5–1(–1.5) mm; pileus paler: whitish, pale beige, pinkish or pale violaceous grey .. var. *pluteoides*
1. Basidiocarps with pileus 12–45 mm, stipe 20–55 × 1–4 mm; pileus violaceous grey, greyish brown or brown with darker centre ..... var. *reticulatus*
   2. Pileus 25–45 mm, near centre wrinkled to reticulate ..... f. *reticulatus*
   2. Pileus 12–30 mm, smooth ..... f. *aleuriatus*

5b. **Bolbitius reticulatus** var. **pluteoides** (M.M. Moser) Arnolds, *comb. nov.*

Basionym: *Bolbitius pluteoides* M.M. Moser, Fung. rar. Ic. col. 7 (1978) 27.

Bolbitius reticulatus is easily recognized in the field by the delicate basidiocarps with a viscid, greyish, violaceous or brownish pileus, free, orange-brown lamellae and habitat on woody substrates, ranging from small twigs and wood chips to decaying trunks. Moreover, the spores are considerably smaller and paler than in the other European species of *Bolbitius* (Fig. 1). However, size, colour and structure of pileus surface are exceedingly variable and have lead in the past to the distinction of several species or intraspecific taxa. Already Fries (1821) described *B. reticulatus* and *B. aleuriatus* as different species. Moser (1983) and Courtecuisse & Duhem (1994) distinguished 3 species, *B. reticulatus*, *B. aleuriatus* and *B. pluteoides*. Watling (1982) and Bon (1992) recognized two species, *B. pluteoides* and *B. reticulatus*, the latter including *B. aleuriatus*. Bon (1992) distinguished *B. aleuriatus* in the rank of variety. On the other hand, Enderle et al. (1985) argued that the characters of these taxa are intergrading and they recognise only one species, *B. reticulatus*. Also Ryman & Holmåsen (1984) and Ludwig (2000) considered all variants as belonging to one taxon.

Of this complex 20 collections were studied, mainly from the Netherlands. On the basis of macromorphology three groups could be distinguished. Part of the collections had very small and pale basidiocarps in agreement with the description of *B. pluteoides* by Moser (1978). According to this author, Watling (1982) and Bon (1992) *B. pluteoides* differs from *B. reticulatus* not only in small and pale basidiocarps, but also in smaller spore size. However, this character could not be confirmed (Fig. 4). Since size and colour of the basidiocarps appears to be the only difference, *B. pluteoides* is reduced to a variety of *B. reticulatus*. Occasionally basidiocarps are found that are more or less intermediate between var. *reticulatus* and var. *pluteoides*, for instance combining a pileus over 20 mm wide with pale pinkish colours (see e.g. Ludwig, 2000, plate 13, fig. 5.3B). However, the large majority of the collections studied could be easily assigned to one of the varieties.

Several collections in Dutch herbaria, identified as *B. lacteus*, appeared to belong to *B. reticulatus* var. *pluteoides*. See also notes on *B. lacteus*.

The remaining collections of the *B. reticulatus* complex had larger basidiocarps with a more intense violaceous, greyish or brownish pileus. They could be separated in two groups, viz. a group with a smooth pileus, 12–30 mm broad, and a group with a wrinkled to reticulate pileus, 25–45 mm broad. However, these groups are intergrading to some extent and may be only phenotypic variants of a single taxon. For the time being they are distinguished in the rank of forma, as suggested also recently by Enderle (1996).

A full description of *B. reticulatus* and its intraspecific taxa will be published in Flora agaricina neerlandica (Arnolds, in prep.).

6. **Bolbitius ferrugineus** Arnolds, *spec. nov.* — Fig. 4, 5

Pileus 25–35 mm latus, convexus, dein plano-convexus vel applanatus, hygrophanus, aurantio-brunneus, striatus, glutinosus. Lamellae liberae, confertae, aurantio-brunneae. Stipes 50–65 × 3–4 mm, subcylindraceus, fistulosus, pallide brunneo-aurantius, albo-striatus, apice pruinatus. Caro fragilis, concolorata.

Sporae 7.5–9.5(–10.5) × 4.5–5.5(–6.0) μm, av. 8.5–9.0 × 4.9–5.2 μm, Q = 1.6–2.0, av. Q = 1.7–1.75, ellipsoideae-oblongae vel subamygdaliformae, haud lentiformes, tenuitunicatae, poro germinativo 1.0–1.5 μm. Basidia 18–26 × 7.0–9.0 μm, clavatae, tetrasporigera. Cheilocystidia 18–35 × 5.0–10 μm, utriformia, clavata vel subcylindracea. Pleurocystidia nulla. Pileipellis hymenidermium, cellulae pyriformes vel clavatae, 14–35(–47) × 8.0–15 μm. Caulocystidia 20–53 × 5.0–14(–19) μm, utriformia, clavatae, lageniformia vel subcylindricacea. Fibulae presentes. Ad terram humosam in nemoribus frondosis.

Holotypus: Italia, La Basilicata, Laghi di Monticchio, 15.XI.2000, *E. Arnolds 00-178* (L).

Pileus 25–35 mm, at first convex, then plano-convex to flattened, with or without low umbo, hygrophanous, when moist orange-brown to rusty brown (K. & W. 6D8, 6D8/7D8), translucently striate up to halfway the radius, strongly glutinous, on drying becoming pale dull orange (5A3/B3) with slightly darker centre, smooth or slightly wrinkled at centre. Lamellae, L = 47–50, l = 3–7, crowded, free, thin, up to 5 mm broad, orange-brown, slightly paler than the pileus, with slightly paler edge. Stipe 50–65 × 3–4 mm, cylindrical or slightly thickened towards base, fistulose, pale brownish orange (5B3/C4), white striate lengthwise, at apex pruinose. Context fragile, concolorous with surface, in pileus up to 2.5 mm thick. Smell weak, not distinctive. Taste not recorded.

Spores 7.5–9.5(–10.5) × 4.5–5.5(–6.0) μm, av. 8.5–9.0 × 4.9–5.2 μm, Q = 1.6–2.0, av. Q = 1.7–1.75, ellipsoid-oblong to subamygdaliform in side-view, a few phaseoliform, not flattened in front-view, thin-walled, with sometimes indistinct apical pore, 1.0–1.5 μm wide. Basidia 18–26 × 7.0–9.0 μm, clavate, 4-spored. Lamella edge sterile. Cheilocystidia 18–35 × 5.0–10 μm, densely packed, variable, utriform, clavate or subcylindrical. Pleurocystidia absent. Pseudoparaphyses not observed. Hymenophoral trama regular, made up of cylindrical to strongly inflated elements, up to 80 μm long and 4.0–25 μm broad, with thin, hyaline wall. Pileipellis an epitheliod hymeniderm, made up of pyriform and clavate elements, 14–35(–47) × 8.0–15 μm, with pale brown intracellular pigment, apparently covered with gelatinous layer when fresh (but invisible in the studied exsiccata). Stipitipellis made up of thin, parallel hyphae, 2.0–6.0 μm wide, near apex with clusters of cystidia. Caulocystidia 20–53 × 5.0–14(–19) μm, very variable, utriform, clavate, lageniform or subcylindrical, sometimes branched or furcate at apex. Clamp-connections present in hymenium, hymenophoral trama and numerous in stipitipellis.

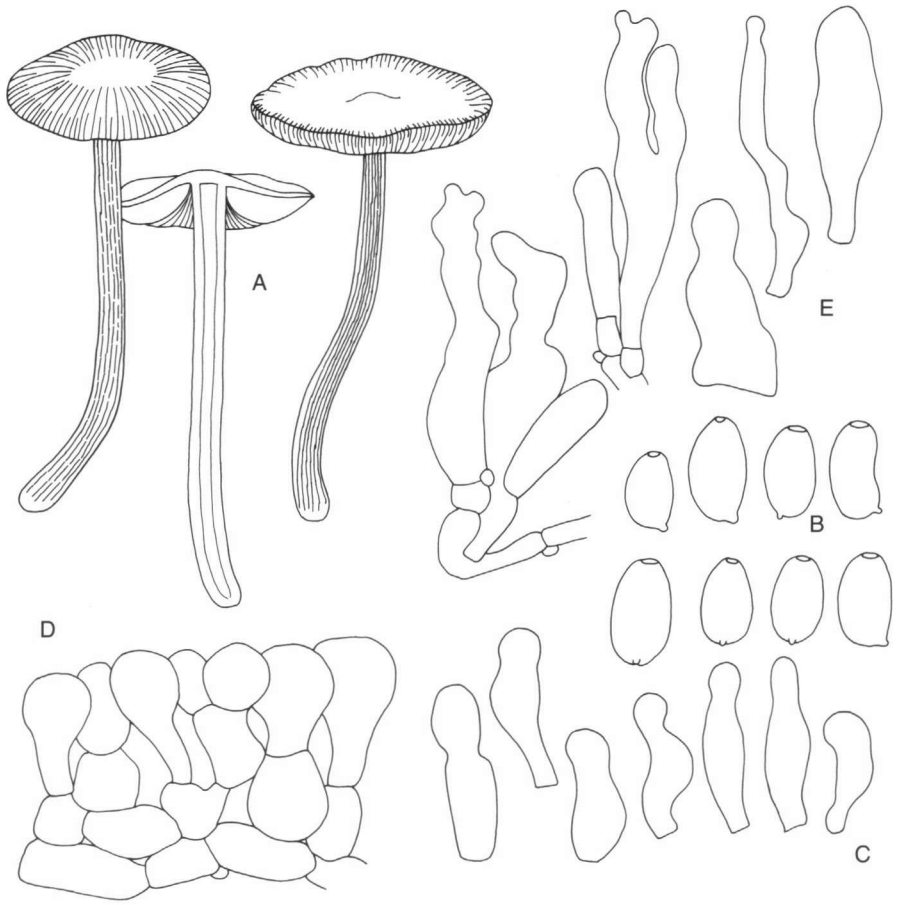

Fig. 5. *Bolbitius ferrugineus*. A. basidiocarps (× 1); B. spores (× 1500); C. cheilocystidia; D. pileipellis; E. caulocystidia (all ×1000). (A–D from *E. Arnolds 00-178*, holotype).

Habitat & distribution — In a small group on humus in semiruderal roadside-verge along deciduous forest on loamy soil. November.

Collections examined. ITALIA: La Basilicata, Laghi di Monticchio (15°36'24"–40°55'30"), 15.XI.2000, E. Arnolds 00-178 (L).

Bolbitius ferrugineus is unique among the European representatives of *Bolbitius* in the orange-brown colour of the pileus. The spore size is much smaller than in *B. titubans* and related species (see Fig. 1) and falls into the range of *B. reticulatus* (Fig. 4). Also the pale colour and thin wall of the spores may indicate affinity to the latter species. However, *B. reticulatus* differs macroscopically markedly in the pinkish to violaceous brown or grey pileus and white stipe that is not striate lengthwise. Besides, that species is usually found on woody substrates, not on soil.

The structure of the pileipellis in *B. ferrugineus* resembles that of *B. titubans* and allies since it is made up of only clavate and pyriform elements. However, in *B. titubans* these elements are much larger, measuring 26–84 × 8.0–26 μm (Arnolds, 2003). Their size is in better agreement with *B. reticulatus* (14–40 × 10–30 μm; Arnolds, 2003), but in that species the clavate elements are intermixed with branched, trichodermal hyphae with short, subcylindrical elements. Such hyphae are lacking in *B. ferrugineus*. The numerous clamp-connections may also be distinctive for *B. ferrugineus*.

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