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NOTES ON CYSTOLEPIOTA: SECTIONS CYSTOLEPIOTA AND PULVEROLEPIOTA

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A key to the species of *Cystolepiota* Sing., and descriptions of *C. cystidiosa* (A.H. Smith) M. Bon, *C. adulterina* (F. Møller) M. Bon, *C. hetieri* (Boud.) Sing., and *C. moelleri* Knudsen are given. Four taxonomic revisions were made: 1. type studies of *C. cystidiosa*, *C. luteicystidiata* (D. Reid) Knudsen, and *Lepiota lycoperdoides* Kreisel have revealed these three species to be conspecific; 2. *C. adulterina* var. *reidii* (M. Bon) M. Bon is synonymized with *C. adulterina*; 3. the type collection of *C. subadulterina* M. Bon appeared to be a mixed collection of *C. hetieri* and *C. adulterina*, and 4. the genus *Pulverolepiota* M. Bon, created to accommodate *C. pulverulenta* (Huijsman) Vellinga, is reduced to a section of *Cystolepiota*.

The European species of the genus *Cystolepiota* Sing. are assigned to two sections (Bon, 1993b), viz. section *Pseudoamyloideae* Sing. & Clémenç. accommodating the species with dextrinoid spores, and section *Cystolepiota* for species with non-dextrinoid spores. A third section is added here, to accommodate *C. pulverulenta* (Huijsman) Vellinga, for which Bon (1993a) created the genus *Pulverolepiota*.

Species delimitation in *Cystolepiota* section *Cystolepiota* is still problematic, though recently several books and keys on the genus have been published (Candusso & Lanzoni, 1990; Bon, 1993b; Kelderman, 1994). The authors of the past did not make things easy for the present-day taxonomist, with their diverse and differing interpretations of names, the frequent introduction of new names (often not according to the rules of the International Code of Botanical Nomenclature) and the use of quite similar epithets (e.g. *hetieri* and *hetieriana*). Some authors appear to attach major significance to small differences between collections, while neglecting gross and overall similarities. This has resulted in an undesirable proliferation of names.

Most problematic is the group to which the following taxa belong: *C. adulterina* (F. Møller) M. Bon with its variety *reidii* (M. Bon) M. Bon, *C. subadulterina* M. Bon, *C. hetieri* (Boud.) Sing., and *C. cystidiosa* (A.H. Smith) M. Bon, *C. luteicystidiata* (D. Reid) Knudsen and *L. lycoperdoides* Kreisel. The confusion is caused by the similarities in macroscopic characters between the species involved, and the fact that they often grow together, or quite close to each other. Mixed herbarium collections have been encountered more than once. As already pointed out by Candusso & Lanzoni (1990) it is extremely difficult to name species from pictures or in the field. Fortunately, microscopic characters give excellent clues for identification of the species involved.

Other characters which could prove to be very valuable are the colours of the lamellae of the exsiccates, the chemical reactions of (parts of) the basidiocarps with $FeSO_4$ and with NH_3 vapours, and the spore print colour. Unfortunately, there are as yet no systematic

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studies of the chemical and spore print characters available, only some incidental observations.

Type collections have been studied to establish the differences and/or similarities of the taxa. A key to the species of the genus *Cystolepiota* occurring in the Netherlands and adjacent regions is included. The species are treated in alphabetical order.

Colour annotations in the descriptions are from Munsell Soil Color Charts (1975).

The notation [45, 4, 3] indicates that measurements were made on 45 spores from 4 basidiocarps in 3 collections.

The abbreviation avl stands for average length, avw for average width and avq for average quotient.

Shape and size of the cheilocystidia have been studied halfway between stipe and pileus margin.

Abbreviations of herbaria are according to Index herbariorum (Holmgren et al., 1990).

KEY TO THE SPECIES OF CYSTOLEPIOTA OCCURRING IN THE NETHERLANDS AND ADJACENT REGIONS

1. Elements of pileus covering elongate, oblong, inflated; clamp-connections absent; basidiocarps white, discolouring orange-brown, with (sub)conical pileus and big floccose-granulose warts; cystidia absent ..... *C. pulverulenta*
   (For a discussion on and description of this species see Vellinga, 1992.)
1. Elements of pileus covering globose; clamp-connections present; basidiocarps white, remaining white or changing colour, or distinctly coloured, with applanate, rounded, or umbonate pileus, with or without floccose warts; cystidia absent or present.
   2. Basidiocarps with distinct lilac or violaceous tinges; smell strong, like indole, unpleasant; spores (6.5–)7.0–9.0(–10.0) µm long, dextrinoid, though the reaction can be very slow or weak ..... *C. bucknallii*
      (Not treated here; for a description see e.g. Candusso & Lanzoni, 1990.)
   2. Basidiocarps white, pink, brownish, yellow, greyish etc.; smell not like indole; spores up to 7.0 µm long, not dextrinoid, or rarely dextrinoid (but then basidiocarps yellow).
      3. Cheilocystidia absent; pileus white, rarely pale pink or yellowish, not discolouring with age or when damaged ..... *C. seminuda*
         (For a discussion on and description of this species see Vellinga, 1987.)
      3. Cheilocystidia present; pileus either white and discolouring orange-brown, or with other colours.
         4. Basidiocarps white, cream or greyish, discolouring (orange-)brown with age or on damaging.
            5. Cheilocystidia and pleurocystidia with yellow contents and exudates ..... *C. cystidiosa*
            5. Cheilocystidia (and pleurocystidia) without yellow contents and exudates.
               6. Spores 5.0–6.5(–7.0) × 2.0–3.0 µm, Q = (1.8–)2.0–2.6, average Q = 2.1–2.4; pleurocystidia absent ..... *C. adulterina*
               6. Spores 4.0–6.0(–6.5) × 2.0–3.0(–3.5) µm, Q = (1.5–)1.6–2.1(–2.3), average Q = 1.8–2.0; pleurocystidia present, especially close to lamella edge ..... *C. hetieri*

4. Basidiocarps with greyish, pale lilac-brown, cream, yellow, yellowish-ochraceous or pink(-brown) covering, not discolouring orange-brown when damaged or with age.
   7. Basidiocarps yellow (sulphur-yellow or yellowish brown); spores dextrinoid *C. icterina*

   (Not yet known from the Netherlands; for a description of this species see Knudsen, 1978.)
   7. Basidiocarps with grey, brown or pink tinges, not yellow throughout; spores not dextrinoid.
      8. Pileus covered with small pink-coloured granulose warts, often resembling members of *Lepiota* section *Echinatae*; cheilocystidia narrowly clavate to obovate, usually with cylindrical, moniliform or branched, excrescence at apex; pleurocystidia absent ..... *C. moelleri*
      8. Pileus covered with a uniform, thick velar layer, or with pinkish grey-brown to greyish yellow, pyramidal warts; pleurocystidia present or absent, if present with distinct yellow contents.
         9. Cheilocystidia without yellow contents or exudate; pleurocystidia absent; spores 5.0–6.5(–7.0) × 2.0–3.0 µm, Q = (1.8–)2.0–2.6, average Q = 2.1–2.4; elements of pileus covering 15–45 µm ..... *C. adulterina*
         9. Cheilocystidia and pleurocystidia with yellow contents or exudate; spores 3.5–5.5(–6.0) × 2.0–3.0 µm, Q = 1.5–2.2(–2.4), average Q = 1.7–2.1; elements of pileus covering (10–)20–70(–95) µm ..... *C. cystidiosa*

Cystolepiota adulterina (F. Møller) M. Bon — Figs. 1, 2a, 3a

Lepiota adulterina F. Møller, Friesia 6 ('1957–1958', 1959) 23; *Cystolepiota adulterina* (F. Møller) M. Bon, Doc. mycol. 7 (27–28) (1977) 54. — *Cystolepiota subadulterina* M. Bon, Doc. mycol. 6 (24) (1976) 43; *Cystolepiota adulterina* var. *subadulterina* (M. Bon) M. Bon, Doc. mycol. 22 (88) (1993) 27 (not valid, basionym not mentioned). — *Cystolepiota adulterina* f. *reidii* M. Bon, Doc. mycol. 11 (43) (1981) 25; *Cystolepiota adulterina* var. *reidii* (M. Bon) M. Bon, Doc. mycol. 22 (88) (1993) 27.

Misapplied. Cystolepiota hetieri sensu J. Lange, Fl. agar. dan. 1 (1935) 35–36, pl. 14J.

Excluded. Cystolepiota adulterina sensu Kelderman, Coolia 31 (1988) 15 (= *C. cystidiosa*). — *Cystolepiota adulterina* f. *reidii* sensu Lanzoni & Zecchin, Riv. Micol. 31 (1988) 104; sensu Candusso & Lanzoni, Fungi eur. 4 (1990) 88–90 (= *C. moelleri* in both cases).

Selected icons. J. Lange, Fl. agar. dan. 1 (1935) pl. 14J (as *C. hetieri*); Rald et al., Svampe 26 (1992) 34 (dry specimens); Ryman & Holmåsen, Svampar (1984) 411.

Selected descriptions & figures. F. Møller, Friesia 6 ('1957–1958', 1959) 22–23, figs. a–d; D. Reid, Fung. rar. Ic. col. 6 (1972) 10–11, figs 18a & b.

Pileus 15–30(–50) mm, conico-convex, applanate to convex, when young covered with a thick cream whitish, to beige layer, later with cream-ochre to greyish yellow flocculose warts; margin with velar remnants. Lamellae crowded, free, sordid cream. Stipe 30–60 × 3–7 mm, cylindrical or tapering downwards, fistulose, at apex whitish, lower down covered with floccules, concolorous with pileus, brown discolouring at base. Smell and taste not known.

Spores [125, 8, 6] 5.0–6.5(–7.0) × 2.0–3.0 µm, Q = (1.8–)2.0–2.6, average Q = 2.1–2.4, cylindrical to slightly broadened in basal part, not colouring in Melzer's Reagent, with pink inner wall in Cresyl Blue. Basidia 14.5–23 × 5.0–9.0 µm, (2–)4-spored.

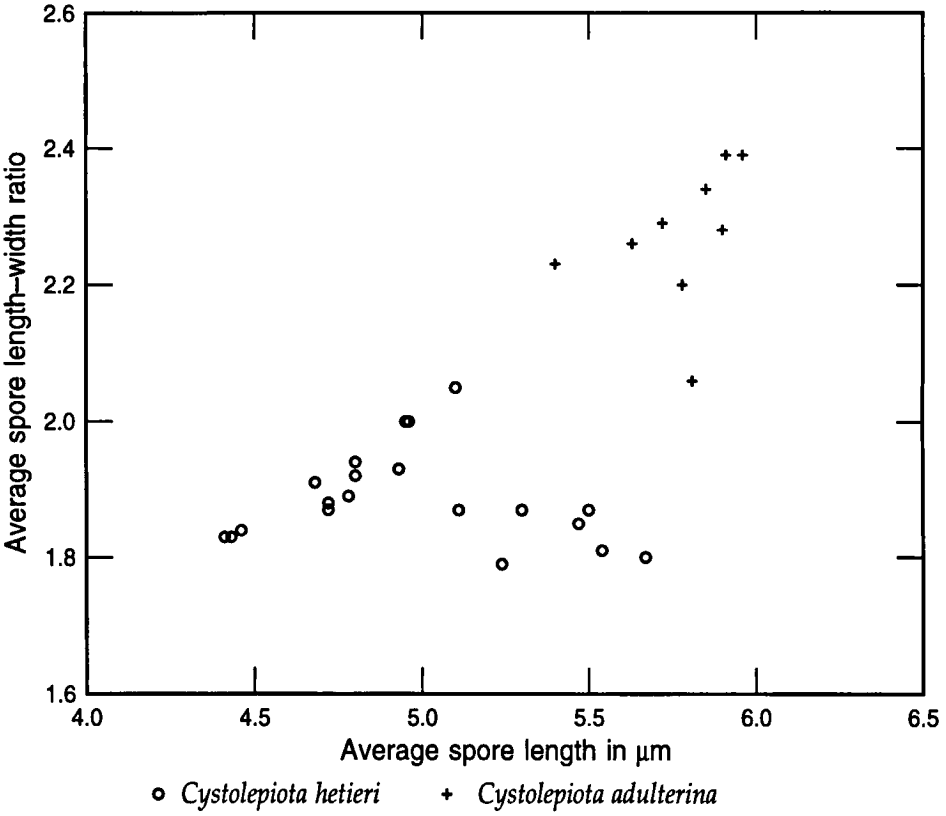

Fig. 1. Scatterdiagram of average spore length and average length-width ratio of the spores of *C. hetieri* and *C. adulterina*.

Cheilocystidia abundant, 17–32 × 5.5–9.0 µm, lageniform with abrupt, cylindrical to slightly moniliform, flexuous, 1.5–4.0 µm wide neck, rarely without neck or only with short excrescence, colourless. Pleurocystidia not observed. Velar elements on pileus globose, 13–46 µm in diam., thick-walled and slightly incrusted, colourless. Clamp-connections present in all tissues.

Habitat & distribution — In small groups, saprotrophical and terrestrial, often on mull (Knudsen, pers. comm., July 1997), in deciduous woods, often on calcareous soils. Sept.–Oct. Not yet known from the Netherlands, rare and scattered in Europe, from southern Scandinavia southwards, not yet recorded from Mediterranean countries.

Collections examined. DENMARK: Falster, Kohave, 10-X-1960, *F.H. Møller* (L); Sjaelland, Avnstrup near Osted, 7-IX-1980, *E. Bille Hansen* (C); Jaegersborg Dyrehave near Rådvad, 28-IX-1982, *T. Læssøe* TL 430 (C). — GERMANY: Nordrhein-Westfalen, Heesten near Detmold, X-1976, *G.A. de Vries* (L); Baden-Württemberg, Gottenheim, Wasenweiler Wald, 4-IX-1975, *M. Bon 750904* p.p. (herb. Bc · lectotype of *C. subadulterina*); Ueberlingen, Affenberg, 17-IX-1987, *E. Ludwig* (L). — GREAT E 'TAIN: England, Gloucestershire, Stonehouse, Nymfsfield, Woodchester Park Field Station, 4-X-19(*E.C. Hemken* (K; holotype of *C. adulterina* var. *reidii* (M. Bon) M. Bon).

The short macroscopical description is based on the notes accompanying the collection made by Ludwig and the descriptions selected above.

Møller (1959) did not indicate a type collection, though he did call Sønder Kohave near Nykøbing on Falster (Denmark) the type locality. Knudsen (1978) chose one of the two collections still preserved in C as lectotype (viz. 1-X-1955, Sønder Kohave). A later collection, made by Møller himself, from the type locality was studied for this paper.

Reid (1972) described a collection of *C. adulterina*. This collection was the basis for Bon's (1993a) variety (first described as a forma in 1981), *C. adulterina* var. *reidii*. On account of the bigger spores and the more pink colours Bon (1993a) considers this to be a good variety. The colours of the pileus are, according to Reid (1972), "beige (Light Pinkish Cinnamon)" in young specimens, and "ochraceous (Light Ochraceous-Salmon)" in older specimens. The codes in brackets are taken from Ridgway (1912). According to Hamley (1949) they correspond to the following Munsell notations, resp. 1 YR 8.0/5.0, and 8 YR 8.0/5.5. Especially the colour of the young pilei of this collection seems to be a bit more pink than encountered in other collections. To judge whether this taxon deserves infraspecific rank the type collection of *C. adulterina* var. *reidii* (M. Bon) M. Bon was studied. The microscopical characters are as follows: spores 5.4–6.5 × 2.4–2.9 µm, avl × avw = 5.9 × 2. 6 µm, Q = (1.9–)2.05–2.4(–2.6), average Q = 2.3; basidia 4-spored; cheilocystidia 19–32 × 7.0–9.0 µm, lageniform, mostly with up to 17 µm long, cylindrical or slightly moniliform neck; velar elements of pileus globose, 13–28 µm in diam., thin-walled. The relatively long spores, the shape of the cheilocystidia, and the small elements of the pileus covering are all very characteristic for *C. adulterina*.

In all respects, this collection fits perfectly in *C. adulterina*, and there is no reason to keep the variety as a separate taxon.

Another taxon in this group was named *C. subadulterina* by Bon (1976a and b). Bon (1976a) gave a comprehensive description of this taxon (which he described as a new species later in the same year). His description clearly combines the macroscopic features of *C. adulterina* or *C. cystidiosa*, and the microscopic characteristics of *C. hetieri*. The figures reflect the same ambiguity. Examination of the type collection confirmed the suspicion that two species are involved.

The type collection consists of basidiocarps belonging to *C. hetieri* and basidiocarps representing *C. adulterina*. The microscopic characteristics of the former are as follows: spores 4.8–5.8 × 2.3–2.5(–2.8) µm, Q = 1.95–2.1(–2.3), average Q = 2.05; cheilocystidia abundant, fusiform and capitate to moniliform, colourless; pleurocystidia present; elements of velum universale globose and around 35 µm in diameter.

The basidiocarps belonging to *C. adulterina* are microscopically characterized in the following way: spores 5.0–5.8 × 2.3–2.5 µm, Q = 2.0–2.4, average Q = 2.25; cheilocystidia abundant, with long cylindrical and slightly flexuous neck; pleurocystidia absent; elements of velum universale globose, 18–30 µm in diameter. These specimens are chosen here as the lectotype of *C. subadulterina*.

The type collection was not in a state to reveal further details.

After we had notified Mr. Bon of the identity of this collection, he reduced the species in rank to a variety of *C. adulterina* (Bon, 1993a), though invalidly, citing the publication in which he gave a desription of the species (Bon, 1976a), rather than the paper in which the official publication had been made (Bon, 1976b).

Many authors had difficulties distinguishing *C. hetieri* from *C. adulterina* (for example Breitenbach & Kränzlin, 1995). This is probably due to the incomplete descriptions of Moser (1978, 1984), the abundance of names and taxa without a set of well-discriminating characters as given by Bon (1981, 1993b), and the fact that the original publication of Møller (1959) is not widely known.

The characters that differentiate *C. hetieri* most clearly from *C. adulterina*, are microscopical, and can easily be confirmed on herbarium material: the shape of the spores, the shape of the cheilocystidia, and the size of the velar elements. The spores of *C. adulterina* are longer than those of *C. hetieri*; the average length-width ratio in the former is 2.1–2.4, whereas it does not exceed 2.1 in *C. hetieri* (see Fig. 1, 2). The cheilocystidia in *C. hetieri* measure 14–32 × 7–12 µm, with up to 15 µm long, abrupt, capitulate and cylindrical or moniliform excrescence at apex, and the cystidia are widest just below the excrescence, whereas in *C. adulterina* the cheilocystidia have a very long, protruding neck (Fig. 3). But the exact shape of the cystidia in *C. adulterina* is often difficult to see; though the necks are quite obvious. Furthermore, pleurocystidia are often present in *C. hetieri*, and absent in *C. adulterina*. Velar elements of *C. hetieri* measure 20–60 µm; in *C. adulterina* they do not exceed 50 µm and are generally around 30 µm.

Some authors have taken *C. moelleri* for *C. adulterina* f. *reidii* (Lanzoni & Zecchin, 1988; Candusso & Lanzoni, 1990). The differences between the two taxa are very distinctive, and easily observed, even in the field.

Cystolepiota cystidiosa differs from *C. adulterina* in the presence of pleurocystidia, which are conspicuous and have yellow contents. The spores of *C. adulterina* are the longest and narrowest in this subsection, with an average length-width ratio of 2.1–2.4. The spores of *C. cystidiosa* are shorter, and the average length-width ratio is 1.7–2.1. Furthermore, there is a difference in the size of the velar elements: 13–46 µm in *C. adulterina*, and (10–)20–70(–95) µm in *C. cystidiosa*.

Cystolepiota cystidiosa (A.H. Smith) M. Bon — Figs. 2b–d; 3b, c

Lepiota cystidiosa A.H. Smith, Papers Mich. Acad. Sci., Arts Letters 27 ('1941', 1942) 58; *Cystolepiota cystidiosa* (A.H. Smith) M. Bon, Doc. mycol. 11 (43) (1981) 26. — *Lepiota luteicystidiata* D. Reid, Fung. rar. Ic. col. 2 (1967) 9; *Cystolepiota luteicystidiata* (D. Reid) M. Bon, Doc. mycol. 6 (24) (1976) 43. — *Lepiota lycoperdoides* Kreisel, Wiss. Z. Ernst Moritz Arndt-Univ. Greifswald 16 (1967) 238; *Cystolepiota luteicystidiata* var. *lycoperdoides* (Kreisel) M. Bon, Doc. mycol. 11 (43) (1981) 26. — *Lepiota huysmani* Wichanský, Mykol. Sbornik 37 (1960) 121 (not valid, no type collection indicated).

Misapplied. Lepiota rufescens sensu Huijsman, Meded. Ned. mycol. Vereen. 28 (1943) 47–48.

Selected icons. Lonati, Boll. Ass. micol. ecol. Romana 12 ('1987', 1988) 15 (as *C. luteicystidiata*); Migl. et al., Riv. Micol. 32 (1989) 103 (as *C. luteicystidiata*); D. Reid, Fung. Ic. rar. col. 2 (1967) pl. 10b (as *L. luteicystidiata*, basidiocarps exceptionally dark).

Selected descriptions & figures. Huijsman, Schweiz. Z. Pilzk. 39 (1961) 51; Kelderman, Coolia 31 (1988) 5, fig. II (as *C. adulterina*); Kreisel, Wiss. Z. Ernst Moritz Arndt-Univ. Greifswald 16 (1967) 237–238 (as *L. lycoperdoides*); D. Reid, Fung. rar. Ic. col. 2 (1967) 9–10, fig 3 (as *L. luteicystidiata*); A.H. Smith, Papers Mich. Acad. Sci., Arts Letters 27 ('1941'; 1942) 58–60, pl. 1, 2.; H.V. Smith, Lloydia 17 (1954) 318–319; Winterhoff & Bon, Carolinea 52 (1994) 6.

Pileus 20–40(–70) mm, when young spherical to hemispherical with inflexed margin, expanding to applanate-campanulate, plano-convex with or without broad umbo, covered

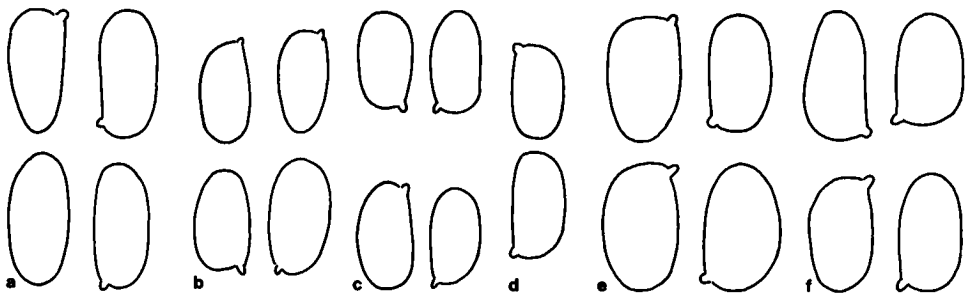

Fig. 2. Spores of a. *C. adulterina* (from holotype of *C. adulterina* f. *reidii*), b–d. *C. cystidiosa* (b. from holotype, *A.H. Smith 15268*; c. from holotype of *L. luteicystidiata*; d. from holotype of *L. lycoperdoides*), e. *C. hetieri* (from *E.C. Vellinga 1020*), and f. *C. moelleri* (from *E.C. Vellinga 666*). — 3000 ×.

with floccose, granular pyramidal warts, up to several millimeters high, varying in colour from whitish when very young, to cream discolouring pinkish, to pinkish grey-brown, pinkish-brownish (7.5 YR 6/4, 10 YR 4/3 –7.5 YR 5/4, 10 YR 7/6, 10 YR 8/4 to 7.5 YR 7/6), often staying paler at margin, and there covering thinner, showing the whitish context; when warts are removed, a whitish 'scar' remains; margin exceeding lamellae. Lamellae, L = 30–45, l = 1–3, moderately crowded to crowded, free, segmentiform to slightly ventricose, up to 4.5 mm wide, cream coloured, and brown-spotted with age, with even or flocculose, white to concolourous edge, which is also brown-spotted with age. Stipe 15–70 × 2.5–5 mm, cylindrical, sometimes widened at apex, occasionally curved in lower part, fistulose, at apex whitish or cream, finely pubescent, glabrescent with age, in lower half or 3/4 of length, below an annular zone which is more or less distinct, granular floccose or with floccose patches, concolorous with pileus, often discolouring (e.g. pinkish brown, 7.5 YR 6/6) when touched. Context white or whitish cream and dull in pileus, shiny and cream in stipe, brownish or vinaceous downwards. Smell fungoid or 'lepiotoid', often like *Lepiota cristata*, but not always. Taste a bit unpleasant, musty fungoid, with unpleasant lingering aftertaste. Spore print cream.

Spores [252, 19, 18] 3.5–5.5(–6.0) × 2.0–3.0 µm, Q = 1.5–2.2(–2.4), average Q = 1.7–2.1, ellipsoid to cylindrical with parallel sides, sometimes in side-view slightly widened at base, often in tetrads, colourless, with slightly thickened wall, non-dextrinoid, non-amyloid, with cyanophilous wall, and inner wall pink in Cresyl Blue. Basidia 12.5–20 × 4.5–6.5 µm, 4-spored. Lamella edge sterile, in fresh specimens covered in a yellow exudate. Cheilocystidia 17–40(–50) × 6.5–12 µm, cylindrical-fusoid, narrowly clavate, rather variable in shape, without or with apical excrescence, varying from a small capitulum, 3.0–4.0 × 3.0 µm, to a long moniliform neck, up to 45 µm long; occasionally whole cystidium moniliform; often thick-walled, with yellow, often granular, contents. Pleurocystidia abundant, similar to cheilocystidia, but without or with short-moniliform neck; at a magnification of 400 × cystidia clearly visible as yellow dots, evenly distributed over lamella surface. Elements of velar covering on pileus (10–)20–70(–95) µm in diam., globose to slightly subglobose, thin-walled or slightly thick-walled, often with slightly brownish walls; in fresh specimens with very small yellow droplets or particles. Stipitipellis a

cutis made up of cylindrical narrow hyphae, 1.5–5.0 µm in diam.; below covered in elements as on pileus, and often more irregular in shape (pyriform, ellipsoid etc.). Clamp-connections present in all tissues.

Habitat & distribution — Gregarious, sometimes in big flocks, saprotrophical and terrestrial in deciduous woods on nutrient-rich soils, and in greenhouses. Known in the Netherlands from several localities in southern Limburg; also found in several regions of Germany; also growing in North America. Aug.–Oct. in the wild, throughout the year in greenhouses.

Collections examined. NETHERLANDS: prov. Utrecht, Baarn, Cantonspark, VIII-1943 and V-1945, *G.A. de Vries* (L); prov. Noord-Holland, Kortenhoef, tomato-greenhouse, I-1971, *J. Daams* (herb. Tjallingii); 's-Graveland, Boekesteyn, 10-X-1983, *J. Daams* (L); prov. Zuid-Holland, Leiden, Botanical Garden, 4-VIII-1958, *C. Bas* (L), 16-VI-1997, *E.C. Vellinga 2078* (L), and 8-VII-1997, *E.C. Vellinga 2086* (L); prov. Limburg, *Cadier & Keer*, Riesenberg, 4-X-1989, *E.C. Vellinga 1615 & 1619*, 9-X-1991, *E.C. Vellinga 1758*, 20-VIII-1993, *E.C. Vellinga 1899* (all in L); Valkenburg, Schaelsberg, *H.A. Huijser*, 23-IX-1989 (L). — BELGIUM: prov. Antwerpen, Antwerpen, Kruidtuin, 13-XII-1981, *A. de Meijer 539* (L). — GERMANY: Bayern, Erlangen, Botanical Garden, 4-I-1987, *G. Wölfel* (L); Mecklenburg, Greifswald, Botanical Garden, 6-XII-1964, *H. Kreisel* (GFW, holotype of *L. lycoperdoides*); Nordrhein-Westfalen, Mönchengladbach, 29-IX-1987, *H. Bender* (L); Neeosen Truppenbahn, 17-X-1984, *H. Bender* (herb. Bender). — GREAT BRITAIN: England, Surrey, Richmond, Kew, Royal Botanic Gardens, Palm House, 25-IV-1961, Mr. *Harrison* (K, holotype of *C. luteicystidiata*), and Princess of Wales Conservatory, 9-III-1993, *E.W. Brown* (L). — USA: Michigan, Washtenaw Co., Ann Arbor, 9-IX-1940, *A.H. Smith 15268* (MICH, holotype of *C. cystidiosa*).

The type collections of *C. cystidiosa*, *C. luteicystidiata* and *L. lycoperdoides* have been studied. Knudsen (1978) considered *C. luteicystidiata* and *L. lycoperdoides* synonymous, though he did not study the type collections. This opinion was not shared by Bon (1981), who lowered *L. lycoperdoides* in rank to a variety of *C. luteicystidiata*, on account of presumed bigger size of the basidiocarps and the smell like *Lycoperdon*. However, Kreisel (1967) gives the smell as very faint, reminiscent of the smell of *L. cristata*. The basidiocarps of the type collection of *L. lycoperdoides* are surprisingly small.

The microscopic characters of the three type collections are presented in Table I. Judging from this table and the macroscopic characters (see resp. Smith, 1942; Reid, 1967; and Kreisel, 1967), there are no reasons to keep them separate. Although American specimens of *C. cystidiosa* are sturdy and much bigger than the average European basidiocarps, pilei up to 7 cm in diameter can be encountered in Europe as well.

Table I. Type studies on *Cystolepiota cystidiosa*, *C. luteicystidiata*, and *L. lycoperdoides*.

type collection	spores	avl × avw	avq	pleurocystidia & cheilocystidia	velar elements
cystidiosa A.H. Smith	3.7–4.8 × 2.1–2.7 µm	4.2 × 2.4 µm	1.75	with yellow contents, capitulate	35–57 µm in diam.
luteicystidiata D. Reid	3.7–4.6 × 2.1–2.5 µm	4.1 × 2.3 µm	1.83	with yellow contents	up to 55 µm in diam.
lycoperdoides Kreisel	4.1–4.9 × 2.1–2.6 µm	4.3 × 2.4 µm	1.82	with yellow contents, some capitulate	32–65 µm in diam.

Cystolepiota cystidiosa can be confused with *C. hetieri*; the spores are of the same size in the two species. The yellow contents of the cystidia are the best character to distinguish between the two. The colours of young basidiocarps can be quite similar, but are different in mature specimens.

In the field *C. cystidiosa* shows a certain resemblance to *C. pulverulenta* as well. Both species may have pyramidal warts on the pileus, and also the colours can be rather similar. The pileus of *C. pulverulenta*, however, is often quite conical, whereas in *C. cystidiosa*, the pileus is rounded, or umbonate. The two species share certain chemical characters. Both colour bright yellow by NH_3 vapours and both discolour very dark violet-blue when rubbed with $FeSO_4$, whereas some other species in this group become more greenish blue. The microscopical characters, like the shape of the velar elements, and the presence of cystidia and clamp-connections, are in cases of confusion of decisive value. It is striking that in *C. cystidiosa* the velar elements close to the stipe surface show a tendency to become ellipsoid or even oblong, resembling the velar elements of *C. pulverulenta*.

It is often quite difficult to get a good view of the shape of the cystidia of *C. cystidiosa*.

The colour of exsiccates varies greatly; some specimens remained greyish-brownish, others have become orange-brown. Huijsman (1943) (mis)applied the name *L. rufescens* B. & Br. sensu Lange to the latter. In all specimens examined the lamellae are pinkish grey-brown (7.5 YR 6/3), except in freshly dried specimens, in which the colour is still cream.

Cystolepiota cystidiosa is known in Europe mostly from greenhouses, but in the woods of southern Limburg it has been known to the second author since 1977; more recently there are records by Kelderman (1994) and Winterhoff & Bon (1994) of occurrences in the wild.

Plate 210 (as *C. hetieri*) in Breitenbach & Kränzlin (1995) strongly resembles *C. cystidiosa*, although the microscopical characters, and especially the spore shape, excellently fit *C. adulterina*. Plate 212 (as *C. spec.*) in the same work, which is there considered to be different, on account of its yellow-cream coloured spores, resembles *C. adulterina*, both visually and microscopically. Little is known about the variability of the spore print colour in the taxa in this group, and the use of this character in species delimitation remains to be studied.

Cystolepiota hetieri (Boud.) Sing. — Figs. 1, 2e, 3d

Lepiota hetieri Boud., Bull. Soc. mycol. Fr. 18 (1902) 137; *Cystoderma hetieri* (Boud.) Sing., Schweiz. Z. Pilzk. 17 (1939) 53; *Cystolepiota hetieri* (Boud.) Sing., Beih. Sydowia 7 (1973) 67. — *Agaricus granulosus* var. *rufescens* B. & Br., Ann. Mag. nat. Hist. 5, Ser. VII (1881) 124 (Notic. Brit. Fungi 1834); *Lepiota rufescens* (B. & Br.) J. Lange, Dansk bot. Ark. 9 (6) (1938) 65, non *L. rufescens* Morgan, 1906; *Lepiota langei* Locq., Bull. mens. Soc. linn. Lyon 14 (1945) 87, non *L. langei* Knudsen, 1980; *Cystolepiota langei* (Locq.) M. Bon, Doc. mycol. 22 (88) (1993) 27.

Excluded. Lepiota hetieri sensu J. Lange, Fl. agar. dan. 1 (1935) 35–36, pl. 14J (= *C. adulterina*); *Cystolepiota hetieri* sensu Breitenb. & Kränzl., Pilze Schweiz 4 (1995) pl. 210 (= *C. adulterina* or *C. cystidiosa*). — *Lepiota rufescens* sensu Huijsman, Meded. Ned. mycol. Vereen. 28 (1943) 46–51 (= *C. cystidiosa*); sensu Kühner & Romagn., Fl. anal. Champ. sup. (1953) 396 (=? *C. cystidiosa*).

Selected icons. Boud., Bull. Soc. mycol. Fr. 18 (1902) pl. 6, fig. 1; J. Lange, Fl. agar. dan. 1 (1935) pl. 14I; Rald et al., Svampe 26 (1992) 34.

Selected descriptions & figures. Herink, Česká Mykol. 15 (1961) 226–233, figs 6–8; Kelderman, Parasolzw. Zuid-Limburg (1994) 36–37; Kühner, Bull. trimest. Soc. mycol. Fr. 52 (1936) 205–206; F. Møller, Friesia 6 ('1957–1958', 1959) 25.

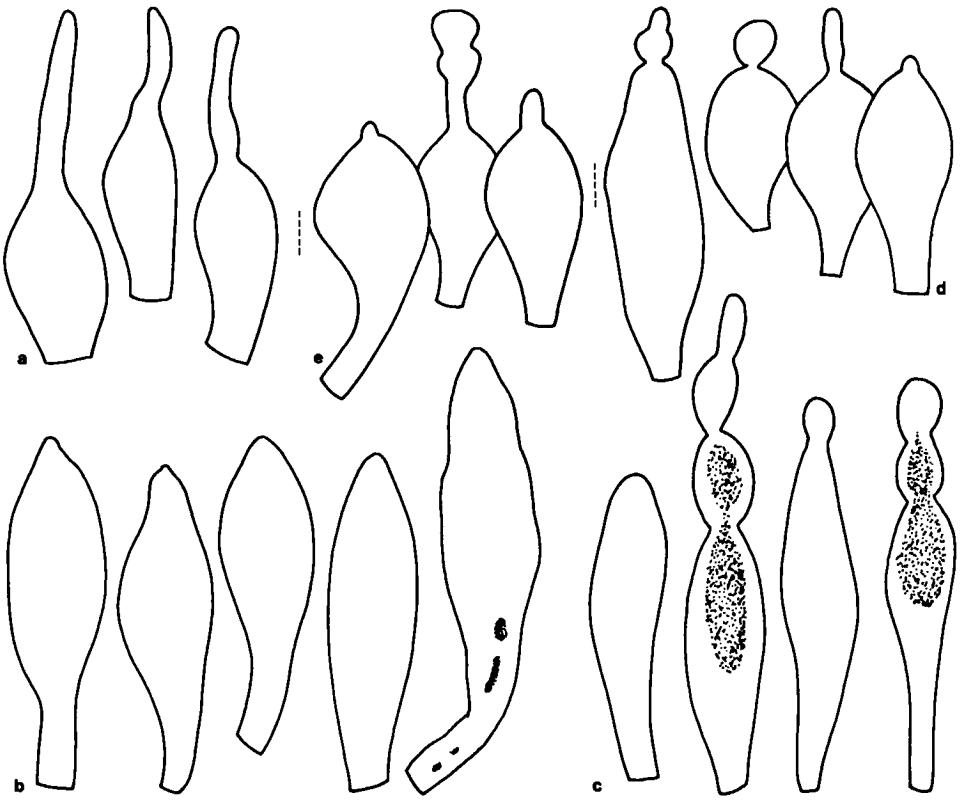

Fig. 3. Cheilocystidia of a. *C. adulterina* (from holotype of *C. adulterina* f. *reidii*), b. & c. *C. cystidiosa* (b. from Wölfel, 4-I-1987; c. from *E.C. Vellinga 1758*), d. *C. hetieri* (from *E.C. Vellinga 1020*), and e. *C. moelleri* (from *C. Bas 8305*). — 1500 ×.

Pileus 10–22(–30) mm, when young hemispherical, expanding to plano-convex with umbo, with velar remnants at margin, at first white to whitish cream, rarely greyish, soon discolouring to orange-brown in patches or totally discoloured (5 YR 5/6–8), granulose to more or less squamulose, when young often with low pyramidal warts on woolly background; warts at centre rather crowded. Lamellae, L = 35–60, l = 3, moderately crowded, free, segmentiform to subventricose, up to 3 mm broad, white to cream coloured, with age discolouring, especially at edge, to orange-brown or rarely to pale buff (7.5 YR 8/4) when touched, with white, concolorous even edge. Stipe 15–40(–50) × 2–4 mm, cylindrical, fistulose, with or without woolly ring-like zone, whitish cream, rarely greyish, at apex pruinose, below ring-like zone granulose to flocculose, often rather quickly discolouring orange-brown or red-brown, especially when touched, with white basal tomentum. Context whitish in pileus, in stipe apex cream coloured, and orange-brown (7.5 YR 4/6) at base, white around cavity. Smell unpleasant sweetish-fungoid, not resembling the smell of *L. cristata*, or according to other observations like the smell of *L. cristata*. Taste not recorded. Spore print colour not known.

Spores [210, 21, 21] 4.0–6.0(–6.5) × 2.0–3.0(–3.5) µm, Q = (1.5–)1.6–2.1(–2.3), average Q = 1.8–2.0, oblong, some (sub-)cylindrical, some slightly broadened at basal part, colourless, with slightly thickened wall, often in tetrads, non-dextrinoid, non-amyloid, with cyanophilous wall; spore wall pink in Cresyl Blue. Basidia 15–25 × 5–7 µm, 4-spored. Cheilocystidia usually abundant, 14–32 × 7–12 µm, with up to 15 µm long abrupt, capitulate and cylindrical or moniliform excrescence at apex, clavate or ellipsoid, thin-walled to slightly thick-walled especially in apical part, usually colourless, some with brownish granular contents. Pleurocystidia present, especially near lamella edge, sometimes rather rare, similar to cheilocystidia. Hymenium at lamella edge brown coloured. Pileus covered with a velar epithelium, made up of globose to ellipsoid and spheropedunculate elements, 20–60(–80) µm in diam., slightly thick-walled, with, rarely without, brownish parietal pigment. Stipitipellis at apex a cutis of cylindrical elements, 4–10 µm in diam., usually colourless, sometimes red-brown coloured, slightly thick-walled, lower down with chains of globose elements, 20–60 µm in diam., slightly thick-walled and brown coloured. Clamp-connections present in all tissues.

Habitat & distribution — Saprotrophical and terrestrial, gregarious in deciduous woods on clayey, loamy soils, rich in humus, often rich in lime; also in greenhouses. In the Netherlands widespread, but not common. Occurring from the end of Aug.–Oct.(–Nov.), but in greenhouses throughout the year. Known from temperate regions of Europe.

Collections examined. NETHERLANDS: prov. Gelderland, Neerijnen, estate Neerijnen, 6-IX-1980, *Th. W. Kuyper 1424* (L); prov. Noord-Holland, Amsterdam, Amsterdamse Bos, 5-X-1983, *C.B. Uljé 455* (herb. Uljé); 's-Graveland, Boekesteyn, 1-V-1971, *H.S.C. Huijsman 8* (L); prov. Zuid-Holland, Rotterdam, Kralinger Hout, 30-IX-1961, *C. Bas 2454a* (L); prov. Noord-Brabant, Eindhoven, Philips de Jong Park, 30-VIII-1979, Aug.–Sept. 1980, *H.A. Huijser* (herb. Huijser); prov. Limburg, Brunssum, mine stone heap of mine 'Hendrik', 13-IX-1980, *P.H. Kelderman 240* (L); Cadier en Keer, Örenberg, 4-X-1989, *E.C. Vellinga 1601* (L) and Riesenberg, 4-X-1989, *E.C. Vellinga 1616* (L); Gronsveld, Savelsbos, 4-IX-1977, *Th.W. Kuyper 895* (L); Gulpen, Wijlrebossen, 6-XI-1982 and 25-IX-1986, *P.H. Kelderman 1604 & 1630* resp. (L); Heerlen, Imstenrader Bosch, 21-IX-1988, *E.C. Vellinga 1402*; Heerlen, Putberg, 25-VIII-1982, *H.A. Huijser* (herb. Huijser) and 3-VIII-1988, *E.C. Vellinga 1323* (L). — BELGIUM: prov. Liège, Tilff, Vallon de la Chawresse, 11-IX-1995, *E.C. Vellinga 1928* (L); prov. Namur, Dourbes, Grand Mont, 22-IX-1986, *E.C. Vellinga 1020* (L); Dourbes, Tiêne-aux-Pauquis, 8-X-1982, *T. Boekhout 1032* (L); Rochefort, Fond des vaux, 10-IX-1975, *M.E. Noordeloos 128* (L). — CZECH REPUBLIC: Česky Kras, near Cernosiče, 5-IX-1981, *Th.W. Kuyper 1719* (L). — DENMARK: Falster, Kohaven, 10-X-1960, *F.H. Møller* (L). — GERMANY: Berlin, Berlin-Grünewald, Riemeister Fenn, 8-IX-1979, *E. Ludwig* (L); Berlin-Lichtenrad, 15-X-1987, *E. Ludwig* (L); Baden-Württemberg, Gottenheim, Wasenweiler Wald, 4-IX-1975, *M. Bon 750904* p.p. (herb. Bon; part of type collection of *C. subadulterina*), and 5-IX-1975, *C. Bas 6591* p.p. (L). — SWITZERLAND: ct. Neuchâtel, Planeyse, 16-IX-1965 and 16-IX-1968, *H.S.C. Huijsman* (L).

In the field, *Cystolepiota hetieri* can easily be confused with *C. pulverulenta*. The latter differs from *C. hetieri* in the oblong, inflated elements of the veil, the absence of cystidia and the absence of clamp-connections.

Cystolepiota seminuda is slender, does not discolour orange-brown and lacks cystidia, and is therefore easily recognized.

Cystolepiota adulterina is often confused with *C. hetieri*, and some authors doubt whether it is a separate species. For comments on differences and similarities, see under *C. adulterina*. *Cystolepiota cystidiosa* comes very close to *C. hetieri*, has similar spores (both in shape and size), but differs in the colour of the basidiocarps and the yellow contents and exudates of the cystidia and other parts of the basidiocarps.

Bon (1993b) distinguishes *C. langei* from *C. hetieri*, on account of the distinct ring-like zone on the stipe and the non-moniliform cystidia in the former. Both characters were found in the material studied, but are not correlated. The shape of the cystidia is very variable, and changes with the age of the basidiocarps.

Cystolepiota moelleri Knudsen — Figs. 2f, 3e

Lepiota rosea Rea, Trans. Br. mycol. Soc. 6 (1918) 61–62; *Cystolepiota rosea* (Rea) M. Bon, Doc. mycol. 6 (24) (1976) 43, non *Cystolepiota rosea* Sing., 1969; *Cystolepiota moelleri* Knudsen, Bot. Tidsskr. 73 (1978) 134; *Cystolepiota rosella* Mos., Röhrlinge Blätterpilze, 4. Aufl. (1978) 236 (superfluous name change).

Misapplied. Cystolepiota adulterina f. *reidii* sensu M. Bon, Doc. mycol. 11 (43) (1981) 25; sensu Lanzoni & Zecchin, Riv. Micol. 31 (3–4) (1988) 104; sensu Candusso & Lanzoni, Fungi eur. 4 (1990) 88–90; *Lepiota pseudoasperula* sensu Enderle & Krieglst., Z. Mykol. 55 (1989) 86.

Selected icons. Enderle & Krieglst., Z. Mykol. 55 (1989) opp. p. 96 (as *L. pseudoasperula*); R. Phillips, Paddest. Schimm. (1981) 30 (as *L. rosea*).

Selected descriptions & figures. Kelderman, Coolia 31 (1988) 12–14, fig. 1; P.D. Orton, Trans. Br. mycol. Soc. 43 (1960) 287 (as *L. rosea*).

Pileus 8–40 mm, when young hemispherical with inflexed margin, expanding to plano-convex with shallow central depression, or with applanate centre, at centre densely set with low acute and (sub-)pyramidical pink or pinkish red-brown squamules or warts (2.5 YR 3/5, 3–2.5/2, 2.5–5 YR 4/4), at margin with more widespread squamules, on a very pale pinkish-brownish background (7.5 YR 7/6), with velar remnants at margin when young. Lamellae, L = 30–40, l = 1–3, moderately crowded to crowded, free, segmentiform to ventricose, up to 3.5 mm wide, whitish cream, greyish cream with age, with concolorous to pinkish even to flocculose (under lens) edge. Stipe 15–40(–70) × 2–5 mm, cylindrical or slightly broadening towards base, curved at base, fistulose, at apex pinkish cream and pruinose at fibrillose background, lower down with scattered pink or reddish brown flocculose or lanate bands of warts (2.5 YR 6/4) on pale pink to vinaceous red background. Context in pileus white to cream, white to pale pinkish in stipe. Smell faint and sweetish, pleasant or like *Lepiota cristata*. Taste indistinct, fungoid. Spore print 'white'.

Spores [167, 16, 15] 4.0–5.5(–6.0) × 2.5–3.0 µm, Q = (1.5–)1.6–2.2(–2.3), average Q = 1.7–1.9(–2.0), oblong to cylindrical, some slightly phaseoliform in side-view, thin-walled and colourless, non-dextrinoid, cyanophilous, congophilous, metachromatic in Cresyl Blue; often in tetrads. Basidia 16–26 × (3.5–)5.0–7.5 µm, 4-spored. Lamella edge sterile; cheilocystidia abundant, 15–35(–39) × 7.0–15 µm, narrowly clavate to obovate, usually with cylindrical, moniliform or branched, excrescence at apex, up to 22 µm long, colourless and thin-walled. Pleurocystidia not present. Squamules on pileus made up of globose to ellipsoid elements, 15–70 µm in diam., slightly thick-walled, with brown parietal pigment. Stipitipellis at apex of stipe a cutis of cylindrical to inflated, 4.0–8.0 µm wide, not coloured elements, lower down with chains of globose to ellipsoid elements, 30–60 µm in diam., brown-coloured and slightly thick-walled. Clamp-connections present in all tissues.

Habitat & distribution — Gregarious or solitary, saprotrophical and terrestrial in mixed deciduous woods on loamy, calcareous or nutrient-rich soils; in the Netherlands rare,

mostly in southern Limburg, Aug.–Oct. Widespread and rather rare in temperate parts of Europe.

Collections examined. NETHERLANDS: prov. Utrecht, Breukelen, estate Nijenrode, 28-VIII-1983 and 25-IX-1983, *G. Immerzeel* (L); prov. Limburg, Bemelen, 9-X-1991, *E. C. Vellinga 1756* (L); Brunssum, mine stone heap of mine 'Hendrik', 9-X-1987, *P. H. Kelderman 1514* (L); Cadier en Keer, Orenberg, 9-X-1991, *E. C. Vellinga 1768* (L); Savelsbos, 6-VIII-1976, *H. A. Huijser* (L); Elsloo, Bunderbos, 7-IX-1996, *E. C. Vellinga 2010* (L). — BELGIUM: prov. Namur, Han-sur-Lesse, Grande Tinémont, 9-IX-1975, *F. & G. Tjallingii* (herb. Tjallingii); Matagne la Grande, Bois les Mires, 4-X-1984, *C. Bas 8305* (L); Nismes, 30-IX-1984, *E. C. Vellinga 666* (L). — FRANCE: dept. Haute Savoie, le Salève, 6-IX-1986, *E. C. Vellinga 993* (L); dept. Pas de Calais, Bois de Hardelot, 18-X-1991, *E. C. Vellinga 1801* (L). — GERMANY: Baden-Württemberg, Nerenstetten, 9-X-1984, *M. Enderle* (L); Bayern, Kissendorf, Bubesheimerwald, 19-IX-1988, *M. Enderle* (L); Nordrhein-Westfalen, Sauerland, Almequellen, 1-IX-1974, *F. & G. Tjallingii* (herb. Tjallingii); Mönchengladbach, Volksgarten, 16-X-1984, *H. Bender* (herb. Bender); Rheinland-Pfalz, Müllenborn, 20-IX-1990, *E. C. Vellinga 1689* (L); Nohn, Dreimüllerwald, 28-IX-1987, *E. C. Vellinga 1201* (L). — GREAT BRITAIN: Somerset, Higher Merridge, 15-IX-1960, *D. A. Reid* (neotype, K); Surrey, Mickleham, Norbury Park, 29-VIII-1992, *N. W. Legon* (K).

The type collection of *Lepiota rosea* Rea (Caughley Woods, Shropshire (Salop), 29-IX-1917) does not exist any more. The original water colour of Rea's collection, preserved at K, shows a pink *Cystolepiota* species; there is no discrepancy between this picture and the present-day interpretations of the species. A neotype has been selected, viz. Somerset, Higher Merridge, 15-IX-1960, *D. A. Reid* (K), a collection also seen by Orton.

Bon (1993b) cites this taxon as *C. rosea* (Rea) Sing. However, Singer (1969) validly describes the new species *Cystolepiota rosea*, a species in its own right, differing from *C. moelleri* in the absence of cheilocystidia and in the rather smooth surface of the pileus.

Cystolepiota moelleri might be confused with *Lepiota pseudoasperula*, but in the latter spores are dextrinoid and cheilocystidia absent.

Cystolepiota section **Pulverolepiota** (M. Bon) Vellinga, *comb. et stat. nov.*

Basionym: *Pulverolepiota* M. Bon, Doc. mycol. 22 (88) (1993) 30.

This section of *Cystolepiota* is characterized as follows: spores very slowly becoming red-brown in Melzer's Reagent, clamp-connections absent, and velar elements elongate and inflated.

Further research is necessary to determine whether *C. pseudogranulosa* (B. & Br.) Pegler, also belongs in this section, just as *C. pulverulenta*. *Cystolepiota pseudogranulosa* is provided with numerous, though small, clamp-connections (Pegler, pers. comm., Febr. 1996), and the spores are strongly dextrinoid (Dennis, 1952).

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