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The genus *Leucocoprinus* in western Washington

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Abstract — The genus *Leucocoprinus* in Washington state was investigated based on fresh and herbarium collections as a part of a survey to assess the biodiversity and abundance of all lepiotaceous (*Agaricaceae*) fungi in the Pacific Northwest. Seven species were found to occur in the study area. *Leucocoprinus (Lc.) flavescens* is reported from Washington while *Lc. brebissonii* and *Lc. heinemannii* are credibly recorded in North America for the first time. The complex history of *Lc. cretaceus* in North America including its first record from Washington is discussed. The above four species as well as *Lc. birnbaumii, Lc. cepistipes,* and *Lc. ianthinus* are described and their microscopic characters illustrated.

Keywords — agarics, introduced species, western North America

Introduction

Pale-spored members of the family *Agaricaceae* (lepiotaceous fungi as defined by Vellinga 2004a; formerly *Lepiotaceae*) have remained rather understudied in North America (Vellinga, 2004a). The western half of the continent has received little attention since the works of Burlingham (1945), Murrill (1912), and Zeller (1922, 1929, 1933 1934, 1938). The methods of investigation ignored characters now considered of great importance, and microscopic features were left essentially unexamined. Although the lepiotaceous flora of California (and to a lesser extent that of Oregon) has received much attention in the last 40 years bringing to light many of the details needed to clarify species' identities and relationships (Smith & Sundberg 1979; Sundberg 1967, 1971a, 1971b, 1976, 1989 1995; Vellinga 2001a, 2001b, 2007a, 2007b, 2007c, 2007d; Vellinga & Davis 2007; Vellinga & Sundberg 2008), pacific northwest species have been relatively neglected, except for the work by Sieger (2003).

In an attempt to lessen the disparity of knowledge regarding lepiotaceous fungi, the present paper is presented as a first in a series of investigations concerned with assessing the biodiversity of lepiotaceous fungi in the Pacific Northwest.

The genus *Leucocoprinus* Pat. was originally erected to accommodate the sulcate/plicate species intermediate between *Leucoagaricus (La.)* Locq. ex Singer and *Macrolepiota* Singer (Singer 1986). This position is problematic as there are many *Leucoagaricus* species that have moderately to slightly sulcate pileus margins. The distinction was clarified with the discovery of pseudoparaphyses (also called brachybasidioles and pavement cells) between the basidia, which species of *Leucoagaricus* lack.

Genetic investigations have not well supported *Leucocoprinus* as independent but show its species intermixed with *Leucoagaricus* species. The possible monophyly of *Leucocoprinus* cannot, however, be completely rejected (Vellinga 2004b). The present paper treats *Leucocoprinus* as an artificial but conveniently recognizable morpho-genus rather than a natural assemblage of species. It appears that the presence of pseudoparaphyses is not phylogenetically significant, but it is still unclear whether this character has evolved several times to give rise to close groups of species or whether it has been gained and lost several times at the species level and thus has no particular taxonomic value. Here *Leucocoprinus* is used in a sense that excludes species of *Leucoagaricus* section *Annulati* and section *Piloselli* — e.g., *La. americanus (*Peck) Vellinga, *La. badhamii* (Berk. & Broome) Singer — which some authors (e.g. Moser 1967; Reid 1990) have included.

Species of *Leucocoprinus* appear to benefit greatly from human disturbance. They grow quickly and readily in potting soils and other man-made organic-rich materials in which they appear to have been transported. As a result, it is probable that all seven species known to occur in Washington were introduced during the 20th century. *Leucocoprinus brebissonii* is especially interesting: since the first report in 1994, its populations have become very common and are now readily encountered in most Puget Sound basin forests. Vellinga (2001c) suggests that *L. brebissonii* has become more common in the Netherlands due to increasing nitrogen enrichment of the soil (Vellinga 2001c).

The first report of a *Leucocoprinus* species from Washington was "*Lepiota cretacea* (Bull.) Morgan" reported by Murrill (1912), who cited "*Lepiota cepaestipes* Quél." as a synonym. It is impossible to discern exactly what species Murrill reported as he had an extremely broad species concept (see remarks under *Lc. cretaceus*). Sheridan (1956) reported *Lc. birnbaumii* (as "*Lepiota lutea* (Bolton) Matt.") from Washington for the first time as a common greenhouse inhabitant or found outdoors in soil that had been artificially heated during the winter. The next two additions to the Washington *Leucocoprinus* mycota were *Lc. cepistipes* and *Lc. ianthinus* (as *Lc.* "*lilacinogranulosus*") by Sieger (2003). This paper presents the first reports of *Lc. flavescens* and *Lc. cretaceus* (in the narrow sense) from Washington state and the first documented reports of *Lc. brebissonii* and *Lc. heinemannii* from North America.

Materials and methods

Synonyms are listed only when helpful or informative. For a complete list, see Vellinga (2009). The generic names *Lepiota, Leucoagaricus, and Leucocoprinus* are abbreviated as *L., La.,* and *Lc.*

Because of the lack of data on fresh material, the macroscopic description for *Lc. ianthinus* is borrowed from Sieger (2003). Color notations in quotation marks are from Ridgway (1912).

Descriptions of microscopic characters were made using the glossary of Vellinga & Noordeloos (2001) whenever possible. Microscopic observations were made from exsiccate revived in 3% KOH. Dimensions were recorded from 30 measurements made from one specimen for spores (in profile view), cheilocystidia, and pileus covering cells. Ten basidia and pseudoparaphyses from each collection were measured. Measurements and Q-values (a ratio of length over width) are displayed as follows: lower extreme–mean–upper extreme. Pseudoparaphyses, sterigmata, and basidia were measured during, or shortly after, sporulation. The pileus covering was sectioned at the disc and mid-margin and near the edge to observe the full variability of pileus structure. When possible, both immature and mature pileus were sectioned to determine the development of the covering.

All cited collections are deposited at the University of Washington herbarium (WTU).

Results

Of the seven species of *Leucocoprinus* encountered, four were found to grow only indoors or in artificially heated habitats, one grew both indoors and outdoors, and two were found only outdoors. Basidiocarps of *Leucocoprinus* species are most often encountered July through September rarely fruiting as late as November.

The seven *Leucocoprinus* species known from Washington state are described and illustrated. An artificial key to their identification is presented below.

Key to *Leucocoprinus* species of Washington

1. Carpophores with yellow tones 2
1. Carpophores lacking yellow tones 3

2. Center of pileus with fulvous tones, lacking scales; pileus covering composed of loosely arranged globose cells; spores subglobose, lacking a germ pore ..... 5. *Leucocoprinus flavescens*

2. Center of pileus lacking fulvous tones, with distinct scales; pileus covering lacking globose cells; spores broadly amygdaliform and with a distinct germ pore ..... 1. *Leucocoprinus birnbaumii*

3. Pileus and stipe covered with a copious farinose covering; lacking contrasting scales or fibrils; entire fruiting body white to cream colored ..... 4. *Leucocoprinus cretaceus*

3. Pileus and stipe only slightly farinose (if at all); with contrasting scales or fibrils. . . .4

4. Pileus with black to dark grey disc and scales 5
4. Pileus with purple to brown colored disc and scales 6

5. Pileus with minute, granule-like scales; found in forests (suspected from green-houses) ..... 2. *Leucocoprinus brebissonii*
5. Pileus with small, fibrillose scales; known only from greenhouses ..... 6. *Leucocoprinus heinemannii*

6. Pileus with small, violet- to lilac-brown scales; found indoors (to date) in flower pots etc. ..... 7. *Leucocoprinus ianthinus*
6. Pileus with medium to small, brown to tan, appressed scales; found in wood-chips, compost heaps, gardens etc. ..... 3. *Leucocoprinus cepistipes*

1. *Leucocoprinus birnbaumii* (Corda) Singer, Sydowia 15(1-6): 67 (1962) Fig. 1

≡*Agaricus birnbaumii* Corda, Icon. Fung. (Prague) 3: 48 (1839)
=*Lepiota lutea* Godfrin, Bull. Soc. mycol. Fr. 13: 33 (1897)
≡*Leucocoprinus luteus* (Godfrin) Locq., Bull. mens. Soc. linn. Lyon 14: 93 (1945)

Pileus: 2.0–7.5 cm, at first paraboloid to cylindrical, later paraboloid to obtusely conical upon expansion, more or less plane to broadly umbonate with age; margin at first incurved, later decurved, sometimes straight with age, sulcate-striate; with appressed-fibrillose scaly to squarrose scales; disc solid, breaking up outward into scales on a somewhat farinose background, these often absent by 3/4th out; scales "old gold" to "Verona brown" to "raw umber;" background "barium yellow" to "citron yellow" to "massicot yellow" to "naphthalene yellow" to "sulphur yellow", pallid in the furrows; texture moderately firm when young but soft and fragile with age. Odor: absent to sometimes fungal (like *Lycoperdon* spp.). Lamellae: free, often noticeably remote, subdistant to crowded, ventricose with age, soft, very thin, "sulphur yellow" to "citron yellow", edge notably fimbriate. Stipe: 2.5–9.0 cm long, 2–6 mm broad at apex, often gradually enlarging below to a slightly enlarged to somewhat clavate to bulbous, 4–15 mm broad, base, farinose to pruinose to somewhat floccose-squamulose, "citron yellow" to "massicot yellow" to "naphthalene yellow," sometimes discoloring "buffy brown", hollow and stuffed with pith. Annulus: thin, felt-like, superior to inferior, moveable, band-like, "citron yellow" to "barium yellow" to "naphthalene yellow;" rarely leaving remnants on pileus margin.

Spores: 7.7–8.9–10.5 × 5.9–6.5–7.3 µm, Q-value 1.12–1.36–1.56, ellipsoid to slightly amygdaliform in profile view, thick-walled, with a large apical germ pore that is often covered with a hyaline cap, metachromatic, dextrinoid. Basidia: 19.8–27.5 × 7.7–11.0 µm, pyriform to narrowly clavate, 4-spored, surrounded by four pseudoparaphyses. Sterigmata: 1.4–2.2 × 0.8–1.2 µm. Pseudoparaphyses: 16.5–22.1 × 10.5–12.8 µm, narrowly utriform to narrowly clavate, lacking a pedicel, often somewhat angular. Cheilocystidia:

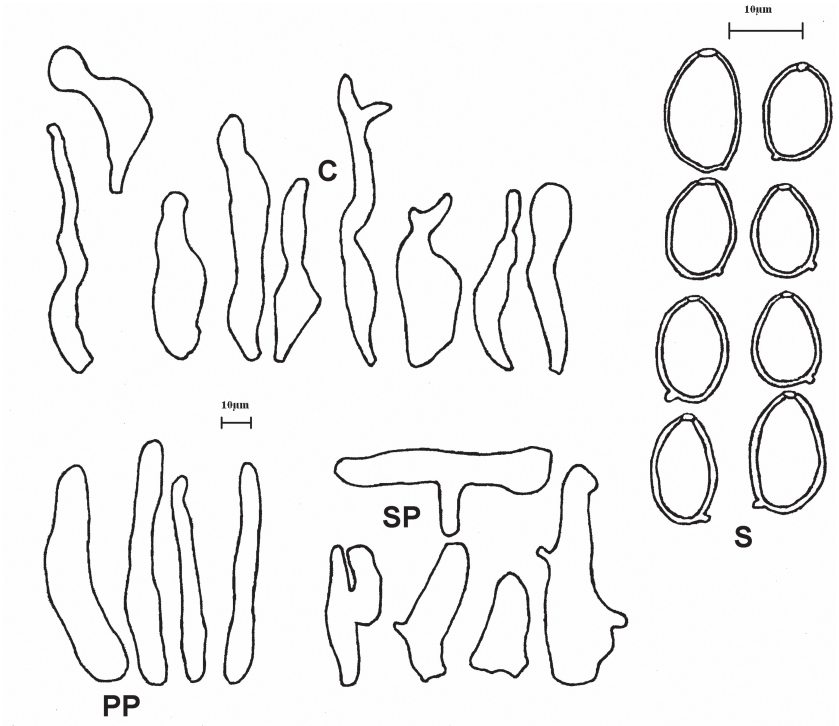

Figure 1. *Leucocoprinus birnbaumii* –
S. spores; C. cheilocystidia; PP. pileus covering; SP. contextual elements
(all from collection PBM 1943).

22.5–40.4–62.5 × 7.5–11.3–14.3 µm, very variable, lageniform to fusiform, less often clavate to utriform, at apex often with a flexuous excrescence that is up to ½ of total length, rarely with mucronate to obtuse apices, thin-walled, often with somewhat yellow colored vacuolar contents. Pileus covering: a confluent layer of terminal cells when young, disarticulating into scales and/or patches revealing short, inflated to cylindrical, loosely attached cylindrical, H-, T- to L-shaped contextual elements (these being the only discernable cell type in poorly preserved collections or in collections in which scales are indistinct or absent). Terminal elements ascending to somewhat repent conglomerations of 32.5–65.7–155.0 × 7.5–12.8–18.8 µm, flexuous cylindrical to somewhat narrowly lageniform to rarely elongate clavate terminal. Stipe covering: composed of repent to ascending, cylindrical, 5–8 µm broad elements similar to the terminal elements of the pileus. Stipitipellis: a cutis made up of 10–15 µm broad, cylindrical elements. Clamp Connections: absent.

Habitat and distribution: solitary to subconnate imbricate in rich soils, very often in greenhouses or in flowerpots indoors. Cosmopolitan.

Collections examined: U.S.A.: Washington, King Co., Seattle: PBM 1943, det. P.B. Matheny, 8/21/2000; University of Washington Botany greenhouse: SAR 88/417, det. S.A. Rehner, 2/24/1988; University of Washington campus: MTS 4997, det. M.T. Seidl, 8/29/2002; STZ 9330, det. D. Stuntz, 11/09/1955. Spokane Co., Whitworth College: D. Brown 9/1989, det. J.M. Birkebak

Remarks: The bright yellow coloration and cosmopolitan distribution in areas of human disturbance has made *Lc. birnbaumii* one of the most easily recognized mushrooms. Its toxicity (Singer 1986) further contributes to its fame.

The species is reputedly an indoor species in northern temperate locations, but it has been collected outdoors in Washington in an area with artificially heated soils (Sheridan 1956). It is unclear whether this species is truly restricted to artificially warm soils, as I have heard many unconfirmed reports and at one point seen what appeared to be an immature *Lc. birnbaumii* in natural conditions in a pacific northwest forest.

There is some confusion regarding the structure of the pileus covering, and sometimes only the upper contextual elements are described and illustrated (e.g., Sundberg 1967, Pegler 1972).

2. ***Leucocoprinus brebissonii*** (Godey) Locq., Bull. mens. Soc. linn. Lyon 12: 41. 1943 Fig. 2

≡*Lepiota brebissonii* Godey in Gillet, Hyménomycètes: 64. 1874.

Pileus: 2.0–5.5 cm broad, short cylindrical when very young, becoming conic to convex to more or less paraboloid, sometimes becoming plano-convex when mature, often collapsing to more or less truncate conic; margin often straight to decurved, sulcate-striate, sometimes with sparse velar remnants, often eroding with age; disc subtomentose to velutinous, immediately around disc breaking up into granular scales that are very sparse near margin; "dark grey" to black to sometimes "fuscous" tinted, rarely as pale as "smoky grey;" context white, rarely discoloring slightly yellow, very soft and thin, somewhat fragile. Odor: distinctly fungal. Lamellae: free, close to crowded, 2–6 mm broad, at margin fimbriate; white or with "cream buff" tints. Stipe: 3.5–9.0 cm long, 1–4 mm thick at apex, enlarging downward to clavate, 3–6(–10) mm thick base, sometimes rather flexuous, central to very rarely slightly eccentric, often appearing minutely fibrillose or minutely pruinose near apex, white to "ivory yellow," sometimes discoloring pinkish flesh–colored to dingy orange-pink with age especially near the base, at very base often with some light grey tints, hollow and often stuffed, somewhat fibrous–friable when fresh. Annulus: thin, upturned, median; white to pale cream, sometimes leaving loose remnants on the pileus margin.

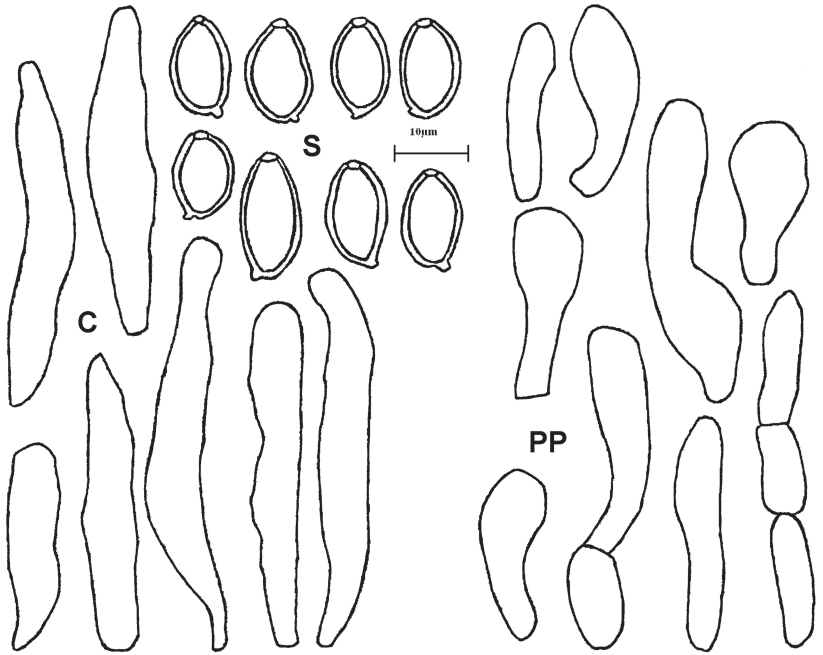

Figure 2. *Leucocoprinus brebissonii* – S. spores; C. cheilocystidia; PP. pileus covering (all from collection JMB 9-13-2006-01).

Spores: 9.2–10.6–12.1 × 4.9–6.0–7.2 µm, Q-value 1.50–1.77–2.08, oblong ellipsoid to slightly amygdaliform, thick-walled, with an apical germ pore that often somewhat slants toward the adaxial side, metachromatic, dextrinoid. Basidia: 18.7–23.1 × 9.2–10.8 µm, pyriform, 4-spored, surrounded by four pseudoparaphyses. Sterigmata: 1.0–1.5 × <0.7 µm. Pseudoparaphyses: 14.3–17.6 × 6.6–10.2 µm, narrowly clavate, only slightly enlarged at apex. Cheilocystidia: 22.0–46.8–73.7 × 7.7–11.4–19.8 µm, cylindrical to very slightly fusiform, somewhat flexuous, often slightly constricted before the apex giving the cells a slightly capitate appearance, often somewhat pedicellate to tapered, thin-walled, hyaline. Pileus covering: a dense layer of terminal cells that disarticulates into several minute scales and remaining confluent at disc revealing cylindrical to sometimes branching, repent, contextual elements; terminal cells 26.3–41.8–60.0 × 15.0–19.1–27.5 µm, broadly clavate to ellipsoid to pyriform, often with a very broad point of attachment, rarely with a short pedicel, filled with grayish-olive brown vacuolar pigment, somewhat loosely chained with 1–6 pigmented elements that become narrower, longer and blend

into contextual cells. Stipe covering: restricted to very base, composed of cylindrical to sometimes narrowly clavate, moderately pigmented, sparse elements. Stipitipellis: a cutis made up of 7.5–11.3 μm broad, cylindrical, repent elements. Clamp Connections: absent.

Habitat and Distribution: scattered to gregarious, sometimes imbricate and more or less connate, growing on duff of *Alnus rubra*, *Acer macrophyllum* and/or *Thuja plicata*, less commonly on debris of *Tsuga heterophylla* and/or *Pseudotsuga menziesii* or sometimes on very decayed *Thuja plicata* wood. Known from throughout the tropics: known from Europe and the Pacific Northwest (where it is likely invasive for the latter; see below) in temperate areas.

> Collections examined: U.S.A.: Washington, King Co., Bridle Trails State Park: LB 2007-06-18-05, LB 2007-06-21-06, LB 2007-07-16-09, LB 2007-07-23-01, LB 2007-07-23-02, LB 2007-07-27-03, LB 2007-07-30-01, All det. J.M. Birkebak and L. Bayler; Carkeek Park: JMB 68, det. J.M. Birkebak, 10/13/2003; D. Oliver s. n. 2004, det. J.M. Birkebak, 2004; Coal Creek Park: JMB 75, det. J.M. Birkebak, 9/25/2003; Fauntleroy Park, JMB 258, det. J.M. Birkebak, 9/17/2004; JMB 9-13-2006-01, det. J.M. Birkebak, 9/13/2006; Lincoln Park: JMB 56, det. J.M. Birkebak, 9/30/2003; Redmond Preserve: Forrest Beckwith 7140402, det. J.M. Birkebak, 7/14/2004; St. Edwards State Park: GRW 778, det. J.M. Birkebak, 10/02/1994. Snohomish Co., Tulalip: M. Bennett 6/24/2004, det. J.M. Birkebak.

Remarks: *Leucocoprinus brebissonii* may be the most commonly encountered *Leucocoprinus* species in Washington. This species has probably gone unnoticed, despite its abundance, as a misdetermined *Lepiota atrodisca* Zeller, another species that features black scales on a white background but which is easily distinguished by a more robust stature and the vastly differing microscopic characters easily distinguish it. *Leucocoprinus heinemannii*, the other *Leucocoprinus* species with a black pileus covering, is differentiated by its punctate scales and short, broad elements.

Leucocoprinus brebissonii appears to have been introduced to Washington, as its first collection dates from 1994; given its current abundance, it is highly improbable that it could have gone uncollected and unnoticed for so long. This species has become naturalized to a great extent and is commonly encountered in most forests in the greater Seattle area. Whereas interspecies competition and displacement are poorly known, it is impossible to determine whether the arrival of this species has impacted native mycoflora to any significant extent.

This report extends the known distribution of *Lc. brebissonii* to include North America. The three previous reports of this species from North American are doubtful or ambiguous. Smith's (1981) report of "*Lc. brebissonii*" refers to a fibrillose pileus composed of narrow, somewhat cylindrical elements, features that clearly separate her description from the current concept and likely represent something in the *Lepiota atrodisca* complex (Else Vellinga, pers.

com.). Arora (1986) mentioned collecting "*Lepiota" brebissonii* from a lawn in Berkeley, California. Not only is this habitat highly unusual, the description of the carpophores as "2-3cm, with brownish to grayish scales," casts further doubt upon his identification, as *Lc. brebissonii* is described as a black to dark grey (at palest) species; the name is probably a misapplication based on Smith's 1981 species concept. It has not been seen in the Berkeley area since this report (Else Vellinga, pers. com.) and there is also no preserved collection that can be examined. Akers (1997) reports "*Leucocoprinus cf. brebissonii*" from Florida, but the reference seems doubtful as he described the stature as resembling *Lc. fragilissimus* "(Rav. & Berk.) Pat.", a much more fragile species than *Lc. brebissonii*.

The present paper cites many collections for the species in Washington, and the nrITS sequence of Washington material is identical to those from European collections (Else Vellinga, pers. com.). The distribution in North America needs further investigation.

3. *Leucocoprinus cepistipes* (Sowerby: Fr.) Pat., J. Bot., Paris 3: 336 (1889) [sensu J. E. Lange] Fig. 3

≡*Lepiota cepistipes* (Sowerby: Fr.) P. Kumm., Führ. Pilzk. : 136 (1871)

Pileus: 2.5–5.5 cm broad, ovoid to conic when young, becoming obtusely campanulate, broadly umbonate to somewhat truncate at times; margin at first incurved, becoming straight to more often decurved, sulcate-striate; glabrous to finely appressed tomentose at disc, toward margin becoming diffracted into sometimes slightly recurved to appressed squamulae, widely spaced near margin, rest of surface radially fibrillose to farinose; disc and scales "mummy brown" to "hazel" to "sayal brown" to "snuff brown" to "cinnamon brown" to "cinnamon" to "clay color" to "buffy brown" to "warm buff" to "honey yellow," background white to "pale pinkish buff" to "pale cream buff;" context soft (but rather sturdy for this genus), more or less white. Odor: mild, fungal. Lamellae: free, often noticeably remotely so, close, rather broad, thin; white, sometimes discoloring "amber yellow," edge notably fimbriate. Stipe: 2.5–7.5 cm long, 1.5–4.0 mm broad at apex, often slightly and gradually increasing in breadth downward to an often moderately clavate base, 6–7 mm broad base, glabrous to innately fibrillose to slightly tomentose (especially toward base), "light vinaceous cinnamon" to "light pinkish cinnamon" to "pinkish buff" to "buffy brown" to "avellaneous," generally darker downward, often discoloring "clay color" to "sayal brown." Annulus: membranaceous, flaring, superior, "avellaneous" to "buffy brown" to "cinnamon."

Spores: 7.7–9.2–10.5 × 5.5–6.7–7.7 μm, Q-value 1.19–1.37–1.52, ellipsoid to slightly amygdaliform, thick-walled, with an apical germ pore covered with a hyaline lens, metachromatic, dextrinoid. Basidia: 22.9–28.3 × 9.7–10.8 μm,

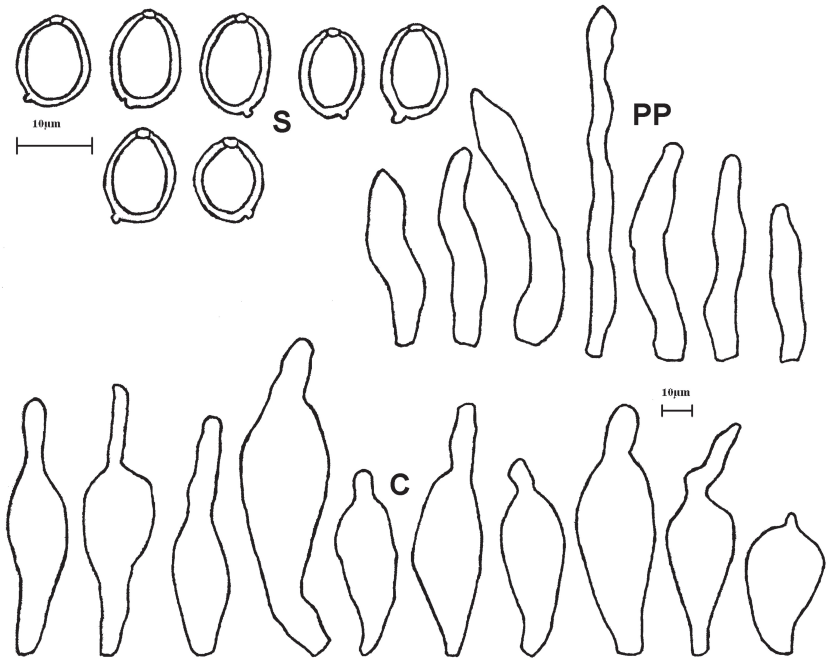

Figure 3. *Leucocoprinus cepistipes* – S. spores; C. cheilocystidia; PP. pileus covering (all from collection STZ 14210).

clavate pedicellate to cylindrical pedicellate, 4- to rarely 2-spored, surrounded by 4 pseudoparaphyses. Sterigmata: 1.4–2.2 × 0.7–1.2 µm. Pseudoparaphyses: 16.4–18.7 × 9.4–10.4 µm, pyriform to more or less sphaeropedunculate with a very short, broad pedicel, rarely broadly fusiform. Cheilocystidia: 30.0–45.3–57.5 × 10.0–14.8–17.5 µm, clavate to lageniform to rarely fusiform, often with a pedicel of short to moderate length, with obtuse to mucronate apices or with a flexuous, often tapering but sometimes capitulate, rarely forked, 4.5–6.5 µm broad excrescence up to 2/5th of cystidium length, thin-walled, hyaline. Pileus covering: a loose turf of terminal cells when young, thinning with age and breaking into scales, revealing repent, cylindrical to T-shaped contextual elements that often become loose and disarticulated; terminal cells 32.5–56.0–92.5 × 5.6–8.3–11.3 µm, very variable, flexuous, lageniform to less often cylindrical to narrowly clavate, yellowish brown, loosely chained; with 2-5 pigmented, angular globose to short cylindrical cells that generally blend into trama. Stipe covering: like pileus covering but more often cylindrical to narrowly clavate, less often lageniform, shorter and broader, 30.4–58.0 × 7.6–10.8 µm. Stipitipellis: made up of cylindrical, 10.0–17.5 µm broad, elements.

Clamp connections: absent.

Habitat and distribution: solitary to gregarious to subconnate imbricate on rich soils, compost heaps, and wood chips. Can be found both indoors (greenhouse) and outdoors. Cosmopolitan.

Collections Examined: U.S.A.: Washington, King Co., Foster Island: STZ 14859, det. D. Stuntz, 9/12/1968; Lincoln Park: STZ 14210, det. D. Stuntz, 8/30/1967; University of Washington Arboretum: STZ 18980, det. J.M. Birkebak, 9/8/191975; University of Washington Botany Greenhouse: FVDB 3787, det. F. Van De Bogart, 9/23/1976; STZ 786, det. J.M. Birkebak, 9/10/1944; STZ 1638, det. D. Stuntz, 8/9/1945; STZ 19453, det. J.M. Birkebak, 9/10/1976.

Remarks: This cosmopolitan *Leucocoprinus* rivals *Lc. brebissonii* as the most common representative of the genus in Washington. Like many of its brethren, this species fruits both indoors and outdoors.

One *Lc. cepistipes* collection included numerous primordia in a large, tight, confluent patch with mature specimens. The development of the universal veil and the hymenophoral cavity was found to be essentially the same as described for *Lepiota clypeolaria* (Bull. : Fr.) P. Kumm. and *Lepiota magnispora* Murrill (Atkinson 1914). The only difference noticed was that considerable elongation of the stipe tissue (2–3 mm) preceded hymenophoral differentiation and enlargement of the pileal cells. This difference between cell enlargement in the stipe and lack of enlargement in the center of the pileus context explains the abrupt cellular difference between the pileus and stipe context causing their very easy separation ("ball and socket" attachment).

4. *Leucocoprinus cretaceus* (Bull.: Fr.) Locq., Bull. mens. Soc. linn. Lyon 14: 93 (1945) Fig. 4

≡*Lepiota cretacea* (Bull.: Fr.) Morgan, J. Mycol. 13: 3 (1907)

=*Lepiota farinosa* Peck, Rep. N.Y. St. Mus. nat. Hist. 43: 81. (1890)

=*Leucocoprinus breviramus* H.V. Sm. & N.S. Weber, Contrib. Univ. Mich. Herb. 15: 301. (1982)

Pileus: 3.5–6.0 cm broad, hemispherical when young, expanding to plano-convex to campanulate, often somewhat umbonate; margin decurved, slightly sulcate-striate, at most sulcate to 1/5th to center; when young with many, dense, soft floccules, readily collapsing or wearing off to leave farinose covering; "light buff" to white at center, white elsewhere. Lamellae: remotely free, close, rather broad, thin; white, edge slightly fimbriate. Stipe: 5–8 cm long, 4–6 mm broad at apex, gradually enlarged downward to a broadly clavate to somewhat fusiform 6–13 mm broad base; sometimes coarsely farinose to slightly flocculose-farinose below annulus, subfarinose above; white to ivory yellow tinted (especially darker below). Annulus: very soft, somewhat flaring, median to superior, white.

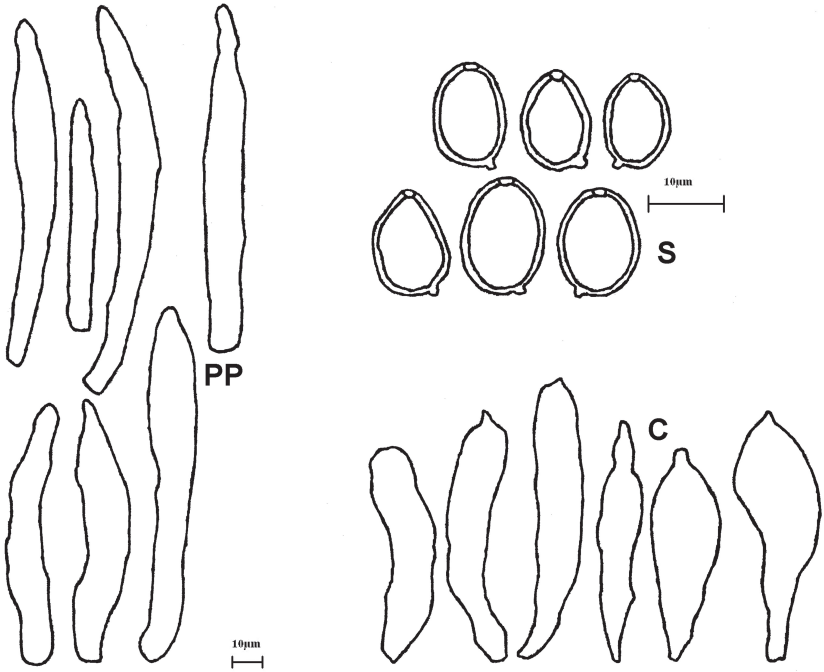

Figure 4. *Leucocoprinus cretaceus* – S. spores; C. cheilocystidia; PP. pileus covering (all from collection SJ22).

Spores: 8.1–9.4–11.8 × 5.9–6.8–7.8 µm, Q-value 1.32–1.47, ellipsoid to somewhat amygdaliform, thick-walled, with an apical germ pore covered with a hyaline lens, metachromatic, dextrinoid. Basidia: 16.9–21.3 × 9.3–11.2 µm, pyriform to somewhat clavate with a somewhat bulbous base, 4-spored, surrounded by 4 pseudoparaphyses. Sterigmata: 1.3–2.0 × 0.7–1.1 µm. Pseudoparaphyses: 10.4–13.3 × 7.4–9.6 µm, sphaeropedunculate to broadly clavate to pyriform, point of attachment very broad. Cheilocystidia: 27.0–49.3–75.6 × 7.2–10.5–17.6 µm, subcylindrical to narrowly fusiform to slightly narrowly lageniform, mucronate, rarely obtuse, or with a flexuous excrescence, moderately pedicellate, thin-walled, hyaline. Pileus covering: a sparse layer of terminal cells essentially absent on mature pilei, most prevalent near the center of young pilei, 45.0–73.9–117.0 × 7.0–8.1–9.3 µm, cylindrical to somewhat narrowly lageniform, with flexuous necks, often mucronate or with a short, tapering, apical excrescence with thinner wall than subterminal cells, very loosely chained to elements that become shorter, broader and blending with the anastomosing, often H- to T-shaped very loosely disarticulating contextual elements with numerous excrescences: these elements being very common on

the entirety of the pileus surface and making up the farinose covering. Stipe covering: structure like that of pileus, with terminal cells even more sparse. Stipitipellis: a cutis of narrowly cylindrical, 5.0–7.5 μm broad elements. Clamp connections: absent.

Habitat and Distribution: subconnate imbricate on heap of mixed wood chips and horse manure. Cosmopolitan.

Collection examined: USA: Washington, Snohomish Co., Monroe: SJ 22, det. J.M. Birkebak, 9/28/1990.

Remarks: My species concept for *Lc. cretaceus* follows Bulliard's original (for a detailed account of the complex history of usage of the name *Agaricus cretaceus* see Vellinga 2001c).

In North America most authors — notably Morgan (1907) and Kauffman (1924) — have applied the name *Lepiota cretacea* to what is now considered *Leucocoprinus cepistipes* (i. e. sensu J. E. Lange). Murrill (1914), however, used the name *Lepiota cretacea* in its broadest sense, which included *Leucocoprinus birnbaumii* (as "*Agaricus luteus* With."), *Leucocoprinus cepistipes* (as "*Lepiota cepaestipes* Quél."), and even *Leucocoprinus fragilissimus* (as "*Hiatula fragilissima* Berk. & Rav.").

Peck (1890) created the name *Lepiota farinosa* for the all white, farinose species here referred to *Lc. cretaceus*. Murrill (1911, 1914) included Peck's species as a synonym for *L. cretacea*. To complicate matters further, Smith and Weber (1982), who applied the name *Lc. cretaceus* to the current concept of *Lc. cepistipes,* published the name *Lc. breviramus* for the species I refer to *Lc. cretaceus*. Their "breviramus" is distinguished only by slightly smaller spores and subtle differences in the size and shape of cheilocystidia, differences that I regard as taxonomically insignificant. Akers (1997) applies the name *Lc. breviramus* to what clearly represents my concept of *Lc. cretaceus*.

5. ***Leucocoprinus flavescens*** (Morgan) H.V. Sm., The Michigan Botanist 20(2): 50 (1981) Fig. 5

≡*Lepiota flavescens* Morgan, Journal of Mycology 13(1): 5 (1907)

Pileus: 20–32 mm broad when expanded, cylindrical with a blunt disc in button stage, rounded conic to more obtuse and with a rounded umbo, more or less collapsing and curling on drying; margin decurved to straight, sulcate-striate, especially so in older specimens; surface dry and coated with a more or less loose granular layer; at disc "barium yellow" to "amber yellow" or faintly tinted brown, "sulphur yellow" to white tinted with "sulphur yellow" to "naphthalene yellow' outward, paler at margin; context very thin and soft, pliable, white with yellow tint at cuticle on disc. Odor: more or less pungent. Lamellae: free, more or less close, narrow; edges straight at first then becoming crisped with age; faces white, edge appears tinted with more or less "sulphur yellow" to "pale yellowish

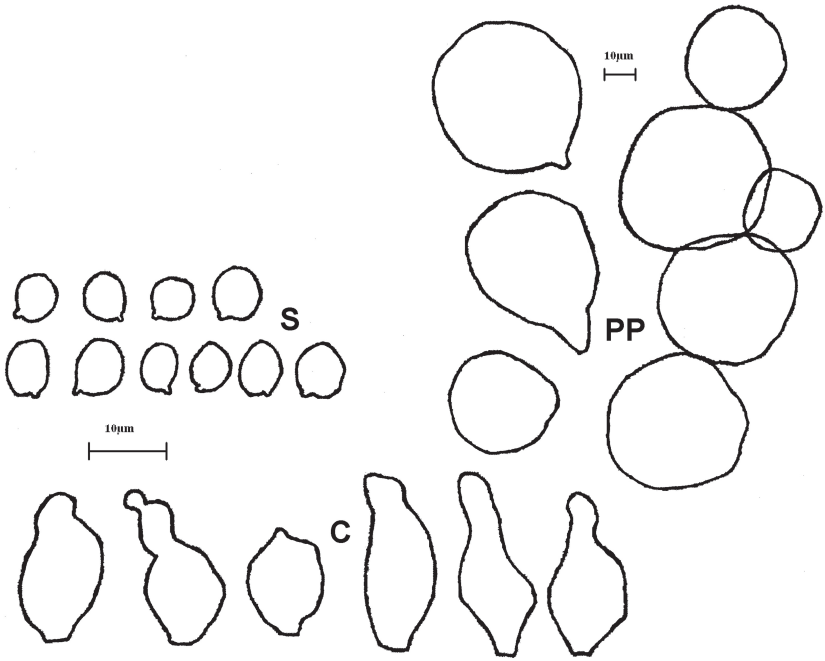

Figure 5. *Leucocoprinus flavescens* – S. spores; C. cheilocystidia; PP. pileus covering (all from collection JFA 8466).

white." Stipe: 65–85 mm long, at apex 4mm wide, at base narrowly clavate (up to 5–6 mm); with a granular to farinose coating; more or less "sulphur yellow" or this tinted with white, in age and with handling the stipe becomes deeper and brighter yellow (more or less "picric yellow"). Annulus: fragile, moveable, median to superior, "sulphur yellow" to "picric yellow."

Spores: 4.4–5.1–5.9 × 3.6–4.1–4.8 µm, Q-value 1.00–1.27–1.42, broadly ellipsoid, thin walled, dextrinoid, metachromatic. Basidia: 13.4–16.5 × 6.1–7.2 µm, clavate pedicellate to pyriform, 4-spored; surrounded with 4 pseudoparaphyses at right angles (in a more or less checkerboard pattern). Sterigmata: 1.7–2.2 × 0.7–1.0 µm. Pseudoparaphyses: 11.4–15.3 × 6.9–8.5 µm, sphaeropedunculate to broadly clavate, more rarely ellipsoid with very short pedicel, often somewhat angular/isodiametric. Cheilocystidia: 11.0–17.1–24.2 × 5.5–8.2–13.2 µm, very variable, lageniform to utriform to, more rarely, clavate to obclavate, apex obtuse to mucronate or with a strangulate to constricted-subcapitate excrescence up to ½ of cell length, thin walled, hyaline.

Pileus covering: of a loose layer of terminal elements concentrated on disc and somewhat sparse on rest of pileus, on a cutis of cylindrical, repent contextual elements; terminal elements loose globose to subglobose, sometimes ellipsoid, 13.8–34.4–50.0 × 15.0–30.3–47.5 µm, (Q-value 1.00–1.14–1.32) loosely chained, sometimes with a short excrescence connecting it to adjacent cells, generally more ellipsoid to fusiform downward. Stipe covering: composed of loose, globose elements like those of the pileus covering. Stipitipellis: composed of short, cylindrical elements 20–30 µm broad. Clamp connections: absent.

Habitat and Distribution: In an outdoor covered can filled with greenhouse potting soil, growing in large clusters at ambient temperature. For distribution see remarks below.

Collection examined: USA: Washington, King Co., Seattle, University of Washington campus: JFA 8466, det. J.M. Birkebak, 12/19/1979.

Remarks: This sole representative of section *Denudati* Beeli in Washington has been collected only once in the Pacific Northwest. It was found on the University of Washington campus in a covered can outside of the botany greenhouse.

This is the first report of *Leucocoprinus flavescens* in the Pacific Northwest. It was originally described from Ohio (Morgan 1907) and also from Illinois (Kuo 2007), Massachusetts, and California (the last two from greenhouses; Smith 1981).

6. *Leucocoprinus heinemannii* Migl., Micol. Ital. 16(2): 9 (1987) Fig. 6

Pileus: 16–22 mm when expanded, ovate when young, expanding to convex to plano-convex, center sometimes slightly depressed, often with a small umbo; margin more or less straight to uplifted, sulcate-striate; disc black to dark grey, innately fibrillose, very soon breaking into small, fibrillose scales on a white background that thin greatly until nearly absent near margin; context very thin and fragile, white. Odor: fungal. Lamellae: free, crowded, somewhat broad, white. Stipe 12–35 mm long, 2 mm broad at apex, with an enlarged, bulbous, up to 5 mm broad base, with abundant white rhizomorphs from base, longitudinally silky, often innately fibrillose; white, often with a thin black to "dark grey" band near very base of stipe, hollow; context white. Annulus: membranous, white, somewhat band-like to slightly upturned, median.

Spores: 6.3–6.9–7.4 × 3.5–3.8–4.2 µm, Q-value 1.66–2.10, oblong ellipsoid, rarely slightly amygdaliform or slightly phaseoliform, thin-walled, dextrinoid, faintly metachromatic. Basidia: 14.5–17.8 × 7.3–8.4 µm, broadly clavate, rarely pyriform, 4-spored; surrounded with 4 pseudoparaphyses at right angles (in a more or less checkerboard pattern). Sterigmata: 1.5–2.2 × 0.8–1.1 µm. Pseudoparaphyses: 8.9–13.3 × 4.4–6.8 µm, broadly clavate to short cylindrical, more rarely ellipsoid, point of attachment often quite broad. Cheilocystidia:

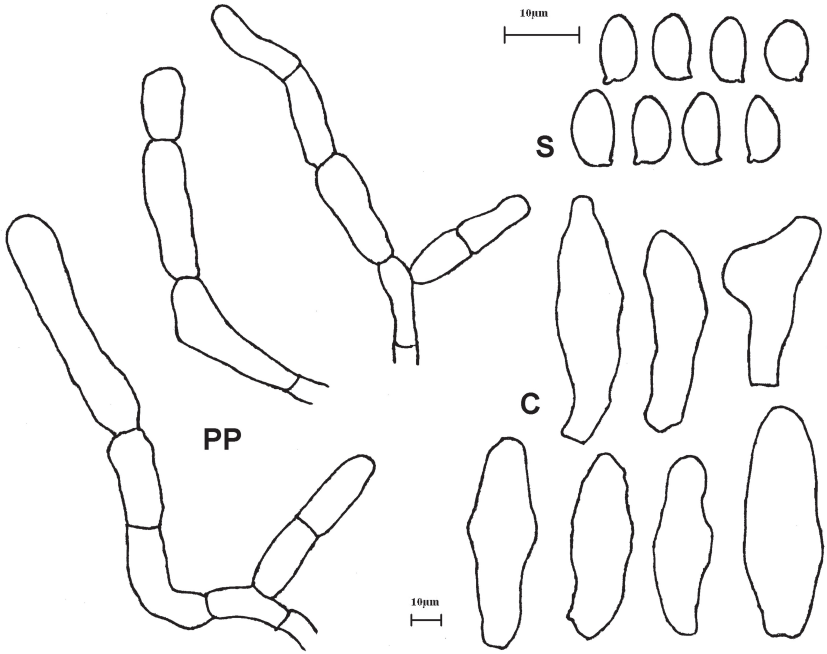

Figure 6. *Leucocoprinus heinemannii* – S. spores; C. cheilocystidia; PP. pileus covering (all from collection JMB 07-11-08-2001).

15.1–20.1–25.9 × 5.2–7.2–8.9 µm, cylindrical, broadly fusiform to slightly utriform, occasionally somewhat irregular in outline, not distinctly pedicellate, thin-walled, hyaline. Pileus covering: a loose cutis made of long chained, cylindrical to inflated, 23.4–42.6–63.0 × 6.1–8.6–14.4 µm, olivaceous grey to dark brownish grey vacuolar pigmented elements with moderately constricted septa, occasionally developing slight secondary septations, blending into cylindrical to branched, hyaline contextual elements. Bare areas a cutis of cylindrical to branching, hyaline hyphae. Stipe covering: limited to the very base of the stipe, like that of the pileus but elements thinner and less strongly pigmented. Stipitipellis: a cutis made of narrowly cylindrical to somewhat interwoven, 4–9 µm broad cells. Clamp connections: absent.

Habitat and Distribution: gregarious in potting soil in greenhouses. Known from Europe and western North America.

Collections examined: U.S.A.: Washington, King Co., University of Washington Botany greenhouse: JMB 07-07-2008-01, det. J.M. Birkebak, 7/7/2008; JMB 07-11-2008-01, det. J.M. Birkebak, 7/11/2008; JMB 07-18-2008-01, det. J.M. Birkebak, 7/18/2008.

Remarks: The pileus margin of this species is barely sulcate and strongly resembles *Leucoagaricus* species, especially *La. melanotrichus* (Malençon & Bertault) Trimbach (see Migliozzi & Zecchin 1999). This species also resembles *L. phaeostictiformis* Murrill from Florida but this similarity needs closer examination.

This species has probably been found in the University of Colorado greenhouse (Vellinga, pers. com.).

7. ***Leucocoprinus ianthinus*** (Sacc.) Locq., Bull. mens. Soc. linn. Lyon 14: 94. (1945) Fig. 7

≡*Lepiota ianthina* Sacc., Syll. Fung. 9: 10 (1891) [as "*Lepiota janthina*"]

=*Leucocoprinus lilacinogranulosus* (Henn.) Locq., Bull mens. Soc. linn. Lyon 12: 94 (1943)

≡*Lepiota lilacinogranulosus* Henn., Verh. bot. Ver. Prov. Brandenb. 40: 145 (1898)

Pileus: 1.5–4.5 cm broad, ovoid to parabolic when young, truncate conic and collapsing slightly with age; margin decurved when young, sulcate-striate; disc unbroken, violet brown to reddish violet, breaking into minute granular scales the color of the disc or lighter on a buff background. Odor: unremarkable or merely fungal. Lamellae: free, crowded, becoming wrinkled, whitish aging to pale flesh. Stipe: 4–5 cm long, 2.5–4.0 mm thick at apex, base bulbous; whitish, darker at base, not changing when bruised. Annulus: membranous, whitish, median. (Adapted from Singer 2003)

Spores: 8.8–9.9–11.6 × 6.0–6.8–7.7 μm, Q-value 1.29–1.46–1.60, ellipsoid to somewhat amygdaliform, sometimes tapering slightly toward apical germ pore, with a small hyaline cap, thick-walled, thinning toward apex, dextrinoid, metachromatic. Basidia: 18.7–25.1 × 7.7–9.9 μm, pyriform to clavate, less often cylindrical-pedicellate, 4-spored, surrounded by 4 pseudoparaphyses. Sterigmata: 2.3–3.3 × 1.1–1.7 μm. Pseudoparaphyses: 16.6–20.5 × 9.6–11.4 μm, sphaeropedunculate to broadly clavate. Cheilocystidia: 37.5–60.1–88.6 × 11.3–17.3–23.8 μm, quite variable, cylindrical to utriform to broadly clavate, often, but not always, distinctly pedicellate, thin walled, hyaline. Pileus covering: of a dense covering of terminal elements that breaks into scales usually leaving the disc confluent, revealing cylindrical to branching, hyaline contextual elements; terminal elements more or less erect, loose chains of 2–4, lightly grayish-lilac vacuolar pigmented, globose to cylindrical, 12.5–20.4–28.8 × 8.8–12.4–21.3 μm. Stipe covering: restricted to very base of stipe, erect to semi-erect, cylindrical elements, approximately 50–75 × 5–8 μm. Stipitipellis: a cutis made of rather short, cylindrical, 13–18 μm broad elements. Clamp connections: absent.

Habitat and Distribution: solitary to gregarious on potting soil in artificially high temperatures indoors (especially prevalent in greenhouses). Cosmopolitan

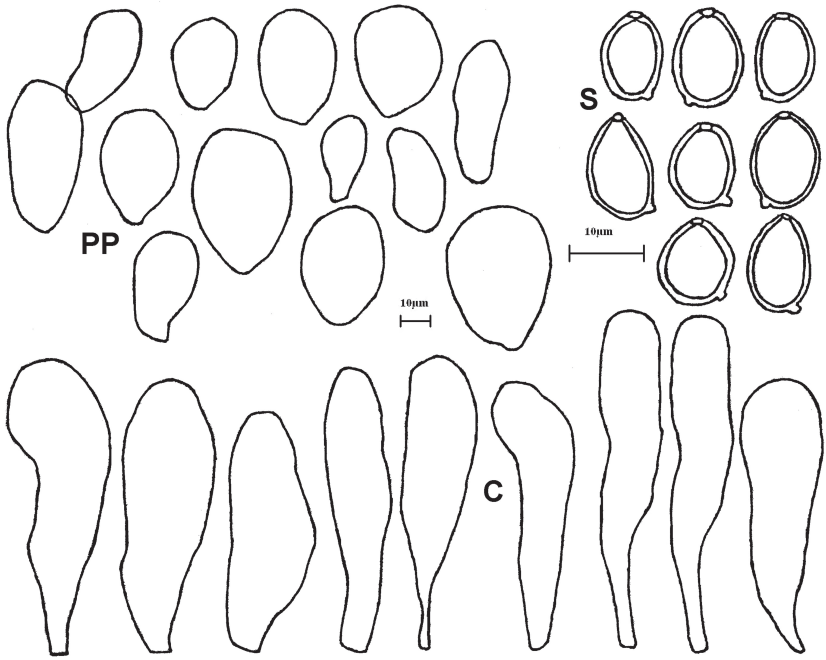

Figure 7. *Leucocoprinus ianthinus* – S. spores; C. cheilocystidia; PP. pileus covering (all from collection SAT 99-198-01).

Collections examined: U.S.A.: Washington, King Co., Seattle: PBM 0020—040096, det. P. B. Matheny (as *Lepiota lilacinogranulosus*); SAT 99-198-01, det. S. Trudell (as "*Leucocoprinus lilacinosquamulosus*"), 7/17/1999; University of Washington Botany greenhouse: JFA 10097, det. J.M. Birkebak, 5/23/1990.

Remarks: This distinctive species is the only *Leucocoprinus* with purple tones known from western North America. It has been collected several times in plant pots indoors. It has not yet been found outdoors.

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