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Clathrus roseovolvatus, a new phalloid fungus from the Caribbean

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Abstract – A new species of *Clathrus* (Phallomycetideae) with white receptacle, formerly assimilated to the African species *C. baumii* and *C. preussii*, is described and illustrated from various collections from the Caribbean and Venezuela. It is characterized by a lilaceous-pink to vinaceous peridium and a tropical habitat in mesophilic to meso-hygrophilic managed forests and plantations.

Basidiomycota / Phallomycetideae / Phallales / Clathraceae / French West Indies

Résumé – Une nouvelle espèce du genre *Clathrus* (Phallomycetideae) à réceptacle blanc, jusqu'ici confondue avec les espèces africaines *C. baumii* et *C. preussii*, est décrite et illustrée d'après plusieurs collections originaires des Antilles et du Venezuela. Elle se caractérise par un péridium rose lilacin à vineux et un habitat en forêts exploitées et plantations en milieu tropical mésophile à hygro-mésophile.

Basidiomycota / Phallomycetideae / Phallales / Clathraceae / Antilles Françaises

INTRODUCTION

Currently the Clathraceae family (Phallales, Basidiomycota), as circumscribed by Hosaka *et al.* (2006) and Cabral *et al.* (2012), encompasses species with gleba attached to the inner side of the arms, such as *Clathrus*, but also

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Fig. 1. Distribution map of *Clathrus roseovolvatus* sp. nov. Locality in Cuba not documented (see Material studied).

Aseroe Labill., *Ileodictyon* Tul., *Laternea* Turpin, as well as a few "truffle-like" collections of *Gelopellis* and *Protubera*. Despite the recent efforts of Cabral *et al.* (2012) to refine the Clathraceae phylogeny, with the segregation of a new genus *Abrachium*, several morphologically defined and currently recognized genera: *Blumenavia* A. Møller, *Colus* Cavalier & Séchier, *Ligiella* J.A. Sáenz, *Pseudoclathrus* B. Liu & Y.-S. Bau, and *Pseudocolus* Lloyd (Dring 1980; Liu & Bau, 1979; Sáenz 1980) are still in need of molecular data.

The genus *Clathrus* P. Micheli ex L.: Pers. is a widespread, well-documented genus, although many tropical species are only known from a single or few records. The fundamental revision by Dring (1980), following the older but accurate synopsis by Fischer (1909) and Lloyd (1909), makes an account of 20 (two of them unnamed) species worldwide and includes the formerly segregated genus *Anthurus* Kalchbr. & MacOwan. Such a treatment may appear almost exhaustive, and in fact only four further species, C. *transvaalensis* Eicker & D.A. Reid, *C. hainanensis* X.L. Wu, *C. argentinus* L.S. Domínguez, and *C. cristatus* Fazolino *et al.*, nearly all known from a single specimen, have been added since (Domínguez de Toledo 1985; Eicker & D.A. Reid 1990; Wu 1998; Fazolino *et al.* 2010, respectively). Nevertheless, Dring (1980) identified some points requiring further study, one being the delimitation of white clathroid species. During field work in the French West Indies (Guadeloupe and Martinique) between 2003 and 2011 (Courtecuisse 2006) seven specimens were collected of a species which turned out to have been already collected but misnamed by Dennis (1953: 313) in Jamaica and (1970: 7) in Trinidad, then dealt with by Dring (1980: 38) from Dennis' collections and from a Martinique sample collected by one of us (J.-P. Fiard). All these collections show a stable morphology, especially a striking and characteristic lilaceous-pink to purplish peridium, already observed by Dennis (*loc. cit.* and unpublished notes, K; in Dring, 1980: 38) on his four collections, a character here considered as unique in the genus.

This article aims to name this species, after having checked collections preserved in the herbarium at Kew (K) in addition to our own material. A comparison with similar species and an identification key to white clathroid species of *Clathrus* worldwide are also proposed.

MATERIAL AND METHODS

All specimens found in Guadeloupe and Martinique between 2003 and 2012 (see Material studied below) were photographed *in situ*, described for macromorphology, and air-dried. Exsiccata are kept at the herbarium of the Faculté des Sciences pharmaceutiques et biologiques, Lille (LIP). The fungal herbarium K (Royal Botanical Garden, Richmond, OK) was visited in April 2012 by P.-A. Moreau, who took notes and pictures of specimens.

Microscopical characters were described on exsiccata, in Congo red (10 % NH4OH solution) after revival in 5 % KOH aqueous solution, also directly observed in 5 % KOH after reviving, and in Melzer's reagent (0.5 mg I, 1.5 mg IK, 20 mg chloral hydrate, for 22 ml distilled water). Descriptive terminology follows Dring (1980).

DESCRIPTION

Clathrus roseovolvatus Lécuru, Mornand, Fiard & Courtec., ***sp. nov.*** **Fig. 2 (A-G)**

MycoBank: MB 800546

Diagnosis: Differs from other white species in the genus by pinkish to vinaceous peridium. In mesophilic to meso-hygrophilic tropical forests, widespread in the Caribbean.

Holotype: France, Martinique, Sainte-Luce, forêt départementalo-domaniale de Montravail, on ground in a mahogany (*Swietenia macrophylla*) plantation, leg. R. Courtecuisse and P.-A. Moreau, 20 August 2007, CL/Mart07.094 (LIP).

Misapplied names: Clathrus cf. *chrysomycelinus* sensu Dennis (1953: 132); *C. preussii* sensu Dennis (1970: 7), Baroni (2012); *C. baumii* sensu Dring (1980: 38), pro parte.

Illustrations: Dring (1980, pl. 10, as "*Clathrus baumii*", line drawings); Baroni (2012, as "*C. preussii*").

Etymology: Roseovolvatus (Latin: *roseus, -a, -um*, adj: pink; *volvatus, -a, -um,* adj., from *Volva, ae,* f: volva); with pink volva, reference to the distinctive colour of outer peridium.

Basidiome usually solitary, when unexpanded subglobose, 35-45 mm diam., firm, surface smooth, pinkish from the beginning, marbled by white veins forming wide polygonal areolae. **Peridium** when expanded, lilaceous, pinkish brown, vinaceous pink to dark purplish, somewhat greyish-tinged in places, opening into several rounded, triangular or irregular lobes, often partly cut into irregular patches at receptacle apex. **Receptacle** obovate with distinct pseudostipe immersed in volva (double in JC 08.02.29.01), pure white to pale cream yellow

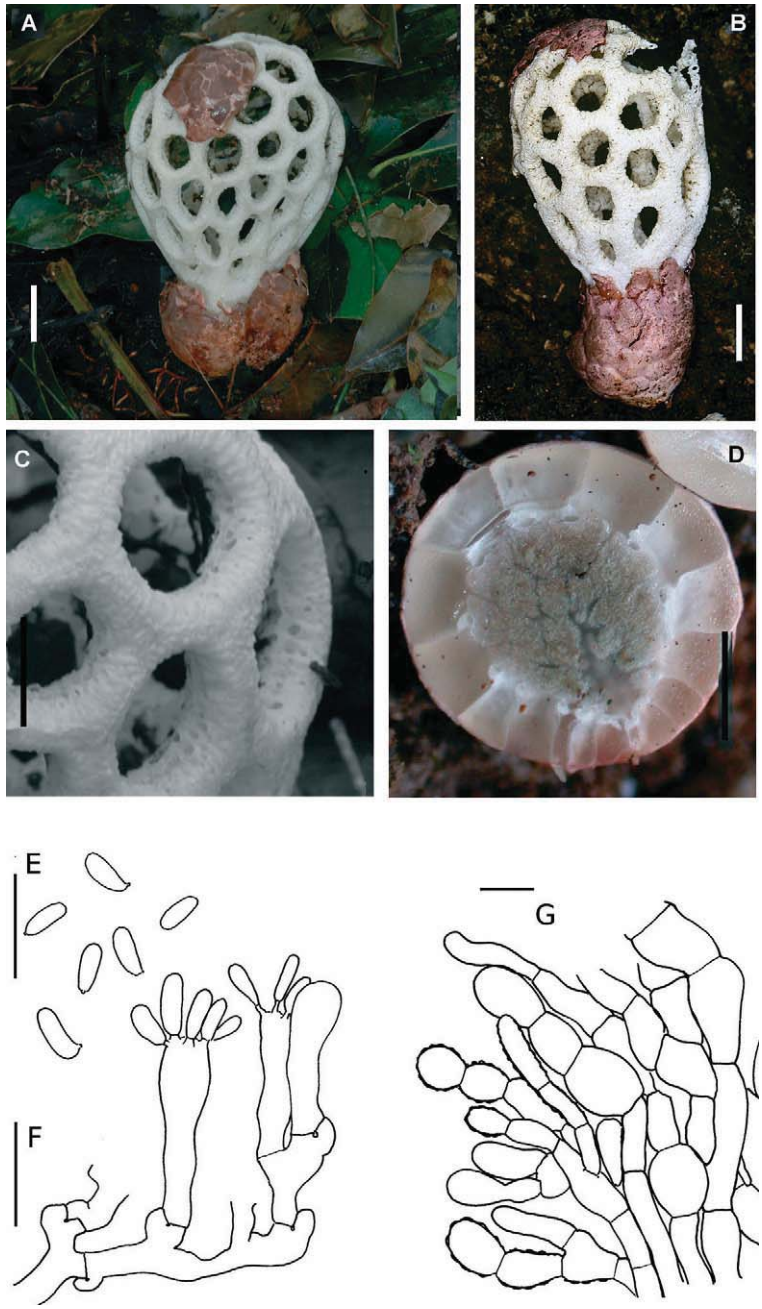

Fig. 2. *Clathrus roseovolvatus* sp. nov. **A-D:** Basidiomata (scale bar = 10 mm). **A:** expanded basidiome, CL/Mart07.094 (holotype). **B:** Expanded basidiome, Fiard 2740 LIP. **C:** Detail of receptacle (CL/Mart07.094) showing porose inner wall of meshes. **D:** Longitudinal section of unexpanded basidiome, CL/Mart08.067. **E-G:** Microscopical features, CL/Mart08.067 (scale bar = 10 µm). E: basidiospores. **F:** Basidia and subhymenium. **G:** Exoperidium in radial section. Credits: A, C, E-G: P.-A. Moreau; B: J.-P. Fiard; D: C. Lécuru.

(butter yellow when dry), up to 8-10 × 5-6 cm, formed of 4-6 mm wide, densely wrinkled and crispate arms triangular in section, without setae or membrane, surrounding large rounded to ovoid meshes. **Gleba** dark olivaceous green, then blackish. Smell raphanoid before expansion, then strong, unpleasant to distinctly putrid. **Mycelium** cord-like, white.

Basidiospores (3.5-) 3.8-5.0 × 1.8-2.2 (-2.8) µm, Q (L/w) = 1.90-2.50, smooth, cylindrical to slightly rod-shaped in profile, cylindrical to slightly pyrenoid in front view, with truncate apiculus. **Basidia** 18-24 × 3.5-5.0 µm, (4-)6-8(-9)-spored, club-shaped with variously elongated base; sterigmata very short (up to 1 µm long). **Subhymenium** made of slender colourless hyphae, 3-4.5 µm wide. **Receptacle** made of parallel hyphae, 4-7 µm wide, septate and mostly clamped, some inflated at septum, mostly colourless, some with irregularly thickened yellowish wall. **Peridium** about 150 µm thick, orange yellow in KOH, 2-layered, made of filamentous hyphae, smooth in depth, incrusted towards surface; outer surface a subepithelial structure of cylindrical to globose elements, 4-5-8(-16) µm wide, mostly with encrusting pigment.

Ecology and distribution: On bare soil, sparse and relatively infrequent but apparently widespread in the Greater Antilles (Cuba, Jamaica, likely also Puerto Rico: Lodge, 1998; T.J. Baroni, 2012) as well as volcanic Lesser Antilles (French West Indies, Trinidad); also present in Venezuela and likely throughout tropical America. Collections are made throughout the year, always observed by us after heavy rainfalls (the type was collected a few days after Dean hurricane crossed over Martinique in 2007). Mainly in anthropic or secondary forests (plantations of coffee or cocoa trees, palms, mahogany, etc.), at mesophilic or meso-hygrophilic levels. Stable in its growing sites in Martinique and Guadeloupe.

Other collections studied: Cuba, in palm forests, "on rotten wood?", 26 June, Wright, Curtis 714 (K, as "*Clathrus crispus"*)[1]. France, Guadeloupe, Sainte-Rose, Trace de Sofaia, 250 m. alt, on earth, lower hygrophilic forest, 29 August 1975, J.-P. Fiard, 570A (K, as "*Clathrus* sp."); Guadeloupe, Petit-Bourg, route forestière de Jules, on soil, mesophilic forest, 29 February 2008, J. Chabrol, JC 08.02.29.01 (LIP); *ibidem*, 17 June 2008, J. Chabrol, JC 08.06.17.01 (LIP); Martinique, not dated, J.-P. Fiard, 3169 (LIP); Martinique, le Marin, Morne Aca, 26 November 2002, J.-P. Fiard, 2740 LIP (colour slide only); Martinique, Sainte-Luce, forêt départementalo-domaniale de Montravail, on ground in hygro-mesophilic forest, 23 August 2008, C. Lécuru, CL/Mart08.015 (LIP); Martinique, Prêcheur, Anse Couleuvre, degraded secondary tropical hygrophilic forest, on soil amongst decaying litter of bamboos, with *Mutinus bambusinus* and *Phallus indusiatus*, 24 August 2008, C. Lécuru, CL/Mart08.067 (LIP). Jamaica, Clydesdale, 19 December 1949, R.W.G. Dennis, Flora of Jamaica 10 (K, as "*Clathrus* cf. *chrysomycelinus*" corrected into "cf. *preussii*" by Dennis' hand)1. Venezuela, Caracas, Mariposa, 26 June 1958, R.W.G. Dennis, 1079 (K, as "*Clathrus* cf. *preussii*", unopened specimen, annoted "Receptacle pure white, peridium lilaceous")1; Distr. Federal, Chichiriviche, on soil under bushes in coffee plantations, 500 m, 6 July 1958, R.W.G. Dennis, Flora of Venezuela 1392 (K, as "*Clathrus* cf. *preussii*")1.

Comparative material studied: ***Clathrus baumii***: Angola, Cazengo, Granja de S. Luiz, on rotting roots of Firmiana, November 1909 after the African

1. These collections were all revised by D.M. Dring and gathered by him or by R.W.G. Dennis (in accordance with Dring's taxonomic concepts, 1980: 38) in the same pack "*Clathrus baumii*" at K (visited by P.-A. Moreau, 18 April 2012).

spring rains, J. Gossweiler (K, 159797); Kenya, Malindi Distr., Malindi, Robertson Plot, in relict coastal bush on coral rag, 15 January 1998, S.A. Robertson, 7257B (K, 77477). ***Clathrus chrysomycelinus***: Venezuela, Miranda, Guatupo, on soil in forest, 26 June 1958, R.W.G. Dennis, Flora of Venezuela 1100 (K). ***Clathrus oahuensis***: U.S.A., Hawaii, Oahu, Koko Head crater, 29 January 1970, J.A. Meeker and W. Stump (K, Holotype). ***Clathrus transvaalensis***: Republic of South Africa, Pretoria, Country Club, on soil beneath *Eucalyptus* trees, 16 February 1989, A. Eicker, PRUM 2687 (K, Holotype).

DISCUSSION

As many as seven white or whitish species of *Clathrus* are described in literature: *C. baumii* Henn. (Hennings 1903), *C. cameroensis* Henn. ex Sacc. (Hennings 1891, Saccardo 1891), *C. chrysomycelinus* A. Møller (Møller 1895), *C. preussii* (Henn.) Henn. (Hennings 1895, 1897), the minute and outstanding *C. delicatus* Berk. & Broome (Berkeley & Broome 1875, from Sri Lanka; Swapna *et al.* 2010, from India), and the more recently published *C. transvaalensis* Eicker & D.A. Reid (Eicker & Reid 1990, from South Africa) and *C. hainensis* X.L. Wu (Wu, 1998, from China). In addition some occasional albino collections of usually red-coloured species are known, usually mixed with "normal"-coloured specimens (for instance *Clathrus ruber* P. Micheli ex Pers.: Pers.; a white form of *C. crispus* Turpin is also known from Puerto Rico and Guadeloupe; Lodge 2012, as "*Clathrus* sp."; Lécuru, unpublished data).

Finally, a white clathroid species with grey-brown peridium: *Ligiella rodrigueziana* J.A. Sáenz (Sáenz 1980) is known from Mexico and Costa Rica, and shows some morphological affinity with *C. crispus*, with meshes similarly surrounded by a membrane.

Albeit incomplete, current knowledge on geographical distribution of *Clathrus* species suggests a strong continental endemism (Mediterranean basin, Neotropics, Australasia, Africa; Dring, 1980). According to Dring, *C. baumii* would be an exception as being known from both Africa and Central America. However his description is taken from Dissing & Lange (1963a) while the line drawings are based upon Dennis' Caribbean and Venezuelan collections. The British specialist indicates that *C. baumii* is characterized by "strikingly flat outer surface of the arms", a character which might have led him to this identification from herbarium material and pictures, despite of differences in colours of receptacle and particulary peridium especially (see Tab. 1 below).

Before comparing more closely *C. baumii* and *C. roseovolvatus* (Tab. 1) it is useful to consider all other white or whitish-coloured clathroid species of *Clathus*.

African species:

— *Clathrus baumii* is described in detail by Dissing and Lange (1963a: 334) on the basis of a collection of Mrs Gossens-Fontana (from Congo Kinshasa, 1923) preserved at BR. It is in agreement with the two collections observed by us at K, from Angola (cited by Dring 1980) and a more recent from Kenya. Both collections, on dry specimens as well as on colour photographs, show a deep butter yellow colour of expanded receptacle, also present on Gossens-Fontana's

aquarelle (in Dissing & Lange 1963b: 221, pl. 38 fig. 5). See Table 1 for comparison with *C. roseovolvatus*.

— *Clathrus preussii* has typical setae and " teeth " (Dring 1980) on arms of the receptacle.

— *Clathrus cameroensis* is, according to Dring (1980: 37), a close relative of *C. preussii* but lacking the tooth-like "fringe". Hennings (1892: 358, as "*C. camerunensis*") apparently forgot to note the colour of the receptacle ("presumably not red"; Dring, *loc. cit.*); however Saccardo (1891: 264) indicates "*albo*". It is known only from the original collection.

— *Clathrus transvaalensis* (Eicker and Reid 1990) is known only from the type specimen, well preserved at K. The receptacle is irregularly branched, not anastomosing in the lower middle part, with gleba as discontinuous spots formed on glebifers, and with a pure white, brittle peridium. The figure of Lloyd (1918, fig. 1128) erroneously identified as "*Clathrus camerunensis*", based on a picture sent to him from "Africa" (probably Transvaal, South Africa) by Paul A. van der Bijl, is probably the first representation of *C. transvaalensis*. Its structure looks similar to that of the red-coloured *C. treubii* C. Bern., of which Lloyd (1909) published pictures of original collections.

American species

— *Clathrus chrysomycelinus* (Møller 1895) is a rare species so far only reported from a few localities of South America (Brazil, Venezuela: Dring 1980, Fazolino *et al.* 2010) and Costa Rica (Calonge *et al.* 2005). Lloyd (1909) reports that the mycelium may not always be typically yellow, however the species is best characterized by its gleba forming small isolated spot-like masses on the inner side of pale orange to whitish arms (Møller 1895; Fischer 1909: 284, fig. 132A).

— *Clathrus oahuensis* (Dring *et al.* 1971; Dring 1980: 41) looks morphologically closer to *C. preussii* with some setae on the lowest arms of the receptacle, but the gleba is arranged in droplets such as in *C. chrysomycelinus* (Dring *et al.* 1971: 895, fig. 6). It seems to be known only from the type collection from Hawaii.

— *Clathrus* "*species 1*" of Dring (1980: 23) is a white species known only from a damaged specimen without volva (but egg noted "cream"), found in Brazil, with smaller spores than *C. roseovolvatus.* It is said to be characterized by arms triangular in section with a median groove and "glebiferous crests along the sides". In the reconstructed drawing by Dennis (in Dring, *loc. cit.*: 21, fig. 1A) spines on rather long basal arms are reminiscent of those described for *C. preussii* and *C. oahuensis*. It should also be compared to *Clathrus affinis* Lloyd (Lloyd 1909: 60), a forgotten taxon based on a single specimen from Brazil, observed by Lloyd at the British Museum but not cited by Dring (1980), as well as with the similarly small-spored *Ligiella rodrigueziana* (Sáenz 1980) and with the recently described red-coloured *C. cristatus* (Fazolino et al. 2010), described on a single specimen, with comparably fringed meshes and brownish volva.

Australasian species

— *Clathrus hainanensis* (Wu 1998) is a robust, fleshy species similar to *C. ruber*, known from coastal sands in China.

— *Clathrus cibarius* (Tul.) E. Fischer (better known as *Ileodictyon cibarius* Tul.; Raoul 1844), taken in a wide sense including *C. gracile* Berk.

Table 1. Comparative morphology of Cl*athrus baumii an*d *C. roseovolvatus* (adapted respectively from Dissing and Lange 1963a, 1963b, and personal observations).

	Clathrus baumii	*Clathrus roseovolvatus*
Egg	About 3 cm diam.	3.5-4.5 cm diam.
Peridium	Dirty whitish	Lilaceous to dark purplish
Receptacle	Bright yellow to yellow-brown	Pure white then pale cream yellow
Spore mass	Brownish to violaceus	Dark olivaceous green
Distribution	Tropical Africa	West Indies, South America
Spores	4.6-5.4 × 1.6-2.2 µm	4.0-5.0 × 2.0-2.2 µm

(Fischer 1909), is a well-known, large species found indigenously from India to Australia and Japan, with a sessile receptacle which usually separates spontaneously from volva when mature. Its inclusion in *Clathrus*, as recommended by Lloyd (1909) and Fischer (1909), is not followed by Dring (1980). Lloyd's intuition might find new support in phylogenetic studies such as published by Hosaka *et al.* (2006).

Clathrus species are not as numerous in the Neotropics (Dring 1980; Minter *et al.*, 2001) as they can be in Australasia (Lloyd 1909). As far as French West Indies are concerned, in addition to *C. roseovolvatus* only five species of *Clathrus* are reported so far, all from one or a very few collections: *C. berkeleyi* W.R. Gerard (Duss 1903, as "*Laternea pusilla* Turpin"), *C. columnatus* Bosc (Duss 1903), *C. crispus* (Plumier 1705, as "*Boletus cancellatus purpureus*"; Duss 1903; Montagne 1855), and *C. triscapus* (Turpin) Fr. (Dring 1980). According to our own experience *C. roseovolvatus* is by far the most frequently observed species of clathroid Phallales in the Lesser Antilles. Moreover, since no other species of *Clathrus* is known to show such a coloured peridium and regarding its constant morphology in comparison with other neotropical species, we cannot interpret *C. roseovolvatus* as an occasional albino form of any already described red-coloured species and therefore suggest it is an undescribed autonomous species.

Key to white or yellowish species of *Clathrus*

1. Gleba on mature receptacle arranged continuously along the inner side of arms 2
1. Gleba on mature receptacle forming discontinuous spots or spherical droplets formed on glebifers 7
2. Peridium pinkish to purple. Tropical America *C. roseovolvatus*
2. Peridium pure white, cream to grayish 3
3. Receptacle meshes surrounded by a membrane with distinct striate rims. Known from the Caribbean (with brownish volva, see *Ligiella rodrigueziana*). albino form of *C. crispus*
3. Receptacle meshes not delimited by a membrane. Asia and Paleotropics 4
4. Receptacle pure white, loose, globose without pseudostipe, with large polygonal meshes. South Eastern Asia and India to Australia see *Ileodictyon* spp.
4. Receptacle compact, with pseudostipe 6

5. China, on coastal sands. Receptacle white, fleshy with very short pseudostipe. Meshes irregular, more or less elongated *C. hainanensis*
5. Tropical Africa. Receptacle pale yellowish to butter yellow, obovoid with distinct pseudostipe. Meshes pentagonal to hexagonal 7
6. Meshes with marginal fringe. Receptacle white when fresh *C. preussii*
6. Meshes without marginal fringe. Receptacle butter yellow when fresh *C. baumii*
7. South African species. Gleba forming irregular polygonal spots *C. transvaalensis*
7. Tropical America, India and Hawaii. Gleba forming distant rounded droplets 8
8. India and Sri Lanka. Minute lignicolous species *C. delicatus*
8. Tropical America and Hawaii. Terrestrial, small- to medium-sized species 9
9. Tropical America. Arms of receptacle without setae. Mycelium usually deep yellow *C. chrysomycelinus*
9. Known from Hawaii. Lower arms with setae. Mycelium white *C. oahuensis*

(see also *Clathrus affinis* and C. "sp1", Dring 1980, known from Brazil)

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