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New species of *Entoloma* (*Basidiomycetes, Agaricales*) from Kerala State, India

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Abstract — Three new species of *Entoloma* (*E. suaveolens, E. crassum*, and *E. aurantio-quadratum*) are described, illustrated, and discussed based on collections made from Kerala State, India.

Key words — agaric diversity, under-explored, Western Ghats

Introduction

Entoloma is one of the largest genera of *Agaricales,* with more than 1500 species known worldwide (Noordeloos 1981a). However, vast areas are still under-explored, especially in Africa, South America, India, and South East Asia (Noordeloos & Morozova 2010). Recent studies of the genus in Kerala State, India, by Manimohan et al. (1995, 2002, 2006) documented 39 species, of which 26 are new to science, indicating that *Entoloma* is especially rich in the state. While documenting the agaric diversity of Western Ghats of Kerala, the authors collected several specimens of *Entoloma*. Our detailed study of these collections has resulted in three new species, which are described, illustrated, and discussed here.

Materials & methods

Gross morphological descriptions are based exclusively on fresh materials collected from Kerala State, India. Color coding follows Kornerup & Wanscher (1978). Microscopic characters were studied from hand cut sections of dried basidiomata revived in a 3% KOH aqueous solution, stained with 1% Congo red, and examined under a Leica DME 1000 compound microscope. The mean quotient (Q) of spore length divided by spore width was calculated from measurements of 30 basidiospores; the hilar

appendix was included in the measurement of the spore length. Line drawings were made with assistance of an attached drawing tube. All specimens cited were collected by the authors unless otherwise indicated. Holotypes are deposited at the Herbarium of the Royal Botanic Gardens, Kew (K), and all isotypes and additional materials examined are deposited at the Mycological Herbarium of Tropical Botanic Garden and Research Institute, Trivandrum (TBGT).

Taxonomy

Entoloma suaveolens C.K. Pradeep & K.B. Vrinda, **sp. nov.** Plate 1a–b; Fig. 1

MycoBank MB 564454

Differs from other blue *Entoloma* species in combining an appressed squamulose pileus and stipe with the lack of hymenial cystidia and the presence of a strong fragrant odor.

Type – India, Kerala State, Trivandrum District, Palode, TBGRI campus, 25 Sep 1996, Pradeep 3621 (**Holotype**, K(M) 172393).

Etymology –*suaveolens* refers to the fragrant odor of the basidiomes

Pileus 20–53 mm diam., convex with a broad obtuse umbo; surface ink blue, dark blue to greyish blue (20F4/21F4/21F8/22F4/21D5) at disc with greyish violet to dark blue (18E5/19E4/19E5/19E6) elsewhere, appressed squamulose throughout, often cracked to expose the white underlying context in dry season; squamules often washed off during heavy rain towards margin to appear subsquamulose, dry; margin straight, entire. Lamellae adnate, white, cream to greyish orange (4A3/4B4/5A2/5B3/6A2/6B4), ≤ 11 mm wide, close to crowded, with lamellulae of different lengths; edge concolourous, entire. Stipe 35–114 × 3–10 mm, central, cylindric, curved, fistulose to narrowly hollow, brittle, tapering up from a subclavate base; surface mostly concolorous with pileus or greyish violet (19D5), greyish blue (20D5), appressed squamulose throughout; base white with white mycelial mat and mycelial cords. Context white, up to 3 mm, soft. Odor strong, distinct, pleasant, fragrant, similar to holy ash. Spore print pink.

Basidiospores 10–12 × 5–7.5(–8) µm, avL = 11, avW = 6.77, Q = 1.3–1.7, avQ = 1.65, heterodiametric ovate, 5–7 facets in profile. Basidia 32–42.5 × 8.5–14 µm, clavate, 4-spored; sterigmata up to 4.5 µm long. Lamella edge fertile. Cheilocystidia and pleurocystidia absent. Hymenophoral trama regular; hyphae 2.5–16(–28) µm wide, thin-walled, hyaline. Pileal trama interwoven; hyphae similar to hymenophoral trama. Pileipellis a trichoderm with clavate to cylindro-clavate elements, 62.5–147 × 10–14 µm, thin-walled with bluish (in water) contents which dissolve in 3% KOH. Stipitipellis a cutis of loosely arranged septate thin-walled hyphae, 2.4–4.8 µm wide, with pale greyish plasmatic contents. Caulocystidia in tufts present on the upper part of the stipe, 41–67 × 5–9 µm, cylindro-clavate, thin-walled with pale brown vacuolar contents. Clamp connections and oleiferous hyphae present in all parts.

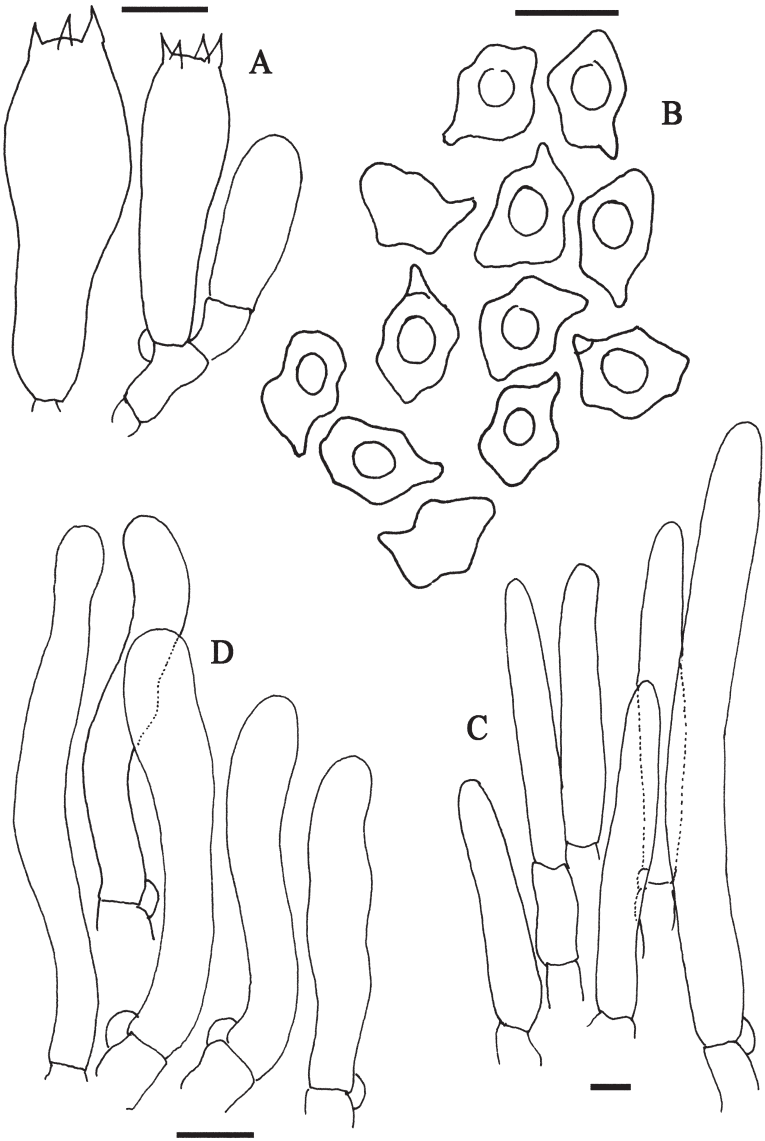

Fig. 1: *Entoloma suaveolens*. A, basidia; B, basidiospores;
C, trichodermial elements; D, caulocystidia. Scale bars = 10 μm.

Habit & habitat — Solitary, scattered on soil among decayed litter in evergreen forest, June–December.

Additional specimens examined — **INDIA**, **Kerala State**, Trivandrum District, Palode, TBGRI campus: 16 Sep 1997, TBGT 3887; 15 Oct 2001, TBGT 6770; 8 Jun 2005, TBGT 8907; 4 Nov 2005, TBGT 9425; 17 Jul 2007, TBGT 10427; 25 Jul 2008, TBGT 11513; 30 Jul 2008, TBGT 11554; 16 Dec 2009, TBGT 13058; Wayanad District, Nadavayal: 27 Sep 2007, TBGT 10575 (all at TBGT).

Discussion — *Entoloma suaveolens* is characterized by the unique combination of medium to large bluish terrestrial tricholomatoid basidiomes, convex umbonate appressed squamulose pileus and stipe, adnate pink lamellae, heterodiametric ovate basidiospores, absence of hymenial cystidia, trichodermial pileipellis, abundant caulocystidia, clamp connections present in all hyphae, and strong fragrant odor.

The present collections invite comparison with a number of blue *Entoloma* species described from various regions of the world by different workers. *Entoloma rugosopruinatum* Corner & E. Horak, originally described from Sabah (Horak 1980) and recently recorded from Kerala (Manimohan et al. 1995), differs by its violaceous purple finely tomentose pileus, presence of cylindro-clavate cheilocystidia, and subfarinaceous odor. *Entoloma divum* Corner & E. Horak is distinguished by a deep blue pruinose pileus, palisadic pileipellis, and lack of any odor. Three other comparable blue species —*E. simillimum* Corner & E. Horak, *E. egregium* E. Horak, *E. marinum* Corner & E. Horak— are easily separated by their velutinous pileus, presence of cheilocystidia, and lack of any distinctive odor. The European taxa *E. chalybeum* (Pers.) Noordel. and *E. chalybeum* var. *lazulinum* (Fr.) Noordel. (Noordeloos 1992) are distinguished by their depressed velutinous pileus, heterodiametrical 5–9-angled spores, sterile lamella edge, a cutis pileipellis, and absence of clamps. *Entoloma bloxamii* (Berk. & Broome) Sacc. and *E. nitidum* Quél. (Horak 1973, 1978, 1980; Noordeloos 1992), though comparable in gross morphology and pigmentation, vary markedly in their smooth glabrous subviscid pileus (pileipellis an ixocutis) and distinctive farinaceous odor. *Entoloma dichroum* (Pers.) P. Kumm. (Noordeloos 1992) differs in its violaceous purple pileus, heterogeneous lamella edge, and unpleasant odor. The recently described *E. eugenei* Noordel. & O. Morozova (Noordeloos & Morozova 2010) from Russia differs in its velvety deep blue pileus, sterile lamellae edge with cylindrical, narrowly lageniform or irregularly shaped cheilocystidia, and mild spicy odor.

Leptonia carnea Largent, a rather uncommon species restricted to coastal and northern California, is characterized by a blue black densely appressed fibrillose squamulose pileus and stipe, blue–violet–black lamella edge, cuticular pileipellis, and distinctive farinaceous odor and taste (Largent 1977); *L. carnea* is further distinguished by the insoluble blue pigment, contrasting with the readily KOH-soluble pigment in *E. suaveolens*.

Two recently described blue species from Kerala State, *E. griseolazulinum* Manim. & Noordel. and *E. indoviolaceum* Manim. & Noordel. (Manimohan et al 2006), clearly differ in their velutinous pileus, presence of cheilocystidia, large heterodiametric spores, and lack of any distinct odor.

Tricholomatoid habit, convex umbonate bluish pileus, trichodermial pileipellis, and presence of clamp connections place this species in subg. *Leptonia* sect. *Leptonia* (Noordeloos 1981a).

Entoloma crassum C.K. Pradeep & K.B. Vrinda, **sp. nov.** Plate 1c–d; Fig. 2

MycoBank MB 564455

Differs from *Entoloma flavidum* in its glabrous creamy to yellow white pileus, lack of cheilocystidia, and strong, nauseating odor.

Type – India, Kerala State, Trivandrum District, Palode, TBGRI campus: 7 Oct 2004, Pradeep 8154 (**Holotype**, K(M) 172394).

Etymology –*crassum* refers to the thick, stout basidiomes

Basidiomes thick, fleshy, robust, tricholomatoid. Pileus 45–160 mm diam., convex to planoconvex with a broad obtuse umbo, becoming uplifted in old ones; surface uniformly creamy white to yellowish white (4A2/4A3) when young and yellowish white to brownish orange (4A2/4A3/3B3/3C3/4B2/ 4B3/4B4) with brownish disc (4B3/4B4/4C4/5C2/5C3/5D3/5D4/5E3/5E4/6E4) in mature ones, moist, smooth, glabrous, not hygrophanous; margin incurved when young becoming straight, wavy, folded, entire to incised. Lamellae broadly adnate to subdecurrent, yellowish white to greyish red (4A2/5A2/6A2/5B3/6C6/7B4), ≤ 20 mm wide, close to crowded with lamellulae of 3–4 lengths; edge concolourous, entire. Stipe 35–150 × 10–25 mm, central (often excentric in some specimens), cylindric (rarely compressed), twisted, thick, fibrous, solid, equal, with a slightly broad base; surface white, cream, ivory (4B3) turning brownish orange (5C3), hair brown (5E4), greyish brown (6D3), brownish grey (6E2) on handling, fibrillose striate, smooth. Basal white mycelial mat present in some specimens. Context white, ≤ 11 mm thick, soft, fleshy. Odor strong, unpleasant, pungent, nauseating. Spore print cinnamon to reddish brown (6D6/8D6).

Basidiospores (8–)9–10 × (6–)6.5–7.5 µm, avL = 9.3, avW = 6.8, Q = 1.25–1.50, avQ = 1.34, heterodiametric ovate with 5–6 facets in profile. Basidia 45–58.5 × 7.5–10 µm, clavate, 4-spored. Lamella edge fertile, Cheilocystidia and pleurocystidia absent. Hymenophoral trama regular; hyphae 2.5–14 µm wide, thin-walled, hyaline. Pileal trama interwoven; hyphae similar to that of hymenophoral trama. Pileipellis a cutis passing to a trichoderm at the centre, elements 15–38 × 4–8 µm, clavate, cylindro-clavate to strangulated, thin-walled, hyaline. Stipitipellis a cutis of longitudinally parallel hyphae, 2.5–5 µm wide, thin-walled, hyaline. Caulocystidia abundant throughout the stipe surface, 25–80 × 6–9 µm, lageniform or narrowly utriform, cylindric, cylindro-

clavate, subutriform, strangulated, flexuous, often with a short subobtuse apex, thin-walled with intracellular granular contents. Clamp connections and oleiferous hyphae present.

Habit & Habitat — Solitary, scattered or in groups on soil among litter in evergreen forest or under reeds in sandy soil on riverbanks, April–December.

Additional specimens examined — **INDIA**, **Kerala State**, Trivandrum District, Palode, TBGRI campus: 21 Oct 1995, TBGT 2758; 19 May 1997, TBGT 3858; 13 May 1999, TBGT 4659; 19 Jun 2000, TBGT 5072; 21 Jun 2000, TBGT 5081; 27 Jun 2001, TBGT 5351; 29 Apr 2002, TBGT 5502; 7 Jul 2005, TBGT 9064; 23 Sep 2005, TBGT 9278; 17 Jun 2008, TBGT 11122; 25 Jun 2008, TBGT 11237; 30 Sep 2008, TBGT 12064; 4 Nov 2008, TBGT 12189; 11 Jun 2009, TBGT 12577; 16 Jun 2009, TBGT 12606; 29 Jun 2009, TBGT 12685; 16 Sep 2009, TBGT 12918; 23 Sep 2009, TBGT 12940; 14 Oct 2009, TBGT 12980; 23 Oct 2009, TBGT 13012; 25 Nov 2009, TBGT 13110; 11 Dec 2009, TBGT 13128; 6 Jul 2010, TBGT 13373; 4 Aug 2011, TBGT 13768; Kallar: 10 Jul 2007, TBGT 10411 (all at TBGT).

Discussion — *Entoloma crassum* is a very remarkable species characterized by large robust tricholomatoid basidiomata, a convex umbonate smooth glabrous yellowish white pileus with a brownish disc, broadly adnate to subdecurrent lamellae, a fibrillose striate white stipe that bruises brown, strong unpleasant nauseating odor, heterodiametric spores, fertile lamella edge, trichodermial pileipellis, caulocystidia that are abundant over the entire stipe surface, and presence of clamp connections in all hyphae.

The most closely related entolomas with large tricholomatoid yellowish white basidiomes are compared and discussed here. Despite its macroscopic and microscopic similarities, *E. flavidum* (Massee) Corner & E. Horak (Horak 1980) differs from *E. crassum* in its white subtomentose to floccose pileus that yellows with age, hollow fibrillose-striate non-yellowing white stipe, cylindric to subclavate cheilocystidia arrayed on a sterile lamella edge, a cuticular pileipellis, sour odor, and absence of caulocystidia. Among similar species that differ by possessing an ixocuticular pileipellis, *E. sinuatum* (Bull.) P. Kumm. (Noordeloos 1981b) is further distinguished by its viscid pale ochraceous pileus, characteristically yellow lamellae, and small isodiametric spores; *E. niphoides* Romagn. ex Noordel. (Largent 1994) is separated by its snow-white pileus and stipe and fruity odor; *E. moserianum* Noordel. (Noordeloos 1983) is distinguished by its typically yellow spotted pileus, lamellae, and stipe and sterile lamella edge; *E. albomagnum* G.M. Gates & Noordel. and *E. cretaceum* G.M. Gates & Noordel. (Gates & Noordeloos 2007) disagree by their pure white pileus and small spores; and *E. sepium* (Noulet & Dass.) Richon & Roze and *E. saundersii* (Fr.) Sacc. (Breitenbach & Kränzlin 1995) differ mainly in their silky white pileus, farinaceous odor, and lack of caulocystidia.

The large tricholomatoid habit, nonhygrophanous convex umbonate smooth pileus, adnate decurrent lamellae, regular hymenophoral trama, and abundant

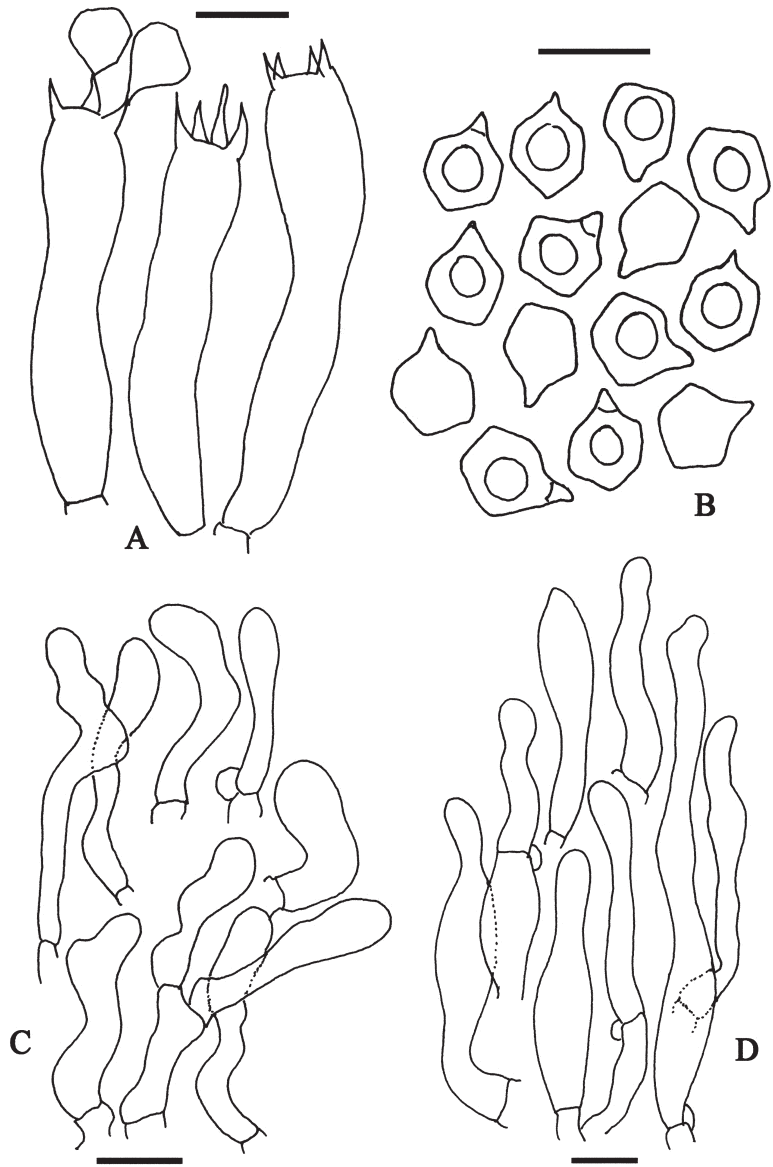

Fig. 2: *Entoloma crassum*.
A, basidia; B, basidiospores; C, trichodermial elements; D, caulocystidia. Scale bars = 10 µm.

clamps indicate that the species belongs to subg. *Entoloma* sect. *Entoloma* (Noordeloos 1981a).

Entoloma aurantioquadratum C.K. Pradeep & K.B. Vrinda, **sp. nov.**

MycoBank MB 564456 Plate 1e–f; Fig. 3

Differs from *Entoloma talisporum* and *E. gracilius* in the absence of clamp connections, from *E. hyalodepas* in its large quadrate basidiospores, and from *E. albogracile* in the absence of hymenial cystidia.

Type – India, Kerala State, Trivandrum District, Palode, TBGRI campus: 11 Nov 2009, Shibu 13048 (**Holotype**, K(M) 172395).

Etymology — *aurantioquadratum* refers to the orange basidiome with quadrate spores

Pileus 10–30 mm diam., convex to applanate with a small shallow depression at centre, often uplifted in old ones; surface orange white to brownish orange (5a2/5a3/5b2/5b3/5c3), with hair brown to greyish brown (5e4/7d3/7e3) centre or even paler towards margin, dry, velvety at disc (under a lens), elsewhere smooth, glabrous, nonhygrophanous; margin straight to uplifted in old ones, wavy, entire to incised, pellucid striate when wet. Lamellae adnexed, orange white to pinkish white (5a2/7a2), up to 4 mm wide, close with lamellulae of different lengths; edge concolourous to the sides, entire. Stipe 20–50 × 1–3 mm, central, cylindric, twisted, hollow, equal, curved, often narrowly tapering up from a slightly broad base; surface white turning brown on handling or bruising, pruinose in the upper part (under the lens) elsewhere smooth and glabrous. Context thin, concolourous to pileus, soft. Odor none.

Basidiospores (9–)9.5–12.5(–13) × (6–)6.5–8.5(–9.5) µm, avL = 10.8, avW = 7.6, Q = 1.05–1.7, avQ = 1.4, quadrate in profile. Basidia 23–36 × 9–12.5 µm, clavate, 4-spored. Lamella edge fertile, Cheilocystidia and pleurocystidia absent. Hymenophoral trama regular, 2–12 µm wide, thin-walled, hyaline. Pileal trama interwoven; hyphae similar to hymenophoral trama. Pileipellis a cutis with transitions towards a trichoderm at centre, elements 19.5–65 × 7.5–11 µm, clavate to cylindro-clavate, thin-walled with brown plasmatic intracellular contents. Stipitipellis a cutis of loosely arranged, septate, thin-walled, 2–4 µm wide, hyaline hyphae. Caulocystidia in groups on the upper part, 14–32 × 4.5–10.5 µm, clavate, cylindro-clavate with septate base, thin-walled, hyaline. Clamp connections absent. Oleiferous hyphae present.

Habit & Habitat — Scattered on forest floor in tropical evergreen forest, July–November.

Additional specimens examined — **India**, **Kerala State**, Trivandrum District, TBGRI campus: 10 Nov 2009, TBGT 13043; 15 Jul 2011, TBGT 13685; 11 Aug 2011, TBGT 13781 (all at TBGT).

Discussion — *Entoloma aurantioquadratum* is a typical member of subg. *Inocephalus* due to its nonhygrophanous nonstriate pileus and quadrate spores.

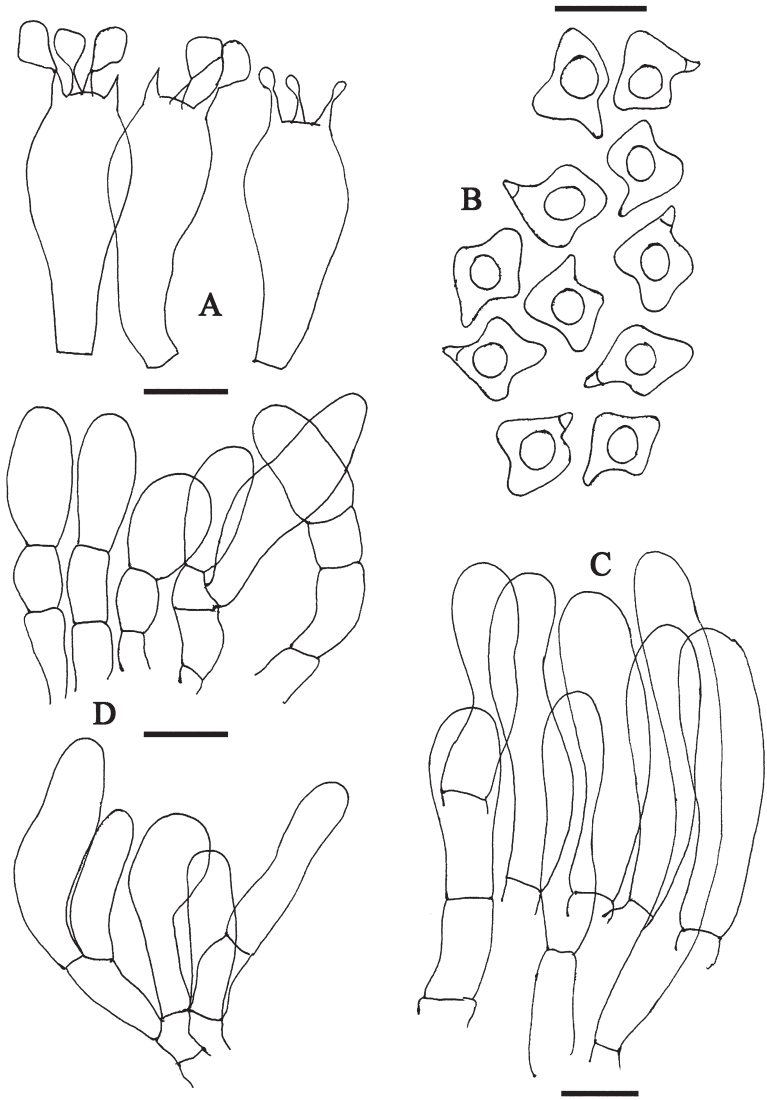

Fig. 3: *Entoloma aurantioquadratum.*
A, basidia; B, basidiospores; C, trichodermial elements; D, caulocystidia. Scale bars = 10 µm.

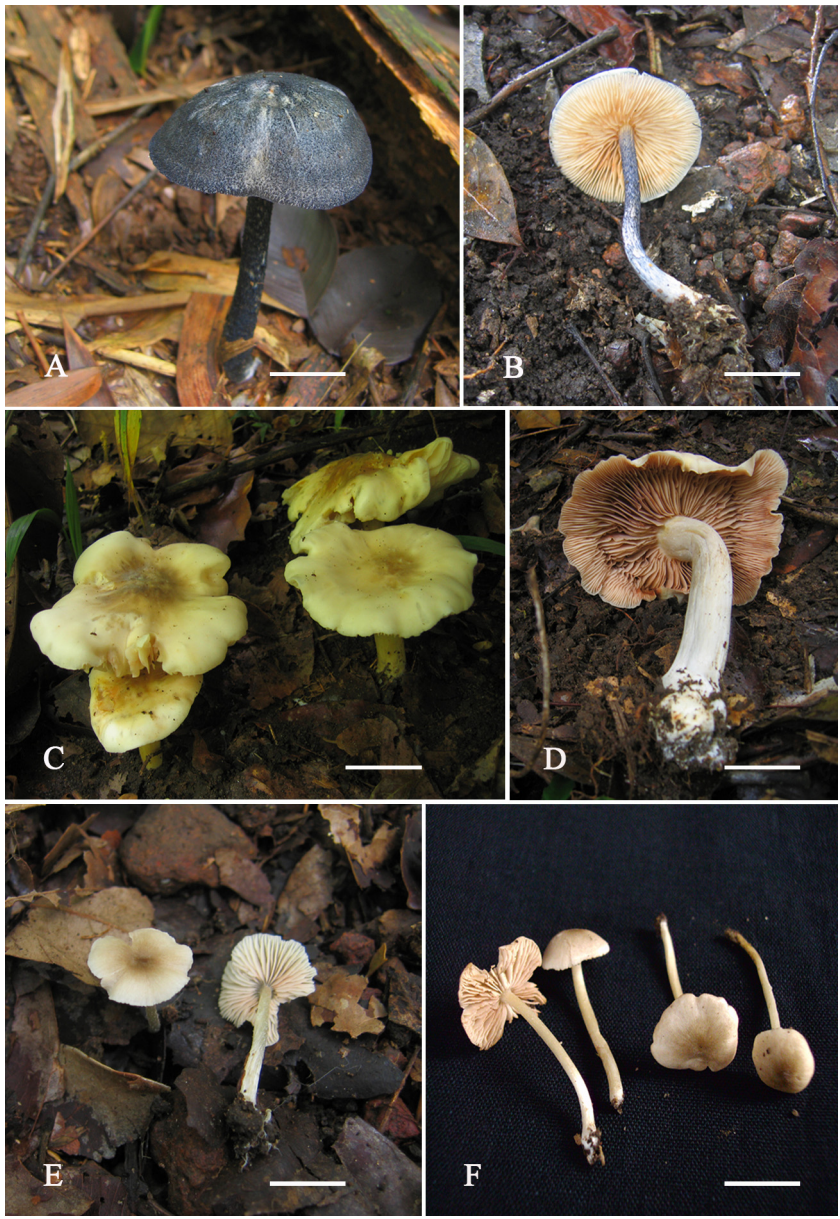

Plate 1: A–B, *Entoloma suaveolens*; C–D, *E. crassum*; E–F, *E. aurantioquadratum.* Scale bars: A–B, E–F = 10 mm; C–D = 20 mm.

The combination of small collybioid basidiomes with pale orange pileus, white stipe turning brownish, large spores, fertile lamellae edge, cuticular pileipellis with transitions towards a trichoderm, presence of caulocystidia, and lack of clamp connections are diagnostic for this species.

A comprehensive literature search (Horak 1976, 1977, Hesler 1967, Pegler 1986, Noordeloos 1987, 1992, Noordeloos & Hausknecht 2007, Manimohan et al. 1995, 2006) revealed that although some species are comparable, none matches *E. aurantioquadratum* exactly. *Entoloma talisporum* Corner & E. Horak differs in its yellowing white fibrillose pileus, smaller cuboid spores, and presence of clamp connections. *Entoloma hyalodepas* (Berk. & Broome) E. Horak is distinguished by its depressed to infundibuliform ivory yellow or ochraceous buff pileus, decurrent lamellae, large pentagonal spores, and cuticular pileipellis (Baroni & Lodge 1998). *Entoloma albogracile* E. Horak has a convex-umbonate papillate white to yellowish pileus, cylindrical to subclavate cheilocystidia, and cuboid to tetrahedral spores. *Entoloma gracilius* E. Horak can be separated by its small fragile basidiomes, yellowish green tinted pileus, broadly adnate lamellae, smaller cuboid spores, and presence of clamp connections.

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