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CHRYSOMYCENA PERPLEXA GEN. ET SP. NOV. (*AGARICALES*, *POROTHELEACEAE*), A NEW ENTITY FROM THE LAZIO REGION

Abstract

Based on morphological and molecular phylogenetic analyses, the new genus *Chrysomycena* is described for the species *C. perplexa* which shows a peculiar combination of features within the *Porotheleaceae* family: a mycenoid *habitus*, a pileipellis structured as an ixocutis with some pileocystidioid elements, slightly amyloid spores and basidia, long lageniform to flagellate (flagelliform) cheilocystidia, abundant clamp-connections and sarcodimitic tissues.

Key words: *Basidiomycota*, *Agaricomycetes*, *Marasmineae*, hydropoid clade, *Gerronema*, *Phloeomana*, *Trogia*, nrITS, nrLSU, Phylogeny, Taxonomy.

Introduction

During an investigation on the macromycetes of the Castelfusano coastline (Rome) some basidiomata of an unknown species with mycenoid *habitus* were found on a degraded stump of *Pinus pinea* L. characterized by yellowish colorations on the gills and on the stipe. The subsequent microscopic examination was able to highlight characters that did not allow a secure generic attribution on a traditional basis. The purpose of this article is therefore to provide a detailed macro- and microscopic description of the species, accompanied by colour images, and to identify, on a molecular basis, the phylogenetic position.

Materials & Methods

The annotations concerning the description of the collected samples (fresh basidiomata), of the habitat and of the plant associated with them were taken at the place of collection.

The microscopic characters were detected from fresh and dried material. In the case of dried material, rehydration was carried out with water (H_2O), Ammonia (NH_3) and Potassium hydroxide (KOH) at 5%. Glycerine buffer (L4) was also used for the observation of the preparations.

The observation of the structures and the measurements of the anatomical characters was carried out through the use of ammoniacal Red Congo (RCA) and 1% Floxin. For the observation of the parietal and intracellular pigment Blue Cotton in lactic acid (BCAL) and Toluidine Blue (BDT) was used, while Melzer's reagent (M) to test the iodine reaction of spores and other tissues.

Measurements of hyphae and spores were performed with 1000 × immersion objective lenses equipped with a calibrated micrometer. The instruments used were a Zeiss Universal R trinocular microscope with Leitz Wetzlar and PL Fluotar Lens and Zeiss Axiolab A1, with objective lenses 5 ×, 10 ×, 40 ×, 50 ×, 60 × and 100× oil immersion.

The measurement of the spores was carried out considering, from time to time, all the spores present in the visual field of the microscope, in order to satisfy the principle of randomness. In particular, the spore size was detected, excluding the apiculus, by measuring 32 basidiospores taken from several basidiomata. The values were given as minimum-<u>average</u>-maximum, Q = length/width with minimum and maximum values and Q_m = average quotient. The abbreviations L and l refer, respectively, to the total number of gills present in the basidioma and to the number of lamellulae between two gills. The photomicrographs were taken with Canon Powershot G10 and G11 digital cameras, while the photographs of the fresh specimens were taken *in situ* with Nikon D300 and D80 digital cameras.

The basidiomes of the examined collection have been deposited in MCVE.

Molecular analysis

DNA was extracted following the CTAB protocol according to Doyle & Doyle (1987). The nrITS region was amplified using the ITS1F primers (Gardes & Bruns, 1993) and ITS4 (White *et al.*, 1990), while the nrLSU region was amplified with the primers LR0R and LR05 (Vilgalys & Hester, 1990). The sequences obtained were edited with Geneious v. 11.1.4 (Kearse *et al.*, 2012) and then filed in GenBank (http://www.ncbi.nlm.nih.gov/genbank). GenBank access numbers are present in Fig. 1. The dataset used in the analyses was prepared mainly on the basis of the results present in Yang *et al.*, 2012, Dutta *et al.*, 2017, Latha *et al.*, 2018, Antonín *et al.*, 2019, Liu *et al.*, 2019, and the results obtained in BLASTN. The sequences of *Gamundia leucophylla* (EU669424) and *Myxomphalina maura* (AF261378) were used as outgroups. The alignment was carried out with MAFFT v7.388 (Katoh & Toh, 2008) and the Maximum Likelihood analysis was conducted with the software RAxML 8.2.7 (STAMATAKIS, 2006) using the GTR + G model and 1000 replicas of bootstrap for statistical validation of tree nodes. Only tree support values (bootstrap-MLB) greater than or equal to 50% are shown in the tree.

Taxonomy

Chrysomycena Vizzini, Picillo, Perrone & Dovana, nov. gen.
MycoBank MB 832697

Etymology *from the ancient Greek chrysós (gold) + Mycena, referring to the golden yellow tinges on gills and stipe of this mycenoid species.*

Diagnosis: *Habit mycenoid to omphalinoid, with yellow tinges on lamellae and stipe, lamellae adnate to subdecurrent; spore deposit whitish; spores ellipsoid, thin-walled, smooth, acyanophilous, with iodine reactions; basidia clavate, amyloid at apex; subhymenium filamentous; hymenophoral trama regular; pleurocystidia absent; cheilocystidia abundant, in clusters, lageniform to flagelliform; pileipellis as an ixocutis; caulocystidia present, similar to cheilocystidia; clamp-connections present, sometimes of the medallion-type. Context sarcodimitic. Habitat on decayed wood.*

Type species: *Chrysomycena perplexa.*

Chrysomycena perplexa Picillo, Vizzini & Perrone, nov. sp. (Photo 1-31)
MycoBank MB 832698

Etymology *the specific epithet is from the Latin adjective "perplexus" (unintelligible, intricate, inscrutable, ambiguous, obscure) and refers to the puzzling features of the species.*

Diagnosis: *Pileus 7-13 mm broad, hemispheric to convex, often weakly depressed at centre, slightly undulate at margin, surface smooth, lubricous when wet, not hygrophanous, translucent-striate (pellucid) up to the centre, ochraceous-brownish at the centre, ochraceous at margin, at first covered by a dense whitish bloom which soon tends to disappear in mature specimens or due to rain. Lamellae adnate, sometimes with short decurrent tooth, spaced, up to 2 mm wide, intercalated with lamellulae, L = 15-20, l = 1-2(-3), first whitish, then yellowish with an entire to minutely crenulate, concolorous edge. Stipe 12-25 × 2-3 mm, central, cylindrical, slightly enlarged at the base, translucent, fistulous, bright golden-yellow, surface completely decorated with a dense whitish bloom, which gives it a fluffy appearance, with evident whitish mycelial residues (rhizomorphs) at the base. Context thin, fibrous, concolorous to the external surfaces, smell and taste indistinct. Spore deposit whitish. Spores 7-8.5-9.6 × 5.2-6.1-7 µm, Q = 1.2-1.6, Q_m = 1.4, broadly ellipsoid to ellipsoid, with large central guttula or even pluriguttulate, with rather pronounced apiculus, smooth, weakly amyloid, not dextrinoid, acyanophilic. Basidia 30.4-47.8 × 6.1-9.6 µm, long clavate, pluriguttulate, tetrasporic (also bisporic) with sterigmata up to 6.1 µm long, amyloid at the apex. Subhymenium filamentous, consisting of up to 3 µm wide hyphae. Cheilocystidia 23.5-90 × 2.6-7.4 µm, with a moderately thicked wall (0.4 µm), mostly grouped in clusters (tufts), of the lageniform type but with a characteristic very thin neck of varying length (in some cases up to 70 µm long), similar to a flagellum, but also lageniform without flagellum, clavate, knotty stick shaped, bifurcate at*

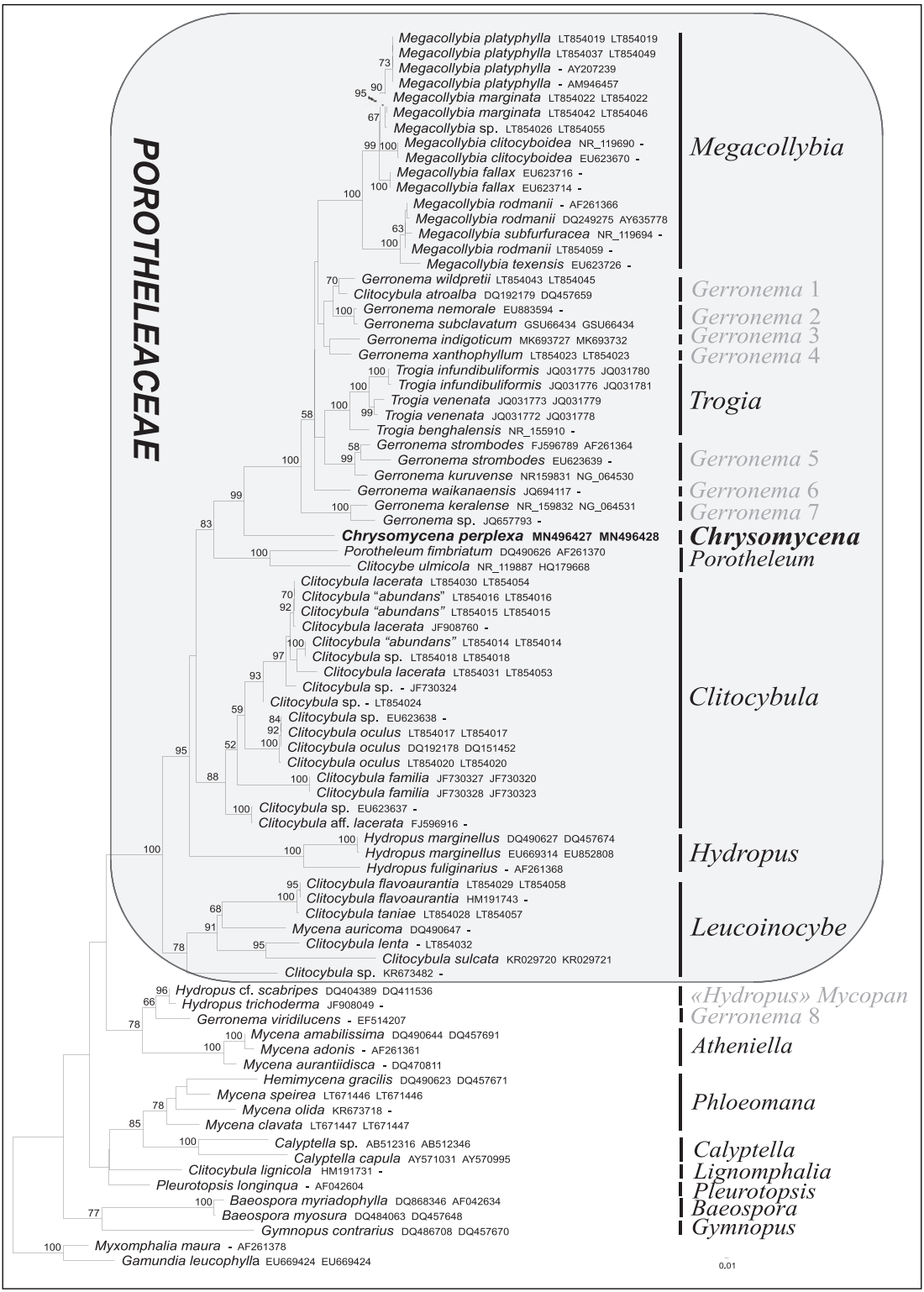

Figure 1 (tree). RAxML analysis of the combined nrITS / nrLSU (28S) dataset of *Porotheleaceae*. Only MLB values ≥ 50% are shown. Overall, an alignment of 82 sequences of the length of 1954 positions was obtained.

the apex, diverticulate. Pleurocystidia absent. Hymenophoral trama regular, sarcodimitic. Stipe structure consisting of an outer layer of thin, intertwined, knotted, diverticulate hyphae, × 0.9-2.6(3.2) μm and an inner layer of cylindrical hyphae, swollen in the median part, with parallel pattern, × 7.8-13.6(18) μm, with a fairly thick wall (0.4-0.8 μm). Caulocystidia present, of shape and size comparable to that of cheilocystidia, 37.4-69.6 × 4.3-7.8 μm. Pileipellis sarcodimitic: suprapellis of the ixocutis type, gelified, with cylindrical, vesicular, utriform hyphae, with rounded apex, pointed, with a short beak or capitulum (in some cases pileocystidioid), restricted to the septa, with a fairly thick wall (0.8 μm) at the base of which no clamp-connections were observed, with terminal elements of 36.5-143 × 14.8-34.8 μm, and thinner, intertwined, knotted, diverticulate, bifurcate hyphae, with terminal elements of 61-78.3 × 2.6-3.5 μm; a brownish mixed parietal and intracellular pigment is present. Subpellis similar to the suprapellis. Oleiferous hyphae uncommon but present in all tissues of the basidioma. Clamp-connections abundant, also of the medallion type, present at the base of the cheilocystidia and caulocystidia, as well as in the thin hyphae of the pileipellis, of the hymenophoral and stipe trama; infrequent at the base of basidia. Not observed elsewhere. Habitat gregarious on a decaying Pinus pinea wood in the Mediterranean area, in late autumn. So far known from only one location in Lazio.

Holotype: *Italy, Lazio, Pineta di Castel Fusano urban park, Castel Fusano (RM), on a Pinus pinea stump, 20-12-2014, leg. B. Picillo & L. Perrone (MCVE 30184).*

Pileus 7-13 mm, from hemispherical to convex with slight depression to the disc, smooth, slippery in wet weather, not hygrophanous, entire margin, slightly wavy, striated for transparency up to the centre, ochre-coloured at the edge, ochre-brown to the disc; surface completely covered by a thick whitish bloom which tends to dissolve in mature specimens or by washing away.

Gills from adnate to briefly decurrent, spaced, L = 15-20, l = 1-2 (-3) wide up to 2 mm, intercalated by lamellule, at first whitish, then yellowish with the concolorous thread, from intact to slightly crenulated.

Stipe 12-25 × 2-3 mm, central, cylindrical, slightly enlarged at the base, translucent, fistulous, golden-yellow shining, surface completely decorated with a dense whitish bloom, which gives it a fluffy appearance, there are evident whitish mycelial residues (mycelial cords/rhizomorphs) at the base.

Context fibrous, concolorous to external surfaces. No distinctive smell and taste.

Spore whitish.

Spores (Photo 2) 7-8.5-9.6 × 5.2-6.1-7 μm, Q = 1.2-1.6, Qm = 1.4, from broadly ellipsoidal to ellipsoidal, with large central guttula or also pluriguttulate, smooth, with rather pronounced apiculus, not dextrinoid, weakly amyloid (Photo 3), acyanophilic (Photo 4).

Basidia (Photo 5) 30.4-47.8 × 6.1-9.6 μm, long clavate, pluriguttulate, tetrasporic (also bisporic) with long sterigmata up to 6.1 μm, amyloid at the apex (Photo 6).

Cheilocystidia 23.5-90 × 2.6-7.4 μm, with a fairly thick wall (0.4 μm), mostly gathered in clusters, of the lageniform type but with a characteristic very thin and varied neck length (in some cases up to 70 μm long), similar to a flagellum, but also lageniforms without flagellum, clavates, claviform-nodose, bifurcated at the top, diverticulated. (Photos 7-8-9-10-11).

Subimenium filamentous, consisting of hyphae up to 3 μm wide (Photo 12).

Pleurocystidia absent.

Hymenophoral trama sarcodimitic, consisting of very variable hyphae for size and shape, with a fairly thick wall (0.4-0.6 μm). In fact, there are cylindrical, vesicular, even catenulated, utriform hyphae, with a rounded, pointed apex, restricted to the septa, and thinner, intertwined, knotted, diverticulated, bifurcated hyphae, with terminals 78-156.6 × 3.5-63 μm. A mixed brownish parietal and intracellular pigment is present. (Photos 13-14-15-16).

Photo 1. *Chrysomycena perplexa* Photo by Bernardo Picillo

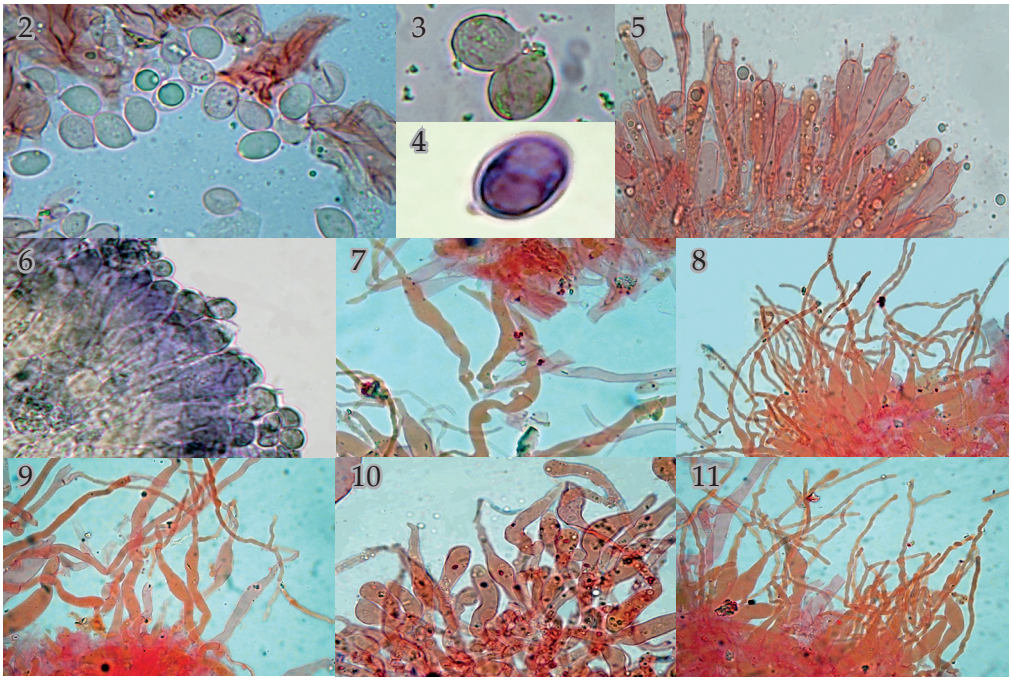

Photo 2. Spores (RCA); **3. S**pores (M); **4.** Spore (BCAL); **5.** Basidia; **6.** Hymenium (M); **7.** Cheilocystidia with clamp-connections (RCA); **8-9-10-11.** Cheilocystidia (RCA).

Photos by Luigi Perrone and Bernardo Picillo

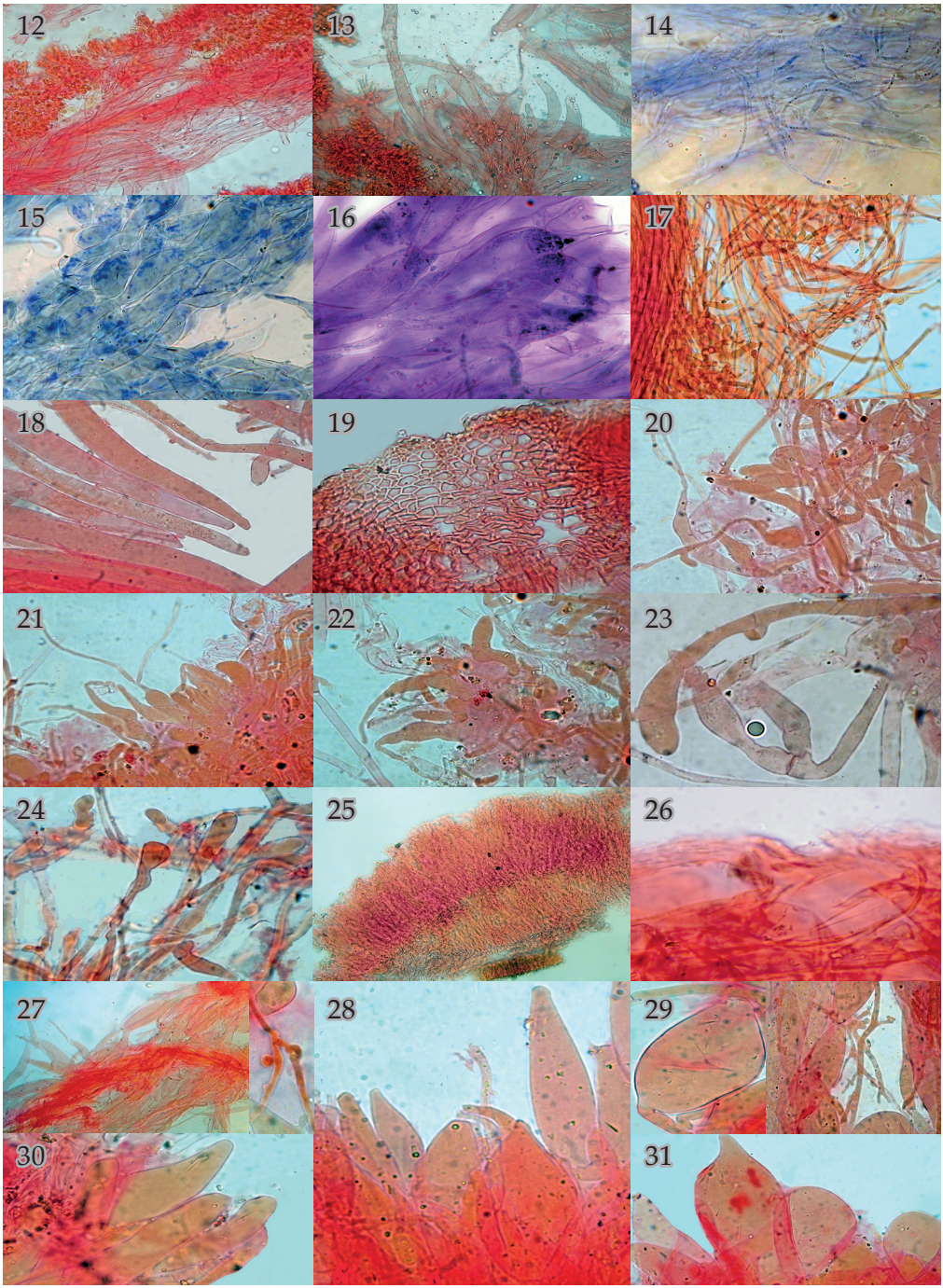

Photo 12. Hymenium and subhymenium (RCA); **13.** Lamellar texture (RCA); **14-15-16**. Pigmented lamellar texture (BDT and BCAL); **17.** Caulopellis (RCA); **18.** Stipe texture (RCA); **19.** Cross section of the stipe (RCA); **20-21-22-23-24.** Caulocystidia (RCA); **25.** Pilepellis, complete section, without pressure on the slide (RCA); **26.** Suprapellis without pressure o.t.s. (RCA); **27.** Suprapellis hyphae with clamp-connections after pressure o.t.s. (RCA); **28-29-30-31.** Suprapellis hypha of various morphology after pressure o.t.s. (RCA).
Photos by Luigi Perrone and Bernardo Picillo

Stipe structure consisting of an outer layer of thin, intertwined, knotted, diverticulated hyphae, × 0.9-2.6 (3.2) μm and an inner layer of cylindrical hyphae, swollen in the median part, with parallel pattern, × 7.8-13.6 (18) μm, with a fairly thick wall (0.4-0.8 μm) (Photo 17-18-19).

Caulocystidia present, of shape and size comparable to that of cheilocystidia, 37.4-69.6 × 4.3-7.8μm (Photos 20-21-22-23-24).

Pileipellis sarcodimitic: suprapellis ixocutis-type, gelled, with cylindrical, vesicular, utriform hyphae, with rounded apex, pointed, with short beak or capitulus (in some cases pileocystidiod), restricted to septa, with fairly thick wall (0.8 μm) at the base of which no buckle joints were observed, with terminals of 36.5-143 × 14.8-34.8 μm, and thinner, intertwined, knotted, diverticulated, bifurcated hyphae, with terminals of 61-78, 3 × 2.6-3.5. There is a mixed, parietal and intracellular brownish pigment (Photos 25-26-27-28-29-30-31); subpellis similar to the suprapellis.

Oleiferous hyphae non-common, but present in all tissues of the basidioma.

Clamp-connections abundant, also of the medallion-type, present at the base of the cheilocystidia and caulocystida, as well as in the thin hyphae of the pileipellis, of the hymenophoral trama and the stipe structure. Infrequent at the base of basidia. Not observed elsewhere. (Photos 7-17-23-27).

Habitat and collections made: Italy, Lazio, Pineta di Castelfusano, urban park, gregarious on a decaying *Pinus pinea* wood, in the Mediterranean area, 20.12.2014; *legit* B. Picillo & L. Perrone (MCVE 30184). Known in that one location.

Discussion

The new genus belongs to the so-called hydropoid clade (/hydropoid). This clade was first highlighted by Moncalvo *et al.* (2002), in which analysis based on nrLSU sequences consisted of some species of *Hydropus* Kühner ex Singer, *Gerronema* Singer, *Megacollybia* Kotl. & Pouzar, *Clitocybula* (Singer) Singer ex Métrod and from the poroid/cifelloid genus *Porotheleum* Fr. The same configuration of the clade was present in Bodensteiner *et al.* (2004). In the multigenic analysis of Matheny (2006) the hydropoid clade (part of the larger marasmioid clade) also included *Henningsomyces candidus* (Pers.) Kuntze, some *Mycena* (Pers.) Roussel (*M. auricoma* Har. Takah., *M. amabilissima* (Peck) Sacc., *M. aurantiidisca* (Murrill) Murrill) and *Hydnopolyporus fimbriatus* (Cooke) DA Reid. *Calyptella capula* (Holmsk.) Quél. and two species of *Trogia* Fr. (*T. infundibuliformis* Berk. & Broome and *T. venenata* Zhu L. Yang) also belonged to this clade in the study of Yang *et al.* (2012). Redhead (2012, 2013, 2016a, b) included in the clade the species of the mycenoid genera *Atheniella* Redhead, Moncalvo, Vilgalys, Desjardin, B.A. Perry and *Phloeomana* Redhead. Finally Antonín *et al.* (2019) put in the hydropoid clade the new genera *Leucoinocybe* Singer ex Antonín, Borovička, Holec & Kolařík (segregated from *Clitocybula*) and *Lignomphalia* Antonín, Borovička, Holec & Kolařík.

For this clade it is possible to use the name *Porotheleaceae* Murrill, while "*Trogiaceae*" Locq. is nom. inval. (Art. 39.1, Melbourne).

Porotheleaceae is part of the suborder *Marasmineae* Aime, Dentinger & Gaya as circumscribed on a phylogenomic basis by Dentinger *et al.* (2016) (= Marasmioid clade s. Binder *et al.* 2010). Many taxa in this family have a sarcodimitic structure in the sense of Redhead (1987).

In our analysis (Fig. 1) a statistically well-supported *Porotheleaceae* family is recognized (MLB = 100%) only when it consists of the genera *Hydropus, Clitocybula, Leucoinocybe, Megacollybia, Porotheleum, Trogia* and some species of *Gerronema. Chrysomycena* occupies an independent position in the *Porotheleaceae* and is sister (MLB = 99%) to a clade (MLB = 100%) formed by *Megacollybia, Trogia* and some species of *Gerronema*.

The genus *Megacollybia* is characterized by a *habitus* from collybioid to clitocyboid, a pileic fibrillary surface, abundant rhizomorphs at the base of the stipe, a sub-hymenidermic

to sub-trichodermic pileipellis (at least in the middle of the pileus), non-amyloid spores, widely clavate cheilocystidia (Hughes *et al.*, 2007; Antonín *et al.* 2019), presence of clamp-connections and a sarcodimitic structure of the stipe (Redhead, 1987). The phylogenetically and morphologically closest genera are *Gerronema* and *Trogia*.

Gerronema is a broadly distributed genus (Singer, 1964, 1970, 1986) with about 130 specific names (including synonyms) reported in the Index Fungorum database (http://www.indexfungorum.org/, last accessed 20/09/2019). The genus was originally proposed by Singer (1951) to accommodate three species (*G. melanomphax* Singer, *G. elasticum* Singer and *G. depauperatum* Singer) collected in the province of Tucumán (tropical Argentina) and characterized by a omphalinoid-to-clitocyboid growth, central or slightly eccentric long stipe, growth on rotting wood, irregular/confused lamellar texture, absence of cystidia, non-amyloid spores, intracellular pigment, present or absent clamp-connections. The definition of the genus has subsequently been met by numerous remodulations (ex. Singer, 1964, 1970, 1975, 1986; Bigelow, 1970; Clémençon, 1982; Redhead, 1986, 1987, 2002a, b; Norvell *et al.*, 1994). Singer (1964-1986) had extended the concept of the genre by transferring some species previously included in *Omphalina* Quél. Bigelow (1970) considered *Gerronema* synonymous posterior to *Omphalina*. Many authors (Clémençon, 1982; Moser, 1983; Kuyper, 1986; Redhead, 1986, 1987, 2002a, b; Norvell *et al.*, 1994; Antonín *et al.*, 2008) considered *Gerronema* sensu Singer (1964, 1975, 1986) as extremely artificial and heterogeneous. In this sense, the first molecular analyses of Lutzoni (1997), Moncalvo *et al.* (2002) and Redhead (2002a, b), based on the study of ribosomal genes, suggested the polyphilicity of the genus *Gerronema* as defined by Singer. Norvell *et al.* (1994), following the studies of Redhead (1986, 1987) limited *Gerronema* to only lignicole species, with thin-walled spores, pileipellis in the form of cutis and with sarcodimitic structure. Thus delimited *Gerronema* would be monophyletic in the studies of Moncalvo *et al.* (2002), Antonín *et al.* (2008, 2019), Yang *et al.* (2012), Liu *et al.* (2019), whose analyses, however, took into consideration only an extremely limited number of species and collections of *Gerronema* and/or of neighboring genera. Investigations in Latha *et al.* (2018) and in the present work (Fig. 1), based on a wider taxon sampling, would indicate a polyphyletic status also for *Gerronema* s.s. in the sense of Norvell *et al.* (1994).

Over the years, some species of *Gerronema* sensu Singer (1951, 1964) have been included in the genera *Blasiphalia* Redhead, *Cantharellopsis* Kuyper, *Chrysomphalina* Clémençon, *Haasiella* Kotl. & Pouzar, *Contumyces* Redhead, Moncalvo, Vilgalys & Lutzoni, *Gyroflexus* Raithelh. (= *Sphagnomphalia* Redhead, Moncalvo, Vilgalys & Lutzoni), *Lichenomphalia* Redhead, Lutzoni, Moncalvo & Vilgalys, *Loreleia* Redhead, Moncalvo, Vilgalys & Lutzoni and *Rickenella* Raithelh. (Kotlába & Pouzar, 1966; Clémençon, 1982; Kuyper, 1986; Redhead, 2002a, b).

The genus *Trogia*, established by Fries (1835) with the Indian species *Trogia montagnei* as type, includes generally lignicolous species with clitocyboids to omphalinoids basidioma of tenacious consistency and reviviscent *in situ* (Kumar & Manimohan, 2009, Yang *et al.*, 2012). Corner (1966), author of the first monographic work on the genus, adopted a very broad concept, recognizing 56 species united only by possessing a sarcodimitic structure. This extended concept of *Trogia* was much criticized by Singer (1986), believing that Corner had over-emphasized the importance of the sarcodimitic structure; Singer limited the genus to only three species characterized by reviviscent basidioma, narrow and often forked gills, intricate lamellar texture and trichodermic pileipellis and distributed the others in *Gerronema*, *Hemimycena* Singer, *Hydropus* and *Mycena* (Pers.) Roussel. Redhead (1987), in a study aimed at understanding the taxonomic value of the presence of sarcodimitic tissues in the basidiomata of the *Agaricales*, emphasized the importance of this character. But instead of bringing together all the taxa with sarcodimitic tissues in a single genus (*Trogia*) as done by Corner (1966), he recognized several genera that he included in the family *Xerulaceae* Jülich (now *Physalacriaceae* Corner partim).

In the 1991 monograph Corner reconfirmed his 1966 definition of *Trogia*, recognizing 90 species for Asia, Australasia and neotropics. In the sense of Singer (1986) *Trogia* appears to be a good monophyletic genus (Wilson & Desjardin, 2005; Yang *et al.*, 2012; Dutta *et al.*, 2017; Antonín *et al.*, 2019; Fig. 1 of this work) even though *T. montagnei*, type species of the genus, has never been sequenced (the holotypus is not traceable: Corner, 1991; Wilson & Desjardin, 2005).

The genus *Hydropus* based on *Agaricus plexipes* b *fuliginaria* Batsch (1783) contains species with mycenoid, omphalinoid to collybioid habit with amyloid or inamyloid spores and a pileipellis generally at least in a subimeniform part and/or with ventricose/swollen pileocystidia (Singer, 1982, 1986; Hausknecht *et al.*, 1997; Contu & Robich, 1998; Bas, 1999; Estève-Raventós *et al.*, 2002). The genus is not monophyletic (see ex.: Moncalvo, 2002; Antonín *et al.*, 2019: and our analysis in Fig. 1) and the genus *Mycopan* Redhead, Moncalvo, Vilgalys was recently established for *Prunulus scabripes* Murrill 1916 (Redhead, 2013).

Among the genera similar to *Chrysomycena* close to *Porotheleaceae* (Fig. 1), *Phloeomana*, established by Redhead (2013) (type species *Agaricus speireus* Fr. 1815) and corresponding to species in *Mycena*, section *Hiemales* Konrad & Maubl. (Holec & Kolařík, 2017), includes species with grayish-brownish mycenoid basidiomata, growing on bark and dead wood, adnate gills, decurrent with tooth, non-amyloid spores, cheilocystidia of shape slightly different from that of basidia and hyphae of pileipellis with ramified digitations (Maas Geesteranus, 1992; Ronikier & Aronsen; 2007, Redhead, 2013; Aronsen & Læssøe, 2016; Robich, 2016; Holec & Kolařík, 2017). *Atheniella* Redhead, Moncalvo, Vilgalys, Desjardin, B.A. Perry (species like *Agaricus adonis* Bull. 1793), corresponding to the adonis clade of Moncalvo et al., (2002) and to *Mycen*a, section *Adonideae* (Fr.) Quél., is a genus consisting of mycenoid species with brightly coloured pileus of red, orange, yellow or white, ascending gills, inamyloid spores, cheilocystidia and generally fusiform pleurocystidia and elements of the pileipellis with simple diverticula or branched (Maas Geesteranus, 1992; Redhead, 2012; Aronsen & Læssøe, 2016; Robich, 2016).

Among the mycenoid-omphalinoid genera belonging to other families, morphologically the closest is *Chrysomphalina* (type species *Agaricus chrysophyllus* Fr. 1821), which phylogenetically belongs to the *Hygrophoraceae* (Moncalvo *et al.* 2002; Matheny *et al.*, 2006; Vizzini *et al.*, 2012; Lodge *et al.*, 2014) and that stands out for the presence of carotenoid pigments, a pachipodial hymenium, a monomitic structure, the absence of clamp-connections and for poorly differentiated hymenial cystidia (Clémençon, 1982; Norvell *et al.*, 1994; Lodge *et al.*, 2014).

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Bibliography

Antonín, V. Ryoo R. & Shin H.D. – 2008: Gerronema nemorale (Basidiomycota, Agaricomycetes*): anatomic-morphological, cultivational, enzymatic and molecular characteristics and its first records in the Republic of Korea*. Czech Mycology 60: 197-212.

Antonín V., Borovička J., Holec J., Piltaver A. & Kolařík M. – 2019: *Taxonomic update of* Clitocybula *sensu lato with a new generic classification*. Fungal Biology 123(6): 431-447.

Aronsen A. & Læssøe T. – 2016: *The genus* Mycena *s.l. Fungi of northern Europe vol. 5*. Narayana press, Gylling.

Bas C. – 1999: *8.* Hydropus *(Kühner) ex Singer*. In: Bas C., Kuyper T.W., Noordeloos M.E. & Vellinga E.C. *Flora Agaricina Neerlandica*. Rotterdam, A. A. Balkema: 166-172.

Bigelow H.E. – 1970: Omphalina *in North America*. Mycologia 62: 1-32.

Binder M., Larsson K.H., Matheny P.B. & Hibbett D.S. – 2010: Amylocorticiales *ord. nov. and Jaapiales ord. nov.: early diverging clades of agaricomycetidae dominated by corticioid forms*. Mycologia 201: 865-880.

Bodensteiner P., Binder M., Moncalvo J.M., Agerer R. & Hibbett D.S. – 2004: *Phylogenetic relationships of cyphelloid homobasidiomycetes*. Molecular Phylogenetics and Evolution 33 (2): 501-515.

Bon M. – 1997: Tricholomataceae *(2e partie). Genres*: Clitocybe, Armillaria, Lepista, Ripartites, Omphalina, Gerronema, Rickenella, Chrysomphalina, Haasiella, Gamundia, Omphaliaster, Cantarellula, Pseudoomphalina, Clitocybula, Pseudoclitocybe, Myxomphalia, Fayodia. Flore Mycologique d'Europe n° 4. Documents Mycologiques Mémoires Hors-Série 4: 1-181.

Clémençon H. – 1982: *Kompendium der Blätterpilze. Europäische omphalinoide* Tricholomataceae. Zeitschrift für Mykologie 48: 195-237.

Contu M. & Robich G. – 1998: Hydropus liciosae *spec. nov., con chiave per la determinazione delle specie del genere* Hydropus *in Europa*. Rivista di Micologia 41(2): 109-118.

Cooper J.A. – 2014: *New species and combinations of some New Zealand agarics belonging to* Clitopilus, Lyophyllum, Gerhardtia, Clitocybe, Hydnangium, Mycena, Rhodocollybia *and* Gerronema. Mycosphere 5(2): 263-288.

Cooper A.C., Desjardin D.E. & Perry B.A. – 2018: *The genus* Mycena (Basidiomycota, Agaricales, Mycenaceae) *and allied genera from Republic of São Tomé and Príncipe, West Africa*. Phytotaxa 383(1): 1-47.

Corner E.J.H. – 1966: *A monograph of cantharelloid fungi*. Oxford University Press, Oxford.

Corner E.J.H. – 1991: *Trogia (Basidiomycetes)*. The Gardens' bulletin, Singapore, Suppl 2: 1-100.

Dentinger B.T.M., Gaya E., O'Brien H., Suz L.M., Lachlan R., Díaz-Valderrama J.R., Koch R.A. & Aime M.C. – 2016: *Tales from the crypt: genome mining from fungarium specimens improves resolution of the mushroom tree of life*. Biological Journal of the Linnean Society 117: 11-32.

Doyle J.J. & Doyle J.L. – 1987: *A rapid DNA isolation procedure for small quantities of fresh leaf material*. Phytochemical Bulletin 19: 11-15.

Dutta A.-K., Nandi S., Tarafder E., Sikder R., Roy A. & Acharya K. – 2017: Trogia benghalensis (Marasmiaceae, Basidiomycota), *a new species from India*. Phytotaxa 331(2): 273-280.

Dutta A.R., Antonín A., Barui R. & Acharya K. – 2017: *A new species of* Clitocybula (Marasmiaceae) *from West Bengal, India*. Nova Hedwigia 107 (1-2): 195-203.

Esteve-Raventós F., Villarreal M. & Heykoop M. – 2002: Hydropus paradoxus *var.* xerophyticus *and a key to the taxa known from Europe*. Persoonia 17 (4): 631-635.

Fries E.M. – 1818: *Observationes mycologicae*. Gerh. Bonnier, Copenhagen, 372 pp.

Fries E.M. – 1836[1835]: *Corpus Florarum provincialium suecicae I*. Floram Scanicam: 1-349.

Gardes M. & Bruns T.D. – 1993: *ITS primers with enhanced specificity for basidiomycetes application to the identification of mycorrhizae and rusts*. Molecular Ecology 2: 113-118.

Hausknecht A., Krisai-Greilhuber I. & Klofac W. – 1997: *Die Gattung* Hydropus *in Österreich*. Österreichische Zeitschrift für Pilzkunde 6: 181-210.

Holec J. & Kolařík M. – 2017: *First report of* Mycena clavata (Fungi, Agaricales) *in the Czech Republic including notes on its taxonomy, phylogenetic position and ecology*. Czech Mycology 69(1): 1-14.

Hughes K.W., Petersen R.H., Mata J.L., Psurtseva N.V., Kovalenko A.E., Morozova O.V., Lickey E.B., Cifuentes Blanco J., Lewis D.P., Nagasawa E., Halling R.E., Takehashi S., Aime M.C., Bau T. & Henkel T. – 2007: *Megacollybia (Agaricales).* Reports of the Tottori Mycological Institute 45: 1-57.

Katoh K. & Toh H. – 2008: *Recent developments in the MAFFT multiple sequence alignment program.* Briefings in Bioinformatics 9: 286-298.

Kearse M., Moir R., Wilson A., Stones-Havas S., Cheung M., Sturrock S., Buxton S., Cooper A., Markowitz S., Duran C., Thierer T., Ashton B., Meintjes P. & Drummond A. – 2012: *Geneious Basic: an integrated and extendable desktop software platform for the organization and analysis of sequence data.* Bioinformatics 28: 1647-1649.

Kotlába F. & Pouzar Z. – 1966: Haasiella, *a new Agaric genus and* H. splendidissima *sp. nov*. Ceská Mykologie 20(3): 135-140.

Kumar T.K.A. & Manimohan P. – 2009: *Rediscovery of* Trogia cyanea *and record of* T. infundibuliformis (Marasmiaceae, Agaricales) *from Kerala State, India*. Mycotaxon 109: 429-436.

Kuyper T.W. – 1986: *Generic delimitation in European omphalinoid* Tricholomataceae. Atti del Centro Studi per la Flora Mediterranea (Borgo Val di Taro, Italy) 6: 83-104.

Latha K.P.D., Raj K.N.A., Sharafudheen S.A. & Manimohan P. – 2015: Clitocybula sulcata-*a new species from India*. Phytotaxa 208(1): 63–69.

Latha K.P.D., Nanu S., Sharafudheen S.A. & Manimohan P. – 2018: *Two new species of* Gerronema (Agaricales, Basidiomycota) *from Kerala State, India*. Phytotaxa 364(1): 81-91.

Liu L.-N., Mou G.-F., Bau T. – 2019: *A new* Gerronema *species with striking colours from China*. Phytotaxa 405(2): 74-82.

Lodge D.J., Padamsee M., Matheny P.B., Aime M.C., Cantrell S.A., Boertmann D., Kovalenko A., Vizzini A., Dentinger B.T.M., Kirk P.M., Ainsworth A.M., Moncalvo J.M., Vilgalys R., Larsson E., Lücking R., Griffith G.W., Smith M.E., Norvell L.L., Desjardin D.E., Redhead S.A., Ovrebo C.L., Lickey E.B., Ercole E., Hughes K.W., Courtecuisse R., Young, A., Binder M., Minnis A.M., Lindner D.L., Ortiz-Santana B., Haight J., Læssøe T., Baroni T.J., Geml J. & Hattori T. – 2014: *Molecular phylogeny, morphology, pigment chemistry and ecology in* Hygrophoraceae (Agaricales). Fungal Diversity 64: 1-99.

Lutzoni F.M. – 1997: *Phylogeny of lichen-and non-lichen-forming omphalinoid mushrooms and the utility of testing for combinability among multiple data sets*. Systematic Biology 46(3): 373-406.

Maas Geesteranus R.A. – 1992: *Mycenas of the Northern Hemisphere, vol. 1: Studies in Mycenas and other papers; vol. 2*. Conspectus of the Mycenas of the Northern Hemisphere. North-Holland, Amsterdam.

Matheny P.B., Curtis J.M., Hofstetter V., Aime M.C., Moncalvo J.M., Ge Z.W., Slot J.C., Ammirati J.F., Baroni T.J., Bougher N.L., Hughes K.W., Lodge D.J., Kerrigan R.W., Seidl M.T., Aanen D.K., DeNitis M., Daniele G.M., Desjardin D.E., Kropp B.R., Norvell L.L., Parker A., Vellinga E.C., Vilgalys R.& Hibbett D.S. – 2006: *Major clades of Agaricales: a multilocus phylogenetic overview*. Mycologia 98(6): 982-995.

Métrod G. – 1952: *Les Collybies*. Revue de Mycologie 17: 60-93.

Moncalvo J.M., Vilgalys R., Redhead S.A., Johnson J.E., James T.Y., Aime M.C., Hofstetter V., Verduin S.J.W., Larsson E., Baroni T.J., Thorn R.G., Jacobsson S., Clemencon H. & Miller Jr. O.K. – 2002: *One hundred and seventeen clades of eu-agarics*. Molecular Phylogenetics and Evolution 23: 357-400.

Moser M. – 1983: *Keys to Agarics and Boleti (*Polyporales, Boletales, Agaricales, Russulales). Roger Phillips, London, 535 pp.

Norvell L.L., Redhead S.A. & Ammirati J.F. – 1994: Omphalina *sensu lato in North America 1–2. 1:* Omphalina wynniae *and the genus* Chrysomphalina, *2:* Omphalina *sensu Bigelow*. Mycotaxon 50: 379-407.

Redhead S.A. – 1986: *Mycological observations: 17–20. Nomenclatural notes on some omphalioid genera in Canada*: Chrysomphalina, Rickenella, Gerronema, Omphalina. Acta Mycologica Sinica 1: 297-304.

Redhead S.A. – 1987: *The* Xerulaceae (Basidiomycetes), *a family with sarcodimitic tissues*. Canadian Journal of Botany 65: 1551-1562.

Redhead S.A. – 2012: *Nomenclatural novelties*. Index Fungorum 14: 1.

Redhead S.A. – 2013: *Nomenclatural novelties*. Index Fungorum 15: 1-2.

Redhead S.A. – 2016a*: Nomenclatural novelties*. Index Fungorum 290: 1.

Redhead S.A. – 2016b: *Nomenclatural novelties*. Index Fungorum 291: 1.

Redhead S.A., Moncalvo J.-M., Vilgalys R. & Lutzoni F. – 2002a: *Phylogeny of agarics: Partial systematics solutions for bryophilous omphalinoid agarics outside of the* Agaricales (*Euagarics*). Mycotaxon 82: 151-168.

Redhead S.A., Lutzoni F., Moncalvo J.M. & Vilgalys R. – 2002b: *Phylogeny of agarics: partial systematics solutions for core omphalinoid genera in the* Agaricales (*Euagarics*). Mycotaxon 83: 19-57.

Robich G. – 2016: Mycena *d'Europa, Vol. 2.* Associazione Micologica Bresadola, Trento.

Ronikier A. & Aronsen A. – 2007: *Type study of* Mycena phaeophylla *reveals its conspecificity with* M. clavata. Mycologia 99: 924-935.

Singer R. – 1951: *New genera of fungi V.* Mycologia 43: 598-604.

Singer R. – 1964: *Die Gattung* Gerronema. Nova Hedwigia 7: 53-92.

Singer R. – 1970: *Omphalinae (Clitocybeae – Tricholomataceae, Basidiomycetes)*. Flora Neotropica 3: 1-84.

Singer R – 1982: *Hydropus (Basidiomycetes – Tricholomataceae – Myceneae)*. Flora Neotropica,32: 1-152.

Singer R. – 1986: *The Agaricales in modern taxonomy. 4th edition*. Koeltz Scientific Books, Koenigstein, 981 pp.

Stamatakis A. – 2006: *RAxML-VI-HPC: maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models*. Bioinformatics 22: 2688-2690.

Vilgalys R. & Hester M. – 1990: *Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several Cryptococcus species*. Journal of Bacteriology 172: 4238-4246.

Vizzini A., Consiglio G., Setti L. & Ercole E – 2012 [2011]: *The phylogenetic position of* Haasiella *(Basidiomycota, Agaricomycetes) and the relationship between* H. venustissima *and* H. splendidissima. Mycologia 104: 777-784.

White T.J., Bruns T., Lee S.S. & Taylor J. – 1990: *Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics*. In: Innis M.A., Gelfand D.H., Sninsky J.J. & White T.J. (Eds.) - *PCR Protocols: A Guide to Methods and Applications.* Academic Press, New York, pp. 315-322.

Wilson A.W. & Desjardin D.E. – 2005: *Phylogenetic relationships in the gymnopoid and marasmioid fungi* (*Basidiomycetes, euagarics clade)*. Mycologia 97: 667-679.

Yang Z.L., Li Y.C., Tang L.P., Shi G.Q. & Zeng G. – 2012: Trogia venenata *(*Agaricales*), a novel poisonous species which has caused hundreds of deaths in southwestern China*. Mycological Progress 11(4): 937-945.

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