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Marchandiobasidium aurantiacum gen. sp. nov., the teleomorph of *Marchandiomyces aurantiacus* (*Basidiomycota*, *Ceratobasidiales*)

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The name *Marchandiobasidium aurantiacum* gen. sp. nov. is introduced for the teleomorph of *Marchandiomyces aurantiacus*. Dolipore septa and septal pore caps of the closely related *Marchandiomyces corallinus* are typical of the *Ceratobasidiales*, and the basidiomatal characters of *Marchandiobasidium aurantiacum* are reminiscent of those of the monotypic genus *Waitea*. Morphological, ultrastructural and molecular data suggest that *Marchandiobasidium* should not be included in *Waitea*, but should be treated as a distinct genus.

INTRODUCTION

Lichenicolous fungi that produce sclerotia are rare, although one widespread and common, lichenicolous and algicolous species, *Athelia arachnoidea*, is known. Another fungus, *Leucogyrophana lichenicola*, confined to *Cladonia* and *Stereocaulon* thalli in boreal regions of Europe and America, has been described as producing conspicuous sclerotia (Thorn, Malloch & Ginns 1998). The form-genus *Marchandiomyces* Diederich & D. Hawksw. 1990, of which only the sclerotial morph was known, includes at least two widespread lichenicolous species, *M. aurantiacus* (Lasch) Diederich & Etayo 1996 and *M. corallinus* (Roberge) Diederich & D. Hawksw. 1990; an additional lignicolous species has recently been discovered (DePriest *et al.*, unpubl.). Molecular studies by Sikaroodi *et al.* (2001) suggested that these three *Marchandiomyces* species form a clade, but the phylogenetic relationships with other basidiomycetes, especially members of the *Ceratobasidiales*, were not clear. Although *M. aurantiacus* has much been studied in the field by P.D. during the past 15 yr, no basidiomata have been recognized until recently. The discovery of the teleomorph of *M. aurantiacus*, and ultrastructural information on the dolipore septum and septal pore cap of *M. corallinus* allow comparison of *Marchandiomyces* with similar or related genera. As the generic name *Marchandiomyces* clearly refers to the sclerotial morph (see below), the *Code* requires the description of a new genus, *Marchandiobasidium*, for the teleomorph.

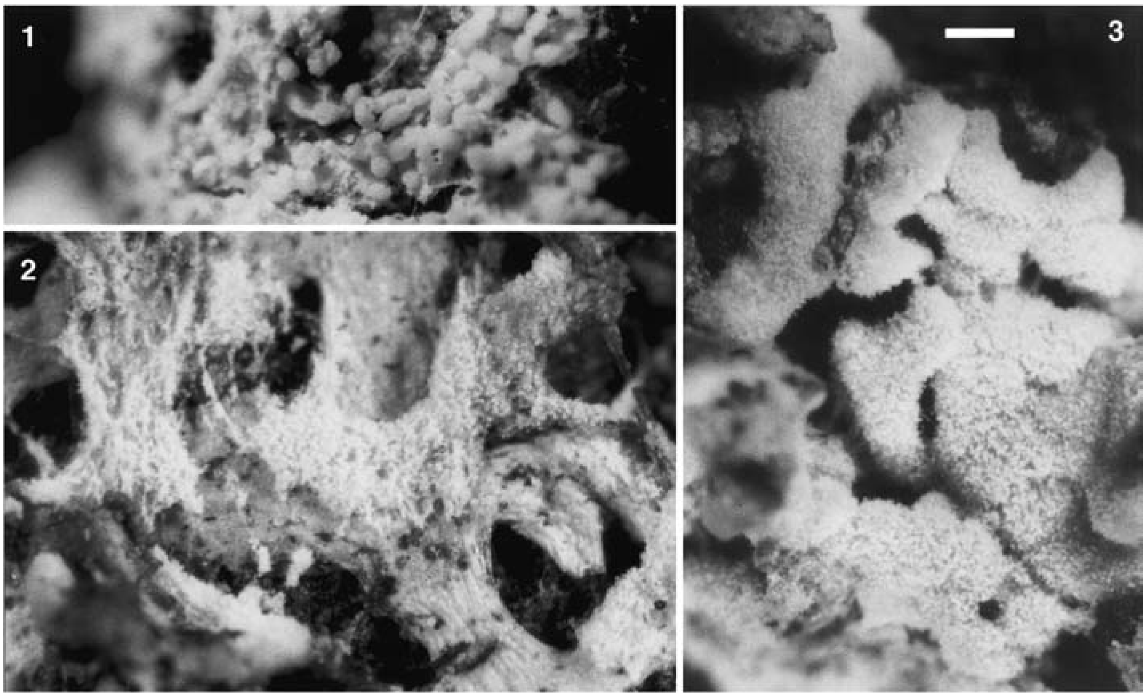
MATERIAL AND METHODS

Material and light microscopy

Fresh material, deposited in LG and in the private collection of P.D., has been studied macroscopically and microscopically, mounted in water or in a mixture of KOH, Congo Red and Phloxin. Dolipore septa are best observed with phase contrast at ×2000. Drawings were prepared with a drawing tube.

Ultrastructure

A culture of *Marchandiomyces corallinus* was examined using TEM (**USA**: *New York*: Essex Co., on *Rhizoplaca chrysoleuca*, 1983, *R. C. Harris 16642*, NY; culture IMI 290746). The culture was fixed with 2% glutaraldehyde in 0.05 M cacodylate buffer on the agar surface overnight at 4 °C. Small pieces (about 5×5×5 mm) of agar were cut out, placed in vials, and postfixed in 2% osmium tetroxide. Dehydration in a graded alcohol series to 100% absolute ethyl alcohol was followed by embedment in low viscosity plastic (Spurr 1969) over a week at 4 ° before hardening in an oven at 70 °. Sections were cut with a diamond knife, and



Figs 1–3. *Marchandiobasidium aurantiacum* (holotype). **Fig. 1.** Dead thallus of *Physcia tenella* with sclerotia (young basidiomata were present on the same thallus). **Fig. 2.** Dead thallus of *P. tenella* with developing basidioma. **Fig. 3.** Mature basidioma. Bar = 250 μm.

the sections were post-fixed on copper grids in uranyl acetate and lead citrate.

TAXONOMY

Marchandiobasidium Diederich & Schultheis, **gen. nov.**

A *Waitea* basidiis longioribus, aliquando probasidio basali laterali vesicario ellipsoideo, et sclerotiis siccis, non gelatinosis differt.

Typus: *Marchandiobasidium aurantiacum* Diederich & Schultheis 2003.

Differing from *Waitea* in the longer basidia, the occasional presence of a basal, lateral probasidial bladder, and dry, non-gelatinous sclerotia.

Sclerotial morph: *Marchandiomyces* Diederich & D. Hawksw. 1990.

Marchandiobasidium aurantiacum Diederich & Schultheis, **sp. nov.** (Figs 1–5)

Basidiomata pallide aurantiaca, effusa, tenuia, adnata, granulosa, floccosa, margine indeterminata, ad 1 cm diam. Hymenium basidiis primum elongato-cylindricis, aliquando probasidio basali laterali vesicario ellipsoideo, ad 57 × 11 μm, maturitate clavatis ad suburniformibus, 25–40 × 12–15 μm, efibulatis, 4 sterigmatibus curvatis, ad 6.5 μm longis, basim ad 3 μm latis. Basidiosporae hyalinae, leves, non-amyloideae, non repetite germinantes, pyriformes vel lacriformes, uno latere saepe complanatae vel concavae, apiculo 1.5–3 μm diam, aseptatae, raro 1-septatae, 13–17.5(–18.5) × 8–11.5 (–13.5) μm, pariete 0.5–1 μm crasso. Hyphidia et cystidia nulla. Hyphae basales hyalinae, aliquando contortae, 3.5–6 μm crassae, cellulis 7–25 μm longis, crassitunicatis. Hyphae superiores hyalinae, tenuitunicatae, efibulatae, 2–4 μm crassae. Conidia ignota.

Typus: **Belgium**: *Lorraine distr.*: Lischert (coord. IFBL: L7.36.44), behind Thoen house, on *Pyrus* branches in garden, on *Physcia tenella*, 21 Dec. 2001, *D. Thoen* & *P. Diederich* 15133 (LG – holotypus; hb. Diederich – isotypus).

Additional specimen examined: **Luxembourg**: *Lorraine distr.*: Dudelange, direction Zoufftgen (coord. IFBL: M8.55.43), on *Populus*, on *Physcia tenella*, 27 Aug. 1987, *P. Diederich* 8526 (hb. Diederich).

Basidiomata light orange (same colour as sclerotia of *Marchandiomyces aurantiacus*), effused, thin, adnate, granulose, floccose, margin indeterminate, reaching 1 cm diam. *Hymenium* comprising one or several layers of basidia on vertically branching, thin-walled hyphae. *Basidia* initially elongate cylindrical, sometimes with a basal, lateral, ellipsoid probasidial bladder, to 57 × 11 μm; when mature, generally becoming clavate to suburniform, exceptionally with one thin, transverse septum in the upper third, 25–40 × 12–15 μm, distinctly wider than the supporting hyphae; wall 0.6–0.8 μm thick; basal clamps lacking; basal septum with dolipore visible by light microscopy. *Sterigmata* 4 per basidium, to 6.5 μm long and 3 μm wide at the base, curved. *Basidiospores* hyaline, smooth, usually aseptate, non-amyloid, not repetitive, pyriform or lacriform, one side frequently flattened or slightly concave, with a prominent truncate apiculus of 1.5–3 μm diam, 13–17.5 (–18.5) × 8–11.5(–13.5) μm; wall 0.5–1 μm thick; exceptionally with one thin, transverse septum, and then wall distinctly constricted at this septum; dolipore of septum visible by light microscopy. *Hyphidia, cystidia* and

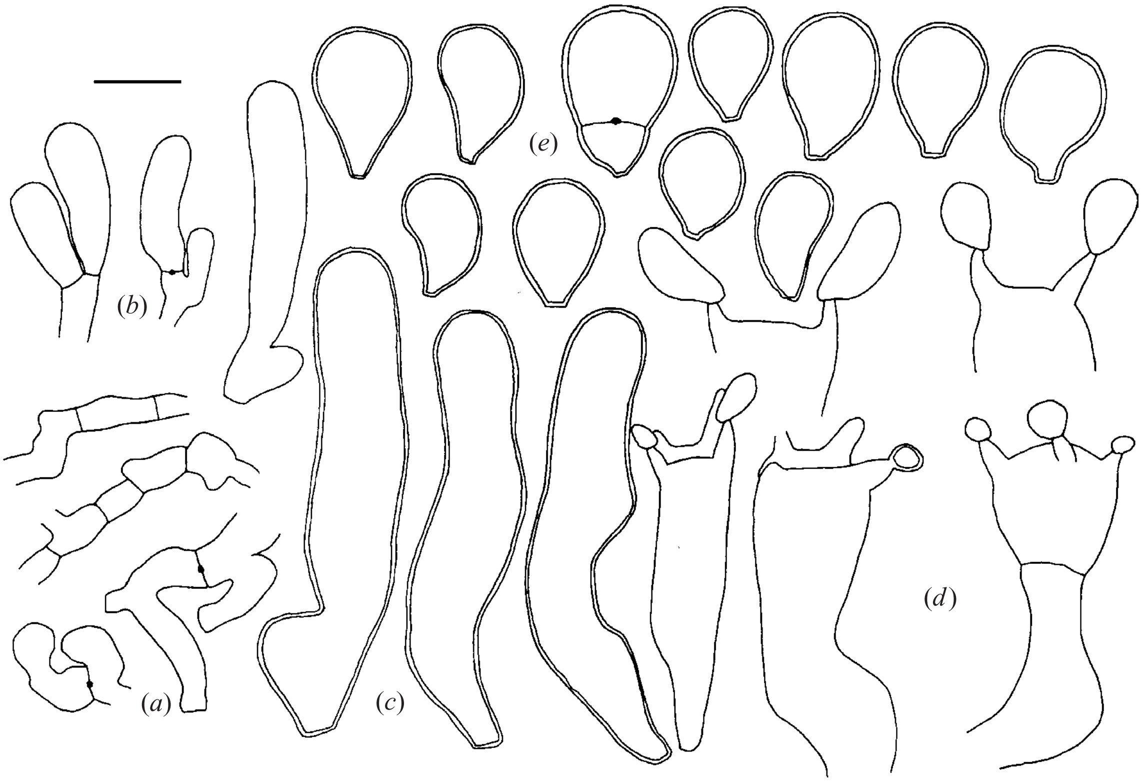


Fig. 4. *Marchandiobasidium aurantiacum* (holotype). (*a*) Basal hyphae; (*b*) young basidia; (*c*) immature basidia with the two on the left showing a basal lateral probasidial bladder; (*d*) mature basidia (in some, only two or three of the four sterigmata are seen); and (*e*) basidiospores. Bar = 10 µm.

other sterile hymenial elements lacking. *Basal hyphae* hyaline, occasionally contorted, 3.5–6 µm thick, cells 7–25 µm long, wall 0.5–1 µm thick; dolipores (observed in phase contrast) 0.5–1 µm wide, 0.5–1 µm thick. *Superior hyphae* hyaline, thin-walled, lacking clamps, septate, 2–4 µm thick. *Conidial morph* unknown. *Sclerotial morph: Marchandiomyces aurantiacus.*

Distribution and ecology: Basidiomata of *Marchandiobasidium aurantiacum* are rare and have hitherto been recognized only in two specimens from Belgium and Luxembourg. The anamorph *Marchandiomyces aurantiacus* is relatively common and widespread in Europe. It has not yet been collected in North America, although its occurrence there is likely. The species is a virulent parasite of corticolous *Physcia* spp., occasionally also attacking neighbouring thalli of other lichens, such as *Xanthoria* spp. The parasite develops mainly in autumn and is able to kill *Physcia* thalli over larger areas within several weeks. Infection results in the thalli shrinking in thickness, leaving at the end the decoloured, film-like, cortical remnants of the hosts.

Observations: *Marchandiobasidium aurantiacum* is an unusual basidiomycete, which produces basidiomata only very rarely, but can easily be recognized in the field by its pale orange colour, parasitic behaviour on corticolous lichens (mostly *Physcia* spp.), and concolourous, but much smaller (50–150 µm diam), subspherical sclerotia that are almost always present.

When describing the new genus *Marchandiomyces* (Diederich 1990), the authors concluded that colonies (of specimens belonging to *M. aurantiacus*!) are formed of sclerotia of 50–150 µm and of sporodochia of 100–500 µm diam. Inside the 'sporodochia' of the specimen *P. Diederich* 8526, elongated cells were considered to be 'conidiophores', and single, detached, obpyriform cells 11–15 × 7–10 µm with a truncate base to be 'conidia'. The discovery of the teleomorph of *M. aurantiacus* revealed the true nature of all these elements: the 'sporodochia' are basidiomata, and the 'conidiophores' and 'conidia' immature basidia and basidiospores. Nevertheless, the type species of *Marchandiomyces* is *M. corallinus*, the type specimen of which entirely consists of sclerotia, and does not include any basidiomata (Desmazières, *Pl. crypt. Fr.*, edn 1, fasc. 32, no. 1551, K–isotype!); thus, the name *Marchandiomyces* refers to the sclerotial morph of these fungi, and as such represents an anamorph name.

According to the original description, the name *Aegerita physciae* Vouaux 1914 (Vouaux 1912–14) might represent an earlier synonym of *Marchandiobasidium aurantiacum*. The conidiophores were said to be straight, aseptate, hyaline, 25–35 × 4–7 µm, corresponding with immature basidia, and the conidia were described as hyaline, aseptate, smooth, thin-walled, perfectly spherical, 10–15 µm diam, suggesting basidiospores. However, the description of conidiogenesis does not entirely correspond to basidiospore formation in *M. aurantiacum*: Vouaux stated that the conidia were formed by budding at the apex of the conidiophores followed by separation by a septum and detachment; furthermore,

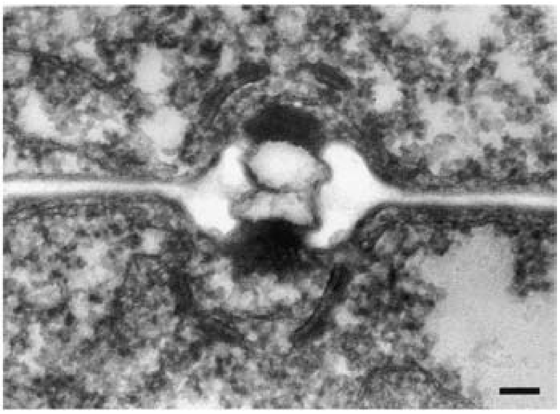


Fig. 5. *Marchandiomyces corallinus* (*R. C. Harris 16642*). Dolipore septum and septal pore cap. Bar = 0.1 µm.

the narrow proximal end with a prominent truncate apiculus, characteristic of basidiospores in *M. aurantiacum*, is not mentioned. As the type specimen is lost (Hawksworth 1979) and there is doubt about the true identity of *Aegerita physciae*, we prefer not to use this name, and instead describe the *Marchandiomyces aurantiacus* teleomorph as a new species.

DISCUSSION

The basidiomatal characters of the new fungus are reminiscent of the monotypic genus *Waitea* Warcup & P. H. B. Talbot 1962. The type species, *W. circinata* Warcup & P. H. B. Talbot 1962 (syn. *W. nuda* Clémençon 1990), has similar subcylindrical to suburniform basidia; four short, curved sterigmata; ellipsoid, basally truncate, rarely transseptate basidiospores, which are usually wider close to the distal end, and are often slightly asymetrical; dolipore septa and septal pore caps are visible by light microscopy; superior hyphae, which are similar in width or slightly narrower than the base of the basidia; contorted basal hyphae; the absence of clamps; the absence of hyphidia, cystidia and other sterile hymenial elements; and pinkish to orange or brownish sclerotia.

The ultrastructure of the septal pore complex of *Marchandiobasidium aurantiacum* has not been studied. However, the structure of the closely related *Marchandiomyces corallinus* was studied by M.B. many years ago, but the results never published. The septal pore complexes observed in this species (Fig. 5) were similar to those in the *Ceratobasidiales*, as circumscribed by Roberts (1999), including the discontinuous septal pore cap, as shown in most species of that order that have been studied ultrastructurally (Anderson 1996, Clémençon 1990, Müller *et al.* 1998, Roberts 1999). The type species of *Ceratobasidium* D. P. Rogers 1935, *C. calosporum* D. P. Rogers 1935, has continuous parenthesomes (Weiß & Oberwinkler 2001), which indicates that many more molecular and ultrastructural studies of *Ceratobasidium* species are needed to understand the phylogenetic relationships of the entire group. Three genera (*Ceratobasidium*, *Thanatephorus* and *Waitea*) were included by Roberts (1999) within the *Ceratobasidiales*, and the new genus *Marchandiobasidium* has to be compared with all of them.

Ceratobasidium differs from *M. aurantiacum* by a hymenium of laterally branching hyphae and much shorter and generally wider, often ellipsoid to subglobose basidia. Species of *Thanatephorus* Donk 1956 are distinguished primarily by their ellipsoid to cylindrical basidia that are never suburniform; sterigmata longer than 6 µm; self-replicating basidiospores, which are aseptate in most species; and basal hyphae that are not contorted (e.g. Talbot 1965). However, in some species of *Thanatephorus*, especially those with ornamented basidiospores, the sterigmata are relatively short, 4.5–10 µm long; in two species, *T. hebelomatosporus* (Boidin & Gilles) P. Roberts 1998 and *T. terrigenus* (Bres.) G. Langer 1994, the basidiospores are not self-replicating; and in *T. terrigenus*, the basidiospores become 1-septate; sclerotia are known from at least two *Thanatephorus* species, *viz. T. cucumeris* (A. B. Frank) Donk 1956 and *T. ochraceus* (Massee) P. Roberts 1998 (Roberts 1999). These morphological observations indicate that the generic limits between *Thanatephorus* and *Waitea* are unclear, and Roberts (1999) suggested that the two genera can hardly be retained as distinct.

W. circinata is similar to *M. aurantiacum*, but differs by its much smaller basidia, 10–18 × 5.5–6.5 µm in culture, 19–29 × 5–8 µm in nature, which never have a basal probasidial bladder; smaller basidiospores, 8–12 × 3.5–5 µm in culture, 8.5–13 × 4–5.5 µm in nature (Warcup & Talbot 1962); a different ecology (pathogenic on cereals, turf grass and legumes, causal agent of 'sheath spot' of rice, or saprobic in soil); and especially by the larger sclerotia, 0.5–3 mm diam (Roberts 1999), which are covered with a gelatinous substance, giving them a glistening appearance (Andersen 1996). Sclerotia of *Marchandiomyces aurantiacus*, like those of *M. corallinus* and the undescribed lignicolous species, are never gelatinous in appearance. Despite these differences, inclusion of *Marchandiobasidium aurantiacum* in *Waitea* might be conceivable.

Sikaroodi *et al.* (2001) studied the phylogenetic relationships of *Marchandiomyces aurantiacus*, *M. corallinus* and the undescribed species (as AF289659), based on parsimony analysis of SSU rDNA sequences of 124 fungal species. The taxa included the type of *Thanatephorus*, *T. cucumeris* (syn. *T. praticola*), and the anamorph of the type of *Waitea*, *Rhizoctonia zeae*. Their results suggested that *Waitea* and *Thanatephorus* belong to distinct lineages and are not closely related. Thus *Waitea* should not be included in *Thanatephorus*, as suggested by Roberts (1999). Furthermore, the phylogenetic tree (Sikaroodi *et al.* 2001) suggested that the three species of *Marchandiomyces* form a clade, closely related to *R. zeae*, but nevertheless different. We conclude that the description of a new genus *Marchandiobasidium* is the best solution.

For the time being, we include *Marchandiobasidium* in the *Ceratobasidiales sensu* Roberts (1999), although we are aware that this order is heterogeneous. The phylogenetic relationships of *Marchandiomyces* with some groups of *Corticiaceae*, based on molecular studies using parsimony, likelihood and bayesian analyses of complete sequences of the nuclear small subunit and internal transcribed spacers ribosomal DNA, and a portion of the nuclear large subunit, will be discussed in a separate paper.

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