

# *Laetisaria* and *Limonomyces* species (Corticaceae) causing pink diseases in turf grasses

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Three pink species of Corticiaceae (Basidiomycetes) growing on living grasses are described: *Laetisaria fuciformis*, the causal organism of the red thread disease and two species classified in the new genus *Limonomyces*: *Limonomyces roseipellis* sp. nov. and *Limonomyces culmigenus* comb. nov. The morphology and disease symptoms of these species are described and their taxonomy discussed.

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Trois espèces roses de Corticiacées (Basidiomycètes) croissant sur les graminées vivantes sont décrites: *Laetisaria fuciformis*, l'organisme responsable du "red tread," et deux espèces classifiées dans le nouveau genre *Limonomyces*: *Limonomyces roseipellis* sp. nov. et *Limonomyces culmigenus* comb. nov. La morphologie de ces espèces et les symptômes pathologiques qu'elles provoquent sont décrits et leur taxonomie est discutée.

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In the past, three reddish corticiaceous fungi have been distinguished as parasites on grasses. Their teleomorphs were first described under the binomials *Hypochnus fuciformis* (McAlpine 1906), *Corticium fuciforme* (Wakefield 1917), and *Exobasidiellum culmigenum* (Reid 1969). Because much confusion exists in phytopathological and mycological literature, especially concerning the first two species, their differentiating characters, disease symptoms, and taxonomy are separately discussed here in detail. *Hypochnus fuciformis*, which represents the causal organism of the red thread disease, is treated as *Laetisaria fuciformis* (Burdall 1979). The other two species are placed in a new genus and treated as *Limonomyces roseipellis* and *L. culmigenus*. Cultivation methods are taken from Stalpers (1978); capitalized colour names refer to Ridgway (1912).

≡ *Athelia fuciformis* (McAlpine) Burdall, *Trans. Br. Mycol. Soc.* **72**: 422. 1979 [as "(Wakef.) Burdall"] misapplied.

ANAMORPHIC NAMES: *Isaria fuciformis* Berk., *J. Linn. Soc. (Bot.)*, **13**: 175. 1872.

≡ *Isaria graminiperda* var. *fuciformis* (Berk.) Cooke, *Handb. Austral. fungi*, p. 383. 1892.

= *Isaria graminiperda* Berk. & Muell. apud Berk., *Gard. Chron.* 1873: 1596. 1873.

Fungus consisting of variously shaped sterile mycelium and (if present) an effused basidiocarp. Sterile mycelium weblike, pale reddish, surrounding and connecting leaf blades, or simple or branched, forming pink flocks and antlerlike processes; threadlike processes simple or branched, occurring at tips of grass blades, typically acuminate, up to 10 mm long (up to 50 mm mentioned in the literature), when fresh gelatinous, pale pink, pale orange, or nearly hyaline, when dry ceraceous and bright pink, orange, or red; flocks brittle, pink, up to 10 mm, consisting of a mass of arthroconidia. Basidiocarps resupinate, effused, adnate, ceraceous to membranaceous, pruinose when dry, up to 120 μm thick. Hymenial surface even, pinkish when fresh, cream coloured to nearly invisible when dry. Hyphal strands often present. Hyphal system monomitic. Subicular hyphae arranged in textura intricata, hyaline to slightly pink, 3–7.5(–10) μm wide, lacking clamps, thin to thick walled (0.4–2.3 μm), multinucleate (up to 11 nuclei per cell). Hyphidia simple, hyaline, thin walled, 20–45 × 2–4 μm, not abundant. Basidia

*Laetisaria fuciformis* (McAlpine) Burdall, *Trans. Br. Mycol. Soc.* **72**: 420. 1979. Figs. 1, 4, 5

≡ *Hypochnus fuciformis* McAlpine, *Ann. Mycol.* **4**: 549. 1906 [as "(Berk.) McAlpine"]

≡ *Epithele fuciformis* (McAlpine) Höhn. & Sydow apud H. and P. Sydow, *Ann. Mycol.* **4**: 551. 1906 [as "(Berk.) Höhn. & Sydow"]

≡ *Phanerochaete fuciformis* (McAlpine) Jülich, *Persoonia*, **8**: 434. 1976 [as "(Berk.) Jülich"]

≡ *Corticium fuciforme* (McAlpine) Wakef., *Trans. Br. Mycol. Soc.* **5**: 481. 1917 (1916) [as

"(Berk.) Wakef."] misapplied.

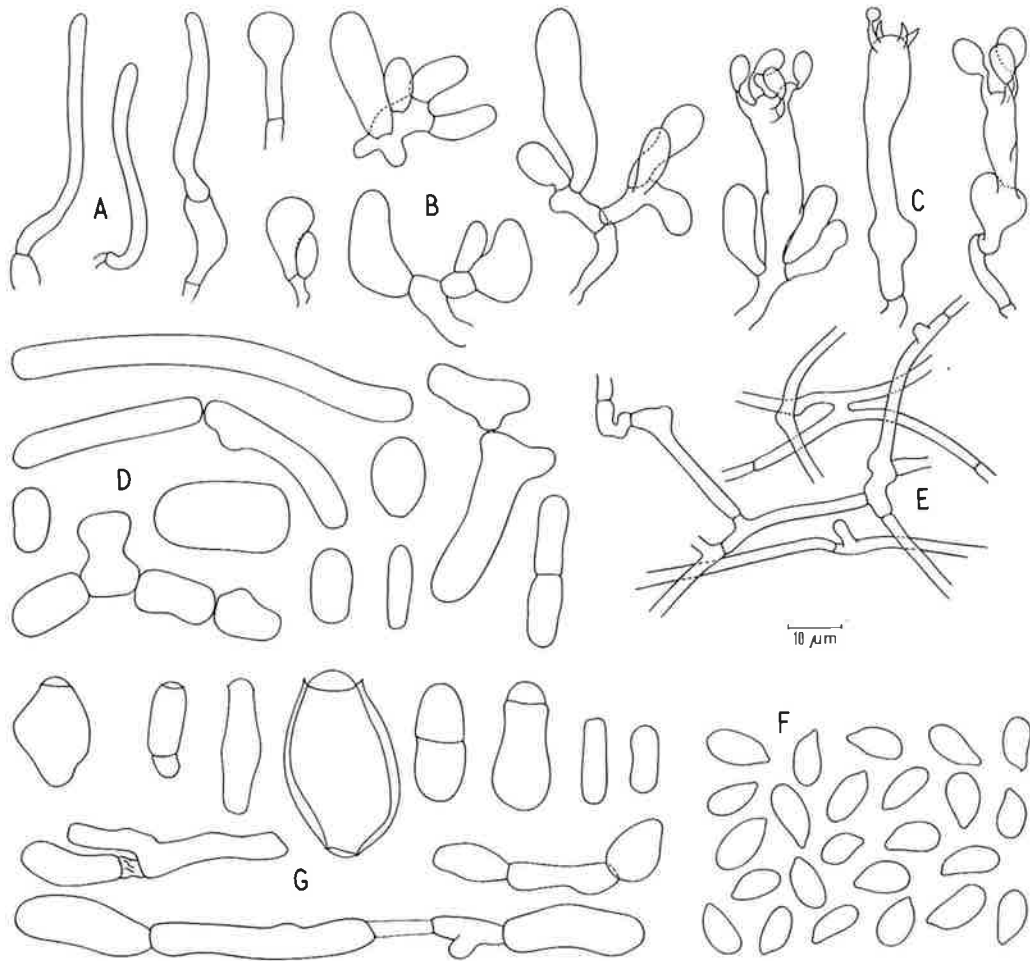


FIG. 1. *Laetisaria fuciformis*. In vivo: (A) Hyphidia. (B) Probasidia. (C) Basidia. (D) Arthroconidia. (E) Hyphae. (F) Basidiospores. In vitro: (G) Arthroconidia.

urniform, originating from probasidia,  $30\text{--}56 \times 6\text{--}8.5 \mu\text{m}$ , with 4 sterigmata. Probasidia irregular to sphaeropedunculate,  $12.5\text{--}20 \times 5.5\text{--}9 \mu\text{m}$ . Sterigmata up to  $6 \mu\text{m}$  long, rarely becoming septate. Basidiospores hyaline, thin walled, smooth, ellipsoid to pip shaped,  $8\text{--}12 \times 5\text{--}6\text{--}(6.5) \mu\text{m}$ , distinctly apiculate, not amyloid. Hyphae of threadlike processes arranged in textura porrecta, hyaline, thin walled,  $3.5\text{--}8 \mu\text{m}$  wide. Arthroconidia hyaline, thin walled, ellipsoid to cylindrical or irregularly shaped,  $10\text{--}47\text{--}(90) \times 5\text{--}17 \mu\text{m}$ , containing up to 32 nuclei, often separated by small, thin-walled cells, which finally disintegrate.

**HOSTS:** Mainly *Lolium perenne* and *Festuca rubra*, occasionally *Agrostis tenuis* and *Poa pratensis*. In literature also known from *Festuca ovina*, *F. ovina* var. *duriuscula*, *F. pratensis*, *Agrostis alba*, *A. canina*, *A. palustris*, *A. repens*, *Poa annua*, *Phleum nodosum*, *Lolium multiflorum*, *Holcus mollis*, *Bromus mollis*, *Briza media*, and *Agropyron repens*.

**GEOGRAPHICAL DISTRIBUTION:** Widespread in humid and cool temperate areas of Europe, North America, and Australasia.

#### Cultural characters

Two different types of strain are found on 2% malt extract agar, mainly depending on the source of inoculum; fast-growing cultures forming strands are derived from the antlerlike processes or basidiocarps, and slow-growing floccose cultures are derived from the brittle flocks. Occasionally floccose cultures may develop strands after several weeks or, vice versa, strand cultures may develop flocks of arthroconidia.

#### Fast-growing type with hyphal strands, Fig. 4

Growth extremely fast on 2% malt agar at room temperature, reaching a radius of 70 mm in 12–14 days. Minimum temperature  $0^{\circ}\text{C}$ , maximum  $28^{\circ}\text{C}$ , optimum  $20\text{--}22^{\circ}\text{C}$ . Marginal hyphae appressed to submerged, even, hyphae distant. Scanty aerial mycelium develop-

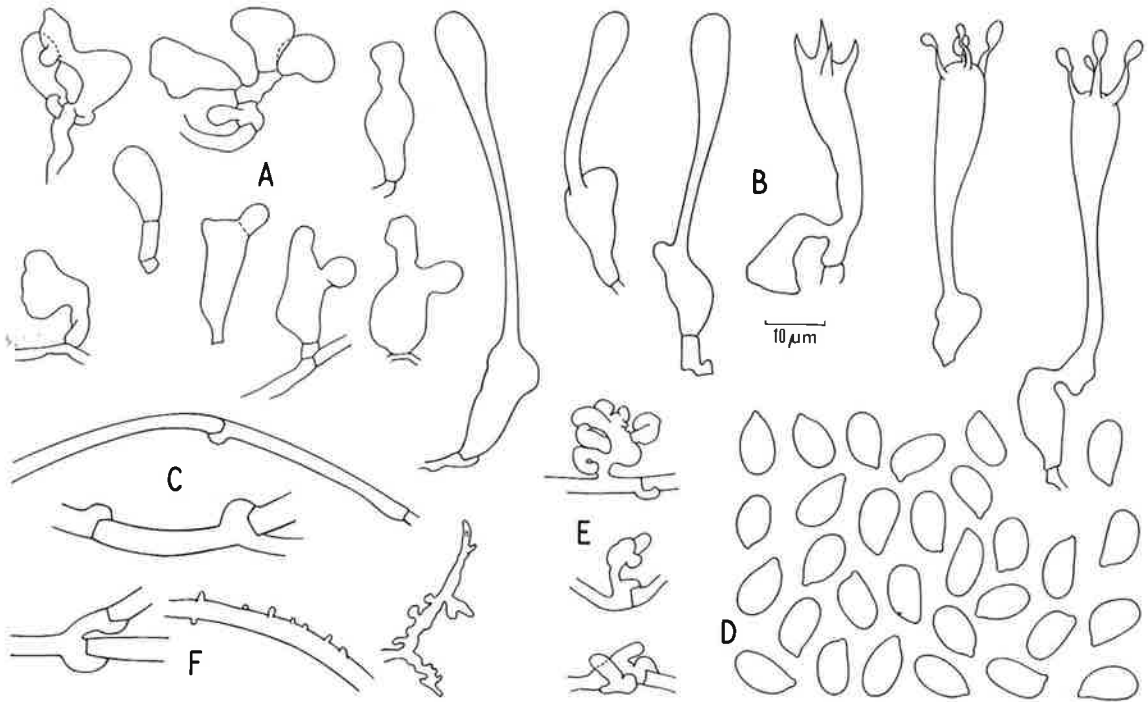


FIG. 2. *Limonomycetes roseipellis*. In vivo: (A) Probasidia. (B) Basidia. (C) Hyphae. (D) Basidiospores. In vitro: (E) *Hyphelia*-like structures. (F) Hyphae.

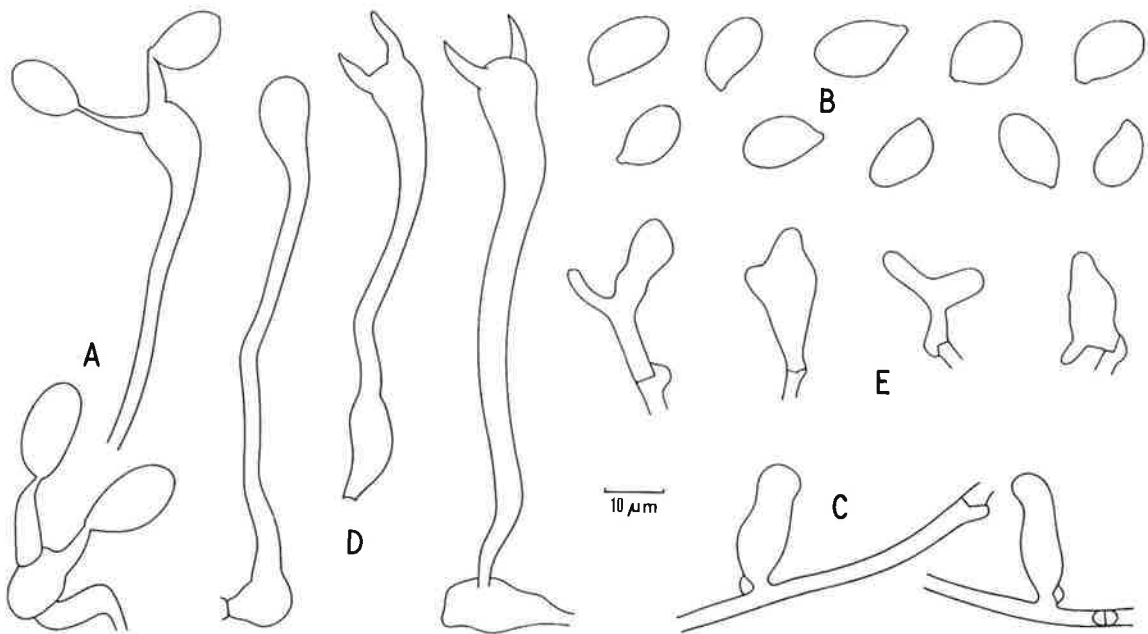
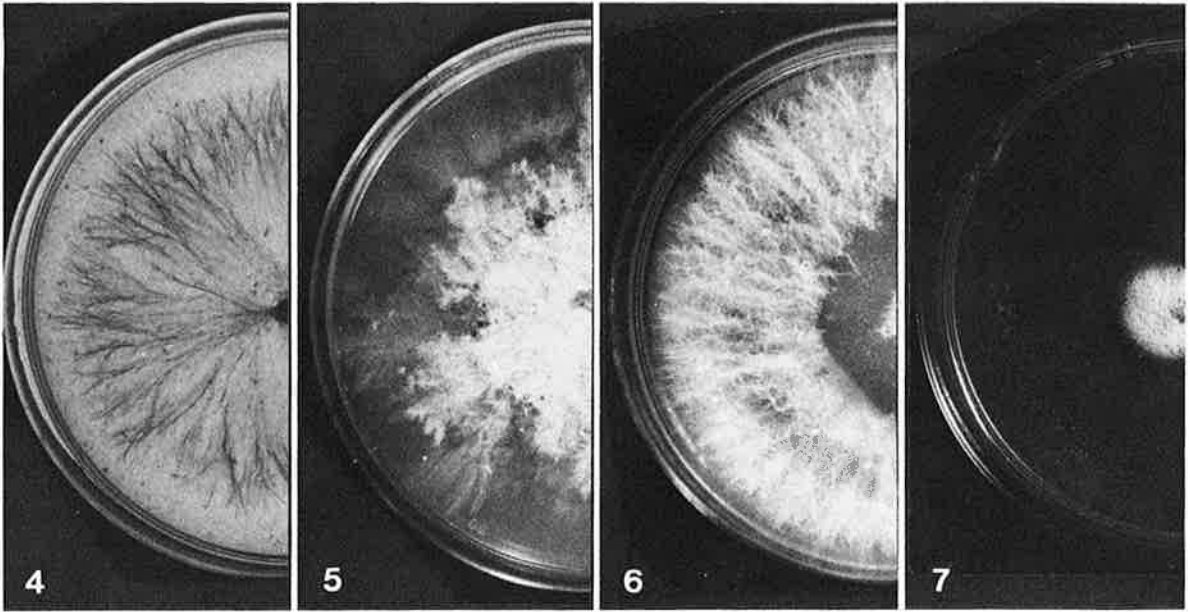


FIG. 3. *Limonomycetes culmigenus*. In vivo: (A) Basidia. (B) Basidiospores. (C) Probasidia. In vitro: (D) Basidia. (E) Probasidia (A, B, and C from Reid 1969; D partly after Bandoni and Johri 1975).



FIGS. 4-7. Colonies on cherry agar, grown at room temperature. Fig. 4. *Laetisaria fuciformis*: strand-type (1 week). Fig. 5. *Laetisaria fuciformis*: floccose type (6 weeks). Fig. 6. *Limonomyces roseipellis* (1 week). Fig. 7. *Limonomyces culmigenus* (1 week).

ing about 15 mm from the margin, mealy to slightly velvety, pink (Shrimp Pink). The colony is very tough and develops appressed hyphal strands, which may become reddish pink (Jasper Pink) and fan shaped. The inoculum may become low woolly or velvety. The mycelium may finally grow over most of the Petri dish lid and is able to grow out of the plate and cross more than 10 cm of a sterile glass plate. Reaction on  $\alpha$ -naphthol (on laccase) negative or weak, showing an open ring after 24 h. Reaction with *p*-cresol (on tyrosinase) negative. Odour absent or sourish. Reverse unchanged or bleached. Marginal hyphae hyaline, thin to firm walled, 3.5–8  $\mu\text{m}$  wide, rarely septate, clamps lacking. Cells may become very long, exceeding 500  $\mu\text{m}$ . Crystals rare. Hyphal strands tough, consisting of conglutinate hyphae, which are 4.5–7(–8.5)  $\mu\text{m}$  wide, hyaline, thin to thick walled, with many septa. Clamps absent. The outermost hyphae may convert into arthroconidia, which are 4–10  $\mu\text{m}$  wide and highly variable in length. Anastomoses present. Submerged hyphae thin to thick walled, (1.5–)2–8  $\mu\text{m}$  wide, much branched. Old hyphae occasionally showing internal development of new hyphae, giving the impression of thick-walled hyphae with meandering lumen. Crystals present in the agar. False clamps occasionally seen.

SPECIES CODE (Stalpers 1978): (1), (3), (6), (7), (11), 13, 14, 18, (24), (26), 33, (37), 48, (49), 50, 52, 53, 54, 55, (80), 81, 83, 84, 89, 96.

SPECIES CODE (Nobles 1965): (1), (2), 6, 16, 35, 36, (38), (40), 42, 43, 56.

#### *Slow-growing floccose type, Fig. 5*

Growth slow on 2% malt agar at room temperature, reaching a radius of 10–25 mm in 14 days. Marginal hyphae appressed, even, rather distant. Colony becoming woolly-floccose in the centre, soon forming distinct dots, tough at first, later becoming soft and brittle, Jasper Pink to Shrimp Pink. Enzyme reactions, temperature relationships, and marginal hyphae as above. Floccose and mealy parts consist of hyphae, which are mostly converted into variously shaped arthroconidia, 7–50(–70)  $\times$  4–12(–15)  $\mu\text{m}$ , which sometimes become thick walled, chlamydosporelike and up to 35  $\times$  22  $\mu\text{m}$ . Wall remnants of adjacent cells often clearly visible.

SPECIES CODE (Stalpers 1978): (1), (3), (8), (9), (10), 13, (14), 19, (21), 22, 33, (38), (48), 50, 52, 53, 54, 55, (80), 83, 84, (85), 89, 96.

SPECIES CODE (Nobles 1965): (1), (2), 6, 7, (34), 35, 36, (38), (39), 45, 46, 47, 56.

MATERIAL EXAMINED: THE NETHERLANDS: LIVING STRAINS: CBS 443.80, CBS 444.80, and CBS 446.80, from *Lolium perenne*, Papendal, Wolfheze; CBS 445.80, from *Lolium perenne*, RIVRO, Sevenum; CBS 447.80, from *Festuca rubra*, RIVRO, Sevenum; CBS 617.80, from *Lolium perenne*, PD Garden, Wageningen. HERBARIUM SPECIMENS: PD 2539, on *Lolium perenne* and *Festuca ovina*, July 1980, Bladel; PD 2541, on *Lolium perenne*, July 1979, Dokkum; PD 2542, on *Lolium perenne*, 21 August 1979, RIVRO, Bennekom; PD 2543, on *Festuca rubra*, 20 June 1979, RIVRO, Bennekom; PD 2544, on *Agrostis tenuis*, 20 June 1979, RIVRO, Bennekom; PD 2545, on *Agrostis* sp. and *Festuca rubra*, 19

September 1979, RIVRO, Sevenum; PD 2546, on *Lolium perenne*, 19 September 1979, RIVRO, Sevenum; PD 2547, on *Lolium perenne* and *Poa pratensis*, 19 September 1979, RIVRO, Sevenum; PD 2549, on *Lolium perenne*, 6 June 1979, Papendal, Wolfheze; PD 2550, on *Poa pratensis* and *Lolium perenne*, 6 June 1979, Papendal, Wolfheze; PD 2551, on *Poa pratensis*, 6 September 1979, Papendal, Wolfheze; PD 2552, on *Festuca rubra*, 6 September 1979, Papendal, Wolfheze; PD 2556, on *Lolium perenne*, 6 September 1979, RIVRO, Bennekom (all specimens in L).

#### Disease symptoms

The red thread disease, caused by *Laetisaria fuciformis*, usually appears on lawns and sports turf on soils of low fertility, particularly those poor in nitrogen. Symptoms of the disease have been discussed by many authors (Smith 1965; Erwin 1941; Sampson and Western 1954; O'Rourke 1976; Sprague 1950). The following description was mainly taken from these authors and completed with our own observations.

The most noticeable symptom on infected patches of turf is the presence of the red antlerlike or clavariiform outgrowths of the fungus on the apices of bleached leaves and frequently additional small cream-coloured or pink brittle flocks (Fig. 8A). Infection takes place through stomatal openings or injuries caused by mowing the grass. If grass growth is slow, the fungus can grow throughout the host, killing all the aboveground parts. Consequently the infected patches often appear withered. Subsequent growth of the fungus is saprophytic and then "red threads" and pink resupinate basidiocarps may be formed. The latter, however, rarely occur and, if present, usually grow on the dead stems apart from the "red threads." According to Luttrell (1974), *L. fuciformis* can be considered a hemibiotrophic pathogen. Judging from the material we have seen, the absence of pink superficial mycelium on living leaves seems to distinguish this disease from that caused by *Limonomyces roseipellis*. According to Dr. Noel Jackson (personal communication), this is not a good criterion in the United States and the United Kingdom.

*Laetisaria fuciformis* spreads vegetatively by means of the "red threads" and the arthroconidia. The "red threads" are a mass of conglutinated parallel hyphae lacking a cortexlike structure. They function as sclerotia and are certainly not stromata as often described in phytopathological literature. The sclerotia survive high (32°C) or low (-20°C) temperatures (Bennett 1935) and remain viable for 2 years when dry (Libbey 1938). According to Erwin (1941) they remain viable for at least 18 months at 25°C. When dry they become brittle and are easily detached and dispersed over short distances by humans or animals. Considerable and rapid expansion of the infected patches, sometimes to up to 10 m, can result from mowing the turf. Long-distance dispersal, however, is probably effected by the wind-borne arthroconidia formed in the pink flocks.

Within the infected patches, fungal spread is mainly due to mycelial growth from leaf to leaf. Optimum mycelial growth is favoured by a temperature of ca. 20°C under wet conditions. After heavy night dews in summer, abundant weblike mycelium can be observed in the morning before prolonged sunshine.

#### Discussion

When Berkeley (1872) described *Isaria fuciformis*, he emphasized the sterile, branched, more or less antlerlike structures and not the subinvisible teleomorph, also present in his specimen. The minute, globose "spores" mentioned by Berkeley (1872) do not belong to this species. They may well have been the yeast *Cryptococcus laurentii* (Kufferath) Skinner which were repeatedly isolated from the "red threads" of *L. fuciformis*. It was kindly identified by Mr. L. Rodrigues de Miranda, who informed us that this species is often isolated from grasses and leaves, especially after summer showers. A probable confusion of yeast cells with spores was also suggested by McAlpine (1906, Figs. 13, 14). The oidia, mentioned by Cunningham (1963) are arthroconidia and belong to *Laetisaria fuciformis*.

McAlpine (1906), who also studied Berkeley's specimens, discovered and described the teleomorph and combined Berkeley's species in the teleomorphic genus *Hypochnus*. According to Article 59 of the *International code of botanical nomenclature* (Stafleu 1978), in such cases the name of the teleomorph has to be attributed to the author who first described it in a teleomorphic genus (in this case McAlpine) and Burdsall (1979) correctly did so. Burdsall also stated that according to the present Article 59 all combinations based on Berkeley's basionym would be invalid. We disagree. All authors who made new combinations were aware of McAlpine's publication and the nature of the teleomorph. It is therefore legitimate to change Berkeley's name in all combinations that were made in teleomorphic genera in that of McAlpine.

#### *Limonomyces* Stalpers & Loerakker, gen. nov.

Basidiomata resupinata, effusa, ceracea. Systema hypharum monomiticum. Hyphae hyalinae, fibulatae, plus minusve agglutinatae. Basidia uniformia, normaliter e probasidiis oriunda, (1-)2-4 sterigmatibus praeditae. Sporae hyalinae, tenuitunicatae, non amyloideae. Fungi parasitici.

Basidiocarps resupinate, effused, ceraceous. Hyphal system monomitic. Hyphae hyaline, somewhat conglutinate, with clamps. Basidia uniform, normally originating from probasidia, with (1-)2-4 sterigmata. Spores hyaline, thin walled, not amyloid. Parasitic.

TYPUS: *Limonomyces roseipellis* Stalpers & Loerakker.

ETYMOLOGY: λειμων = meadow; μυκησ = mould; roseus = pink; pellis = membrane.

### Discussion

The species here placed in *Limonomyces* have to be compared with species of the genera *Galzinia* Bourd., *Vuilleminia* Maire, *Laeticorticium* Donk, and *Laetisaria* Burdsall. The similarities and differences are given in Table 1.

Species of *Vuilleminia* and *Galzinia* differ in the colour of the basidiocarp, the shape of the spores, and in being saprophytic. In addition repetobasidia (*Galzinia*) and hyphidia (*Vuilleminia*) are absent in *Limonomyces*.

*Laeticorticium* differs in the texture of the basidiocarp, the abundance of the branched hyphidia, and in being saprophytic.

*Laetisaria* is probably the most closely related genus. It differs from *Limonomyces* by having hyphidia, hyphae lacking clamps, and multinucleate cells. Their relationship is comparable to that between *Ceratomyces* and *Phanerochaete*. In both cases the nuclear condition (multinucleate–binucleate) and the presence or absence of clamps are the main differentiating characters. Moreover the presence of multinucleate cells seems to be correlated with the absence (or scattered occurrence) of clamps.

*Limonomyces roseipellis* Stalpers & Loerakker, sp. nov. Figs. 2, 6

MISAPPLIED NAMES: *Corticium fuciforme* (McAlpine) Wakef., Trans. Br. Mycol. Soc. 5: 481. 1917 (1916). [as "Berk.) Wakef."]; *Athelia fuciformis* (McAlpine) Burdsall, Trans. Br. Mycol. Soc. 72: 422. 1979 [as "(Wakef.) Burdsall"]].

Basidiomata resupinata, effusa, ceracea vel pruinosa, 50–350  $\mu\text{m}$  crassa. Hymenium glabrum, salmoneum vel roseum. Systema hypharum monomiticum. Hyphae hyalinae, tenues vel rarius crassitunicatae, agglutinatae, fibulatae, 2–7  $\mu\text{m}$  latae. Basidia plerumque e probasidiis oriunda, urniformia, 27–60(–70)  $\times$  6.5–8.5  $\mu\text{m}$ , 4 sterigmatibus praeditae. Basidiosporae hyalinae, tenuitunicatae, ellipsoideae vel subcylindricae, (8–)9–12(–14)  $\times$  (4.5–)5–6(–6.5)  $\mu\text{m}$ , inamyloideae. Fungus parasiticus in graminibus.

TYPUS: in *Lolium perenni*, 21 August 1979, RIVRO, Bennekom, in Neerlandia (L).

Fungus consisting of an effused, ceraceous, pink to reddish film, 18–350  $\mu\text{m}$  thick, which is originally agglutinated onto the grass leaf, but may become detached and fissured after drying, often showing the pattern of the leaf surface on the under side. Sometimes sterile, cream coloured to pale pink or reddish mycelium present, forming dots which surround and connect leaf

blades. Basidiocarps resupinate, effused, adnate, ceraceous when fresh, pruinose when dry, 50–350  $\mu\text{m}$  thick. Hymenial surface even, pink (Shrimp Pink) to reddish pink to orange red when wet, pale orange (Salmon Orange) to pale ochraceous or cream coloured when dry. Hyphal system monomitic. Hyphae hyaline, thin to rarely somewhat thick walled, conglutinate, 2–7  $\mu\text{m}$  wide, with clamps at nearly all primary septa. Basidia typically urniform, originating from probasidia, 27–60(–70)  $\times$  6.5–8.5  $\mu\text{m}$ , sometimes clavate without probasidial swelling, bearing 4 sterigmata. Probasidia irregular to somewhat ovoid, 11–28  $\times$  (4.5–)7.5–13  $\mu\text{m}$ , metabasidia basally 2.5–3.5  $\mu\text{m}$  wide, often arising laterally from the probasidia. Sterigmata stout, curved, 4.5–7.5(–9)  $\mu\text{m}$  long. Basidiospores hyaline, ellipsoid to subcylindrical or pip shaped, (8–)9–12(–14)  $\times$  (4.5–)5–6(–6.5)  $\mu\text{m}$ , somewhat ovoid from above and then 6–7  $\mu\text{m}$  broad, distinctly apiculate, not amyloid. Sterile mycelium consisting of conglutinate hyphae, which are arranged in fascicles or consist of loosely interwoven hyphae. Hyphae hyaline, thin to thick walled, septate, septa with or without clamps.

HOSTS: *Lolium perenne*, occasionally *Festuca rubra*.

GEOGRAPHICAL DISTRIBUTION: Known from Great Britain and the Netherlands, but probably widespread.

### Cultural characters, Fig. 6

Growth on malt 2% agar at room temperature fast, reaching a radius of 70 mm in 7–10 days. Minimum temperature 4°C, maximum 31°C, optimum 21–23°C. Marginal hyphae appressed to submerged, even, hyphae distant. About 10 mm from the margin a zone of cottony to sometimes plumose aerial mycelium develops, diminishing in height towards the inoculum, pink (Shrimp Pink, Saffrano Pink, sometimes La France Pink). The area around the inoculum is typically appressed, except in strains which have been in culture for a long time; there the colony may be low cottony woolly and finally becomes nearly felty. After 6 weeks the mat is appressed, but the mycelium (typically) grows against the lid of the Petri dish. Odour indistinct. Reverse unchanged. Reaction with  $\alpha$ -naphthol strong, with *p*-cresol negative. Strains, which have been in culture for a longer time or are kept in the dark may be cream-coloured to pale ochraceous. However, after 6 weeks the mycelium growing against the lid of the Petri dish may show a pink tinge. When stored at 5°C in the dark, reddish ceraceous bodies may develop, up to 10 mm diam., irregularly shaped. Marginal hyphae

FIG. 8. Pink diseases in perennial Rye-Grass caused by (A) *Laetisaria fuciformis* (red thread disease) (a) red threadlike stromata; (b) effused basidiocarps on dead plant tissue; (c) clampless hyphae; (d) pink arthroconidial flocks. (B) *Limonomyces roseipellis* (a) lesions on living plants; (b) effused basidiocarps on dead plant tissue; (c) clamped hyphae; (d) reddish mycelium, consisting of hyphae without arthroconidial development. (Plate printed by Plantenziektenkundige Dienst, Wageningen.)



TABLE 1. Main characteristics of the corticiaceous genera related to the genus *Limonomces*

|                                     | <i>Vuilleminia</i>      | <i>Galzinia</i>         | <i>Laeticorticium</i> *           | <i>Limonomyces</i>      | <i>Laetisaria</i> †        |
|-------------------------------------|-------------------------|-------------------------|-----------------------------------|-------------------------|----------------------------|
| Basidiocarps                        | Gelatinous to ceraceous | Gelatinous to ceraceous | Membranaceous to subcrustaceous   | Ceraceous               | Ceraceous to membranaceous |
| Colour of hymenial surface          | Grey to violaceous      | Grey to violaceous      | Pink to violaceous                | Pink                    | Pink                       |
| Clamps                              | Present                 | Present                 | Present                           | Present                 | Absent                     |
| Nuclei per cell                     | 2                       | 2                       | 2                                 | 2                       | More than 2                |
| Hyphidia                            | Present, simple         | Absent or rare, simple  | Abundant, branched                | Absent                  | Present, simple            |
| Repetobasidia                       | Absent                  | Present, rare           | Absent                            | Absent                  | Absent                     |
| Basidia                             | Uniform                 | Uniform                 | Uniform to clavate                | Uniform to clavate      | Uniform to clavate         |
| Spores                              | Allantoid               | Allantoid               | Ellipsoid to ovoid or cylindrical | Ellipsoid to pip shaped | Ellipsoid to pip shaped    |
| Nutrition                           | Saprophytic             | Saprophytic             | Saprophytic                       | Parasitic               | Parasitic                  |
| Laccase (not known for all species) | Positive, strong        | Negative                | Positive, strong                  | Positive, strong        | Negative or weak           |

\*Excluding *Laeticorticium quercinum* J. Erikss. & Ryv.

†Excluding *Laetisaria arvalis* Burdsall.

hyaline, 2.5–7.5  $\mu\text{m}$  wide, thin walled, sparsely septate, cell length may be more than 500  $\mu\text{m}$ , with clamps at all septa. Clamps variously shaped: some short and small (*Hyphodontia* type), others large. Some hyphae with granular or somewhat resinous contents. Crystals rare. Aerial hyphae hyaline, (1–)2–6(–7)  $\mu\text{m}$  wide, thin to slightly thick walled, with clamps at most septa. Some hyphae tortuous, others with short projections, but these are not found in all strains. Arthroconidia rarely present in some isolates, 3.5–7  $\mu\text{m}$  wide. Submerged hyphae thin to thick walled, highly branched, 2–5(–8)  $\mu\text{m}$  wide, sometimes with swellings. Sometimes new, narrower hyphae grow inside old hyphae. The narrow hyphae stain densely in cotton blue while the old hyphae do not, thus giving the impression of a thick-walled hypha with a meandering lumen; the fact, that clamps are present at the narrow hypha prevents such an interpretation. Some submerged hyphae may give rise to short, highly branched intertwining hyphae forming a rather compact "bulbil," resembling the *Hyphelia* anamorph of *Laeticorticium pulverulentum* J. Erikss. & Ryv.

NOTE: The cultural characters of this species were previously described by Stalpers (1978) as *Corticium fuciforme* (Berk.) Wakef.

SPECIES CODE (Stalpers 1978): 1, 3, (5), (6), 13, 14, 21, (22), 23, (25), (31), 33, 39, (42), 44, 45, (48), (51), 52, 53, 54, (59), (60), (65), 80, 83, (84), 89, 95.

SPECIES CODE (Nobles 1965): 2, 3, (20), (22), (25), (26), (35), 36, 38, 41, 42, 56.

MATERIAL EXAMINED: THE NETHERLANDS: LIVING STRAINS: CBS 171.36, from turf, F. T. Bennett, 1935, Great Britain; CBS 182.79, from *Lolium perenne*, Rilland; CBS 506.80, from *Festuca rubra*, RIVRO, Sevenum; CBS 201.81, from sports turf, Leusden; CBS 202.81, from a lawn, Bunne. HERBARIUM SPECIMENS: PD 2555, on *Lolium perenne*, 23 August 1979, RIVRO, Bennekom (L); PD 2553, on *Festuca rubra*, 21 August 1979, RIVRO, Bennekom (L); PD 2554, on *Lolium perenne*, 29 October 1979, RIVRO, Bennekom (L); PD 2540, on *Lolium perenne*, 5 February 1979, Rilland (L); PD 2548, on *Lolium perenne*, 30 January 1981, PD-garden, Wageningen (L); on grass beneath Mulberry tennis courts, 11 August 1915, E. M. Wakefield, 11 August 1915 (K).

TYPE: On *Lolium perenne*, 21 August 1979, RIVRO, Bennekom (L).

#### Disease symptoms

Infection by *Limonomyces roseipellis*, which has been observed mainly on perennial Rye-Grass, takes place after contact with formerly attacked leaves or by free-growing mycelium, especially in wet and warm conditions. At first the fungus forms a thin pink membrane on the leaves, which is often loosely attached to the substrate and becomes more ceraceous and thicker during cold periods. It tends to follow the leaf margin, and a narrow chlorotic zone usually surrounds the spot. Finally the entire width of the leaf is affected and the terminal part of it dies (Fig. 8B).

The fungus subsequently continues to grow saprophytically and therefore *L. roseipellis*, just like *Laetisaria fuciformis*, can be considered as a hemibiotrophic

pathogen. The pink resupinate basidiocarps are formed on dead leaves and stems, but when the lawns are mown frequently and most plant debris is removed, basidiocarps rarely occur. On well-mown turf, infected patches seldom reach more than 0.6 m in diameter. Because the fungus lacks both arthroconidia and prominent sclerotiumlike bodies, the spreading of the disease is restricted to hyphal growth and therefore very slow. A comparatively small number of leaves are damaged, grass growth hardly declines and patches usually keep their green colour. All this makes the disease of minor economic importance.

On relatively long, infrequently mown turf, however, damage may be more severe. The fungus kills all parts of the plant above the ground, and dead leaves and stems provide a prolonged source of inoculum; short-distance dispersal occurs by means of mycelial growth and long-distance dispersal by means of basidiospores which are then formed abundantly. The infected patches often assume an overall pinkish tinge. In Wageningen, near the Plant Protection Service the disease attacked the whole area of 250 m<sup>2</sup> of a 3-year-old perennial Ryegrass turf, which was mown only once a year and grew on soil with a low rate of nitrogen.

In vitro low temperatures inhibited mycelial growth and induced the production of small resupinate ceraceous bodies. These bodies are red, up to 350 µm thick and comparable to the red prominent outgrowths of *Laetisaria fuciformis*. They serve to survive prolonged cold periods, but probably do not function as vegetative propagules as do the "red threads" of *L. fuciformis*.

#### Discussion

Wakefield (1917) made a new combination in *Corticium* referring to the names *Isaria fuciformis* (Berkeley 1872; anamorph) and *Hypochnus fuciformis* (McAlpine 1906; teleomorph), but her description refers to a different teleomorph. According to Article 55.2 of the *Code of nomenclature* Wakefield's new combination *Corticium fuciforme* "must be retained for the species to which the epithet was originally applied," which is *Hypochnus fuciformis*. Consequently, the combination *Athelia fuciformis* proposed by Burdsall (1979) must also be applied to the teleomorph described by McAlpine and Burdsall's author citation has to be considered a bibliographic error. Therefore no name was available for Wakefield's fungus.

Burdsall (1979) regarded *Limonomyces roseipellis* and *Athelia singularis* Parm. as synonymous. The type material of the latter was not available for study (just as in the studies by Jülich (1972) and Burdsall (1979)), but the original description differs in some important characters. Parmasto (1967) described *A. singularis* as arachnoid, with pellicular, pale grey to pale cream-coloured hymenium, broadly ellipsoid (7.5–10 × 5–6 µm) spores and growing on wood, while *L.*

*roseipellis* is ceraceous, agglutinated, pink, has ellipsoid to pip shaped or cylindrical spores (9–12 × 5–6 µm) and is parasitic on grasses. Jülich's (1972) description of *A. singularis*, based on a second collection of Parmasto, differs in one important character from the original description; the spores are narrowly ellipsoid, 8–12 × 5–6 µm. *Athelia singularis* is a good *Athelia*, while *L. roseipellis* certainly is not.

*Limonomyces culmigenus* (J. Webster & D. Reid) Stalpers & Loerakker, comb. nov. Figs. 3, 7

≡ *Exobasidiellum culmigenum* J. Webster & D. Reid apud D. Reid, Trans. Br. Mycol. Soc. 52: 20. 1969.

≡ *Galzinia culmigena* (J. Webster & D. Reid) Johri & Bandoni apud Bandoni & Johri, Can. J. Bot. 53: 2563. 1975.

As the type material (K) was too poor to allow examination, the description of the species on the natural substrate is taken mainly from Reid (1969), with some additional data from Bandoni and Johri (1975).

Basidiocarps resupinate, effused, adnate, ceraceous, very thin. Hymenial surface even, pink. Hyphal system monomitic. Hyphae hyaline, thin walled, branched, 2–4 µm wide, with clamp connections. Hyphidia absent. Basidia typically urniform, originating from probasidia, (25–)50–150(–215) × 7–12 µm, with (1–)2(–3) sterigmata. Probasidia 14–25 × 5–10 µm; metabasidia basally 3.5–4.5 µm wide, occasionally arising laterally rather than terminally on the probasidium. Sterigmata stout, curved, 5–12(–13.5) µm long. Basidiospores hyaline, thin walled, smooth, ellipsoid to pip shaped, 13–16 × 7–9.5 µm, distinctly apiculate, not amyloid. Parasitic.

HOSTS: *Dactylus glomerata* and *Carex* sp.

GEOGRAPHICAL DISTRIBUTION: Europe, North America.

#### Cultural characters, Fig. 7

Growth on 2% malt agar slow, reaching a radius of 8–12 mm in 2 weeks. Minimum temperature 2°C, maximum 25°C, optimum 16–21°C. Marginal hyphae appressed, even, hyphae rather distant. Colony forming a cottony ring of aerial mycelium close to the margin of the colony or completely appressed, salmon to pink (Grenadine Pink to Coral Pink), sometimes forming very scanty whitish to pale pink aerial mycelium, which is often conglutinate and forms minute strands. Reverse unchanged. Odour indistinct. Reaction with α-naphthol positive, with *p*-cresol negative. Marginal hyphae hyaline, thin walled, 2–5 µm wide, septate, with clamps at all septae. Some wider hyphae (3.5–5 µm) filled with resinous material. Aerial hyphae after 4 weeks hyaline, thin walled, irregular, often with swellings, which branch in various directions, 2–4 µm wide. Probasidia present, irregular, 14–25 × 5–12 µm. Some basidia mature, with 2 sterigmata. Submerged hyphae 1.5–

pathogen. The pink resupinate basidiocarps are formed on dead leaves and stems, but when the lawns are mown frequently and most plant debris is removed, basidiocarps rarely occur. On well-mown turf, infected patches seldom reach more than 0.6 m in diameter. Because the fungus lacks both arthroconidia and prominent sclerotiumlike bodies, the spreading of the disease is restricted to hyphal growth and therefore very slow. A comparatively small number of leaves are damaged, grass growth hardly declines and patches usually keep their green colour. All this makes the disease of minor economic importance.

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4 µm wide, often tortuous. Crystals present in the aerial mycelium, rare in the agar.

SPECIES CODE (Stalpers 1978): 1, 3, (9), (10), 13, (14), 16, (19), (21), 33, 39, 42, 44, (45), 52, 53, 60, 80, (81), 82, (83), 88, 89.

SPECIES CODE (Nobles 1965): 2, 3, (7), (16), 26, 32, 36, 38, 47, 48, 56, (57), (58).

MATERIAL EXAMINED: LIVING STRAIN: CBS 136.69 = IMI 136.517, from *Dactylus glomerata*, 3 November 1968, J. Webster, North Wootton, near King's Lynn, Norfolk.

### Discussion

*Limonomyces culmigenus* is a very rare species, found once in England and a few times in Canada. The fungus produces a very thin, pink hymenium, nearly invisible to the naked eye. The hyphae mainly grow immersed in the host tissue. The species closely resembles *L. roseipellis*, but differs in having larger basidiospores and longer basidia with two sterigmata. In culture it is characterised by comparatively slow growth, and the development of mature basidia. Disease symptoms unknown.

### KEY TO THE PINK BASIDIOMYCETES ON GRASSES

- 1a. Clamps absent; reaction on laccase negative or weak, with an open ring; cells multinucleate; "red threads" present. . . . . *Laetisaria fuciformis*  
 1b. Clamps present, but not necessarily at all septa; reaction on laccase strong; cells binucleate; "red threads" absent. . . . . 2  
 2a. Basidia typically with 4 sterigmata; spores (8-)9-12(-14) × (4.5-)5-6(-6.5) µm; growth fast, colonies reaching a radius of 70 mm within 2 weeks. . . . . *Limonomyces roseipellis*  
 2b. Basidia typically with 2 sterigmata; spores 13-16 × 7-9.5 µm; growth slow; colonies reaching a radius of 8-12 mm in 2 weeks. . . . . *Limonomyces culmigenus*

### Acknowledgement

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