Fungal Diversity (2011) 48:1–250
DOI 10.1007/s13225-011-0088-y

European species of *Hypocrea* part II: species with hyaline ascospores

Walter M. Jaklitsch

Received: 23 November 2010 / Accepted: 19 December 2010 / Published online: 15 March 2011
© The Author(s) 2011. This article is published with open access at Springerlink.com

Abstract To date 75 species of *Hypocrea*/*Trichoderma* forming teleomorphs are recognised in Europe. The 56 hyaline-spored species are here described in detail and illustrated in colour plates, including cultures and anamorphs. This number includes 16 new holomorphs, two new teleomorphs and nine anamorphs of species previously described as teleomorphs. Phylogenetic placement and relationships of the species are shown on the strict consensus tree, based on sequences of RNA polymerase II subunit b (*rpb2*) and translation elongation factor 1 alpha (*tef1*) exon, comprising 135 species of the genus *Hypocrea*/*Trichoderma*. All available holotypes of species described from Europe including some from North America have been examined. A dichotomous key to the species is provided primarily utilising ecological and morphological traits of the teleomorphs and, where necessary, morphology of the anamorphs and cultures, and growth rates. Species descriptions are subdivided among five chapters, arranged primarily according to the larger phylogenetic clades, viz. section *Trichoderma* with 13 species, the pachybasium core group with 13 species including four species with stipitate stromata ('*Podostroma*'), species forming large effused stromata with 10 species including the section *Hypocreanum*, 9 species of the *Brevicompactum*, *Lutea* and *Psychrophila* clades, and 11 residual species of various smaller clades or of unknown phylogenetic placement. Finally, a list comprising dubious names and species excluded from *Hypocrea* that are relevant for Europe, or species claimed to occur in Europe by other authors is provided. *Hypocrea minutispora* is by far the most common species in Europe. For *H. moravica*, *H. subalpina* and *H. tremelloides* the anamorphs are newly described. The anamorphs of the latter two species and *H. sambuci* produce hyaline conidia on unusual structures new to *Trichoderma*. These three species form a new subclade of the morphologically strikingly different section *Longibrachiatum*, which is currently only represented by *H. schweinitzii* in Europe as a holomorph. The subclade is not named yet formally due to low statistical support. *H. fungicola* f. *raduli* is described as the new species *H. austriaca*, while *H. hypomycella* was found not to belong to *Hypocrea*. The typification of *H. pilulifera*, *H. tremelloides* and *H. lutea* has been clarified. *Gliocladium deliquescens*, the anamorph of *H. lutea*, is combined in *Trichoderma*. Species are epitypified where appropriate. Anamorph names are established prospectively to avoid numerous new combinations in future when they may be possibly used as holomorphic names if the ICBN is altered accordingly.

Keywords *Arachnocrea* · Ascomycetes · DNA barcode · *Gliocladium* · *Hypocreales* · ITS · Morphology · *Protocrea* · *rpb2* · Phylogenetic analysis · Systematics · Taxonomy · *tef1* · *Trichoderma*

Taxonomic novelties: *Hypocrea*/*Trichoderma albolutescens* Jaklitsch, *Trichoderma alutaceum* Jaklitsch, *Hypocrea atlantica* Jaklitsch, *Trichoderma atlanticum* Jaklitsch, *Hypocrea auranteffusa* Jaklitsch, *Trichoderma auranteffusum* Jaklitsch, *Hypocrea austriaca* Jaklitsch & Voglmayr, *Trichoderma austriacum* Jaklitsch, *Hypocrea bavarica* Jaklitsch, *Trichoderma bavaricum* Jaklitsch, *H.*/*T. calamagrostidis* Jaklitsch, *Trichoderma delicatulum* Jaklitsch, *H.*/*T. junci* Jaklitsch, *Trichoderma leucopus* Jaklitsch, *Hypocrea luteffusa* Jaklitsch, *Trichoderma*

W. M. Jaklitsch (✉)
Department of Systematic and Evolutionary Botany,
Faculty Centre of Biodiversity, University of Vienna,
Rennweg 14,
1030 Vienna, Austria
e-mail: walter.jaklitsch@univie.ac.at

luteffusum Jaklitsch, *Hypocrea luteocrystallina* Jaklitsch, Siepe & L.G. Krieglst., *Trichoderma luteocrystallinum* Jaklitsch, *Hypocrea margaretensis* Jaklitsch, *T. margaretense* Jaklitsch, *Trichoderma moravicum* Jaklitsch, *H./T. neorufoides* Jaklitsch, *Hypocrea pachypallida* Jaklitsch, *Trichoderma pachypallidum* Jaklitsch, *H./T. phellinicola* Jaklitsch, *Trichoderma placentula* Jaklitsch, *Trichoderma psychrophilum* Jaklitsch, *Hypocrea rhododendri* Jaklitsch & Voglmayr, *Hypocrea sambuci* Jaklitsch & Voglmayr, *H./T. silvae-virgineae* Jaklitsch, *Trichoderma subalpinum* Jaklitsch, *Hypocrea subeffusa* Jaklitsch, *Trichoderma subeffusum* Jaklitsch, *Trichoderma tremelloides* Jaklitsch, *Hypocrea valdunensis* Jaklitsch, *T. valdunense* Jaklitsch.

New combination: *Trichoderma deliquescens* (Sopp) Jaklitsch.

Introduction

Hypocrea/*Trichoderma* is a taxonomically difficult, hyperdiverse genus with an extraordinarily high number of species, similar to *Fusarium* sensu lato. While in *Fusarium* the high species number is in part due to a heterogeneous assemblage of species based on the morphologically easily recognisable shape of macroconidia (Booth 1971), and *Fusarium* sensu stricto is more or less highly specialised to host plants (O'Donnell et al. 2000; Kvas et al. 2009), the high diversity in *Hypocrea*/*Trichoderma* is a result of its hyperparasitic life style on other fungi.

Jaklitsch (2009) treated several aspects of the genus *Hypocrea*/*Trichoderma*, including the taxonomic history of the teleomorph genus *Hypocrea* and the anamorph genus *Trichoderma*, the development of the species concept, and important economic and social aspects. He explained the strategy of species identification and recognition followed in the underlying project. The project was designed to study the diversity of *Hypocrea*/*Trichoderma* starting from teleomorphs in Europe, because no such monograph was available for any continent including Europe, executed with a modern approach including multigene phylogeny.

A survey of 6 years resulted in about 620 specimens representing 75 species of *Hypocrea*. For all species sequences of ITS, *rpb2* and *tef1* were obtained, except for the three species *H. argillacea*, *H. splendens* and *H. strobilina*, which could not be recollected despite intense searches. Jaklitsch (2009) reported also on difficulties and reliability in ascospore isolation, and sketched the overall ecology of *Hypocrea* in Europe. A phylogenetic strict consensus tree based on sequences of *rpb2* and the *tef1* exon of the genus comprising 135 species, showed all species detected in Europe including many from other continents or others that are only known as *Trichoderma* anamorphs. He explained and defined the morphological traits used in the species descriptions and provided generalised descriptions of phenotypes of the *Hypocrea* teleomorph and the *Trichoderma* anamorph. A diagram illustrated the variation of growth rates among the European species of *Hypocrea*/*Trichoderma*, excluding most of those known exclusively as anamorphs.

In the first part of this treatment Jaklitsch (2009) keyed out and described the 19 green-spored species of *Hypocrea* detected in Europe in detail. This second part serves to describe all 56 hyaline-spored species of *Hypocrea* currently recognised in Europe.

Materials and methods

All materials and methods are as described by Jaklitsch (2009). Table 1 lists cultures and GenBank accession numbers of those species numbered as *Hypocrea* sp. 1, 2, etc. in Jaklitsch (2009). The following methodological issues are emphasised: 1) Colour perception is strongly dependent on lighting conditions and the magnification level. A factor with strong impact on colour reproduction is the characteristics of digital cameras, particularly the mode of white balance. Some images in the colour plates therefore deviate from the natural situation, most notably under-representing yellow hues in images taken through the stereo-microscope. 2) The reaction to 3% KOH has been examined after rehydration of dry stromata overnight by vapour in a wet chamber; it is usually weak or absent in immature stromata, therefore mature stromata have to be used for examinations. 3) The detailed descriptions and illustrations of cultures are based on conditions standardised for growth experiments as defined in Jaklitsch (2009). Deviating conditions including the use of older cultures may cause different results; this may apply in particular to colony development, times and organisation of conidiation; the latter is also affected by the placement and shape of the inoculation plug. Some additional explanations: 'holomorph' given in specimen data means that both stromata and closely associated anamorph colonies are present in the specimen; 'under strong magnification' used in connection with stromata (surface, ostiolar dots, etc.) means observations at highest magnification levels in the stereo-microscope; the abbreviation '*t.*' means *'textura'*. Types of teleomorphs and anamorphs were not examined of those recently described species unequivocally identified by gene sequences.

Table 1 Isolates and accession numbers for *rpb2* and *tef1* sequences of the species that were numbered in Jaklitsch (2009; 'part I') in the overall phylogenetic tree (Fig. 1) of the genus *Hypocrea*/*Trichoderma*. For ITS sequences search GenBank under the respective taxon or strain numbers

Taxon	Name in part I	Strain	Accession rpb2	Accession tef1
Hypocrea albolutescens	H. sp. 1	CBS 119286	FJ860517	FJ860609
H. atlantica	H. sp. 11	C.P.K. 1896	FJ860545	
H. atlantica	H. sp. 11	CBS 120632		FJ860649
H. aurantiaffusa	H. sp. 2	CBS 119284	FJ860520	FJ860613
H. austriaca	H. sp. 3	CBS 122494	FJ860525	FJ860619
H. bavarica	H. sp. 4	C.P.K. 2021	FJ860526	FJ860620
H. calamagrostidis	H. sp. 5	CBS 121133	FJ860528	FJ860622
H. margaretensis	H. sp. 6	C.P.K. 3127	FJ860529	FJ860625
H. junci	H. sp. 9	CBS 120926	FJ860540	FJ860641
H. luteffusa	H. sp. 10	CBS 120537	FJ860543	FJ860645
H. luteocrystallina	H. sp. 8	CBS 123828	FJ860544	FJ860646
H. neorufoides	H. sp. 12	C.P.K. 1900	FJ860553	
H. neorufoides	H. sp. 12	CBS 119506		FJ860657
H. pachypallida	H. sp. 13	CBS 120533	FJ860559	
H. pachypallida	H. sp. 13	CBS 122126		FJ860662
H. phellinicola	H. sp. 14	CBS 119283	FJ860569	FJ860672
H. rhododendri	H. sp. 15	CBS 119288	FJ860578	FJ860685
H. sambuci	H. sp. 16	WU 29467	FJ860585	FJ860693
H. silvae-virgineae	H. sp. 7	CBS 120922	FJ860587	FJ860696
H. subeffusa	H. sp. 17	CBS 120929	FJ860597	FJ860707
H. valdunensis	H. sp. 18	CBS 120923	FJ860605	FJ860717

Results and discussion

Overview and phylogeny of the European Hypocreas

Of the 75 species of *Hypocrea*/*Trichoderma* so far recognised as forming teleomorphs in Europe 56 species have hyaline ascospores. These species are here described in detail and illustrated by colour plates, including cultures and anamorphs. The number of species described in this volume includes 16 new holomorphs, two new teleomorphs and nine anamorphs of species previously described as teleomorphs. Phylogenetic placement and relationships of all species are shown on the strict consensus tree (Fig. 1) based on a combined analysis of sequences of RNA polymerase II subunit b (*rpb2*) and translation elongation factor 1 alpha (*tef1*) exon of the genus comprising 135 species. The tree is the same as presented by Jaklitsch (2009), but names are inserted for the species cited there only with a number. See Jaklitsch (2009) for a discussion of the tree topology. Sectional and clade names are used in a phylogenetic sense. This means that they are not necessarily congruent with the *Trichoderma* sections defined by Bissett (1991a) and that they are used synonymously for both *Hypocrea* and *Trichoderma*.

In fact, all major phylogenetic clades or sections except section *Hypocreanum* are heterogeneous with respect to anamorph morphology, i.e. many morphological traits in *Trichoderma* have evolved several times. Of Bissett's sections only *Longibrachiatum* and *Hypocreanum* represent natural entities.

Key to the European species of *Hypocrea*, *Arachnocrea* and *Protocrea*

'Keys are written by those who don't need them for those who can't use them' (Packer 2008).

Nevertheless, the following dichotomous key attempts to provide a basis for the identification of *Hypocrea* species. It is only applicable for species occurring in Europe. For many species the anamorph in culture is indispensable, but generally gene sequences are more reliable in identification. It is important to note that *Trichoderma* associated with stromata in nature are frequently misleading in identification.

Some definitions White-conidial means conidia white in mass and individually hyaline, green-conidial means conidia green or yellow green in mass and individually green or subhyaline. Colony traits were generally determined under standard conditions of growth rate experiments under 12/12 h alternating light/darkness at 25°C except where noted. The letter in parentheses after

each species name indicates the chapter where the description can be found (1T.. section *Trichoderma*; 2P.. pachybasium core group; 3E.. Species with effuse stromata including section *Hypocreanum*; 4B.. *Brevicompactum*, *Lutea* and *Psychrophila* clades; 5M.. miscellaneous species). For descriptions of *Arachnocrea stipata* see Moravec (1956), Dennis (1981) or Rossman et al. (1999), for *Protocrea farinosa* and *P. pallida* (formerly *Hypocrea pallida*) see Jaklitsch et al. (2008b). For a detailed explanation of morphological terminology the reader is referred to Jaklitsch (2009).

Not included in the key are species of the hypomyces-like genus *Sporophagomyces*, (Põldmaa et al. 1999), where bicellular fusoid ascospores frequently disarticulate into part-spores after discharge. Reports from Europe include *S. chrysostomus* on *Ganoderma* spp. (Põldmaa 1999), or *S. lanceolatus* on a *Byssocorticium* (Dämon 1996). See Rogerson and Samuels (1993) for descriptions.

1 Ascospores green — see Jaklitsch (2009)
1′ Ascospores hyaline — 2
2 On *Juncus*, gramineous or herbaceous hosts; stromata pulvinate — 3
2′ On wood and bark, fungi or forest litter; stromata of various shapes — 6
3 Stromata yellow; anamorphs white-conidial — 4
3′ Stromata orange- or reddish brown; anamorphs white- or green-conidial — 5
4 On *Juncus* and herbaceous plants; stromata attached to the host by hyphae, easily falling off, KOH+ red; distal ascospore cell 2.8–4.2×2.5–3.8 µm; conidia ellipsoidal — **H. placentula** (2P)
4′ Only exceptionally on *Juncus*; stromata firmly attached to the host, KOH-; distal ascospore cell 3.7–6.0×3.5–5.5 µm; conidia globose — **H. pilulifera** (2P)
5 Stromata glabrous, orange- to reddish brown; ostiolar dots distinct; conidia hyaline — **H. calamagrostidis** (4B)
5′ Stromata hairy when young, red to dark reddish brown; ostiolar dots absent or indistinct; conidia green — **H. junci** (1T)
6 Stromata upright, height usually exceeding the width, with a sterile stipe (formerly *Podostroma*, *Podocrea*) — 7
6′ Stromata different — 10
7 On wood and bark, stromata clavate or irregular, fertile part yellow; slow-growing; anamorph on CMD trichoderma-like, green-conidial when fresh — **H. alutacea** (2P)
7′ On the ground on forest litter; anamorphs on CMD verticillium-like or reduced, white-conidial; predominantly in North Europe — 8
8 Stromata large, to more than 10 cm long; fertile part reddish brown to brownish orange, pigment inhomogeneously distributed; distal ascospore cell 3.0–5.5×3.0–4.2 µm; conidia large, 5–21×3–9 µm, typically produced on solitary phialides — **H. nybergiana** (2P)
8′ Stromata smaller, typically <5 cm long, fertile part paler, yellowish; distal ascospore cell 2.7–4.0×2.3–3.5 µm; anamorph verticillium-like — 9
Colour not changing upon drying, fertile part sharply delimited from the stipe; conidia ellipsoidal, 2.8–6.2×2.0–3.0 µm — **H. leucopus** (2P)
9′ Colour changing to ochre upon drying, perithecia decurrent on the stipe; conidia subglobose to ellipsoidal, 2.5–4.5×2.0–3.7 µm — **H. seppoi** (2P)
10 Stromata hypomyces-like, perithecia seated on or in a subiculum; anamorphs white-conidial — 11
10′ Perithecia embedded in a fleshy, at least partially pseudoparenchymatous stroma — 16
11 Ascospore cells conical, 4–6×2–3 µm, with minute acute appendages; anamorph verticillium-like — **Arachnocrea stipata**
11′ Ascospores rounded — 12
12 On aphyllophoralean fungi; anamorphs gliocladium-like — 13
12′ On wood and bark, overgrowing fungi or bryophytes; anamorphs verticillium-like — 14
13 On *Skeletocutis* spp. and other polypores; perithecia yellowish, amber to olive; subiculum white, KOH- — **Protocrea farinosa**
13′ On *Oligoporus* and *Tyromyces* spp., perithecia orange, subiculum white or orange, KOH+ purple — **Protocrea pallida**
14 Perithecia ochre, orange or brown, subiculum white or brownish, KOH-; perithecia small, up to 200 µm diam; distal ascospore cell 2.3–3.7×2.0–3.2 µm — **H. delicatula** (3E)
14′ Subiculum with different colours, more compact, KOH+; distal ascospore cell 3.0–5.5×2.5–4.0 µm — 15
15 Subiculum red in fertile areas, purple in KOH — **H. parmastoi** (3E)
15′ Subiculum olive-brown to yellow-brown, turning brown to grey in KOH — **H. alcalifuscescens** (3E)
16 Stromata effuse to subpulvinate at maturity, extending to >1 cm; margin often attached on the substrate at least when

young; surface not conspicuously hairy or velutinous except in *H. pulvinata*; anamorphs white-conidial 17

16′ Stromata effuse, pulvinate, turbinate, lenticular or discoid; margin usually becoming free during stromatal development; surface hairy or glabrous; when effuse, then anamorphs green-conidial 23

17 On fungi 18

17′ Not predominantly on fungi, but occasionally overgrowing fungi 22

18 On heterobasidiomycetes; stromata bright yellow 19

18′ On polypores; stromata paler 20

19 On basidiomes of *Exidia* spp., distal ascospore cell 5–10×4.3–7.0 μm **H. sulphurea** (3E)

19′ On basidiomes of *Eichleriella deglubens*; distal ascospore cell 3.7–6.5×3.0–5.0 μm **H. austriaca** (3E)

20 On effused basidiomes of *Phellinus* spp. **H. phellinicola** (3E)

20′ On other polypores 21

21 On *Fomitopsis pinicola* and *Piptoporus betulinus*; stromata subpulvinate or effuse, (greenish-, brownish-) yellow pigment concentrated around the ostioles; surface velutinous to farinose due to numerous verrucose hairs; ascospore cells monomorphic; apical ostiolar cells lanceolate **H. pulvinata** (3E)

21′ On *Fomitopsis pinicola*; stromata effuse; brownish pigment homogeneously distributed; surface if farinose only due to spore powder; ascospore cells dimorphic; ostiolar cells not lanceolate **H. protopulvinata** (3E)

22 On forest litter and soil, spreading from stumps, less commonly on attached bark; stromata whitish, yellow or cream to pale ochre; cortical tissue pseudoparenchymatous; distal ascospore cell 3.7–5.8×3.5–4.8 μm **H. citrina** (3E)

22′

31′ Stromata white, yellowish to honey-coloured, reddish brown when old; on *Sambucus nigra* **H. sambuci** (5M)
32 Stromatal surface hairy, at least when young (section *Trichoderma*, *H. crystalligena*; also stromata of *H. pachybasioides* and *H. pachypallida* (see [47] and [63]) are sometimes velutinous in young stages); ostiolar dots invisible or inconspicuous, at least when young and fresh 33
32′ Stromatal surface glabrous under a lens; stromata pulvinate, turbinate or discoid 46
33 Stromata distinctly pulvinate when fresh, dark reddish brown to violaceous-brown when dry, often covered by powder of white crystals; ostiolar dots becoming distinct with age, particularly when dry; ascospores small, distal ascospore cell 2.5–4×2.5–3 μm; colony on CMD finely zonate, of radial fan-shaped segments, sometimes forming crystals in the agar; conidia hyaline **H. crystalligena** (4B)
33′ Stromatal shape and colour variable; crystalline covering absent or rare; ostiolar dots generally inconspicuous; ascospores larger; conidia green (sect. *Trichoderma*) 34
34 Stromata effuse, extending to >3 cm, white with unevenly distributed ochre to orange-brown fertile patches; margin fraying out as white mycelium attached to the substrate **H. ochroleuca** (1T)
34′ Stromata smaller, typically less than 1 cm long, often subeffuse when young 35
35 Stromata more or less reddish brown or variable within specimens; conidia smooth or ornamented 36
35′ Stromata orange, orange-brown, or violaceous-brown to dark brown, more or less uniform within specimens; conidia smooth 39
36 Conidia smooth 37
36′ Conidia verruculose or verrucose 38
37 Stromata reddish brown with a brick-red component; conidia subglobose; conidiophores with conspicuously widely spaced short branches; colony radius 45–48 mm on CMD at 25°C after 3 days; teleomorph rare **H. atroviridis** (1T)
37′ Stromata without brick-red component; conidia ellipsoidal; growth slow, colony radius to 23 mm on CMD at 25°C after 3 days; only known from the type locality in Austria **H. valdunensis** (1T)
38 Stromata small, typically around 1 mm diam, very variable in colour, white, yellow, yellowish brown, light brown, rust, reddish brown, often varying within a specimen; conidia distinctly tubercular, (sub-)globose with l/w=1.0–1.1, conidiophores and phialides on dense pustules on CMD conspicuously curved, not submoniliform; anamorph common, teleomorph uncommon **H. rufa** (1T)
38′ Stromata similar, mostly reddish brown; conidia verruculose, subglobose to ellipsoidal with l/w=1.0–1.3; conidiophores and phialides not conspicuously curved; on CMD terminal conidiophores often conspicuously submoniliform; pustules if formed not compact; common **H. viridescens** (1T)
39 Dry mature stromata dark brown, violaceous-brown, to nearly black 40
39′ Fresh and dry mature stromata primarily with orange, orange-brown to rust colours 43
40 Perithecial wall colourless; effuse and pustulate conidiation structurally similar 41
40′ Perithecial wall yellow; stromata yellow when young and fresh; if pustules formed then effuse conidiation structurally different from pustulate conidiation 42
41 Stromata effuse to subpulvinate, typically dark violaceous-brown; in association with green algae on decorticated wood; large characteristic coilings produced on CMD; poor and limited growth at 30°C **H. subeffusa** (1T)
41′ Stromata pulvinate, lacking violet tones; good growth at 30°C **H. petersenii** (1T)
42 On SNA pustules with phialides 4–11×3–3.7 μm formed, mean l/w of conidia 1.4; uncommon **H. neorufa** (1T)
42′ On SNA no pustules formed but characteristic broad and flat shrubs, in fresh isolates aggregating to flat hedges with phialides 7–20×3–5 μm; mean l/w of conidia 1.5; widespread and common **H. neorufoides** (1T)
43 Stromata up to 15 mm long, effuse to flat pulvinate; usually associated with abundant, widely effused, bright blue-green anamorph; conidial pustules in culture with a yellow reverse, surrounded by surface hyphae with conspicuously thickened cells; conidiophores dimorphic, curved in a dense cluster and/or long regularly tree-like; uncommon **H. stilbohypoxyli** (1T)
43′ Stromata smaller; anamorph in nature less conspicuous 44
44 Stromata pulvinate, yellow- or orange-brown when young, becoming dark brown; mean l/w of conidia 1.2 **H. petersenii** (1T)
44′ Stromata discoid or flat pulvinate when dry, remaining more or less orange-brown 45
45 Mean l/w of conidia 1.5; teleomorph rare **H. koningii** (1T)
45′ Mean l/w of conidia 1.3–1.4; teleomorph locally common on *Fagus* **H. rogersonii** (1T)
46 Stromata rosy, reddish, reddish-brown, at least when young 47
46′ Stromata different in colour 50
47 Stromata remaining reddish during their development, ostiolar dots conspicuous, dark brown to black; on *Alnus* spp.

above 1000 m in the Alps **H. voglmayrii** (5M)
47′ Ostiolar dots not dark brown to black, except when old 48
48 Stromata rosy, off-white to pale yellowish; conidia hyaline, formed in white pustules with sterile helical elongations, best seen on SNA **H. pachybasioides** (2P)
48′ Stromata changing from rosy or pink when young to yellow, yellowish brown to reddish brown during their development; conidia green, formed in shrubs or pustules lacking elongations 49
49 Distal ascospore cell 3.7–6.0×3.2–5.0 μm; colony radius on CMD 46–51 mm at 25°C after 3 days, conidiation on CMD effuse to subpustulate; the commonest species of *Hypocrea* in temperate zones **H. minutispora** (2P)
49′ Distal ascospore cell 3.0–5.3×2.5–4.0 μm; colony radius on CMD 22–25 mm at 25°C after 3 days; conidiation on CMD pustulate; known only from the type and one additional specimen **H. atlantica** (2P)
50 Stromata bright golden-yellow to bright orange; distinctly pulvinate with firm consistency 51
50′ Stromatal colour different 52
51 On *Rhododendron* spp. in the subalpine zone; anamorph gliocladium-like, conidia hyaline **H. psychrophila** (4B)
51′ On *Prunus laurocerasus* in England; only known from the type specimen; anamorph unknown **H. splendens** (5M)
52 Stromata with conspicuously projecting perithecial contours; white when young, turning yellow-orange, apricot or orange-brown; sometimes appearing waxy to gelatinous; distal ascospore cell 4.3–9.0×3.3–5.3 μm; growth poor at 30°C; effuse conidiation gliocladium-like, pustulate conidiation on SNA pachybasium-like, with straight to sinuous fertile elongations; conidia oblong, green **H. silvae-virgineae** (5M)
52′ Stromata without conspicuously projecting perithecial contours; stromatal colour in shades of whitish, yellow to brown; distal ascospore cell smaller 53
53 On cones of *Pseudotsuga menziesii* in England; stromata white to yellowish with orange-brown perithecial dots, KOH-; distal ascospore cell 4.3–5.7×3.5–4.8 μm; anamorph unknown; only known from the type specimen with certainty **H. strobilina** (5M)
53′ On wood and bark; ascospores smaller 54
54 Stromata changing colour upon drying from pale or clear yellow to shades of dull orange, rust or brown 55
54′ Stromata not or only slightly changing colour upon drying 59
55 Stromata pale yellowish when fresh, pale yellow-orange when dry, KOH-; on *Rhododendron ferrugineum* in the subalpine zone; no anamorph but white mycelial clumps formed on PDA, and sterile stromata on SNA **H. rhododendri** (4B)
55′ Stromata on other hosts; KOH+reddish orange or red 56
56 On *Betula*, less commonly on *Alnus* in riverine forests; ostiolar dots typically diffuse; distal ascospore cell (2.5–)2.8–3.2(–3.5)×(2.3–)2.5–3.0(–3.2) μm; cultures on CMD and PDA with characteristic, unpleasant odour; conidiation effuse, conidia hyaline **H. bavarica** (2P)
56′ Ascospores larger 57
57 Stromata argillaceous when fresh, greyish orange when dry; ostiolar dots typically diffuse; distal ascospore cell 4–6×3.5–5 μm; anamorph unknown; on wood of *Fraxinus excelsior* in England; only known from the holotype **H. argillacea** (5M)
57′ Stromata pale to bright yellow when fresh, turning brown; ostiolar dots well-defined when mature; ascospores smaller 58
58 Stromata typically on well-rotted wood in moist, often muddy places; surface glabrous; anamorph pachybasium-like, pustulate on CMD and SNA; conidia green **H. moravica** (5M)
58′ Stromata on *Fagus*; surface with short hairs when mature; conidiation in white pustules with sterile helical elongations; conidia hyaline; rare, teleomorph in Europe known from a single location in the Czech Republic **H. parapilulifera** (2P)
59 On wood of *Betula*; stromata pale yellow, KOH-; conidia hyaline, globose; teleomorph rare **H. pilulifera** (2P)
59′ On other hosts; conidia not globose 60
60 Stromata pale to dull yellow, sometimes with a conspicuous whitish young stage; anamorph distinctly gliocladium-like with green conidia formed in large, dark green to black, deliquescent heads 61
60′ Anamorph not gliocladium-like 62
61 Stromata small, with angular outline, typically in small numbers; fast growth at 35°C; conidia ellipsoidal or oblong; widespread but uncommon **H. lutea** (4B)
61′ Teleomorph with a subeffuse, whitish young stage; mature stromatal surface covered with yellow crystals turning violet in KOH; poor or no growth at 35°C; conidia subglobose; on *Abies* and *Picea*; rare **H. luteocrystallina** (4B)
62 Stromata when dry yellow-brown, brown-orange, brown, to reddish brown or dark brown, glabrous; conidiation effuse to subpustulate on CMD and SNA; conidia green **H. minutispora** (2P)

62′ Stromata paler, often slightly downy when young; conidia hyaline 63
63 Stromata white, turning yellow, brown-orange to golden-yellow during their development; anamorph effuse, verticillium-like, lacking sterile helical elongations **H. pachypallida** (2P)
63′ Stromatal colour variable, when fresh mostly white, pale yellowish, pale orange, yellow- brown or light brown; ostiolar dots often diffuse, large, often irregularly disposed; conidiation in white pustules with sterile helical elongations **H. pachybasioides** (2P)

Note: To those who wished to see a key based exclusively on the *Trichoderma* anamorph and those who consider the lack of such a key a weak point of this work, I want to say the following: 1) This work is based on teleomorphs. No attempt has been made to identify *Trichoderma* anamorphs from natural sources based on morphology. We have no information on how many species occur in Europe above ground. To assess this information a project would be necessary that by far exceeds the scope of the current projects. 2) Gene sequences provide convincingly superior certainty in identification than morphology. 3) A key to anamorphs is not provided deliberately to avoid the deceptive impression that it may be possible to identify species of *Trichoderma* on natural substrates on few morphological traits like colour, size and shape of phialides and conidia. In addition, many *Trichoderma* species are currently only known as isolates from soil and we do not know whether they could be found on plant material or not. I am not familiar with the soil-inhabiting species and any key would thus have many gaps. 4) Finally, some species of *Hypocrea* do not form anamorphs or anamorphs are rare in nature, particularly in sect. *Hypocreanum*. To include such anamorphs in a key would not aid in identification.

Description of the species

As done in the first part of the monograph (Jaklitsch 2009), both combinations in *Hypocrea* and *Trichoderma* are given for all species, for the following reasons: For species described earlier I want to provide as complete taxonomic and nomenclatorial information as possible, and for new species I also establish names in *Trichoderma* for those who may need them and to avoid numerous new combinations in future when they may be possibly used as holomorphic names if the ICBN is altered accordingly. Article 59 and the recommendation 59A.3 of the ICBN demand the use of *Hypocrea* alone for the holomorphs, i.e. the anamorphs should not be named separately. There is, however, increased pressure to use the anamorphic generic name *Trichoderma*. Editors of certain journals are even trying to force authors to use *Trichoderma* instead of *Hypocrea* for naming new holomorphs, because *Trichoderma* is the older generic name. Such a concept has not reached a consensus among mycologists and is accordingly not implemented in Art. 59. To the contrary, this concept, using the older name in disregard whether it denotes a teleo- or an anamorph genus, aims at the abolishment of Art. 59 of the Code. This is an alarming development, because forcing authors in such a direction is a top-down call to violate consensus-driven procedures and rules, i.e. a call towards non-compliance with the Code. Furthermore this constraint is unfair to authors, because it diminishes the availability of journals for systematic mycologists. In my opinion the disregard of a recommendation is much less severe than violating teleomorph priority that is clearly defined in Art. 59 of the Code.

Subgeneric organisation of the species

The 56 species of *Hypocrea* with hyaline ascospores occurring in Europe are described in five separate chapters, predominantly grouped according to their phylogenetic placements and subsidiarily to their stroma shape and size. The detailed descriptions are meant as small databases rather than concise descriptions for those who may study the morphology of these fungi in future. Species are epitypified where appropriate.

The chapters are as follows:

1) *Hypocrea*/*Trichoderma* section *Trichoderma* and its European species treats the thirteen species *H. atroviridis*, *H. junci*, *H. koningii*, *H. neorufa*, *H. neorufoides*, *H. ochroleuca*, *H. petersenii*, *H. rogersonii*, *H. rufa*, *H. stilbohypoxyli*, *H. subeffusa*, *H. valdunensis*, and *H. viridescens*.
2) The pachybasium core group comprises the four species *H. alutacea*, *H. leucopus*, *H. nybergiana* and *H. seppoi* forming upright, stipitate stromata, i.e. assignable to the former genus *Podostroma*, and the eight species *H. atlantica*, *H. bavarica*, *H. minutispora*, *H. pachybasioides*, *H. pachypallida*, *H. parapilulifera*, *H. pilulifera*, and *H. placentula* with pulvinate stromata, and *H. luteffusa* that forms effuse stromata.
3) European species of *Hypocrea* section *Hypocreanum* and other species forming large effused to subpulvinate stromata, comprises the ten species *H. alcalifuscescens*, *H. austriaca*, *H. citrina*, *H. decipiens*, *H. delicatula*, *H. parmastoi*, *H. phellinicola*, *H. protopulvinata*, *H. pulvinata*, *H. sulphurea*.

4) The *Brevicompactum*, *Lutea* and *Psychrophila* clades. This chapter treats the three species *H. aurantiaffusa*, *H. margaretensis* and *H. rodmanii* of the *Brevicompactum* clade, the two species *H. lutea* and *H. luteocrystallina* of the *Lutea* clade, and the four species *H. calamagrostidis*, *H. crystalligena*, *H. psychrophila* and *H. rhododendri* of the *Psychrophila* clade.
5) Miscellaneous species: The eleven residual species *H. albolutescens*, *H. argillacea*, *H. moravica*, *H. sambuci*, *H. schweinitzii*, *H. silvae-virgineae*, *H. splendens*, *H. strobilina*, *H. subalpina*, *H. tremelloides* and *H. voglmayrii* are described in detail.

A list of dubious and excluded names concludes the work.

Hypocrea/*Trichoderma* section *Trichoderma* and its European species

Introduction

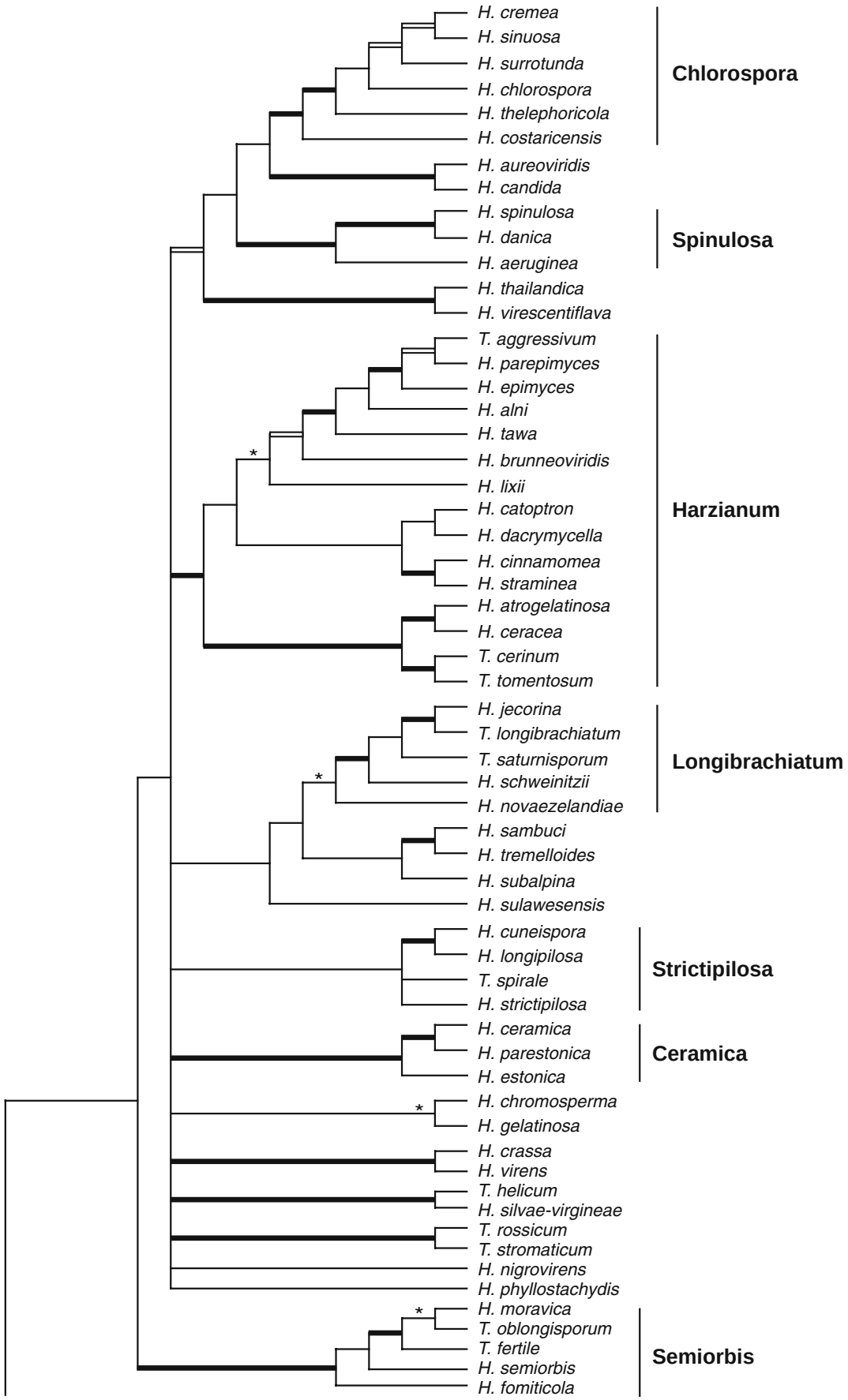
Hypocrea/*Trichoderma* section *Trichoderma* is the central phylogenetic clade of the genus, as it contains the type species *H. rufa* with its anamorph *T. viride*, the type species of *Trichoderma*. Originally (Bissett 1991a) the section was established to define a group of *Trichoderma* anamorphs with repeatedly rebranching, narrow and flexuous conidiophores with main axes up to 6 μm wide, paired or verticillate branches, and lageniform to subulate phialides mostly in verticils of two or three. This group contained the '*T. viride* aggregate' of Rifai (1969), *T. atroviride*, *T. koningii*, and *T. aureoviride*. Conidiophore morphology can be misleading, thus also *T. harzianum* belonged to the group for some time, but was later removed to 'section *Pachybasium*', and now is considered a clade of its own. *Trichoderma aureoviride* has conidiophores similar to those of the section, but its teleomorph is green-spored and phylogenetically it forms a sister group to the *Chlorospora* clade (see Fig. 1). No species of this section has green ascospores, while all have green or yellow conidia. Conidiophores of the section *Trichoderma* vary a great deal in morphology, making a definition of typical *Trichoderma* conidiophores difficult. Samuels et al. (2006a) presented the '*T. koningii* aggregate species group' characterised by conidiophores, which can be subsumed as regularly tree-like. Jaklitsch et al. (2006b) in describing some species around *H. rufa*, recognised three types of conidiophores in this subgroup. In addition, even some species with typical pachybasium-like conidiophores, viz. *T. hamatum*, *T. pubescens*, *T. strigosum* and others (Chaverri et al. 2003; Samuels and Ismaiel 2009), are now placed in this section by phylogenetic analyses. Inconveniently, the type of the former section *Pachybasium*, *T. hamatum*, belongs to this section, rendering the name 'section *Pachybasium*' obsolete. As in other clades of *Trichoderma*, phialides generally tend to be more plump with increasing complexity of the conidiation system, i.e. with a lower l/w ratio in pustules than in solitary, effuse conidiophores. However, this is not the case in many species of this section, particularly in *H. rufa* and *H. viridescens*.

The section conceived here is monophyletic; it is phylogenetically complex and a morphological species delimitation of anamorphs is difficult. Teleomorph morphology is essentially homogeneous. All species are characterised by more or less hairy or velutinous and often subeffuse stromata when young, of mostly small or moderate sizes with few exceptions, and generally inconspicuous ostiolar dots. More distinct or projecting dots may sometimes occur as a consequence of repeated drying and rehydration. It is generally easy with a good hand lens to determine whether stromata belong to the section or not but, due to a high degree of morphological conservation of the teleomorphs, the possibilities of morphological species delimitation are limited. Some teleomorphs, e.g. those of *H. neorufa* and *H. neorufoides*, are indistinguishable. In addition, not all traits that may be useful for identification are always present in a colony of stromata. Based on the colour of stromata, two series of species can be recognised: those with orange to orange-brown stromata, largely coinciding with the so-called '*T. koningii* aggregate species group' (see Samuels et al. 2006a) and those with reddish brown to dark brown stromata mostly with the '*viride* or *viridescens* clades' (see Jaklitsch et al. 2006b). However, several species form separate subsectional clades. Due to extensive and thorough investigations by Gary Samuels, many new species have been discovered and described in recent years, but the section *Trichoderma* has not yet been monographed as a whole. Even from the papers cited above it is obvious that species delimitation on a world-wide scale based on teleomorphs is impossible. Considering species like *T. martiale* (Hanada et al. 2008), which has essentially the *T. viride* morphology, anamorphs also will eventually not provide sufficient variation for species delimitation and identification. Ecological and biogeographic traits are therefore increasingly gaining importance in the species concept in addition to phylogeny.

Species descriptions

In Europe currently the following 13 species including four new ones of the section *Trichoderma* forming teleomorphs

are recognised: *H. atroviridis*, *H. junci*, *H. koningii*, *H. neorufa*, *H. neorufoides*, *H. ochroleuca*, *H. petersenii*, *H. rogersonii*, *H. rufa*, *H. stilbohypoxyli*, *H. subeffusa*, *H. valdunensis*, and *H. viridescens*. They are described below. Species of *Hypocrea*/*Trichoderma* section *Trichoderma* known so far to occur in Europe exclusively as anamorphs, such as *T. asperelloides*, *T. asperellum* (Samuels et al. 2010), *T. gamsii* (Jaklitsch et al. 2006b), and *T. koningiopsis* (Samuels et al. 2006a) are beyond the scope of this work.


H. cremea
H. sinuosa
H. surrotunda
H. chlorospora
H. thelephoricola
H. costaricensis
Chlorospora
H. aureoviridis
H. candida
H. spinulosa
H. danica
H. aeruginea
Spinulosa
H. thailandica
H. virescentiflava
T. aggressivum
H. parepimyces
H. epimyces
H. alni
H. tawa
*
H. brunneoviridis
H. lixii
H. catoptron
H. dacrymycella
H. cinnamomea
H. straminea
H. atrogelatinosa
H. ceracea
T. cerinum
T. tomentosum
Harzianum
H. jecorina
T. longibrachiatum
T. saturnisporum
*
H. schweinitzii
H. novaezelandiae
Longibrachiatum
H. sambuci
H. tremelloides
H. subalpina
H. sulawesensis
H. cuneispora
H. longipilosa
T. spirale
H. strictipilosa
Strictipilosa
H. ceramica
H. parestonica
H. estonica
Ceramica
*
H. chromosperma
H. gelatinosa
H. crassa
H. virens
T. helicum
H. silvae-virgineae
T. rossicum
T. stromaticum
H. nigrovirens
H. phyllostachydis
*
H. moravica
T. oblongisporum
T. fertile
H. semiorbis
H. fomiticola
Semiorbis

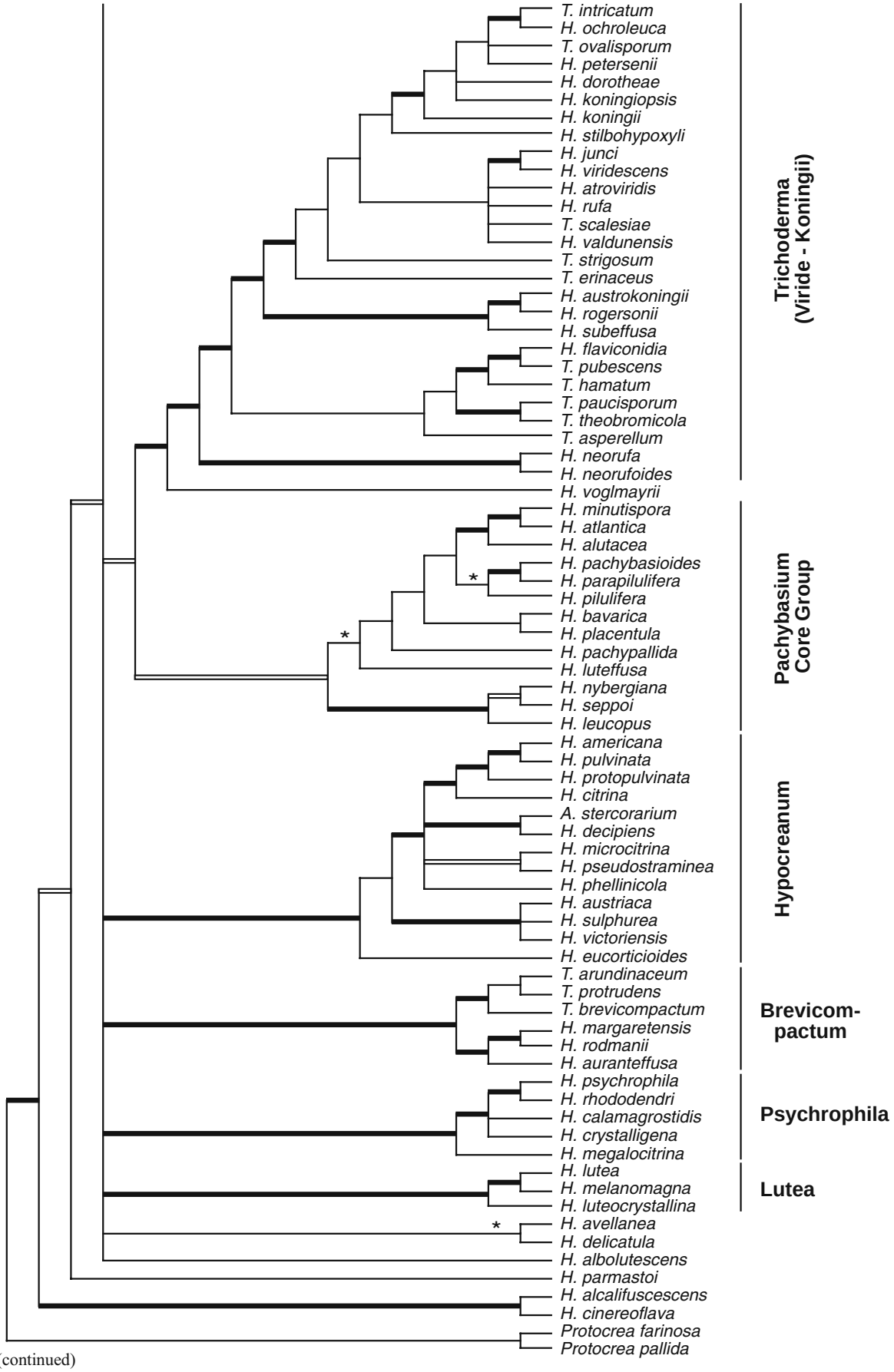


Fig. 1 (continued)

(–5.4), (1.4–)1.6–2.2(–2.8) µm wide at the base (*n*=30), lageniform, less commonly ampulliform, straight or slightly curved upward; widest part mostly median. Conidia formed in minute wet or dry heads <20 µm diam; conidia (2.8–)3.2–4.0(–4.7)×(2.8–)3.0–3.5(–3.8) µm, l/w 1.0–1.2(–1.3) (*n*=30), dark green (also in microscopic mounts), (sub)globose or oval, smooth, finely multiguttulate when young; scar indistinct. At 15°C conidiation concentrated in large dark green tufts in distal areas of the colony; odour coconut-like; chlamydospores numerous. At 30°C concentric zones of green conidiation tufts well separated, agar turning yellow, 2A3–4, 4A4–5, 4B5–6. Odour pronounced coconut-like due to the formation of 6-pentyl-α-pyrone; chlamydospores numerous.

On PDA after 72 h 26–28 mm at 15°C, 57–62 mm at 25°C, 40–43 mm at 30°C, to 1.1 mm at 35°C; mycelium covering the plate after 4 days at 25°C. Colony thick; mycelium dense, of thick primary and narrow secondary hyphae, nearly reticulate; surface becoming hairy due to aerial hyphae. Aerial hyphae numerous, loosely disposed in the centre, thick and branched, mostly radially arranged, in a white to yellowish mat several mm high, forming strands and floccules with numerous large yellow to green drops. Autolytic excretions moderate to frequent, coilings inconspicuous. Reverse pale to dull yellow, 3–4AB3–4, centre grey-green, 29CD5–6, due to conidiation. Odour coconut-like. Conidiation noted after 1 day, loose on aerial hyphae and dense in compact white tufts in the centre, coalescing into an aggregate in a dense circular zone, turning yellow after 3–4 days and finally grey-green, 28E6–8, 27DE4–5. Eventually additional white, yellow to green, concentric conidiation zones formed. At 15°C white mat of aerial hyphae distinctly floccose, conidiation reduced, remaining white. Autolytic excretions numerous. At 30°C conidiation dense in several well-defined concentric zones, pale grey-green, 28–29CD5–6, 25CD3–4.

On SNA after 72 h 21–22 mm at 15°C, 34–37 mm at 25°C, 25–29 mm at 30°C, to 1.1 mm at 35°C; mycelium covering the plate after 6 days at 25°C. Colony hyaline, thin, resembling an ice crystal due to thick primary and numerous, densely arranged, short secondary hyphae at the margin; loose in the centre; margin wavy or lobed. Surface hyphae soon degenerating (appearing empty) from the centre. Aerial hyphae numerous, loosely disposed, long and high at the colony margin. Autolytic excretions and coilings inconspicuous. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 1 day, numerous, particularly in areas of conidiation, terminal, globose. Conidiation noted after 2 days, green after 3 days, scant on aerial hyphae, dense in minute heads <20 µm diam in tufts/pustules to 1 mm diam, sometimes coalescing up to 13 mm; arranged in several concentric zones spreading from the centre, first white, turning dark green, 25–27F6–8, to nearly black. Zones denser and better separated and pustules more compact than on CMD. At 30°C conidiation reduced relative to 15 and 25°C; coilings abundant.

Habitat: on wood and bark and fungi growing on them.

Distribution: Europe (Austria, France), Central and North America.

Holotype: **France**. Pyrénées Atlantiques, Isle de la Sauveterre de Bearn, elev. 100 m, on decorticated wood, 25 Oct. 1998, Samuels & Candoussau (BPI 748312, cultures G.J.S. 98-134 = CBS 110086) (not examined).

Other material examined: **Austria**, Oberösterreich, Schärding, St. Willibald, Aichet, riverine forest, MTB 7648/1, 48°21′17″ N, 13°41′01″ E, elev. 400 m, on corticated twigs of *Prunus padus*, 0.5–1.5 cm thick, on ostioles of *Diaporthe padi*, bark and wood, soc. rhizomorphs, holomorph, 30 July 2005, H. Voglmayr, W.J. 2824 (WU 29178, cultures CBS 119499, C.P.K. 2192).

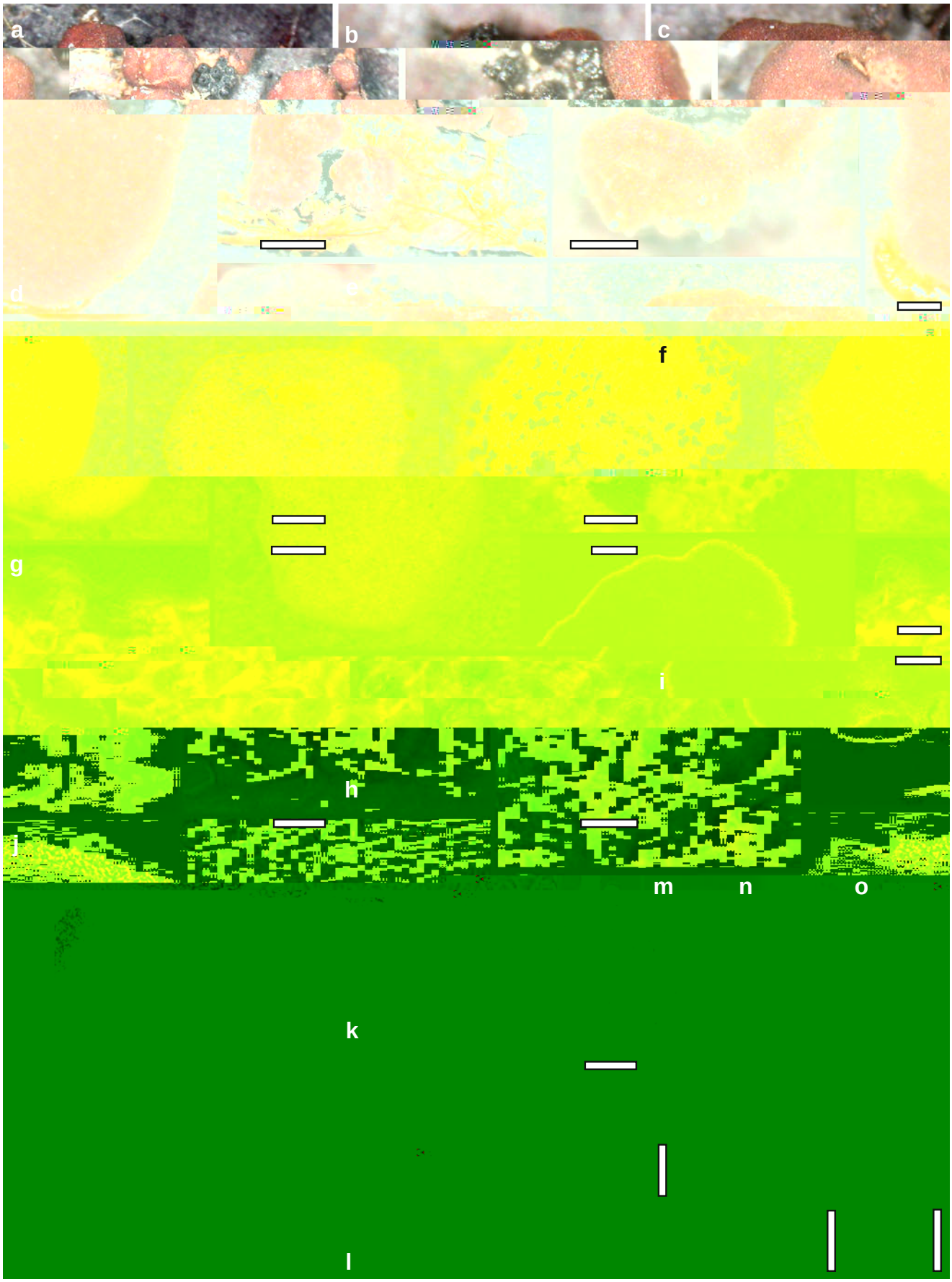
Notes: The teleomorph of *Hypocrea atroviridis* seems to be rare, as it was only collected once in this study, while the anamorph is common in soil and also found as a contaminant of other *Hypocrea* species. Despite the characteristic brick-red stroma colour (see also Dodd et al. 2003), the teleomorph is difficult to distinguish from other species of the *Viride* clade, particularly from *H. viridescens* and *H. valdunensis*. However, the subglobose conidia, smooth in the light microscope, formed on minute heads on long conidiophores with conspicuously widely spaced short branches or phialides are diagnostic.

Hypocrea junci Jaklitsch, **sp. nov.** Fig. 4
MycoBank MB 516681
(?) = *Hypocrea rufa* f. *sterilis* Rifai & J. Webster, Trans. Brit. Myc. Soc. 49: 294 (1966).
Anamorph: ***Trichoderma junci*** Jaklitsch, **sp. nov.** Fig. 5
MycoBank MB 516682

Stromata typice in culmis *Junci effusi*, pulvinata, fusco-rufa vel vinosa, 0.5–2 mm lata. Asci cylindrici, (64–)67–83(–98)×(4.0–)4.5–6.0(–6.5) µm. Ascosporae bicellulares, hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa, (3.3–)3.5–4.0(–4.6)×3.0–3.5(–4.0) µm, pars proxima oblonga vel cuneata, (4.0–)4.5–5.2(–5.5)×(2.3–)2.5–3.0(–3.1) µm. Anamorphosis *Trichoderma junci*. Conidiophora similia *Verticillii* vel *Trichodermati*, in pustulis disposita in agaro CMD. Phialides divergentes, lageniformes, (6–)8–14(–19)×(2.0–)2.5–3.3(–3.7) µm. Conidia ovalia vel ellipsoidea, viridia, glabra, (3.5–)3.7–4.6(–5.3)×(2.4–)2.5–3.0 µm.

Etymology: *junci* refers to the occurrence on *Juncus*.

Stromata when fresh 0.5–2 mm diam, 0.5–1 mm thick, solitary or gregarious or aggregated in small numbers, lenticular to flat pulvinate, broadly attached, margin becoming free. Surface smooth. Ostioles indistinct, minute, hyaline. Colour dark reddish brown, 8EF6–8, when mature. Spore deposits white.


a
b
c
d
e
f
g
i
h
j
m
n
o
k
l

◀ **Fig. 2** Teleomorph of *Hypocrea atroviridis* (WU 29178). **a**–**d**. Fresh stromata (**b**. around ostioles of *Diaporthe padi*; **d**. with spore deposits and anamorph on surface). **e**, **f**. Dry stromata (**e**. immature, hairy; **f**. same as in **c**). **g**. Stroma on an ostiole of *Diaporthe* in section. **h**. Cortex in section with a hair on the surface. **i**. Cortex in face view. **j** Perithecium in section. **k**. Subcortical tissue in section. **l**. Subperithecial tissue in section. **m**. Ascus. **n**, **o**. Ascospores in ascus apex (**m**, **n**, **o** in cotton blue/lactic acid). Scale bars: **a**=1 mm. **b**–**f**=0.3 mm. **g**=0.2 mm. **h**, **i**, **n**, **o**=5 μm. **j**=30 μm. **k**–**m**=10 μm

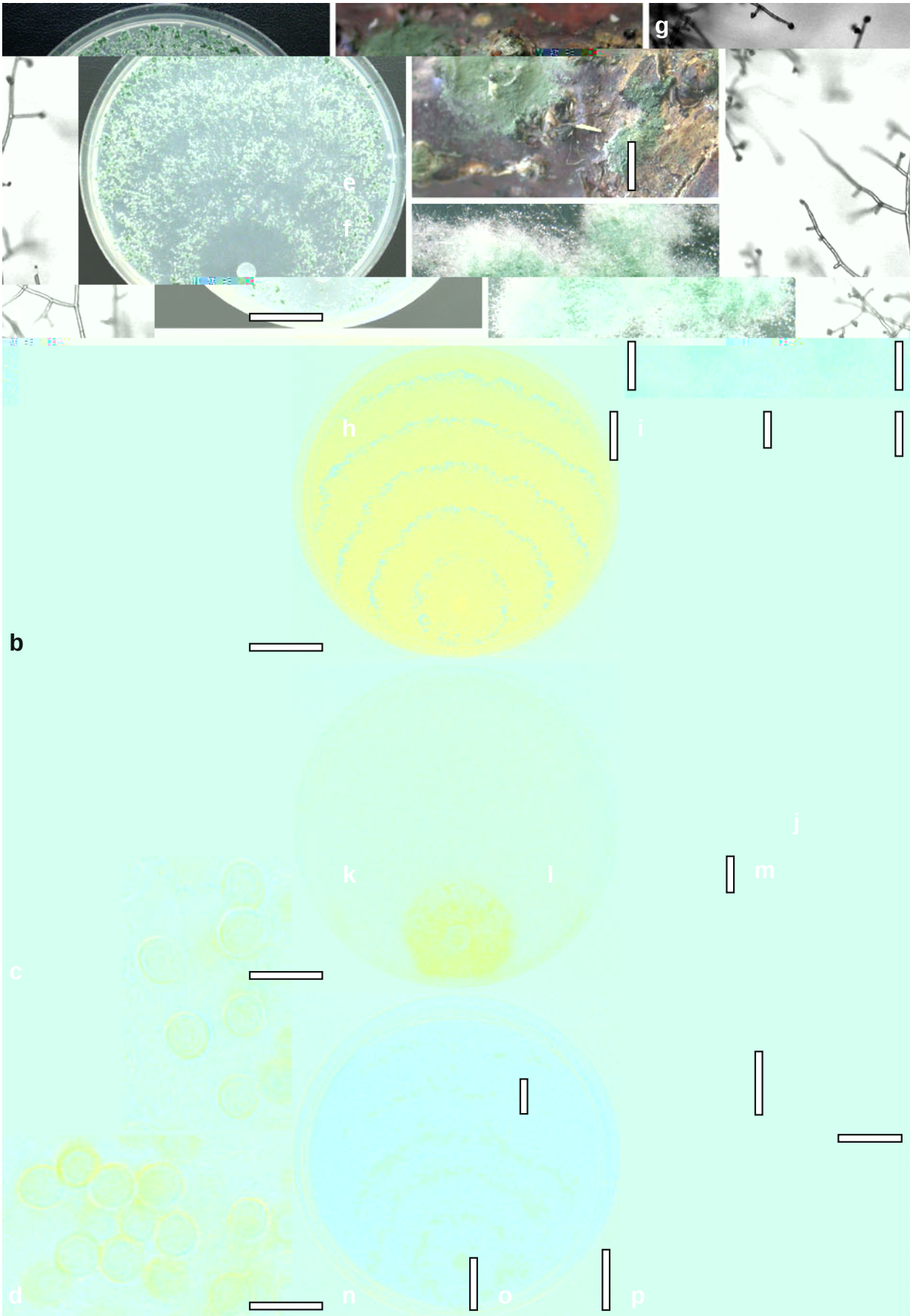
Stromata when dry (0.5–)0.8–1.6(–2.2)×(0.4–)0.7–1.3(–1.8) mm, (0.1–)0.2–0.4(–0.6) mm thick (*n*=30); starting as white mycelium, turning reddish brown from the centre; finally pulvinate or discoid, broadly attached, margin free; outline circular or oblong. Surface smooth, rugose or slightly tubercular, velutinous when young. Ostiolar dots 16–28(–32) μm (*n*=30) diam, hardly visible, circular, light reddish or hyaline. Stroma colour dark reddish brown, vinose to nearly black, sometimes with fine rust floccules on the surface and sides. Rehydrated stromata larger than dry ones, shiny, dark reddish brown; pigment inhomogeneous; ostioles minute, subhyaline; in 3% KOH darker reddish brown to black.

Stroma anatomy: Ostioles (42–)48–65(–73) μm (*n*=30) long, not projecting, (10–)12–23(–27) μm wide at the apex (*n*=30), without specialized apical cells. Perithecia (110–)140–180(–210)×(105–)120–170(–200) μm (*n*=30), globose or flask-shaped, peridium (13–)14–18(–22) μm (*n*=30) thick at the base, (7–)10–16(–19) μm (*n*=30) at the sides, hyaline to pale yellowish. Cortical layer (15–)18–30(–40) μm (*n*=33) thick, orange-brown, also present on steeply declining sides, composed of a thin amorphous, dull orange to reddish brown crust, concealing a narrow 2–4 celled layer of thin-walled, subhyaline or yellow, isodiametric to oblong, angular cells (3–)5–9(–12)×(2–)4–7(–9) μm (*n*=50) in face view and in vertical section. Hairs on mature stromata (6–)9–20(–24)×(2–)3–5(–6) μm (*n*=20), infrequent, mostly at the sides, golden-yellow, 1-celled, smooth or verrucose, collapsing. Subcortical tissue a mixture of hyaline hyphae (2–)3–6(–9) μm (*n*=30) wide and (sub-)globose, thin-walled cells (4–)5–8(–11)×(2–)3–6(–9) μm (*n*=30) in varying ratios. Subperithecial tissue a *t. epidermoidea* of hyaline, thin-walled, globose, angular, elongate or lobed cells (7–)11–28(–33)×(5–)7–13(–17) μm (*n*=30); in the middle of the stroma merging into a basal layer to 250 μm thick of loosely intertwined, thick-walled, yellow- to orange-brown hyphae (2–)3–6(–9) μm (*n*=30) wide. Asci (64–)67–83(–98)×(4.0–)4.5–6.0(–6.5) μm, including a stipe (1–)4–9(–13) μm long (*n*=31). Ascospores hyaline, finely verruculose to nearly smooth, cells dimorphic; distal cell (3.3–)3.5–4.0(–4.6)×3.0–3.5(–4.0) μm, l/w 1.0–1.2(–1.3) (*n*=31), (sub)globose or wedge-shaped; proximal cell (4.0–)4.5–5.2(–5.5)×(2.3–)2.5–3.0(–3.1) μm, l/w (1.4–)1.6–1.9(–2.1) (*n*=31), oblong or wedge-shaped.

Cultures and anamorph: optimal growth at 25°C on all media; short, restricted growth, peg formation and autolysis at 30°C; no growth at 35°C.

On CMD after 72 h 17–21 mm at 15°C, 28–31 mm at 25°C, 2–4 mm at 30°C; mycelium covering the plate after 7–9 days at 25°C. Colony hyaline, thin, of coarse radial threads, wide and finely submoniliform marginal surface hyphae and characteristic minute secondary hyphae in the centre; margin ill-defined. Aerial hyphae numerous in distal areas, long and several mm high, forming strands, collapsing and eventually appearing as floccules. Autolytic activity none or inconspicuous, but numerous minute excretions seen at 30°C. Coilings moderate, dissolving, causing yellowish discoloration of the agar, 1A3, 3–4AB3. No distinct odour noted. Conidiation at 25°C noted after 9–11 days in lateral and distal regions of the plate or in a broad distal zone, on white tufts or pustules to 2 mm diam, aggregating to 4–5 mm diam, turning pale to dull grey-green, 29CD4–6, 27DE4–6, or green with yellow margins, after 12–13 days. Pustules circular to oblong, of a loose reticulum of thin branches formed on a to 6 μm wide stipe of variable length. Conidiophores on the periphery of the pustules numerous, narrow, radial, to 0.5 mm long, 2–4 μm wide; with branches and phialides mostly in right angles or slightly inclined upwards, not or slightly increasing in length downwards; typically ending in 1–3(–4) phialides, often cruciform, followed by paired phialides and/or 1-celled branches 30–40 μm long, bearing 1–3 phialides, and/or slightly longer, 2–3 celled branches to *ca* 100 μm long on lower levels. Sometimes longer branches occurring at higher levels, causing a broad conidiophore system. Phialides borne by 2–4(–5) μm wide cells, (6–)8–14(–19)×(2.0–)2.5–3.3(–3.7) μm, l/w (2.2–)2.4–5.2(–8.9), (1.6–)2.0–2.4(–2.7) μm wide at the base (*n*=30), narrowly lageniform, widest in or above the middle; neck long, straight, becoming green with age. Conidia formed in minute wet heads <20 μm diam. Conidia (3.5–)3.7–4.6(–5.3)×(2.4–)2.5–3.0 μm, l/w 1.3–1.8(–2.2) (*n*=30), yellowish green or lively green, oval, ellipsoidal with one end slightly attenuated, or oblong with walls often nearly parallel, thick-walled, smooth, with few minute guttules; scar minute, sometimes distinct. Chlamydospores noted after 12–14 days, (6–)7–12(–15)×(5–)6–11(–15) μm, l/w (0.8–)1.0–1.3(–1.5) (*n*=30), globose or ellipsoidal, infrequent, mainly in thin central hyphae, terminal and intercalary. At 15°C colony margin ill-defined; fine needle-like yellowish crystals formed along hyphae; surface becoming downy except for the centre; entire colony diffuse yellowish, 3–4A3; conidiation in pale green fluffy tufts and on long aerial hyphae.

On PDA after 72 h 18–20 mm at 15°C, 36–37 mm at 25°C, 3–4 mm at 30°C; mycelium covering the plate after 6–7 days at 25°C. Colony circular, dense; margin well-defined, marginal surface hyphae delicately submoniliform. Centre remaining flat and hyaline, larger outer part of the colony becoming covered by a thick whitish mat of aerial


g
e
f
h
i
b
j
k
l
m
c
d
n
o
p

◀ **Fig. 3** Cultures and anamorph of *Hypocrea atroviridis* (CBS 119499). **a**–**d**. Cultures after 7 days (**a**. on CMD, 25°C and **b**. 30°C, **c**. on PDA and d. on SNA, 25°C). **e**. Anamorph on natural substrate. **f**. Conidiation tufts (CMD, 4 days). **g**. Conidiophore on tuft margin on growth plate. **h**, **i**. Conidiophores. **j**, **k**. Phialides. **l**. Stipe and primary branches of conidiation tuft. **m**, **p**. Conidia. **n**. Autolytic excretion (PDA, 25°C, 1 days). **o**. Chlamydospore (CMD, 11 days). **e**–**o**. All at 25°C except **b** and **e**. **g**–**m**, **p** On CMD, after 5 days. Scale bars: **a**–**d**= 20 mm. **e**=1.1 mm. **f**=0.5 mm. **g**, **n**=40 μm. **h**=20 μm. **i**, **l**, **o**=10 μm. **j**, **k**, **m**, **p**=5 μm

hyphae ascending to the lid of the Petri dish; orientation of aerial hyphae irregular, radial towards the margin, forming numerous drops, collapsing, becoming floccose and turning cream to yellowish. Autolytic activity none or inconspicuous, numerous minute excretions seen at 30°C. No coilings, no distinct odour noted. Reverse (except centre) becoming dull greyish yellow, 3B3, 4BC4, 4B5, to golden-yellow, 4C5–7. Conidiation at 25°C noted after 7 days on long aerial hyphae, starting at the proximal margin and on low levels at the inner margin of the thick mat of aerial hyphae, on irregular short broad conidiophores bearing minute heads becoming dry; fluffy, spreading along the margin and ascending along the walls of the Petri dish; later also on small white tufts appearing along the flat centre and at the proximal margin; remaining colourless. At 15°C conidiation more abundant than at 25°C, starting in the centre on long regular trees on aerial hyphae and on indistinct tufts at the margin of the flat centre and at the proximal margin, becoming tardily pale green, 30B4.

On SNA after 72 h 13–15 mm at 15°C, 24–25 mm at 25°C, 1–3 mm at 30°C; mycelium covering the plate after 7 days at 25°C. Colonies hyaline, thin, resembling snow crystals; margin ill-defined. Surface becoming downy due to numerous long and high aerial hyphae. Marginal surface hyphae submoniliform, hyphae degenerating, becoming empty. Autolytic activity none or inconspicuous, excretions more frequent at 15 and 30°C; coilings moderate, dissolving yellowish; colony faintly yellowish. No distinct odour noted. Chlamydospores noted after 9–11 days, infrequent, terminal and intercalary, (sub)globose. Conidiation noted after 10–11 days, in numerous minute wet heads <20 μm diam on long regular trees in tufts and on long aerial hyphae at the distal margin, becoming dry. Tufts to 2 mm diam, loosely and irregularly disposed, white, loose, with long narrow radial branches, turning pale greenish, 30CD5–6 after 12–14 days. No compact pustules formed within 3 week. At 15°C scant fine crystals formed along the hyphae; surface floccose due to long aerial hyphae aggregated in strands. Conidiation in thick, green, 27DE3–6, pustules to 6 mm diam, with long, mostly narrow radial conidiophores. Autolytic excretions and coilings frequent.

Habitat: on culms of *Juncus effusus*.

Distribution: Denmark, known only from the holotype specimen.

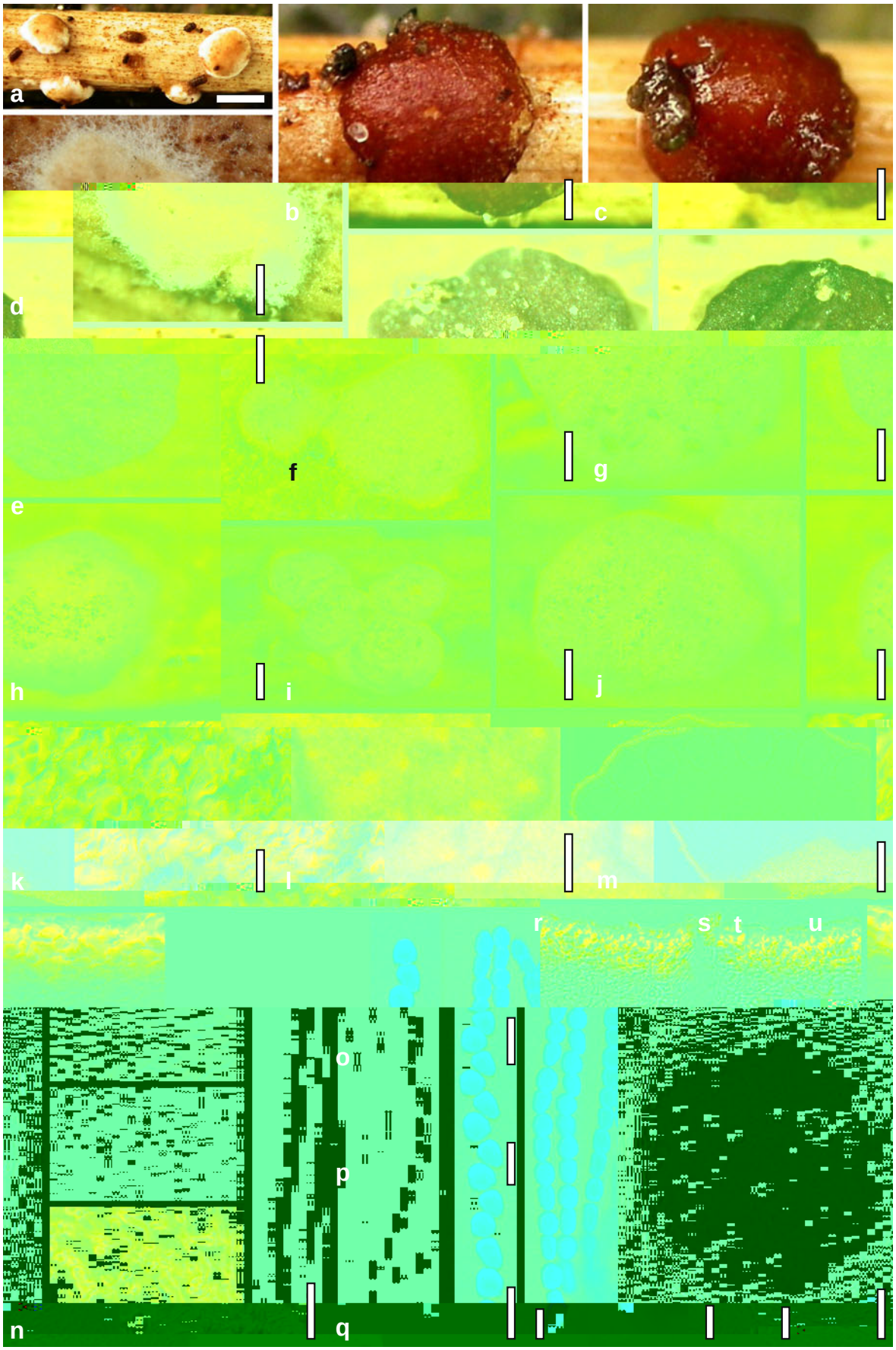
Holotype*: Denmark**, Nordjylland, Tranum Strand, behind the Himmerlandsfondens Kursus- og Feriecenter Tranum Strand, 57°09′04″ N, 09°26′12″ E, elev. 6 m, on dead standing stems of *Juncus effusus*, soc. effete immersed pyrenomycete, holomorph, 24 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2942 (**WU 29229**, ex-type culture CBS 120926=C.P.K. 2445). ***Holotype of *Trichoderma junci* isolated from WU 29229 and deposited as a dry culture with the holotype of *H. junci* as **WU 29229a**.

Notes: *H. junci* is currently the only species of sect. *Trichoderma* known on *Juncus*. Stromata resemble sclerotia of basidiomycetes like e.g. *Typhula*, with ostiolar openings virtually invisible. The conidiation on long radial conidiophores in green pustules is reminiscent of those in *T. atroviride*. However, *T. atroviride* and the closely related *T. viridescens* can be easily distinguished from *T. junci* by distinctly slower growth and development of conidiation in the latter. *T. junci* sporulated after more than 1 week on CMD, while conidiation in *T. atroviride* and the closely related *T. viridescens* can be noted from 2 days after inoculation. In addition, conidia of *T. junci* differ by a larger length/width ratio from those of the related species.

The holotype of *Hypocrea rufa* f. *sterilis* Rifai & J. Webster, England, Norfolk, Holme-next-the-Sea, on culms of *Agropyron pungens*, 12 Sep. 1962, J. Webster (K(M) 154038), was examined and found to be morphologically indistinguishable from *H. junci*. Here it is briefly described: Stromata 0.5–1.6×0.4–1.3 mm, 0.15–0.6 mm thick (n=20), pulvinate, solitary or aggregated in small numbers. Ostioles inconspicuous, minute, plane or convex, hyaline. Surface covered with brown hairs when young, later finely velutinous, some rugose. Colour dark red, vinose, dark reddish brown to nearly black, 8E5–8, some with mycelial margin. Asci (76–)80–90(–96)×(4.5–)5.0–5.7(–6.2) μm (n=30). Ascospores hyaline, finely verruculose to nearly smooth, cells dimorphic; distal cell (3.5–)3.8–4.5(–5.0)×(3.2–)3.3–3.8(–4.2) μm, l/w (1.0–)1.1–1.3 (n=30), (sub)globose or wedge-shaped; proximal cell (3.8–)4.2–5.5(–6.6)×(2.5–)2.7–3.2(–3.4) μm, l/w (1.2–)1.4–1.9(–2.5) (n=30), oblong or wedge-shaped. A search at the original collection site was without success due to drought. The ascospore isolate (Rifai and Webster 1966) did not produce an anamorph on MEA, but abundant chlamydospores and a coconut odour. These findings are not in accordance with *H. junci*. The coconut odour rather suggest species such as *H. atroviridis* or *H. viridescens*.

Hypocrea koningii Lieckf., Samuels & W. Gams, Can. J. Bot. 76: 1519 (1998). Fig. 6

Anamorph: ***Trichoderma koningii*** Oudem. in Oudemans & Koning, Arch. Néerl. Sci. Exactes Nat., Sér. 2, 7: 291 (1902). Fig. 7


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u

◀ **Fig. 4** Teleomorph of *Hypocrea junci* (**a**–**g**, **j**–**t**; WU 29229) and *H. rufa f. sterilis* (**h**, **i**, **u**; K 154038). **a**–**c**. Fresh stromata (a. immature). **d**–**i**. Dry stromata (e. immature). **j**. Rehydrated stroma. **k**. Stroma surface showing ostiolar openings after rehydration. **l**. Stroma in vertical section. **m**. Stroma surface in horizontal section. **n**. Perithecium in section. **o**. Cortical and subcortical tissue in section. **p**. Subperithecial tissue in section. **q**. Stroma base in section. **r**–**u**. Asci with ascospores (t, u. in cotton blue/lactic acid). Scale bars: **a**= 1.3 mm. **b**, **c**, **e**, **g**, **i**=0.3 mm. **d**, **f**, **l**=0.2 mm. **h**, **j**=0.5 mm. **k**= 50 μm. **m**, **r**, **u**=10 μm. **n**, **p**, **q**=25 μm. **o**=15 μm. **r**–**t**=5 μm

Stromata when fresh 0.5–3 mm diam, 0.5 mm thick, solitary or gregarious, pulvinate, smooth, lively orange-brown. Stromata when dry (0.4–)0.8–1.8(–2.4)×(0.3–)0.6–1.3(–1.5) mm (*n*=30), 0.15–0.45 mm (*n*=20) thick; flat pulvinate, discoid or lenticular; margin free. Outline circular or oblong. Ostiolar dots (17–)22–34(–38) μm (*n*= 30) diam, typically invisible, only rarely distinct, convex to semiglobose, hyaline, or with a dark ring. Stromata when young white, the centre turning pale yellow or orange, eventually dark orange-brown to reddish brown, 7–8CE7–8, with or without white mycelial margin. Rehydrated stromata light orange-brown; ostiolar openings minute, hyaline; surface smooth, slightly velutinous. No change seen in 3% KOH.

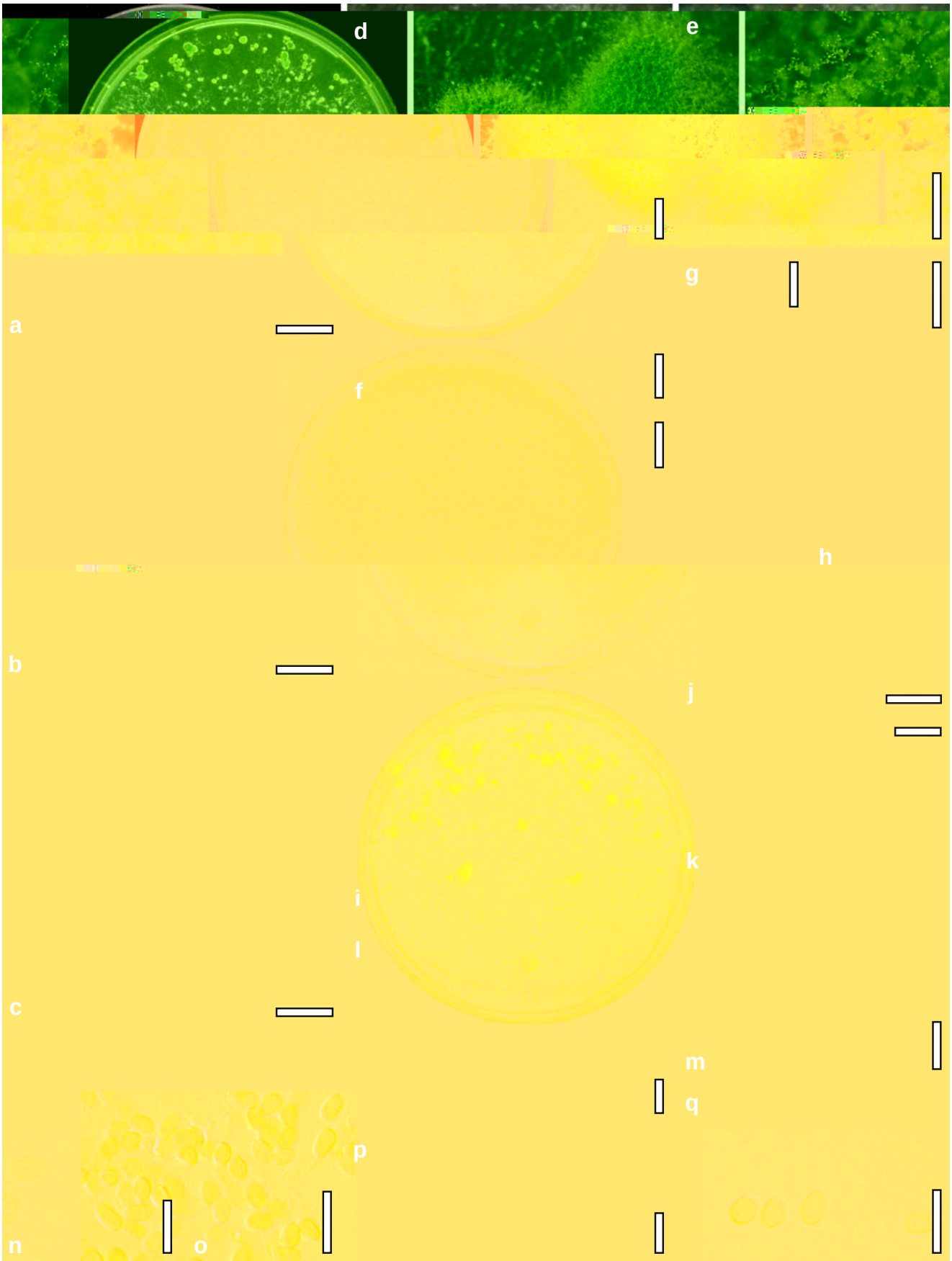
Stroma anatomy: Ostioles (42–)49–70(–84) μm long, projecting to 15 μm, (12–)17–37(–50) μm wide at apex (*n*= 20), conical, without conspicuous apical cells. Perithecia (130–)145–180(–195)×(93–)110–160(–175) μm (*n*=20), globose or flask-shaped. Peridium (11–)13–17(–20) μm (*n*=20) thick at the base, (6–)9–14(–16) μm (*n*=20) thick at the sides, hyaline. Cortical layer (13–)16–23(–27) (*n*=30), an orange-brown *t. angularis* of minute thin-walled cells (2–)3–6(–7) μm long (*n*=60) in face view and in vertical section. Hairs on mature stroma (6–)8–11(–12)×2–4(–6) μm (*n*=20), 1–2 celled, ends rounded, cylindrical or globose, smooth or warty, yellow-orange to pale brown, surface warty by projecting cells. Subcortical tissue a loose *t. intricata* of hyaline thin-walled hyphae 2.5–4.0(–4.5) μm (*n*=10) wide. Subperithecial tissue a dense *t. epidermoidea* of hyaline thin-walled cells (5–)6–14(–20)×(3–)4–9(–13) μm (*n*=30). Stroma sides of a thin layer of narrow hyphae (2.0–)2.5–4.5(–5.0) μm (*n*=10) wide. Asci (62–)68–75(–77)×(4.5–)4.8–5.5(–6.0) μm, stipe to 10 μm long (*n*=30). Ascospores hyaline, verruculose, cells dimorphic, but with little difference in shape, distal cell (2.7–)3.0–3.8(–4.3)×3.0–3.5(–4.0) μm, l/w (0.9–)1.0–1.1(–1.2) (*n*= 30), (sub)globose, proximal cell (3.0–)3.5–5.0(–6.3)×(2.2–)2.5–3.2(–3.8) μm, l/w (0.9–)1.2–1.7(–2.3) (*n*=30), subglobose, oblong or wedge-shaped.

Cultures and anamorph: optimal growth at 25°C on all media; no or short growth at 35°C.

On CMD after 72 h 22–23 mm at 15°C, 46–51 mm at 25°C, 38–43 mm at 30°C; to 1 mm at 35°C, hyphae autolysing within 1–2 days. Mycelium covering the plate after 4–5 days at 25°C. Colony circular, hyaline, thin; mycelium loose, little on the agar surface, hyphae with conspicuous differences in width, numerous characteristic minute secondary hyphae present. Margin becoming downy due to aerial hyphae. No autolytic activity seen; coilings not checked. No distinct odour noted. Chlamydospores noted after 5–7, measured after 11 days, (6–)7–10(–12)×5–8(–9) μm, l/w 1.0–1.5(–1.9) (*n*=25), infrequent, intercalary and terminal, globose, pyriform or oblong. Conidiation noted after 2 days, becoming green, 26E3–4, 27F6–8 after 4–5 days; first effuse in small shrubs 0.1–0.5 mm diam forming aggregates to 1 mm diam and on side branches to 100 μm long on aerial hyphae; spreading from the plug across the plate; later in fluffy tufts in distal and lateral areas, eventually compacting into granular pustules to 2.5 mm diam; aggregates to 6 mm long. Gradual transition from effuse to pustulate conidiation without distinct structural difference. Shrubs and pustules of a stipe with one or several long main axes with little branching and one or several regularly tree-like, terminal conidiophores 3–4(–5) μm wide. Side branches mostly paired, in right angles or slightly inclined upward, increasing in length from the top, with simple further branching. Phialides formed on cells mostly 2.5–3.5 μm wide, solitary or in whorls of 2–4(–5), rarely repetitive, i.e. terminal branches submoniliform. Conidiation starting within the shrubs. Conidia produced in small numbers in minute dry heads, aggregating in chains after 5–6 days. Phialides (5–)7–11(–15)×(2.4–)3.0–3.7(–4.3) μm, l/w (1.4–)2.0–3.6(–5.3), (1.3–)1.7–2.5(–2.9) μm wide at the base (*n*=60); variable, lageniform or ampulliform, also cylindrical terminally on main axes, straight, mostly equilateral, widest in or below the middle, neck short. Conidia (3.8–)4.0–4.6(–5.0)×2.5–3.0(–3.5) μm, l/w (1.2–)1.4–1.7(–1.8) (*n*=30), pale green, mostly oblong, also ellipsoidal or oval, smooth, multiguttulate, scar sometimes distinct. At 15°C development distinctly slower. At 30°C conidiation effuse and in green tufts or pustules to 5 mm diam, arranged in ill-defined concentric zones.

On PDA after 72 h 17–20 mm at 15°C, 47–50 mm at 25°C, 34–43 mm at 30°C; mycelium covering the plate after 4–5 days at 25°C. Colony dense, thin, silky, not zonate. Surface becoming covered by a white cottony mat of aerial hyphae ascending to the lid of the Petri dish, forming strands, collapsing. Autolytic activity moderate. No diffusing pigment, no distinct odour noted. Conidiation noted after 1–2 days on low levels of aerial hyphae, becoming matt to dark grey-green, 25DE5–6, 26–27DE3–4, after 3 days, spreading from the centre across the plate. At 15°C marginal surface hyphae conspicuously wide; distinct concentric zones formed; conidiation pale green, effuse and in fluffy tufts. At 30°C irregular concentric zones formed; conidiation effuse, pale green.

On SNA after 72 h 15–20 mm at 15°C, 37–39 mm at 25°C, 22–30 mm at 30°C after 72 h; mycelium covering the plate


d
e
g
a
f
h
b
j
k
i
l
c
m
q
p
n
o

after 5 days at 25°C. Colony as on CMD. Autolytic activity and coilings moderate. No pigment, no distinct odour noted. Chlamydospores noted after 6–7 days. Conidiation noted after 2 days, effuse and in pustules to 2 mm diam, forming aggregates to 5 mm diam, arranged in several concentric zones, first white, becoming dark green, 26–27F5–8, from pustule centres after 3–4 days. At 15°C conidiation effuse, green, short and on long aerial hyphae, also in pustules concentrated in lateral and distal areas of the colony. At 30°C conidiation mostly in central green pustules to 3 mm diam.

Habitat: teleomorph on wood and bark, rare; anamorph mostly isolated from soil.

Distribution: Europe, North America.

Holotype: **USA**, Maryland, Garrett County, approx. 10 mi SSE of Grantsville, near Bittinger, High Bog, on decorticated wood, 23 Sep. 1989, G.J. Samuels et al. (BPI 745885, ex-type culture G.J.S. 89-122=IMI 378801=CBS 989.97). ***Neotype*** of *T. koningii*: **Netherlands**, Spanderswoud near Bussum, isolated from soil under pure stand of *Pinus sylvestris*, 1996, W. Gams (CBS 457.96=G.J.S. 96-117).

Specimen examined: **Austria**, Oberösterreich, Grieskirchen, Neukirchen am Walde, Leithen (Schluchtwald), MTB 7648/2, 48°22′25″ N, 13°47′00″ E, elev. 400 m, on stump of *Carpinus betulus*, in a dry streambed, holomorph, 9 Sep. 2003, H. Voglmayr, W.J. 2392 (WU 29230, culture CBS 119500=C.P.K. 957).

Notes: The teleomorph of *Hypocrea koningii* is rare. It was collected only once in Europe in 6 years. Another teleomorph specimen from the Netherlands and two from Maryland and Pennsylvania were cited by Samuels et al. (2006a). Based on teleomorphs alone, *H.*

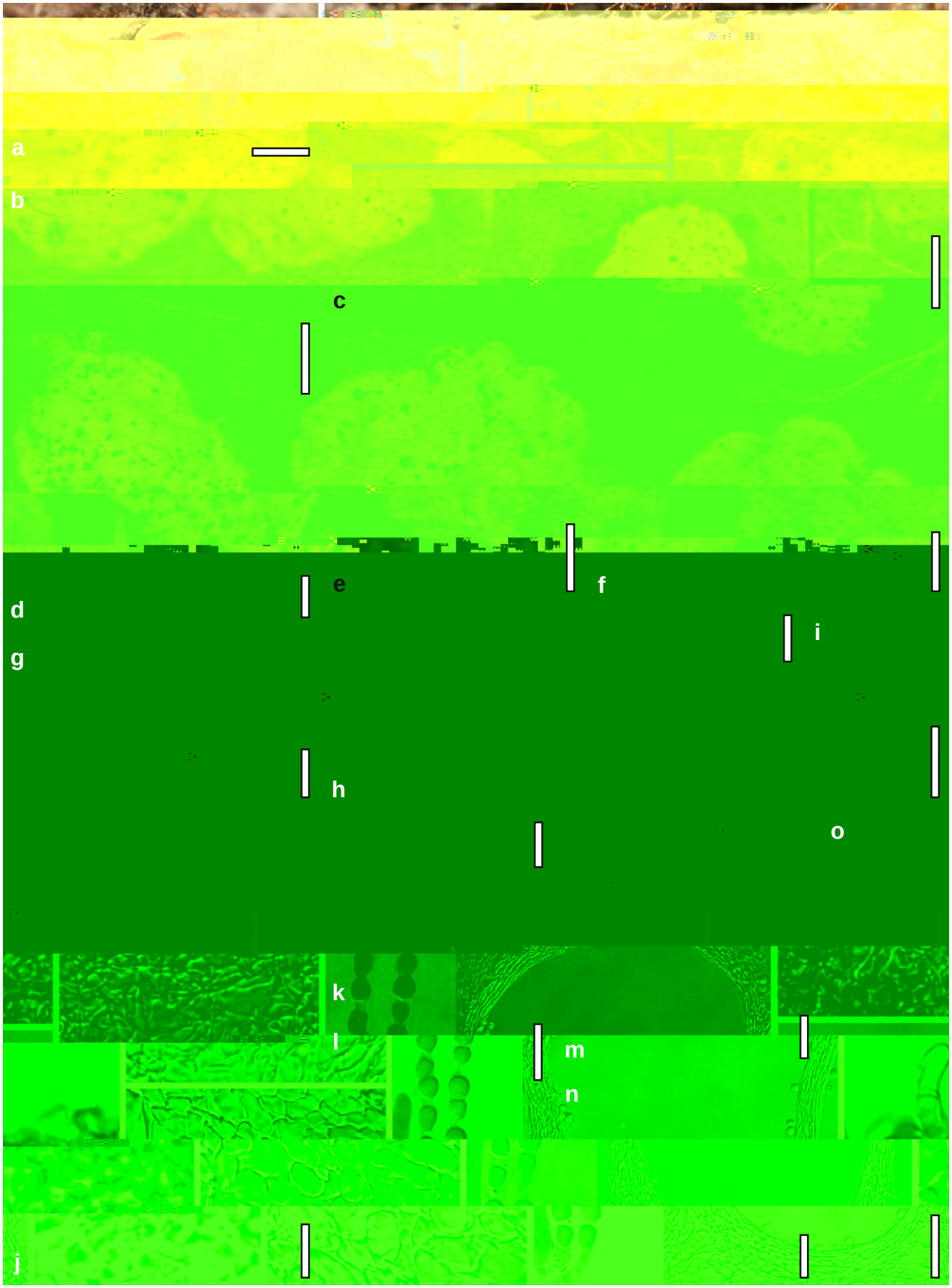

a
b
c
d
e
f
g
h
i
j
k
l
m
n
o

Fig. 6 Teleomorph of *Hypocrea koningii (WU* 29230*)*. **a**–**f**. Dry stromata (a. immature). **g.** Rehydrated stromata. **h**. Part of stroma in vertical section. **i**. Ascus apex in cotton blue/lactic acid. **j**. Perithecium in section. **k**. Stroma surface. **l**. Hair and cortical tissue in section. **m**. Cortical and subcortical tissue in section. **n**.la.0 *)*

(–45) µm (*n*=30) thick, a *t. angularis* of thick-walled cells (3–)4–8(–12)×(2–)3–5(–8) µm (*n*=60) in face view and in vertical section; intensely (reddish-) brown, gradually lighter downwards. Subcortical tissue where present a loose *t. intricata* of hyaline, thin-walled hyphae (2–)3–5 (–6) µm (*n*=20) wide. Subperithecial tissue a dense hyaline *t. epidermoidea* of variable cells (7–)9–25(–37)× (6–)7–13(–16) µm (*n*=30), partly with yellowish brown spots. Base a loose *t. intricata* of hyaline, thin-walled hyphae (2.0–)2.5–5.5(–6.5) µm (*n*=20) wide, sometimes partly intermingled with subperithecial cells. Asci (64–) 72–93(–102)×(4.5–)4.7–5.5(–6.0) µm, stipe (3–)5–17(–24) µm long (*n*=60). Ascospores hyaline, verruculose, cells dimorphic; distal cell (3.0–)3.3–4.0(–5.0)×3.0–3.5(–4.0) µm, l/w (0.9–)1.0–1.2(–1.6) (*n*=62), (sub)globose, oval or wedge-shaped; proximal cell (3.8–)4.2–5.5(–6.0)× (2.4–)2.5–3.0(–3.5) µm, l/w (1.3–)1.5–2.0(–2.3) (*n*=62), oblong, wedge-shaped, less commonly globose.

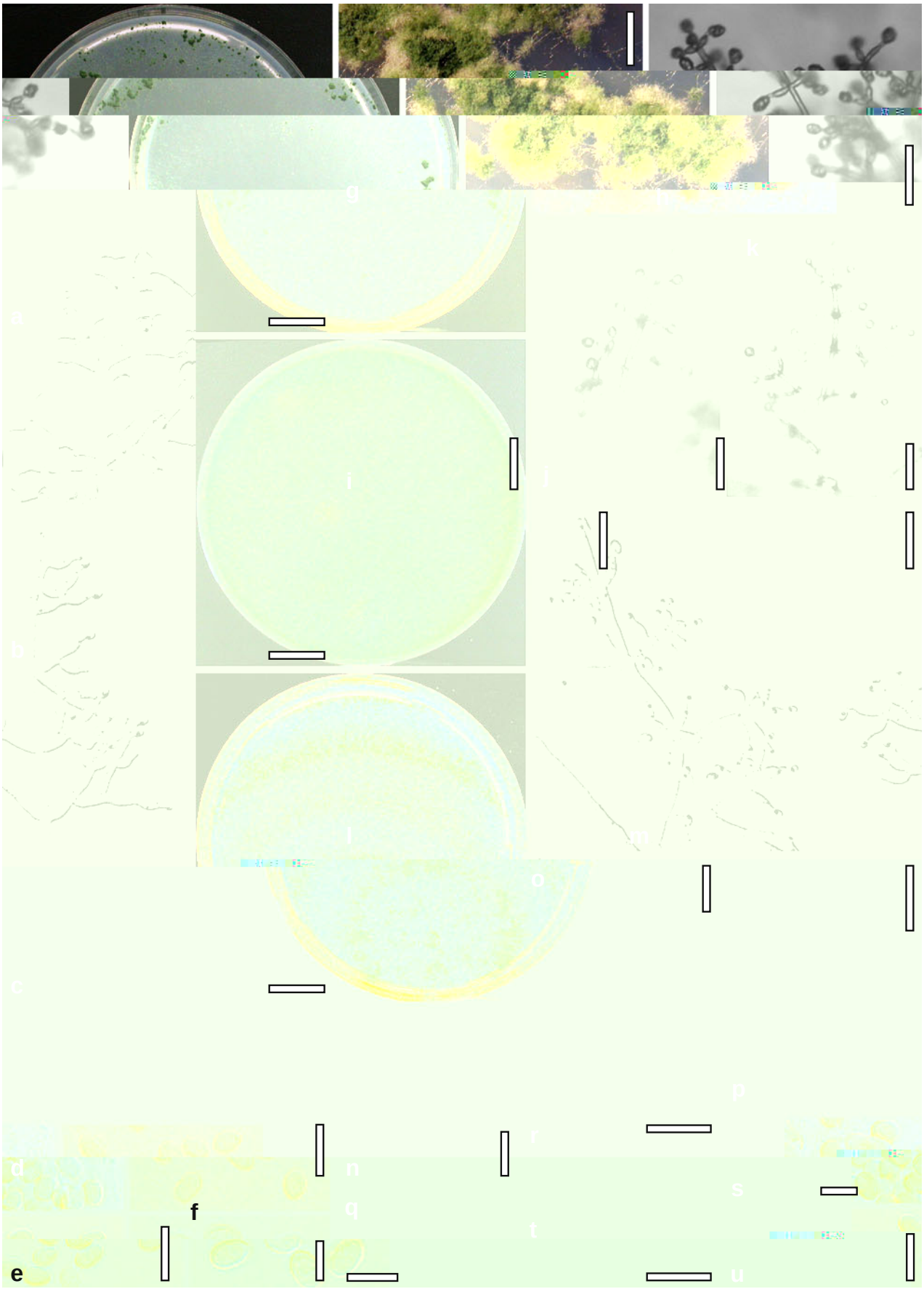
Anamorph on the natural substrate hairy, light bluish-, medium- to dark green.

Cultures and anamorph: optimal growth at 30°C on all media; at 35°C solitary hyphae growing to less than 1 mm.

On CMD after 72 h 10–11 mm at 15°C, 28–29 mm at 25°C, 29–32 mm at 30°C; mycelium covering the plate after 7–8 days at 25°C. Colony hyaline, thin, dense, not zonate; with indistinct or irregular margin; hyphae thin, with low variation in width; surface slightly downy. Aerial hyphae inconspicuous, but long and ascending several mm along the margin. No autolytic excretions, no coilings noted. Agar turning diffusely yellow, 1–3A3, 3–4B4. No distinct odour noted. Chlamydospores (after 15 days) abundant in lateral and distal pustule areas, terminal and intercalary, noted after 5–6 days, large, (10–)12–16(–19)×(10–)12–15(–18) µm, l/w (0.8–)0.9–1.2 (–1.6) (*n*=32), globose, oval or fusoid. Conidiation noted after 1 days at 25°C; first effuse, spreading quickly from the plug across the entire colony, forming several inconspicuous, macroscopically hardly visible, finely downy concentric zones. Conidia produced in numerous colourless to pale greenish wet heads <30 µm on short erect, irregularly verticillium-like conidiophores, also ascending on aerial hyphae. After 5–7 days white fluffy tufts appearing at the sides of the colony, spreading in a distal zone, turning to pustules 0.7–2.3(–3.7) mm diam, grey-green to dark green, 28–29CD5–6, 27–28EF7–8, 26F7–8 after 7–10 days, with variable outline, loose texture and granular surface. Conidiation symmetric, dense, dry; conidia finally adhering in chains. At 15°C conidiation effuse and in green granules concentrated in proximal and central areas of the colony. At 30°C mycelium dense, colony indistinctly zonate by aerial hyphae; zones turning greyish yellow, 1A3, 3–4AB4–5 by effuse conidiation; pustulate conidiation in granules and small pustules mainly along lateral and distal margins, pale to greyish green, 28CD5–7.

On PDA after 72 h 8–9 mm at 15°C, 23–25 mm at 25°C, 26–27 mm at 30°C; mycelium covering the plate after 8–9 days at 25°C. Colony dense, margin hyaline, irregularly wavy; surface becoming downy to farinose, white from the centre due to conidiation. Aerial hyphae abundant, forming flat mats in several irregularly serrate concentric zones; each zone first white, turning yellowish to pale brownish. Autolytic excretions and coilings inconspicuous. Colony reverse yellow to brown-orange, 4A5, 4B5–6, 5C6–7; no distinct odour noted. Conidiation noted after 1 days at 25°C, dense, effuse and in shrubs on surface and aerial hyphae, white to yellowish, degenerating after *ca* 5 days; not becoming green. At 15°C concentric zones more regular. At 30°C zones becoming obscured by a conspicuously dense flat mat of aerial hyphae; surface turning yellow, reverse more intensely coloured than at lower temperatures, orange to brown.

On SNA after 72 h 8–9 mm at 15°C, 25–26 mm at 25°C, 27–28 mm at 30°C; mycelium covering plate after 9–11 days at 25°C. Colony as on CMD, but mycelium denser and margin more irregular. No autolytic excretions noted, coilings inconspicuous. No diffusing pigment, no distinct odour noted. Chlamydospores absent or rare, more frequent at 15°C. Conidiation noted after 1 days at 25°C, first effuse, macroscopically invisible or finely downy, spreading from the centre across the entire colony; developing over a long period, usually still fresh during pustulate conidiation. Conidiophores simple, short, erect, acremonium- to irregularly verticillium-like, of a single whorl of phialides on a short stipe, or branched basally, broad, with few phialides or short side branches, or of short side branches emerging from a single axis. Side branches typically unpaired, in right angles or inclined upwards, typically of 1–3(–6) long cells, re-branching into short, often paired, 1–2 celled terminal branches. Phialides formed on cells (2–)2.5–5 µm wide, solitary or in whorls of (2–)3(–4–5). Conidia produced in wet heads, green in the stereo-microscope. Phialides (5–)8–15(–19)×2.3–3.0(–3.3) µm, l/w (2.0–)2.7–5.8(–8), (1.4–)1.7–2.4(–2.8) µm wide at the base (*n*=30), lageniform or nearly cylindrical, straight or slightly curved upwards, widest in or below the middle. Conidia (2.8–)3.3–4.3(–4.8)×(2.0–)2.3–2.7(–3.0) µm, l/w (1.1–)1.4–1.7(–2.0) (*n*=30), pale yellow-greenish, ellipsoidal or oval, smooth, scar indistinct or distinctly projecting. Pustulate conidiation starting slightly after effuse conidiation in a central zone, later in one or several additional distal zones. Pustules


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u

◀ **Fig. 7** Cultures and anamorph of *Hypocrea koningii* (CBS 119500). **a**–**c**. Cultures at 25°C (**a**. on CMD, 14 days; **b**. on PDA, 13 days; **c**. on SNA, 14 days). **d**. Hyphae on agar surface (SNA, 15°C, 3 days). **e**, **f**. Chlamydospores (**e**. intercalary, **f**. terminal; 11 days). **g**–**j**. Conidiation on SNA, observed in the stereo-microscope (**g**. pustules, 25°C, 7 days; **h**–**j**. on aerial hyphae; **h**, **i**. 25°C, 3 days, **j**. 15°C, 8 days). **k**–**n**. Conidiophores (**k**. showing lageniform and ampulliform phialides; 5–6 days). **o**, **p**. Phialides (5 days). **q**. Conidial chains (7 days). **r**–**u**. Conidia (6 days). **e**, **f**, **k**–**u**. On CMD, at 25°C. Scale bars: **a**–**c**= 15 mm. **d**=50 μm. **e**, **k**, **o**, **p**, **r**, **t**=10 μm. **f**, **s**, **u**=5 μm. **g**=3 mm. **h**–**j**, **q**=30 μm. **l**–**n**=15 μm

large, 0.5–5(–7) mm long, aggregating to 9×5 mm, variable in outline, flat, fluffy to loosely granular, grey-green, 27CE4–6, 28DE5–7, after 5–6 days. Pustules (after 8 days) apparently without a stipe. Complexity of branching within pustules depending on their size; with one or several long main axes emerging, often sterile on lower levels, bearing numerous, widely spaced, short side branches mostly paired, in right angles or slightly inclined upwards. Side branches wide, mostly 3-celled, shorter towards apices, re-branching 1–2 fold, forming short, 1–2 celled terminal branches. Resulting regular trees dense. Phialides formed on cells 2.5–4 μm wide, solitary or predominantly in whorls of 3–5 on all kinds of branches within the pustule. Conidia dry, produced in dense pachybasium-like clusters. Phialides (4–) 5–8(–12)×(2.8–)3.0–3.5(–3.7) μm, l/w (1.3–)1.5–2.7(–4.1), (1.5–)2.0–2.5(–3.0) μm wide at the base (n=30), ampulliform or lageniform, widest in various position, most commonly in the middle. Conidia 3.0–3.8(–5.0)×(2.0–)2.2–2.6(–2.8) μm, l/w (1.2–)1.3–1.6(–2.2) (n=30), pale green, ellipsoidal, less commonly subglobose, smooth, thick-walled; scar indistinct. At 15°C conidiation effuse and mainly in dense green aggregates around the plug. At 30°C coilings more frequent, fertile aerial hyphae forming several narrow, downy, whitish to greenish concentric zones; pustulate conidiation mainly along the colony margin, fluffy, pale or grey-green.

Habitat: on dark, medium to well-decayed wood and bark of deciduous trees.

Distribution: Europe (Austria), North America; uncommon.

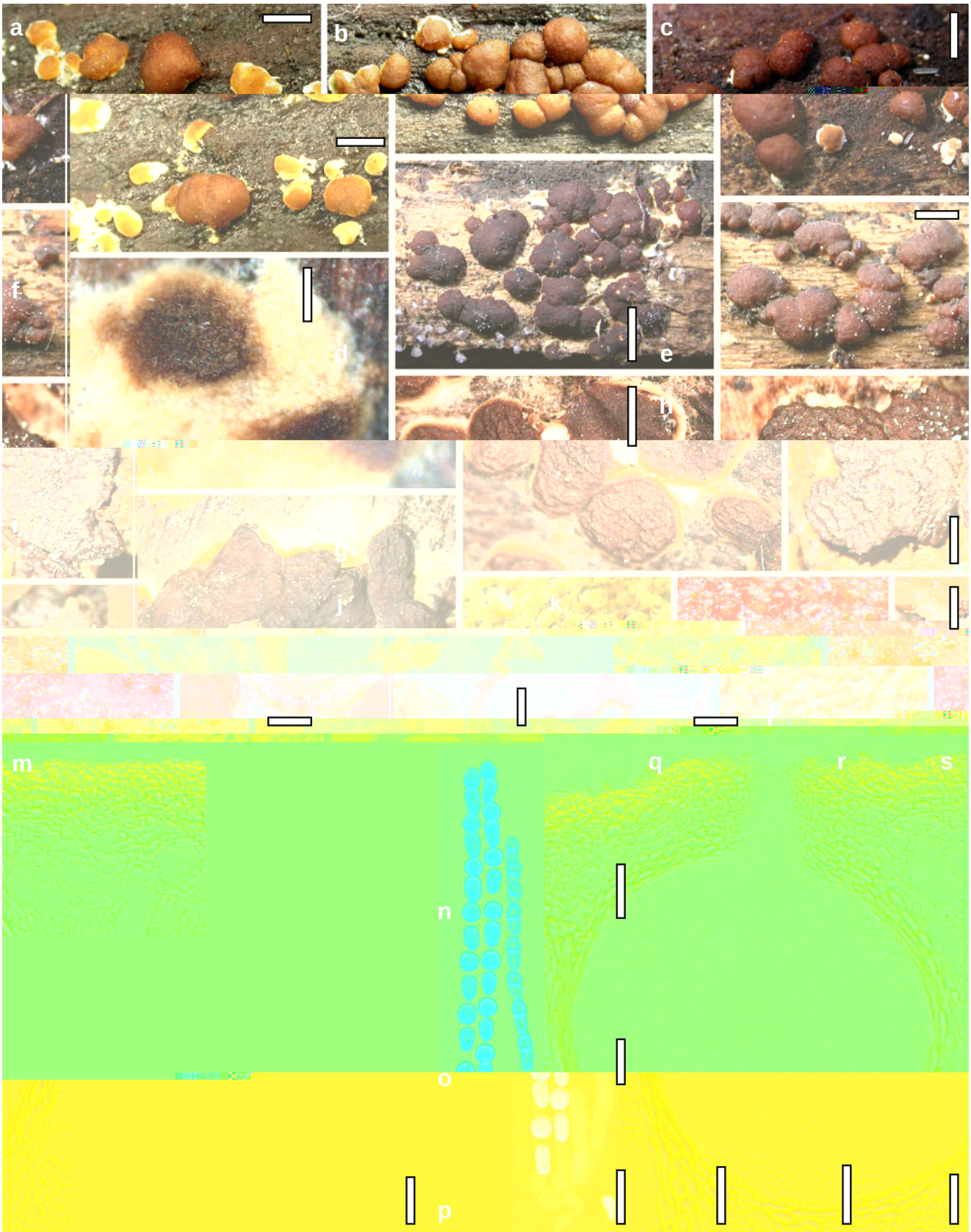
Holotype: **USA**, New Jersey, Cumberland County, Haleyville, at intersection of NJ routes 649 & 718, in mixed hardwood, elev. 0 m, on bark, G.J. Samuels, H.-J. Schroers & G. Bills, 6 Jun. 1996, (BPI 744493, culture G.J. S. 96-135=CBS 111144; both not examined).

Specimens examined: **Austria**, Kärnten, Spittal/Drau, Mallnitz, Stappitz, at the brook parallel to the hiking trail 518, close to Gasthof Alpenrose, MTB 8945/3, 47°01′05″ N, 13°11′14″ E, elev. 1340 m, on a decorticated branch of *Alnus incana* 8–10 cm thick, on wood, soc. *Hypoxylon fuscum*, *Neodasyscypha cerina*, a myxomycete, white hyphomycete, 5 Sep. 2003, W. Jaklitsch, W.J. 2380 (WU 29290, culture CBS 119498=C.P.K. 949). Oberösterreich, Grieskirchen, Natternbach, at Gaisbuchen, MTB 7548/3, 48° 24′36″ N, 13°41′22″ E, elev. 560 m, on a branch of *Fagus sylvatica* 4 cm thick, on wood, 10 Sep. 2003, H. Voglmayr, W.J. 2393 (WU 29291, culture C.P.K. 958). Same area, host and date, partly attacked by a grey mould, W.J. 2394 (part of WU 29291, culture C.P.K. 959). Natternbach, NE Oberantlang, MTB 7648/1, 48°23′15″ N, 13°42′18″ E, elev. 550 m, on a branch of *Fagus sylvatica*, on wood, soc. hyphomycetes, 17 Jul. 2004, H. Voglmayr, W.J. 2529 (WU 29292, culture C.P.K. 1613). Schärding, Kopfing, Ahörndl, MTB 7547/2, elev. 730 m, on a branch of *Betula pubescens* lying in moss, 15 Aug. 2006, H. Voglmayr, W.J. 2929 (WU 29295, culture C.P.K. 2438). Vorarlberg, Bludenz, Nenzing, Rabenstein, at Beschling, MTB 8824/1, 47°11′20″ N, 09°40′ 34″ E, elev. 660 m, on a decorticated branch of *Fagus sylvatica* 4–5 cm thick, on wood, soc. *Nemania*-anamorph, 29 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2631 (WU 29293, culture C.P.K. 2016). Same area, 47°11′24″ N, 09°40′ 16″ E, elev. 680 m, on partly decorticated branch of *Corylus avellana* 3 cm thick, on wood, also below bark, holomorph, 29 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2633 (WU 29294, culture C.P.K. 1969).

Notes: The stromata of *Hypocrea neorufa* are typical for teleomorphs of *Trichoderma* section *Trichoderma*, while the cortical cells are more distinct, also the dark colour is remarkable, as is the yellow perithecial wall. Conspicuous is also the colour change from bright yellow in fresh young stromata to brown upon drying or incubation in a moist chamber. The yellow peridium helps to distinguish this species and *H. neorufoides* from species like *H. petersenii* and *H. subeffusa*, which are also characterised by dark brown stromata, but have hyaline peridia. *H. neorufoides* is indistinguishable in teleomorph morphology from *H. neorufa*. Fresh mature stromata may sometimes resemble those of *Hypoxylon fuscum* in colour, but have a smooth even surface instead of large perithecial mounds in the latter fungus. *Hypocrea neorufa* was described by Dodd et al. (2002). See this paper for a more detailed description of the conidiophores of the pustulate conidiation. Although phylogenetically belonging to *Trichoderma* section *Trichoderma*, the anamorph of *H. neorufa* deviates in having both effuse and pustulate stages differing in structure from each other, and also in the pachybasium-like conidiophores in pustules.

Hypocrea neorufoides Jaklitsch, **sp. nov.** Fig. 10
MycoBank MB 516692
Anamorph: ***Trichoderma neorufoides*** Jaklitsch, **sp. nov.** Fig. 11
MycoBank MB 516693

Differt ab *Hypocrea neorufa* genetice, incremento optimo ad temperaturam inferiorem et anamorphosi. Anamorphosis *Trichoderma neorufoides*; conidiophora effuse


a
b
c
d
e
f
g
h
j
k
m
n
o
p
q
r
s

disposita et in pustulis parvis et planis, albis vel pallide luteis in agaris CMD et PDA, viridibus in agaro SNA. Conidiophora gradatim transeuntia de typo verticillii ad typum pachybasii, typice ad basim sterilia. Phialides in pustulis divergentes, variabiles, lageniformes, (5.5–)7–14(–20)×(2.5–)3.0–4.0(–5.0) µm. Conidia pallide viridia, ellipsoidea vel oblonga, glabra, (3.3–)3.8–5.2(–6.3)×(2.5–)2.7–3.2(–3.8) µm.

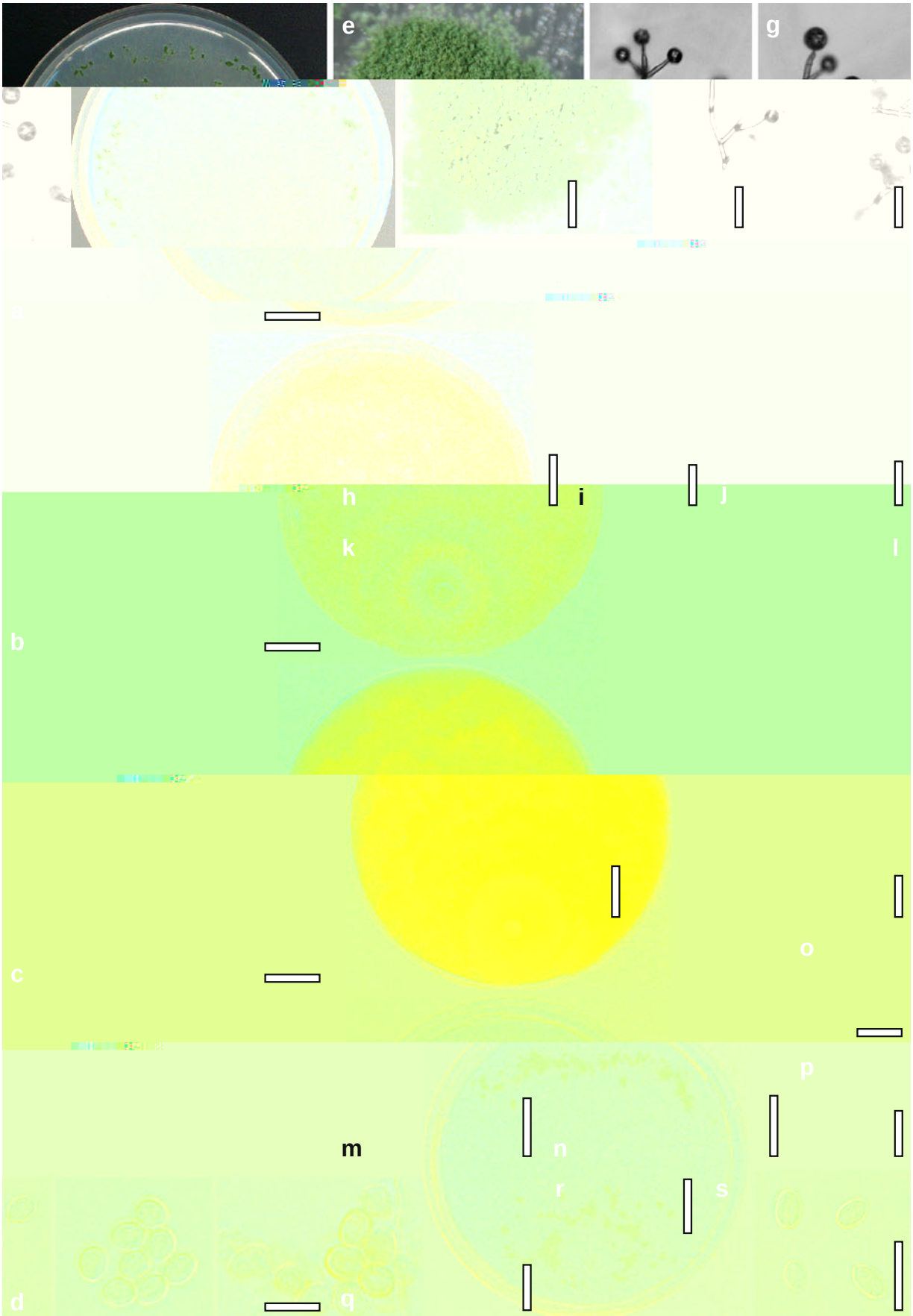
Etymology: *neorufoides* denotes the resemblance and close relationship with *Hypocrea neorufa*.

Stromata when fresh 1–6(–8) mm diam, to 2 mm thick, at first often thinly effuse, with white mycelial margin, becoming pulvinate or discoid, compact. Outline roundish, angular or irregular. Margin free, sides often steep, smooth, white or yellowish. Surface downy when young, glabrous when mature, smooth or finely granular. Ostioles typically invisible, only rarely visible as darker dots, ostiolar openings appearing as minute, light reddish or hyaline convex dots under strong magnification. Stromata first yellow, yellow-orange, yellow-brown, 4B5–7, 5DE5–8, light brown, orange-, reddish brown, 6CD5–8, 7CE6–8, 8D7–8, with age darkening, mostly dark brown, 7E7–8, or dark reddish or purplish brown, 8–9F7–8. Injured areas yellow due to yellow perithecia. Spore deposits white, less commonly yellowish.

Stromata when dry (0.6–)1.0–3.6(–5.5)×(0.4–)0.7–2.7(–5.5) mm, (0.2–)0.3–0.7(–1.3) mm thick (*n*=50). solitary, gregarious or densely aggregated in variable numbers, thinly effuse to distinctly pulvinate, broadly attached, with often persistent, radiating, white to yellowish base mycelium. Outline variable. Margin attached or free, white or yellow when young. Surface hairy when young, slightly velutinous when mature, smooth, tubercular or rugose. Ostioles typically only seen under strong magnification as minute, slightly projecting, light dots (15–)19–40(–55) µm (*n*=60) diam; distinct after re-wetting. Stromata when young yellow, 4A5, 4B5–7, yellow-brown, light brown, medium brown or orange-brown, 5–6CE7–8, 6CD4–5, 7–8E7–8; darkening with age to dark brown, dark chocolate brown, dark reddish or purplish brown, 6F4–7, 7–9F4–8, to nearly black. Rehydrated stromata not different from the fresh state, colour not changed in 3% KOH.

Stroma anatomy: Ostioles (47–)55–80(–94) µm long, plane or projecting to 22 µm, (12–)22–38(–45) wide at the apex internally (*n*=36); without differentiated apical cells. Perithecia (124–)160–205(–225)×(97–)125–175(–205) µm (*n*=47), globose or flask-shaped; peridium (6–)10–16(–22) µm (*n*=80) thick at the base and sides, yellow in lactic acid; orange with vinaceous tone in 3% KOH. Cortical layer (17–)20–30(–35) µm (*n*=40) thick, a *t. angularis* of distinct, isodiametric, thick-walled, reddish- or yellowish brown cells (3–)5–11(–16)×(2.5–)4–9(–13) µm (*n*=120) in face view and in vertical section, gradually paler downwards; absent at the attached base. Hairs on mature stromata (6–)8–25(–38)×(2–)3–4(–5) µm (*n*=31), rare, inconspicuous, 1–3 celled, cylindrical, straight or curved, smooth, rarely verruculose, brownish. Subcortical tissue a *t. intricata* of hyaline thin-walled hyphae (2–)3–6(–7) µm (*n*=40) wide. Subperithecial tissue a *t. epidermoidea* of hyaline thin-walled cells (6–)9–35(–50)×(5–)7–12(–16) µm (*n*=60), appearing as wide, mostly vertically oriented hyphae under lower magnification. Stroma base a *t. intricata* of hyaline hyphae (2–)3–5(–6) µm (*n*=16) wide. Asci (76–)83–96(–108)×(4.7–)5.0–6.0(–6.5) µm, stipe (2–)6–14(–24) µm long (*n*=50). Ascospores hyaline, verruculose; cells dimorphic, distal cell (3.0–)3.4–4.3(–5.7)×(3.0–)3.5–4.0(–4.5) µm, l/w (0.9–)1.0–1.2(–1.6) (*n*=90), subglobose or oval, proximal cell (3.0–)4.0–5.5(–7.3)×(2.2–)2.8–3.4(–4.0) µm, l/w (1.0–)1.2–1.8(–2.6) (*n*=90), oblong, wedge-shaped or subglobose.

Anamorph on the natural substrate typically light bluish green, effuse or pulvinate, powdery or hairy. Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C. On CMD after 72 h 8–9 mm at 15°C, 21–24 mm at 25°C, 17–23 mm at 30°C; mycelium covering the plate after 8–10 days at 25°C. Colony hyaline, thin, dense, with wavy margin, not zonate; hyphae with radial arrangement, thin, with low variation in width. Aerial hyphae scant, becoming fertile. Autolytic activity nearly absent, no coilings seen. No chlamydospores seen. Agar becoming diffusely dull yellow, 3–4AB3–4, mostly in distal areas. Odour weakly coconut-like. After *ca* 1 month at 15°C sometimes yellow crystals appearing in the agar. Conidiation noted after 2 days, white to pale yellowish, green only in the stereo-microscope; effuse, macroscopically invisible, spreading from the plug. Conidiophores (after 4–12 days) simple, erect, verticillium-like, mostly short, 100–250 µm


e
g
a
h
i
j
k
l
b
c
o
p
m
n
r
s
d
q

◀ **Fig. 9** Cultures and anamorph of *Hypocrea neorufa* (CBS 119498). **a**–**d**. Cultures after 14 days (**a**. on CMD; **b**. on PDA; **c**. on PDA, reverse; **d**. on SNA). **e**. Conidiation pustule (CMD, 14 days). **f**–**i**. Conidiophores on growth plates (**f**, **g**. effuse conidiation, CMD, 2–3 days; **h**, **i**. pustulate conidiation, SNA, 6 days). **j**–**l**. Conidiophores (SNA, 8 days). **m**, **n**. Phialides (SNA, 8–9 days; **m**. effuse; **n**. from pustules). **o**, **p**. Chlamydospores (CMD, 15 days; **o**. terminal, **p**. intercalary). **q**–**s**. Conidia (SNA, 8–9 days, **q**. from effuse conidiation). **a**–**s**. All at 25°C. Scale bars: **a**–**d**=15 mm. **e**=0.5 mm. **f**, **g**, **j**=20 μm. **h**, **i**=40 μm. **k**, **l**=15 μm. **m**, **q**–**s**=5 μm. **n**–**p**=10 μm

subulate, sometimes sinuous, straight or slightly curved upwards, scarcely swollen, widest mostly below the middle. Conidia (3.4–)4.0–5.6(–7.4)×(2.3–)2.7–3.2(–3.8) μm, l/w (1.2–)1.3–1.9(–2.6) (*n*=122), hyaline to pale green, ellipsoidal or oblong, sides often parallel, smooth, finely multiguttulate or with 1 to few large guttules, scar indistinct.

Effuse conidiation followed and accompanied by conidiation in broad, flat shrubs aggregating to 'hedges' several mm long, arranged in one or few distal wavy concentric zones, first becoming visible after *ca* 6 days at colony sides, white, downy or farinose, with age at most pale yellowish or with a greenish shimmer, pale greenish in the stereomicroscope (also at 15 and 30°C). Shrubs (after 10–13 days) 0.4–0.8(–1) mm diam, fluffy to granular, transparent, of a loose reticulum of thick primary branches 6–8 μm wide in right angles with long fertile main axes; on a thick-walled (1 μm) stipe 9–11(–16) μm wide including outer layer swelling in KOH. Conidiophores (main axes) similar to effuse conidiation to pachybasium-like, 4–8 μm wide, 2.5–4 μm terminally, typically with long stretches from the base sterile and only few, mostly short, 1–4 celled, side branches or phialides along their length; branches concentrated on the apex. Apex typically of few terminal branches and/or phialides or richly branched in dense fascicles forming narrow regular trees to 200 μm long. Short 1–2 celled terminal branches and phialides often paired and slightly inclined upwards, sometimes appearing rough by minute guttules. Branching points sometimes globose, to 10–12 μm wide. Phialides emerging solitary or divergent in whorls of 2–5 on often slightly thickened cells 2.5–5 μm wide. Conidia produced in numerous minute, first wet, soon dry heads <20 μm diam. Phialides (5.5–)7–14(–20)×(2.5–)3.0–4.0(–5.0) μm, l/w (1.6–)2.1–4.1(–6.1), (1.5–)2.2–3(–4) wide at the base (*n*=90), lageniform or conical, rarely ampulliform, straight or curved upwards in dense whorls, widest mostly in or below the middle. Conidia (3.3–)3.8–5.2(–6.3)×(2.5–)2.7–3.2(–3.8) μm, l/w (1.2–)1.3–1.7(–2.1) (*n*=90), subhyaline to pale yellowish green, ellipsoidal, less commonly oblong or subglobose, smooth, finely multiguttulate; scar indistinct, less commonly prominent.

On PDA after 72 h 6–8 mm at 15°C, 24–26 mm at 25°C, 11–20 mm at 30°C; mycelium covering plate after 10–14 days at 25°C. Colony first hyaline, thin, dense, with coarsely wavy margin, not zonate; hyphae with radial arrangement, thin, with low variation in width. Aerial hyphae numerous, thick, several mm long and high, forming strands, uniting into a dense reticulum, radially arranged on the margin, forming a thick mat separated into 2–3 broad zones; with large drops and coilings, finally collapsing. Autolytic activity moderate, coilings frequent. Reverse yellow, golden yellow to brownish from the centre, 3A4–5, 4AB4–6, 5CD7–8. Odour indistinct or faintly coconut-like. Conidiation noted after 2 days, effuse in dense lawns of small shrubs, short and on long aerial hyphae, long steep phialides, colourless, only pale greenish in the centre (stereo-microscope !). At 15°C yellow zones with broad thick, white hairy marginal zone of a reticulum of numerous aerial hyphae forming strands; reverse yellowish, 4A3–4, 4B4–5; conidiation effuse, colourless. At 30°C colony zonate, downy; reverse yellow; conidiation effuse, poor, colourless.

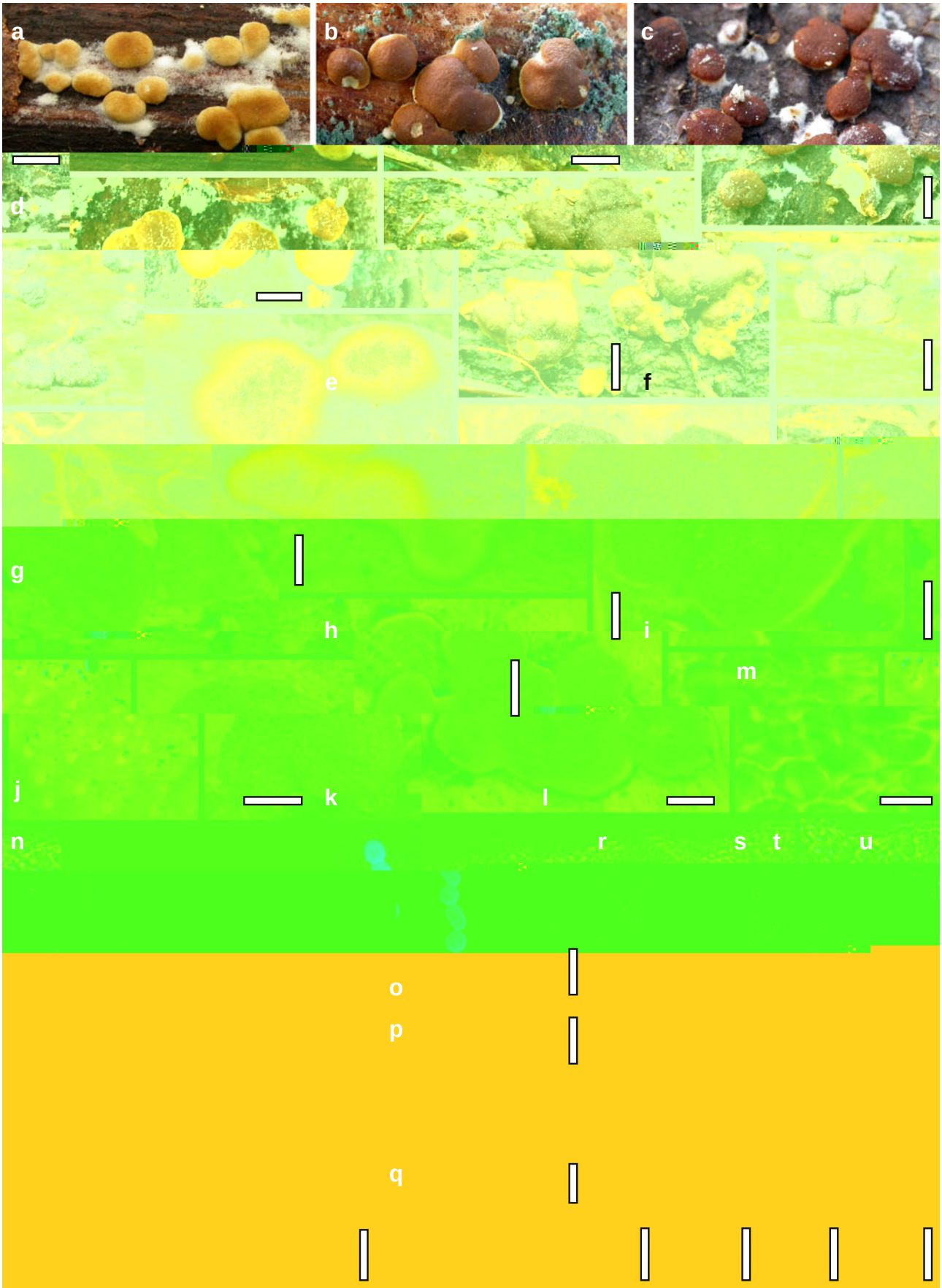
On SNA after 72 h 7–9 mm at 15°C, 21–22 mm at 25°C, 4–16 mm at 30°C; mycelium covering plate after 10–14 days at 25°C. Colony similar to CMD. Aerial hyphae inconspicuous, more frequent along the margin, becoming fertile. Autolytic activity inconspicuous, coilings nearly absent. No diffusing pigment, no distinct odour noted. No chlamydospores seen. Conidiation noted after 2 days, abundant, first effuse, denser than on CMD, more or less evenly distributed on the colony surface or concentrated with distance from the plug; later in shrubs 0.2–0.8 mm diam formed in several narrow, wavy, downy to finely powdery to granular, equidistant concentric zones appearing consecutively, starting in a distal area, densely aggregating to 3–8 mm, becoming light green or grey-green, 1C4–5, 29–30CD5–6, after 6–7 days. Conidiation structures same as on CMD, described above, measurements united. At 30°C growth slow, hyphae becoming multiguttulate, forming pegs, dying soon. Conidiation scant, effuse, simple, colourless.

Habitat: on medium to well-decayed wood and bark of deciduous trees, predominantly *Fagus sylvatica*.

Distribution: Europe (Austria, Denmark, Germany, Netherlands, United Kingdom).

Holotype: **Austria**, Niederösterreich, Wien Umgebung, Pressbaum, Rekawinkel, forest path south from the train station, MTB 7862/1, 48°10′40″ N, 16°01′55″ E, elev. 390 m, on corticated branch of *Fagus sylvatica* 5–6 cm thick, mainly on bark, soc. white mould, effete *Hypoxylon fragiforme*, partly overgrown by a white mould, 18 Oct. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2474 (**WU 29296**, culture CBS 119506=C.P.K. 993). ***Holotype*** of *Trichoderma neorufoides* isolated from WU 29296 and deposited as a dry culture with the holotype of *H. neorufoides* as **WU 29296a**.

Other specimens examined: **Austria**, Niederösterreich, Melk, Loosdorf, Dunkelsteiner Wald, 0.7 km south of Umbach, MTB 7758/4, 48°14′04″ N, 15°25′48″ E, elev. 370 m, on decorticated branch of *Fagus sylvatica* 2–3 cm thick, on wood and bark, soc. *Chaetosphaeria bramleyi*; partly overgrown by a black hyphomycete, holomorph, 5 Oct. 2004, W. Jaklitsch, W.J. 2769 (WU 29303, culture C.P.


a
b
c
d
e
f
g
h
i
m
j
k
l
n
r
s
t
u
o
p
q

◀ **Fig. 10** Teleomorph of *Hypocrea neorufoides*. **a**–**f**. Fresh stromata (**a**, **b**, **d**. immature). **g**–**j**. Dry stromata (**g**, **j**. immature). **k**. Stroma surface in face view. **l**. Rehydrated stroma surface showing ostiolar openings. **m**. Rehydrated stroma. **n**. Perithecium in section. **o**. Cortical and subcortical tissue in section. **p**. Subperithecial tissue in section. **q**. Stroma base in section. **r**–**u**. Asci with ascospores (**u**. in cotton blue/lactic acid). **a**, **f**, **g**. WU 29301. **b**, **j**, **k**, **n**–**q**, **s**. WU 29300. **c**, **h**, **l**, **m**, **r**. WU 29296. **d**, **t**, **u**. WU 29304. **e**, **i**. WU 29302. Scale bars: **a**, **c**, **d**, **f**, **i**, **j**=1.3 mm. **b**, **e**=2 mm. **g**, **h**=0.5 mm. **k**, **r**–**u**=10 μm. **l**=100 μm. **m**=0.8 mm. **n**, **p**=25 μm. **o**, **q**=15 μm

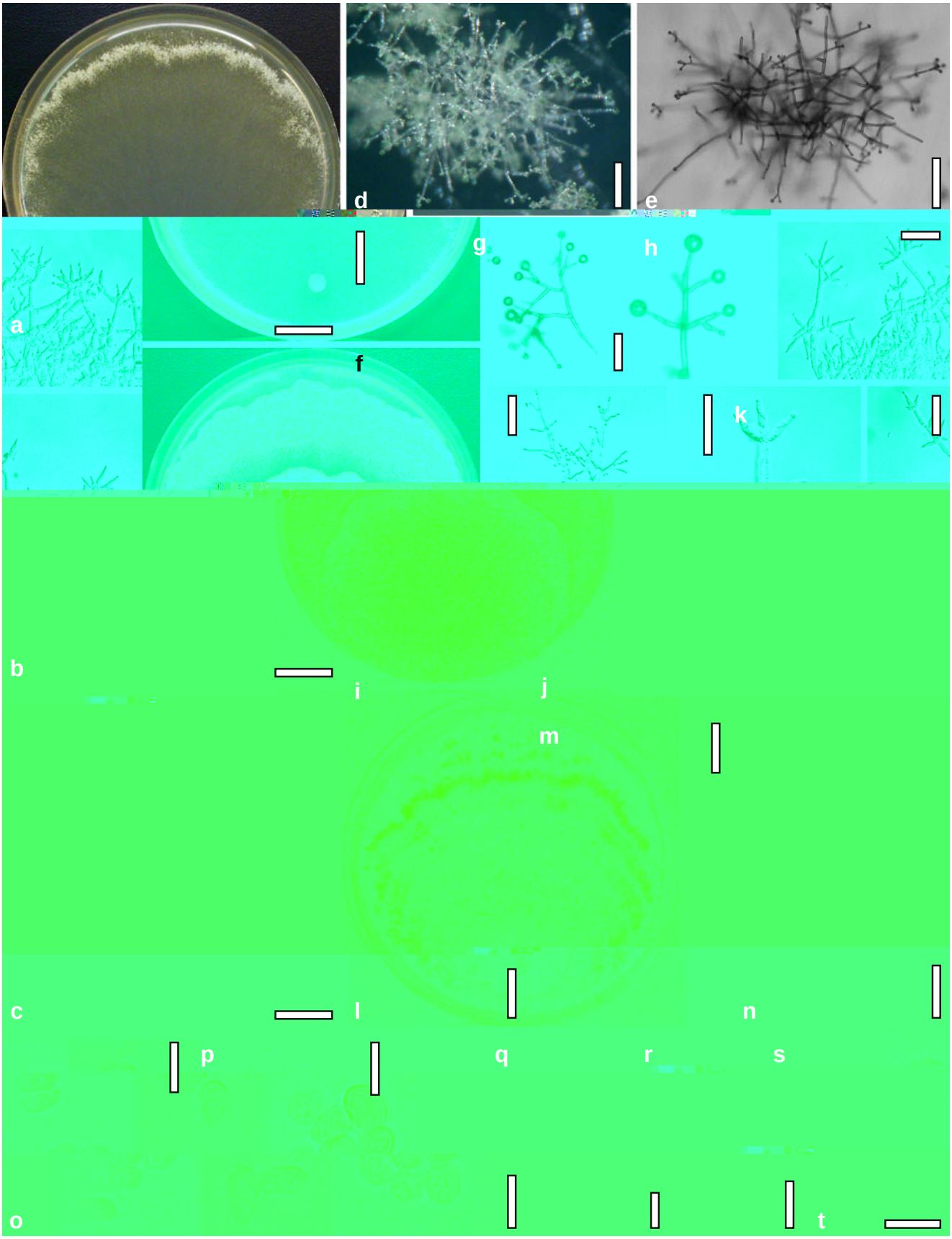
K. 1905). Oberösterreich, Vöcklabruck, Nußdorf am Attersee, close to Aichereben, MTB 8147/3, 47°50′45″ N, 13°30′13″ E, elev. 710 m, on decorticated branch of *Fagus sylvatica* 3 cm thick, on wood, holomorph, 8 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2590 (WU 29297, culture C.P.K. 1898). **Denmark**, Nordjylland, Tversted, Tversted Plantage, 57°35′18″ N, 10°15′19″ E, elev. 10 m, on partly decorticated branches of *Fagus sylvatica* 4–6 cm thick, on wood and bark, soc. white mould, *Hypoxylon fragiforme* with *Polydesmia pruinosa*, holomorph, 24 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2941 (WU 29304, culture C.P.K. 2444). **Germany**, Niedersachsen, Landkreis Soltau-Fallingbostel, Bispingen, Niederhaverbeck, riverine forest in the Lüneburger Heide, 53°08′54″ N, 09°54′38″ E, elev. 90 m, on partly decorticated branches of *Alnus glutinosa* 2–4 cm thick, on wood, holomorph, 26 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2950 (WU 29305, culture C.P.K. 2451). **Netherlands**, Gelderland, Otterlo, National Park De Hoge Veluwe, close to the hunting castle St. Hubertus, 52°07′15″ N, 05°49′47″ E, elev. 45 m, on mostly decorticated branch of *Fagus sylvatica* 5 cm thick, on wood, 18 Sep. 2004, H. Voglmayr, W. Jaklitsch & W. Gams, W.J. 2728 (WU 29302, culture C.P.K. 1904). **United Kingdom**, Buckinghamshire, Slough, Burnham Beeches, 51°33′08″ N, 00°37′56″ W, elev. 30 m, on partly decorticated branches of *Fagus sylvatica* 4–5 cm thick, on wood and bark, soc. *Tubeufia cerea* on an effete pyrenomycete, white mould, mostly old, holomorph, 15 Sep. 2004, W. Jaklitsch, W.J. 2718 (WU 29301, culture C.P.K. 1902). Same area, on partly decorticated branches of *Fagus sylvatica* 2–3 cm thick, on wood and bark, holomorph, 15 Sep. 2004, W. Jaklitsch, W.J. 2719 (combined with WU 29301, culture CBS 119505=C.P.K. 1903). Same area, 51° 33′34″ N, 00°37′41″ W, elev. 40 m, on partly decorticated branches of *Fagus sylvatica* 5–6 cm thick, on well-decayed wood and bark, soc. *Hypoxylon fragiforme*, resupinate polypores, holomorph, 15 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3165 (WU 29306, culture C.P.K. 3153). Norfolk, Thetford, Thetford National Forest Park, north of the town, MTB 35-30/4, 52°26′26″ N, 00°43′55″ E, elev. 30 m, on corticated branch of *Fagus sylvatica* 4 cm thick, on bark, soc. *Lopadostoma turgidum*, mostly old, holomorph, 13 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2707 (WU 29298, culture C.P.K. 1899). Same region, shortly before Lynford coming from Thetford, MTB 35-30/1, 52°28′54″ N, 00°41′01″ E, elev. 30 m, on corticated branch of *Fagus sylvatica* 4–5 cm thick, on bark, few stromata on wood below loose bark, and on a Corticiaceae, soc. effete *Diatrypella cf. verruciformis*, holomorph, 13 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2709 (WU 29299, culture C.P.K. 1900). Thetford, Emilys Wood, near Brandon, MTB 35-31/2, 52°28′08″ N, 00°38′20″ E, elev. 20 m, on partly decorticated branch of *Fagus sylvatica* 3 cm thick, mainly on wood, and a white Corticiaceae, soc. *Hypocrea minutispora* and *Trichoderma stilbohypoxyli*, holomorph, 13 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2713 (WU 29300, culture C.P.K. 2357). Same area, on partly decorticated branches of *Fagus sylvatica* 3–4 cm thick, on bark and wood, soc. *Hypocrea minutispora*, holomorph, 13 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2714 (combined with WU 29300, culture C.P.K. 1901).

Notes: *Hypocrea neorufoides* is closely related to *H. neorufa*. The teleomorphs of these species are indistinguishable. *H. neorufoides* is widespread in Europe and more common than *H. neorufa*, particularly in southern England and eastern Austria. Morphologically these species establish an intermediate position between *Trichoderma* sect. *Trichoderma* and the pachybasium core group, deviating from other species of the first section in more distinct surface cells and in a yellow perithecial wall, and in thick, i.e. pachybasium-like conidiophores. Contrary to *H. neorufa* the conidiation in *T. neorufoides* develops continuously from effuse and verticillium-like to a pachybasium-like shrub conidiation without statistically significant differences in the sizes of phialides and conidia. Nevertheless, both measurements are given in order to highlight the differences to *H. neorufa*. Additional differences from *H. neorufa* are a lower growth optimum, particularly on SNA and PDA, a different macroscopic growth pattern on PDA, larger and more variable conidia and slightly longer phialides. The pigmentation of the reverse on PDA is distinctly less pronounced than in *H. neorufa*. The shrub conidiation of *H. neorufoides* on CMD often disappears after several transfers and only simple effuse conidiation remains.

Hypocrea ochroleuca Berk. & Ravenel, Grevillea 4: 14 (1875). Fig. 12
Anamorph: *Trichoderma* sp. Fig. 13

Stromata when fresh 2–33×(1–)7–12 mm, 0.5–1 mm thick, widely effuse, entirely attached, of a white mat with indeterminate growth, containing greyish orange to brown orange, 6B5–6 to 6C7–8, fertile patches in varying configurations; margin mycelial, fimbriate, white.

Stromata when dry (2–)5–23(–33)×(1–)3–15(–21) mm (n=37), 0.15–0.4 mm thick (n=20), widely and thinly effuse, following bark contours, with white margin; outline


d
e
a
g
h
f
k
b
i
j
m
c
l
n
p
q
r
s
o
t

◀ **Fig. 11** Cultures and anamorph of *Hypocrea neorufoides*. **a**–**c**. Cultures (**a**. on CMD, 21 days; **b**. on PDA, 21 days; **c**. on SNA, 14 days). **d**, **e**. Conidiation shrubs (**d**. SNA, 11 days; **e**. CMD, 10 days). **f**, **g**. Conidiophores of effuse conidiation on growth plates (SNA, 4–9 days). **h**, **k**–**n**. Conidiophores from shrubs; **h**. SNA, 9 days; **k**–**n**. CMD, 13 days). **i**, **j**. Conidiophores of effuse conidiation (CMD, 9 days). **o**–**q**. Phialides from shrubs (SNA, 9 days;). **r**–**t**. Conidia (CMD; **r**, **s**. from effuse conidiation, 6–12 days; t. from shrubs, 11 days). **a**–**t**. All at 25°C. **a**–**h**, **o**, **q**, **s**–**t**. CBS 119506. **i**, **j**. C.P.K. 2357. **k**, **n**. C.P.K. 1900. **r**. C.P.K. 2451. Scale bars: **a**–**c**=15 mm. **d**, **e**=100 μm. f=50 μm. g, j, l, m=20 μm. h, i, k=30 μm. n–q=10 μm. r–t=5 μm

variable; perithecia immersed, irregularly scattered, aggregated in patches. Surface velvety when young, later smooth, with inconspicuous, minute, plane, rarely convex, light ostiolar dots (20–)25–40(–47) μm (*n*=30) diam only seen under high magnification; surface around dots sometimes cracked in stellate configuration. Stromata white, fertile patches brown-orange, light brown, 6CD6–8. Spore deposits white. Rehydrated stromata with more distinct hyaline ostiolar openings, not changing colour in 3% KOH.

Stroma anatomy: Ostioles (65–)72–92(–102) μm long, plane or projecting to 17 μm, (22–)27–41(–45) μm wide at the apex (*n*=20), periphysate, without differentiated apical cells. Perithecia (130–)150–185(–195)×(125–)140–180(–195) μm (*n*=20), flask-shaped or subglobose, loosely disposed, sometimes crowded, often slightly projecting including covering cortex; peridium (11–)13–17(–20) μm (*n*=40) thick at the base and sides, hyaline. Cortical layer (15–)17–27(–35) μm (*n*=30) thick, mostly only present above the perithecia and their surroundings, a *t. angularis* of thin-walled, angular, globose or ellipsoidal cells (3–)4–7(–9)×(2–)3–5 μm (*n*=60) in face view and in vertical section, yellow to golden-brown, gradually lighter to subhyaline downwards. Hairs on mature stromata (7–)11–22(–29)×(2.5–)3–4(–4.5) μm (*n*=20), 1–2 celled, cylindrical, subhyaline to pale brown, smooth or verruculose, unevenly distributed on the stroma surface, sometimes mixed with undifferentiated hyphae. Subcortical tissue a dense *t. intricata* of hyaline thin-walled hyphae (2–)3–6(–7.5) μm (*n*=30) wide. Subperithecial tissue a dense *t. angularis* of thick-walled refractive cells (3–)5–11(–15)×(3–)4–7(–9) μm (*n*=30), stratified, i.e. interrupted by a denser, narrow, horizontal, hyaline hyphal layer; also at the base intermingled with thick-walled hyaline hyphae. Asci (80–)85–103(–118)×5.0–6.5(–8.0) μm, stipe (6–)8–26(–40) μm (*n*=30); no croziers seen. Ascospores hyaline, verrucose or spinulose, warts to 0.5 μm high and wide; cells dimorphic; distal cell (3.3–)3.5–4.5(–5.0)×(3.3–)3.5–4.3(–5.0) μm, l/w 0.9–1.1(–1.5) (*n*=30), globose to ellipsoidal; proximal cell (3.5–)4.0–5.5(–6.2)×(2.5–)3.0–3.8(–4.3) μm, l/w (1.1–)1.2–1.7(–2.3) (*n*=30), oblong or wedge-shaped, sometimes subglobose; at the septum often flattened.

Cultures and anamorph: optimal growth at 25°C on all media, poor growth at 30°C; no growth at 35°C.

On CMD after 72 h 11–13 mm at 15°C, 29–31 mm at 25°C, 2–5 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony hyaline, thin, loose; margin irregularly wavy; mycelium cobweb-like, of thin hyphae with little variation in width and irregular orientation, not distinctly radial. Aerial hyphae inconspicuous, becoming fertile; more frequent on the distal margin, causing a long persistent white margin. Autolytic excretions and coilings absent or rare; autolytic excretions abundant at 30°C. No diffusing pigment noted; odour indistinct. Chlamydospores rare, noted after 3–6 days. Conidiation noted after 1 days, abundant, effuse, on simple conidiophores spread in a lawn, on thick long aerial hyphae, and in short complex shrubs to 0.5 mm diam and height spreading from the centre across the entire colony, concentrated in finely powdery or granular, indistinct concentric or radial zones, after 3 days turning bluish green to grey-green from the proximal margin, 26–27DE4–6, finally dark green, 26F5–8, denser on lateral and distal margins, forming a continuous aggregate, and only few irregularly distributed individual shrubs growing to pustules 1–1.5 mm diam; soon dry, degenerating from the centre and proximal margin, with conidia adhering in chains, with new shrubs emerging at the same time. Conidiophores mostly symmetric, verticillium- to trichoderma-like, similarly in more simple solitary forms to *ca* 180 μm diam, often forked or branched close to the base, only scarcely re-branching into steep long branches, and in shrubs more richly, broader and more densely branched than solitary conidiophores. Shrubs consisting of a thick-walled (1–2.5 μm) stipe 6–7 μm wide, with several unpaired primary branches (=main axes) 5–6 μm wide in right angles. Main axes typically forming long slender conidiophores with narrow side branches loosely disposed, paired or unpaired, long at lower levels, shorter with distance from the base, in right angles or more commonly slightly inclined upwards. Phialides solitary, often paired, or divergent in whorls of 2–5, mostly 3, on often widened cells 2–3 μm wide. Conidia formed in minute dry heads. Phialides (5.5–)7–13(–18)×(2.3–)2.5–3.2(–3.8) μm, l/w (1.8–)2.4–5(–7), (1.3–)1.5–2.3(–2.8) μm wide at the base (*n*=65), lageniform, often subulate in the middle of the whorls, rarely ampulliform, straight or slightly curved, necks often narrow, long; widest point in variable positions. Conidia (2.5–)3.2–4.5(–5.5)×(2.0–)2.5–3.0(–3.2) μm, l/w (1.0–)1.2–1.7(–1.9) (*n*=30), yellowish green, ellipsoidal, oval or oblong, smooth, with several minute guttules; scar indistinct; often agglutinated in dense packets or chains. At 15°C conidiation similar to 25°C in shrubs arranged in several flat, powdery greenish concentric zones. At 30°C colony finely zonate, conidiation effuse, scant; autolytic excretions frequent, minute.

On PDA after 72 h 10–12 mm at 15°C, 27–30 mm at 25°C, 2–3 mm at 30°C; mycelium covering the plate after 7–8 days

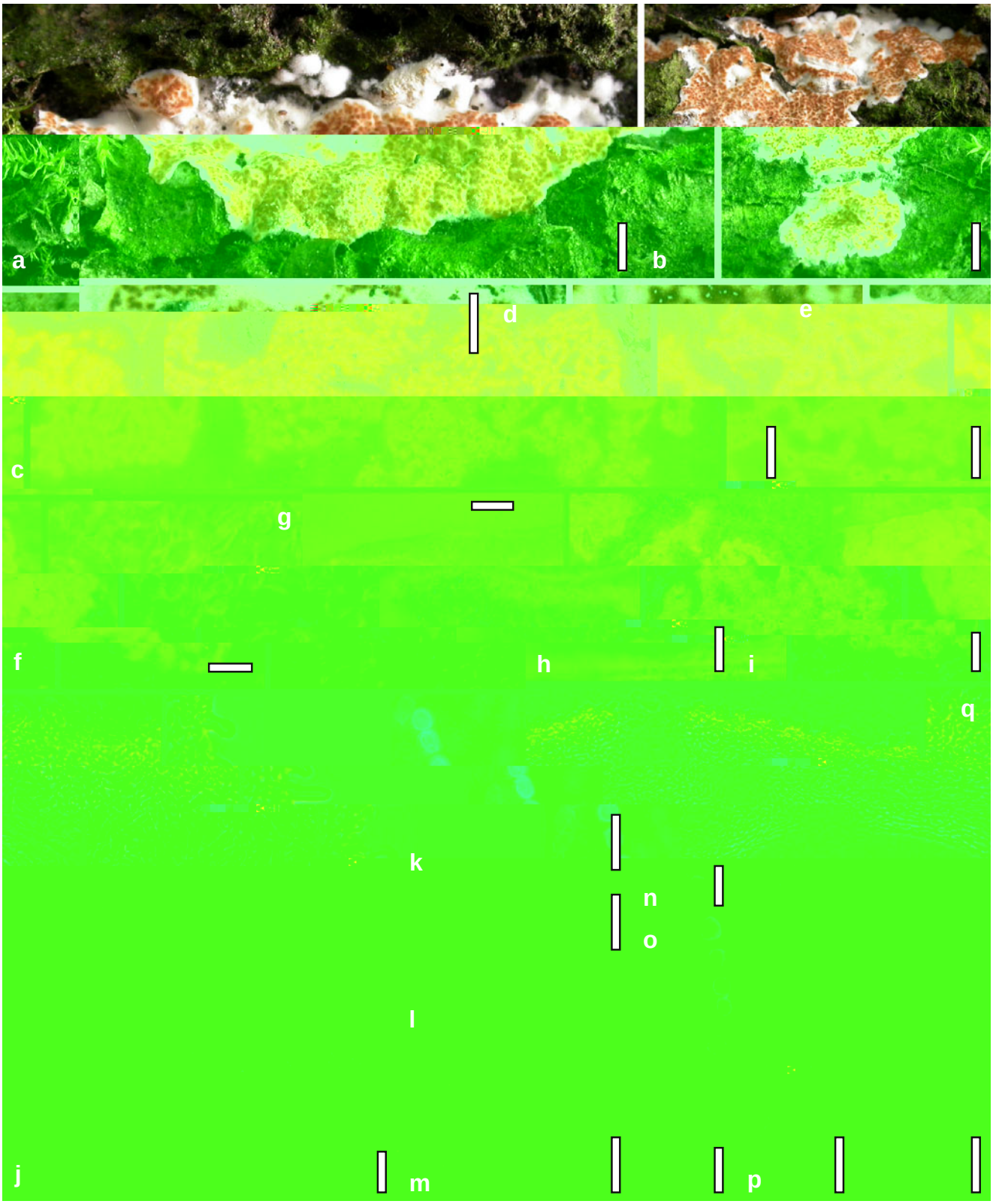


Fig. 12 Teleomorph of *Hypocrea ochroleuca*. **a**, **b**. Fresh stromata. **c**, **d**, **f**, **g**. Dry stromata (**f**. vertical section showing layered subperithecial tissue). **e**, **h**. Stromata in 3% KOH after rehydration. **i**. Stroma surface in face view. **j**. Perithecium in section. **k**. Cortical and subcortical tissue in section. **l**. Subperithecial tissue in section. **m**. Stroma base in section. **n**. Hairs on the stroma surface. **o**. Ascospores. **p**, **q**. Asci with ascospores (**q**. in cotton blue/lactic acid). **a**–**f**, **h**–**q**. WU 29310. **g**. holotype K 56075. Scale bars: **a**=1.5 mm. **b**=2.5 mm. **c**=1 mm. **d**, **e**, **g**, **h**=0.5 mm. **f**=150 μm. **i**, **o**=5 μm. **j**, **k**, **m**=20 μm. **l**, **n**, **p**, **q**= 10 μm

at 25°C. Colony circular, dense, hyphae thin except for wider marginal surface hyphae. Aerial hyphae frequent, mostly short and erect, becoming fertile; at the margin long, forming radial strands. Autolytic excretions frequent on surface hyphae within the colony, coilings moderate to frequent. No diffusing pigment noted; reverse pale yellowish, 3–4A3, to greenish due to translucent conidiation, dull yellowish brown, 4B4–5, 5C6–7, below mycelial aggregations. Odour indistinct or like fermenting fruits. Conidiation noted after 1 days, abundant, effuse, on short, mostly symmetric, verticillium- to trichoderma-like conidiophores as on CMD, also on aerial hyphae to 2 mm high, starting around the plug, spreading across the entire colony, eventually arranged in several broad, flat, indistinctly separated, concentric zones, with the distal margin long remaining white, cottony. Surface of the conidiation zones finely granular to floccose, after 2 days greyish green, 27DE4–7, 28D5–6, 27C4–5, after 10–14 conidiation also in some coarse mycelial spots or fluffy tufts; soon degenerating/collapsing from the centre. At 15°C conidiation similar, abundant. At 30°C growth poor, hyphae dying soon, autolytic excretions abundant, conidiation effuse, scant.

On SNA after 72 h 10–11 mm at 15°C, 25–27 mm at 25°C, 2–3 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony similar to CMD apart from thick marginal surface hyphae. Autolytic excretions and coilings common. No diffusing pigment noted; odour indistinct. Chlamydospores noted after 5–9 days, uncommon, irregularly distributed, after 22 days (5–)6–11(–16)×(3–)4–8(–11) µm, l/w (1.0–)1.1–1.7(–2.1) (n=20), terminal and intercalary, globose or angular, smooth. Conidiation noted after 1 days, effuse, starting around the plug, simple, verticillium-to trichoderma-like, short, to 2 mm high on aerial hyphae along the colony margin, and in loose shrubs to 0.5 mm diam with regularly symmetric trichoderma-like conidiophores, spreading across the entire colony, greyish green, 26–27E4–6, after 3–4 days, later to dark green to 26F5–8, arranged in finely granular to powdery radial patches and eventually concentrated in distal areas of the colony, there also some small pustules to 1 mm diam formed. Conidia produced in minute dry heads, soon degenerating, adhering in chains or agglutinated in dense clumps, with a concomitant emergence of fresh shrubs. At 15°C conidiation in shrubs with looser branching than on CMD, appearing as a green, 26–27E4–6, powder in fine concentric zones; autolytic excretions frequent. At 30°C growth poor, hyphae dying soon, autolytic excretions frequent, minute, conidiation effuse, scant.

Habitat: on bark, possibly associated with other fungi.

Distribution: Europe, North America.

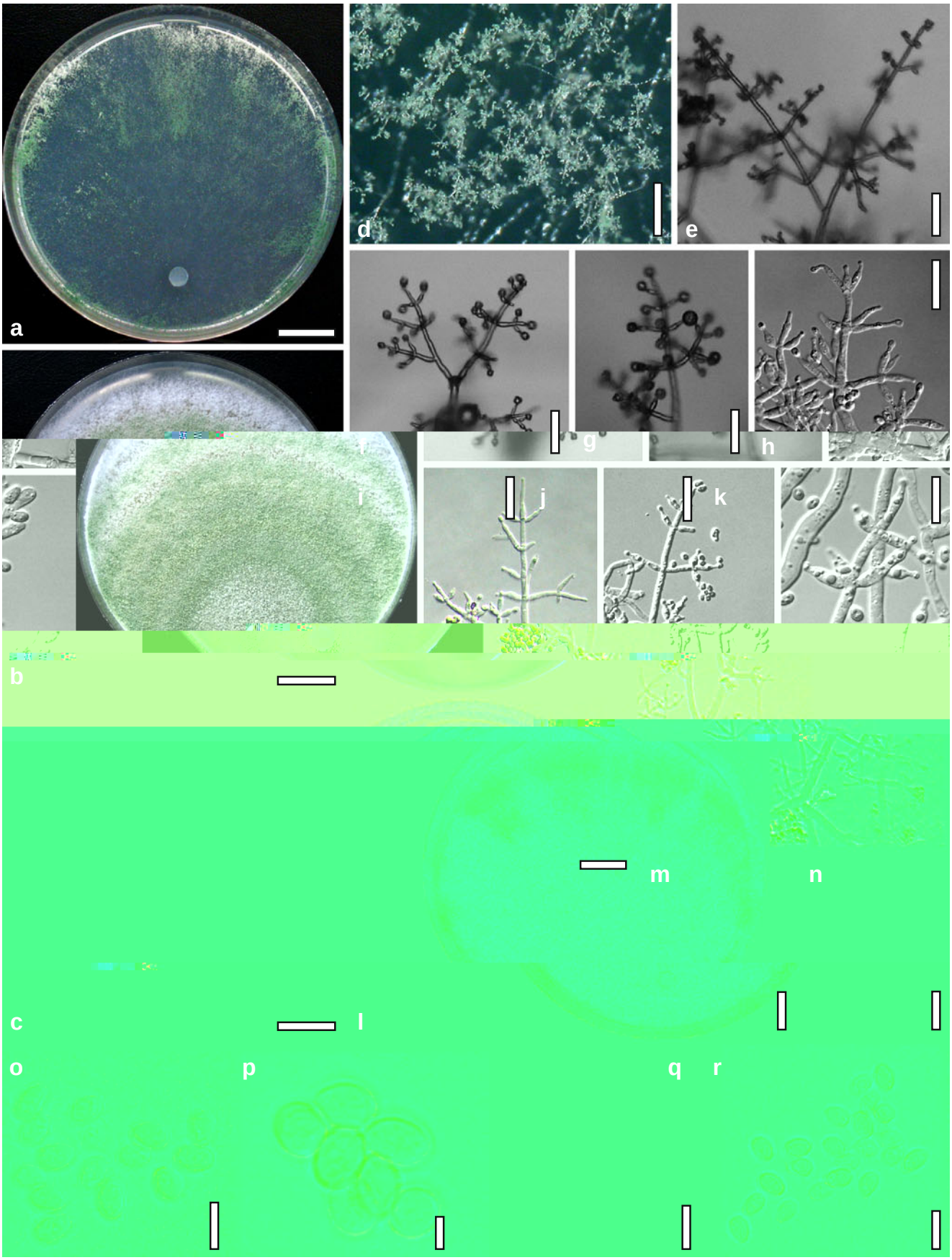
Holotype: **USA**, South Carolina, unlocalised, on trunk of *Myrica cerifera*, partly soc. *Hymenochaete* sp. and a pyrenomycete in the bark, H.W. Ravenel 1382 (K 56075).

Other material examined: **United Kingdom**, North East London, Epping Forest, Strawberry Hill Ponds, MTB 43-34/1, 51°39′01″ N, 00°02′34″ E, elev. 30 m, on corticated log of *Betula pendula* 17 cm thick, on bark, soc. *Annulohypoxylon multiforme*, holomorph, anamorph dark green, teleomorph largely immature; cultured from ascospores and conidia, 16 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2725 (WU 29310, culture CBS 119502=C.P.K. 1895).

Notes: *Hypocrea ochroleuca* was originally described from South Carolina, USA. The British collection agrees perfectly in teleomorph morphology with the holotype. However, due to the lack of any specimen collected recently in the USA, the British collection is only tentatively named *H. ochroleuca*. The material is therefore not used to epitypify the species, nor is the anamorph formally described as a new taxon. The situation is complicated by the Asian *Hypocrea albofulva* Berk. & Broome (J. Linn. Soc., Bot. 14(2): 113 (1875)), which agrees morphologically with *H. ochroleuca*, apart from a slight difference in ascospore size (G.J. Samuels, pers. comm.). Several isolates of specimens collected in Thailand (G.J. Samuels, pers. comm.) differ in ITS sequences consistently in a single nucleotide from the British isolate, while *tef1* and *rpb2* sequences deviate more distinctly. The strains G.J.S. 01-234 and G.J.S. 01-265, with gene sequences deposited in GenBank are assignable to *H. albofulva* rather than to *H. ochroleuca*. It is still possible that these species are conspecific, as Y. Doi annotated on the holotype of *H. ochroleuca*. Also the conidiophores, phialides and conidia illustrated by Doi (1972, p. 736) for a Japanese isolate of a fungus determined by him as *H. albofulva* agree well with the anamorph of the British isolate. However, proof of conspecificity requires fresh North American material.

Hypocrea ochroleuca is obviously rare in north temperate regions. It is a typical member of *Trichoderma* sect. *Trichoderma* except for the large effuse stromata. The conidiation in culture persists for a long time, because several new generations of shrubs develop after the collapse of older ones.

The holotype of *Hypocrea ochroleuca* consists of two pieces of bark with effuse stromata. Growth indeterminate, stromata widely effuse. Largest stroma *ca* 46×12 mm, effluent, disintegrated into many smaller angular part stromata (0.5–)0.8–11.5(–25)×0.5–7(–12) mm (n=17), 0.1–0.2 mm thick, entirely attached when young, margin of white mycelium; in older stromata margin free or elevated, white mycelium between fertile patches and part stromata. Surface smooth to somewhat tubercular, velvety, with perithecia partly convex, solitary or in groups, gregarious in lawns. Ostiolar dots (30–)35–70(–95) µm (n=30) diam, plane or convex, reddish under strong magnification, shiny, distinct, with a circular perforation 10 µm diam. Surface unevenly pigmented, whitish to yellowish and light to dull brown, 4A3(–4), 5A3, 5B4, 5CD4–6 in fertile areas, lively orange-, reddish


a
d
e
g
h
i
j
k
b
m
n
c
l
o
p
q
r

brown. Stromata KOH-; with numerous short hyaline rounded

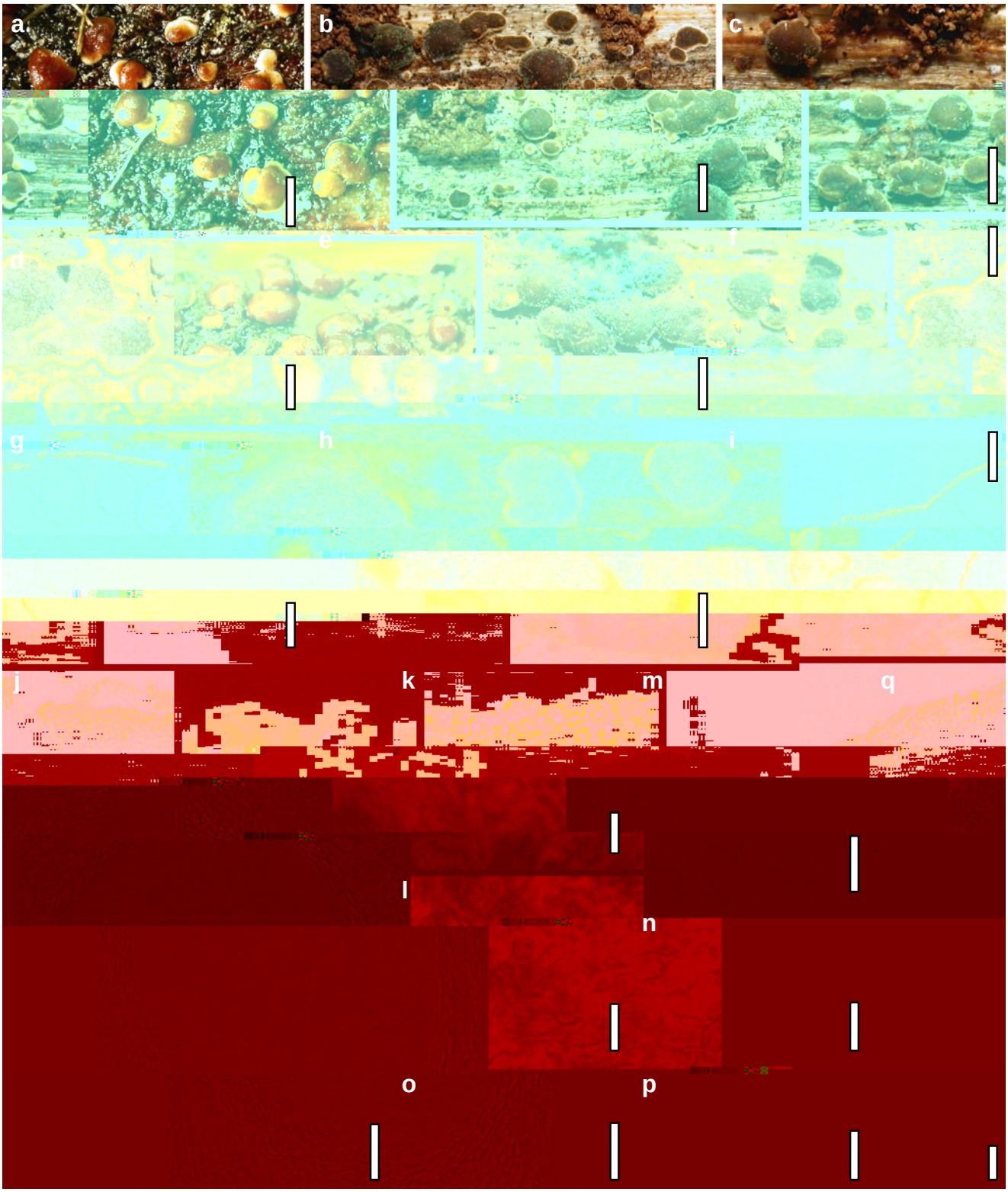
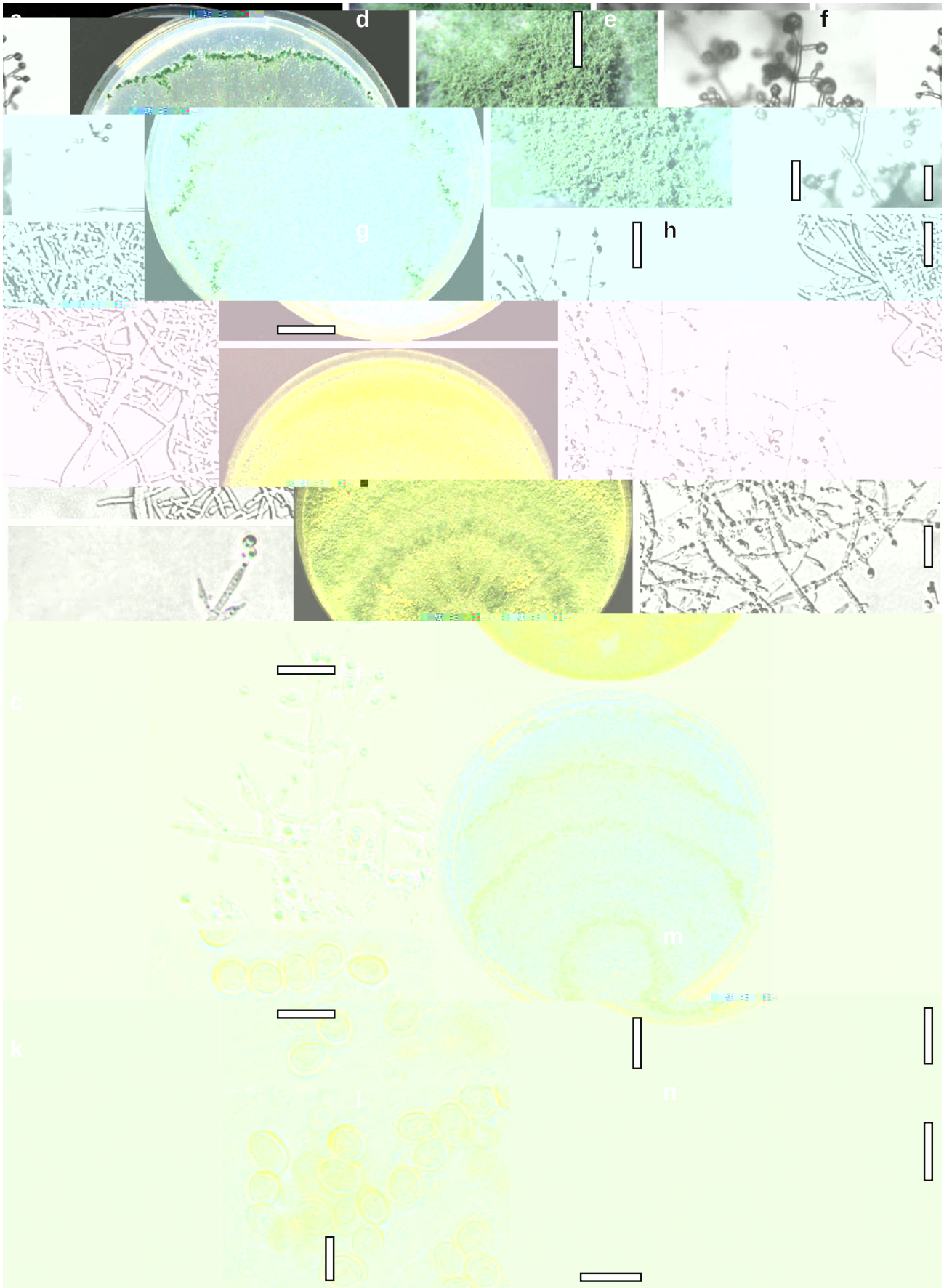


Fig. 14 Teleomorph of *Hypocrea petersenii*. **a–e**. Fresh stromata (most immature; **a, d**. wet; **e**. showing also the anamorph). **f, g, i**. Dry stromata (**f**. early subeffuse stage). **h**. Part of stroma in section**. j**. Perithecium in section. **k**. Curved hairs. **l**. Cortex in face view. **m**. Cortical and subcortical tissue in section. **n**. Subperithecial tissue in section. **o, p**. Ascospores. **q.** Ascus. **a, d**. WU 29398. **b, c, e, f**. WU 29397**. g–q.** WU 29396. Scale bars: **a**, **c–e**=1.3 mm. **b**=2 mm**. f**, **g**= 0.7 mm. **h**=0.2 mm. **i**=0.3 mm. **j**=30 μm**. k**, **l, o–q**=5 μm. **m, n**= 15 μm


d
e
f
g
h
c
k
l
m
n

◀**Fig. 15** Cultures and anamorph of *Hypocrea petersenii* (CBS 119507). **a**–**c**. Cultures after 7 days (**a**. on CMD, **b**. on PDA, **c**. on SNA). **d**. Conidiation tuft (12 days). **e**, **f**. Conidiophores on growth plates (3 days; **e**. on SNA). **g**. Conidiophores on tuft margin. **h**. Stipe and primary branches of conidiation tuft. **i**, **j**. Conidiophores. **k**, **l**. Phialides. **m, n**. Conidia. **a**–**n**. At 25°C. **d**–**n**. On CMD except **e**. **g**–**n**. After 5–6 days. Scale bars: **a**–**c**=15 mm. **d**=0.3 mm. **e**, **f**=30 μm. **g**, **h**=20 μm. **i**, **j**, **l**=10 μm. **k**, **m**, **n**=5 μm

(*n*=62), broadly ellipsoidal or oval, green, smooth, finely multiguttulate; scar indistinct. At 15°C colony not or faintly zonate; conidiation in numerous tufts or pustules 0.7–2 mm diam mostly in a broad marginal zone, greenish after 7–8 days, green, 26DE5–6, 26F6, after 14 days. At 30°C little mycelium on the surface; conidiation on aerial hyphae and in irregular pustules to 2 mm long, arranged in several incomplete concentric zones, greenish after 4 days, turning dark green.

On PDA after 72 h 14–16 mm at 15°C, 39–42 mm at 25°C, 35–38 mm at 30°C; mycelium covering the plate after 5 days at 25°C. Colony circular, compact, dense, aerial hyphae frequent, particularly at the distal margin. Autolytic activity low to moderate, coilings inconspicuous. No diffusing pigment produced; reverse greenish yellow, 1CD6–8, due to translucent conidiation. Odour indistinct. Conidiation noted after 1–2 days, in densely aggregated erect shrubs with regular trees, dense, thick, white, in 2–4 concentric zones, also in tufts 0.5–1 mm diam spreading from the centre; green, 29CD5–6, from the proximal margin and centre after 3 days, zones with varying tones of yellow-green or green. At 15°C colony centre yellow 2A2–3 after 6 days; conidiation seen after 3 days, distinctly decreased, in shrubs and on aerial hyphae, white, fluffy, thick, in several zones, greenish after 7–9 days, green, 27D4–6, in the centre after 14 days. At 30°C colony circular, shiny; hyphae thick; autolytic activity increased to conspicuous, surface white, downy. Conidiation after 2 days in the central zone, effuse, abundant, thick, dense, white, later forming several bright (yellow-)green zones, eventually dark green.

On SNA after 72 h 16–17 mm at 15°C, 39–41 mm at 25°C, 30–35 mm at 30°C; mycelium covering the plate after 5–6 days at 25°C. Colony similar to CMD, but with more aerial hyphae, hyphae thick. Autolytic activity absent to moderate, coilings inconspicuous. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 13–14 days at 25°C, uncommon. Conidiation noted after 2 days, green after 3 days, in steep erect shrubs and fluffy tufts, less on aerial hyphae; starting at the proximal margin, later in up to eight concentric zones of thick pustules 0.4–1.5 mm diam, aggregating to 7×2.5 mm, some pustules also between the zones, pustules turning green from inside. At 15°C pustules to 2 mm diam, aggregating to 7×3.5 mm, formed in several incomplete concentric zones, fluffy, green after 7 days from the proximal margin, dark green, 27E4–6, after 14 days. At 30°C colony with a broad white downy marginal zone; reverse yellow-green, 3BC5–6, after 7 days. Conidiation seen after 2 days, effuse on irregularly disposed aerial hyphae, and after 3 days in thick tufts or pustules to 3.5× 2.5 mm in several concentric zones, green after 3 days.

Habitat: on medium-decayed wood and bark of deciduous trees.

Distribution: North America (common in the East), Europe (uncommon).

Holotype: **USA**, Tennessee, Great Smoky Mts. National Park, vic. Cosby, Maddron Bald Track, 35°46′ N, 83°16′ W, elev. 500 m, 12 July 2004, on decorticated wood (?*Tsuga*), G.J. Samuels (BPI 864092A; holotype of *T. petersenii* dry culture BPI 864092B; ex-type culture G.J.S. 04-355=CBS 119051; not examined).

Material examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, Drau-Auen, path south from the road to Dullach, MTB 9452/1, 46°32′51″ N, 14°24′32″ E, elev. 410 m, on branch of *Salix caprea* 3 cm thick, on wood, on/soc. *Hypoxylon perforatum*/*Immotthia atrograna*, soc. *Ionomidotis fulvotingens*, holomorph, teleomorph largely immature, 6 Sep. 2003, W. Jaklitsch, W.J. 2386 (WU 29396, culture CBS 119507=C.P.K. 953). **Germany**, Bavaria, Landkreis Traunstein, Grabenstätt, south from Winkl and the A8, MTB 8141/3, 47°48′50″ N, 12°31′05″ E, elev. 530 m, on partly decorticated log of *Alnus glutinosa* 9 cm thick, on wood, soc. *Inonotus radiatus*, holomorph, teleomorph immature, culture from conidia, 4 Sep. 2005, W. Jaklitsch, H. Voglmayr & W. Klofac, W.J. 2841 (WU 29397, culture C.P.K. 2413). Hessen, Landkreis Fulda, Rhön, Rotes Moor, between Gersfeld and Wüstensachsen, from the parking place Moordorf at the B 278 heading to the peat bog, 50°27′35″ N, 09°58′59″ E, elev. 810 m, on branch of *Salix* sp. 1–3 cm thick, mostly on bark, attacked by a white hyphomycete, soc. *Xylaria hypoxylon* and moss, immature, 29 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2957 (WU 29398).

Notes: *Hypocrea petersenii* is uncommon if not rare in Europe and has been only found in wet habitats like riverine forests preferring species of *Salix* and *Alnus*, although it occurs commonly and sympatrically with *H. rogersonii* in diverse habitats on various trees in the Eastern USA (G.J. Samuels, pers. comm.). In Europe, *H. rogersonii* is found in beech forests. *Hypocrea petersenii* shares dark brown stromata with *H. neorufa*, *H. neorufoides* and *H. subeffusa*. The first two species can be distinguished from *H. petersenii* by yellow perithecial walls and pachybasium-like anamorphs, while *H. subeffusa* does not form distinctly pulvinate stromata, has more violet colour tones, and differs also in culture and anamorph characteristics like characteristic coilings, slower growth and lack of concentric zones of distinct conidiation tufts. Both Central European isolates of *H. petersenii*

produced a characteristic, intense yellow colour on CMD not seen in any other species upon prolonged storage at 15°C.

Hypocrea rogersonii Samuels, Stud. Mycol. 56: 125 (2006a). Fig. 16
Anamorph: ***Trichoderma rogersonii*** Samuels, Stud. Mycol. 56: 125 (2006a). Fig. 17

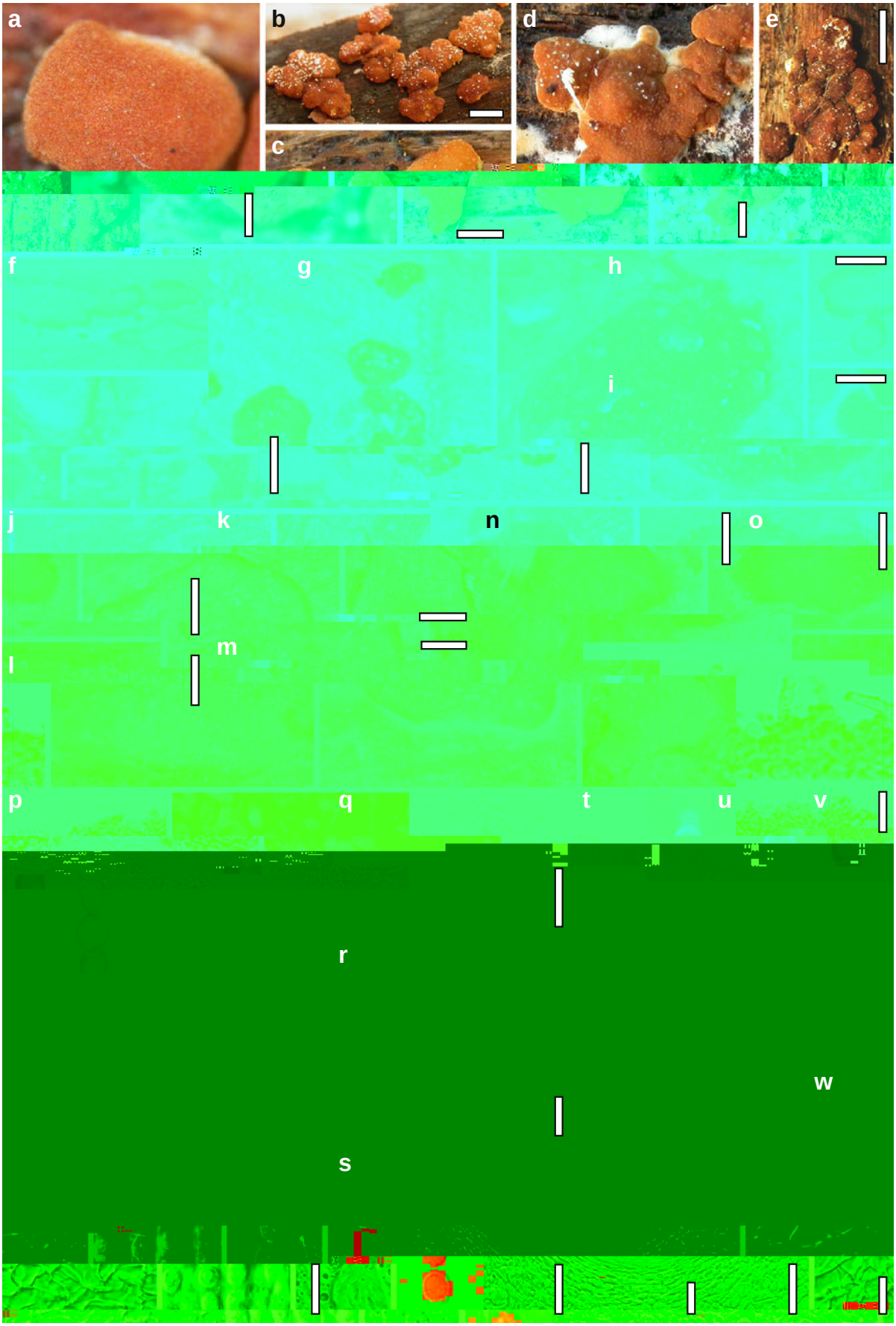
Stromata when fresh 1–8(–20) mm long, to *ca* 1 mm thick, solitary, gregarious or aggregated, generally in small numbers, thinly effuse, discoid or pulvinate; outline variable. Margin often white when young, first attached, cottony, later concolorous, free, sometimes irregularly crenate. Stroma surface velutinous, smooth or tubercular, typically without ostiolar dots; ostioles invisible or appearing as minute, inconspicuous light dots under high magnification. Perithecia entirely immersed, sometimes translucent as dark, indistinct, diffuse dots. Stromata first white, then yellow, ochre, orange to orange-brown with brown or rust hairs, 6B6–7, 6C7–8, 7CD6–8, 8CD5–6; white, sometimes yellowish inside. Spore deposits white.

Stromata when dry 0.5–4(–20)×0.4–2(–4) mm, 0.15–0.3 (–0.4) mm (*n*=30) thick, thinly effuse, discoid or flat pulvinate; outline variable, mostly oblong, angular or lobed; broadly attached. Margin first white or yellowish, cottony, attached, becoming free. Surface smooth, tubercular or wrinkled, velvety or hairy. Ostioles typically invisible, under high magnifications appearing as light or concolorous dots, sometimes slightly projecting to semiglobose; sometimes dark dots (23–)30–54(–63) µm (*n*=30) diam visible. Colour when young pale orange with white margin, turning yellow-brown, orange-brown to medium brown 5CD6–8, 6CD7–8, 6E6–8, finally dark orange-brown to reddish brown, dark brown 7–8CF6–8. Spore deposits white. Mature stromata slightly thicker upon rehydration; not changing or turning reversibly slightly darker reddish brown in 3% KOH.

Stroma anatomy: Ostioles (52–)63–93(–102) µm long, plane or projecting to 25(–32) µm, (30–)40–60(–65) µm wide at the apex (*n*=20), with an apical palisade of hyaline, narrowly clavate cells. Perithecia (210–)225–265(–270)× (150–)170–230(–250) µm (*n*=20), globose or ellipsoidal; peridium (17–)21–27 µm (*n*=20) thick at the base, (10–) 13–20(–23) µm (*n*=20) thick at the sides, hyaline. Cortical layer (17–)20–32(–47) µm (*n*=30) thick, an orange *t. angularis* of small thick-walled angular, globose or oblong cells (2.5–)4.0–8.0(–9.5)×(2.2–)3.0–5.5(–6.5) µm (*n*=30) in face view and in vertical section; surface uneven due to projecting groups of cells. Hairs on mature stromata frequent, (7–)12–26(–32)×(2–)3–5(–6) µm (*n*=20), 2–5 celled, sometimes originating at the base of the cortical layer, then up to 10-celled and to 40×6 µm including cells within the cortex, light brownish, cylindrical or with widened base, smooth or tubercular, with broadly rounded or truncate apex. Subcortical tissue a loose *t. intricata* of short-celled, thin-walled, hyaline hyphae (2–)3–5(–6) µm (*n*=20) wide. Subperithecial tissue a dense homogenous *t. epidermoidea* of variably shaped cells (4–)6–23(–44)×(3–) 5–12(–15) µm (*n*=30), at the base sometimes intermingled with few narrow hyphae. Asci (70–)82–100(–117)×(4.5–) 5.0–6.0(–6.5) µm, stipe (3–)6–15(–28) µm long (*n*=45), ascospores often oblique; no croziers apparent. Ascospores hyaline, verruculose, cells dimorphic, distal cell (3.5–)3.8–4.5(–5.5)×(3.2–)3.5–4.3(–5.5) µm, l/w (0.9–)1.0–1.2(–1.4) (*n*=70), subglobose to nearly wedge-shaped, proximal cell (3.3–)4.2–6.0(–7.2)×(2.7–)3.0–3.7(–4.7) µm, l/w (1.1–) 1.3–1.8(–2.4) (*n*=70), oblong or subglobose; both cells showing light dots in cotton blue in contact areas.

Cultures and anamorph: optimal growth at 25–30°C on CMD and PDA, at 25°C on SNA; no growth at 35°C.

On CMD after 72 h 16–19 mm at 15°C, 38–43 mm at 25°C, 36–42 mm at 30°C; mycelium covering the plate after 5–7 days at 25°C. Colony thin, hyaline, dense, homogeneous, not zonate; margin ill-defined, diffuse. Hyphae thin, finely reticulate, curly, i.e. without distinct radial arrangement. Aerial hyphae only frequent in a broad distal zone, causing a downy surface, becoming fertile. Minute green tufts appearing in 1–2(–4) indistinct concentric zones, typically concentrated at the distal margin. Autolytic activity and coilings absent or inconspicuous. Agar colourless to faintly yellowish, 3A3–3B4 after 1 or 2 week; no distinct odour noted. Chlamydospores noted after 4–6 days at 15 and 30°C. Conidiation noted after 1–2 days, effuse, verticillium-like, on simple erect conidiophores to *ca* 100 µm long arising from surface and aerial hyphae and in minute loose shrubs or tufts 0.1–0.6(–1) mm diam of irregular outline, mostly at the distal and proximal margins; green after 4 days, with conidia packed in minute wet to mostly dry heads of <20 µm diam. Shrubs/tufts arising on thick, sometimes submoniliform stipes to *ca* 15 µm thick, with wide primary branches, attenuated upwards along a short distance, sparsely branched in right angles, bearing few short tree-like main axes with phialides at the top and branches progressively longer with distance from the top, once rebranching into mostly paired side branches, in right angles or slightly inclined upwards. Phialides arising solitary or in whorls of 2–4 on cells often slightly inflated and *ca* 2–4(–5.5) µm wide. Phialides (4.5–) 6.7–11.0(–14.0)×(2.3–)2.5–3.0(–3.5) µm, l/w (1.4–)2.2–4 (–5), (1.5–)2.0–2.5(–2.7) µm wide at the base (*n*=30), lageniform, conical, to nearly ampulliform, straight, inaequilateral or slightly curved upwards, widest in or below the middle, neck variable. Conidia (3.7–)4.0–4.7(–5.3)× (2.5–)3.0–3.5(–3.7) µm, l/w (1.2–)1.3–1.5(–1.6) (*n*=30), ellipsoidal to oval, green, smooth, finely multiguttulate, scar rarely distinct. At 15°C up to 6 indistinct concentric


a
b
c
d
e
f
g
h
i
j
k
n
o
l
m
p
q
t
u
v
r
w
s

◀ **Fig. 16** Teleomorph of *Hypocrea rogersonii*. **a**–**g**. Fresh stromata (**a**. immature; **f**, **g**. eaten by insect larvae). **h**–**k**, **m**–**o**. Dry stromata (**h**–**k**. immature; **i**. stroma initial with anamorph). **l**. Hairs on stroma surface. **p**. Perithecium in section. **q**. Stroma surface in face view. **r**. Cortical and subcortical tissue in section. **s**. Subperithecial tissue in section. **t**, **u**. Asci with ascospores. **v**, **w**. Ascospores in cotton blue/lactic acid. **a**, **g**. WU 29451. **b**, **e**, **h**. WU 29450. **c**, **f**, **k**, **l**, **p**–**t**, **v**, **w**. WU 29448. **d**. WU 29447. **i**, **j**. WU 29449. **m**, **o**. WU 29446. **n**. WU 29453. **u**. WU 29456. Scale bars: **a**=0.2 mm. **b**, **e**=2 mm. **c**, **d**, **f**, **i**, **m**, **o**=0.8 mm. **g**, **j**, **k**, **n**=0.4 mm. **h**=1.5 mm. **l**, **r**, **s**=15 μm. **p**=30 μm. **q**, **u**=10 μm. **t**, **v**, **w**=5 μm

zones formed; conidiation in distinct, green 26E4–6 to 26F7–8 tufts at the distal and lateral margins after 10 days, more abundant than at 25°C. At 30°C conidiation effuse, macroscopically invisible.

On PDA after 72 h 14–16 mm at 15°C, 39–43 mm at 25°C, 37–38 mm at 30°C; mycelium covering the plate after 5–7 days at 25°C. On PDA hyphae without distinct radial arrangement; colony dense; margin ill-defined, diffuse; centre flat, with moniliform surface hyphae; residual part covered by a loose mat of long white aerial hyphae to 7 mm high, radially arranged towards the distal margin, particularly in up to four ill-defined concentric zones, becoming agglutinated in strands, bearing many coilings and guttules. Autolytic excretions frequent at all temperatures; coilings frequent at 25°C. Reverse becoming diffusely yellow, 3A3, 3–4B4, 3C4–5. Odour indistinct. Conidiation noted after 1 days, dry, on numerous short, verticillium-like conidiophores on long aerial hyphae ascending several mm high, and on compact short basal tree-like conidiophores, concentrated in the concentric zones, green 27CD3–5 after 7 days. At 15°C development slower; at 30°C colony conspicuously dense, thick, whitish, up to five downy to floccose zones of irregular outline; conidiation green only under the stereo-microscope.

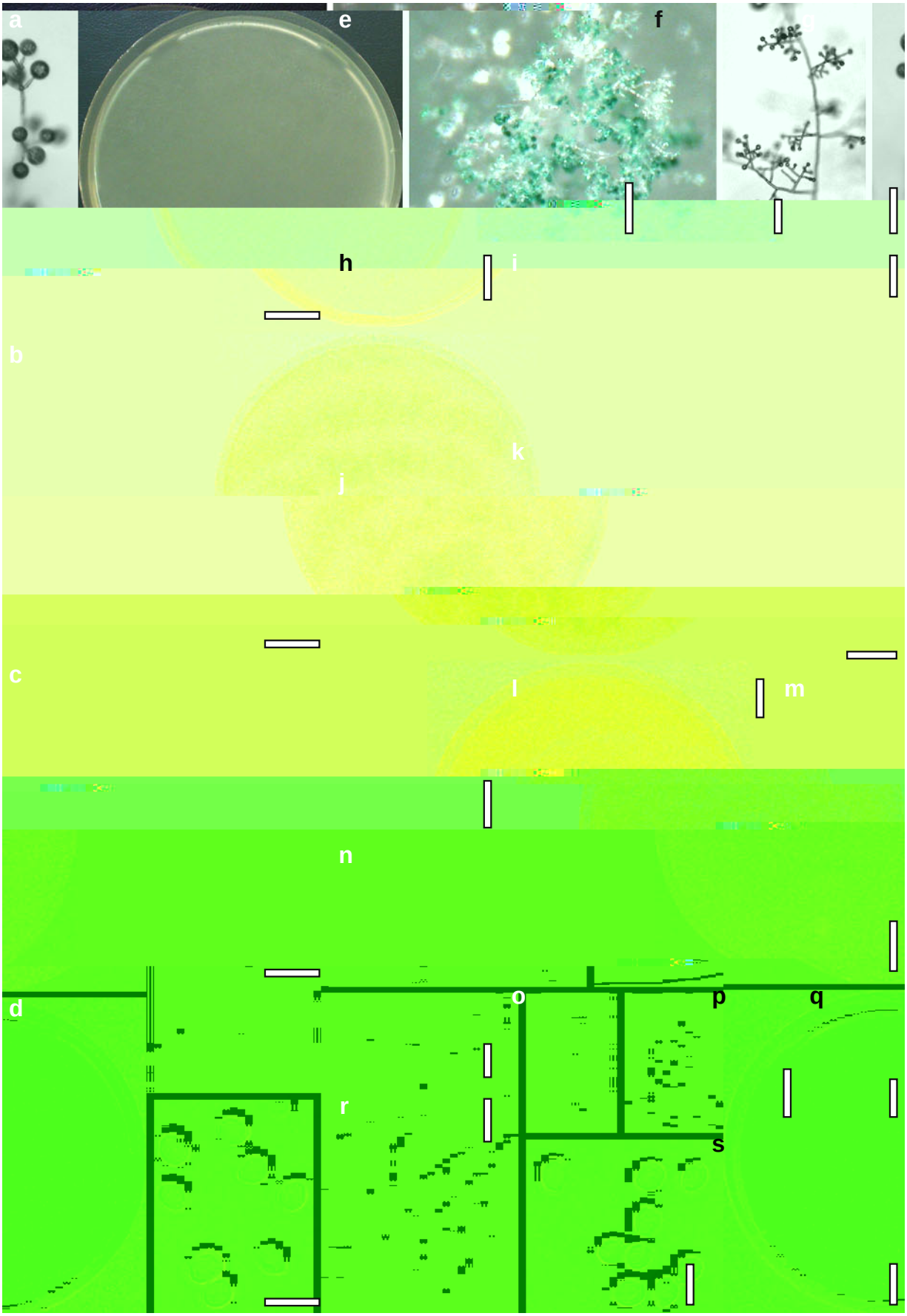
On SNA after 72 h 14–18 mm at 15°C, 33–41 mm at 25°C, 17–34 mm at 30°C; mycelium covering the plate after 5–7 days at 25°C. Colony thin, hyaline, homogeneous, of irregularly oriented secondary hyphae forming a delicate reticulum between thick curved primary hyphae. Margin ill-defined, diffuse. Surface becoming downy, particularly in distal regions due to long aerial hyphae several mm high. Autolytic excretions frequent at all temperatures; coilings inconspicuous at 25°C, frequent at 15 and 30°C. No diffusing pigment formed, no odour noted. Surface mycelium degenerating and disappearing after 6–7 days. Chlamydospores scant at 25°C, more frequent after 4–6 days at 30°C, (5–)6–10 (–12)×(4.5–)5–8(–11) μm, l/w 1.0–1.4(–1.8) (*n*=30), loosely disposed across the entire plate, terminal and intercalary, globose, pyriform, or ellipsoidal. Conidiation noted after 1–2 days, green after 4–5 days, eventually 26–27F6–8, effuse, verticillium-like, on aerial hyphae in up to 4(–5) indistinctly separated, downy concentric zones, and dry and regularly tree-like in tufts eventually compacted to dense pustules of 0.5–3 mm diam, aggregating to 12 mm length, in concentric zones or irregularly distributed on the plate. Conidia formed in numerous wet heads growing to 60(–90) μm diam. At 15° C conidiation in irregular, loose green 26DE4–5 tufts to 6 mm long. At 30°C growth slower than on CMD and PDA; margin with irregular outgrowths; conidiation effuse, powdery or finely granular.

Habitat: on wood and bark of deciduous trees, in Central Europe chiefly on *Fagus*.

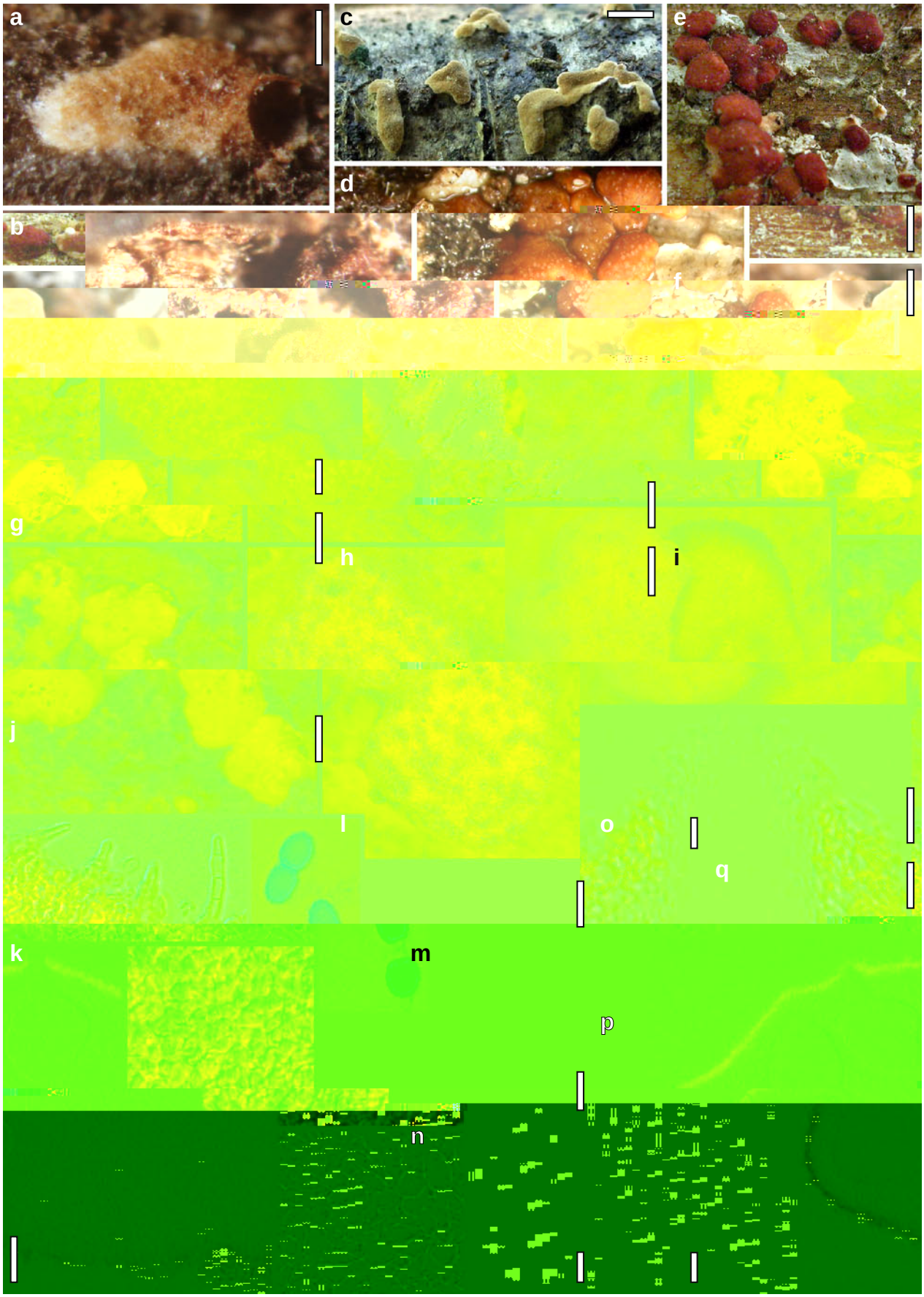
Distribution: Central Europe (Austria), Eastern North America.

Holotype: **USA**, Tennessee, Great Smoky Mts. National Park, vic. Cosby, Albright Trail, on decorticated wood, July 2005, B.E. Overton 04-04 (BPI 870964A; ***holotype*** of anamorph BPI 870964B; ex-type culture G.J.S. 04-158= CBS 119233; not examined).

Specimens examined: **Austria**, Kärnten, Klagenfurt Land, Obermieger, Sabuatach, MTB 9452/2, 46°35′22″ N, 14°27′03″ E, elev. 650 m, at forest edge, on twigs of *Corylus avellana* 2–4 cm thick, on inner bark, soc. *Bisporella citrina*, 14 Oct. 2006, W. Jaklitsch, W.J. 3020 (WU 29454, culture C.P.K. 2488). St. Margareten im Rosental, Sabosach, MTB 9452/3, 46°32′23″ N, 14°24′40″ E, elev. 550 m, on decorticated branches of *Fagus sylvatica* 1–2.5 cm thick, on wood, soc. *Exidia truncata*, old *Neodasyscypha cerina*; pulvinate, light bluish green anamorph, 25 Oct. 2004, W. Jaklitsch, W.J. 2783 (WU 29448, culture CBS 119503=C.P.K. 1994). Same locality, on decorticated branch of *Fagus sylvatica* 5–6 cm thick, on wood, soc. *Lophiotrema nucula*, *Resupinatus applicatus*, rhizomorphs, Corticiaceae, a myxomycete; holomorph, 9 Jul. 2007, W. Jaklitsch, W.J. 3117 (WU 29455). St. Margareten im Rosental, Zabrde, MTB 9452/4, 46°32′59″ N, 14°25′12″ E, elev. 565 m, on partly decorticated branch of *Fagus sylvatica* 1–1.5 cm thick, on wood, 29 Oct. 2005, H. Voglmayr & W. Jaklitsch, W.J. 2869 (WU 29453, culture C.P.K. 2424). Niederösterreich, Hollabrunn, Hardegg, Semmelfeld, between Niederfladnitz and Merkersdorf, MTB 7161/3, 48°48′49″ N, 15°52′43″ E, elev. 450 m, on partly corticated branch of *Quercus petraea* 4 cm thick, on wood and resupinate polypore, 21 Jul. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2531 (WU 29446, culture CBS 119504=C.P.K. 1614). Melk, Loosdorf, Dunkelsteiner Wald, 0.7 km south from Umbach, MTB 7758/4, 48°14′04″ N, 15°25′48″ E, elev. 370 m, on branch of *Fagus sylvatica* on the ground in leaf litter, on wood, 5 Oct. 2004, W. Jaklitsch, W.J. 2768 (WU 29447, culture C.P.K. 1993). Wien-Umgebung, Mauerbach, east from the cemetery, MTB 7763/1, 48°15′11″ N, 16°10′22″ E, elev. 330 m, on partly decorticated branch of *Fagus sylvatica* 4 cm thick, on wood, soc. young *Hypoxylon rubiginosum*, holomorph, 24 Sep. 2005, W. Jaklitsch, W.J. 2858 (WU 29451, culture C.P.K. 2420). Mauerbach, halfway heading to Allhang, MTB 7763/1, 48°14′54″ N, 16°08′34″ E, elev. 330 m, on


a
e
f
h
i
b
k
j
c
l
m
n
d
o
p
q
r
s

decorticated branch of *Fagus sylvatica*, on wood, soc. *Cryptadelphia* sp., black crust, Corticiaceae, 3 Aug. 2008,


a
c
e
d
b
f
g
h
i
j
l
o
q
k
m
p
n

◀ **Fig. 18** Teleomorph of *Hypocrea rufa*. **a**, **b**, **f**, **g**. Dry stromata (**a**. immature, downy; **f**. "albino" stroma; **g**. immature and mature). **c**–**e**, **h**. Fresh stromata (**c**. immature, nearly dry). **i**. Rehydrated stroma. **j**. Ostiole in section. **k**. Section of stroma with perithecia. **l**. Hairs on the surface of mature stroma. **m**. Stroma surface in face view. **n**. Subperithecial tissue in section. **o**, **p**. Ascospores (**o**. in cotton blue/lactic acid). **q**. Asci with ascospores. **a**, **b**, **p**. neotype Scleromyceti Sueciae 303; **c**, **h**. WU 24011; **d**, **e**, **i**–**o**, **q**. epitype WU 24013, **f**, **g**. WU 24015. Scale bars: **a**, **b**, **g**, **i**=0.3 mm. **c**, **d**, **f**=0.5 mm. **e**, **h**=0.8 mm. **j**, **l**–**n**, **q**=10 μm, **k**=100 μm, **o**, **p**=5 μm

10–22 μm thick. Cortical layer (12–)17–30(–35) μm (n=20) thick, a *t. angularis* of cells (3.5–)4.5–10(–14.5) μm (n=60) diam in face view and in section, with walls to 1 μm thick, reddish brown in water, orange-brown in lactic acid, pigment unevenly deposited in cell walls, giving a mottled appearance to the stroma surface. Hairs arising from the stroma surface, yellowish to pale brown, comprising 2–5 cells, apically rounded, rarely branched, sometimes consisting of only one inflated cell, (7–)10–30(–62)×(2.0–)3.5–5.0(–6.5) μm (n=49), walls 0.5–1 μm thick. Subcortical tissue comprising a hyaline mixture of intertwined hyphae, (2.5–)3.0–6.0(–6.5) μm (n=10) wide, vertical and parallel between perithecia, and few subglobose to angular cells similar to those of the cortex. Subperithecial tissue a homogeneous, dense *t. epidermoidea* of globose to elongate, thin-walled, hyaline cells, (4–)5–19(–26)×(3–)4–10(–13) μm (n=30), gradually smaller and interspersed with some narrow hyphae (2.0–)2.5–5.5(–6.5) μm (n=10) wide towards the base of the stroma. Asci (70–)87–112(–132)×(4.0–)5.5–7.0(–8.5) μm (n=72), stipe (5–)9–17(–22) μm (n=30) long. Ascospores hyaline, verrucose, verrucae *ca* 0.5 μm diam; cells dimorphic, distal cell (3.7–)4.5–5.7(–7.7)×(3.2–)4.0–4.7(–6.5) μm, l/w (0.9–)1.0–1.4(–1.8) (n=120), subglobose or oval, sometimes wedge-shaped, proximal cell (3.7–)4.7–6.5(–8.0)×(3.0–)3.5–4.2(–5.2) μm, l/w (1.2–)1.3–1.9(–2.3) (n=120), oblong to wedge-shaped, the lower end broadly rounded.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 25–27 mm at 15°C, 39–40 mm at 25°C, 8–14 mm at 30°C; mycelium covering the plate after 5–6 days at 25°C. Colony thin, hyaline, dense, homogeneous, not zonate; margin ill-defined, diffuse. Hyphae loosely arranged, thin, finely reticulate. Autolytic activity absent, coilings and aerial hyphae inconspicuous. No diffusing pigment formed. A weak coconut-like odour formed in some but not all strains. Chlamydospores rare, typically subglobose, terminal, less frequently intercalary, hyaline to pale yellowish. Conidiation noted after 2 days, in pustules more or less regularly distributed on the plate or forming in a broad band around the margin, less frequently in concentric rings, usually starting close to the point of inoculation, formed exclusively or preceded or accompanied by various amounts of simple conspicuously curved conidiophores or minute transparent tufts or shrubs. Pustules at first white, becoming green after 4 days or later, depending on the isolate, 28D3–5 or 26E4–6 to 27E4–6, finally 26F5–8 to 27F6–8 after 1 week, compact to cottony, pulvinate to hemispherical, 0.5–2.5(–5.0) mm diam, 0.5–1.6 mm high. Structure of typical conidiophores, determined after 5–7(–11) d: pustules and minute tufts arising on 8–12 μm thick stipes, often with constricted septa, bearing several thick primary branches arising at various angles, both partly verrucose, further branching dense and complex, final long branches thin, bearing short terminal branches at various angles, with 1 or 2(–3) terminal phialides. Conidiophores ill-defined, no main axes discernible or at best weakly developed, conspicuously and extremely variably curved to sinuous, often seen as short elongations on the periphery of pustules; branches and phialides generally unpaired. Simple conidiophores and shrubs sometimes tending to be more regularly paired, with tree-like branching. Branches sometimes originating on thickened nodes, 7–11 μm wide with up to 5 branches, often tending to be less curved. Phialides (4.0–)6.5–11.5(–18.5)×(1.0–)2.5–3.3(–4.0) μm, l/w (1.2–)2.0–4.5(–13.2), (1.0–)1.7–2.5(–3.0) μm wide at the base (n=600), originating singly or in groups of 2–3, on rarely inflated, 2–3 μm thick cells, usually not paired, variable among isolates, lageniform to long cylindrical, typically strongly curved to sinuous, less commonly straight, usually with long necks up to 10 μm, not or slightly thickened in various positions, tending to be longer and narrower in minute tufts and shorter and more swollen when crowded. Conidia (3.0–)3.5–4.5(–5.5)×(2.8–)3.5–4.0(–5.0) μm, l/w=(0.8–)1.0–1.2(–1.5) (n=720), globose to subglobose, infrequently nearly oval, (olive-)green, basal scar sometimes visible, coarsely tuberculate, containing few guttules, in aged cultures often in chains.

On PDA after 72 h 21–23 mm at 15°C, 29–31 mm at 25°C, 4–10 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony dense, whitish, downy. Aerial hyphae well developed at the margin, soon degenerating, colonies therefore flat. Autolytic activity absent. No diffusing pigment formed, odour indistinct or rarely slightly coconut-like. Conidiation effuse, starting in the centre, white, condensed, farinose to finely granular, green from the centre after 3 days, subsequently forming alternating green, 28DE5–7, 27DE3–6 to 27F7–8 and dull yellow, 3A3–4, concentric zones.

On SNA after 72 h 21–22 mm at 15°C, 27–31 mm at 25°C, 1–8 mm at 30°C; mycelium covering the plate after 7–8 days at 25°C. Colony similar to CMD, not zonate. Aerial hyphae inconspicuous, autolytic activity absent, coilings somewhat more pronounced than on CMD.

No pigment, no distinct odour noted. Chlamydospores noted after 1 week, inconspicuous, more frequent than on


a
d
f
g
e
b
h
i
j
k
c
l
m
n
o
p

◀ **Fig. 19** Cultures and anamorph of *Hypocrea rufa*. **a**–**c**. Cultures after 12 days at 25°C (**a**. on CMD; **b**. on PDA; **c**. on SNA). **d**, **e**. Anamorph on natural substrate showing yellow mycelium. **f**, **g**. Conidiation pustules (6 days). **h**. Conidiophores from shrub (7 days). **i**–**k**. Conidiophores from pustule periphery (7–8 days). **l**. Conidiophore thickenings (10 days). **m**. Phialides (8 days). **n**–**p**. Conidia (7–8 days). **f**–**p**. From CMD, 25°C. **a**–**c**, **f**–**h**, **n**. CBS 119326. **d**, **e**, **l**. CBS 119325. **i**–**k**. C.P.K. 2867. **m**, **o**, **p**. CBS 119327. Scale bars: **a**–**c**= 14 mm. **d**, **e**=3 mm. **f**=1.5 mm. **g**=0.5 mm. **h**=50 μm. **i**, **k**=10 μm. **j**=15 μm. **l**–**p**=5 μm

CMD, terminal and intercalary, (5.0–)6.5–10.5(–12.5) μm (*n*=21) diam, mostly globose, smooth, hyaline to pale yellowish. Conidiation similar to CMD, asymmetrical, starting in the centre in loosely arranged compact pustules of *ca* 1–2 mm diam, aggregating to 4 mm diam, and on smaller shrubs and solitary conidiophores, green 26EF5–7 to 27F6–8 after 3–4 days; conidia formed in minute dry heads.

Habitat: Anamorph common, isolated from soil, peat, wood, and leaf litter. Teleomorph uncommon, inconspicuous, found on wood, less commonly on bark of cut branches, tree tops or logs. In Europe found in open coniferous or mixed deciduous forests, grassland with single trees or at shady roadsides, often in piles of logs stored or lying on bare moist soil, in leaf litter or in grass, to 3 m above the ground at the edge of forests, on often hard wood in little to medium degree of decomposition. In Central and Northern Europe mainly on coniferous trees (*Pinus sylvestris*, *Picea abies*), in Western Europe more frequent on deciduous trees (e.g. found on *Quercus robur*, *Acer pseudoplatanus*).

Distribution: Teleomorph collected in Europe (Austria, Czech Republic, France, Germany, Netherlands, Sweden, UK) and USA (North Carolina, Virginia). Anamorph north and south-temperate, including Canada, Europe, Japan, New Zealand, and USA.

Neotype: Scleromyceti Sueciae No. 303 (UPS). ***Epitype***, designated by Jaklitsch et al. (2006b): **Czech Republic**, South Bohemia, Frymburk, 3.4 km north from Lipno, MTB 7351/3, 48°38′04″ N, 14°11′19″ E, elev. 745 m, on partly decorticated logs of *Pinus sylvestris* 12–30 cm thick, on the ground or elevated in a pile of logs stored at the roadside and edge of a coniferous (*Picea*/*Pinus*) forest, soc. *Ophiostoma* sp., *Neonectria fuckeliana*, *Pezicula eucrita*, *Schizophyllum commune*, *Valsa pini*, unidentified Corticiaceae, 3 Oct. 2004, W. Jaklitsch, W.J. 2753 (**WU 24013**; culture CBS 119325 = C.P.K. 1997 = G.J.S. 04-372). ***Lectotype*** of *Trichoderma viride* (designated by Bisby 1939): 'Prope Parisiis, Hb. Pers.', Herb. Lugd. Bat. 910 263-877 (L 0018559 = 'Rijksherbarium No 148-1'). ***Epitype*** of *Trichoderma viride* isolated from WU 24013 and deposited as a dry culture with the holotype of *H. rufa* as **WU 24013a**.

Other specimens examined: **Austria**, Niederösterreich, Zwettl, Traunstein, roadside, 1 km after the western end of the village, MTB 7556/4, 48°26′10″ N, 15°05′57″ E, elev. 830 m, on partly decorticated cut logs of *Picea abies*, up to 45 cm thick, in a pile stored at the edge of a *Picea*/*Fagus* forest, soc. *Ophiostoma* sp., 5 Oct. 2004, W. Jaklitsch, W.J. 2766 (WU 24015; culture CBS 119327=C.P.K. 1999). Steiermark, Liezen, Kleinsölk, close to the NE corner of the Schwarzensee, MTB 8749/1, 47°17′38″ N, 13°52′36″ E, elev. 1170 m, on partly decorticated cut logs of *Pinus sylvestris*, 20–25 cm thick, stored in a pile at roadside and edge of a spruce forest, soc. *Ophiostoma* sp., 7 Oct. 2004, W. Jaklitsch, W.J. 2773 (WU 24016; culture C.P.K. 2000). Liezen, Weng im Gesäuse, Ennstal, Gstatterboden, 0.9 km after the village heading east, MTB 8453/2, 47°35′ 34″ N, 14° 39′ 09″ E, elev. 570 m, on cut log of *Picea abies* 120 cm thick, 2.5 m above ground, in a pile stored at roadside, soc. *Trichaptum abietinum*, 8 Oct. 2004, W. Jaklitsch, W.J. 2774 (WU 24017; isolate C.P.K. 2001). **Czech Republic**, South Bohemia, at roadside 5.7 km north from Frymburk, MTB 7250/4, 48°42′36″ N, 14°08′06″ E, elev. 750 m, on partly decorticated cut log of *Picea abies* 22 cm thick, on the ground, protected by grass, herbs, soc. *Neonectria fuckeliana*, *Stereum sanguinolentum*, *Sarea resinae*, immature, culture from conidia, 22 Sep. 2003, W. Jaklitsch, W.J. 2408 (WU 24010; culture C.P.K. 965); 2.7 km before Frymburk approaching from Lipno, MTB 7351/3, 48°38′22″ N, 14°10′52″ E, elev. 740 m, on partly decorticated logs of *Pinus sylvestris* 10–43 cm thick, stored in a pile at the roadside, mostly immature, 3 Oct. 2004, W. Jaklitsch, W.J. 2758 (WU 24014; culture C.P.K. 1998). **France**, La Moselle, Parc Lorraine, Héming, between Étang du Stock and Maizières de Vic, 48°43′35″ N, 06° 54′07″ E, elev. 180 m, on cut and mostly corticated branches and logs of *Quercus robur* 2–40 cm thick, on bare ground or squeezed into moist soil, soc. *Amphiporthe leiphaemia*, *Diatrypella* sp., *Bulgaria inquinans*, part attacked by white mould, 5 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2677 (WU 24011; culture C.P.K. 1995). **Germany**, Bavaria, Unterfranken, Landkreis Haßberge, Haßfurt, close to Mariaburghausen, left roadside heading from Knetzgau to Haßfurt, MTB 5929/3, 50°00′31″ N, 10° 31′17″ E, elev. 270 m, on cut branches of *Quercus robur* 4–5 cm thick, on bark, holomorph, teleomorph immature, 29 Aug. 2006, W. Jaklitsch & H. Voglmayr, W.J. 2962 (WU 29457, culture C.P.K. 2457). Nordrhein-Westfalen, Märkischer Kreis, Plettenberg-Böddinghausen, Naturschutzgebiet Bommecketal, 1 km south from the entrance to the nature reserve, MTB 4713/3, elev. 300 m, on corticated log of *Fraxinus excelsior* 15 cm thick, on bark, soc. *Neonectria coccinea*, 8 Oct. 2006, K. Siepe & F. Kasparek, W.J. 3061 (WU 29459, culture C.P.K. 2867). **Netherlands**, Putten, in Armen Bos of the arboretum Landgoed Schovenhorst, elev.

0 m, on corticated branch of *Quercus robur* 4–10 cm thick, on bark, holomorph, teleomorph immature, 19 Nov. 2006, H. Voglmayr, W.J. 3048 (WU 29458, culture C.P.K. 2856). **Sweden**, Uppsala Län, Fredrikslund, pine forest near nature reserve Kungshamn-Morga, 1.5 km NE of Fredrikslund, 59°47′00″ N, 17°39′00″ E, elev. 50 m, on cut and mostly corticated tree tops and branches of *Pinus sylvestris* 5–9 cm thick, on the ground, 8 Oct. 2003, W. Jaklitsch & S. Ryman, W.J. 2450 (BPI 872089; cultures CBS 119326=C. P.K. 984, G.J.S. 04-21 from white stroma). **United Kingdom**, Derbyshire, Baslow, Longshaw Country Park, Peak District National Park, 53°18′26″ N, 01°36′08″W, elev. 350 m, on corticated branches and logs of *Acer pseudoplatanus* 2–10 cm thick, on the ground in open grassland, holomorph, teleomorph immature, culture from conidia, 10 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2695 (WU 24012; culture C.P.K. 1996). Hampshire, Lyndhurst, New Forest, Whitley Wood, 50°50′50″ N, 01°34′50″ W, elev. 30 m,, on basidiome of *Phellinus ferruginosus* and wood of *Fagus sylvatica*, holomorph, scant, 14 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3161 (WU 29461). Hertfordshire, Hertford, Waterford, Waterford Heath, 51°48′51″ N, 00°05′25″ W, elev. 70 m, on cut branch of *Betula pendula* 15–20 cm thick, holomorph, teleomorph immature, soc. *Annulohypoxylon multiforme*, *Oligoporus* sp., Corticiaceae, 12 Sep. 2007, W. Jaklitsch, H. Voglmayr & K. Robinson, W. J. 3154 (WU 29460).

Notes: *Hypocrea rufa* is the type species of the genus *Hypocrea*. Despite frequent citations in the literature and the numerous, often wrongly identified specimens in herbaria the teleomorph of this species is uncommon or even rare in many regions. It occurs typically on stored wood of conifers such as *Picea* or *Pinus* in Central Europe. In Western Europe it has been primarily collected on wood and bark of *Quercus* and other deciduous trees. It is difficult to find good teleomorph material. Stromata apparently develop slowly and in a narrow range of ecological conditions, particularly regarding moisture, temperature, and age and degree of decay of the substrates. Moreover, they often develop in open habitats, well susceptible to desiccation. The frequency of long dry periods has increased in recent years. This may contribute to the fact that teleomorphs are rather rarely collected. On the other hand, if a habitat is too moist, stromata are soon attacked by hyphomycetes, often seen in specimens as white mould on stromata. These are obviously reasons why specimens mostly contain immature stromata. Anthropogenic influence, particularly cutting of logs and branches, strongly enhances growth of this species.

The most common species of *Hypocrea* in temperate regions, *H. minutispora*, or sometimes *H. pachybasioides*, are frequently wrongly identified as *H. rufa*. Stromata of *H. rufa* may approach those of *H. pachybasioides* or *H. minutispora* in shape and colour, particularly when their ostiolar openings are clearly visible, but *H. rufa* forms typically inconspicuous, small stromata, mostly 1–2 mm diam, and the stroma surface is velutinous or hairy, especially in young stromata.

Hypocrea rufa cannot be confidently differentiated from its closest relative, *H. viridescens*, by the morphology of the teleomorph, and also barely from other similar species. Stromata of *H. rufa* are usually accompanied by the *Trichoderma viride* anamorph. Conidia found in nature are dark green, 26F5–8 to 27F4–8, and often citrine- to sulphur-yellow, 4A4–6, hairy patches of mycelium are found. Intensely yellow cottony patches are found also with *H. viridescens*. However, the coarsely warted, globose or subglobose conidia of *T. viride* are diagnostic of the species, except for the recently described Brazilian *Theobroma* endophyte *T. martiale* (Hanada et al. 2008), while *T. viridescens* has finely verruculose, ellipsoidal conidia. Conidia of most other *Trichoderma* species have smooth conidia.

Measurements of perithecia, asci, ascospores, phialides and conidia given above include those obtained on North American material studied by G.J. Samuels. For more information see Jaklitsch et al. (2006b).

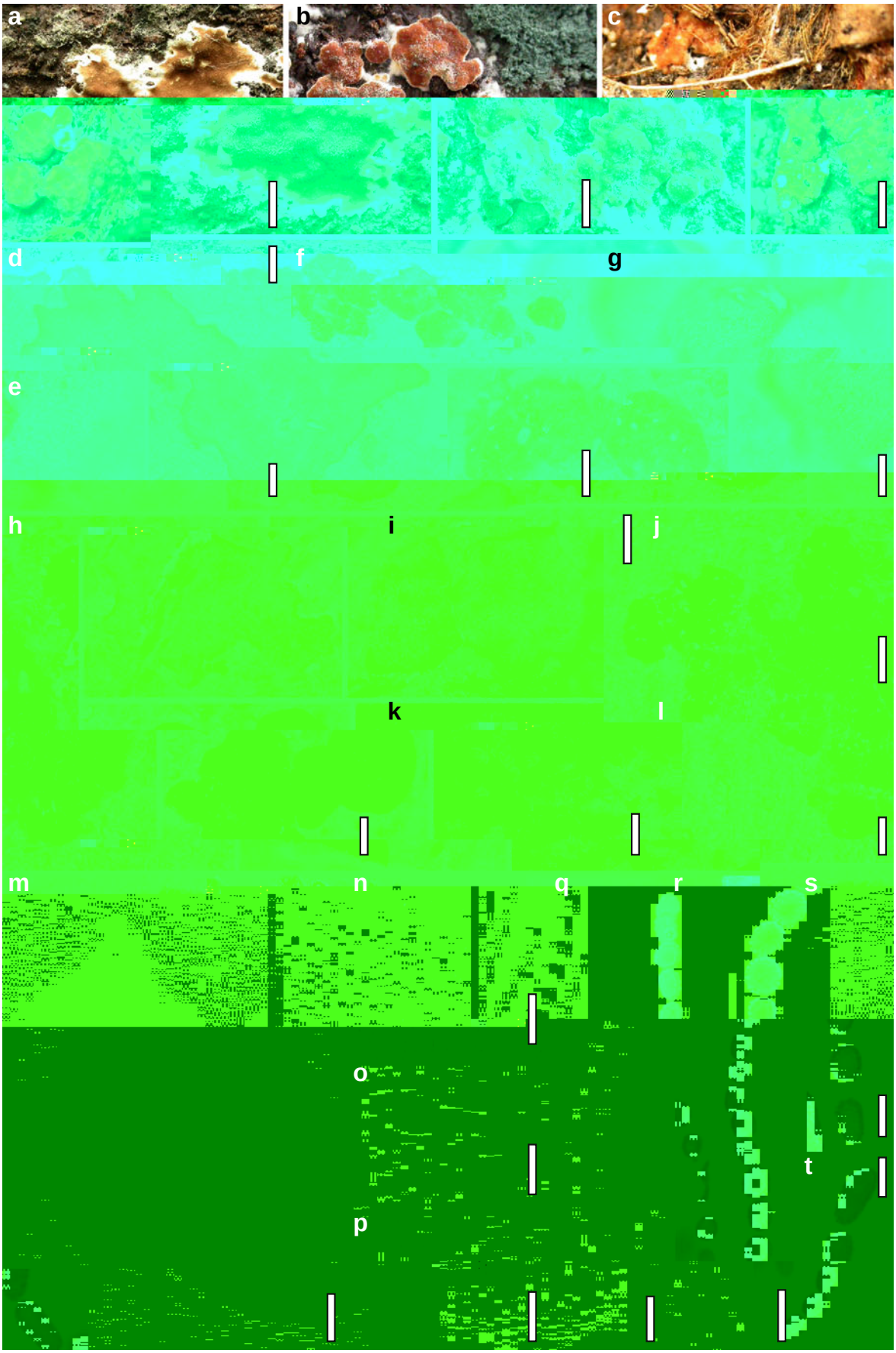
Hypocrea stilbohypoxyli B.S. Lu & Samuels, Sydowia 55: 265 (2003). Fig. 20

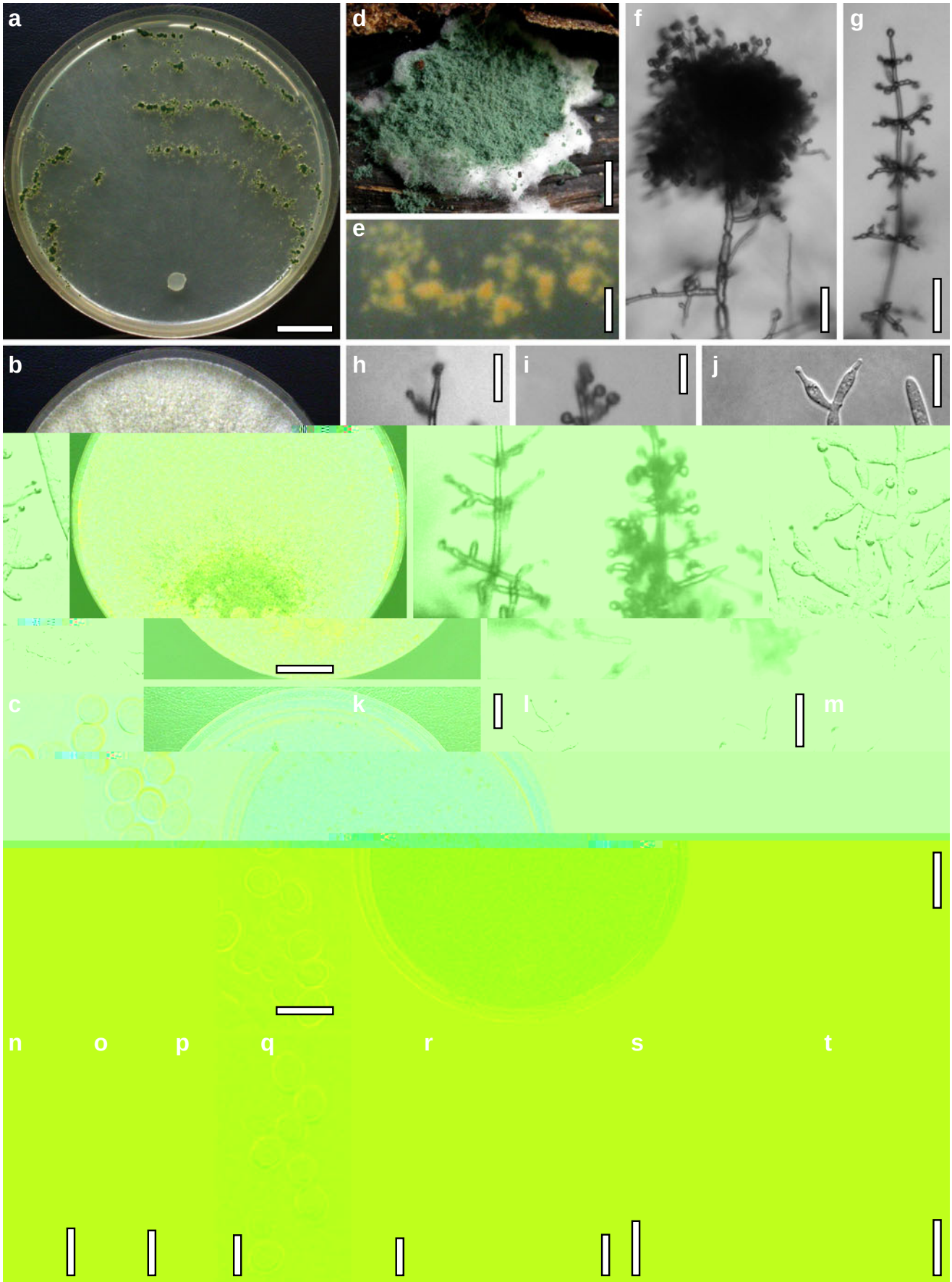
Anamorph: ***Trichoderma stilbohypoxyli*** Samuels & Schroers, Stud. Mycol. 56: 128 (2006a). Fig. 21

Stromata when fresh 1–15 mm diam, to 1 mm thick, solitary, gregarious or densely aggregated in small numbers, thinly effuse to subpulvinate. Margin first white, later concolorous, attached or free and rounded. Surface hairy when young, becoming glabrous, smooth to tubercular. Perithecia entirely immersed; ostiolar dots invisible or indistinct brownish dots or spots. Stroma colour orange to reddish brown, 7–8C6–8.

Stromata when dry (0.7–)1.1–6.2(–12)×0.6–4.3(–8.0) mm, 0.2–0.4(–0.7) mm thick (n=30); effuse or subpulvinate; outline variable, circular, oblong or irregularly lobed. Surface velutinous, covered by whitish to rust hairs when immature, smooth or irregularly tubercular, sometimes with white or green conidiophores when immature; glabrous when mature. Ostiolar dots (31–)50–78(–94) μm (n=20), appearing

Fig. 20 Teleomorph of *Hypocrea stilbohypoxyli*. **a**–**d**. Fresh stromata (**a**, **b**. immature; **b**. holomorph). **e**–**j**. Dry stromata (**f**, **g**, **i**, **j**. immature; **f**. on stroma of *Rosellinia corticium*). **k**. Rehydrated mature stromata. **l**. Stroma surface in face view. **m**. Perithecium in section. **n**. Cortical and subcortical tissue in section. **o**. Subperithecial tissue in section. **p**. Stroma base in section. **q**, **r**. Asci with ascospores (**q**. in cotton blue/lactic acid). **s**, **t**. Ascospores in cotton blue/lactic acid (**t**. immature, before disarticulation). **a**, **c**, **f**, **g**, **j**, **r**. WU 29479. **b**, **i**. WU 29477. **d**, **e**, **h**, **k**–**q**, **s**, **t**. WU 29478. Scale bars: **a**, **b**=2 mm. **c**, **d**, **i**=1.3 mm. **e**, **f**= 0.3 mm. **g**=0.8 mm. **h**, **j**, **k**=0.5 mm. **l**, **o**, **q**, **r**=10 μm. **m**, **p**=30 μm. **n**=20 μm. **s**, **t**=5 μm


a
b
c
d
f
g
e
h
i
j
k
l
m
n
q
r
s
o
t
p


a
d
f
g
e
b
h
i
j
c
k
l
m
n
o
p
q
r
s
t

◀ **Fig. 21** Cultures and anamorph of *Hypocrea stilbohypoxyli*. **a**–**c**. Cultures after 14 days (**a**. on CMD; **b**. on PDA; **c**. on SNA). **d**. Fresh anamorph on the natural substrate. **e**. Reverse of conidiation pustules (CMD, 14 days). **f**. Dense core of conidiation pustule on stipe (CMD, 7 days). **g**–**i**. Regularly tree-like conidiophores on growth plates (7 days; **g**, **i**. SNA; **h**. CMD). **j**–**l**, **r**. Conidiophores (CMD, 7 days; **r**. from dense pustule core). **m**, **t**. Conidia (CMD, 6 days). **n**. Submoniliform surface hypha (PDA, 30°C, 1 days). **o**, **p**. Chlamydospores (SNA, 30°C, 8 days). **q**. Thickenings in surface hyphae around conidiation pustules (CMD, 16 days). **s**. Phialides (CMD, 7 days). **a**–**c**, **e**–**m**, **q**–**t**. At 25°C. **a**–**c**, **e**–**g**, **i**, **n**–**q**. C.P.K. 1978. **d**, **h**, **j**–**m**, **r**–**t**. CBS 119501 (WU 29478). Scale bars: **a**–**c**=15 mm. **d**. 2 mm. **e**. 4 mm. **f**=50 μm. **g**, **n**, **q**= 30 μm. **h**, **i**, **k**, **o**=15 μm. **j**, **l**, **p**, **r**, **s**=10 μm. **m**, **t**=5 μm

slightly darker than the stroma surface, of hyaline ostioles with darker margin, plane or slightly projecting, mostly ill-defined, more distinct after rehydration. Stromata dark orange-brown to reddish brown, with lighter or white margin, 5–6EF6–8, 6–7CD7–8, 7–8E5–8. Stromata unchanged or orange-red in 3% KOH, with mottled pigment and minute hyaline ostiolar openings.

Stroma anatomy: Ostioles (55–)65–86(–99) μm long, umbilicate or projecting to 20(–37) μm, (30–)37–61(–80) μm wide at the apex (*n*=20); apical palisade of hyaline, narrowly clavate cells. Perithecia (175–)210–275(–300)× (105–)150–225(–270) μm (*n*=20), globose or flask-shaped; peridium hyaline, (7–)11–18(–20) μm (*n*=40) thick at the base and sides. Cortical layer (20–)21–38(–47) μm (*n*=20) thick, yellow-brown, mottled, i.e. with inhomogeneously distributed pigment, a *t. angularis* of thin-walled cells (3.5–) 5–10(–13)×(3–)4–7(–9) μm (*n*=60) in face view and in vertical section; present around the entire stroma except for the attachment area. Hairs (12–)13–28(–35)×(2.5–)3–5(–6) μm (*n*=15), scant, short, 2–4 celled, verrucose, narrowly rounded apically. Subcortical tissue a loose *t. intricata* of hyaline, thin-walled hyphae (2.5–)3.5–6.0(–7.5) μm (*n*=20) wide. Subperithecial tissue a narrow, dense, hyaline *t. epidermoidea* of thin-walled cells (5–)7–18(–26)×(3–)5–11 (–14) μm (*n*=30), followed by a palisade of coarse, elongate, thick-walled, refractive cells (15–)16–29(–36)×(8–)10–15(– 18) μm (*n*=20), and a basal layer of hyphae (2.0–)2.8–5.2(– 6.0) μm wide (*n*=10), intermingled with small-celled textura angularis, hyaline, partly brownish. Asci (74–)84–105(– 116)×(4.7–)5.3–6.3(–7.0) μm, stipe 2–13(–16) μm long (*n* =50), without croziers. Ascospores hyaline, distinctly verrucose or spinulose with tubercles to *ca* 0.7 μm long and wide; cells dimorphic, distal cell (2.8–)4.0–5.5(–6.6)×(2.7–)3.3– 4.3(–5.2) μm, l/w 1.0–1.4(–2.2) (*n*=70), globose, subglobose or wedge-shaped, particularly in the ascus apex, proximal cell (3.7–)4.5–6.3(–7.5)×(2.8–)3.0–3.7(–4.7) μm, (1.1–)1.3–1.9(–2.4) (*n*=70), oblong, wedge-shaped or subglobose, contact area distinctly flattened before maturation.

Anamorph on the natural substrate typically conspicuous, spreading over large areas or entire branches, thickly effuse, bright blue-green when fresh, when dry dull or grey-green 25E4–6, 26E3–4 to 26F5, with white margin when young.

Cultures and anamorph: optimal growth at 25°C on all media, no growth at 35°C.

On CMD after 72 h 12–16 mm at 15°C, 35–37 mm at 25°C, 28–34 mm at 30°C; mycelium covering the plate after 6–7 days at 25°C. Colony hyaline, thin, dense, not zonate. Autolytic excretions inconspicuous, frequent at 30°C, coilings and aerial hyphae inconspicuous. Reverse diffuse greenish yellow 1–3B3–4 after 1 week; after 2 weeks a weak coconut-like odour noticeable. Chlamydospores noted after 3–6 days, frequent in distal and lateral areas, intercalary and terminal, (sub-)globose, ellipsoidal to oblong. See under SNA for measurements. Conidiation starting after 3 days, in cottony tufts at the distal margin or in several often incomplete concentric rings. Tufts growing to 1.5(–2) mm diam, confluent to *ca* 5 mm, compacting to pustules and turning dark green, 28F7–8, 27EF6–8, after 5 days; pustule reverse yellow, 2C4–5, darkening to dull orange, greyish yellow or golden, 4A6–7 to 4BC5–6. Surface hyphae surrounding pustules often with conspicuously and irregularly thickened to moniliform cells. Tufts/pustules originating on a more or less erect stipe up to 12 μm thick, often with strongly constricted septa. Larger pustules consisting of a conspicuously dense, more or less globose conidiation unit (pustule core) to *ca* 0.5 mm diam, surrounded by loosely radially emerging, long regular tree-like conidiophores. Both types of conidiophores also independently formed in shrubs, small tufts, directly on surface or aerial hyphae. Dense conidiation units consisting of ill-defined, broadly tree-like or irregular conidiophores with conspicuous curvatures and curved phialides. Regularly tree-like conidiophores 0.1–1 mm long, of a narrow, straight main axis bearing mostly paired side branches in right angles or slightly inclined upwards, the latter short or replaced by phialides on upper levels, tree-like and longer, 50–100 μm, on lower levels. Phialides formed solitary or mostly in whorls of 2–3(–4), divergent, sometimes cruciform, often on 1–2 celled, sometimes thickened terminal branches mostly 2–3 μm wide. Phialides (4.5–)6–11(–14) × 2.3–3.0(–3.5) μm, l/w=(1.7–)2.4–4.6(–5.6), (1.2–)1.5–2.0(– 2.5) μm wide at the base (*n*=30), narrowly lageniform, often with long neck, mostly inaequilateral, straight in tree-like conidiophores, curved in dense pustule cores. Conidia (2.8–) 3.2–4.0(–4.5) × (2.3–)2.5–3.0 μm, l/w=(1.1–)1.2–1.5(–1.7) (*n*=30), yellowish green, ellipsoidal, smooth, with 1–2 guttules or eguttulate, scar indistinct. At 30°C surface hyphae with numerous submoniliform thickenings and constricted septa; autolytic activity and coilings conspicuous; coconut-like odour appearing after 3–4 days; chlamydospores more abundant; conidiation scant and ill-organised.

On PDA after 72 h 9–12 mm at 15°C, 38–40 mm at 25°C, 27–33 mm at 30°C; mycelium covering the plate after 5– 6 days at 25°C. Colony with distinct circular outline and well-

defined margin, conspicuously dense with thick surface hyphae radially agglutinated in densely arranged strands, not zonate. Centre flat, mottled, with moniliform surface hyphae, surface of the residual colony covered by a thick whitish tomentum of long and high aerial hyphae, the latter radially arranged towards the margin, often agglutinated into strands, soon collapsing, producing yellow drops. Autolytic excretions abundant, coilings frequent. Reverse turning yellow from the centre, 3A3–5, dull yellow, 4AB4–5, after 2 weeks; odour indistinct. Conidiation starting after 2 days in the flat centre mostly on short aerial hyphae, effuse, spreading slowly towards the distal margin, ascending on long aerial hyphae, mostly as long narrow regularly tree-like conidiophores, turning green only in the centre. At 15°C development slower, at 30°C marginal hyphae submoniliform, chlamydospores abundant in aerial hyphae, conidiation scant.

On SNA after 72 h 8–12 mm at 15°C, 24–35 mm at 25°C, 19–22 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony hyaline, thin, loose; indistinctly broadly, irregularly zonate with margins of individual zones ill-defined with irregular outgrowths; hyphae with conspicuous differences in thickness; distal region slightly downy due to aerial hyphae arising several mm high; surface and aerial hyphae degenerating within a week. Autolytic excretions inconspicuous, frequent at 30°C, coilings common, abundant at 30°C. No pigment, no distinct odour noted. Chlamydospores seen after 3–4 days, abundant, terminal and intercalary, globose to pyriform, often in chains. Conidiation tufts or pustules appearing after 3–4 days in indistinctly separated concentric rings and close to the distal margin, up to 4 mm diam, aggregations to 9 mm long, turning green, 26–27F6–8, after 4–5 days. Structure of tufts or pustules similar to CMD. At 15°C slow development, with tufts confluent to large irregular masses; chlamydospores rare. At 30°C growth more regular, denser, surface hyphae with submoniliform thickenings and often in irregular strands, conidiation macroscopically invisible, scant, on short conidiophores with moniliform terminal branches. Autolytic activity conspicuous, coilings abundant. Chlamydospores conspicuously abundant, intercalary and terminal, (6–)7–13(–21) × (3–)5–10(–14) µm, l/w=0.8–2.1 (–4.4) (n=91), variable, subglobose, fusoid, ellipsoidal, oblong to rectangular, often in chains and sometimes resembling dimorphic ascospores.

Habitat: on wood, bark and lignicolous fungi such as species of *Stilbohypoxylon* or *Rosellinia*, also endophytic in wood of *Theobroma* spp.

Distribution: uncommon but widespread, Africa (Ghana), Central and South America (Brazil, Costa Rica, Ecuador, Puerto Rico), Europe (Germany, UK).

Holotype: **Puerto Rico**, Caribbean National Forest, El Yunque Recreation Area, trail from Palo Colorado, elev. 700–800 m, on palm leaf midribs with *Stilbohypoxylon moelleri*, 22 Feb. 1996, G.J.S. 8076 (BPI 744463; ***holotype*** of *T. stilbohypoxyli* BPI 744463B; ex-type culture G.J.S. 96-30=ATCC MYA 2970=CBS 992.97=DAOM 231834; not seen).

Specimens examined: **Germany**, Rheinland-Pfalz, Eifel, Landkreis Daun, Gerolstein, Eifel, forest path shortly after Mürlenbach, left off the road heading north, 50° 09′ 32″ N, 06° 36′ 36″ E, elev. 380 m, on partly decorticated branch of *Carpinus betulus* 8 cm thick on moist bare ground, on wood, soc. *Hypoxylon howeianum*, *Mollisia* sp., holomorph, 20 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2736 (WU 29478, culture CBS 119501=C.P.K. 1979). **United Kingdom**, Essex, Loughton, Epping Forest, Strawberry Hill Ponds, MTB 43-34/1, 51° 38′ 58″ N, 00° 02′ 22″ E, elev. 30 m, on a branch of *Fagus sylvatica* 15 cm thick, on bark, stromata and subiculum of *Rosellinia corticium* and ozonium, holomorph, 12 Sep. 2007, H. Voglmayr & W. Jaklitsch, W.J. 3158 (WU 29479, culture C.P.K. 3150). Norfolk, Thetford, Emilys Wood, near Brandon, MTB 35-31/2, 52° 28′ 08″ N, 00° 38′ 20″ E, elev. 20 m, on partly decorticated branch of *Fagus sylvatica* 3.5 cm thick on the ground, present as anamorph, soc. *Hypocrea neorufoides*, 13 Sep. 2004, H. Voglmayr & W. Jaklitsch (deposited as *H. neorufoides* WU 29300; culture C.P.K. 1978). Thetford, close to the town on the right side of the road from Elveden, at a parking place, 52° 24′ 00″ N, 00° 42′ 43″ E, elev. 30 m, on branches of *Fagus sylvatica* 10 cm thick in a small pile on the ground, holomorph, teleomorph immature, culture from conidia, 12 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2704 (WU 29477, culture C.P.K. 1977).

Notes: *Hypocrea stilbohypoxyli* is a typical species of the section *Trichoderma* with low tendency to form pulvinate stromata, i.e. often maturing when effused. It produces the largest stromata of the section in Europe apart from *H. ochroleuca* and *H. subeffusa*. The anamorph of *H. stilbohypoxyli* may attract attention in nature due to its abundance under favourable conditions and its bright blue-green colour. In culture, *T. stilbohypoxyli* is conspicuous particularly on CMD at 25°C, due to pustules with a yellow reverse that consist of a dense core of curved conidiophores and phialides reminiscent of *H. rufa*/*T. viride*, surrounded by regularly tree-like conidiophores. Characteristic are also the irregularly thickened cells in surface hyphae around pustules, and notable the abundant chlamydospores on SNA at 30°C that are sometimes reminiscent of ascospores. These cultural traits have not been ascertained in non-European strains. According to Samuels et al. (2006a) *H. stilbohypoxyli* has a remarkably wide geographic distribution. Whether or not all these specimens and cultures represent a single species is not clear. In fact, although clustering together, the European isolates differ from others consistently in gene sequences, one nucleotide in ITS, five in rpb2 and 21 nucleotides in tef1 introns four and five. Other differences deduced from the description in Samuels et al. (2006a) are smaller stroma size, slightly smaller

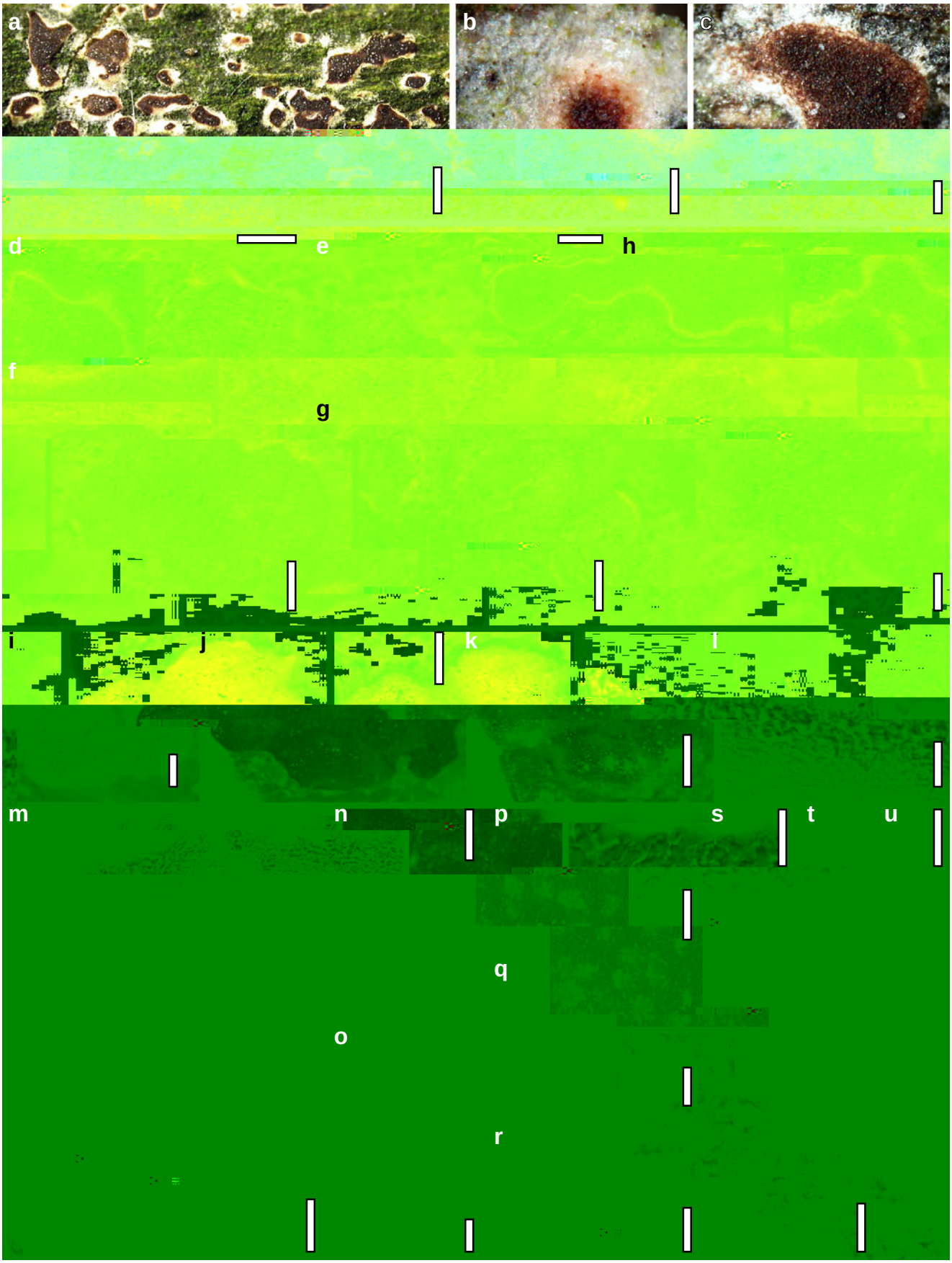
ascospores, faster growth, distinctly zonate, green colonies on PDA, and infrequent chlamydospores in non-European strains.

Hypocrea subeffusa Jaklitsch, **sp. nov.** Fig. 22
MycoBank MB 516705
Anamorph: ***Trichoderma subeffusum*** Jaklitsch, **sp. nov.** Fig. 23
MycoBank MB 516706

Stromata subeffusa vel subpulvinata, fusce rubro- ad ianthinobrunnea, tomentosa, 1–8 mm lata. Asci cylindrici, (63–)70–90(–114)×(4–)5–6(–7) μm. Ascosporae bicellulares, hyalinae, verruculosae vel spinulosae, ad septum disarticulatae, pars distalis (sub)globosa, (3.3–)3.5–4.2(–4.7)×(3.0–)3.5–4.0(–4.7) μm, pars proxima oblonga vel cuneata, (3.3–)4.0–5.0(–6.3)×(2.3–)2.8–3.5(–4.0) μm. Anamorphosis *Trichoderma subeffusum*. Conidiophora disposita in pustulis laxis in agaro CMD. Phialides divergentes, anguste lageniformes, (9–)10–14(–18)×(2.0–)2.2–2.5(–3.0) μm. Conidia ellipsoidea, dilute viridia, glabra, (2.8–)3.3–4.0(–4.7)×(2.3–)2.5–3.0(–3.5) μm.

Etymology: *subeffusa* addresses the subeffuse stroma shape.

Stromata when collected were not quite fresh; 1–8 mm


a
b
c
d
e
h
f
g
i
j
k
l
m
n
p
s
t
u
q
o
r

◀ **Fig. 22** Teleomorph of *Hypocrea subeffusa*. **a**–**i**. Dry stromata (**a**. habit, nearly fresh; **b**. stroma initial; **c**–**e**. immature). **j**. Rehydrated mature stroma. **k**. Stroma of j in 3% KOH. **l**. Hairs on stroma surface. **m**. Perithecium in section. **n**. Rehydrated stroma surface. **o**. Stroma surface in face view. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue in section. **r**. Stroma base in section. **s**–**u**. Asci with ascospores (**t**, **u**. in cotton blue/lactic acid). **a**, **c**, **e**, **j**–**t**. holotype WU 29487. **b**, **d**, **g**–**i**. WU 29488. **f**, **u**. WU 29490. Scale bars: **a**= 1.5 mm. **b**, **c**=0.12 mm. **d**=1 mm. **e**–**i**=0.3 mm. **j**, **k**=0.8 mm. **l**, **p**= 15 μm. **m**, **r**=25 μm. **n**=70 μm. **o**=5 μm. **q**, **s**–**u**=10 μm

numerous asymmetrical shrubs on distal and lateral margins, growing to amorphous fluffy tufts or loose transparent pustules 0.8–1.5 mm diam, confluent to 3–5 mm, becoming pale yellowish green, 28–29CD5–8 to 28E5–8, after 9–10 days; spreading back across the plate, finally collapsing; pustules more regularly circular and compact at 15°C. No major structural differences apparent between effuse and tuft conidiation. Shrubs or tufts arising on thick-walled stipes to 0.3 mm long, with few mostly unpaired, primary branches in right angles. Stipes and primary branches 5–7.5 μm wide, thickenings to 10 μm. Primary branches either forming tree-like conidiophores directly or rebranching into a loose net of delicate branches mostly 3–4(–5) μm wide, giving rise to regular terminal tree-like conidiophores with branches attenuated to (1.5–)2.0–2.5(–3.0) μm in terminal regions. Branches slightly or distinctly inclined upwards, bearing phialides solitary or divergent, rarely parallel, in simple whorls of 2–3 (–4) on cells 1.5–3 μm wide. Phialides (9–)10–14(–18)× (2.0–)2.2–2.5(–3.0) μm, l/w (3.3–)4.0–5.7(–7.0), (1.3–)1.7–2.2(–2.7) μm (n=60) wide at the base, narrowly lageniform, straight, slightly curved or sinuous, not or only slightly thickened in various positions. Conidia produced in small numbers in minute wet to dry heads. Conidia (2.8–)3.3–4.0 (–4.7)×(2.3–)2.5–3.0(–3.5) μm, l/w (1.2–)1.3–1.4(–1.6) (n= 63), pale green, ellipsoidal, less commonly oval or pyriform, smooth, with 1 or several guttules, scar indistinct or broadly truncate. At 15°C conidiation in compact pustules to 2 mm diam along distal and lateral margins, green, 30CD4–6, 30E5–8, 28E4–8. At 30°C poor growth, hyphae forming numerous pegs, conidiation finely effuse, simple, dry; chlamydospores abundant, globose, mainly terminal.

On PDA after 72 h 14–16 mm at 15°C, 25–28 mm at 25°C, 2–3 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony circular, compact, dense, zonate; margin well-defined; hyphae narrow. Surface becoming whitish, downy to floccose, centre denser and farinose. Aerial hyphae numerous, thin, complexly branched, becoming fertile; simpler, longer and more radially arranged on the distal margin, forming strands arranged in a stellate manner. Autolytic activity inconspicuous, but numerous minute excretions noted at 30°C; coilings absent or inconspicuous. Reverse turning dull yellow to yellow-brown, 4BD4–5; no distinct odour noted. Conidiation at 25°C noted after 2 days, effuse and farinose, short, spreading from the plug or proximal margin across the colony, in numerous densely set fine asymmetrical shrubs appearing as floccules or diffuse tufts with delicate tree-like conidiophores; also loose on long thin aerial hyphae; eventually condensing into a flat continuum in the centre and at the proximal margin, becoming pale yellowish green, 28BC4–6, 29B2–5, 29CD5–6, 30B2–3, 30AB4–5 to 27CD4–5 after 4–6 days, diffusely spreading from the centre along the margin. At 15°C conidiation dry, in confluent shrubs to 0.8 mm diam with regular radial trees, becoming yellowish green, 29AB4, 30AB3–4, 29–30CD4–6, from the proximal margin. At 30°C growth poor, hyphae autolysing quickly.

On SNA after 72 h 12–13 mm at 15°C, 16–19 mm at 25°C, 4–5 mm at 30°C; mycelium covering the plate after 2 weeks at 25°C. Colony irregular, with ill-defined to lobed margins; hyphae narrow, finely tubercular, loosely branched; usually only irregular lobes growing and few hyphae reaching the distal margin. Aerial hyphae scant, short, becoming fertile. Autolytic excretions frequent, minute, more numerous at 30°C, coilings absent or inconspicuous; no pigment, no distinct odour noted. Chlamydospores noted after ca 1 week, infrequent, abundant at 30°C. Conidiation at 25°C noted after 1 day, not becoming green within 3 weeks; effuse, on loosely disposed, simple, short conidiophores and in loose delicate shrubs with asymmetrical branching; at most visible as whitish down or few whitish fluffy tufts resulting from aggregation of small shrubs; wet conidial heads to 40 μm diam, green in the stereomicroscope. Chlamydospores at 30°C (6–)8–14(–17)×(6–)7–13(–18) μm, l/w (0.8–)0.9–1.2(–1.3) (n=33), globose, oval or ellipsoidal, terminal and intercalary. At 15°C marginal surface hyphae sinuous; conidiation scant, effuse. At 30°C growth poor, hyphae narrow, forming numerous pegs, autolysing with numerous minute excretions; chlamydospores frequent; conidiation effuse.

Habitat: on decorticated, medium to well-decomposed wood, apparently associated with green algae.

Distribution: Europe (Austria, Ukraine).

Holotype: **Austria**, Niederösterreich, Wien-Umgebung, Mauerbach, Friedhofstrasse, MTB 7763/1, 48°15′25″ N 16° 10′18″ E, elev. 320 m, on decorticated branch of *Sambucus nigra* 1.5–3 cm thick partly attached to the shrub, on/soc. green algae, soc. *Hyphoderma sambuci* and an effete pyrenomycete, holomorph, 30 Sep. 2006, W. Jaklitsch, W. J. 2998 (**WU 29487**; ex-type culture CBS 120929=C.P.K. 2479). ***Holotype*** of *Trichoderma subeffusum* isolated from WU 29487 and deposited as a dry culture with the holotype of *H. subeffusa* as **WU 29487a**.

Other specimens examined: **Austria**, Niederösterreich, Hagenbrunn, east side of the Bisamberg, entering from Wolfsbergen-Siedlung, MTB 7664/3, 48°19′25″ N 16°23′ 18″ E, elev. 300 m, on branch of *Carpinus betulus* 5–6 cm thick, on wood, 1 Nov. 2007, W. Jaklitsch, W.J. 3185 (WU 29490, culture C.P.K. 3171). **Ukraine**, Kharkivska Oblast,

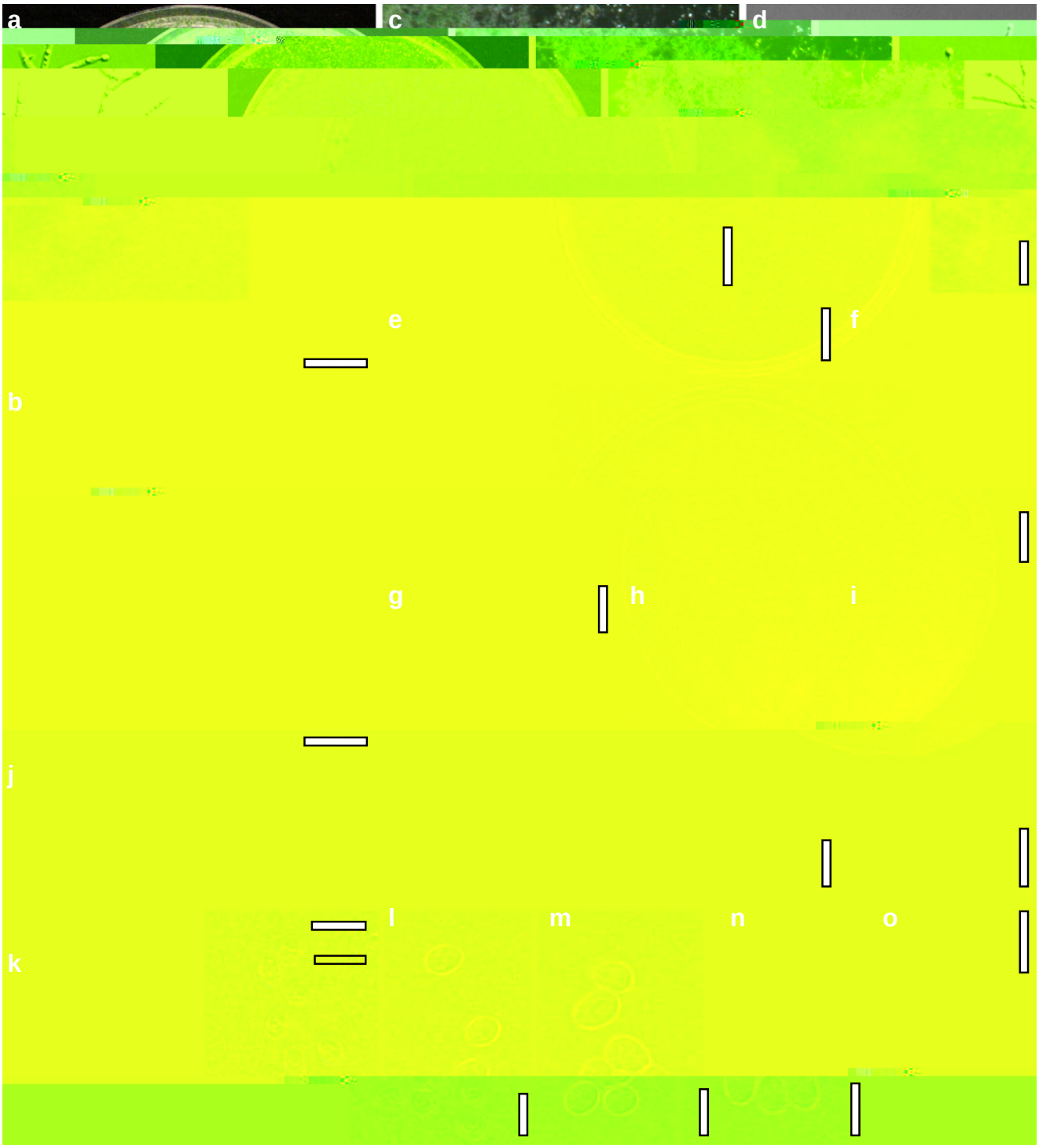


Fig. 23 Cultures and anamorph of *Hypocrea subeffusa*. **a**, **b**. Cultures (**a**. on CMD, 14 days; **b**. on PDA, 7 days). **c**. Conidiation tufts (CMD, 20 days). **d**–**h**. Conidiophores (6–7 days). **i**. Phialides (6 days). **j**. Sinuous surface hyphae (SNA, 15°C, 4 days). **k**. Coilings in surface hyphae (5 days). **l**. Terminal chlamydospore (SNA, 30°C, 7 days). **m**–**o**. Conidia (5–7 days). **a**–**o**. All at 25°C except **j**, **l**. **d**–**i**, **k**, **m**–**o**. From CMD. **a**–**f**, **i**–**m**. CBS 120929. **g**, **h**, **n**, **o**. C.P.K. 2864. Scale bars: **a**, **b**=15 mm. **c**. 0.5 mm. **d**, **f**–**h**=15 μm. **e**=30 μm. **i**=10 μm. **j**=50 μm. **k**=100 μm. **l**–**o**=5 μm

Kharkov, National nature park Gomolshanskie lesa, Zmiev area, on decorticated branch of *Quercus robur*, soc. green algae and immature thyriothecia, 25 Nov. 2006, O. Prilutsky, comm. A. Akulov AS 2136 (WU 29488, culture C.P.K. 2864). Same area, on hardwood, 6 July 2007, A. Akulov AS 2441 (WU 29489, culture C.P.K. 3134).

Notes: *Hypocrea subeffusa* is characterised by more or less effuse, violaceous-brown stromata growing in associ-

ation with green algae on decorticated wood. Stromata were nearly dry at collection times and may be more reddish brown when fresh, as suggested by the red colour after rehydration. Dry stromata may be confounded with those of *H. neorufa* and *H. neorufoides*, which differ in a yellow colour when young, in darker and more compact dry stromata, in yellow perithecial walls, and in many culture and anamorph characteristics. The dark brown dry stromata of *H. petersenii* lack violet tones. *T. petersenii* sporulates well on all media, grows well at 30°C and grows substantially faster on all media than *T. subeffusum*. The large coilings on the surface of larger colonies of *T. subeffusum* on CMD close to the distal margin have been detected in all isolates. They have not been seen in any other *Hypocrea* anamorphs in Europe so far, i.e. they are characteristic for this species. In addition, *T. subeffusum* is one of the few species that sporulate well on CMD, but poorly on SNA.

Hypocrea valdunensis Jaklitsch, **sp. nov.** Fig. 24
MycoBank MB 516708
Anamorph: ***Trichoderma valdunense*** Jaklitsch, **sp. nov.** Fig. 25
MycoBank MB 516709

Differt a *Hypocrea viridescente* ascosporis minoribus, incremento tardiore et conidiis glabris. Ascosporae bicellulares, hyalinae, verruculosae vel spinulosae, ad septum disarticulatae, pars distalis (sub)globosa, (3.0–)3.3–3.7 (–4.0)×(2.8–)3.0–3.5 μm, pars proxima oblonga, (3.5–)3.8–4.5(–5.0)×(2.3–)2.5–3.0 μm. Phialides divergentes, lageniformes, (4.5–)6–11(–14)×(1.8–)2.2–2.8(–3.2) μm. Conidia ellipsoidea vel ovalia, luteo-viridia in agaro CMD, glabra, (2.7–)3.2–3.8(–4.0)×(2.3–)2.5–2.8(–3.0) μm.

Etymology: referring to its occurrence in Valduna, Vorarlberg, Austria.

Stromata when fresh 1–6 mm diam, 0.5–1.5 mm thick, gregarious, first effuse, effluent, becoming pulvinate, compact; outline circular to oblong; margin attached or free. Surface smooth, without ostiolar dots, yellowish brown to light brown with white margin in early stages, later caramel to bright reddish brown, eventually dark red when mature.

Stromata when dry (0.7–)1.2–5(–7)×(0.5–)1–3(–4.3) mm, 0.2–0.7(–1.1) mm thick (*n*=30); first thin, membranaceous, becoming flat pulvinate when mature, broadly attached; margin mostly concolorous, partly free, rounded. Outline circular, oblong or irregularly lobed. Surface smooth, tubercular or rugose, when young finely velvety or covered by rust hairs. Ostiolar dots absent, ostiolar openings sometimes visible, (16–)20–30(–32) μm (*n*=30) wide, inconspicuous, pale, more distinct and shiny after rehydration. Stromata starting as an effuse white mycelium, becoming light, yellowish-, orange-brown from the centre, 5B4, 5–6CD(E)5–8, eventually entirely medium to dark brown, 6–7E6–8, 6F7–8, 7F4–8. Rehydrated pulvinate stromata thicker than dry; hyaline ostiolar openings and radial cracks surrounding them becoming visible; turning dark red 8F6–8 to black in 3% KOH.

Stroma anatomy: Ostioles (50–)56–73(–86) μm long, plane with the surface, (10–)14–24(–28) μm wide at the apex (*n*=30); with convergent periphyses 1–2 μm wide, lined by a palisade of hyaline, cylindrical to subclavate cells to 3 μm wide at the apex. Perithecia (128–)145–210(–255)×(75–)115–175(–190) μm (*n*=30), numerous, 7–8 per mm stroma length, subglobose or flask-shaped; peridium (9–)14–21(–25) μm (*n*=60) thick at the base and sides; hyaline to pale yellowish. Cortical layer (20–)26–43(–57) μm (*n*=30) thick, a thin irregular, amorphous, pigmented crust above a dense unevenly pigmented *t. angularis* of indistinct, thick-walled cells (3–)4–9(–12)×(2.2–)3.5–6.0(–9.0) μm (*n*=65) in face view and in vertical section; orange-brown in lactic acid, reddish brown in water. Hairs on mature stromata (7–)9–24(–40)×(2–)3–5(–6) μm (*n*=35), short cylindrical, smooth, rarely verrucose, of 1 to few cells, pale brown, infrequent at the upper surface, more frequent at stroma sides. Subcortical tissue a loose hyaline *t. intricata* of thin-walled hyphae (2–)3–5(–5.5) μm (*n*=30) wide. Subperithecial tissue a hyaline *t. epidermoidea* of thin-walled cells (5–)8–20(–29)×(4–)6–11(–12) μm (*n*=32), partly orange-brown due to basal tissue reaching upwards into the subperithecial tissue in the centre. Basal and lateral tissue towards the base a dense *t. intricata* of hyaline to yellowish-, or orange-brown hyphae (2.0–)2.5–5.5(–7.0) μm (*n*=33) wide. Asci (69–)70–80(–84)×(3.8–)4.2–5(–5.7) μm, stipe (4–)6–12(–16) μm (*n*=30) long. Ascospores hyaline, verruculose, cells dimorphic, distal cell (3.0–)3.3–3.7(–4.0)×(2.8–)3.0–3.5 μm, l/w 1.0–1.1(–1.2) (*n*=34), (sub-)globose, proximal cell (3.5–)3.8–4.5(–5.0)×(2.3–)2.5–3.0 μm, l/w (1.2–)1.3–1.7(–1.9) (*n*=34), oblong or slightly tapered downwards.

Cultures and anamorph: optimum but often limited growth at 25°C on all media except MEA; no growth at 35°C. Good growth on MEA, therefore precultures were prepared using this medium.

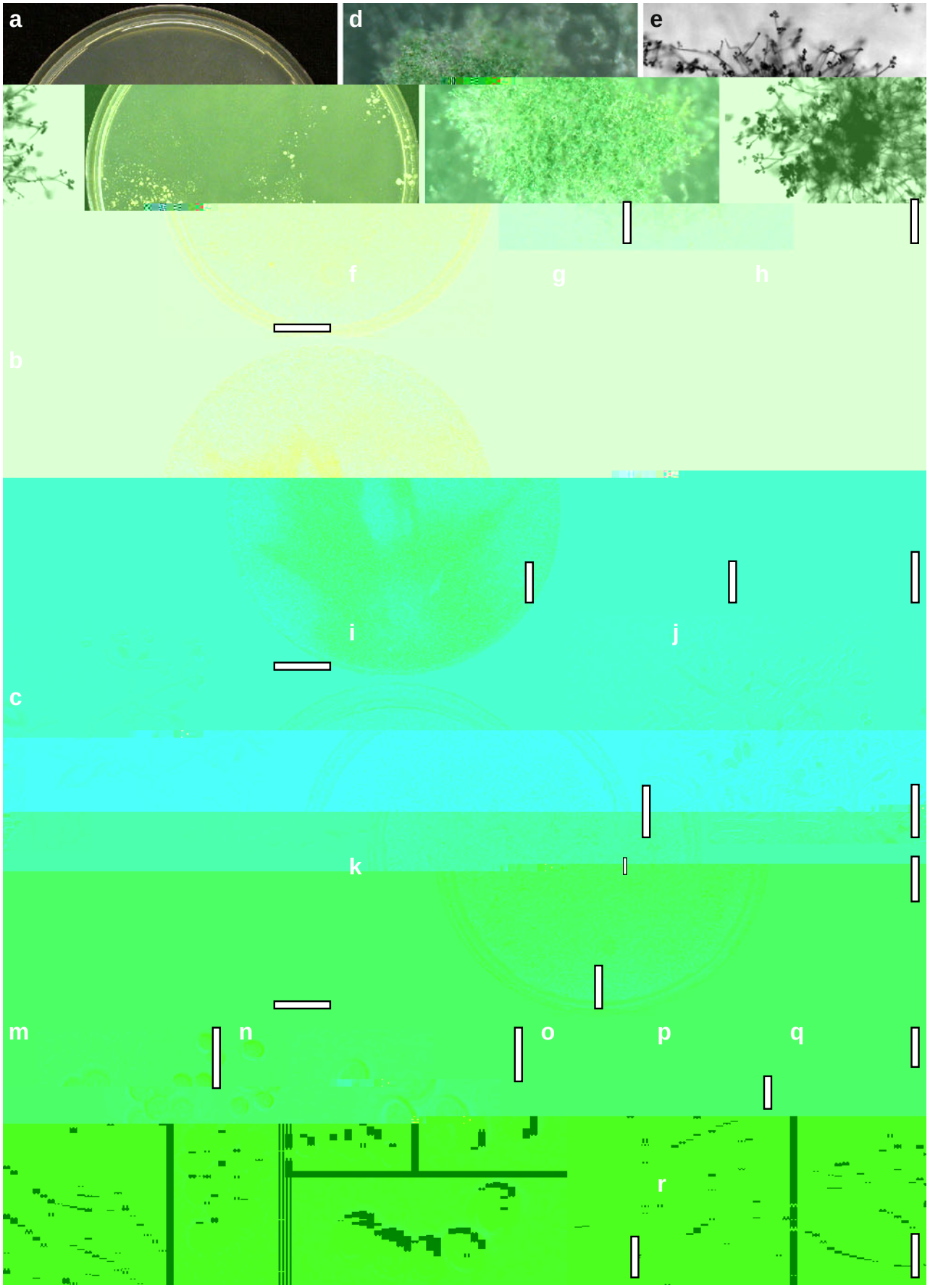
On MEA plate nearly entirely covered by mycelium after 10 days. Conidiation effuse or in floccose (yellow-)green shrubs; right angles common; phialides in whorls to 4 on cells 2–4 μm wide, becoming green with age, often curved to sinuous; thickly lageniform, often inaequilateral, with variable thickenings, mostly in or above the middle. Conidia pale, hyaline to yellowish green, distinctly yellow-green only in mass, smooth, subglobose or ellipsoidal, rarely oblong, with few minute guttules, scar indistinct.

On CMD after 72 h 1–10 mm at 15°C, 1–23 mm at 25°C, 1–13 mm at 30°C; mycelium covering the plate after 19–25 days at 25°C. Colony of narrow hyphae, hyaline, thin,

dense, homogeneous, with ill-defined, often irregularly lobed margin. Surface becoming finely downy to granular due to conidiation, granules growing to pustules 1(–2) mm diam with granulose surface. Aerial hyphae scant, autolytic activity and coilings inconspicuous. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 1 week at 30°C, infrequent, terminal and intercalary, 5–11(–18)×(5–)6–9(–11) µm, l/w 0.8–1.4(–2.1) (*n*=30), (sub-)globose, often only thickenings without septa formed. Conidiation noted after 2 days, (yellow-)green after 6–8 days; first effuse, on scant, short, simple conidiophores 30–100 µm long, sessile on surface hyphae, little and loosely branched, asymmetrical, with regularly tree-like terminal conidiophores; the latter also on some long aerial hyphae, 100–170 µm long. Phialides loosely disposed, solitary or in whorls of 2–3. Branches and phialides slightly or strongly inclined upwards. Effuse conidiation shortly followed by the formation of whitish shrubs 0.2–0.7 mm diam, growing to pustules, more or less radially disposed and along the margin, bearing minute wet conidial heads to 20(–40) µm diam, drying. Pustules formed on a thick stipe asymmetrically branched into primary branches; stipe and primary branches 7–9 µm wide, thick-walled, verrucose, wall with wavy outline, swelling in KOH; primary branches gradually tapering to 2 µm terminally or forming a loosely branched right-angled reticulum. Peripheral terminal conidiophores steep, variable, broad, narrow with parallel sides, or regularly tree-like, i.e. with phialides on top, followed by 1-celled branches, and branches longer downwards, straight, in right angles or slightly inclined upwards. Phialides arising from sometimes slightly thickened cells 2–3.5 µm wide, divergent in whorls of 2–4(–6), commonly 4, often with 2 paired phialides emerging directly below the whorl. Phialides (4.5–)6–11(–14)×(1.8–)2.2–2.8(–3.2) µm, l/w (1.8–)2.3–4.6(–5.5), (1.0–)1.5–2.0(–2.5) µm wide at the base (*n*=32), lageniform, not thickened or thickened at various positions, straight, mostly inaequilateral. Conidia (2.7–)3.2–3.8(–4.0)×(2.3–)2.5–2.8(–3.0) µm, l/w (1.1–)1.2–1.5(–1.7) (*n*=30), subhyaline to yellowish green, ellipsoidal or oval, smooth, with minute guttules; scar indistinct or distinct and truncate. No structural difference except for increased complexity in pustules apparent between effuse and pustulate conidiation. At 15°C conidiation effuse, farinose. At 30°C colony outline irregular with wavy to lobed margin, dense; conidiation effuse, mostly central, with wet heads to 40 µm diam, and in green, 28–30F5–8, pustules to 1 mm diam with minute wet heads on regular trees with narrow branches and fertile straight elongations to 0.3 mm long.

On PDA after 72 h 1–5 mm at 15°C, 0–15 mm at 25°C, 0–5 mm at 30°C; mycelium covering the plate after 2–3 weeks at 25°C. Colony circular, dense to opaque, margin wavy to lobed, surface flat, whitish, downy to granular or floccose; often irregular outgrowths formed after temporary termination of growth; often a dense continuous, chalky to yellow zone of irregular outline or broad yellow, 4AB4, areas formed. Aerial hyphae numerous, forming a flat layer of radiating shrubs and short thick, irregularly oriented strands resulting in broom-like floccules or granules, becoming fertile. Autolytic activity inconspicuous, excretions minute, coilings moderate to frequent. Reverse becoming yellow, 4AB3–5, spreading from the plug; odour indistinct or slightly mushroomy. Conidiation noted after 2–4 days, effuse, on aerial hyphae mostly on lower levels, spreading from the plug, also on sessile, densely disposed, shrubs, remaining colourless. Conidial yield poor, more abundant in yellow areas.

On SNA after 72 h 1–4 mm at 15°C, 1– 1 2 (;) - 2 1 3 . 7 (d e r a) -


a
d
e
f
g
h
b
i
j
c
k
m
n
o
p
q
r

◀ **Fig. 25** Cultures and anamorph of *Hypocrea valdunensis* (CBS 120923). **a**–**c**. Cultures (**a**. on CMD, 19 days; **b**. on PDA, 19 days; **c**. on SNA, 21 days). **d**, **e**. Conidiation tufts (CMD; d. 27 days, stereomicroscope. **e**. 11 days, compound microscope, 10× objective). **f**–**m**. Conidiophores (**f**–**h**, **k**–**m**. CMD, 6–8 days; **i**, **j**. MEA, 10 days). **n**. Phialides (CMD, 8 days). **o**–**r**. Conidia (**o**. MEA, 10 days; **p**. from tuft, CMD, 27 days; **q**, **r**. CMD, 6 days). **a**–**r**. All at 25°C. Scale bars: **a**–**c**= 15 mm. **d**, **e**. = 80 μm. **f**, **g** = 20 μm. **h**–**k**=15 μm. **l**–**n**=10 μm. **o**, **p**= 5 μm. **q**, **r**=3 μm

brown colours when fresh and *H. neorufa*, *H. neorufoides*, *H. petersenii* and *H. subeffusa* due to the dark brown colour when dry. The phylogenetically closest related species, *H. viridescens*, has in addition smaller stromata, slightly larger perithecia, larger ascospores and wider, verruculose conidia. Limited and conspicuously slow growth, i.e. less than half of the growth rate of *H. neorufoides*, necessitating the use of MEA as a preculture medium for growth rate experiments, but also the farinose yellow conidiation on PDA, set it apart from all other species of the section *Trichoderma* currently known in Europe to form teleomorphs. However, one isolate may not be sufficient to estimate its entire variation.

Hypocrea viridescens Jaklitsch & Samuels, Stud. Mycol. 56: 156 (2006b). Fig. 26
Anamorph: ***Trichoderma viridescens*** (A.S. Horne & H.S. Williamson) Jaklitsch & Samuels, Stud. Mycol. 56: 156 (2006b). Fig. 27
≡ *Eidamia viridescens* A.S. Horne & H.S. Williamson, Ann. Bot. 37: 396 (1923).

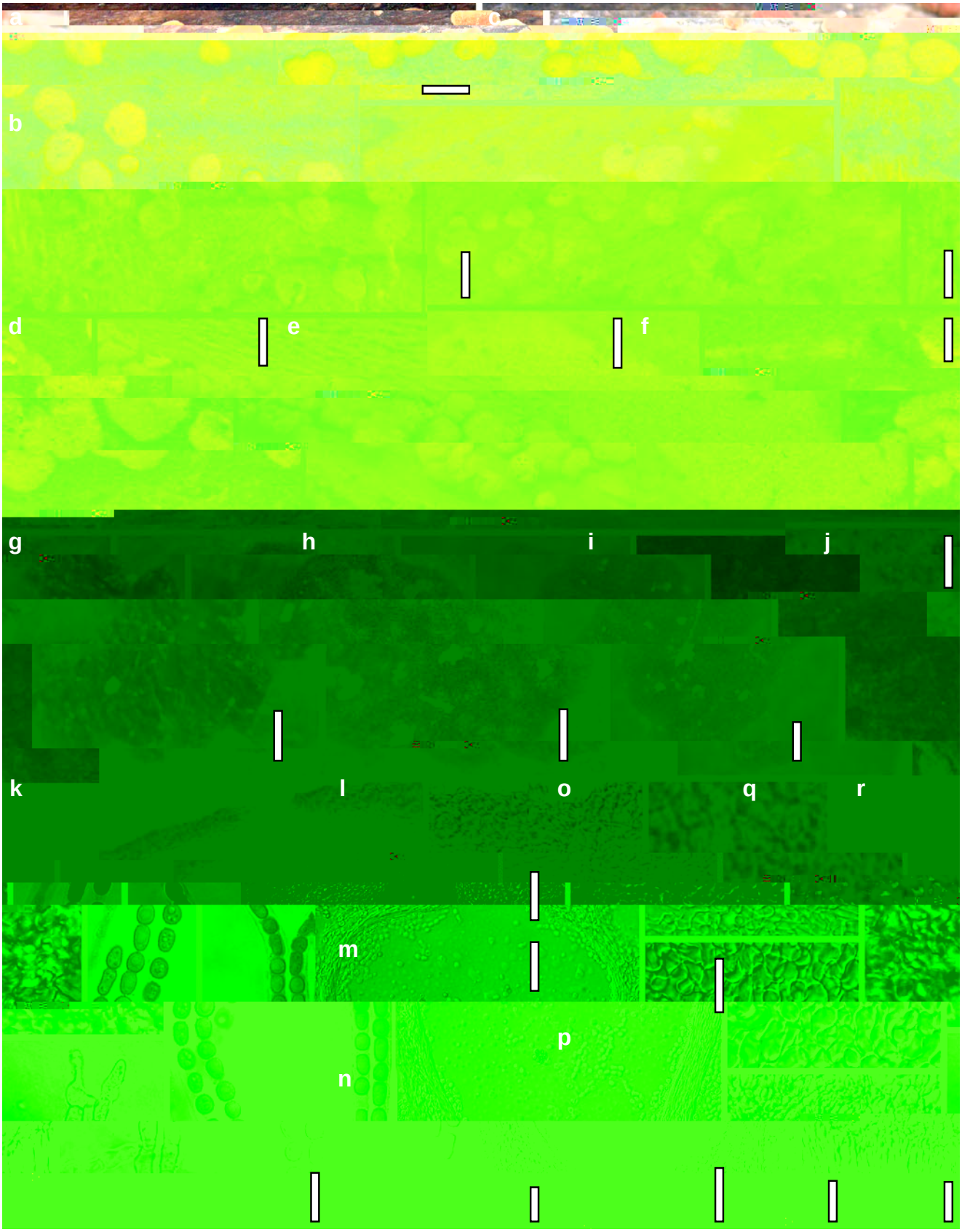
Stromata when fresh 0.5–4 mm diam, 0.5–1.5 mm thick, solitary, loosely gregarious or densely aggregated in lines, first subeffuse, becoming pulvinate, broadly or centrally attached; margins free, concolorous, sometimes white when young. Outline circular, angular or irregular. Surface downy when young, covered with yellowish to rust hairs; later glabrous, smooth or finely granular by perithecial contours. Ostiolar dots invisible or appearing as inconspicuous, light to dark dots. Stroma colour when young brown-orange, light brown, yellow-brown to bright reddish brown, 5B5–6, 6CD5–8, 8BC7–8; when mature mostly dark reddish brown to dark red, 7DE7–8, 8–9EF6–8, 10CD7–8; rarely rosy-brownish or greyish red, 8CD5–6, or orange to orange-red, 6A6–7, 7A5–6.

Stromata when dry (0.2–)0.6–1.6(–3.6) mm (n=277) diam, 0.2–0.5(–0.8) mm (n=33) thick; thin, semi-effuse to effuse, hairy, with white to rust margin young; later effluent, discrete and pulvinate with circular, angular to irregular outline. Surface uneven, tubercular to wrinkled; ostioles invisible or appearing as dots (24–)34–64(–79) μm (n=33) diam, light with darker marginal rings, plane or convex. Stromata when young first white, turning yellowish, yellow-, orange-, rust-brown, 4A4, 5BD4–7, 6–7CD(E)5–8, later in the great majority of stromata deep and dark reddish brown, 7–9EF5–8, unchanged or slightly darkened in 3% KOH.

Stroma anatomy: Ostiolar canal (53–)70–98(–130) μm (n=138) long, plane or projecting up to 15 μm, (30–)33–49(–57) μm (n=15) wide at the opening, the opening formed by a palisade of hyaline, apically elongate narrowly clavate cells. Perithecia flask-shaped, ellipsoidal or globose, (135–)220–290(–340)×(72–)150–225(–280) μm (n=149); peridium (17–)19–26(–30) μm thick at the base, (11–)13–20(–22) μm thick laterally (n=15), hyaline. Cortical tissue (15–)18–36(–60) μm (n=63) thick, present around the entire stroma except for the point of attachment, a *t. angularis* of isodiametric to slightly elongated, thin- to thick-walled cells (2–)3–9(–19)×(1.5–)2.5–6(–10) μm (n=360) in face view and in vertical section, with reddish brown to yellow-brown pigment inhomogeneously deposited. Hairs arising from cells of the stroma surface, usually abundant when young, scant on mature stromata, 1–5 celled, thin- or thick-walled, (5–)10–24(–47) μm (n=240) long, (2.0–)3.2–5.0(–7.0) μm (n=83) wide, apically rounded, pale brownish, smooth to slightly verruculose. Subcortical tissue comprising a mixture of intertwined hyphae (3–)4–6(–7) μm (n=15) wide, vertical and parallel between perithecia, and hyaline, subglobose to angular cells (3–)5–10(–13) μm (n=30) diam, flanking the ostioles. Subperithecial tissue a homogeneous, dense *t. angularis–epidermoidea* of thin-walled cells (3.5–)4.5–15(–39)×(2.0–)4.5–10(–17) μm (n=337, 240) wide, hyaline to pale brownish, gradually smaller and interspersed with few narrow hyphae 3–4 μm wide towards the base; above the point of attachment stratified by a palisade of oblong refractive glassy cells 14–31×4–9 μm; sometimes irregular brownish pigment in patches incorporated through the whole tissue; basally delimited by the reddish brown cortex. Asci (56–)82–101(–118)×(3–)5–7(–9) μm (n=314), stipe (4–)6–22(–33) μm (n=31) long. Ascospores hyaline, verruculose to verrucose with verrucae *ca* 0.5 μm long and diam, cells dimorphic; distal cell (3.3–)4.0–5.2(–7.5)×(3.2–)3.8–4.5(–5.5) μm (n=411), subglobose, oval to wedge-shaped; proximal cell (3.4–)4.5–5.8(–8.0)×(2.7–)3.3–4.0(–5.3) μm (n=411), oblong to wedge-shaped, lower end broadly rounded.

Cultures and anamorph: optimal growth at 25°C on all media, no growth at 35°C.

On CMD after 72 h 14–17 mm at 15°C, 39–41 mm at 25°C, 14–24 mm at 30°C; mycelium covering the plate after 5–6 days at 25°C. Colony hyaline, thin, circular, not zonate; hyphae loosely arranged. Autolytic activity inconspicuous, coilings abundant in some isolates. Aerial hyphae scarce during fast growth, becoming abundant, particularly towards the margin, broad zone at the margin becoming downy. A diffuse greenish yellow pigment, 1B2–6, 2A3, 3B4, 29A2–3, often diffusing through the entire culture after 1–2 weeks. Typically a distinct coconut-like odour formed. Chlamydo-


b
d
e
f
g
h
i
j
k
l
o
q
r
m
p
n

◀ **Fig. 26** Teleomorph of *Hypocrea viridescens*. **a**–**g**. Fresh stromata (**a**, **d**, **e**: immature). **h**, **i**. Dry mature stromata. **j**. Surface of rehydrated stroma showing ostioles and unevenly distributed pigment. **k**. Perithecium in section. **l**. Cortical and subcortical tissue in section. **m**. Subperithecial tissue in section. **n**. Basal palisade of cells above the attachment point in section. **o**. Stroma surface in face view. **p**. Hairs on lateral stroma surface. **q**, **r**. Asci with ascospores in cotton blue/lactic acid. **a**, **l**, **o**, **p**, **q**. WU 24025. **b**, **c**. WU 24027. **d**, **f**. holotype WU 24029. **e**. WU 24024. **g**, **j**, **k**, **m**, **n**, **r**. WU 24019. **h**. WU 24018. **i**. WU 24028. Scale bars: **a**=1.3 mm. **b**, **c**, **e**, **f**=1 mm. **d**, **g**=0.5 mm. **h**, **i**=0.2 mm. **j**=90 μm. **k**=35 μm. **l**–**n**=15 μm. **o**–**r**=10 μm

spores noted after 5–6 days, uncommon, terminal or intercalary, (7–)8–12(–16)×(6–)7–11(–13) μm, l/w (0.9–)1.0–1.3(–1.5) (*n*=28), globose or subglobose; size dependent on hyphal width. Conidiation starting after 2 days, developing slowly, turning pale to dark green, 28A4–5 to 27F5–8, after 5 days; typically effuse, spreading from the centre and particularly concentrated at the distal and lateral margins, often followed by the formation of polymorphic, loose shrubs or tufts of 0.2–1.5 mm diam, confluent up to 3×2 mm, sometimes in up to three concentric rings or evenly or irregularly disposed. Sometimes small pustules formed early in proximal areas of the plate. Inoculation in the middle of the plate often resulting in more regular distribution of tufts or pustules. Conidiophores typically visible at the surface of the pustules. Shrubs, tufts or pustules arising on a thick-walled and verrucose stipe to ca 11 μm wide, of varying length, asymmetrically branched into thick and long primary branches 2–3 times further branched, spanning a loose reticulum of long and thin, paired or unpaired conidiophores. Conidiophores not conspicuously curved or sinuous, comprising a) a well-discernible main axis with a tree-like terminus and short, more or less straight, regularly tree-like side branches, often paired and mostly inclined upwards along the axis or b) particularly in effuse, more simple conidiophores, a distinct or indistinct main axis with or without paired or unpaired, long, straight or curved, side branches in right angles or inclined upwards, terminating in one or two phialides; phialides appearing to proliferate percurrently, often resulting in a submoniliform chain of 2–6 cells swollen in the middle and more or less conspicuously constricted above and below the middle. Phialides produced on cells 2–3(–5) μm wide, singly or divergent in often cruciform whorls of 2–3. Phialides (4.8–)6–11(–16)×(2.0–)2.5–3.3(–4.0) μm, l/w (1.4–)2.2–3.9(–5.6), (1.2–)1.5–2.2(–2.5) μm wide at the base (*n*=60), lageniform to nearly ampulliform, mostly straight, sometimes slightly curved to sinuous, widest in various positions, mostly median, neck and often base narrow. Conidia (2.8–)3.5–4.3(–5.2)×(2.8–)3.0–3.7(–4.0) μm, l/w 1.0–1.3(–1.7) (*n*=123), subglobose, oval or ellipsoidal, green, verruculose, with minute guttules, rarely with a distinct apiculus. At 15 and 30°C slower development with less conidiation and less strong coconut-like odour formed, coilings more frequent at 30°C.

On PDA after 72 h 10–13 mm at 15°C, 32–37 mm at 25°C, 10–19 mm at 30°C; mycelium covering the plate after 5–6 days at 25°C. Colony homogeneous, typically not zoned, covered by a dense mat of aerial hyphae several mm thick. Autolytic activity low or conspicuous, more pronounced at 15°C, coilings more frequent at 30°C. No diffusing pigment formed, reverse only slightly yellowish, 3A3–4, 3B4; odour indistinct or weakly coconut-like. Conidiation starting after 2 days, effuse in lower regions of long aerial hyphae in proximal and central parts of the colony, ill-defined, dry, usually not becoming green and soon degenerating. In some isolates conidia developing in 3 or 4 distinct concentric green rings. Slower development at 15 and 30°C, conidiation becoming green, 28DE5–6.

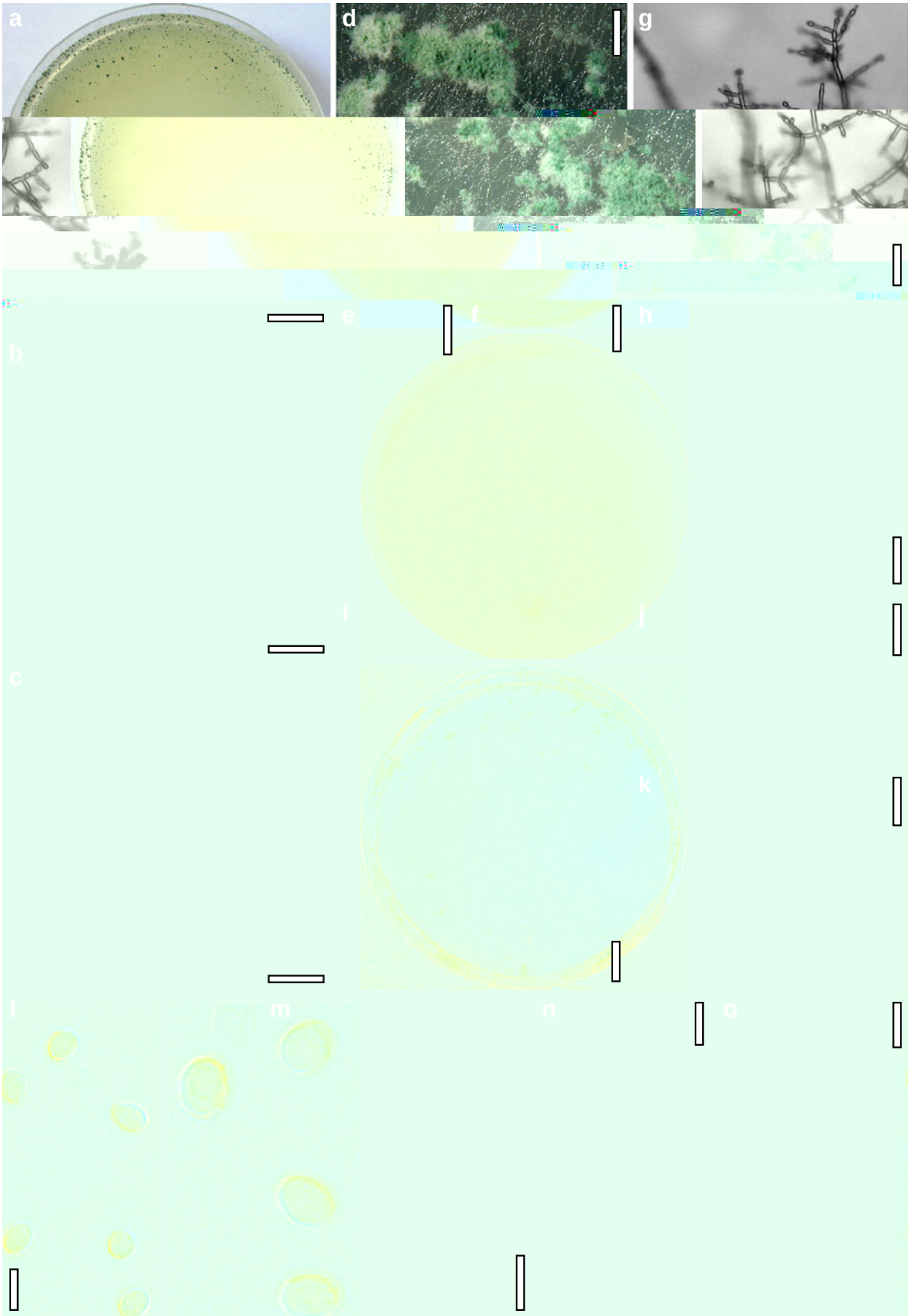
On SNA after 72 h 11–12 mm at 15°C, 34–37 mm at 25°C, 5–13 mm at 30°C; mycelium covering the plate after 6 days at 25°C; hyphae loosely arranged radially. Colony similar to CMD, not zoned; aerial hyphae and coilings often more pronounced. Chlamydospores noted after 6–9 days, mostly intercalary and angular to ellipsoidal, more frequent than on CMD. No distinct odour and no pigment formed. Conidiation starting after 2 days, first effuse on long aerial hyphae, spreading across the entire plate, followed by a formation of loose tufts or pustules to *ca* 1 mm diam, more conspicuous than on CMD, confluent to 6×4 mm, becoming green after 5 days, eventually after *ca* 2 weeks dark green, 27F4–8. Conidiophores more or less regularly tree-like, submoniliform terminal branches rare. At 30°C autolytic activity conspicuous and percurrently proliferating phialides more frequent.

Habitat: Anamorph isolated from various materials. Holomorph or teleomorph occurring on wood and bark of deciduous and coniferous trees, often on cut and usually at least partly decorticated branches and logs; overgrowing various fungi.

Distribution: Common, especially as anamorph, in north- and south-temperate regions: Europe (Austria, Czech Republic, England, France, Germany, Northern Ireland, Russia, Sweden) and North America (USA: Georgia, North Carolina, Oregon; Mexico); also Australia, Japan, New Zealand and Taiwan.

Holotype of the teleomorph: **Austria**, Kärnten, Völkermarkt, Eisenkappel-Vellach, Vellacher Kotschna, MTB 9653/1, 46°24′02″ N, 14°34′06″ E, elev. 970 m, on split and partly decorticated branch of *Fagus sylvatica* 7–8 cm thick, on the ground, soc. *Corticium roseum*, 31 Oct. 2005, H. Voglmayr & W. Jaklitsch, W.J. 2881 (WU 24029, culture CBS 119321=C.P.K. 2140). ***Neotype*** of *Eidamia viridescens*, dried culture of the original strain CBS 433.34 (herb. CBS 7868), isolated from rotten apples, UK. ***Epitype*** of *T. viridescens*, designated by Jaklitsch et al. (2006b): C.P.K. 2140 deposited as a dry culture together with the holotype of *H. viridescens* as WU 24029a.

Other specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, Trieblach, above


a
d
g
e
f
h
b
i
j
c
k
l
m
n
o

◀ **Fig. 27** Cultures and anamorph of *Hypocrea viridescens*. **a**–**c**. Cultures (**a**. on CMD, 11 days; **b**. on PDA, 14 days; **c**. on SNA, 11 days). **d**. Conidiation tufts (6 days). **e**, **f**. Stipe and primary branches (5–8 days). **g**, **h**. Conidiophores on growth plates (**h**. showing submoniliform branches; 7 days). **i**, **j**, **l**. Conidiophores (**i**, **l**. . regularly tree-like conidiophores; **j**. with submoniliform branches; 6–8 days). **k**. Autolytic excretion (Difco-PDA, 25°C, 3 days). **m**. Proliferating phialides (5 days). **n**, **o**. Conidia (6 days). **d**–**o**. All on CMD at 25°C except **k**. **a**–**c**, **f**, **g**, **h**, **j**. CBS 119324. **d**, **e**, **i**, **l**–**o**. CBS 119322. **k**. holotype CBS 119321. Scale bars: **a**–**c**=15 mm. **d**= 0.4 mm. **e**, **i**=15 μm. **f**, **j**=30 μm. **g**, **h**, **l**=20 μm. **k**=50 μm. **m**, **n**= 5 μm. **o**=3 μm

Kucher at roadside, MTB 9452/2, 46°33′15″ N, 14°25′19″ E, elev. 440 m, on logs of *Picea abies* >20 cm thick in a pile, holomorph, 14 Oct. 2006, W. Jaklitsch, W.J. 3022 (WU 29520, culture C.P.K. 3122). Oberösterreich, Grieskirchen, Natternbach, forest close to Gaisbuchen, MTB 7548/3, 48°24′39″ N, 13°41′40″ E, elev. 580 m, on branch of *Fagus sylvatica* on leaf litter in spruce forest, 1 Aug. 2004, H. Voglmayr, W.J. 2553 (WU 24022; culture C.P.K. 2043). Schärding, St. Willibald, Großer Salletwald at the road to Geiselham, MTB 7648/1, 48°21′06″ N 13°42′19″ E, elev. 450 m, on branch of *Salix caprea* 3–4 cm thick, 2 Sep. 2006, H. Voglmayr, W.J. 2970 (WU 29519, culture C.P.K. 2462). Steiermark, Liezen, Kleinsölk, walking path between Schwarzensee 1170 m, on log segment of *Picea abies* 100 cm thick in grass, soc. *Neonectria fuckeliana*, 6. Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2306 (WU 24018; culture CBS 119324=C.P.K. 942); (Ost-)Tirol, Lienz, Defereggental, Hopfgarten in Defereggen, Dölsach, at roadside between the current transformer and the beverage depot, MTB 9041/3, 46°55′23″ N, 12°32′41″ E, elev. 990 m, on stored log of *Picea abies* 16 cm thick, in grass, 4. Sep. 2003, W. Jaklitsch, W.J. 2374 (WU 24019; culture C.P.K. 947). Vienna, 22nd district, Lobau, at Panozzalacke, MTB 7865/1, 48°11′11″ N, 16°29′23″ E, elev. 150 m, on branch of *Ulmus campestris* 5 cm thick, holomorph, 18 Nov. 2006, W. Jaklitsch, W.J. 3037 (WU 29521, culture C.P.K. 2851). Vienna, 23rd district, Maurer Wald, MTB 7863/1, 48°08′57″ N 16 14′50″ E, elev. 360 m, on decorticated branch of *Carpinus betulus* on the ground, soc. *Tubeufia cerea*, 3 Oct. 1998, W. Jaklitsch, W.J. 1223 (WU 24009, BPI 747557; culture G.J.S. 98-182=CBS 120067). **Denmark**, Soenderjylland, Roedekro, Rise Skov, between Roedekro and Aabenraa, 55°03′34″ N, 09°22′01″ E, elev. 70 m, on decorticated branch of *Quercus robur* 9 cm thick, on wood, soc. *Mycena sanguinolenta*, holomorph, anamorph with yellow spots, 23 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2935 (WU 29517, culture C.P.K. 2442). **Germany**, Baden-Württemberg, Freiburg, Landkreis Schwarzwald-Baar-Kreis, Furtwangen, shortly before Kaltenherberg coming from Gasthof Thurner, MTB 8015/1, 47°59′36″ N, 08°10′50″ E, elev. 1000 m, on cut logs of *Picea abies* 20–40 cm thick, in a pile at roadside, part with white mould, 2 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2664 (WU 24023; culture C.P.K. 2138); Landkreis Breisgau-Hochschwarzwald, St. Märgen, shortly after Glashütte, coming from Hexenloch, on the right side of the road close to a bridge, MTB 8014/2, 47°59′37″ N, 08° 07′32″ E, elev. 750 m, on cut branch of *Picea abies* 4 cm thick on moist ground, 2 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2665 (WU 24024; culture C.P.K. 2044); Landkreis Lörrach, Todtnau, at the crossing to St. Blasien, MTB 8113/4, 47°48′11″ N, 07°56′01″ E, elev. 490 m, on mostly decorticated cut logs of *Picea abies* up to 35 cm thick, in pile, soc. effete *Ophiostoma* sp., white mould, 3 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2670 (WU 24025; culture CBS 119323=C.P.K. 2045); Bavaria, Starnberg, Tutzing, Erling, at the Hartschimmel terrain, 47°56′ 41″ N, 11°10′37″ E, elev. 700 m, on partly decorticated branch of *Fagus sylvatica* 13–15 cm thick, on the ground in leaf litter, 3 Sep. 2005, W. Jaklitsch, W.J. 2838 (WU 24028; culture C.P.K. 2139). Hessen, Rhön, SW Gersfeld, "Gichenbachtal", MTB 5525/3, elev. 550 m, on wood of *Picea abies*, 20 July 2008, L. Krieglsteiner. Niedersachsen, Landkreis Soltau-Fallingbostel, Bispingen, Behringen, east of Hengstberg and the road leading to the NSG Lüneburger Heide, 53°07′17″ N, 09°57′27″ E, elev. 100 m, on cut branch segments of *Betula pendula*, *Pinus sylvestris* and *Quercus robur* 6–10 cm thick, on wood, mostly cutting areas, soc. *H. schweinitzii*, *H. minutispora* on *Betula*, holomorph, anamorph with yellow spots, 26 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2948 (WU 29518, culture C.P.K. 2449). **Sweden**, Stockholms Län, Nothamn, mixed forest at the coast, MTB 4179/3, 60°01′42″ N, 18° 50′46″ E, elev. 10 m, on corticated branch of *Corylus avellana* 2–3 cm thick, in moss, soc. *Diatrype stigma* s.l., 7 Oct. 2003, W. Jaklitsch, W.J. 2447 (WU 24020; culture C.P.K. 983); Uppsala Län, Sunnersta, forest opposite the virgin forest Vardsätra Naturpark across the main road, MTB 3871/2, 59°47′24″ N, 17°37′51″ E, elev. 15 m, on cut branch of *Salix caprea* 7 cm thick, soc. *Capronia cf. pilosella*, 8 Oct. 2003, W. Jaklitsch, W.J. 2453 (WU 24021; culture C.P.K. 985). **Ukraine**, Kharkivska Oblast, Kharkov, National nature park Gomolshanskie lesa, Zmiev area, on branch of *Quercus robur*, 27 July 2007, A. Akulov (AS 2440, culture C.P.K. 3133). **United Kingdom**, Devon, Exeter, Stoke Woods, close to the parking place Forest Walks, SX919959, 50°45′10″ N, 03°31′54″ W, elev. 30 m, on branch of *Fagus sylvatica* 4 cm thick, on the ground in leaf litter, 8 Sep. 2004, H. Voglmayr, W. Jaklitsch & J. Webster, W.J. 2686 (WU 24026; culture C.P.K. 2046); Hertfordshire, Stevenage, Box Wood, on decorticated branch of *Quercus robur*, 4 Dec. 2007, Kerry Robinson (WU 29523). Waterford, Waterford Heath, Mole Wood, elev. 70 m, 51°48′42″ N, 0°05′22″ W, on basidiomata of *Hymenochaete corrugata* on cut branches, 10–12 cm thick,

orylus avellana 12 Sep 2007, W. Jaklitsch, K. ison, H. Voglmayr, W.J. 3186 (WU 29522, culture . 3172). Westland Green, Caley Wood, on decorti- branch of *Carpinus betulus*, cm thick, on, 23 Dec. Kerry Robinson (WU 29524). North East London, g Forest, between Robin Hood Roundabout and Hill , 43–34/1, 51°39′15″ N, 00°02′13″ E, elev. 40 m, on h of *Fagus sylvatica* on the ground in leaf litter, soc. partly on a resupinate polypore, soc. *Hypocrea lixii*, *coryne sarcoides*, *Diatrype decorticata*, 16 Sep. 2004, oglmayr & W. Jaklitsch, W.J. 2723 (WU 24027; e CBS 119322=C.P.K. 2047).

otes: Measurements of teleomorph characters include determined by G.J. Samuels on non-European material Jaklitsch et al. 2006b). Culture characteristics are here ibed for European isolates only. Conidiophores with arly tree-like side branches correspond to Type 2 liophores, and those with percurrently proliferating ides, i.e. submoniliform side branches, to Type 3 liophores of Jaklitsch et al. (2006b). Sometimes both occur in the same isolate. In nature the teleomorph of *H. escens* is usually associated with its anamorph, some- s showing citrine to sulphur-yellow hairy patches as in *ufa*. The conidia, globose to subglobose and coarsely rcular in *H. rufa*/*T. viride* versus subglobose to ellipsoi- and verruculose in *H./T. viridescens*, from natural trates as well as from agar media help to distinguish e two species, although their teleomorphs are indistin- hable. Phialides of *H. rufa* are often solitary, hooked to ous, and conidiophores lack a discernable main axis, and also usually distinctly curved to sinuous on pustule rgins, whereas conidiophores of *T. viridescens* observed SNA, and often also CMD, tend to be more typical of *choderma*, i.e. regularly tree-like, with paired branches t increase in length with distance from the tip. Phialides in stules of *T. viride* do not proliferate percurrently, a mmon and distinctive feature of *T. viridescens*. A coconut our is typical of *T. viridescens* but unusual in *T. viride*. nother species forming submoniliform conidiophore anches is *T. gamsii*, which can be distinguished from *T. ridescens* by narrower, smooth conidia. See Jaklitsch et al. 006b) for further details on this and similar species.

The pachybasium core group, including species formerly classified in *Podostroma*

Introduction

The genus *Pachybasium* Sacc. (Saccardo 1885) was originally established for *P. hamatum* and similar species. Bissett (1991a) reduced the genus to a section of *Trichoderma*, with *Trichoderma hamatum* as its type, including also *T. harzianum*, *T. piluliferum*, *T. polysporum* and the anamorph of *Hypocrea gelatinosa*. Later (Bissett 1991b) he enlarged the section to 20 species. Species of this section are characterised by repeatedly branched, stout conidiophores with dense clusters of plump, ampulliform phialides. These conidiophores are formed in pustules and have frequently conspicuous sterile or terminally fertile, straight, sinuous or helical elongations. Conidia are green or hyaline. However, molecular phylogeny (Kindermann et al. 1998; Kullnig-Gradinger et al. 2002) has shown that *Trichoderma* section *Pachybasium* as defined by Bissett (1991b) was paraphyletic. *Trichoderma hamatum* and some other species cluster with section *Trichoderma*, and all species that have green-spored *Hypocrea* teleomorphs turned out to belong to several unrelated clades (Chaverri et al. 2003; Chaverri and Samuels 2003; Jaklitsch 2009). The phylogenetic clade representing the remaining species around *T. polysporum* was later termed the *Pachybasioides* clade (Jaklitsch et al. 2005, 2006a; Samuels et al. 2006a). Doi (1972) discovered and described *H. pachybasioides*, the teleomorph of *T. polysporum*, having earlier (Doi 1966) interpreted it as *H. citrina*. Lu et al. (2004) reviewed some species of the clade and added several new species, among them *H. minutispora*, the common teleomorph of *T. minutisporum*. Jaklitsch et al. (2008b) discovered that species with upright stromata, assignable to the former genera *Podostroma* or *Podocrea*, also belonged in this clade. Accordingly, this phylogenetic clade, now termed the pachybasium core group, is morphologically heterogeneous, comprising teleomorphs with upright, stipitate stromata and small pulvinate stromata. *Hypocrea luteffusa* is an exception, because the teleomorph superficially resembles those of section *Hypocreanum* and the *Brevicompactum* clade, being closer to the latter. Also anamorphs in this group vary greatly. The pachybasium-like conidiation as defined by Bissett (1991b) is present in pustules, but several species produce only effuse, verticillium-like conidiophores.

Species forming rosy or yellow pulvinate stromata are difficult to distinguish. *Hypocrea parapilulifera* can hardly be distinguished morphologically from *H. pachybasioides*, even in the anamorph. *Hypocrea minutispora* is by far the commonest species of the genus in Europe. The teleomorphs of *H. atlantica*, *H. minutispora* and *H. pachybasioides* are similar. The typification of *H. pilulifera* was debated by Lu et al. (2004). This issue has been settled and it appears that the species forms its stromata on wood of *Betula* rather than on *Juncus*, where the holotype was collected, apparently as an exception.

Species like *H. argillacea* and *H. strobilina* not collected recently, may also belong in this clade. *Hypocrea moravica* of the *Semiorbis* clade and *H. silvae-virgineae*, which clusters with *Trichoderma helicum* (see Fig. 1), are morphologically similar to species of the pachybasium core group

Species descriptions

The following 13 species including four new ones are grouped in alphabetical order within two morphologically defined groups, treating the species assignable to the former genus *Podostroma* first: *Hypocrea alutacea*, *H. leucopus*, *H. nybergiana*, and *H. seppoi*; followed by *H. atlantica*, *H. bavarica*, *H. luteffusa*, *H. minutispora*, *H. pachybasioides*, *H. pachypallida*, *H. parapilulifera*, *H. pilulifera*, and *H. placentula*.

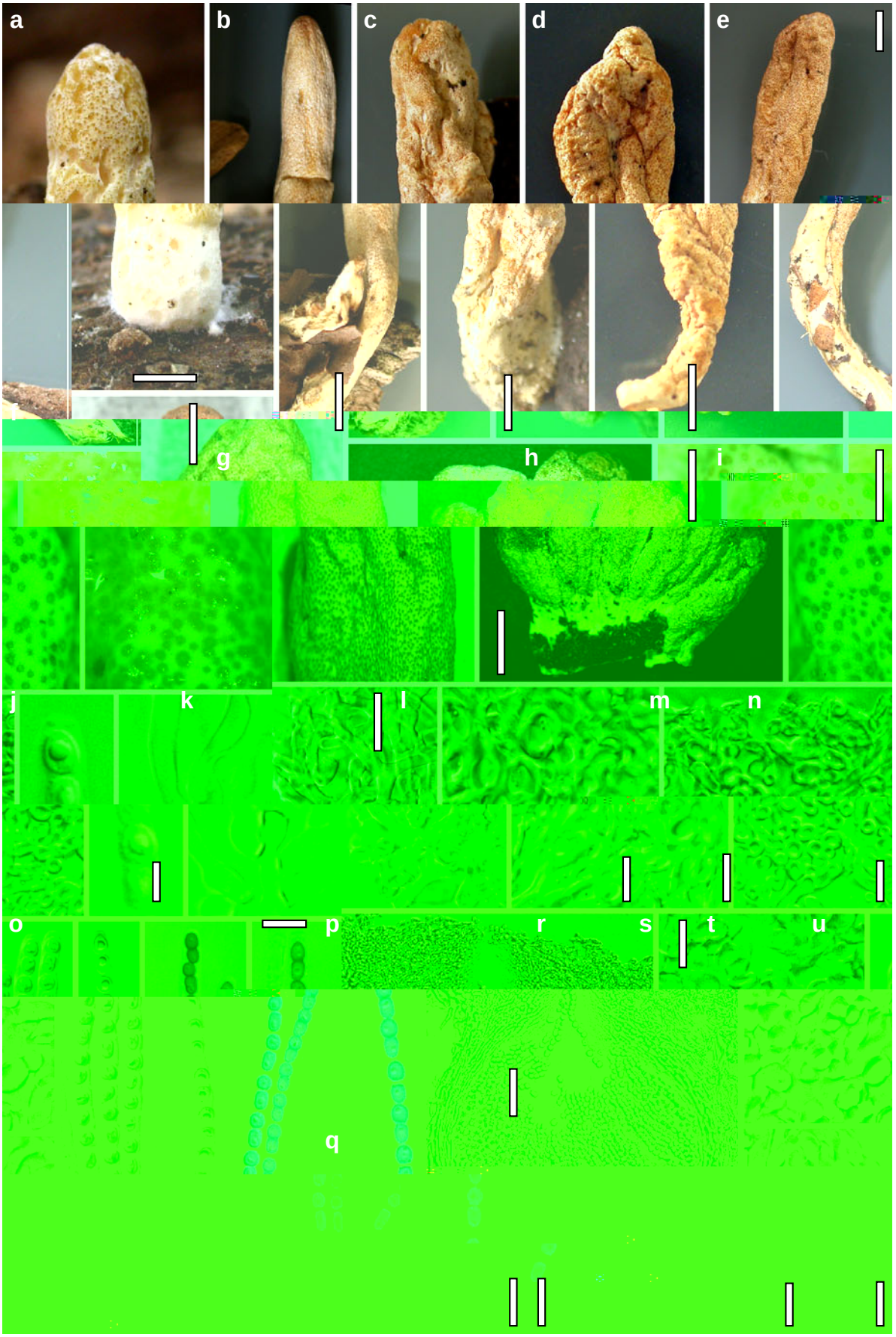
Hypocrea alutacea (Pers. : Fr.) Tul. & C. Tul., Sel. Fung. Carpol. I: 62. (1861). Fig. 28
≡ *Sphaeria alutacea* Pers., Comm. fung. clav. (Lipsiae): 12 (1797) : Fries, Syst. Mycol. 2: 325 (1823).
≡ *Hypocrea alutacea* (Pers. : Fr.) Ces. & De Not., Schem. Classif. Sferiacei. Comm. Soc. Critt. Ital. 1: 193. (1863).
≡ *Cordyceps alutacea* (Pers.) Quél., Mém. Soc. Émul. Montbéliard, Sér. 2, 5: 487 (1875).
≡ *Podocrea alutacea* (Pers.) Lindau, in Engler & Prantl, Nat. Pflanzenfam. (Leipzig) 1(1): 364 (1897).
≡ *Podostroma alutaceum* (Pers.) G.F. Atk., Bot. Gaz. 40: 401 (1905).
= *Sphaeria clavata* Sowerby, Col. Fig. Engl. Fung. Mushr. 2: 67 (1799).
Anamorph: ***Trichoderma alutaceum*** Jaklitsch, **sp. nov.** Fig. 29
MycoBank MB 516665

Incrementum tardum in agaro CMD. Conidiophora irregularia in micropustulis. Phialides lageniformes, (5–)8–13(–19)×(2.5–)3.0–3.8(–4.8) µm. Conidia (3.0–)3.5–5.5(–8.5)×(2.0–)2.5–3.0(–3.8) µm, viridia, oblonga, cylindracea vel ellipsoidea.

Fresh stromata similar to dry stromata, with smoother surface and lighter colour, typically pale yellowish, 4A3. Stromata when dry (7–)11–38(–50) (*n*=12) mm long, upright; solitary, more frequently gregarious or densely aggregated and often laterally fused in fascicles of 3–5 with demarcating lines in both fertile part and stipe; sometimes basally branched, i.e. fertile parts fasciculate on a common stipe. Fertile (upper) part (5–)7–22(–30) mm long, corresponding to (50–)60–70(–80)% of total length (*n*=11); (2.5–)3–9(–11)×(1.5–)2–5(–6.5) mm (*n*=19) thick, clavate, cylindrical, spathulate or of irregular shape, with apex slightly attenuated; often laterally compressed, transverse sections therefore more frequently oblong or ellipsoidal than circular; sometimes patches or one entire side sterile. Surface often with wrinkles or folds, otherwise smooth and with white covering mycelial layer when young, or finely roughened by numerous, densely disposed ostiolar dots (25–)40–100(–160) µm (*n*=150) diam. Dots light and diffuse when young, later distinct, circular, plane or convex, pale brown or ochre with hyaline centre. Stroma colour determined by the ostiolar dots on whitish to pale yellowish background, light orange, grey-orange, brown-orange to pale greyish brown, 5AB3–4(–5), 5CD3–5, 6CD3–4; white to yellowish inside; variable parts often hollow. Spore deposits fine, white, first appearing at the lower end of the fertile part. Sterile stipe (2–)3–14(–20) mm (*n*=11) long, (2–)4–9(–10)×(1–)2–3.5(–4) mm (*n*=20) thick; cylindrical or laterally compressed, typically not distinctly separated from the fertile part, with fertile patches often decurrent on the stipe. Stipe white or light cream-coloured, frequently curved, smooth or longitudinally rugose; base sometimes thickened, sometimes with white arachnoid base mycelium. Rehydrated stromata smoother, white with lively ochre or yellow ostiolar dots (50–)60–140 µm diam; no colour change noted after addition of 3% KOH, except for a better rehydration, with the whole surface becoming uniformly orange-ochre.

Stroma anatomy: Ostioles (50–)56–75(–85) µm long, plane with the surface or projecting to 10, rarely 50 µm, (27–)30–50(–60) µm wide at the apex (*n*=30), conical, periphysate, with some subclavate or globose cells to 6 µm diam flanking their margins. Perithecia (160–)220–270(–290)×(100–)120–190(–220) µm (*n*=30), flask-shaped or subglobose, crowded, (6–)8–9/mm stroma length. Peridium (11–)18–29(–34) µm thick at the base, (10–)13–19(–22) µm at the sides (*n*=30), hyaline to yellowish. Entostromatic tissues prosenchymatous, but in part appearing cellular (mostly globose) due to sectioning through variably oriented hyphae. Cortical layer (19–)23–40(–46) µm (*n*=30) thick, pale yellowish, a dense *t. intricata* of hyphae (2.2–)3.0–4.5(–7.0) µm (*n*=30) wide in face view, with numerous hyphae appearing as thick-walled globose or oblong cells (3–)4–9(–16)×(2.5–)3.5–6.0(–8.5) (*n*=60) in face view and (2.5–)3.5–6.5(–8.0)×(2.5–)3.0–4.5(–5.0) µm (*n*=30) in vertical section. Subcortical tissue a loose *t. intricata* of hyaline hyphae (2.0–)2.5–5.0(–6.0) µm (*n*=30) wide, with slightly narrower walls than the cortical hyphae. Subperithecial tissue a dense small-celled *t. angularis–globulosa* of hyaline, thick-walled cells (3–)4–9(–11)×(2.5–)3.5–5.0(–6.0) µm (*n*=30), interspersed with thick-walled hyphae (2.5–)3.0–6.0(–7.5) µm (*n*=40) wide. Asci (67–)77–100(–115)×(4.2–)4.5–5.2(–6.0) µm, stipe (5–)9–25(–40) µm long (*n*=100), with minute pore or ring, croziers present. Ascospores hyaline, verruculose, smooth within asci, cells dimorphic; distal cell (sub)globose, sometimes wedge-shaped, (3.0–)3.3–4.0(–4.8)×(2.8–)3.0–3.6(–4.0) µm, l/w (0.9–)1–1.2(–1.3); proximal cell oblong or wedge-shaped, (3.2–)4.0–5.0(–6.0)×(2.3–)2.7–3.1(–3.5) µm, l/w (1.1–)1.3–1.8(–2.2) (*n*=120).

Cultures and anamorph: ascospore germination and growth slow, optimal growth at 25°C on all media; no growth at 30 and 35°C.


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u

◀ **Fig. 28** Teleomorph of *Hypocrea alutacea*. **a**. Fresh young stroma. **b**–**g**. Dry stromata (**b**. immature, **f**. upper part of fertile region, **g**. laterally fused stromata). **h**, **i**. Stroma surface showing ostiolar dots (**h**. dry, **i**. in 3% KOH after rehydration). **j**. Surface hyphae in face view. **k**. Surface cells close to ostiole in face view. **l**. Cortical and subcortical tissue in section. **m**. Ascus ring. **n**. Crozier. **o**. Perithecium in section. **p**, **q**. Subperithecial tissue (**p**. featuring angular cells, **q**. featuring hyphae). **r**–**u**. Asci with ascospores (**t**, **u**. in cotton blue/lactic acid). **a**, **m**, **n**, **s**, **u**. WU 29177. **b**. K 142759. **c**, **d**, **h**, **i**, **l**, **o**–**q**, **t**. WU 8690. **e**, **f**, **j**, **k**. K 155403. **g**, **r**. IMI 47042. Scale bars: **a**=2 mm. **b**, **d**, **e**=5 mm. **c**, **f**, **g**= 3 mm. **h**, **i**=0.5 mm. **j**–**l**, **p**–**u**=10 μm. **m**, **n**=5 μm. **o**=25 μm

On CMD after 72 h 1–2 mm at 15°C and 5–7 mm at 25°C; mycelium covering the plate after 3–4 weeks at 25°C. Colony hyaline, thin, radial, shiny, indistinctly zonate; little mycelium on the agar surface, dense mycelium within the agar. Aerial hyphae inconspicuous, becoming fertile. No autolytic excretions nor coilings seen. Colour none to pale yellowish in aged cultures; odour indistinct or mushroomy, aromatic, reminiscent of *Sarcodon imbricatus*, vanishing with age. Chlamydospores (examined after 46 days) noted after 3–7 weeks in surface and aerial hyphae, (10–)11–18(–22)×(9–)10–16(–19) μm, l/w (0.9–)1.0–1.3(–1.6) (*n*=21), globose or oblong, smooth, intercalary, less commonly terminal. Conidiation noted after 4–5 days, green after (7–)14–25 days, effuse, on simple, erect conidiophores around the plug and on aerial hyphae (0.1–1 mm long), and in loosely disposed loose shrubs and denser granules to 0.5 mm diam, aggregations to 2 mm, mainly concentrated along the colony margin; white, turning green, 28D5–6 to 27E4–6, finally degenerating and conidia often adhering in chains. Conidiophores (CBS 332.69, CBS 120535) short, simple, of a stipe with thick wavy (verrucose when old) outer wall to 6–11 μm wide, with asymmetric branches, or broad shrubs or small pustules with sparse asymmetric branches, without clearly discernable main axes. Branches mostly 4–6 μm wide, attenuated terminally to 2.5–3.5 μm. Branches and phialides typically divergent but steeply inclined upward. Phialides and conidial heads concentrated in the upper, terminal levels of the conidiophores, in verticillium-like or irregular arrangements on short, 1–3 celled, broad (e.g. fan-shaped, 200 μm diam, 80–100 μm long) terminal branches. Terminal branches and phialides often paired, straight, sometimes sinuous. Phialides arising solitarily or in whorls of 2–4(–5) on cells 2.5–4.5 μm wide. Conidia formed in mostly dry minute heads <30 μm diam. Phialides (5–)8–13(–19)×(2.5–)3.0–3.8(–4.8) μm, l/w (1.7–)2.3–3.8(–5.4), (1.5–)2.0–2.8(–4.0) μm wide at the base (*n*= 91), lageniform or subulate, straight, curved or sinuous, mostly inaequilateral, not or slightly widened in or above the middle. Conidia (3.0–)3.5–5.5(–8.5)×(2.0–)2.5–3.0(–3.8) μm, l/w (1.1–)1.3–1.9(–3.0) (*n*=97), light (yellowish) green, oblong or cylindrical, more ellipsoidal in lower size range, smooth, finely multiguttulate or with 1–2 larger guttules, scar indistinct. On MEA structure of conidiophores and sizes identical to those on CMD (measurements here united).

On PDA after 72 h<1 mm at 15°C and 1–3 mm at 25°C; mycelium covering the plate after 3–4 weeks at 25°C. Colony zonate, with radial streaks and thick, wavy or crenate margin; mycelium conspicuously dense, hyphae agglutinated. Surface downy to floccose, whitish-cream, reverse pale yellow to greyish yellow, 3A3–4, 4A3–4B4. Aerial hyphae numerous, appearing rigid, thick, long and high, forming radial strands, becoming fertile; white mycelial patches appearing in aged cultures. Autolytic excretions rare; no coilings seen. Odour mushroomy, aromatic, reminiscent of *Sarcodon imbricatus*, vanishing with age. Conidiation noted after 4–5 days, effuse, in minute dry heads on small side branches formed on thick aerial hyphae ascending several mm, spreading from the plug, colourless, greenish only in the stereo-microscope.

On SNA after 72 h 1.5–2 mm at 15°C and 2–4 mm at 25°C; mycelium covering the plate after *ca* 2 months at 25°C. Colony irregular, dense, indistinctly zonate, with little mycelium on the surface; hyphae appearing rigid, reminiscent of *H. aureoviridis*, but branching not distinctly in right angles. Aerial hyphae frequent, long, high, becoming fertile. Autolytic excretions and coilings absent or inconspicuous. No distinct odour, no pigment noted. Chlamydospores noted after 3–4 weeks, infrequent. Conidiation noted after 4 days, turning green after 12–14 days; effuse, in dry heads on aerial hyphae; upon stronger branching and aggregation appearing powdery, concentrated in minute white granules at the proximal margin and in ill-defined concentric zones and radial patches, becoming yellow- or grey-green, 29CD4–6, 28CD5–6; sometimes aggregated to nearly 2 mm diam. At 15°C conidiation concentrated in a ring of dense shrubs around the plug.

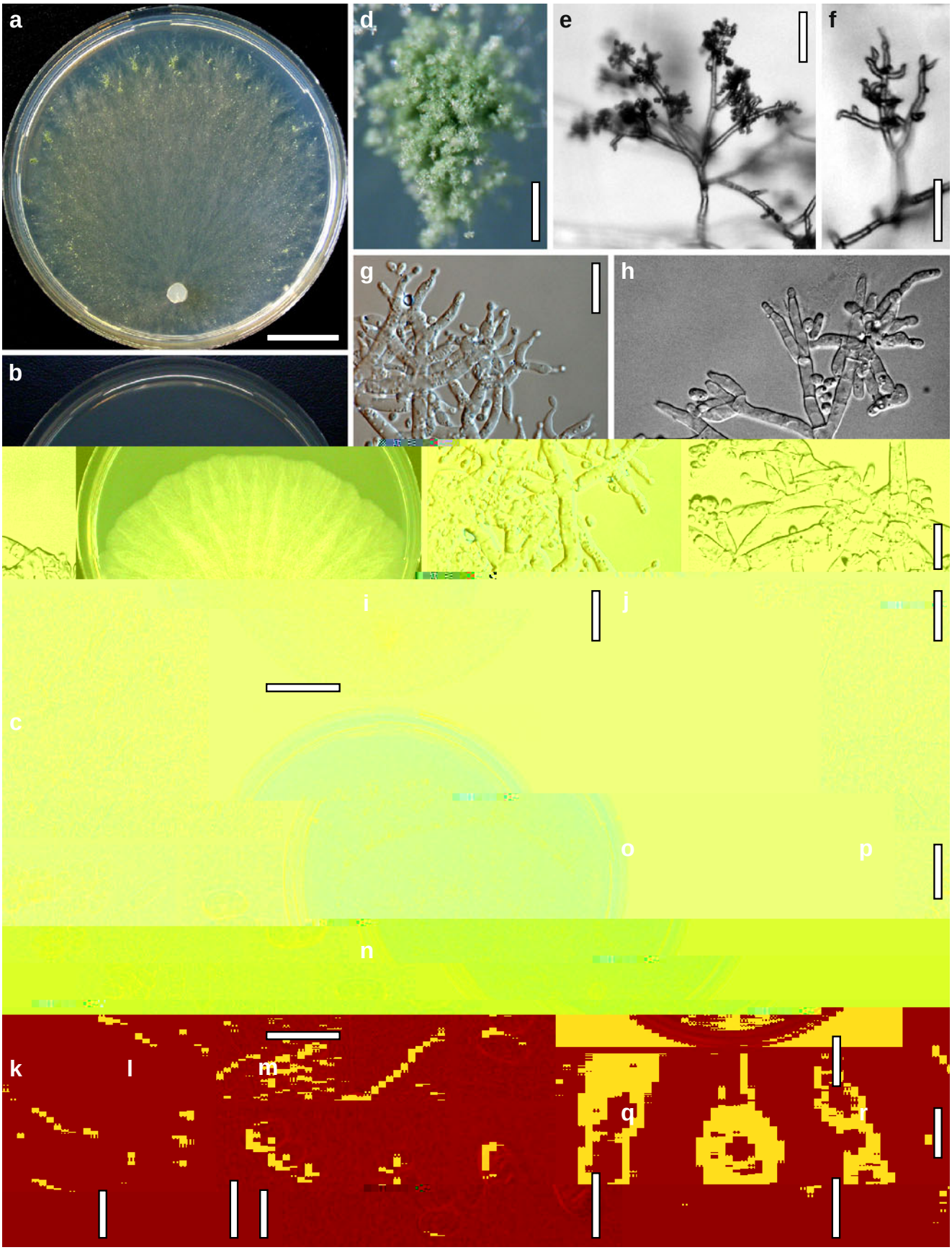
Habitat: on well-decayed wood of angiosperms.

Distribution: Europe (Austria, Germany, UK), Japan, North America.

Neotype designated by Chamberlain et al. (2004): Illustration in Persoon (1800), Obs. Mycol. 2: 66, Tab I, Fig. 2 a–c, evidenced in a copy at BPI.

Holotype of *T. alutaceum* isolated from WU 29177 and deposited with the teleomorph specimen as the dry culture **WU 29177a**.

Other specimens examined: **Austria**, Niederösterreich, Ziersdorf, Kleinwetzdorf, Heldenberg, MTB 7561/2, on partly corticated, deciduous wood, soc. ?*Helicosporium* sp., A. Hausknecht, 30 June 1990 (WU 8690). **Germany**; Teutoburger Wald, Beller Holz, on decaying wood, Jan. 1973, W. Gams (CBS 199.73; only culture used for sequencing). **Japan**, Matsumoto (CBS 332.69, only culture available). **United Kingdom**, England, Herefordshire, Downton Gorge, on wood of *Quercus* sp., 17 Sep. 1951, J. Webster (IMI 47042). Nottinghamshire, East Midlands, Worksop, Clumber Park, near Visitors Centre, SK 627739, 53°16′16″ N, 01°04′19″ W, elev. 100 m, on branch of *Quercus robur* 15 cm thick, on crumbly wood, (below bark), soc. rhizomorphs and an effete ?*Ophiostoma* sp., 11 Sep.


a
b
d
e
f
g
h
i
j
c
o
p
n
k
l
m
q
r

◀ **Fig. 29** Cultures and anamorph of *Hypocrea alutacea*. **a**–**c**. Cultures (**a**. on CMD, 35 days. **b**. on PDA, 14 days. **c**. on SNA, 35 days). **d**. Conidiation granule (28 days). **e**, **f**. Conidiophores on growth plate (**e**. 21 days; **f**. SNA, 15°C, 21 days). **g**–**j**. Conidiophores (**g**, **i**.7 days; **h**, **j**. MEA, 11 days). **k**–**m**. Chlamydospores (46 days). **n**. Phialides (7 days). **o**. Phialides and conidia (20 days). **p**–**r**. Conidia (**p**–**q**. 20 days, **r**. 7 days). All at 25°C except **f**. **d**–**r**. On CMD except **f**, **h**, **j**. **a**–**f**, **h**, **j**, **k**–**m**, **o**–**q**. CBS 120535. **g**, **i**, **n**, **r**. CBS 332.69. Scale bars: **a**–**c**=19 mm. **d**=100 μm. **e**, **f**=40 μm. **g**, **m**=15 μm. **h**–**l**, **n**, **o**=10 μm. **p**–**r**=5 μm

2004, H. Voglmayr & W. Jaklitsch, W.J. 2699, (WU 29177, culture CBS 120535=C.P.K. 1906). Surrey, Sheepleas, on decayed log of *Fagus sylvatica*, R. Alder, 4 Nov. 2006, confirmed by B. Spooner (K 142759). Same area, 7 Oct. 1982, I. Frazer (K 155403).

Notes: *Hypocrea alutacea* is currently the only species of *Hypocrea* in Europe that forms upright, stipitate stromata on logs lying on the ground. It has been mixed up with *H. leucopus* since Saccardo (1883a), and Atkinson (1905) synonymized the two species. Chamberlain et al. (2004) and Jaklitsch et al. (2008b) showed that *H. leucopus* and other species found on the ground on leaf litter in coniferous forests are different species, both morphologically and phylogenetically. No evidence supports the earlier view (see Winter 1885 [1887], p. 142) that the upright shape of *H. alutacea* (obviously meaning *H. leucopus*), would result from parasitism of basidiomes of a *Clavaria* or ascomata of a *Spathularia* by an effused *Hypocrea* stroma. Doi (1975) interpreted the specimen IMI 47042 with laterally fused stromata as *Hypocrea brevipes* Mont. Although lateral fusion of stromata was also described for *H. brevipes* by Samuels and Lodge (1996), probably only based on IMI 47042, there is no convincing evidence for this identification, because this morphological trait is not uncommon in *H. alutacea*. The tropical *H. brevipes* typically forms capitate stromata; it has not been found in Europe. Lateral 'fusion' of stromata or fasciculate stromata on a common stipe may alternatively mean, that first a complex, large compound stroma is formed, which breaks up into several individual stromata during its development, as seen in many *Hypocrea* species forming pulvinate stromata. After several transfers the conidiation in *H. alutacea* remains colourless or white on all media including CMD.

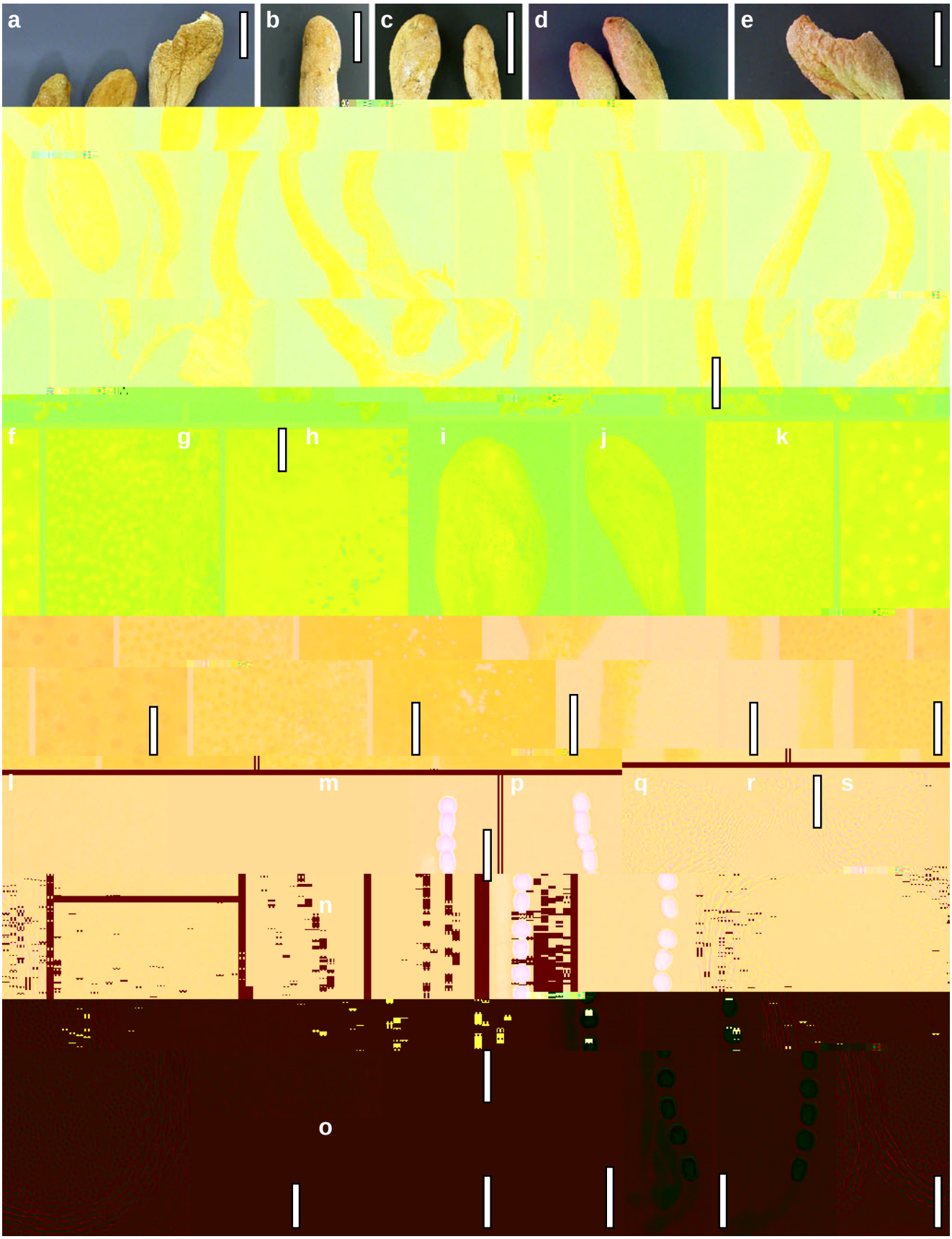
Hypocrea leucopus (P. Karst.) H.L. Chamb., Karstenia 44: 16 (2004). Fig. 30
≡ *Podostroma leucopus* P. Karst., Hedwigia 31: 294 (1892).
Anamorph: ***Trichoderma leucopus*** Jaklitsch, **sp. nov.** Fig. 31
MycoBank MB 516683

Conidiophora in agaro CMD effuse disposita, simplicia, ramis sparsis brevibus praedita, similia *Verticillii*. Phialides divergentes, lageniformes vel subulatae, (7–)10–17(–26)×(2.0–)2.4–3.0(–3.7) μm. Conidia ellipsoidea vel oblonga, hyalina, glabra, (2.9–)3.2–5.5(–8.3)×(1.9–)2.2–3.4(–5.4) μm. Pustulae in agaro SNA tarde provenientes, conidiophoris similibus *Pachybasii*. Phialides lageniformes, (5.0–)6.0–8.5(–9.2)×(2.3–)2.5–3.2(–3.4) μm. Conidia ellipsoidea, hyalina, glabra, (2.5–)2.8–3.3(–3.7)×(2.2–)2.3–2.5(–2.7) μm.

Etymology: a white foot, taken from the teleomorph epithet.

Stromata not seen in fresh condition. Stromata when dry (20–)28–40(–41) mm long, clavate, straight or more commonly curved. Fertile part (7–)8–14(–16) mm long, comprising 30–40% of the total length; typically well-delimited and distinctly broadened above the cylindrical stipe, typically laterally compressed and (2–)3–6(–7)×(1–)1.5–4(–5) mm thick (*n*=20). Apex often broadly rounded. Often hollow inside. Surface smooth, slightly tubercular or somewhat rugose, often more tubercular towards the stipe. Ostiolar dots (23–)40–75(–118) μm (*n*=120) diam, numerous, well-defined, plane or convex, with circular outline. Colour of fertile part pale yellow or greyish orange, 4A3–4, 5AB4, due to a white to pale yellow stroma surface and yellow to nearly orange ostiolar dots. Stipe (14–)20–27(–28) mm (*n*=11) long, (1.3–)1.7–3.3(–4.5)×(0.8–)1.0–2.5(–3.0) mm thick (*n*=22); base often thickened and 2–6 mm (*n*=11) thick. Stipe cylindrical, sterile, sometimes with inconspicuous, short, longish vertical fertile patches or few solitary perithecia in the uppermost part; straight or curved, smooth or slightly longitudinally furrowed, white or yellowish, similar to or paler than fertile part. Stroma white inside. Spore deposits white or yellowish. Rehydrated stromata slightly larger than dry, pale ochre, ostiolar dots 90–200 μm diam, indistinct, diffuse, with little white stroma in between, stroma inside appearing watery or gelatinous; no distinct colour change noted after the addition of 3% KOH.

Stroma anatomy: Ostioles (45–)63–85(–94) μm long, projecting to 30 μm, (40–)48–74(–86) μm wide at the apex (*n*=30); with a thick wall and narrow opening 13–20 μm wide; rarely with clavate to fusoid cells to 6 μm diam at the apex. Perithecia (200–)225–285(–310)×(115–)160–220(–270) μm, flask-shaped, ellipsoidal or subglobose. Peridium (17–)18–25(–30) μm (*n*=30) thick at the base, (13–)16–22(–25) μm (*n*=30) thick at the sides, subhyaline or pale yellowish; of coarse cells merging at the perithecial apex abruptly into the palisade of narrow periphyses. Cortical layer (18–)22–43(–60) μm (*n*=30) thick, a hyaline to pale yellowish *t. angularis* of thin-walled cells (2–)5–10(–12)×(2–)3–6(–8) μm in face view and in vertical section (*n*=65). Subcortical tissue when present a hyaline *t. intricata* of thin-walled hyphae (2–)3–5(–7) μm (*n*=30) wide. Subperithecial tissue an ill-defined *t. intricata* of thin-walled hyaline hyphae (2–)3–8(–12) μm (*n*=31) wide. Asci (57–)62–80(–93)×(3.3–)4.0–5.0(–5.3) μm; stipe (3–)4–16(–25) μm long (*n*=70), with two basal septa. Ascospores hyaline,


a
b
c
d
e
f
g
h
i
j
k
l
m
p
q
r
s
n
o

◀ **Fig. 30** Teleomorph of *Hypocrea leucopus*. **a**–**g**. Dry stromata. **h**–**k**. Stroma surface in the stereo-microscope (**h**–**j**. dry, **j**. showing spore deposits, **k**. in 3% KOH after rehydration). **l**. Perithecium in section. **m**. Surface cells in face view. **n**. Cortical and subcortical tissue in section. **o**. Subperithecial tissue. **p**–**s**. Asci with ascospores (**r**, **s**. in cotton blue/lactic acid). **a**, **d**–**f**, **h**, **i**, **k**–**o**, **r**. WU 29231. **b**, **j**. Huhtinen 07/108. **c**, **g**, **p**, **q**, **s**. T. Rämä 21 Sep.07. Scale bars: **a**–**e**=5 mm. **f**, **g**= 2 mm. **h**=1 mm. **i**=0.3 mm. **j**, **k**=0.7 mm. **l**, **o**=30 μm. **m**=15 μm. **n**=20 μm. **p**–**s**=10 μm

finely verruculose or spinulose; cells dimorphic, distal cell (2.7–)3.0–3.5(–4.0)×(2.3–)2.8–3.2(–3.5) μm, l/w (0.9–) 1.0–1.2(–1.5) (*n*=120), (sub)globose, proximal cell (3.0–) 3.4–4.2(–5.0)×(2.0–)2.4–2.8(–3.0) μm, l/w (1.1–)1.3–1.6(– 1.9) (*n*=120), oblong, wedge-shaped or subglobose; contact area usually distinctly flattened.

Cultures and anamorph: optimal growth at 25°C on all media; at 30°C death of hyphae observed after short growth; no growth at 35°C. The values given below are from a single experiment.

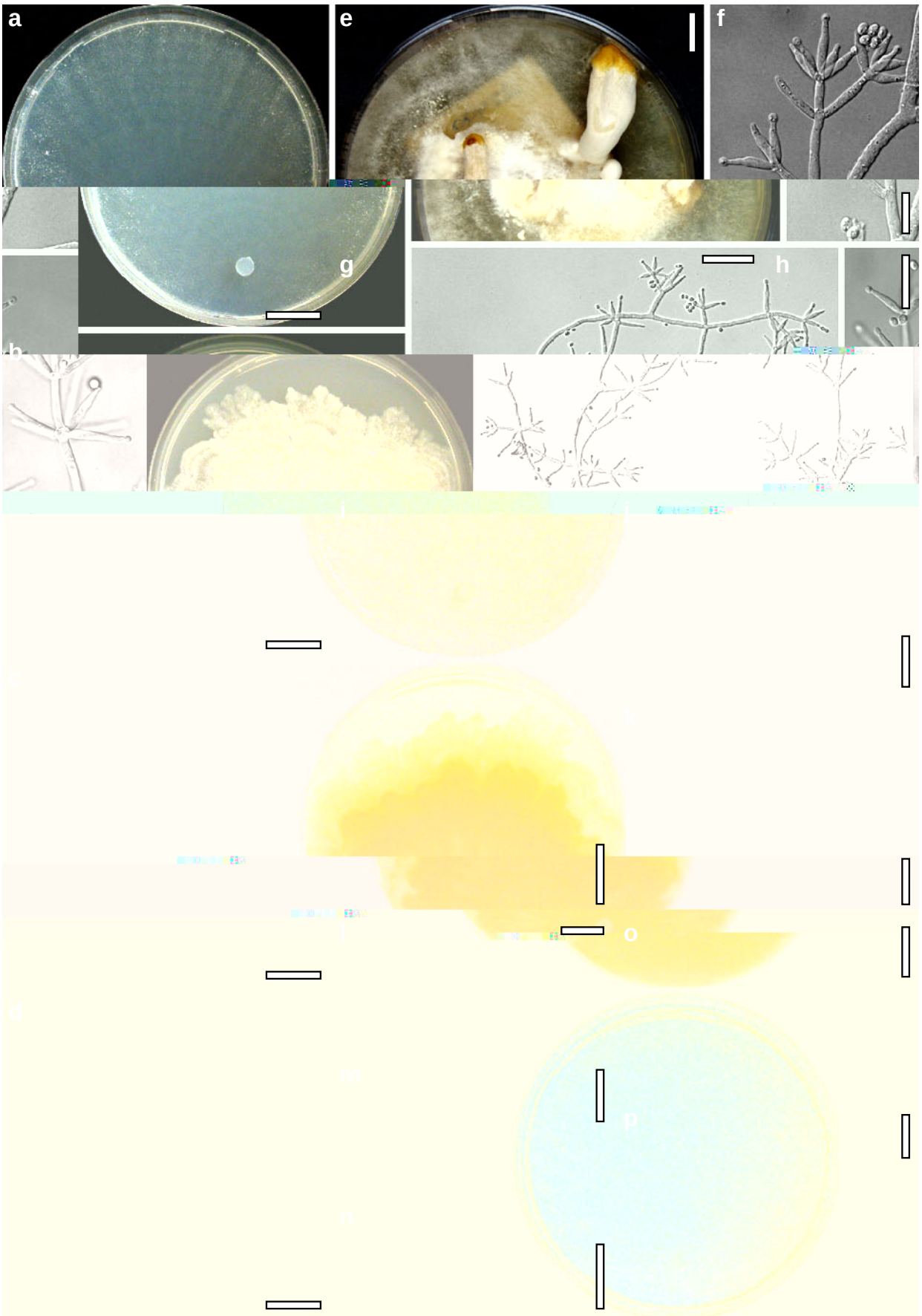
On CMD 6–7 mm at 15°C, 12 mm at 25°C, 3 mm at 30°C after 72 h; mycelium covering the plate after 16 days at 25°C. Colony circular, hyaline, thin, dense, finely zonate; margin well defined or slightly wavy, hyphae distinctly sinuous. Margin becoming downy and whitish due to conidiation. Aerial hyphae inconspicuous. No autolytic excretions noted, coilings infrequent. No chlamydospores seen. No diffusing pigment noted. Odour indistinct or slightly unpleasant, 'chemical'. Conidiation noted after 3 days, colourless to white, effuse, farinose, floccose or cottony, on short, mostly 50–150(–250) μm long, simple, verticillium-like conidiophores erect on surface hyphae; similar conidiophores also 30–120 μm long formed widely spaced on aerial hyphae to 1 mm long; conidiophores with more complex branching in loose shrubs along the margin. After several months at 15°C sometimes white, pachybasium-like pustules to *ca* 1 mm diam appearing along margin. Pustules not examined. Structure of conidiophores determined after 5–7 days; consisting of a straight stipe or axis with a single terminal whorl of phialides or with solitary phialides or 1–2 whorls of 3–5(–6) phialides along its length; sometimes with few paired or unpaired branches in right angles or slightly inclined upwards, each with 1–3 whorls of phialides. Branches straight, less commonly sinuous. Conidiophores 3–6 μm wide at the base, 2–3 μm at the apex. Phialides solitary or more commonly divergent in whorls of 2–5 on cells 2–3.5 μm wide. Conidia formed in minute wet heads to 10(–15) μm diam. Phialides (7–)10–17(–26)×(2.0–)2.4–3.0 (–3.7) μm, l/w (2.2–)3.6–6.4(–8.8), (1.5–)1.7–2.4(–3.3) (*n*= 65) wide at the base, lageniform or subulate, straight or slightly curved, narrow, mostly symmetric, widest in or below the middle. Conidia (2.9–)3.2–5.5(–8.3)×(1.9–)2.2– 3.4(–5.4) μm, l/w (0.8–)1.2–2(–2.8) (*n*=84), hyaline, variable, ellipsoidal or oblong, smooth, with few guttules, scar indistinct, sometimes pointed or truncate.

On PDA 8 mm at 15°C, 18 mm at 25°C, 1–2 mm at 30°C after 72 h; mycelium covering the plate after 4 weeks at 25°C. Colony dense, indistinctly coarsely zonate, first circular, margin becoming dentate or lobed. Surface flat, white, centre finely floccose. Aerial hyphae numerous, dense and short in the centre, loose, long and high in distal areas, becoming fertile, collapsing. Autolytic excretions infrequent, no coilings noted. Reverse yellow- to orange-brown, 5–6CD5–7, pigment diffusing into the agar. Odour unpleasant, reminiscent of cultures of *H. bavarica*. No chlamydospores seen. Conidiation noted after 3 days, effuse, white, verticillium-like, first short on surface hyphae in the centre, later ascending onto high levels on aerial hyphae along margin. At 15°C hyphae conspicuously sinuous, brown crystals appearing in the agar; conidiation on aerial hyphae.

On SNA 3–4 mm at 15°C, 8 mm at 25°C, 1–2 mm at 30°C after 72 h; mycelium covering the plate after 2 weeks at 25°C. Colony hyaline, thin, circular, finely zonate, dense, with a well-defined or wavy margin; hyphae conspicuously sinuous. Long aerial hyphae frequent, becoming fertile, collapsing, forming floccules. No autolytic excretions noted, coilings infrequent. No chlamydospores seen. No diffusing pigment, no distinct odour noted. Conidiation noted after 3 days, similar to CMD, effuse, spreading across entire plate, also noted within agar to the bottom of the plate. Conidiophores short, on surface and aerial hyphae, also in small white pustules; little branched, with a single terminal whorl of phialides or with 1–2 additional whorls below, mostly to 100 μm long, to 220 μm long towards margin. Phialides mostly in whorls of 2–5(–6), formed on cells 2–4(–5.5) μm wide, corresponding to condiophore width. Conidia formed in minute wet heads <30(–50) μm diam. Phialides (8–)11–17(–23)×(2.0–)2.3–2.8(–3.0) μm, l/ w (3.5–)4–7(–9.5), (1.5–)1.7–2.5(–3.0) μm wide at the base (*n*=30), lageniform or subulate, mostly symmetric, sometimes shorter and with median thickening. Conidia (2.8–) 3.0–4.7(–6.2)×(2.0–)2.3–2.5(–3.0) μm, l/w (1.1–)1.2–1.9(– 2.7) (*n*=45), hyaline, mostly ellipsoidal, also oblong or subglobose, with few minute guttules and indistinct scar. Pustules formed after 20 days, starting in marginal areas, small, thick, dense, with wide pachybasium-like branches in right angles and phialides mostly in whorls of 2–3(–4). Phialides (5.0–)6.0–8.5(–9.2)×(2.3–)2.5–3.2(–3.4) μm, l/ w (1.6–)2.0–3.0(–3.7), (1.5–)2.0–2.5(–2.8) (*n*=30) wide at the base, lageniform. Conidia (2.5–)2.8–3.3(–3.7)×(2.2–) 2.3–2.5(–2.7) μm, l/w (1.1–)1.2–1.3(–1.4) (*n*=30), hyaline, ellipsoidal, smooth, with few minute guttules, no scar, smaller than in effuse conidiation due to the absence of oblong conidia.

On OA erect stromata were produced by the strain CBS 122499 (CBS, pers. comm.).

Habitat: on forest litter in mixed forests dominated by conifers such as *Picea abies*.


a
e
f
g
h
o
p

Distribution: Europe (Austria, Finland, Germany), North America.

Holotype: **Finland**, Etelä-Häme. Tammela, Syrjä, 30 Sep. 1892, P.A. Karsten 3247 (H; not examined). ***Holotype*** of *Trichoderma leucopus* isolated from WU 29231 and deposited as a dry culture with the holotype of *H. leucopus* as **WU 29231a**.

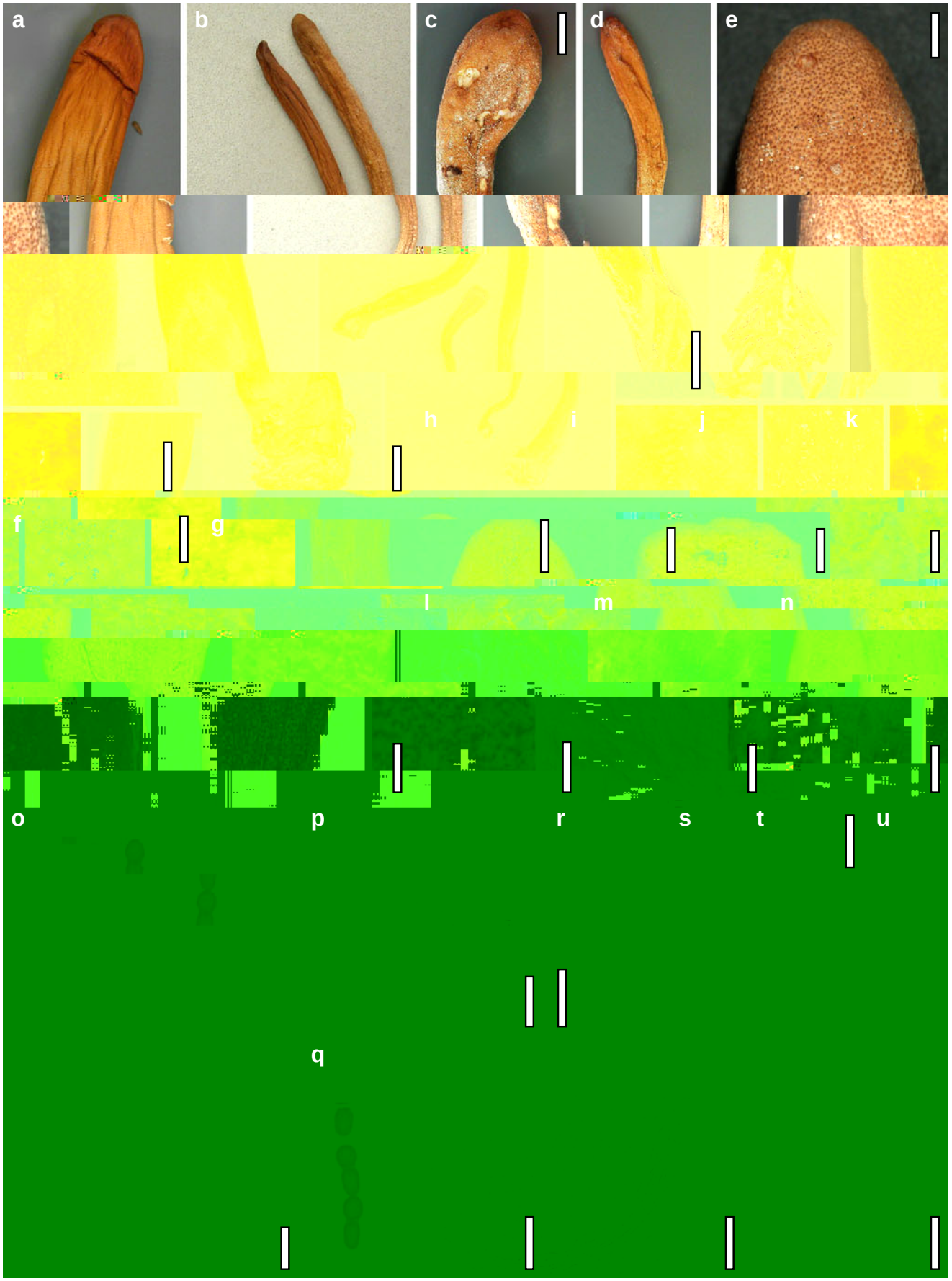
Specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, Oberdörfl, at Nagu, MTB 9452/4, 46°31′55″ N, 14°27′01″ E, elev. 710 m, on the ground under *Picea abies*, 8 Sep. 1998, H. Voglmayr (WU 18557). **Finland**, Etelä-Häme, Luopioinen; grid 68100:2544, on needle litter in spruce forest, 14 Aug. 2007, E. Smolander (WU 29231, culture CBS 122499=C.P.K. 3160). Pohjois-Karjala, Kitee, Komolinmäki Nature Reserve, grid 6888:664, mixed forest with spruce and birch, on the ground under *Picea abies*, soc. *Oxalis* sp., attached to litter of spruce needles and birch leaves, 21 Sep. 2007, S. Huhtinen 07/108 (TUR, culture CBS 122495, C.P.K. 3164). Pohjois-Karjala, Kitee, Komolinmäki Nature Reserve, grid 6888:664, mixed forest with spruce and birch, on the ground, 21 Sep. 2007, T. Rämä (TUR), culture C.P.K. 3527. **Germany**, Bavaria, Oberfranken, 10 km W of Bayreuth, grid 6034/2, in leaf litter on the ground between *Pseudotsuga menziesii*, *Fagus*, *Betula* and *Larix*, soc. *Spathularia flavida*, 27 Aug. 2010, A. Bröckel, comm. C. Gubitz (WU 30205).

Notes: *Hypocrea leucopus*, the type species of *Podostroma* P. Karst. (1892), has long been considered as a synonym of *H. alutacea*, the type species of *Podocrea* (Sacc.) Lindau (1897). The latter forms clavate to irregular, often laterally fused stromata on branches and logs of deciduous trees usually well above the ground, and forms a *Trichoderma*-like anamorph with conidia being green on CMD, at least in fresh cultures. *Hypocrea leucopus* occurs on the ground in forests typically containing coniferous trees. Forest debris such as leaves, needles, minute twigs, moss and fungal rhizomorphs are typically firmly appressed to the base of the stromata. The fungus may therefore probably feed on cellulose-containing materials and/or fungi. Associated bryophytes are often vital and possibly provide for a favourable moist microclimate. Stromata of a specimen from South Carolina, U.S.A. (WU 30284), identified using gene sequences from DNA extracted from them, were growing on *Carya* nutshells.

Other species forming upright stromata in leaf litter of North European forests are *Hypocrea nybergiana* and *H. seppoi*. The former differs from *H. leucopus* by larger and more intensely pigmented stromata, slightly larger ascospores and larger conidia on large solitary phialides, while the latter forms smaller, delicate stromata with horizontal perithecial groups in the transition area between the fertile part and the stipe, a more irregular verticillium-like anamorph, and it grows considerably more slowly at 25°C on CMD, PDA and SNA than *H. leucopus*. Pustulate pachybasium-like conidiation in addition to effuse verticillium-like conidiation on SNA or CMD has not been seen in any of the other *Hypocrea* species with upright stromata. Due to difficulties to reproduce pustules, only a short description of an overmature pustule of *T. leucopus* is given.

Hypocrea nybergiana T. Ulvinen & H.L. Chamb., Karstenia 44: 21 (2004). Fig. 32
Anamorph: *Trichoderma* sp. Fig. 33

Stromata not seen in fresh condition. Stromata when dry (37–)46–93(–106) mm (n=11) long, cylindrical, clavate,


a
b
c
d
e
h
i
j
k
f
g
l
m
n
o
p
r
s
t
u
q

◀ **Fig. 32** Teleomorph of *Hypocrea nybergiana*. **a**–**d**. Dry stromata. **e**–**g**. Apical fertile part of dry stromata. **h**–**j**. Stroma surface in the stereo-microscope (**h**. dry, showing inhomogeneous pigment distribution; **i**. rehydrated; **j**. in 3% KOH after rehydration). **k**, **l**. Stipe surface in the stereo-microscope (**l**. showing pigment flakes). **m**. Part of an ostiole in vertical section showing inflated marginal apex cells. **n**. Surface cells in face view. **o**. Perithecium in section. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue. **r**–**u**. Asci with ascospores (**u**. in cotton blue/lactic acid). **a**. L. Koukku Aug. 2007 (JOE). **b**, **e**, **g**, **s**. WU 29308. **c**, **d**, **f**, **n**, **r**. S. Huhtinen 07/98 (TUR). **h**–**m**, **o**–**q**, **u**. WU 29307. **t**. WU 29309. Scale bars: **a**, **b**, **d**=10 mm. **c**=5 mm. **e**–**g**=1.5 mm. **h**=250 μm. **i**, **l**=0.5 mm. **j**=150 μm. **k**=2.5 mm. **m**, **n**, **p**–**u**=10 μm. **o**=30 μm

macroscopically light brown, without a colour change, under the stereo-microscope more orange and fine pigment stripes more distinct, often concentric around the ostioles.

Stroma anatomy: Ostioles (50–)57–75(–90) μm long, projecting to 25 μm, (40–)47–68(–76) μm wide at the apex (*n*=30), short-cylindrical, periphysate, sometimes lined at the apex by subglobose or apically pointed, hyaline cells 5–9(–14) μm wide. Perithecia (190–)260–320(–340)×(120–)160–240(–285) μm (*n*=30), crowded, flask-shaped, ellipsoidal or globose; peridium (15–)18–25(–28) μm (*n*=30) thick at the base, (10–)13–19(–22) μm (*n*=30) at the sides, yellow. Cortical layer (18–)24–38(–44) μm (*n*=30) thick, a *t. angularis* of distinct, thin- or thick-walled cells (3.5–)6–14(–23)×(3–)5–9(–10) μm (*n*=60) in face view and in vertical section, subhyaline, yellow to orange, with inhomogeneously distributed pigment, around the ostioles typically smaller and in parallel rows. Subcortical tissue variable, mostly a *t. intricata* of hyaline, thin-walled hyphae (2–)4–6(–7) μm (*n*=30) wide, or a *t. angularis* of hyaline, thin-walled cells (3–)5–9(–15)×(3–)4–7(–8) μm (*n*=30). Subperithecial tissue an ill-defined *t. intricata* of hyaline, thin-walled hyphae (2.5–)4–9(–12) μm (*n*=40) wide. Asci (63–)80–98(–112)×(4.5–)4.7–5.5(–6.0) μm, stipe 5–18(–34) μm long (*n*=90), apex with a minute flat ring, base with crozier. Ascospores hyaline, verruculose or spinulose with spines to 0.5 μm long; cells dimorphic; distal cell (3.0–)3.5–4.0(–5.5)×3.0–3.5(–4.2) μm, l/w (0.9–)1.0–1.3(–1.7) (*n*=120), (sub)globose, sometimes wedge-shaped at the apex; proximal cell (3.2–)4.0–4.8(–5.5)×(2.2–)2.7–3.0(–4.0) μm, l/w (1.2–)1.4–1.7(–2.1) (*n*=120), oblong, ellipsoidal or plump wedge-shaped, sometimes subglobose.

Cultures and anamorph: growth rate only studied in a single experiment using a single isolate; optimal growth at 25°C on all media; at 30°C hyphae dying after a short initial growth of max. 0.5 mm; no growth at 35°C.

On CMD after 72 h 8 mm at 15°C, 11 mm at 25°C; mycelium covering the plate after 17 days at 25°C. Colony hyaline, thin, circular, indistinctly broadly zonate, margin diffuse; hyphae with little variation in width. Aerial hyphae inconspicuous, loose, several mm long and high. Autolytic activity absent, coilings rare. No chlamydospores seen. No diffusing pigment, no distinct odour noted. Conidiation noted after 10 days as scant conidia on aerial hyphae.

On PDA after 72 h 5 mm at 15°C, 12 mm at 25°C; mycelium covering the plate after 10 days at 25°C. Colony circular, dense, compact with well-defined margin, numerous yellow crystals formed in the agar. Aerial hyphae abundant, often with subglobose thickenings to 6–11 μm terminally or along their length; forming a thick white to yellowish cottony mat, ascending to the lid of the Petri dish. Autolytic activity and coilings absent. Reverse yellow, orange, 4–5AB4–5, to orange-brown or yellow-brown, 5CD7–8. No distinct odour noted. Conidiation noted after 3 days; conidia produced in small numbers in wet to dry heads on scant solitary, cylindrical or subulate phialides on aerial hyphae. Conidia (5–)6–15(–21)×(3.0–)4.0–6.7(–9.3) μm, l/w (1.1–)1.3–2.7(–3.9) (*n*=30), variable in shape, ellipsoidal, oval, subglobose, oblong, broadly fusoid, or clavate, hyaline, smooth, eguttulate or rarely with few small guttules; scar indistinct or truncate; often adhering in small clusters. At 15°C colony coarsely zonate, with crystals and white cottony mat; no conidiation seen.

On SNA after 72 h 4 mm at 15°C, 10 mm at 25°C; mycelium covering the plate after 13 days at 25°C. Colony circular, dense, with well-defined or irregular margin, becoming hairy by numerous, loosely disposed, long, dichotomously branched aerial hyphae ascending to the lid of the Petri dish along the colony margin, with some thickenings 6–9(–15) μm. Autolytic excretions locally frequent, coilings absent. No diffusing pigment, no distinct odour noted. No chlamydospores seen. Conidiation noted after 10 days. Conidia (examined after 14–28 days) produced in small numbers in minute wet to dry heads on solitary phialides or simple conidiophores on long aerial hyphae in mostly marginal, whitish, arachnoid to cottony areas. Conidiophores 2–5(–6.5) μm wide, of a main axis to 150 μm long, with few unpaired, often right-angled branches or phialides, apically with one, more rarely 2–3(–4) divergent phialides. Phialides (11–)22–43(–55)×(2.3–)3.0–4.0(–5.0) μm, l/w (2.7–)6.5–13(–17), (1.7–)2.2–3.0(–3.5) μm wide at the base (*n*=40), cylindrical or subulate, sometimes lanceolate or fusoid, mostly straight, equilateral, sometimes with a clamp-like widening on their base. Conidia (5–)6–16(–29)×(3.0–)4.0–6.5(–8.0) μm, l/w (1.2–)1.3–3.0(–5.0) (*n*=70), hyaline, extremely variable in shape, mostly oblong to cylindrical, also ellipsoidal, subglobose, oval, pyriform, sometimes curved, smooth, eguttulate, scar indistinct or truncate; often adhering in clusters.

Habitat: on forest litter in mixed forests dominated by conifers such as *Picea abies*.

Distribution: North Europe, northern areas of Finland and Sweden.

Holotype: **Finland**, Oulun Pohjanmaa. Haukipudas, Kello, Kalimeenkylä, Kalimeenoja, 1.5 km upstream of Saarela, in a spruce forest at the Suo-oja brook, 24 Aug.

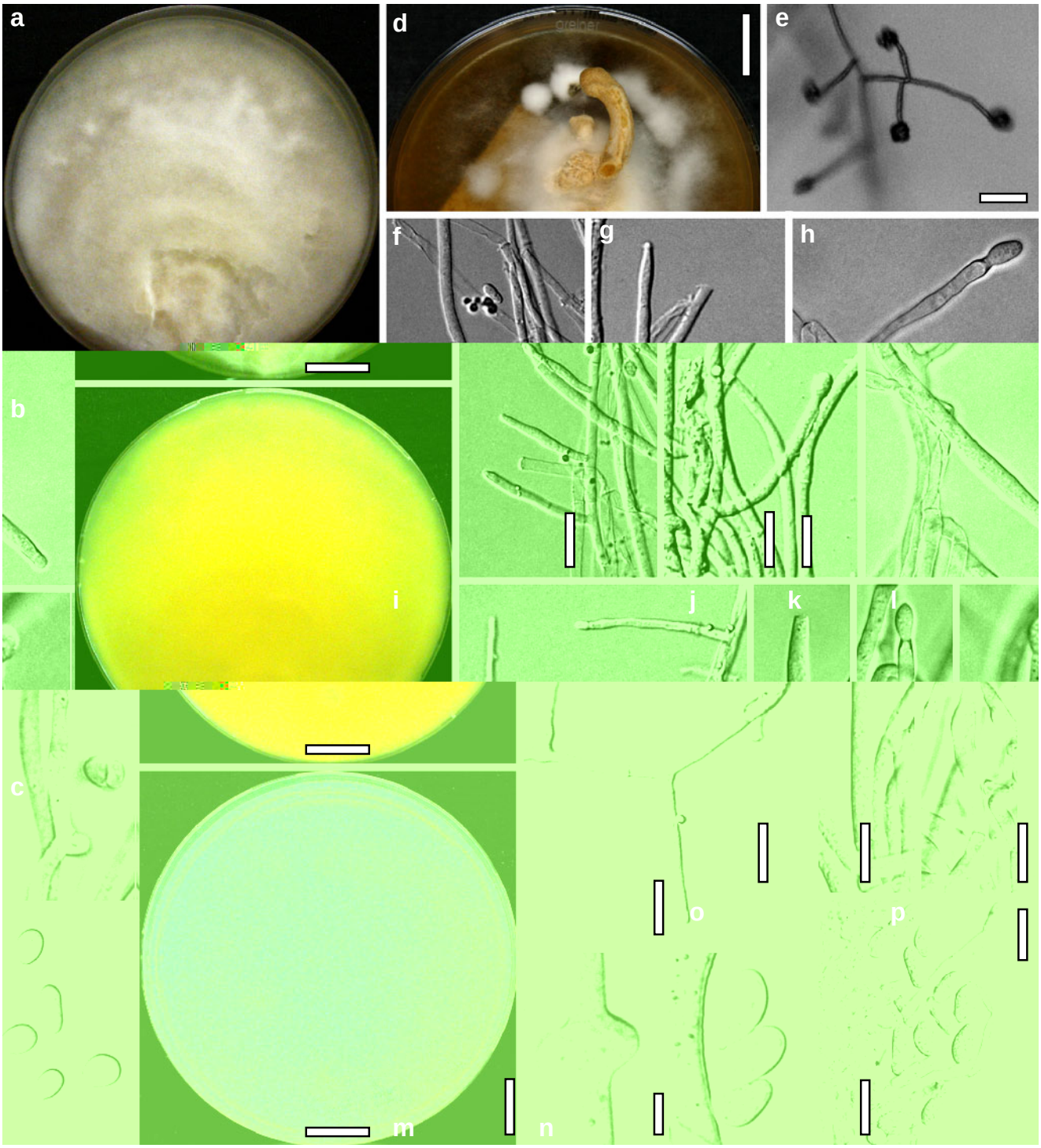


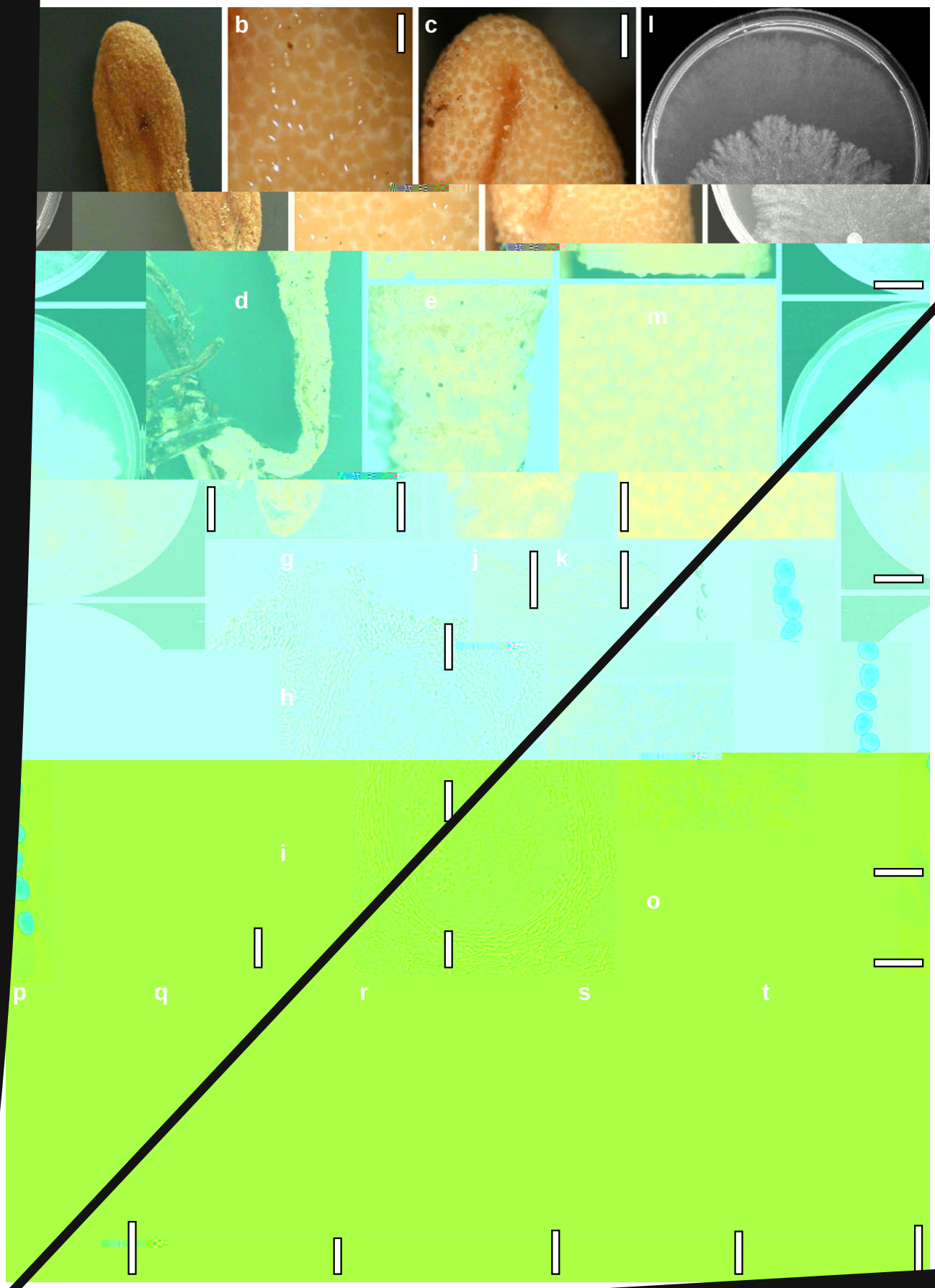
Fig. 33 Cultures and anamorph of *Hypocrea nybergiana*. **a**–**c**. Cultures after 14 days (**a**. on PDA. **b**. on PDA, reverse. **c**. on SNA). **d**. Stroma on OA (20°C, 3 weeks; photograph: G. Verkley, CBS). **e**. Conidiophore on aerial hypha on the growth plate (14 days). **f**–**i**. Conidiophores (14 days). **j**–**l**. Phialides (**j**. PDA, 10 days; **k**, **l**. 14 days). **m**. Thickened cell in aerial hypha (14 days). **n**–**p**. Conidia (**n**. PDA, 7 days; **o**, **p**. 28 days). **a**–**p**. All at 25°C. **e**–**p**. All on SNA except **j**, **n**. **a**–**c**, **j**, **n**. CBS 122500. **d**–**i**, **k**–**m**, **o**, **p**. CBS 122496. Scale bars: **a**–**d**=15 mm. **e**=30 mm. **f**, **i**=20 μm. **g**, **o**=15 μm. **h**, **j**–**l**, **p**=10 μm. **m**, **n**=5 μm

1967, T. Ulvinen (OULU F 49597, isotype OULU F 49596; not examined).

Material examined: **Finland**, Oulun Pohjanmaa, Kiiminki. Pikkuhalmeenmaa, Jolosmäki. In calcareous spruce forest. Grid 27°E 7228:445, elev. 45 m, on soil/leaf litter, 15 Aug. 2007, T. Rahko, det. I. Kytovuori (WU 29307). Pohjois-Karjala, Tohmajärvi, Kaurila, Okkula, 700–800 m east of the statue of Siiri Rantanen, grid 27° E 6902:683, on

the ground in a spruce-dominated mixed forest in leaf litter, immature, 9 Aug. 2007, L. Koukku, det. M. Kirsi 07-045 as *P. alutaceum* (JOE). Pohjois-Pohjanmaa, Koillismaa, Kuusamo, Oulanka National Park, E of Nurmisaarenniemi; grid 27° E 73638:6104; in a moist mossy eutrophic depression in a forest with *Picea abies* and *Betula*, on leaf litter in moss, 27 Aug. 2007, J. Vauras 25047 (WU 29308, part in TUR-A; culture CBS 122500=C.P.K. 3159). Kuusamo, Iivaara, Tienoro, N slope, grid 27° E 7304:622; forest with *Picea abies*, *Pinus sylvestris* and *Betula*, on soil/leaf litter, 4 Sep. 2007, K. Kokkonen & J. Vauras 25276 (WU 29309, part in TUR-A). Pohjois-Savo, Heinävesi, Heinolanmäki Nature Reserve, grid 6923:582, on thick needle litter with a moss cover under a large spruce, 19 Sep. 2007, S. Huhtinen 07/98 as *H. alutacea* (TUR; culture CBS 122496=C.P.K. 3163).

Notes: Among the species with upright stromata in Europe *Hypocrea nybergiana* forms the largest and darkest stromata. This species is characterized by an unusual combination of traits found in different clades of *Hypocrea*/*Trichoderma*. Although *H. nybergiana* phylogenetically belongs to the pachybasium core group, the inhomogeneous distribution of the cortical pigment is mainly found in teleomorphs of *Trichoderma* sect. *Trichoderma*. However, in contrast to that section the cortical cells are distinct, and inflated cells line the ostiolar apex. The anamorph is primitive, unusual for *Trichoderma*, and at most some m7(a)]a0Tc[(c6.9(d)-32.4c9TDF31Tf9.18(27(m)-56.9ac)0(o)1e.2(e)-615.r-41.4(
seppoi17(c97(it)16.)0(439(t)0(o)-Jaklits.4(nma)](e2760TDK.7(s8(h)-4e-98.-36(ny)48:


b
c
l
d
e
m
g
j
k
h
i
o
p
q
r
s
t

◀ **Fig. 34** *Hypocrea seppoi*. **a**–**k**. Teleomorph. **a**. Dry stroma. **b**. Stroma surface in 3% KOH. **c**. Rehydrated fertile stroma fraction. **d**. Part of stipe with groups of perithecia. **e**. Rehydrated stroma surface. **f**. Perithecium in section. **g**. Cortical and subcortical tissue in section. **h**. Stroma surface in face view. **i**. Subperithecial tissue in section. **j**, **k**. Asci with ascospores (**k**. in cotton blue/lactic acid). **l**–**t**. Cultures and anamorph. **l**–**n**. Cultures after 21 days at 25°C (l. on CMD, **m**. on PDA, **n**. on SNA). **o**. Conidia (SNA, 18 days, 15 C). **p**–**t**. Conidiophores with phialides on SNA (18 days, 15°C). **a**, **d**, **e**, **h**. WU 28698. **b**, **c**, **f**, **g**, **i**–**k**. WU 28699. **l**–**n**. CBS 122498. **o**–**t**. CBS 122497. Scale bars: **a**=2 mm. **b**, **e**=0.25 mm. **c**=0.5 mm. **d**=0.8 mm. **f**, **g**, **i**, **p**=25 μm. **h**, **l**–**n**, **r**=15 μm. **j**, **k**, **o**, **q**, **s**, **t**=10 μm

Odour none to slightly mushroomy. Conidiation noted after 3 days at 25°C, effuse, spreading from the plug, dense, short, white, irregularly verticillium-like. At 30°C little growth, no conidiation seen.

On SNA 1 mm at 15°C, 2 mm at 25 and 30°C after 72 h. Colony irregularly lobed, radial, developing white farinose streaks; hyphae narrow, forming pegs. Autolytic excretions, coilings, pigment, distinct odour, and chlamydospores absent. Conidiation noted after 9 days at 25°C, effuse, on short, irregularly verticillium-like conidiophores, particularly in streaks. At 30°C colony dense, white; conidiation effuse. At 15°C colony circular, hyaline, dense, narrow, white, farinose ring formed around the plug. Conidiation effuse, better developed than at 25°C, noted after 9 days, examined after 18 days: Conidiophores in dense lawns, erect on surface hyphae and paired or unpaired, in right angles on aerial hyphae; simple, short, 20–60(–150) μm long, 2–5(–7) μm wide, with some thickenings to 9.5 μm wide, 1–3 celled, unbranched or branched at up to 4 levels. Branches 1(–2) celled, right-angled or slightly inclined upwards, mostly paired, often thickened in the middle. Phialides formed on cells 3–5 μm wide, solitary or in whorls of 2–6, often inclined upwards in steep angles, sometimes nearly cruciform. Conidia mostly formed in minute dry heads <10 μm diam and in some wet heads <40 μm diam. Phialides (5–)6–11(–19)×(2.5–)2.8–3.6(–4.0) μm, l/w (1.4–)1.8–3.5(–7.3), (1.3–)1.7–2.5(–3.0) μm (n=63) wide at the base, lageniform, mostly symmetric and with long, abruptly attenuated narrow tip, also base often thin; straight, less commonly strongly curved, generally distinctly thickened in or below the middle; often longer (>11 μm) and nearly subulate when solitary. Conidia (2.5–)3.0–3.8(–4.5)×(2.0–)2.5–3.0(–3.7) μm, l/w (1.1–)1.2–1.4(–1.5) (n=93), hyaline, subglobose to ellipsoidal, smooth, with 1 to few guttules, scar indistinct.

Habitat: on the ground in *Picea*-dominated forests.

Distribution: Finland, only known from the type locality.

Holotype: Finland, Pohjois-Savo, Heinävesi, close to Hernelampi, grid 6925:586, on soil in a grass-rich spruce forest slope, 19 Sep. 2007, Stefan Jakobsson 4741 (**WU 28698**; culture CBS 122498=C.P.K. 3161).

Other specimen examined: *ca* 100 m from the type location, grid 6925:587, on soil in mossy and old spruce-dominated forest, 19 Sep. 2007, H. & M. Lahti (WU 28699; culture CBS 122497=C.P.K. 3162).

Notes: This species forms the smallest stromata, with a maximum length of 2.5 cm, of the stipitate species of *Hypocrea* found in Europe. The colour of the fertile part of dry stromata is between the lighter yellow *H. leucopus* and the darker orange-brown *H. nybergiana*, being closer to the latter. Also the decurrent perithecia on the stipe of stromata are shared with *H. nybergiana*. However, the latter species has slightly larger ascospores, while *H. leucopus* cannot be differentiated from *H. seppoi* by ascospore characters. The conidiophores of *T. seppoi* are not as regularly verticillate as in the anamorph of *H. leucopus*; the phialides are wider and shorter, and the conidia tend to be subglobose, smaller-sized than in both *H. leucopus* and *H. nybergiana*.

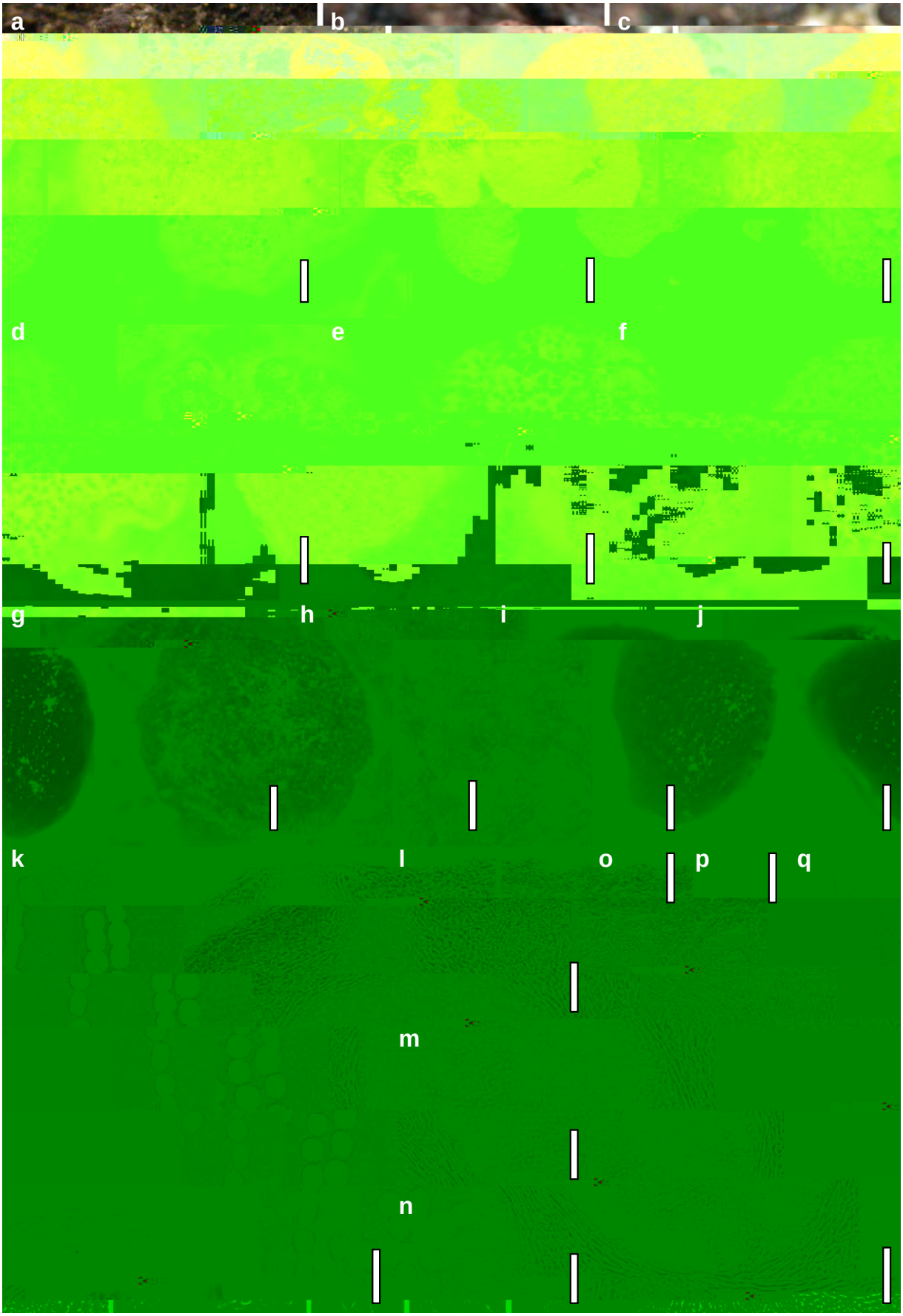
Hypocrea atlantica Jaklitsch, **sp. nov.** Fig. 35
MycoBank MB 516666
Anamorph: ***Trichoderma atlanticum*** Jaklitsch, **sp. nov.** Fig. 36
MycoBank MB 516669

Stromata typice in cortice et ligno *Fagi sylvaticae*, 2–8 mm diam, pulvinata, rosea, rufa, luteo-brunnea vel brunnea. Asci cylindrici, (73–)80–96(–107)×(4.0–)4.3–5.5(–6.0) μm. Ascosporae hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa vel ellipsoidea, (3.0–)3.3–4.0(–5.3)×(2.5–)3.0–3.5(–4.0) μm, pars proxima oblonga, ellipsoidea vel cuneata, (3.3–)3.7–4.8(–6.3)×(2.3–)2.5–3.1 μm. Anamorphosis *Trichoderma atlanticum*. Conidiophora in agaro CMD in pustulis disposita, similia *Pachybasii*. Phialides divergentes, lageniformes, (6–)8–13(–17)×(2.5–)2.7–3.4(–4.3) μm. Conidia pallide viridia, ellipsoidea, partim oblonga, glabra, 3.2–4.5(–5.8)×2.5–3.0(–3.2) μm.

Etymology: *atlantica* denotes its occurrence in the atlantic climate zone.

Stromata when fresh 2–8 mm diam, to 3 mm thick, pulvinate; surface smooth, with numerous brown ostiolar dots; colour rosy when immature, yellow-brown to reddish brown when mature or old.

Stromata when dry (0.6–)1.7–4.2(–5.4)×(0.5–)1.4–3.4(–5.1) mm, (0.4–)0.5–1.3(–1.8) mm thick (n=35), solitary, gregarious or aggregated in small numbers, pulvinate or placentiform, broadly attached, edge rounded, free; sometimes with a white mycelial margin when young; sometimes consisting of a white or yellowish base and a laterally projecting fertile part above; perithecia sometimes free. Outline circular, angular oblong or irregularly lobed. Surface smooth or rugose, iridescent, sometimes covered by a white scurf when young, or downy before the appearance of ostiolar dots. Ostiolar dots (40–)48–82(–102) μm (n=60) diam, numerous, densely disposed, well-defined, minute but distinct, plane or convex, with circular


a
b
c
d
e
f
g
h
i
j
k
l
o
p
q
m
n

◀ **Fig. 35** Teleomorph of *Hypocrea atlantica*. **a**. Fresh stromata (half mature). **b**–**g**. Dry stromata (**b**, **c**. immature, **b**. with whitish scurf). **h**. Stroma surface in face view. **i**. Stroma of e rehydrated. **j**. Stroma of i in 3% KOH. **k**. Perithecium in section. **l**. Cortical and subcortical tissue in section. **m**. Subperithecial tissue in section. **n**. Stroma base in section. **o**–**q**. Asci with ascospores (**p**, **q**. in cotton blue/lactic acid). **a**–**c**, **e**–**n**, **q**. WU 29280. **d**, **o**, **p**. WU 29279. Scale bars: **a**=1 mm. **b**, **d**, **e**=0.5 mm. **c**=0.3 mm. **f**=0.2 mm. **g**, **i**, **j**=0.7 mm. **h**, **o**–**q**=10 μm. **k**, m=30 μm. **l**, **n**=20 μm

outline, brown with light centres on rosy to yellow background, dark brown to black and shiny when old. Stroma colour first white, turning yellowish, rosy or greyish red 9C4, darkening to (yellow-) brown, brown-orange, reddish brown, 7–8CE4–6. Spore deposits white or yellow. Rehydrated stromata slightly larger than dry, semiglobose, surface smooth, yellow; ostiolar dots red, well-defined. After addition of 3% KOH stroma surface orange-red in the stereo-microscope, macroscopically dark reddish brown; compact, hard.

Stroma anatomy: Ostioles (63–)67–98(–120) μm long, projecting to 20 μm, (32–)38–54(–63) μm wide at the apex (*n*=30), with broad yellow wall, without specialized apical cells. Perithecia (170–)200–250(–260)×(120–)140–220(–240) μm (*n*=30), 6–7 per mm stroma length, flask-shaped; peridium (15–)18–25(–28) μm (*n*=30) thick at the base, (7–)11–19(–23) μm (*n*=30) thick at the sides, distinctly thickened in upper part, yellow, distinctly paler than the cortex; turning orange in KOH. Cortical layer (15–)18–30(–41) μm (*n*=30) thick, a *t. epidermoidea–angularis* of indistinct, compressed, thick-walled (1–2.5 μm) cells (3–)5–11(–16)×(2–)3–5(–7) μm (*n*=70) in face view and in vertical section, dense, yellow, turning deeply orange in KOH, more hyphal at stroma sides. Subcortical tissue where present a loose hyaline *t. intricata* of thick-walled (1 μm) hyphae (2–)3–5(–6) μm (*n*=30) wide; if absent, cortex >30 μm thick. Subperithecial tissue a dense, hyaline *t. epidermoidea* of thick-walled (2 μm), elongate to globose or angular cells (8–)11–38(–52)×(7–)9–14(–18) μm (*n*=30); towards the stroma base smaller, (3–)4–10(–14)×(3–)4–7(–8) μm (*n*=30), merging into a dense hyaline *t. intricata* of thick-walled hyphae (3–)4–6(–8) μm (*n*=35) wide at the base, often appearing as globose cells when cut across. Asci (73–)80–96(–107)×(4.0–)4.3–5.5(–6.0) μm, stipe (5–)10–21(–32) μm long (*n*=45). Ascospores hyaline, verruculose, cells dimorphic, distal cell (3.0–)3.3–4.0(–5.3)×(2.5–)3.0–3.5(–4.0) μm, l/w 1.0–1.3(–1.6) (*n*=60), (sub)globose or ellipsoidal, proximal cell (3.3–)3.7–4.8(–6.3)×(2.3–)2.5–3.1 μm, l/w (1.1–)1.3–1.8(–2.6) (*n*=60), oblong, ellipsoidal or subglobose.

Cultures and anamorph: optimal growth at 25°C on all media, slow growth at 30°C; no growth at 35°C.

On CMD 13–16 mm at 15°C, 22–25 mm at 25°C, 7–11 mm at 30°C after 72 h; mycelium covering the plate after 8–9 days at 25°C. Colony circular, mycelium loose, radially arranged, primary surface hyphae to *ca* 10 μm wide; several narrow concentric zones formed by conidiation; zones downy, later granular by small tufts or pustules. Pustules 0.5–1.5 mm diam concentrated and larger at the proximal margin and at lateral zone ends, first white, turning greyish yellow, light or grey-green, 2B3–4 to 28–30B4–5, 29–30CD5–6, 29D4. Aerial hyphae inconspicuous, more frequent in distal areas, thick, long, richly branched. Autolytic activity and coilings inconspicuous, autolytic excretions frequent at 30°C. No diffusing pigment noted, agar at most diffusely greyish yellow, 1B3, odour indistinct or slightly acidic. After prolonged storage at 15°C agar dull orange, with crystals in the agar. Chlamydospores noted after 7–9 days, uncommon, mostly around conidiation pustules, terminal and intercalary, globose. Conidiation at 25°C noted after 3 days, green after 6–7 days, nearly entirely confined to shrubs, tufts or small pustules without sterile elongations at the proximal margin and in concentric conidiation zones, particularly at their lateral ends. Pustulate conidiation preceded only by scant effuse conidiation on aerial hyphae and by few simple short erect conidiophores around the plug with conidial heads to 40 μm diam. Pustules 1–2 mm diam, discrete, circular or confluent in oblong groups to 3 mm long; generally pale (yellow-)green, loose or compact, dry, with velutinous or fluffy surface due to short, straight conidiophores projecting to 200 μm beyond the pustule surface, fertile to their tips. Pustules (examined after 12 days) of a thick-walled stipe to 7–10 μm wide, with asymmetric, thick-walled (to 2 μm) primary branches, forming a reticulum with right-angled branching points, sometimes thickened to 9 μm. Main axes to 300 (400) μm long, emerging from the reticulum in radial arrangement. Conidiophores (mostly unpaired side branches of main axes) (3–)4–6(–7) μm wide, attenuated to 2–4 μm terminally, variable, slender or often broader from the top down, with 1–3 phialides at the apex, followed by solitary phialides, typically paired branches in right angles or slightly inclined upwards, 20–40 μm long on upper levels, unpaired, rebranching and <170 μm long on lower levels. Phialides solitary or in whorls of 2–4(–5), most commonly 3–4, divergent, sometimes nearly parallel in terminal whorls, emerging from cells 2.0–3.5 μm wide. Conidia condensed in wet heads <30 μm in older pustules. Phialides (6–)8–13(–17)×(2.5–)2.7–3.5(–4.3) μm, l/w (1.9–)2.5–4.3(–5.5), (1.3–)1.8–2.6(–3.0) μm wide at the base (*n*=62), slender, lageniform, less commonly plump, nearly ampulliform, straight or curved and inaequilateral, widening at variable position, mainly median or above the middle. Conidia 3.2–4.5(–5.8)×2.5–3.0(–3.2), l/w (1.1–)1.2–1.6(–2.0) (*n*=62), pale green, ellipsoidal, less commonly subglobose or oblong, smooth, finely multiguttulate; scar indistinct, sometimes narrowly projecting. At 15°C similar to 25°C, increased effuse conidiation noted. At 30°C

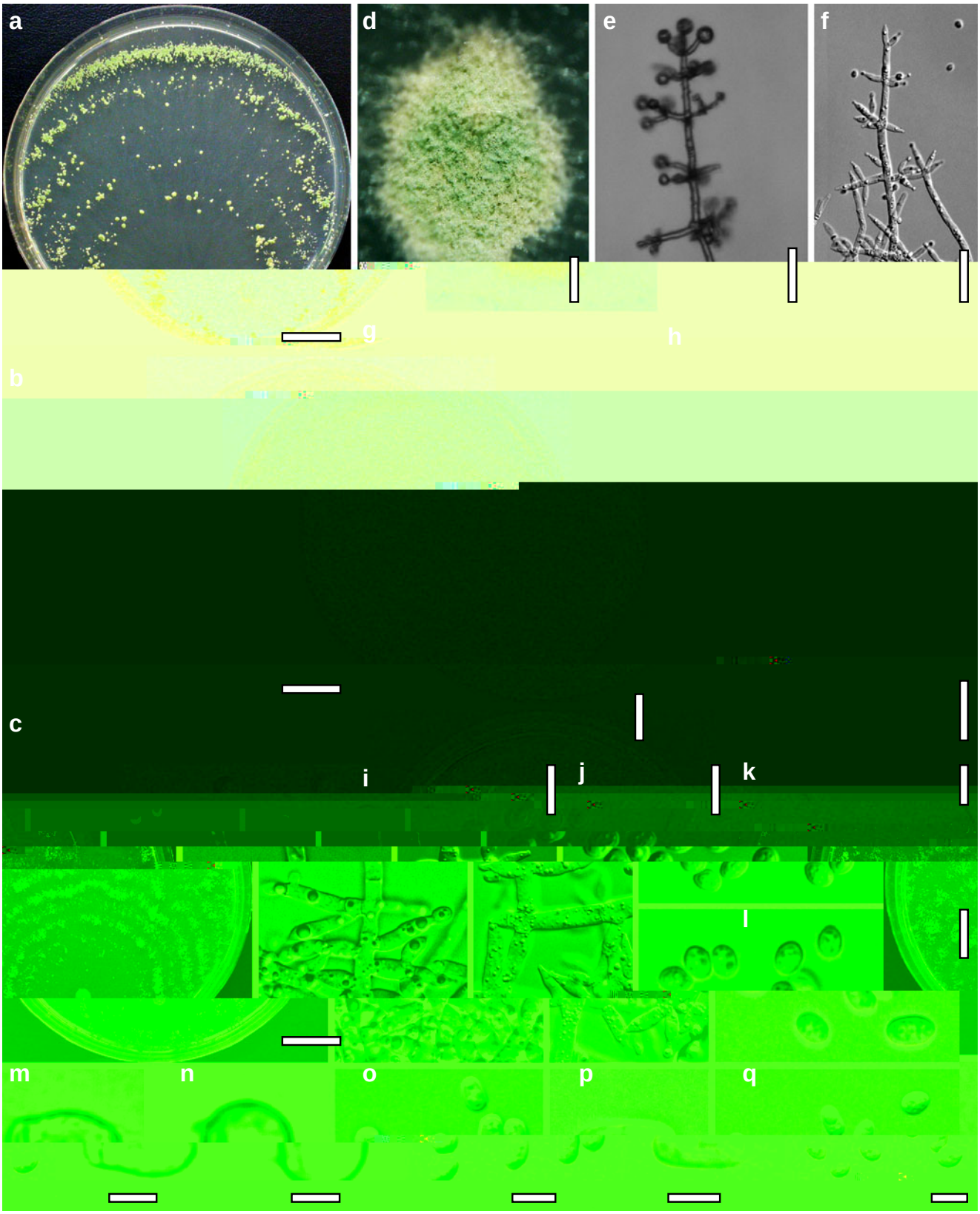


Fig. 36 Cultures and anamorph of *Hypocrea atlantica*. **a**–**c**. Cultures at 25°C after 14 days (**a**. on CMD; **b**. on PDA; **c**. on SNA). **d**. Conidiation pustule (16 days). **e**. Conidiophore on pustule margin on growth plate (SNA, 14 days). **f**–**h**. Conidiophores (12–13 days). **i**, **j**. Phialides (12–13 days). **k**, **l**, **o**–**q**. Conidia (12 days). **m**, **n**. Chlamydospores (SNA, 17 days). **d**–**q**. All at 25°C; all from CMD except **e**, **m**, **n**. **a**–**c**, **e**, **l**–**n**. C.P.K. 1896; **d**, **f**–**k**, **o**–**q**. CBS 120632. Scale bars: **a**–**c**=15 mm. **d**= 0.3 mm. **e**, **f**=30 μm. **g**, **i**, **j**=10 μm. **h**=15 μm. **k**–**o**, **q**=5 μm. **p**=3 μm

poor growth, hyphae autolysing; conidiation in small shrubs, remaining colourless.

On PDA 11–13 mm at 15°C, 20–22 mm at 25°C, 4–5 mm at 30°C after 72 h; mycelium covering the plate after 9–10 days at 25°C. Colony dense, with thin, diffuse margin, surface hyphae forming radial strands; marginal surface hyphae thick. Surface downy, farinose to floccose, macroscopically homogeneous, later indistinctly and irregularly zonate by aerial hyphae, whitish to pale yellowish. Aerial hyphae numerous, richly branched, ascending several mm, radial towards margin, forming a loose mat and strands collapsing into floccules; coalescing in the centre to a continuum. Autolytic activity inconspicuous, no coilings seen, autolytic excretions frequent at 30°C. No diffusing pigment noted, reverse yellowish, 4AB4–5. Odour rancid. Conidiation at 25°C noted after 2 days, mostly in small shrubs in the central continuum and aerial hyphae; more or less verticillium-like, with short numerous phialides, but small numbers of conidia; remaining colourless or white. At 15°C colony well-defined, finely zonate; zones crenate or angular; conidiation colourless. At 30°C poor growth, no conidiation seen.

On SNA 11–12 mm at 15°C, 15–16 mm at 25°C, 3–5 mm at 30°C after 72 h; mycelium covering the plate after 9–15 days at 25°C. Colony similar to CMD; except for up to 12 narrow, indistinctly separated, concentric zones of numerous irregular, powdery granules or small white pustules becoming light green, 29CD4, from the proximal margin. Aerial hyphae scant. Autolytic excretions inconspicuous, abundant and yellow at 30°C; no coilings seen. No diffusing pigment noted. Odour indistinct to slightly rancid. Chlamydospores noted after 6–9 days, loosely disposed, terminal and intercalary, (4–)6–10(–13)×(4–)6–9(–10) μm, l/w (0.9–)1.0–1.3(–1.5) (n=32), globose to ellipsoidal, sometimes oblong and 2-celled. Conidiation at 25°C noted after 4 days, green after 6–7 days, only in shrubs, tufts or pustules to 1 mm diam with granular surface, with short phialides in whorls of 2–3, often strongly inclined upwards; conidia dry or in wet heads to 50 μm. At 15°C conidiation in small pustules, at most pale greenish. At 30°C short growth, hyphae autolysing.

Habitat: on wood and bark of *Fagus sylvatica* and fungi growing on it.

Distribution: Europe (Austria, France).

Holotype: **France**, Lorraine, Vosges, Col de la Schlucht, shortly after the village heading to Le Hohneck, 48°03′18″ N, 07°00′46″ E, elev. 1050 m, on mostly corticated branches of *Fagus sylvatica* 6–9 cm thick, on wood and bark, on/soc. stromata of *Hypoxylon fragiforme*, soc. *Annulohypoxylon cohaerens* with *Polydesmia farinosa*, effete *Quaternaria quaternata*; holomorph, anamorph pustulate, light green, 4 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2676 (**WU 29280**, culture CBS 120632= C.P.K. 1897). ***Holotype*** of *Trichoderma atlanticum* isolated from WU 29280 and deposited as a dry culture with the holotype of *H. atlantica* as **WU 29280a**.

Other specimen examined: **Austria**, Vorarlberg, Bludenz, Nenzing, Rabenstein, at Beschling, MTB 8824/1, 47°11′28″ N, 09°40′04″ E, elev. 670 m, on decorticated branch of *Fagus sylvatica* 4 cm thick, on hard wood, below bark, soc. *Bertia moriformis*, black hyphomycetes, etc.; 29 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2630 (WU 29279, culture C.P.K. 1896).

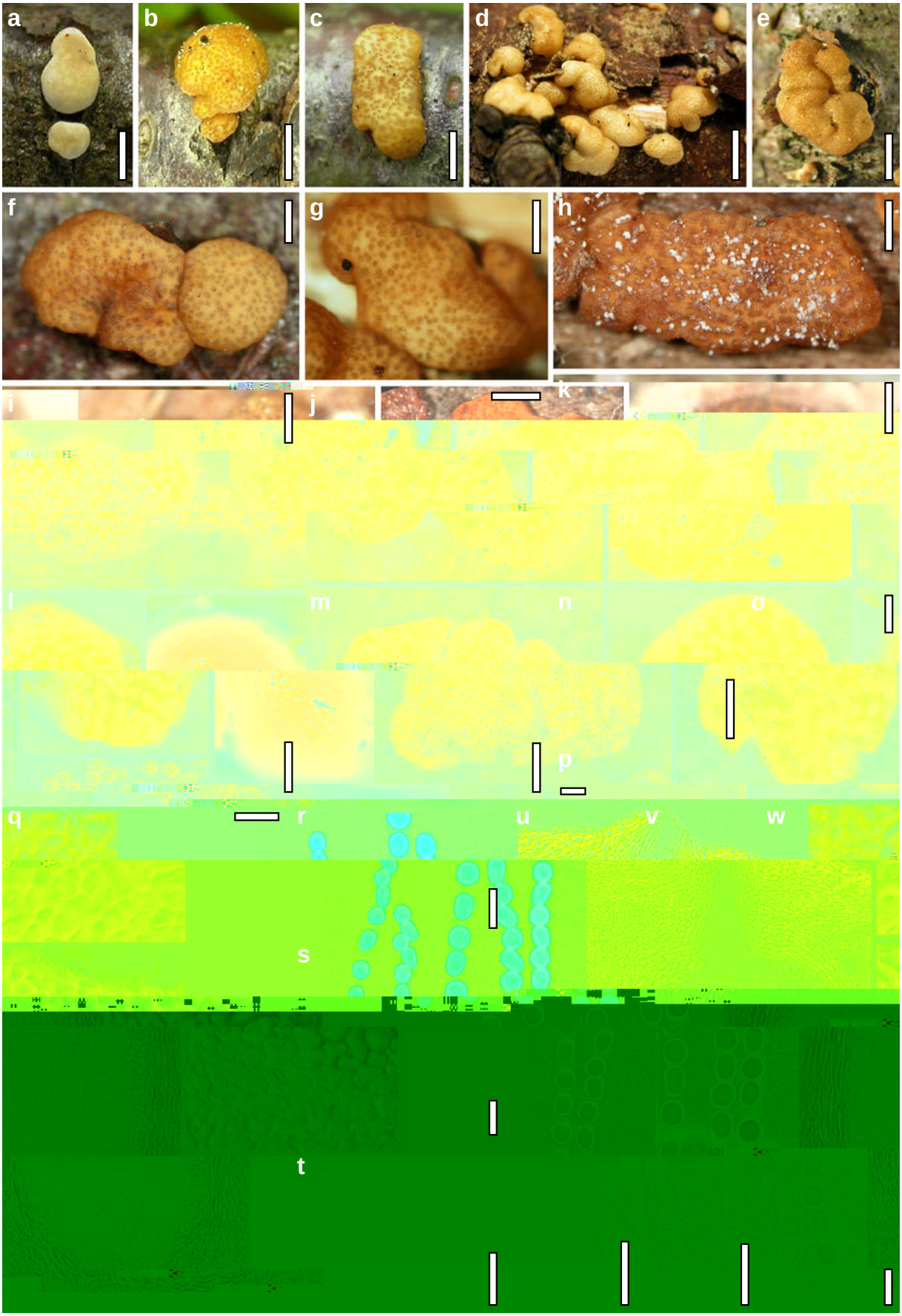
Notes: *Hypocrea atlantica* was first collected as *H. minutispora*, because it is morphologically barely distinguishable from the latter, except for the slightly smaller ascospores. Two specimens may possibly not be sufficient to ascertain differences in the teleomorph such as the stronger orange KOH reaction of the stromata of *H. atlantica*. *Trichoderma atlanticum* differs from *T. minutisporum* by growth only half as fast on all media, more distinctly pustulate conidiation on CMD and the presence of oblong conidia in addition to ellipsoidal ones.

Hypocrea bavarica Jaklitsch, **sp. nov.** Fig. 37
MycoBank MB 516673
Anamorph: ***Trichoderma bavaricum*** Jaklitsch, **sp. nov.** Fig. 38
MycoBank MB 516674

Stromata typice in cortice *Betulae*, 1–8 mm diam, pulvinata vel semiglobosa, humida lutea, sicca brunnea. Asci cylindrici, (50–)60–75(–85)×(3.3–)3.8–4.7(–5.5) μm. Ascosporae hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa vel oblonga, (2.5–)2.8–3.2(–3.5)×(2.3–)2.5–3.0(–3.2) μm, pars proxima oblonga vel cuneata (2.8–)3.3–4.2(–5.0)×(1.8–)2.2–2.5(–2.8) μm. Anamorphosis *Trichoderma bavaricum*. Conidiophora in agaros CMD, PDA et SNA effuse disposita, simplicia, similia *Acremonii* vel *Verticillii*. Phialides divergentes, lageniformes vel subulatae, (7–)11–22(–33)×(2.0–)2.5–3.3(–4.3) μm. Conidia hyalina, subglobosa, ovalia vel pyriformia, partim oblonga vel ellipsoidea, glabra, (2.5–)3.0–4.8(–6.7)×(2.0–)2.3–3.0(–3.5) μm.

Stromata when fresh 1–8 mm diam, to 1–2 mm thick, erumpent from or superficial on bark, less commonly on wood, solitary, gregarious, or aggregated in small fascicles, pulvinate, broadly attached. Surface smooth, with brown ostiolar dots. Colour first white to pale citrine, pale ochre or yellow, darkening within few hours after collecting except when immature (without dots, pale yellow 3A3), to yellow, greyish orange or light brown, 4A3–4, 5B4–5, 6D6–8; also with a rosy or reddish tone.

Stromata when dry (0.5–)1–3(–5)×(0.5–)1.0–2.2(–3) mm, (0.2–)0.4–1.0(–1.4) mm thick (n=70); solitary, gregarious to aggregated in small groups, pulvinate to semiglobose, less commonly subeffuse to effluent; flat,


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
u
v
w
s
t

◀ **Fig. 37** Teleomorph of *Hypocrea bavarica*. **a**–**e**. Fresh stromata (**a**. immature). **f**–**m**. Dry stromata (**f**. 'halfdry'; **j**. 'effluent', breaking up into several single stromata). **n**. Rehydrated stroma. **o**. Stroma in 3% KOH after rehydration. **p**. Ejected orange ascospores. **q**. Perithecium in section. **r**. Stroma surface in face view. **s**. Cortical and subcortical tissue in section. **t**. Subperithecial tissue in section. **u**–**w**. Asci with ascospores (**v**, **w**. in cotton blue/lactic acid). **a**–**g**, **k**, **m**–**t**, **v**. WU 29196. **h**–**j**, **l**, **w**. WU 29197. **u**. WU 29195. Scale bars: **a**–**c**=1 mm. **d**, **e**=1.5 mm. **f**–**i**, **k**, **m**–**o**=0.4 mm. **j**, **l**=0.7 mm. **p**, **w**=5 μm. **q**, **t**=20 μm. **r**, **s**, **u**, **v**=10 μm

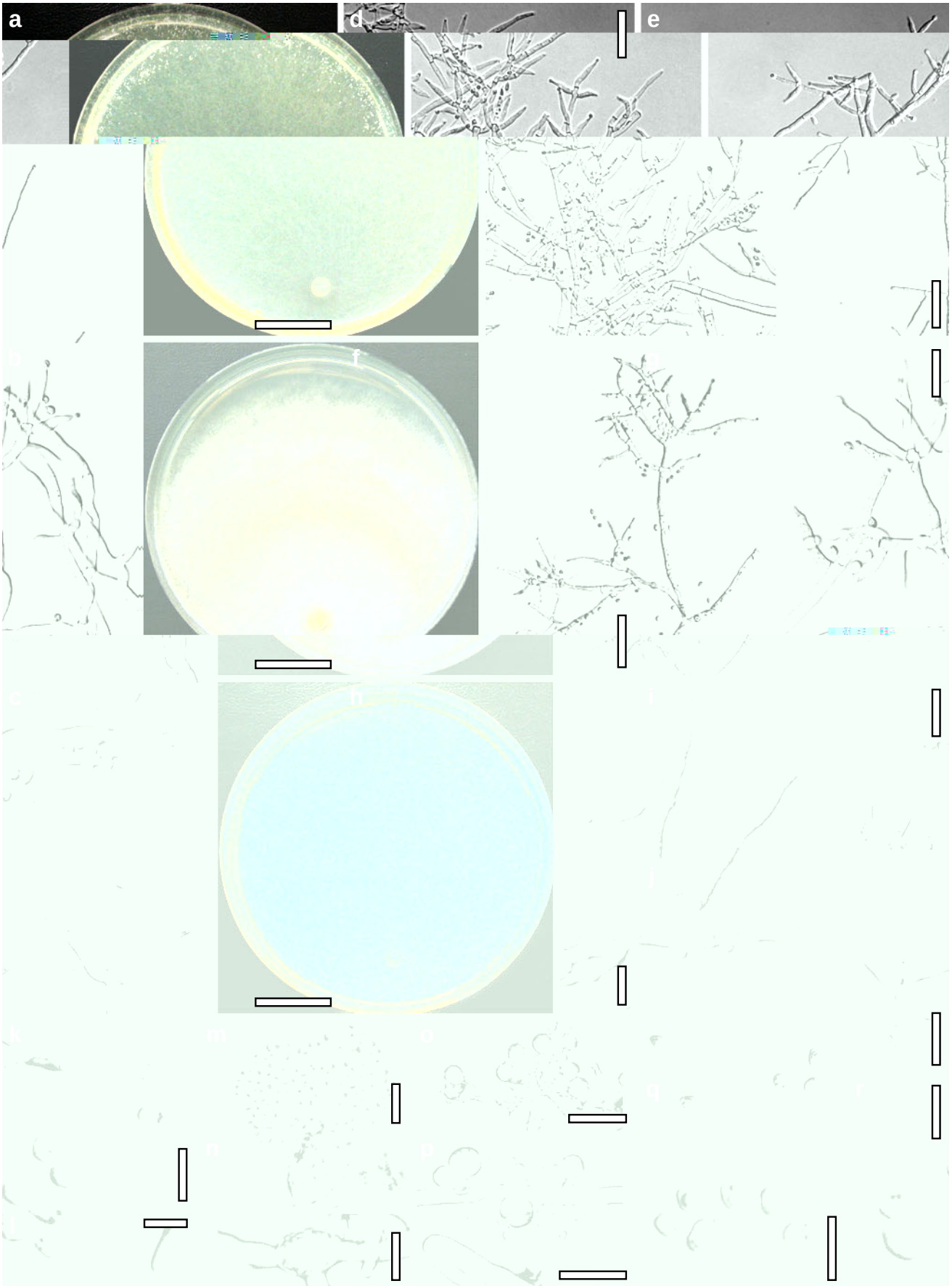
placentiform, discoid and irregularly tubercular or rugose when old. Outline circular, oblong or irregularly lobed. Margin free, thick, rounded, sometimes strongly projecting beyond a short wide base, or with smooth, vertical, sterile sides. Sides when young sometimes whitish and with white basal mycelium. Surface smooth to finely granular due to ostiolar dots, sometimes with white anamorph flakes or downy when young, strongly tubercular to rugose when old. Perithecia sometimes slightly prominent. Ostiolar dots (31–)40–96(–197) μm (n=110) diam, numerous, typically inconspicuous or ill-defined, diffuse, flat or convex, pale brown; more conspicuous, distinct and dark brown in overmature stromata. Development and colour: starting as white mycelium, becoming compact, yellow or greyish orange, 4–5AB4–5, from the centre; mature stromata mostly yellow-brown, brown-orange, golden-brown or light brown (5–)7CD5–6, 5CD6–8 (yellow stroma surface plus ochre or brown ostiolar dots), dark reddish-brown to dull brown, 8CD6–8, (6–)7–8E5–8, 8–9F5–8, when old. Spore deposits minute, white or yellow. Rehydrated stromata thickly pulvinate to semiglobose, slightly larger than dry. Margin free, projecting. Stromata orange, with ochre ostiolar dots and yellow surface between them. After addition of 3% KOH turning macroscopically dark (orange-)red to nearly black, bright red in the stereo microscope.

Stroma anatomy: Ostioles (60–)65–77(–84) μm long, plane or projecting to 20 μm, (19–)24–35(–40) μm (n=30) wide at the apex, conical or cylindrical, periphysate; no specialised apical cells seen. Perithecia (150–)180–235(–260)×(97–)110–170(–225) μm (n=30), flask-shaped to subglobose, crowded, *ca* 8 per mm of stromal length; peridium (14–)17–25(–31) μm thick at the base and (7–)11–17(–20) μm (n=30) at the sides, turning orange-red in KOH, yellow in lactic acid, paler than cortex. Surface smooth, with rare remnants of short, collapsed, brownish hyphae. Cortical layer (14–)16–26(–33) μm (n=30) wide, a distinct, yellow *t. angularis* of isodiametric to oblong, thick-walled, angular cells (4–)6–11(–13)×(3–)4–8(–10) μm (n=60) in face view and in vertical section. Cortex turning bright orange in KOH. Subcortical tissue a pale yellowish *t. angularis* of thin-walled cells (4–)5–11(–16)×(3–)3.5–6(–7) μm (n=30), mixed with scant, subhyaline to yellowish hyphae (2.5–)3–5(–6) μm (n=30) wide. Subperithecial tissue a hyaline to yellowish *t. epidermoidea* of thin-walled cells (6–)10–28(–42)×(4–)7–15(–19) μm (n=30), extending into the substrate. Asci (50–)60–75(–85)×(3.3–)3.8–4.7(–5.5) μm, stipe (1–)5–15(–25) μm long (n=80); fasciculate on long ascogenous hyphae. Ascospores hyaline, often yellow or orange after ejection, nearly smooth to minutely verruculose, cells dimorphic; distal cell (2.5–)2.8–3.2(–3.5)×(2.3–)2.5–3.0(–3.2) μm, l/w (0.9–)1.0–1.2(–1.4), (sub-)globose or oblong; proximal cell (2.8–)3.3–4.2(–5.0)×(1.8–)2.2–2.5(–2.8) μm, oblong or wedge-shaped (or subglobose), l/w (1.2–)1.4–1.8(–2.3) (n=100).

Anamorph on natural substrate observed as a white, thin, loose, crumbly layer in association with stromata; dense conidial heads on small regular conidiophores with 1–3(–4) terminal phialides. Phialides (6–)8–15(–17)×(2.5–)3–4(–4.1) μm, l/w (2–)2.5–4.3(–5.4), (1.9–)2.2–2.8(–3.1) μm (n=20) wide at the base, lageniform, pointed, straight to sinuous, often collapsed. Conidia (2.8–)3.0–4.5(–5.6)×(2.3–)2.4–3.0(–3.6) μm, l/w 1.2–1.6(–2.4) (n=30), hyaline, mostly subglobose to pyriform, less commonly broadly ellipsoidal or oblong, smooth, scar sometimes distinct.

Cultures and anamorph: optimal growth at 25°C on all media, at 30°C hyphae soon dying after onset of growth; no growth at 35°C.

On CMD after 72 h 5–8 mm at 15°C, 7–10 mm at 25°C, 0–3 mm at 30°C; mycelium covering the plate after *ca* 2 weeks at 25°C. Colony hyaline, thin, smooth, homogeneous, not zonate. Mycelium loose, little on the surface; hyphae generally narrow, curly, without specific orientation. Margin ill-defined, diffuse, of solitary strands. Aerial hyphae infrequent, loose, thick, becoming fertile. Surface becoming indistinctly downy by conidiation mainly on the distal and lateral margins. Autolytic activity moderate to strong, coilings abundant. Sometimes fine whitish granules 0.5–0.7 mm diam of aggregated conidiophores with dry conidiation appearing in distal and lateral areas of the plates. No chlamydospores seen, but globose or irregularly thickened cells appearing in surface hyphae in aged cultures. Conidia swelling on the agar surface forming clumps, probably wrapped in an excreted substance. Agar hyaline, sometimes becoming faintly yellowish, 2AB3. Odour after 14 days week unpleasant, chemical (reminiscent of organic solvents like pyridin). Colony after 3–4 months condensed, opaque, with a rubber-like consistency and a peculiar unpleasant odour. Conidiation noted after 3–4 days at 25°C, macroscopically invisible or arranged in inconspicuous, downy, concentric zones; colourless, effuse, starting around the plug, spreading across plate and often pronounced at distal and lateral margin of growth plates; simple, acremonium- to verticillium-like. Phialides arising directly from surface hyphae or from conidiophores. Conidiophores (after 7–10 days) loosely disposed, short, typically to 250(–450) μm tall, longer (to ca 1 mm) with distance from the plug; erect, simple, forked or sparsely,


a
d
e
f
h
k
m
o
n
p
q
r

asymmetrically branched. Side branches 1–7 celled, to *ca* 120 µm long, typically strongly inclined upwards. Main axis to 7(–9) µm wide and thick-walled at the base, 2–3 µm wide terminally. Phialides borne on cells 2–4.5 µm wide, solitary or divergent in whorls of 2–3(–4); phialides (7–)11–22(–33)×(2.0–)2.5–3.3(–4.3) µm, l/w (2.0–)4.0–7.5(–13.5), (1.2–)2.0–2.8(–3.8) µm (*n*=120) wide at the base, lageniform or subulate, narrow and pointed, only slightly widened at a variable level, often inaequilateral and slightly curved. Conidia formed in wet heads to 30(–50) µm diam, (2.5–)3.0–4.8(–6.7)×(2.0–)2.3–3.0(–3.5) µm, l/w (1.1–)1.2–1.8(–2.8) (*n*=130), subglobose, oval or pyriform, partly ellipsoidal or oblong, hyaline, smooth, finely multiguttulate, abscission scar inconspicuous or projecting and narrowly truncate. Chlamydospores rare, 12–22×10–20 µm, l/w 1.1–1.4 (*n*=4), globose or ellipsoidal; hyphal thickenings more frequent. Swollen conidia to 6 µm diam commonly noted after 3 weeks on the agar surface, globose, smooth, often surrounded by an amorphous, resinous substance.

On PDA after 72 h 2–5 mm at 15°C, 7–8 mm at 25°C, <1 mm at 30°C; mycelium covering plate after 9–14 days at 25°C. Colony flat, of thin, densely interwoven hyphae, more loosely arranged with distance from the plug. Surface hyaline, finely zonate, becoming white and farinose or finely floccose from the centre; slightly yellowish in age. Margin diffuse and thin. Aerial hyphae short, thick, loosely disposed; longer and forming a flat mat of nearly reticulate, irregular strands towards the margin. Autolytic excretions inconspicuous, coilings abundant and conspicuous. Surface white, reverse becoming yellow from the centre, 2A2–3, 3A3–4, 4AB3–5, occasionally with brownish zones 5CD6–8. Odour strong after ca 2 weeks, unpleasant, pungent, pyridine-like. Chlamydospores abundant in marginal hyphae, subglobose to angular. Conidiation noted after 3 days at 25°C, white, effuse, spreading from the plug, in continuous, dense lawns of fine, ill-defined, spiny, sessile shrubs, and on long aerial hyphae, particularly in the centre and in white, mealy to floccose areas of the colony. Shrubs finally collapsing and becoming condensed into roundish aggregates. Conidiophores (from Sigma-PDA after 9 days) variable, irregularly branched, mostly 100–150 µm long, broad, asymmetric, mostly 2–5(–7) µm wide, 7–9 µm wide at the base, 2.0–2.5 µm at the ends; often with paired branches towards the ends. Phialides borne on cells 2.0–3.5 µm wide, solitary or in whorls of 2–3(–5), divergent, lageniform to beak-like, long, often curved or sinuous, often longer when solitary. Conidia formed in minute wet heads, minute, pyriform, oval or subglobose, less commonly oblong and larger; hyaline, smooth, with few finest guttules; abscission scar often distinct, projecting, short and flat. Measurements united with those determined on CMD.

On SNA after 72 h 4–6 mm at 15°C, 4–8 mm at 25°C, < 1 mm at 30°C; mycelium covering plate after 2–3 weeks at 25°C. Colony similar as on CMD, slightly more irregular and mycelium looser; hyaline, margin diffuse, growth faster inside the agar. Surface becoming floccose, with fine white granules or floccules (0.2–0.6 mm) of larger or aggregated conidiophores. Autolytic activity moderate to strong, coilings abundant. No distinct odour, no pigment, no chlamydospores noted. Conidiation effuse, starting after 3–4 days at 25°C around the plug, spreading across the entire colony, denser in downy areas; similar to but more abundant than on CMD. Phialides often sinuous, spiny, on thick stipes, conidia formed in minute wet heads to 20–30(–60) µm diam, colourless. At 15°C poor growth observed.

Habitat: on corticated branches of *Betula pendula*, rarely other hosts

Distribution: Europe, collected in Germany (Bavaria) and Austria

Holotype: **Germany**, Bavaria, Landkreis Traunstein, Grabenstätt, south from Winkl and the A8, MTB 8141/3, 47°48

hours. Similar colour changes are seen in *H. moravica* and *H. subalpina*. Superficially the teleomorph of *H. bavarica* is similar to *H. argillacea*, albeit with a more intense stroma colour when dry. *H. argillacea*, as far as known, differs primarily by distinctly larger ascospores. Also *H. moravica* can be easily confounded with *H. bavarica*, but differs generally in more conspicuous ostiolar dots, larger ascospores, and in a green-conidial pustulate anamorph. Overmature, rugose stromata sometimes also resemble those of *H. tremelloides*. *H. bavarica* is an unusual species of the pachybasium core group, in forming an effuse, irregularly verticillium-like anamorph, and no pustules on the media examined. In this respect, this species resembles stipitate species like e.g. *H. seppoi*. Another interesting trait of *H. bavarica* is the peculiar, unpleasant odour detected in cultures on CMD and PDA, apparently caused by an excreted resinous substance, that also provokes hardening of the agar in aged cultures.

Hypocrea luteffusa Jaklitsch, **sp. nov.** Fig. 39
MycoBank MB 516685
Anamorph: ***Trichoderma luteffusum*** Jaklitsch, **sp. nov.** Fig. 40
MycoBank MB 516686

Stromata effusa, lutea, prosenchymatosa, 2–50×1–22 mm. Asci cylindrici, (70–)78–93(–104)×3.5–4.5 µm. Ascosporae bicellulares, hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa vel ovoidea, (2.3–)2.7–3.5(–4.3)×(2.3–)2.5–3.0(–3.2) µm, pars proxima oblonga, (2.8–)3.2–4.4(–5.0)×2.0–2.5(–2.8) µm. Anamorphosis *Trichoderma luteffusum*. Conidiophora in agaro SNA effuse disposita, simplicia, ramis sparsis brevibus, similia *Verticillii*. Phialides divergentes, lageniformes vel subulatae, (6–)7–14(–20)×(2.0–)2.3–3.0(–3.3) µm. Conidia subglobosa, ellipsoidea, oblonga vel cylindracea, viridia in acervulis, glabra, (2.7–)3.0–5.3(–8.2)×(2.0–)2.2–2.8(–3.3) µm.

Etymology: referring to the yellow effuse stromata.

Stromata when fresh 2–50×1–22 mm; 0.5–2 mm thick, aggregated in small numbers, (semi-) effuse. Surface smooth or slightly tubercular, with numerous brown dots; pale yellowish, 3–4A3–4.

Stromata when dry 0.2–0.6(–0.8) mm (n=17) thick, effuse, entirely attached, following the host surface; white inside; consistency tough, nearly leathery. Margin white, mycelial, partly rounded, compact, sterile. Surface smooth. Ostiolar dots (32–)46–97(–126) µm (n=30) diam, numerous, first appearing as indistinct spots with circular perforation, becoming distinct, plane or convex, yellowish, ochre or brownish, responsible for the stroma colour; stroma surface between ostiolar dots white to cream. Stroma colour pale yellow or yellow-orange, 4A3–4(–6); in 3% KOH unchanged or slightly darker brown and appearing gelatinous. Spore powder white.

Stroma anatomy: Ostioles (67–)73–94(–112) µm long, (20–)32–50(–62) µm wide internally directly below the dense apex (n=20); umbilicate or plane, broad, in section visible as densely packed sheets of hyaline, parallel, narrow cylindrical hyphae obliquely oriented to the ostiolar axis. Perithecia (180–)230–310(–320)×(130–)170–260(–300) µm (n=20), subglobose, ellipsoidal or flask-shaped, crowded, usually with the height exceeding diam; peridium (15–)16–25(–30) µm (n=20) thick at the base, (9–)13–22(–24) µm (n=20) thick at the sides, pale yellowish. Cortical layer (17–)23–34(–40) µm (n=30) thick, pale yellowish or subhyaline, labyrinthine, of extremely densely compacted, refractive hyphae and minute globose or ellipsoidal cells (2.5–)3.5–6.0(–8.0)×(2.0–)3.0–4.5(–5.5) µm in face view and in vertical section (n=60), with walls 0.5–1.5(–2) µm thick; hairs absent. Residual entostroma a hyaline *t. intricata*, with hyphae becoming thicker and more loosely arranged downwards, some appearing globose or compressed due to various sectioning angles; subcortical hyphae (2.5–)3.0–5.5(–7.5) µm (n=30) wide, hyaline, thin-walled; subperithecial hyphae (3–)5–11(–15) µm (n=30) wide, thin- to thick-walled; basal hyphae thick-walled (to *ca* 1.5 µm), (3–)4–8(–10) µm (n=30) wide, deeply penetrating into the wood. Asci (70–)78–93(–104)×3.5–4.5 µm; stipe (10–)14–25(–33) µm long (n=30); apex with a minute pore; no croziers seen. Ascospores hyaline, nearly smooth to verruculose or spinulose; cells dimorphic, distal cell (2.3–)2.7–3.5(–4.3)×(2.3–)2.5–3.0(–3.2) µm, l/w (0.9–)1.0–1.3(–1.5) (n=30), (sub-)globose or oval, proximal cell (2.8–

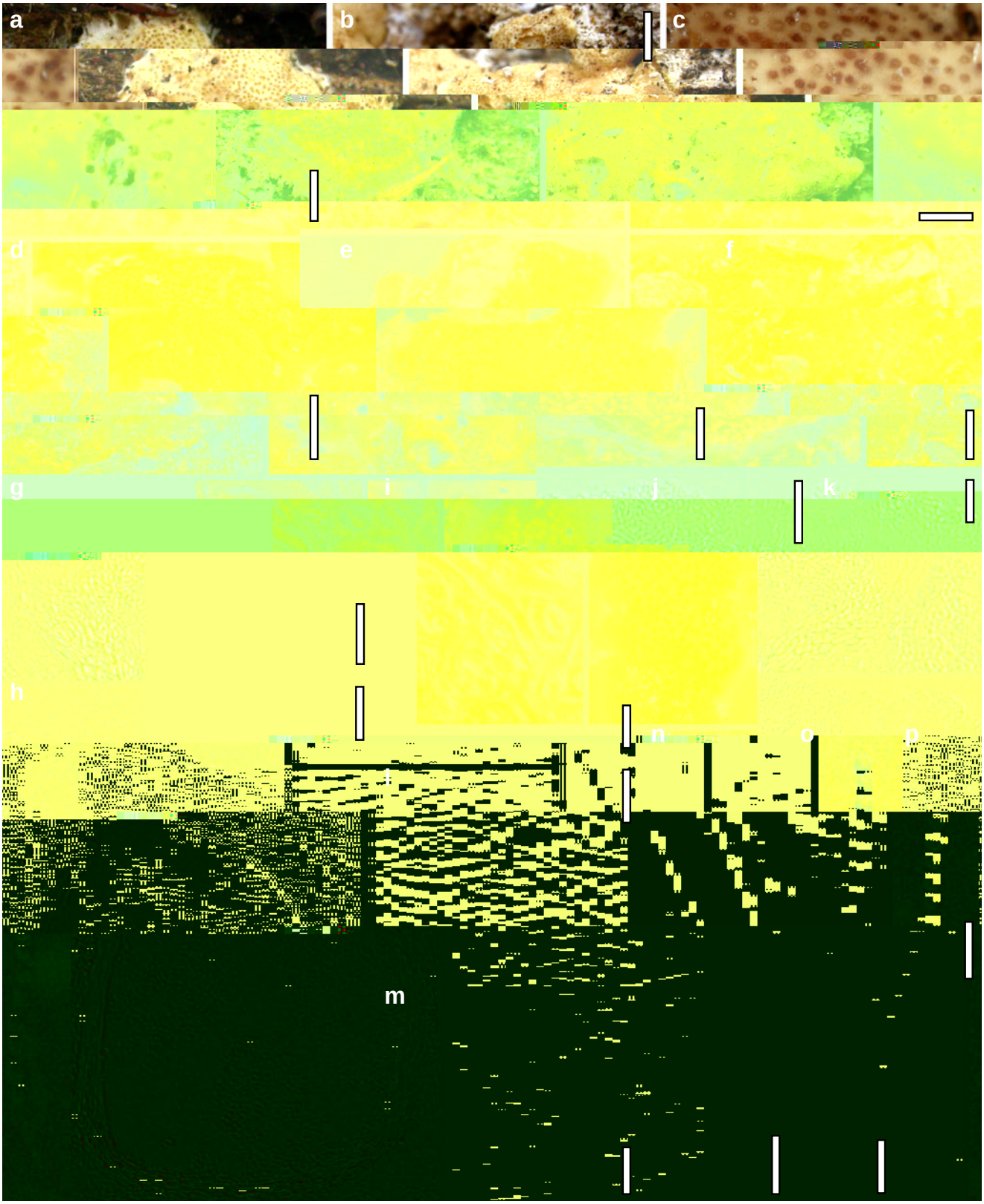


Fig. 39 Teleomorph of *Hypocrea luteffusa* (holotype WU 29236). **a**, **b**. Fresh stromata. **c**–**e**. Dry stromata (**c**, **d**. in the stereo-microscope). **f**. Rehydrated stroma. **g**. Ostiole in section. **h**. Perithecium in section. **i**. Cortical and subcortical tissue in section. **j**. Stroma surface in face view. **k**. Stroma in 3% KOH after rehydration. **l**

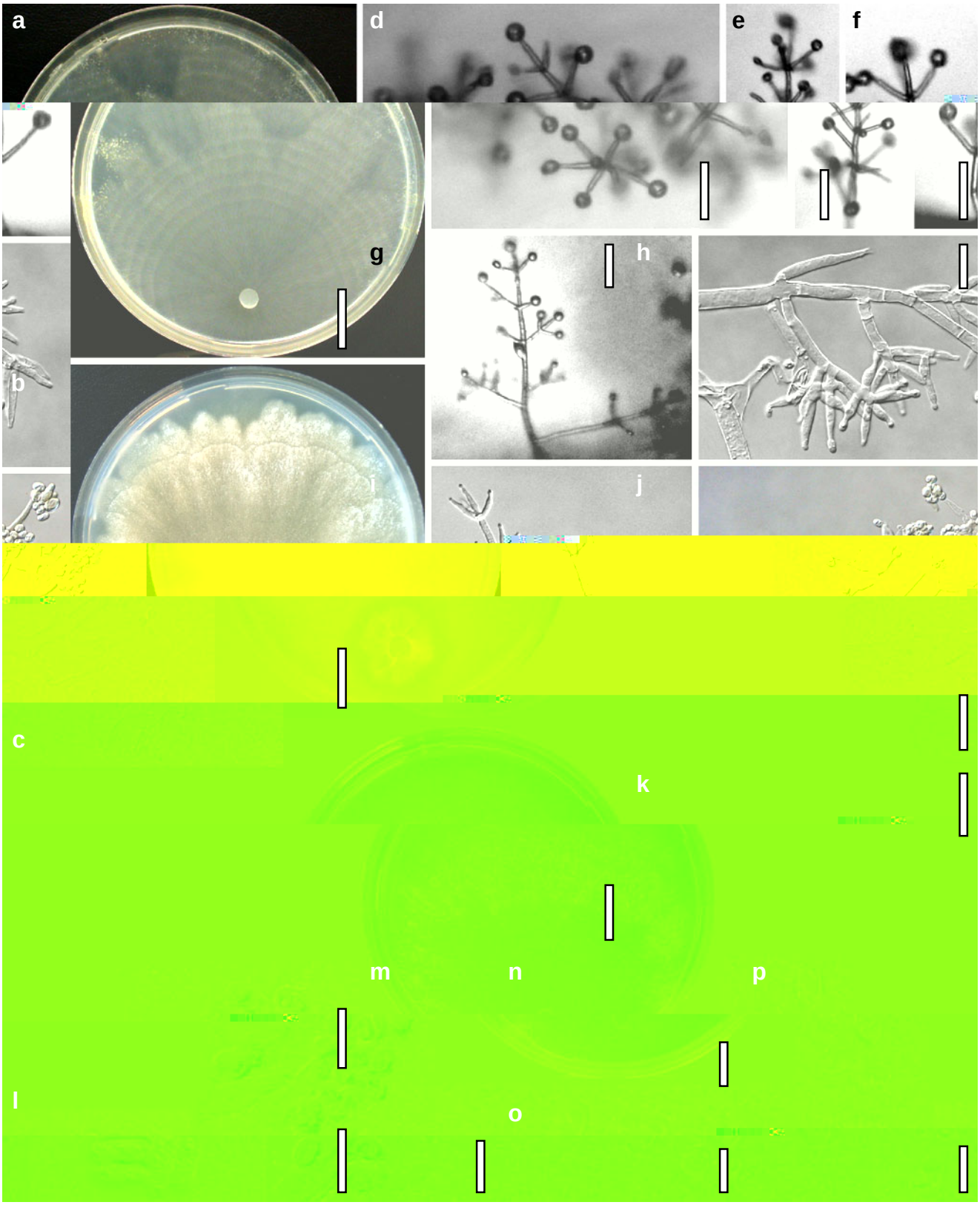


Fig. 40 Cultures and anamorph of *Hypocrea luteffusa* (CBS 120537). **a**–**c**. Cultures (**a**. on CMD, 21 days; **b**. on PDA, 21 days; **c**. on SNA, 14 days). **d**. Conidiophores on growth plate in face view (CMD, 3 days). **e**–**g**. Conidiophores on inoculation plug (3 days; **e**, **f**. CMD, **g**. SNA). **h**–**j**. Conidiophores. **k**, **n**. Phialides. **l**, **m**, **o**, **p**. Conidia. **a**–**p**. All at 25°C. **h**–**p**. On SNA after 9–14 days. Scale bars: **a**–**c**=15 mm. **d**, **f**, **i**=20 μm. **e**, **g**=30 μm. **h**, **k**, **n**=10 μm. **j**=15 μm. **l**, **m**, **o**, **p**= 5 μm

paired or unpaired phialides bearing numerous wet, minute conidial heads <20 μm diam. Phialides long, thin, acute.

On PDA after 72 h 4–8 mm at 15°C, 7–9 mm at 25°C, to 0.3 mm at 30°C; mycelium covering the plate after *ca* 3 weeks at 25°C. Hyphae finely sinuous, becoming multiguttulate. Colony compact, dense, indistinctly zonate; appearing as a small yellowish centre with a granular surface, followed by a densely farinose or loosely floccose white zone, and a broad, downy or slightly floccose major part; margin broadly wavy to lobed. Sometimes irregular patches of condensed mycelium appearing, forming broad white spots with dense short conidiation. Aerial hyphae loosely disposed, short in the centre, long and dense close to the colony margin; erect, arising several mm, richly branched, becoming fertile, soon collapsing, aggregating into strands appearing as floccules or irregular white spots after 3 weeks. Autolytic activity moderate; coilings moderate or frequent. Colony reverse, particularly in the centre, turning pale yellow, greyish yellow or yellow-brown 4A3–4, 3–4B4, 5C7. Odour indistinct. Chlamydospores abundant. Conidiation starting after 2–4 days around the plug, effuse, short and dense in a central lawn and loosely disposed on long aerial hyphae spreading across the colony, longer and ascending higher in more distal areas; also short and dense in white spots. Conidia formed in minute heads on thin and needle-like phialides; colourless, white in mass. Dense white conidiation and increased autolytic activity noted at 15°C.

On SNA after 72 h 6–8 mm at 15°C, 11–13 mm at 25°C, to 0.3 mm at 30°C; mycelium covering the plate after 15–16 days at 25°C. Colony hyaline, thin, circular, smooth, indistinctly zonate; margin becoming wavy; hyphae forming radial threads; primary hyphae wide, distinctly sinuous along their length; surface hyphae degenerating from the centre; greatest part of the mycelium disappearing within 3–4 weeks. Aerial hyphae scant, short, becoming fertile. Autolytic activity and coilings inconspicuous. No pigment, no distinct odour noted. No chlamydospores seen. Conidiation noted after 2–3 days around the plug and at the proximal margin; effuse, verticillium-like; more abundant than on CMD; first macroscopically invisible; spreading across the colony, loosely disposed across entire plate; greenish in the stereomicroscope after 5–6 days, first at the proximal margin. After (7–)9–10 days conidiation becoming visible as a fine, green 29D4–6, 29E6–7, 28DE5–7 powder, consisting of granules or aggregated conidiophores to 0.5 mm diam, arranged in indistinct concentric zones, particularly in distal areas of the colony. Conidiophores after 3–15 days short, first simple, of an unbranched stipe 5–6(–8) μm wide with a terminal whorl of up to 5 phialides bearing minute wet conidial heads 5–15 μm diam; becoming forked or branched close to the base, mostly asymmetrical, forming 3–5 main axes to 300 μm long, bearing 1–2 celled, paired or unpaired side branches. Side branches inclined upwards at upper levels; at lower levels longer, often in right angles and sometimes re-branching, bearing phialides mostly in terminal whorls of 3–5, or singly, on cells (2.0–)2.5–4.5(–5.5) μm wide; whorls often appearing complex due to several paired or unpaired phialides situated directly below the terminal whorl. Main axes and side branches (3–)4–5 μm wide at the base, attenuated upwards to 2–3 μm. Phialides (6–)7–14(–20)×(2.0–)2.3–3.0(–3.3) μm, l/w (2.5–)3.0–5.4(–7.4), (1.5–)1.8–2.4(–2.8) μm wide at the base (n=60); lageniform or subulate, often inaequilateral, widest mostly in or below the middle, longer ones more frequent on lower branches. Conidia (2.7–)3.0–5.3(–8.2)×(2.0–)2.2–2.8(–3.3) μm, l/w (1.1–)1.2–2.0(–3.1) (n=63), subglobose, ellipsoidal, oblong or cylindrical, green in mass, individually subhyaline, smooth, with few small guttules; scar indistinct, sometimes distinct and projecting. At 15°C growth more irregular; conidiation dense, white, partly in fluffy tufts.

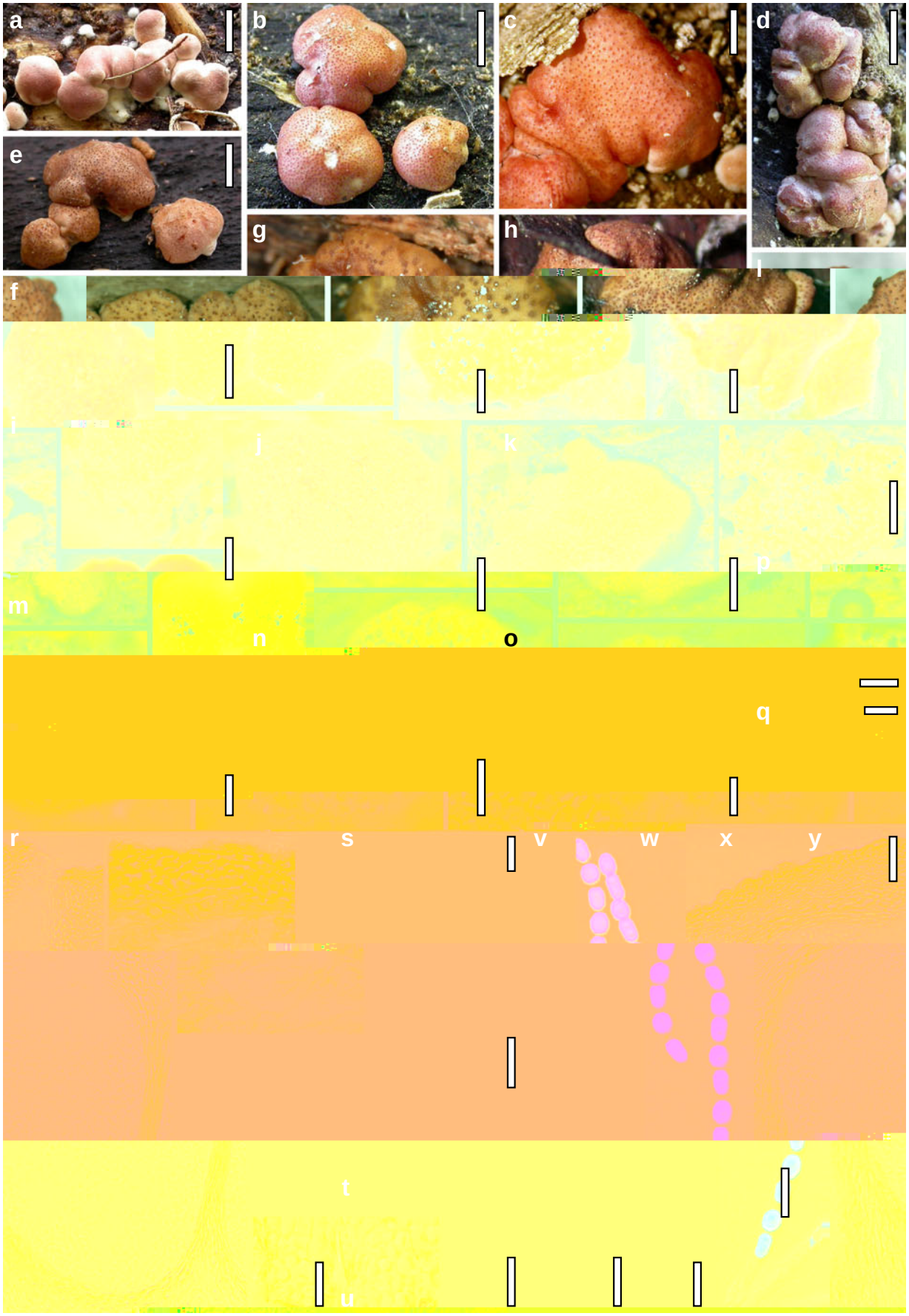
Habitat: on strongly decomposed crumbly wood and bark of deciduous trees.

Distribution: Germany; known only from the type locality.

Holotype: **Germany**, Rheinland-Pfalz, Eifel, Landkreis Daun, Gerolstein, between Büscheich and Salm, 50°10′33″ N, 06°41′50″ E, elev. 560 m, on decorticated, cut branch of *Fagus sylvatica* 15 cm thick, on moist, strongly decomposed wood, soc. *Armillaria* rhizomorphs, *Ascocoryne cylichnium*, effete *Coniochaeta cf. velutina*, *Trametes versicolor*, *Xylaria hypoxylon* anamorph, etc., 20 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2732 (**WU 29236**, culture CBS 120537=C.P.K. 2018). ***Holotype*** of *Trichoderma luteffusum* isolated from WU 29236 and deposited as a dry culture with the holotype of *H. luteffusa* as **WU 29236a**.

Notes: The description of *Hypocrea luteffusa* is based on a single, for the greatest part, overmature specimen. Morphologically, both in teleomorph and anamorph, this species is similar to the species of the *Brevicompactum* clade, *H. auranteffusa*, *H. margaretensis*, and *H. rodmanii*, while the teleomorph has some similarity to *H. citrina*. The peculiar ostioles, the labyrinthine cortex of thick-walled surface cells and the hyphal subperithecial tissue in *H. luteffusa* has not been seen in any of these species. *H. luteffusa* differs from *H. citrina* also by smaller ascospores, warmer yellow colour, growth on wood, smaller phialides and smaller and green conidia. *H. auranteffusa*, *H. margaretensis* and *H. rodmanii* differ from *H. luteffusa* also in brighter stroma colour, larger ascospores, and smaller conidia. The conidiation is morphologically similar to *H. pachypallida*, but the conidia of the latter species do not turn green on SNA or CMD.

Hypocrea minutispora B.S. Lu, Fallah & Samuels, Mycologia 96: 335 (2004) Fig. 41


a
b
c
d
e
g
h
f
i
j
k
l
m
n
o
p
q
r
s
v
w
x
y
t
u

Anamorph: ***Trichoderma minutisporum*** Bissett, Can. J. Bot. 69: 2396 (1991b). Fig. 42

Stromata when fresh 1–7(–11) mm diam, 0.5–2.5(–3) mm thick, pulvinate or semiglobose, sometimes turbinate or discoid, broadly attached, sometimes with white base mycelium. Margin or edges adnate or free, often lobed or undulate, smooth, sterile, lighter than stroma surface or white when young, typically rounded and concealing sides, less commonly sharp with visible sides. Sides sterile, white, smooth. Outline circular, oblong, ellipsoidal or irregular. Surface smooth or slightly wrinkled, finely tubercular due to convex ostioles, sometimes with white or silvery covering layer; rarely perithecia slightly protuberant when old. Ostiolar dots numerous, minute but well-defined, plane or convex, slightly darker than the stroma surface, to reddish-, olive- or dark brown. Stromata starting as a white mycelium, becoming compacted, turning rosy from the centre, 7–8A2, or rosy-brown, brown-orange, light brown, pale red, greyish red to reddish brown, with or without white margin, 7–8A3–5, 7–8B4–6, 7–8CD5–7, 10C3, 9A5, or reddish yellow, 4A6–7, later rosy colour disappearing and margin concolorous, yellow ground colour becoming apparent, resulting colour greyish orange, brown-orange, yellow-brown, brown, 5AC5–7, 5D8, 6B4–5, 6AD6–7, to reddish brown, 7–8CE6–8, 9CD5–7 when old; alternatively yellow to (greyish-) orange, 3A5–6, 4–5A2–5, 5B4, to yellow-brown without previous formation of rosy tones.

Stromata when dry (0.8–)1.8–4.5(–7.5)×(0.5–)1.5–3.5(–5.4) mm, (0.2–)0.5–1.4(–2.5) mm thick (n=140), solitary, gregarious or aggregated in variable numbers, often in lines, sometimes in compound stromata disintegrating into several parts; pulvinate, discoid or undulate, broadly attached; sometimes with white base mycelium. Outline circular, angular or oblong. Margin often lobed, edges or margin adnate or free, rounded or sharp, white when young; fertile part sometimes projecting beyond the sterile sides. Sides smooth, white or concolorous with the surface. Stroma surface first finely velutinous while still lacking ostiolar dots; soon glabrous and smooth or rugose or finely tubercular by papillate ostioles; sometimes with white, finely floccose scurf when young. Ostiolar dots (20–)30–70(–173) µm (n=250) diam, numerous, plane or convex, well-defined, distinct, also appearing annular with light centre, slightly or distinctly darker than the stroma surface, red or brown, nearly black when mature or old. Stroma colour variable, first white, then typically rosy with white to yellowish margin, with or without a white covering layer, or entirely rosy, greyish orange, pale red, greyish red when immature, 5–8A2–3, 7–9BD4–7, 9A4, to reddish brown, 9CE5–8, 10DE4. Reddish pigment persistent or disappearing and yellow to brown colours emerging, stromata becoming yellow-brown, brown-orange, brown, mostly (5–)6–7CD5–8 when mature, to reddish brown or dark brown, 7–8CE4–8, 8F5–8; less commonly yellow to greyish orange 4–6B4, 5A4; sometimes yellow-brown from the start without rosy colours. Spore deposits white.

Mature stromata after rehydration brown with yellow surface and reddish brown dots 47–80(–95) µm diam; white inside; perithecia brown; lower margin white, smooth. After addition of 3% KOH brown, no distinct discoloration but brown to reddish perithecial colour more prominent; ostiolar openings hyaline.

Stroma anatomy: Ostioles (50–)56–80(–105) µm long, plane or projecting to 15 µm, (20–)26–40(–47) µm wide at the apex (n=30), conical or cylindrical, periphysate; no specialized cells apparent. Perithecia (190–)210–270(–320)×(115–)130–200(–240) µm (n=3[illegible]0.0282Tc()2

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD 22–24 mm at 15°C, 46–51 mm at 25°C, 24–36 mm at 30°C after 72 h; mycelium covering the entire plate after 4–5 days at 25°C. Colony hyaline, thin, circular;

[redacted]nct odo[redacted]noted. Chlamydospores noted [redacted] 5[redacted]uncommo[redacted], sometimes becoming abundan[redacted] t[redacted]culation pl[redacted]g. Conidiation noted after 2–[redacted]fter 4–5 day[redacted]; starting at the distal margin[redacted]on surface hy[redacted]ae and aerial hyphae, formin[redacted] concentric [redacted]s of shrubs or granules. [redacted]ced in minu[redacted]t heads. Typically no [redacted]es formed; oc[redacted]lly (4 of 60 isolates) gr[redacted]stules to 2 m[redacted] seen on CMD direc[redacted]pore isolation. [redacted] hyphae wider; eff[redacted]on remaining [redacted]after 14 days). A[redacted]ny zonate, ch[redacted] increased in [redacted]diation green aft[redacted]

[redacted]On PDA 18–20 m[redacted]42 mm at 2[redacted]C, 11–22[redacted]mm at 30°C afte[redacted] coveri[redacted] the plate aft[redacted]5–6 days at 25[redacted]se, [redacted]becoming ha[redacted]floccose by[redacted]dant aerial hyp[redacted]orming a w[redacted] mat and radial stran[redacted] Autolytic ex[redacted]gs inconspicuous. No di[redacted]sing pig-m[redacted]rse yellowish, 2–4A3. Odo[redacted]r incon-s[redacted]nt, rancid. Conidiation no[redacted]ed after 2[redacted] e.g. on solitary phialides [redacted] aerial [redacted]white, not becoming green. [redacted]15°C [redacted] wide, sometimes monilif[redacted]con-[redacted]C colony irregular, flat, w[redacted]s. [redacted]ting. Autolytic excretions[redacted]ish orange, 3A3, 4A4–[redacted]us. Conidiation reduced[redacted] at 15°C, 36–42 mm a[redacted] 22 [redacted]2 h; mycelium coverin[redacted] after 5–[redacted]. Colony hyaline, th[redacted]ose, not zonate; hyphae wide, [redacted]hyphae sca[redacted]nd long at the distal [redacted]lytic a[redacted]uous, coilings moderate. [redacted]pig[redacted]ct odour noted. Chlamydospores[redacted]r 5 d[redacted]uncommon; terminal and intercalary, (5–)6[redacted])×(4–)5–8(–10) μm, l/w (0.9–)1.0–1.5(–2.1) (*n*=27), so[redacted]times to 20 μm long when intercalary, globose, ovoid [redacted] pyriform, also fusoid or rectangular when intercalary. C[redacted]iation noted after 2 days, pale green after 5–6 days; effus[redacted]ple, minute, short, erect conidiophores in lawns, in[redacted]all shrubs to 0.3 mm diam and 0.2 mm high[redacted]in axes, irregularly distributed or in broad[redacted]diffuse concentric zones, more abundant with distance from [redacted] aerial hyphae. Branches of simple [redacted] unpaired, in shrubs tending to be pa[redacted] branches; generally short, 1–3 celled. [redacted] 11 μm wide, simple conidiophores and [redacted] wide at their bases, 2–4 μm terminally. [redacted] solitary or in whorls of 2–3(–5) on cells 3[redacted] Conidia formed in minute wet green heads to [redacted] Shrubs growing to circular or oblong tufts to 1.[redacted]ays, aggregating [redacted]ar, loose, of a stipe [redacted]mary branches 6–9 μm [redacted]al main axes 200–400 μm [redacted]ired side branches emerging in [redacted]and side branches fertile to the tips, [redacted] to 2–4(–5) μm. Side branches often [redacted]lender with short side branches 20–80 μm [redacted]times 1- or 2- fold re-branching, forming dense [redacted]es. Phialides divergent in whorls of 2–5(–6) on cells [redacted].5–)2.0–3.5 μm wide and often thickened their apices. Conidia formed in minute wet heads to 20 μm diam. Phialides (4–)6–10(–17)×(2.7–)3.2–4.0(–4.8) μm, l/w (1.2–)1.5–2.8(–4.3), (1.3–)1.7–2.5(–3.3) μm wide at the base (*n*=63), lageniform, long and in effuse conidiation, ampulliform and short in tufts or pustules, widest mostly below the middle, often inaequilateral and curved, with abruptly narrowed, thin, cylindrical neck. Terminal phialides in extension of the conidiophore axis often long, slender, nearly subulate. Conidia (2.8–)3.3–4.0(–5.0)×(2.5–)2.7–3.2(–3.8) μm, l/w (1.1–)1.2–1.4(–1.7) (*n*=63), green, ellipsoidal, less commonly subglobose, smooth, with minute guttules in varying numbers; scar indistinct. At 30°C colony irregular, conidiation effuse, greenish.

Habitat: on hard, little degraded or medium-decayed wood and bark of deciduous trees, mostly *Fagus sylvatica*, and fungi growing on it, less commonly on wood and bark of coniferous trees.

Distribution: the commonest hyaline-spored *Hypocrea* [redacted]ecies in the temperate zones of Europe and North [redacted]erica.

[redacted]*olotype*: **USA**, North Carolina, Macon County, Ammo[redacted] Branch Campground, off Bull Pen road, elev. 3000 ft.[redacted] Y Rossm[redacted] G.J.S. 90-[redacted]

Specime[redacted] burg, Bad Sa[redacted] 31″ N, 16°21[redacted] *petraea* 3 cm [redacted]nomycetes, immature, 13 Ju[redacted]ayr & W. Jaklitsch, W.J. 2525. Kärnten, K[redacted]agenfurt Land, St. Margareten im Rose-nta[redacted]f, above Umwiese, MTB 9452/4, 46°31′ [redacted] E, elev. 870 m, on partly decorticated branches of *Fagus* [redacted] soc. *Melanon*[redacted]ph, 21 Oc[redacted]

J. 2606, 2609 (WU 29259, cultures C.P.K. 1951, 1952); same village, Wograda, near Fechterkreuz, MTB 9452/3, 46°32′41″ N, 14°24′59″ E, elev. 560 m, on branch of *Fagus sylvatica* 4–5 cm thick, on wood, soc. *Laxitextum bicolor* with *Capronia porothelia*, holomorph, 22 Oct. 2003, W. Jaklitsch, W.J. 2484 (WU 29251, culture C.P.K. 995); same area, MTB 9452/3, 46°32′36″ N, 14°24′50″ E, elev. 540 m, on partly decorticated branches of *Fagus sylvatica* 7–10 cm thick, on wood, soc. hyphomycetes, holomorph, 25 Oct. 2004, W. Jaklitsch, W.J. 2781 (WU 29272, culture C.P.K. 1968). Spittal/Drau, Mallnitz, Stappitz, along hiking trail 518 close to Gasthof Alpenrose, MTB 8945/3, 47°01′06″ N, 13°11′14″ E, elev. 1340 m, on decorticated branch of *Alnus incana* 9 cm thick, on wood, soc. Corticiaceae, holomorph, 5 Sep. 2003, W. Jaklitsch, W.J. 2381 (WU 29241, culture C.P.K. 950). Völkermarkt, Globasnitz, Altendorf, on roadside heading to Sagerberg, MTB 9453/4, 46°32′52″ N, 14°38′45″ E, elev. 570 m, on decorticated branch of *Fagus sylvatica* 8 cm thick, on wood, soc. *Hypocrea lixii*, *Nemania* sp., Corticiaceae; holomorph, teleomorph mostly immature, 17 Aug. 2004, W. Jaklitsch, W.J. 2599 (WU 29258, culture C.P.K. 1950). Niederösterreich, Hollabrunn, Hardegg, Semmelfeld, between Niederfladnitz and Merkersdorf, MTB 7161/3, 48°48′49″ N, 15°52′43″ E, elev. 450 m, on branch of *Fagus sylvatica* 3 cm thick, on/soc. effete *Hypoxylon fragiforme*, immature, 21 Jul. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2530. Krems Land, Krumau, virgin forest at the dam of the Dobra reservoir, MTB 7458/1, 48°35′18″ N, 15°23′56″ E, elev. 490 m, on decorticated branch of *Fagus sylvatica* 2.5 cm thick, on wood, soc. Corticiaceae, holomorph, 28 Sep. 2003, W. Jaklitsch, W.J. 2432 (WU 29245, culture C.P.K. 979). Rastenfeld, Mottingeramt, MTB 7458/1, 48°33′55″ N, 15°24′36″ E, elev. 600 m, on branch of *Fagus sylvatica*, on wood, 31 Aug. 2008, W. Jaklitsch & O. Sükösd, W.J. 3204 (WU 29278). Lilienfeld, Sankt Aegyd am Neuwalde, Lahnsattel, virgin forest Neuwald, MTB 8259/1, 47°46′24″ N, 15°31′20″ E and 47°46′21″ N, 15°31′16″ E, elev. 950 m, on partly decorticated branches of *Fagus sylvatica* 4–10 cm thick, on wood, emergent through bark, soc. *Bisporella citrina*, white corticiaceous fungus, 16 Oct. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2464+2467 (WU 29248, cultures C.P.K. 2400, 2402); same area, elev. 1000 m, on branch of *Fagus sylvatica*, on hard wood, 25 Sep. 2007, H. Voglmayr, W.J. 3171 (WU 29277, culture C.P.K. 3156). Melk, Sankt Leonhard am Forst, 400 m after Großweichselbach heading to Melk, MTB 7857/2, 48°10′39″ N, 15°17′48″ E, elev. 380 m, on decorticated branch of *Fagus sylvatica* 3 cm thick, on wood, holomorph, 30 Sep. 2004, W. Jaklitsch, W.J. 2750 (WU 29269, culture C.P.K. 1964). Yspertal, Altenmarkt, MTB 7756/1, 48°15′43″ N, 15°03′21″ E, elev. 460 m, on decorticated branches of *Fagus sylvatica* 2–8 cm thick, on wood, soc. Corticiaceae, effete pyrenomycetes, myxomycete, holomorph, 25 Jul. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2541 (WU 29252, culture C.P.K. 1944). Scheibbs, Lunz am See, forest path from Schloß Seehof in the direction Mittersee, MTB 8156/3, 47°50′44″ N, 15°04′30″ E and 47°50′39″ N, 15°04′24″ E, elev. 620 m, on branches of *Fagus sylvatica* 2–3 cm thick, on wood, soc. effuse *Hypoxylon* sp., *Diatrypella verruciformis*, *Quaternaria quaternata*, 16 Oct. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2457+2462 (WU 29247, culture C.P.K. 2399). Wien-Umgebung, Mauerbach, Friedhofstraße, MTB 7763/1, 48°15′14″ N, 16°10′15″ E, elev. 320 m, on branch of *Carpinus betulus* 7–8 cm thick, on wood and bark, soc. *Armillaria* rhizomorphs, holomorph, 9 Jul. 2003, W. Jaklitsch, W.J. 2278 (WU 29238, culture C.P.K. 940). Tulbinger Kogel, NE Passauerhof, on the hiking trail to Mödihütte, MTB 7762/2, 48°16′08″ N, 16°08′31″ E, elev. 400 m, on branch of *Fraxinus excelsior* 5 cm thick, on wood and bark, soc. Corticiaceae, light rhizomorphs, effete *Hypoxylon* sp. on bark, *Cryptosphaeria eunomia* in bark, holomorph, 11 Oct. 2003, H. Voglmayr, W.J. 2456 (WU 29246, culture C.P.K. 988). Pressbaum, Rekawinkel, forest path south from the train station, MTB 7862/1, 48°10′40″ N, 16°01′55″ E to 48°10′46″ N, 16°02′03″ E, elev. 360–390 m, on decorticated branches of *Fagus sylvatica* 2–8 cm thick, on wood and bark, soc. effete *Annulohypoxylon cohaerens*, *Armillaria* rhizomorphs, *Phlebiella vaga*, holomorph, 18 Oct. 2003 and 26 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2468, 2471, 2472, 2741 (combined as WU 29249, cultures C.P.K. 1963, 2403, 2405, 2406). Zwettl, Altmelon, Kleinpertenschlag, at the wayside shrine Zum Eisernen Bild, MTB 7555/4, 48°24′49″ N, 14°57′00″ E, elev. 850 m, on partly decorticated branches of *Fagus sylvatica* and *Picea abies*, 3–9 cm thick, on wood and bark, soc. *Laxitextum bicolor*/*Capronia porothelia*, *Annulohypoxylon cohaerens*, *Hypoxylon fragiforme*, *Pycnoporus cinnabarinus*, *Neobulgaria pura*, *Quaternaria quaternata*, *Trametes versicolor*, *Polyporus brumalis*, holomorph, 5 Oct. 2004, W. Jaklitsch (W.J. 2765, WU 29271, culture C.P.K. 1967). Oberösterreich, Grieskirchen, Natternbach, at Gaisbuchen, MTB 7548/3, 48°24′39″ N, 13°41′40″ E, elev. 580 m, on partly decorticated branch of *Fagus sylvatica*, on wood, on/soc. *Bertia moriformis*, 1 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2552 (WU 29253, culture C.P.K. 1945). Vöcklabruck, Nußdorf am Attersee, small wood at Aicher-eben, MTB 8147/3, 47°50′45″ N, 13°30′13″ E, elev. 710 m, on corticated branch of *Fagus sylvatica* 6–7 cm thick, on bark and in bark fissures, soc. *Hypoxylon fragiforme*, *Quaternaria quaternata*, holomorph, teleomorph mostly immature, 8 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2589 (WU 29257, culture C.P.K. 1949). Steiermark, Leoben, Gesäuse, Hieflau, Hartelsgraben, MTB 8454/1, 47°35′29″ N, 14°42′24″ E, elev. 520 m, on branches of

Fagus sylvatica 10 cm thick, on wood and a phlebioid corticiaceous fungus, soc. *Hypocrea sinuosa*, effete pyrenomycete; holomorph, 7 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2315 (WU 29239, culture C.P.K. 2386). Weiz, Laßnitzthal, opposite to the Arboretum Gundl, MTB 8959/2, 47°04′17″ N, 15°38′38″ E, elev. 420 m, on branch of *Fagus sylvatica* 5 cm thick, on hard wood, holomorph, 8 Aug. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2323 (WU 29240, culture C.P.K. 2387).Vorarlberg, Bludenz, Nenzing, Rabenstein, at Beschling, MTB 8824/1, 47°11′20″ N, 09° 40′34″ E, elev. 660 m, on corticated branch of *Fagus sylvatica* 8 cm thick, on bark, soc. Corticiaceae, effete pyrenomycete, 29 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2632 (WU 29260, culture C.P.K. 1953). Feldkirch, Rankweil, behind the hospital LKH Valduna, MTB 8723/2, 47°15′40″ N, 09°39′00″ E, elev. 510 m, on mostly decorticated branches of *Fagus sylvatica* 4–6 cm thick, on wood, 31 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2641 (WU 29261, culture C.P.K. 1954). **Czech Republic**, Bohemian Switzerland, Mezní Louka, Kozí Hrbet/Ponova Louka, MTB 5151/2, 50°53′05″ N, 14°19′27″ E and 50°53′ 06″ N, 14°19′37″ E, elev. 350 m, on decorticated branches of *Fagus sylvatica*, 4–7 cm thick, on wood, soc. Corticiaceae with rhizoids, holomorph, 19 Sep. 2003, W. Jaklitsch, W.J. 2400, 2401 (WU 29242, cultures C.P.K. 963, 964). Southern Bohemia, Záhvozdí, Černý les, MTB 7149/4, 48° 50′43″ N, 13°58′34″ E to 48°50′38″ N, 13°58′41″ E, elev. 850 m, 6 specimens on corticated and decorticated branches of *Fagus sylvatica* 2–6 cm thick, on wood and bark, on and soc. *Inonotus hastifer*, soc. *Annulohypoxylon cohaerens*, *Chaetosphaeria pygmaea*/*myriocarpa*, *Diatrype disciformis*, *Nemania serpens*, *Orbilia delicatula*, *Phanerochaete* sp. with *Helminthosphaeria cf. odontiae*, *Quaternaria quaternata*, holomorph, 24 Sep. 2003, W. Jaklitsch, W.J. 2414–2420 (combined as WU 29243, cultures C.P.K. 969–973). Záton, Boubínský prales (NSG), MTB 7048/2, 48°58′ 03″ N, 13°49′24″ E and 48°58′30″ N, 13°49′15″ E, elev. 900–1000 m, on mostly decorticated branches of *Fagus sylvatica* 2–11 cm thick, on wood and bark, soc. pyrenomycetes, Corticiaceae, *Bisporella citrina*, *Oligoporus subcaesius*, holomorph, 4 Oct. 2004, W. Jaklitsch, W.J. 2759+ 2760 (WU 29270, culture C.P.K. 1965, 1966). Žofín, Žofínský prales (NSG), MTB 7354/1, 48°40′13″ N, 14° 42′28″ E to 48°40′07″ N, 14°42′22″ E, elev. 820 m, on branches of *Fagus sylvatica* 2–7 cm thick, on wood, in bark fissures, soc. white mould, holomorph, 26 Sep. 2003, W. Jaklitsch, W.J. 2429–2431 (WU 29244, cultures C.P.K. 978, 2392, 2393). **Denmark**, Soenderjylland, Roedekro, Rise Skov, between Roedekro and Aabenraa, 55°03′34″ N, 09°22′01″ E, elev. 70 m, on partly decorticated branch of *Fagus sylvatica* 15–20 cm thick, on wood and bark and stromata of *Hypoxylon fragiforme*, soc. *Calocera cornea*, 23 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2937 (WU 29274, culture C.P.K. 2443). **Estonia**, Harjumaa Co., Põhja-Kõrvemaa landscape reserve, on wood, 28 Oct. 2007, K. Põldmaa K.P. 375. **France**, Lorraine, Vosges, Col de la Schlucht, Route des Crêtes, Gazon du Faing, Forêt des Hospices de Nancy, 48°07′24″ N, 07°04′11″ E, elev. 1000 m, on decorticated branch of *Fagus sylvatica* 8 cm thick, on black wood, soc. *Phlebia* sp., effete pyrenomycetes, 4 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2675 (WU 29263, culture C.P.K. 1956). Moselle, Lorraine, Pont a Mousson, close to the motorway Nancy/Metz, 48°55′26″ N, 06°05′55″ E, elev. 200 m, on decorticated branch of *Fagus sylvatica* 5–7 cm thick, along the whole branch, soc. *Hypocrea lixii*, holomorph, 5 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2682 (WU 29264, culture C.P.K. 1957). **Germany**, Baden Württemberg, Freiburg, Landkreis Breisgau-Hochschwarzwald, St. Märgen, parking area Holzschlag, MTB 8014/2, 47°59′53″ N, 08°05′03″ E, elev. 620 m, on partly decorticated cut log of *Abies alba* 18–22 cm thick, on wood and bark, soc. *Armillaria* rhizomorphs, *Trichaptum abietinum*, *Exidiopsis* sp., 2 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2667 (WU 29262, culture C.P.K. 1955). Tübingen-Pfrondorf, Tiefenbach, Einsiedlerweg, on branch of *Fagus sylvatica*, on wood, 20 Oct. 2002, W. Jaklitsch & H.O. Baral, W.J. 2006. Bavaria, Oberbayern, Altmühltal, Eichstätt, 2–3 km after Pfahldorf heading to Eichstätt, MTB 7033/4, 48°57′00″ N, 11°18′20″ E, elev. 540 m, on decorticated branch of *Fagus sylvatica* 4 cm thick, on wood, soc. Corticiaceae, holomorph, 5 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2574 (WU 29255, culture C.P.K. 1947). Habach, Thomamühle, south of the road B472, elev. 640 m, MTB 8233/4/23, on branch of *Picea abies*, on bark, 23 Dec. 2008, P. Karasch, WU 29528. Starnberg, Tutzing, Pähl, Pähler Schlucht, MTB 8033/3, 47°54′38″ N, 11°11′50″ E, elev. 650 m, on decorticated branch of *Fagus sylvatica* 10 cm thick, soc. effete *Eutypa lata*, 7 Aug. 2004, H. Voglmayr, W. Jaklitsch & P. Karasch, W.J. 2586 (WU 29256, culture C.P.K. 1948). Unterfranken, Landkreis Haßberge, Haßfurt, close to Mariaburghausen, left roadside heading from Knetzgau to Haßfurt, MTB 5929/3, 50°00′33″ N, 10°31′10″ E, elev. 270 m, on mostly corticated branches of *Tilia cordata* 5–6 cm thick, on wood and bark, soc. *Hypocrea strictipilosa*, Corticiaceae, 04 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2561+2562 (WU 29254, culture C.P.K. 1946). Nordrhein-Westfalen, Herne, Böwinghauser Bachtal, MTB 4409/4, elev. 80 m, on decorticated branch of *Fraxinus excelsior* 15 cm thick, on wood, holomorph, teleomorph immature, 3 Jun. 2007, K. Siepe & F. Kasparek (WU 29276, culture from conidia, C.P. K. 3125). Rheinland-Pfalz, Eifel, Daun, Weinfelder Maar, 50°10′44″ N, 06°51′07‴ E, elev. 480 m, on partly decorticated branch of *Alnus glutinosa* 6 cm thick, on wood, soc. *Hypoxylon rubiginosum*, *Peniophora cinerea*, Corticiaceae, holomorph, 21 Sep. 2004, H. Voglmayr & W.

Jaklitsch, W.J. 2737 (WU 29268, culture C.P.K. 1962). Gerolstein, between Büscheich and Salm, 50°10′33″ N, 06° 41′50″ E, elev. 560 m, on partly decorticated branches of *Fagus sylvatica* 7–8 cm thick, on dark wood, soc. ? *Cylindrobasidium evolvens*, 20 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2733 (WU 29267, culture C.P.K. 1961). **Spain**, Canarias, La Palma, San Isidro, elev. 700 m, on decorticated branch of *Chamaecytisus proliferus*, on wood, holomorph, 13 Jan. 2005, P. Karasch, W.J. 2795 (WU 29273, culture C.P.K. 2022). **Sweden**, Uppsala Län, Sunnersta, forest opposite the virgin forest Vardsätra Naturpark across the road, MTB 3871/2, 59°47′24″ N, 17°37′51″ E, elev. 15 m, on branch of *Salix caprea* 8 cm thick, on wood, 8 Oct. 2003, W. Jaklitsch, W.J. 2454, culture C.P.K. 986. **United Kingdom**, Buckinghamshire, Chorleywood, Carpenters' Wood, on branch of *Fagus sylvatica*, on wood, soc. hyphomycetes, pyrenomycetes, algae, 4 Mar. 2007, K. Robinson, comm. P. Wilberforce, W. J. 3084 (WU 29275, culture C.P.K. 2869). Slough, Burnham Beeches, 51°33′07″ N, 00°37′50″ W, elev. 30 m, on decorticated branches of *Fagus sylvatica* 5–11 cm thick, on wood, 15 Sep. 2004, W. Jaklitsch, W.J. 2717 (WU 29266, culture C.P.K. 1960). Derbyshire, Baslow, Stand Wood Walks behind Chatsworths House, 53°13′47″ N, 01° 36′20″ W, elev. 200 m, on thick cut corticated log segment of *Fagus sylvatica* 35 cm thick, on wood, 10 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2698, culture C.P.K. 1958. Norfolk, Thetford, Emilys Wood, near Brandon, MTB 35-31/2, 52°28′08″ N, 00°38′20″ E, elev. 20 m, on partly decorticated branch of *Fagus sylvatica* 4 cm thick, on wood, soc. *Hypocrea neorufoides*, *cf. Letendraea helminthicola*, attacked by white mould, 13 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2712 (WU 29265, culture C.P.K. 1959).

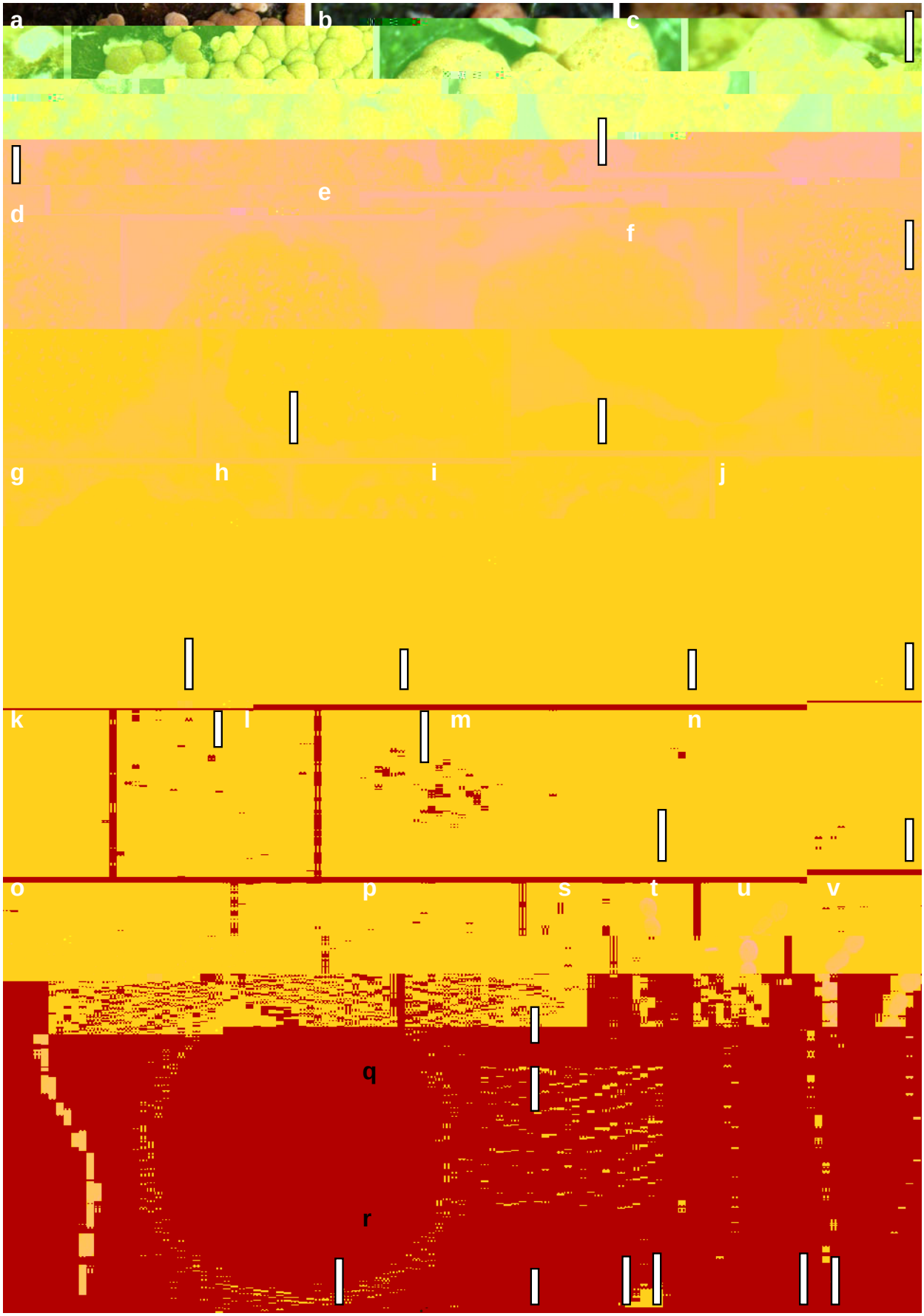
Notes: This common species is usually identified as the uncommon *Hypocrea rufa* by amateur mycologists, but it is unrelated to that species, which differs in a hairy stroma surface, inconspicuous ostiolar dots, smaller stromata, larger ascospores, globose verrucose conidia, slender trichoderma-like conidiophores on well-defined pustules, etc. *Hypocrea rufa* is often found on wood of coniferous trees, while *H. minutispora* is rarely encountered on such hosts. *Hypocrea minutispora* does not have particularly small ascospores; the species epithet is taken from the anamorph *T. minutisporum* (see Lu et al. 2004), originally described by Bissett (1991b). The conidiation in *Trichoderma minutisporum* shows a gradual transition from effuse to pustulate, with pustules typically distinctly less developed on CMD than on SNA. Generally, phialides tend to be more lageniform on simple conidiophores, wider and more ampulliform with increasing complexity and density of conidiation structures. Branching of conidiophores is asymmetric in simple conidiophores and symmetric in tufts or pustules.

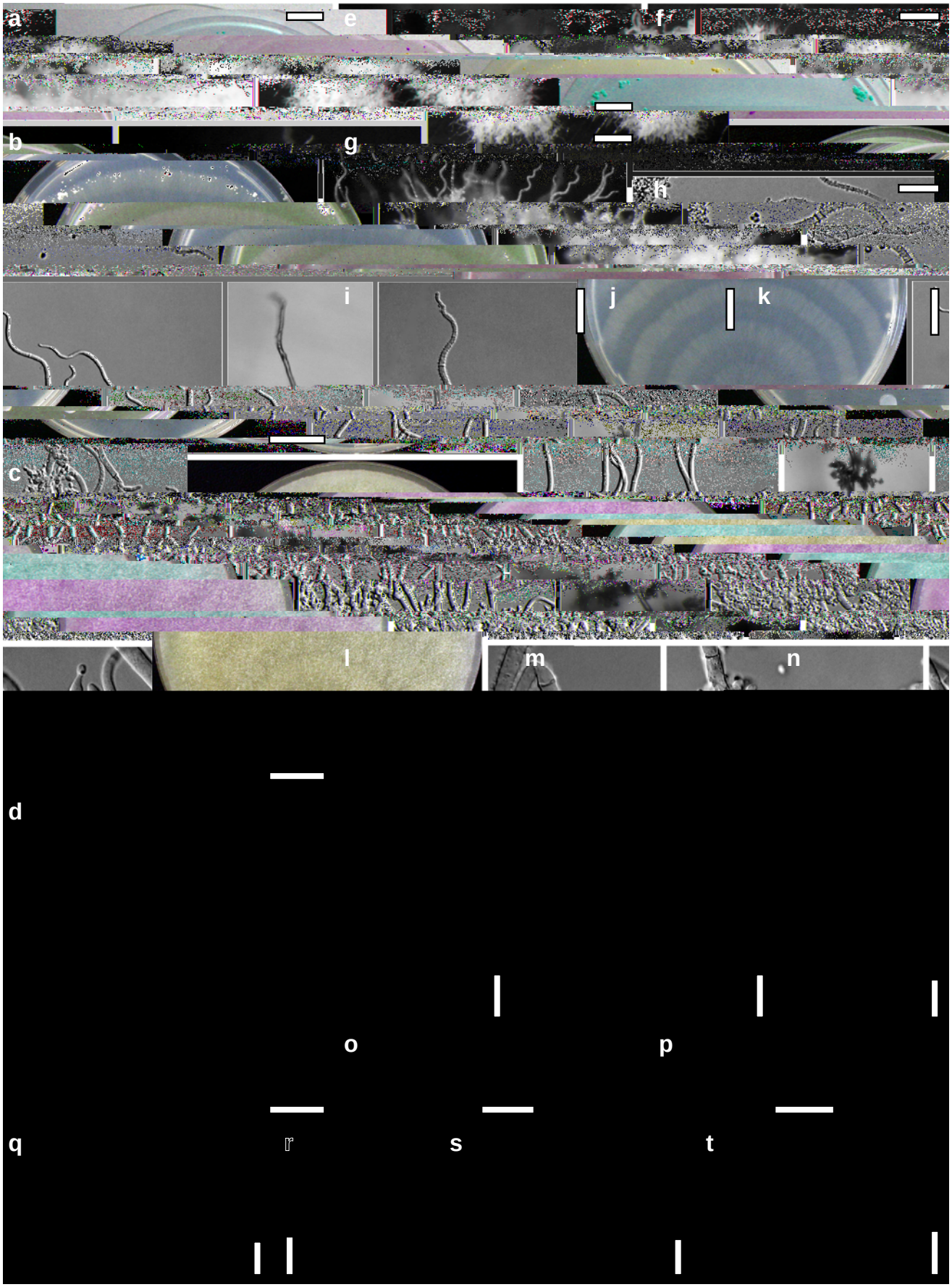
Hypocrea pachybasioides Yoshim. Doi, Bull. Natn. Sci. Mus. Tokyo 12: 685 (1972). Fig. 43
Anamorph: ***Trichoderma polysporum*** (Link : Fr.) Rifai, Mycol. Pap. 116: 18 (1969). Fig. 44
= [*Sporotrichum polysporum* Link, Mag. Ges. Naturf. Freunde Berl. 7: 34 (1815): Fries, Syst. Mycol. 3: 424 (1832)]. (See Rifai [1969] for further synonyms).

Stromata when fresh (0.5–)1–6 mm diam, 0.5–1.5(–2) mm thick, solitary, scattered, gregarious or aggregated, typically in small numbers, sometimes in lines or large convolutes; pulvinate to semiglobose, broadly attached, sometimes on a sterile base; margin rounded or sharp; edge free. Outline circular, sometimes angular or with undulate margin. Surface smooth, perithecial contours rarely slightly projecting. Ostiolar dots typically large and diffuse when young, when mature well-defined, plane or convex, brownish, often irregularly disposed. Stromata first white, remaining nearly white or yellowish, turning either rosy, pale yellow, 3A2–3, 3AB4–6, 4A5, pale orange 5AB4–5(–6), 6A3–4, to brown-orange or yellow- brown, 5–6CD5–6, rosy-brown or light brown, 7CD6–7(8), eventually dark reddish brown. Spore deposits white to yellowish,

Stromata when dry (0.5–)1–3(–5)×(0.3–)0.8–2.3(–3.8) mm, (0.2–)0.3–1.0(–1.6) mm thick (n=97); solitary, scattered, gregarious or aggregated in small numbers, less commonly formed by disintegration of a flat subeffuse compound stroma to 3 cm long; pulvinate to discoid, flatter than fresh, broadly attached, with white base mycelium and/or white margin when young. Margin attached or free, rounded, sometimes lobed. Outline circular, angular, oblong or irregular. Sides when visible, vertical or slightly constricted downwards, concolorous, smooth and glabrous, floccose when young. Surface finely floccose or downy in initial stages, later typically glabrous, smooth, tubercular or rugose. Ostiolar dots (24–)35–76(–134) μm (n=175), in small or large numbers, well-defined, plane or convex, circular to oblong in outline, brown, red or reddish brown, large and diffuse due to translucent perithecia when young. Stromata first white, turning either yellow or rosy or more rarely directly brownish. Yellow stromata 2–3A2–3, 4A3, 4B4, turning pale or greyish orange, 5A3,

Fig. 43 Teleomorph of *Hypocrea pachybasioides*. **a–f**. Fresh stromata (**a–d**. immature). **g–j**. Dry stromata (**g**. downy stroma initial). **k**. Ostiole apex in section. **l**. Stroma surface in face view. **m**. Rehydrated stroma (black dots are *Cheirospora* conidia). **n**. Stroma in 3% KOH after rehydration. **o**. Perithecium in section. **p**. Cortical and subcortical tissue in section. **q.** Subperithecial tissue in section. **r**. Stroma base in section. **s–v**. Asci with ascospores (**u, v**. in cotton blue/lactic acid). **a**. WU 29324. **b, e**. WU 29322. **c**, **k–r**. WU 29325. **d**. WU 29311. **f**. WU 29321. **g**. WU 29312. **h**. WU 29319. **i**. WU 29314. **j**. WU 29315. **s**. WU 29318. **t–v.** WU 29323. *Scale bars* **a**=1 mm. **b, c, f, g**, **m**= 0.4 mm. **d, h–j**, **n**=0.3 mm. **e**=0.7 mm. **k, l**, **r–v**=10 μm. **o**=25 μm. **p**, **q**=15 μm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
s
t
u
v
q
r


a
e
f
b
g
h
i
j
k
c
l
m
n
d
o
p
q
r
s
t

◀ **Fig. 44** Cultures and anamorph of *Hypocrea pachybasioides* (= *Trichoderma polysporum*). **a**. Yellow conidiation pustules on CMD (28 days). **b–d**. Cultures after 14 days (**b**. on CMD; **c**. on PDA; **d**. on SNA). **e**. Periphery of a conidiation tuft on the natural substrate. **f, g**. Conidiation pustules on SNA (**g.** showing elongations on pustule margin; 13 days). **h, i.** Elongations (SNA, **h**. verrucose, 8 days at 25°C plus 25 days at 15°C; **i**. 9 days). **j**. Conidiophore on growth plate (SNA, 7 days). **k–n**. Conidiophores (SNA, 9 days; **n.** lacking elongation). **o, p**. Chlamydospores (SNA, 30°C, 11 days). **q, r**. Phialides (SNA, 9 days). **s, t**. Conidia (SNA, 8 days at 25°C plus 25 days at 15°C). **a–r**. All at 25°C except **h, o, p. a–d, h, j, o, p, s, t**. CBS 121277. **e**. WU 29321**. i, k–n, q, r**. C.P.K. 2461. **f, g.** C.P.K. 989. *Scale bars* **a**=10 mm. **b–d**= 15 mm. **e**, **g**=100 μm. **f**=0.3 mm. **h**, **k**=30 μm. **i**, **j**=40 μm. **l, n, p**, **r**= 10 μm. **m**, **o**=15 μm. **q**, **s**=5 μm. **t**=3 μm

6AB4–6, brown-orange, ochre, light brown or yellow-brown, 6–7CD5–8, 6E7–8; eventually dark brown, 7–8EF6–8. Rosy or greyish red stromata 7A4, 6–7B4–5, sometimes first with a white covering, turning brown-red to greyish brown, 8CD4–6, eventually dark (reddish-)brown, 8EF5–8, with nearly black ostiolar dots. Spore deposits white or pale yellow. Mature yellow stromata after rehydration thicker, more pulvinate, surface smooth, light yellow to nearly white between large, yellow-brown ostiolar dots (50–)90–170 μm diam; after addition of 3% KOH colour change absent or inconspicuous, perithecial dots slightly more ochre to nearly orange.

Stroma anatomy (yellow mature stroma sectioned): Ostioles (47–)59–74(–90) μm long, plane or projecting to 30 μm, (22–)26–34(–41) μm wide at the apex (n=30) inside, periphysate, apical marginal cells cylindrical, sometimes clavate, to 5 μm wide. Perithecia (130–)160–205(–235)×(85–)120–180(–220) μm (n=30), globose or flask-shaped, crowded, 6–7 per mm stroma length; peridium (11–)14–18(–20) μm (n=30) thick at the base, (5–)10–15(–17) μm (n=30) thick at the sides, pale yellow, in 3% KOH pale orange. Stroma surface smooth, without hairs. Cortical layer (17–)20–30(–37) μm (n=30) thick, a dense *t. angularis* of isodiametric, thin-walled cells (3–)4–9(–12)× (2.5–)3–6(–7) μm (n=65) in face view and in vertical section, pale yellow. Subcortical tissue where present a loose *t. intricata* of thin-walled hyaline hyphae (2.0–)2.5–4.0(–5.5) μm (n=35) wide. Subperithecial tissue a *t. angularis-epidermoidea* of thin-walled hyaline cells (5–)6–18(–31)×(3.5–)5–9(–12) μm (n=30), smaller towards the base and intermingled with hyaline hyphae (2–)3–5(–7) μm (n=30) wide in attachment areas, otherwise base consisting of cortical tissue. Asci (65–)82–100(–115)× (4–)5–6(–7.5) μm, stipe to 20(–35) μm long (n=70); croziers present. Ascospores hyaline, verruculose; cells dimorphic; distal cell (3.0–)3.7–4.8(–5.7)×(2.5–)3.5–4.0(–4.5), l/w 1.0–1.3(–1.6) (n=160), (sub)globose or ellipsoidal; proximal cell (3.0–)4.3–5.8(–7.0)×(2.3–)2.8–3.5(–4.0) μm, l/w (1.2–)1.3–1.9(–2.6) (n=160), oblong, ellipsoidal, wedge-shaped, or subglobose, to 10 μm long in aberrant ascospores; contact area often flattened.

Anamorph on natural substrates in accordance with the anamorph in culture, typically appearing as discrete white tufts 0.5–5 mm long in close association with stromata, less commonly as effuse mats; with sterile, helical elongations projecting.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 19–21 mm at 15°C, 32–34 mm at 25°C, 9–21 mm at 30°C; mycelium covering the plate after 6–7 days at 25°C. Colony hyaline, thin, distinctly zonate, zones of similar width, alternating light and dark; primary hyphae conspicuously wide, tertiary/terminal hyphae thin and short. Aerial hyphae inconspicuous, more frequent along the margin. Autolytic activity and coilings lacking or inconspicuous. No diffusing pigment, no distinct odour noted. Rarely (CBS 119319) yellow crystals appearing in the agar. Chlamydospores noted after 2–3 weeks. Conidiation visible after 4–5 days, first effuse, scant, simple, only in distal areas and at the ends of lighter zones, as early stages of pustulate conidiation. After 7 days conidiation in the most distal zones in white pustules 0.5–1.7 mm diam, confluent to 5 mm (after 10 days), with sterile, smooth to rough helical elongations from the beginning. Pustules sometimes turning yellow 4A4–5 after 20–28 days, to saffron or dark orange 5A6–8 after 6 months at 15°C without light. At 15°C development slower, colony circular, zonation absent or inconspicuous, hyphae >10 μm wide, conidiation late, after 9–10 days, scant. Conidiation often absent after several transfers. At 30°C colony circular, zonate, darker zones narrower, autolytic activity increased, no conidiation noted.

On PDA after 72 h 15–17 mm at 15°C, 31–34 mm at 25°C, 9–16 mm at 30°C; mycelium covering the plate after 6 days at 25°C. Colony denser than on CMD, indistinctly zonate, hyphae becoming moniliform, mycelium conspicuously dense, surface hyphae forming radial strands. Aerial hyphae numerous, long, dense, forming strands or irregular aggregates in a white to yellowish, downy, farinose to granular mat. Autolytic activity variable, coilings lacking or inconspicuous. No diffusing pigment, no distinct odour noted. Conidiation noted after (6–)10–14 days, white, effuse and in fluffy tufts. At 15°C hyphae conspicuously wide; conidiation more abundant and earlier (after 6–8 days) than at 25°C, on small shrubs and long aerial hyphae, chalky, dense, granular. At 30°C reverse yellow 3A4–5 after 7 days, surface thickly downy, white to yellowish; odour mushroomy; conidiation lacking or scant at the proximal margin.

On SNA after 72 h 17–19 mm at 15°C, 37–30 mm at 25°C, 3–10 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony hyaline, thin, loose, with little mycelium on the agar surface, not or indistinctly zonate, becoming zonate by conidiation in white tufts after 5–6 days; margin downy by long aerial hyphae; hyphae degenerating/dissolving soon.

Autolytic activity and coilings lacking or inconspicuous. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 6 days, (4–)5–7(–8)×(3–)4–6(–7) µm, l/w 1.0–1.4 (–1.8) (*n*=21), globose to oval when terminal, when intercalary 5–32×(4–)5–7(–8) µm, l/w 1.0–6.5 (*n*=32), globose, fusoid, oblong, cylindrical, 1–4 celled, smooth. Conidiation noted after 4–5 days, in white tufts or pustules visible after 5–6 days in distal and lateral areas of the colony or irregularly disposed, dry. Tufts or pustules 1–2.5 mm diam, aggregating and confluent to convolutes 4–12×3–6 mm, convex, thickly pulvinate, chalky, dense. Pustules of a reticulum with branching points often thickened to 8–9 µm and numerous main axes (= conidiophores) apically tapering off into helical elongations or less commonly fertile to the tip, in the latter case 4–5 µm wide, tapered to 2.5 µm apically, with phialides in whorls to 5. Side branches on several levels at the base of the elongations mostly paired and in right angles, short, 10–40(–50) µm long, (3–)5–7.5 µm wide, of 1–3 cells 1–5 µm long, often rebranching into short 1–2 celled branches, with phialides solitary or in dense whorls to *ca* 6. Side branches on lower levels longer and often unpaired, in right angles or slightly inclined upwards. Elongations formed from the beginning, conspicuous, 50–200(–330) µm long from last branching, gradually attenuated upwards to 1.5–3 µm terminally, unbranched, helical, often distinctly warted, sterile, rarely fertile with 1–2 phialides terminally. Phialides (3.5–)4.5–6.7(–10)×(2.7–)3.2–3.8(–4.2) µm, l/w (1.0–)1.3–1.9(–2.7, (1.5–)2.0–3.0(–3.8) µm wide at the base (*n*=60), ampulliform, tending to be lageniform on elongations and conidiophores lacking elongations, straight or inaequilateral, short or often long and thin. Conidia (2.5–)3.0–3.7(–5.0)×(2.0–)2.3–2.6(–3.0) µm, l/w (1.1–)1.2–1.5(–1.9) (*n*=63), hyaline, ellipsoidal, less commonly oblong, smooth, scarcely with minute guttules, scar indistinct. At 15°C similar to CMD, not zonate; conidiation in thick white pustules to 2 mm diam, growing or confluent to 7 mm after 2 weeks. At 30°C colony not zonate, chlamydospores more abundant.

Habitat: on wood and bark of deciduous and coniferous trees, overgrowing fungi. ,tal

Distribution: Australia, Europe, Japan, Korea, New Zealand, North America, according to Lu et al. (2004).

Holotype: **Japan**, Otsuno, Kochi City, on bark, 3 May 1966, Y. Doi TNS.D-77 (TNS-F-190528, not examined).

Specimens examined: **Austria**, Kärnten, Völkermarkt, Gallizien, shortly after Vellach heading to Sittersdorf, MTB 9453/1, 46°34′11″ N, 14°31′37″ E, elev. 440 m, on corticated branch of *Corylus avellana* 2 cm thick, on bark, soc. young stromata of *Hypoxylon howeianum*, green *Trichoderma*, holomorph, 11 Jul. 2007, W. Jaklitsch, W.J. 3122 (WU 29323, culture C.P.K. 3131). Niederösterreich, Lilienfeld, Sankt Aegyd am Neuwalde, Lahnsattel, virgin forest Neuwald, MTB 8259/1, 47°46′24″ N, 15°31′19″ E, elev. 950 m, on mostly decorticated branch of *Fagus sylvatica* 6 cm thick, on wood, on/soc. Corticiaceae, 16 Oct. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2466 (WU 29312, culture CBS 121277=C.P.K. 991); same area, elev. 1000 m, on hymenophore of *Fomes fomentarius*, 25 Sep. 2007, H. Voglmayr, W.J. 3173 (WU 29324, culture from conidia C.P.K. 3157). Scheibbs, Lunz am See, forest path from Schloß Seehof in the direction Mittersee, MTB 8156/3, 47°50′39″ N, 15°04′24″ E, elev. 630 m, on a decorticated branch of *Fagus sylvatica* 6 cm thick, on wood, on/soc. stromata of *Hypoxylon rubiginosum*, holomorph, 16 Oct. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2461 (WU 29311, culture C.P.K. 989). St. Pölten Land, Michelbach, Mayerhöfen, Hegerberg, MTB 7860/4, 48°07′48″ N, 15°46′03″ E, elev. 450 m, on corticated branch of *Tilia cordata* 3 cm thick, on bark, soc. *Nematogonum ferrugineum*, *Trichoderma cerinum*, ?*Exosporium* sp., effete *Hypoxylon* sp., holomorph, 24 Nov. 2004, W. Klofac, W.J. 2791 (WU 29319, culture C.P.K. 1989). Wiener Neustadt Land, NW Pernitz, Muggendorf, brook margin shortly above the Myra falls, MTB 8061/4, elev. 560 m, on branch of ?*Alnus glutinosa*, on *Phellinus punctatus*, moss and well-decomposed dark wood, holomorph, 9 Jun. 2007, H. Voglmayr, W.J. 3100 (WU 29322, culture C.P.K. 3123). Oberösterreich, Schärding, St. Willibald, between Loitzmayr and Obererleinsbach at the Erleinsbach, MTB 7648/3, 48° 20′43″N 13°43′03″E, elev. 420 m, on branch of *Fraxinus excelsior*, on bark, soc. *Hypoxylon cercidicola*, Corticiaceae, ?*Hymenochaete* sp., green *Trichoderma*, holomorph, 2 Sep. 2006, H. Voglmayr, W.J. 2969 (WU 29321, culture C.P.K. 2461). Steiermark, Graz-Umgebung, Peggau, at the castle ruin Peggau, MTB 8758/3, elev. 460 m, on branch of *Corylus avellana*, on inner bark, soc. *Melogramma campylosporum*, *Tubeufia cerea*, *Cheirospora botryospora*, white hyphomycete, green *Trichoderma*, holomorph, 26 Oct. 2007, H. Voglmayr, W.J. 3184 (WU 29325, culture C.P.K. 3170). Vorarlberg, Feldkirch, Rankweil, behind the hospital LKH Valduna, MTB 8723/2, 47°15′40″ N, 09°39′00″ E, elev. 510 m, on a stump ,un..1(a)-8J/F1189T/nf3.8397.4(tal)]T91189T

W.J. 2579 (WU 29313, culture C.P.K. 1983); same region, Hartschimmel area, MTB 8033/1, 47°56′37″ N, 11°10′42″ E, elev. 700 m, on decorticated branch of *Fagus sylvatica*, on wood, soc. *Trichoderma harzianum*, a resupinate polypore, Corticiaceae, holomorph, 3 Sep. 2005, W. Jaklitsch, W.J. 2836 (WU 29320, culture from conidia CBS 119319); same area, at the crossing to Hartschimmelhof (halfway between Erling and Fischen), MTB 8033/3, 47°56′46″ N, 11°10′15″ E, elev. 650 m, on decorticated branch of *Fagus sylvatica* 4 cm thick, on wood, soc. hyphomycetes, effete pyrenomycetes, *Phlebiella vaga*, 7 Aug. 2004, H. Voglmayr, W. Jaklitsch, P. Karasch & E. Garnweidner, W.J. 2583 (WU 29314, culture C.P.K. 1984); same region, Leutstetten, Würmtal, parking area at a bridge over the Würm, MTB 7934/3, 48°02′15″ N, 11°22′10″ E, elev. 600 m, on two mostly decorticated branches of *Fagus sylvatica* 4–8 cm thick, on dark wood and bark, on/soc. *Phellinus ferruginosus*, soc. *Annulohypoxylon cohaerens*, green *Trichoderma*, 7 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2587 (WU 29315, culture C.P.K. 1985). **United Kingdom**, Norfolk, Lynford, Lynford Lakes and Arboretum, close to Lynford Hall, MTB 34-30/3, 52°30′43″ N, 00°40′41″ E, elev. 30 m, on decorticated branch of *Acer pseudoplatanus* 4 cm thick, on a brown crust on wood, mostly overgrown by white mould, 13 Sep. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2710 (WU 29317, culture C.P.K. 1987).

Notes: *Hypocrea pachybasioides* is difficult to recognize in the field. Its stromata are often indistinguishable from those of *H. minutispora*, although they are usually paler and less rosy than in the latter species and have large watery spots when young. The stroma colour is remarkably variable, making also a distinction from other species of the pachybasium core group difficult or even impossible. *Trichoderma polysporum*, the white pustulate anamorph with helical elongations, typical for section *Pachybasium* sensu Bissett (1991a, b), provides a good basis for the distinction from other species except for the rare *H. parapilulifera*, which produces a similar anamorph. See Lu et al. 2004 for more information on the taxa discussed here. *T. polysporum* is a low-temperature representative of the genus (Domsch et al. 2007) that has been used for biological control of pathogenic fungi in low-temperature situations.

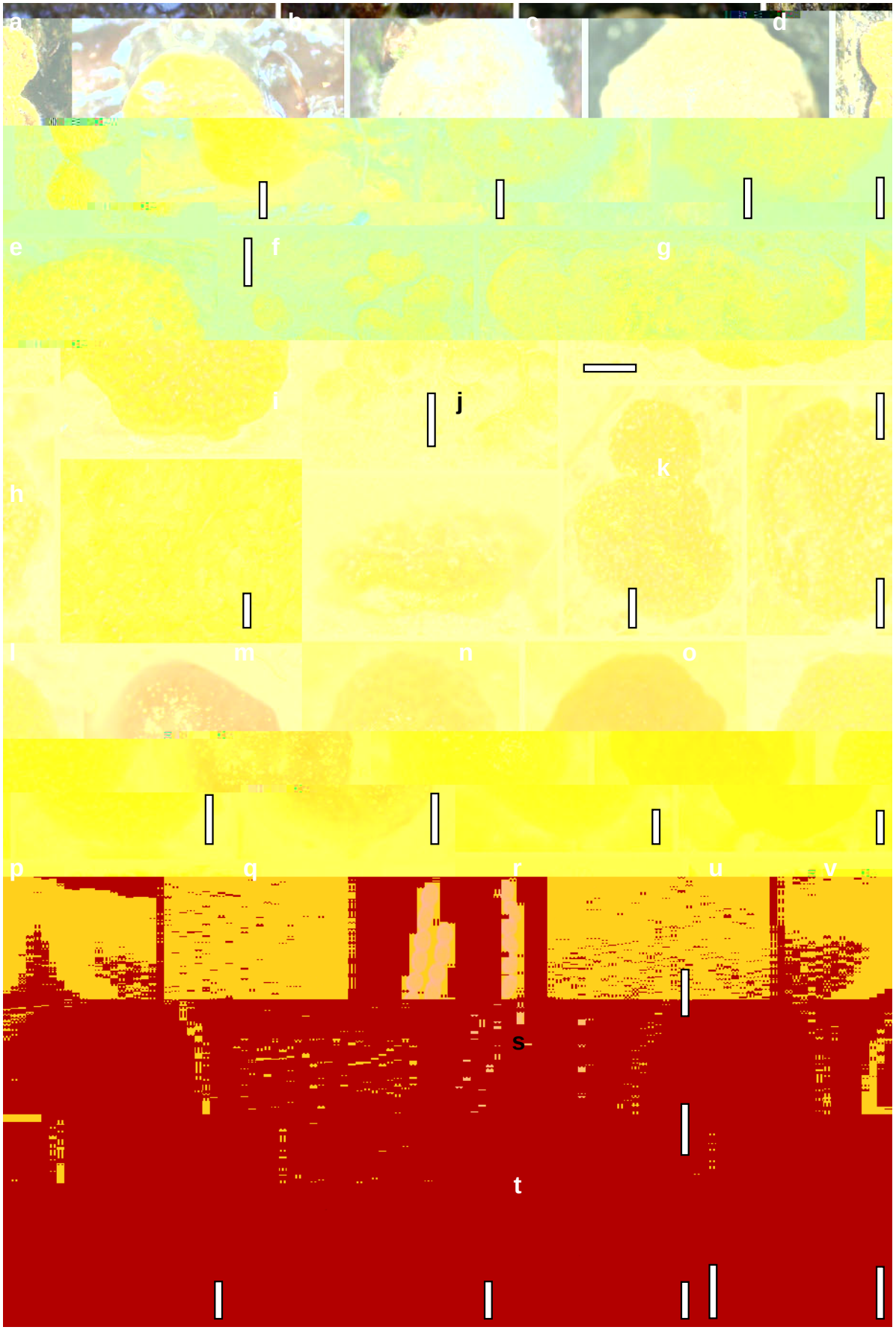
Hypocrea pachypallida Jaklitsch, **sp. nov.** Fig. 45
MycoBank MB 516694
Anamorph: ***Trichoderma pachypallidum*** Jaklitsch, **sp. nov.** Fig. 46
MycoBank MB 516695

Stromata 1–8 mm diam, pulvinata vel subeffusa, pallide lutea. Asci cylindrici, (65–)70–90(–110)×(3.5–)4.0–4.7(–5.0) μm. Ascosporae hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa vel cuneata, (3.0–)3.5–4.0(–4.7)×(2.7–)3.0–3.5(–4.0) μm, pars proxima oblonga vel subglobosa, (3.3–)3.8–5.0(–6.3)×(2.2–)2.5–3.0(–3.3) μm. Anamorphosis *Trichoderma pachypallidum*. Conidiophora in agaris CMD, PDA et SNA effuse disposita, simplicia, similia *Acremonii* vel *Verticillii*. Phialides divergentes, lageniformes, (8–)10–17(–26)×(1.8–)2.3–3.0(–4.0) μm. Conidia hyalina, oblonga vel ellipsoidea, glabra, (3.0–)3.5–5.0(–7.0)×(2.0–)2.2–2.7(–3.0) μm.

Etymology: *pachy* indicates the pertinence of the species to the pachybasium core group, *pallida* stands for the pallid stromata.

Stromata when fresh 1–8 mm diam, 0.5–1.5 mm thick, pulvinate, or flat, sometimes discoid, elongate or irregular effluent bands; broadly attached, often with fertile part elevated on a short stipe-like, white base. Outline circular to irregular. Margin or edges free, sharp or rounded, often white when young. Surface smooth, rugose when old. Ostiolar dots minute, olive or brown. Stroma colour first white, turning yellow, 4A3–4, brown-orange, 5CD5, greyish- to golden-yellow, 3B5–6, 4BC5–7, eventually (reddish) brown, 7E7–8, 6D7–8; mostly distinctly yellow when wet.

Stromata when dry (0.6–)1.3–3.8(–8.0)×(0.4–)1.1–2.7(–4.7) mm, (0.3–)0.4–0.8(–1.1) mm thick (n=75); solitary, gregarious or aggregated in small numbers (to 3) and pulvinate, or formed in large, subeffuse, flat and effluent, longish masses, becoming separated into individual stromata by cracks. Fertile part often flat, elevated on a short, stout, white stipe-like base, with margins laterally projecting beyond the base. Outline circular, angular, oblong or irregular. Margin margin sharply delimited, rounded, free, often white when young. Sides vertical or slightly retracted downwards, white or yellowish, initially with radiating base mycelium. Surface initially typically with a white, later disintegrating, covering layer, smooth, finely granular to rugose, often slightly downy. Ostiolar dots minute, (20–)32–58(–80) μm (n=75) diam, numerous, first often concealed by the covering white layer, becoming distinct, plane, less commonly convex, with circular or oblong outline, brown. Stromata first of small white mycelial tufts, becoming compacted, turning argillaceous, pale to greyish yellow-orange, 4A3–4, 5A2–4, 4–6B4–5, 6A4, 6C4, mostly yellow with brown dots, i.e. yellow-brown, 5CD4–7, eventually pale brown to reddish brown, 6E6–8, 7CD5–6, 8E5–8, when old. Spore deposits white or yellow. Rehydrated mature stromata pulvinate, with plane, finely floccose, yellow surface and numerous distinct, plane, (orange-)brown ostiolar dots. Ostiolar openings hyaline in water. After addition of 3% KOH stroma surface turning bright red to dark red; ostiolar openings hyaline; drying reddish brown. Immature stroma after rehydration semiglobose, smooth, white,


a
b
c
d
e
f
g
i
j
k
h
l
m
n
o
p
q
r
u
v
s
t

◀ **Fig. 45** Teleomorph of *Hypocrea pachypallida*. **a**. Wet fresh stroma with unusual bright colour. **b–j**. Dry stromata (**b, c**. immature. **e, f.** effluent). **k**. Stroma surface with undifferentiated hyphae in face view. **l, n.** Rehydrated stromata (**l**. immature; **n**. mature). **m, o**. Stromata in 3% KOH after rehydration (**m**. immature; **o**. mature). **p, q**. Perithecium in section (**p**. in lactic acid; **q**. in 3% KOH). **r**. Cortical and subcortical tissue in section. s. Subperithecial tissue in section. **t.** Stroma base in section**. u, v.** Asci with ascospores in cotton blue/lactic acid. **a, j.** WU 29328**. b, c, h, i, l–t**. WU 29326. **d, g**. WU 29329**. e, v**. WU 29330**. f, k, u.** WU 29327. Scale bars: **a, c, g, j**, **l–o**=0.5 mm. **b**, **h**=0.2 mm**. d**, **e**= 1.3 mm**. f**, **i**=1 mm. **k, u, v**=10 μm. **p–s**=20 μm. **t**=30 μm

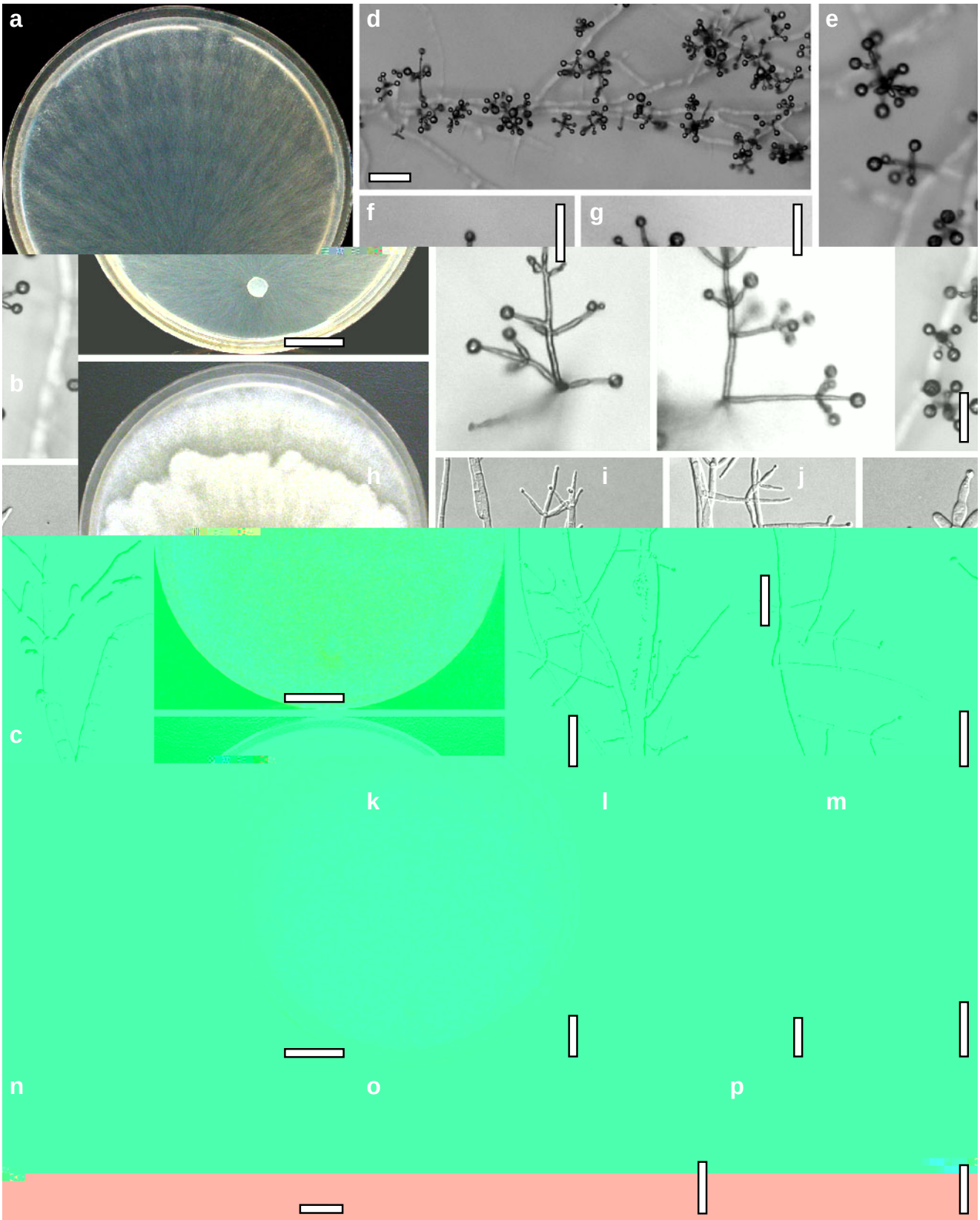
with numerous irregular, plane or convex, light ochre dots; after addition of 3% KOH ostiolar dots first slightly orange, later surface turning homogeneously pale orange; eventually stroma macroscopically dark brown to nearly black.

Stroma anatomy: Ostioles (58–)66–85(–92) μm long, plane or projecting to 20(–30) μm, (20–)25–40(–57) μm wide at the apex (*n*=30), periphysate, sometimes with clavate marginal cells to 6 μm wide at the apex. Perithecia (148–)180–220(–230)×(90–)110–170(–205) μm (*n*=30), 7–8 per mm stroma length, flask-shaped or globose, often crowded and laterally compressed; peridium (11–)14–17(–18) μm (*n*=30) thick at the base, (3–)8–15(–18) μm (*n*=30) thick at the sides, golden yellow; bright orange-red in 3% KOH. Cortical layer (18–)20–35(–42) μm (*n*=30) thick; surface of a thin adhesive layer of undifferentiated, often collapsed, thick-walled, subhyaline or yellow hyphae (2–)3–5(–7) μm (*n*=30) wide, usually with numerous ascospores, followed downwards by a dense, small-celled *t. angularis-epidermoidea* of indistinct, isodiametric or oblong, thin- to thick-walled, refractive cells (3–)5–10(–13)×(3–)4–7(–10) μm (*n*=30) in face view, (3–)4–9(–13)×(2–)3–5(–6) μm (*n*=30) in vertical section; cells distinctly (golden-)yellow, orange-red in 3% KOH; downwards at stroma sides paler, of hyphae partly projecting as cylindrical, thick-walled, smooth 'hairs' (9–)12–26(–35)×(2.5–)3.0–5.0(–6.5) μm (*n*=30), 1–5 celled, with rounded end cells. Subcortical tissue a well-defined *t. intricata* of thin-walled, hyaline hyphae (2–)3–5(–7) μm (*n*=30) wide. Subperithecial tissue a dense *t. epidermoidea* of mostly oblong, thin-walled, hyaline cells 4–16(–26)×(2.5–)4.5–8.5(–12) μm (*n*=33), containing some hyphae. Stroma base of subperithecial cells mixed with thick-walled hyaline to brownish hyphae (2–)3–6(–8) μm (*n*=33) wide. Asci (65–)70–90(–110)×(3.5–)4.0–4.7(–5.0) μm, stipe (1–)6–18(–31) μm long (*n*=80); in fascicles on ascogenous hyphae. Ascospores hyaline, often yellow or orange after ejection, verruculose, cells dimorphic; distal cell (3.0–)3.5–4.0(–4.7)×(2.7–)3.0–3.5(–4.0) μm, l/w 1.0–1.2(–1.6) (*n*=120), (sub-)globose or wedge-shaped; proximal cell (3.3–)3.8–5.0(–6.3)×(2.2–)2.5–3.0(–3.3) μm, l/w (1.1–)1.4–1.9(–2.5) (*n*=120), oblong or subglobose; septal areas often flattened.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 10–16 mm at 15°C, 30–34 mm at 25°C, 7–16 mm at 30°C; mycelium covering the plate after 6–7 days at 25°C. Colony hyaline, thin, circular, with well-defined margin, little mycelium on the surface, conspicuously (to *ca* 15 μm) wide, distinctly radially oriented primary hyphae; loose, not zonate; 2–4 finely downy or floccose concentric zones produced by effuse conidiation. Margins downy, floccose to powdery by aerial hyphae to 3 mm long and high; aerial hyphae scant in other areas, becoming fertile. Floccules caused by thick and short strands. Autolytic activity lacking or inconspicuous, coilings nearly lacking. No diffusing pigment, no distinct odour produced. Chlamydospores lacking or rare. After extended storage (e.g. 4 months) at 15°C agar turning pale yellowish and hard, rubber-like. Conidiation noted after 2 days at 25°C, effuse, colourless, macroscopically invisible apart from indistinct down or floccules; abundant; spreading from the centre across the entire colony, sessile, short, from solitary phialides or whorls of 2–6 phialides on short stipes originating on surface hyphae, acremonium- like, to verticillium-like conidiophores, concentrated in concentric zones and arising typically unpaired, in right angles or inclined upwards on long aerial hyphae along the colony margin. Conidiophores 25–150(–200) μm long, 4–6(–8) μm wide at the base, attenuated upwards to 2–3 μm terminally, simple, unbranched with verticils of phialides or with few, loosely spaced, short, 1-celled branches slightly inclined upwards, each with a whorl of phialides. Phialides arising solitary, paired or in whorls of 3–4(–6) on often thickened cells 2–5 μm wide. Conidia produced in colourless wet heads mostly <40 μm, sometimes to 70(–100) μm diam, eventually conidia lying on the agar surface. Phialides (8–)10–17(–26)×(1.8–)2.3–3.0(–4.0) μm, l/w (2.8–)3.5–6.5(–10.3), (1.2–)1.7–2.3(–3.0) μm wide at the base (*n*=94), lageniform, long, slender, often thickened below the middle, less commonly in the middle, typically constricted below a long neck, straight or slightly curved upwards. Conidia (3.0–)3.5–5.0(–7.0)×(2.0–)2.2–2.7(–3.0) μm, l/w (1.2–)1.5–2.1(–2.5) (*n*=90), hyaline, oblong, less commonly ellipsoidal, often slightly constricted in the middle, smooth, finely multiguttulate or with 1–2 larger guttules; scar indistinct. Conidiation also occurring within the agar, particularly in proximal and central areas, conidia formed in heads <15 μm with maximal 15 conidia per head. At 15°C minute sinuous secondary hyphae dominant, particularly at the colony margin. Conidiation colourless, effuse, spreading across the entire colony. At 30°C colony denser in the centre; hyphae thin; conidiation effuse, less abundant than at lower temperatures.

On PDA after 72 h 6–10 mm at 15°C, 20–24 mm at 25°C, 7–15 mm at 30°C; mycelium covering the plate after 9–10 days at 25°C. Colony dense, of few flat, broad, concentric zones with irregular outline and a whitish to pale yellowish, downy, hairy, finely floccose or farinose


a
d
e
f
g
b
h
i
j
c
k
l
m
n
o
p

◀ **Fig. 46** Cultures and anamorph of *Hypocrea pachypallida*. **a–c.** Cultures after 14 days at 25°C (**a**. on CMD; **b.** on PDA; **c**. on SNA). **d, e.** Short conidiophores on surface hyphae in face view on growth plate (7 days). **f, g**. Conidiophores on growth plates (**f**. SNA, 15°C, 8 days; **g**. 4 days). **h–m**. Conidiophores and phialides (4–14 days). **n**. Conidiation submerged in agar (9 days). **o**, **p**. Conidia (14 days). **d–p**. All from CMD at 25°C except **f. a, b, f, j, n–p**. CBS 120533. **c**. C.P.K. 1975. **k**. C.P.K. 2458. **g–i, l, m**. C.P.K. 967. *Scale bars* **a–c**=15 mm. **d**=50 μm. **e–i**=30 μm. **j**=15 μm. **k–n**=10 μm. **o**=5 μm. **p**=3 μm

surface. Aerial hyphae numerous, loose, only few mm high, without a distinct orientation, becoming fertile. Autolytic activity inconspicuous or moderate, no coilings seen. Reverse yellowish, cream, 3A3, 4AB3–4. Odour indistinct or slightly sour. Conidiation noted after 2 days at 25°C, effuse, spreading from the centre across the entire colony, abundant, dense in downy areas, short and ascending on aerial hyphae. Conidiophores loose, verticillium-like; phialides in whorls of 3–5; conidia hyaline, formed in wet heads to 50(–70) μm diam. At 15°C colony dense, hyphae thin, yellowish 3A3, surface downy to farinose, not zonate or 2 irregular zones; conidiation effuse. At 30°C colony compact, circular, dense, finely zonate, glabrous or centre hairy to fluffy. Autolytic excretions lacking at the colony margin, frequent inside the colony, yellow-brown. Reverse yellowish, 4AB3–4. Odour yeast-like to sour. Conidiation effuse, scant or in dense lawns.

On SNA after 72 h 9–12 mm at 15°C, 27–32 mm at 25°C, 3–11 mm at 30°C; mycelium covering the plate after 6–7 days at 25°C. Colony similar to CMD, but denser and surface hyphae degenerating, appearing empty. Mycelium not zonate, colony becoming zonate by conidiation. Autolytic activity moderate to conspicuous, coilings nearly lacking. No diffusing pigment, no distinct odour produced. Chlamydospores noted after 2–3 weeks, scant, mainly in the centre; appearing after 10 days and more frequent at 30°C, (4–)5–8(–12)× (4.0–)4.5–6.0(–7.0) μm, l/w 1.0–1.5(–2.2) (*n*=30), globose, pyriform or oval, mostly terminal, more ellipsoidal, rectangular or fusoid when intercalary. Conidiation noted after 2 days at 25°C, effuse, similar to CMD, but less abundant, concentrated in finely floccose, concentric zones and on the downy margin; conidial heads to 40(–70) μm diam. At 15°C similar to CMD, conidiation also on long aerial hyphae, reminiscent of T. sect. *Hypocreanum*; solitary phialides common. At 30°C growth variable, often poor, faster within the agar; colony irregular. Conidiation effuse, more abundant than on CMD, conidial heads to 40 μm diam.

Habitat: on medium- to well-decayed wood and bark of deciduous trees.

Distribution: Europe (Austria, Czech Republic, Germany, Sweden), uncommon.

Holotype: **Czech Republic**, Southern Bohemia, Záton, Boubínský prales (NSG), MTB 7048/2, 48°58′34″ N, 13° 49′03″ E, elev. 1010 m, on branch of *Fagus sylvatica* 4 cm thick, on dry bark, partly on wood in bark fissures, also on ?*Diatrypella* sp., soc. effete pyrenomycetes, a hyphomycete, rhizomorphs, 23 Sep. 2003, W. Jaklitsch, W.J. 2412 (**WU 29327**, ex-type culture CBS 122126=C.P.K. 968). ***Holotype*** of *Trichoderma pachypallidum* isolated from WU 29327 and deposited as a dry culture with the holotype of *H. pachypallida* as **WU 29327a**.

Other material examined: **Austria**, Burgenland, Oberpullendorf, Raiding, Ragerwald, MTB 8465/1, 47°33′49″ N, 16°34′08″ E, elev. 260 m, on decorticated branch of *Carpinus betulus* 4 cm thick, on well-decayed wood, soc. *Hypoxylon fuscum*, *H. howeianum*, dematiaceous hyphomycete, effete pyrenomycete, rhizomorphs, resupinate polypore, green *Trichoderma*, 3 Sep. 2006, W. Jaklitsch & O. Sükösd, W.J. 2965 (WU 29330, culture C.P.K. 2458). **Czech Republic**, Southern Bohemia, Záton, Boubínský prales (NSG), MTB 7048/2, 48°58′34″ N, 13°49′03″ E, elev. 1010 m, on partly decorticated branches of *Fagus sylvatica* 2–5 cm thick, on well-decayed, crumbly wood, partly attacked by a white hyphomycete, soc. effete *Eutypa* sp., ?*Lasiosphaeria* sp., rhizomorphs, *Quaternaria quaternata* in bark, 23 Sep. 2003, W. Jaklitsch; two specimens from different branches, W.J. 2410, 2411 (united as WU 29326, cultures C.P.K. 967, CBS 120533=C.P.K. 966). **Germany**, Baden-Württemberg, Stuttgart, Landkreis Schwäbisch Hall, Sulzbach-Laufen, Krempelbachtal near Wengen (between Gaildorf and Abtsgmünd in a side valley of Kochertal, N from Ulm, NE from Stuttgart), MTB 7025/3, 48°55′50″ N, 09°52′20″ E, elev. 370 m, on a branch of *Fagus sylvatica*, on wood, soc. effete pyrenomycete, rhizomorphs, 21 Oct. 2004, L. Krieglsteiner, K. Siepe, Hena, SI 28/2004, W.J. 2790 (WU 29329, culture C.P.K. 1975). **Sweden**, Uppsala Län, Vänge, Fiby urskog, MTB 3970/1, 59°52′57″ N, 17°21′04″ E, elev. 50 m, on decorticated branches *Corylus avellana* 3–4 cm thick, on wood, soc. *Bertia moriformis*, Corticiaceae, *Orbilia delicatula*, *Hymenochaete tabacina*, green *Trichoderma*; 6 Oct. 2003, W. Jaklitsch, W.J. 2443 (WU 29328, culture C.P.K. 982).

Notes: *Hypocrea pachypallida* is a species of the pachybasium core group forming pale pulvinate stromata, which may be similar to those of several other species including *H. bavarica*, *H. moravica*, *H. pachybasioides* and *H. parapilulifera*. These species form either green or white pustulate *Trichoderma* anamorphs, while *H. bavarica* and *H. pachypallida* produce their hyaline conidia in verticillium-like effuse conidiation. *Hypocrea bavarica* differs from *H. pachypallida* in a different ecology, i.e. a distinct affinity to *Betula*, typically appearing on bark early after the death of branches, a conspicuous and fast colour change upon drying, a pseudoparenchymatous subcortical tissue, slightly smaller ascospores, predominantly subglobose to oval conidia, an unpleasant odour on PDA, and a substantially slower growth. *H. moravica* differs from *H.*

pachypallida also in considerably larger ostiolar dots, *H. argillacea* differs in larger ascospores. The Swedish specimen of *H. pachypallida* is somewhat untypical due to more intense yellow colours and larger ostiolar dots. ITS and *rpb2* sequences of the six isolates are identical, while there is considerable variation in *tef1* sequences, which may eventually lead to a recognition of two species. However, differences may possibly be caused by technical issues rather than a true genetic difference.

Hypocrea parapilulifera B.S. Lu, Druzhin. & Samuels, Mycologia 96: 331 (2004). Fig. 47
Anamorph: *Trichoderma* sp. Fig. 48

Stromata when fresh 2–4 mm diam, 0.5–1.5 mm thick, solitary or gregarious, pulvinate; surface smooth, ostiolar dots large, irregularly disposed; colour first white, then pale to bright yellow 3A2–6, turning reddish yellow, orange-brown, brown, 4A5–6 to 6CD6–7.

Stromata when dry (0.5–)1.0–2.3(–3.0)×(0.5–)0.8–1.8 (–2.2) mm, (0.3–)0.4–1.0(–1.4) mm thick (*n*=30); solitary, gregarious or aggregated in small numbers, pulvinate or semiglobose, broadly attached, margin rounded, angular or undulate, often free, with a white mycelial base margin when young or sometimes fertile yellow part laterally projecting over a whitish, stipe-like base or stromata arising from and lifted above a thick whitish mat containing the anamorph. Outline circular, oblong or irregular. Surface smooth to finely tubercular or wrinkled, often slightly downy or floccose. Ostiolar dots (39–)50–100(–140) μm (*n*=33) diam, plane, circular, brown with lighter centres, first diffuse, becoming distinct. Stroma colour from yellow, 4AB4–6, over yellow-brown, 5CD5–8, to brown-orange or brown, 6–7CD7–8, 7E6–8. Spore deposits white or yellowish. Rehydrated stromata larger by 30–40%, reddish brown to the unaided eye, yellow to orange in the stereo-microscope, with papillate, orange-brown dots; after addition of 3% KOH instantly orange-red, macroscopically dark red.

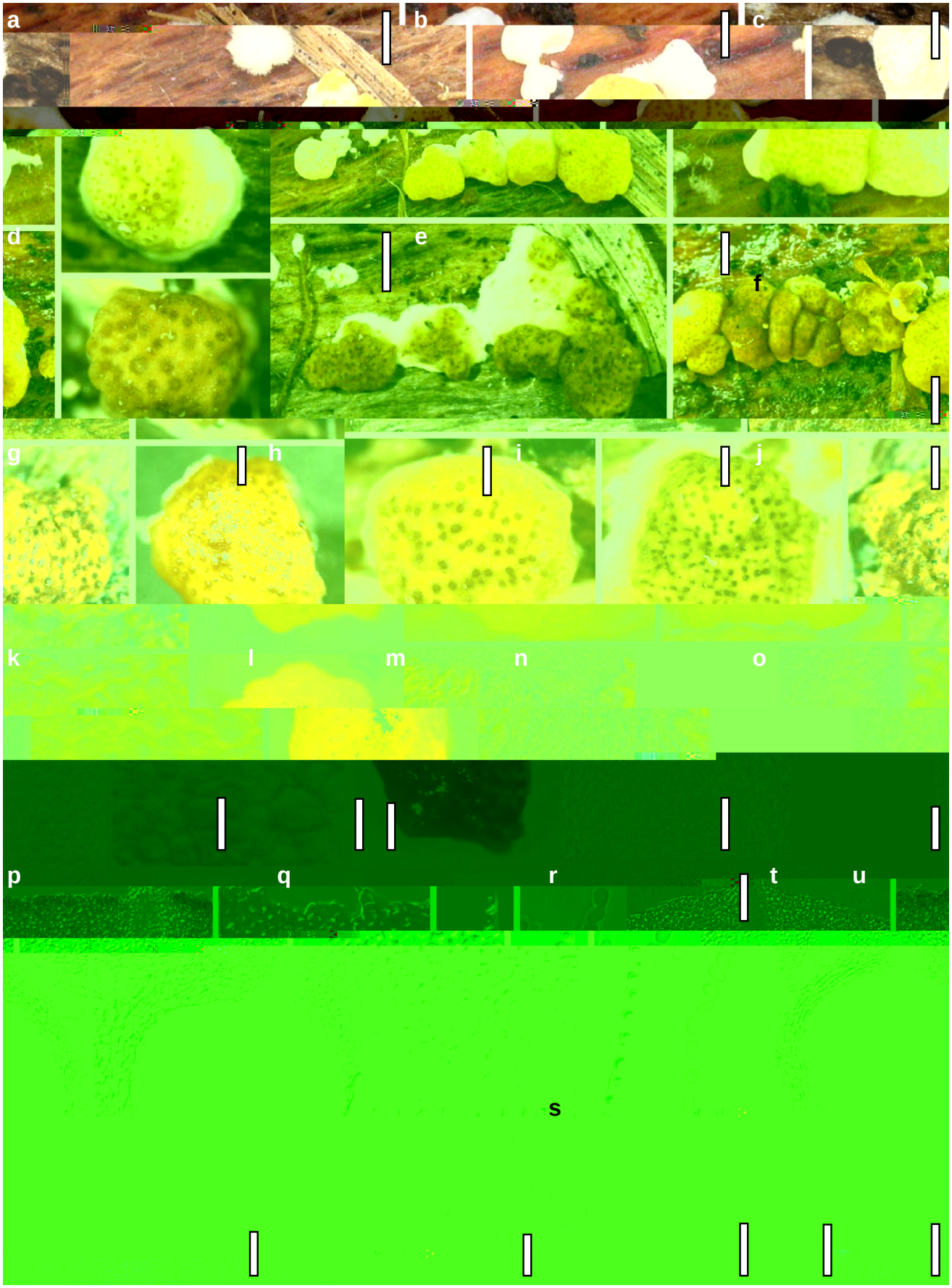
Stroma anatomy: Ostioles (67–)74–100(–128) μm long, plane or projecting to 20 μm, (15–)20–35(–50) μm wide at the apex inside (*n*=30), cylindrical, with or without clavate marginal cells 3–5 μm wide at the apex. Perithecia (180–)225–300(–325)×(100–)130–230(–290) μm (*n*=30), globose or flask-shaped; peridium (15–)18–27(–33) μm (*n*=30) thick at the base, (6–)12–22(–24) μm (*n*=30) thick at the sides, pale yellowish, in KOH pale orange. Cortical layer (20–)25–37(–46) μm (*n*=30) thick, a dense *t. angularis* of distinct, thin- to thick-walled cells (3–)5–10(–12)×(2.5–)4–7(–11) μm (*n*=63) in face view and in vertical section, yellow, gradually paler downwards, in KOH orange, on stroma sides paler to hyaline and intermingled with hyaline hyphae (2–)3–6(–7) μm (*n*=30) wide in lower parts. Hair-like projections on mature stromata (4–)5–12(–17)×(2–)3–5(–6.5) μm (*n*=30), 1–3 celled, hyaline or yellowish, mostly cylindrical, often with thickened base, smooth or verruculose. Subcortical tissue a loose *t. intricata* of hyaline thin-walled hyphae (2–)3–5(–6) μm (*n*=30) wide. Subperithecial tissue a *t. angularis–epidermoidea–prismatica* of hyaline, mostly oblong, thin-walled cells (7–)10–30(–58)×(4.5–)6–11(–14) μm (*n*=30). Asci (98–)110–130(–140)×(4.8–)5.3–6.5(–7.0) μm, stipe (13–)23–40(–50) μm (*n*=30). Ascospores hyaline, sometimes yellow, even inside asci, verruculose; cells dimorphic, distal cell (3.5–)4.0–5.3(–5.7)×(3.2–)3.5–4.0(–4.5) μm, l/w (0.9–)1.1–1.4(–1.7) (*n*=32), (sub)globose or wedge-shaped, proximal cell (3.8–)5.0–6.5(–7.5)×(2.8–)3.2–3.8(–4.0) μm, l/w (1.1–)1.4–1.9(–2.2) (*n*=32), oblong or wedge-shaped; contact area often flattened.

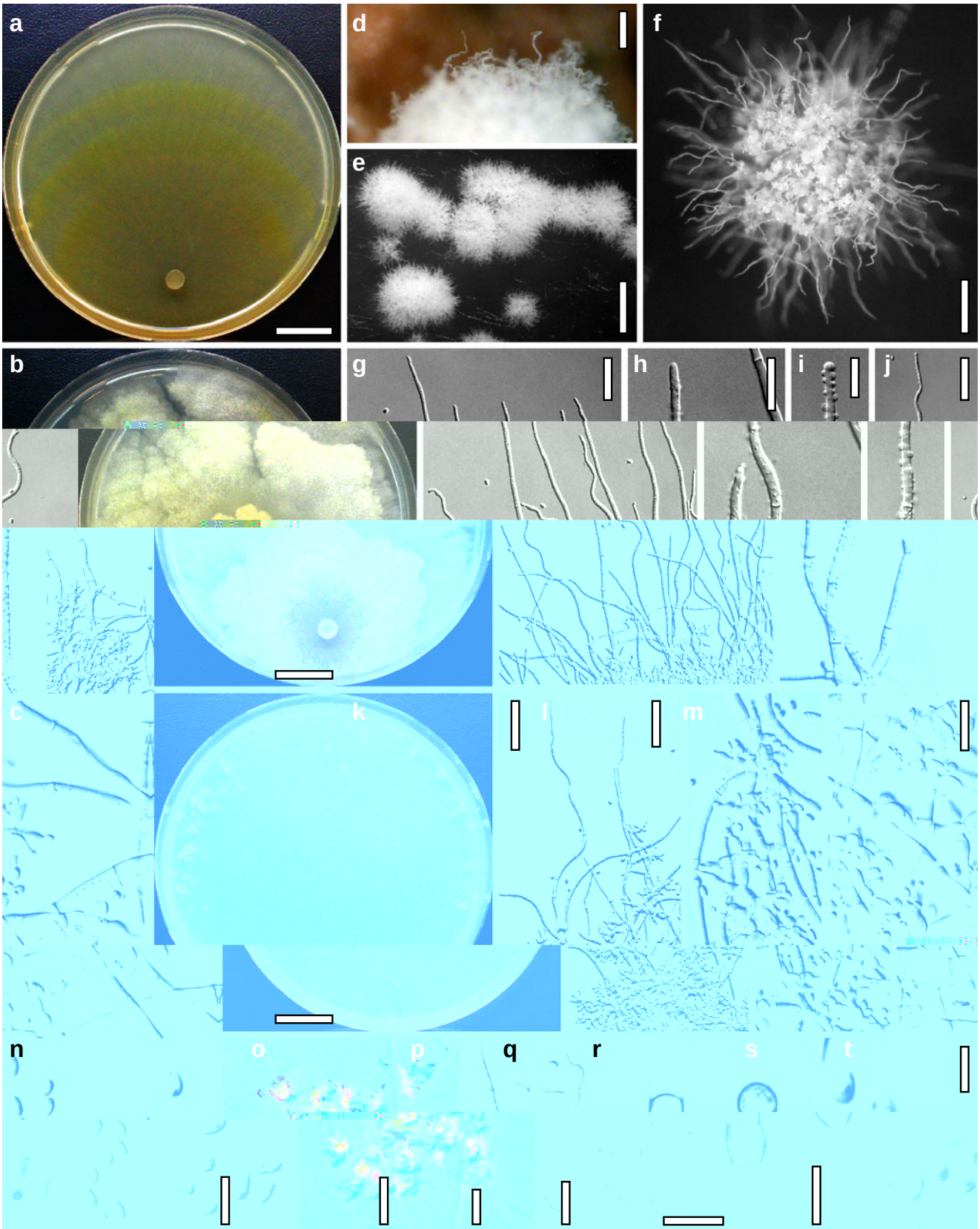
Anamorph on the natural substrate forming white cottony tufts, e.g. 1.5×1 mm, associated with stromata, with short, straight to helical elongations. Right-angled branching common. Conidiophores often fertile to the tip, 4–6(–8.5) μm wide, 3 μm terminally. Phialides (4–)5–7(–9)×(2.5–)3.0–3.8(–4.0) μm, l/w (1.2–)1.3–2.1(–2.9), (1.5–)2.0–3.0(–3.5) μm wide at the base (*n*=30), lageniform or ampulliform, neck short cylindrical. Conidia (3.0–)3.2–3.7(–4.2)×(2.0–)2.2–2.5(–2.8) μm, l/w (1.2–)1.4–1.6(–1.9) (*n*=32), hyaline, oblong or ellipsoidal, smooth, with minute guttules; scar indistinct.

Cultures and anamorph: optimal growth at 25°C on all media; at 30°C hyphae autolysing after short growth; excretions abundant, brown; no growth at 35°C.

On CMD after 72 h 17–22 mm at 15°C, 32–34 mm at 25°C, 0.6–1.2 mm at 30°C; mycelium covering the plate after 6–7 days at 25°C. Colony hyaline, thin, first loose, becoming dense in distal regions, zonate, margin wavy; hyphae radially arranged, thick surface hyphae irregularly curved around the plug, surface mycelium scant. Aerial hyphae scant. After 6 days numerous long acicular, radial, yellow to reddish crystals appearing in the agar from the centre, on the agar surface disintegrating into minute part crystals; also hyphae becoming yellow to red; colony turning light to golden yellow, 3A3–5, 3–4B4–5, 4C6–7, in broad concentric zones. Autolytic activity inconspicuous, conspicuous at 30°C, no coilings seen. No distinct odour noted. No conidiation seen within 4 weeks. Chlamydospores noted after 6–7 days, uncommon, eventually more common than on SNA, terminal and intercalary, globose or

Fig. 47 Teleomorph of *Hypocrea parapilulifera* (WU 29395). **a, b**, **e**. ▶ Fresh stromata. **c, d, f–i**. Dry stromata (**c**. immature). **j**. Rehydrated stroma. **k**. Ostiole, upper part in section. **l**. Lateral cortex, lower region. **m**. Lateral cortex, upper region. **n**. Stroma surface in face view. **o**. Stroma in 3% KOH after rehydration. **p, q**. Perithecia in section (**p**. in lactic acid; **q**. in 3% KOH). **r**. Cortical and subcortical tissue in section showing hair-like outgrowths on the stroma surface. **s**. Subperithecial tissue in section. **t, u**. Asci with ascospores (**u**. in cotton blue/lactic acid). *Scale bars* **a**, e=1.5 mm. **b**, d=1 mm. **c, h–j**, **o**=0.5 mm. **f**, **g**=0.3 mm. **k**, **n**=10 μm. **l, m**, **r–u**=15 μm. **p**=40 μm. **q**=30 μm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
t
u
s


a
d
f
e
b
g
h
i
j
c
k
l
m
n
o
p
q
r
s
t

◀ **Fig. 48** Cultures and anamorph of *Hypocrea parapilulifera* (CBS 120921). **a–c**. Cultures (**a**. on CMD, 10 days; **b**. on PDA, 14 days; **c**. on SNA, 28 days). **d**. Periphery of a conidiation tuft on the natural substrate (WU 29395). **e, f**. Conidiation pustules on SNA (14–20 days; **f**. showing elongations on pustule margin). **g–i**. Elongations (**h, i**. showing semiglobose warts). **j–m**. Conidiophores. **n**. Crystals on CMD (9 days). **o**. Phialides. **p, q**. Chlamydospores (SNA, 25°C, 23 days). **r–t**. Conidia (**r**. on the natural substrate). **g–m, o, s, t**. On SNA at 25°C after 20 days. *Scale bars* **a–c**=15 mm. **d**=100 μm. **e**=0.8 mm. **f**=0.2 mm. **g, j, k**=40 μm. **h, i, m, o**, **s**=10 μm. **l**=15 μm. **p–r**, **t**=5 μm

ellipsoidal. Dark olive colours developing after extended storage at 15°C in CMD cultures. At 15°C colony zonate, crystalline pigment turning the agar yellow, 1A3, 2A3–4, 3A5, 3B3–4; no conidiation seen.

On PDA after 72 h 14–17 mm at 15°C, 23–26 mm at 25°C, <1 mm at 30°C; mycelium covering the plate after 10–14 days at 25°C. Colony conspicuously dense to opaque; surface hyphae forming irregularly oriented strands at the colony margin; growth discontinuous, resulting in a large, flat, golden yellow central zone with irregular margin, and irregular outgrowths forming zonate patches and yellow spots. Aerial hyphae loose in the central zone, otherwise numerous, forming a dense, downy to floccose flat reticulum of irregular strands with large connectives and drops, and yellow acicular crystals, eventually orange, collapsing. Autolytic activity and coilings conspicuous at all temperatures. Numerous minute, yellow crystals appearing in the agar turning it yellow, 2–3A3–6, from the centre on the surface and the reverse, centre eventually 4B4–6. No distinct odour noted. No conidiation seen within 4 weeks. At 15°C colony indistinctly zonate, margin angular to lobed, surface downy; yellow pigment and crystals produced turning the agar yellow, 2A4–5, 3AB4–6, 4AB5–6; no conidiation seen.

On SNA after 72 h 17–20 mm at 15°C, 22–25 mm at 25°C, <1 mm at 30°C; mycelium covering the plate after 9–10 days at 25°C. Colony similar to CMD, zonate, with little mycelium on the agar surface, surface hyphae soon degenerating, appearing empty. Aerial hyphae nearly lacking. Autolytic activity and coilings moderate. No diffusing pigment, no distinct odour produced. Chlamydospores noted after 3–5 days, uncommon, mostly intercalary, (5–)6–10(–13)×5–8(–10) μm, l/w 1.0–1.5(–1.8) (*n*=30), globose, ellipsoidal, fusoid or angular, smooth, rarely 2-celled. Conidiation noted after 12–14 days in white shrubs slowly developing into tufts or pustules 0.5–1.5 mm diam in lateral and distal areas of the colony, aggregating in groups to 11 mm or confluent to *ca* 5 mm long. Conidiation dense, dry, mainly inside tufts. Tufts/pustules loose to compact, but not opaque, i.e. with small spaces between dense conidial clusters, consisting of a right-angled reticulum of branches 4–7 μm wide, with connectives thickened to 8 μm and long, little branched, radially divergent main axes fertile to the tip, mostly 4–5 μm wide and to 150(–220) μm long, or with straight, sinuous or helical elongations to 300 μm long to the first branching, 1.5–2 μm wide terminally, with semiglobose warts 1–2 μm diam, sterile, rarely with 1(–2) lageniform to subulate phialides (7–)11–17(–19)×(1.7–)2.0–2.5(–3.0) μm, l/w (2.6–)4.4–8.0(–8.9), 1.5–2.0(–2.2) μm wide at the base (*n*=20). Side branches on elongation bases in right angles or slightly inclined upwards, paired or unpaired, short, 1-celled, longer, 2–3 celled, downwards, unbranched or rebranching into short, 1-celled branches 2.5–5.5 μm wide with phialides solitary or in whorls of 2–3. Phialides (4.3–)5.0–7.5(–9.5)×(2.8–)3.0–4.0(–4.3) μm, l/w (1.1–)1.3–2.3(–3.0), (1.8–)2.0–2.8(–3.0) μm wide at the base (*n*=30), lageniform or ampulliform. Conidia (3.2–)3.5–4.0(–4.7)×(2.2–)2.3–2.5(–2.7) μm, l/w (1.3–)1.4–1.7(–2.0) (*n*=30), hyaline, oblong or ellipsoidal, smooth, with two groups of terminal guttules or minute guttules irregularly disposed, scar indistinct. At 15°C colony zonate; conidiation after *ca* 3 weeks in white tufts with mostly straight elongations, scant.

Habitat: on decorticated wood.

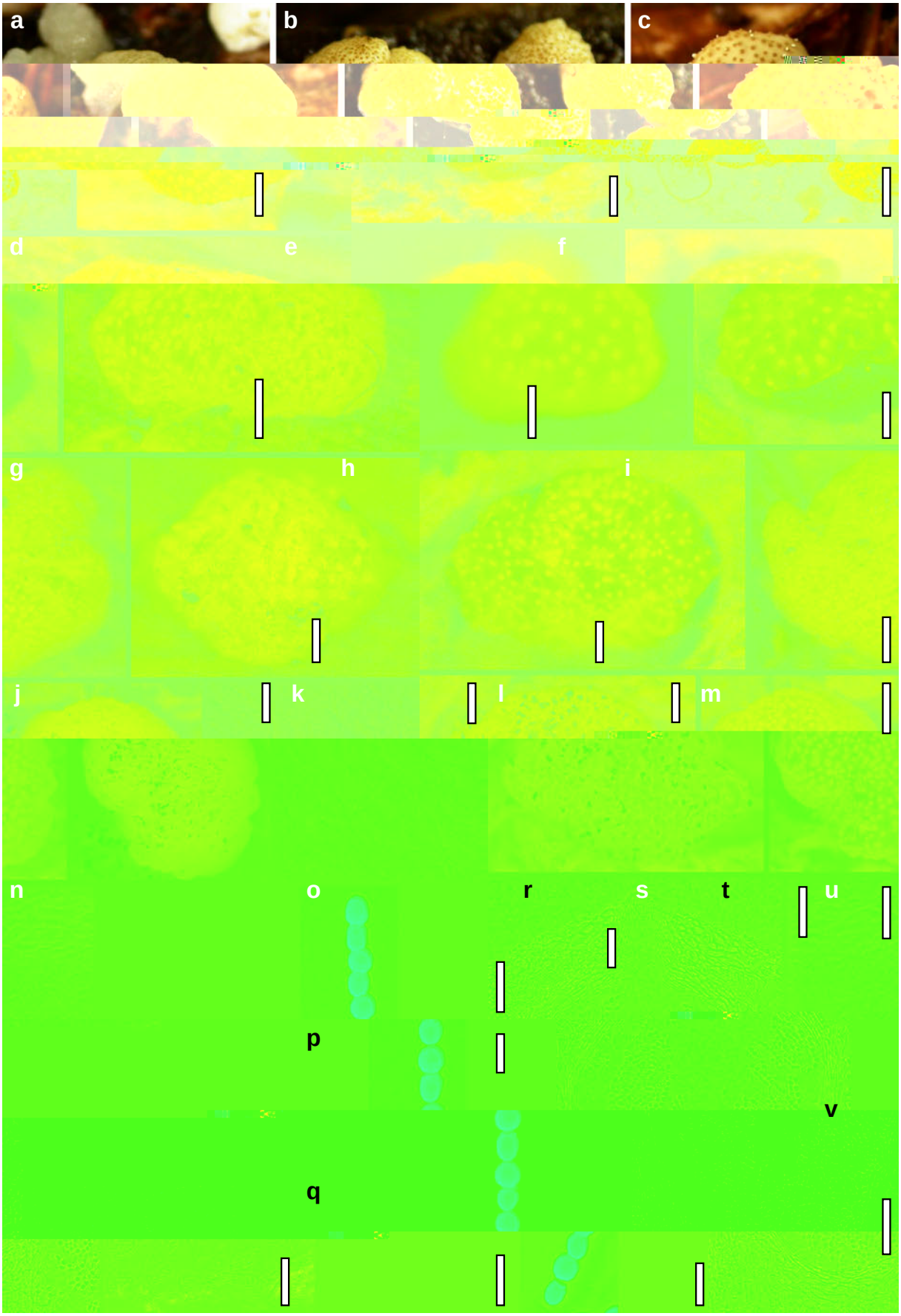
Distribution: Europe (Czech Republic), USA; also Australia fide Lu et al. (2004); rare.

Holotype: **USA**, Virginia: Giles County, Mountain Lake Biological Station, Little Spruce Bog, 378229 N, 808319 W, elev. 1170 m, on decorticated wood, 17 Sep. 1991, G.J. Samuels et al. (BPI 112832, culture G.J.S. 91-60; not examined).

Material examined: **Czech Republic**, Southern Bohemia, Záton, Boubínský prales (NSG), MTB 7048/2, 48°58′34″ N, 13°49′07″ E, elev. 1000 m, on decorticated branch of *Fagus sylvatica* 5 cm thick, on wood, soc. greenish *Trichoderma*, *Melanopsammella inaequalis*, rhizomorphs, holomorph, 4 Oct. 2004, W. Jaklitsch, W.J. 2762 (WU 29395, culture CBS 120921=C.P.K. 1908).

Notes: *Hypocrea parapilulifera* is a rare species, with certainty known from only two teleomorphic specimens, one from North America, one from Europe. It was also identified in drinking water by Hageskal et al. (2008). The most closely related species is *H. pachybasioides*. *H. parapilulifera* differs from the latter in hairs on the stroma surface, a more distinct colour change during development and drying, a positive KOH reaction of the stromata, later appearance and slower development of conidiation, virtually no growth at 30°C, pustules with a looser structure and the formation of a yellow to dark olive pigment on CMD. The latter two traits and formation of crystals on CMD do not seem consistent, because the *H. pachybasioides* strain CBS 119319 behaves similarly. The semiglobose warts on elongations of *H. parapilulifera* may be diagnostic for the species if consistent among the strains. The isolate from the Czech specimen sporulated only on SNA, while Lu et al. (2004) reported also conidiation on CMD for their North American isolate.

Hypocrea pilulifera J. Webster & Rifai, Trans. Brit. Mycol. Soc. 51: 511 (1968). Fig. 49


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
r
s
t
u
p
v
q

◀ **Fig. 49** Teleomorph of *Hypocrea pilulifera*. **a–d**. Fresh stromata (**a, d**. immature, **b**. partly immature). **e–j**. Dry stromata (**e**. immature, with stipe-like base). **k**. Rehydrated stroma. **l**. Stroma in 3% KOH after rehydration. **m**. Stroma surface in face view. **n**. Perithecium in section. **o**. Cortical and subcortical tissue in section. **p**. Subperithecial tissue in section. **q**. Stroma base in section. **r–t**. Asci with ascospores (**t**. in cotton blue/lactic acid). **u, v**. Ascospores (**u**. vital, multiguttulate; **v**. cells distinctly dimorphic; viable and dead). **a, b, d, f, h, k–q, v**. WU 29408. **c, e, g, j, r, t, u**. WU 29409. **i, s**. Holotype K 64379. *Scale bars* **a, b, k**, **l**=1 mm. **c**, **h**=0.6 mm. **d**, **i**=0.3 mm. **e–g**, **j**=0.4 mm. **m**, **r–v**=10 μm. **n**, **q**=40 μm. **o**, **p**=20 μm

Anamorph: ***Trichoderma piluliferum*** J. Webster & Rifai, Mycol. Pap. 116: 16 (1969). Fig. 50

Stromata when fresh 1–5 mm diam, 1–1.5 mm thick, pulvinate, broadly attached, margin free, surface smooth, ostiolar dots distinct, first watery, yellowish to olive-greenish, later ochre to brown. Stroma colour first white, turning light yellow, nearly citrine, 2–3A2–4, cream or argillaceous when mature, mostly 4AB4.

Stromata when dry (0.7–)1.5–3.4(–4.0)×(0.6–)1.2–2.6(–3.5) mm, (0.3–)0.5–1.1(–1.5) mm thick (*n*=44), solitary, scattered or aggregated in small numbers (2–3), pulvinate or discoid, broadly attached; outline circular or oblong; rarely with radiating white basal mycelium. Edges free, sides rounded or straight vertical, smooth, sometimes present as a white broad stipe-like base with the apical fertile part laterally projecting over it. Surface smooth, finely granular due to ostiolar dots or rugose. Ostiolar dots distinct, (39–)48–97(–165) μm (*n*=85) diam, plane or convex, with circular or oblong outline; bright ochre or brown. Development from white cottony pulvinate mycelium, compacting, turning yellow from the centre before the appearance of ostiolar dots. Stroma colour pale yellow to nearly citrine, 2–3A3, 3A4, 4A3–5, more greyish yellow, cream, greyish orange or pale brown when mature, 4–5B4–6, 5CD5–6; sometimes reddish brown when older and with densely disposed dots. Spore deposits white or yellowish. Rehydrated stromata thickly pulvinate, smooth, with distinct, convex, bright ochre ostiolar dots, white in between. No distinct colour change noted after addition of 3% KOH, only dots more papillate and rehydration more efficient, colour more evenly pale brownish, paler again after drying.

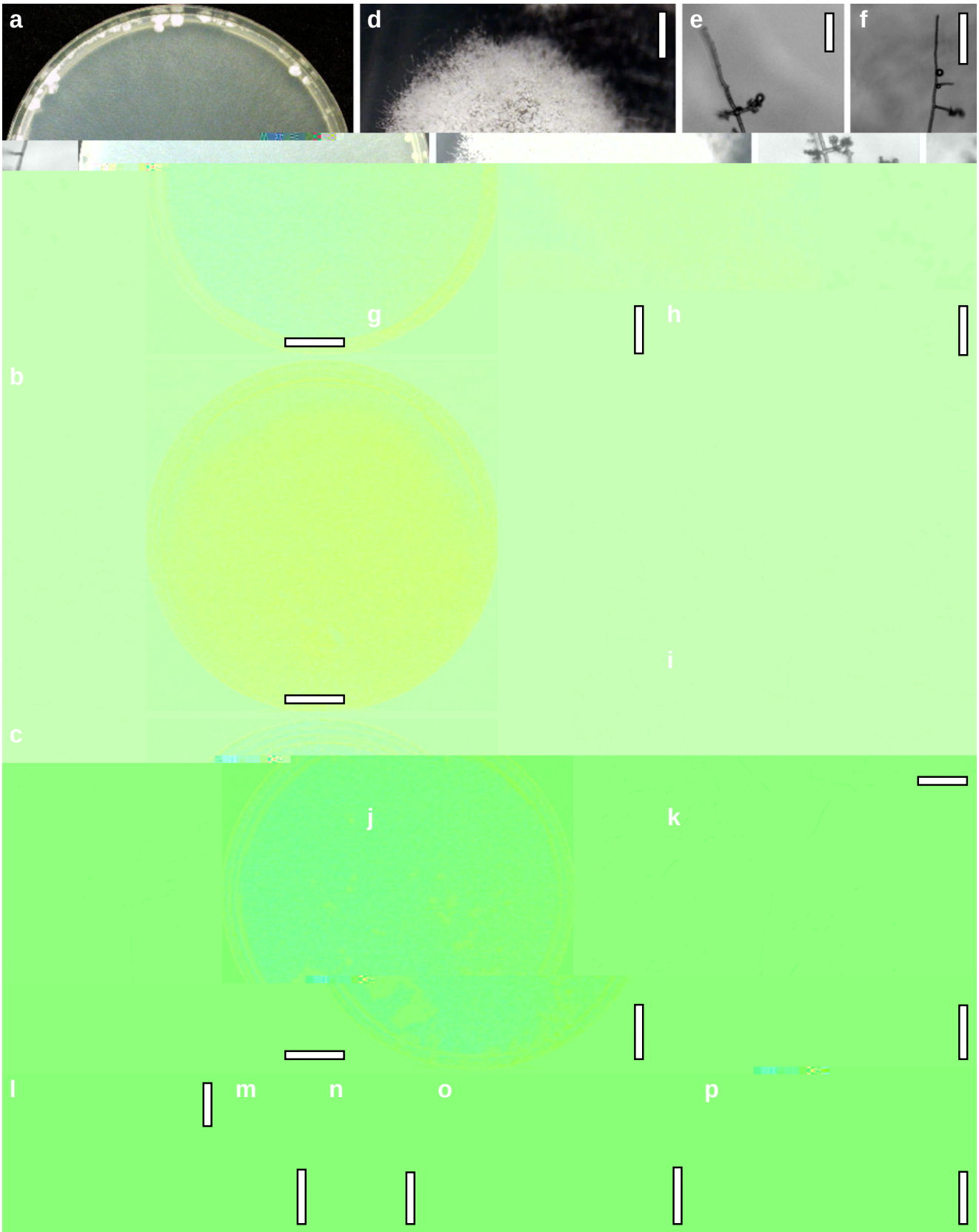
Stroma anatomy: Ostioles (65–)82–104(–110) μm long, plane or projecting to 20(–30) μm, (38–)42–66(–75) μm wide at the apex (*n*=30); hyaline marginal apical cells cylindrical or clavate, 2–5 μm wide. Perithecia (180–)240–305(–330)×(130–)180–260(–330) μm (*n*=30), globose or flask-shaped, crowded or not; peridium (14–)17–25(–32) μm (*n*=30) thick at the base, (10–)15–21(–26) μm (*n*=30) thick at the sides, hyaline to pale yellowish. Cortical layer (22–)24–35(–41) μm (*n*=30) thick, a *t. angularis* of distinct thick-walled, hyaline to pale yellowish cells (5–)6–12(–17)×(3–)5–8(–10) μm (*n*=30) in face view, (4–)6–19(–30)×(3–)4–8(–10) μm (*n*=31) in vertical section; surface smooth, no hairs present. Subcortical tissue where present a loose *t. intricata* of thin-walled hyaline hyphae (2–)3–5(–7) μm (*n*=30) wide. Subperithecial tissue a dense *t. epidermoidea* of thick-walled hyaline cells (4–)8–28(–53)×(4–)7–14(–17) μm (*n*=30). Stroma base a *t. intricata* of thick-walled hyaline hyphae (2–)3–6(–9) μm (*n*=32) wide. Asci (78–)88–110(–136)×(5.0–)5.5–6.5(–7.5) μm, stipe (3–)8–20(–42) μm long (*n*=80). Ascospores hyaline, spinulose or verruculose, cells dimorphic, but often with little difference in shape and size; distal cell (3.7–)4.3–5.3(–6.0)×(3.5–)4.0–4.8(–5.5) μm, l/w (0.9–)1.0–1.2(–1.5) (*n*=110), (sub)globose or wedge-shaped; proximal cell (4.0–)4.8–6.0(–7.0)×(3.0–)3.2–4.3(–5.4) μm, l/w (1.0–)1.2–1.7(–2.2) (*n*=110), oblong, ellipsoidal, wedge-shaped or subglobose.

Cultures and anamorph: optimal growth at 15–20°C on all media; no growth at 30 and 35°C.

On CMD after 72 h 14–18 mm at 15°C, 13–14 mm at 25°C; mycelium covering the plate after 10–11 days at 15°C, after 19–20 days at 25°C. Colony hyaline, thin, with discontinuous/multiphasic growth resulting in irregular zones of varying density ('imbricate') and an ill-defined, often lobed margin; numerous characteristic, narrow, short and irregularly sinuous ('curly') secondary peg-like hyphae present. Aerial hyphae virtually absent. Autolytic activity and coilings absent. No pigment, no distinct odour noted. Chlamydospores noted after 10–20 days in variable numbers. No conidiation seen at 25°C. At 15°C colony circular, with similar hyphae but denser and margin better defined than at 25°C. Conidiation noted after 12–20 days, scant, developing slowly, pachybasium-like, in thick white fluffy tufts 2–9 mm diam, mostly on the distal and lateral margins, with many right angles and straight or slightly sinuous sterile elongations to 0.5 mm long.

On PDA after 72 h 12–14 mm at 15°C, 11–13 mm at 25°C; mycelium not covering the plate within a month at 15 and 25°C. Hyphae narrow, secondary hyphae minute, wavy, peg-like. Colony with wavy or lobed margin, not zonate, dense to opaque, with lighter radial patches or homogeneous, whitish downy surface. Aerial hyphae numerous, without distinct orientation, forming a loose whitish mat with irregular strands and large connectives, eventually collapsing to floccules. Autolytic activity absent, coilings common. No diffusing pigment produced, reverse cream-yellowish, 3–4A3, 4B4; odour indistinct. Conidiation absent at 25°C. At 15°C similar, colony more regular, dense, shiny, with lighter radial rays. Conidiation noted after 25–32 days in white tufts to 3 mm diam in the centre, scant, pachybasium-like; sometimes confluent to larger masses.

On SNA after 72 h 10–13 mm at 15°C, 4–5 mm at 25°C; mycelium covering the plate after 2 weeks at 15°C, not covering the plate within a month at 25°C. Colony circular, dense, with numerous minute, peg-like secondary hyphae; indistinctly zonate, hyphae degenerating from the centre, becoming empty. Aerial hyphae inconspicuous, minute.


a
d
e
f
g
h
b
i
c
j
k
l
m
n
o
p

◀ **Fig. 50** Cultures and anamorph of *Hypocrea pilulifera* (CBS 120927). **a–c**. Cultures (**a**. CMD, 25 days. **b**. PDA, 28 days. **c**. SNA, 25 days). **d**. Conidiation pustule on SNA (18 days). **e, f**. Conidiophores with elongations on pustule margins on growth plate (**f**. young, showing right-angled branching; 18 days). **g–k**. Conidiophores (18 days; **g**. showing sterile elongations). **l**. Phialides (18 days). **m, n**. Chlamydospores (21 days). **o, p**. Conidia (25°C, 45 days). **a–p**. All at 15°C except **o, p. d–p**. All on SNA. *Scale bars* **a–c**=15 mm. **d**=0.5 mm. **e, g**, **h**=30 μm. **f**=70 μm. **i, k**, **n**=15 μm. **j, l**, **m**=10 μm. **o**, **p**=5 μm

Autolytic activity and coilings absent. Chlamydospores noted after 10–14 days at 15°C, common, irregularly distributed, terminal and intercalary, (6–)7–11(–15)×(4–)6–10(–11) μm, l/w 0.9–1.4(–2.1) (*n*=30), globose, oblong or clavate, sometimes 2–3 celled. No diffusing pigment noted; odour indistinct. Conidiation absent at 25°C or in white pustules after *ca* 1.5 months. At 15°C colony circular, margin becoming wavy to lobed. Conidiation noted after 9–11 days, dry, pachybasium-like, developing from within white tufts or pustules 1–3(–5) mm diam, confluent up to 9 mm long, irregularly disposed or in a concentric zone including the proximal margin and centre, or/and in a broad zone including the margin. Pustules dense but not opaque, a reticulum of mostly unpaired branches in right angles with erect conidiophores (main axes) to *ca* 0.5 mm long emerging from it. Main axes to 7.5 μm wide and thick-walled at the base, attenuated upwards to 2.5–4 μm terminally, fertile to the tip or terminating in a straight or sinuous sterile elongation 50–150(–300) μm long to the first branching, smooth or appearing rough in the stereomicroscope. Conidiophores (main axes without elongations and side branches) with a whorl of phialides at the top, followed by short paired or unpaired 1–2 celled branches in right angles, each with a terminal whorl of phialides. Branches not or once rebranching into thick, short paired, right-angled branches with 1–3 whorls of phialides resulting in dense structures. Generally branches more commonly unpaired, but tending to be paired in short terminal branches to 150 μm long or side branches directly below elongations. Branching points sometimes thickened to 10–12 μm. Phialides mostly in whorls of 2–4, less commonly solitary. Conidia densely packed in minute globose dry heads. Phialides (4.5–)5.0–8.0(–11.5)×(3.0–)3.4–4.2(–5.0) μm, l/w (1.2–)1.3–2.0(–3.0), (1.2–)2.0–3.0(–4.0) μm wide at the base (*n*=34), ampulliform or subglobose with a curved neck and narrow base, less commonly lageniform, often inaequilateral or curved, widest mostly in or below the middle. Conidia (2.5–)2.8–3.5(–4.0)×(2.5–)2.7–3.2(–3.7) μm, l/w 1.0–1.2(–1.3) (*n*=80), hyaline, globose, subglobose, sometimes oval, smooth, eguttulate, scar indistinct.

Habitat: on wood of *Betula* spp., less commonly on other hosts, e.g. *Juncus effusus*.

Distribution: Europe (Germany, United Kingdom), uncommon.

Typification: Webster and Rifai (1968) collected a specimen containing stromata on *Juncus effusus* in Derbyshire and designated it as the holotype of their new species *H. pilulifera*. Several other specimens were found by them only in the conidial state on wood of *Betula* and basidiomata of *Heterobasidion annosum*. One of them, on wood of *Betula* from Lancashire is available as the living culture CBS 814.68 providing a reference, e.g. for gene sequences. ***Holotype***: **United Kingdom**, England, Derbyshire, Glossop, Chunal Moore, on dead culms of *Juncus effusus*, 11 Jul. 1965, J. Webster (K(M) 64379). The stroma of the holotype matches recently collected specimens. It is firmly attached to a culm of *Juncus*, pulvinate, KOH- and has ascospores distinctly larger than in *H. placentula*, which is found on the same host. However, only one incomplete stroma remains, therefore an ***epitype*** is designated here: **Germany**, Hessen, Landkreis Fulda, Gersfeld, Rhön, Rotes Moor (between Gersfeld and Wüstensachsen), from the parking place Moordorf at B278 to the peat bog, 50°27′42″ N, 09°58′58″ E, elev. 810 m, on a branch of *Betula pubescens* subsp. *carpatica* 6–8 cm thick, on medium- to well-decayed wood, soc. *Chaetosphaeria ovoidea*, ?*Mollisia* sp., dark hyphomycete, algae and moss, 29 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2959 (**WU 29408**, ex-epitype culture CBS 120927=C.P.K. 2455).

Additional material examined: **United Kingdom**, Staffordshire, Cannock Chase, Rugeley, Beaudesert Old Park, right from the car park (heading to Lichfield), 52°43′14‴ N, 1°56′48″ W, elev. 150 m, on a decorticated twig of *Betula pendula* 2–3 cm thick embedded in moss, on well-decayed wood, soc. effete pyrenomycete, 7 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3142 (WU 29409, culture C.P.K. 3143). Culture only: Lancashire, Clitheroe, Dunsop Bridge, on dead wood of *Betula*, 23 Sep. 1962, J. Webster, culture CBS 814.68.

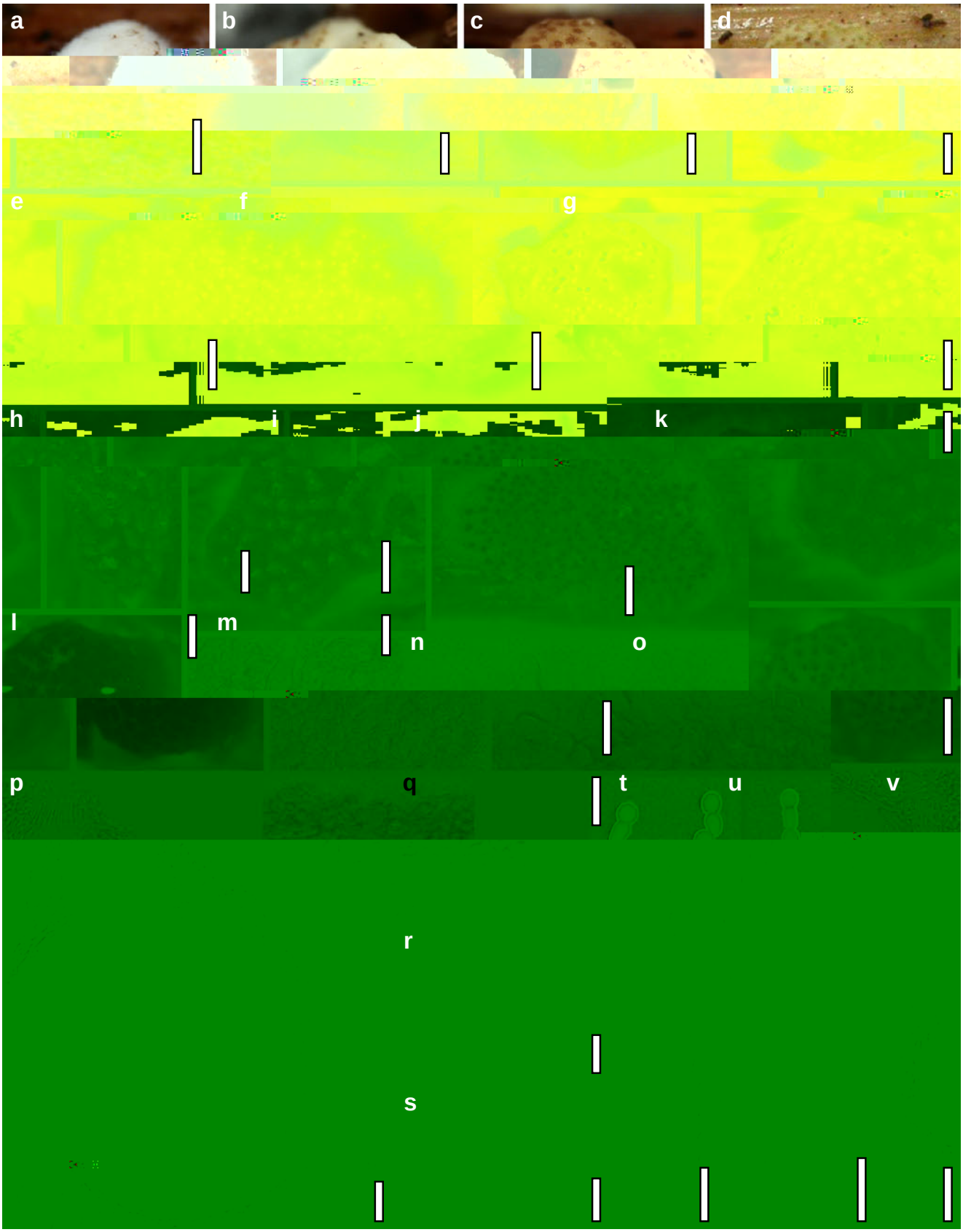
Notes: *Hypocrea pilulifera* seems to be specifically associated with *Betula* wood. A conspecificity of the material collected on *Heterobasidion annosum* (see Lu et al. 2004) has not been proven by gene sequences. The occurrence of the holotype specimen on *Juncus* may be a result of infection by this fungus from a *Betula* branch lying in a *Juncus* habitat. Several searches in such habitats including original collection sites in recent years failed to detect *H. pilulifera*, while *H. placentula* was found several times on *Juncus*. *H. placentula* differs from *H. pilulifera* by paler KOH+stromata with smaller perithecia and smaller ascospores, faster growth with a higher temperature optimum, and by ellipsoidal conidia produced in pustules lacking sterile elongations. In addition, conidiation in *H. placentula* starts terminal in the tuft, but within the pustule in *H. pilulifera*. Stromata of *H. pilulifera* are firmly attached

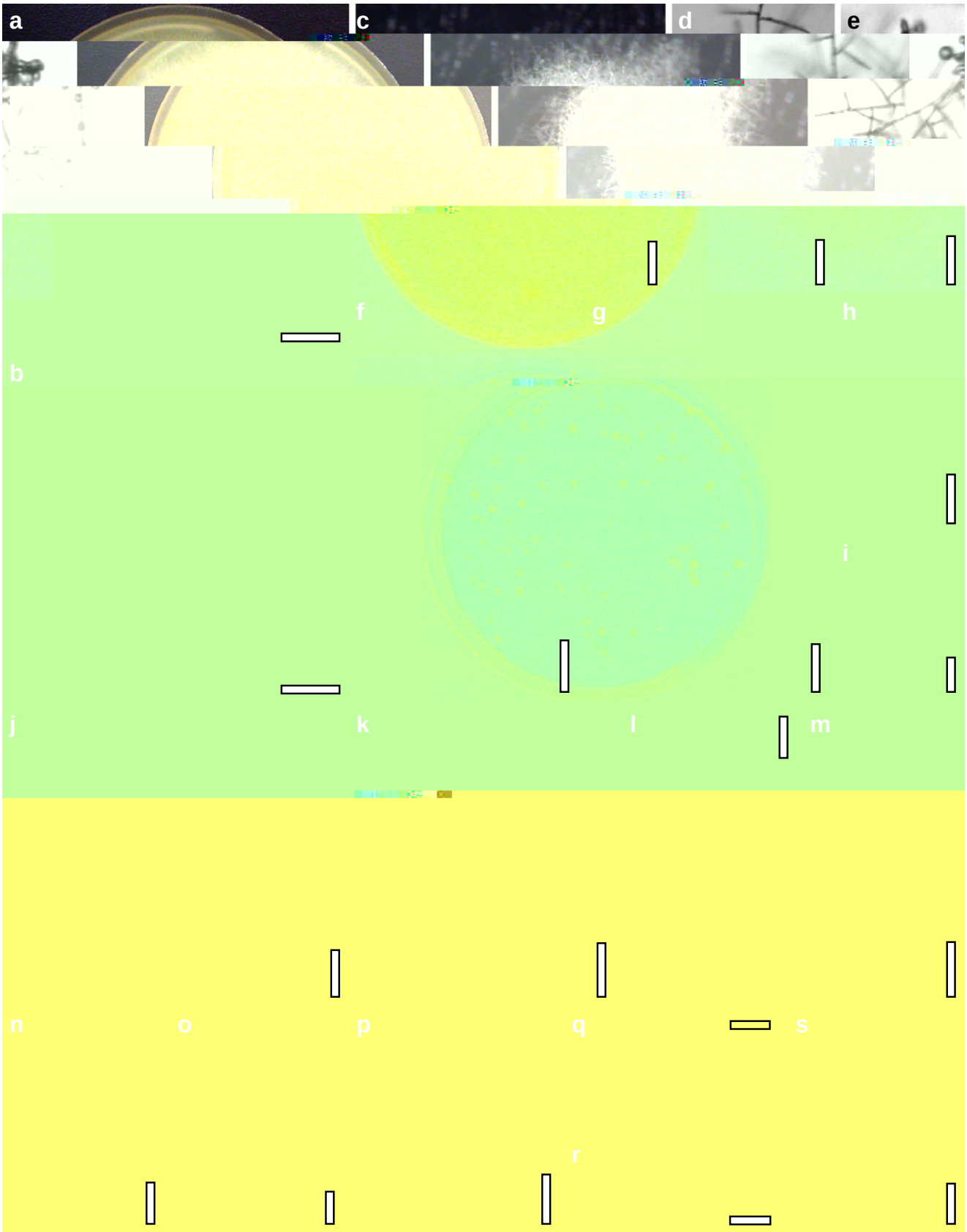
to the host, whereas those of *H. placentula* are only attached by hyphae and fall off easily. All other species of *Hypocrea* forming yellow stromata in Europe, have differently shaped conidia, including *H. bavarica*, which also occurs on *Betula*, and differs also by smaller ascospores, KOH+stromata and an effuse, verticillium-like conidiation.

The growth rates given above were determined with CBS 120927 after several transfers. Freshly prepared cultures of *H. pilulifera* grow considerably faster, e.g. C.P. K. 3143 covered a 90 mm diam Petri dish in *ca* 10 days on SNA at 15°C. This may indicate that richer media like MEA or OA should be used for precultures of growth rate experiments. However, the characteristic minute peg-like secondary hyphae were seen in all three isolates examined.

Hypocrea placentula Grove, J. Bot. (Lond.) 23: 133 (1885). Fig. 51
Anamorph: ***Trichoderma placentula*** Jaklitsch, **sp. nov.** Fig. 52
MycoBank MB 516698

Anamorphosis *Trichoderma placentula*: Conidiophora in agaro SNA emergentia ex pustulis laxis albis, stipitata, similia *Pachybasii*. Phialides vulgo in fasciculis brevibus, lageniformes, (4.5–)5.5–9.0(–12.5)×(2.3–)2.5–3.2(–


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
t
u
v
r
s


a
c
d
e
f
g
h
b
i
j
k
l
m
n
o
p
q
s
r

(2.0–)2.3–2.8(–3.2) µm, l/w (1.2–)1.5–1.9(–2.6) (*n*=120), oblong or wedge-shaped; contact areas truncate.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 9–12 mm at 15°C, 26–28 mm at 25°C, 15–24 mm at 30°C; mycelium covering the plate after 7–8 days at 25°C. Colony scarcely visible, hyaline, thin, dense, homogeneous, not zonate, with ill-defined, diffuse margin; of narrow reticulate hyphae with more or less rectangular branching and little variation in width. Aerial hyphae variable, inconspicuous. Autolytic activity absent, coilings variable, scant or common. No chlamydospores, only some hyphal thickenings seen. No diffusing pigment noted; odour indistinct. Conidiation scant, only seen in fresh cultures after entire covering of the plate by mycelium.

On PDA after 72 h 5–7 mm at 15°C, 23–25 mm at 25°C, 11–19 mm at 30°C; mycelium covering the plate after 10–11 days at 25°C. Colony dense, homogeneous, not zonate; margin diffuse, surface hyphae in marginal areas aggregated into radial strands. Aerial hyphae abundant, causing a whitish to yellowish downy surface, of two kinds, a) short, erect, spiny hyphae, disposed in dense lawns, particularly in distal areas superposed by an indistinctly zonate reticulum of b) long, several mm high aerial hyphae forming strands. Autolytic activity inconspicuous or moderate, coilings frequent. No diffusing pigment noted, reverse yellowish, 3–4AB4, 4B5; odour indistinct. No conidiation noted.

On SNA after 72 h 10–11 mm at 15°C, 27–28 mm at 25°C, 8–14 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony hyaline, thin, dense, homogeneous, not zonate; mycelium reticulate, with rectangular branching; hyphae with more conspicuous difference in width than on CMD; surface hyphae degenerating soon, appearing empty. Aerial hyphae common, several mm long and high, often branched in right angles. Autolytic activity inconspicuous, more pronounced at 15°C, coilings frequent. No chlamydospores, only some hyphal thickenings seen. No diffusing pigment, no distinct odour noted. Conidiation noted after (8–)13 days at 25°C, developing slowly, examined after 24–52 days; first scant on distal aerial hyphae and in short shrubs close to the distal margin. Shrubs growing to white fluffy tufts appearing in a broad distal zone, spreading back across the entire plate. Tufts compacting to pustules 0.5–3 mm diam, to 1 mm thick, with roundish or irregular outline, often semiglobose or oblong, remaining transparent; of a loose reticulum with branches conspicuously at right angles and straight main axes emerging from the reticulum in right angles. Main axes 100–150(–200) µm long, first appearing as erect sterile elongations. Branches and elongations beset with numerous small drops, appearing verrucose under low magnification, but dissolving in microscopic mounts. Elongations becoming fertile, i.e. conidiation first terminal, concentrated in the pustule periphery, later also within tufts, dense, eventually making them opaque. Conidiophores (main axes and side branches) 4–6 µm wide basally, attenuated upwards to 2.5–4 µm, smooth in microscopic preparations, sometimes with clamp-like thickenings, stipitate, with branches generally widely spaced, typically with a short terminal cluster of phialides and/or few short perpendicular branches, and with or without paired or unpaired, short, 1–4 celled side branches along their length. Clusters and side branches 15–40(–60) µm long, generally in right angles, typically of a terminal phialide or whorl of phialides and additional phialides or short, sometimes rebranching, branches on 1–3 levels below the terminal whorl, each branch with a whorl of phialides. Conidiophores with a regular tree-like shape uncommon. Phialides solitary or divergent, sometimes parallel, in whorls of 2–5(–6), often supported by short cells 4–6×2.5–4 µm. Conidia formed in small numbers in minute wet heads to 20 µm diam, often densely packed. Phialides (4.5–)5.5–9.0(–12.5)×(2.3–)2.5–3.2(–3.5) µm, l/w (1.5–)1.9–3.1(–4.7), (1.4–)1.8–2.5(–3.0) µm wide at the base (*n*=78), lageniform, less commonly ampulliform, mostly inaequilateral, straight or curved, rarely sinuous, with widening in variable position, mostly in or below the middle. Conidia (2.5–)2.8–3.5(–4.2)×2.0–2.5(–3.0) µm, l/w (1.0–)1.2–1.5(–1.8) (*n*=125), hyaline, ellipsoidal, less commonly subglobose or oblong, smooth, with several minute guttules, scar indistinct. At 15°C no conidiation seen.

Habitat: on recently dead culms of *Juncus effusus*, and gramineous and herbaceous plants.

Distribution: Europe (Denmark, Germany, United Kingdom).

Holotype: **United Kingdom**, Warwickshire, Olton Reservoir, base of *Juncus* stems, 13 Sep. 1884, W.B. Grove (K(M) 154041). ***Epitype***: **United Kingdom**, Derbyshire, Baslow,

6 m, on mostly basal parts of *Juncus effusus* stems, 24 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2943 (WU 29411, culture C.P.K. 2446). **Germany**, Niedersachsen, Landkreis Soltau-Fallingbostel, Soltau, Großes Moor, entering from Wardböhmen, 52°51′09″ N, 09°56′28″ E, elev. 70 m, on standing, dead and partly still green and thick tough culms of *Juncus effusus*, spreading to leaves, soc. old microfungi; 27 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2952 (WU 29412, culture CBS 121134=C.P.K. 2452). **United Kingdom**, Anglesey, Newborough Warren, on decaying stem of ? *Epilobium angustifolium*, Sep. 1988, P. Roberts (K; only culture IMI 328575 examined). Lancashire, Ribble Valley, Clitheroe, north from and close to Dunsop Bridge, 53°56′44″ N, 02°32′28″ W, elev. 300 m, on dead culms of *Juncus effusus*, 6 Sep. 2007, H. Voglmayr & W. Jaklitsch, W.J. 3139 (WU 29413, culture C.P.K. 3140).

Notes: *Hypocrea placentula* was described by Grove (1885) in a detailed manner including the anamorph on the natural substrate. Spooner and Williams (1990) redescribed it based on stromata grown on ?*Epilobium angustifolium*, prepared a culture and added a description of the anamorph in culture including a SEM image of the conidia. Their isolate IMI 328575 is identical in gene sequences and in the anamorph with recently collected material. It differs from *H. pilulifera*, which exceptionally occurs on culms of *Juncus*, by smaller and more homogeneously pigmented stromata, smaller perithecia, smaller ascospores with more distinctly dimorphic cells, a deeply yellow cortex and peridium, the latter turning red in KOH, presence of hair-like outgrowths on the stroma surface, more distinctly lageniform phialides, ellipsoidal conidia, conidiation on stipitate conidiophores becoming fertile from the tuft periphery, faster growth with its optimum at a higher temperature, and a different hyphal system lacking peg-like secondary hyphae in *H. placentula*.

European species of *Hypocrea* section *Hypocreanum* and other species forming large effused to subpulvinate stromata

Introduction

Trichoderma section *Hypocreanum* was established by Bissett (1991a) for anamorphs of *Hypocrea* (and *Podostroma*), with the type species *T. lacteum* Bissett [as *T. lactea*] formally described as the anamorph of *H. citrina*. Species of this section have primitive, sparsely branched, acremonium- to verticillium-like conidiophores and hyaline conidia highly variable in shape. Respective anamorphs are only rarely encountered in nature, which may be the reason why workers in this group did not establish combinations in *Trichoderma*. Epithets in *Trichoderma* for this section are here only established for newly described species, combinations for earlier described species are left to future researchers.

Stromata are usually large, widely effused or subpulvinate. Species of the section were reviewed by Overton et al. (2006a, b), who clarified the nomenclature of *H. citrina* and determined the phylogenetic positions of the species. Unfortunately several species, particularly some described by Doi (1972) from Japan, could not be subjected to sequencing yet. Acremonium- or verticillium-like conidiophores are plesiomorphic; they occur also in other clades than the phylogenetically conceived section *Hypocreanum*, and even outside generic limits. In terms of teleomorph morphology, several species of other clades form similar stromata, viz. *Hypocrea luteffusa* of the pachybasium core group and the species of the *Brevicompactum* clade. These species differ from those described here by green-conidial anamorphs and smaller stromata with minute cortical cells. This chapter describes species of *Hypocrea*/*Trichoderma* section *Hypocreanum* including some species of *Hypocrea* outside this section, with similar conidiophores and at the same time effused stromata reduced to subicula located ‘basal’ in the phylogenetic tree of the genus (Fig. 1).

Species descriptions

The following ten species including two new ones are described below: *H. alcalifuscescens*, *H. austriaca*, *H. citrina*, *H. decipiens*, *H. delicatula*, *H. parmastoi*, *H. phellinicola*, *H. protopulvinata*, *H. pulvinata*, and *H. sulphurea*. *Hypocrea austriaca* is based on *H. fungicola* f. *raduli*.

Hypocrea alcalifuscescens Overton, Stud. Mycol. 56: 62 (2006) Fig. 53

The holomorph of this species was described by Overton et al. (2006b). The following short description of the teleomorph is based on a re-examination of the holotype.

Stromata when dry 3–15×2.4–6.7 mm, 0.1–0.4 mm thick; effused, thin, entirely attached; surface finely downy, with circular, slightly papillate, black ostiolar dots (30–)37–60(–71) µm (*n*=30) diam; olivaceous-brown to yellow-brown, 3–5F4–6 to 5F7–8; similar when young and immature, but lacking ostiolar dots. A KOH-treated spot became hard, dark grey with silver shine and papillate surface (ostioles). Perithecia immersed in a single layer, peridium yellow in KOH. Ostioles with partly clavate cells on apices, 3–5 µm wide. Stroma tissues entirely prosenchymatous, a *t. intricata* of hyphae (2.5–)3.0–10.5(–18.5) µm (*n*=45) wide, thin-walled, hyaline to dilute olive-yellow, with stronger pigmentation close to the surface; hyphae in part submoniliform with distinctly inflated cells. Asci (89–)93–114(–127)×(4.5–)5.0–5.7(–6.5) µm

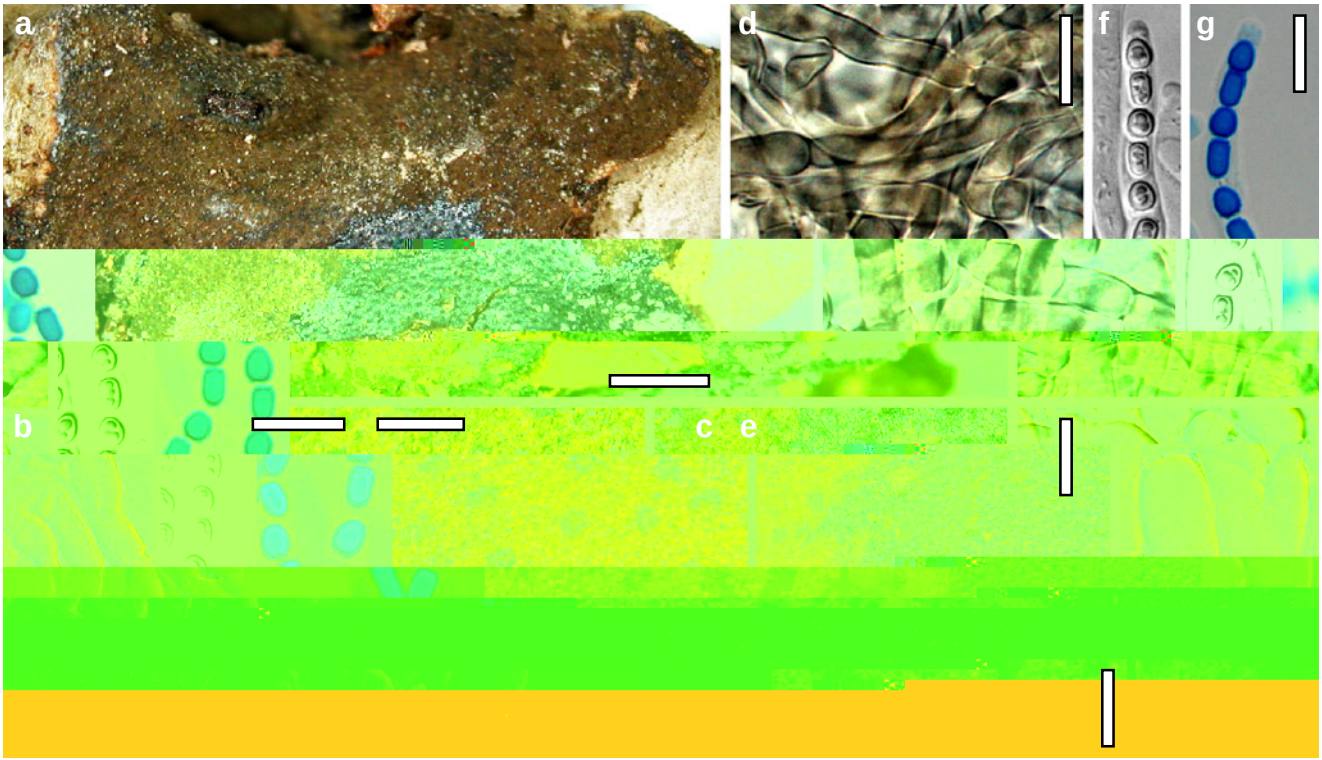


Fig. 53 Teleomorph of *Hypocrea alcalifuscescens* (holotype BPI 843638). **a–c**. Dry stroma (**b**. part of KOH-treated spot; **c**. stroma surface with ostiolar dots). **d, e**. Subiculum hyphae (**d**. close to the surface, **e.** submoniliform hyphae). **f, g.** Asci (**g**. in cotton blue/lactic acid). *Scale bars* **a**=1.5 mm. **b**=0.4 mm. **c**=150 µm. **d–g**=10 µm

(*n*=30), stipe (7–)10–27(–42) µm (*n*=30) long; no croziers seen. Ascospores hyaline, smooth to finely verruculose, cells dimorphic; distal cell (3.5–)3.8–4.5(–5.0)×(3.3–)3.5–3.7(–4.0) µm, l/w (1–)1.1–1.3(–1.5) (*n*=30), (sub)globose to ellipsoidal, less commonly wedge-shaped; proximal cell (3.7–)4.4–5.6(–6.2)×(2.7–)2.8–3.0(–3.2) µm, l/w (1.3–)1.5–1.9(–2.2) (*n*=30), oblong (to ellipsoidal or subglobose).

Habitat: on a *Piloderma* or *Amauroderma* sp. on forest debris

Distribution: Europe (Estonia) and USA (Delaware).

Holotype: **Estonia**, on a *Piloderma* (?*Amauroderma*) sp., 13 Sep. 2000, U. Kõljalg, BPI 843638, ex-type culture TFC 2000-36).

Notes: This is one of the few species in *Hypocrea* that exhibit an entirely prosenchymatous stroma. In addition, it differs from all other species of the genus in its olive colour. *Hypocrea alcalifuscescens* is probably fungicolous. In the holotype the corticiaceous host (pale yellow loose mycelium without clamps) grew apparently on bark of *Picea* or *Pinus* and saw dust. Whether the specimen reported by Overton et al. (2006b) from bark of *Liriodendron* in Delaware, USA represents the same species is unclear, because no gene sequences from this specimen are available.

Hypocrea austriaca Jaklitsch & Voglmayr, **sp. nov.** Fig. 54

MycoBank MB 516670

= *Hypocrea fungicola* f. *raduli* Höhn. in Rehm, Ann. Mycol. 3: 227 (1905).

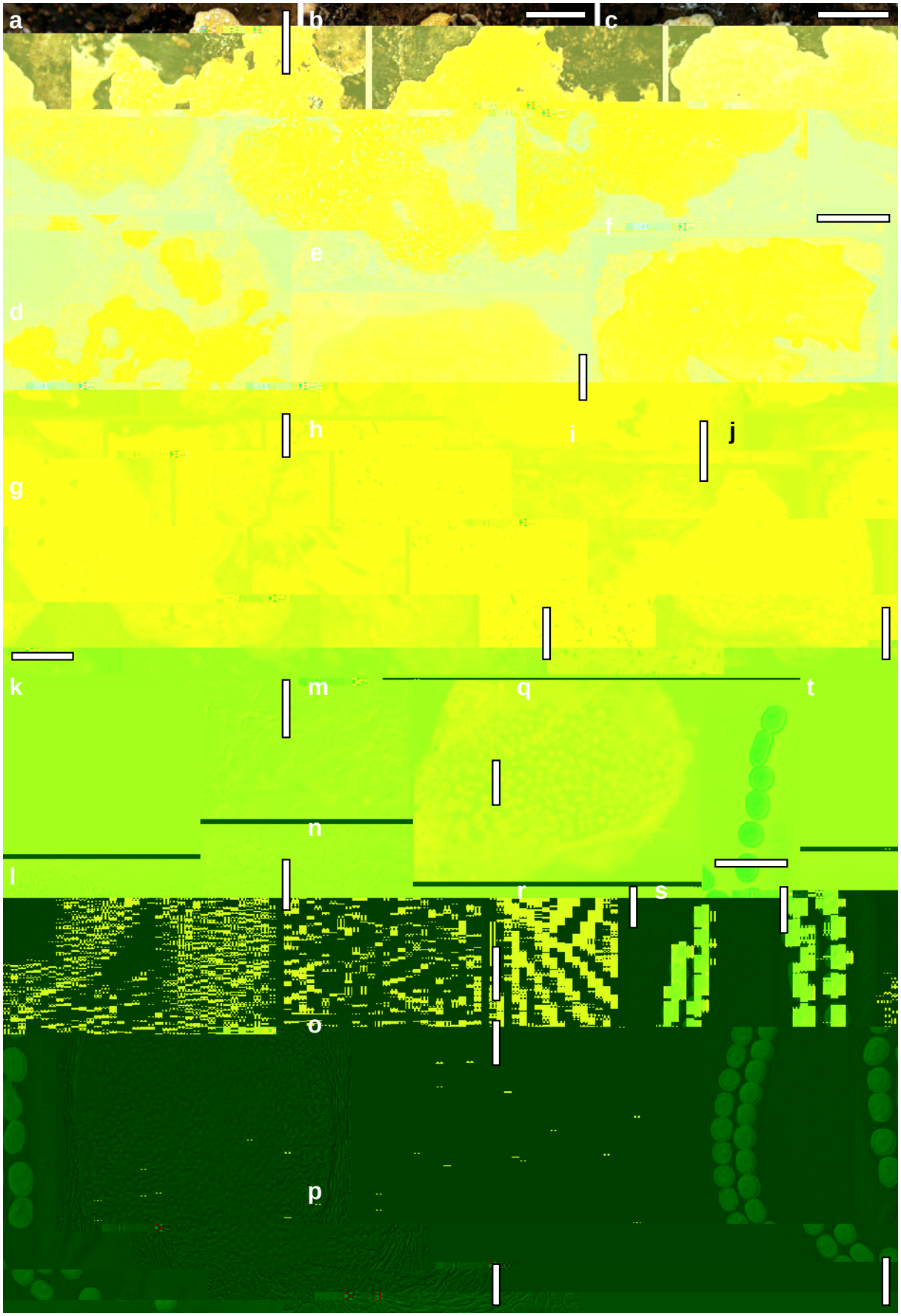
Anamorph: ***Trichoderma austriacum*** Jaklitsch, **sp. nov.** Fig. 55

MycoBank MB 516671

Stromata late effusa, lutea, 1–60×1–20 mm. Asci cylindrici, (64–)81–106(–115)×(4.8–)5.4–6.6(–8.0) µm. Ascosporae bicellulares, hyalinae, verruculosae vel spinulosae, ad septum disarticulatae, pars distalis (sub)globosa vel ellipsoidea, (3.7–)4.2–5.0(–5.7)×(3.0–)3.6–4.2(–4.7) µm, pars proxima ellipsoidea vel oblonga, (4.3–)4.7–5.6(–6.5)×(2.8–)3.2–3.8(–4.5) µm. Anamorphosis *Trichoderma austriacum*. Conidiophora in agaro PDA effuse disposita, simplicia, ramis sparsis brevibus praedita, similia *Acremonii* vel *Verticillii*. Phialides divergentes, subulatae vel lageniformes, (9–)15–30(–46)×(2.3–)3.0–3.5(–4.0) µm. Conidia oblonga, cylindracea vel ellipsoidea, hyalina, glabra, (3.7–)4.7–10(–18)×(2.3–)3.0–4.0(–5.5) µm.

Etymology: referring to its occurrence in Austria.

Stromata when fresh 1–60×1–20 mm, 0.3–0.8(–1.2) mm thick, thinly and widely effuse, sometimes appearing subpulvinate due to substrate protuberances. Outline variable. Margin mostly broadly rounded, with free edges. Surface smooth, sometimes with white floccules when young.


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t

◀ **Fig. 54** Teleomorph of *Hypocrea austriaca*. **a–d**. Fresh stromata. **e–i**. Dry stromata (**i**. part of stroma on basidiome of *Eichleriella deglubens*). **j**. Stroma surface in 3% KOH after rehydration. **k**. Ostiole in section. **l**. Perithecium in section. **m**. Surface of stroma in face view. **n**. Cortical and subcortical tissue in section. **o**. Subperithecial tissue in section. **p**. Stroma base in section. **q**. Rehydrated stroma. **r–t**. Asci with ascospores (**s, t**. in cotton blue/lactic acid). **a–c, f–h, j–q, s**. WU 29193. **d**. WU 29194. **e, r**. WU 29192. **i, t**. *H. fungicola* **f**. *raduli* (FH). *Scale bars* **a**, c=2 mm. **b**, **e**=3 mm. **d**, **j**=0.3 mm. **f**=7 mm**. g, i, q**=1 mm. **h**=0.5 mm. **k, m, n**, **p**=15 μm. **l**=30 μm. **o**=20 μm. **r–t**= 10 μm

Ostiolar dots plane, pale yellow to yellow-brown on a white to pale yellowish stroma surface. Resulting stroma colour pale or greyish yellow, 3A2–6, 3B4–8. Spore deposits white.

Stromata when dry 1–26(–55)×(0.5–)1–11(–28) mm, 0.1–0.6(–0.8) mm thick (*n*=44), solitary, gregarious or aggregated in small numbers; with effluent development, i.e. formed in a large mass, breaking up into smaller stromata, forming blank spaces within; thin, membranaceous, widely effuse, first entirely attached, often becoming detached at the margins; easily detachable from wood. Outline variable, oblong, lobed or circular. Margin usually compact and rounded, less commonly with white, compact, rarely arachnoid white marginal mycelium or radiating hyphae. Surface smooth or tubercular due to unevenness of the substrate. Ostiolar dots (30–)40–90(–160) μm (*n*=80) diam, numerous and densely disposed, plane or convex, diffuse and pale yellow when young, well-defined, circular and bright yellow, reddish orange or brown when mature. Colour more intense than in fresh stromata, typically bright yellow, 3A4–7, 4A4–5, or greyish- to orange-yellow, 4B4–7. Rehydrated stromata distinctly lighter in colour than dry ones, white with well-defined, convex, pale yellow-ochre dots 80–105(–240) μm diam; when wet (after prolonged incubation) entire surface homogeneously coloured like the ostiolar dots. After addition of 3% KOH no distinct colour change noted, but perithecia swelling and dots larger, 150–250 μm, i.e. larger parts of perithecial walls becoming visible.

Stroma anatomy: Ostioles (64–)72–88(–98) μm long, plane or projecting to 30(–40) μm, (36–)48–70(–80) μm wide at the apex (*n*=30), cylindrical, periphysate, with a marginal palisade of clavate or (sub)globose terminal cells, 5–10(–13) μm wide, at the apex. Perithecia (185–)215–270(–305)× (100–)145–230(–260) μm (*n*=30), globose or flask-shaped. Peridium (13–)15–22(–26) μm thick at the base, (7–)10–17(–19) μm at the sides (*n*=30), pale yellowish, at the base often difficult to differentiate from subperithecial tissue. Cortical layer (20–)24–40(–54) μm (*n*=30) thick, a hyaline to pale yellowish *t. angularis* of isodiametric or oblong, thin-walled cells (5–)7–18(–32)×(4–)5–13(–20) μm (*n*=35) in face view, and (4–)5–15(–23)×(3.5–)4.5–7.5(–10) μm in vertical section (*n*=35); pale yellow in KOH. No hairs, but some solitary, projecting cells seen on surface. Subcortical tissue if present a *t. intricata* of hyaline, thin-walled hyphae (2.5–)4–8 (–9) μm (*n*=30) wide. Subperithecial tissue narrow, a hyaline *t. angularis* of thin-walled cells (6–)10–31(–43)×(6–)8–17(–25) μm (*n*=35), interspersed with some wide hyphae. Base consisting of a narrow layer of variably oriented, thick-walled, (sub)hyaline hyphae (2.5–)3.5–7.0(–9.5) μm (*n*=30) wide. Asci (64–)85–113(–126)×(4.8–)5.5–7.0(–8.0) μm, stipe (0–)3–23(–47) μm long (*n*=80). Ascospores hyaline, verruculose or finely spinulose, cells dimorphic, often with little difference between cells; distal cell (3.7–)4.3–5.5(–6.5)×(3.0–)3.7–4.5(–5.0) μm, l/w (0.9–)1.1–1.3(–1.6) (*n*= 168), (sub)globose or ellipsoidal; proximal cell (4.0–)4.5–6.5 (–9.2)×(2.8–)3.2–4.0(–4.5) μm, l/w (1.1–)1.3–1.8(–2.4) (*n*= 168), ellipsoidal, oblong or wedge-shaped.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 13–20 mm at 15°C, 38–40 mm at 25°C, 30–33 mm at 30°C; mycelium covering plate after 5 days at 25°C. Colony hyaline, thin, not zonate; mycelium loose, little on the surface, with conspicuously thick primary and thin secondary hyphae, surface hyphae soon appearing empty; mycelium becoming dense in the distal half, with long aerial hyphae and conidiophores on the colony surface. Aerial hyphae scant, becoming more frequent with time and forming white floccules after *ca* 2 weeks, causing a mottled appearance of the colony surface. No autolytic excretions noted, coilings inconspicuous. No diffusing pigment, no distinct odour noted. Conidiation noted after 3–4 days, scant, short, simple, acremonium- to irregularly verticillium-like, longer and slightly denser towards the distal margin, also submerged in the agar. Phialides scattered and solitary on surface hyphae, or in whorls of 3–4. Conidia densely packed in minute heads, first wet, soon dry. Chlamydospores noted after 5–7 days, measured after 17 days, (6–)9–22(–32)×(6–)9–17(–22) μm, l/w 0.9–1.5(–2.3) (*n*=32), uncommon and with uneven distribution, globose, also oblong, ellipsoidal, oval or clavate, terminal and intercalary.

On PDA after 72 h 4–7 mm at 15°C, 8–13 mm at 25°C, 4–5 mm at 30°C; mycelium covering plate after 6 days at 25°C. Growth slow with a distinct lag phase of *ca* 2 days, followed by considerably faster logarithmic growth. Colony circular, dense, margin wavy to sublobed; hyphae with short, forked terminal branches at the colony margin; surface becoming white and hairy due to aerial hyphae. Aerial hyphae numerous, wide, radially arranged, forming strands and large crossing points and drops. Centre remaining flat, with few aerial hyphae, turning yellow, pale orange, greyish orange to brown-orange, 5AB4, 5BC5–6. No autolytic excretions noted, coilings inconspicuous. Odour indistinct or slightly must-like. Conidiation noted after 3 days, effuse, concentrated in the flat centre, also spreading in a lawn at low levels, short or ascending on

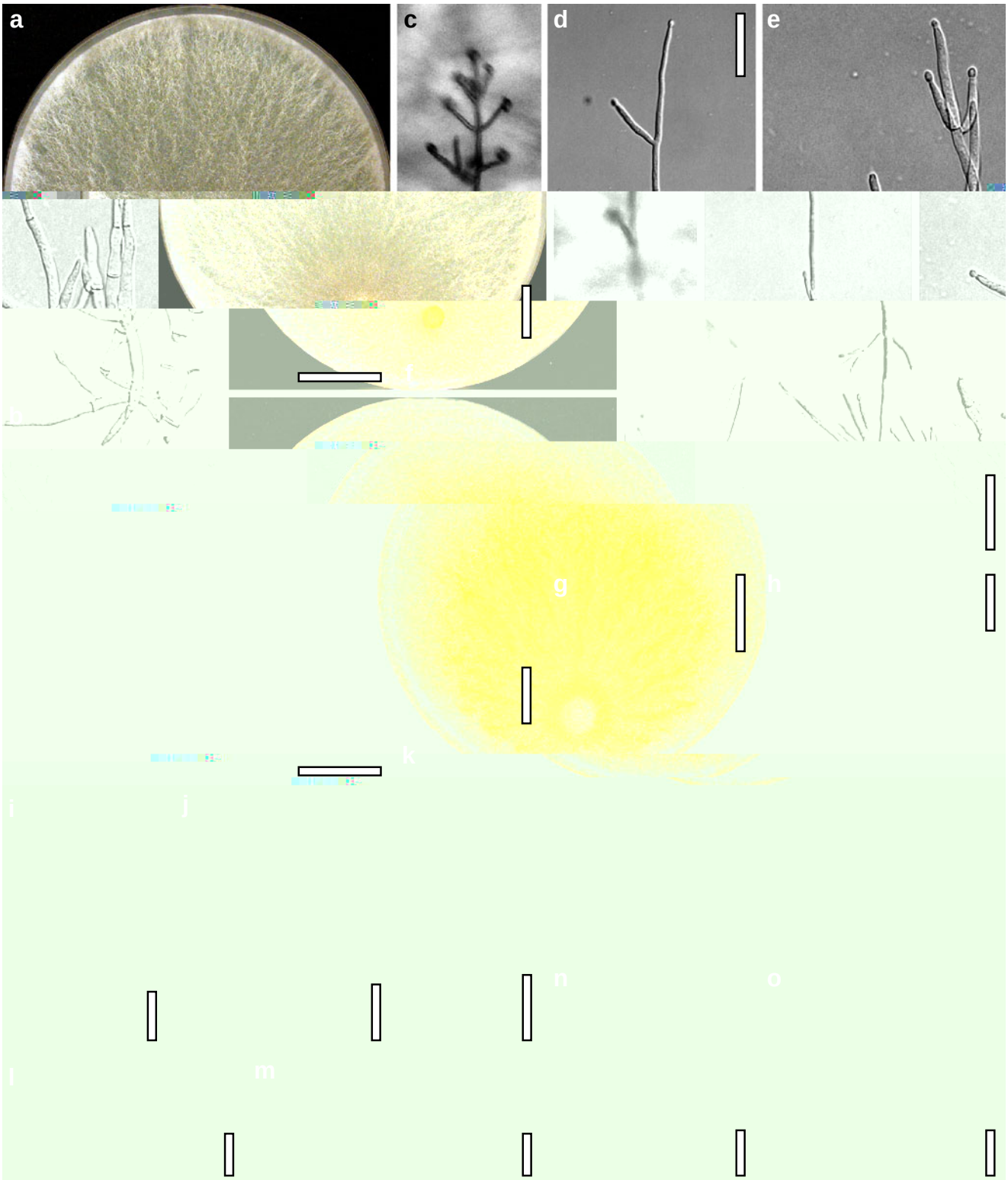


Fig. 55 Cultures and anamorph of *Hypocrea austriaca*. **a, b**. Cultures on PDA (**a**. 25°C, 7 days. **b**. 30°C, 10 days). **c**. Conidiophore on growth plate. **d, e, g, h**. Conidiophores. **f, j, k**. Phialides**. i, l**. Chlamydospores (CMD, 17 days). **m–o**. Conidia. **a**–**o**. All on/from PDA except **i** and **l. c–h, j, k, m–o. At** 25°C after 4 days. **a–d, g, i, k, l.** CBS 122494. **e, f, h, j, m–o**. CBS 122770. *Scale bars* **a**, **b**=19 mm. **c, d**, **g**=40 µm. **e**, **h**=20 µm. **f**, **i**–**l**=10 µm. **m**–**o**=5 µm

aerial hyphae, simple, acremonium- to irregularly verticillium-like. Conidiophores loosely disposed, mostly to 200(–300) µm long on surface hyphae, *ca* 100 µm long on aerial hyphae; simple, of a thick-walled axis, 6–10 µm wide at and close to the base, attenuated upward to 4–6 µm, unbranched, with solitary phialides or a single terminal whorl of phialides, or with sparse, short, typically unpaired, 1-celled side branches in various angles, also downward, 2–3(–4) µm wide, corresponding to the width of the phialide origins. Phialides often solitary or divergent in whorls of 2–4. Phialides (9–)15–30(–46)×(2.3–)3.0–3.5(–4.0) µm, l/w (3.1–)4.8–9.4(–12), (1.4–)2.0–3.2(–4.0) µm wide at the base (n=70), subulate or lageniform, mostly equilateral, widest at or slightly above the base, symmetric or slightly curved or sinuous. Conidia mostly formed in dry heads <30 µm diam; conidia (3.7–)4.7–10(–18)×(2.3–)3.0–4.0(–5.5) µm, l/w (1.2–)1.4–2.8(–4.4) (n=70), hyaline, smooth, variable, mostly oblong, but also ellipsoidal or subglobose (small) or long-cylindrical (large), with or without minute guttules, scar indistinct or truncate; often adhering in globose packets of *ca* 5(–10). At 30°C colony circular, thick, dense. Aerial hyphae forming strands arranged in a stellate manner, becoming yellow-orange. Conidiation inconspicuous, spreading across the plate. Diffusing pigment discolouring the agar bright yellow, 3A4–8, 4AB5–6, from the centre, changing to bright orange, 4A7–8, 5AB6–8; margin subsequently becoming covered by white cottony mycelium.

On SNA after 72 h 6–9 mm at 15°C, 16–20 mm at 25°C, 12–17 mm at 30°C; mycelium covering the plate after 9 days at 25°C. Colony circular, considerably denser than on CMD, indistinctly zonate; margin ill-defined; superficial mycelium locally condensed to 0.5 mm diam with numerous conidial heads on the top. Aerial hyphae inconspicuous, loose, becoming fertile. Autolytic excretions scant, coilings moderate. Chlamydospores noted after 5–7 days, uncommon, variable, terminal and intercalary. Conidiation noted after 2 days, similar to but more pronounced than that on CMD, mostly acremonium-like; conidia formed in wet heads <50 µm diam.

Habitat: on and around basidiomes of *Eichleriella deglubens*, particularly on branches of *Populus tremula*.

Distribution: Eastern Austria.

Holotype: **Austria**, Vienna, 23rd district, Maurer Wald, MTB 7863/4, 48°09′00″ N 16°15′11″ E, elev. 330 m, on basidiomes of *Eichleriella deglubens* on a branch of *Populus tremula*, also on bark, wood and effete ?*Cryptosphaeria lignyota*, soc. hyphomycetes, 4 Oct. 2007, H. Voglmayr, W.J. 3175 (**WU 29193**, ex-type culture CBS 122494=C.P.K. 3165). ***Holotype*** of *Trichoderma austriacum* isolated from WU 29193 and deposited as a dry culture with the holotype of *H. austriaca* as **WU 29193a**.

Other specimens examined: **Austria**, Burgenland, Bad Sauerbrunn, Hirmer Wald, MTB 8264/1, elev. *ca* 250 m, on basidiomes of *Eichleriella deglubens* on a branch of *Populus tremula*, soc. effete *Cryptosphaeria lignyota* in the bark, 10 Aug. 2008, A. Urban, W.J. 3213 (WU 29194, culture CBS 123829=C.P.K. 3538. Niederösterreich, Tulln, Langenschönbichler Donau-Auen, on *Radulum kmetii* (=*Eichleriella deglubens*) and bark of *Populus* sp., soc. effete ?*Cryptosphaeria lignyota*, Oct. 1904, Höhnel (Rehm: Ascomycetes exs. Fasc. 34, no. 1588; as *H. fungicola* f. *raduli* in M! and FH!). Weichtalklamm, south side of Schneeberg, MTB 8260/4, elev. *ca* 1000 m, on a branch of ?*Populus tremula*, on wood, soc. effete pyrenomycete, and rhizomorphs, 17 Jun. 2007, A. Urban, W.J. 3101 (WU 29192, culture CBS 122770=C.P.K. 3124). Vienna, 23rd district, Maurer Wald, MTB 7863/4, on basidiomes of *Eichleriella deglubens* on *Populus tremula*, 8 Oct. 2009, H. Voglmayr, WU 29538.

Notes: *Hypocrea austriaca* appears to be specifically associated with the heterobasidiomycete *Eichleriella deglubens*. The latter occurs typically on *Populus tremula* in eastern Austria; basidiomes are usually sterile at the time of infection and stroma development. In the occurrence on a heterobasidiomycete and in morphology *H. austriaca* is similar to *H. sulphurea*, which differs in a more intense, deep yellow colour when fresh and by slightly larger ascospores from *H. austriaca*. Growth of *H. austriaca* on PDA is substantially slower than that of *H. sulphurea* or *H. citrina*. *Hypocrea fungicola* f. *raduli* was edited as a part of an exsiccatum by Rehm (1905). No description apart from collection data and the presumed host *Radulum kmetii* Bres. was given. The latter is now considered a synonym of *Eichleriella deglubens* (Berk. & Broome) Lloyd. Two parts of Höhnel's specimen (from M and FH) were examined. They agree with recently collected material, except for some large aberrant ascospores. The basidiomycetous host is not apparent in the part in M. Phylogenetically the closest relative of *H. austriaca* is the morphologically similar Australian *H. victoriensis*. No fungal host of the latter has been detected yet.

Hypocrea citrina (Pers. : Fr.) Fr., Summa Veg. Scand.: 383 (1849). Fig. 56

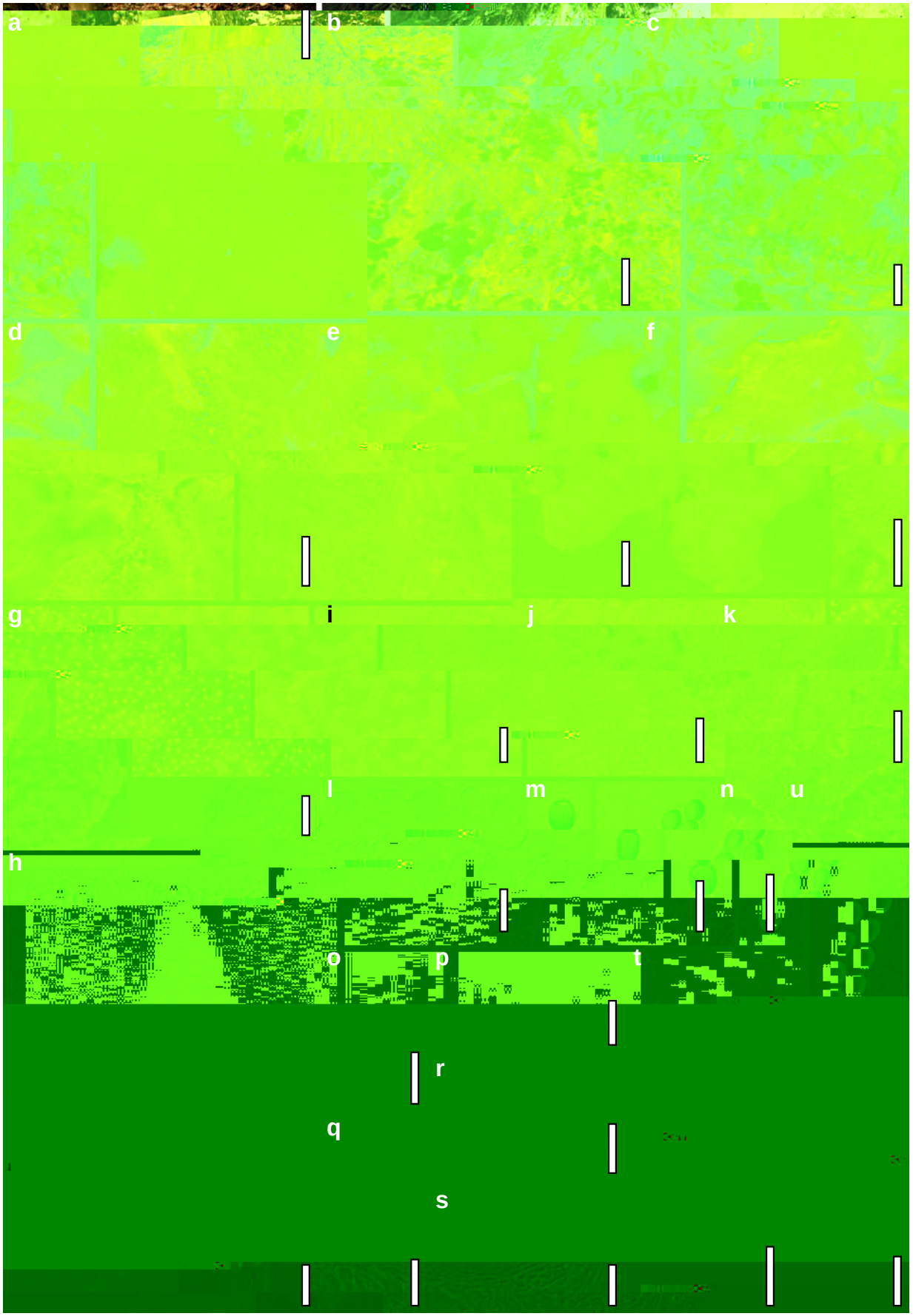
≡ *Sphaeria citrina* Pers., Obs. Mycol. 1: 68. 1796 : Fr., Syst. Mycol. 2: 337 (1823).

= *Sphaeria lactea* Fr., K. Svenska VetenskAkad. Handl. II, 37: 141. 1816 : Fr., Syst. Mycol. 2: 337 (1823).

≡ *Hypocrea lactea* (Fr. : Fr.) Fr., Summa Veg. Scand.: 383 (1849).

Anamorph: *Trichoderma lacteum* Bissett [sect. Hypocreanum Bissett], Can. J. Bot. 69: 2367 (1991a). Fig. 57

Stromata when fresh 1–40×1–20 cm, 1–4 mm thick, widely effuse, indeterminate, covering large areas of tree stumps, forest soil and debris, usually spreading as one

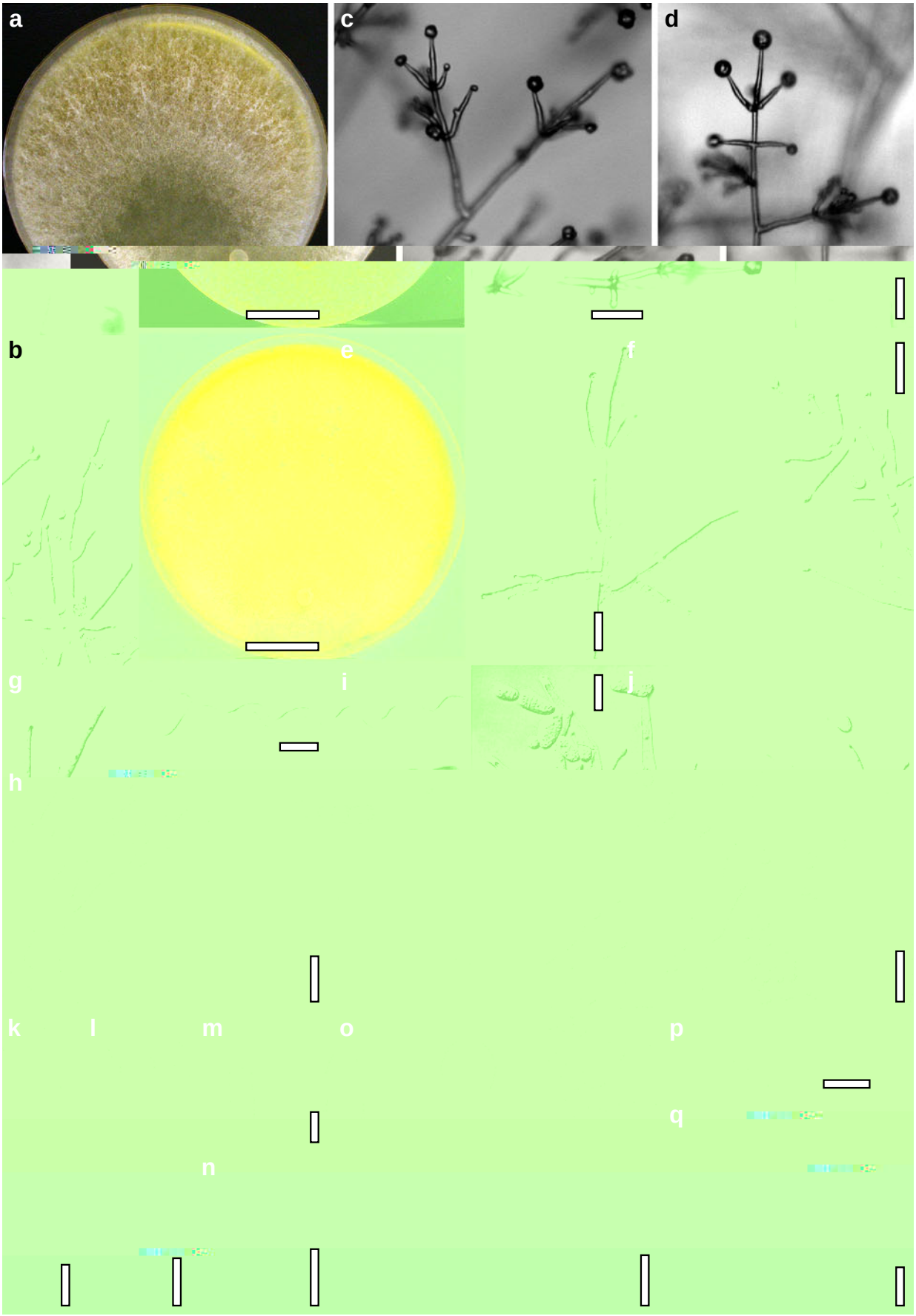

a
b
c
d
e
f
g
i
j
k
l
m
n
u
h
o
p
t
r
q
s

large mass on the substrate forming irregular patches with discontinuities, eventually sometimes dividing into discrete part stromata; entirely attached. Margin usually sterile, white or concolorous, mycelial. Surface smooth or irregularly wrinkled. Perithecia entirely immersed, ostiolar dots circular, brown. Colour whitish, pale citrine, greyish yellow, or light brown, 3A3–4, 3B4–6, 5D6–7, 4C7–8; dull and dark yellow- or olive-brown when old.

Stromata when dry 0.2–3.4 mm (n=33) thick, widely effuse, following and incrusting debris; starting as white mycelium, becoming compact, white with indistinct yellowish ostiolar dots, turning yellow with brown dots. Outline extremely variable. Margin often thin, cottony, white or yellowish. Surface smooth, becoming farinose due to spore powder. Ostiolar dots (35–)45–77(–90) μm (n=33) diam, in young stromata diffuse and honey coloured or yellowish-brown, later fine but distinct, plane to convex or semiglobose, medium, olive- or dark brown, numerous, variably arranged. Stromata at first white to pale yellow (corresponding to stroma surface with no or few ostiolar dots), 1–3A2, becoming dull or greyish yellow to olive-brown, or brown-orange, 2–4A2–3(–4), 3–4B3–4(–5), 4CD4–8, 5CD3–4, (5E6–8); white inside. Spore powder white or yellow. Rehydrated stromata not changing colour or turning slightly brownish in 3% KOH.

Stroma anatomy: Ostioles (55–)65–90(–115) μm long, projecting to 13(–20) μm, (30–)34–51(–55) μm wide at the apex (n=20), periphysate, lined at the apex by hyaline, clavate to cylindrical cells to 7 μm wide, broadly rounded at ends. Perithecia (166–)200–280(–300)×(82–)130–210(–230) μm (n=20), flask-shaped or globose, laterally compressed when crowded; peridium (14–)17–24(–27) μm thick at the base, (7–)9–16(–20) μm at the sides (n=20), hyaline to pale yellowish. Cortical layer (22–)28–58(–87) μm (n=30) thick, a hyaline to pale yellowish *t. globulosa-angularis* of thin-walled, globose, angular or oblong cells (4–)7–15(–20)×(3.5–)6–11(–15) μm (n=60) in face view and in vertical section, penetrated by some hyphae of subcortical origin. Hairs on mature stroma (10–)16–30(–40)×(3.5–)5–9(–11) μm (n=20), inconspicuous, 1–3 celled, smooth or slightly verruculose, of variable shape, often ampulliform or appearing as short, submoniliform chains of cells. Subcortical tissue a hyaline *t. intricata* of thin-walled hyphae (2–)4–7(–9) μm (n=30) wide, in part appearing as *t. globulosa* due to variable orientation of hyphae. Subperithecial tissue a dense *t. epidermoidea* of thin-walled cells (4.5–)6–22(–34)×(3.5–)6–13(–16) μm (n=30), penetrated by hyphae (4–)5–10(–12) μm (n=20) wide. Stroma base a loose hyaline *t. intricata* of thin-walled hyphae (3–)4–9(–12) μm (n=20) wide. Asci (84–)93–115(–124)×(5.0–)5.3–6.3(–7.0) μm, stipe (2–)5–17(–30) μm long (n=30); base not or slightly thickened, no croziers seen. Ascospores hyaline, verrucose or spinulose, cells dimorphic, distal cell (3.7–)4.4–5.2(–5.8)×(3.5–)3.8–4.4(–4.8) μm, l/w (1.0–)1.1–1.3(–1.5) (n=90), subglobose, oval or oblong, proximal cell (3.6–)4.7–6.0(–7.0)×(2.8–)3.3–4.0(–4.3) μm, l/w (1.0–)1.3–1.7(–2.1) (n=90), oblong or wedge-shaped; often turning yellow or orange after ejection.

Cultures and anamorph: optimal growth at 25°C on CMD and PDA, at 25–


a
c
d
b
e
f
g
i
j
h
k
l
m
o
p
q
n

aerial hyphae. At 30°C alternating broad and narrow concentric zones, flat radial mat of aerial hyphae and abundant conidiation after 2–3 days produced. Pigment conspicuous, more intense than at 25°C, first light yellow to orange-yellow, 2–3A3–6, 4AB7–8, turning bright orange, golden yellow to orange-brown, 5BC7–8, 6AC6–8, 7C7–8.

On SNA after 72 h 10–12 mm at 15°C, 31–33 mm at 25°C, 28–32 mm at 30°C; mycelium covering the plate after 6 days at 25°C. Colony hyaline, hardly visible, thin, smooth, not zonate, hyphae loosely disposed. Aerial hyphae apparent toward the downy or floccose distal margin, becoming fertile. No autolytic activity and coilings, no distinct odour and pigment noted. Chlamydospores noted after 4 days at 15°C (after 7 days at 25°C, less commonly), 6–21(–66)×(4–)6–10(–12) µm, l/w 0.9–2.4(–4.0) (*n*=51), abundant, more frequent than on CMD, terminal and intercalary, variable in shape and size, globose, oval, ellipsoidal, fusoid, clavate or rectangular, sometimes 2–3(–4)-celled, smooth. Conidiation noted after

18′49″ E, elev. 250 m, on corticated branch of *Picea abies* 11 cm thick lying on the ground, on bark, infected by a hyphomycete, soc. *Trichoderma viride*, 19 Sep. 2003, J. Holec & W. Jaklitsch, W.J. 2398 (WU 29207, culture C.P. K. 961). **Netherlands**, Putten, in Drie-Continentenbos of the arboretum Landgoed Schovenhorst, elev. 0 m, on and around thick old stump of *Pseudotsuga menziesii* 1 m thick, on bark, soil and plants, 19 Nov. 2006, H. Voglmayr, W.J. 3046 (WU 29212). **United Kingdom**, Devon, Bovey Tracey, Great Plantation, SX8275, 50°35′00″ N, 03°41′00″ W, elev. 60 m, on soil and forest litter, 5 Sep. 2004, P. Roberts, (WU 29208, culture C.P.K. 1909).

Notes: Overton et al. (2006a) clarified the complex nomenclature of this widespread species. They also pointed out that *Hypocrea lactea* sensu Doi (1972) is probably a different taxon in Japan. *Hypocrea citrina* differs from other species forming effuse stromata by growth on soil and forest debris. It forms the largest stromata known in *Hypocrea*. *H. sulphurea* differs e.g. by distinctly brighter stroma colour, occurrence on *Exidia* on branches, larger ascospores, lack of hairs on the stroma surface and lack of chlamydospores in culture. *Hypocrea pulvinata* differs from *H. citrina* by its occurrence on polypores, a tendency to form determinate pulvinate stromata, inhomogeneously distributed pigment and verrucose hairs on the stroma surface, lanceolate ostiolar cells, and slightly smaller, more or less monomorphic ascospores. *H. auranteffusa*, *H. margaretensis*, *H. luteffusa,* and *H. rodmanii* differ e.g. by minute cortical cells and green-conidial anamorphs. The moniliform surface hyphae on PDA around the plug seem to be characteristic for *H. citrina*; in addition all fresh isolates of *H. citrina* formed a yellow to orange pigment on PDA, particularly at 30°C. This ability may be lost in older strains, as the CBS strain studied by Overton et al. (2006a) did not form a distinct pigment.

Hypocrea decipiens Jaklitsch, K. Põldmaa & Samuels, Mycologia 100: 981 (2008a). Fig. 58
= '*Hypocrea farinosa* Berk. & Broome' sensu Overton et al. Stud. Mycol. 56: 59 (2006).
[non *Hypocrea farinosa* Berk. & Broome, Ann. Mag. Nat. Hist. Ser. 2, 7: 186 (1851).]
Anamorph: *Trichoderma* sp., acremonium/verticillium-like.

For descriptions and illustrations see Overton et al. (2006b) under *Hypocrea farinosa*. A short redescription of stromata based on a re-examination of the holotype is given here.

Stromata when dry 5–43×2–17 mm, 0.1–0.4 mm thick (n=9), thinly effuse, indeterminate, entirely attached. Margin hyphal, white or yellowish. Stroma surface smooth, or more or less farinose, uneven, also rugose, depending on substrate contours; whitish between ostiolar dots or perithecia. Ostiolar dots (16–)22–38(–50) µm (n=30) diam in face view when dry, prominent, papillate or conical, concolorous with or lighter than the perithecial apex, sometimes surrounded at the apex by a white fringe of often apically enlarged hyphae. Perithecial outlines translucent, visible part (35–)45–155(–205) µm (n=30) diam in face view when dry. Perithecia brown, numerous, crowded, slightly projecting, some free at the margin, globose, not collapsed except for few old perithecia. Colour brown-orange or light brown, 5CD4–5(–5B3), 6CD5–6; a previously KOH-treated spot was discoloured orange- to reddish-brown, 8CD5–8. Younger stroma parts lighter or whitish, with perithecia at larger distances. Spore deposits fine, white. Stroma turning orange-brown in 3% KOH, with stromatal hyphae and cells remaining unchanged, but peridium turning bright orange; bright yellow after subsequent addition of lactic acid. Cortical tissue of hyaline or brownish, thin-walled hyphae (3.0–)3.5–6.0(–7.5) µm (n=30) wide; surface pseudoparenchymatous around the ostioles in face view. Subperithecial tissue compact, a *t. angularis* of hyaline or brownish, thin-walled, angular to globose cells (5–)6–12(–15)×(3–)5–9(–10) µm (n=30), mixed with some wide hyaline hyphae. Asci (57–)65–73(–76)×(3.0–)3.5–4.5 µm, stipe (1–)2–6(–8) µm long (n=31), fasciculate on long ascogenous hyphae; no croziers seen. Ascospores hyaline, spinulose, cells dimorphic; distal cell (3.0–)3.3–3.7×3.0–3.2(–3.5) µm, l/w (1.0–)1.1–1.2(–1.3) (n=30), (sub)globose, ellipsoidal or wedge-shaped; proximal cell (3.2–)3.5–4.5(–5.5)×(2.2–)2.3–2.7(–3.0) µm, l/w (1.1–)1.4–2.0(–2.3) (n=31), oblong, wedge-shaped or subglobose.

Habitat: bark/immersed ascomycetes and aphyllophoralean fungi (*Stereum*, *Lentinula* cultures, *Phellinus gilvus*).

Known distribution: France, USA, ?Japan.

Holotype: **France**, Pyrénées atlantiques, Forêt Domaniale d'Oloron, on *Quercus* sp., soc. effete stromatic pyrenomycete (?*Botryosphaeria* sp.), 30 Aug. 1997, F. Candoussau 513 (BPI 747356; culture G.J.S. 97-207=CBS 121307).

Notes: The holotype is the only specimen of *H. decipiens* known from Europe. It remains to be clarified, whether specimens occurring on wood of *Lentinula* cultures in Japan (Overton et al. 2006b) indeed represent *H. decipiens*, because no Japanese material has been sequenced. For a description of the anamorph see Overton et al. (2006b) under *Hypocrea farinosa*. The latter is a synonym of *Protocrea farinosa*, the type species of *Protocrea* Petch. Jaklitsch et al. (2008b) have clarified the phylogenetic and phenotypic concept of this genus. The main distinguishing characters of *Protocrea* are the absence of a pseudoparenchymatous subperithecial stroma tissue, and a white *Gliocladium* anamorph.

Hypocrea delicatula Tul. & C. Tul., Selecta Fung. Carpol. 3: 33, t. IV, f. 7–13 (1865). Fig. 59

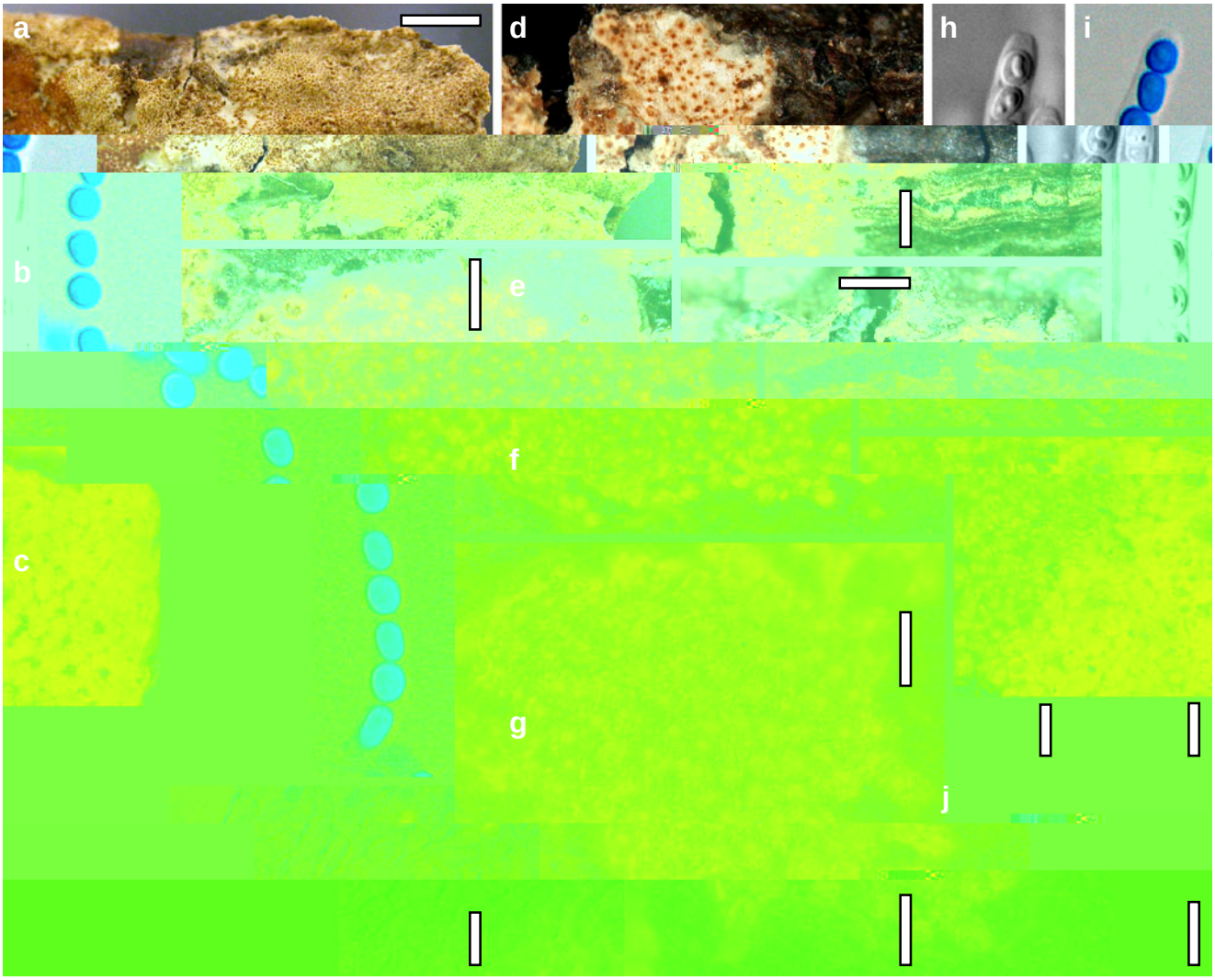
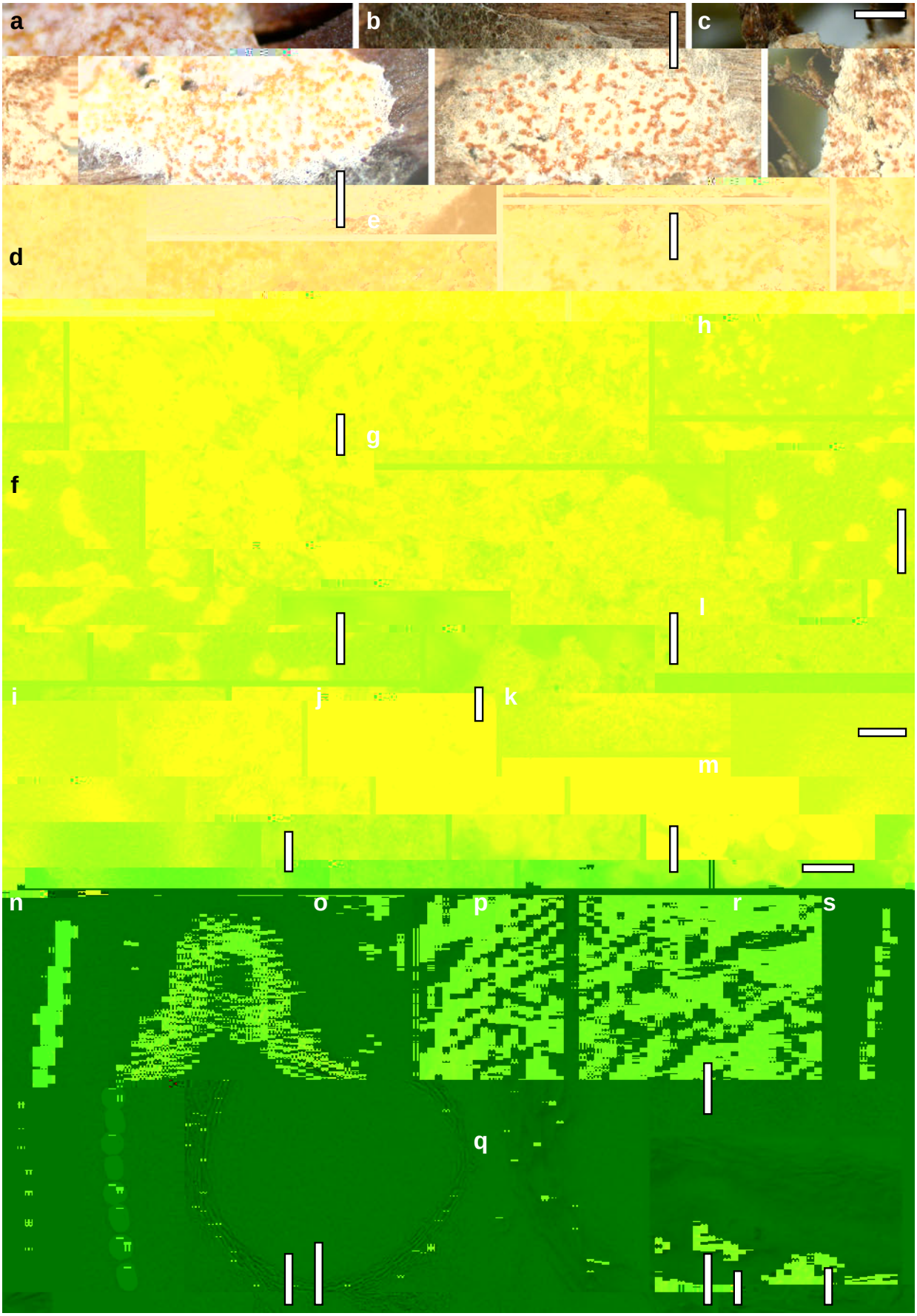


Fig. 58 *H. decipiens* (holotype BPI 747356). **a–d, f**. Dry stromata (**f**. spot treated with KOH). **e**. Pyrenomycete associated with stromata. **g**. Cortical tissue. **h, i**. Asci with ascospores (**i**. in cotton blue/lactic acid). **j**. Subperithecial tissue in section. *Scale bars* **a**=3 mm, **b**, **c**=0.3 mm, **d–f**=0.5 mm, **g**, **j**=10 μm, **h**, **i**=5 μm

= *Protocrea delicatula* (Tul. & C. Tul.) Petch, J. Bot. (Lond.) 75: 219 (1937).
Anamorph: ***Trichoderma delicatulum*** Jaklitsch, **sp. nov.** Fig. 60
MycoBank MB 516680

Conidiophora in agaro SNA effuse disposita, simplicia, ramis sparsis brevibus, similia *Verticillii*. Phialides divergentes, subulatae vel lageniformes, (8–)11–16(–23)×(2.0–)2.3–3.0(–3.5) μm. Conidia ellipsoidea vel oblonga, hyalina, glabra, (2.6–)3.0–4.0(–5.2)×(2.0–)2.2–2.5(–2.8) μm.

Stromata when fresh widely effuse, of ampulliform, ochre or orange perithecia on or partly immersed in a white subiculum. Stromata when dry 1–42×1–23 mm, 0.2–0.5 mm thick, inconspicuous, indeterminate, of a widely effused, white, cream or light brownish subiculum varying from scant hyphae, thin arachnoid mycelium to a thick, dense, continuous and membranaceous hyphal mat, often fraying out at the margins; with delicate, bright ochre, orange to light brown perithecia superficial on to nearly entirely immersed in the subiculum. Perithecia scattered, gregarious or densely aggregated, mostly sphaeroid to globose, also ampulliform to subconical, often showing lateral collapse, only rarely collapsed from above, smooth, glabrous or partly covered by radiating hyphae; visible part (55–)80–118(–140) μm (n=90) diam. Ostioles (16–)24–43(–63) μm (n=90) diam, distinctly prominent, cylindrical or conical, sometimes pointed, more rarely short papillate, amber, caramel or dark brown, typically darker than the perithecial body. Overall colour pale apricot, dull cream to pale orange, 5AB(2–)3–4, 6A3, or brown, 6CD(5–)7–8, 6–7E5–8. Spore deposits minute, white. After rehydration


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s

◀ **Fig. 59** Teleomorph of *Hypocrea delicatula*. **a**. Part of fresh stroma. **b–h, j**. Dry stromata (**d, f**. overmature; **f, h**. showing papillate ostioles). **i**. Ostiole in section showing wide apical cells. **k**. Part of rehydrated stroma. **l**. Perithecia superficial on subiculum. **m**. Perithecia in 3% KOH after rehydration. **n**. Perithecium in section. **o**. Peridium in section. **p**. Subiculum in section. **q**. Base of peridium and collapsed subiculum hyphae on host hyphae. **r, s**. Asci with ascospores (s in cotton blue/lactic acid). **a, b, h, n, q–s**. WU 29225. **c–e, i, k–m, o, p**. lectotype PC 93188. **f, g, j**. PC 93187. *Scale bars* **a, b**=1 mm. **c, e**=0.6 mm. **d, f**=0.3 mm. **g, k, m**=0.2 mm. **h, j, l**=0.1 mm. **i, o–q**=10 μm. **n**=20 μm. **r, s**=5 μm

perithecia slightly larger, not collapsed, sphaeroid, smooth, orange-brown, 6CD6–8. No distinct colour change after addition of 3% KOH, perithecia only slightly darker brown, subiculum unchanged.

Stroma anatomy: Ostioles (36–)46–68(–84) μm long, projecting from the perithecial body by (25–)33–55(–70) μm, (18–)33–61(–76) μm (*n*=60) wide at the apex, conical or cylindrical, periphysate, hyaline inside, yellow outside; apex sometimes flattened, with hyaline, cylindrical or subclavate cells 3–5(–9) μm wide. Perithecia (78–)100–140(–160)×(78–)94–140(–200) μm, total height including ostiole (115–)140–185(–205) μm (*n*=61), globose or subconical, loosely disposed or aggregated, in lactic acid smaller than in KOH. Peridium (6–)9–16(–21) μm (*n*=122) thick at the base and sides, pseudoparenchymatous, of narrow, thick-walled, yellow cells (4–)5–11(–14)×(3–)4–8(–12) μm (*n*=30) in face view, 2–6 μm wide in section; ochre or pale orange in KOH. Subiculum variable, a loose or dense *t. intricata* of hyphae (1.5–)2–4(–7.5) μm (*n*=65) wide; hyphae thin-walled, hyaline or pale yellow-brown, sometimes ascending to the ostiolar level; sometimes intermingled with submoniliform hyphae (7–)8–12(–16) μm (*n*=20) wide, collapsed when old. Asci (52–)55–62(–70)×(3.2–)3.5–4.0(–4.2) μm, stipe 3–8(–10) μm (*n*=31) long; no croziers seen. Ascospores hyaline, becoming yellowish orange after ejection, finely verruculose; cells dimorphic; distal cell (2.3–)2.5–3.0(–3.7)×(2.0–)2.5–3.0(–3.2) μm, l/w (0.9–)1.0–1.1(–1.3), (sub)globose; proximal cell (2.4–)3.0–4.0(–4.7)×(1.7–)2.0–2.5(–2.8) μm, l/w (1.0–)1.3–1.7(–2.1) (*n*=106), oblong or subglobose.

Cultures and anamorph: optimal growth at 25°C on all media; limited growth at 30°C on all media, terminating after reaching a radius of 5–10 mm, and hyphae autolysing; no growth at 35°C.

On CMD after 72 h 4–6 mm at 15°C, 11–13 mm at 25°C, 6–8 mm at 30°C; mycelium covering the plate after >2 weeks at 25°C. Colony hyaline, thin, finely zonate, with irregular or lobed margin. Mycelium loose, hyphae narrow, wavy, little on the agar surface. Area around the plug becoming dense and white due to fluffy aerial mycelium spreading from the plug. Autolytic activity inconspicuous, coilings frequent. No diffusing pigment, no distinct odour noted. No chlamydospores seen. Conidiation noted after 2 days, white, effuse, short and sessile on surface hyphae, or on aerial hyphae of variable length; spreading from the plug across the plate. Conidia formed in wet heads on long narrow phialides, drying soon; scant after few transfers. At 15°C a rosy to pale carrot pigment, 5A4, 6A2–4, 7A2, spreading from the plug.

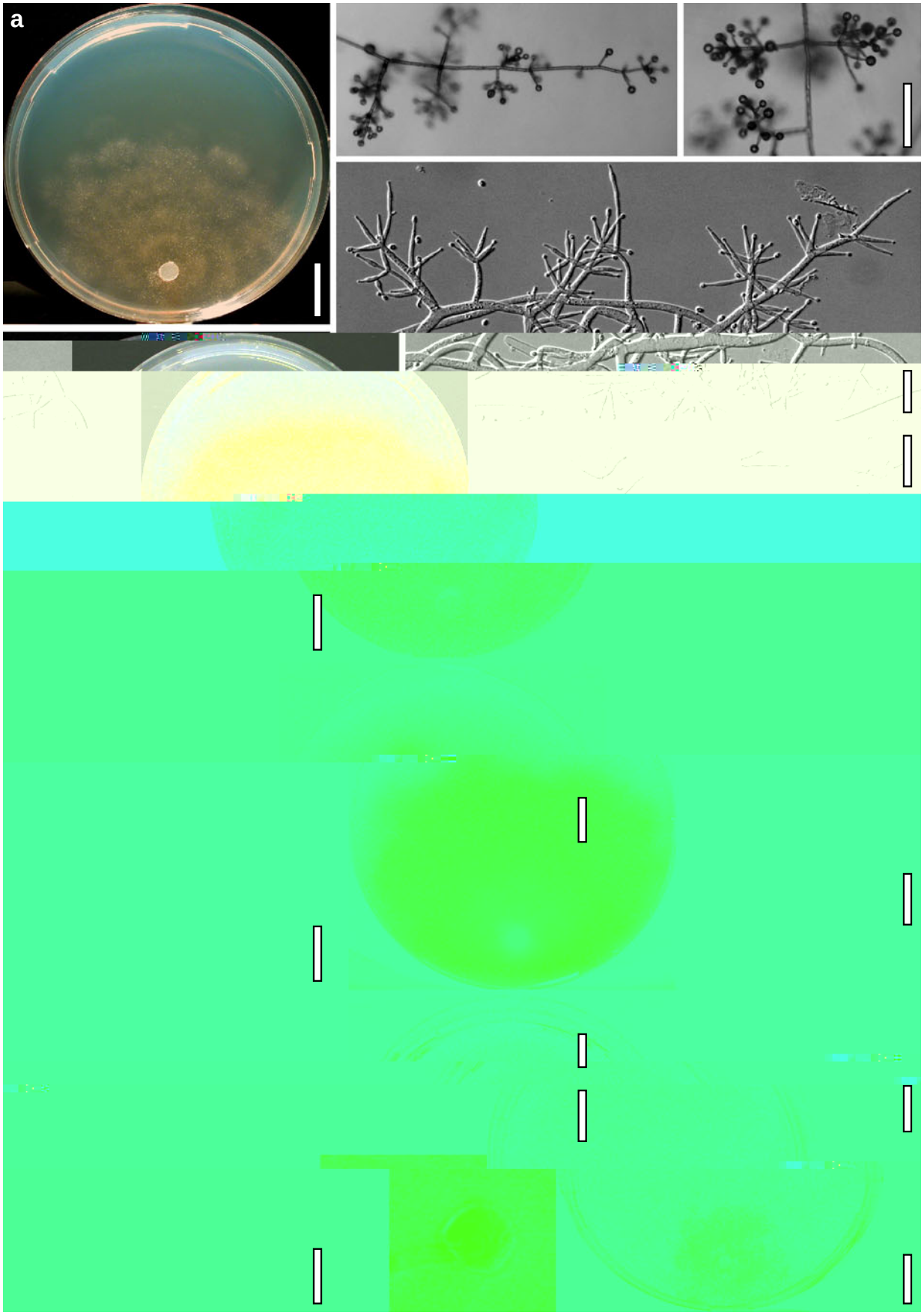
On PDA after 72 h 2–4 mm at 15°C, 10–12 mm at 25°C, 4–5 mm at 30°C; mycelium covering the plate after *ca* 2 weeks at 25°C. Colony first thin, becoming covered by a thick white layer of cottony aerial hyphae ascending to the lid of the Petri dish. Aerial hyphae dichotomously branched, appearing rigid or setose terminally, with inconspicuous and widely spaced septa. Autolytic excretions numerous, turning orange to reddish-brown. Plug becoming rosy, carrot to dark reddish-brown, 7–8EF6–8; colony becoming discoloured from the plug in zones, pale orange, reddish-brown, carrot, to dull orange-brown, 5AB5–6, 6BD5–7. No distinct odour noted. Conidiation noted after 3 days, effuse on long aerial hyphae, verticillium-like, particularly dense in the centre. At 15°C conidiation reduced, colony turning orange to brown, 5AB4–6 to 7DE7–8, pigment diffusing from pigmented hyphae into the agar.

On SNA after 72 h 4–6 mm at 15°C, 11–13 mm at 25°C, 3–5 mm at 30°C; mycelium covering the plate after more than 2 weeks at 25°C. Colonies similar to CMD, but more irregular, marginal hyphae forming pegs. Aerial hyphae abundant, cottony, ascending to the lid of the Petri dish, dichotomously branched, appearing nearly setose with pointed ends. Autolytic excretions scant, coilings frequent. No diffusing pigment, no distinct odour noted. No chlamydospores seen. Conidiation noted after 3–4 days, effuse, white, loose, translucent, verticillium-like. Main axes 7–9 μm wide, with walls to 2.5 μm thick and outer layer deliquescent, bearing numerous short, usually unpaired conidiophores, often in right angles. Conidiophores mostly 3–6 μm wide, sometimes widening to 7.5 μm; terminally 2–3 μm wide. Side branches simple or rebranching, 60–160 μm long; tips of side branches with phialides or short, unpaired or paired, 1-celled branches 10–20 μm long, slightly inclined upwards. Phialides solitary or divergent in whorls of 2–6(–8), arising from cells 2–4(–5.5) μm wide, forming conidia in minute wet heads mostly <20 μm diam. Phialides (8–)11–16(–23)×(2.0–)2.3–3.0(–3.5) μm, l/w (3.3–)4.0–6.6(–10), 1.5–2.5(–3.0) wide at the base (*n*=40), narrowly lageniform, subulate or fusoid, widest in or below middle. Conidia (2.6–)3.0–4.0(–5.2)×(2.0–)2.2–2.5(–2.8) μm, l/w 1.2–1.7(–2.2) (*n*=50), hyaline, ellipsoidal or oblong, smooth, with several guttules and indistinct scar.

Habitat: on wood and bark of deciduous and coniferous trees, leaves, and moss.

Known distribution: Europe (Austria, France, United Kingdom).

Lectotype, designated by Rossman et al. (1999): **France**, Clamart, 4 Jan. 1860, M.L.-R. Tulasne, PC 93188 (PC);


a

◀ **Fig. 60** Cultures and anamorph of *Hypocrea delicatula* (CBS 120631). **a–d**. Cultures (**a**. on CMD, 15 days; **b**. on PDA, 9 days; **c**. on PDA, 15 days, reverse; **d**. on SNA, 10 days). **e, f**. Conidiophores on growth plate (SNA, 10 days). **g–j, l**. Conidiophores and phialides (SNA, 5 days). **k**. Dichotomously branched, setose aerial hyphae (PDA, 8 days). **m, n**. Conidia (SNA, 5 days). **o**. Pigmented autolytic excretion (PDA, 15°C, 10 days). **a–n**. At 25°C. *Scale bars* **a–d**= 15 mm. **e, f**, **k**=0.1 mm. **g–i**, **o**=20 μm. **j**, **l**=10 μm. **m**, **n**=5 μm

fungus on thin twig of *Quercus*, moss and leaves, soc *Mycosphaerella punctiformis* on leaves. ***Epitype*** here designated in order to connect the morphology with molecular phylogeny: **Austria**, Osttirol, Lienz, Kals am Großglockner, Teischnitztal, MTB 8941/4, 47°01′46″ N, 12°37′49″ E, elev. 1670 m, on log of *Picea abies* 14 cm thick at roadside, on ?*Tomentellastrum* sp. and wood, attacked by a hyphomycete, 5 Sep. 2003, W. Jaklitsch W. J. 2377 (**WU 29225**, culture CBS 120631=C.P.K. 1603). ***Holotype*** of *Trichoderma delicatulum* isolated from WU 29225 and deposited as a dry culture with the epitype of *H. delicatula* as **WU 29225a**.

Other specimens examined: **France**, Chaville, 21 Mar. 1860, M.L.-R. Tulasne, PC 93187 (PC); 2 pieces of ? *Quercus* bark, soc. effete black pyrenomycete. **United Kingdom**, Devon, Dartmoor, Bellever forest, 30 Sep. 1990, P. Roberts, (K(M)16595). Wiltshire, Lucknam, April 1866, Herb. C.E. Broome (K).

Notes: Superficially, stromata of *Hypocrea delicatula* look like those of a *Hypomyces*. Although teleomorph morphology would suggest affiliation with *Protocrea*, particularly due to the absence of any pseudoparenchymatous stroma tissue, gene sequences place it within *Hypocrea*. *H. delicatula* differs from *P. farinosa* by different hosts, different perithecial colour, smaller perithecia and ascospores, a yellow, distinctly pseudoparenchymatous peridium, which is less susceptible to collapse upon drying, and a verticillium-like anamorph. *Protocrea pallida* differs e.g. by a distinct, purple KOH-reaction and laterally pinched collapse of the perithecia. The anamorphs of *Protocrea* spp. are morphologically typical *Gliocladium*, while *H. delicatula* has a verticillium-like anamorph. *Arachnocrea stipata* differs by biconical ascospores from all species discussed here.

Hypocrea parmastoi Overton, Stud. Mycol. 56: 62 (2006b). Fig. 61
Anamorph: *Trichoderma* sp. [sect. *Hypocreanum*]. Fig. 62

Stromata when fresh to 7×3 cm, thinly effuse, of a subiculum to 1 mm thick, with hyaline to dull brownish perithecia immersed in a single layer; outline variable; margin mycelial, white to distinctly yellow. Surface smooth apart from slightly projecting ostiolar dots, colour red in fertile areas. Spore deposits white.

Stromata when dry 3–70×3–30 mm, 0.15–0.5(–0.8) mm thick (n=20), indeterminate, widely and thinly effused on wood, incorporating leaves and other plant material, of longish to irregular patches, entirely attached. Surface hyphal to hairy, finely rough due to slightly projecting ostioles. Ostiolar dots (30–)45–73(–87) μm (n=60) diam, papillate to conical and pointed or with flattened apices, irregularly disposed or arranged in lines, dark red (including upper part of perithecia); surrounded by radiating mycelium, red around the perithecia, gradually lighter to whitish or yellow with distance from the ostiolar dots. Margin cottony or membranaceous, white to yellow, 4A3–4, 4B4–5. Colour of fertile areas pink with yellow tones, greyish red or reddish brown, 8CD6–8, 9CD5–6, 9DE7–8, 10AB4, to dark red or violaceous-brown, 10CD4–6, 10E4–8, 11DE5-8. Subiculum in section whitish to bright yellow in lower layers. After rehydration, perithecial mounds becoming evident, upper part and subiculum yellow to orange-red, upper layer turning deeply purple in 3% KOH; ostioles minute, hyaline. Previously KOH-treated spot of the holotype discoloured dark reddish brown to purple, with collapsed perithecia (150–)170–240(–252) μm (n=20) diam, surrounded by black lines, and dark red ostioles with hyaline openings.

Stroma anatomy: Ostioles (70–)84–105(–123) μm long, projecting to 40(–60) μm, (37–)40–65(–85) μm wide at the apex (n=30), blunt conical, periphysate; marginal cells on apices variable, long-cylindrical and 2–3 μm wide, or clavate and 5–8(–10) μm wide, broadly rounded, or fusoid, or cylindrical with inflated bases. Perithecia (170–)200–255(–285)×(118–)145–210(–240) μm (n=30), large, globose to sphaeroid or flask-shaped, crowded or separated by hyphae; peridium (15–)17–23(–27) μm thick at the base and sides (n=60), subhyaline to pale yellow, in 3% KOH purple around the ostiolar apex. Cortical and subcortical tissue consisting of a loose *t. intricata* of thin-walled hyphae (1.5–)2–5(–6) μm (n=30) wide above and between the perithecia, hyaline, in uppermost layers subhyaline to yellow; turning purple to violet in 3% KOH. Subperithecial tissue variable, thick or nearly absent with perithecia sitting directly on the wood, a *t. intricata* to *epidermoidea* of thin-walled hyphae (2–)3–9(–14) μm (n=60) wide, with partly inflated, submoniliform cells (6–)8–25(–36)×(4–)6–11(–15) μm (n=30), hyaline to yellowish, not changing colour in 3% KOH. Base of densely intertwined, cylindrical, thin-walled, hyaline hyphae (2–)3–4(–5) (n=30) wide. Asci (68–)78–103(–123)×(3.8–)4.2–5.0(–5.5) μm, stipe (5–)12–35(–50) μm long (n=50); on spiral ascogenous hyphae; no croziers seen. Ascospores hyaline, verruculose to spinulose; cells dimorphic; distal cell (3.0–)3.5–4.5(–5.5)×(2.5–)3.0–3.5(–4.0) μm, l/w (1.0–)1.1–1.4(–1.8) (n=63), subglobose to wedge-shaped; proximal cell (3.5–)4.0–5.0(–6.6)×(2.3–)2.5–3.0(–3.5) μm, l/w (1.3–)1.4–1.8(–

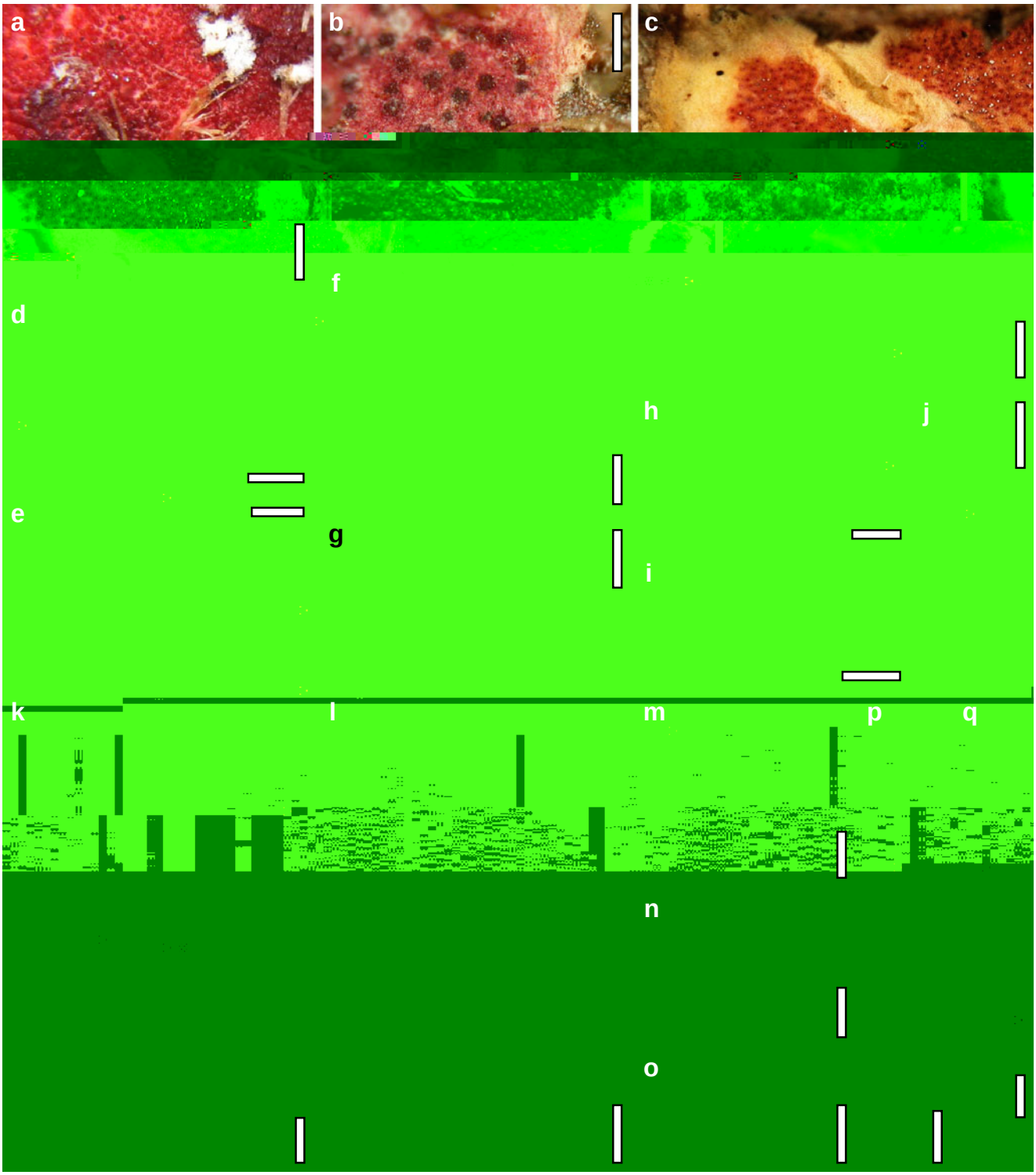


Fig. 61 Teleomorph of *Hypocrea parmastoi*. **a**. Part of fresh stroma (attacked by white mould). **b–f**. Dry stromata (**c**. with yellow subiculum; **d**. part with KOH-treated spot on the right side; **e**. part of KOH-treated spot; **f**. stroma surface). **g**. Surface hyphae in 3% KOH. **h**. Part of rehydrated stroma. **i.** Part of stroma in 3% KOH after rehydration**. j.** Ascogenous hyphae. **k, l**. Perithecia in section (**k**. in lactic acid; **l.** in 3% KOH). **m**. Cortical and subcortical tissue in section. **n**. Subperithecial tissue in section. **o**. Stroma base in section. **p, q**. Asci with ascospores (**q**. in cotton blue/lactic acid). **a**. WU 29526. **c, f, g–i, k–o, q**. WU 29033. **b, d, e, j, p**. holotype BPI 843639. *Scale bars* **a**, **c**, **d**=1.2 mm. **b**, **f**=0.2 mm. **e**, **h**=0.3 mm. **g, j, p**, **q**=10 μm. **i**=0.5 mm. **k**, **l**=30 μm. **m**, **n**=20 μm. **o**=50 μm

Fig. 62 Cultures and anamorph of *Hypocrea parmastoi* (CBS 121139). **a–d**. Cultures after 14 days (**a**. on PDA; **b**. on CMD; **c**. on SNA; **d**. on PDA, reverse). **e**. Conidiophores attached to the lid of the Petri dish (PDA, 7 days). **f–k**. Conidiophores (PDA, 5 days). **l, m**. Chlamydospores (CMD, 17 days). **n, o**. Conidia and phialides (PDA, 5 days). **a–o**. All at 25°C. *Scale bars* **a–d**=15 mm. **e**=100 μm. **f**=40 μm. **g, h, j**=20 μm. **i, k, m–o**=10 μm. **l**=5 μm

2.3) (n=63), wedge-shaped, oblong, ellipsoidal, less commonly subglobose.

Cultures and anamorph: optimal growth at 25°C on all media, poor growth at 30°C, no growth at 35°C.

On CMD after 72 h 3–4 mm at 15°C, 4–6 mm at 25°C, 1–2 mm at 30°C; growth limited; mycelium not covering the plate within a month. Colony hyaline, thin, dense, subcircular, not zonate, of narrow hyphae branched in steep angles; soon turning yellow-orange, yellow-, golden- to orange-brown, 4AB6–8, 5–6CD7–8. Aerial hyphae variable, scant or frequent, short or long, distinctly less than on PDA and SNA, becoming fertile, collapsing to form inconspicuous whitish floccules. Autolytic activity and coilings absent or scant. Odour slightly unpleasant, reminiscent of *Sarcodon imbricatus* mixed with apple. Chlamydospores noted after 9–11 days, terminal and intercalary, mainly in surface hyphae, (7–)8–13(–19)×(5–)6–10(–12) μm (n=30), l/w 1.0–1.7(–2.7) (n=30), subglobose, clavate or ellipsoidal, smooth, often with a pedicel. Conidiation noted after 1–2 days, effuse, colourless, acremonium- to verticillium-like, spreading from the plug on surface and aerial hyphae. Conidia produced in minute wet heads <40 μm diam on long thin phialides in steep whorls of 4–6. At 30°C growth soon stopping, hyphae forming pegs; yellow pigment diffusing into the agar; conidiation scant.

On PDA after 72 h 2–4 mm at 15°C, 3–5 mm at 25°C, <1 mm at 30°C; mycelium covering the plate after *ca* 2 weeks at 25°C. Colony circular, dense to opaque, indistinctly zonate; of richly branched, narrow, radial hyphae. Aerial hyphae abundant, dichotomously branched, first forming a white flat mat in distal areas, turning yellowish and ascending as a loose or dense fluffy mat, becoming fertile up to the lid of the Petri dish. Autolytic excretions scant; no coilings noted. Colony surface turning reddish-brown, 8CD5–6, hyphal mat whitish to yellow 4A3–4 or pale orange. Reverse orange-brown, 5–6CD7–8, to dark brown, 6F7–8, 7EF7–8, in the centre, yellow, 4AB4–5, orange, 4A5–7, to orange-brown, 6–7CD7–8, in the residual colony. Odour as on CMD or more fruity. Conidiation noted after 2 days, effuse, spreading from the centre on surface and aerial hyphae, acremonium- to irregularly verticillium-like. Conidiophores arising from aerial hyphae mostly in steep angles, mostly unpaired, short, unbranched or once loosely rebranching with side branches similar to the main axis, mostly 1–2 celled. Conidiophores and aerial hyphae 4–7 μm wide, attenuated upwards and terminally 2–3 μm wide. Phialides divergent in whorls of 2–4 on the apices of main and side branches, and solitary or paired along their length. Phialides (10–)16–28(–38)×(1.8–)2.0–3.0(–3.5) μm, l/w (3–)7–11(–13), (1.5–)1.7–2.5(–3.5) μm wide at the base (n=30), subulate, equilateral, only rarely thickened close to the base. Conidia formed in low numbers in minute wet heads to 30 μm diam; conidia (3.2–)3.5–5.0(–6.0)×(2.0–)2.3–2.6(–2.8) μm, l/w (1.2–)1.4–2(–2.5) (n=30), hyaline, ellipsoidal to oblong, smooth, with few small guttules, and often with a projecting scar. At 15°C colony similar to that at 25°C, but more regularly zonate, aerial hyphae forming a flatter mat. At 30°C hardly growing, yellow pigment forming minute radiating hair-like crystals around the plug.

On SNA after 72 h 4–5 mm at 15°C, 4–12 mm at 25°C, 1–2 mm at 30°C; mycelium covering the plate after *ca* 3 weeks at 25°C. Growth at first slow, producing a small dense circular colony centre. Residual colony with an irregularly lobed margin produced by fast growing, long aerial hyphae first arising from the plug and central colony area, declining, reaching the agar and propagating the colony on the surface and in the uppermost layer of the agar; hyphae generally dichotomously branched; mycelium looser than on CMD and PDA; soon degenerating, hyphae becoming yellow or empty. Aerial hyphae abundant, long, forming a high, loose, hairy, irregular mat, ascending several mm, partly reaching the lid of the Petri dish, eventually collapsing to large longish strands and floccules. Autolytic activity and coilings moderate to conspicuous; coilings turning yellow-orange upon autolysis. Colony pale yellow to orange 4–5AB3–4. Odour as on CMD, but less distinct. Chlamydospores noted after 9–11 days, terminal and intercalary, mainly in surface hyphae. Conidiation noted after 1–2 days, effuse, spreading from the centre on surface and aerial hyphae, acremonium- to irregularly verticillium-like. Conidia produced in minute wet heads <40 μm diam. At 30°C little growth, yellow pigment forming minute radiating hair-like crystals around the plug.

Habitat: on medium to well-decayed wood and bark of deciduous trees.

Distribution: Europe (Austria, Estonia, Finland, France, Germany); uncommon.

Holotype: **Estonia**, Võru Commune, Võrumaa County, Kütiorg, in a spruce forest, 57°47′ N, 27°9′ E, on partly moss-covered bark of a fallen trunk of *Alnus incana*, 3 Oct. 1997, I. Parmasto (TAA(M) 169055; ex-type culture TFC 97-143); isotype BPI 843639.

Other specimens examined: **Austria**, Niederösterreich, Wien-Umgebung, Mauerbach, Friedhofstraße, MTB 7763/1, 48°15′20″ N 16°10′12″ E, elev. 330 m, on decorticated branch of *Fagus sylvatica* 5 cm thick, on wood, soc. Corticiaceae, 7 Oct. 2006, W. Jaklitsch & H. Voglmayr, W. J. 3006 (WU 29033, culture CBS 121139=C.P.K. 2483). Salzburg, Anthering, Acharting-Würzenberg, Adelsberg, Haunsberg-Forststraße, MTB 8044/3, elev. 650 m, on cut wood of *Fagus sylvatica*, 11 Sep 2010, M. Dämon (WU). **Finland**, near Tampere, on wood of Alnus sp., 18 Oct. 2010, L. Kosonen (WU 30203). **Germany**, Baden-Württemberg, Schwäbisch Gmünd, Weiler i. d. B., "Költ", MTB 7225/1, elev. 450 m, on decorticated deciduous wood

at a Fraxinus/Fagus forest borderline, 13 Oct. 10, leg. & comm. L. Krieglsteiner. Bavaria, Magnetsried, between Gumpenau and Hirschberg am Haarsee south of the Starnberger See and Ammersee, in a steep mixed beech forest, MTB 8133/341, elev. 640 m, on a branch of *Fagus sylvatica* 10 cm thick, on medium- to well-decomposed wood, overmature, 6 Dec. 2008, P. Karasch (WU 29527). München-Dachau, Karlsfeld, Nature Reserve Krenmoos, MTB 7734/422, elev. 480 m, on well-decayed deciduous wood of ?*Alnus glutinosa*, attacked by a *Hypomyces*, 1 Nov. 2008, K. Reitmeier, comm. B. Fellmann (WU 29526, culture C.P.K. 3717). Niedersachsen, "Oderwald" s. Wolfenbüttel, MTB 3829/1, elev. 120 m, on decaying wood in an Quercus-Carpinus mixed forest, 21 Sep. 10, leg. & comm. L. Krieglsteiner.

Notes: This species is characteristic because of its red or purple colour of the indeterminate effuse hyphal stromata. The above description includes characteristics of the holotype. Similar to *H. alcalifuscescens*, the inflated, submoniliform cells, particularly in the subperithecial tissue indicate a tendency of stroma development from a subiculum towards a pseudoparenchymatous tissue.

Hypocrea phellinicola Jaklitsch, **sp. nov.** Fig. 63
MycoBank MB 516696
Trichoderma phellinicola Jaklitsch, **sp. nov.** Fig. 64
MycoBank MB 516697

Stromata late effusa vel pulvinata in basidiomatibus generis *Phellinus*, lutea, 0.1–30×0.1–5 cm. Asci cylindrici, (50–)60–70(–80)×3.5–4.5(–5.5) µm. Ascosporae bicellulares, hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa, (2.4–)2.7–3.5(–4.7)×(2.3–)2.5–3.0(–3.5) µm, pars proxima oblonga, ellipsoidea vel subglobosa, (2.7–)2.8–4.2(–5.2)×2.0–2.7(–3.4) µm. Anamorphosis *Trichoderma phellinicola*. Conidiophora in agaro PDA effuse disposita, simplicia, ramis sparsis brevibus, similia *Acremonii* vel *Verticillii*. Phialides divergentes, subulatae vel cylindricae, (11–)19–33(–41)×(1.8–)2.0–3.0(–3.2) µm. Conidia oblonga vel cylindracea, hyalina, glabra, (5–)6–11(–15)×(2.0–)2.2–2.7(–3.0) µm.

Etymology: reflecting its specific occurrence on basidiomes of *Phellinus* spp.

Stromata when fresh 0.1–11(–30)×0.1–5 cm, 0.5–2.5 mm thick, gregarious, densely aggregated or effluent, starting as white mycelium, becoming compacted and pigmented, broadly pulvinate or widely effuse, often with a white cottony to arachnoid margin sometimes forming extended mats. Outline and surface variable, depending on the host, entirely attached, indeterminate, overgrowing leaves lying on the substrate. Ostiolar dots distinct, usually densely disposed, plane or convex, yellowish, olive, amber to brown dots, sometimes diffuse spots, rarely conical and projecting to *ca* 80 µm. Surface smooth or coarsely tubercular depending on the host surface. Perithecia entirely immersed, rarely projecting at the stroma margin. Stromata first white, turning yellow, 3A3–5, 4A3–6, yellow-, orange-brown, pale brown, 5CD5–7, 6C6–7, or greyish yellow, 4B4–8, 5B5.

Stromata when dry typically shrunken to thin crusts 0.1–0.4 mm thick (n=24), even when initially pulvinate, membranaceous to papery, flat pulvinate or widely effuse with discontinuities. Outline highly variable, margin rounded or extended as white mycelium. Surface smooth, sometimes velvety when immature. Ostiolar dots numerous, (35–)40–80(–105) µm (n=30) diam, distinct, more diffuse and irregularly distributed when immature, plane, convex or conical and slightly projecting; yellowish-brown to dark brown, always darker than the stroma surface. Stromata at first whitish, turning yellow, orange-yellow, greyish orange, 4A4–5, 4B6–7, 5B4, yellow-brown, golden, orange-brown, brown, 5–6CD5–8, 5E7–8. Reaction to 3% KOH variable, reddish, orange-brown or darker brown, confined to the perithecial wall and apex. Spore deposits white or yellow.

Stroma anatomy: Ostioles (32–)43–60(–62) µm long, plane or projecting to 25 µm, rarely to 80 µm, (20–)24–36(–42) µm wide at the apex (n=20), conical, with broadly clavate to subglobose, hyaline marginal cells 3–8 µm diam wide at the apex. Perithecia (154–)160–190(–210)×(90–)100–160(–190) µm (n=20), globose, flask-shaped or ellipsoidal, crowded or widely spaced; peridium (10–)12–19(–22) µm (n=20) thick at the base, (3–)7–12(–14) µm (n=20) at the sides, yellow. Cortical layer (14–)16–22(–26) µm (n=30) thick, clearly differentiated, a dense *t. globulosa–angularis* of mostly isodiametric, thick-walled (*ca* 1 µm) cells (2–)4–10(–16)×(2–)3–6(–7) µm (n=60) in face view and in vertical section; yellow or pale brownish in lactic acid, orange in KOH. Hairs on mature stroma infrequent, 7–16(–26)×(2–)3–5 µm (n=20), hyaline to yellowish, 1–3 celled, apically rounded or truncate, smooth, or warted, cylindrical or basally widened to 6 µm; basal cells often embedded in the cortex. Subcortical tissue a *t. intricata* of thin-walled hyaline hyphae 2–5(–6) µm (n=30) wide, mixed with angular cells 3–9(–17) µm (n=30) diam. Subperithecial tissue a *t. epidermoidea* of hyaline, thin-walled, angular, oblong or lobed cells (3–)7–20(–30)×(2.5–)5–13(–15) (n=30), interspersed with some hyphae to 8 µm wide in basal regions. Asci (50–)60–70(–80)×3.5–4.5(–5.5) µm, stipe (2–)3–10(–14) µm long (n=30), fasciculate; ascospores sometimes biseriate in the apical part. Ascospores hyaline, often yellow-orange outside asci, verruculose; cells dimorphic but often asci with monomorphic ascospores present in the same perithecium; distal cell (2.4–)2.7–3.5(–4.7)×(2.3–)2.5–3.0(–3.5) µm (n=30), l/w 1.0–1.3(–1.7) (n=30), (sub-)globose; proximal cell (2.7–)2.8–4.2(–5.2)×2.0–2.7(–3.4) µm (n=30), l/w (1.1–)


a

◀ **Fig. 63** Teleomorph of *Hypocrea phellinicola*. **a–d, f–i.** Fresh stromata. **e, j**. Dry stromata. **k**. Rehydrated stromata. **l**. Ostiolar apex in section. **m**. Cortical tissue in face view. **n**. Ejected yellow-orange ascospores. **o**. Perithecium in section. **p**. Cortex with hairs in section. **q**. Cortical and subcortical tissue in section. **r**. Subperithecial tissue in section. **s, t**. Asci with ascospores (**t**. in cotton blue/lactic acid). **u, v**. Apical ascospores with dimorphic cells in cotton blue/lactic acid. **a, f, s, t**. WU 29404. **b, e, g**. WU 29407. **c, k–m, o–r**. WU 29402. **d**. WU 29403. **h**. WU 29406. **i, j, n, u, v**. WU 29401. Scale bars: **a, c, e**, **g–i**= 1 mm. **b**=3 mm. **d**, **k**=0.7 mm. **f**=0.5 mm. **j**=5 mm. **l, p**, **r**=10 μm. **m, n**, **s–v**=5 μm. **o**, **q**=20 μm

1.2–1.8(–2.4) (*n*=30), oblong, ellipsoidal or subglobose, only slightly attenuated towards the base.

Cultures and anamorph: optimal growth at 25°C on all media, slightly faster on CMD than on PDA and SNA; at 30°C death autolysis of hyphae after short growth; no growth at 35°C.

On CMD after 72 h 19–21 mm at 15°C, 32–35 mm at 25°C, 1–1.5 mm at 30°C; covering the Petri dish after 5–6 days at 25°C. Colony homogeneous, not zonate. Mycelium first loose, becoming more dense in distal regions, hyphae thin, with little differences in width, third order hyphae short and thin in marginal regions, surface hyphae becoming empty with distinct septa, little mycelium on surface, growth radially fan-shaped with forked to fasciculate ends, centre shiny, margin wavy, becoming downy to slightly mottled after 2 weeks. Aerial hyphae inconspicuous, autolytic activity and coilings absent, hyaline, no odour noted. Little central conidiation from 2 to 6 days, later also on the distal margin, effuse, short, simple, phialides single or in small whorls of 2–3. Chlamydospores noted after 3 days, infrequent, (5–)6–14 (–18)×(4–)5–8(–10) μm (*n*=30), l/w (0.9–)1.1–1.9(–2.4) (*n*=30); variable in shape and size, globose, clavate or with a pedicel, hyaline, sometimes 2–3 celled. At 15°C mycelium loose, soon degenerating. Red diffusing pigment developed upon storage at 15°C for >1 month.

On PDA after 72 h 13–14 mm at 15°C, 24–26 mm at 25°C, 0–0.5 mm at 30°C, covering the Petri dish after 6 days at 25°C. Colony circular, centre flat and shiny, margin wavy, coarsely fan-shaped to nearly radially folded or lobed. Mycelium dense, surface hyphae thick, ends fasciculate. Surface white and villose by a loose mat of numerous long and thick, radially arranged aerial hyphae, ascending several mm, forming conspicuous thick strands with large connectives, collapsing and developing yellow, 3A6 to 4AB4–5, guttules to 0.6 diam in a broad distal region; also aerial hyphae turning yellow to orange. Agar plug turning red, surrounding central area yellowish to pale reddish. White tufts developing in the centre. Autolytic activity inconspicuous, coilings infrequent. Odour slightly mushroomy. Conidiation noted after 2 days around the plug, effuse, short, simple, sessile, acremonium-like, long phialides singly or in pairs, spreading across the plate, later verticillium-like, concentrated at the end of the flat centre, and ascending on aerial hyphae, loosely disposed, with phialides often in pairs or cruciform, from 1 week white granules or tufts 0.4–0.8 mm diam around the plug with numerous wet heads mostly to 20 μm diam, some 60–100 μm diam. Tufts appearing as white spots to 4 mm diam, spreading irregularly across the plate. At 15°C colony indistinctly zonate; agar and hyphae turning sometimes bright yellow, 3A5–8, orange 5AB7–8, 6B7–8, or darker, brown from *ca* 10 days on.

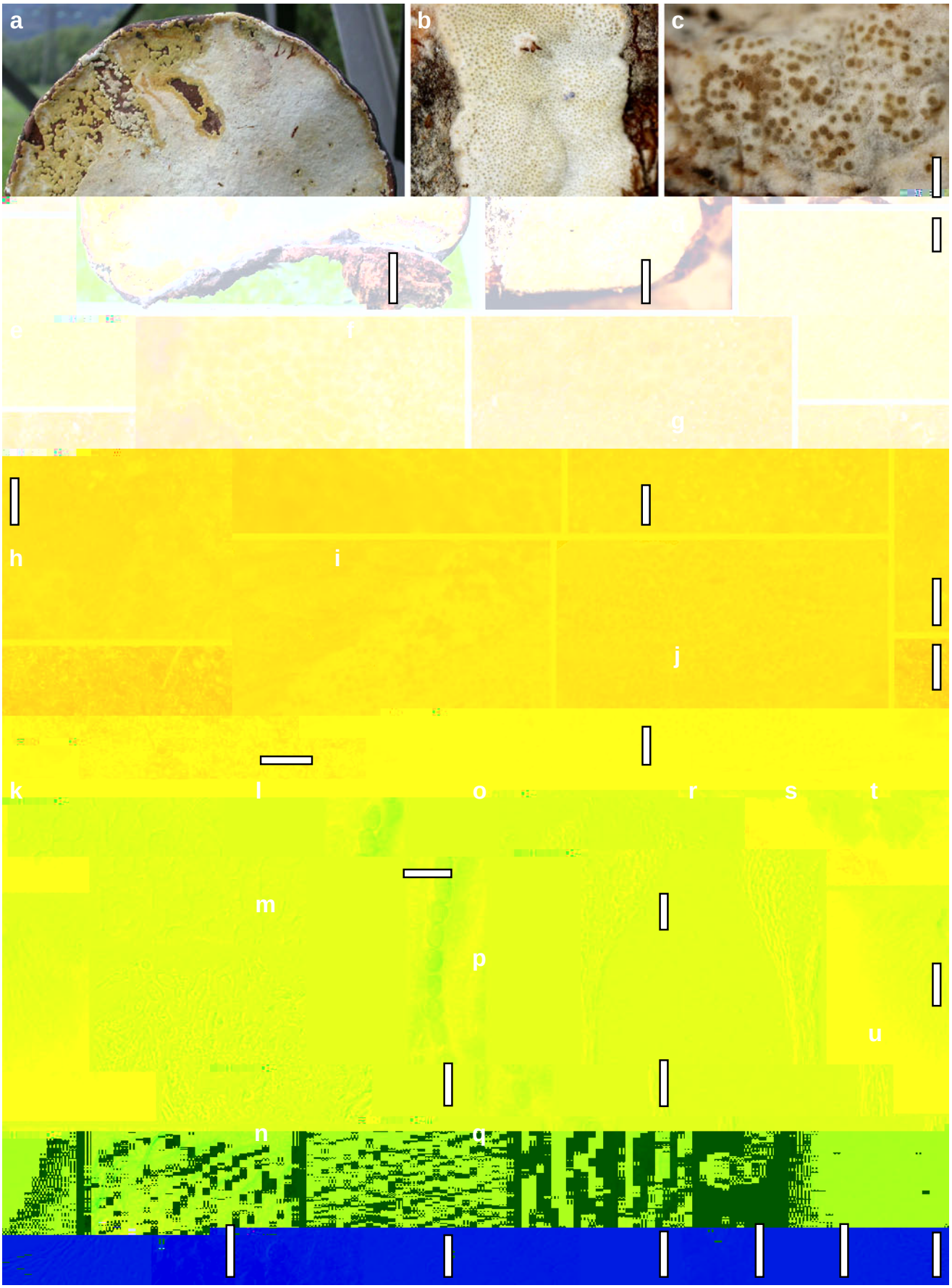
On SNA after 72 h 13–16 mm at 15°C, 24–29 mm at 25°C, 0.5–1 mm at 30°C, covering the Petri dish after 6–7 days at 25°C. Colony homogeneous, not zonate, similar to CMD, but hyphae wider and more densely disposed; margin coarsely wavy and distinctly radially fan-shaped. Surface hyphae thick, terminal branches fasciculate, often wavy and curved, mycelium only loose in the centre, hyphae degenerating and becoming empty after <1 week; nearly no macroscopic changes after 1 week, except for the margin becoming finely downy to floccose due to dense conidiation. Aerial hyphae inconspicuous, long and thick and more frequent at distal and lateral margins, becoming fertile. Autolytic activity low to moderate, coilings infrequent. No distinct odour, no diffusing pigment observed. Chlamydospores rare. Conidiation better developed and denser than on CMD, starting after 2 days, effuse, acremonium- to verticillium-like, irregularly distributed, absent or scant in the centre, mainly concentrated in distal and lateral regions of the plate; sessile or on long aerial hyphae. Conidiophores simple or rebranching 1(–2) times, i.e. 1 main axis of variable length, tapering from 7 to 8 μm at the base to 2–3 μm wide terminally, with 1–2 celled, often asymmetric terminal branches, replaced by phialides in apical regions. Phialides solitary or divergent in whorls of 2–4(–5), often distinctly inclined upwards, arising from cells 2–4 μm thick. Phialides (11–)19–33(–41)×(1.8–)2.0–3.0(–3.2) μm, (1.3–)1.5–2.5(–3.2) μm wide at the base, l/w (5.7–)7.8–13.5 (–16.8) (*n*=30), subulate or cylindrical, widest at or slightly above the base, straight or curved. Conidia formed in minute wet heads, rarely >50 μm diam, distributed across the whole plate, denser around the margin. Conidia (5–)6–11(–15)× (2.0–)2.2–2.7(–3.0) μm, l/w (2.0–)2.5–4.2(–5.0) (*n*=30), oblong, cylindrical, less commonly sub-ellipsoidal, hyaline, smooth, with few minute guttules; scar indistinct.

Habitat: On basidiomes of resupinate species of *Phellinus*, particularly *P. ferruginosus* on wood strongly decomposed by the basidiomycete.

Distribution: Europe (Austria, Denmark, Germany).

Holotype: **Austria**, Niederösterreich, Wien-Umgebung, Mauerbach, walking path from the cemetery, MTB 7763/1, 48°15′16″ N 16°10′33″ E, elev. 350 m, on *Phellinus ferruginosus*/*Fagus sylvatica*, decorticated branch 6 cm thick, on the polypore and wood, 24 Sep. 2005, W. Jaklitsch & O. Sükösd, W.J. 2857 (**WU 29402**, culture CBS 119283=C.P.K. 2137). ***Holotype*** of *Trichoderma phellinicola* isolated from WU 29402 and deposited as a

Fig. 64 Cultures and anamorph of *Hypocrea phellinicola* (CBS 119283). **a–d**. Cultures (**a**. on PDA, 7 days; **b**. on CMD, 14 days; **c**. on SNA, 14 days; **d**. on PDA, 15°C, 28 days). **e**. Golden drops on aerial hyphae (PDA, 7 days). **f**. Conidiophore on the growth plate. **g–k**. Conidiophores and phialides. **l, m**. Chlamydospores (CMD, 8–18 days). **n–p**. Conidia. **a–p**. All at 25°C except d. **f–k, n–p**. On SNA after 4 days. *Scale bars* **a–d**=15 mm. **e**=0.4 mm. **f**=30 µm. **g–i, m**=15 µm. **j–l**=10 µm. **n–p**=5 µm


a
b
c
e
f
g
h
i
j
k
l
o
r
s
t
m
p
u
n
q

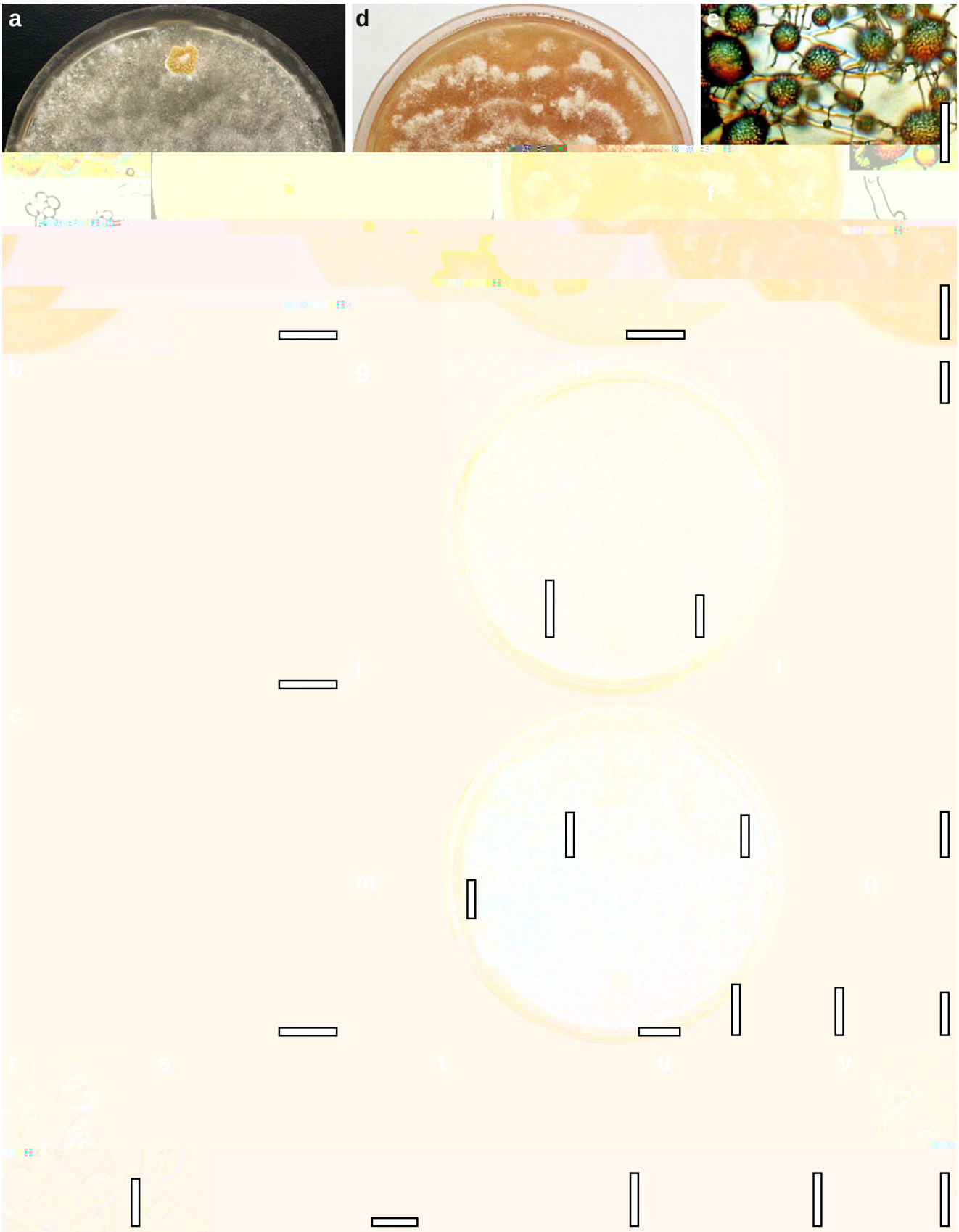
◀ **Fig. 65** Teleomorph of *Hypocrea protopulvinata*. **a–g**. Fresh stromata (**a**. habit, soc. *H. pulvinata* on upper left side**; b–d**. immature; **d–g.** surface). **h, i**. Parts of dry stromata. **j**. Stroma surface in 3% KOH. **k**. Perithecium in section. **l**. Hairs on stroma surface. **m**. Apical periphyses. **n**. Marginal cells at the ostiolar apex. **o**. Cortical tissue in face view. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue in section. **r, s**. Asci with ascospores (**s**. in cotton blue/lactic acid). **t**. Ascospores in ascus apex. **u**. Swollen and germinating ascospores on agar surface. **l–n**. In 3% KOH. **a, r–t**. WU 29425. **b, d, e, h, i, l–n, u**. WU 29417. **c, f, g**. WU 29416. **j**. WU 29419. **k, o–q**. WU 29414. *Scale bars* **a**=20 cm. **b**=1 mm. **c**, **i**=0.5 mm. **d**, **j**=0.15 mm. **e–g**=0.3 mm. **h**=0.8 mm. **k**, **u**=30 μm. **l, p**, **q**=20 μm. **m–o, r**, **s**=10 μm. **t**=5 μm

apex; ends rounded; periphyses 1–3 μm wide. Perithecia (120–)190–270(–310)×(100–)110–160(–180) μm (*n*=20), flask-shaped, often densely crowded; peridium (12–)13–25 (–37) μm (*n*=20) thick at the base, (5–)8–15(–17) μm (*n*= 20) at the sides, bright yellow in lactic acid, deeply orange in KOH. Cortical and subcortical layer when present 20–53(–70) μm (*n*=30) thick, a homogeneous *t. intricata* of thin-walled, hyaline to yellowish hyphae (2–)3–6(–9) μm (*n*=30) wide in vertical section, surrounding entire perithecia, often scant between upper parts of the perithecia, sometimes with yellow guttules; appearing as globose to oblong cells (3–)4–12(–22)×(3–)4–7(–9) μm (*n*=30) in face view. Hyphal ends ('hairs') on the surface inconspicuous, (9–)13–27(–38)×(3–)5–8(–10) μm (*n*=30), smooth or roughened, cylindrical to clavate, yellowish, not or only slightly projecting as single cells or rows of 2–3 cells with constricted septa, orange in KOH, often collapsed in mature stromata. Subperithecial tissue a dense hyaline to yellowish *t. angularis–epidermoidea* of thin-walled cells 5–21(–34)×(3–)5–9(–11) μm (*n*= 30), mixed with few broad yellowish hyphae; often strongly reduced between perithecia and host surface, but often deeply penetrating into the pores of the host. Asci (63–)70–90(–116)×(4.0–)4.3–5.0(–5.5) μm, stipe (0–)3–12(–18) μm (*n*=30) long; no croziers seen. Ascospores hyaline, often yellow to orange after ejection, smooth to finely spinulose, cells dimorphic; distal cell (3.0–)3.3–4.2(–5.0)×(2.7–)3.0–3.5(–4.0) μm, l/w (0.9–)1.1–1.3(–1.5) (*n*=90), subglobose, ellipsoidal or wedge-shaped; proximal cell (3.3–)4.0–5.5(–6.3)×(2.3–)2.5–3.0(–3.5) μm, l/w (1.0–)1.5–2.0(–2.4) (*n*= 90) oblong or wedge-shaped. Ascospores characteristically conspicuously swelling to *ca* 25 μm diam on the agar surface before germination.

Cultures and anamorph: optimal growth at 30°C on CMD and SNA, at 25°C on PDA, at 25°C faster on PDA than on CMD and SNA; no growth at 35°C.

On CMD after 72 h 10–12 mm at 15°C, 17–20 mm at 25°C, 18–24 mm at 30°C; mycelium covering the plate after 12–14 days at 25°C. Colony hyaline, thin, not or indistinctly zonate, with wavy margin; mycelium loose, hyphae thin, little branched, irregularly oriented and coarsely wavy, causing radially oriented fan-shaped structures. Surface becoming downy, floccose or farinose along the margin due to conidial heads. Aerial hyphae scant, short. Autolytic activity moderate, excretions small, hyaline to yellowish; coilings rare or absent: No diffusing pigment formed. Odour fruity. Chlamydospores uncommon, only seen at 30°C, intercalary, rarely terminal, (11–)13–26(–35)×(8–)9–20(–27) μm, l/w (1–)1–1.7(–2.1) μm (*n*=30), broadly ellipsoidal, subglobose, pyriform or oblong. Conidiation starting after 2 days on short, simple or scarcely asymmetrically branched, acremonium-like conidiophores, loosely disposed, becoming dense along the margin of the plate; with solitary subulate phialides and wet conidial heads to 150 μm diam. Conidia as described on SNA, hyaline, conspicuously swelling after transfer to fresh agar. Some conidiation also submerged in the agar. Fruity, apple-like odour noted also at 15 and 30°C. At 15°C fan-shaped colony becoming diffuse yellow, 2–3AB3–4, conidiation dense along the margin. At 30°C colony irregular, fan-shaped to lobed; conidiation concentrated in powdery or granular distal concentric zones, in white tufts to 1.5 mm diam or in broad white spots. Tufts loosely asymmetrically branched, right angles frequent.

On PDA after 72 h 10–11 mm at 15°C, 30–33 mm at 25°C, 20–22 mm at 30°C; mycelium covering the plate after 5–6 days at 25°C. Colony flat, indistinctly zonate, imbricate, mottled due to varying mycelial density, white in denser regions; margin wavy to lobed, thinner than the residual colony. Mycelium dense; surface hyphae thick. Surface becoming farinose or granulose due to conidial heads. Aerial hyphae in lawns of varying density, short, thick, erect, often fasciculate, becoming fertile. Sometimes dense white spots appearing, with brownish droplets, turning golden brown. Autolytic excretions abundant, small, <50 μm diam; coilings absent. Agar/reverse turning pale rosy with yellow tones or dull orange around the plug, 5AB4–5. Odour fruity, apple-like. No chlamydospores seen. Conidiation noted after 2 days, effuse, in a dense lawn of simple, short, scarcely branched, acremonium-like conidiophores 3–5 μm wide terminally, 6–8 μm basally, with 1–2 terminal phialides, spreading from the centre. Conidia formed in numerous wet heads 20–80(–160) μm diam, confluent, becoming irregular. Phialides (6–)25–53 (–76)×(2.8–)3.5–5.5(–7.0) μm, l/w (2–)6–12(–18), (2.5–)3.5–5.0(–6.5) μm (*n*=90) wide at the base, subulate or cylindrical, straight, curved or sinuous. Conidia (5–)7–14(–18)×(3–)4–8(–12) μm, l/w (1.1–)1.3–2.0(–2.7) (*n*=90), hyaline, quite variable, subglobose, oval, pyriform, oblong to cylindrical, smooth, with minute guttules and indistinct or truncate scar. At 15°C colony crystal-, fan- or star-shaped due to fasciculate radial surface hyphae, becoming mottled with large thick powdery whitish spots to 1 cm long. Agar rosy, greyish orange or reddish, 5AB4–5, 6B4–5, 7A4; odour distinct, 'artificially fruity'. Conidiation in numerous wet heads to 250 μm diam, particularly dense in white spots.


a
d
e
f
b
g
h
i
j
k
l
c
m
n
o
p
q
r
s
t
u
v

◀ **Fig. 66** Cultures and anamorph of *Hypocrea protopulvinata*. **a–d.** Cultures (**a**. on PDA, 21 days. **b**. on CMD, 14 days. **c**. on SNA, 14 days. **d.** on PDA, 30°C, 13 days). **e**. Conidial heads on growth plate close to the plug (SNA, 7 days). **f**. Conidiophore on growth plate (CMD, 30°C, 14 days). **g–o**. Conidiophores and phialides (**g–k, n**. SNA, 4–8 days; **l, m, o**. PDA, 3 days). **p, q**. Chlamydospores (CMD, 30°C, 14 days). **r**. Autolytic excretions on hyphal tips (PDA, 15°C, 5 days). **s–v**. Conidia (**s**. SNA, 6 days; **t–v**. PDA, 3–6 days**). a–c, e, g–o, s–v**. At 25°C. **a–f, k, l, n–r, u**. C.P.K. 2434. **g–j, s**. CBS 121270. **m, v**. CBS 739.83. **t**. CBS 121274. *Scale bars* **a–d**=15 mm. **e**=0.2 mm**. f, i, j, n**=30 μm. **g, h**=50 μm. **k, m, o, s**=20 μm**. l, p, q**=15 μm. **r**=80 μm. **t–v**=10 μm

At 30°C colony of white concentric zones on reddish agar and yellow to orange-red spots due to dead yellow hyphae; irregularly mottled. Conidial heads to 300 μm around the plug. Agar turning greyish orange to greyish red, 6B4–6, 7AB3–4; pigment more distinct than at 15 and 25°C; odour indistinct.

On SNA after 72 h 8–10 mm at 15°C, 20–22 mm at 25°C, 22–24 mm at 30°C; mycelium covering the plate after 10–11 days at 25°C. Colony similar to CMD, but denser. Surface hyphae soon degenerating, appearing empty. Aerial hyphae variable, long in distal and lateral areas of the colony, becoming fertile, sometimes aggregating to loose tufts, forming indistinct concentric zones or white spots. Autolytic activity inconspicuous, coilings rare or absent. No pigment, no distinct odour noted. No chlamydospores seen. Conidiation starting after 2 days mostly around the plug and towards proximal margin, or irregularly distributed; on simple, erect, acremonium-like to irregularly verticillium-like conidiophores, short or on long aerial hyphae at the distal margin. Conidia amassing in numerous wet heads growing to 200 μm diam, largest around the plug, becoming concentrated in irregular white spots or in irregular loose tufts of aerial hyphae, sometimes in few concentric zones, finally becoming dry. Conidial yield conspicuously higher than on CMD and PDA. Conidiophores to 2 mm long, 6–9 μm wide at the base, attenuated terminally to 2.5–6 μm, asymmetrically branched, typically of a single main axis with several long, unpaired, widely spaced branches. Branches with short side branches or phialides. Phialides solitary, not in whorls, often on 1-celled side branches, or in extension of the conidiophore or branching off in right angles. Phialides (10–)30–60(–95)×(3–)4–6(–7) μm, l/w (3–)6–12(–17) (*n*=90), (2.7–)4.0–5.5(–6.3) μm (*n*=90) wide at the base, subulate or cylindrical, straight or slightly sinuous, widest at or slightly above the base. Conidia (5–)8–16(–26)×(3–)4–9(–12) μm, l/w (1.3–)1.4–2.2(–3.6) μm (*n*=93), hyaline, smooth, highly variable, oval to pyriform, oblong to cylindrical, or irregular, usually broadly rounded, base often truncate, eguttulate, often densely packed in heads. At 30°C conidiation in up to 8 finely granular concentric zones.

Habitat: on basidiomes of *Fomitopsis pinicola*, often in association with *H. pulvinata*.

Distribution: Europe (Austria, Czech Republic, Spain, Switzerland), Japan, North America, depending on the distribution of its host.

Holotype: **Japan**, Chiba Prefecture, Fudagou, Kiyosumi Forestry Exp. Station of the Univ. of Tokyo, on *Fomitopsis pinicola*, 24 Oct. 1967, Y. Doi (TNS.D-365=TNS-F-223431; ex-type culture CBS 739.83; only culture examined).

Specimens examined: **Austria**, Kärnten, Völkermarkt, Eisenkappel, at roadside, 1–2 km from the village, heading to Seebergsattel, MTB 9553/3, 46°26′16″ N 14°33′40″ E, elev. 780 m, on the hymenium of *Fomitopsis pinicola*/*Picea abies*, soc. *Ophiostoma polyporicola*, 31 Oct. 2005, H. Voglmayr & W. Jaklitsch, W.J. 2882 (WU 29414, culture CBS 121274=C.P.K. 2430). Niederösterreich, Lilienfeld, Sankt Aegyd am Neuwalde, Lahnsattel, virgin forest Neuwald, MTB 8259/1, 47°46′32″ N 15°31′25″ E, elev. 980 m, on the hymenium of a basidiome of *Fomitopsis pinicola* lying on the ground, soc. *Melanospora* sp., *Ophiostoma polyporicola*, 27 Sep. 2006, H. Voglmayr, W. J. 2990 (WU 29416, culture C.P.K. 2476). Mödling, Wienerwald, Kaltenleutgeben, between Am Brand and Stangau, MTB 7862/4, 48°06′41″ N, 16°08′26″ E, elev. 500 m, on a basidiome of *Fomitopsis pinicola* on a log of *Fagus sylvatica*, soc. *Hypocrea pulvinata*, 5 Oct. 2008, W. Jaklitsch & O. Sükösd, W.J. 3221 (WU 29418). Steiermark, Bruck/Mur, Gußwerk, Rotmoos bei Weichselboden, forest edge, MTB 8356/2, 47°40′58″ N 15°09′26″ E, elev. 690 m, on *Fomitopsis pinicola* on corticated log of *Alnus incana* lying on the ground, 12 cm thick, soc. *Ophiostoma polyporicola*, 27 Sep. 2006, H. Voglmayr, W.J. 2993 (WU 29417, culture CBS 121270=C.P.K. 2478). Tirol, Innsbruck-Land, Zirl, Zirler Alnetum (south of the river Inn), MTB 8733/1, 47°16′22″ N 11°13′50″ E, elev. 600 m, on hymenium and upper side of *Fomitopsis pinicola* fallen from standing trunk of *Alnus incana* to the ground, also on bark, soc. *H. pulvinata*, 2 Sep. 2003, W. Jaklitsch, W.J. 2359 (WU 29425). **Czech Republic**, Southern Bohemia, Žofín, Žofínský prales, MTB 7354/1, on a basidiome of *Fomitopsis pinicola*, soc. *Ophiostoma polyporicola*, 27 Sep. 2008, A. Urban, W.J. 3223 (WU 29419). **Spain**, Asturias, Puerto de Pajares, Hayedo de Valgrande, 43º 00′ 04″ N 5º 46′ 41″ W, elev. 1000 m, on *Fomitopsis pinicola*/*Fagus sylvatica*; 14 Aug. 2009 (ERD-4884). **Switzerland**, Bern, Büetigen, on *Fomitopsis pinicola*, soc. various hyphomycetes, overmature, 13 Oct. 2005, W. Gams (WU 29415, culture C.P.K. 2434).

Notes: This species, originally described from Japan (Doi 1972), occurs also in North America, but was apparently unknown in Europe until recently. It often occurs together with *H. pulvinata* on the same basidiome, both species residing on the hymenium, while *H. pulvinata*

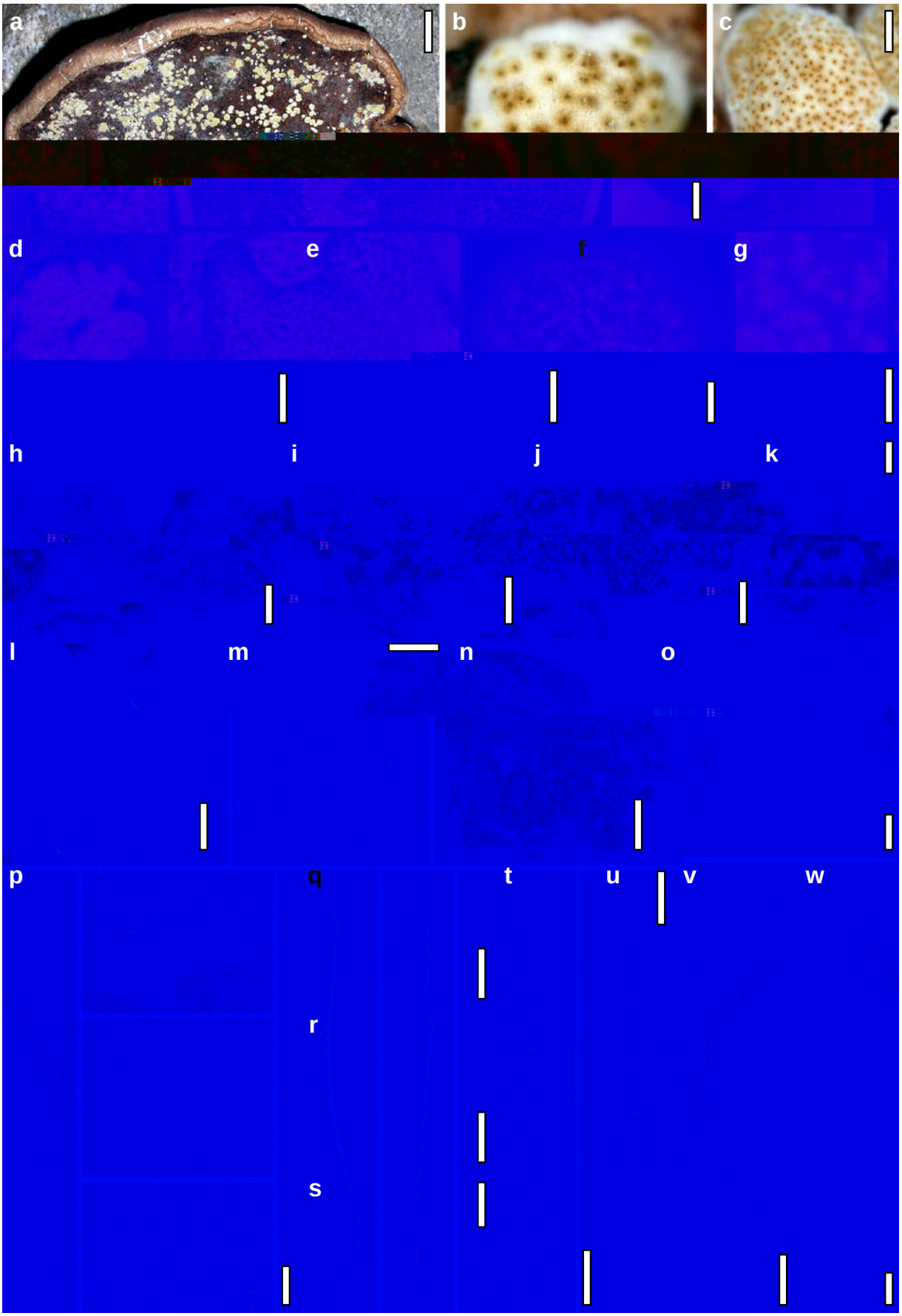
frequently also grows on the upper side. Both species are often accompanied by *Ophiostoma polyporicola*, sometimes by *Melanospora cf. lagenaria*. Morphological differences permit easy distinction from *H. pulvinata*. Examination of the surface of fresh stromata, ideally before ascospore ejection, in the stereo-microscope is usually sufficient: *H. pulvinata* has minute ostioles surrounded by a ring-like, diffusely greenish yellow to orange-brown coloured stroma surface, followed by white mycelium, while *H. protopulvinata* has wide brown perithecial dots surrounded by a homogeneously coloured, white to brownish stroma surface. Further differences are lanceolate ostiolar cells and more or less monomorphic ascospores in *H. pulvinata*. In culture the apple-like odour and the large phialides are characteristic for *H. protopulvinata*. Earlier authors (Doi 1972; Overton et al. 2006a) reported considerably smaller phialides. However, a re-examination of the ex-type strain CBS 739.83 on PDA revealed phialides (13–)32–55(–67)×(4–)5–6(–7) µm (*n*=30). See also the website www.asturnatura.com for a good illustration of *H. protopulvinata*.

Hypocrea pulvinata Fuckel, Jahrb. Nassau. Ver. Naturk. 23–24: 185 (1870 [‘1869’]). Fig. 67
= *Hypocrea citrina* * *fungicola* P. Karst., Mycol. Fenn. 2: 204 (1873).
≡ *Hypocrea karsteniana* Niessl in Rehm. Ascomyceten, Hedwigia 22: 53 ([Apr.] 1883).
≡ *Hypocrea fungicola* (P. Karst.) Sacc., Syll. Fung. 2: 528 ([13 June] 1883a).
≡ *Protocrea fungicola* (P. Karst) Lar.N. Vassiljeva, NizshieRasteniya, Griby i Mokhoo-braznye Dal’nego Vostoka Rossii, Griby. Tom 4. *Pirenomitsety i Lokuloaskomitsety* (Sankt-Petersburg): 162 (1998).
= *Hypocrea colliculosa* Fr., in Cooke, Grevillea 12: 79 (1884).
= *Hypocrea citrina* (Fr.) Fr. var. *citrina* sensu Canham, Mycologia 61: 318 (1969).
Anamorph: *Trichoderma* sp. [sect. *Hypocreanum*]. Fig. 68

Stromata when fresh 1–150×0.5–130 mm, 0.5–2 mm thick, solitary, gregarious or densely aggregated, small and pulvinate or large and broadly pulvinate or effuse; outline roundish, elongate or irregular. Surface smooth, slightly velutinous; ostiolar dots minute, plane, (olive-)brown, pale and diffuse when young. Stroma colour white, yellowish, greenish-yellow, brown-orange, 2–3A2–4, 3–4A5–6, 5CD8, often with olive tones.

Stromata when dry 0.2–0.8(–1.5) mm (*n*=30) thick, broadly pulvinate, subeffuse or effuse, the latter particularly on the hymenial margin of the host, broadly attached, with rounded, less commonly mycelial margin. Surface velutinous or farinose; perithecia immersed or perithecial contours sometimes slightly projecting. Ostioles visible as minute, plane, brown perforations. Ostiolar areas (27–)40–77(–94) µm (*n*=30) diam, including brown diffuse margins. Stroma colour first white, after the development of ostioles pale yellowish, greenish- or greyish-yellow; later yellow-brown or dull (orange-)brown with olive tones, 3–4A2–3, 4B3–4, 5CD4–6. Pigment inhomogeneously distributed, usually only present around the ostioles, lighter or white outside the ostiolar areas. Reaction to 3% KOH variable, inconspicuous or reddish, orange-red to dark red. Spore deposits white or yellow, often condensing to a thick crust.

Stroma anatomy: Ostioles (62–)72–90(–97) µm long, projecting to 16(–27) µm, (22–)36–56(–62) µm wide at the apex (*n*=20), filled with short narrow cylindrical periphyses and lined by a palisade of narrow hyaline hyphae with


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
t
u
v
w
r
s

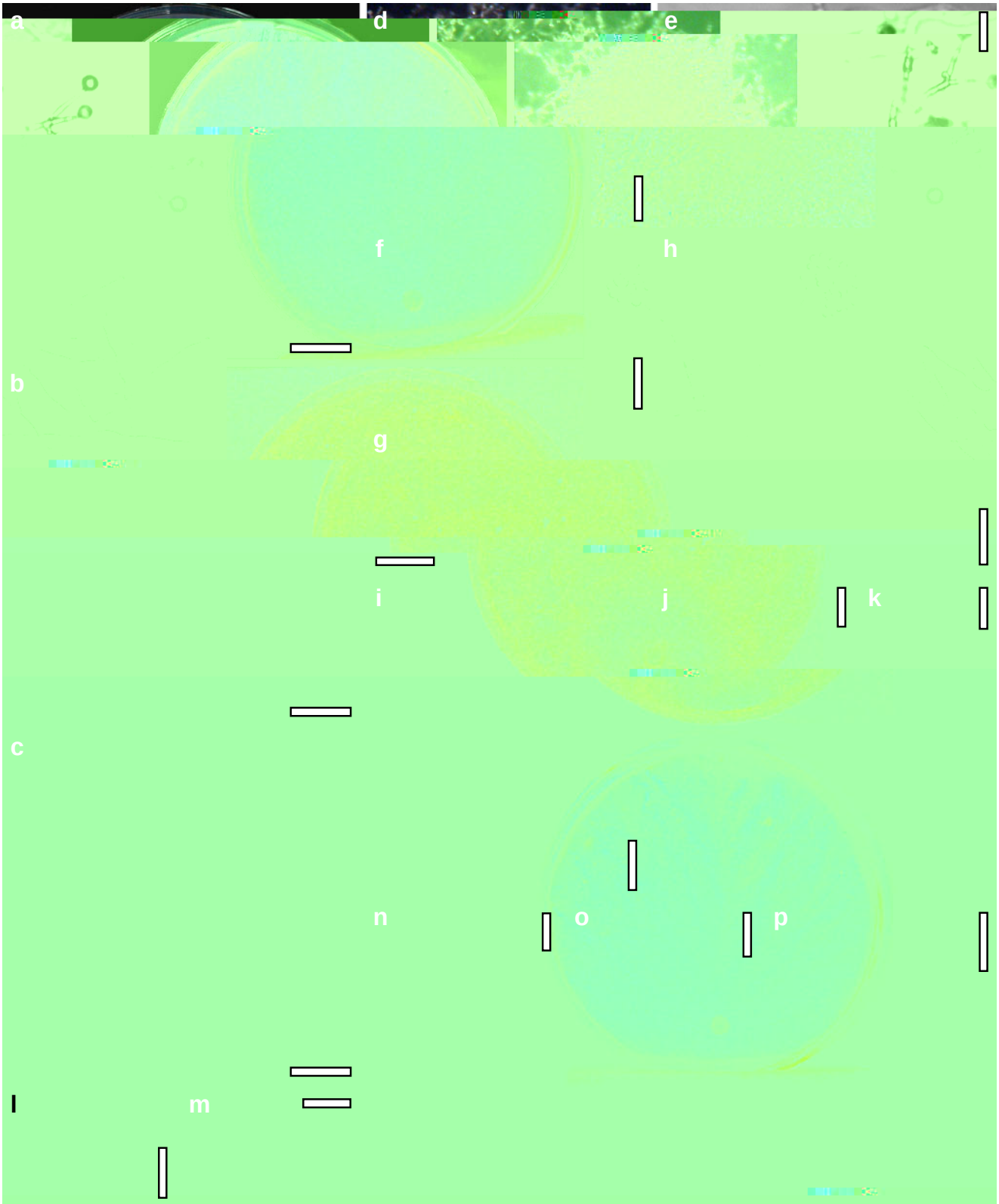


Fig. 68 Cultures and anamorph of *Hypocrea pulvinata*. **a–c**. Cultures (**a**. on CMD, 7 days. **b**. on PDA, 14 days. **c**. on SNA, 14 days). **d**. Conidiation tuft (SNA, 15 days). **e**. Simple conidiophores on growth plate (CMD, 8 days). **f.** Simple conidiophores submerged in agar (CMD, 14 days). **g–k, n**. Conidiophores and phialides (PDA, 4–5 days). **l**, **m**. Chlamydospores (CMD, 30°C, 30 days). **o, p**. Conidia (PDA, 5 days). **a–k, n–p**. At 25°C. **a–d, f–p**. CBS 121279. **e**. C.P.K. 1991. *Scale bars* **a–c**=15 mm. **d**=0.3 mm. **e**, **h**=30 µm. **f, g, i**, **k**= 20 µm. **j, l**, **n**=10 µm. **m, o**, **p**=7 µm

proximal cell (3.0–)3.5–5.0(–5.5)×(2.0–)2.5–3.2(–3.7) μm, l/w (0.9–)1.1–1.8(–2.4) (*n*=33); both cells ellipsoidal or oblong, nearly rectangular or projectile-shaped, sometimes subglobose, often truncate at the contact area and wider towards rounded ends; sometimes dimorphic in the ascus base, less commonly in other positions.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 10–11 mm at 15°C, 23–27 mm at 25°C, 13–15 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony hyaline, thin, not zonate; margin wavy or forming lobes. Mycelium loose, organised in radial patches, little on the agar surface; primary hyphae to *ca* 15 μm wide. Aerial hyphae short, scant. No autolytic activity and coilings noted. No diffusing pigment, no distinct odour noted. Chlamydospores absent or rare, slightly more frequent at 30°C, (8–)10–17(–26)×(8–)9–15 (–23) μm, l/w (0.9–)1.0–1.4(–1.6) (*n*=30), (sub)globose, ellipsoidal or pyriform, terminal, less frequently intercalary and then more angular, multiguttulate. Conidiation starting after 3–4 days mainly around the plug and at the proximal margin, variable, scant or abundant, on solitary phialides sessile on surface hyphae or minute erect, acremonium-like to irregularly verticillium-like conidiophores; sometimes concentrated in narrow concentric zones, sometimes also submerged in the agar to the bottom of the plate; macroscopically invisible, sometimes appearing in white fluffy tufts in distal areas. Conidial heads to 50 μm diam. At 15°C dense white pustules noted after 2 weeks, mostly at the colony sides. At 30°C colony forming empty spaces, resembling snow crystals.

On PDA after 72 h 12–13 mm at 15°C, 19–30 mm at 25°C, 1–5 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony irregularly leaf- or crystal-like, flat, margin wavy; mycelium dense, primary hyphae to *ca* 10(–15) μm thick, parallel and particularly densely arranged at the margin. Centre thin, becoming finely farinose to granular at the surface; residual part of the colony developing several concentric, downy, whitish, mottled zones or becoming irregularly mottled with more or less radially arranged whitish downy spots. Aerial hyphae thick, short and dense in the centre; long, rather flat and radially arranged toward the margin, becoming fertile. Autolytic activity inconspicuous, coilings absent. No pigment, no distinct odour noted. Conidiation starting after 3–4 days at the proximal margin and around the plug, short, mostly on 1–2(–3) phialides on aerial and surface hyphae, dense, spreading across entire plate, concentrated in concentric zones and white spots, often on stromatic bases, sometimes in irregularly distributed white tufts or pustules to 1.5(–4) mm diam. Conidial heads wet, minute, sometimes to 50 μm diam. Conidiophores (main axis) short, simple, acremonium-like, or irregularly verticillium-like, unbranched or branched 3 fold, thick-walled and to 10(–15) μm wide at the base, erect or obliquely arising from surface hyphae, gradually attenuated upwards to 3 μm; bearing phialides in irregular distances, mostly solitary, infrequently paired, often in right angles on the main axis, often on 1-celled, sometimes thickened branches. Phialides (7–)17–38(–59)×(2.7–)3.3–4.2(–4.5) μm, l/w (2.8–)4.8–9.5(–14) (*n*=30), (2.5–)3.0–3.8(–4.3) μm (*n*=30) wide at the base, subulate, usually straight, widest at or slightly above the base. Conidia (2.5–)3.7–8.5 (–11)×(2.5–)3–6(–7.5) μm, l/w (1.0–)1.1–1.6(–2.0) (*n*=30), hyaline, oval, subglobose or pyriform, smooth, finely multiguttulate, often with distinct truncate scar. At 15 and 30°C often yellow spots apparent due to pigmented hyphae, 3A4, 3B6–7, becoming brown, 5CD5–8. At 30°C colony zonate; autolytic activity sometimes conspicuous in yellow spots.

On SNA after 72 h 10–11 mm at 15°C, 25–27 mm at 25°C, 3–7 mm at 30°C; mycelium covering the plate after 1 week at 25°C. Colony hyaline, thin, leaf-like with empty spaces, not zonate; margin wavy or irregular; mycelium loose, little on the agar surface; primary hyphae thick. Aerial hyphae short, infrequent. Autolytic activity and coilings lacking. No pigment, no distinct odour noted. Chlamydospores infrequent, noted after 2 weeks, earlier at 30°C. Conidiation starting after 3–4 days mainly around the plug and at the proximal margin, on solitary phialides on surface hyphae or 1–2 phialides on short, often 1-celled, acremonium-like conidiophores, usually scant, loosely arranged, spreading across the plate, after >10 days denser in white fluffy tufts to 2 mm diam in distal areas. At 15°C helical hyphae inside agar around the plug. At 30°C colony irregular, autolytic activity, terminal and intercalary thickenings of hyphae conspicuous; no conidiation seen. After *ca* 1 year at 15°C small stromata seen. Fertile pulvinate stromata 2–4 mm diam agreeing in morphology with stromata found in nature also formed within a month at 15°C on MEA covered by cellophane.

Habitat: on basidiomes of *Fomitopsis pinicola* and *Piptoporus betulinus*. Reports from *Laetiporus sulphureus* and *Ganoderma* spp. have not been confirmed in recent years.

Distribution: common in north temperate regions of the world, Europe, Japan, North America.

Lectotype, designated by Overton et al. (2006a): **Germany**, Hessen, Eltville am Rhein, Hattenheimer Wald (Geis), on *Polyporus sulphureus* (= *Laetiporus sulphureus*), identified as *Fomitopsis pinicola* !, L. Fuckel, autumn, No. 876 (FH!).

Other specimens examined: **Austria**, Burgenland, Mattersburg, Bad Sauerbrunn, Hirmer Wald, MTB 8264/1, 47° 45′28″ N 16°21′26″ E, elev. 270 m, on *Piptoporus betulinus*, 13 Jul. 2004, W. Jaklitsch & H. Voglmayr. Oberpullendorf, Mitterwald, MTB 8465/3, 47°31′30″ N 16°29′57″ E, elev. 270 m, on *Piptoporus betulinus*, 13 Jul. 2004, W. Jaklitsch. Kärnten, Klagenfurt Land, St. Margareten im Rosental,

Schwarzgupfweg-Umwiese, MTB 9452/4, 46°31′52″ N 14° 24′55″ E, elev. 730 m, on hymenium of *Fomitopsis pinicola* on *Picea abies*, soc. *Ophiostoma polyporicola*, 6 Sep. 2003, W. Jaklitsch, W.J. 2384 (WU 29426, culture C.P.K. 952). Drau-Auen, Dullach, MTB 9452/1, 46°32′51″ N 14°24′30″ E, elev. 410 m, on *Fomitopsis pinicola*, 22 Oct. 2003, W. Jaklitsch. Niederösterreich, Baden, Klausen-Leopoldsdorf, Hochstraß, MTB 7862/3, 48°07′40″ N 15°59′26″ E, elev. 470 m,on *Fomitopsis pinicola*/*Fagus sylvatica*, 23 May 1999, W. Jaklitsch, W.J. 1319. Klosterneuburg, Kritzendorf Kierlinger Gasse, on hymenium of *Piptoporus betulinus*, effuse form, 15 cm long, 2 Dec. 2009, C. Bazant (WU 30204). Lilienfeld, Sankt Aegyd am Neuwalde, Lahnsattel, virgin forest Neuwald, MTB 8259/1, 47°46′32″ N 15°31′25″ E, elev. 980 m, on *Fomitopsis pinicola* lying on the ground, 27 Sep. 2006, H. Voglmayr, W.J. 2990 (WU 29434). Mödling, Wienerwald, Kaltenleutgeben, between Am Brand and Stangau, MTB 7862/4, 48°06′41″ N, 16°08′26″ E, elev. 500 m, on a basidiome of *Fomitopsis pinicola* on a log of *Fagus sylvatica*, soc. *Hypocrea protopulvinata*, 5 Oct. 2008, W. Jaklitsch & O. Sükösd, W.J. 3222 (WU 29441). Wien-Umgebung, Mauerbach, Friedhofstraße, MTB 7763/1, 48° 15′09″ N 16°10′19″ E, elev. 340 m, on upper side of *Piptoporus betulinus*, 23 Jul. 2005, W. Jaklitsch, W.J. 2821 (WU 29432). Oberösterreich, Schärding, Kopfing, Hötzenedt, MTB 7548/1, elev. 730 m, on *Piptoporus betulinus* on standing trunk of *Betula pubescens*, 15 Aug. 2006, H. Voglmayr, W.J. 2930 (WU 29433). Steiermark, Bruck/Mur, Gußwerk, Rotmoos bei Weichselboden, riverine forest, MTB 8356/2, 47°40′57″ N 15°09′26″ E, elev. 690 m, on *Fomitopsis pinicola* on a trunk of *Alnus incana* lying on the ground, 27 Sep. 2006, H. Voglmayr, W.J. 2994 (WU 29435). Liezen, Kleinsölk, close to the crossing Tuchmoar/Breitlahnhütte, MTB 8649/4, 47°19′46″ N 13°56′38″ E, elev. 1140 m, on hymenium of *Piptoporus betulinus* on *Betula pendula*, 5 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2289 (WU 29423). Same region, Wasserschaupfad, between Breitlahnhütte and Schwarzensee, MTB 8649/3, 47°18′29″ N 13°53′07″ E, elev. 1100 m, on hymenium of *Fomitopsis pinicola* on *Picea abies*, 6 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2294 (WU 29424, culture C.P.K. 2385). Mönichkirchen, Tränktörl, 47°30′10″ N 16°00′58″ E, elev. 1030 m, on *Piptoporus betulinus*, 13 Sep. 2008, W. Jaklitsch & O. Sükösd, W.J. 3207 (WU 29440). Tirol, Innsbruck-Land, Zirl, Zirler Alnetum (south of the river Inn), MTB 8733/1, 47°16′22″ N 11°13′50″ E, elev. 600 m, on hymenium and upper side of *Fomitopsis pinicola* fallen from standing trunk of *Alnus incana* to the ground, also on bark, soc. *H. protopulvinata*, 2 Sep. 2003, W. Jaklitsch, W.J. 2359 (WU 29425, deposited as *H. protopulvinata*, culture CBS 121279=C.P.K. 946). Vorarlberg, Bludenz, Sonntag, forest path at the Lutz bridge, Großes Walsertal, MTB 8725/3, 47°14′17″ N 09°54′27″ E, elev. 780 m, on *Fomitopsis pinicola*, 1 Sep. 2004, H. Voglmayr & W. Jaklitsch. **Czech Republic**, Southern Bohemia, Stráž nad Nežárkou, nature reserve Fabián, district Jindrichuv Hradec, *ca* 4 km E of Liborezy village near Stráž nad Nežárkou town, 49°01′55″ N 14°59′00″ E, elev. 600 m, on *Fomitopsis pinicola* on *Picea abies*, 18 Oct. 2003, G. Koller, W.J. 2487 (WU 29429, culture C.P.K. 1991). **Germany**, Baden Württemberg, Freiburg, Landkreis Breisgau-Hochschwarzwald, St. Märgen, shortly after Glashütte coming from Hexenloch, MTB 8014/2, 47°59′37″ N 08°07′32″ E, elev. 750 m, on hymenium of *Fomitopsis pinicola* on *Picea abies*, 2 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2666 (WU 29431). Schramberg, Heiligenbronn, Schwarzwald, Spitalwald, on basidiome of *Fomitopsis pinicola*, 4 Oct. 2006, W. Gams, W.J. 3055 (WU 29436, culture CBS 120643). Bavaria, Starnberg, Tutzing, Hartschimmel, Goaslweide, MTB 8033/3/1, 47°56′35″ N 11°11′02″ E, elev. 735 m, on hymenium of *Fomitopsis pinicola*, 22 Oct. 2003, P. Karasch, W.J. 2488 (WU 29430, culture C.P.K. 1992). Hessen, Eltville am Rhein, Hattenheim, forest at Geis, on *Polyporus resinosus*, identified as *Fomitopsis pinicola*, L. Fuckel, autumn, Fungi Rhenani 2467 (M!). **Italy**, Südtirol, Pustertal, Sexten, Porzenwald, near Moos, MTB 9340/1, 46°40′34″ N 12°23′08″ E, elev. 1470 m, on *Fomitopsis pinicola*, 1 Sep. 2000, W. Jaklitsch & H. Voglmayr. **Sweden**, Uppsala Län, Österbybruk, 3–4 km north from the town, right from the road to Forsmark, MTB 4373/4, 60°14′10″ N 17°55′41″ E, elev. 40 m, on hymenium of *Fomitopsis pinicola* on *Picea abies*, soc. *Melanospora* sp., *Ophiostoma polyporicola*, scant material, 5 Oct. 2003, W. Jaklitsch, W.J. 2439 (WU 29427, culture C.P.K. 2395). Stockholms Län, Nothamn, forest at the east coast, MTB 4179/3, 60°01′45″ N 18°50′43″ E, elev. 10 m, on hymenium and upper part of *Fomitopsis pinicola* on *Picea abies*, 7 Oct. 2003, W. Jaklitsch, W.J. 2446 (WU 29428, culture C.P.K. 2397). **Switzerland**, Neuchatel, Lac de la Gruère, on basidiome of *Fomitopsis pinicola*, 10 Oct. 2006, W. Gams, W.J. 3056 (WU 29437, culture CBS 120640=C.P.K. 2862). **United Kingdom**, Buckinghamshire, Slough, Burnham Beeches, 51°33′39″ N 00°37′55″ W, elev. 30 m, on hymenium of *Piptoporus betulinus* 23 cm diam, 15 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3166 (WU 29439). Herefordshire, Leominster, Queenswood Country Park, Dinmore Hill, 52°09′13″ N 02°43′38″ W, elev. 150 m, on *Piptoporus betulinus* 2 m above ground on a standing trunk of *Betula pendula*, 11 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3152 (WU 29438).

Notes: This species is common and easily identified by ecological (growth on polypores) and morphological characteristics (unevenly distributed pigment, monomorphic ascospores, verrucose surface hairs, and lanceolate ostiolar cells). On *Fomitopsis pinicola*, *H. pulvinata* is often accompanied by *H. protopulvinata*; for differentiation see also under that species. To verify whether the fungus occurs on

Laetiporus sulphureus (*Polyporus sulphureus*) and *Ischnoderma resinosum* (*Polyporus resinosus*), the lectotype from FH and the part of Fungi Rhenani 2467 from M were examined. In both specimens the host has a light to medium brown context and a resinous crust that melts in heat. This latter trait occurs only in basidiomata of *Fomitopsis pinicola* and uncommon species of *Ganoderma*, viz. *G. pfeifferi* and *G. resinosum*. The latter genus differs from *Fomitopsis* by a dark brown context. No generative hyphae and no conspicuous binding hyphae characteristic for *L. sulphureus* were found.

Hypocrea citrina stromata occur on the ground spreading from trunks; their yellow pigment is not concentrated around the ostioles. Conidiation in *H. citrina* is generally more regularly verticillium-like. The type specimen of *Hypocrea colliculosa* (K) was examined and found to represent *H. pulvinata*, based on the shape and size of ascospores, verrucose hairs on the stroma surface and colour and KOH reaction of stromata. The host of *H. colliculosa* is apparently old *Fomitopsis pinicola* with a largely disintegrated tooth-like hymenium. The specimen was collected in Vermlandia, Sweden and named but not published by Fries. He sent the specimen to Berkeley. Cooke found it in Berkeley's herbarium and described it.

Hypocrea sulphurea (Schwein.) Sacc., Syll. Fung. 2: 535 (1883a). Fig. 69
≡ *Sphaeria sulphurea* Schwein., Trans. Amer. Phil. Soc. 2: 193 (1832).
= *Hypocrea sulphurea* f. *macrospora* Yoshim. Doi, Bull. Natl. Sci. Mus. 15: 699 (1972).
Anamorph: *Trichoderma* sp. Fig. 70

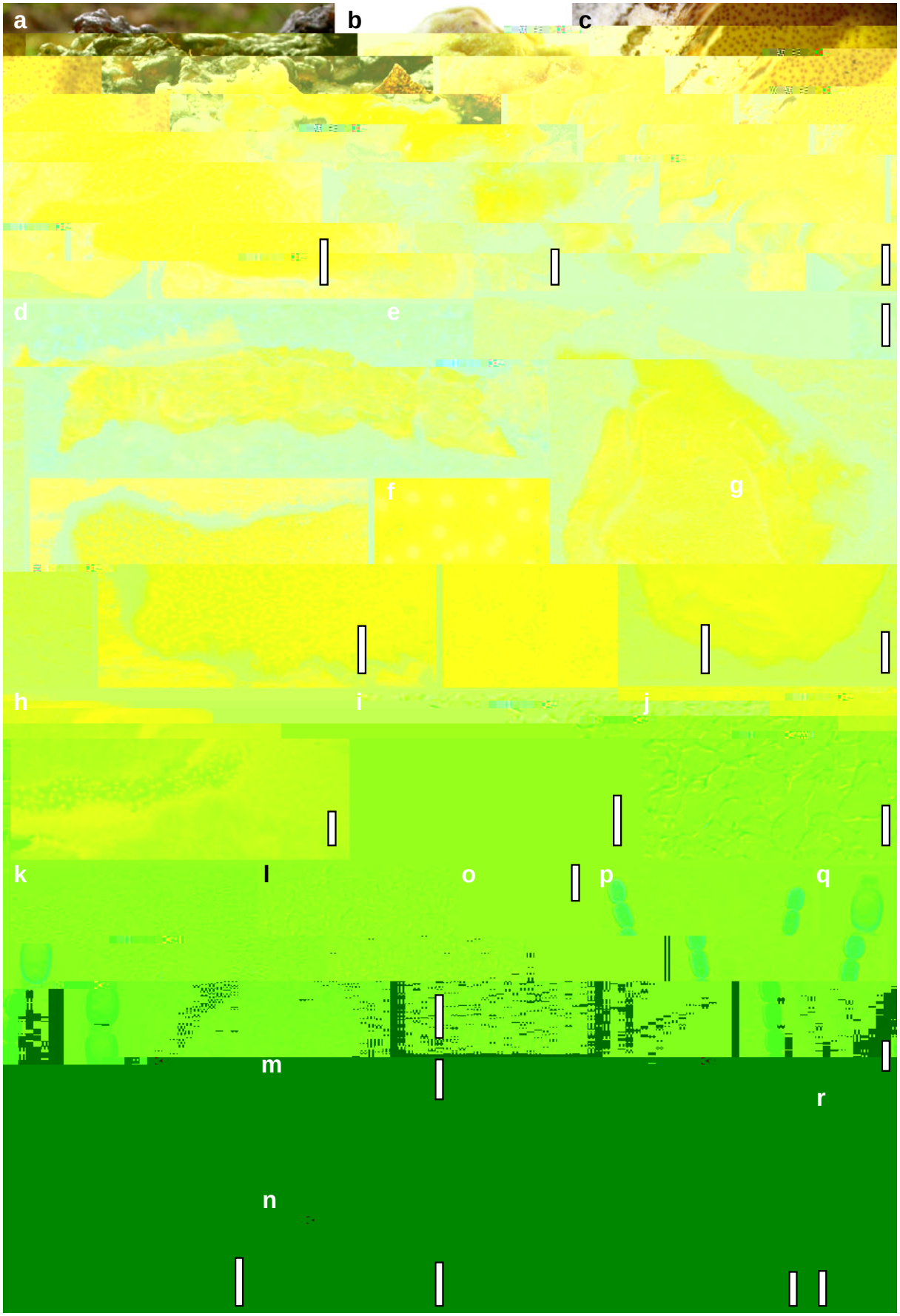
Stromata fresh and dry with little difference, (1–)3–50(–120)×(1–)3–22(–50) mm (n=50); 0.2–2(–3) mm thick when fresh, mostly less than 1 mm thick when dry, solitary or in dense aggregations to *ca* 30 cm long, widely effuse, flat, rarely subpulvinate, of indeterminate growth, following its heterobasidiomycetous host, often erumpent from cracks in bark. Outline circular, elongate to irregular, depending on the dimensions of the host, thinner at the periphery, entirely attached, enclosing leaves, twigs; margin sterile, thin, finely fibrous to membranaceous, white to yellowish; when dry often becoming detached with the host. Surface smooth, rugose or tubercular; perithecia entirely immersed. Ostiolar dots (31–)47–73(–110) μm (n=80) diam, densely disposed, well-defined, mostly plane or slightly convex, yellow-brown, ochre, orange or reddish brown. Stroma development and colour: starting as a white to yellow mycelium, becoming compacted, turning light yellow, 2A4–6, when immature, bright yellow, greyish yellow, citrine to orange-yellow, sometimes with olive tints, 3AB(3–)5–8, 4AB4–6(–8) when mature; white inside, perithecial layer reddish; colour unchanged in 3% KOH.

Stroma anatomy: Ostioles (57–)70–94(–104) μm long, plane with the surface or projecting to 20(–27) μm; (40–)45–64(–72) μm wide at the apex (n=23); apex lined with mostly clavate hyaline cells to 9 μm wide. Perithecia (260–)275–315(–325)×(120–)145–230(–270) μm (n=30); peridium (7–)9–13(–15) μm (n=16) thick at the base, (12–)17–24(–26) μm (n=16) apically; hyaline to pale yellowish. Cortical layer (40–)47–64(–74) μm (n=30) thick, glabrous, a dense *t. angularis–globulosa* of thin-walled, hyaline to pale yellowish cells (4–)6–16(–24)×(4–)5–12(–14) μm (n=60) in face view and vertical section. Subcortical layer a *t. intricata* of hyaline hyphae (3.5–)5–6(–7) μm (n=11) wide, mixed with hyaline cells (3.5–)7–19(–27)×(3–)6–13(–17) μm (n=30). Subperithecial tissue a coarse and dense *t. angularis–epidermoidea* of thin-walled cells (6–)10–28(–35) μm×(5–)9–15(–19) μm (n=30), tending to be smaller towards the base; cells sometimes distinctly elongate directly below the perithecia. Base comprising a *t. intricata* of hyphae (3–)4–6(–7) μm (n=20) wide. Asci (100–)115–140(–155)×(5.5–)6.0–7.5(–8.8) μm, stipe to 16(–32) μm long (n=50). Ascospores hyaline, verruculose, cells dimorphic; distal cell (5–)6–8(–10)×(4.3–)5.0–6.0(–7.0) μm, l/w (1.0–)1.1–1.4(–1.7) (n=90), ellipsoidal, oval, oblong or subglobose; proximal cell (5.7–)6.5–8.5(–10.5)×(4.0–)4.5–5.3(–6.0) μm, l/w (1.1–)1.3–1.7(–2.2) (n=90), oblong, ellipsoidal, oval or wedge-shaped; cells sometimes nearly monomorphic.

Cultures and anamorph: growth rate optimal at 25°C on all media, no growth at 35°C.

On CMD after 72 h 7–14 mm at 15°C, 30–37 mm at 25°C, 19–29 mm at 30°C; mycelium covering the plate after 5–6 days at 25°C. Colony hyaline, thin, loose, with inhomogeneous density, typically broadly lobed with irregular margin; lobes meeting at the distal margin of the plate, margin becoming downy due to long aerial hyphae. Primary hyphae thick, curved, with conspicuous septa; surface hyphae soon becoming empty from the centre. Autolytic excretions absent or rare, coilings infrequent or moderate. Odour indistinct. After 2 weeks sometimes pale yellow 1A3–4, 2–3B4–5 pigment diffusing through the agar from the distal margin. No chlamydospores seen. Conidiation noted after 6–8 days, sparse or lacking, sometimes denser after 2–3 weeks at margins, visible as white granules, of conidial heads to 50 μm diam. Structure as described on SNA. At 30°C growth often limited, diffusing pigment yellow 2A4–5 to 3A5, or lacking.

On PDA after 72 h 2–6 mm at 15°C, 18–32 mm at 25°C, 23–25 mm at 30°C, mycelium covering the plate after 6–8 days at 25°C. Hyphae thick, curved, becoming densely agglutinated. Colony first thin, hyaline to whitish, compact, not or indistinctly zonate; margin crystal-like, angular to coarsely wavy. Surface becoming white, velvety or downy by a dense flat mat of long aerial hyphae from 2 days; floccose in distal regions due to dense aggregations to 0.5 mm diam of aerial hyphae bearing numerous conidial


a
b
c
d
e
f
g
h
i
j
k
l
o
p
q
m
r
n

heads and drops; centre dense and finely farinose due to short and loosely arranged aerial hyphae. Autolytic activity low to moderate. Odour indistinct, no diffusing pigment formed, reverse only slightly yellowish, 4A3–4B4, after 2 weeks. Conidiation starting around the plug after 2–4 days, dense, effuse, on short conidiophores and aerial hyphae, spreading across the whole plate within a week; conidia produced in heads to 50 μm diam. At 15°C autolytic activity sometimes more distinct, at 30°C growth limited.

On SNA after 72 h 5–8 mm at 15°C, 7–18 mm at 25°C, 14–16 mm at 30°C, mycelium covering the plate after (5–) 10–15 days at 25°C. Colony hyaline, thin, leaf-like or fan-shaped with wavy outline; density irregular; orientation of hyphae irregular, hyphae narrower than on CMD, curved; surface hyphae soon degenerating from the centre. Long aerial hyphae frequent, particularly at the downy margins, loose and little ascending; minute white pustules forming along the margin. Autolytic activity absent or low, sometimes increasing after 1 weeks, coilings in some cultures extremely abundant, conspicuous, 50–120 μm diam. Conidiation starting after 4–5 days, effuse, spreading from the plug and proximal margin, better developed than on CMD, white, downy, becoming farinose to finely floccose. Phialides formed on surface hyphae, on simple, short, unbranched acremonium-like or sparsely branched, verticillium-like conidiophores to 300 μm long and 200 μm diam, arising from surface or aerial hyphae, the latter to 0.5 (–1) mm long at the distal margin. Main axes of conidiophores 3–7 μm wide, with mostly unpaired branches mostly distinctly inclined upwards, simple or once rebranching; terminal branches 1–2 celled. Phialides formed on cells 3–5(–6) μm wide, solitary or divergent in whorls of 2–3, often cruciform at conidiophore apices. Conidia formed in large numbers in wet heads eventually growing up to 120 μm diam and appearing as fine white granules, particularly dense in distal regions, soon drying with conidia lying on the agar surface. Phialides (10–)14–28(–40)×3.0–4.5(–5) μm, l/w=(3.0–)4.0–7.4(–8.3), (2.0–)

–

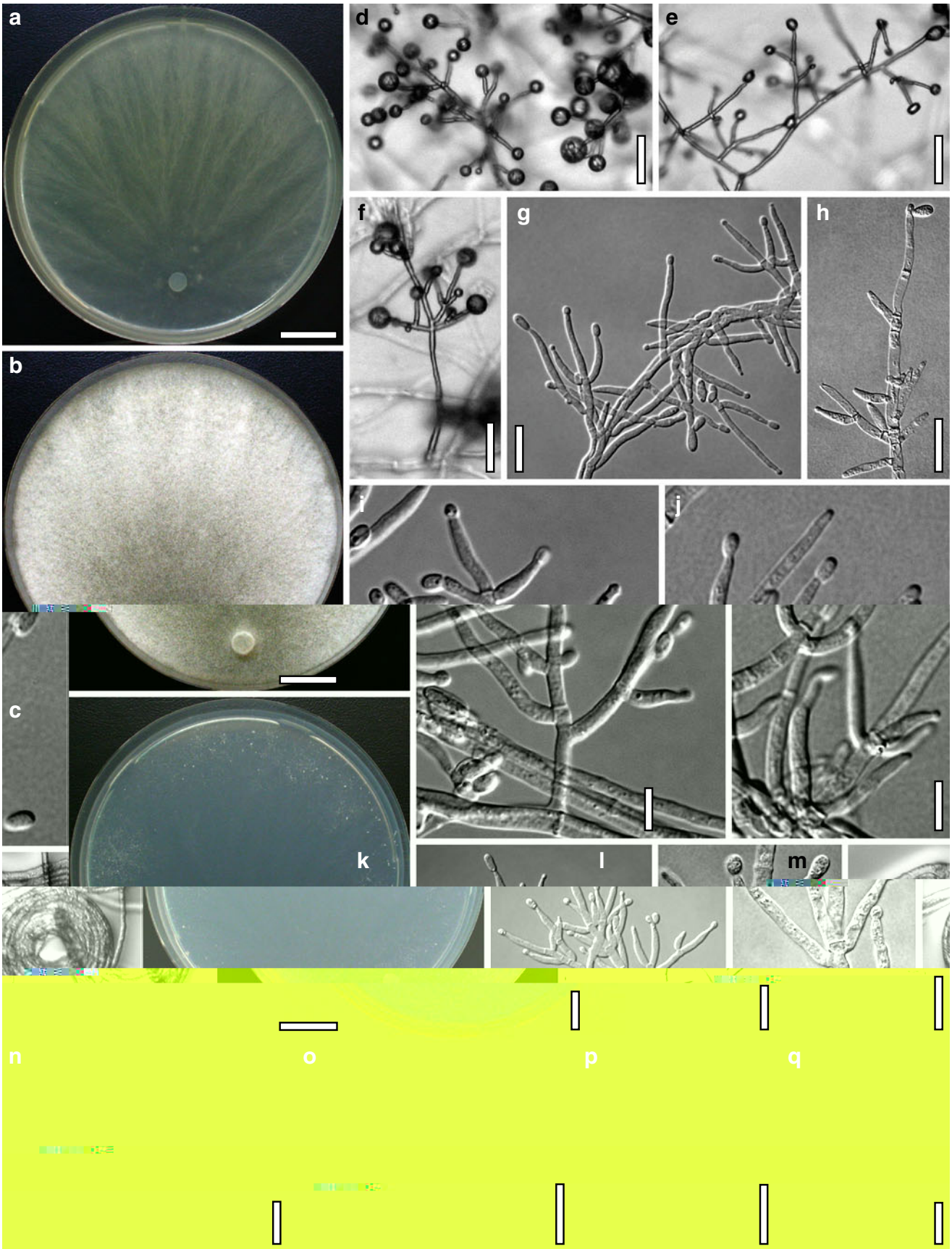

a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q

Fig. 70 Cultures and anamorph of *Hypocrea sulphurea*. **a–c**. Cultures after 14 days (**a**. on CMD. **b**. on PDA. **c**. on SNA). **d–f**. Conidiophores on growth plates (5–10 days; **f**. 30°C). **g–k**. Conidiophores (10–19 days). **l**. Phialides (19 days). **m**. Coiling (CMD, 10 days). **n.** Conidiophore with dry conidia on agar surface (19 days). **o–q**. Conidia (7–19 days). **d–q**. On SNA except m. **d–q**. At 25°C except **f**. **a–d, f, h, l, n–p**. C.P.K. 1593. **e, g, i, k, m**. CBS 119929. **j, q**. C.P.K. 1597. *Scale bars* **a–c**=15 mm. **d–f**, **m**=40 μm. **g, h**, **k**=20 μm. **i, j, l**, **o**=10 μm. **n**=30 μm. **p**, **q**=5 μm

Jaklitsch & O. Sükösd, not harvested. Same area, 48°15′19″ N, 16°10′13″ E, elev. 330 m, on *Exidia* on *Quercus* sp., soc. hyphomycetes, 6 Aug. 2006, W. Jaklitsch & O. Sükösd, W. J. 2927 (WU 29502). Mödling, Wienerwald, Gießhübl, Wassergspreng, MTB 7963/1, 48°06′00″ N 16°13′05″ E, elev. 460 m, on *Fagus sylvatica*, immature. 27 June 2004, H. Voglmayr. Wöglerin, MTB 7862/4, elev. 490 m, on *Exidia* sp. on a lying trunk of *Fagus sylvatica* 10 cm thick, soc. *Lopadostoma turgidum* in bark, 16 Aug. 2008, W. Jaklitsch & O. Sükösd (WU 29504). Sulz im Wienerwald, SE from the pub Wöglerin, MTB 7862/4, 48°06′30″ N, 16° 07′39″ E, elev. 460 m, on branch of *Carpinus betulus*, 7 Oct. 2003, H. Voglmayr & I. Greilhuber, W.J. 2444 (WU 29497, culture C.P.K. 987). Wien Umgebung, Pressbaum, Rekawinkel, forest path south from the train station, MTB 7862/1, 48°10′37″ N, 16°01′33″ E, elev. 415 m, on *Exidia glandulosa* on *Fagus sylvatica*, 21 Sep. 2002, W. Jaklitsch, W.J. 1975. Same area, 48°10′40″ N, 16°01′54″ E, elev. 380 m, on corticated log of *Carpinus betulus* 12 cm thick, erumpent through cracks in bark, soc. green *Trichoderma* below bark, 18 Oct. 2003, H. Voglmayr & W. Jaklitsch, W. J. 2473 (WU 29498, culture C.P.K. 2407). Steiermark, Graz-Umgebung, Mariatrost, Wenisbucherstraße, close to the crossing with Himmelreichweg, MTB 8858/4, 47°06′ 47″ N, 15°29′03″ E, elev. 470 m, on *Exidia glandulosa* on *Corylus avellana* 3–4 cm thick, soc. Corticiaceae, 8 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2319 (WU 29492, culture C.P.K. 1597). Same area, on/soc. *Exidia glandulosa* on twigs of *Carpinus betulus* and *Fagus sylvatica* 2–3 cm thick, W.J. 2320 (WU 29493, culture CBS 119929=C.P.K. 1598). Leibnitz, Berghausen, Graßnitzberg, MTB 9259/4, elev. *ca* 350 m, on *Fagus sylvatica*, 20 Sep. 1996, W. Jaklitsch, W.J. 958. Weiz, Laßnitzthal, from Arboretum Gundl across the main road, MTB 8959/2, 47°04′17″ N, 15°38′38″ E, elev. 420 m, on/soc. *Exidia glandulosa* on *Fagus sylvatica*, branch 4 cm thick, 8 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2326 (WU 29494, culture C. P.K. 2388). **Ukraine**, Kharkivska Oblast, Kharkov, Zmiev area, Gomolshansky National nature park, 49°42′09″ N 36° 22′37″ E, elev. 100 m, on *Exidia glandulosa* on *Quercus* sp., 25 June 2004, A. Akulov, W.J. 2513 (WU 29499, culture C.P.K. 2040).

Notes: *Hypocrea sulphurea* is a conspicuous species, easily recognized by the large, bright yellow stromata occurring on basidiomes of *Exidia* spp. The *Exidia* host usually does not mature when attacked by the *Hypocrea*. Stromata are often more or less dry when collected, because they develop predominantly in warm and dry *Quercus*/*Carpinus* forests. In Austria stromata of *H. sulphurea* occur in the East, i.e. Lower Austria, Burgenland to southern Styria, where they can be observed from May or June onwards starting as a homogeneous, subiculate, yellow covering on fresh and thick *Exidia* basidiomes. Specimens from the Ukraine suggest that this species is predominantly distributed in south-eastern regions in Europe. Fresh stromata are thicker and slightly less bright than dry stromata. Largest ascospore measurements, i.e. ascspore cells >9 μm are from fresh specimens. Ascospore cells in North American and Japanese specimens of *H. sulphurea* are in average 1–2 μm smaller than in European specimens. This variation in ascospore size had led Doi (1972) to erect *H. sulphurea* f. *macrospora*. *H. megalosulphurea* Yoshim. Doi (Doi 1972) differs from *H. sulphurea* by pulvinate stromata, while *H. subsulphurea* Syd. has monomorphic ascospores (Overton et al. 2006b). Similar are also *H. austriaca* and *H. victoriensis*. *Hypocrea austriaca* differs from *H. sulphurea* by lighter stromata, slightly smaller ascospores and the occurrence on *Eichleriella deglubens*, while no fungal host has so far been detected for the Australian *H. victoriensis*.

The *Brevicompactum*, *Lutea* and *Psychrophila* Clades

Introduction

Species of three clades adjacent in the generic phylogenetic tree of the genus *Hypocrea*/*Trichoderma* (Fig. 1) are here subsumed, primarily in order to reach comparable quantitative scopes in each descriptive chapter.

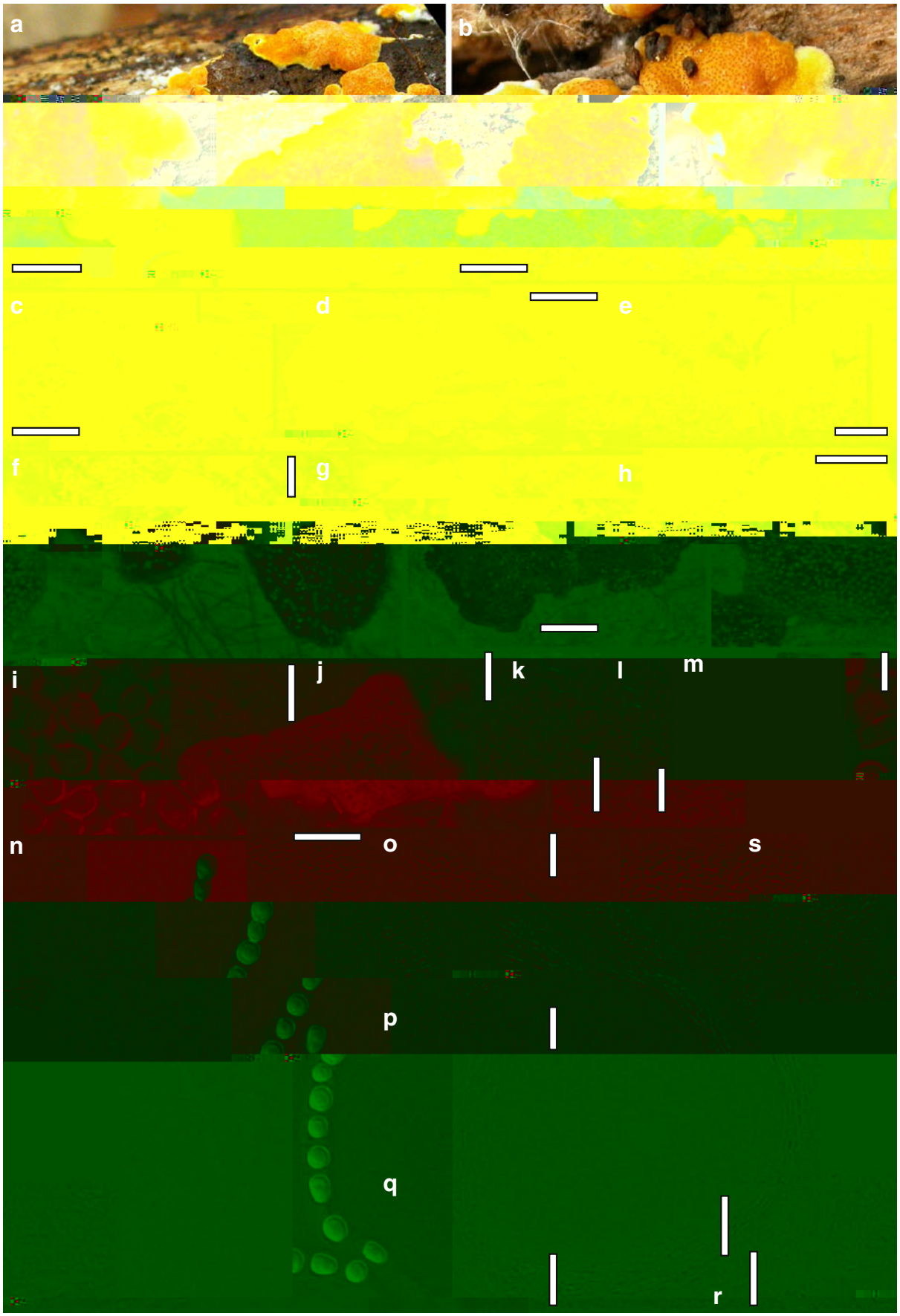
The *Brevicompactum* clade is the result of an integrated approach of molecular biology (DNA sequence data), morphology, phytopathology (search for plant-protective agents useful for biocontrol of the vine diseases *Eutypa* dieback and Esca) and profiling of secondary metabolites such as peptaibiotics and trichothecenes. First recognised by Degenkolb et al. (2006) the clade was established by Degenkolb et al. (2008a) with the new formally described species *Trichoderma arundinaceum*, *T. turrialbense*, *T. protrudens* and *Hypocrea rodmanii*, in addition to *T. brevicompactum* that had been described by Kraus et al. (2004). Chemotaxonomic potential, prediction of biocontrol suitability, health concerns of secondary metabolites including trichothecenes and hydrophobins analysed by mass spectrometry of this group of species was discussed by Degenkolb et al. (2008b). Three holomorphic *Hypocrea*/*Trichoderma* species including two new ones are described in this clade below.

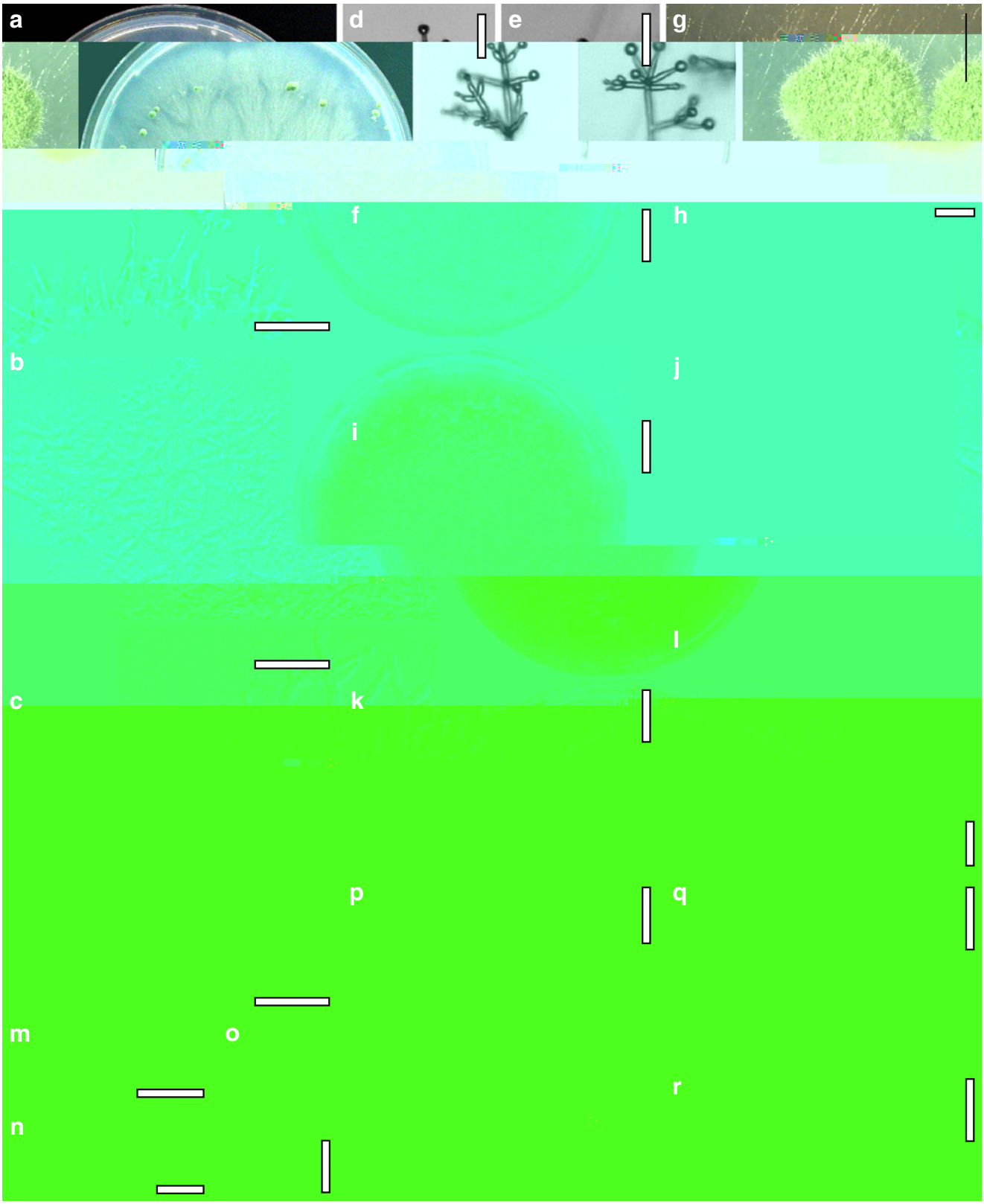
The *Lutea* clade currently comprises only the two species *H. lutea* and *H. melanomagna* (Chaverri and Samuels 2003). A third species is added below. The clade is exceptional due to the distinctly gliocladium-like anamorphs characterised by more or less mononematous penicillate conidiophores and green conidia that are eventually embedded in a mucous exudate. Like the *Semiorbis* clade, this clade contains both species with hyaline and green ascospores. The typification of *H. lutea* is clarified here and the anamorph of *H. lutea*, *Gliocladium deliquescens*, is combined in *Trichoderma*.

Hypocrea megalocitrina and *H. psychrophila* were recognised as the *Megalocitrina* clade (Chaverri and Samuels 2003). This was adopted by Jaklitsch et al. (2006a) when describing *H. crystalligena*. The clade including *H. megalocitrina* is now called the *Psychrophila* clade; it is well supported and now comprises four European species including two new ones. These species are characterised by pulvinate stromata and white-conidial anamorphs with more or less gliocladium-like conidiophores.

Species descriptions

Clades and the species within the clades are arranged in alphabetical order. The *Brevicompact*[illegible]


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
s
p
q
r


a
d
e
g
f
h
b
j
i
l
c
k
p
q
m
o
r
n

celled, cylindrical, ends rounded, rooting in cortical or subcortical tissues, entire length to *ca* 50 µm; young stromata with long and branched hyaline to light brownish collapsing hyphae. Subcortical tissue a loose to dense *t. intricata* of hyaline thin-walled hyphae (2–)3–4(–5) µm (*n*=30) wide. Subperithecial tissue a *t. epidermoidea* to *t. intricata* at the base, of variable hyaline, thin-walled cells (3–)4–28(–47)×(3–)4–8(–10) µm (*n*=30). Hyphae compressed at the basal margin. Asci (73–)80–95(–106)×(4.0–)4.5–5.5(–6.2) µm, stipe (3–)6–16(–24) µm long (*n*=60). Ascospores hyaline, verruculose to spinulose, cells dimorphic; distal cell (3.2–)3.5–4.4(–5.0)×(3.0–)3.3–3.8(–4.3) µm, l/w 1.0–1.2(–1.3) (*n*=90), (sub-)globose or tapered upward; proximal cell (3.5–)4.0–5.5(–7.0)×(2.5–)2.7–3.3(–4.0) µm, l/w (1.2–)1.3–1.9(–2.4) (*n*=90), oblong, wedge-shaped or subglobose. Discharged ascospores often yellow to orange in KOH.

Anamorph on natural substrates effuse and pale bluish-green, 25DE4–5, 26D3–4, often with white margin.

Cultures and anamorph: growth slow, optimal at 25°C on all media, on CMD sometimes slightly faster at 30°C than at 25°C; no growth at 35°C.

On CMD after 72 h 0.2–1 mm at 15°C, 4–6 mm at 25°C, 3–6 mm at 30°C; growth often terminating before the Petri dish is covered by mycelium. Colony hyaline, first circular, becoming lobed at margin, thin, with little mycelium on the surface, dense, silky, finely and regularly zonate, zones of more or less equal width; hyphae narrow (<10 µm wide). Aerial hyphae scant. Coilings and autolytic activity absent. Chlamydospores noted from 2 weeks. No pigment, no distinct odour noted. Conidiation after 3–4 days, green after 2–4 weeks, rarely earlier, or remaining hyaline for more than 2 months, depending on the isolate; effuse, first on minute conidiophores around the plug, spreading irregularly or in concentric rings, remaining invisible, growing to small, inconspicuous greenish granules, or rarely (CBS 119285) emerging from compact and opaque, grey-green, 27D4, 28DE4–6, pustules 1–5 mm diam and 1–1.5 mm thick, with straight sterile or fertile elongations on the distal margin of the colony after 1–2 months. Pustule formation enhanced by incubation at 15°C after growth at 25°C. Conidia yellow-green in mass.

On PDA after 72 h reaching at most 0.5 mm at 15°C, 4–5 mm at 25°C, 0.5–4.5 mm at 30°C; mycelium covering the entire plate after *ca* 6 weeks; hyphae conspicuously narrow. Colony circular, dense, thin, smooth, indistinctly zonate, with radial folds formed around the plug; with short aerial hyphae becoming fertile. Margin downy after *ca* 1 month due to long aerial hyphae. Autolytic excretions rare or uncommon, no coilings seen. No distinct odour, no diffusing pigment noted. Reverse becoming pale yellow, 3–4A3–4, from the centre. Conidiation noted after 3 days, effuse, spreading from the plug on short conidiophores, appearing powdery, yellow, turning greenish, 30A3, from *ca* 2 weeks; white, downy to cottony, close to margin after >1 month. At 30°C colony turning yellow to brown-yellow, 3A6–7, 4AB4–6, 5C5–7; conidiation remaining white (within 2 weeks).

On SNA after 72 h 0.2–1 mm at 15°C, 2–3 mm at 25°C, 0–2.5 mm at 30°C; mycelium covering the entire plate after >6 weeks, scant on the surface; hyphae thin, soon degenerating, becoming multiguttulate. Colony dense, with irregular outline, finely and often indistinctly zonate, hyaline. Aerial hyphae scant, short, becoming fertile. No autolytic excretions, no coilings noted. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 10 days, (5–)6–17(–25)×(3–)4–7(–9) µm, l/w=(0.9–)1.2–3.3(–5.7) (*n*=30), extremely variable in shape, terminal and intercalary. Conidiation noted after 4 days, effuse, on short simple conidiophores spreading from the centre, and in small granules or pustules (with granular surface) 0.3–1(–2.5) mm diam in a broad distal concentric zone. Pustules first white, becoming pale yellowish green or grey-green, 29–30B3–4, after 1 or several week; first maturing within pustule, dense and green, while white and with sparse or without straight sterile elongations in the periphery. Elongations 30–150 µm long from last side branch, with numerous guttules, appearing verrucose under low magnification, becoming fertile. Structure of conidiophores examined after 6–18 days. Simple conidiophores or shrubs around the agar plug of a short stipe with 1–3 main axes to *ca* 75 µm long, bearing several asymmetric or paired 1–4(–6) celled terminal branches with phialides solitary or in whorls of 2–5. Pustules of a loose reticulum with right-angled branching. Branches mostly unpaired, with numerous free ends bearing terminal whorls of phialides and minute conidial heads <15 µm. Conidiophores 2–5 µm wide, with side branches increasing in length from the top in a short distance, resulting in broad structures. Branching points often thickened to 6 µm. Phialides arising from cells 2–3 µm wide. Conidiophores appearing verrucose with age due to fine guttules. Phialides (4–)5–9(–12)×(2.0–)2.3–2.8(–3.3) µm, l/w=(1.5–)2.0–3.7(–5.0), (1.3–)1.7–2.3(–2.6) µm wide at the base (*n*

opaque. Pustule stipe and primary branches 7–8 μm wide. Conidiophores (= main axes) projecting to 0.5 mm from pustule margins, 3–4(–5) μm wide, 2–3.5 toward ends. Main axes richly rebranching, with side branches mostly 80–150 μm long, increasing in length from the top in a short distance, causing broad dense structures. Branches mostly in right angles or slightly inclined upward, paired or not; branching points often thickened to 7(–8) μm. Phialides solitary or distinctly divergent in whorls of 2–5; conidia formed in minute wet heads <15 μm diam, soon drying. Phialides lageniform, less commonly ampulliform, often inaequilateral, widest in or below the middle. Conidia subhyaline to greenish yellow, light green in mass, ellipsoidal, less commonly subglobose or pyriform, smooth, with few minute guttules; scar indistinct. Measurements of phialides and conidia combined with those on SNA. Asynchronous development of conidiation within pustules.

Habitat: on wood and bark of deciduous trees in association with basidiomycetous rhizomorphs, overgrowing leaves and other fungi, mainly on *Fagus*.

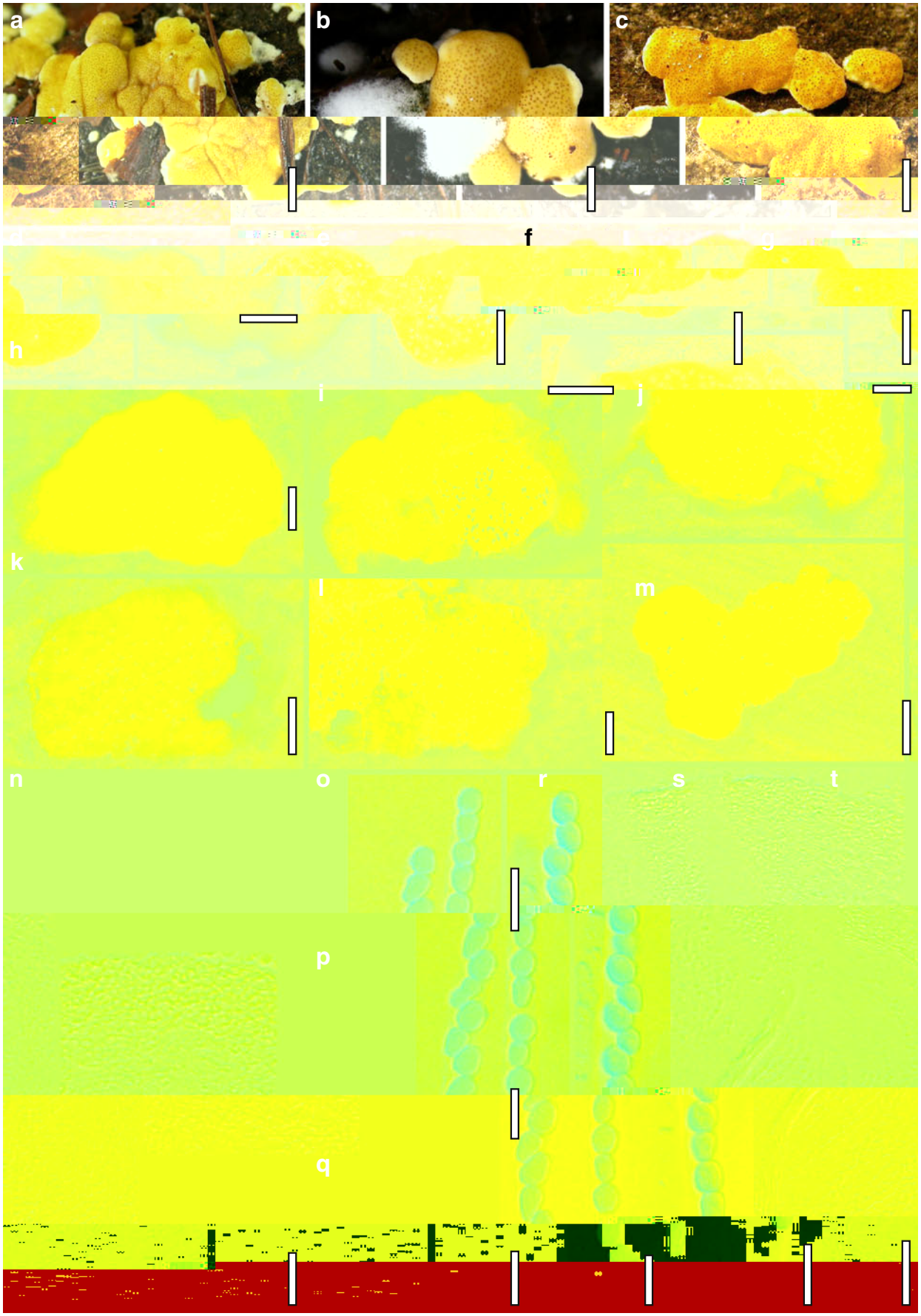
Distribution: Central Europe (collected in Austria and Germany).

Holotype: **Austria**, Niederösterreich, Melk, Weins, eastern access, left side at main road to Persenbeug, MTB 7756/3, 48°12′00″ N, 15°02′39″ E, elev. 290 m, on two partly decorticated branches of *Fagus sylvatica*, 3–6 cm thick, on wood and bark, soc. effete pyrenomycete and rhizomorphs (ozonium) of a *Coprinellus*, 25 July 2004, H. Voglmayr & W. Jaklitsch, W.J. 2542 (**WU 29183**, ex-type culture CBS 119284=C.P.K. 1972). ***Holotype*** of *Trichoderma auranteffusum* isolated from WU 29183 and deposited as a dry culture with the holotype of *H. auranteffusa* as **WU 29183a**.

Additional specimens examined: **Austria**, Burgenland, distr. Eisenstadt, W Mörbisch, on ozonium on *Robinia pseudacacia*, grid square 8265/2, elev. 200 m, 11 Sep 2010, H. Voglmayr & I. Greilhuber (WU). Burgenland, Leithagebirge, Lebzelterberg, between Hornstein and Leithaprodersdorf, MTB 8064/4, elev. 250 m, on branch of *Carpinus betulus*, 16 Sep. 2007, H. Voglmayr, W.J. 3167 (WU 29190). Kärnten, Klagenfurt Land, St. Margareten im Rosental, Gupf (Writze), MTB 9452/2, 46°33′04″ N, 14° 27′11″ E, elev. 730 m, on partly decorticated branches of *Salix caprea* and *Corylus avellana* 3–6 cm thick, on wood and cutting area, holomorph, soc. rhizomorphs, 24 Sep. 2006, W. Jaklitsch & H. Voglmayr, W.J. 2982 (WU 29189, culture C.P.K. 2470). St. Margareten im Rosental, village area, close to Bauhof Jaklitsch, MTB 9452/4, elev. 600 m, on well-decayed branch of *Fagus sylvatica* 2 cm thick, soc. brown rhizomorphs and *Lasiosphaeria strigosa*, 29 Sep. 2007, W. Jaklitsch, W.J. 3174 (WU 29191, culture C.P.K. 3158). Niederösterreich, Hollabrunn, Hardegg, beech forest close to Felling, MTB 7161/1, 48°51′47″ N, 15°49′49″ E, elev. 480 m, on decorticated branch of *Fagus sylvatica* 4–5 cm thick, on wood, 21 Jul. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2534 (WU 29181, culture C.P.K. 1617). Krems, Krumau, virgin forest at the Dobrasperre on south side of the Dobra storage lake, MTB 7458/1, elev. 490 m, 48°35′19″ N, 15°23′56″ E, on branch of *Fagus sylvatica* 2 cm thick, on wood and bark, 12 Jul. 2003, W. Jaklitsch, W.J. 2281 (WU 29179, culture C.P.K. 1594). Loosdorf, Dunkelsteiner Wald, 0.7 km south from Umbach, MTB 7758/4, 48°14′04″ N, 15°25′48″ E, elev. 370 m, on decorticated branch of *Fagus sylvatica* 2–4 cm thick, on wood, 5 Oct. 2004, W. Jaklitsch (not harvested). Melk, Leiben, at Hofmühle, Weitental, MTB 7757/2, 48°14′51″ N, 15°17′23″ E, elev. 270 m, on 3 decorticated branches of *Fagus sylvatica* 1.5–5 cm thick, on wood, soc. ozonium of *Coprinellus cf. domesticus*, *Lasiosphaeria hirsuta* and other effete pyrenomycetes, and *Auricularia auricula-judae*, 25 July 2004, H. Voglmayr & W. Jaklitsch, W.J. 2538 (WU 29182, culture C.P.K. 1971). Melk, Sankt Leonhard am Forst, *ca* 400 m after Großweichselbach in direction Melk, MTB 7857/2, 48°10′39″ N, 15°17′48″ E, elev. 380 m, on decorticated branch of *Fagus sylvatica*, on wood, holomorph, 30 Sep. 2004, W. Jaklitsch (not harvested). Wien-Umgebung, Mauerbach, Friedhofstrasse, MTB 7763/1, elev. 335 m, 48°15′22″ N, 16°10′14″ E, on branch of *Carpinus betulus* 6 cm thick, on wood, soc. *Hypoxylon howeianum*, 13 Aug. 2005, W. Jaklitsch (not harvested). Pressbaum, Rekawinkel, forest path south of the train station, MTB 7862/1, 48°10′46″ N, 16°02′03″ E, elev. 365 m, on decorticated branch of *Fagus sylvatica* 3 cm thick, on wood, overgrowing leaves on branch, soc. white Corticiaceae, holomorph, 18 Oct. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2477 (WU 29180, culture CBS 119285=C. P.K. 1605). Same area, elev. 430 m, 48°10′33″ N, 16°02′ 03″ E, on decorticated branch of *Fagus sylvatica* 7 cm thick, on wood, holomorph, soc. ozonium, 20 Aug. 2005, W. Jaklitsch, W.J. 2827 (WU 29186, culture C.P.K. 2409). Oberösterreich, Vöcklabruck, Nußdorf am Attersee, close to Limberg, MTB 8147/1, 47°51′48″ N, 13°30′27″ E, elev. 680 m, on 3 partly decorticated branches of *Fagus sylvatica* 1.5–3 cm thick, on wood, below bark and leaves, on and soc. *Lasiosphaeria strigosa*, soc. *Tubeufia cerea*, ozonium and a ?*Tomentella* sp., 8 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2593 (WU 29184, culture C.P.K. 1973). Steiermark, Riegersburg, MTB 8961/4, on decorticated branch of *Fagus sylvatica*, 26 Oct. 2004, Dobernig, Draxler & Maurer (GZU). Weiz, Laßnitzthal, opposite to the Arboretum Gundl across the road, MTB 8959/2, elev. 420 m, 47°04′17″ N, 15°38′38″ E, on branch of *Fagus sylvatica* 11 Sep. 2002, H. Voglmayr & W. Jaklitsch, W.J. 2883. Vienna, 23rd district, Maurer Wald, MTB 7863/1, elev. 350 m, on decorticated branch of *Acer pseudoplatanus*, on wood and *Eutypa maura*, 4 Oct. 2002, H.

Voglmayr, W.J. 1991. Vorarlberg, Feldkirch, Rankweil, behind the LKH Valduna, MTB 8723/2, 47°15′40″ N, 09° 39′00″ E, elev. 510 m, on decorticated branch of *Fagus sylvatica* 3–4 cm thick, on wood, below bark and leaves, soc. old *Eutypa* sp. and ozonium, 31 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2645 (WU 29185, culture CBS 119287=C.P.K. 1974). **Germany**, Bavaria, Starnberg, Tutzing, Erling, Hartschimmel-Gelände, 47°56′34″ N, 11° 10′47″ E, elev. 700 m, on three decorticated branches of *Fagus sylvatica* 2–6 cm thick, on wood, holomorph, soc. *Phlebiella vaga*, ?*Tulasnella* sp., old *Lasiosphaeria* sp., 3 Sep. 2005, W. Jaklitsch, W.J. 2834 (WU 29187). Unterfranken, Landkreis Haßberge, Haßfurt, close to Mariaburghausen, left roadside heading from Knetzgau to Haßfurt, MTB 5929/3, 50°00′31″ N, 10°31′17″ E, elev. 270 m, on partly decorticated branch of *Fagus sylvatica* 6 cm thick, on wood and bark, soc. ozonium, rhizomorphs, *Lopadostoma turgidum* in bark, 29 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2963 (WU 29188, culture C.P.K. 3119).

Notes: Stromata of *H. auranteffusa* are usually accompanied by rhizomorphs, particularly those of *Coprinellus domesticus* ('ozonium'). Colour and micro-morphological characteristics of this species are similar to those of *H. splendens*. However, the type material of the latter species (on *Prunus laurocerasus*) is represented by distinctly pulvinate stromata not found in the numerous specimens of *H. auranteffusa*. Searches for fresh material of *H. splendens* in England conducted to elucidate the concept and phylogenetic relationships of the latter species have been without success. The species phylogenetically most closely related to *H. auranteffusa* in the *Brevicompactum* clade are *H. margaretensis*of fusaozoniug-57niu.1Tf2ua05.4805.481Tf14.68160TDu62l52(ozot)-m5h-340.8(sp)6(le)5.6t6a7481Tf1u.3(p84r6ai58374


a
b
c
f
g
h
i
j
k
l
m
n
o
r
s
t
p
q

◀ **Fig. 73** Teleomorph of *Hypocrea margaretensis*. **a–e**. Fresh stromata (**b**. with young anamorph). **f–l**. Dry stromata (**f**. immature, early phase). **m**. Rehydrated stromata. **n**. Perithecium in section. **o**. Stroma surface in face view. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue in section. **r–t**. Asci with ascospores (**s, t**. in cotton blue/lactic acid). a. WU 29203. **b, d–f, h**. WU 29201. **c, l, m–q**. WU 29199. **g, j, s, t**. WU 29202. **i, r**. WU 29205. **k**. WU 29200. *Scale bars* **a, c**, **d**=1.5 mm. **b, e, f**, **k**=1 mm. **g–j**, **m**=0.5 mm. **l**= 0.3 mm. **n**=30 μm. **o**, **r–t**=10 μm. **p**, **q**=20 μm

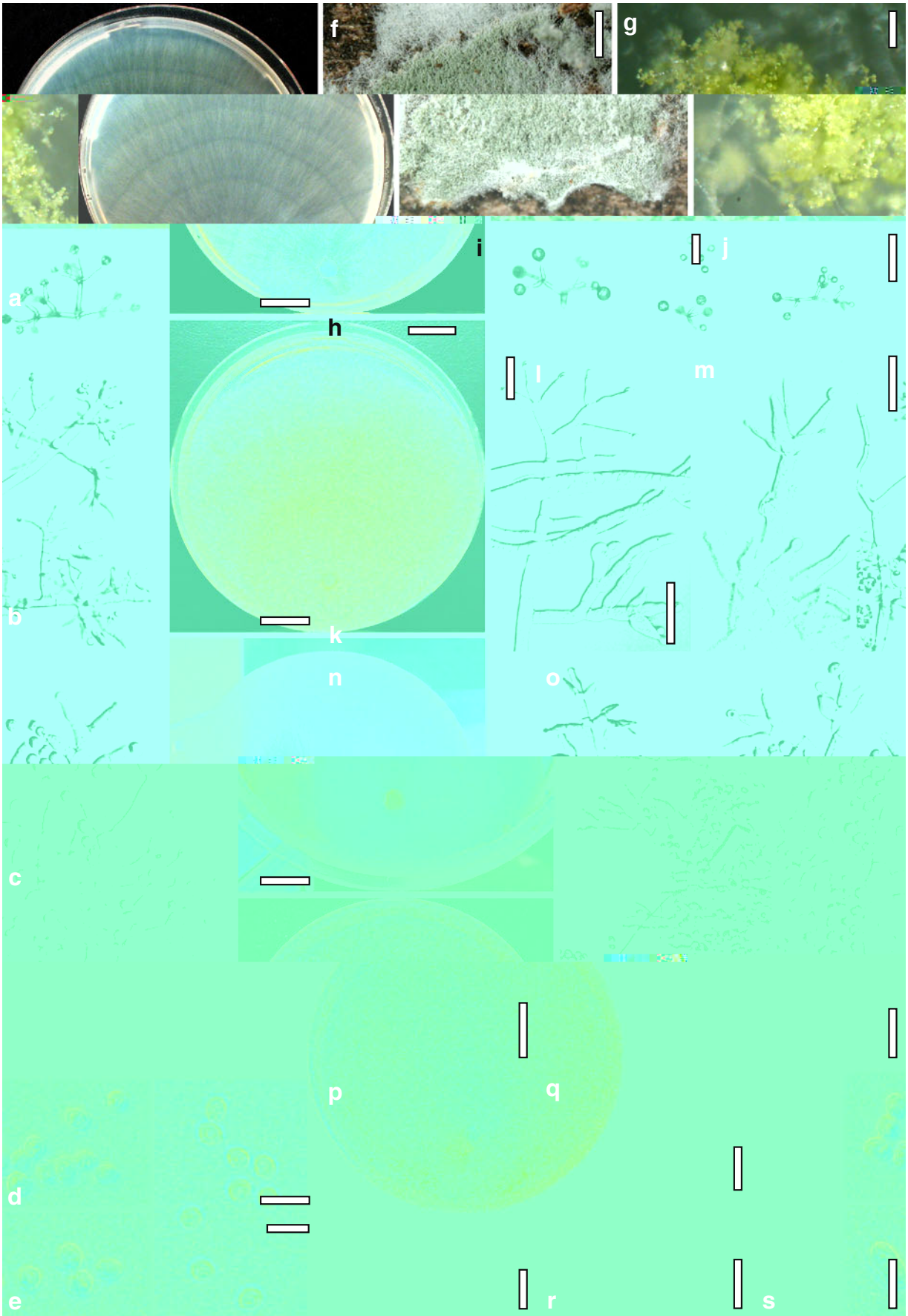
a dense *t. angularis* of hyaline or pale yellow, thin-walled cells (2.5–)4–8(–10)×(2–)3–6(–7) μm (*n*=60) in face view and in vertical section. Surface smooth. Subcortical tissue a loose *t. intricata* of thin-walled hyphae (2.0–)2.5–4.5(–6.0) μm (*n*=30) wide, mixed with some subhyaline, angular cells. Subperithecial tissue a dense homogeneous *t. epidermoidea–angularis* of variously shaped, thin-walled, hyaline cells (5–)7–26(–36)×(4–)5–11(–13) (*n*=30); cells smaller towards the base, and interspersed with thick-walled, yellowish hyphae, (2.0–)2.5–4.5(–6.0) μm (*n*=30) wide. Asci (75–)88–106(–117)×(4.0–)4.5–5.5(–6.5) μm, stipe (6–)9–23(–35) μm long (*n*=73); no croziers seen. Ascospores hyaline, verruculose; cells dimorphic, but often similar; distal cell (3.5–)3.8–5.0(–6.0)×(3.3–)3.5–4.2(–5.0) μm, l/w 1.0–1.3(–1.7) (*n*=72), subglobose or slightly elongated and attenuated upward; proximal cell (3.5–)4.3–6.2(–7.6)×(2.7–)3.0–3.6(–4.7) μm, l/w (1.1–)1.3–1.9(–2.3) (*n*=72), oblong, wedge-shaped, or subglobose.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C.

On CMD after 72 h 7–11 mm at 15°C, 22–28 mm at 25°C, 11–21 mm at 30°C; mycelium covering plate after 7–8 days at 25°C. Colony hyaline, distinctly circular with well-defined margin, with little mycelium on surface, forming up to 7 broad and 6 narrow concentric zones. Mycelium radially arranged, with conspicuous difference in width between primary and secondary hyphae. Surface hyphae degenerating, appearing empty. Aerial hyphae scant, short, more frequent and longer mainly at distal margin of the plate Autolytic activity and coilings absent or rare. No distinct odour noted. Sometimes pale yellowish on distal margin from 2 weeks, with minute yellow crystals at the very distal margin in densely packed mycelium. Chlamydospores (7–)8–12(–16)×(5.5–)6–11(–14) μm, l/w 0.9–1.5(–2) (*n*=32), noted after 50 days, uncommon, terminal and intercalary, globose, ovoid or clavate. Conidiation from 1 to 2 weeks, macroscopically invisible, scant, effuse, on loosely disposed, minute, simple conidiophores spreading from the plug and proximal margin; at distal margin also on long aerial hyphae; greenish only in the stereo microscope; degenerating from *ca* 3 weeks; cultures usually sterile after several transfers.

On PDA after 72 h 4–9 mm at 15°C, 19–26 mm at 25°C, 8–14 mm at 30°C; mycelium covering plate after 8–10 days at 25°C. Colonies circular, dense, compact, indistinctly zonate, mycelium radially arranged, surface hyphae becoming moniliform in the centre due to ?chlamydospores. Aerial hyphae inconspicuous, loosely disposed, short and needle-like, superposed by scant thin and long hyphae, decreasing outwards, forming thin radial strands, soon degenerating, collapsing, giving surface finely downy to granular appearance. Autolytic activity and coilings absent or rare. Odour faint, like fermenting fruits (noted from 1 weeks), colony turning pale or greyish yellow, 3AB3–4, 3B5–6, from the centre. Conidiation from 3 to 5 days, macroscopically invisible, effuse, short, spreading from the plug, becoming farinose in the centre, remaining colourless (1 month). At 15°C conidiation dense in white central area.

On SNA after 72 h 4–7 mm at 15°C, 10–15 mm at 25°C, 1–9 mm at 30°C; mycelium covering plate after *ca* 2 weeks at 25°C. Colonies distinctly circular with well-defined margin, compact, hyaline, thin, silky, with fine concentric zonation of unequal width. Hyphae radially arranged, thin, little on surface; surface hyphae degenerating, becoming multiguttulate. Aerial hyphae scant. Autolytic excretions rare; coilings variable, sometimes abundant. No distinct odour, no pigment noted. Chlamydospores uncommon. Conidiation noted after 4–6 days, better developed than on CMD, invisible to the unaided eye, effuse, on loosely disposed minute conidiophores spreading from the plug and proximal margin irregularly across the entire colony; at the distal margin also verticillium-like on aerial hyphae. Conidial heads minute, <30 μm diam, wet, becoming dry, greenish in the stereo-microscope. Conidiophores (after 6–12 days at 25°C) to 150(–300) μm long, erect, simple, asymmetric, of a short stipe or single axis 3–5 μm wide, with a single terminal whorl of phialides and some scattered solitary phialides, or with up to five steep, unpaired main axes emerging at low levels. Main axes unbranched or with unpaired branches. Branches 2–3 μm wide at ends, bearing solitary phialides or short, tree-like, often paired and mainly 1-celled terminal branches, strongly inclined upwards. Phialides arising from cells 2–4 μm wide, solitary or divergent in whorls of 2–4(–6). Phialides (5–)7–12(–18) μm (*n*=120) μm long, lageniform or subcylindrical, less commonly ampulliform with long neck, mostly inaequilateral. Conidia as in granules. After *ca* 1 month (or growth for 16 days at 25°C plus 6–12 days at 15°C) conidiation becoming visible as minute, white to greenish granules or minipustules 0.2–0.8 mm diam, formed mainly along margin of the plate; slightly more complex and stout in structure than effuse conidiation. Compared to effuse conidiation, main axes more pachybasium-like, longer, with 1–2 fold branching at higher levels, terminal branches short, often paired and right-angled or inclined upwards, 1–3 celled. Branches 3–5(–6) μm wide. Phialides arising singly or in whorls on cells 2.5–4 μm wide. Phialides (4.5–)5.5–9.0(–12)×(2.3–)2.5–3.2(–3.7) μm, l/w (1.5–)1.7–3.2(–4.8), (1.4–)1.8–2.5(–2.8) μm (*n*=61) wide at the base;


f
g
a
i
h
j
l
m
b
k
n
o
c
p
q
d
r
s
e

◀ **Fig. 74** Cultures and anamorph of *Hypocrea margaretensis*. **a–d**. Cultures (**a**. on CMD, 13 days, showing unequal zonation. **b**. on PDA, 7 days. **c**. on SNA, 7 days, showing well-defined circular colony. **d**. on MEA, 11 days, showing green granules). **e**. Chlamydospores (CMD, 52 days). **f**. Anamorph on the natural substrate. **g**. Conidiation shrub (MEA, 11 days). **h–j**. Conidiophores of effuse conidiation on growth plate (SNA, 9 days; **j**. dry heads, without lid). **k, l**. Conidiophores of effuse conidiation (**k**. MEA, 5 days. **l**. SNA, 6 days). **m–p**. Conidiophores of pustulate conidiation (MEA, 11 days). **q–s**. Conidia (MEA, 5–11 days). **a–s**. All at 25°C. **a–c, e, h–j.** CBS 119320. **d, g, m–r**. CBS 120540. **f**. WU 29199. **k, l, s**. C.P.K. 3129. *Scale bars* **a, b**, **d**=14 mm. **c**=10 mm. **e, k, l, o**, **p**=10 μm. **f**= 0.7 mm. **g**=100 μm. **h**–**j**=30 μm. **m**, **n**=20 μm. **q**–**s**=5 μm

narrowly lageniform or subulate, more rarely ampulliform, straight, sometimes curved or sinuous, usually widest below the middle, without conspicuous thickenings. Ampulliform phialides more frequent in microtufts or granules formed late. Phialides from simple conidiophores and granules combined (4.5–)6–11(–18)×(2.0–)2.5–3.3(–4.0) μm, l/w (1.5–)2–4(–7.5) (*n*=181). Conidia (2.2–)2.5–3.5(–5.5)×(1.8–)2.0–2.5(–3.0) μm, l/w (1.0–)1.1–1.5(–2.1) (*n*=180), subhyaline to pale yellowish green, subglobose, oval, less commonly ellipsoidal, smooth, with few minute guttules; scar indistinct. At 15°C growth irregular, effuse conidiation on the entire colony except the centre.

On MEA mycelium covering the plate entirely after *ca* 10 days. Aerial hyphae abundant, forming strands and causing a white, hairy colony surface. Coilings numerous, also in aerial hyphae. No diffusing pigment, no distinct odour noted. Conidiation effuse, on simple conidiophores often emerging in right angles on long aerial hyphae, solitary, unpaired or fasciculate. Conidiation also in pale yellowish green shrubs or granules along the margin and next to the plug. Shrubs or granules (examined after 11 days) 0.2–0.8(–1) mm diam, confluent to 2–3 mm; of a loose reticulum, with primary branches to 7 μm wide, often at right angles, and with broad peripheral conidiophores to *ca* 120 μm long. Conidiophores (simple and in minipustules) 3–6 μm wide, 2–3 μm at the ends; sometimes widening to 7–10(–11) μm; variable, short and regular, or asymmetric and main axis with 1–2 fold additional branching. Branches straight, slightly inclined upward. Phialides arising on cells 2–4 μm wide, solitary or in whorls of 2–4(–5). Phialides lageniform, mostly equilateral, widest in or below the middle. Conidia formed in minute wet or dry heads; subhyaline to pale yellowish green, minute, smooth, subglobose or ellipsoidal, less commonly oblong, finely multiguttulate or with one guttule and with indistinct or truncate scar. Measurements as on SNA, results combined.

Habitat: on medium- to well- decayed wood and bark of deciduous trees, typically at forest edges.

Distribution: Europe (Austria).

Holotype: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, 'Aussicht', MTB 9452/3, 46°32′50″ N 14°25′01″ E, elev. 600 m, at forest edge, on decorticated branches of *Fagus sylvatica* 1–4 cm thick, in leaf litter on the ground; holomorph, soc. *Tubeufia cerea*, *Lasiosphaeria strigosa*, *Mollisia* sp., 29 Oct. 2005 and 14 Oct. 2006 (from the same branches), W. Jaklitsch & H. Voglmayr, W.J. 2868 (**WU 29201**, culture CBS 120540=C.P.K. 2423). ***Holotype*** of *Trichoderma margaretense* isolated from WU 29201 and deposited as a dry culture with the holotype of *H. margaretensis* as **WU 29201a**.

Additional specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, 'Aussicht', MTB 9452/3, elev. 600 m, 46°32′48″ N 14°25′00″ E, on branches of *Fagus sylvatica*, on wood, soc. *Lasiosphaeria strigosa*, Corticiaceae, holomorph, 3 July 2007, W. Jaklitsch, W.J. 3107 (WU 29203, culture C.P.K. 3127). St. Margareten im Rosental, Gupf, close to Berghof Schuschnig, MTB 9452/4, elev. 800 m, 46°32′48″ N 14°26′57″ E, in shrubs, on mainly corticated branch of *Crataegus monogyna* 1–4 cm thick, in leaf litter on the ground; on wood and bark, soc. *Hyphodontia* sp., *Crepidotus* sp., *Mollisia* sp., ?*Tomentella* sp., holomorph, 21 Oct. 2003, W. Jaklitsch, W.J. 2481 (WU 29199, culture C.P.K. 994. Same locality, same date, on decorticated branch of *Carpinus betulus* 1–2 cm thick, on wood, upper side, holomorph, W.J. 2482 (WU 29200, culture CBS 119320=C.P.K. 1609). Same locality; on corticated branch of *Carpinus betulus*, 1–2 cm thick, in bark fissures, holomorph, 29 Oct. 2005, H. Voglmayr & W. Jaklitsch, W.J. 2877 (WU 29202, culture C.P.K. 2428). St. Margareten im Rosental, Sabosach, MTB 9452/3, elev. 550 m, 46°32′20″ N 14°24′35″ E, at forest edge, on decorticated branch of *Fagus sylvatica* 1–2 cm thick, immersed in leaf litter, on dark decayed wood, soc. leaves, rhizomorphs, hyphomycetes, etc., holomorph, 9 July 2007, W. Jaklitsch, W.J. 3116 (WU 29204, culture C.P.K. 3128). St. Margareten im Rosental, at the brook 'Tumpfi', close to Ledra, at forest edge, MTB 9452/2, elev. 570 m, 46°32′58″ N 14°25′52″ E, on branches of *Fagus sylvatica* and *Carpinus betulus* 1–6 cm thick, on medium to well decayed wood, a black crust, bark and leaves, soc. effete black pyrenomycete and *Tubeufia cerea*, holomorph, 9 July 2007, W. Jaklitsch, W.J. 3118 (WU 29205, culture C.P.K. 3129).

Notes: *Hypocrea margaretensis* has only been found around St. Margareten im Rosental, Kärnten, Austria, and always at forest edges, typically on steep slopes. The bright yellow and subeffuse stromata are reminiscent of sect. *Hypocreanum*, particularly *H. sulphurea*, but they are less than 2 cm diam, and the anamorph is green-conidial, as in other species of the *Brevicompactum* clade. The ascospores are distinctly smaller than in *H. sulphurea*. *Hypocrea margaretensis* is most closely related to *H. auranteffusa* and *H. rodmanii* and difficult to distinguish from these species in teleomorphs. The colour of fresh stromata is intermediate between the pale yellow *H. rodmanii* and the

bright orange *H. aurantieffusa*, but there are transitions particularly between the latter and *H. margaretensis*. Compared to *H. aurantieffusa*, *H. margaretensis* grows substantially faster and colonies on CMD show zones of unequal width in alternating light/darkness. No statistically significant differences were found between effuse and pustulate conidiation; only phialides are slightly longer on simple conidiophores, as noted in many other species of the genus. Conidiophores of effuse disposition are reminiscent of those of *H. lixii* and *H. strictipilosa*. *H. rodmanii* differs from *H. margaretensis* in more pulvinate or discoid stromata with pale yellow colour when fresh, as well as in well-defined green conidiation zones on PDA and in faster growth.

Hypocrea rodmanii Samuels & Chaverri, in Degenkolb et al., Mycol. Progress 7: 213 (2008a). Fig. 75
Anamorph: *Trichoderma* sp. Fig. 76

Stromata when fresh 1–8 mm diam, to *ca* 1 mm thick, effuse, discoid or pulvinate, broadly attached, margin often free; outline variable. Surface smooth, ostiolar dots diffuse when young, becoming distinct, densely arranged, brown on yellow stroma surface. Stromata white to pale yellow, 3A(2–)3, when immature, turning ochre-yellow, greyish- to dull orange-yellow, 4B5–8, or golden-brown, finally dull reddish brown.

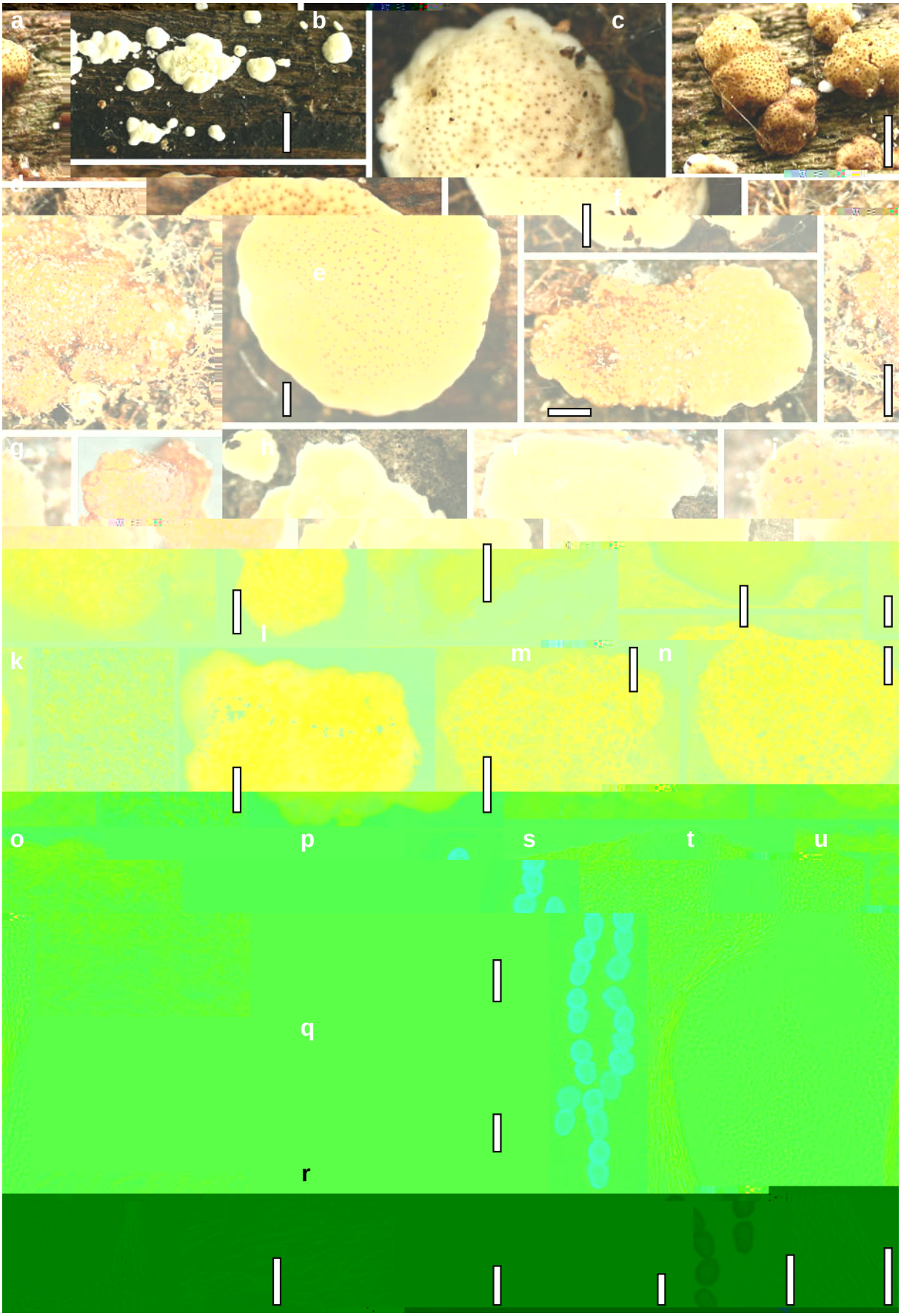
Stromata when dry (0.4–)1.3–4.4(–7.6)×(0.4–)1.1–2.6 (–4) mm, 0.1–0.4(–0.7) mm thick (n=70), solitary, gregarious or aggregated in small numbers, thinly effuse, following contours of the substrate, or flat pulvinate, thinner than fresh; broadly attached, or discoid and typically narrowly attached. Outline roundish, longish or irregular. Margin of effuse stromata typically adnate, thin and cottony, sometimes fraying out as white radiating mycelium; often thin, sharp and widely free in discoid stromata, rounded with free edge in pulvinate stromata; sometimes undulate; often white when young. Surface smooth, finely granular or slightly rugose, yellow to nearly orange. Ostiolar dots (27–)30–70(–118) μm (n= 90) diam, irregularly or evenly and densely distributed, plane or convex, roundish or longish, first diffuse, greyish, pale reddish brown or nearly orange when young, later well-defined, ochre, brown to nearly black even on a single stroma. Development and colour: Stromata starting as white mycelial tufts, compacting, turning pale yellow to greyish yellow with first white margin becoming concolorous, 3–4A2–4, 4B3–6; after the appearance of ostiolar dots deeper yellow, yellow-brown to dull orange, greyish orange, 5–6B4, 5CD5–8, 5E6–8, finally dull brown, 6CD4–8, 7E5–6, when old. Spore deposits white or yellow. Mature stromata after rehydration up to 30% larger than in dry condition, reddish brown, in the stereo-microscope yellow with flat ochre to reddish brown dots. Reaction to 3% KOH variable, typically becoming more distinctly orange- to reddish brown when mature.

Stroma anatomy: Ostioles (50–)60–100(–110) μm long, plane or projecting to 10(–17) μm, (30–)40–60(–70) μm wide at the apex inside (n=30), without differentiated marginal cells; periphyses to 3.5 μm wide. Perithecia (150–)180–240(–260)×(105–)130–200(–230) μm (n=30), crowded, globose, ellipsoidal or flask-shaped; peridium (11–)14–20(–23) μm (n=30) thick at the base, (6–)10–16(–20) μm (n=30) thick at the sides, yellow, when mature in KOH orange-red, particularly at the sides. Cortical layer (9–)11–23(–30) μm (n=30) thick, a thin, dense, yellow *t. angularis* of minute, partly compressed cells (2–)3–7(–9)×(2–)3–5(–6) μm (n=60) in face view and in vertical section, orange in 3% KOH. Subcortical tissue of thin-walled, hyaline or yellowish hyphae (2.5–)3.0–5.0(–7.0) μm (n=30) wide, partly appearing as angular cells (3–)4–8(–12)×3–6 μm (n=30) due to variable orientation. Subperithecial tissue a hyaline *t. angularis–epidermoidea* of thin-walled cells 6–25(–44)× (3.5–)5–14(–20) μm (n=35), becoming smaller and yellowish towards the base and mixed with thick-walled yellow hyphae (2.5–)3.5–7.0(–9.5) μm (n=30); in attachment areas exclusively pseudoparenchymatous of cells 3–15 μm diam. Asci (62–)75–90(–101)×(4.3–)4.5–5.5(–6.5) μm, stipe (1–) 5–13(–20) μm (n=80) long. Ascospores hyaline, yellow when old, verruculose, cells dimorphic; distal cell (3.3–)3.7–4.5(–5.5)×(2.8–)3.5–4.0(–4.2) μm, l/w (0.9–)1.0–1.2(–1.4) (n=90), (sub)globose or ellipsoidal; proximal cell (3.8–)4.3–5.8(–7.4)×(2.5–)3.0–3.3(–3.5) μm, l/w (1.2–)1.4–1.9(–2.4) (n=90), oblong or wedge-shaped, often longer in the ascus base.

Cultures and anamorph: optimal growth at 25–30°C on all media; slow and often limited growth at 35°C.

On CMD after 72 h 10–12 mm at 15°C, 32–34 mm at 25°C, 34–37, 1–5 mm at 35°C; mycelium covering the plate after 6–7 days at 25°C. Colony hyaline, thin, circular, dense, with indistinct light/dense and darker/looser concentric zones; denser zones slightly narrower. Hyphae curved, secondary hyphae narrow, sinuous, in steep angles in growth direction; little mycelium on the agar surface. Aerial hyphae scant, short. Autolytic activity lacking or inconspicuous, no coilings seen. No

Fig. 75 Teleomorph of *Hypocrea rodmanii*. a–f. Fresh stromata (**a, b**. immature). **g–i, k, l**. Dry stromata (**g, h**. immature). **j.** Rehydrated stroma. **m**. Stroma surface in face view. **n**. Stroma in 3% KOH after rehydration. **o**. Perithecium in section. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue in section. **r**. Stroma base in section. **s–u**. Asci with ascospores (**u**. in cotton blue/lactic acid). **a, c, g, j–l, n–s**. WU 29443. **t**. WU 29445. **b, d–f, h, i, m, u**. WU 29444. *Scale bars* **a**= 3 mm. **b, d, e, j–l**, **n**=0.5 mm. **c**=1.5 mm. **f–h**=1 mm. **i**=0.2 mm. **m, p, t**, **u**=10 μm. **o**=30 μm. **q**, **r**=15 μm. **s**=5 μm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u


a
d
e
f
b
g
h
i
c
j
k
l
n
o
m
p
q
r
s

diffusing pigment, no distinct odour noted. Chlamydospores noted after 4–7 days, uncommon, terminal and intercalary, (6–)8–13(–16)×(6–)7–10(–11) µm, l/w 0.9–1.5(–2) (*n*=30), globose, oblong, ellipsoidal or clavate. Conidiation at 25°C starting after 3–4 days, not becoming green within 2 weeks; effuse, on mostly short, simple conidiophores concentrated in the centre and in lighter concentric zones, longer in distal areas; sometimes also in minute loose shrubs formed on locally aggregated hyphae; some conidiation also submerged in the agar. Short simple conidiophores 1–2 celled, with phialides solitary or in a terminal whorl of 2–3; longer ones of a main axis with few unpaired side branches; side branches with short, 1–2 celled, unpaired or paired terminal branches. Shrubs broad, to *ca*

noted. Chlamydospores noted after 4–7 days, rare. After storage for 1.5 years at 15°C small sterile stromata observed. At 15°C colony centre loose, margin dense; conidiation in the centre pachybasium-like in green, 28–30CD4–6, pustules 2–4 mm diam, with rough, straight, sterile elongations to 0.5 mm long. At 30°C colony similar to 25°C, indistinctly zonate; conidiation effuse, scant. At 35°C growth slow, colony circular, dense, finely zonate; hyphae forming pegs; conidiation effuse, scant. Conidiation at 25°C starting after 3–5 days, green after *ca* 11 days. Effuse conidiation scant, simple, minute, in narrower zones; substantially less than on CMD (for measurements see CMD). Conidiation in pustules pachybasium-like. Primary branching within pustule asymmetric, thick, often in right angles, with short intervals between secondary branches. Conidiophores numerous, fertile to the tip or terminating in short straight sterile elongations to 200(–300) µm long, the latter appearing rough under lower magnifications, but smooth or with minute droplets on their surface in the microscope, often becoming fertile. Conidiophores often regularly tree-like in peripheral position on the pustule, comprising a main axis with side branches progressively longer from the tip downwards. Side branches paired or unpaired, in right angles or slightly inclined upwards, short, *ca* 10–50 µm long, 1-celled in terminal position, 1–4 celled on lower levels, giving rise to 1-celled secondary side branches, all bearing dense whorls of phialides, i.e. forming dense structures. Main axes and side branches 4–6 µm wide, terminally 2.5–4 µm, with some globose thickenings to 7–10 µm. Phialides divergent in whorls of (2–)4–6 on cells 2.5–4.5 µm wide, rarely solitary. Phialides (from SNA and PDA) (4.5–)5.0–8.0(–12.5)×(2.5–)2.8–3.5(–3.8) µm, l/w (1.3–)1.5–2.6(–4.8), (1.3–)2.0–2.8(–3.3) µm wide at the base (n=97), lageniform or ampulliform, often with long, abruptly attenuated neck, straight, symmetric, widest in or below the middle. Conidial heads <20 µm diam, wet in shrubs, dry in pustules. Conidia (from SNA and PDA) (2.2–)2.5–3.0(–3.5)×(1.7–)2.0–2.5(–2.8) µm, l/w 1.1–1.3(–1.5) (n=106), pale green, subglobose or oval, smooth, with few minute guttules; scar indistinct. Combined measurements from effuse and pustulate conidiation (CMD, PDA, SNA): phialides (4.5–)5.0–10.5(–16.5)×(2.0–)2.5–3.3(–3.8) µm, l/w (1.3–)1.5–4(–7.3), (1.3–)1.8–2.5(–3.3) µm wide at the base (n=168). Conidia (2.2–)2.5–3.3(–4.5)×(1.7–)2.0–2.5(–3.2) µm, l/w (1.0–)1.1–1.4(–1.8) (n=216).

Habitat: on medium- to well-decayed wood, below peeling bark, less commonly on bark.

Distribution: Canada, Central Europe (Austria, Germany), USA (Maryland, Virginia).

Holotype: **USA**, Virginia, Giles County, Cascades Recreation Site, 4 mi N of Pembroke, along Little Stony Creek, 37°02′N, 80°35′W, elev. 838 m, 18 Sep. 1991, on branchlets, G.J. Samuels, C.T. Rogerson, S.M. Huhndorf, S. Rehner & M. Williams (BPI 1112859, ex-type culture CBS 120895; not examined).

Specimens examined: **Austria**, Vienna, 22nd district, Lobau, at the Panozzalacke, MTB 7865/1, 48°11′06″ N, 16°29′20″ E, elev. 150 m, on branches of *Populus alba*, *Ulmus campestris* and *Fraxinus excelsior*, on little to well-decayed wood, partly on a brown ?*Tomentella* and *Eutypa* sp., soc. brown rhizomorphs and its pale green anamorph, 18 Nov. 2006, W. Jaklitsch W.J. 3039 (WU 29444, culture C.P.K. 2852). **Canada**, Québec, Ville de Québec, Arrondissement de Beauport, forest SW of the Lac du Délaissé, on twig of *Fagus grandifolia* 1 cm thick, on medium decayed wood, soc. effete pyrenomycetes, white to light green *Trichoderma*, pustulate on bark, effuse on wood, 29 Jul. 2006, H. Voglmayr W.J. 3060 (WU 29445, culture C.P.K. 2871). **Germany**, Sachsen-Anhalt, Landkreis Bernburg (Saale), Bernburg, Krumbholzallee, alluvial forest at the river Saale, MTB, 51°47′23″ N, 11°43′00″ E, elev. 85 m, on branches of *Fraxinus excelsior* 2–3 cm thick, on medium to well-decayed wood and *Eutypa* sp., partly also on bark, soc. effete *cf. Lasiosphaeris hirsuta*, *Patellaria atrata*, brown rhizomorphs, 22 Aug. 2006, H. Voglmayr & W. Jaklitsch W. J. 2931 (WU 29443, culture CBS 121553=C.P.K. 2439).

Notes: *Hypocrea rodmanii* produces stromata that are generally less brightly pigmented and more pulvinate than *H. auranteffusa* and *H. margaretensis* when fresh; when dry they are thinly effuse. Among the species with effuse stromata, *H. rodmanii* forms the smallest ones. The dull yellow stroma colour may cause confusion with *H. moravica* or *H. bavarica*. '*Trichoderma rodmanii*' differs from *T. auranteffusum* and *T. margaretense* by pustulate conidiation arranged in dense concentric rings on PDA. For comparison with Degenkolb et al. (2008a), who described the pustulate anamorph, I give measurements of phialides and conidia separately for effuse and pustulate conidiation. In the effuse conidiation phialides are more slender and distinctly lageniform, and conidia are produced in wet heads and are more variable in shape than in the pustulate conidiation. Sizes of phialides and conidia are similar in all species of the *Brevicompactum* clade treated here, but the species can be unequivocally identified by gene sequences.

Hypocrea lutea (Tode : Fr.) Petch, J. Bot. (Lond.) 75: 231 (1937). Fig. 77

≡ *Sphaeria gelatinosa* α *lutea* Tode, Fungi Mecklenb. 2: 48 (1791).

≡ *Sphaeria gelatinosa* b. *lutea* Tode : Fr., Syst. Mycol. 2 (2): 336 (1823).

Anamorph: ***Trichoderma deliquescens*** (Sopp) Jaklitsch, comb. nov. Fig. 78

MycoBank MB 516684
≡ *Gliocladium deliquescens* Sopp, Monogr. *Penicillium*, p. 89, tab. 1, Fig. 15 (1912)
= *Gliocladium viride* Matr., Bull. Soc. Mycol. Fr. 9: 251 (1893)

Stromata when fresh 0.5–2.5 mm, to *ca* 1 mm thick, solitary, gregarious or aggregated in small numbers, or initially an effuse stroma breaking up into 2–4 part-stromata; pulvinate or turbinate, broadly attached; outline typically angular or irregular; margin often lobed, attached or free; surface flat, smooth, or with some coarse tubercles. Perithecia entirely immersed, sometimes prominent at the margin. Ostiolar dots first appearing as large diffuse spots, becoming distinct, brown. Stromata first white, turning pale yellow, 1–4A2–5, greyish yellow or argillaceous, 4B5–6.

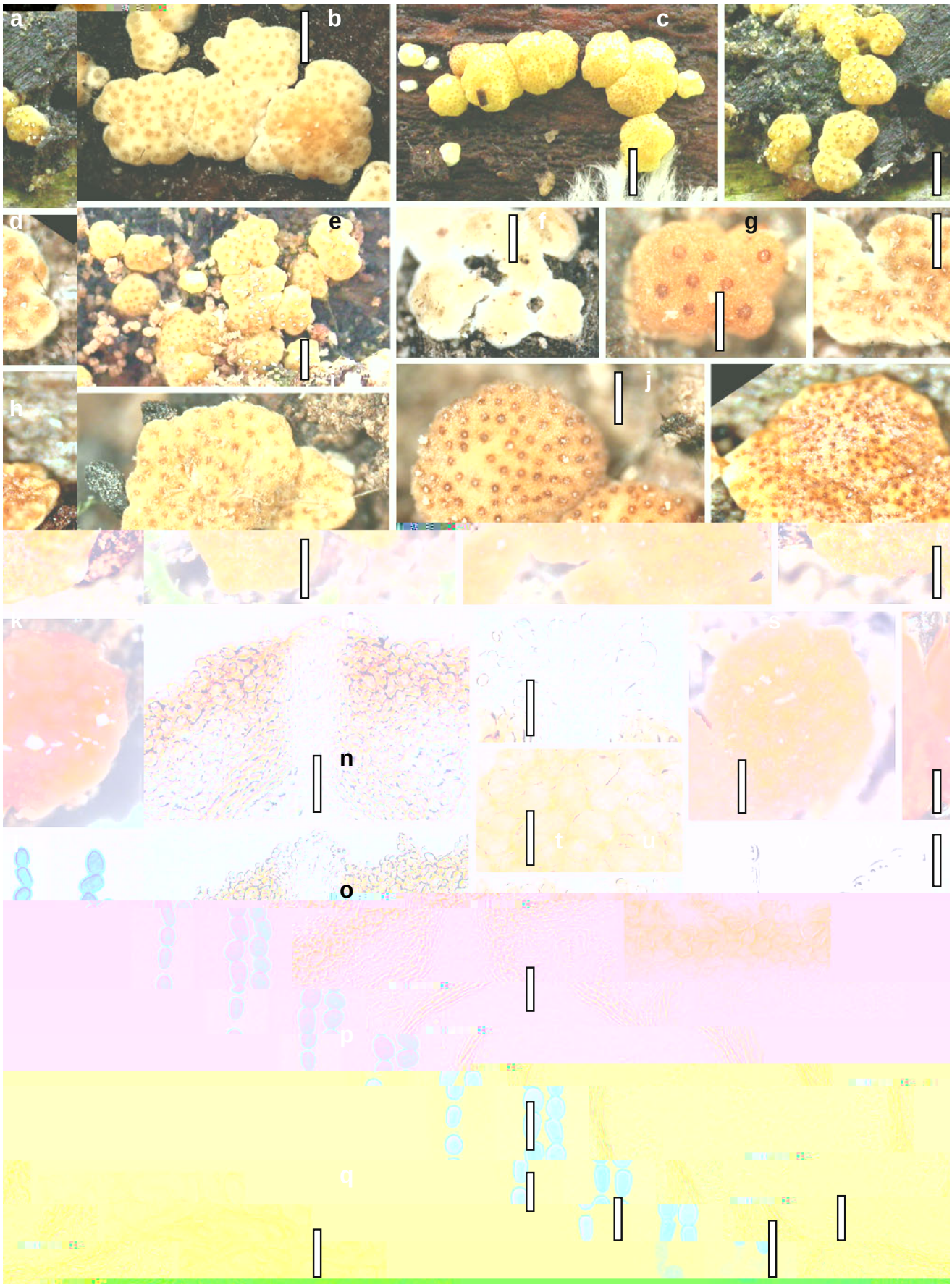
Stromata when dry (0.3–)0.6–1.5(–2.1)×(0.2–)0.5–1.2(–1.9) mm, (0.15–)0.2–0.3(–0.45) mm thick (*n*=75), flat pulvinate or discoid, sometimes with convex surface, broadly or narrowly attached; outline mostly isodiametric and angular; margin attached or free, often lobed, white or pale yellow, often lighter than the stroma centre when young; sides often vertical, often covered with white mycelium. Surface smooth, coarsely tubercular or rugose, glabrous or finely white-farinose or floccose, finely downy when young. Ostiolar dots (24–)40–80(–134) μm (*n*=120) diam, plane or convex, diffuse or distinct, brown, often appearing as dark rings with hyaline centres. Stromata pale yellow, 4A2–4, 4B4–5, when immature, later pale to greyish orange, 5AB4–5, brown yellow or brown orange, 5AB5–6, 5–6CD6–8. Spore deposits white or yellow. Rehydrated stromata more pulvinate; surface smooth, more orange- to reddish brown due to darker dots; after addition of 3% KOH turning orange red; ostioles convex, hyaline.

Stroma anatomy: Ostioles (60–)70–103(–125) μm long, projecting to 30(–70) μm, hyaline part (23–)33–52(–70) μm wide at the apex (*n*=30), cylindrical, periphysate, more prominent at the stroma periphery; with broad clavate or subglobose cells to 7 μm wide at their apical margins. Perithecia (164–)190–250(–275)×(107–)140–205(–230) μm(*n*=30), globose or flask-shaped; peridium (10–)12–18(–22) μm (*n*=30) thick at the base, (6–)10–16(–18) μm (*n*=30) thick at the sides, pale yellow, in 3% KOH rosy-orange at the sides. Cortical layer (14–)17–29(–37) μm (*n*=30) thick, of a few layers of a well-defined, coarse *t. angularis* of thin-walled cells (4–)6–16(–24)×(3–)5–10(–16) μm (*n*=73) in face view and in vertical section; yellow, subhyaline at stroma sides; orange-red in 3% KOH. Hairs on upper and lateral surface of mature stromata (7–)8–23(–37)×(3.5–)4–7(–9) μm (*n*=35), of 1–2(–4) cells, subhyaline or yellow, cylindrical, often with a globose basal cell, smooth or rough, sometimes moniliform or branched. Subcortical tissue a hyaline *t. intricata* of thin-walled hyphae (2–)3–6(–8) μm (*n*=35) wide, appearing also as angular or globose cells (2.5–)4–9(–13)×(2.5–)3–6(–8) μm (*n*=30) due to varying cutting angles. Subperithecial tissue a hyaline *t. epidermoidea-angularis* of variable thin-walled cells (7–)9–24(–39)×(5–)7–14(–22) μm (*n*=30). Stroma base similar to subperithecial tissue except for a narrow layer of subhyaline or yellowish, thin- or thick-walled hyphae (2–)3–6(–9) μm (*n*=30) wide at attachment areas. Asci (70–)80–96(–106)×(4.3–)4.5–5.5(–6.3) μm, stipe (3–)8–16(–21) μm long (*n*=70), with two basal septa; often formed on sinuous ascogenous hyphae. Ascospores hyaline, sometimes yellow or orange when old, verruculose; cells dimorphic; distal cell (3.2–)3.8–4.5(–5.0)×(3.0–)3.2–3.6(–4.5) μm, l/w (0.8–)1.1–1.3(–1.5) (*n*=100), subglobose or ellipsoidal; proximal cell (3.7–)4.3–5.5(–6.5)×(2.4–)2.5–3.2(–5.0) μm, l/w (0.7–)1.5–2.0(–2.5) (*n*=100), wedge-shaped or oblong, less commonly subglobose.

Anamorph on the natural substrate: gliocladium-like conidiophores to 250 μm long, with dry green heads 30–100(–170) μm diam, appearing on or around stromata.

Cultures and anamorph: optimal growth at 30°C on all media; good growth at 35°C.

On CMD after 72 h 17–19 mm at 15°C, 51–58 mm at 25°C, 64–66 mm at 30°C, 48–53 mm at 35°C; mycelium covering the plate after 4 days at 25°C. Colony hyaline, thin; hyphae with conspicuous differences in width; mycelium mostly of primary hyphae, loose, forming radial strands; conspicuously wide (to *ca* 15 μm) at the marginal surface. Aerial hyphae absent or scant. Autolytic excretions lacking or rare, no coilings seen. No diffusing pigment, no distinct odour noted. Agar of cultures stored for *ca* 3 months at 15°C sometimes rosy. Chlamydospores noted after 1–2 days at 25–35°C, spreading from the centre across entire plate, numerous, globose, mostly terminal in narrow hyphae. Conidiation noted after 2(–3) d at 25–35°C, green after 3–4 days; effuse, first appearing mainly around the plug and along the margin as green to black dots 150 μm diam, growing to *ca* 0.5 mm diam, eventually arranged in indistinct concentric zones; zones becoming more distinct and regular with increasing temperature. Conidiophores (after 8 days) solitary or in fascicles of up to 10 to 0.6 mm wide in total; to 0.4 mm long including conidial head; originating from several hyphal fascicles (roots) and often surrounded by narrow hyphae on lower levels. Conidiophores consisting of a single erect, thick-walled stipe or main axis 7–13(–14) μm wide at the base, attenuated to 7 μm upwards and mostly to 120 μm long to the first branching, smooth, appearing rough under low magnification due to guttules; repeatedly narrow branches growing out below septa, directed downwards, giving the impression of a synnema; bearing an apical penicillus of 3–4 levels of steeply ascending, nearly parallel unicellular branches


a
b
c
d
e
f
g
h
j
k
n
o
p
q
s
t
u

◀ **Fig. 77** Teleomorph of *Hypocrea lutea*. **a–d**. Fresh stromata. **e–j**. Dry stromata (**e**. stroma initials; **h**. showing farinose to floccose stroma surface). **k**. Cortex and ostiole in 3% KOH in section. **l**. Perithecium in section. **m**. Cells of ostiolar apex in side view. **n**. Stroma surface in face view. **o**. Cortical and subcortical tissue in section with hairs on the surface. **p**. Subperithecial tissue in section. **q**. Base in section. **r**. Rehydrated stroma. **s**. Stroma in 3% KOH after rehydration. **t–w**. Asci with ascospores (**v, w**. in cotton blue/lactic acid). **a, g, w**. WU 29235. **b, j**. WU 29233. **c–f, i, k–t, v**. neotype WU 29232. **h, u**. WU 29234. *Scale bars* **a, c**, **d**=0.6 mm. **b**=1 mm. **e, g, h**, **j**=0.4 mm. **f**=0.2 mm. **i, r**, **s**=0.3 mm. **k**, **l**=30 μm. **m–o**=15 μm. **p**=20 μm. **q**, **t–w**=10 μm

originating on a single level, re-branching into whorls of (1–)4–5(–6) similar branches. Penicilli without conidial masses in mounts mostly to 100 μm long and 70–120 μm wide at the apex. Branches attenuated from 6 μm at the base to 2.5–3.5 μm upwards. Phialides formed densely appressed and parallel in whorls of 2–6 on terminal branches (=metulae) 2.5–3.5 μm wide. Phialides (6–)8–11 (–12)×(1.8–)2.0–2.5(–3.0) μm, l/w (2.3–)3.4–5.1(–6.1), (1.0–)1.3–2.0(–3.0) μm wide at the base (n=60), lageniform, subulate or subcylindrical, inaequilateral and curved when lateral in the whorl, neck short, becoming green with age. Conidia produced in large masses in heads (30–)80–200(–270) μm diam. Heads wet, mucous, shiny, appearing velutinous when dry, small and light green when young, growing and becoming opaque, dark green to black. Conidia (3.0–)3.2–3.8(–4.7)×(2.2–)2.3–2.5(–2.7) μm, l/w (1.2–)1.3–1.6(–2) (n=68), (yellow-)green, ellipsoidal or oblong, often attenuated towards the base, smooth, with few minute guttules, scar indistinct. At 35°C hyphae narrower than at lower temperatures; conidiation in distinct concentric zones of green to black dots. Conidiophores arising in bundles to 1 mm diam; conidia formed in heads to 0.4 mm diam.

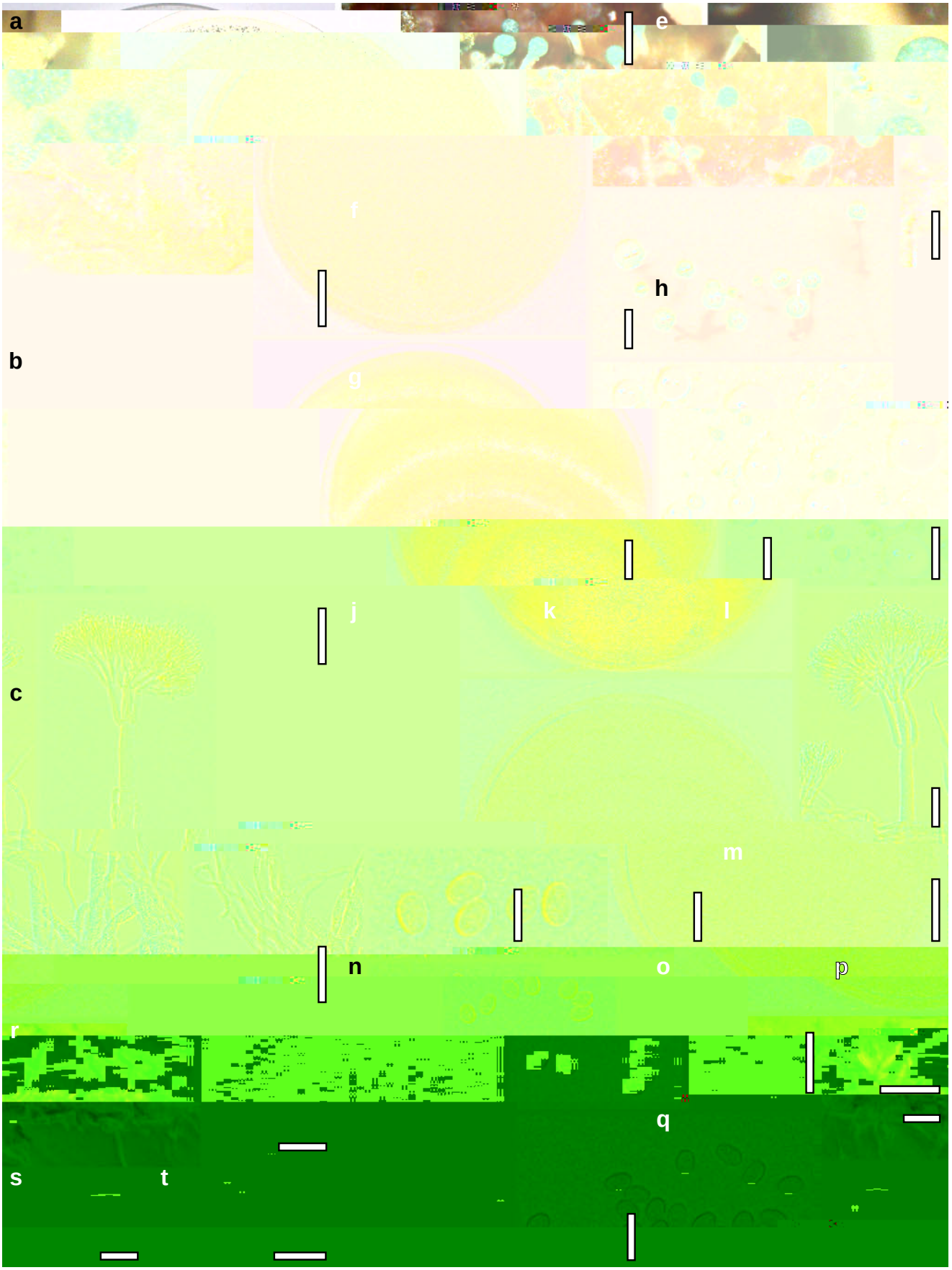
On PDA after 72 h 15–16 mm at 15°C, 38–40 mm at 25°C, 46–48 mm at 30°C, 38–41 mm at 35°C; mycelium covering the plate after 6–7 days at 25°C. Colony first hyaline, dense, becoming concentrically zonate; zones and margin thick, convex, densely hairy to cottony; numerous red crystals to *ca* 150 μm diam appearing in the agar; green, 27D5-6, 27F7-8, later black dots appearing in the centre and in the concentric zones, confluent to spots 2.5 mm long. Aerial hyphae numerous, several mm high, forming strands. Autolytic excretions lacking or rare at lower temperatures, abundant at 35°C, no coilings seen. Reverse exhibiting varying colours, olive, 1E5–6, yellowish, 3B4, and grey- to brown-red, 8BC5-6; conidiation zones on the reverse finally yellow- to orange-brown, 5CD5–6. No distinct odour noted. Conidiation noted after 1–2 days at 25–35°C, green after 2–3 days; appearing as numerous, mostly unbranched, short gliocladium-like 'brushes' around the plug; conidial heads to *ca* 0.3 mm diam, wet or dry, green, confluent. Red crystals formed at all temperatures; gliocladium-like conidiophores spreading across entire plate at 15°C. At 30°C conidiation in several concentric zones; zones flat; crystals dissolving in the agar with time. Conidiation abundant, green, 27EF7–8, conidial heads confluent early. Reverse brown-orange, 7C5–6, below concentric zones. At 35°C colony with fine farinose green zones. Conidiation abundant; conidial heads small. Autolytic excretions abundant, yellowish. Centre on the reverse yellowish, 1-3AB4-5.

On SNA after 72 h 15–16 mm at 15°C, 44–47 mm at 25°C, 54–57 mm at 30°C, 32–36 mm at 35°C; mycelium covering the plate after 4–5 days at 25°C. Colony as on CMD; but hyphae degenerating soon, appearing empty. Autolytic excretions lacking or rare at lower temperatures, abundant at 35°C, coilings lacking or moderate. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 1–2 days, abundant at all temperatures, distinctly more abundant than on CMD, mostly terminal, also intercalary, (4–)6–10(–12)× (3.5–)5–9(–12) μm, l/w (0.9–)1.0–1.2(–1.5) (n=70), (sub-) globose, less commonly ellipsoidal or fusoid, smooth. Conidiation noted after 2–3 days at 25–35°C, green after 3–4 days. Gliocladium-like conidiophores arising in bundles to 1 mm diam of up to 25, basal branching or aggregations of conidiophores in bundles more pronounced than on CMD and more pronounced with increasing temperature; also concentric conidiation zones more distinct and regular with increasing temperature. Main axes of conidiophores appearing verrucose under low magnification due to small drops. Conidial heads to 0.4 mm diam, green to black, confluent.

Habitat: teleomorph on soft, crumbly wood of deciduous trees; also reported from leaves (Petch 1938); anamorph in soil, on diverse fungi and other substrates (see Domsch et al. 2007).

Distribution: Europe, North America, possibly cosmopolitan; teleomorph uncommon.

Typification: No original specimen exists, because Tode's specimens were destroyed in World War II. ***Holotype***: illustration Tab. XVI, Fig. 123a–f in Tode (1791). Fries (1823, p. 336) sanctioned the name. No material seen by Fries could be located in UPS. Petch (1937) elevated the infraspecific taxon to species rank. The two specimens cited by him are scant and not particularly well representative of the species. Petch did not designate a type. Therefore the following ***epitype*** is here designated in order to define the correct relationship of teleomorph, anamorph and gene sequences: **United Kingdom**, Buckinghamshire, Slough, Burnham Beeches, 51°33′13″ N, 00° 37′52″ W, elev. 30 m, on a wet cut log of *Fagus sylvatica* 27 cm thick, on well-decomposed, crumbly wood, soc. effete *Eutypa spinosa*, coelomycetes, hyphomycetes, rhizomorphs, waxy Corticiaceae; holomorph, 15 Sep. 2004, W. Jaklitsch W.J. 2715 (**WU 29232**, ex-epitype culture CBS 121131=C.P.K. 1942). The anamorph has apparently never been typified, therefore a ***neotype*** is proposed for *Gliocladium deliquescens*: isolated from WU 29232 and deposited as a dry


a
e
f
h
i
b
g
j
k
l
c
m
n
o
p
r
q
s
t

◀ **Fig. 78** Cultures and anamorph of *Hypocrea lutea*. **a–c**. Cultures after 7 days (**a**. on CMD, 35°C; **b**. on PDA, 25°C; **c**. on SNA, 35°C). **d, e**. Conidiophores/conidial heads on the natural substrate. **f, g**. Conidiophores/conidial heads in culture. **h**. Conidiophore on inoculation plug (SNA, 3 days). **i**. Part of conidiophore on growth plate showing basal architecture of apical penicillus (SNA, 16 days). **j, k**. Conidiophores. **l, p**. Phialides. **m, o, q**. Conidia. **n**. Apical penicillus of conidiophore. **r**. Crystals along a hypha submerged in agar (PDA, 15°C, 5 days). **s, t**. Chlamydospores (SNA, 16 days; **s**. terminal, **t**. intercalary). **f–t**. All at 25°C except r. **f, g, j–q**. On CMD after 8 days. **a–c, g–i, l–q, r–t**. CBS 121131. **d, e**. WU 29235. **f, j, k**. CBS 121132. *Scale bars* **a–c**=15 mm. **d, f, g**=150 μm. **e, h, j, k, r**=40 μm. **i, n**= 15 μm. **l, m, q, s**=5 μm. **o, p, t**=10 μm

culture with the epitype of *H. lutea* as *Trichoderma deliquescens* **WU 29232a**.

Other specimens examined: **Germany**, Nordrhein-Westfalen, Detmold, Landkreis Lippe, Hiddesen, Teutoburger Wald, nahe Donoper Teich, MTB 4018/4, 51°55′43″ N, 08°48′17″ E, elev. 150 m, on partly decorticated branch of *Fagus sylvatica* 10 cm thick, on wood, soc. effete pyrenomycete, coelomycete, white Corticiaceae, *Phlebiella vaga*; largely immature, 19 Sep. 2004, W. Jaklitsch, W.J. 2730 (WU 29233, culture C.P.K. 1943). Sachsen-Anhalt, Landkreis Aschersleben-Staßfurt, Staßfurt, Horst, MTB 4135/1, 51°51′24″ N, 11°33′40″ E, elev. 70 m, on decorticated branch of *Fraxinus excelsior* 6–8 cm thick, on black, crumbly wood, soc. moss, effete pyrenomycetes (*Chaetosphaerella* sp., *Eutypa* sp., *Lasiosphaeria* sp.), *Mollisia* sp. and few conidiophores of the anamorph, 22 Aug. 2006, W. Jaklitsch & H. Voglmayr, W.J. 2932 (WU 29234, culture CBS 121132=C.P.K. 2440). **United Kingdom**, Buckinghamshire, Slough, Burnham Beeches, 51°33′ 30″ N, 00°37′43″ W, elev. 40 m, on log of *Fagus sylvatica* 40 cm thick, on dark, moist, crumbly wood, soc. long-necked coelomycete, dark hyphomycete on a light mucous corticiaceous fungus and *Eutypa spinosa* in bark, holomorph, 15 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3164 (WU 29235, culture C.P.K. 3152).

Notes: The gliocladium-like anamorph is essential for morphology-based identifications of *Hypocrea lutea*. The teleomorph is characterised by small yellow stromata with angular outline, usually appearing in small numbers, but this is hardly sufficient for recognition, because several other species may produce similar stromata, e.g. *H. luteocrystallina*, *H. moravica*, *H. pachypallida* or *H. parapilulifera*. These species differ markedly in their anamorphs except *H. luteocrystallina*. The latter species is similar to *H. lutea* in both teleomorph and anamorph, but can be distinguished by yellow crystals on the mature stroma surface turning violet in KOH, a conspicuous white young stage, subglobose conidia, slower growth, a growth optimum at 25°C and virtually no growth at 35°C. The red pigment is produced by both species. According to G.J. Samuels (pers. comm.), isolates of *H. lutea* are known that do not produce a reddish pigment. *H. lutea* typically occurs on the upper side of logs or branches or on standing branches, i.e. freely exposed to climatic elements. This correlates with its growth at 35°C.

Species concept and history: Tode (1791) described *Sphaeria gelatinosa* with the two varieties α. *lutea* and β. *viridis*. Petch (1937) summarised the history of the two varieties and the interpretations of Tode's (1791) protologues by various mycologists. The notion whether the stromata were gelatinous or not varied among authors, and *S. gelatinosa* was regarded as having hyaline ascospores until Saccardo (1883a) described it with green ascospores. Petch (1937) determined that Tode meant two different species, i.e. *Sphaeria gelatinosa* f. *viridis* representing the green-spored *Hypocrea gelatinosa* and a hyaline-spored *Sphaeria gelatinosa* f. *lutea* Tode, which he elevated to species rank as *Hypocrea lutea*. He based this latter species on yellow stromata collected by F. Currey in 1856 and Hawley in 1905 on leaves. An anamorph was never included in the description of *H. lutea*. Also Petch's scant material is not particularly informative due to the lack of conidiophores. Doi (1966) observed a gliocladium-like anamorph in ascospore-derived cultures of *Hypocrea lutea*, and later (Doi in Samuels et al. 1990) he named it *Gliocladium cf. deliquescens*. The connections *H. lutea*/*G. viride* (= *G. deliquescens*) was accepted by Chaverri and Samuels (2003), Domsch et al. (2007) and Samuels (2006) and is also accepted here.

The anamorph name: Matruchot (1893) described *Gliocladium viride* Matr. from a *Stereum* sp. with conidia 3–6× 2–3 μm. Sopp (1912) described *Gliocladium deliquescens* from *Cerrena unicolor* with conidia 1.5–2×1 μm on top of phialides during their formation, noting that 'later the conidia become more roundish and larger, but not much'. Morquer et al. (1963) kept the two species separate, stating nearly identical conidial sizes for them, but obviously these authors studied a generically heterogeneous assemblage of species, because *G. deliquescens* and other species were characterised by catenate conidiation. Matsushima (1975, 1989), Domsch et al. (2007) and the MycoBank database (CBS; under *G. deliquescens*) treat *G. deliquescens* as a synonym of *G. viride*, although without explanations. If it is assumed that the wide variation of conidial size given by Matruchot (1893) is due to non-standardised culture conditions, including aberrant extremes, and that the size given by Sopp (1912) is based on immature conidia, then the synonymy makes sense. The fact that type material is neither available for *G. viride* (J. Mouchacca, pers. comm.) nor for *G. deliquescens* (W. Gams, pers. comm.) makes a verification impossible. The description by Gilman and Abbott (1927; also cited by Gilman 1957, Thom 1930, Subramanian 1971) of *G.*

deliquescens is morphologically in accordance with the anamorph of *H. lutea*. Assuming conspecificity of *G. deliquescens* and *G. viride*, the latter would have priority for the combination of the anamorph taxon in *Trichoderma*, but is unavailable because of the resulting homonymy with *T. viride* Pers. Therefore *G. deliquescens* becomes the valid name to be combined in *Trichoderma* as the anamorph of *H. lutea*.

Morphologically *T. deliquescens* is an extreme form or final stage in a development from dendritic *Trichoderma* conidiophores with divergent phialides to a virtually unbranched conidiophore with more or less parallel phialides, i.e. mononematous, penicillate conidiophore, and in addition with conidia wrapped in a mucous exudate. This latter trait is absent in other species of *Trichoderma* except for *T. luteocrystallinum*. Considerably more distinctly branched conidiophores with a *gliocladium*-like arrangement of phialides and green conidia are found in several other species of *Trichoderma*, e.g. *T. gelatinosum*. Similar conidiophores but with hyaline conidia occur in the *Psychrophila* clade.

Hypocrea luteocrystallina Jaklitsch, Siepe & L.G. Krieglst., **sp. nov**. Fig. 79
MycoBank MB 516687
Anamorph: ***Trichoderma luteocrystallinum*** Jaklitsch, **sp. nov.** Fig. 80
MycoBank MB 516688

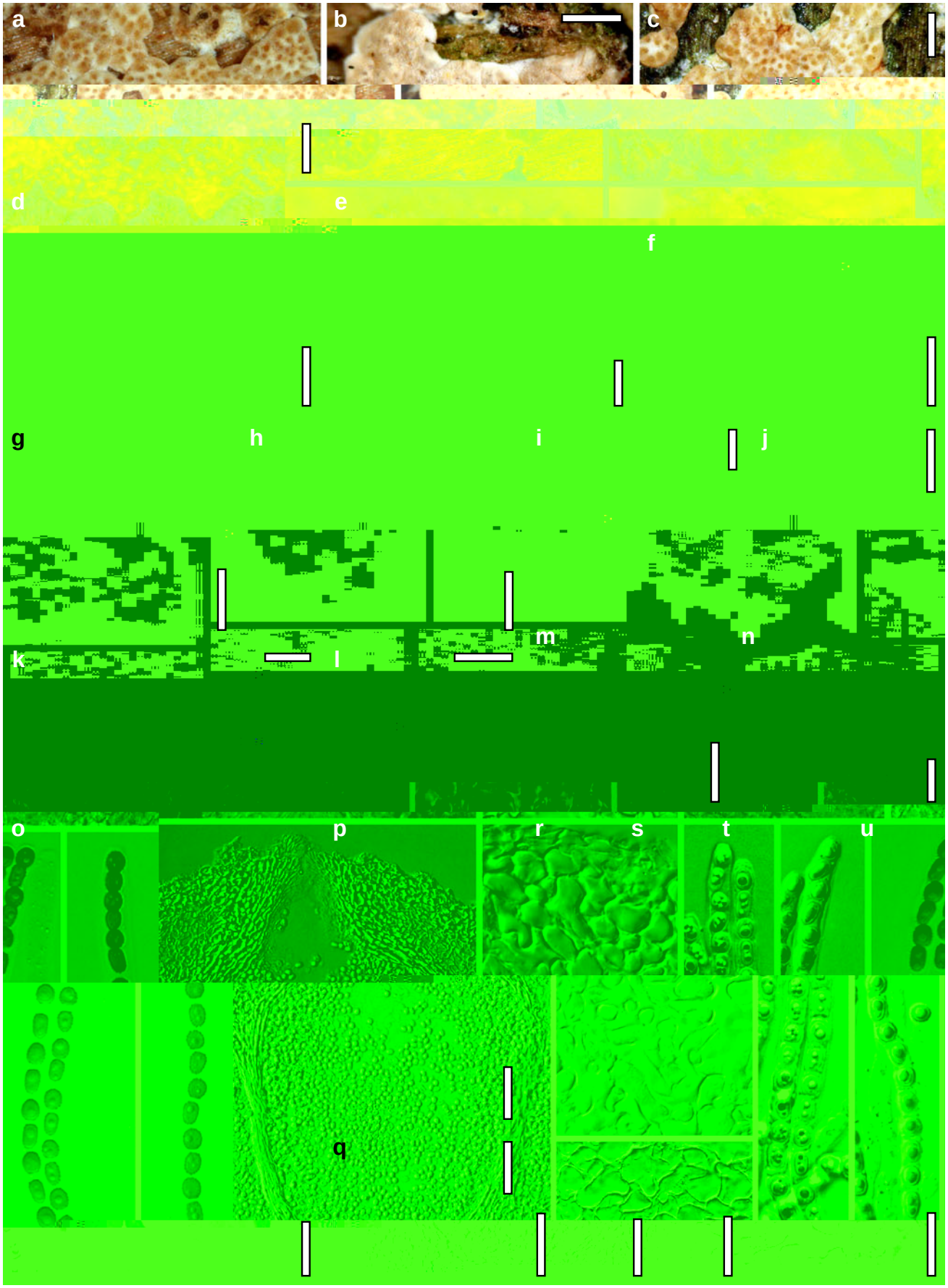
Stromata in ligno arborum coniferarum, solitaria vel gregaria vel dense aggregata, 0.3–2.2×0.2–1.6 mm, pulvinata, alba vel lutea ad brunnea, ostiolis brunneis, superficie saepe flavis crystallis obtecta. Asci cylindrici, (58–)67–82(–91)×(4.0–)4.2–5.0(–5.5) μm. Ascosporae bicellulares, verruculosae, hyalinae, ad septum disarticulatae, pars distalis subglobosa vel ellipsoidea, (3.0–)3.4–3.8(–4.0)×(2.5–)2.9–3.2(–3.3) μm, pars proxima oblonga, cuneata vel ellipsoidea, (3.3–)3.7–4.7(–6.0)×(2.0–)2.3–2.7(–3.0) μm. Anamorphosis *Trichoderma luteocrystallinum*. Conidiophora similia *Gliocladii*. Phialides lageniformes, (5–)7–10(–13)×(2.0–)2.2–2.8(–3.4) μm. Conidia viridia, subglobosa, glabra, (2.5–)2.7–3.3(–3.6)×(2.2–)2.5–2.8(–3.1) μm in agaro SNA.

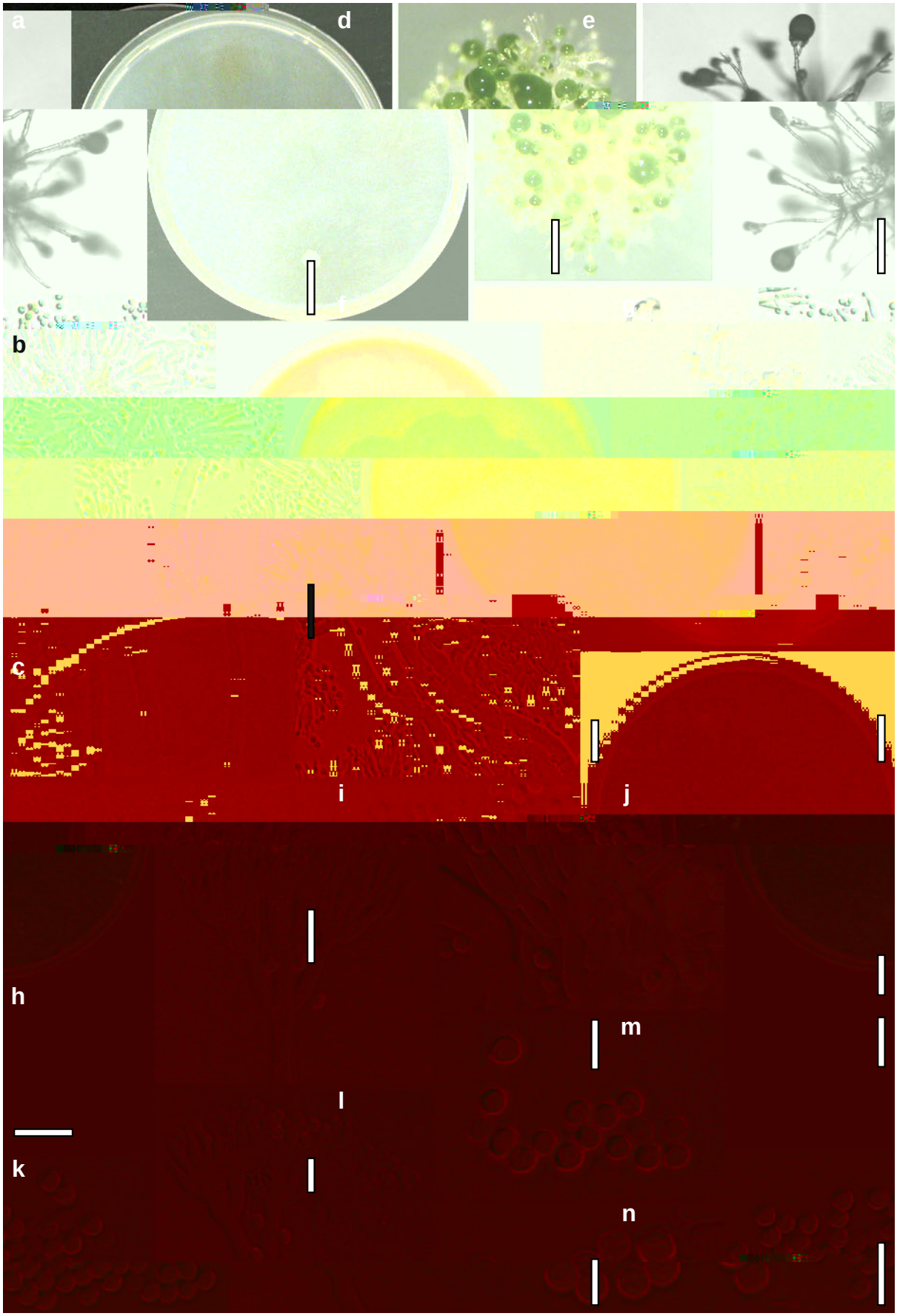
Etymology: referring to the yellow crystals formed on mature stromata.

Stromata not seen in fresh condition. Stromata when dry (0.3–)0.5–1.4(–2.2)×(0.2–)0.4–1.0(–1.6) mm, (0.15–)0.2–0.4(–0.8) mm thick (*n*=45), solitary, gregarious or aggregated in large numbers; effluent, large subeffuse complexes disintegrating into individual stromata; (flat) pulvinate, broadly attached; with white basal mycelium when young. Outline circular, angular or irregular. Margin rounded, edge free; sides often vertical and concolorous with the surface. Surface smooth, or tubercular by convex dots or projecting perithecia, slightly downy or powdery due to minute sulphur-yellow crystals, mostly on brown spots; crystals less common on light-coloured young, immature stromata; rarely covered by white scurf. Ostiolar dots (30–)40–90(–157) μm (*n*=60) diam, conspicuous, diffuse when young, becoming distinct, well-defined, plane or convex, circular, ochre or brown, sometimes black when old. Stromata white to pale yellowish, 1–4A2–A3, when young, turning greyish yellow, 3–4B3, pale or grey-orange, 5A3–4, 5B4, yellow-brown, or light brown, 5–6CD4–6, when mature; finally entirely brown when old and crystals disappear. Spore deposits white. Stroma surface after rehydration smooth, nearly white, the convex ochre to brown ostiolar dots with hyaline centres; turning light brown or ochre with darker ostiolar rings after addition of 3% KOH.

Stroma anatomy: Ostioles (49–)61–87(–98) μm long, plane or projecting to 12 μm, (28–)34–61(–90) μm wide at the apex (*n*=30), conical, periphysate, with thick walls orange in KOH in the upper part; margin lined by hyaline cylindrical to clavate cells 2–6(–8) μm wide at the apex. Perithecia (140–)180–240(–275)×(95–)115–205(–280) μm (*n*=30), flask-shaped, crowded, 5–6 per mm stroma length; peridium (11–)13–20(–23) μm (*n*=30) thick at the base, (8–)10–16(–20) μm (*n*=30) thick at the sides, yellowish. Cortical layer (15–)20–30(–36) μm (*n*=30) thick, a pale yellow *t. angularis* of thin-walled cells (4–)6–12(–18)×(2.5–)4–8(–12) μm (*n*=100) in face view and in vertical section. Surface with undifferentiated hyphae when young, rarely with some projecting cells to 26×4–7 μm when mature. Crystals on the stroma surface without a distinct structure, golden-yellow in water, dissolving and turning violet in 3% KOH; becoming dissolved as oily drops in lactic acid. Subcortical tissue a hyaline *t. angularis* of thin-walled cells (4–)5–10(–14)×(2.5–)3–6(–7) μm (*n*=30), interspersed with hyphae (2–)3–5(–7) μm (*n*=30) wide. Subperithecial tissue a hyaline *t. angularis–epidermoidea* of variable, thin-walled cells (5–)10–24(–33)×(5–)7–15(–21) μm (*n*=60). Base not differentiated or limited by a narrow layer of thick-walled compressed hyaline hyphae (1.5–)2.5–5(–7) μm (*n*=60) wide facing the substrate. Asci (58–)67–82(–91)×(4.0–)4.2–5.0(–5.5) μm, stipe (0–)3–12(–20) μm long (*n*=50). Ascospores hyaline, finely verruculose with verrucae to 0.4 μm high; cells dimorphic; distal

Fig. 79 Teleomorph of *Hypocrea luteocrystallina*. **a–h**. Dry stromata (**a–c**. immature. **e, f**. showing yellow crystals on stroma surface. **d, e, g**. showing white spore deposits). **i**. Rehydrated stroma. **j**. Stroma in 3% KOH after rehydration. **k**. Ostiolar apex in 3% KOH. **l**. Stroma surface in face view. **m**. Yellow crystals from stroma surface in water. **n**. Crystals from stroma surface in 3% KOH. **o**. Perithecium in section. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue in section. **r–u**. Asci with ascospores (**t, u**. in cotton blue/lactic acid). **a, h, s–u**. L.K. 53/2008. **b, d, e, g, i–r**. WU 29237. **c, f**.L.K. 26/2007. *Scale bars* **a–c**=0.5 mm. **d, h**, **j**=0.4 mm. **e**=100 μm. **f**, **g**, **i**=0.2 mm. **k**, **l**=15 μm. **m, n**, **p**, **r–u**=10 μm. **o**=35 μm. **q**=20 μm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u


a
d
e
b
c
i
j
h
m
l
k
n

cell (3.0–)3.4–3.8(–4.0)×(2.5–)2.9–3.2(–3.3) µm, l/w (1.0–)1.1–1.3 (*n*=60), subglobose or ellipsoidal; proximal cell (3.3–)3.7–4.7(–6.0)×(2.0–)2.3–2.7(–3.0) µm, l/w (1.2–)1.4–2.0(–2.5) (*n*=60), oblong, wedge-shaped or ellipsoidal.

Cultures and anamorph: optimal growth at 25°C on all media; no growth at 35°C after hyphae reaching a radius of less than 1 mm on all media.

On CMD after 72 h 17–21 mm at 15°C, 39–42 mm at 25°C, 21–28 mm at 30°C; mycelium covering the plate after 6 days at 25°C. Colony circular, hyaline, thin, dense, homogeneous, not zonate; mycelium with radial arrangement; hyphae with conspicuous difference in width, primary surface hyphae to *ca* 10 µm wide, secondary hyphae thin and scant. Aerial hyphae lacking. Autolytic excretions and coilings rare. No diffusing pigment, no distinct odour noted. Chlamydospores rare, minute. Conidiation noted after 2–7 days, gliocladium-like with wet heads to 100 µm diam; scant, mostly around the plug and at the distal margin when the mycelium has covered the entire plate. At 30°C colony developing yellowish 4A2–3 spots; conidiation scant, mostly on unbranched gliocladium-like conidiophores; coilings frequent at the distal margin.

On PDA after 72 h 10–12 mm at 15°C, 30–32 mm at 25°C, 21–26 mm at 30°C; mycelium covering the plate after 8–9 days at 25°C. Colony circular, dense; surface hyphae sinuous, primary hyphae thick; central surface becoming mottled, hyphae becoming pigmented, forming dull orange spots. Aerial hyphae infrequent, richly branched in a hairy reticulum of short strands, intermingled with numerous widely branched microtufts, forming several concentric zones with wavy outline, with whitish grey, hairy to floccose surface on orange-brown background; finally collapsing, containing numerous drops. Autolytic activity moderate, excretions minute; coilings inconspicuous. Reverse from the centre dull reddish orange, orange-brown, 6–8CD6–8, 8EF6–8, to reddish-brown, 7E6–8. No distinct odour noted. Conidiation noted after 2–3 days, on several thick mononematous conidiophores with a gliocladium-like apical penicillus arising from common bases forming micropustules to 0.6 mm diam, superposed by aerial hyphae. Conidia formed in small numbers in wet or dry heads, remaining colourless; only few heads appearing greenish in the stereo-microscope. Poor conidial yield also noted at other temperatures. Phialides more divergent than on CMD and SNA.

On SNA after 72 h 11–14 mm at 15°C, 25–28 mm at 25°C, 16–17 mm at 30°C; mycelium covering the plate after 10–11 days at 25°C. Colony hyaline, thin, circular, dense, not zonate; mycelium radial, scarce on the agar surface; margin wavy. Aerial hyphae scant or lacking. Autolytic excretions and coilings lacking. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 1–

Conidia (2.5–)2.7–3.3(–3.6)×(2.2–)2.5–2.8(–3.1) µm, l/w (1.0–)1.1–1.2(–1.3) (*n*=60), yellow-green, globose to subglobose for more than 90%, rarely ellipsoidal or oblong, smooth, eguttulate, with indistinct scar, rarely truncate.

On MEA mycelium covering the entire plate after *ca* 5 days at 25°C; surface hyphae distinctly sinuous; conidiation mainly along the margin; gliocladium-like conidiophores arising in fascicles from basal hyphal tufts. Conidial yield poor.

Habitat: wood of conifers (*Abies alba*, *Picea abies*).

Distribution: Europe (Denmark, Germany); rare.

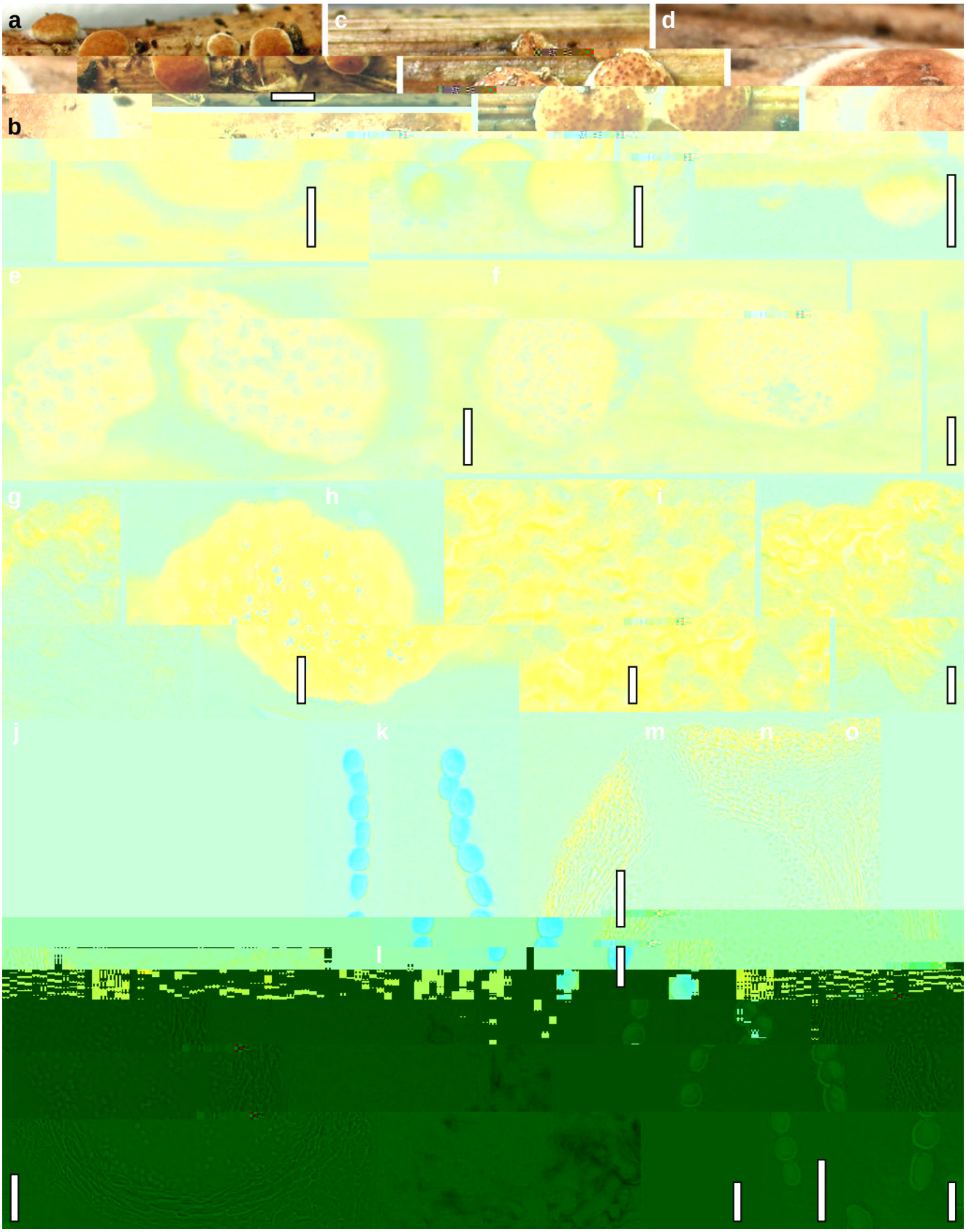
Holotype: **Germany**, Baden Württemberg, Schwäbisch Gmünd, Spraitbach, Welzheimer Wald, at Hof Hafental, MTB 7124/1, elev. 450 m, on partly decorticated thick log of *Abies alba*, on wood and a black crustose fungus, soc. algae and moss, ?*Brachysporium* sp., 4 Jul. 2008, L. Krieglsteiner & K. Siepe (**WU 29237**, ex-type culture CBS 123828= C.P.K. 3537). ***Holotype*** of *Trichoderma luteocrystallinum* isolated from WU 29237 and deposited as a dry culture with the holotype of *H. luteocrystallina* as **WU 29237a**.

Other specimens examined: **Denmark**, S. Jutland, Bevtoft Plantage, on well decayed *Picea* wood, 6 Aug. 2010, J. Maarbjerg, comm. T. Laessoe (WU 30202; culture Hypo 636). **Germany**, same place and log as given for the holotype, 24 Jun. 2007, L. Krieglsteiner LK 026/2007; 4 Jul. 2008, LK 053/2008.

Notes: Stromata of *Hypocrea luteocrystallina* resemble those of *H. pachypallida*, but the latter species lacks yellow crystals on the stroma surface and produces a hyaline-conidial anamorph. *Hypocrea lutea* is also similar, particularly in the anamorph. See the notes to that species for morphological differences. *Hypocrea luteocrystallina* seems to prefer richer media for consistent growth, while the conidial yield is poor on MEA and PDA. The conidial colour in *T. luteocrystallinum* is apparently light-dependent, because conidial heads turn black at 25°C (12/12 h light/darkness), but remain green at 30°C (darkness).

Hypocrea calamagrostidis Jaklitsch, **sp. nov.** Fig. 81
MycoBank MB 516678
Anamorph: ***Trichoderma calamagrostidis*** Jaklitsch, **sp. nov.** Fig. 82
MycoBank MB 516679

Stromata in caulibus *Calamagrostidis*, 1–2.5 mm diam, plane pulvinata, aurantio- vel rubro-brunnea. Asci cylindrici, (63–)66–74(–80)×(3.6–)3.8–4.2(–4.6) µm. Ascosporae hyalinae, languide verruculosae, ad septum disarticulatae, pars distalis (sub)globosa vel cuneata, (3.0


a
c
d
b
e
f
g
h
i
j
k
m
n
o
l

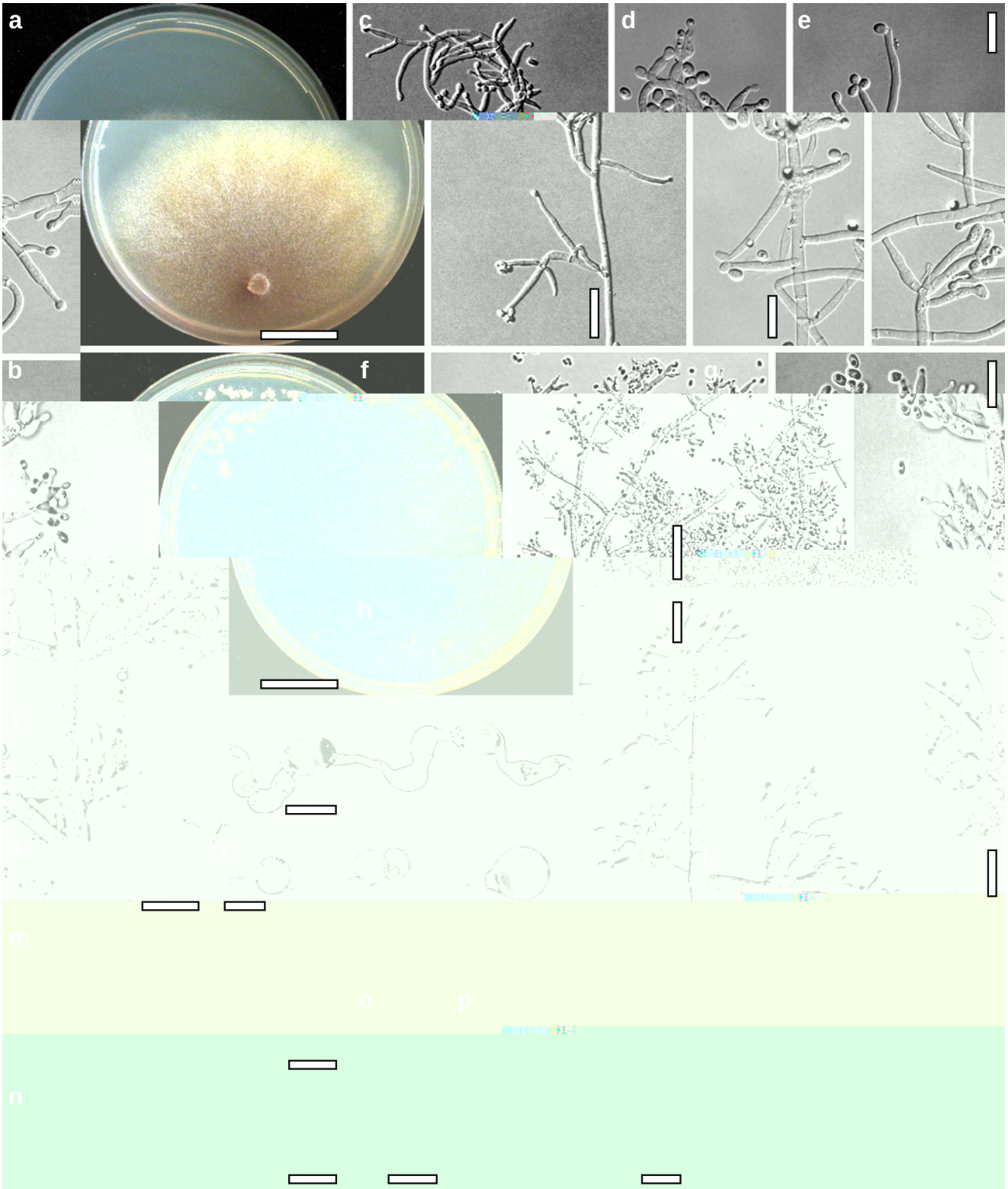


Fig. 82 Cultures and anamorph of *Hypocrea calamagrostidis* (CBS 121133). **a–b**. Cultures (**a**. on PDA, 25°C, 14 days. **b**. on SNA, 15°C, 32 days). **c–e**. Conidiophores of effuse conidiation (SNA, 25°C, 20 days). **f–i**. Conidiophores of pustulate conidiation (SNA, 15°C, 26–32 days). **j–l**. Chlamydospores (CMD, 25°C, 22 days). **m–o**. Conidia (**m, n**. from pustules, SNA, 15°C, 26–32 days; **o**. effuse conidiation, SNA, 25°C, 16 days). **p**. Phialides frpm pustules (SNA, 15°C, 26 days). *Scale bars* **a**, **b**=20 mm. **c**, **j**=20 μm. **d, e, g–i, l**, o= 10 μm. **f**, k=30 μm. **m**, **n**, **p**=5 μm

(*n*=30) thick at the base, (8.5–)11–16(–19) μm (*n*=30) at the sides, well-defined, reddish-brownish, nearly hyphal at the sides. Cortical layer (7–)12–21(–27) μm (*n*=30) thick, a thin, dense, small-celled *t. angularis* of thin-walled, isodiametric, angular cells (2.5–)3.5–7(–9)×(2.0–)2.5–4.5(–7) μm (*n*=60) in face view and in vertical section; yellow- to dull orange-brown, with inhomogeneously distributed pigment. Subcortical tissue a loose, hyaline *t. intricata* of thin-walled hyphae (1.5–)2–4(–6) μm (*n*=30) wide. Subperithecial tissue ill-defined, a coarse *t. epidermoidea* to *t. intricata*, of large thin-walled cells (4–)10–28(–36)×(4–)7–13(–16) μm (*n*=33), and hyphae (2.0–)3.5–8(–11.5) μm (*n*=30) wide. Basal tissue similar to the cortex. Asci (63–)66–74(–80)×(3.6–)3.8–4.2(–4.6) μm, stipe (3–)5–11(–16) μm long (*n*=31); no croziers seen. Ascospores hyaline, multiguttulate, dimorphic, smooth to finely verruculose; distal cell (3.0–)3.3–4.0(–4.5)×(2.8–)2.9–3.3(–3.5) μm, l/w (1–)1.1–1.3(–1.5) (*n*=30), (sub-)globose to wedge-shaped; proximal cell (3.5–)4.0–4.7(–5.2)×(2.3–)2.5–2.8(–3.0) μm, l/w (1.3–)1.5–1.8(–2) (*n*=30), oblong to plump wedge-shaped.

Cultures and anamorph: optimal growth at 25°C on all media; at 30°C limited growth, hyphae dying soon; no growth at 35°C.

On CMD after 72 h 5–13 mm at 15°C, 9–17 mm at 25°C, 1–2 mm at 30°C; mycelium covering the plate after 9–20 days at 25°C. Colony hyaline, thin, circular, dense, homogeneous, not zonate. Hyphae curly or wavy along their length. Centre becoming loose, with hyphae soon degenerating, appearing empty and with conspicuous septa. Aerial hyphae inconspicuous. Autolytic excretions lacking or rare, coilings infrequent, large. No pigment, no distinct odour noted. Conidiation noted after 4–11 days, scant, effuse, on few long aerial hyphae, irregularly distributed, macroscopically invisible. Chlamydospores noted after 9–10 days, (9–)14–32(–50)×(6–)14–24(–30) μm, l/w (0.9–)1.0–1.5(–2.0) (*n*=32), globose or ellipsoidal, also fusoid to oblong, often appearing empty inside agar, thick-walled, smooth, abundant in the inner half of the colony; mainly intercalary. At 15°C rarely scant conidiation in white pustules to 1 mm diam.

On PDA after 72 h 4–8 mm at 15°C, 9–16 mm at 25°C, <1 mm at 30°C; mycelium covering the plate after 10–20 days at 25°C. Colony circular, dense, opaque; hyphae curly. Surface downy to hairy, becoming bright yellow, 4B4–8 to 4C6–8, on and around the plug, pigment spreading and finally turning dull brown. Numerous minute yellow crystals and tiny stromatic condensations of surface hyphae formed throughout the pigmented region. Aerial hyphae abundant, forming a loose irregular reticulum of strands several mm high, collapsing after forming large drop-like branching and crossing points. Autolytic excretions lacking, but conspicuous at 15°C; coilings rare. Reverse becoming discoloured from the centre, yellow, 3A4–6, 4B4, brown-orange, yellow-brown, reddish-brown to dark brown, 5–8CD5–6, 6E5–8, 7–8EF5–8. Odour indistinct. Conidiation noted after 3–4 days, white, effuse, starting in short narrow, ill-defined, sinuous trees, ascending on long central aerial hyphae, and spreading across the colony. At 15°C autolytic excretions abundant; centre becoming greyish red, 7B4, 7CD5–6, with irregular brown spots, 8E6–8. Conidiation scant, effuse, and in few small pachybasium-like pustules with minute phialides.

On SNA after 72 h 5–7 mm at 15°C, 7–12 mm at 25°C, to 1 mm at 30°C; mycelium covering the plate after 2–4 weeks at 25°C. Colony hyaline, thin, margin ill-defined. Mycelium appearing macroscopically curly; hyphae loose, little branched, soon degenerating and appearing empty from around the plug. Aerial hyphae inconspicuous, more frequent and long along the margin, often becoming fertile. No autolytic excretions noted; coilings infrequent, more frequent at 15°C. No pigment, no distinct odour noted. Chlamydospores noted after 9–14 days, mostly intercalary in wide surface hyphae around the plug, often angular or several-celled, less common than at 15°C and on CMD. Conidiation irregular, effuse and/or pustulate; pustule formation distinctly enhanced by lower temperatures (15°C). Effuse conidiation noted after 3–7 days, scant, but more than on CMD; macroscopically invisible. Conidia formed in small numbers in minute wet heads to 10 μm diam on short, usually unpaired, sinuous conidiophores to 100(–150) μm long and 4–5 μm wide at the base, 2–3 μm terminally. Conidiophores arising mostly from long aerial hyphae 4–5(–6) μm wide, loosely disposed, thin, asymmetric, with sparse paired branches; of a main axis bearing long, thin phialides and 1-celled side branches. Branches and phialides often curved to sinuous, in right angles or inclined upwards or downwards; phialides solitary or in ill-defined whorls of 2–3(–5); mainly supported by cells 2–3 μm wide. Phialides (10–)12–18(–22)×(2.0–)2.2–2.7(–3.4) μm, l/w (3.7–)4.7–8(–9.5) (*n*=30), (1.0–)1.6–2.4(–3.1) μm wide at the base (*n*=30), subulate, cylindrical, or lageniform. Conidia (2.5–)2.8–5.0(–7.5)×(2.0–)2.3–2.8(–3.5) μm, l/w (1–)1.2–1.8(–2.7) (*n*=45), hyaline, smooth, ellipsoidal, oblong or subglobose, with few small guttules; scar indistinct or projecting. Pustulate conidiation after 3–4 weeks at 15°C: pustules 0.5–2.5 mm diam, irregularly distributed in varying numbers across the colony or concentrated close to the distal margin; white, loose, with frequent right angles, and several main axes. Main axes broad, forming conidiophores to *ca* 0.6 mm long or bearing shorter lateral trees. Trees mostly wider downwards; branches right-angled or slightly inclined upwards, usually paired, unpaired in lower regions, 1-celled at the top, 2- to several-celled downwards, with 1–2 further 1-celled branches bearing terminal whorls of phialides. Phialides mostly in whorls of 3–4(–5), divergent, but often strongly

curved upward and nearly parallel, gliocladium-like. Conidia formed in small numbers. Stipe and primary branches thick-walled and to 8–9 µm wide, conidiophores 3–5 µm wide for the most part; phialide origins 3–4 µm wide. Phialides 6–10 (–13)×(2.5–)2.8–3.5(–4.0) µm, l/w (1.7–)2.0–3.1(–4), (1.5–)1.9–2.6(–3) µm (n=40) wide at the base, lageniform, or beak-like with a pointed apex, widest in or below the middle, sometimes strongly curved to sinuous. Conidia (2.8–)3.5–4.5(–5.7)×(2.0–)2.2–2.6(–3.0) µm, l/w (1.3–)1.5–1.8(–2.1) (n=46), hyaline, smooth, narrowly ellipsoidal or oblong, with numerous minute guttules or 1 to few larger guttules, scar indistinct or narrowly truncate.

Habitat: on stalks of *Calamagrostis epigejos*.

Distribution: Denmark, known only from the type location.

Holotype *and only known specimen*: **Denmark**, Nordjylland, Tranum, meadow at Vestkystvejen, close to crossing with Strandvejen, 57°08′32″ N, 09°26′28″ E, elev. 10 m, on stalks of *Calamagrostis epigejos*, 25 Aug. 2006, W. Jaklitsch & H. Voglmayr, W.J. 2944 (**WU 29198**, culture CBS 121133=C.P.K. 2447). ***Holotype*** of *Trichoderma calamagrostidis* isolated from WU 29198 and deposited as a dry culture with the holotype of *H. calamagrostidis* as **WU 29198a**.

Notes: *Hypocrea calamagrostidis* differs from *H. junci*, found on *Juncus* in a comparable habitat, in distinct ostiolar dots, lighter and more rosy stroma colour, and a white-conidial anamorph. The pachybasium- to gliocladium-like conidiation on stout conidiophores in white pustules is in good agreement with other species of the *Psychrophila* clade like *H. crystalligena* and *H. psychrophila*.

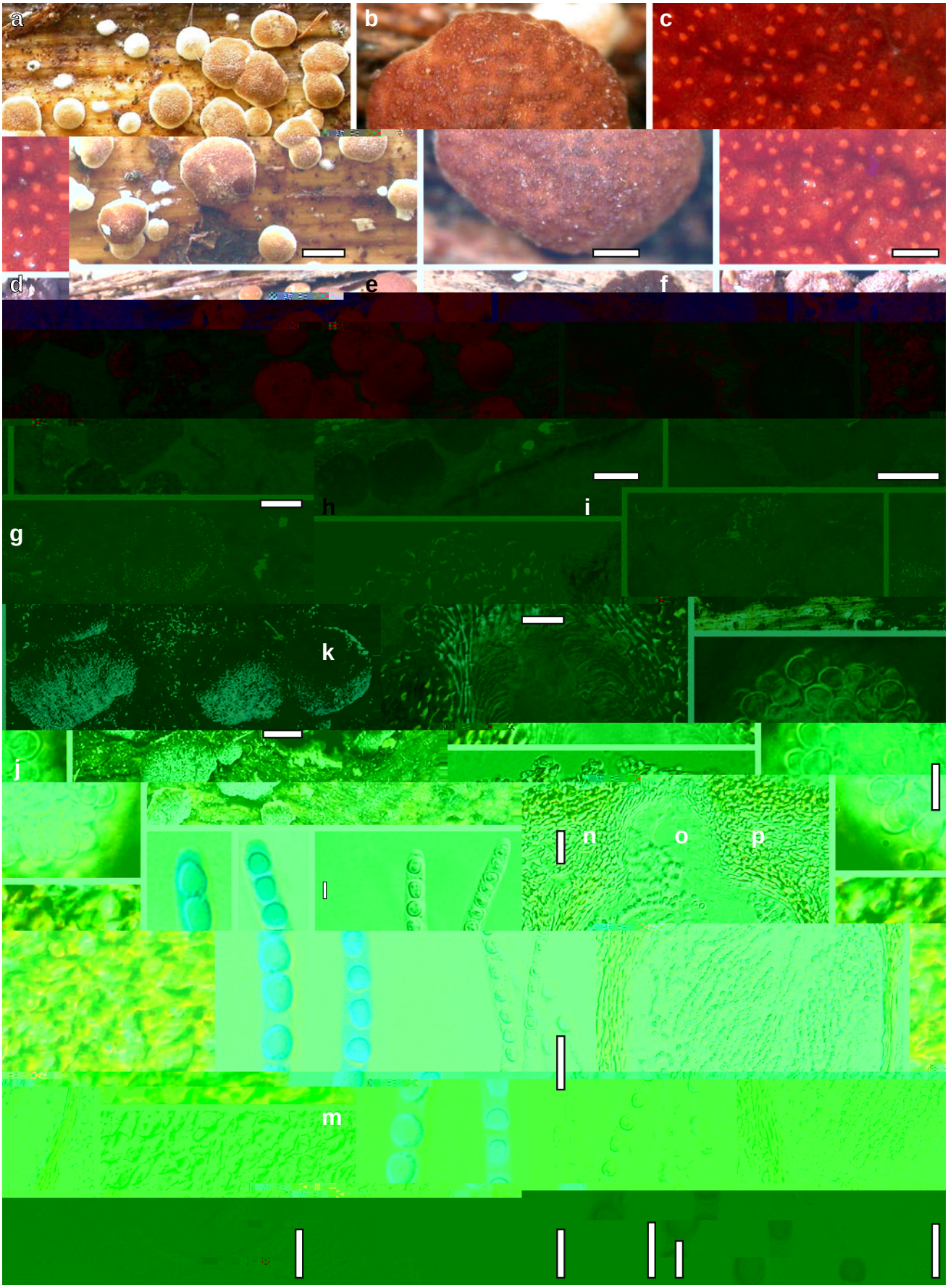
Hypocrea crystalligena Jaklitsch, Mycologia 98: 502 (2006a). Fig. 83
Anamorph: ***Trichoderma crystalligenum*** Jaklitsch, Mycologia 98: 502 (2006a). Fig. 84

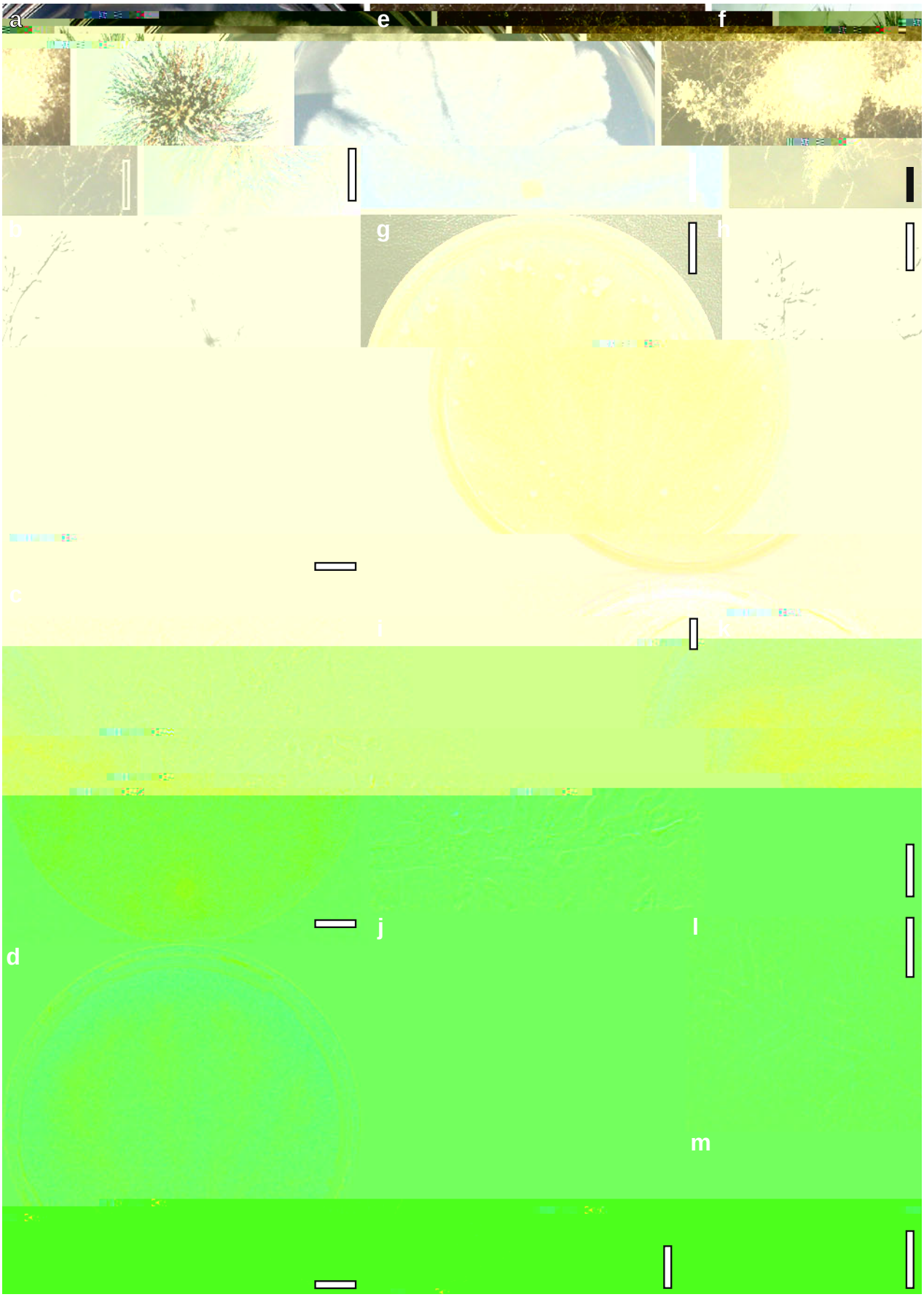
Stromata when fresh 1–6(–8) diam, 0.5–2 mm high, gregarious or densely aggregated, typically in large numbers; pulvinate or semiglobose, less commonly discoid, broadly attached. Outline circular or irregular. Margin free, white or concolorous. Surface finely tomentose to velutinous when young, becoming glabrous and smooth, often covered with a white crystalline powder in addition to white ascospore deposits. Ostiolar dots typically indistinct, but often becoming distinct with age, appearing as dark rings with light-coloured centres. Colour light (yellowish-, ochre- or reddish-)brown, 4A4, 5–6B5–6, 6–7D5–6, 7–8CD7–8, when young, turning to dull red, 8–9B4, or mostly dark brown to dark reddish brown, 9DE7–8, 8E6–8, 9F5–8.

Stromata when dry (0.7–)1.5–3.5(–4.7)×(0.5–)1.2–3.0(–4.0) mm, (0.2–)0.5–1.0(–1.7) mm thick (n=30), flatter than fresh, pulvinate or discoid. Surface velutinous when young; when mature finely verrucose, tubercular or wrinkled, glabrous, but often covered with conspicuous water-insoluble, white powder. Ostiolar dots (24–)32–53(–63) µm (n=30) wide, typically inconspicuous when young, due to colours similar to the surrounding stroma surface, more distinct and dark with age; ostioles after addition of water appearing as minute hyaline dots on a bright red stroma surface. Colour of young, velutinous stromata greyish orange, brown-orange, light, medium, yellow- or greyish brown, 5B4–6, 5CD3–8, 6CD4–6, 6E4–8, 7CD7–8, 5EF2–4, 6F4–5; mature stromata reddish-, violaceous- or dark brown, 9D7–8, 6–10EF5–8 or darker. No distinct colour change in 3% KOH noted.

Stroma anatomy: Ostioles in section (42–)48–69(–77) µm long, plane or projecting to 16(–22) µm, (20–)22–45(–69) µm at the apex (n=20), cylindrical, with an apical palisade of narrow hyaline hyphae terminating in distinctly clavate to subglobose cells to 6 µm wide. Perithecia (169–)200–230(–245)×(97–)110–160(–211) µm (n=30), flask-shaped, subglobose in lateral regions. Peridium 8–13(–15) µm thick at the base, (14–)15–20(–22) µm at the apex (n=15), yellowish- to reddish brown. Cortical layer (12–)15–22(–25) µm (n=15) thick, reddish brown in water, orange-brown in lactic acid, with inhomogeneously disposed pigment; of small angular, thick-walled, glassy, compressed cells of indistinct outline, (3–)5–10(–11) µm diam in face view, 3–6(–7) µm diam (n=15) in vertical section. Hairs rare on mature stromata, 10–20 µm long, subhyaline to reddish brown, apically rounded. Subcortical tissue thin, a loose *t. intricata* of thin-walled, hyaline hyphae (3–)4–7(–9) µm (n=15) wide. Subperithecial tissue a dense hyaline *t. angularis–epidermoidea* of isodiametric subglobose or angular, thin-walled cells (4–)12–44(–63)×(3.5–)6–15(–19) µm (n=30), becoming smaller towards the stroma base and intermingled with hyphal elements. Asci (68–)72–86(–98)×(3.5–)4.0–4.8(–5.2) µm, stipe (5–)7–20(–28) µm long (n=30); no croziers apparent. Ascospores hyaline, finely verruculose, cells dimorphic, but often similar, distal cell (2.4–)2.6–3.3(–4.3)×(2.4–)2.5–3.0(–3.6) µm, l/w (0.9–)1.0–1.2(–1.4) (n=70), subglobose, sometimes slightly tapered towards upper end, proximal cell (2.4–)3.0–3.7(–4.5)×(2.0–)2.2–2.6(–3.2) µm, l/w (1.0–)1.2–1.5(–1.9) (n=70), wedge-shaped or oblong, broadly rounded at lower end.

Fig. 83 Teleomorph of *Hypocrea crystalligena*. **a, b, d, f.** Fresh ▶ stromata (**a**. young, velutinous, **b**. with visible ostioles, **f.** (over-)mature). **e, h, i**. Dry stromata (**e**. fraction of d; **i**. showing white powder on surface). **c**. Surface of rehydrated wet stroma showing hyaline ostioles. **g**. Ostiole in section showing periphyses and apical cells. **j.** Perithecium in section. k**.** Ostiole in face view. **l**. Stroma surface in face view. **m**. Subperithecial tissue in section. **n, o, p**. Asci with ascospores (**n, o**. in cotton blue/lactic acid). **a, c, d, e**. WU 24050. **b**. WU 24059. **f**. WU 24060. **g, h, j–o**. holotype WU 24041. **i**: WU 24053. **p**: WU 24052. Scale bars: **a, e, f, h**, **i**=1.5 mm. **b**=0.3 mm. **c**=0.2 mm. **d**=2 mm. **g, l**, **p**=10 µm. **j, m**=25 µm. **k, n**, **o**=5 µm


a
b
c
d
e
f
g
h
i
k
j
l
n
o
p
m


a
e
f
b
g
h
c
i
k
d
j
l
m

Anamorph on the natural substrate (WU 24044): White hairy tufts on wood, partly in close association with stromata, in circular to oblong, confluent patches to 15 mm long, with long sterile elongations when immature. Main axes 3–5 µm wide, with short branches in right angles, loosely disposed or pachybasium-like, i.e. richly and densely branched, with dense whorls of 2–5(–6) phialides on 1–2 celled branches 3–4(–7) µm wide; branching points often thickened. Phialides (4.2–)4.7–8.2 (–12.0)×(2.5–)2.7–3.2(–3.5) µm, l/w=1.5–2.8(–4.5), (1.4–) 2.0–2.7(–3.0) µm wide at the base (*n*=30), plump, short and thick, ampulliform or lageniform, widest in or below the middle. Conidia (2.2–)2.5–3.2(–3.7)×1.7–2.0(–2.5) µm, l/w=1.2–1.5(–1.7) (*n*=30), hyaline, ellipsoidal or oval, smooth, with one or few guttules.

Cultures and anamorph: optimal growth at 25°C on all media, no growth at 35°C.

On CMD after 72 h 5–7 mm at 15°C, 7–10 mm at 25°C, 3–10 mm at 30°C; mycelium covering the plate after 3–6 weeks. Colony characteristic, forming silky, fan-shaped lobes, with little mycelium on the agar surface, finely but distinctly zonate; hyphae narrow, soon degenerating in the centre. Aerial hyphae inconspicuous, but sometimes appearing in loose, irregular, sterile or fertile tufts mostly in distal or lateral regions of the colony, on plates entirely covered by mycelium. After *ca* 6 days often characteristic colourless to white crystals appearing on the surface, growing to 0.5–1.5 mm diam, sometimes appearing as oily drops inside the agar; in some isolates or after several transfers no crystals formed. Autolytic activity and coilings variable, usually inconspicuous. No distinct odour detected. Either no diffusing pigment formed or a diffuse greyish yellow, golden- or yellow-brown, 4B4–

cells 2–3 µm wide, solitary or in dense terminal whorls of 3–5(–8), divergent or parallel. Phialides (4.7–)5.5–9.0(–13.0)×2.2–2.7(–3.2) µm, l/w=(1.5–)2.0–3.5(–5.7), (1.2–)1.5–2.0(–2.5) µm wide at the base (n=30), narrow, straight or curved upwards, widest mostly below the middle. Conidia (2.5–)2.7–3.5(–4.0)×1.8–2.0(–2.2) µm, l/w=(1.2–)1.5–1.7(–2.0) µm (n=30), hyaline, ellipsoidal or oblong, smooth, abscission scar sometimes distinct.

Habitat: stromata usually occurring in large groups on wood and bark of dead and usually well-rotted branches of various deciduous trees such as *Alnus glutinosa*, *A. incana*, *Carpinus betulus*, *Cornus sanguinea*, *Corylus avellana*, *Fagus sylvatica*, *Quercus petraea* or *Tilia cordata*, lying on the ground in warm and dry forests and shrubs; also on fungi, e.g. stromata of *Hypoxylon* or *Diatrypella* spp.

Known distribution: Europe (Austria, Estonia, Germany, Netherlands, Sweden, Ukraine, UK).

Holotype: **Austria**, Steiermark, Weiz, Laßnitzthal, from Arboretum Gundl across the main road, MTB 8959/2, 47° 04′17″ N, 15°38′38″ E, elev. 420 m, on branch of *Carpinus betulus* 4–5 cm thick, on the ground, 8 Aug. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2325 (**WU 24041**, ex-type culture CBS 118980=C.P.K. 1600). ***Holotype*** of *Trichoderma crystalligenum* isolated from WU 24041 and deposited as a dry culture with the holotype of *H. crystalligena* as **WU 24041a**.

Other specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, Gupf, close to Berghof Schuschnig, MTB 9452/4, 46°32′48″ N, 14°26′57″ E, elev. 800 m, on a partly decorticated branch of *Cornus sanguinea* 4 cm thick, on the ground in leaf litter, soc. Corticiaceae, 29 Oct. 2005, H. Voglmayr & W. Jaklitsch, W.J. 2876 (WU 24060, culture C.P.K. 2136). Same village, Trieblacher Weg (from Bauhof), at forest margin, MTB 9452/4, 46°32′32″ N, 14°25′50″ E, elev. 590 m, on twigs of *Fagus sylvatica* and *Sambucus nigra* 1–5 cm thick, on bark and wood, soc. *Diatrype disciformis*, *Hypoxylon fragiforme*, *Steccherinum ochraceum* and *Stereum hirsutum*, 10 Jul. 2007, W. Jaklitsch, W.J. 3120 (WU 29220). Niederösterreich, Krems, Krumau, virgin forest at south side of the Dobra-barrage, MTB 7458/1, 48°35′16″ N, 15° 24′00″ E, elev. 480 m, on a branch of *Fagus sylvatica* 3–4 cm thick, and on old *Diatrypella cf. verruciformis*, on the ground in leaf litter, soc. effete *Hypoxylon fragiforme*, 28 Sep. 2003, W. Jaklitsch, W.J. 2433 (WU 24045, culture C. P.K. 980); Hollabrunn, Hardegg, Semmelfeld, forest between Niederfladnitz and Merkersdorf, MTB 7161/3, 48° 48′49″ N, 15°52′43″ E, elev. 450 m, partly decorticated branch of *Quercus petraea*, 5–6 cm thick, on the ground in leaf litter, 21 Jul. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2532, (WU 24048, culture C.P.K. 1615); Krems, Egelsee, close to Forsthaus Waldhof, MTB 7559/3, N 48°25′55″ E 15°33′23″, elev. 420 m, branch of *Quercus petraea* 2 cm thick, 24 Sep. 2005, H. Voglmayr, W.J. 2859 (WU 24059). Melk, Leiben, Weitental, at Hofmühle, MTB 7757/2, 48° 14′51″ N, 15°17′23″ E, elev. 270 m, partly decorticated branch of *Fagus sylvatica* 6 cm thick, soc. *Tubeufia cerea* (on ?*Diatrype decorticata*), *Lasiosphaeria hirsuta*, *Hypoxylon cohaerens*, *Lopadostoma turgidum*, *Orbilia inflatula*, Corticiaceae, 25 Jul. 2004, H. Voglmayr & W. Jaklitsch, W. J. 2539 (WU 24049, culture C.P.K. 1910). Melk, Sankt Leonhard am Forst, 2 km before Großweichselbach towards Melk, MTB 7857/2, 48°09′42″ N, 15°17′36″ E, elev. 285 m, on partly decorticated branch of *Quercus petraea* 3–4 cm thick, soc. effete *Diatrypella quercina*, *Phellinus ferruginosus*, 30 Sep. 2004, W. Jaklitsch, W.J. 2748 (WU 24056, culture CBS 118979=C.P.K. 1917). Wienerwald, Kaltenleutgeben, near Stangau, MTB 7862/4, 48°06′20″ N, 16°08′12″ E, elev. 450 m, on thick branch of *Quercus cerris*, 5 Oct. 2008, W. Jaklitsch & O. Sükösd, 5 Oct. 2008, W.J. 3220 (WU 29224). Wien-Umgebung, Mauerbach, walking path from the cemetery, MTB 7763/1, 48°15′19″ N, 16°10′13″ E, elev. 330 m, on a log segment of *Carpinus betulus* on moist ground in leaf litter, soc. *Steccherinum ochraceum*, 23 Jul. 2005, W. Jaklitsch, W.J. 2820 (WU 24057, culture C.P.K. 2134). Same area, 48°15′18″ N, 16° 10′10″ E, elev. 325 m, on decorticated branch of *Fagus sylvatica* 8 cm thick, on wood, soc. *Bertia moriformis*, *Hypoxylon fragiforme*, 7 Oct. 2006, W. Jaklitsch & H. Voglmayr, W.J. 3002 (WU 29217). Pressbaum, Rekawinkel, forest path south of the train station, MTB 7862/1, 48° 10′47″ N, 16°02′03″ E, elev. 360 m, on corticated branch of *Alnus glutinosa* 5 cm thick, holomorph, soc. a myxomycete, effete ?*Diatrypella*, 18 Oct. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2476 (WU 24047, culture C.P.K. 2133). Oberösterreich, Schärding, St. Willibald, Großer Salletwald, MTB 7648/3, 48°20′57″ N, 13°42′22″ E, elev. 660 m, on corticated branch of *Fagus sylvatica* on the ground, soc. old Corticiaceae, 26 Oct. 2005, H. Voglmayr, W.J. 2866 (WU 24061). Großer Salletwald, MTB 7648/1, elev. 455 m, on branch of *Fagus sylvatica*, 13 Aug. 2006, H. Voglmayr, W.J. 2928 (WU 29215, culture C.P.K. 3117). Steiermark, Graz-Umgebung, Mariatrost, Wenisbucher Straße, MTB 8858/4, 47°06′40″ N, 15°29′11″ E, elev. 470 m, on a 4–5 cm thick branch of a large dead tree of *Fagus sylvatica*, lying on the ground, 20 Aug. 2004, W. Jaklitsch, W.J. 2611 (WU 24054, culture C.P.K. 1915). Tirol, Innsbruck-Land, Ampass, Ampasser Hügel, MTB 8734/2, 47°15′31″ N, 11° 27′16″ E, elev. 720 m, on decorticated branch of *Alnus incana*

Steccherinum ochraceum, 31 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2644 (WU 24055, culture C.P.K. 1916). **Estonia**, Ida-Virumaa County, Illuka Commune, Puhatu Nature Reserve, Poruni virgin forest, on branch of ?*Salix* sp., 1 Oct. 2006, K. Pärtel (WU 29218, culture C.P.K. 2485). **Germany**, Bavaria, Unterfranken, Landkreis Haßberge, Haßfurt, close to Mariaburghausen, left roadside heading from Knetzgau to Haßfurt, MTB 5929/3, 50°00′33″ N, 10°31′10″ E, elev. 280 m, on partly decorticated branch of *Carpinus betulus* 5 cm thick, holomorph, soc. *Phlebiella vaga*, 4 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2568 (WU 24050, culture C.P.K. 1911); same collection data, on corticated branches of *Tilia cordata*, W.J. 2570 (WU 24052, culture C.P.K. 1913); same area, 50°00′23″ N, 10°31′08″ E, elev. 270 m, on mostly decorticated branch of *Fagus sylvatica* 4 cm thick, on wood, 29 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2961 (WU 29216, culture C.P.K. 3118). Starnberg, Tutzing, Erling, Goaßlweide near Hartschimmelhof, MTB 8033/3, 47°56′33″ N, 11°11′00″ E, elev. 730 m, on partly decorticated branch of *Fagus sylvatica* 4 cm thick, on the ground in grass, soc. *Bertia moriformis*, *Neobarya parasitica*, *Tomentella* sp., 7 Aug. 2004, W. Jaklitsch, H. Voglmayr, P. Karasch & E. Garnweidner, W.J. 2581 (WU 24053, culture C.P.K. 1914). **Netherlands**, Putten, in the main arboretum of Landgoed Schovenhorst, elev. 0 m, on partly decorticated branch of ?*Taxus baccata* 7–10 cm thick, on wood and bark, 19 Nov. 2006, H. Voglmayr, W.J. 3047 (WU 29219, culture C.P.K. 2855). **Sweden**, Uppsala Län, Sunnersta, forest opposite the virgin forest Vardsätra Naturpark across the road, MTB 3871/2, 59°47′23″ N, 17°37′53″ E, elev. 15 m, on corticated branch of *Corylus avellana* 2–3 cm thick, on bare, moist soil, soc. *Stereum rugosum*, *Diatrypella verruciformis*, 8 Oct. 2003, W. Jaklitsch, W.J. 2451 (WU 24046, culture C.P.K. 1604). **Ukraine**, Kharkov district, Zmiev, National nature park Gomolshanskie lesa, flooded forest near Seversky Donets river, on branch of *Alnus glutinosa*, 26 Jul. 2007, A. Akulov, AS 2439 (WU 29221, culture C.P.K. 3132). **United Kingdom**, Hertfordshire, Hertford, Waterford, Waterford Heath, Mole Wood, 51°48′44″ N, 00°05′20″ W, elev. 70 m, on *Hypoxylon fuscum*/*Corylus avellana* 9 cm thick, 12 Sep. 2007, W.Jaklitsch, K. Robinson & H. Voglmayr, W.J. 3155 (WU 29222).

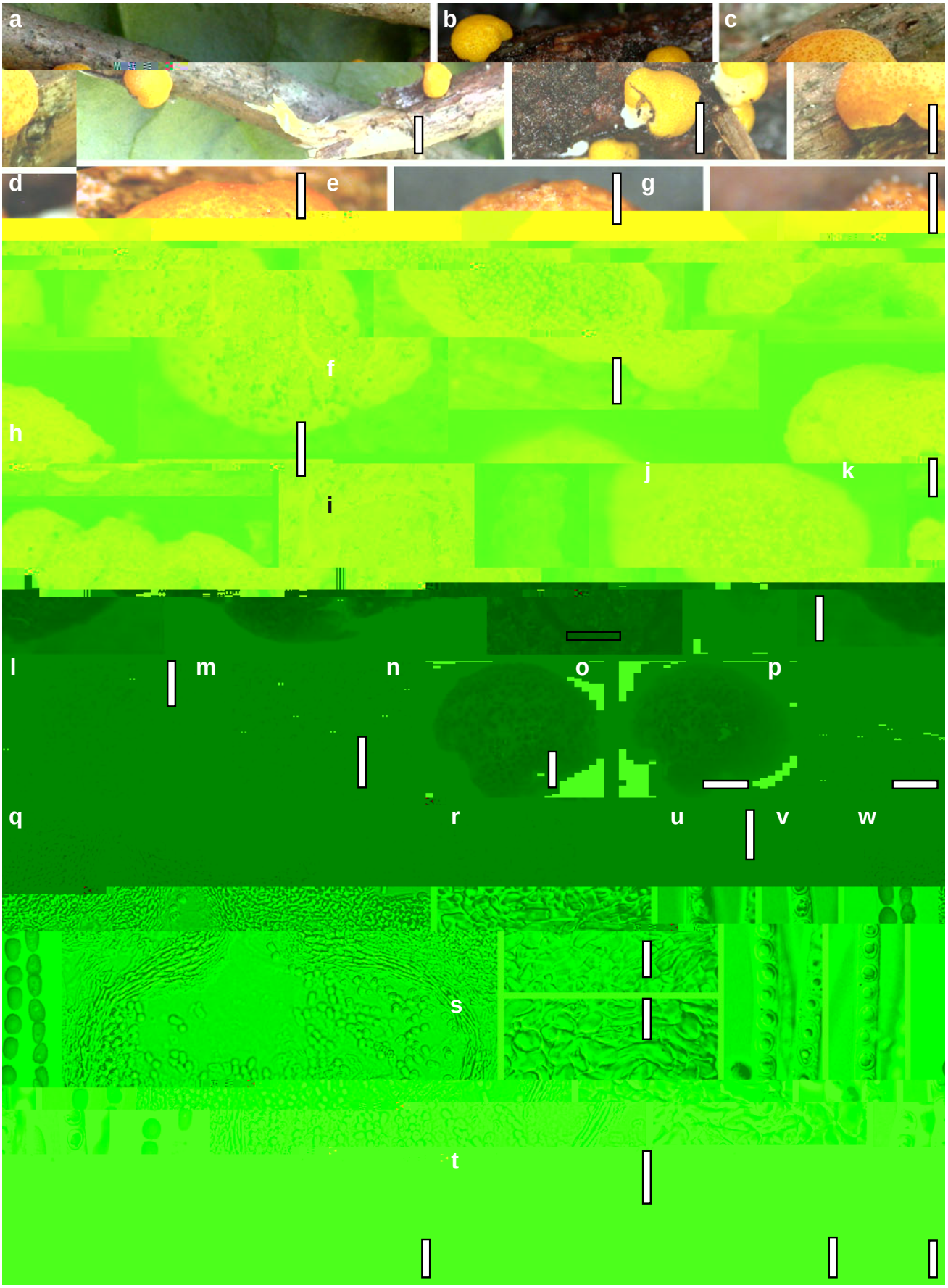
Notes: *Hypocrea crystalligena* is common in Central Europe, and occurs occasionally also in other European regions. Its white gliocladium-like anamorph is typical of the *Psychrophila* clade, while the stromata suggest affiliation with sect. *Trichoderma*, because of the inconspicuous ostiolar dots, at least when young, the downy surface of young stromata, and the inhomogeneously disposed, reddish brown cortical pigment. However, the white, powdery covering on the stroma surface and the globose or clavate cells lining the ostiole apices are not known in sect. *Trichoderma*. In addition, the ascospores are extraordinarily small, smaller than those of any species of sect. *Trichoderma* currently known in Europe. Cultures of *H. crystalligena* on CMD and SNA are characteristic due to slow growth and the formation of finely zonate radial lobes. The formation of a diffuse yellowish to brownish pigment varies among the strains. Initially after isolation, nearly all strains formed a water-insoluble substance, appearing as colourless or white crystals on CMD, but after several transfers this ability was lost. This may be attributable to the CMA, because conspicuous crystals were only seen on the first batch of CMA used. On batches used thereafter, crystals were only rarely found (e.g. in C.P.K. 2855), while white crystalline powder was regularly seen on the surface of stromata, at least in larger populations, collected after the original description by Jaklitsch et al. (2006a).

Hypocrea psychrophila E. Müll., Aebi & J. Webster, Trans. Brit. Mycol. Soc. 58:1 (1972). Fig. 85
Anamorph: ***Trichoderma psychrophilum*** Jaklitsch, **sp. nov.** Fig. 86
MycoBank MB 516699

Anamorphosis *Hypocreae psychrophilae*: incrementum optimum ad 15–20°C in agaris CMD, PDA, SNA, prope absens ad 25°C; incrementum et sporulatio etiam occurrens ad 6–10°C in agaro SNA. Conidiophora in pustulis albis similia *Gliocladii* in agaro SNA. Phialides lageniformes, (6–)7–12(–19)×(2.3–)2.8–3.5(–4.5) µm. Conidia hyalina, ellipsoidea vel oblonga, glabra, (3.2–)3.8–5.3(–7.0)×(2.3–)2.5–3.0(–3.7) µm.

Stromata when fresh 2–7 mm diam, 1–2.5 mm thick, pulvinate or semi- to subglobose, centrally attached, margin free, often lobed. Surface smooth, bright yellow, ostiolar dots darker yellow or reddish brown, resulting colour 4A8.

Stromata when dry (1.3–)1.5–3.3(–5.1)×(0.9–)1.2–2.4(–3.2) mm, (0.5–)0.6–1.4(–2.0) mm thick (n=20), solitary, less commonly gregarious or aggregated in small numbers, erumpent from bark, centrally attached, typically on a white, columnar or pulvinate, compact mycelial base, with upper fertile part free and often incurved at the margin, pulvinate or semiglobose; outline roundish, oblong or irregularly lobed. Surface smooth, slightly tubercular or rugose, glabrous or slightly downy or whitish floccose. Ostiolar dots (30–)47–106(–165) µm (n=90) diam, numerous, densely disposed, well-defined when mature, often confluent, convex to papillate, orange to nearly red. Stroma colour bright orange (bright yellow surface, orange dots), 5–6AB5–8. White inside. Spore deposits white. Dry stromata instantly transparent and discoloured to pale yellowish after addition of 3% KOH on a slide. Rehydrated stromata *ca* 30% larger than dry, semiglobose, light


a
b
c
d
e
g
f
h
i
j
k
l
m
n
o
p
q
r
u
v
w
s
t

◀ **Fig. 85** Teleomorph of *Hypocrea psychrophila*. **a–d**. Fresh stromata (**a, b**. habit; **d**. moist/partly dry). **e–j**. Dry stromata (**e, f**. side view; **j**. stroma surface). **k**. Dry stroma treated with 3% KOH. **l**. Hair on stroma surface in section. **m**. Hyphae on stroma surface in face view. **n**. Stroma surface without hyphal covering in face view. **o**. Rehydrated stroma. **p**. Stroma in 3% KOH after rehydration. **q**. Perithecium in section. **r**. Cortical and subcortical tissue in section. **s**. Subperithecial tissue in section. **t.** Stroma base in section. **u–w**. Asci with ascospores (**w**. in cotton blue/lactic acid). **a, c, h, m**. WU 29421. **b, e, g, j–l**, **n–w**. WU 29422. **d, f**. WU 29420. **i**. holotype K 155404. *Scale bars* **a**, **b**= 1.7 mm. **c, d, f, i, o**, **p**=0.8 mm. **e, g**, **h**=0.5 mm. **j**=0.2 mm. **k**= 0.3 mm. **l, n, r**, **u–w**=10 μm. **m, q, s**, **t**=20 μm

yellowish, discoloured, white with pale orange-ochre ostiolar dots; no change noted after addition of 3% KOH.

Stroma anatomy: Ostioles (67–)75–98(–116) μm long, plane or projecting to 15(–30) μm, (28–)30–45(–60) μm wide at the apex (n=31), typically only periphysate, less commonly with some clavate marginal cells to 6 μm wide at the apex; often ostiolum and stroma cortex projecting to 50–90 μm. Perithecia (160–)200–250(–290)×(90–)130–200(–215) μm (n=31), flask-shaped, ellipsoidal or subglobose, mostly crowded, 7–8 per mm stroma length. Peridium (11–)13–19(–21) μm (n=31) thick at the base, (5–)10–16(–18) μm (n=31) at the sides, pale yellowish. Cortical layer (16–)20–30(–35) μm (n=30) thick, a dense, subhyaline to pale yellowish *t. angularis* of isodiametric or oblong, thick-walled cells (2.5–)4–8(–11)×(2.5–)3–5(–7) μm in face view and in vertical section (n=62). Cortex of young stromata covered by a reticulum of thick-walled hyaline hyphae, when mature remaining as hairs (4–)8–24 (–35)×(2.5–)3.0–4.5(–5.5) μm (n=30), cylindrical, straight or curved, simple or branched, hyaline, thin-walled. Subcortical tissue a *t. intricata* of thin-walled hyaline hyphae (2.0–)2.5–4.5(–7.0) μm (n=30) wide. Subperithecial tissue a *t. epidermoidea–intricata* of thick-walled hyaline cells (4–)7–30(–58)×(4–)7–14(–22) μm (n=30) and hyphae (3.5–)6–13(–19) μm (n=30) wide. Non-attached base a loose or dense *t. intricata* of hyaline or yellowish, thick-walled hyphae (2.0–)2.5–4.5(–6.0) μm (n= 30) wide. Asci (85–)100–130(–150)×(5.0–)5.5–6.2(–7.0) μm; stipe (5–)13–28(–41) μm long (n=60); croziers present. Ascospores hyaline, verruculose; cells dimorphic; distal cell (4.0–)4.5–5.7(–6.7)×(3.7–)4.0–4.5(–5.0) μm, l/w (1.0–)1.1–1.4(–1.7) (n=110), subglobose or wedge-shaped; proximal cell (4.5–)5.2–6.5(–7.8)×(3.0–)3.3–4.0(–4.5) μm, l/w (1.2–) 1.4–1.8(–2.2) (n=110), oblong or subglobose; size increasing with maturation.

Cultures and anamorph: optimal growth at 15–20°C, growth virtually absent at 25°C, no growth above 25°C.

On CMD after 72 h 3–5 mm at 15°C, 0.2–1.5 mm at 25°C; after 2 weeks 7–11 mm at 6–10°C in the dark and 21–25 mm at 15°C; mycelium typically covering the plate after more than a month at 15°C. Colony at 15°C hyaline, thin, indistinctly concentrically zonate, hardly visible; mycelium loose, hyphae hyaline, becoming moniliform and turning reddish brown. Aerial hyphae scant, short, more frequent along the distal margin. Autolytic activity low at 15°C, conspicuous at 25°C; coilings inconspicuous. Diffusing pigment turning the agar yellow, pale or greyish orange to yellow-brown, 4–5A3–5, 6B5–6, beginning in the centre. No distinct odour noted. No chlamydospores noted within a month. Conidiation noted after a month or later at 15°C, gliocladium-like in small white pustules. At 6–10°C colony colourless, sterile, margin becoming downy by long aerial hyphae.

On PDA after 72 h 3–4 mm at 15°C, <1 mm at 25°C; after 2 weeks 3–9 mm at 6–10°C in the dark and 9–24 mm at 15°C; mycelium not covering the plate within a month at 15°C. Colony at 15°C first hyaline, thin, dense; becoming downy by long stout aerial hyphae; marginal hyphae sinuous or helical. Autolytic activity moderate at 15°C, conspicuous at 6–10°C; no coilings observed. No distinct odour noted. Plug and colony centre turning bright yellow to orange, 3–4A4–7, 6AB6–7, after a week, changing to orange-brown to reddish brown, 6–8CD6–8; 9C7–8; hyphae turning red. Conidiation lacking or noted after *ca* 1 weeks, scant, around the plug, effuse, spreading, gliocladium-like, soon degenerating.

On SNA after 72 h 1–2 mm at 15°C; after 2 weeks 2–4 mm at 6–10°C in the dark and 10–16 mm at 15°C; mycelium not covering the plate within a month at 15°C. Colony at 15°C hyaline, thin, dense, zonate; margin downy; hyphae with irregular thickenings. Aerial hyphae typically abundant and long in downy distal areas of the colony. Autolytic activity inconspicuous to moderate at 15°C; coilings inconspicuous or frequent. No diffusing pigment, no distinct odour noted. No chlamydospores seen. Conidiation seen after (1–)2–3 weeks at 15°C, first scant and effuse in mostly central minute shrubs, becoming visible at the beginning of a broad concentric downy zone as white floccules or tufts 0.5–1.5 mm diam, confluent to 5 mm, and on long branched aerial hyphae, gliocladium-like. Sometimes tufts evenly or irregularly disposed on the colony surface. Tufts fluffy or compact, typically transparent, of a loosely branched reticulum with long main axes and a minutely granular surface caused by whorls of phialides and conidial heads. Primary branches often paired, terminal branches paired or not. Main axes mostly erect, branched 2–3 fold, with side branches mostly unpaired and inclined upwards in steep angles. Terminal branches emerging in right angles or steeply inclined upwards, at the highest levels often paired, also often in clusters of 2–3. Sometimes conidiation restricted to small clusters or short tree-like conidiophores emerging at right angles terminally on the main axis. Conidiophores (main axes to terminal branches) mostly 4–6 μm wide, terminally 2–3 μm. Phialides parallel, less commonly divergent, in whorls of 2–6(–8), rarely solitary; whorls solitary when terminal, otherwise often

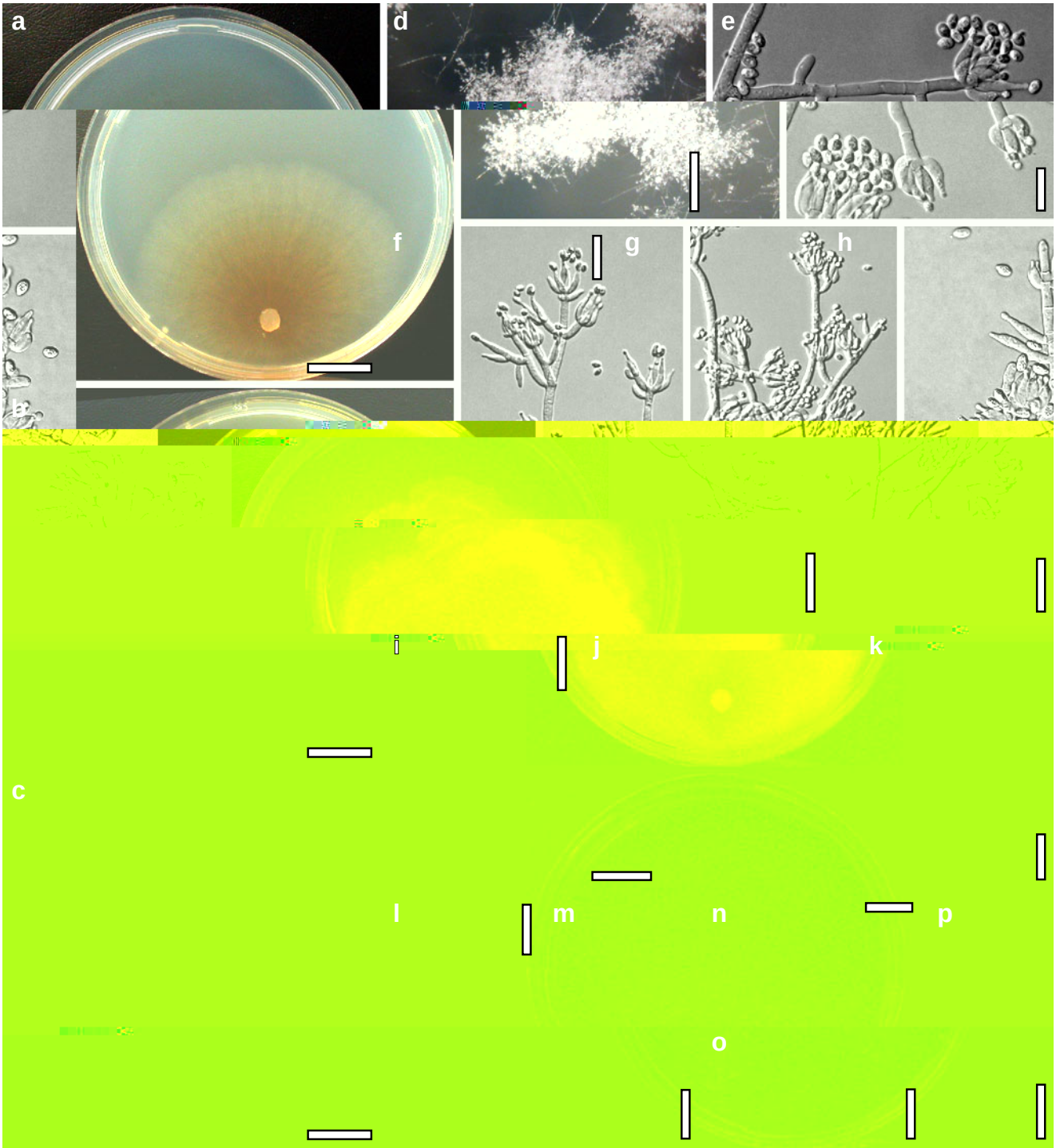


Fig. 86 Cultures and anamorph of *Hypocrea psychrophila*. **a–c**. Cultures (**a**. on CMD, 35 days. **b**. on PDA, 41 days. **c**. on SNA, 27 days). **d**. Conidiation tuft (31 days). **e–l**. Conidiophores (31–39 days). **m**. Phialides. **n–p**. Conidia (**o, p**. 31 days). **a–l, o, p**. At 15°C. **d–l, o, p**. On SNA. **a–c, h, j, k**. C.P.K. 1602. **d, e, g, i, o, p**. CBS 119129. **f, l**. C.P.K. 2435. **m, n**. holotype K 155404, dry culture. *Scale bars* **a–c**=15 mm. **d**=0.5 mm. **e**, **k**=10 µm. **f**=20 µm. **g**=30 µm. **h–j**, **l**=15 µm. **m**, **o**=5 µm. **n**, **p**=7 µm

paired; supporting cells (metulae) (6–)7–11(–14) µm long, (2.0–)3.0–4.0(–4.5) µm wide at the apex, 2.2–3.0(–3.5) µm wide at the lower end (*n*=20), often thickened. Phialides (6–)7–12(–19)×(2.3–)2.8–3.5(–4.5) µm, l/w (1.8–)2.3–4.0 (–5.8), (1.5–)2.0–2.8(–3.5) µm wide at the base (*n*=125), lageniform, straight in the middle of the whorl, otherwise distinctly curved, inaequilateral, sometimes sigmoid, often attenuated at the base and apex, widest mostly in or below

the middle; neck variable, often long and thin, abruptly attenuated and nearly cylindrical. Conidia formed in mostly dry minute heads <20 μm diam. Conidia (3.2–)3.8–5.3(–7.0)×(2.3–)2.5–3.0(–3.7) μm, l/w (1.3–)1.4–2.0(–2.5) (*n*=148), hyaline, ellipsoidal to oblong, smooth, eguttulate or finely multiguttulate; scar indistinct or prominent. At 6–10° C colony irregular, hyaline, loose; aerial hyphae abundant, arising several mm, arachnoid to nearly cottony.

Fertile stromata characteristically formed in culture on OA (W. Gams, pers. comm.).

Habitat: on dead twigs of *Rhododendron ferrugineum* and *R. hirsutum*, also reported from stems of *Vaccinium myrtillus* (Müller et al. 1972).

Distribution: Central Europe (alpine regions of Austria, Germany and Switzerland).

Holotype: **Switzerland**, Kanton Wallis, Brig, Aletschreservat, alter Belalpweg, on wood of *Rhododendron ferrugineum*, 12 Sep. 1968, E. Müller & B. Aebi (K(M) 155404, ex herb. Sheffield Univ. 3031). ***Holotype*** of *Trichoderma psychrophilum* isolated from WU 29420 and deposited as a dry culture with *H. psychrophila* WU 29420 as **WU 29420a**.

Other specimens examined: **Austria**, Tirol, Imst, Silz, between Haggen and Kühtai, close to the Zirmbachalm, MTB 8732/3, 47°13′15″ N, 11°03′13″ E, elev. 1920 m, on a thin corticated twig of *Rhododendron ferrugineum* 9 mm thick, on bark, 3 Sep. 2003, W. Jaklitsch, W.J. 2366 (WU 29420, culture C.P.K. 1602). Same area, 47°13′14″ N, 11° 03′17″ E, elev. 1940 m, on thin corticated twigs of *Rhododendron ferrugineum* 2–6 cm thick, on bark, 28 Aug. 2004, W. Jaklitsch & H. Voglmayr, W.J. 2624 (WU 29421, culture CBS 119129=C.P.K. 1990). **Germany**, Bavaria, Landkreis Garmisch-Partenkirchen, Garmisch, Wettersteingebirge, Garmisch-Partnachklamm, Reintal, Kreuzeck MTB 8532/14, elev. 1700 m, on corticated twigs of *Rhododendron hirsutum*, 30 July 2006, P. Karasch, W.J. 2926 (WU 29422, culture C.P.K. 2435). **Switzerland**, Kanton Wallis, Brig, Aletschreservat, alter Belalpweg, on wood of *Rhododendron ferrugineum*, Riederfurka, 9 Sep. 1970, E. Müller (culture CBS 343.71; only culture examined).

Notes: This species is unequivocally characterised by bright yellow to orange stromata on *Rhododendron* spp. in the Alps. In specimens, stromata of *H. psychrophila* are usually present in small numbers, also in the holotype K(M) 155404. The identity of *H. psychrophila* is clear due to the holotype and the culture CBS 343.71, therefore an epitypification does not appear to be necessary, although CBS 343.71 is not derived from the holotype but from the second specimen mentioned by Müller et al. (1972). The holotype includes pale yellowish stromata (having lost their colour upon incubation in a damp chamber) on a corticated twig; a convolute of three typical, densely aggregated, bright orange stromata wrapped in filter paper, a dry culture agreeing with the fresh anamorph, and a slide with a stroma section. Conidiophores and whorls of phialides of *T. psychrophilum* are similar to those of the closely related *T. crystalligenum*, i.e. phialides may be parallel or divergent on the same conidiophore. Sometimes the conidiation is concentrated on the tuft periphery, in such cases tufts are similar to those of *T. placentula*.

Hypocrea rhododendri Jaklitsch & Voglmayr, **sp. nov.** Fig. 87
MycoBank MB 516700

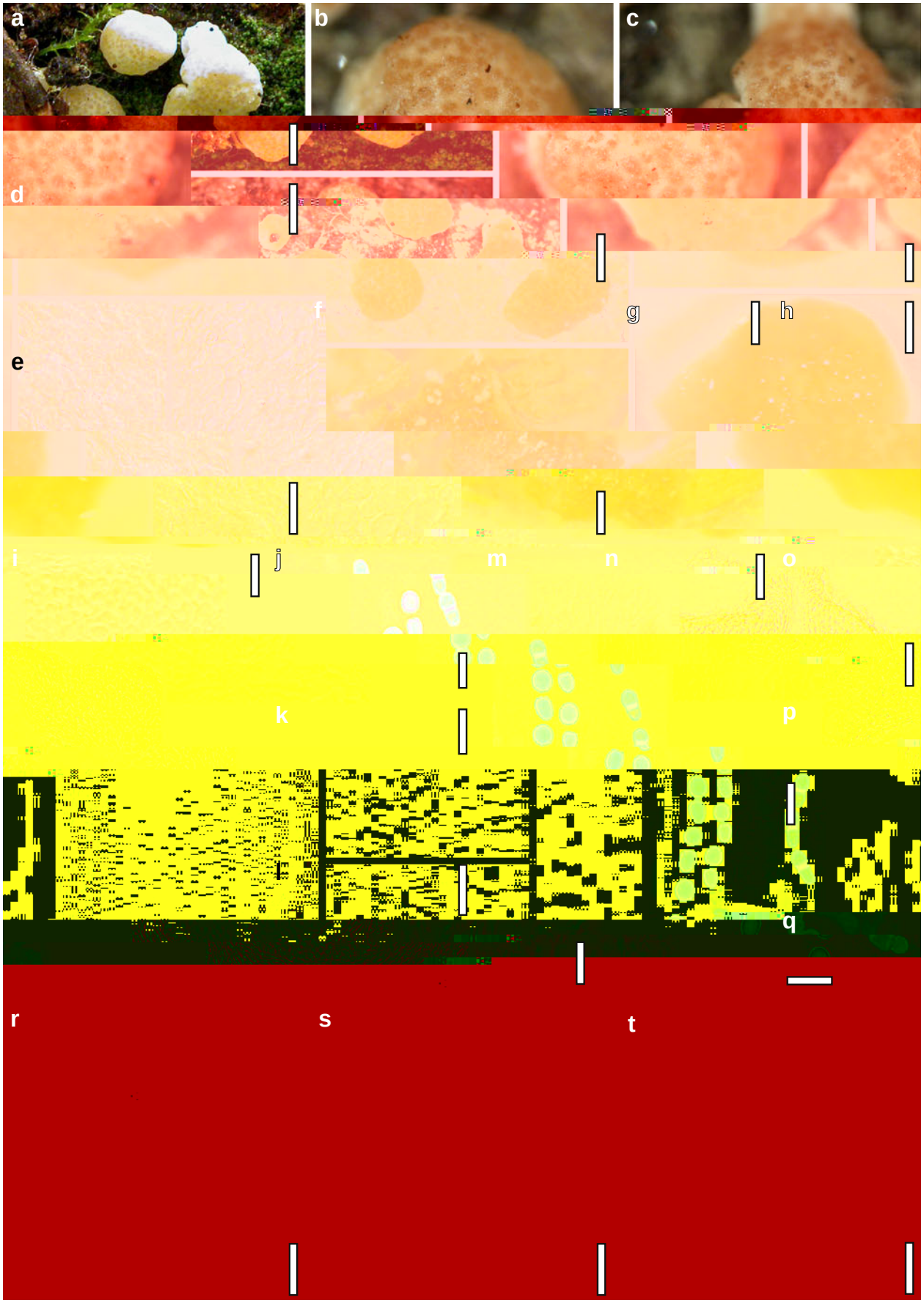
Stromata in ramulis *Rhododendri ferruginei*, pulvinata, pallide lutea. Asci cylindrici, (97–)100–116(–135)×(4.5–)5.0–6.0(–6.5) μm. Ascosporae bicellulares, hyalinae, verruculosae, ad septum disarticulatae, pars distalis subglobosa, ellipsoidea vel cuneata, (3.8–)4.0–5.0(–5.5)×(3.3–)3.5–4.0(–4.3) μm, pars proxima cuneata, oblonga vel subglobosa, (4.0–)4.5–5.5(–6.0)×(2.7–)3.0–3.5(–4.0) μm. Colonia in vitro sterilis.

Etymology: *rhododendri* due to its occurrence on *Rhododendron*.

Stromata when fresh 2–3 mm diam, to 1 mm thick, solitary or gregarious, pulvinate. Surface smooth; ostiolar dots yellowish. Stromata whitish to pale yellowish.

Stromata when dry (0.7–)1.3–2.6(–3.0)×(0.7–)1.0–1.7 mm (*n*=9), (0.2–)0.3–0.6 mm (*n*=11) thick, erumpent through or superficial on bark, pulvinate or discoid; outline roundish or oblong; broadly or centrally attached; margin free, plump, rounded or rolled in at the base, sometimes undulate, pale incarnate. Surface smooth to slightly tubercular by slightly projecting perithecia. Ostiolar dots (30–)52–97(–134) μm (*n*=30) diam, circular, convex or plane, often diffuse. Stroma colour yellowish to pale orange, 5A4, resulting from white surface and cream to yellow-ochre dots or spots; white inside. Spore deposits white. Stromata after rehydration more thickly pulvinate than dry, white with ochre-yellow perithecia; pale yellow, ochre-yellowish, dots (80–)100–160 μm diam; not changing colour in 3% KOH.

Stroma anatomy: Ostioles (69–)86–111(–126) μm long, plane or projecting 14–37(–45) μm, (32–)36–54(–75) μm wide at the apex (*n*=31), with clavate marginal cells to 6 μm wide at the apex, projecting in fascicles. Perithecia (170–)200–245(–270)×(115–)130–200(–235) μm (*n*=31), globose, ellipsoidal or flask-shaped, variably disposed; peridium (13–)15–21(–25) μm (*n*=31) thick at the base, (6–)12–19(–22) μm (*n*=31) thick at the sides; hyaline to pale yellowish. Cortical layer (15–)20–37(–56) μm (*n*=30) thick, a dense *t. angularis* of thin- or thick-walled cells (3–)4–8(–10)×(2–)3–5(–8) μm (*n*=60) in face view and in vertical section; subhyaline to pale yellowish. Cortex partly covered by a thin amorphous layer of more or less compressed, undifferentiated hyphae; no differentiated hairs present. Subcortical tissue of thin-walled hyaline cells (3–)5–8(–10)×(2.5–)3.5–5.5(–7.0) μm (*n*=31), mixed with


a
b
c
d
e
f
g
h
i
j
m
n
o
k
p
q
r
s
t

◀ **Fig. 87** *Hypocrea rhododendri*. **a–o**. Teleomorph (WU 29442). **a**. Fresh stromata. **b–e**. Dry stromata (**e**. showing spore deposits). **f**. Stroma in 3% KOH after rehydration. **g**. Hyphae on stroma surface in face view. **h**. Stroma surface without hyphal covering in face view. **i**. Perithecium in section. **j**. Cortical and subcortical tissue in section. **k**. Subperithecial tissue in section. **l**. Stroma base in section. **m, n**. Asci with ascospores (**n**. in cotton blue/lactic acid). **o**. Marginal cells at the ostiolar apex. **p–t**. *Hypocrea rhododendri* (CBS 119288) in culture. **p**. Autolytic excretion (PDA, 4 days). **q**. Peg-like terminal branches on marginal hypha (PDA, 7 days). **r–t**. Cultures (**r**. on CMD, 35 days. **s**. on PDA, 35 days. **t**. on SNA, 28 days). **p–t**. At 15°C. *Scale bars* **a**, **d** =1 mm. **b**, **c**=0.3 mm. **e**, **f**=0.4 mm. **g, h, j, m**, **n**=10 μm. **i**=30 μm. **k, l**, **o**=15 μm. **p**=50 μm. **q**=100 μm. **r–t**=15 mm

hyaline hyphae (3.0–)3.5–5.5(–7.5) μm (*n*=30) wide. Subperithecial tissue a *t. angularis–epidermoidea* of thin-walled hyaline cells (6–)8–21(–28)×(3–)7–13(–15) μm (*n*= 30). Stroma base of often strongly compressed, thick-walled, hyaline to pale yellowish hyphae (1.8–)2.5–5.2(–7.5) μm (*n*=30) wide, extending upwards along the sides and forming the amorphous layer on the upper surface. Asci (97–)100–116(–135)×(4.5–)5.0–6.0(–6.5) μm, stipe (11–)12–24(–31) μm long (*n*=30), croziers present. Ascospores hyaline, verruculose; cells dimorphic; distal cell (3.8–)4.0–5.0(–5.5)×(3.3–)3.5–4.0(–4.3) μm, l/w (1.0–)1.1–1.3(–1.4) (*n*= 30), subglobose, ellipsoidal or wedge-shaped; proximal cell (4.0–)4.5–5.5(–6.0)×(2.7–)3.0–3.5(–4.0) μm, l/w (1.1–)1.4–1.7(–1.8) (*n*=30), wedge-shaped, oblong or subglobose.

Cultures and anamorph: optimal growth at 15°C on all media; no growth at and above 30°C. No conidiation noted on all media.

On CMD after 72 h 9–11 mm at 15°C, 5–7 mm at 25°C; mycelium covering the plate after 3 weeks at 15°C. At 15°C colony hyaline, thin, loose, circular with wavy margin, zonate; hyphae finely wavy along their length, wide, narrow secondary hyphae scant. Dense mycelial clumps formed immersed in the agar, becoming visible as whitish spots, 1–6×0.5–2.5 mm, in concentric zones, radially elongate, eventually turning brown. Sometimes few small brown sterile stromata appearing in irregular disposition on the colony surface. Aerial hyphae inconspicuous, more frequent at the margin. Autolytic excretions absent at 15°C, abundant at 25°C in the entire colony, minute, turning yellowish brown; coilings rare. No chlamydospores, only widened cells in surface hyphae seen. Reverse faintly yellowish, 2A3; odour indistinct. At 25°C colony irregularly lobed. Hyphae often with short pegs or becoming moniliform, many dying soon. Mycelial density inhomogeneous. Autolytic excretions turning the colony yellowish to dull yellowish brown, 4B4–5.

On PDA after 72 h 8–10 mm at 15°C, 4–5 mm at 25°C; mycelium covering the plate after 18–20 days at 15°C. At 15°C colony well-defined with wavy margin, dense, zonate, mainly of thick primary hyphae finely wavy along their length; marginal surface hyphae conspicuously wide, terminally branched into short pegs. Distal surface becoming hairy due to thick, long and high aerial hyphae radially oriented at the margin, forming short strands, collapsing as fine floccules. Mycelial clumps formed in the agar and above as white, eventually brownish, superficial tufts to 1.5 mm thick in a broad central zone with irregular margin and in a distal zone. Autolytic activity conspicuous, excretions brownish, absent in fresh growth zones. Coilings frequent, autolysing yellow to reddish. Reverse turning yellowish to brown-orange, 4B4–6, 5C5, darker and with reddish tones below the mycelial spots. At 25°C colony conspicuously dense, mycelium with extremely dense broom-like branching, thick; yellow-brown pigment diffusing into the agar; reverse brown 5D5–6, 6E7–8. Odour indistinct. Autolytic excretions frequent, coilings absent.

On SNA after 72 h 8–10 mm at 15°C, 4–6 mm at 25°C; mycelium covering the plate after 3–4 weeks at 15°C. At 15°C colony similar to that on CMD, with little mycelium on the surface; hyphae often helical within the agar; hyphae degenerating, appearing empty; eventually small sterile, yellowish to brownish, roundish, pulvinate stromata to 5× 3 mm forming. Aerial hyphae, autolytic activity and coilings inconspicuous. No pigment, no distinct odour noted. Autolytic excretions nearly absent at 15°C, frequent at 25°C; coilings rare. Chlamydospores noted after 2–3 weeks at 25°C, after 3–4 weeks also at 15°C, (6–)7–12(–15)×(5–)6–9(–11) μm, l/w (0.7–)1.0–1.7(–2.1) (*n*=21), only in distal surface hyphae, terminal and intercalary, subglobose, pyriform or ellipsoidal. Stromata pseudoparenchymatous, of globose to oblong cells (16–)24–48(–60)× (13–)19–32(–41) μm (*n*=30). At 25°C colony as on CMD, but only pale yellowish, 4A3; hyphae often moniliform; minute sterile, pale brownish stromata to 1.5 mm diam formed.

Habitat: on corticated twigs of *Rhododendron ferrugineum*.

Distribution: Austria, known only from the type locality.

Holotype and only known specimen: **Austria**, Tirol, Sölden, Venter Tal, Vent, MTB 9131/2, 46°52′24″ N, 10° 55′52″ E, elev. 1840 m, on corticated twigs of *Rhododendron ferrugineum* 0.5–1.3 cm thick, emergent through bark, soc. *Bertia moriformis*, *Hymenochaete* sp., rhizomorphs; 28 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2627 (**WU 29442**, ex-type culture CBS 119288=C.P.K. 2015).

Notes: *Hypocrea rhododendri* is known from only a single specimen. It shares the same host and habitat with *H. psychrophila*, differing from the latter mostly by pale stromata lacking hairs on their surface, growth at 25°C, absence of an anamorph on artificial media and the formation of chlamydospores.

European species of *Hypocrea*: Miscellaneous species

Introduction

The residual European species of *Hypocrea* not clustered in larger clades are presented in this chapter. It includes also the three species *H. argillacea*, *H. splendens* and *H. strobilina* that have not been recollected recently; accordingly, their phylogenetic position is not known. These species are redescribed below based on their holotypes.

At this point I want to note that at least six additional teleomorphic or holomorphic species of *Hypocrea*/*Trichoderma* and several anamorphic species have been detected in Europe. They are not described here either due to material insufficient for a thorough description or due to sequencing issues. A description of the undescribed anamorphic species is beyond the scope of this work.

Apart from the three species mentioned above, the following eight are described below: *Hypocrea albolutescens*, morphologically unique, residing in a basal position of uncertain affinity in the generic tree (Fig. 1); *H. moravica* as a member of the *Semiorbis* clade with a marked morphological similarity to species of the pachybasium core group. *Hypocrea sambuci*, *H. subalpina* and *H. tremelloides* form a weakly supported, therefore unnamed subclade of the section *Longibrachiatum*, which so far is represented in Europe by only the single holomorphic species *H. schweinitzii*. Included are also *H. silvae-virgineae*, which has a pachybasium-like anamorph and clusters with *Trichoderma helicum*; and *H. voglmayrii*, which forms an isolated lineage associated with sect. *Trichoderma*. For *H. moravica*, *H. subalpina* and *H. tremelloides* the anamorphs are newly described. The anamorphs of the latter two species and of *H. sambuci* are white-conidial, with unusual structures new to *Trichoderma*. See the notes after each species description for more information on species similarities and delimitation.

Species descriptions

Hypocrea albolutescens Jaklitsch, **sp. nov.** Fig. 88
MycoBank MB 516663
Anamorph: ***Trichoderma albolutescens*** Jaklitsch, **sp. nov.** Fig. 89
MycoBank MB 516664

Stromata in ligno putridissimo, pulvinata vel effusa, alba maculis flavis, 0.5–10×0.5–5 mm. Asci cylindrici, (40–)47–67(–77)×(2.7–)3.3–5.0(–6.0) µm. Ascosporae bicellulares, hyalinae, verruculosae, ad septum disarticulatae, cellulis forma similibus, (sub-)globosis, (2.0–)2.5–3.5(–4.5) µm diam. Anamorphosis *Trichoderma albolutescens*. Conidiophora in agaro PDA disposita in pustulis elongationes breves, steriles, raro fertiles proferentia. Phialides in pustulis divergentes vel parallelae, ampulliformes vel lageniformes, (4.0–)4.5–8.0(–11.0)×2.5–3.2(–3.7) µm. Conidia oblonga vel cylindracea, hyalina, glabra, (3.3–)3.8–5.5(–7.0)×2.0–2.5(–3.0) µm.

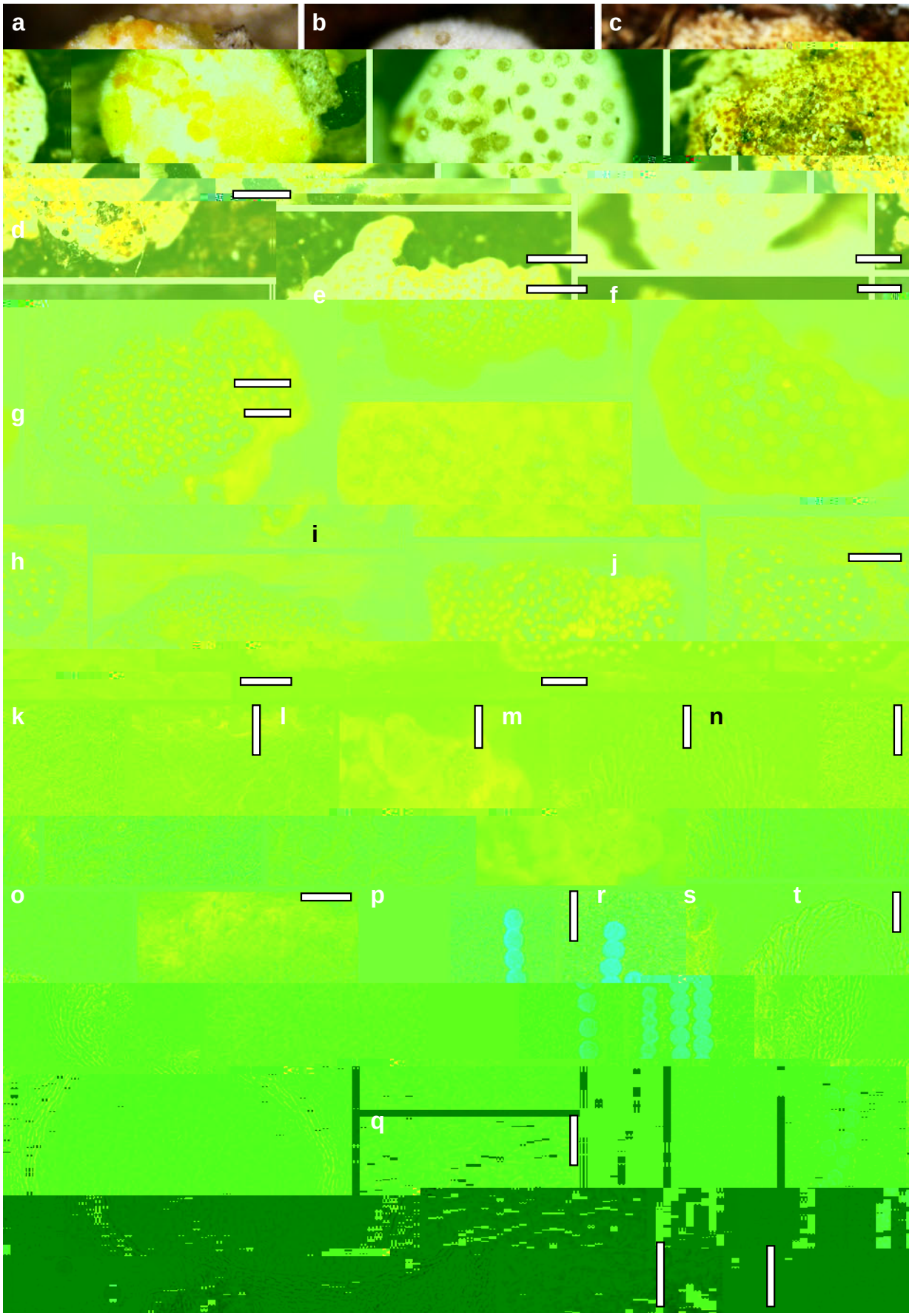
Etymology: referring to the white stromata developing yellow spots.

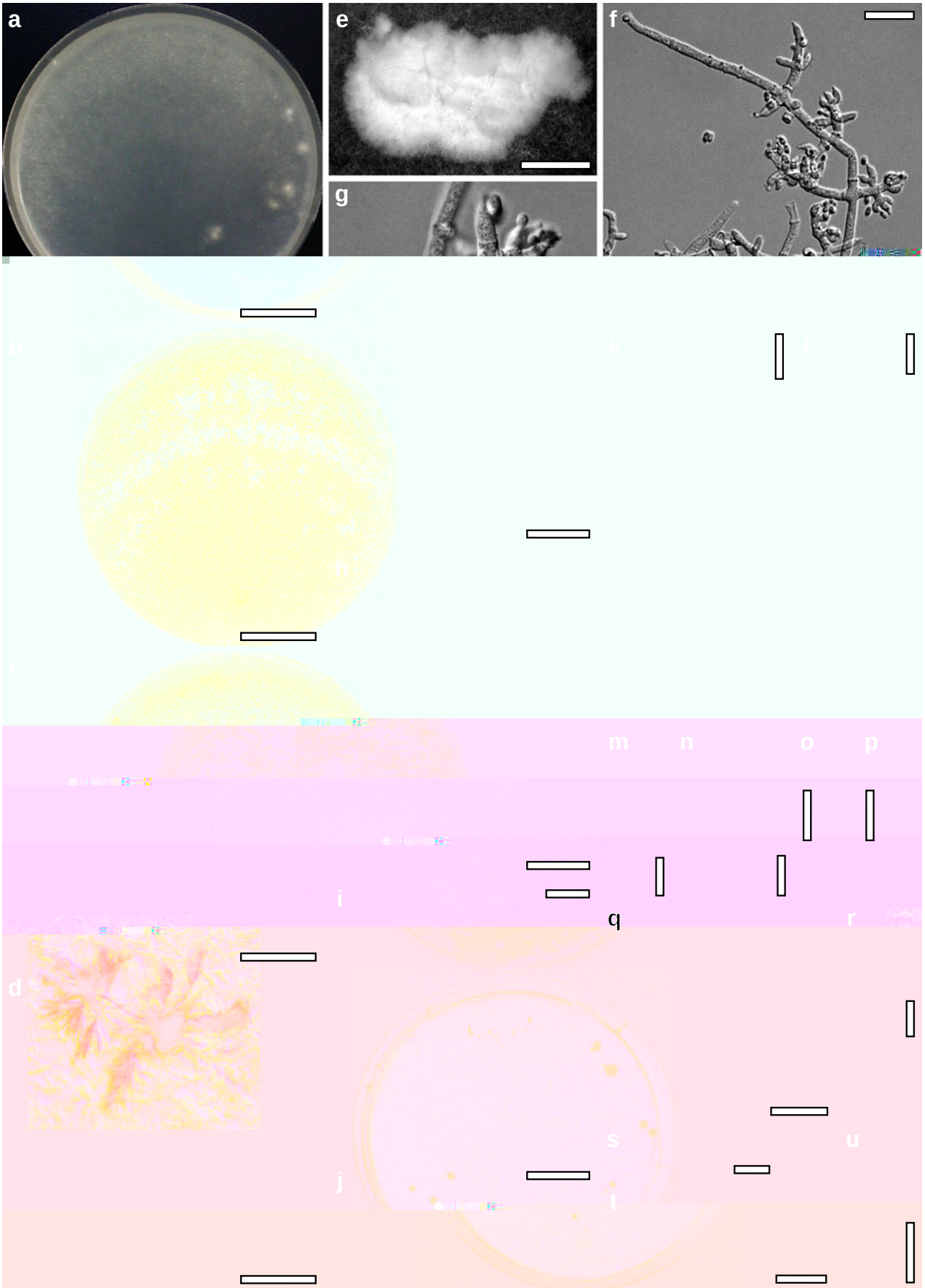
Stromata when fresh 0.5–10×0.5–5 mm, 0.5–1.5(–2) mm thick, solitary or gregarious in small numbers, (flat) pulvinate to subeffuse. Outline variable, circular, oblong or slightly lobed, broadly attached. Margin well defined, attached or free, white, sterile, vertical or attenuated towards the base. Surface farinose or papyraceous. Stromata white, often with bright yellow spots. Ostioles distinct, slightly projecting, light olive, yellowish brown, ochre, amber, rarely orange, 60–95 µm diam. Resulting colour white to yellow, 4A1–2, 4A6–8, sometimes becoming entirely yellow with age. Spore deposits white or yellow.

Stromata when dry (0.5–)0.8–4.1(–8.4)×(0.4–)0.7–2.1(–3.2) mm, 0.1–0.6(–1) mm thick (n=51); (flat) pulvinate or subeffuse, membranaceous and with white radiating marginal mycelium, broadly attached. Surface often uneven due to the surface of the host, farinose or downy, smooth where pigmented. Outline variable, often considerably longer than wide. Margin rounded, adnate or free. Ostioles (30–)40–70(–95) µm (n=51) diam, distinct, slightly projecting, convex or conical, sometimes laterally compressed, light yellow, yellow-brown, ochre, cinnamon, rarely orange-red. Perithecia sometimes becoming free, distinctly lighter than the ostioles. Stromata white, with yellow to orange spots, resulting colour including ostioles light yellow, greyish yellow to orange-yellow, 4A3–4, 4B3–6(–8). Stromata after rehydration slightly thicker and lighter, less yellow than fresh, ostioles more amber, resulting colour yellow to brown-orange, 4B4 to 5C5–6. No change seen in 3% KOH.

Stroma anatomy: Ostioles (46–)60–83(–93) µm long, projecting (13–)20–52(–80) µm (n=30), broadly conical; with often flattened apex, (38–)52–87(–106) µm wide outside, (15–)20–40(–50) µm (n=30) inside, margin lined by a palisade of broadly clavate or fusoid hyaline cells 3–7

Fig. 88 Teleomorph of *Hypocrea albolutescens*. **a–g**. Fresh stromata (a. ▶ immature). **h–i**. Dry stromata. **j**. Rehydrated stroma. **k**. Ostiolar apex in section. **l, m**. Stroma surface in face view (**m**. *textura angularis* in pigmented area). **n**. Part of fresh stroma with free perithecia. **o**. Perithecium in section. **p**. Cortical and subcortical tissue in section, from pigmented area. **q**. Subperithecial tissue facing host in section. **r–t**. Asci with ascospores. **a, g**. WU 29171. **b, d, e, h, l, m**. WU 29174. **c**. WU 29176. **f, j, k, n, o–q**. WU 29172. i, r, s. WU 29170. **t**. WU 29173. *Scale bars* **a, b**, **e**=0.3 mm. **c, d**, **j**=0.7 mm. **f, h**, **i**=0.4 mm. **g**, **n**=150 µm. **k**=15 µm. **l, m**, **p–s**=10 µm. **o**=20 µm. **t**=5 µm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t


a
e
f
g
b
k
l
h
c
m
n
o
p
i
q
r
d
s
u
j
t

(−8) µm wide; periphyses 1–2(−3) µm wide. Perithecia (85–)110–150(−170)×(100–)110–150(−185) µm (*n*=30), flask-shaped or globose, usually not crowded; peridium yellowish, (8–)10–14(−18) µm (*n*=60) thick at the base and sides. Cortical layer (3–)4–13(−19) µm (*n*=30) thick, consisting of a hyaline *t. intricata* of narrow, thin-walled hyphae (1.2–)2.0–3.2(−4.3) µm (*n*=40) wide, often spiral at the surface, and of an incomplete cellular cortex present in pigmented areas, of cells (5–)7–13(−15)×(3–)4–9(−12) µm (*n*=30) in face view; often covered by yellow(-brown) amorphous material; no subcortical tissue differentiated. Subperithecial tissue a hyaline *t. intricata* of thin-walled hyphae (2.5–)3–6(−7) µm (*n*=40) wide, merging into a *t. angularis–epidermoidea* of hyaline, thin-walled, isodiametric to oblong cells (3–)4–8(−11)×(2.5–)3–6(−9) µm (*n*=30) in discontinuous areas close to the host. Asci (40–)47–67(−77)×(2.7–)3.3–5.0(−6.0) µm, stipe (1–)3–11(−20) µm long (*n*=127); apex truncate, with a flat ring below the apical thickening; no croziers seen. Ascospores hyaline, smooth inside the asci, finely verruculose after ejection, verrucose in cotton blue/lactic acid; cells monomorphic, (sub-)globose; distal cell (2.0–)2.5–3.5(−4.0) µm diam, l/w 0.9–1.1(−1.2); proximal cell (2.0–)2.5–3.5(−4.5) µm diam, l/w (0.8–)0.9–1.1(−1.3) (*n*=181).

Stroma margins often bearing conidiophores (1–)2–3.5 µm wide, with sinuous ends and sparse, narrow, subulate phialides and minute globose conidial heads 10–15 µm diam. Conidia (3.5–)4.0–5.7(−7.5)×(2.0–)2.5–3.0(−3.4) µm, l/w (1.2–)1.5–2.1(−2.6) (*n*=78), oblong-cylindrical or ellipsoidal, hyaline, smooth.

Cultures and anamorph: optimal growth at 25°C on all media, negligible growth at 30°C, no growth at 35°C.

On CMD after 72 h 17–22 mm at 15°C, 36–46 mm at 25°C, 0.5–1 mm at 30°C; mycelium covering the plate after 5 days at 25°C. Colony hyaline to pale yellowish or greyish orange, 5A2, 5B3, after 3 weeks, thin, indistinctly zonate, mycelium dense, with radial streaks; primary surface hyphae conspicuously thick and coarsely wavy; mycelial aggregations and long aerial hyphae appearing along the margin, sometimes forming white cottony spots. No conidiation seen within 7 weeks. No autolytic excretions noted. Coilings moderate. No distinct odour noted. Chlamydospores frequent, terminal and intercalary, noted after 3–6 days at 25°C.

On PDA after 72 h 15–17 mm at 15°C, 31–36 mm at 25°C, 0.3–0.6 mm at 30°C; mycelium covering the plate after 1 weeks at 25°C. Colony circular, thin, zonate, hairy. Margin shiny, thin and smooth. Mycelium densely agglutinated, appearing glassy, primary surface hyphae conspicuously wide. Aerial hyphae of two kinds, a lawn of numerous short, erect, narrow, spiny hyphae becoming verrucose, and numerous long ones forming a reticulum or thick white tomentum above, ascending several mm high; to the lid of the Petri dish on Difco PDA; with numerous colourless to orange droplets, collapsing, and colony surface becoming mottled. Fan-shaped crystals 0.1–0.7 mm diam formed within the agar (also numerous at 15°C) after 4–5 days from the centre, colourless, appearing red in DIC, macroscopically noted as granules, spreading across the entire colony. Numerous light brown, sterile hairy stromata 0.2–2 mm diam appearing in the centre. Autolytic excretions and coilings inconspicuous. Odour slightly mushroomy, colour white, pale yellow to greyish yellow or beige, 3A4, 3B4–6, 4B4–6, 4C5–8, plus a greenish tone. Conidiation noted after 2 weeks, first scant and effuse in the outer half of the colony, on short, erect conidiophores; later in numerous white, partly confluent tufts or pustules 0.3–1.5 mm diam, formed in a thick white tomentum, mostly in the outer half of the colony, forming several concentric zones in addition to the growth zones. Conidiation within pustules dense, but the pustule margin remaining sterile. Structure of pustulate conidiation examined on Difco-PDA after 20–22 days: pustules on this medium more numerous than on Merck-PDA, large, 1–11 mm long, 1–2 mm high, with circular or oblong outline; white, turning brownish with age. Margin of pustules beset with numerous short, straight or sinuous elongations 15–300 µm long, smooth, often with semiglobose mucous exudates 5–6 µm long, along the entire length. Elongations tapering to 2.5–4 µm towards the narrowly or broadly rounded ends, rarely with a solitary terminal phialide. Pustules inside consisting of a dense, opaque, complex reticulum. Conidiophores 3–6 µm, at branching points to 7 µm wide, with complex, mostly symmetric, i.e. paired, and often distinctly rectangular branching. Side branches 18–50 µm long, with verticils of short, 1–2 celled side branches at right angles, slightly increasing in length downward. Phialides supported by cells (1.7–)3.0–5.0(−5.5) µm wide, solitary or paired along the conidiophores, and terminally in whorls of (2–)4–6, divergent, sometimes appressed parallel in dense terminal whorls. Phialides (4.0–)4.5–8.0(−11.0)×2.5–3.2(−3.7) µm, l/w (1.4–)1.6–2.8(−4), (1.7–)2.0–3.0(−3.7) µm wide at the base (*n*=31), ampulliform, less commonly lageniform, short, mostly inequilateral or curved upwards. Conidia formed in minute dry heads 10–15 µm diam. Conidia (3.3–

On SNA after 72 h 13–16 mm at 15°C, 33–40 mm at 25°C, 0–0.1 mm at 30°C; mycelium covering the plate after 5–7 days at 25°C. Colony similar to that on CMD, with less conspicuous zonation. Surface hyphae soon degenerating, appearing empty. Margin hairy due to long aerial hyphae, the latter aggregating to white flakes or tufts in distal areas. Autolytic excretions inconspicuous; coilings moderate. No diffusing pigment, no distinct odour noted. Chlamydospores (5–)7–13(–19)×(6–)7–12(–15) µm, l/w 0.9–1.3(–1.6) (n=32), noted after 4 days at 25°C, becoming extremely abundant (also at 15°C) on the entire plate, globose, oval or ellipsoidal to angular in thick hyphae, terminal and intercalary. Conidiation unreliable, noted after 2–4 weeks. Effuse conidiation seen as scant minute heads on aerial hyphae, appearing warted under low magnification, in distal areas of the colony. Conidiation dense in few irregularly disposed, compact, white pustules 1–4 mm diam; with short straight to slightly sinuous elongations bearing minute droplets. Conidia formed in minute dry heads of 10–15 µm. Sometimes few light brownish stromata 0.4–1.3 mm diam appearing close to the distal margin, surrounded by moniliform hyphae.

Habitat: on well-rotted, soft wood of deciduous trees and shrubs, often emerging from underneath loosely attached bark or from cracks in the wood.

Distribution: Europe (Austria, Germany).

Holotype: **Germany**, Baden-Württemberg, Freiburg, Landkreis Breisgau-Hochschwarzwald, shortly before Breisach heading north, in the riverine forest at the river Rhine, MTB 7911/4, 48°00′10″ N, 07°36′55″ E, elev. 190 m, on 2 partly decorticated branches of *Fraxinus excelsior* 3–4 cm thick, on wood, soc. *Gliocladium* sp. and *Chaetosphaeria pulviscula*, 3 Sep. 2004, H. Voglmayr & W. Jaklitsch W.J. 2671 (**WU 29173**, culture CBS 119286=C.P.K. 2017). ***Holotype*** of *Trichoderma albolutescens* isolated from WU 29173 and deposited as a dry culture with the holotype of *H. albolutescens* as **WU 29173a**.

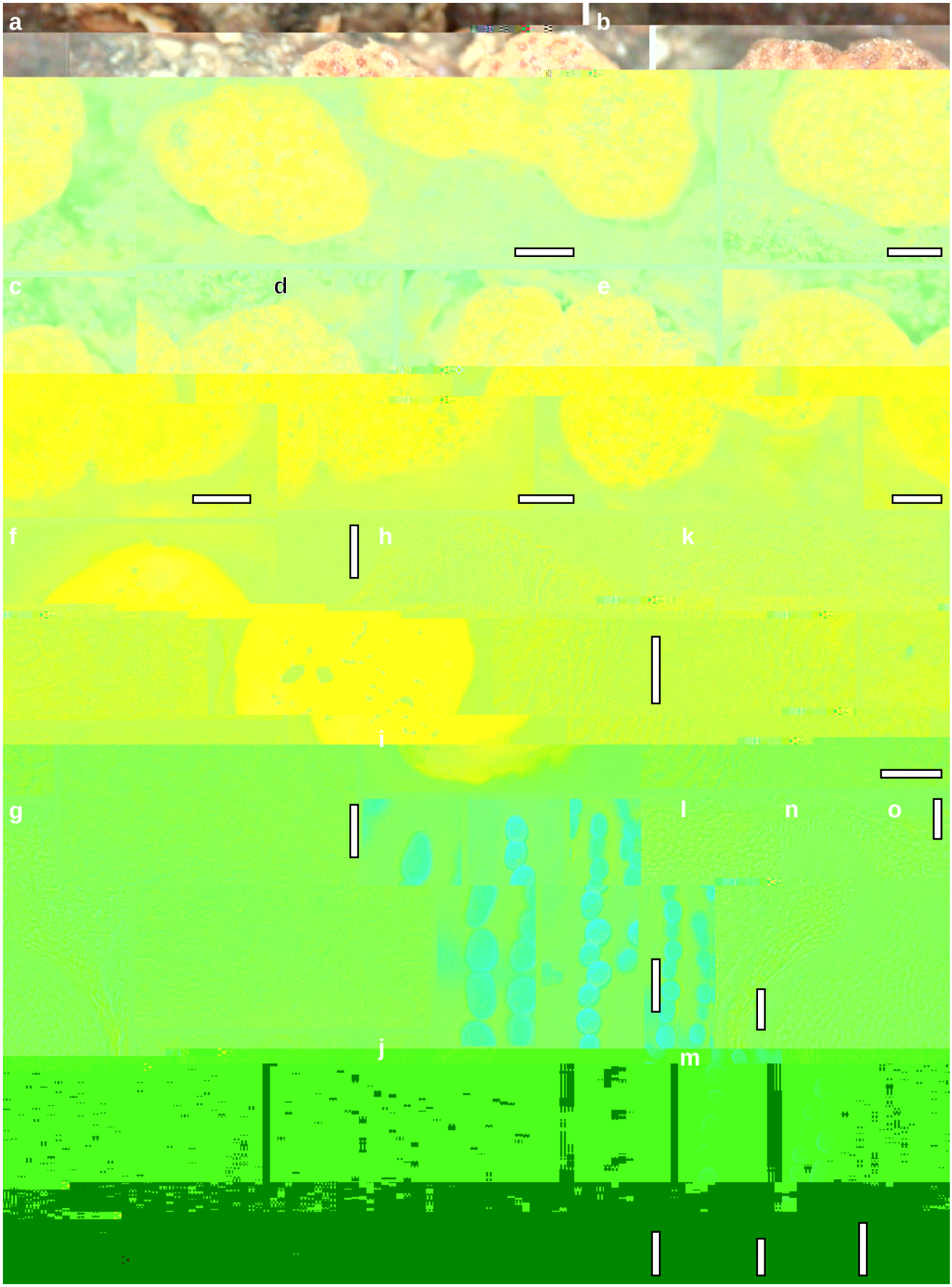
Other specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, Tumpfi, MTB 9452/4, 46°32′35″ N, 14°25′32″ E, elev. 565 m, on decorticated branch of *Alnus glutinosa* 1.5 cm thick, on wood, 25 Sep. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2986 (WU 29174). Niederösterreich, Scheibbs, Lunz am See, forest path from Schloß Seehof in direction Mittersee, MTB 8156/3, 47°50′40″ N, 15°04′25″ E, elev. 630 m, on decorticated branches of *Corylus avellana* and *Fraxinus excelsior*, on wood, soc. *Nemania chestersii*, 16 Oct. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2459+2460, WU 29171. Tirol, Innsbruck-Land, Ampass, Ampasser Hügel, MTB 8734/2, 47°15′31″ N, 11°27′13″ E, elev. 700 m, on decorticated branches of *Corylus avellana*, *Quercus robur* and *Alnus incana*, on wood, soc. rhizomorphs, 2 Sep. 2003, W. Jaklitsch & U. Peintner, W.J. 2352+2356 (WU 29170). Vienna, 10th district, recreation park Wienerberg, MTB 7864/1, 48°09′56″ N, 16°20′56″ E, elev. 220 m, on thin decorticated branches of well-rotted ?*Populus tremula*, 1–3 cm thick, on wood, erumpent from holes, between thick fibres, soc. *Eutypa* sp., *Lycogala epidendron*, 13 Jun. 2004, W. Jaklitsch, W.J. 2509 (WU 29172). 22nd district, Lobau, at Panozzalacke, MTB 7865/1, 48°11′06″ N, 16°29′20″ E, elev. 150 m, on branches of *Prunus padus*, 18 Nov. 2006, W. Jaklitsch, W.J. 3035 (WU 29175; white form with smaller ascospores). W.J. 3036 (WU 29176; form with yellow spots).

Notes: *Hypocrea albolutescens* is one of the exceptions among hyaline-spored species that occur on well-rotted wood. Its stromata resemble those of *H. chionea* Ellis and Everhart (1892). However, no yellow discolorations have been reported for the latter, and the smaller ascospores disarticulate into dimorphic cells (Samuels et al. 2006b). In addition, *H. chionea* typically occurs on recently dead hosts like lianas often well above the ground (G.J. Samuels, pers. comm.). Reports of *H. chionea* from Europe (Bresadola 1903; no specimen seen) are probably *H. albolutescens*. Despite overlapping ranges, two forms differing in ascus and ascospore sizes can be recognized: one (WU 29173, WU 29175) with asci (40–)45–52(–60)×(2.7–)3.0–3.5(–3.8) µm (n=62), distal ascospore cell=(2.0–)2.2–2.5(–2.7)×(2.1–)2.2–2.5(–3.0) µm, and proximal ascospore cell=(2.0–)2.2–2.5(–2.7)×(2.0–)2.3–2.5(–2.7) µm (n=60); the second form (all other specimens) with asci=(57–)60–70(–77)×(4.4–)4.7–5.4(–6.0) µm (n=65), distal ascospore cell=(2.8–)3.0–3.5(–4.0)×3.0–3.5(–4.0) µm, and proximal ascospore cell=3.0–3.7(–4.5)×3.0–3.6(–4.0) µm. Other traits of the teleomorphs are indistinguishable. Only one (WU 29173) of six specimens yielded a culture on CMD supplemented with vitamins, trace elements and peptone. Although scant, this specimen is designated as the holotype. WU 29172 is more appropriate for the examination of the teleomorph, but has larger asci and ascospores than the holotype. The *Trichoderma* often present on stroma margins forms the same conidia as the ex-type culture CBS 119286, and is probably the anamorph of *H. albolutescens*. The phialides, however, are subulate and to *ca* 25 µm long. They resemble terminal cells of pustule elongations on PDA.

Hypocrea argillacea W. Phillips & Plowr., Grevillea 13: 79 (1885). Fig. 90

Anamorph unknown.

Fig. 90 Teleomorph of *Hypocrea argillacea* (holotype K 61846). **a–d**. ▶ Dry stromata. **e**. Rehydrated stromata. **f**. Ostiolar apex in section. **g**. Perithecium in section. **h**. Stroma surface in face view. **i**. Cortical and subcortical tissue in section. **j**. Subperithecial tissue in section. **k**. Stroma in 3% KOH after rehydration. **l**, **m**. Ascospores (**l**. in ascus apex, in cotton blue/lactic acid; **m**. in ascus base, in 3% KOH). **n**, **o**. Asci with ascospores in cotton blue/lactic acid. Scale bars: **a, c–e**, **k**=0.3 mm. **b**=0.2 mm. **f**, **i**=15 µm. **g**=30 µm. **h, j, n**, **o**=10 µm. **l**, **m**=5 µm


a
b
c
d
e
f
h
k
i
g
l
n
o
j
m

Stromata when dry (0.4–)0.8–1.6(–1.7)×(0.4–)0.6–1.1(–1.4) mm, (0.25–)0.3–0.5(–0.6) mm thick (*n*=20); gregarious in small numbers; pulvinate, broadly or narrowly attached, with free, broadly rounded margins and sometimes white or brownish mycelium around the base; sometimes with a short stout stipe. Surface smooth, slightly uneven, with some whitish floccules and numerous well-defined, circular, convex, reddish brown ostiolar dots (23–)37–80(–118) μm (*n*=30) wide. Stroma colour light orange to grey-orange, 5–6AB4. Stroma size unchanged after rehydration, colour more yellow; dots brown; after addition of 3% KOH stromata macroscopically black; in the stereomicroscope stroma surface yellow between distinctly orange-red ostiolar dots/perithecia.

Stroma anatomy: Ostioles (55–)70–107(–121) μm long, plane with surface or projecting to 20(–32) μm (*n*=30), (38–)45–65(–77) μm (*n*=30) wide at the apex, cylindrical or conical, with periphyses 2–4.5 μm wide; apical cells inconspicuous, some marginal cells clavate and 4–6 μm wide. Perithecia (160–)190–240(–260)×(100–)120–180(–200) μm (*n*=30), flask-shaped. Peridium (7–)12–19(–22) μm (*n*=60) thick at the base and sides, yellow in lower parts, turning orange in KOH. Cortical layer (25–)28–41(–50) μm (*n*=30) thick, around entire stroma, but hyphal, thicker and stronger pigmented in lateral and basal regions; pale yellow, distinctly paler than the peridium. Cortical tissue a dense and compact *t. angularis–globulosa* of thick-walled, isodiametric to oblong cells (3.5–)5–10(–14)×(3–)4–7(–9) (*n*=64) in face view and in vertical section. Subcortical tissue a loose *t. intricata* of thin-walled hyaline hyphae (2–)3–5(–6) μm (*n*=30) wide, partly also present in areas directly below the perithecia. Subperithecial tissue a loose *t. epidermoidea* of thin-walled, hyaline to yellowish cells (6–)9–19(–24)×(4–)6–12(–15) μm (*n*=30). Asci 100–120×5–6 μm, including a stipe 28–38 μm (*n*=6) long (only few intact). Ascospores hyaline, verruculose or spinulose, cells dimorphic, distal cell (4.0–)4.4–5.3(–6.0)×(3.5–)3.8–4.5(–5.0) μm, l/w (0.9–)1.1–1.3(–1.5) (*n*=40), subglobose or ellipsoidal, proximal cell (4.0–)4.8–7.0(–9.0)×(2.8–)3.0–3.7(–4.3) μm, l/w (1.2–)1.4–2.1(–2.8) (*n*=40), oblong or ellipsoidal, often elongate in the ascus base.

Habitat: on wood of *Fraxinus*.

Distribution: Europe (England).

Holotype: **England**, West Norfolk, Dersingham, ex herb. C.B. Plowright, on (blackened) wood of *Fraxinus excelsior*, Nov. 1881, **K(M) 61846**.

Notes: *Hypocrea argillacea* is known with certainty only from the holotype. Two attempts to recollect it during this study failed; therefore its anamorph and phylogenetic placement are unknown. The above description is based on the holotype.

Superficially, *H. bavarica* is similar to *H. argillacea*, but differs by paler stroma colours and distinctly smaller ascospores. *H. moravica* differs in more distinct ostiolar dots present in lower numbers. *H. argillacea* could perhaps even be interpreted as a form of *H. splendens* with smaller and less brightly coloured stromata and slightly larger ascospores. Re-descriptions of *H. tremelloides* as '*H. argillacea*' by Medardi (1999) and Klok (2006) without reference to the holotype may have been based on Ellis and Ellis (1985). The latter work is not recommended to be used for the identification of *Hypocrea* species. It is also uncertain, which species Petch (1938, p. 291) had seen when he redescribed *H. argillacea*.

Hypocrea moravica Petr., Ann. Mycol. 38: 260 (1940). Fig. 91

Anamorph: ***Trichoderma moravicum*** Jaklitsch, **sp. nov.** Fig. 92

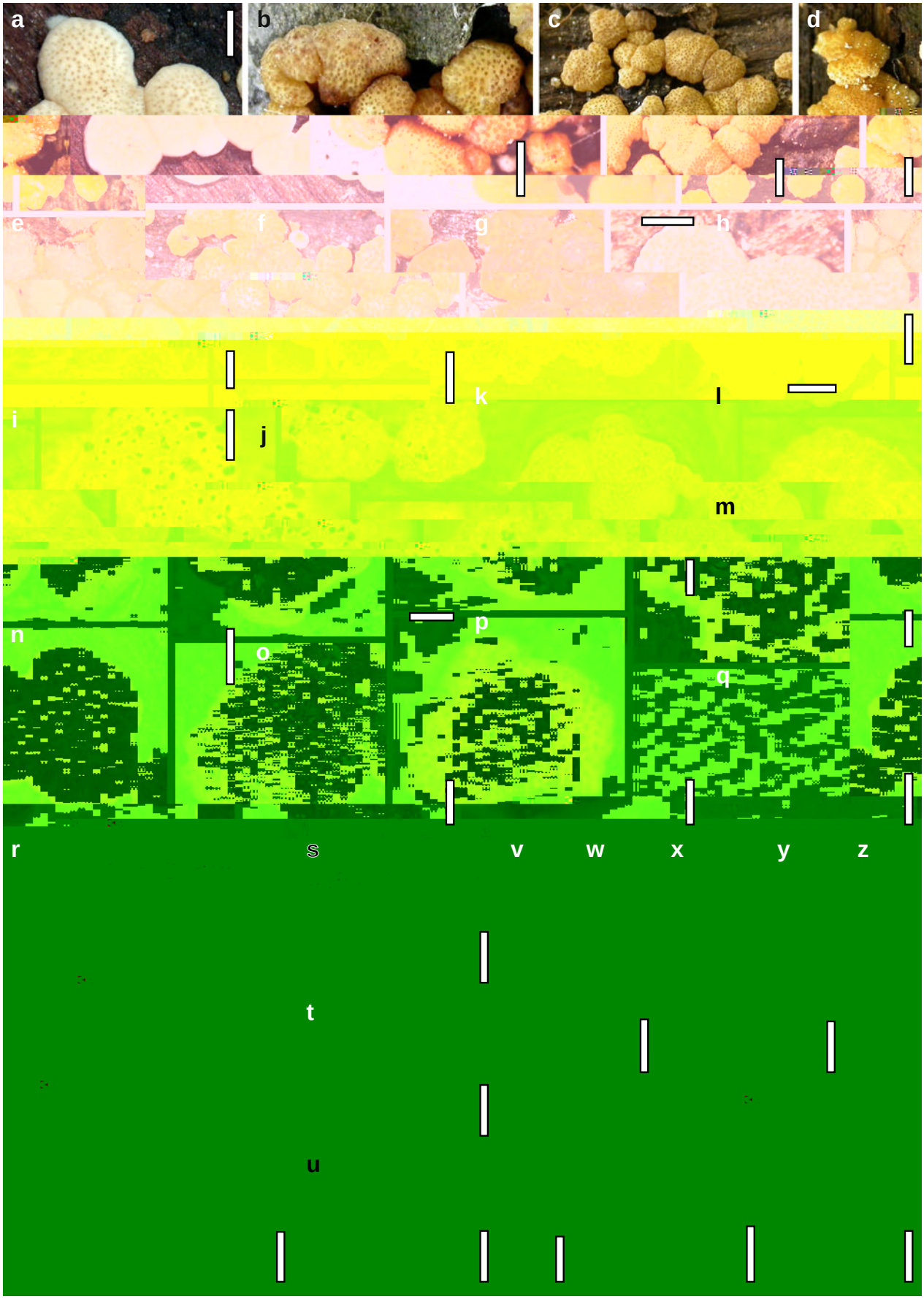
MycoBank MB 516691

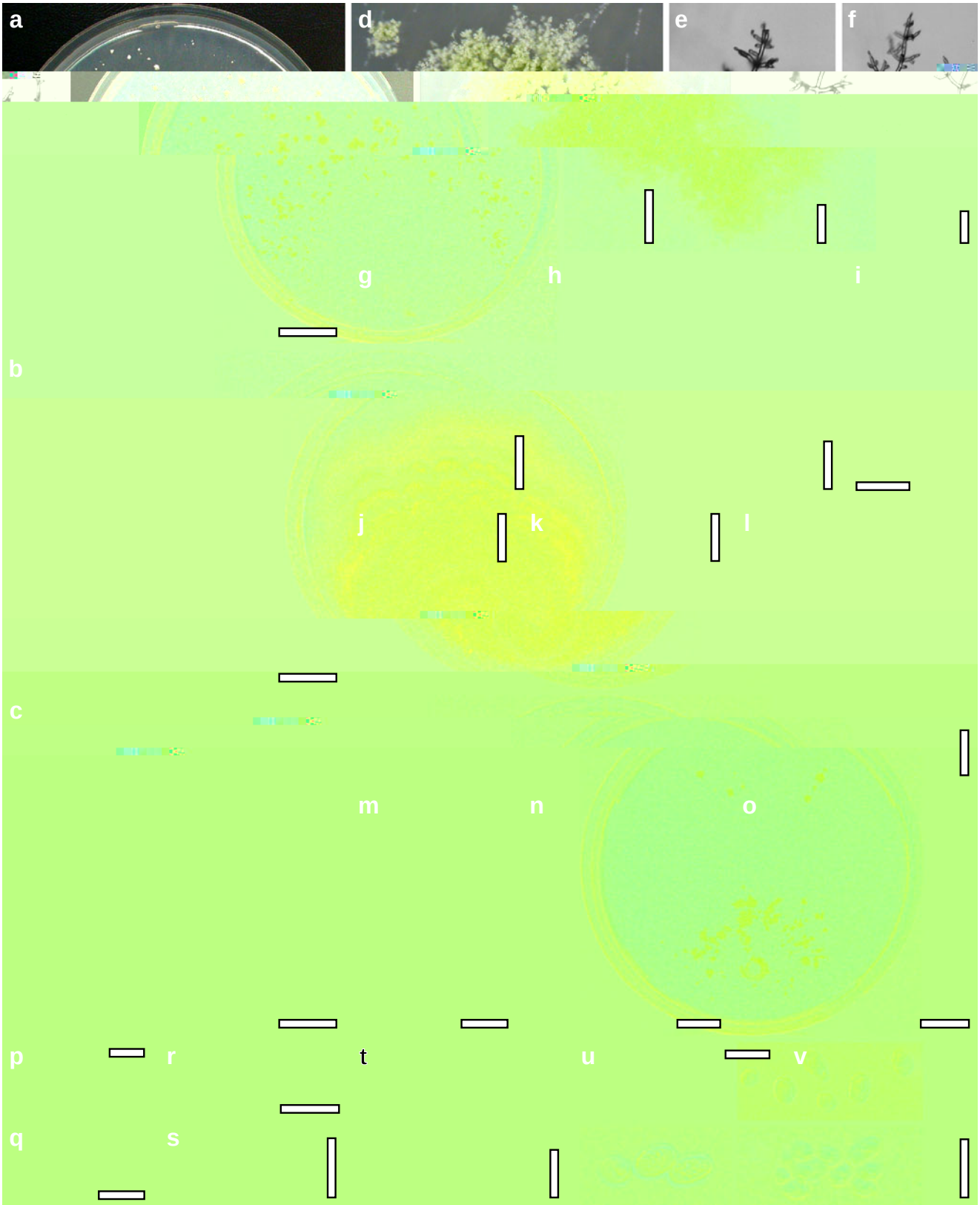
Anamorphosis *Hypocreae moravicae*; conidiophora typo pachybasii, fertilia per totam longitudinem, in pustulis viridibus granulosis in agaris CMD et SNA disposita. Phialides divergentes, variabiles, lageniformes vel ampulliformes, (4–)5–10(–20)×(2.8–)3.0–4.0(–4.8) μm. Conidia pallide viridia, ellipsoidea vel subglobosa, partim oblonga, glabra, (2.5–)3.0–5.0(–6.8)×(2.0–)2.5–3.0(–3.7) μm.

Stromata when fresh 0.5–4(–18) mm diam, 0.5–1.5 mm thick, pulvinate, broadly attached, edges free, sometimes with white mycelium around the base. Outline circular, angular or irregular. Surface smooth or finely tubercular. Ostiolar dots numerous, distinct and conspicuous, brown, determining the overall colour; more indistinct, watery and olive when immature. Stromata first white, turning pale yellow, brown dots appearing on yellow stroma surface, resulting in pale yellow, greyish orange, brown-orange, yellow-brown, brown, finally reddish-brown, 2A3, 3–4A3–4, 4A5, 5B5, 6–7CE6–8; colour change to brown enhanced by drying.

Stromata when dry (0.3–)0.5–2.5(–4)×(0.2–)0.5–2(–3) mm, 0.2–0.4(–0.6) mm thick (*n*=75), solitary, gregarious, often densely aggregated in large numbers; pulvinate or discoid, broadly attached, often with white mycelium at the base; when young/immature sometimes effuse, to 18 mm long, effluent, i.e. breaking up into several part-stromata. Outline circular, angular, oblong or irregular with wavy or indented margin. Sides often vertical, edges free, rounded

Fig. 91 Teleomorph of *Hypocrea moravica*. **a–f**. Fresh stromata (**a**. ▶ immature). **g–o**. Dry stromata (**g, j**. immature. **h**. effluent, with granular covering). **p**. Stroma in 3% KOH after rehydration. **q**. Stroma surface in face view. **r**. Perithecium in section. **s**. Cortical and subcortical tissue in section. **t**. Subperithecial tissue in section. **u**. Stroma base in section. **v–z**. Asci with ascospores (**y, z**. in cotton blue/lactic acid). **a, c, e, f, n–u, z**. WU 29283. **b, h, i**. WU 29286. **d, k**. WU 29282. **g**. WU 29287. j. WU 29284. **l, x**. WU 29288. **m, v**. holotype K 154039. **w, y**. WU 29281. Scale bars: **a, g, p**=0.6 mm. **b–f, h, i**=1 mm. **j, k, m**=0.2 mm. **l, n, o**=0.4 mm. **q, v–z**=10 μm. **r**=30 μm. **s, t**=20 μm. **u**=15 μm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w
x
y
z


a
d
e
f
g
h
i
b
j
k
l
c
m
n
o
p
r
t
u
v
q
s

◀ **Fig. 92** Cultures and anamorph of *Hypocrea moravica*. **a–c**. Cultures (**a**. on CMD, 14 days; **b**. on PDA, 21 days; **c**. on SNA, 28 days). **d**. Conidiation pustule on CMD after 14 days. **e–g**. Conidiophores on growth plates (9–10 days; **e, f**. CMD, **g**. SNA). **h–o**. Conidiophores (CMD, 8–12 days; **h**. young, showing curvatures). **p**. Intercalary chlamydospore (SNA, 35 days). **q–s**. Conidia (CMD, 8–12 days). **t–v**. Phialides (CMD, 12 days). **a–v**. All at 25°C. **a–d, f, g, p**. C.P.K. 954. **e**, **l, m, o, r–v**. CBS 120539. **h–k, n, q**. C.P.K. 2492. *Scale bars* **a–c**= 15 mm. **d**=0.4 mm. **e**, **f**, **h**=30 μm. **g**, **k**=25 μm. **i**, **j**, **l, n**, **o**=15 μm. **m**, **r–v**=10 μm. **p**, **q**=5 μm

or sharp. Surface first smooth, becoming tubercular by projecting perithecia or convex ostiolar dots, smooth between tubercles, sometimes with fine whitish granular covering in addition to spore deposits. Ostiolar dots (24–)37–75(–102) μm (*n*=110) diam, conspicuous, well-defined, densely disposed, brown, circular, plane or convex, with barely visible pale to hyaline centres. Stromata white when immature and without ostioles, centre compacting and becoming pale cream or yellowish; then diffuse pale olive spots appearing; later colour determined by brown ostiolar dots in various shades on a yellow background, appearing pale yellow, 4A2–5, pale to greyish orange, 5AB3–6, 6B4, later dull orange-brown, yellow-brown, golden-, light- or medium brown, 5CD6–7, 6CD4–8, finally reddish brown to dark brown 7(–8)CD4–6, 7–8EF5–8. Spore deposits white to yellow. Rehydrated stromata pulvinate with considerably increased size, smooth, bright yellow with orange-brown ostiolar dots; in 3% KOH turning reddish-orange; ostiolar dots dark reddish-brown.

Stroma anatomy: Ostioles (50–)58–80(–94) μm (*n*=30) long, plane or projecting to 12 μm, (15–)22–36(–45) μm wide at the apex internally (*n*=30), without differentiated apical cells. Perithecia (130–)190–250(–260)×(82–)115–195(–240) μm (*n*=30), flask-shaped or globose, numerous, often densely disposed and laterally compressed; peridium (11–)13–21(–27) μm wide at the base, (5–)7–13(–15) μm (*n*=30) at the sides; orange in KOH. Cortical layer (12–)16–25(–30) μm (*n*=30), a dense yellow *t. angularis-globulosa* of thin-walled isodiametric cells (3–)5–11(–16)×(3–)4–7(–11) μm (*n*=90) in face view and in vertical section, orange in KOH, at least around the ostiole; without hairs on the surface, but often undifferentiated hyphae on stroma sides present. Subcortical tissue a *t. intricata* of hyaline thin-walled hyphae (2–)3–6(–8) μm (*n*=65) wide, sometimes mixed with coarse angular hyaline cells. Subperithecial tissue a *t. epidermoidea* of coarse, thin-walled, angular, oblong or lobed hyaline cells (6–)9–30(–48)×(4–)7–16(–25) μm (*n*=60), interspersed with some wide, mostly vertically oriented hyphae; cells slightly smaller towards the base; basal tissue dense, particularly at the area of attachment to the substrate, of angular to globose cells with walls to 1 μm thick, intermingled with thick-walled hyphae 3–6(–8) μm (*n*=60) wide. Asci (66–)75–95(–109)×(4.8–)5.0–6.0(–6.5) μm, stipe (1–)5–15(–24) μm long (*n*=100). Ascospores hyaline, sometimes becoming yellow or orange after ejection, verruculose or spinulose; cells dimorphic; distal cell (3.0–)3.5–4.5(–5.3)×(2.6–)3.2–4.0(–4.6) μm, l/w (0.9–)1.0–1.3(–1.8) (*n*=155), (sub-)globose, less commonly wedge-shaped; proximal cell (2.8–)4.0–5.5(–7.8)×(2.2–)2.7–3.3(–3.8) μm, l/w (1.0–)1.2–2.0(–3.3) (*n*=155), oblong or subglobose.

Cultures and anamorph: optimal growth at 25°C on all media; limited growth at 30°C, no growth at 35°C.

On CMD after 72 h 5–8 mm at 15°C, 12–13 mm at 25°C, 1–7 mm at 30°C; mycelium covering the plate after 12–17 days at 25°C. Colony hyaline, thin, circular, dense, shiny, with little mycelium on the surface, indistinctly zonate; hyphae thin with little difference in width; surface hyphae minutely tuberculate or submoniliform. Aerial hyphae scant, short, erect, loosely disposed, simple, becoming fertile. Autolytic activity absent or inconspicuous. No coilings noted. No diffusing pigment seen; odour indistinct or slightly mushroomy. Chlamydospores rare. Conidiation noted after 4–6 days on scant short solitary conidiophores with minute wet conidial heads 10–40(–50) μm diam, and mostly dry in shrubs becoming visible as white floccules, growing to circular or oblong pustules 1–2.5 mm diam, confluent to 5–7 mm length, spreading across the plate; after 6–11 days turning light green, 27DE4–6, 28CE5–7(–8), often with white margin; pustule surface appearing granular due to condensed whorls of phialides. Conidiation sometimes also within the agar in aged cultures. Conidiophores (after 10–12 days) usually on short stipes with mostly asymmetrical branching, with two to several primary branches often dichotomously branched at several levels. Stipe and primary branches 6–10 μm wide, thick-walled (to 1.5 μm), with coarsely wavy outer wall; further branches thin-walled and 2.5–5 μm wide; origin of phialides often thickened, sometimes globose, to 7 μm wide. Branches often curved or sinuous. Peripheral conidiophores short (30–100 μm), variable, either with long sterile stretches and short irregular terminal heads, or regularly symmetrical with densely arranged, paired, 1–2 celled branches at right angles or slightly inclined upwards; often branches of similar length on all levels. Production of conidia starting within the pustule. Phialides solitary along terminal branches in short intervals and in whorls of 3–5(–6). Phialides (4–)5–10(–20)×(2.8–)3.0–4.0(–4.8) μm, l/w 1.3–3.0(–6.3), (1.5–)2.3–3.2(–4.0) μm wide at the base (*n*=70), variable, ampulliform or lageniform, with short necks, widest mostly below the middle; straight or curved upwards and inequilateral, sometimes sigmoid, typically narrowly lageniform on younger and more simple conidiophores; terminal phialides in extension of main axes often appearing longer, but separated from the origin of the whorl by an additional cell. Conidia (2.5–)3.0–5.0(–6.8)×(2.0–)2.5–3.0(–3.7) μm, l/w (1.1–)1.2–1.6(–2.0) (*n*=80), pale greenish, variable, ellipsoidal or subglobose, sometimes oblong, smooth, with

1–2 guttules; scar indistinct or narrowly projecting; aggregating in chains in age. At 15°C conidiation abundant in large green, 27–28CD4–7 to 27E4–8, pustules aggregating to 10 mm length. At 30°C either hyphae dying after a few days or colony dense, downy, with growth slowing down after 1 weeks; autolytic activity conspicuous, excretions yellow; conidiation effuse, colourless.

On PDA after 72 h 5–8 mm at 15°C, 8–9 mm at 25°C, 1–3 mm at 30°C. Growth limited, typically stopping before covering the plate. Hyphae narrow, all of similar width, surface hyphae finely wavy. Colony compact, dense, flat, zonate. Central zone circular, broad, opaque, farinose to finely granulose, first white to yellowish, 3A3–4, becoming light greenish after 7–10 days due to conidiation, with rosy margin, followed by several farinose zones with wavy outline, light green, 28A3–4, 28B4, 28C4–5, 27AB2–3, with rosy to reddish-brown tones, 5B3, 6AB3, 6B4, 6A2–3, 7B4. Reverse becoming yellow with rosy tones from the centre, spreading across the whole plate, finally turning dark brown, (6–)7–8F5–8; pigment diffusing into the agar; also present within hyphae. Aerial hyphae scant, loosely disposed, becoming fertile. Autolytic activity appearing as numerous minute yellowish-brown excretions mainly along hyphae; no coilings noted. Odour indistinct to mushroomy, reminiscent of the mushroom *Sarcodon imbricatus*. Conidiation noted from 2 to 3 days, effuse, starting around the plug on short erect conidiophores in a dense lawn spreading across the colony, growing to densely branched granules to 1 mm diam in the centre; mostly dry, first white, becoming green. Phialides short, spiny, inclined upwards, curved to sinuous. At 15°C growth limited; surface hyphae widely curved to coiled, forming broom-like structures with pegs or moniliform hyphae; colony becoming yellowish-brown; with little effuse conidiation. At 30°C growth limited; hyphae curly, dying soon, sometimes good growth after a slow initial phase; colony zonate; with numerous minute autolytic excretions, little effuse conidiation; centre yellow to reddish-brown, 5AB5 to 9–10F7–8.

On SNA after 72 h 5–7 mm at 15°C, 9–11 mm at 25°C, 1–4 mm at 30°C; mycelium covering the plate after 1 m at 25°C. Colony similar to CMD, denser, silky, not zonate, margin more irregular, wavy to lobed. Surface hyphae minutely tuberculate, with little difference in width, degenerating and appearing empty in aged cultures. Aerial hyphae inconspicuous, but more abundant than on CMD, erect, thin, loosely disposed, long and several mm high towards the margin, becoming fertile. No autolytic activity and coilings noted. No pigment, no distinct odour noted. Conidiation noted from 4 to 5 days, on white shrubs or granules appearing on the plug margin, growing and condensing into an annular continuum with a granular surface, becoming macroscopically pale green 28DE5–7 after 6–8 days. Additional large granular pustules to 7 mm long formed in the centre, later also in a more distal concentric zone or irregularly disposed, pale green, 28–29CD4–6, 27–28E4–6; some conidiation also on erect aerial hyphae without structural difference to pustulate conidiation. Conidiation starting within pustules, dense but transparent; marginal branches first appearing as straight to sinuous elongations, becoming fertile, forming mostly broad pachybasium-like conidiophores. Tufts 0.3–4.5 mm diam, confluent to oblong pustules 7×3 mm. Phialides short, conidia dry or in minute wet heads <20 μm diam, aggregating in chains. Chlamydospores noted after (2–)3 weeks, infrequent, 6–14(–23)×(3–)4–6(–8) μm, l/w 1.0–2.7(–4.8) (n=33), variable, oval, clavate, rectangular, ellipsoidal, etc., mostly intercalary, size strongly depending on hyphal width. At 15°C central granulose tufts coalescing to 10 mm, becoming green 27D4–6, 28AB4, 28D4–6; dry conidiation abundant in tufts with mostly fertile, straight to sinuous elongations; terminal and intercalary chlamydospores noted. At 30°C growth often limited; colony dense, silky; conidiation effuse, remaining colourless.

Habitat: usually in large numbers on moist (medium- to) well-decayed wood and bark.

Distribution: Europe (Austria, Czech Republic, Germany)

Holotype: **Czech Republic**, Mährisch Weißenkirchen, Podhorn, on stump of *Fagus sylvatica* (determined by wood microscopy), on light, well-decayed wood, soc. hyphomycete, effete pyrenomycete, Oct. 1920, F. Petrak, **K(M) 154039**. ***Epitype*** designated here to establish the correct relationship of teleomorph, anamorph and gene sequences: **Austria**, Niederösterreich, Wien-Umgebung, Mauerbach, Friedhofstraße, MTB 7763/1, 48°15′08″ N, 16°10′34″ E, elev. 380 m, on moist decorticated branch of *Carpinus betulus* 9–10 cm thick, 10 Sep. 2005, W. Jaklitsch W.J. 2850 (**WU 29283**, ex-epitype culture CBS 120539=C.P.K. 2418). ***Holotype*** of *Trichoderma moravicum* isolated from WU 29283 and deposited as a dry culture with the epitype of *H. moravica* as **WU 29283a**.

Other specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, Stariwald, MTB 9452/4, 46°32′51″ N, 14°25′29″ E, elev. 580 m, on decorticated branch of *Fagus sylvatica* 5 cm thick; soc. *Nemanis serpens*, effete pyrenomycete, Corticiaceae, *Mollisia* sp.; holomorph, 16 Sep. 2005, W. Jaklitsch, W.J. 2855 (WU 29284, culture C.P.K. 2419). Trieblach, Drau-Auen, below Kucher, MTB 9452/2, 46°33′12″ N, 14°25′01″ E, elev. 400 m, on partly decorticated branch of *Corylus avellana*, on wood, bark and stromata of *Hypoxylon fuscum*, soc. Corticiaceae, 14 Oct. 2006, W. Jaklitsch, W.J. 3021 (WU 29286, culture C.P.K. 2489). Niederösterreich, Hollabrunn, Hardegg, National Park Thayatal, at the traverse of the Umlaufberg (Hardegg side), MTB 7161/3, 48°50′40″ N, 15°53′33″ E, elev. 300 m, on fallen decorticated log of ?*Alnus glutinosa* 20 cm thick, on

strongly decayed crumbly wood, soc. effete pyrenomycetes, 1 Sep. 2005, H. Voglmayr, W.J. 2832 (WU 29282, culture C.P.K. 2411). Mödling, Wienerwald, Kaltenleutgeben, along brook Dürre Liesing between Am Brand and Stangau, MTB 7862/4, 48°06′45″ N, 16°08′43″ E, elev. 450 m, on decorticated branches of *Alnus glutinosa* 5–20 cm thick, on wood, soc. *Arcyria* sp., *Chlorociboria aeruginascens*, *Orbilia delicatula*, *Steccherinum ochraceum*, effete pyrenomycete, Corticiaceae, 22 Oct. 2006, W. Jaklitsch & H. Voglmayr, W.J. 3025 (WU 29287, culture C.P.K. 2492). Oberösterreich, Schärding, St. Willibald, riverine forest near Aichet, MTB 7648/1, 48°21′17″ N, 13°41′01″ E, elev. 400 m, on partly decorticated, well-decayed branch of *Alnus glutinosa*, on wood and bark, soc. *Chaetosphaeria ovoidea*, *Tubeufia cerea*/effete pyrenomycete, *Diatrypella cf. verrucaeformis* in the bark, 26 Oct. 2005, H. Voglmayr, W.J. 2867 (WU 29285, culture C.P.K. 2431); same locality, on branch of *Alnus glutinosa*, soc. *Orbilia delicatula*, effete pyrenomycete, hyphomycetes, 27 Oct. 2006, H. Voglmayr, W.J. 3031, WU 29288. Steiermark, Weiz, Laßnitzthal, opposite to the Arboretum Gundl across the road, MTB 8959/2, 47°04′ 17″ N, 15°38′34″ E, elev. 410 m, on moist lower side of decorticated, well-decayed branch of *Fagus sylvatica* 6 cm thick, on bare ground beside a small brook, soc. various hyphomycetes, 7 Sep. 2003, W. Jaklitsch, W.J. 2388 (WU 29281, culture C.P.K. 954). **Germany**, Baden Württemberg, Schwarzwald, SW Fixenhof at Welschenstainach, MTB 7714/1, elev. 480 m, on decorticated branch of *Fraxinus excelsior*, 19 Oct. 2008, L. Krieglsteiner (WU 29289). Niedersachsen, close to Wolfenbüttel, "Lechlumer Holz", MTB 3829/1, on decorticated branch of *Fagus sylvatica*, 13 Sep. 2008, L. Krieglsteiner (culture C.P.K. 3566).

Notes: *Hypocrea moravica* is apparently the most common species in Central Europe of those forming yellow pulvinate stromata lacking an initially rosy or reddish stage. The teleomorph can be mistaken for a number of other species, e.g. *Hypocrea lutea*, and was regarded a synonym of it by Doi (1972). *H. lutea* differs by smaller and paler stromata and a distinctly gliocladium-like anamorph. *H. argillacea* is more similar to *H. bavarica* in terms of stroma colour and ostiolar dots, but in absence of information on the natural variation of *H. argillacea*, *H. moravica* may be a synonym of that species, despite the slightly larger ascospores in *H. argillacea*. Recollection and sequencing of *H. argillacea* is necessary to ascertain this. *H. bavarica*, once even found together with *H. moravica* on the same branches, differs e.g. by smaller ascospores, usually more diffuse ostiolar dots, an effuse white-conidial anamorph and a characteristic unpleasant odour on PDA. Effuse forms of *H. moravica* are uncommon; they can be mistaken for *H. phellinicola*, which occurs on *Phellinus ferruginosus* and differs e.g. also by drying to thin crusts and a white-conidial anamorph. Stromata of species of the *Brevicompactum* clade may sometimes be similar to those of *H. moravica*. They differ e.g. by smaller cortical stroma cells and smaller and mostly paler conidia. On average, the stromata are brighter than those of *H. lutea* or species of the pachybasium core group. All these species are phylogenetically unrelated to *H. moravica*, which belongs to the *Semiorbis* clade. Conidiophores in pustules of *T. moravicum* are similar to those of the pachybasium core group, but more variable, often curved to sinuous.

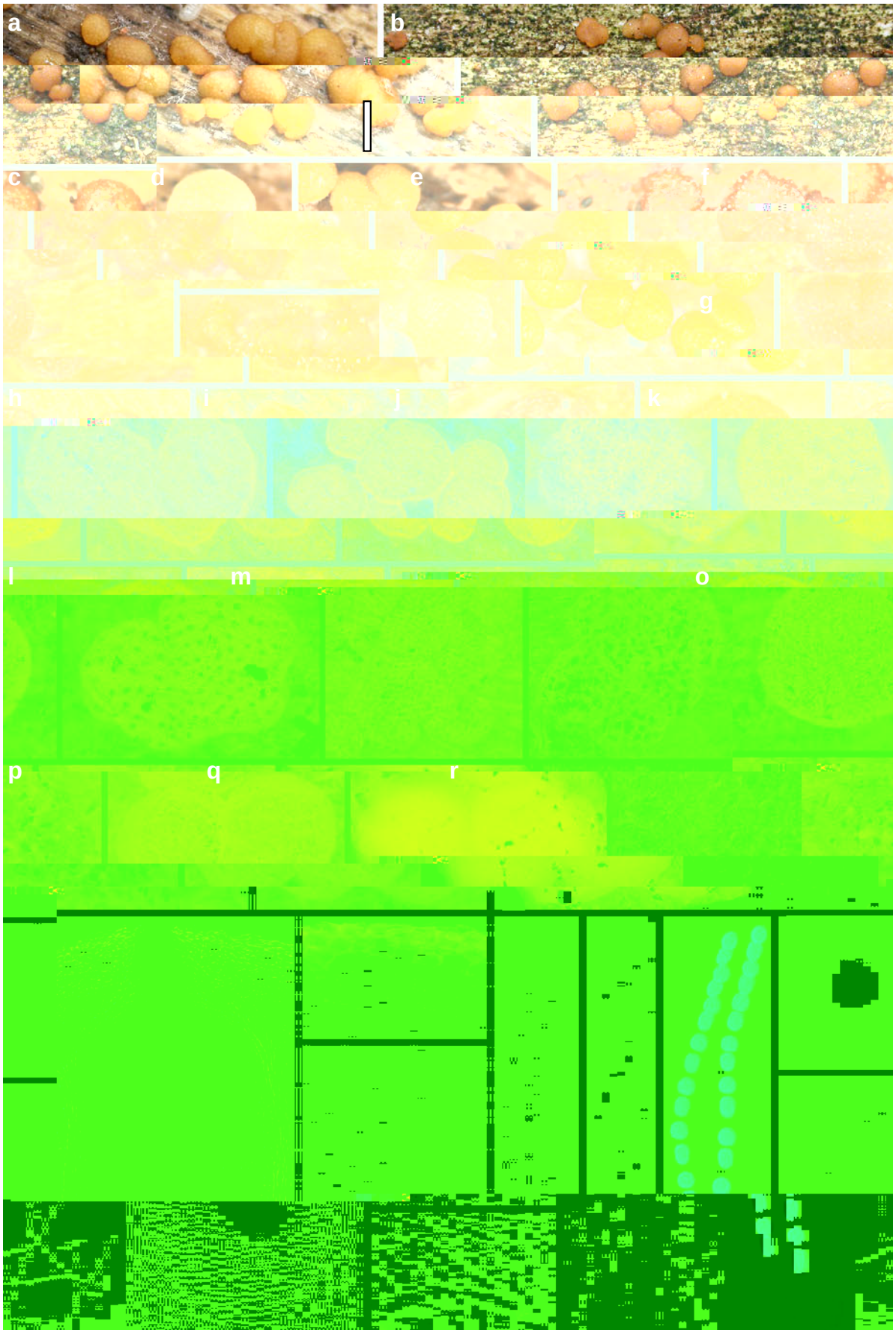
Hypocrea sambuci Jaklitsch & Voglmayr, **sp. nov.** Fig. 93
MycoBank MB 516701

Stromata in ligno putrido *Sambuci nigrae*, pulvinata, ceracea ad gelatinosa apparenter, mellea in statu humido, plane pulvinata ad discoidea, mellea vel brunnea in statu sicco. Asci cylindrici, (54–)68–82(–92)×(3.7–)4.0–5.0(–5.7) μm. Ascosporae bicellulares, hyalinae, verruculosae, ad septum disarticulatae, pars distalis (sub)globosa vel ellipsoidea, (2.8–)3.0–3.8(–4.5)×(2.5–)2.8–3.2(–3.5) μm, pars proxima oblonga vel cuneata, (3.0–)3.5–4.7(–6.0)×(2.0–)2.3–2.7(–3.2) μm.

Etymology: the epithet refers to the occurrence on *Sambucus*.

Stromata when fresh 1–2(–3) mm diam, to 1 mm thick, solitary, scattered or aggregated in small numbers, pulvinate or lenticular, broadly attached, edge free. Surface smooth or finely verruculose, appearing waxy or gelatinous. Ostioles concolorous, hardly visible when moist, with age distinct brown dots appearing. Stromata first white, later pale yellow, 4A2–4, honey-yellow, honey-brown, yellowish brown, 5CD6–8, 6CD5–7, golden–yellow to dark brown, 7E6–8, when old. Spore deposits white to yellowish.

Stromata when dry (0.4–)0.7–1.6(–2.5)×(0.3–)0.6–1.3(–2) mm, (0.12–)0.2–0.5(–0.7) mm thick (n=100), solitary, gregarious in lawns on wood, often in large numbers, aggregated only in small groups; flat pulvinate, lenticular or discoid, less commonly turbinate with short and thick, white or yellowish, glabrous or downy, sterile cylindrical base; sometimes first subeffuse, breaking up into up to ten laterally fused or densely aggregated parts, broadly attached. Outline circular, angular or oblong. Margin rounded or sharp, free, sometimes involute. Surface convex or flat, smooth, tubercular or rugose, often shiny or iridescent, sometimes glassy, but generally appearing distinctly less glassy or waxy than fresh, sometimes covered with whitish floccules when young. Ostiolar dots (20–)30–54(–80) μm (n=170) diam, often indistinct and concolorous with the stroma surface when young, later well–defined, circular or oblong in outline, plane or convex, shiny, brown, reddish brown to nearly black when old; sometimes without dots, but light, translucent perithe-


a
b
c
d
e
f
g
h
i
j
k
l
m
o
p
q
r

◀ **Fig. 93** *Hypocrea sambuci*. **a**–**h**. Fresh stromata (**a**–**c**. immature; **h**. overmature). **i**–**p**. Dry stromata (**i**–**k**. immature; **p**. overmature). **q**. Rehydrated stromata. **r**. Stromata in 3% KOH after rehydration. **s**. Stroma surface in face view. **t**. Perithecium in section. **u**. Cortical and subcortical tissue in section. **v**. Subperithecial tissue in section. **w**. Stroma base in section. **x**–**z**. Asci with ascospores (**z**. in cotton blue/lactic acid). aa. Conidiation tuft. bb. Conidiophore with phialides and conidia. **a**, **h**. WU 29465. **b, k, l, q–w**. WU 29463. **c, d, i**. WU 29467. **e–g, n**. WU 29466. **j**. WU 29468. **m, o, y, z**. WU 29462. **p, x**. WU 29464. aa, bb. C.P.K. 3718, MEA, 20°C, 29 days. *Scale bars* **a**= 1 mm. **b**=1.5 mm. **c–g**, **n**=0.6 mm. **h, k, o, q, r**, **aa**=0.4 mm. **i, j, l, m**, **p**=0.2 mm. **s, u**, **x**–**z**=10 μm. **t**, **w**=30 μm. **v**, **bb**=20 μm

cia projecting, papillate. Stromata first white, turning pale yellow, 4A3, 4B4, light honey-yellow, ochre or greyish orange, brown–orange, light brown, 5B5, 5–6CD5–8, older material mostly dark reddish brown, 7–8EF5–8. Spore deposits white to yellowish; also light honey-yellow stromata sometimes mature, i.e. with spore deposits. Rehydrated stromata thickly pulvinate, up to three times thicker than dry stromata, ochre, without ostiolar dots, but minute concolorous or lighter ostiolar openings visible under strong magnification. Reaction to 3% KOH variable, absent in young stromata, surface slightly or distinctly more orange in mature stromata; perithecia translucent, light.

Stroma anatomy: Ostioles (44–)50–66(–78) μm long, plane or projecting to 15 μm, (14–)17–27(–35) μm wide at the opening inside (*n*=30), without specialized apical cells. Perithecia (150–)170–205(–215)×(80–)100–155(–180) μm (*n*=30), flask–shaped, ellipsoidal or subglobose, *ca* nine per mm stroma length; peridium (10–)13–20(–21) μm (*n*= 30) thick at the base, (4–)8–13(–15) μm (*n*=30) at the sides, pale yellow. Cortical layer (7–)10–15(–20) μm (*n*= 30) thick, a thin, light yellow *t. angularis* of 2–3 layers of thick-walled cells (4.5–)5.5–11(–19)×(3–)4–8(–10) μm (*n* =65) in face view and in vertical section; orange in KOH; cells tending to be larger and lighter in the lateral cortex; surface smooth, glabrous. Subcortical tissue a hyaline to yellowish *t. angularis* of thin-walled cells (5–)6–13(–18)× (3–)4–8(–11) μm (*n*=30). Subperithecial tissue a (sub-) hyaline *t. angularis* of cells (6–)9–22(–31)×(4–)7–14(–18) μm (*n*=35), often smaller, compressed or yellow towards stroma base. Asci (54–)68–82(–92)×(3.7–)4.0–5.0(–5.7) μm, stipe (2–)6–15(–22) μm long (*n*=111); croziers present. Ascospores hyaline, verruculose, cells dimorphic; distal cell (2.8–)3.0–3.8(–4.5)×(2.5–)2.8–3.2(–3.5) μm, l/w 1.0–1.3(–1.6) (*n*=180), (sub)globose or ellipsoidal; proximal cell (3.0–)3.5–4.7(–6.0)×(2.0–)2.3–2.7(–3.2) μm, l/w (1.1–)1.3–1.8(–2.7) (*n*=180), oblong or wedge-shaped, less commonly subglobose.

Cultures and anamorph: Growth slow on CMD, MEA, PDA and SNA.

On MEA colony not reaching more than 12 mm at 20°C after a month. Colony hyaline or turning brown, producing white spiny tufts to *ca* 1.6 mm diam. Tufts comprising a thick long stipe with few thick, asymmetric primary branches, both 5–6.5(–7.5) μm wide, the latter unbranched or bearing some side branches. Side branches/conidiophores tapering to (2–)2.5–3(–5) μm wide terminally, to 6.5 μm wide downwards, simple or branched once, typically projecting as stiff, straight, fertile elongations 0.1–0.5 mm from the tuft. All branches at acute angles, only rarely 1–2 celled rectangular branches. Phialides produced on 1–6 celled branches, solitary or in whorls of 2–3 (to four in pseudo-whorls). Conidia formed in small numbers. Phialides (3–)10–28(–37)×(1.8–)2.5–3.5(–4.5) μm, l/w (1.7–)3.7–8.2(–10.9), (1.2–)2.0–3.3(–4.0) μm wide at the base (*n*=30), subulate, widest below the middle. Conidia (4.8–)6.0–8.7(–10)×(2.8–)3.7–5.8(–7.3) μm, l/w (0.9–)1.2–2.0(–2.4) (*n*=30), variable, ellipsoidal, oblong, rhomboid etc., hyaline, smooth, finely multiguttulate, scar indistinct. Sterile, yellowish- to dull reddish brown, pulvinate stromata 1–3×0.9–2.3 mm produced on MEA after 50 days at 20°C.

Habitat: on decorticated branches of *Sambucus nigra*.

Distribution: Europe (Austria, Germany, Italy)

Holotype: **Austria**, Steiermark, Graz-Umgebung, Mariatrost, Wenisbucher Straße, left side shortly before the main crossing in the forest, MTB 8858/4, 47°06′40″ N, 15°29′ 11″ E, elev. 470 m, on decorticated branches of *Sambucus nigra* 1–2 cm thick on the ground, on moist wood, partly attacked by a white hyphomycete, soc. green *Trichoderma* sp., moss, algae, greyish brown Corticiaceae, black debris, 20 Aug. 2004, W. Jaklitsch, W.J. 2612 (**WU 29463**).

Other specimens examined: **Austria**, Kärnten, Klagenfurt Land, St. Margareten im Rosental, boggy area behind Bauhof Jaklitsch heading to Trieblach, MTB 9452/4, 46°32′ 29″ N, 14°25′40″ E, elev. 580 m, on decorticated branches of *Sambucus nigra* 1–1.5 cm thick, on wet wood, soc. hyphomycete, 19 Aug. 2004, W. Jaklitsch, W.J. 2610 (WU 29462).

Same village, at the brook Tumpfi (upper part), MTB 9452/4, 46°32′34″ N, 14°25′29″ E, elev. 570 m, on decorticated, well-decayed branches of *Sambucus nigra* 0.5–2 cm thick, partly on and soc. *Hyphodontia sambuci*, soc. white and black mould, effete *Lophiostoma* sp., etc., 13 Oct. 2006, W. Jaklitsch, W.J. 3018 (WU 29468). Same village, at the brook Tumpfi (lower part), MTB 9452/2, 46° 32′59″ N, 14°25′50″ E, elev. 560 m, on decorticated branches of *Sambucus nigra* and *Clematis vitalba*, soc. *Hyphodontia sambuci*, 9 July 2007, W. Jaklitsch, W.J. 3119 (WU 29469). Niederösterreich, Baden, Berndorf, Großer Geyergraben at Steinhof, MTB 8062/3, 47°56′08″ N, 16° 04′33″ E, elev. 360 m, on decorticated branches of Sambucus nigra, soc. algae, mud, 8 Oct. 2005, H. Voglmayr, W.J. 2860 (WU 29466). Hernstein, Grillenbergtal at the Veitsauer brook, shortly after Grillenberg, MTB 8062/3, 47°55′23″ N 16°04′35″ E, elev. 350 m, on

decorticated branches of *Sambucus nigra*, soc. moss, old pyrenomycete, 16 Sep. 2006, H. Voglmayr, W.J. 2973 (WU 29467). Hollabrunn, Hardegg, NP Thayatal, at the Bossengraben, alluvial–like forest stretch, MTB 7161/3, 48°50′42″ N, 15°53′00″ E, elev. 300 m, on decorticated branches of *Sambucus nigra*, on wood, soc. moss, effete *Diaporthe* sp., *Hypomyces* anamorph, Corticiaceae, green pachybasium-like *Trichoderma*, 1 Sep. 2005, H. Voglmayr, W.J. 2831 (WU 29464). **Germany**, Baden Württemberg, Karlsruhe, Heidelberg, northern shore of the river Neckar, at the Haarlass, MTB 6518/34, on decorticated branch of *Sambucus nigra*, soc. *Trichoderma cf. cerinum*, 28 July 2009, M. Bemmann (WU 29103, culture C.P.K. 3718). Bavaria, Starnberg, Tutzing, Erling, Hartschimmel area, MTB 8033/1, 47°56′35″ N, 11°10′51″ E, elev. 700 m, on decorticated branches of *Sambucus nigra* 10–12 cm thick, on wet wood, soc. moss, *Trichoderma harzianum*, brown rhizomorphs, effete pyrenomycete, 3 Sep. 2005, W. Jaklitsch, W.J. 2837 (WU 29465). **Italy**, Apulia, Foggia, Gargano, Foresta Umbra, roadside of SP52bis close to Monte Nicola, 41°48′45″ N, 16°00′17″ E, elev. 670 m, on decorticated branches of *Sambucus nigra* 1–2 cm thick in leaf debris, 21 Nov. 2009, H. Voglmayr & W. Jaklitsch (WU 30191, culture S 94=CBS 126958).

Notes: *Hypocrea sambuci* is well characterised by its occurrence on decorticated branches of *Sambucus nigra*, by minute fresh stromata that appear waxy or gelatinous, similar to those of *H. tremelloides*, and flat pulvinate to discoid dry stromata that often look like a miniature of *H. subalpina*. *H. tremelloides* differs e.g. by incarnate stromata that are typically densely aggregated in large groups, and by faster growth at higher temperatures. Stromata of *H. sambuci* are usually accompanied by different green-conidial species of *Trichoderma*, such as *T. harzianum* or *T. cerinum*.

Several attempts to prepare a culture under standard conditions failed, because the germ tubes died shortly after germination. Only one specimen (WU 29103) yielded an unstable culture (C.P.K. 3718) upon ascospore isolation on CMD at 20°C. The short description above is based on this culture. Conidiophores are similar to those of *T. tremelloides*, albeit somehow simpler and more regular in structure than the latter. It has not yet been possible to obtain the sequence of *tef1* introns of *H. sambuci*, due to priming issues. Other sequences were obtained using DNA extracted from stromata (WU 29467) and from the culture C.P.K. 3718. ITS, *rpb2* and *tef1* exon sequences show that *H. sambuci* is phylogenetically distinct from, but closely related to, *H. tremelloides*.

Hypocrea schweinitzii (Fr. : Fr.) Sacc., Syll. Fung. 2: 522 (1883a). Fig. 94

≡ *Sphaeria schweinitzii* Fr. : Fr., Elench. Fungorum 2: 60 (1828).

= *Sphaeria rigens* Fr., Elench. Fung. 2: 61 (1828).

≡ *Hypocrea rigens* (Fr. : Fr.) Sacc., Michelia 1: 301 (1878).

= *Sphaeria lenta* Schwein., Schriften Naturf. Ges. Leipzig 1: 4 (1822).

= *Sphaeria contorta* Schwein., Trans. Amer. Phil. Soc. II, 4 (2): 194 (1832).

≡ *Hypocrea contorta* (Schwein.) Berk. & M.A. Curtis, Grevillea 4: 14 (1875).

= *Hypocrea atrata* P. Karst., Mycol. Fenn. 2: 207 (1873).

= *Hypocrea repanda* Fuckel, Symb. Mycol. Nachtr. 1: 312, 3: 23 (1871).

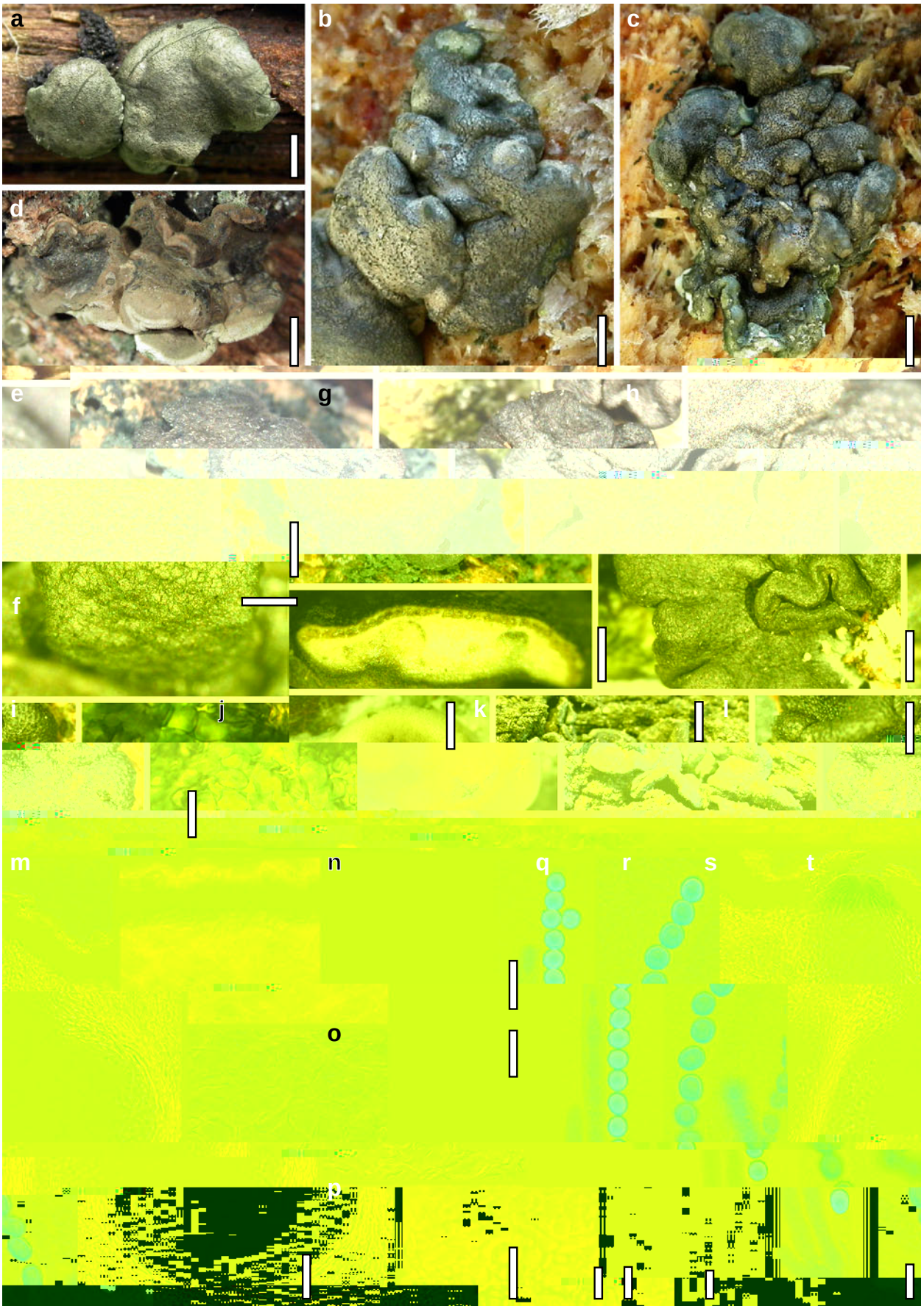
= *Hypocrea rufa* * *umbrina* Sacc., Atti Soc. Venet.-Trent. Sci. Nat., Padova 4: 124 (1875).

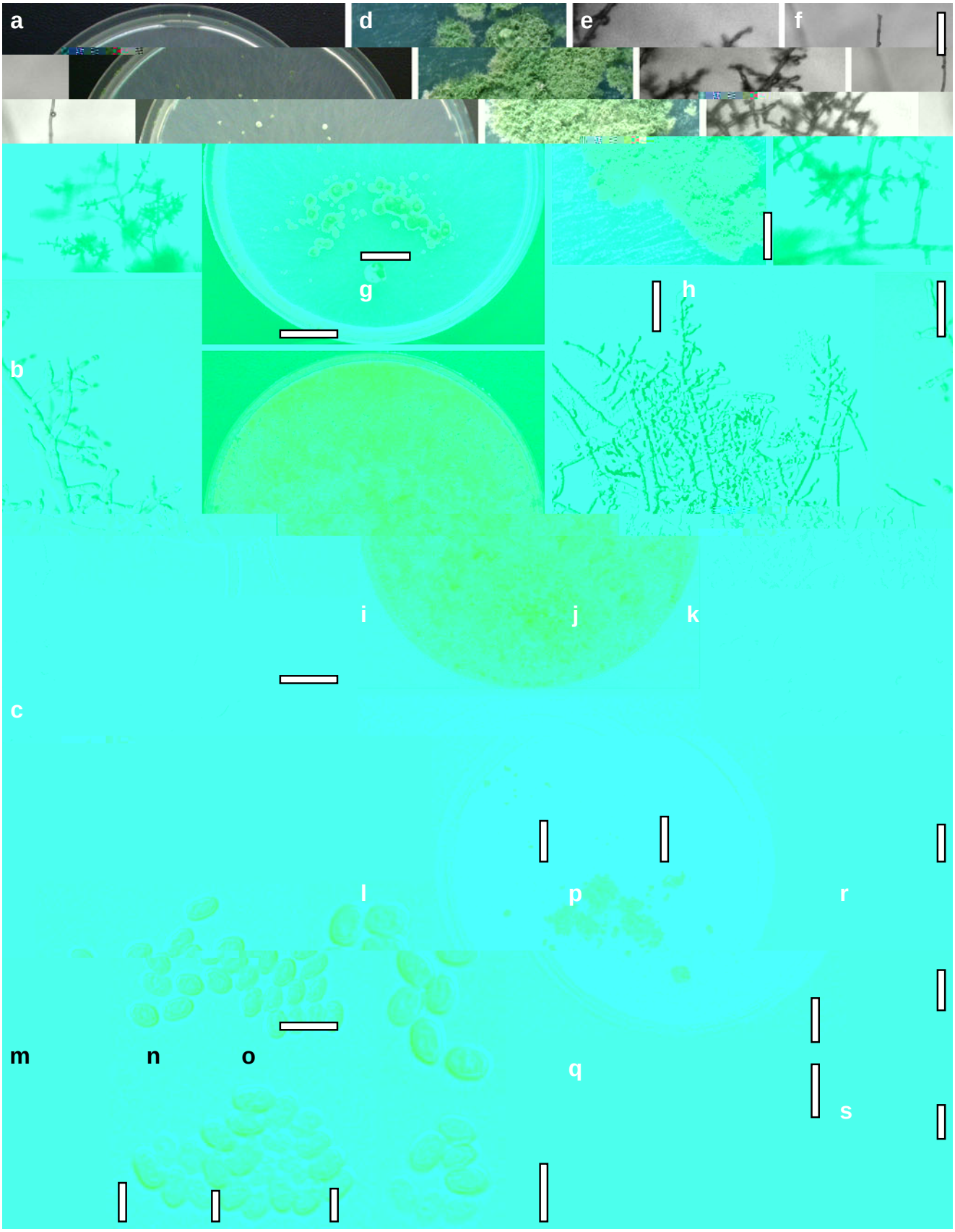
Anamorph: ***Trichoderma citrinoviride*** Bissett, Can. J. Bot. 62: 926 (1984). Fig. 95

Stromata when fresh 1–10 mm diam, 0.5–2.5 mm thick, solitary, gregarious or densely aggregated to clusters up to 17 mm diam, usually in small numbers; first pulvinate or lenticular, becoming discoid, undulate, lobed, convoluted. Outline circular, oblong or irregular. Margin sharp or rounded, often free for a large part, sometimes lighter or white when young. Surface smooth, often with a silvery covering layer with fine fissures, or finely verruculose by numerous black, pointed, slightly projecting ostioles. Stroma colour pale olive or greenish with or without white margin when young, later greyish green to dark grey or dark green, 1DE3–5, 25E4, 25F2–3, 26E2–3, 26–27F1–3(–6), 28F5–6 to 29F4.

Stromata when dry (0.8–)1.8–5.3(–9.1)×(0.5–)1.3–4(–7.1) mm (n=98), (0.3–)0.5–1.1(–1.8) mm (n=91) thick, on wood or bark or emerging through bark fissures, solitary and roundish or variably lobed or in densely aggregated, lobed, laterally fused clusters or irregular masses with several attachment areas; variable in shape, pulvinate, lenticular, turbinate, discoid, often lobed, undulate to irregularly folded or distorted by mutual pressure; broadly or more commonly narrowly attached, with often a large portion of the stroma free. Margin mostly free, sharp or rounded, sometimes involute, concolorous with the surface, whitish downy when young. Lower free side concolorous, often brown to black downy. Surface smooth or finely tubercular due to the ostioles or with delicately fissured,

Fig. 94 Teleomorph of *Hypocrea schweinitzii*. **a–c**. Fresh stromata (**a**. ▶ immature). **d, e, g–j**. Dry stromata (**d, e**. immature; **e**. with anamorph; **i**. stroma initial). **f, k**. Rehydrated stromata (**f**. in section; **k**. in face view). **l**. Stroma surface in face view. **m**. Perithecium in section. **n**. Cortical and subcortical tissue in section. **o**. Subperithecial tissue in section. **p**. Non-attached stroma base in section. **q–t**. Asci with ascospores (**s, t**. in cotton blue/lactic acid). **a**. WU 29473. **b, c, r**. WU 29471. d**, e**. WU 29472. **g**. WU 29476. **h, i**. WU 29475. **k–q, s**. WU 29470. **f, j**. PRM (leg. Pouzar). **t**. WU 29474. Scale bars: **a**, **e–g**= 1 mm. **b**, **i,** k=0.7 mm. **c**, **d**=1.5 mm. **h**=0.4 mm. **j**=2.5 mm. **l**= 10 μm. **m**=20 μm. **n–p**=15 μm. q–**t**=5 μm


a
b
c
d
e
g
h
f
i
j
k
l
m
n
q
r
s
t
o
p


a
d
e
f
g
h
b
i
j
k
c
l
p
r
m
n
o
q
s

◀ **Fig. 95** Cultures and anamorph of *Hypocrea schweinitzii* (= *T. citrinoviride*). **a–c**. Cultures after 7 days (**a**. on CMD. **b**. on PDA. **c.** on SNA). **d**. Conidiation tufts (SNA, 6 days). **e, f**. Conidiophores on tuft margins on growth plates (**e**. tree-like side branch on main axis; **f**. young main axis with sterile elongation; SNA, 4 days). **g–j**. Conidiophores (**g, i, j**. SNA, 4 days; **h**. CMD, 6 days). **k, l**. Phialides (SNA, 4 days). **m–o**. Chlamydospores (SNA, 16 days). **p–s.** Conidia (**p, r**. CMD, 6 days; **q, s**. SNA, 4 days). **a–s**. All at 25°C. **a–c, e–g, i–o, q, s**. CBS 121275. **d, h, p, r.** C.P.K. 2460. *Scale bars* a–c=15 mm. **d**=1 mm. **e**=30 μm. **f**=50 μm. **g**=20 μm. **h**, **j**=15 μm. **i**, **l**=10 μm. **k**, **m**–**q**=5 μm. **r**, **s**=3 μm

shiny, silvery-grey, greyish green, olive or brownish grey covering layer. Ostioles invisible or appearing as minute, concolorous to black, umbilicate, plane or convex dots (16–)22–42(–63) μm (*n*=115) diam with circular or oblong outline; sometimes surrounded by stellate fissures. Stroma colour initially whitish, greenish yellowish or brownish, later pale greyish green, pale olive with brown tones or grey with pale olive margin when immature, turning dark green-grey, brown-grey, dull olive, dark grey, 1–6F1–3, 2–3DE4–6, 27F2–3, 26–28F4–6, 28–30(D)EF(1–)3–6, to black, appearing carbonaceous when lacking the covering layer. Colour inside whitish, partly diffusely brownish or greenish, perithecia appearing dilute olive. Spore deposits white. Rehydrated mature stromata 10–15% larger than in dry condition, dark grey, surface more distinctly granular than dry; ostiolar dots more distinct, emerging through the covering layer; without distinct difference after addition of 3% KOH.

Stroma anatomy: Ostioles (50–)56–73(–81) μm long, plane or projecting to 12(–20) μm, (17–)23–40(–48) μm wide at the apex (*n*=30), without specialised cells; periphyses 1–2.5 μm wide, apical fascicle of periphyses dark green in lactic acid, olive in KOH. Perithecia (130–)145–177(–190)×(88–)105–140(–170) μm (*n*=30), small, crowded, flask-shaped, ellipsoidal or subglobose; peridium (10–)12–16(–17) μm (*n*=30) thick at the base, (7–)10–14(–16) μm (n=30) at the sides, dull yellowish to light brown, in KOH dull orange-brown. Cortical layer (7–)11–21(–27) μm (*n*=30) thick, an ill-defined *t. epidermoidea–angularis* of thick-walled, vertically compressed cells (3.0–)4.5–7.5(–9.0)×(1.8–)3.0–5.0(–7.0) μm (*n*=60) in face view and in vertical section; in lactic acid dark green to black, particularly around the ostioles, dense on the upper surface, partially covered by a thin, brown amorphous layer, looser, lighter, more olive to brown and more hyphal at stroma sides and base; dark brown in KOH. Subcortical tissue an ill-defined mixture of subhyaline to pale brown, thin-walled, angular cells (3–)4–11(–17)×(2–)3–8(–14) μm (*n*=30) and hyphal elements (2.0–)2.5–4.0(–4.5) μm (*n*=30) wide. Subperithecial tissue a *t. epidermoidea* of thin-walled, subhyaline to pale brownish or greenish cells (3–)6–16(–28)×(3–)5–11(–16) μm (*n*=30). Stroma base formed by thick-walled brown hyphae (3–)4–6(–8) μm (*n*=30) wide. Asci (55–)65–76(–86)×(4.4–)5.0–5.7(–6.5) μm, stipe (0–)3–12(–18) μm long (*n*=90), croziers present. Ascospores hyaline, verruculose, cells monomorphic, globose, subglobose or ellipsoidal, sometimes dimorphic in the ascus base; distal cell (2.7–)3.0–3.8(–4.5)×(2.5–)3.0–3.5(–3.7) μm, l/w (0.9–)1.0–1.2(–1.4) (*n*=160); proximal cell (3.0–)3.3–4.0(–4.8)×(2.2–)3.0–3.5(–4.0) μm, l/w (0.9–)1.0–1.3(–1.8) (*n*=160), sometimes oblong or cuneate.

Anamorph associated with stromata mostly effuse, powdery, first white, turning dull greyish green to dark green, often with white margin.

Cultures and anamorph: optimal growth at 35°C on all media. Values above 70 mm have been extrapolated by linear regression.

On CMD after 72 h 22–26 mm at 15°C, 70–72 mm at 25°C, 86–88 mm at 30°C, 93–96 mm at 35°C; mycelium covering the plate after 3–4 days at 25°C. Colony hyaline, thin, loose, with conspicuous differences in width among thick primary surface hyphae and long and thin, distally reticulate secondary hyphae. Aerial hyphae inconspicuous. Autolytic activity and coilings absent or inconspicuous. Reverse hyaline or diffusely greenish- or greyish-yellow 1B3; colour from above 2A3. Odour indistinct. Chlamydospores appearing after 2 days at 25°C, terminal and intercalary, globose, ellipsoidal, or fusoid. Conidiation noted after 2–5 days at 25°C, green after 3–6 days, earlier at higher temperatures, developing on CMD more slowly than on SNA, first scant, effuse, on aerial hyphae, soon in loose white tufts irregularly disposed or in a concentric zone, turning dull-, greyish- to dark green, 27DE4, 27–28E5–7, 26E4–5, 27F5–8, and thickly pustulate, with margins often long remaining white, some yellow pigment diffusing into the agar around the pustules; cells of surface hyphae around the pustules typically with moniliform thickenings. Tufts 1–9 mm diam and to 2 mm thick, confluent to masses of up to 11 mm long. Structure as described under SNA. At 15°C colony circular, conspicuously loose. Conidiation reduced relative to higher temperatures, on aerial hyphae and in broad, thick, loose, cottony fluffy tufts to 6×5 mm, aggregates to 17×11 mm, turning slowly green, 26E4–6. At 30°C colony dense; conidiation developing on CMD faster than on SNA, abundant in numerous, green, 28DE5–6, tufts up to 7 mm diam and 2 mm thick, arranged in concentric rings or irregularly distributed. At 35°C mycelium loose, conidiation in green, 28E5–7, tufts as at 30°C.

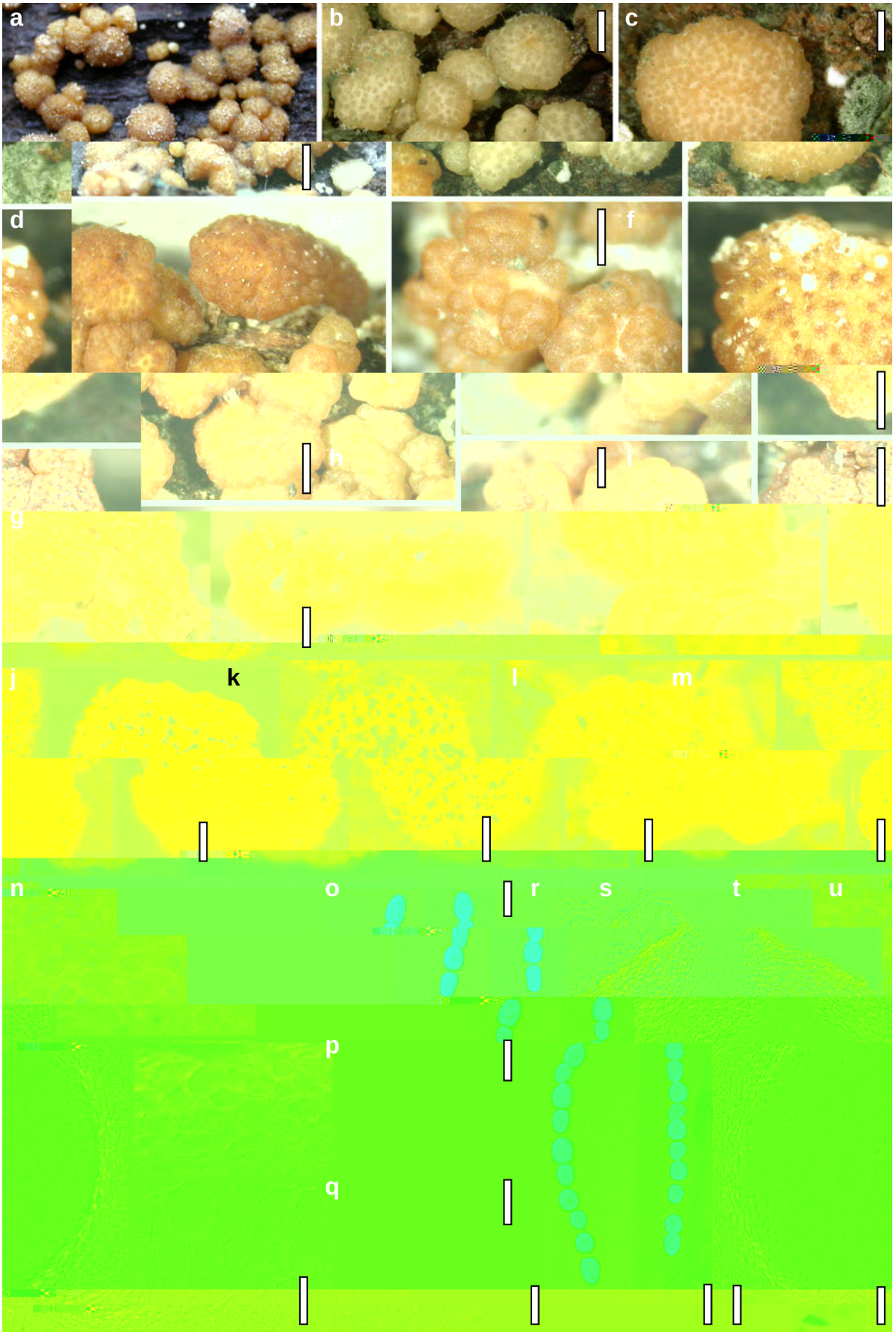
On PDA after 72 h 15–18 mm at 15°C, 54–58 mm at 25°C, 56–59 mm at 30°C, 62–64 mm at 35°C; mycelium covering the plate after 4 days at 25°C. Colony dense, with wavy to lobed margin; mycelium conspicuously differentiated in width of primary and secondary hyphae. Surface becoming indistinctly zonate, chalky, farinose to fluffy in the centre, outside distinctly radially stellate due to strand-like aggrega-

tion of surface hyphae. Aerial hyphae numerous, long and ascending several mm, sometimes nearly to the lid of the Petri dish in distal areas, forming strands and a white tomentum with coarse mesh, eventually collapsing and causing a coarsely granular surface. Tufts/pustules appearing in the tomentum, particularly in the centre, turning yellow, 1A5–6, 2AB4, to pale greenish, spreading, later confluent and eventually covering the plate nearly entirely, with large orange-brown drops on the surface. Autolytic excretions and coilings common, abundant at 35°C. Yellow diffusing pigment abundantly produced, 1A4–6, from above, reverse 2A5–8 to 3A7–8. Odour indistinct or mouldy. Conidiation noted after 1 days at 25°C, yellow or greenish after 6 days, earlier at higher temperatures, regularly tree-like, basally in a dense, downy central area, less commonly ascending on aerial hyphae, eventually in tufts. At 15°C colony stellate and indistinctly concentrically zonate, turning yellow to pale green; conidiation effuse and in loose tufts, less intense than at higher temperatures. At 30 and 35°C colony more distinctly zonate with broad alternating whitish yellow and green zones. Conidiation more abundant and more intensely green, *ca* 28CD4–5, than at lower temperatures; in a dense and fluffy, effuse continuous layer rather than in discrete tufts. Reverse brightly yellow, mixed with green, 1–3A5–8, 1BC5–8, 2A6–8, 3AB7–8.

On SNA after 72 h 18–21 mm at 15°C, 58–60 mm at 25°C, 68–71 mm at 30°C, 77–83 mm at 35°C; mycelium covering the plate after 4 days at 25°C. Colony similar to that on CMD, with wavy margin, mycelium denser and faster on the agar surface, after a week degenerating, many hyphae appearing empty. Aerial hyphae inconspicuous, more frequent and long along the colony margin. Autolytic activity and coilings absent or inconspicuous, more frequent at higher temperatures. No diffusing pigment, no distinct odour produced. Chlamydospores seen after 3–6 days at 25°C, frequent, terminal and intercalary, (5–)6–10(–13)×(3.5–)5–8(–12) μm, l/w (0.9–)1.0–1.4(–1.9) (*n*=40), globose, ellipsoidal or fusoid. Conidiation noted after 3–4 days at 25°C, earlier at higher temperatures, in many amorphous, loose white cottony tufts mostly median from the plug outwards, confluent to masses up to 17 mm long; white, turning green, 27CD3–4, 27E5–6, 28CE5–8, from inside after 4–5 days; conidiation becoming dense within the tufts, loose at their white margins first with long, straight or slightly sinuous, sterile ends in the periphery, projecting 50–150(–300) μm from the tuft margins when young, sterile and beset with minute droplets along their length, mostly becoming fertile and incorporated into the tufts. Tufts consisting of a loose reticulum with mostly unpaired branches often in right angles, giving rise to several main axes. Main axes up to 0.6 mm long, regularly tree-like, with few or many paired or unpaired side branches often in right angles, mostly (30–)40–110(–150) μm longht223.6.d78.9(f)0(t)11.6713.2(e)0gD0Tc(3)14.9422.3.6713.9(pa)(t)-42(e8(t)0(r)1[(4,)-4o.3(l)0(o)13.2(n)0)Tj/F11

P.K. 2460). Vorarlberg, Bludenz, Großes Walsertal, Sonntag, forest path at the Lutz bridge, MTB 8725/3, 47°14′19″ N, 09°54′32″ E, elev. 790 m, on corticated cut log of *Alnus incana* 23 cm thick, on cut wood area, soc. *Armillaria* rhizomorphs, holomorph, 1 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2651 (WU 29471, culture C.P.K. 2003). **Czech Republic**, Southern Moravia, Valtice, at Rendezvous (temple of Diana) near Valtice, on a branch of *Quercus petraea* on the ground, on wood and bark, 15 Sep. 1981, Z. Pouzar (PRM). **Germany**, Bavaria, Unterfranken, Landkreis Haßberge, Haßfurt, close to Mariaburghausen, left roadside heading from Knetzgau to Haßfurt, MTB 5929/3, 50°00′33″ N, 10°31′10″ E, elev. 270 m, on corticated branch of *Tilia cordata* 4 cm thick, on bark, soc. effete pyrenomycete and white *Lasiosphaeria* sp., 4 Aug. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2563 (WU 29470, culture CBS 121275=C.P.K. 2002). Niedersachsen, Landkreis Osterode am Harz, Bad Grund, between Laubhütte and Windhausen, 51°47′16″ N, 10°13′47″ E, elev. 300 m, on cut segment of *Corylus avellana* 13 cm thick (remnant of wood pile at roadside), on black wood and inner bark, soc. *Armillaria* rhizomorphs below bark, immature *Hypocrea minutispora*, holomorph, teleomorph mostly immature, 28 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2956 (WU 29475, culture C.P.K. 2454). Landkreis Soltau-Fallingbostel, Bispingen, Behringen, east of Hengstberg and the road leading to the nature reserve Lüneburger Heide, 53°07′17″ N, 09°57′27″ E, elev. 95 m, on cut branches of *Betula pendula*, *Pinus sylvestris* and *Quercus robur* 6–10 cm thick, mostly on cut wood areas, soc. *Hypocrea viridescens*, *H. minutispora* on *Betula*, holomorph, 26 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2949 (WU 29474, culture C.P.K. 2450). **United Kingdom**, Devon, Exeter, Killerton Park, 50°47′34″ N, 03°27′20″ W, elev. 30 m, on corticated branches of *Quercus robur* 5–6 cm thick, on bark and wood, on bark and partly black wood, holomorph, teleomorph mostly immature, 8 Sep. 2004, H. Voglmayr, W. Jaklitsch & J. Webster, W.J. 2688 (WU 29472, culture C.P.K. 2004).

Notes: *Hypocrea schweinitzii* is distinctive due to its greenish grey undulate stromata containing more or less monomorphic hyaline ascospores. On other continents this species can be confounded with several other similar species like e.g. *H. andinensis*, *H. novaezelandiae*, *H. orientalis* or *H. pseudokoningii* (see Samuels et al. 1998). Young lenticular stromata may also be mistaken for the green-spored *H. lixii*. The anamorph of *H. schweinitzii*, *Trichoderma citrinoviride*, is typical of the section *Longibrachiatum*. In Europe it is the species with the fastest growth rate at the highest optimum temperature. Measurements of phialides and conidia given under SNA are combined with those obtained


a
b
c
d
e
f
h
i
g
j
k
l
m
n
o
r
s
t
u
p
q

◀ **Fig. 96** Teleomorph of *Hypocrea silvae-virgineae*. **a–f**. Fresh stromata (**a**. habit; **b, c, e**. immature). **g–k**. Dry stromata (**g**. showing sterile stipes; **h**. immature). **l**. Rehydrated mature stromata. **m**. Stroma in 3% KOH after rehydration. **n**. Perithecium in section. **o**. Stroma surface in face view. **p**. Cortical and subcortical tissue in section. **q**. Subperithecial tissue in section. **r–u**. Asci with ascospores (t, u. in cotton blue/lactic acid). **a, f, g, j, l–q, s–u**. WU 29227. **b–e, k, r**. WU 29228. **h, i**. WU 29226. Scale bars: **a**= 1.2 mm. **b–d, i**, l=0.5 mm. **e, f, j, k**, **m**=0.3 mm. **g**, **h**=0.2 mm. n= 30 μm. **o, p**, **r–u**=10 μm. **q**=15 μm

brown, tan, reddish brown to dark brown, 6CD4, 6E6–8, 7–8CE5–8, upon maturation; orange colour component more distinct than in the fresh state. Spore deposits white to pale yellowish. Rehydrated mature stromata larger than dry, orange-brown, with smooth yellow surface and projecting brown dots, base yellow; in 3% KOH stromata turning bright red to black; ostioles hyaline.

Stroma anatomy: Ostioles (79–)81–103(–124) μm long, plane or projecting to 20(–23) μm, (28–)32–45(–56) μm wide at the apex inside (*n*=30), apical cells cylindrical or terminally slightly widened to 4 μm. Perithecia (165–)185–235(–270)×(115–)130–185(–210) μm (*n*=30), flask-shaped or globose; peridium (11–)13–20(–26) μm (*n*=30) thick at the base, (4–)8–16(–17) μm (*n*=30) laterally; yellow, orange in KOH. Cortical layer (11–)14–20(–23) μm (*n*=30) thick, a *t. angularis* of cells (5–)7–15(–19)× (3–)5–10(–14) μm (*n*=60) with walls 0.5–1.3 μm thick in face view and in vertical section; yellow, orange in KOH. Subcortical tissue a hyaline *t. angularis* of thin-walled cells (4–)6–11(–16)×(3–)4–7(–8) μm (*n*=33), mixed with scant hyphae. Subperithecial tissue a *t. angularis–epidermoidea* of thin-walled cells (5–)11–22(–27)×(4–)9–16(–19) μm (*n*=30), tending to be smaller towards the stroma base. Asci (110–)116–127(–135)×(5.8–)6.3–7.5(–8.0) μm, stipe (10–)15–28(–40) μm long (*n*=43); croziers present. Ascospores hyaline, verrucose or spinulose with spines to nearly 1 μm long, cells distinctly dimorphic; distal cell (4.3–)5.0–6.8(–9.0)×(3.3–)3.8–4.5(–5.3) μm, l/w (1.1–)1.2–1.7(–2.3) (*n*=90), subglobose, ellipsoidal or wedge-shaped; proximal cell (4.0–)5.3–7.8(–10.0)×(2.8–)3.5–4.0(–4.5) μm, l/w (1.2–)1.5–2.1(–3.2) (*n*=90), oblong or wedge-shaped.

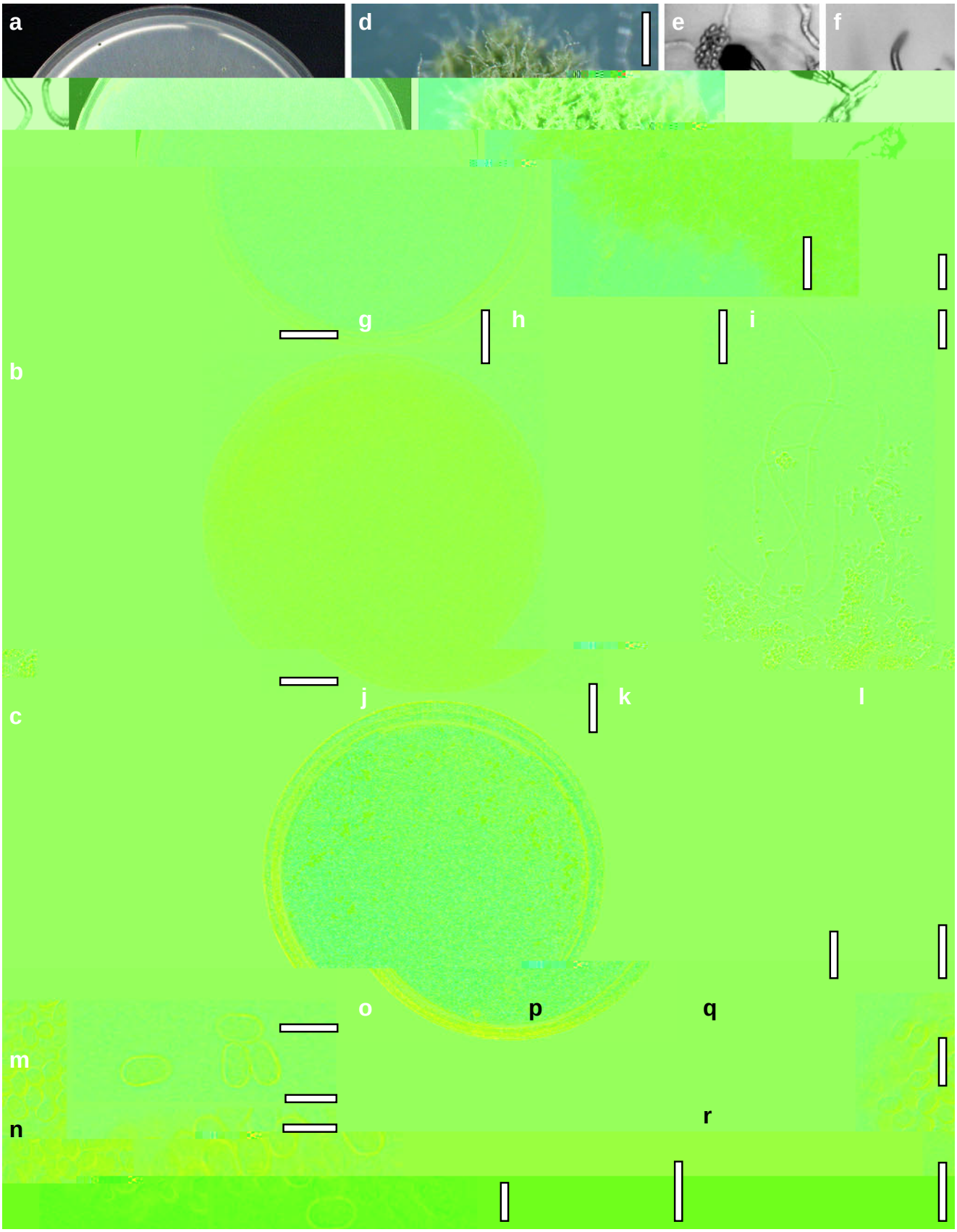
Anamorph associated with stromata effuse, hairy, light to dull greyish green, mostly 25DE4–5.

Cultures and anamorph: optimal growth at 25°C on all media; hyphae autolysing and dying after a few days at 30°C; no growth at 35°C.

On CMD after 72 h 22–23 mm at 15°C, 42–43 mm at 25°C, 1–3 mm at 30°C; mycelium covering the plate after 5 days at 25°C. Colony hyaline, thin, loose, indistinctly zonate, mycelium radially arranged, scant on the agar surface, with conspicuous difference in width between wide primary and narrow secondary hyphae; with long and high, loosely arranged aerial hyphae in a broad marginal zone; surface slightly downy, numerous helical hyphae in the centre within the agar. Autolytic excretions absent or inconspicuous, abundant and yellowish at 30°C, coilings inconspicuous. No diffusing pigment, no distinct odour noted. Chlamydospores noted after 7–9 days, rare. Conidiation starting after 4 days, first effuse, sessile and on aerial hyphae, scant, ill-defined, verticillium- to mostly gliocladium-like, conidia produced in wet to dry heads up to 25 μm diam. After collapse of the effuse conidiation, pustules 0.5–2.4 mm diam appearing mostly in distal areas, green after *ca* 2 weeks; often with white margins and sterile or fertile, straight to subhelical elongations. Formation of pustules not reproducible, absent after a few transfers. At 15°C no conidiation and no chlamydospores seen within 2 weeks.

On PDA after 72 h 18–19 mm at 15°C, 34–35 mm at 25°C, 1–2 mm at 30°C; mycelium covering the plate after 6 days at 25°C. Colony dense, zonate, centre flat, farinose to finely granular due to numerous short erect aerial hyphae, residual part covered by a thick white mat of long aerial hyphae arranged in radial strands and irregular aggregations with large drops. Autolytic activity and coilings inconspicuous. No diffusing pigment formed, centre yellowish, 3A3. Odour indistinct. Conidiation starting after 9–11 days, effuse, gliocladium-like, on aerial hyphae, whitish, not turning green within 3 weeks. At 15°C conidiation starting after 4–5 days, effuse, gliocladium-like, developing conspicuously slowly, condensing to tufts up to 1.5 mm diam on the entire plate, more or less arranged in concentric zones, aggregating to continuous masses, pale greenish after 10 days.

On SNA after 72 h 22–25 mm at 15°C, 34–35 mm at 25°C, 1–2 mm at 30°C; mycelium covering the plate after 6 days at 25°C. Colony similar to CMD, but margin whitish, downy due to numerous long aerial hyphae ascending for several mm; not zonate, first dense, but hyphae soon degenerating, becoming empty, replaced by conspicuously abundant chlamydospores after 3–4 days, terminal and intercalary, globose, oval or fusoid in narrow hyphae (4–)5–7(–10)×(3.5–)4–6(–6.5) μm, l/w 0.9–1.3(–1.8) (*n*=30) or rectangular when intercalary in thicker hyphae, (4–)6–18(–27)×(3–)4–7(–9) μm, l/w (0.6–)0.7–3.7(–7.6) (*n*=31). Autolytic activity inconspicuous, coilings inconspicuous or common. No diffusing pigment, no distinct odour noticeable. Conidiation starting after 3–5 days, green after a week; first effuse, scant, on few simple, verticillium- to gliocladium-like conidiophores with wet conidial heads to 30 μm diam mostly in the centre; after a week dry and dense, pachybasium-like, within green, 28–29CD4–6, 29E6–8, shrubs or tufts 0.3–3 mm diam mostly in a broad distal zone, compacting to transparent pustules with a granular surface, in addition hairy by numerous short elongations. Pustules consisting of a thick stipe with many primary branches in short distances and further paired or unpaired, branching forming a


a
d
e
f
g
h
i
b
j
k
l
c
o
p
q
m
n
r

◀ **Fig. 97** Cultures and anamorph of *Hypocrea silvae-virgineae*. **a**–**c**. Cultures (**a**. on CMD, 20 days. **b**. on PDA, 20 days. **c**. on SNA, 14 days). **d**. Conidiation tuft (SNA, 14 days). **e.** Gliocladium-like conidiophores of effuse conidiation on growth plate (CMD, 9 days). **f.** Sterile helical elongation on pustule margin on growth plate (CMD, 20 days). **g**. Main axis on pustule margin showing fertile elongation and fertile side branches on growth plate (SNA, 8 days). **h–k**. Conidiophores (**h**. with sterile elongations; **j, k**. side branches on elongation bases; SNA, 9–13 days). **l**. Phialide on elongation (SNA, 13 days). **m**, **n**. Intercalary chlamydospores (SNA, 11 days). **o**. Ampulliform phialides (SNA, 13 days). **p**–**r**. Conidia (SNA, 9–13 days). **a**–**r**. All at 25°C. **a**–**e**, **g**, **j, k**, **m**, **n**, **q**. CBS 120922. **f**.C.P.K. 2401. **h**, **i**, **l, o, p, r**. C.P.K. 974. *Scale bars* a–c=15 mm. d=0.3 mm. **e, g**, h=30 μm. **f, l**, n=15 μm. **i–k, m**, p=10 μm. **o, q**, r=5 μm

reticulum with many right angles, giving rise to more or less radially arranged main axes/conidiophores. Conidiophores 4–6(–7) μm wide with branching points often thickened to 7–11 μm, fertile to the tip and narrowly tree-like with short, mostly paired terminal branches in right angles, progressively longer downwards; more commonly terminating in one or several elongations. Elongations mostly straight or slightly sinuous to subhelical, 100–200(–250) μm long, 4–7(–9) wide basally, attenuated to 2.5–3 μm terminally, with numerous minute droplets along their length, smooth in the microscope, first sterile, becoming fertile at the tip, with a single, rarely two terminal phialides, and on their bases with paired or unpaired fertile side branches mostly 1–5 celled and 10–30 μm long close to the pustule surface, in right angles to the main axis or slightly inclined upwards, unbranched or re-branching with 1–3 celled side branches. Phialides produced in whorls or pseudo-whorls of 4–6 on broadly rounded to submoniliform cells, (3.0–)3.5–4.5(–5.5) μm wide. Phialides (4–)5–7(–9)×(3.2–)3.7–4.2(–4.6) μm, l/w (1.0–)1.2–1.8(–2.4), (1.8–)2.7–3.5(–4.0) μm wide at the base (n=60), minute, ampulliform, widest in and below the middle, sometimes with long neck. Phialides on elongations (8–)11–22(–39)×(2.2–)2.5–3.3(–4.3) μm, l/w (1.9–)3.6–8.2 (–14.9), (2.0–)2.2–3.0(–3.2) μm wide at the base (n=35), lageniform to subulate, rarely ampulliform, straight or slightly curved, forming minute wet conidial terminal heads. Conidia (3.5–)3.8–5.0(–7.3)×(2.4–)2.7–3.0(–3.5) μm, l/w (1.2–)1.3–1.7(–2.8) (n=70), yellowish green, oblong to ellipsoidal, smooth, typically with straight, often parallel sides, sometimes slightly attenuated towards one end, ends broadly rounded, with few minute guttules; scar indistinct. At 15°C similar, chlamydospores numerous, conidiation in green, 28CD5–6, 27CE4–5, pustules to 3 mm diam, aggregations to 14 mm long, with elongations.

Habitat: on well-decayed wood and bark of *Fagus sylvatica*.

Distribution: Europe (Austria, Czech Republic); in virgin forests, rare.

Holotype: **Austria**, Niederösterreich, Lilienfeld, Sankt Aegyd am Neuwalde, Lahnsattel, virgin forest Neuwald, MTB 8259/1, 47°46′21″ N, 15°31′16″ E, elev. 950 m, on decorticated branch of *Fagus sylvatica* 14 cm thick, on well-decayed black wood and on/soc. a white corticiaceous fungus, soc. *Steccherinum ochraceum*, holomorph, 16 Oct. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2463 (**WU 29227**, culture CBS 120922=C.P.K. 990). ***Holotype*** of *Trichoderma silvae-virgineae* isolated from WU 29227 and deposited as a dry culture with the holotype of *H. silvae-virgineae* as **WU 29227a**.

Other specimens examined: **Austria**, Niederösterreich, Lilienfeld, Sankt Aegyd am Neuwalde, Lahnsattel, virgin forest Neuwald, MTB 8259/1, 47°46′22″ N, 15°31′16″ E, elev. 960 m, on branch of *Fagus sylvatica* 11 cm thick, on well-decayed, dark wood and bark, soc. moss, rhizomorphs, holomorph, teleomorph mostly immature, 16 Oct. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2465 (WU 29228, culture C.P.K. 2401). **Czech Republic**, Southern Bohemia, Šumava Mts. National Park, Záhvozdí, Černý les, MTB 7149/4, 48° 50′38″ N, 13°58′41″ E, elev. 870 m, on branch of *Fagus sylvatica* 4 cm thick, on well-decayed, soft wood black on its surface, soc. effete pyrenomycete, hyphomycete; mostly decayed before maturation, holomorph, 24 Sep. 2003, H. Deckerová, W.J. 2422 (WU 29226, culture C.P.K. 974).

Notes: *Hypocrea silvae-virgineae* has been collected only in virgin or natural forests in the dry and hot year 2003; the latter fact may be responsible that many asci of the examined material were immature or contained less than eight ascospores. Ascospore size may possibly be slightly smaller in more regularly developed material. Stromata of *H. silvae-virgineae* are reminiscent of several other species. When fresh they may look like immature stromata of the green-spored species *H. strictipilosa* (young, nearly colourless and smooth) or of *H. gelatinosa* (waxy and with perithecial elevations). Yellow stromata are reminiscent of *H. moravica*, but the latter differs e.g. by non-projecting perithecia. Older, overmature, rugose stromata that appear waxy or gelatinous may be mistaken for *H. tremelloides*, which has a somewhat different colour, smaller ascospores and a white-conidial anamorph. The effuse conidiation of *Trichoderma silvae-virgineae* is scant, but peculiar in its short gliocladium-like conidiophores. Oblong conidia are also typical for *T. longipile*, which differs in more consistently oblong conidia often constricted laterally, and good growth at 30°C.

Hypocrea splendens W. Phillips & Plowr, Grevillea 13: 79 (1885). Fig. 98

Anamorph: not known

Stromata when dry (2.3–)2.5–5(–6)×(2.0–)2.2–3.7(–4) mm (n=6), 0.5–1.7(–2.2) mm (n=10) thick, solitary, rarely aggregated, distinctly pulvinate, broadly attached, edges free; outline circular to oblong; margin sterile, smooth, yellow. Surface smooth, yellow-orange between numerous minute, plane or convex, shiny, orange-reddish to reddish-

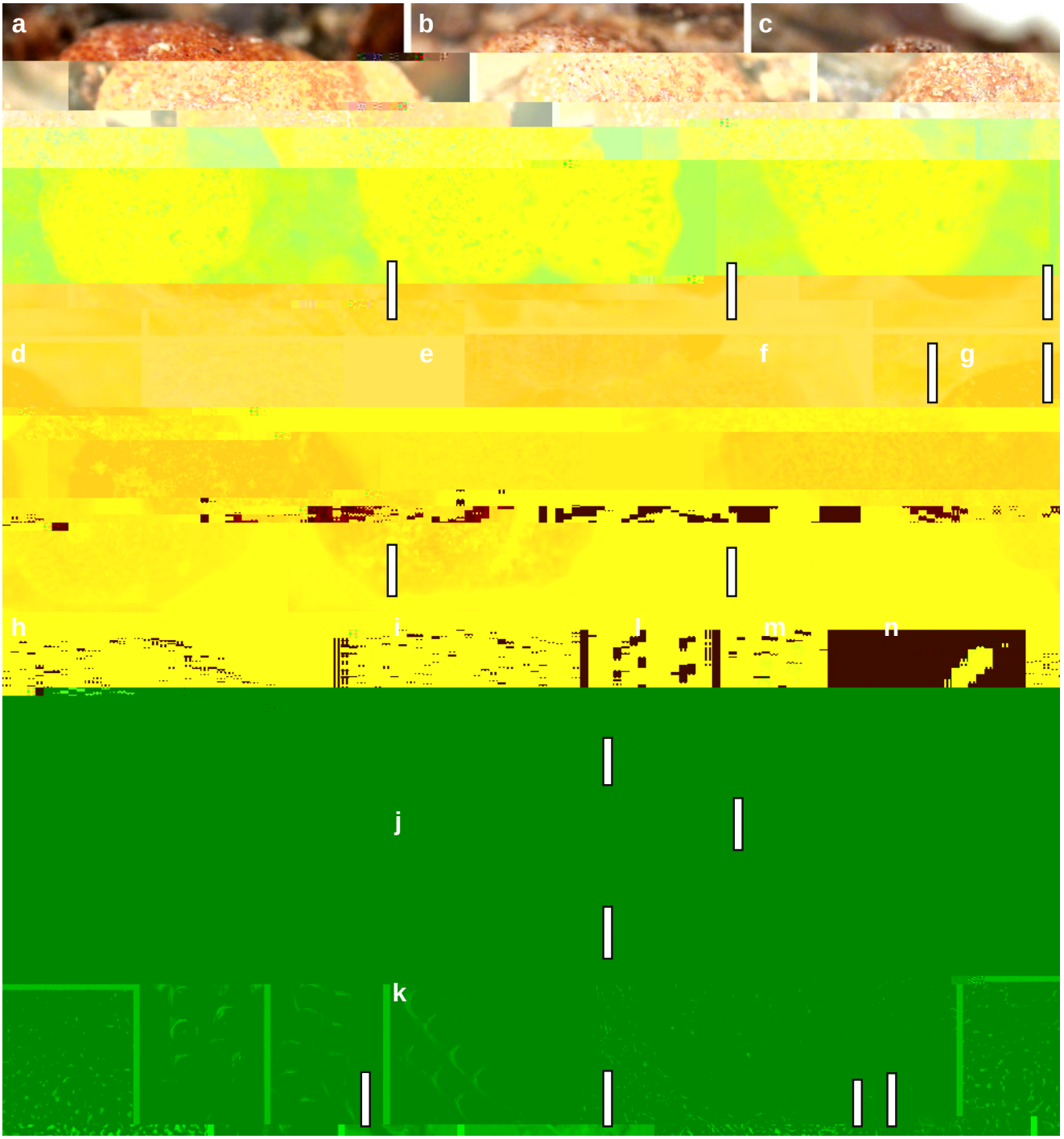


Fig. 98 Teleomorph of *Hypocrea splendens* (holotype K 137610). **a**–**e**. Dry stromata. **f**. Stroma surface in face view. **g**. Ascus top showing apical ring. **h**

brownish ostiolar dots (40–)45–76(–90) µm (n=30) diam. Stromata pale brick-red, brown-orange to reddish brown, 7–8CD4–6, more brightly orange under magnification in the stereo-microscope. Rehydrated stromata lighter orange, unchanged after addition of 3% KOH.

Stroma anatomy: Ostioles (62–)70–98(–124) µm long, plane or projecting to 35(–57) µm, (37–)40–60(–70) µm wide at the apex (n=20); apical palisade of cylindrical to subclavate, hyaline cells 3–6 µm wide. Perithecia (110–)145–225(–260)×(95–)115–180(–206) µm (n=20), globose

or flask-shaped; peridium (6–)10–18(–26 µm (*n*=42) thick at the base and sides, pale yellow. Cortical layer (20–)24–40(–52) µm (*n*=30) thick, a dense, subhyaline to pale yellowish *t. angularis* of thick-walled cells (3.5–)4.5–9.5(–14)×(2.5–)3.5–6.0(–8.5) µm (*n*=60) in face view and in vertical section; nearly labyrinthine, containing some hyphae projecting to *ca* 30 µm from the surface. Subcortical tissue a loose *t. intricata* of thin-walled hyaline hyphae (2.0–)2.5–5.0(–6.0) µm (*n*=30) wide. Subperithecial tissue a *t. intricata–epidermoidea* of mostly oblong to cylindrical cells (7–)11–44(–52)×(5–)7–12(–15) µm (*n*=30) and hyphae of similar width. Basal tissue nearly labyrinthine, a dense, hyaline *t. epidermoidea* of compressed thin-walled hyphae and indistinct, variable cells (4–)6–18(–27)×(3–)4–9(–11) µm (*n*=30). Asci (85–)90–104(–110)×5.0–6.0(–6.6) µm, stipe (6–)8–17(–23) µm long (*n*=30); apex containing a flat ring, no croziers present. Ascospores hyaline, verruculose, cells dimorphic; distal cell (3.8–)4.0–4.8(–5.2)×(3.3–)3.5–4.0(–4.5) µm, l/w (1.0–)1.1–1.3(–1.4) (*n*=30), subglobose or ellipsoidal; proximal cell (4.3–)4.5–5.8(–6.6)×(2.8–)3.0–3.5(–4.0) µm, l/w (1.3–)1.4–1.9(–2.2) (*n*=30), oblong or wedge-shaped.

Habitat: on wood and bark of *Prunus laurocerasus*.

Distribution: England, known only from the type specimen.

Holotype: **United Kingdom**, England, Leicestershire, on laurel sticks, soc. effete pyrenomycete in bark fissures, Oct. 1881T. Howse (K 137610).

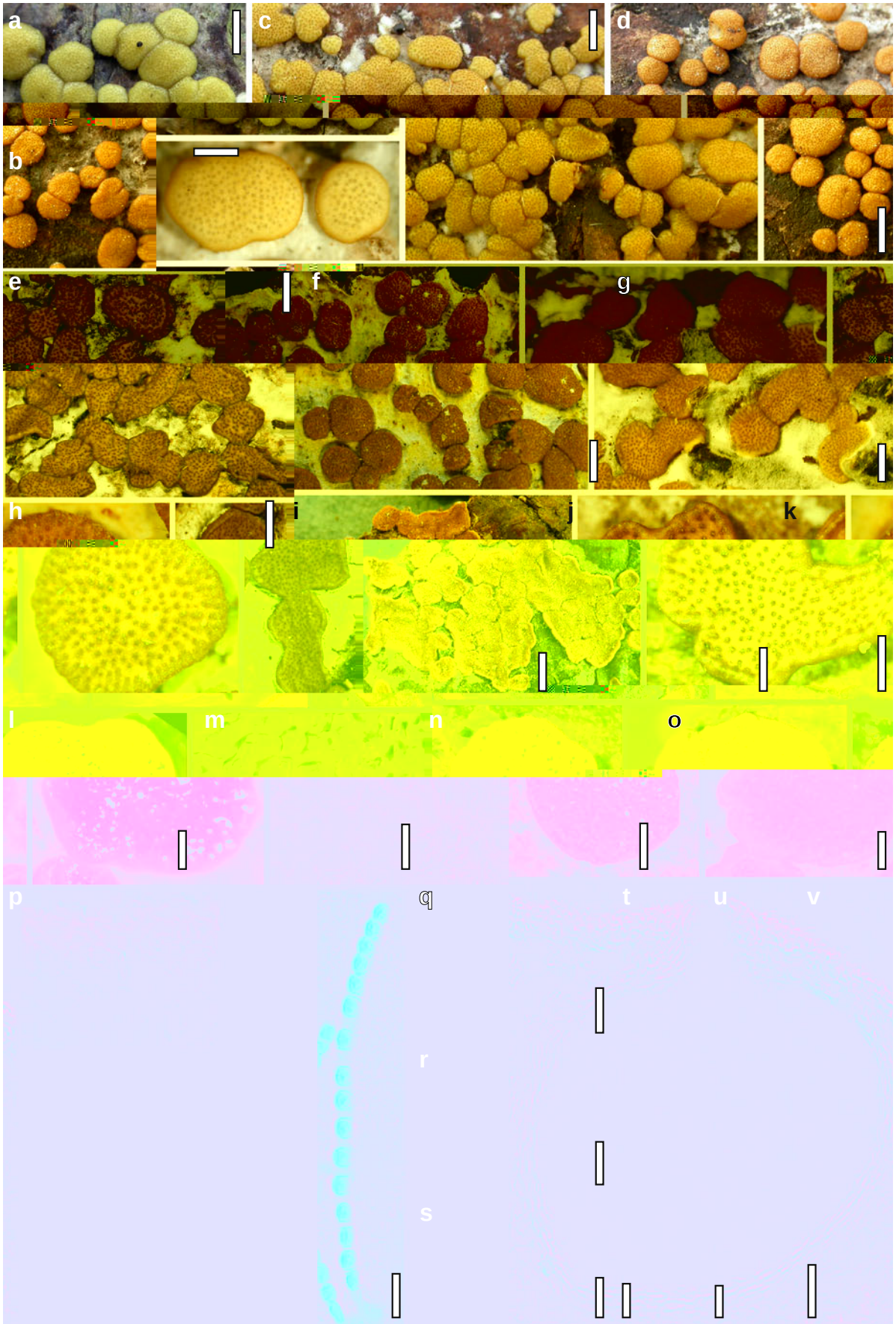
Notes: Stromata of *Hypocrea splendens* in the holotype specimen, said to grow on laurel sticks, are obviously not on *Laurus*, but on corticated branches of *Prunus laurocerasus*, which, usually planted in dry habitats, is an unusual host for a *Hypocrea*. The stromata are pulvinate and compact, unlike those of *H. auranteffusa*, while microscopic traits are indistinguishable in the two species. The anamorph and phylogenetic position of *H. splendens* are to date unknown. For another description see Petch (1938).

Hypocrea strobilina W. Phillips & Plowr., Grevillea 13: 79 (1885). Fig. 99
Anamorph not known

Stromata when dry 0.4–2×0.3–0.8 mm, 0.1–0.3 mm thick (*n*=11); on and between cone scales, discoid, flat pulvinate, or irregularly membranaceous, non-descript, hardly visible

numerous minute, first diffuse, pale greyish to brownish, later well-defined reddish-brown ostiolar dots; perithecia entirely immersed. Stromata pale to bright yellow, 2A2–5, 3A2–7, when immature, yellow, brown-orange or golden-brown when mature, 4A3–4(–5), 5CD5–6.

Stromata when dry 0.5–4(–10)×0.5–2.5(–6) mm, (0.1–)0.2–0.3(–0.6) mm (n=90) thick, effuse/effluent, discoid or flat pulvinate, broadly attached. Outline circular, oblong or irregular. Margin free, sharp and projecting upwards, or rounded; sides mostly vertical, smooth or with slightly projecting perithecia on top. Surface smooth, finely tubercular due to convex dots, sometimes rugose; perithecia entirely immersed. Ostiolar dots (23–)30–60(–110) μm (n=110) diam, numerous, distinct, circular, convex, brown with lighter shiny centres and minute hyaline perforations, distinctly darker than the yellow surface; in young stromata larger, more diffuse and more orange or reddish. Stroma colour mainly determined by the brown ostiolar dots, yellow, 4A3–4(–6), when immature, yellow-brown,


a
c
d
b
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t

Fig. 101 Cultures and anamorph of *Hypocrea subalpina* (CBS 119128). **a**, **d**. Cultures (**a**. on CMD, 35 days; **d**. on PDA, 28 days). **b**. Conidiophore on growth plate (Difco-PDA, 4 days). **c**, **e**–**g**. Conidio.3(i).2(Dif)0(r)-44.6Tj/F11Tf0.52.0239Tcarl4Tf0.46190io.3(i).2(D9am,)-45()Tj/F1 H2eam,tt4 Trate 2C058(2)Tj ET

(–3.5)×(2.2–)2.5–3.0(–3.2) μm, l/w (0.9–)1.0–1.2(–1.5) (n=90), globose to subglobose; proximal cell (2.3–)2.5–3.5(–5.0)×(2.0–)2.5–3.0(–3.2) μm, l/w 0.9–1.3(–2.5) (n=90), (sub)globose; ascospore cells in the ascus base tending to be dimorphic with oblong proximal cells to 5 μm long; ascospores sometimes yellow-orange after ejection.

Cultures and anamorph: slow and limited growth between 15°C and 25°C on all media, slower on PDA than on CMD and SNA; no growth at and above 30°C.

On CMD 4–7 mm at 15°C, 8–9 mm at 25°C after 72 h; growth usually terminating before the plate is entirely covered. Colony hyaline, thin, not or indistinctly zonate, smooth; margin discontinuous, wavy to lobed; hyphae wavy along their length, becoming finely submoniliform and irregularly oriented at the colony margin. Aerial hyphae scant, short, little branched, becoming fertile. White crystals up to *ca* 2×1.5 mm appearing after 1–2 months on the surface and submerged in the agar, causing white spots; the latter also caused by short aerial hyphae emerging in dense fascicles in aged cultures. Autolytic activity low, producing some amorphous brown excretions in aged colonies; coilings absent. Colony remaining hyaline, sometimes turning pale yellowish, 2A3, along the margin; odour indistinct. Widened cells in surface hyphae common; chlamydospores only rarely formed, tardily separated by septa, (10–)11–23(–32)×(9–)10–14(–16) μm, l/w (1.0–)1.1–1.8(–2.1) (n=21), mostly intercalary, variable, globose, ellipsoidal or oblong, smooth, multiguttulate. Conidiation starting after 2–3 days, effuse, scant, starting around the plug, spreading loosely across the colony. Conidiophores appearing gliocladium-like under low magnifications, short, erect, simple, dichotomously branched or with few short unpaired branches along their length, each with a single terminal phialide. Conidia formed in one wet head per phialide, mostly<30(–60) μm diam, eventually drying. Solitary phialides with cylindrical hyaline conidia also formed within the agar. Sizes similar to those determined on PDA and MEA. Aged conidia often swollen, globose, (5–)7–13(–17) μm (n=33) diam.

On PDA 3–4.5 mm at 15°C, 4–4.5 mm at 25°C after 72 h; growth often terminating after 1 week. Colony small, compact, dense, thick, surface becoming downy, whitish, cream or yellowish, hyphae agglutinating to an opaque continuum in the centre. Aerial hyphae short (but to *ca* 2 mm long on Difco-PDA), becoming fertile. No autolytic activity, no coilings seen. Reverse turning yellowish 3A3–4, to (yellow-)brown, *ca* 5B4–6, 5CD5–6, 5E7–8. Odour indistinct to slightly mushroomy. Conidiation starting after 2–3 days, gliocladium-like at low magnifications, effuse, on numerous short erect conidiophores around the plug, spreading across the colony; unbranched or of a main axis bearing few widely spaced unpaired branches, the latter sometimes branched once again. Branches 3–6.5 μm wide, with widenings to 10 μm, each with a solitary terminal phialide. Phialides consisting of a long cylindrical main body (14–)22–32(–38) μm×(3.5–)4–6(–7) μm, l/w (3–)4–7(–8), (1.7–)3.2–4.8(–5.6) μm wide at the base (n=32), terminally often dichotomously or irregularly branched, each branch with (1–)2–3(–6) parallel or divergent terminal 'fingers', rarely unbranched and subulate, sometimes branched at lower levels to produce 2–3 groups of fingers; fingers (1–)2–8(–12)×1.2–1.7(–2) μm, l/w (0.7–)1.3–5.4(–8.6) (n=30), cylindrical, straight or curved, rarely separated by a septum from the main body; producing conidia in colourless wet heads to 40(–50) μm diam. Conidia (3.5–)5–10(–15)×2.2–3.7(–5.0) μm, l/w (1.4–)2.0–3.3(–4.3) (n=33), hyaline, cylindrical, straight, curved to allantoid, less commonly ellipsoidal, oval or kidney-shaped in age, smooth, with few minute guttules or eguttulate, scar indistinct. At 15°C colony compact, dense, thick, finely downy, indistinctly zonate, whitish, reverse becoming yellowish 3–4A3–4 to brownish 5B4–5; conidiation denser than at 25°C.

On MEA colony hyaline to white, dense, homogeneous, long aerial hyphae frequent; conidiophores frequent, erect, simple and with 1 terminal phialide, or basally branched or as a series of branches loosely emerging from aerial hyphae, 6–7.5 μm wide at the base, within a short distance attenuated to 2 μm. Phialides solitary, terminal on branches, (2.3–)2.5–3.7(–4.7) μm (n=28) wide at the base, variable, sometimes subulate, sometimes branched into 2 whorls of 3–4 fingers; fingers commonly separated by a septum; including the fingers (5–)18–41(–46)×(2.5–)3.2–4.5(–5.2) μm, l/w (1.3–)4.4–11(–15), often widest at branching points. Conidia 6–11(–15)×(2.3–)2.7–4.2(–6.0) μm, l/w (1.6–)2–3(–4) (n=32), hyaline, cylindrical, sometimes ellipsoidal or irregular, e.g. constricted in the middle, smooth, scar indistinct or truncate.

On SNA 3.5–5.5 mm at 15°C, 4.5–7 mm at 25°C after 72 h; growth terminating after 2 weeks before covering the entire plate. Colony hyaline, thin, resembling ice crystals, with little mycelium on the surface, irregular density, irregularly oriented marginal hyphae; mycelium degenerating early, with only loose marginal strands growing. Aerial hyphae scant, mostly short and little branched. Autolytic activity variable, excretions minute; no coilings seen. No

pigment, no distinct odour noted. Conidiation after 2–3 days, scant. Structure as described above.

Habitat: usually in large numbers on a white subiculum on bark, less commonly wood, of conifers at upper montane to subalpine altitudes.

Distribution: Europe (Austria, Estonia, Germany, Ukraine). One collection reported by G.J. Samuels (pers. comm.) from the Blue Mts. Natl. Park near Sydney, Australia, agrees well with *H. subalpina* in terms of stromata, phialides and conidia.

Typification: A part of Rehm's original specimen of *Hypocrea rufa* var. *discoidea* is here selected as ***lectotype*** of *Hypocrea subalpina*: **Austria**, Salzburg, Radstadt, on wood and bark of *Picea abies*; 1901, F. v. Höhnel, Rehm Ascomyceten 1446 (**K 165796**). Petrak (1940) listed four paratype specimens. The following specimen is here designated as ***epitype***, in order to consolidate the relationship of teleomorph, anamorph and gene sequences: **Austria**, Vorarlberg, Feldkirch, Satteins, south from Matennawald, MTB 8724/3, 47°15′03″ N, 09°40′33″ E, elev. 930 m, on corticated branch of *Abies alba* 4 cm thick, stromata on bark, few on wood, largely immature, 1 Sep. 2004, A. Hausknecht, W.J. 2663 (**WU 29481**, ex-epitype culture CBS 119128=C.P.K. 2038). ***Holotype*** of the anamorph *Trichoderma subalpinum* isolated from WU 29481 and deposited as a dry culture with the epitype of *H. subalpina* as **WU 29481a**.

Other specimens examined: **Austria**, Niederösterreich, Lunz, on *Abies pectinata* (= *A. alba*), July 1939, F. Petrak, Reliquiae Petrakianae 37 (paratype, GZU). Scheibbs, Lunz am See, Rothwald, Kleiner Urwald, MTB 8256/2, elev. *ca* 1000 m, on branch of *Abies alba*, on bark, 28 June 2007, A. Urban, W.J. 3105 (WU 29484, culture C.P.K. 3126). Salzburg, Radstadt, on wood and bark of *Picea abies*; 1901, F. v. Höhnel (as *Hypocrea rufa* var. *discoidea*; isotype W 7138). Steiermark, Aussee, on *Abies alba*, Sep. 1903, R. Rechinger (paratype, W!). Bruck/Mur, Halltal, Walstern, fluvial alder forest at the white Walster east of the Hubertus lake, MTB 8158/3, 47°48′35″ N, 15°22′41″ E, elev. 830 m, on branch of *Abies alba* 3 cm thick on the ground, on bark, immature, 23 Sep. 2008, H. Voglmayr, W. J. 3219 (WU 29486). Liezen, Kleinsölk, Schwarzensee, hiking trail to Putzentalalm, MTB 8749/1, elev. 1170 m, 47°17′12″ N, 13°52′13″ E, on corticated branch of *Larix europaea* 6 cm thick, 7 Oct. 2004, W. Jaklitsch, W.J. 2772 (WU 29482, culture C.P.K. 2039). St. Lorenzen im Paltental, *ca* 2.5 km WNW from Trieben, MTB 8552/2, elev. 750 m, 47°29′ N, 14°27′ E, on bark of *Pinus sylvestris*, 4 Oct. 2002, A. Draxler & W. Maurer, Scheuer 4834 (GZU). Zauchensee bei Bad Mitterndorf, MTB 8449/2, on bark of *Picea abies*, 24 Aug. 2004, A. Draxler & W. Maurer (GZU). Vorarlberg, Bludenz, Sonntag, forest path at the Lutz bridge, Großes Walsertal, MTB 8725/3, elev. 780 m, 47°14′17″ N, 09°54′27″ E, on fallen, half decorticated tree of *Picea abies* 5–7 cm thick, stromata on wood and bark, soc. *cf. Athelopsis glaucina* and an effete setose pyrenomycete, immature, 1 Sep. 2004, H. Voglmayr & W. Jaklitsch, W.J. 2650 (WU 29480). **Estonia**, Saaremaa island, Tagamoisa, wooded meadow, on cut branch of *Picea abies*, on bark, 10 Aug. 2006, K. Pöldmaa KP06-8 (WU 29483). **Germany**, Baden-Württemberg, Schwarzwald, SW Hornberg, W Oberniedergieß, MTB 7815/1, elev. 580 m, on branch of *Picea abies*, on bark and wood, immature, 23 Oct. 2008, L. Krieglsteiner. Bavaria, Mittenwald, Klais, heading to Kranzbach, MTB 8533/124, elev. 965 m, on branch of *Picea abies* 1–2 cm thick, on bark, 24 Aug. 2008, P. Karasch (WU 29485). **Ukraine**, Carpatirossia, in silvis mixtis virgineis (*Abies alba*, *Picea excelsa*, *Fagus sylvatica*) in valle rivi Berlebas prope vicum Trebušany, alt. 800–1000 m, on bark of *Abies alba*, Aug. 1937, A. Pilát (syntype W 05672).

Notes: *Hypocrea subalpina* is well characterised by discoid stromata with numerous minute ostiolar dots occurring on bark of conifers, usually on a white amorphous crust or subiculum, showing a striking colour change from yellow when fresh to rust, orange-brown to brown when dry. A similar colour change is known from stromata of the unrelated *H. bavarica*. The subiculum, although superficially looking similar to the basidiomycete *Exidiopsis calcea*, apparently belongs to the *Hypocrea*. No clamps, basidia or basidiospores have been found in the subicular hyphae.

Petrak (1940, p. 262) based his species on *H. rufa* var. *discoidea* recognising its uniqueness and giving a detailed description of the teleomorph. Phylogenetically *H. subalpina* is located in a subclade of the section *Longibrachiatum*, albeit not well supported. The formerly unknown anamorph differs substantially from all known members of that section. It is unique in *Trichoderma*, differing from all other species by having synchronously branching/bifurcating polyphialides that are similar to those of the genus *Polypaecilum* G. Sm. The latter genus, however, differs in producing brownish, smooth to verruculose, globose conidia in chains; for descriptions see Smith (1961) and de Hoog et al. (2000). Notable are also the formation of large white crystals on CMD and the conspicuous swelling of conidia on CMD; a similar swelling has been detected in *T. bavaricum*.

Hypocrea tremelloides (Schumach. : Fr.) Fr., Summa veg. Scand., Sect. Post., p. 383 (1849). Fig. 102

≡ *Sphaeria tremelloides* Schumach., Enum. Plant., (Kobenhavn) 2: 173 (1803) : Fr., Syst. Mycol. 2: 335 (1823).

Anamorph: ***Trichoderma tremelloides*** Jaklitsch, **sp. nov.** Fig. 103

MycoBank MB 516707

Incrementum tardum. Conidiophora effusa, in agaro CMD plerumque submersa, in agaris PDA et MEA plerumque superficialia, irregulariter subverticillata, ramis superioribus ascendentibus, inferioribus descendentibus. Phialides divergentes vel parallelae, subulatae vel lageniformes, (4–)10–21(–28)×(1.8–)2.5–3.5(–5.0) μm. Conidia oblonga, ellipsoidea, subglobosa vel suballantoidea, hyalina, glabra, (3.0–)4.2–8.3(–13.0)×(2.0–)2.8–4.0(–4.7) μm.

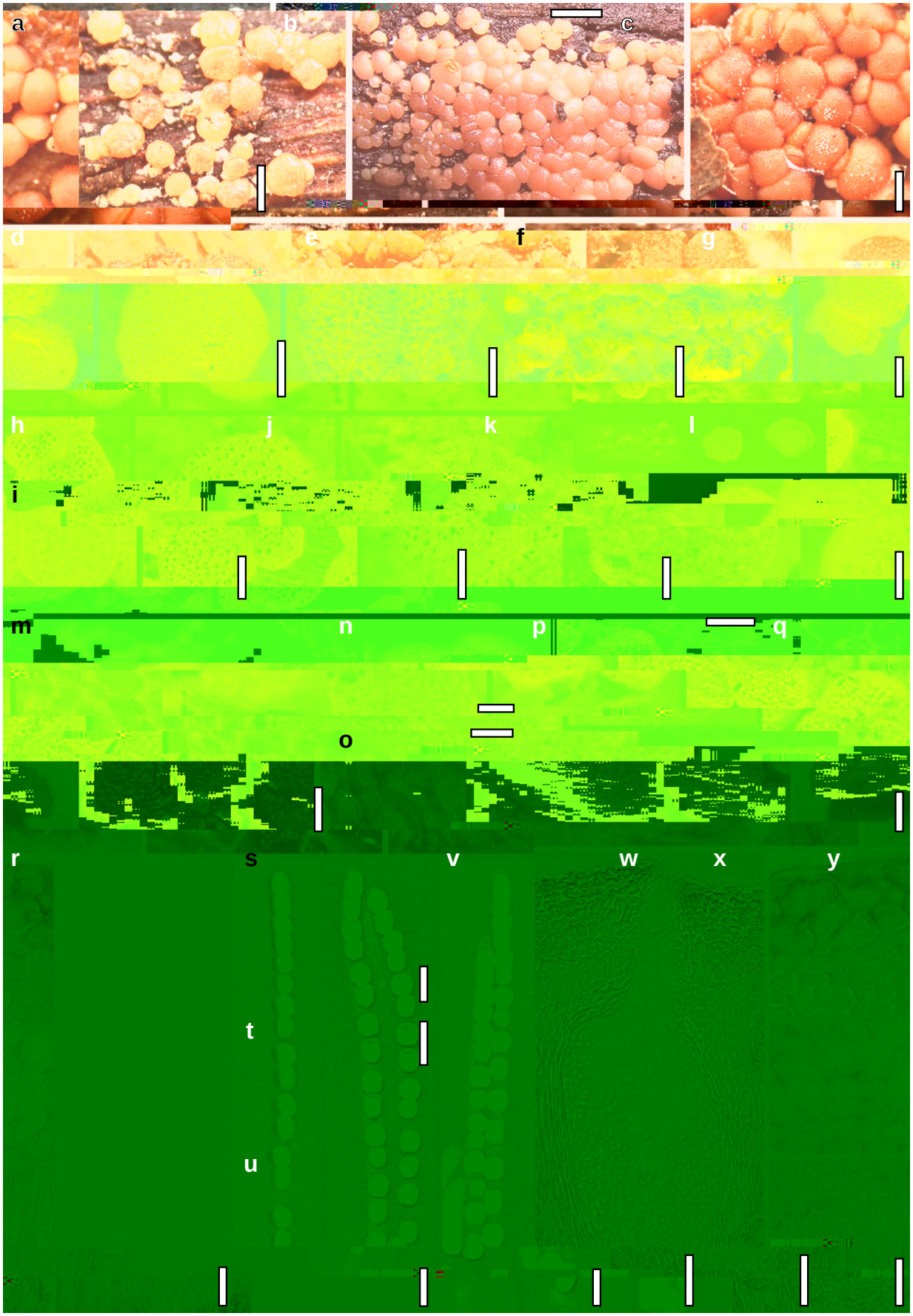
Stromata when fresh 0.5–3 mm diam, to 1–1.5 mm thick, gregarious or most commonly densely aggregated, sometimes turned-up laterally by mutual pressure, lenticular, flat pulvinate to distinctly turbinate with attenuated base often clothed with white mycelium; fertile upper part appearing waxy or gelatinous. Outline circular or oblong. Margin free, rounded or sharp, sometimes crenate. Surface shiny, smooth to finely granular due to slightly projecting, pale translucent perithecia. Distinct ostiolar dots absent; ostioles inconspicuous, minute, often slightly projecting, including variable fractions of upper perithecial parts. Stroma colour homogeneous, initially whitish to yellowish, turning pale or greyish orange, mostly incarnate or ochre, 6AB4–6, 5B4, when young, turning orange-, yellow-brown, light brown to reddish brown, 5CD5–8, 7–8CD(5)6–8, 8E6–8.

Stromata when dry (0.3–)0.7–1.6(–2.4)×(0.2–)0.5–1.4(–2.3) mm (n=120), 0.2–0.5(–0.8) mm (n=95) thick, gregarious to densely aggregated in large numbers in groups up to 2 cm long, less commonly singly erumpent through bark; turbinate, with a short stipe attenuated downwards or cylindrical, with white basal mycelium when young; fertile upper part laterally projecting; or flat pulvinate, lenticular to discoid, then mostly broadly attached; appearing waxy, gelatinous or glassy, shiny. Outline circular, angular or oblong. Margin free, rounded or sharp, sometimes lobed, sometimes turned upwards; concolorous with the stroma surface. Surface plane to slightly convex or depressed, smooth when young, becoming finely but distinctly granular due to slightly or distinctly projecting translucent perithecia. No ostiolar dots apparent but under high magnification slightly prominent, light or concolorous ostioles or perithecial elevations (12–)25–75(–126) μm (n=115) diam noticeable, papillate to conical, light, shiny, with circular perforation, sometimes surface with distinct, long projecting folds or crests, particularly when overmature. Surface between perithecia smooth, yellowish, pale orange to dull orange-brown. Stromata when young pale orange-brown, light brown to ochre, 7CD5–8, 8CD7–8, reddish orange, 7B7–8, 6AB7–8, with stereo-light, or reddish brown, 9CD7–8, 9DE5–6, to dark brown or violaceous brown, 9F5–8, 10EF4–8, less commonly dark reddish-brown, 8–9EF6–8, to nearly black. Colour unchanged in 3% KOH, sometimes some orange pigment dissolved. Spore deposits white to cream.

Stroma anatomy: Ostioles (60–)70–90(–93) μm long, with respect to the stroma surface umbilicate, plane or projecting to 6(–10) μm, (14–)17–30(–40) μm (n=20) wide at the apex, long cylindrical; convergent cylindrical periphyses 1–2.5 μm wide, not widened apically. Perithecia (125–)140–190(–215)×(75–)90–135(–150) μm (n=20), globose or flask-shaped, often laterally compressed by mutual pressure; peridium (9–)12–20(–25) μm (n=40) thick at the base and sides; pale yellowish to pale reddish brown. Surface lacking hairs. Entire stroma pseudoparenchymatous. Cortical layer (16–)20–40(–54) μm (n=30) thick, extending around the entire stroma except for the attachment area, comprising a pale yellow- to orange-brown *t. angularis* of 2–5 layers of distinct angular to oblong cells (6–)8–15(–22)×(4–)6–12(–18) μm (n=105) in face view and in vertical section, with walls 1±0.5 μm thick, gradually merging into the subcortical tissue, a *t. angularis* of paler to hyaline thin-walled cells (6–)12–21(–28)×(5–)8–13(–15) μm (n=40). Subperithecial tissue a *t. angularis* of hyaline to yellowish, thin-walled roundish to oblong cells (8–)15–30(–45)×(6–)9–20(–33) μm (n=40), tending to be smaller towards the base, at the attachment area followed by a palisade of narrow hyaline oblong cells (12–)19–38(–54)×(4–)5–11(–17) μm (n=40). Asci (55–)60–75(–96)×(3.5–)4.0–4.5(–5.5) μm, stipe (2–)5–17(–28) μm long (n=120). Ascospores hyaline, verruculose, variable within asci; cells dimorphic but with little difference; distal cell (2.3–)3.0–4.0(–5.0)×(2.3–)2.7–3.3(–4.7) μm, l/w (0.9–)1.0–1.2(–1.5) (n=192), (sub-)globose, ellipsoidal or oblong; proximal cell (2.3–)3.0–4.5(–5.7)×(2.0–)2.3–3.0(–3.7) μm, oblong or subglobose, l/w (1.1–)1.2–1.8(–2.7) (n=192), usually narrower than the distal cell; cells often distinctly flattened at the contact area, verrucae <0.5 μm long; the ascospore lowest in the ascus maturing first.

Cultures and anamorph: optimal growth at 25°C on CMD and PDA, no growth at and above 30°C.

On CMD after 72 h/1 week 0–2.5/6–13 mm at 15°C, 0.7–5.5/8–21 mm at 25°C; mycelium or often only few single hyphae reaching the distal margin of the plate after 20–30 days at 25°C. Colony hyaline, thin, scarcely visible, margin diffuse. Mycelium loose, hyphae narrow. Aerial hyphae nearly lacking. Autolytic activity moderate, excretions minute, mainly formed within the colony; no coilings present. No diffusing pigment, no distinct odour noted. Chlamydospores mainly intercalary in terminal, fasciculate fertile branches, (7–)9–21(–27)×(8–)9–17(–25) μm, l/w (0.9–)1.0–1.3(–1.6) (n=30), globose or ellipsoidal, smooth, only tardily separated by septa. Conidiation noted after 3–6 days at 25°C, spreading from the plug as more or less pyramidal structures on hyphal ends submerged in the agar, descending to the ground level of the agar, typically with only few short branches or phialides emerging above the agar surface. Conidiophores comprising a main axis


a
b
c
d
e
f
g
h
j
k
l
i
m
n
p
q
o
r
s
v
w
x
y
t
u

with several mostly 1–2 celled, irregularly oriented side branches <100 µm long, solitary or in fascicles or often arising around globose hyphal widenings to 15 µm diam, often directed back on the main axis, terminal branches and phialides arising at acute angles with respect to the axis. Phialides usually formed at different levels rather than in well-defined whorls, producing conidia in low numbers. At 15°C slightly more conidiation above the agar surface in minute white granules with minute conidial heads <20 µm diam.

On PDA after 72 h/1 week 0–0.6/2–3.5 mm at 15°C, 0.2–1.2/4–9.5 mm at 25°C. Growth limited, colony often not covering the entire plate. Colony circular, dense; hyphae thin. Surface becoming white, farinose, downy to floccose from the centre due to a dense mat of long, wide, little ascending aerial hyphae, forming thick strands, becoming fertile. Autolytic activity inconspicuous, coilings moderate or frequent, to *ca* 100 µm diam. Reverse turning yellowish, darkening to dull yellowish brown or orange-brown, 4B4–6, 5AB7–8 to 6CE7–8, eventually dark brown, 7E7–8, often in irregular spots with discoloured hyphae. Odour none or slightly fruity. Conidiation noted after 4–8 days at 25°C, effuse, white, starting around the plug, as long spiny phialides formed directly on surface hyphae or on short conidiophores oriented in various directions, spreading across the colony on the agar surface, later also on strands of aerial hyphae; loosely distributed. Conidiophores (examined after 2 weeks) erect, short, to 200 µm long, irregular, 2–4.5 µm wide, locally widened to 7 µm, consisting of a rigid main axis with few short branches, or more commonly only phialides formed on cells 2–5 µm wide, solitary or divergent or parallel in groups of 2(–3), the second phialide emerging from the base of the first one, often 3 above each other in an inequilateral erect chain; such chains formed apically or at several levels along the axis. Sometimes several short 1–3 celled conidiophores emerging from globose cells to 16 µm diam; conidiophores on thick strands of aerial hyphae sometimes widened basally to 11(–16) µm wide. Aged conidiophores and those in white granules 0.1–0.3 mm diam, ill-defined, with numerous sinuous to helical terminal branches and phialides. Phialides subulate, cylindrical, inequilaterally lageniform or sinuous, sometimes becoming apically branched, widest at or slightly above the base, asymmetrical, not paired; producing conidia in minute heads <30 µm diam. Conidia mostly oblong to cylindrical, but also subglobose or suballantoid, hyaline, smooth, straight or curved, with 1 or few guttules; scar distinct, broad. See under MEA for measurements. At 15°C conidiation dense on the agar surface around the plug, effuse, short, spiny to broom-like, irregularly verticillium-like; phialides often parallel. Reverse dull yellow, 4A3–5, 4B4, darkening to orange-, reddish- or dark brown, 5–6BC7–8, 7–8CD7–8, 7E7–8, with pigment diffusing across the colony.

On MEA colony hyaline, dense, circular. Aerial hyphae long and thick, forming a white mat around the plug, becoming fertile. Conidiation sometimes also in small white pustules on the colony margin, sometimes also submerged in the agar. Conidiophores to *ca* 1 mm long, more or less erect, usually with long sterile stretches and fan-like branching on upper levels, or branching irregular, asymmetrical, at acute angles, terminal branches 1–3 celled; basally to 6 µm wide, terminally attenuated to 2.5–3 µm. Phialides solitary or in dense complex fascicles of 2–10 on cells 2–4.5 µm wide, strongly inclined upwards or downwards to nearly parallel, often one phialide originating below the base of another and often lacking a basal septum. Phialides (4–)10–21(–28)×(1.8–)2.5–3.5(–5.0) µm, l/w (2.0–)3.5–6.5(–8.0), (1.5–)2.2–3.3(–4.2) µm wide at the base (n=62), subulate and equilateral or lageniform, inequilateral, curved upwards and with slightly widened middle, sometimes short-cylindrical, divided by a septum close to the apex, sometimes sinuous; producing conidia in minute wet heads to 25 µm diam. Conidia (3.0–)4.2–8.3(–13.0)×(2.0–)2.8–4.0(–4.7) µm, l/w (1.2–)1.4–2.4(–3.9) (n=63), hyaline, smooth, variable in shape, mostly ellipsoidal, also subglobose or oblong to suballantoid, with few minute guttules; scar often distinct, truncate. Measurements include

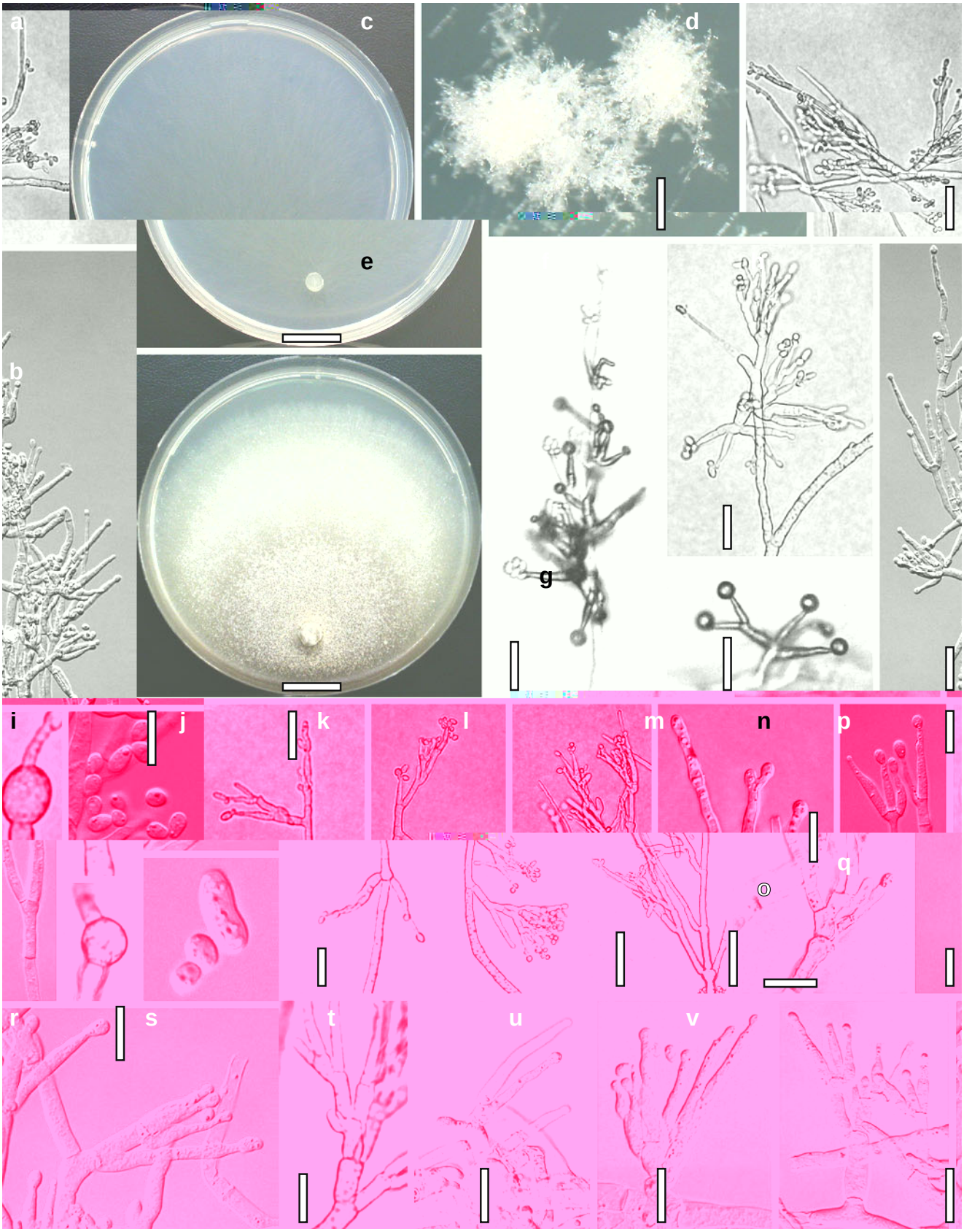

a
c
d
e
b
g
i
j
k
l
m
n
p
q
r
s
t
u
v

Fig. 103 Cultures and anamorph of *Hypocrea tremelloides*

of Denmark, Copenhagen; also reproduced in Flora Danica Tab. 1858, Fig. 2 (cited by Fries 1849). A part of the illustration suggests a globose stroma being hollow inside, but apparently it shows an aggregate of several stromata turned up by mutual pressure forming a cavity. ***Epitype*** designated here in order to ascertain the correct relationship between teleomorph, anamorph and gene sequences: **Austria**, Niederösterreich, Melk, Schönbühel-Aggsbach, Aggsteingraben at walking path to castle ruins Aggstein, MTB 7658/4, 48°18′40″ N, 15°25′32″ E, elev. 380 m, on partly decorticated branch of *Carpinus betulus*, 3–4 cm thick, on medium- to well-decomposed wood, soc. and also on *Steccherinum ochraceum*, 14 Oct. 2006, H. Voglmayr & I. Krisai-Greilhuber, W.J. 3023 (**WU 29508**, ex-epitype culture CBS 121140=C.P.K. 2490). ***Holotype*** of *Trichoderma tremelloides* isolated from WU 29508 and deposited with the epitype of *H. tremelloides* as **WU 29508a**.

Other specimens examined: **Austria**, Niederösterreich, Mödling, Wienerwald, Gruberau, between the village and Buchelbach, MTB 7862/4, 48°06′17″ N, 16°06′01″ E, elev. 380 m, on mostly corticated branch of *Quercus petraea* 5–6 cm thick, on well-decayed wood, in bark fissures, also on bark or overgrowing leaves, soc. Corticiaceae, 22 Oct. 2006, H. Voglmayr & W. Jaklitsch, W.J. 3028 (WU 29509, culture C.P.K. 2495). Steiermark, Grazer Bergland, riverine forest, east from Kickenheim, southeast from St. Radegund, elev. 500 m, on bark, J. Poelt, 27 Sep. 1984, GZU 116.84. **Germany**, Bavaria, south from Scheidegg, MTB 8425/1, on branch of *Abies alba* 1–3 cm thick, on bark, mostly overmature, 15 Aug. 2004, P. Karasch (WU 29505). Nordrhein-Westfalen, Arnsberg, Geseke, Eringerfeld, Rosengartenweg, Erlenbruch at A44, MTB 4416/2, 51°35′30″ N, 08°28′10″ E, elev. *ca* 100 m, on branch of *Alnus* sp., soc. Corticiaceae, 6 Oct. 2000, K. Siepe (WU 29515). Münster, Kreis Recklinghausen, Herten, Schloßpark, MTB 4408/2, 51°36′00″ N, 07°08′00″ E, elev. 60 m, on branch of *Acer pseudoplatanus* on the ground, on wood, soc. effete *Eutypa maura*, 25 Sep. 2004, F. Kasparek, comm. K. Siepe (WU 29506, culture CBS 120634=C.P.K. 2019). Sachsen-Anhalt, Landkreis Aschersleben-Staßfurt, Staßfurt, Horst, MTB 4135/1, 51°51′24″ N, 11°33′40″ E, elev. 70 m, on partly decorticated branch of *Quercus robur* 4–8 cm thick, on wood, partly on grey Corticiaceae, 22 Aug. 2006, H. Voglmayr & W. Jaklitsch, W.J. 2933 (WU 29507, culture C.P.K. 2441). **Italy**, Apulia, Foggia, Gargano, SW from Mandrione, Foresta Umbra/Foresta Domaniale, 41°52′36″ N, 16°03′34″ E, elev. *ca* 200 m, on *Radulomyces molaris*/*Quercus cerris* branch 8–9 cm thick, also on leaves, soc. *Crepidotus mollis var. calolepis*, 21 Nov. 2009, W. Jaklitsch & H. Voglmayr, S 89 (WU 30192). Lazio, Viterbo, Farnese, Selva del Lamone, hiking trail Roppozzo, 42°34′25″ N, 11°42′08″ E, elev. 320 m, on decorticated branch of *Quercus cerris*, well-decayed, blackened wood, soc. *Steccherinum ochraceum*, W. Gams, W. Jaklitsch & H. Voglmayr, 28 Nov. 2009, S 154 (WU 30193). **United Kingdom**, Essex, Loughton, Epping Forest, Strawberry Hill Ponds, MTB 43-34/1, 51°38′57″ N, 00°02′41″ W, elev. 30 m, on a branch of *Quercus robur* 5 cm thick lying in grass, on well-decayed wood and bark, soc. resupinate polypore, 12 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3159 (WU 29514). Herefordshire, Hereford, Mordiford, Sufton Court, on well-decayed wood of *Ulmus* sp., ex herb. C. B. Plowright, Oct. 1878 (K 133302). Same data, coll. C. Spencer-Percival (K 133065). Leominster, Dinmore, on wood, probably *Fagus sylvatica*, Oct. 1878, C. B. Plowright (K 132937). Dinmore Hill, 52°09′23″ N, 02°43′09″ W, elev. 120 m, on a branch of *Quercus robur* 4 cm thick, on well-decayed wood, soc. *Diatrypella quercina* in bark, 11 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3153 (WU 29513, culture C.P.K. 3148). North Yorkshire, Kirkbymoorside, Dawson's Wood, 54°15′ N, 00°52′ W, elev. 70 m, on branch of *Populus* sp. on well-decayed wood, 5 Sep. 2007, H. Voglmayr & W. Jaklitsch, W.J. 3135 (WU 29510, C.P.K. 3138). Shropshire, Ludlow, Downton on the Rock, 52°22′14″ N, 02°48′58″ W, elev. 140 m, on branch of *Acer pseudoplatanus* 7–8 cm thick, on well-decayed wood blackened by *Xylaria longipes*, soc. Corticiaceae, 10 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3151 (WU 29512, culture C.P.K. 3147). Warwickshire, Alcester, Oversley Wood, 52°12′27″ N, 01°50′24″ W, elev. 70 m, on corticated branch of *Quercus robur* 4–6 cm thick, on bark and *Diatrypella quercina*, 10 Sep. 2007, W. Jaklitsch & H. Voglmayr, W.J. 3150 (WU 29511).

Notes: *Hypocrea tremelloides* is morphologically distinct because of its waxy to gelatinous, 'tremelloid' appearance of the stromata, light translucent perithecia and incarnate to pale orange-brown stroma colour. Stromata of the somewhat similar *Hypocrea sambuci* lack reddish colour tones, except when old, and occur specifically on *Sambucus*. Immature stromata may sometimes resemble those of immature *H. gelatinosa*, and Petch (7 Sep. 1936; annotation label) interpreted the specimen K 132937 as immature *H. gelatinosa*, but the latter has larger projecting perithecial protuberances and green ascospores when mature, yielding a green conidial gliocladium-like anamorph. Recent collections are in good agreement with the protologue and the

slightly extended version in Saccardo (1883a), who noted a similarity with *Naematelia*, i.e. *Tremella* basidiomes. An image of this species can be also found in Medardi (1999, p. 331; misidentified as *H. argillacea*). The hyaline-conidial *T. tremelloides*, characterised by densely sympodially elongating conidiophores, with phialides formed in this way often lacking a basal septum, is distinct from all others species of *Trichoderma* currently known, with the exception of the anamorph of the phylogenetically close *H. sambuci*. Apically branched phialides sometimes seen on PDA are also reminiscent of *T. subalpinum*, which clusters with *H. tremelloides* and *H. sambuci* in the phylogenetic analysis (see Fig. 1).

Hypocrea voglmayrii Jaklitsch, Mycologia, 97: 1368 (2005 [2006]). Fig. 104
Anamorph: ***Trichoderma voglmayrii*** Jaklitsch, Mycologia, 97: 1368 (2005[2006]). Fig. 105

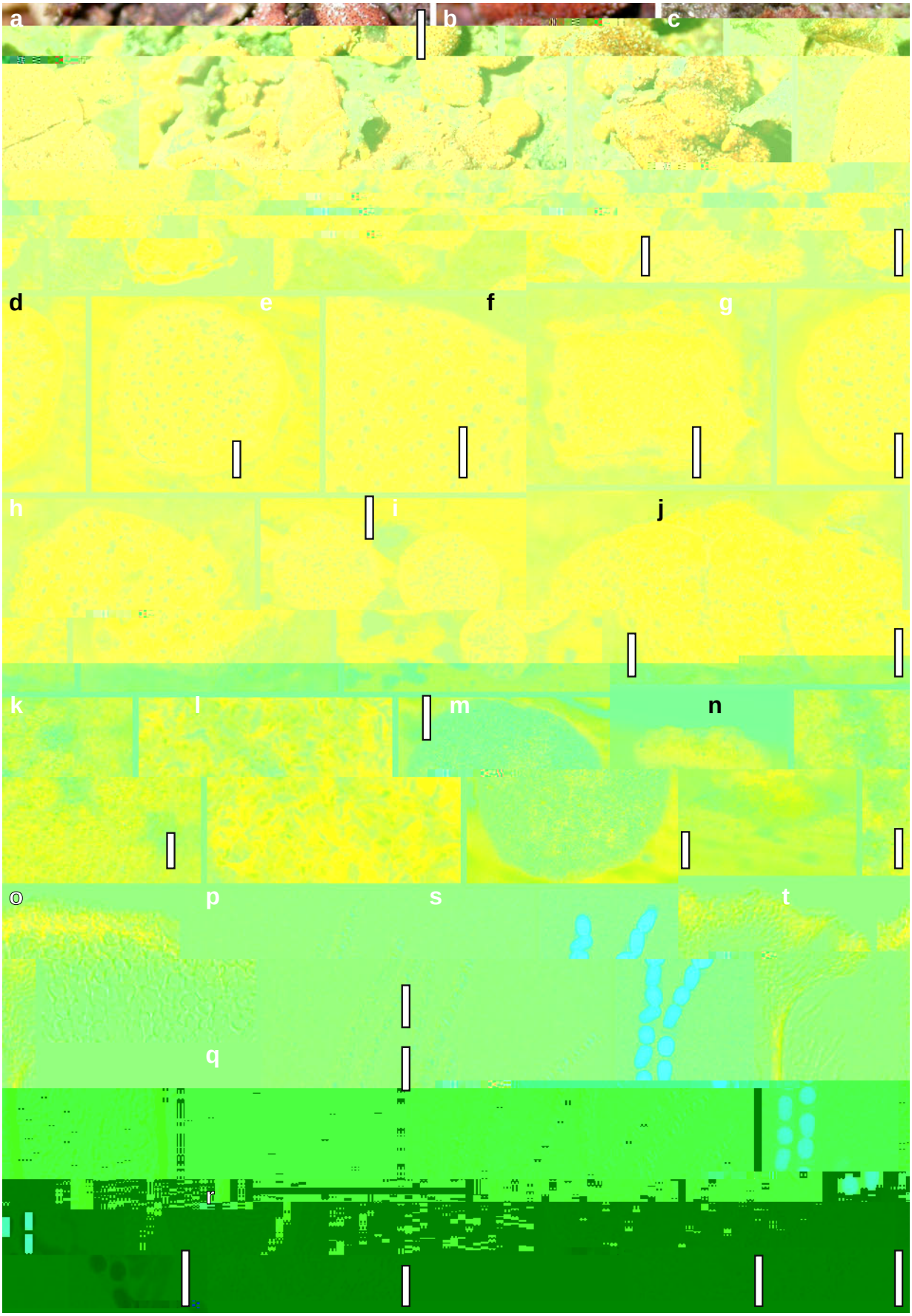
Stromata solitary or in small caespitose groups, on wood or more commonly erumpent through fissures in the bark with the sterile and light-coloured margin surrounded by the epidermis of the host. Stromata when dry (1.0–)1.3–3.0 (–5.1)×(0.7–)1.0–2.2(–3.2) mm, 0.3–0.7(–1.0) mm thick (*n* =30); pulvinate or discoid when fresh, when dry discoid or more or less turbinate, with a short sterile constricted stipe; base often surrounded by radiating white mycelium. Outline circular, angular or oblong. Margin free, rounded or sharp, sometimes undulate. Surface mostly plane or concave, smooth, glabrous, with perithecia entirely immersed. Ostiolar dots (24–)32–54(–70) μm (*n*=60) diam, densely arranged, conspicuous, well-defined, slightly raised, dark brown to black. Stromata brick red, 7CD6–7, rosy, greyish- or brownish red 9C5–6 when fresh, greyish- or brownish red, 9C5–6, to Cuba red, 9E7–8, or violaceous-brown, 10E7–8, when dry, with the margin concolorous or, like the stipe, whitish, yellowish or pale orange. Only slight differences between fresh and dry stromata apparent, except for a smoother surface and lighter, more reddish brown ostioles in fresh stromata, and some wrinkles and fine fissures sometimes in stellate arrangement around the ostiolar dots in dry stromata. Rehydrated stromata turning dark reddish brown to nearly black in 3% KOH,

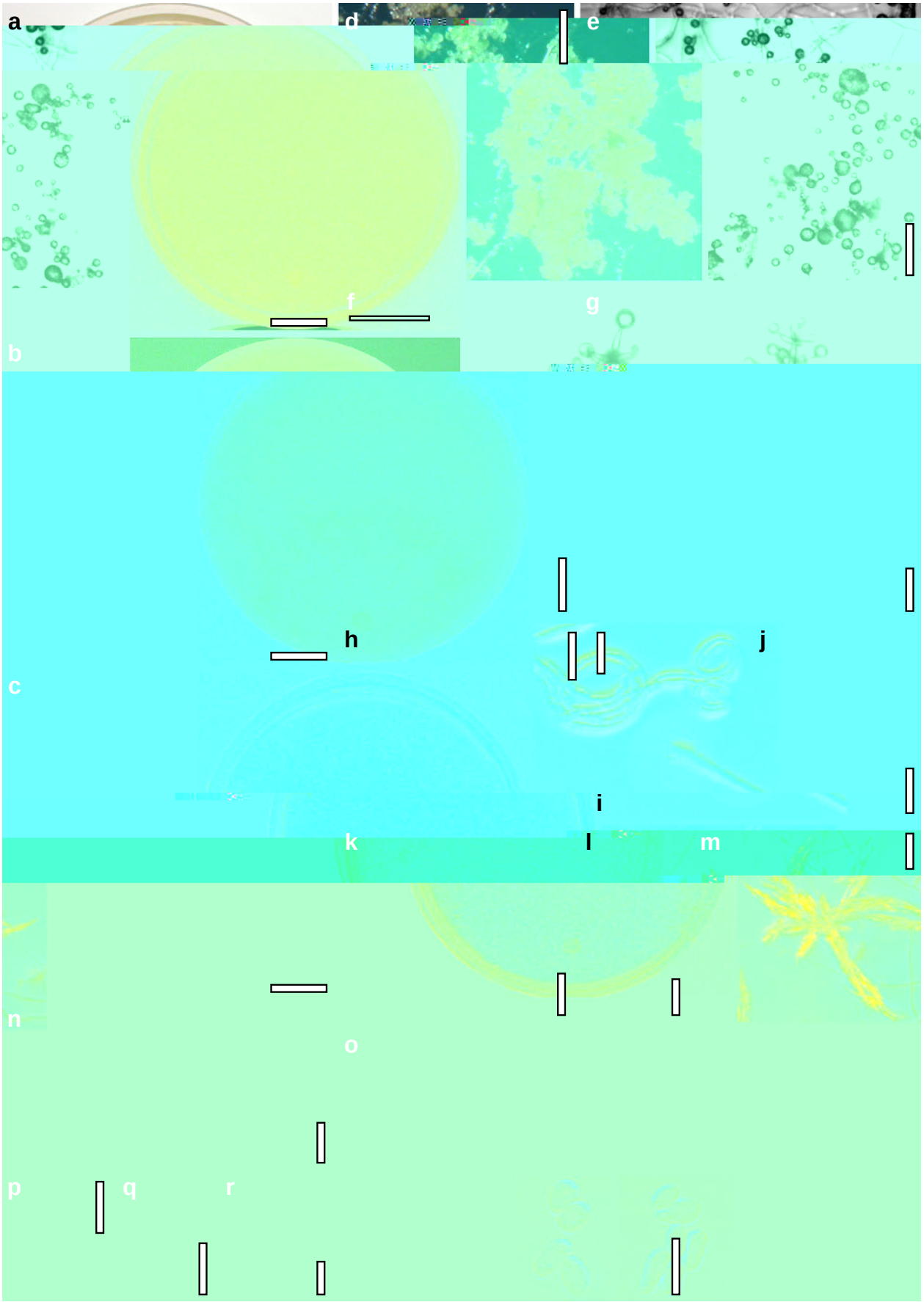
Stroma anatomy: Ostioles (50–)60–89(–100) μm long, projecting to 30(–55) μm (*n*=60), (26–)32–49(–55) (*n*=30) wide at the apex, apically appearing as a palisade of elongate, narrow, strongly compressed, orange to reddish cells, resembling those of the lateral peridium. Perithecia ellipsoidal, broadly cylindrical or flask-shaped, (185–)215–260(–285)×(80–)100–170(–230) μm (*n*=31), laterally compressed and approximately by 40% higher than wide on average. Peridium (12–)13–18(–20) μm (*n*=20) thick at the base, (5–)6–12(–16) μm (*n*=20) at the sides; orange- or reddish brown. Cortical tissue (6–)8–16(–22) μm (*n*=20) thick, consisting of thick-walled, compressed angular cells 3–10 μm (*n*=30) diam of indistinct outline, superposed by a thin compact, amorphous orange or reddish layer. Subcortical tissue a *t. angularis* of subglobose or angular cells (3–)5–11(–13)×(2.5–)4.5–8.5(–10.0) μm (*n*=30), hyaline, but orange to reddish just below the surface layer; entire tissue above the perithecia (30–)41–67(–77) μm (*n*= 20) thick. Subperithecial tissue of hyphae with strongly constricted septa and hyaline, refractive, elongate to subglobose cells (7–)12–38(–57)×(6–)8–18(–24) μm (*n*= 30) with walls *ca* 1–2 μm thick. Stroma base a hyaline, loose *t. intricata* of hyphae (2.0–)2.5–5.2(–7.5) μm (*n*=30) wide. Asci (60–)68–84(–94)×(3.3–)4.0–4.5(–5.5) μm (*n*= 60), stipe (4–)7–13(–17) μm (*n*=30) long. Ascospores hyaline, finely spinulose, cells dimorphic; distal cell 3.0–3.8(–4.5)×(2.5–)2.7–3.2(–3.5) μm, l/w (1.0–)1.1–1.3(–1.7) (*n*=60), subglobose, broadly ellipsoidal or wedge-shaped; proximal cell (3.3–)3.8–4.7(–5.5)×(2.0–)2.2–2.7(–3.2) μm, l/w (1.3–)1.5–2.0(–2.7) (*n*=60), oblong to nearly ellipsoidal, often slightly attenuated toward the base.

Cultures and anamorph: optimal growth at 30°C on all media, also growing at 35°C.

On CMD after 72 h 11–12 mm at 15°C, 35–36 mm at 25°C, 47–49 mm at 30°C, 17–19 mm at 35°C; mycelium covering the plate after 5–6 days at 25°C. Colony hyaline, thin, circular, not zonate, scarcely visible, with little mycelium on the agar surface; hyphae loosely arranged, with conspicuous difference in thickness between primary and secondary hyphae. Distal margin appearing slightly hairy to floccose due to long branched aerial hyphae. Autolytic activity low, coilings conspicuous. A coconut-like odour developing and a yellow pigment diffusing through the agar after 4 days. After 2 weeks the yellow pigment sometimes occurring as long needle-shaped crystals on the agar surface, particularly at higher temperatures. Chlamydospores noted after 6–8 days, scant; see SNA for measurements. Conidiation starting after 2–3 days, effuse; solitary phialides in rows arising from surface hyphae or fascicles of 3–5(–6) phialides from short, erect, scarcely branched conidiophores; within 4–9 days visible as inconspicuous and ill-defined powdery, white to pale yellow granules mainly in the distal third of the plate. Granules 0.1–0.5(–1.0) mm diam, made up of single or few

Fig. 104 Teleomorph of *Hypocrea voglmayrii*. **a**, **b.** Fresh stromata. c–▶ **k.** Dry stromata (**g.** part showing black ostiolar dots; **k.** stipitate stroma in side view). **l.** Ostiole surrounded by stellate fissures in the cortical crust. **m.** Stroma surface in face view. **n.** Rehydrated stroma in 3% KOH. **o.** Perithecium in section. **p.** Cortical and subcortical tissue in section. **q.** Subperithecial tissue in section. **r.** Stroma base in section. **s**, **t.** Asci with ascospores (**t.** in cotton blue/lactic acid). **a**, **b**, **t.** WU 25715. **c**, **g**, **o**–**s.** WU 25713. **d**, **i**, **l.** WU 25712. **e**, **f**, **j**, **k**, **m**, **n.** WU 25711. **h.** WU 25714. *Scale bars* **a**=1.5 mm. **b**=1 mm. **c**, **j**. 0.7 mm. **d**–**f**, **h**= 0.4 mm. **g**, **k**=0.2 mm. **i**, **n**=0.3 mm. **l**, **o**=40 μm. **m**=5 μm. **p**=15 μm. **q**, **r**=20 μm. **s**, **t**=10 μm


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
s
t
q
r


a
d
e
f
g
b
h
j
c
i
k
l
m
n
o
p
q
r

◀ **Fig. 105** Cultures and anamorph of *Hypocrea voglmayrii*. **a**–**c.** Cultures after 14 days (**a.** on CMD; **b.** on PDA; **c.** on SNA). **d.** Conidiation granules (SNA, 25°C, 14 days). **e.** Conidial heads (7 days). **f**, **g.** Conidiophores on growth plate (4 days). **h.** Coilings and autolytic excretion (PDA, 25°C, 5 days). **i.** Conidiophore submerged in agar (CMD, 30°C, 3 days). **j.** Conidial chains (8 days). **k.** Crystal formed on agar surface (CMD, 35°C, 6 days). **l.** Chlamydospores (CMD/SNA, 25/35°C, 6/7 days). **m**–**o.** Conidiophores and phialides (5–7 days). **p**–**r.** Conidia (6 days). **d**–**o.** All on CMD at 25°C except **d**, **h**, **i**, **k**, **l**. **a**, **c**, **e**–**g**, **j**, **m**–**o.** CBS 117710. **b**, **d**, **h**, **i**, **k**, **l**, **p**–**r.** CBS 117711. *Scale bars* **a**–**c**=15 mm. **d**, **e**=100 μm. **f**, **g**, **i**, **j**=20 μm. **h**, **k**=50 μm. **l**–**o**=10 μm. **p**–**r**=5 μm

coalescing conidiophores, bearing conidia in heads of up to 60 μm diam and later sometimes in chains. At the same time conidiation also occurring submerged in the agar. Conidiophores to 200 μm long, simple or with up to 5(–7) primary branches, mostly regularly tree-like, i.e. consisting of a main axis with short, mostly paired side branches to 35 μm long, at right angles in lower positions, inclined upwards in higher positions, increasing in length with distance from the tip, replaced at the tip by phialides. Side branches sometimes rebranching to form complex, dense, non-transparent structures. Phialides solitary or in whorls of 3–5(–7). Sparse conidial development also on long aerial hyphae. Phialides (5.5–)7–12(–17)×(2.7–)3.2–4.0(–4.7) μm, l/w=(1.4–)1.9–3.4(–5.0), (1.5–)2.0–3.0(–4.0) μm wide at the base (n=60), terminal phialides often longer than the flanking ones in the fascicle, lageniform to narrowly subcylindrical, sometimes sinuous, less commonly ampulliform or sometimes ventricose, inequilateral and with a long neck, widest point at various positions. Conidia (3.0–)3.5–6.5(–10.5)×(2.2–)2.5–3.3(–4.2), l/w=(1.1–)1.2–2.2(–3.4) (n=75), hyaline, yellowish in mass, oval to oblong, often attenuated toward one end, smooth, with guttules often in a group at each end. At 15°C development slower; at 30°C faster, with more abundant yellowish conidiation submerged in the agar, morphologically indistinguishable from granules on the surface of the agar. Coconut-like odour also formed at all other temperatures. Most abundant chlamydospores and yellow crystals formed at 30 and 35°C. At 35°C growth continuing for >1 week, with only few hyphae on the agar surface and scanty effuse, simple conidiation without any granulation after 4–5 days.

On PDA 9–11 mm at 15°C, 28–29 mm at 25°C, 27–31 mm at 30°C, 3–6 mm at 35°C; mycelium covering the plate after 7–8 days at 25°C; growth slower than on CMD, with hyphae more thickly and densely arranged than on CMD. Colony thick, dense, not or indistinctly zonate, with a thin, finely granular centre of extremely densely interwoven to condensed hyphae and an ill-defined, diffuse margin with surface hyphae forming strands. Surface whitish, turning yellow or greenish, downy to floccose by a reticulum of aerial hyphae forming thick strands and numerous narrow branches without any noticeable orientation. Autolytic activity and coilings conspicuous at 25 and 30°C. Conidiation finely granular, colourless to white, on numerous single phialides or short verticillium-like, seated on surface and aerial hyphae, effuse, spreading across the entire colony. Reverse and to some extent also surface turning light yellow from the centre, 3A3, 3B5–6, 4B4–5. Odour indistinct to slightly mushroomy. At 35°C growth slow, forming small sterile, white, hairy colonies.

On SNA 11–12 mm at 15°C, 33–35 mm at 25°C, 42–44 mm at 30°C, 9–15 mm at 35°C; mycelium covering the plate after 5–6 days at 25°C. Colony thin, hyaline, growth predominantly submerged in the agar, hyphae loosely arranged and sometimes forming several separated strands rather than a continuous colony. Aerial hyphae scant, more common and longer at the whitish and downy distal margin. Autolytic activity and coilings conspicuous at 25 and 30°C. Surface hyphae soon degenerating. Conidiation slightly more abundant and denser than on CMD, starting within 3 days with sessile phialides or supported by short conidiophores, mainly at the proximal margin, later also on long aerial hyphae in the distal part of the colony. After 5–7 days conidiation becoming visible as fine granules to 0.6 mm diam with conidial heads up to 60 μm diam, spreading from the distal margin back nearly across the entire plate, or concentrated in 2–3 concentric zones, turning greyish- to yellowish green, 28–30CD5–6. Granules more regularly shaped on SNA than on CMD, appearing waxy or glassy in the stereo-microscope. No diffusing pigment, no distinct odour detected. At 30°C conidiation denser, granules more regularly in 3 concentric zones, with conidial heads up to 100 μm diam. At 35°C colonies irregular, dense, hairy to floccose, conidiation more abundant than on CMD. Chlamydospores on SNA at 35°C more abundant than on CMD, spreading from the plug, (4.5–)6–14(–20)×(4.0–)4.5–7.0(–8.2) μm, l/w=1.0–2.7(–4.4) (n=34), globose, oval or subclavate and often truncated at one end when terminal, ellipsoidal, irregularly elongate or sinuous and large when intercalary, smooth.

Habitat: on dead, mostly corticated branches and small trunks of *Alnus alnobetula* (= *A. viridis*) and *A. incana* standing or lying on the ground.

Known distribution: Austria, at elev. 1000–1400 m in the upper montane vegetation zone of the central Alps.

Holotype: **Austria**, Salzburg, Böckstein, hiking trail close to the parking lot in front of the Gasteiner Heilstollen, MTB 8944/1, 47°04′58″ N, 13°06′08″ E, elev. 1280 m, on dead partly standing trunk of *Alnus alnobetula*, 5 Sep. 2003, W. Jaklitsch W.J. 2378 (WU 25711; ex-type culture CBS 117711=C.P.K. 948). ***Holotype*** of *Trichoderma voglmayrii* isolated from WU 25711 and deposited as a dry culture with the holotype of *H. voglmayrii* as WU 25711a.

Other specimens examined: **Austria**, Kärnten, Stappitz, from Gasthof Alpenrose up along the brook parallel to the hiking trail 518, MTB 8945/3, 47°01′07″ N, 13°11′14″ E, elev. 1360 m, on dead branch of *Alnus alnobetula* on the ground, 5 Sep. 2003, W. Jaklitsch, W.J. 2382 (WU 25715, culture C.P.K. 951). Salzburg, Felbertal, Mittersill, on branch of *Alnus* sp., 15 Aug. 2005, G.F. Medardi (K!, as *H. rufa*). Steiermark, Schladminger Tauern, Kleinsölk, steep forest at the western side of the lake Schwarzensee, MTB 8749/1, 47° 17′35″ N, 13°52′15″ E, elev. 1165 m, on dead branch of *Alnus incana* on the ground, 6 Aug. 2003, W. Jaklitsch & H. Voglmayr, W.J. 2302 (WU 25712, culture CBS 117710=C. P.K. 1592); same region, hiking trail between Schwarzensee and Putzentalalm, MTB 8749/1, 47°16′36″ N, 13°51′44″ E, elev. 1320 m, on dead standing trunk of *Alnus alnobetula*, 6 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2304 (WU 25713); same region, 47°17′00″ N, 13°52′02″ E, elev. 1190 m, on dead standing trunk of *Alnus alnobetula*, 6 Aug. 2003, H. Voglmayr & W. Jaklitsch, W.J. 2305 (WU 25714, culture C.P.K. 941).

Notes: *Hypocrea voglmayrii* is well-characterised by a set of ecological and morphological traits: the occurrence on *Alnus* spp., particularly *A. alnobetula*, at high altitudes in the Alps; the conspicuous dark brown to black ostiolar dots in dry stromata; the effuse conidiation and formation of a coconut odour on CMD. The ability of this species to grow at 35°C may be related to its habit to ascend trunks, thereby becoming exposed to microclimatic effects, such as direct sunshine. Phylogenetically *H. voglmayrii* forms a lone lineage in a well-supported clade including the section *Trichoderma*. The formation of 6-pentyl-α-pyrone is otherwise only in that section perceptible as coconut odour (Samuels 2006). However, the conidiation, pale green only on SNA, or growth at 35°C are not typical of the section *Trichoderma*, as well as the glabrous stromata with conspicuous, well-defined dark ostiolar dots. See Jaklitsch et al. (2005) for more details.

List of dubious or excluded names relevant to Europe

This list provides comments to names or species of *Hypocrea*/*Trichoderma* that are relevant for Europe, regarded to be dubious or excluded from the genus, and some species from other regions of the world reported to occur in Europe by other authors. Abbreviations: DU.. dubious, NE.. non-European, EX.. excluded, SYN.. synonym. Recognised binomials in other genera are given in bold. For synonyms of accepted *Hypocrea* species see under the respective accepted taxon and the Index.

DU ***Hypocrea armata*** (Fr.) Fr., Summa Veg. Scand., p. 383 (1849).
≡ *Sphaeria armata* Fr., Syst. Mycol. 2: 336 (1823).
Status: dubious. The protologue suggests a species of *Hypomyces*, such as *H. armeniacus* Tul. & C. Tul. No information on ascospores was given.
Type specimen: unavailable in UPS.
Habitat and distribution: on soil in Europe (Germany, Switzerland).

EX ***Hypocrea atra*** Fr., Summa Veg. Scand., p. 564 (1849).
Status: a synonym of ***Hypomyces luteovirens*** (Fr. : Fr.) Tul. & C. Tul.
Authentic specimens: UPS 113616 and 113617.
Reference: Rogerson and Samuels (1994, p. 854).

NE ***Hypocrea brevipes*** (Mont.) Sacc., Michelia 1: 304 (1878).
≡ *Cordyceps brevipes* Mont., Syll. Gen. Spec. Crypt., p. 201 (1856).
Synonyms: *Podostroma brevipes* (Mont.) Seaver, *Podocrea brevipes* (Mont.) Sacc. & D. Sacc.
Status: accepted species, known from tropical America, New Guinea and Japan, but the occurrence in Europe remains to be proven. Doi (1975) interpreted a specimen from England (Herefordshire, Downton Gorge, on *Quercus*, 17 Sep. 1951, J. Webster IMI 47042), as *H. brevipes*. Samuels and Lodge (1996) accepted Doi's interpretation. This specimen was examined and identified as *H. alutacea* with laterally fused stromata, which is not uncommon in this species.

Additional references: Chamberlain et al. (2004), Doi (1979).

DU ***Hypocrea citrina*** De Not. in Saccardo, Syll. Fung. 2: 528 (1883a).
Status: dubious; given as a synonym of *H. fungicola* (= *H. pulvinata*) in the cryptic citation by Saccardo '*Sphaeria* et *Hypocrea citrina* Pers. et De Not., ex parte'. Apparently this name has never been validly published. No type specimen is available in PAD.

EX ***Hypocrea citrina*** β ***ochracea*** Sacc., Syll. Fung. 2: 528 (1883a).
≡ *Sphaeria ochracea* Pers., Syn. meth. Fung. (Göttingen): 18 (1801).
Status: a synonym of *Hypomyces armeniacus* Tul., syn. ***Hypomyces ochraceus*** (Pers.) Tul. & C. Tul. According to Rogerson and Samuels (1994, p. 846) there is no type material of *Sphaeria ochracea* Pers. in L. According to G. Arnold (K. Põldmaa, pers. comm.) there is a drawing next to the original description of *Sphaeria ochracea*, which could serve as the holotype or lectotype of *Hypomyces ochraceus*, having precedence over *H. armeniacus*.

DU ***Hypocrea cordyceps*** Velenovsky, Ceske Houby, dil. IV-V, Pl. 3 (1922)
Status: dubious. The protologue suggests a typical '*Podostroma'*, the stroma length of 12–20 cm suggests *H. nybergiana*, but ascospore cells are given as only 2 μ

≡ *Acrospermum lichenoides* Tode, Fung. mecklenb. sel. (Lüneburg): 9 (1790).
Status: a synonym of **Hypocreopsis lichenoides** (Tode) Seaver, Mycologia 2: 82 (1910).
Reference: Rossman et al. (1999).

EX ***Hypocrea luteovirens*** (Fr. : Fr.) Fr., Summa Veg. Scand., p. 383 (1849).
≡ *Sphaeria luteovirens* Fr., Kongl. Vetensk. Akad. Handl. 38: 251 (1817) : Fries, Syst. Mycol. 2: 339 (1823).
Status: a synonym of ***Hypomyces luteovirens*** (Fr. : Fr.) Tul. & C. Tul.
Reference: Rogerson and Samuels (1994, p. 854).

?SYN ***Hypocrea moliniae*** Pass., Erb. Critt. Ital. no. 1077 (1881).
Status: probably a synonym of *H. spinulosa*. See Jaklitsch (2009).

EX ***Hypocrea pallida*** Ellis & Everh.. J. Mycol. 2(6): 65 (1886).
Status: basionym of ***Protocrea pallida*** (Ellis & Everh.) Jaklitsch, K. Põldmaa & Samuels.
Habitat and distribution: on basidiomes of *Oligoporus* and *Tyromyces* spp. in Europe, Japan and North America.
Reference: Jaklitsch et al. (2008b).

EX ***Hypocrea papyracea*** Ellis & Holw., J. Mycol. 2(6): 66 (1886).
Status: synonym of ***Arachnocrea stipata*** (Fuckel) Z. Moravec (1956).
See also under *H. stipata*.

EX ***Hypocrea parmelioides*** (Mont.) Mont., Syll. Gen. Spec. Crypt., p. 210 (1856).
≡ *Sphaeria parmelioides* Mont., Ann. Sci. Nat. Bot., Sér. 2, 6: 333, t. 18, Fig. 4 (1836).
Status: a synonym of ***Hypocreopsis lichenoides*** (Tode) Seaver, Mycologia 2: 82 (1910).
References: Rossman et al. (1999), Seaver (1910, p. 82).

NE ***Hypocrea patella*** Cooke & Peck in Peck, Ann. Rep. New York State Mus. Nat. Hist. 29: 57 (1878).
Status: not yet detected in Europe. Dodd et al. (2002), in redescribing the species from North America, also cited two specimens from Styria, Austria, based on teleomorph morphology. One of these specimens (J. Poelt, 27 Sep. 1984, in GZU 116.84) was re-examined and identified as *H. tremelloides*; the other specimen from a nearby area could not be located in GZU.
Habitat and distribution: wood and bark; eastern North America, ?Japan.

NE ***Hypocrea pseudostraminea*** Yoshim. Doi, Bull. Natl. Sci. Mus. (Tokyo) 15: 676 (1972).
This species was originally described from Japan. It was treated by Overton et al. (2006a) in sect. *Hypocreanum*, but no Japanese material was sequenced. Accordingly, it is unclear whether American specimens identified under this name are indeed this species. Overton et al. (2006a) also identified a European specimen (France, Osserain, on *Phyllostachys* sp., 22 Oct. 1989, F. Candoussau No. 4805-16 (BPI 1107143) as *H. pseudostraminea* based on teleomorph morphology. A re-examination of that specimen revealed stromata of 0.5–7×0.5–5×0.1–0.2 mm with minute ascospores, distal cells (2.2–)2.3–2.7(–3.0)×2.0–2.5 μm, proximal cells (2.5–)2.8–3.5(–4.0)×(1.5–)1.7–2.0 μm (n= 30), and a *Trichoderma* with green conidia 2.5–3.5×1.5–2.2 μm, l/w 1.3–1.8 (n=30), directly at the stroma margins. These findings suggest an affiliation of this specimen to the *Brevicompactum* clade rather than to sect. *Hypocreanum*.

DU ***Hypocrea pulvinata*** β ***serialis*** Hazsl., Math. es term. Közlem. 25(2): 20 (1892).
Status: obscure in the absence of type material and cultures.
Type specimen: not available in BP.
Habitat and distribution: on *Thelephora ochracea* Fr. on a conifer (?) in Eperjes, Hungary. If Hazslinsky had meant *Steccherinum ochraceum* instead of *Conferticium ochraceum* (Fr.) Hallenb., the currently accepted name of *Thelephora ochracea*, then he possibly described *Hypocrea thelephoricola*. The protologue favours this option.
Reference: description in Saccardo (1899).

DU ***Hypocrea rufa*** **var.** ***lateritia*** Sacc., Fungi veneti novi vel. crit., Ser. 4: 24 (1875).
Stromata pulvinate, reddish, asci filiform, 95–100×5 μm, ascospore cells 4–4.5 μm diam, 1-guttulate, hyaline.
Status: dubious, possibly a synonym of *H. minutispora*; not interpretable with certainty without a type specimen.
Type specimen: not available in PAD.
Habitat and distribution: on branches of *Fagus sylvatica* in Italy.
References: additional descriptions in Saccardo (1878, p. 301), Saccardo (1883a, p. 520).

DU ***Hypocrea rufa*** **var.** ***minor*** Z. Moravec, Česká Mykol. 10: 89 (1956).
Status: obscure in the absence of type material.
Type specimen: not available in PRM.
Habitat and distribution: on *Stereum* sp. in the Czech Republic.

DU ***Hypocrea rufa*** **var.** ***sublateritia*** Sacc., Fungi veneti novi vel. crit., Ser. 4: 24 (1875).

Said to be similar to *H. rufa* var. *lateritia*, but stromata smaller. Asci 70–80×3–4.5 μm, ascospore cells globose, 3–4 μm diam, 1-guttulate, hyaline.
Status: dubious, not interpretable without a type specimen.
Type specimen: not available in PAD.
Habitat and distribution: branches of *Buxus sempervirens* and *Celtis* in Italy and South America.
References: additional descriptions in Saccardo (1878, p. 301 and 1883a, p. 520).

EX ***Hypocrea stipata*** (Lib.) Fuckel, Jb. Nassau. Ver. Naturk. 25–26: 23 (1871).
≡ *Sphaeria stipata* Lib., Plantae cryptog. Ardenn. no. 343 (1837).
Status: synonym of ***Arachnocrea stipata*** (Fuckel) Z. Moravec (1956).
Habitat and distribution: on wood and bark, leaves and fungi in Europe, Japan and North America.
References: Dennis (1981), Moravec (1956), Rossman et al. (1999), Põldmaa (1999; anamorph).

EX ***Hypocrea tubercullariformis*** Rehm ex Sacc., Michelia 1: 302 (1878).
Status: a synonym of ***Nectria tubercullariformis*** (Rehm ex Sacc.) G. Winter 1884 [1887].
Habitat and distribution: on cow dung/herbs in Tyrol, Austria; alpine.
References: Samuels et al. (1984, p. 1898), Winter 1884 [1887].

DU ***Hypocrea viridis*** (Tode : Fr.) Peck, Ann. Rep. New York St. Mus. 31: 49 (1879).
≡ *Sphaeria gelatinosa* β *viridis* Tode, Fungi Mecklenb. 2: 49 (1791).
Status: according to Chaverri and Samuels (2003) this name is obsolete, because the type specimen is lost and the protologue is not informative. When following Petch (1937), *H. viridis* becomes a synonym of *H. gelatinosa*. See Notes under *Hypocrea lutea*. Barr et al. (1986) noted that Peck meant a species distinct from *H. gelatinosa*. Whatever Peck meant, *H. viridis* cannot be used for his material because of the ambiguous status of the basionym.

EX ***Hypocrea vitalbae*** Berk. & Broome, Ann. Mag. Nat. Hist., Ser. 3, 3: 362, pl. 9, f. 8 (1859).
Status: a synonym of ***Broomella vitalbae*** (Berk. & Broome) Sacc.
References: Saccardo (1883b, p. 558), Shoemaker and Müller (1963, p. 1237).

Acknowledgements I want to express my sincere thanks to all the people mentioned in Jaklitsch (2009), who contributed to this work, particularly Hermann Voglmayr, Christian P. Kubicek, Gary J. Samuels and Walter Gams. In addition I want to thank Till R. Lohmeyer, Martin Bemmann, Bernd Fellmann and Christian Gubitz for specimens of *Hypocrea* teleomorphs. Thanks to Gary Samuels also for literature and investigations into the history of *Hypocrea lenta*. Special thanks to Walter Gams, Eric McKenzie and Christian Kubicek for reviewing the manuscript. Thanks to Ovidiu Constantinescu for checking for original material of *Hypocrea lutea* in UPS, and to K. Seifert for the contribution of the generic name *Polypaecilum* (via G.J. Samuels). The financial support by the Austrian Science Fund (FWF projects P16465-B03, P19143-B17 and P22081-B17) is gratefully acknowledged.

Open Access This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

References

Atkinson GF (1905) Life history of *Hypocrea alutacea*. Bot Gaz 40:401–417
Barr ME, Rogerson CT, Smith SJ, Haines JH (1986) An annotated catalog of the pyrenomycetes described by Charles H. Peck. N. Y. State Mus. Bull. 459:1–74. http://www.mykoweb.com/systematics/Peck.html
Bissett J (1991a) A revision of the genus *Trichoderma.* II. Infrageneric classification. Can J Bot 69:2357–2372
Bissett J (1991b) A revision of the genus *Trichoderma.* III. Section Pachybasium. Can J Bot 69:2373–2417
Booth C (1971) The genus *Fusarium.* Commonwealth Mycological Institute. CAB, Eastern, London, p 237
Bresadola J (1903) Fungi polonici a cl. Viro B. Eichler lecti. Ann Mycol 1:65–131
Cannon PF (1996) IMI Descriptions of Fungi and Bacteria Set 129. CAB International. Mycopathologia 135:37–71
Chamberlain HL, Rossman AY, Stewart EL, Ulvinen T, Samuels GJ (2004) The stipitate species of *Hypocrea* (*Hypocreales*, *Hypocreaceae*) including *Podostroma*. Karstenia 44:1–24
Chaverri P, Samuels GJ (2003) *Hypocrea*/*Trichoderma* (*Ascomycota*, *Hypocreales*, *Hypocreaceae*): species with green ascospores. Stud Mycol 48:1–116
Chaverri P, Castlebury LA, Overton BE, Samuels GJ (2003) *Hypocrea*/*Trichoderma*: species with conidiophore elongations and green conidia. Mycologia 95:1100–1140
Currey F (1863) Transactions of the Linnean Society. Botany 25:244, not traced
Dämon W (1996) Bemerkenswerte Pilzfunde aus dem Schwingrasen-Moorwald am Krottensee (Gmunden, Oberösterreich). Österr Z Pilzk 5:95–129
De Hoog GS, Guarro J, Gené J, Figueras MJ (2000) Atlas of clinical fungi, 2nd edn. CBS, Utrecht, p 884
Degenkolb T, Gräfenhan T, Nirenberg HI, Gams W, Bückner H (2006) *Trichoderma brevicompactum* complex: rich source of novel and recurrent plant-protective polypeptide antibiotics (peptaibiotics). J Agric Food Chem 54:7047–7061
Degenkolb T, Dieckmann R, Nielsen KF, Gräfenhan T, Theis C, Zafari D, Chaverri P, Ismaiel A, Brückner H, von Döhren H, Thrane U, Petrini O, Samuels GJ (2008a) The *Trichoderma brevicompactum* clade: a separate lineage with new species, new peptaibiotics, and mycotoxins. Mycol Prog 7:177–219
Degenkolb T, von Döhren H, Nielsen KF, Samuels GJ, Brückner H (2008b) Recent advances and future prospects in peptaibiotics, hydrophobin, and mycotoxin research, and their importance for

chemotaxonomy of *Trichoderma* and *Hypocrea*. Chem Biodiv 5:671–680
Dennis RWG (1981) British Ascomycetes. Addenda and Corrigenda. J Cramer Vaduz 40
Dodd SL, Lieckfeldt E, Chaverri P, Overton BE, Samuels GJ (2002) Taxonomy and phylogenetic relationships of two species of *Hypocrea* with *Trichoderma* anamorphs. Mycol Prog 1:409–428
Dodd SL, Lieckfeldt E, Samuels GJ (2003) *Hypocrea atroviridis* sp. nov., the teleomorph of *Trichoderma atroviride*. Mycologia 95:27–40
Doi Y (1966) A revision of *Hypocreales* with cultural observation I. Some Japanese species of Hypocrea and Podostroma. Bull Natl Sci Mus Tokyo 9:345–357
Doi Y (1972) Revision of the *Hypocreales* with cultural observations IV. The genus *Hypocrea* and its allies in Japan. (2) Enumeration of the species. Bull Natl Sci Mus Tokyo 15:649–751
Doi (1975) Revision of *Hypocreales* with cultural observations VIII. *Hypocrea peltata* (Jungh.) Berk. and its allies. Bull Natl Sci Mus Tokyo B 1:121–134
Doi Y (1979) Revision of *Hypocreales* with cultural observations XII. Additional note on *Hypocrea peltata* (Jungh.) Berk. and its allied species. Bull Natl Sci Mus Tokyo B 5:37–49
Domsch KH, Gams W, Anderson T-H (2007) Compendium of soil fungi, 2nd edn. IHW Verlag, Eching, p 672
Ellis MB, Ellis JP (1985) Microfungi on land plants. An Identification Handbook. Croom Helm. London & Sydney. 818 pp
Ellis JB, Everhart BM (1892) The North American Pyrenomycetes. Newfield, NJ. 793 pp
Fries EM (1823) *Sphaeria,* Trib. VI. Lignosae. In Systema mycologicum, sistens fungorum ordines, genera et species hucusque cognitas, quas ad normam methodi naturalis determinavit, disposuit atque descripsit 2. Mauritius, Greifswald
Fries EM (1849) Summa Vegetabilium Scandinaviae. Sectio Posterior. Holmiae & Lipsiae, pp 259–572
Fuckel L (1870) Symbolae Mycologicae. Beiträge zur Kenntnis der Rheinischen Pilze. Jahrb Nassau Ver Naturkd 23–24:1–459
Gilman JC (1957) A manual of soil fungi, 2nd edn. Iowa State College, USA, Iowa, Ames, p 450
Gilman JC, Abbott EV (1927) A summary of the soil fungi. Iowa State Coll J Sci 1:225–343
Grove WB (1885) New or noteworthy fungi: - Part II. J Bot 23:129–134
Hageskal G, Vrålstad T, Knutsen AK, Skaar I (2008) Exploring the species diversity of *Trichoderma* in Norwegian drinking water systems by DNA barcoding. Mol Ecol Resour 8(6):1178–1188
Hanada RE, de Souza TJ, Pomella AWV, Hebbar KP, Pereira JO, Ismaiel A, Samuels GJ (2008) *Trichoderma martiale* sp. nov., a new endophyte from sapwood of *Theobroma cacao* with a potential for biological control. Mycol Res 112:1335–1343
Jaklitsch WM (2007) *Immersisphaeria* gen. nov. from Poland. Mycotaxon 101:17–23
Jaklitsch WM (2009) European species of *Hypocrea.* Part I. The green-spored species. Stud Mycol 63:1–91
Jaklitsch WM, Komon M, Kubicek CP, Druzhinina IS (2005) *Hypocrea voglmayrii* sp. nov. from the Austrian Alps represents a new phylogenetic clade in *Hypocrea*/*Trichoderma*. Mycologia 97:1365–1378
Jaklitsch WM, Komon M, Kubicek CP, Druzhinina IS (2006a) *Hypocrea crystalligena* sp. nov., a common European species with a white-spored *Trichoderma* anamorph. Mycologia 98:499–513
Jaklitsch WM, Samuels GJ, Dodd SL, Lu B-S, Druzhinina IS (2006b) *Hypocrea rufa*/*Trichoderma viride*: a reassessment, and description of five closely related species with and without warted conidia. Stud Mycol 56:135–177
Jaklitsch WM, Põldmaa K, Samuels GJ (2008a) Reconsideration of *Protocrea* (*Hypocreales*, *Hypocreaceae*). Mycologia 100:962–984
Jaklitsch WM, Gruber S, Voglmayr H (2008b) *Hypocrea seppoi*, a new stipitate species from Finland. Karstenia 48:1–11
Kindermann J, El-Ayouti Y, Samuels GJ, Kubicek CP (1998) Phylogeny of the genus *Trichoderma* based on sequence analysis of the internal transcribed spacer region 1 of the rDNA cluster. Fungal Genet Biol 24:298–309
Klok P (2006) A rare little cushion: *Hypocrea argillacea* Phill. & Plowr. Coolia 49:70–71
Kraus GF, Druzhinina I, Gams W, Bisset J, Zafari D, Szakacs G, Koptchinski A, Prillinger H, Zare R, Kubicek CP (2004) *Trichoderma brevicompactum* sp. nov. Mycologia 96:1059–1073
Kullnig-Gradinger CM, Szakacs G, Kubicek CP (2002) Phylogeny and evolution of the genus *Trichoderma*: a multigene approach. Mycol Res 106:757–767
Kvas M, Marasas WFO, Wingfield BD, Wingfield MJ, Steenkamp ET (2009) Diversity and evolution of *Fusarium* species in the *Gibberella fujikuroi* complex. Fungal Divers 34:1–21
Lieckfeldt E, Samuels GJ, Börner T, Gams W (1998) *Trichoderma koningii*: neotypification and *Hypocrea* teleomorph. Can J Bot 76:1507–1522
Lu B, Druzhinina IS, Fallah P, Chaverri P, Gradinger C, Kubicek CP, Samuels GJ (2004) *Hypocrea*/*Trichoderma* species with pachybasium-like conidiophores: teleomorphs for *T. minutisporum* and *T. polysporum* and their newly discovered relatives. Mycologia 96:310–342
Matruchot L (1893) Sur un *Gliocladium* nouveau. Bull Trimest Soc Mycol Fr 9:249–252
Matsushima T (1975) Icones Microfungorum a Matsushima Lectorum. Kobe, Japan. 209 pp., 415 plates
Matsushima T (1989) Matsushima mycological memoirs (no. 651) 6:21
Medardi G (1999) Studio sul genere *Hypocrea* Fries. Riv Micol AMB 42:327–338
Migula W (1913) Kryptogamen-Flora von Deutschland, Deutsch-Österreich und der Schweiz. Band III. Pilze. **3**. Teil. 1. und 2. Abteilung. Berlin. Gera. 1404 pp
Moravec Z (1956) *Arachnocrea*, un genre nouveau de la famille des *Nectriaceae*. Bull Trimest Soc Mycol Fr 72:160–166
Morquer R, Viala G, Rouch J, Fayret J, Bergé G (1963) Contribution à l'étude morphogénique du genre *Gliocladium*. Bull Trimest Soc Mycol Fr 79:137–241
Müller E, Aebi B, Webster J (1972) Culture studies on *Hypocrea* and *Trichoderma* V. Hypocrea psychrophila sp. nov. Trans Br Mycol Soc 58:1–4
O'Donnell K, Nirenberg HI, Aoki T, Cigelnik E (2000) A multigene phylogeny of the *Gibberella fujikuroi* species complex: detection of additional phylogenetically distinct species. Mycoscience 41:61–78
Overton BE, Stewart EL, Geiser DM, Wenner NG, Jaklitsch W (2006a) Systematics of *Hypocrea citrina* and allies. Stud Mycol 56:1–38
Overton BE, Stewart EL, Geiser DM (2006b) Taxonomy and phylogenetic relationships of nine species of *Hypocrea* with anamorphs assignable to *Trichoderma* section *Hypocreanum*. Stud Mycol 56:39–65
Packer L (2008) Phylogeny and classification of the *Xeromelissinae* (*Hymenoptera*: *Apoidea*, *Colletidae*) with special emphasis on the genus *Chilicola*. Syst Entomol 33:72–96
Petch T (1935) Notes on British *Hypocreaceae*. J Bot Lond 73:184–224
Petch T (1937) Notes on British *Hypocreaceae* III. J Bot Lond 75:217–231
Petch T (1938) British *Hypocreales*. Trans Br Mycol Soc 21:243–305
Petrak F (1940) Mykologische Notizen XIII. Ann Mycol 38:181–267
Põldmaa K (1999) The genus *Hypomyces* (*Hypocreales*, *Ascomycota*) and allied fungicolous fungi in Estonia 1. Species growing on aphyllophoralean basidiomycetes. Folia Cryptogam Est Fasc 34:15–31
Põldmaa K, Larsson E, Kõljalg U (1999) Phylogenetic relationships in *Hypomyces* and allied genera, with emphasis on species growing on wood-decaying homobasidiomycetes. Can J Bot 77:1756–1768

Rehm H (1905) Ascomycetes exs. Fasc. 34. Ann Mycol 3:224–231
Rifai MA (1969) A revision of the genus *Trichoderma*. Mycol Pap 116:1–56
Rifai MA, Webster J (1966) Culture studies on *Hypocrea* and *Trichoderma* II. Trans Br Mycol Soc 49:289–296
Rogerson CT, Samuels GJ (1993) Polyporicolous species of *Hypomyces*. Mycologia 85:231–272
Rogerson CT, Samuels GJ (1994) Agaricicolous species of *Hypomyces*. Mycologia 86:839–866
Rossman AY, Samuels GJ, Rogerson CT, Lowen R (1999) Genera of *Bionectriaceae*, *Hypocreaceae* and *Nectriaceae* (*Hypocreales*, *Ascomycetes*). Stud Mycol 42:1–248
Saccardo PA (1878) Enumeratio pyrenomycetum *Hypocreacearum* hucusque cognitorum systemate carpologico dispositorum. Michelia 1:301
Saccardo PA (1883a) *Hypocreaceae*, Hyalodidymae, *Hypocrea*. Syll Fung 2:520–536
Saccardo PA (1883b) *Hypocreaceae*, Phragmosporae, Broomella. Syll Fung 2:558
Saccardo PA (1885) Fungi Algerienses, Tahitenses et Gallici. Rev Mycol Toulouse 7:158–161
Saccardo PA (1886) *Hypocrea*. Syll Fung Add 1–4:1–484
Saccardo PA (1899) Pyrenomycetae, *Hypocreaceae*, Hyalodidymae, *Hypocrea*. Syll Fung 14:641–645
Samuels GJ (2006) *Trichoderma*: systematics, the sexual state, and ecology. Phytopathology 96:195–206
Samuels GJ, Ismaiel A (2009) *Trichoderma evansii* and *T. lieckfeldtiae*: two new *T. hamatum*-like species. Mycologia 101:142–156
Samuels GJ, Lodge DJ (1996) Three species of *Hypocrea* with stipitate stromata and *Trichoderma* anamorphs. Mycologia 88:302–315
Samuels GJ, Doi Y, Rogerson CT (1990) Contributions toward a mycobiota of Indonesia: *Hypocreales*. Mem NY Bot Gard 59:6–108
Samuels GJ, Rogerson CT, Rossman AY, Smith JD (1984) *Nectria tubercullariformis*, *Nectriella muelleri*, *Nectriella* sp., and *Hyponectria sceptri*: low temperature tolerant, alpine-boreal fungal antagonists. Can J Bot 62:1896–1903
Samuels GJ, Petrini O, Kuhls K, Lieckfeldt E, Kubicek CP (1998) The *Hypocrea schweinitzii* complex and *Trichoderma* sect. Longibrachiatum. Stud Mycol 41:1–54
Samuels GJ, Dodd S, Lu B-S, Petrini O, Schroers H-J, Druzhinina IS (2006a) The *Trichoderma koningii* aggregate species. Stud Mycol 56:67–133
Samuels GJ, Rossman AY, Chaverri P, Overton BE, Põldmaa K (2006b) *Hypocreales* of the Southeastern United States: an identification guide. CBS Biodivers Ser 4:1–145
Samuels GJ, Ismaiel A, Bon M-C, de Respinis S, Petrini O (2010) *Trichoderma asperellum* sensu lato consists of two cryptic species. Mycologia 102:944–966
Seaver FJ (1910) The *Hypocreales* of North America - III. Mycologia 2:48–92
Shoemaker RA, Müller E (1963) Generic correlations and concepts: *Broomella* and *Pestalotia*. Can J Bot 41:1235–1243
Smith G (1961) *Polypaecilum* gen. nov. Trans Br Mycol Soc 44:437–440
Sopp OJ (1912) Monographie der Pilzgruppe *Penicillium* mit besonderer Berücksichtigung der in Norwegen gefundenen Arten. *Skrift Vidensk-Selsk Christiana* 11:1–208
Spooner BM, Williams MAJ (1990) *Hypocrea placentula* and its *Trichoderma* anamorph. Mycologist 4:66–69
Subramanian CV (1971) *Hyphomycetes*—an Account of Indian Species, except Cercosporae. Indian Council for Agricultural Research, New Delhi
Thom C (1930) The Penicillia. Baillière, Tindall & Cox. London, p 644
Tode F (1791) Fungi Mecklenburgenses selecti, Fasciculus 2. I.F.G. Lemke, Lüneburg
von Höhnel F, Litschauer V (1906) Revision der Corticien in Dr J. Schröter's 'Pilze Schlesiens' nach seinen Herbarexemplaren. Ann Mycol 4:288–294
Webster J, Rifai MA (1968) Culture studies on *Hypocrea* and *Trichoderma* IV. Hypocrea pilulifera sp. nov. Trans Br Mycol Soc 51:511–514
Winter G (1887) Die Pilze. II. Abtheilung: Ascomyceten: Gymnoasceen und Pyrenomyceten. Rabenhorst Kryptogamenflora von Deutschland, Österreich und der Schweiz 1(2):1–928. E. Kummer. Leipzig

Further reading

Errata in Jaklitsch (2009), Studies in Mycology 63: 1) Legends to Fig. 8 of *Hypocrea aureoviridis* on page 32: 'WU 29033' is to be replaced by 'epitype K(M) 162235'. WU 29033 is a specimen of *H. parmastoi*. 2) Notes to *H. sinuosa* on p. 78: 'Generally immature stromata are more diagnostic than dry ones' is to be replaced by 'Generally immature stromata are more diagnostic than mature ones, particularly when dry'.

Index of fungal names

(page numbers in bold indicate start of detailed treatment)