New combinations in *Trichoderma* (*Hypocreaceae, Hypocreales*)

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**Abstract** — Unitary nomenclature demands the use of a single name for pleomorphic fungi determined according to priority. For this reason combinations in *Trichoderma* are here provided for 46 species for which such a combination is lacking. Although many more such species are known, only those are included here that are dealt with in more recent papers and where some DNA data are available in GenBank, even if erroneous; for other species it is strongly recommended to consult databases like Index Fungorum or MycoBank. Information on types is provided for most species, and representative cultures, GenBank accessions for *tef1* and *rpb2*, and important references are given for all species.

**Keywords** — anamorph, Ascomycota, ICN, Kew rule, pyrenomycetes, teleomorph

**Introduction**

*Hypocre* Fr. 1825 is the type and name-giving genus of the *Hypocreaceae, Hypocreales*. However, its anamorphic counterpart, *Trichoderma* Pers. 1794 : Fr. is older. The Melbourne Code of Nomenclature (ICN) dictates a unitary nomenclature, i.e., the use of a single name for a pleomorphic fungus, no matter whether ana- or teleomorphic, based either on priority or on commission-sanctioned decisions. The species of *Hypocre/Trichoderma* are monophyletic and this is to be expressed in a single generic name. *Trichoderma* has priority over *Hypocre* and is commonly used in commercial applications, e.g., cellulase production by *T. reesei*. A poll of individuals interested in the subject was taken by the International Subcommission on *Trichoderma* and *Hypocre* (ISTH), which indicated a clear preference for adoption of *Trichoderma* over *Hypocre*. Thus Rossman et al. (2013) proposed this generic name for acceptance by the Nomenclature Committee for Fungi (NCF) and the General Committee (GC) of the International Association for Plant Taxonomy (IAPT). However, a list of accepted names in *Trichoderma* has not yet been produced. There are some difficulties associated with this task. One example is the wide use
in commercial applications of *Trichoderma* epithets that are younger than the associated *Hypocrea* epithets, e.g., *T. reesei* / *H. jecorina* and *T. citrinoviride* / *H. Schweinitzii*. Gams et al. (2012) suggested that authors establishing lists of protected names and the committees should apply the ‘Kew rule’ and accordingly “not recombine older epithets from a list-demoted genus into the list-accepted genus, when another one from pre-2013 is already available in that genus.”

Index Fungorum lists 509 epithets in *Hypocrea*, including 55 names of varieties and forms (which have no priority at the species level). Many of these names do not represent members of this genus or are synonyms of other species of the genus, and the vast majority has never been re-assessed since their original description. Because of this large number of species names, it is strongly advisable for those who intend to describe new species to consult the Index of Fungi or databases like Index Fungorum or MycoBank, in order to avoid the creation of homonyms. At present, 219 *Trichoderma* epithets (including 9 varieties and forms) are listed in Index Fungorum. Many species have been re-assessed by several recent workers and others have been newly described in recent years. Jaklitsch et al. (2009, 2011), for example, established names in both *Hypocrea* and *Trichoderma* for species that are known to form an anamorph, but provided a name only in *Hypocrea* where no anamorph is known. In another example, Chaverri & Samuels (2003) did not establish names in *Trichoderma* for species earlier described in *Hypocrea* or for new species, where cultures did not survive storage. Such species as described in these works and several other recent papers (see below), are usually well characterized and also documented by molecular data. Therefore we provide here combinations in *Trichoderma* for these species as an intermediate step towards a list of accepted names in the genus *Trichoderma*.

The large number of species on one hand, the large number of isolates of many species on the other, and also the different portions of genes used as molecular-phylogenetic markers has made it difficult to select representative isolates and respective accessions for many species. For this reason we provide information on types, ex-type cultures, representative cultures and representative GenBank accessions for the most important markers, *rpb2* and *tef1*. We indicate also section or clade affinity for the species; when a formally established section is also supported by molecular phylogeny, we give preference to that designation.

**Materials & abbreviations**

All publications on the taxonomy and phylogeny of *Hypocrea* and/or *Trichoderma* that include molecular data were consulted and for species lacking an epithet in *Trichoderma*, information on types, ex-type or representative cultures was extracted. GenBank accessions for representative cultures were retrieved from the NCBI homepage (http://www.ncbi.nlm.nih.gov/). The following abbreviations are used in the
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Results – data arrangement

New combinations in Trichoderma are proposed for Hypocrea names in species where such a combination is lacking. The 46 species treated here are (1) 41 for which DNA data are available and (2) 5 that are included because of confusing data. Additional data are given as: type information; repres. cultures; phylog. clade or section (plus short information on (atypical) anamorphs deviating from Trichoderma that form green conidia); repres. GenBank sequence accessions; important (recent) references.

**Trichoderma albocorneum** (Yoshim. Doi) Jaklitsch & Voglmayr, *comb. nov.*

*Mycobank* MB807413


Holotype: TNS-F-190171, ex-type culture: n.a.; possibly repres.: G.J.S. 97-28 (*tef1*: AY937440).


**Trichoderma albofulvum** (Berk. & Broome) Jaklitsch & Voglmayr, *comb. nov.*

*Mycobank* MB807414


Holotype: n.d.; ex-type culture: n.a. The species is similar to *T. ochroleucum*.

Note: The species was described from Sri Lanka. The strains G.J.S. 01-234 (*tef1* accession: DQ846668) and/or G.J.S. 01-265 (*rpb2* accession: DQ835524) from material collected in Thailand may represent this species (see Jaklitsch 2011).

**Trichoderma alcalifuscescens** (Overton) Jaklitsch & Voglmayr, *comb. nov.*

*Mycobank* MB807415


Holotype: BPI 843638; isotype TAA(M) 181548; ex-type culture: CBS 122303 = TFC 2000-36.


**Trichoderma americanum** (Canham) Jaklitsch & Voglmayr, *comb. nov.*

*Mycobank* MB807416


Holotype: NY ex CUP 38045; ex-type culture: ATCC 18574; other repres. strains: CBS 123072 = G.J.S. 92-93, G.J.S. 96-191.
Trichoderma andinense (Samuels & Petrini) Samuels, Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank* MB807417


**Holotype**: BPI 1109854; ex-type culture: CBS 345.97 = G.J.S. 90-140 = ATCC 208857.


Trichoderma atrogelatinosum (Dingley) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank* MB807418


**Holotype**: PDD 10471; ex-type culture: n.a..

**Reference**: Chaverri & Samuels (2003). Note: Status unclear. Several accessions are deposited in GenBank under the name *Hypocrea atrogelatinosa*; *rpb2* sequences (strains G.J.S. 88-28, 89-136, and 95-159) as well as *tef1* exon sequences belong to *T. ceraceum* (*H. ceracea*); however, *tef1* intron sequences vary considerably among these isolates.

Trichoderma avellaneum (Rogerson & S.T. Carey) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank* MB807419


**Holotype**: NY (MEBB 2471); isotype in K; ex-type culture: n.a.; repres. strain CBS 121667 = C.T.R. 77-155.

**Phylog.**: unknown, ‘basal’; anamorph unknown. Repres. sequences: *tef1*: JQ685865; *rpb2*: JQ685881.


Trichoderma britdaniae (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank* MB807420


**Holotype**: K(M) 89878; ex-type culture: n.a. (ascospores not germinating).


Trichoderma caerulescens (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank* MB807422


**Holotype**: WU 31600; ex-type culture: CBS 130011 = S195.

**Trichoderma citrinum** (Pers. : Fr.) Jaklitsch, W. Gams & Voglmayr, **comb. nov.**

MycoBank MB807423

≡ *Sphaeria citrina* Pers., Observ. mycol. (Lipsiae) 1: 68 (1796) : Fr.


≡ *Hypocrea lactea* (Fr. : Fr.) Fr., Summa veg. Scand., Section Post.: 383 (1849).


Neotype of *Trichoderma citrinum*: W. Gams 4031 (CBS); ex-type culture: CBS 894.85.

Holotype of *Trichoderma lacteum*: DAOM 167644; ex-type culture CBS 853.70. Epitype of *Trichoderma lacteum*, here designated: W. Gams 4031 (CBS); ex-epitype culture: CBS 894.85.


Note: *Hypocrea citrina* is a well-known name for a well-known species, particularly in Europe, and has priority over *H. lactea*. Bissett (1992) erected the name *Trichoderma lacteum* for the anamorph of *H. lactea*. The revised citation of *T. lacteum*, above, follows the working practice advocated by Hawksworth et al. (2013). Application of the ’Kew rule’ would favour *T. lacteum* as the appropriate *Trichoderma* name for a synonymised *H. citrina/H. lactea*. However, this would be undesirable, because the inconsistent application of the name *H. lactea* to a number of different taxa could be misleading; for example, “*Hypocrea lactea*” sensu Doi (1972) was recently described as *T. pseudolacteum* by Kim et al. (2013).

**Trichoderma corneum** (Pat.) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807424

≡ *Hypocrea cornea* Pat., J. Bot. (Morot): 64 (1890).

Holotype: K; ex-type culture: n.a.

The cultures G.J.S. 97-82 (*tef1*: AY937435), G.J.S. 97-75 (*tef1*: AY937431) and G.J.S. 97-90 (*tef1*: AY937426) are isolates from specimens collected in Thailand. As the GenBank *tef1* accessions for these isolates vary considerably, fresh material from the original collecting region Tonkin, Vietnam, is necessary to judge which of them match the species. Phylog.: unclear; species with green ascospores. Reference: Chaverri & Samuels (2003).

**Trichoderma costaricense** (P. Chaverri & Samuels) P. Chaverri, Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807425


Holotype: INB 0003527695; ex-type culture: P.C. 21 (lost after determination of DNA data).

Trichoderma danicum (Jaklitsch) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank MB807426*


**Holotype:** WU 29046; ex-type culture: CBS 121273 = C.P.K. 2448 = Hypo 402.


Trichoderma decipiens (Jaklitsch, K. Põldmaa & Samuels) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank MB807427*


**Holotype:** BPI 747356; ex-type culture: CBS 121307 = G.J.S. 97-207; repres. G.J.S. 91-101.

**Phylog.:** sect. *Hypocreanum*; anamorph verticillium-like, conidia hyaline. **Repres. sequences:** tef1: FJ860635, EF550995; rpb2: DQ835520. References: Jaklitsch et al. (2008), Overton et al. (2006b; as *Hypocrea farinosa*). Some further accessions can be retrieved under the name "*Hypocrea farinosa*", because the name has not been updated, pending consent by B. Overton.

Trichoderma eucorticioides (Overton) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank MB807428*


**Holotype:** LPS 1719; ex-type culture: n.a.; repres. G.J.S. 99-61 (lost).


Trichoderma flaviconidium (P. Chaverri, Druzhin. & Samuels) Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank MB807429*


Trichoderma flavipes (Peck) Seifert, Jaklitsch & Voglmayr, **comb. nov.**

*MycoBank MB807430*


**Holotype of Stilbum flavipes:** NYS; holotype of *Hypocrea cinereoflava*: BPI 802847; ex-teleotype culture: G.J.S. 92-102 = DAOM 222357.
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**Trichoderma foliicola** (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.**
MycoBank MB807431
Holotype: WU 31611; ex-type culture: CBS 130008 = Hypo 645.

**Trichoderma hispanicum** (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.**
MycoBank MB807432
Holotype: WU 31606; ex-type culture: CBS 130540 = S453.

**Trichoderma hunua** (Dingley) Jaklitsch & Voglmayr, **comb. nov.**
MycoBank MB807433
Holotype: PDD 10455; ex-type culture: n.a.; repres. CBS 238.63 (isolated: Dingley, No. 5).

**Trichoderma lacuwombatense** (B.S. Lu, Druzhin. & Samuels) Jaklitsch & Voglmayr, **comb. nov.**
MycoBank MB807434
Holotype: PDD 77489; isotype BPI 746621; ex-type culture: CBS 122668 = G.J.S. 99-198.

**Trichoderma megalocitrinum** (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.**
MycoBank MB807435
Holotype: TNS-F-223220; isotype in NY; ex-type culture: n.a.; repres. BEO 00-09.

**Trichoderma microcitrinum** (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.**
MycoBank MB MB807436
Trichoderma neorufum (Samuels, Dodd & Lieckf.) Jaklitsch & Voglmayr, comb. nov.

MycoBank MB807437

Holotype: BPI 744493; ex-type culture: CBS 111144 = G.J.S. 96-135; repres. CBS 119498.


Trichoderma novae-zelandiae (Samuels & Petrini) Jaklitsch & Voglmayr, comb. nov.

MycoBank MB807438

Holotype: PDD 46792; ex-type cultures: CBS 496.97 and CBS 639.92 = G.J.S. 81-265 = ATCC 208856.


Trichoderma nybergianum (T. Ulvinen & H.L. Chamb.) Jaklitsch & Voglmayr, comb. nov.

MycoBank MB807439

Holotype: OULU F 49597; isotype OULU F 49596; ex-type culture: n.a.; repres. CBS 122500 = C.P.K. 3159 = Hypo 572, CBS 122496 = C.P.K. 3163 = Hypo 577.


Trichoderma ochroleucum (Berk. & Ravenel) Jaklitsch & Voglmayr, comb. nov.

MycoBank MB807440
≡ Hypocreanum ochroleuca Berk. & Ravenel, in Berkeley, Grevillea 4: 14 (1875).

Holotype: K(M) 56075; ex-type culture: n.a.; repres. CBS 119502 = C.P.K. 1895 = Hypo 274.

Trichoderma orientale (Samuels & Petrini) Jaklitsch & Samuels, **comb. nov.**

MycoBank MB807441


Holotype: BPI 1109853; ex-type culture: CBS 130428 = G.J.S. 88-81, repres. CBS 131488, G.J.S. 09-784.


Trichoderma parapiluliferum (B.S. Lu, Druzhin. & Samuels) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807442


Holotype: BPI 112832; ex-type culture: CBS 112771 = G.J.S. 91-60; repres. CBS 120921 = C.P.K. 1908.


Trichoderma parmastoi (Overton) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807443


Holotype: BPI 843639; isotype TAA(M) 169055; ex-type culture: TFC 97-143; repres. CBS 121139.


Trichoderma patella (Cooke & Peck) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807444


Trichoderma peltatum (Berk.) Samuels, Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807511


Note: The original name of this taxon, *Sphaeria peltata*, is an illegitimate later homonym and cannot act as basionym for new combinations (ICN Art. 6.10). The basionym is the earliest legitimate name, *Hypocrea peltata* Berk. 1851, which is to be treated as a replacement name for the illegitimate *S. peltata* (ICN 58.1).

*Trichoderma pezizoides* (Berk. & Broome) Samuels, Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807445


*Trichoderma protopulvinatum* (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807446


Holotype: TNS-F-223421; isotype NY 00965650; ex-type culture: CBS 739.83; repres. C.P.K. 2434, CBS 121274 = C.P.K. 2430.


*Trichoderma pulvinatum* (Fuckel) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807447


Lectotype: FH 00284789 (Fuckel 876); ex-type culture: n.a.; repres. CBS 121279.


*Trichoderma rhododendri* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807448


Holotype: WU 294442 (Hypo 209); ex-type culture: CBS 119288 = C.P.K. 2015.


*Trichoderma rodmanii* (Samuels & P. Chaverri) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807449


Holotype: BPI 1112859; ex-type culture: CBS 120895 = G.J.S. 91-88; repres. CBS 121553.
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*Trichoderma sambuci* (Jaklitsch & Voglmayr) Jaklitsch & Voglmayr, **comb. nov.**

Mycobank MB807450


Holotype: WU 29463 (Hypo 198); ex-type culture: n.a.; repres. CBS 126958 = S 94.


*Trichoderma semiiorbis* (Berk.) Jaklitsch & Voglmayr, **comb. nov.**

Mycobank MB807451

≡ Sphaeria semiiorbis Berk., J. Bot. (Hooker) 2: 146 (1840).

≡ Hypocreosis semiiorbis (Berk.) Berk., in Hooker, Fl. Tasman. 2: 278. (1859 ["1860"]).


*Trichoderma spinulosum* (Fuckel) Jaklitsch & Voglmayr, **comb. nov.**

Mycobank MB807452


Holotype: Fuckel (G); ex-type culture: n.a.; repres. CBS 310.50, CBS 311.50 = C.P.K. 1510, CBS 121272 = C.P.K. 2464.


*Trichoderma stellatum* (B.S. Lu, Druzhin. & Samuels) Jaklitsch & Voglmayr, **comb. nov.**

Mycobank MB807453


*Trichoderma subsulphureum* (Syd.) Jaklitsch & Voglmayr, **comb. nov.**

Mycobank MB807454


Trichoderma sulawesense (Yoshim. Doi) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807455


Trichoderma sulphureum (Schwein.) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807456


Holotype: n.d.; isotype: K, ex herb Schweinitz; not epitypified; ex-type culture: n.a.; repres. C.P.K. 1593, CBS 119929 = C.P.K. 1598.


Trichoderma victoriense (Overton) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807457


Holotype: BPI 747361; ex-type culture: G.J.S. 99-200; repres. C.P.K. 3565.


Trichoderma virecentiflavum (Speg.) Jaklitsch & Voglmayr, **comb. nov.**

MycoBank MB807458


Holotype: LPS 1726 (J. Puiggari 2353), ex-type culture: n.a.; repres. P.C. 278 (lost after determination of DNA data).


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Literature cited

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