Polyphasic taxonomy of the genus *Talaromyces*

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Abstract: The genus *Talaromyces* was described by Benjamin in 1955 as a sexual state of *Penicillium* that produces soft walled ascomata covered with interwoven hyphae. Phylogenetic information revealed that *Penicillium* subgenus *Biverticillium* and *Talaromyces* form a monophyletic clade distinct from the other *Penicillium* subgenera. Subsequently, in combination with the recent adoption of the one fungus one name concept, *Penicillium* was described by Benjamin in 1955 as a sexual state of *Penicillium* that produces soft walled ascomata covered with interwoven hyphae. Phylogenetic information revealed that *Penicillium* subgenus *Biverticillium* and *Talaromyces* form a monophyletic clade distinct from the other *Penicillium* subgenera. Subsequently, in combination with the recent adoption of the one fungus one name concept, *Penicillium* subgenus *Biverticillium* was transferred to *Talaromyces*. At the time, the new combinations were made based only on phylogenetic information. As such, the aim of this study was to provide a monograph on *Talaromyces* applying a polyphasic species concept, including morphological, molecular and physiological characters. Based on an ITS, *BenA* and *RPB2* multigene phylogeny, we propose a new sectional classification for the genus, placing the 88 accepted species into seven sections, named sections *Bacillipori*, *Helici*, *Islandici*, *Purpurei*, *Subinflati*, *Talaromyces* and *Trachyspermis*. We provide morphological descriptions for each of these species, as well as notes on their identification using morphology and DNA sequences. For molecular identification, *BenA* is proposed as a secondary molecular marker to the accepted ITS barcode for fungi.

Key words: Ascomycetes, Trichocomaceae, Ascosporae, Single name nomenclature, *Talaromyces* marneffei, Food spoilage, Biotechnology.

Taxonomic novelties: New sections: *Talaromyces* section *Helici* Yilmaz, Frisvad & Samson, *Talaromyces* section *Bacillipori* Yilmaz, Frisvad & Samson, *Talaromyces* section *Subinflati* Yilmaz, Frisvad & Samson. New combinations: *Talaromyces* section *Islandici* (Pitt) Yilmaz, Frisvad & Samson, *Talaromyces* aerugineus (Samson) Yilmaz, Frisvad & Samson, *Talaromyces* bohemicus (Fassat & Pěček) Yilmaz, Frisvad & Samson, *Talaromyces* liani (Karnyschie) Yilmaz, Frisvad & Samson, *Talaromyces* cinabariius (S.C. Jong & E.E. Davis) Yilmaz, Samson & Frisvad.

Published online 22 September 2014; http://dx.doi.org/10.1016/j.simyco.2014.08.001. Hard copy: June 2014.

INTRODUCTION

Benjamin (1955) introduced the genus *Talaromyces* for teleomorphic *Penicillium* species with *T. vermiculatus* (P.A. Dang.) C.R. Benj. (= *T. flavus* (Klöcker) Stolk & Samson) as generic type. The genus was characterised by soft ascosporae with a cleistothecial wall of interwoven hyphae and typically yellow ascomata, with ovate to globose asci containing mostly spiny ascospores (Benjamin 1955). Stolk & Samson (1971) introduced *Hamigera* for *Talaromyces* species that produce single ascus, limiting *Talaromyces* to species producing ascus in chains (Stolk & Samson 1972). Although Pitt (1980) considered *Hamigera* synonymous with *Talaromyces*, Houbraken & Samson (2011) showed that it is a distinct genus closely related to *Warcupiella*. Thermophilic *Talaromyces* species were shown to be distinct from *Talaromyces* (Houbraken & Samson 2011) and were classified in the new genus *Rasamsonia* and *Thermomyces* (Houbraken et al. 2012, 2014).

Talaromyces used to be associated with the anamorph genera *Geosmithia*, *Merimbia*, *Paecilomyces* and *Penicillium* (Pitt et al. 2000). *Merimbia* was shown to belong to a mono-phylectic clade with *Hamigera*, while both *Geosmithia* and *Paecilomyces* were shown to be polyphyletic (Houbraken & Samson 2011), with *G. lavendula* (generic type) belonging in the *Hypocreales* and *P. variotii* (generic type) monophyletic with *Byssoclamys* in the *Thermoascales*. The remaining *Geosmithia* species belong in *Penicillium*, *Talaromyces* and *Rasamsonia* (Houbraken & Samson 2011), while *Paecilomyces* *aerugineus* belongs in *Talaromyces* (Samson et al. 2011).

A number of species described as *Talaromyces* were shown to not belong in the genus. Three thermophilic species, *T. byssoclamydoides*, *T. eburneus* and *T. emersonii*, belong in the genus *Rasamsonia* and were renamed as *R. byssoclamydoides*, *R. eburneus* and *R. emersonii* (Houbraken et al. 2012). *Talaromyces thermophilus* is a biotechnologically important species and belongs to *Thermomyces*, with Houbraken et al. (2014) introducing the new combination *Thermomyces dupontii* for the species. Houbraken et al. (2012) showed that *T. leycettanus* belongs in the *Hamigera/Warcupiella* clade, and this species exact position within the clade should be further investigated. *Talaromyces luteus* morphologically resembles *T. utagawae* based on their ascospores having transverse to spiral ridges (Stolk & Samson 1972). Phylogenetically, however, *T. luteus* is basal to the *Thermomyces dupontii* and *T. lanuginosus* clade, and most probably represents a distinct genus (Houbraken et al. 2014).

It was well documented that subgenus *Biverticillium* resulted in *Penicillium* being polyphyletic (Frisvad et al. 1990a, b, LoBuglio et al. 1993, Berbee et al. 1995, Ogawa et al. 1997, Ogawa & Sugiyama 2000, Peterson 2000, Heredia et al. 2001, Seifert et al. 2004, Wang & Zhuang 2007). Houbraken & Samson (2011), using a four-gene phylogeny, showed that *Penicillium* subgenus *Biverticillium* and *Talaromyces* species form a monophyletic clade, with Samson et al. (2011) recombining these Penicillia into *Talaromyces* in support of single-name nomenclature (McNeill et al. 2012).

*Talaromyces* contains species that are medically important. *Talaromyces* *marneffei* is an emerging fungal pathogen causing a fatal mycosis in especially immunocompromised individuals.
from East Asian countries such as China, Taiwan, Thailand and Vietnam (Deng et al. 1988, Supparatpinyo et al. 1994, Chiang et al. 1998, Hien et al. 2001), even though infections in HIV negative individuals have been reported (Kwan et al. 1997, Saadiah et al. 1999). Talaromyces marneffei is the only known dimorphic species in the genus, producing filamentous growth at 25 °C and a yeast phase at 37 °C (Andrianopoulos 2002). Because T. marneffei was used to be classified in Penicillium, its associated disease is unfortunately still referred to as penicilliosis. However, true Penicillium species causing human infections are very rare. Other Talaromyces species have also been reported to be medically important. For example, T. indigoticus was isolated from skin and nail lesions from a male who was affected by onychomycosis in Western Panama (Weisenborn et al. 2010), T. picus caused both fungaemia (Horré et al. 2001) and rib osteomyelitis in an X-linked chronic granulomatous disease (X-CGD) patient (Santos et al. 2006), T. radicus caused a fatal infection in a German shepherd dog (de Vos et al. 2009), T. helicus caused granulomatous lymphadenitis in a labrador retriever (Tomlinson et al. 2011), and T. amestokiae and T. stollii were isolated from the lungs and sputum of immunocompromised patients (Yilmaz et al. 2012).

Talaromyces is also of importance in the food industry. Heat resistant ascospores are produced in T. macrosporus, T. flavus, T. bacillisporus, T. helicus, T. stipilatus, T. trachyaspernus and T. wortmannii, and cause spoilage of pasteurised juices and other fruit based products (Pitt & Hocking 1997, Dijksterhuis 2007). In addition, several species produce mycotoxins and can thus be used for the biotechnological production of these pigments (Frisvad et al. 2013).

Talaromyces flavus is one of the most important fungal antagonists used as a bio-control agent of soil-borne pathogens such as Verticillium dahliae, V. albo-atrum, Rhizoctonia solani and Sclerotinia sclerotiorum (Marois et al. 1984, Punja 2001, Brunner et al. 2005, Gohel et al. 2006). It was shown to suppress Verticillium wilt of tomato (Naraghi et al. 2010b), aubergine (Fatima & Henis 1997), potato (Naraghi et al. 2010b, Naraghi et al. 2012), cotton (Naraghi et al. 2012) and green house cucumber (Naraghi et al. 2010a).

Their ability to produce enzymes and soluble pigments make Talaromyces an important genus for biotechnological purposes. Important enzyme producers include T. rugulosus (β-rutinosidase and phosphatase; Reyes et al. 1999, Narikawa et al. 2000), T. pinophilus (endo-, β-glucanase, cellulase; Pol et al. 2012), T. funiculosus (cellulase; Maeda et al. 2013) and T. cellulolyticus (Acremonium cellulolyticum = T. pinophilus), which is reported as an important cellulose-degrading fungus used for biomass degradation (Fuji et al. 2013, Houbraken et al. 2014).

Samson et al. (2011) redefined Talaromyces by combining Penicillium subgenus Biverticillium into Talaromyces using sequence data from the ITS and RPB1 loci. The aim of this study was to follow on from Samson et al. (2011) and provide a taxonomic treatment of the genus Talaromyces using a polyphasic approach. We classify the 88 accepted species in seven sections based on a multigene phylogeny of the ITS, β-tubulin (BenA) and RPB2 gene regions. We provide morphological descriptions using macro- and micromorphological characters and provide tables and notes to be used for morphological identifications. We also provide a nomenclatural list of all accepted species. For molecular identification, GenBank accession numbers to ITS barcodes and BenA sequences for ex-type and reference cultures are given in this list, with BenA proposed as an alternative identification marker for Talaromyces species.

**MATERIAL AND METHODS**

**Strains**

Strains used in this study (summarised in Table 1) were obtained from the public collection of the CBS-KNAW Fungal Biodiversity Centre, Utrecht, the Netherlands; the working collection of the Department of Applied and Industrial Mycology (DTO), housed at CBS-KNAW; the Department of Systems Biology, DTU, Lyngby, Denmark (IBT); and the United States Department of Agriculture, Agricultural Research Service (USDA-ARS), Peoria, United States (NRRL).

**Morphological analysis**

Macroscopic characters were studied on different media and growth conditions. Cultures were inoculated in three point fashion onto Czapek yeast extract agar (CYA), CYA supplemented with 5 % NaCl (CYAS), creatine succrose agar (CREA), dichloran 18 % glycerol agar (DG18), oatmeal agar (OA), malt extract agar (Oxoid; MEA) and yeast extract sucrose agar (YES) (Samson et
Table 1. Strains used in phylogenetic analysis of the genus *Talaromyces*.

| Species name          | CBS no.       | Other collections                                                                 | Substrate and origin                                                                 |
|-----------------------|---------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| *Talaromyces aculeatus* | CBS 136673    | DTO 277-E3 = IBT 14255                                                            | Weathering wood stakes, Palmerston North, New Zealand                                 |
|                       | CBS 282.92    |                                                                                | Soil in secondary forest, Brazil                                                    |
|                       | CBS 289.48    | ATCC 10409 = IMI 040588 = NRRL                                                 | Textile, USA                                                                        |
|                       | CBS 290.65    | IBT 14843 = IBT 36624                                                            | Nut, South Africa                                                                  |
|                       | CBS 563.92    |                                                                                | Stem of *Dicymbe Altsonii*, French Guiana                                         |
| *Talaromyces aerugineus* | CBS 350.66    | BDUN 276 = IMI 105412                                                            | Debris, United Kingdom                                                            |
| *Talaromyces albobicverticillius* | CBS 133440 | DTO 166-E5 = BCRC 34774 = IBT 31667                                                | Decaying leaves of a broad-leaved tree, Taiwan                                      |
| *Talaromyces allahabadensis* | CBS 137397 | DTO 245-E3                                                                       | House dust, Mexico                                                                 |
|                       | CBS 137399    | DTO 267-H6                                                                        | House dust, Thailand                                                                |
|                       | CBS 178.81    | ATCC 48474 = FRR 3579 = IMI 253805                                              | Type of *P. zacinthae*, *Crepis zacintha*, Alicante, Spain                           |
|                       | CBS 441.89    | DTO 247-D5                                                                        | Seed groud, Denmark                                                                |
|                       | CBS 453.93    | CBS 304.63 = ATCC 15067 = NRRL                                                   | Cultivated soil, Allahabad, India                                                   |
| *Talaromyces amestolitiae* | CBS 132696 | DTO 179-F5                                                                        | House dust, South Africa                                                           |
|                       |               | DTO 179-E4                                                                        | House dust, South Africa                                                           |
|                       |               | DTO 179-F1                                                                        | House dust, South Africa                                                           |
|                       |               | DTO 179-F6                                                                        | House dust, South Africa                                                           |
| *Talaromyces angelicus* | KACC 46611    | DTO 303-E2                                                                       | Dried roots of Angelica gigas, Pyeongchang, Korea                                   |
| *Talaromyces apiculatus* | CBS 101366   |                                                                                | Soil, Hong Kong, China                                                            |
|                       | CBS 312.59    | ATCC 18315 = FRR 635 = IMI 068239 = IFO 5728 = IBT 10894 = IBT 14261             | Soil, Japan                                                                        |
|                       | CBS 548.73    | IBT 5037                                                                          | Soil, Suriname                                                                     |
| *Talaromyces assiutensis* | CBS 116554   |                                                                                | Pasteurised canned strawberries, the Netherlands                                    |
|                       | CBS 118440    |                                                                                | Soil, Fes, Marocco                                                                |
|                       | CBS 147.78    |                                                                               | Soil, Egypt                                                                        |
|                       | CBS 645.80    | FRR 1966 = IFO 31750 = IMI 198365                                                | Type of *T. gossypii*, *Gossypium*, India                                           |
| *Talaromyces atricola* | CBS 255.31    | NRRL 1052 = FRR 1052 = Thom                                                     | Unknown                                                                            |
| *Talaromyces atoroseus* | CBS 133442 | IBT 32470 = DTO 178-A4                                                           | House dust, South Africa                                                           |
|                       |               | DTO 267-I1                                                                        | House dust, Thailand                                                               |
|                       |               | DTO 270-D5                                                                        | House dust, Mexico                                                                 |
|                       |               | DTO 270-D6                                                                        | House dust, Mexico                                                                 |
| *Talaromyces aurantiacus* | CBS 314.59   | ATCC 13216 = IMI 099722 = NRRL 3398                                              | Soil, Georgia                                                                       |
| *Talaromyces austrocalifornicus* | CBS 644.95 | IBT 17522                                                                        | Soil, California, USA                                                              |
| *Talaromyces bacillisporus* | CBS 102389  |                                                                                | Sludge of anaerobic pasteurised organic household waste, Sweden                    |
|                       | CBS 110774    |                                                                                | Rye bread, the Netherlands                                                         |
|                       | CBS 116927    |                                                                                | Soil, the Netherlands                                                              |
|                       | CBS 296.48    | ATCC 10126 = IMI 040045 = NRRL 1025                                              | Leaf, New York, USA                                                                |
| *Talaromyces bohemicus* | CBS 545.86    | CCF 2330 = IAM 14789                                                             | Peloids for balneological purposes, Czech Republic                                  |
| *Talaromyces boninensis* | CBS 850.95   | IBT 17516                                                                         | Lawn soil, Japan                                                                   |
|                       | CBS 227.60    | ATCC 18229 = FRR 646 = IFO 6438 = IHEM 3907 = IMI 078259 = MUCL 31318           | Milled rice imported into Japan, Thailand                                          |
| *Talaromyces calidicanius* | CBS 112002   |                                                                                | Soil, Nantou County, Taiwan                                                       |
| *Talaromyces cecidicola* | CBS 101419    | DAOM 233329                                                                       | Cynipid insect galls on *Quercus pacifica* twigs, Oregon, USA                         |
| *Talaromyces chloroloma* | DAOM 241016  |                                                                                | Fynbos soil, Western Cape, South Africa                                           |

(continued on next page)
| Species name                        | CBS no.      | Other collections        | Substrate and origin                                      |
|------------------------------------|--------------|--------------------------|-----------------------------------------------------------|
| Talaromyces chloroloma             | DTO 180-F4   |                          | Fynbos soil, South Africa                                  |
|                                    | DTO 182-A5   |                          | Air sample, Malmesbury, South Africa                       |
| Talaromyces cinnabarinus           | CBS 267.72^T | ATCC 26215 = NHL 2673    | Soil, Japan                                                |
|                                    | CBS 357.72   | NHL 2674                 | Soil, Japan                                                |
| Talaromyces cniidi                 | DTO 269-H8   |                          | House dust, Thailand                                       |
|                                    | DTO 270-A4   |                          | House dust, Thailand                                       |
|                                    | DTO 270-A8   |                          | House dust, Thailand                                       |
|                                    | DTO 270-B7   |                          | House dust, Thailand                                       |
|                                    | KACC 46617^T = DTO 303-E1 |                       | Dried roots of Cnidium officinale, Jecheon, Korea         |
| Talaromyces coalescens             | CBS 103.83^T |                          | Soil under Pinus sp., Spain                               |
| Talaromyces columbinus             | CBS 137393   | IBT 13019 = DTO 189-A5   | Chicken feed (Unga), Nairobi, Kenya                       |
|                                    | NRRL 58644   |                          | Air, Maryland, USA                                         |
|                                    | NRRL 58811^T |                          | Air, Louisiana, USA                                        |
|                                    | NRRL 62680   |                          | Corn grits, Illinois, USA                                  |
| Talaromyces convolutus             | CBS 100537^T | IBT 14989 = SUM 3018     | Soil, Kathmandu, Nepal                                     |
| Talaromyces dendriticus            | CBS 660.80^T | IMI 216897               | Eucalyptus pauciflora leaf litter, New South Wales, Australia |
|                                    | DAOM 226674  |                          | Doryanthes excelsa spathes, Mangrove Mountain, New South Wales, Australia |
|                                    | DAOM 233861  |                          | Unidentified insect gall on Eucalyptus leaf, Kalnura, New South Wales, Australia |
|                                    | DTO 183-G3   |                          | Mite, Struisbaai, South Africa                             |
| Talaromyces derxii                 | CBS 412.89^T | NHL 2981                 | Cultivated soil, Japan                                     |
| Talaromyces diversus               | CBS 320.48^T | ATCC 10437 = DSM 2212 = IMI 040579 = IMI 040579i = NRRL 2121 DTO 133-A7 | Leather, USA |
|                                    |              | DTO 133-E4               | House dust, Thailand                                       |
|                                    |              | DTO 133-16               | House dust, Thailand                                       |
|                                    |              | DTO 244-E6               | Lotus tea, produced in Vietnam, imported to the Netherlands |
|                                    |              |                          | House dust, New Zealand                                    |
| Talaromyces duclauxii              | CBS 322.48^T | ATCC 10439 = IMI 040044 = MUCL 28672 = MUCL 29094 = MUCL 29212 = NRRL 1030 | Canvas, France |
| Talaromyces emodensis              | CBS 100536^T | IBT 14990                | Soil, Kathmandu, Nepal                                     |
| Talaromyces erythromellis          | CBS 644.80^T | FRR 1868 = IMI 216899    | Soil from creek bank, New South Wales                      |
| Talaromyces euchlorocarpius        | PF 1203^T    | DTO 176I3 = DTO 176I4    | Dead leaves of Quercus ilex, Parque del Retiro, Madrid, Spain |
| Talaromyces flavoveirens           | CBS 102801^T | IBT 27044                | Leaves of Quercus suber, port de la Selva, Girona, Spain   |
|                                    | DAOM 236381  |                          | Leaves of Quercus suber, Selva de Mar, Girona, Spain       |
|                                    | DAOM 236382  |                          | Leaves of Quercus suber, Barraca d'en Rabet, Pauu, Girona, Spain |
|                                    | DAOM 236383  |                          | Leaves of Quercus suber, Xòvar, Alt Palàcia, Valencia     |
| Talaromyces flavus                 | CBS 310.38^T | IMI 197477 = NRRL 2098   | Unknown, New Zealand                                       |
|                                    | CBS 437.62   |                          | Compost, Bonn, Germany                                     |
| Talaromyces funiculosus            | CBS 171.91   | NRRL 1035                | Unknown                                                    |
|                                    | CBS 272.86^T | IMI 193019               | Lagenaria vulgaris, India                                  |
|                                    | CBS 883.70   |                          | Unknown, Java                                              |
|                                    | CBS 884.70   |                          | Unknown, Java                                              |
|                                    | CBS 885.71   |                          | Air, Java, Jakarta                                         |
| Talaromyces galapagensis           | CBS 751.74^T | IFO 31796                | Shaded soil under Maytenus obovata, Galapagos Islands, Isla Santa Cruz, Ecuador |
| Talaromyces hachijoimae            | IFM 53624^T  = PF 1174 |                        | Soil, Hachijoima, Japan                                    |
| Talaromyces helicus                | CBS 134.67   |                          | Green house soil under Lycopersicon esculentum, Wageningen, the Netherlands |
Table 1. (Continued).

| Species name               | CBS no.     | Other collections                                                                 | Substrate and origin                                                                                           |
|----------------------------|-------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Talaromyces helicus        | CBS 335.48T | ATCC 10451 = DSM 3705 = IMI 040993 = NRRL 2106                                     | Soil, Sweden                                                                                                    |
|                            | CBS 550.72A |                                                                                    | Saline soil, Vallée de la Seille, France                                                                       |
| Talaromyces indicaicens    | CBS 100534T | IBT 17590 = SUM 3010                                                                | Soil, Japan                                                                                                     |
| Talaromyces intermedius    | CBS 152.65T | BDUN 267 = IFO 31752 = IMI 100874                                                  | Alluvial pasture and swamp soil, Nottingham, England                                                           |
| Talaromyces islandicus     | CBS 117284  | DTO 002-C7                                                                         | Wheat flour, the Netherlands                                                                                   |
|                            | CBS 338.48T | ATCC 10127 = IMI 040042 = MUCL 31324 = NRRL 1036                                  | Unknown, Cape Town, South Africa                                                                               |
|                            | CBS 394.50  | DTO 093-B9                                                                         | Kapok fibre, unknown                                                                                             |
|                            | CBS 165.81  | ATCC 42240; IMI 253796                                                             | Type of *P. aurantiocinamiferum*, spice mixture used in sausage making industry, Spain                        |
| Talaromyces liani          | CBS 118434  |                                                                                    | Soil in orchid garden, Sanur, Bali, Indonesia                                                                  |
|                            | CBS 118885  |                                                                                    | Soil of pepper field, DaeJeon, Korea                                                                           |
|                            | CBS 225.66T | ATCC 18325 = ATCC 18331 = IMI 098480 = NRRL 3380 = VKM F-301 DTO 058-F2            | Heat treated corn kernels, the Netherlands                                                                    |
| Talaromyces lofiiens       | CBS 172.91  | DTO 105-E9                                                                         | Soil, New Zealand                                                                                                |
|                            | CBS 643.80T | ATCC 52252 = FRR 1798 = IMI 216901 = MUCL 31325                                  | Rye grass (Lolium), New Zealand                                                                               |
| Talaromyces macrosporus    | CBS 117.72  | NRRL 2101                                                                          | Cotton fabric, USA                                                                                              |
|                            | CBS 131.87  |                                                                                    | Faecal pellet of grasshopper, Malaysia                                                                        |
|                            | CBS 317.63  | FRR 404 = IMI 197478                                                                | Apple juice, Stellenbosch, South Africa                                                                       |
|                            | CBS 353.72  |                                                                                    | Tengaie, New Guinea                                                                                            |
|                            | DTO 077-C5  |                                                                                   | Pine apple concentrate, the Netherlands                                                                       |
|                            | DTO 105-C4  |                                                                                   | Unknown                                                                                                       |
| Talaromyces marnefei       | CBS 108.89  |                                                                                    | Human (male), China                                                                                            |
|                            | CBS 119456  |                                                                                    | Male blood, Thailand                                                                                            |
|                            | CBS 122.89  |                                                                                    | Male AIDS patient after travel to Indonesia                                                                    |
|                            | CBS 135.94  |                                                                                    | Haemoculture, Nonthaburi, Thailand                                                                             |
|                            | CBS 388.87T | ATCC 18224 = CBS 334.59 = IMI 068794i = IMI 068794ii                               | Bamboo rat (*Rhizomyx sinesis*), Vietnam                                                                        |
|                            | CBS 549.77  | ATCC 24100                                                                         | Man spleen, unknown                                                                                            |
| Talaromyces mimosinus      | CBS 659.80T | FRR 1875 = IMI 223991                                                               | Soil from creek bank, New South Wales                                                                         |
| Talaromyces minioleus      | CBS 137.84  |                                                                                    | Fruit, damaged by insect, Valladolid, Spain                                                                   |
|                            | CBS 270.35  | ATCC 4713 = ATCC 52244 = FRR 1064 = IBT 4302 = NRRL 1064 = NRRL 1142              | Zea mays, Virginia, USA                                                                                       |
|                            | CBS 642.68T | IMI 089377 = MUCL 28666 = NRRL 1714                                               | Unknown                                                                                                       |
| Talaromyces murii          | CBS 261.55  |                                                                                    | Clematis, Boskoop, the Netherlands                                                                            |
|                            | CBS 283.58  |                                                                                    | Jute potato bag, treated with copper oxide ammonia, unknown                                                   |
|                            | CBS 284.58  |                                                                                    | Unknown, the Netherlands                                                                                        |
|                            | CBS 351.61  |                                                                                    | Chicken crop, the Netherlands                                                                                  |
|                            | CBS 756.96T | PF 1153                                                                            | Soil, Taiwan                                                                                                   |
|                            | CBS 889.96  |                                                                                    | Dung of sheep, Papua New Guinea                                                                               |
| Talaromyces oomae-annae    | CBS 138207  | DTO 180-B4                                                                         | House dust, South Africa                                                                                        |
|                            | CBS 138208T| DTO 269-E8                                                                         | House dust, South Africa                                                                                        |
| Talaromyces palmae         | CBS 442.88  | IMI 343640                                                                         | Chrysodiscus lucens seed, Wageningen, the Netherlands                                                          |
| Talaromyces panamensis     | CBS 128.89T| IMI 297546                                                                         | Soil, Barro Colorado Island, Panama                                                                             |
| Talaromyces paucisporus    | PF 1150T    | = IFM 53616                                                                        | Soil, Aso-machi, Japan                                                                                         |
| Talaromyces piceus         | CBS 116872  | DTO 247-E1                                                                         | Production plant, the Netherlands                                                                             |
|                            | CBS 132063  | DTO 191-C5                                                                         | Straw used in horse stable, the Netherlands                                                                    |
|                            | CBS 137363  | DTO 058-D1                                                                         | Pecinin, unknown                                                                                                |
|                            | CBS 137377  | DTO 178-F3                                                                         | House dust, South Africa                                                                                        |

(continued on next page)
| Species name                                      | CBS no.         | Other collections                                      | Substrate and origin                                     |
|--------------------------------------------------|-----------------|--------------------------------------------------------|----------------------------------------------------------|
| *Talaromyces piceus*                             | CBS 361.48^T    | ATCC 10519 = IMI 040038 = NRRL 1051                     | Unknown                                                  |
| *Talaromyces pinophilus*                         | CBS 101709      | Soil, Japan                                            |                                                          |
|                                                  | CBS 173.91      | Unknown, USA                                           |                                                          |
|                                                  | CBS 235.94      | ATCC 11797 = NRRL 3647 = NRRL A-1616 = NRRL A-622      | Unknown, USA                                             |
|                                                  | CBS 269.73      | Unknown, Germany                                       |                                                          |
|                                                  | CBS 440.89      | Zea mays, India                                        |                                                          |
|                                                  | CBS 631.66^T    | ATCC 36839 = CECT 2809 = DSM 1944 = IAM 7013 = IMI 114933 | PVC, France                                              |
|                                                  | CBS 762.68      | DITO 183-6                                             | Type of *Penicillium korosum*, Rhizosphere, India        |
| *Talaromyces pittii*                             | CBS 139.84^T    | IMI 327871                                             | Clay soil under poplar trees, Spain                      |
| *Talaromyces primulinus*                         | CBS 321.48^T    | ATCC 10438 = CBS 439.88 = FRR 1074 = IMI 040031 = MUCL 31221 = MUCL 31330 = NRRL 1074 | Unknown, USA                                             |
| *Talaromyces proteolyticus*                      | CBS 303.67^T    | ATCC 18326 = NRRL 3378                                  | Granite soil, Ukraine                                    |
| *Talaromyces pseudostromaticus*                  | CBS 470.70^T    | ATCC 18919 = FRR 2039                                   | Feather of *Hylocicla fusescens*, Minnesota, USA        |
| *Talaromyces ptychoconidium*                     | DAOM 241017^T   | DITO 180-E7                                            | Fynbos soil, Malmesbury, South Africa                    |
|                                                  | DITO 180-E9     | Fynbos soil, Malmesbury, South Africa                   |                                                          |
|                                                  | DITO 180-F1     | Fynbos soil, Malmesbury, South Africa                   |                                                          |
| *Talaromyces purpureus*                          | CBS 475.71^T    | ATCC 24069 = ATCC 52513 = FRR 1731 = IMI 181546        | Soil, France                                             |
| *Talaromyces purpureogenus*                      | CBS 122434      | NRRL 1059 = ATCC 10064 = IBT 10612 = IBT 3960 = DITO 049-F7 | Unknown                                                  |
|                                                  | CBS 132707      | IMI 136128 = IBT 3658 = IBT 3560 = DITO 189-A1         | Moulded field corn, Wisconsin, USA                       |
|                                                  | CBS 184.27      | IMI 094165 = FRR 1057 = NRRL 1057                       | Soil, Louisiana, USA                                     |
|                                                  | CBS 286.36^T    | IMI 091926 = Thom 17                                    | Parasitic on a culture of *Aspergillus cryze*, Japan     |
| *Talaromyces rademirici*                         | CBS 140.84^T    | CECT 2771 = IMI 282406 = IMI 327870                    | Air under willow tree, Valladolid, Spain                 |
| *Talaromyces radicus*                            | CBS 100488      | DITO 037-F6                                            | Wheat root, New South Wales                              |
|                                                  | CBS 100489^T    | DITO 037-F8                                            | Wheat root, New South Wales                              |
|                                                  | CBS 100490      | DITO 037-F8                                            | Fynbos soil, South Africa                                |
|                                                  | CBS 137382      | DITO 181-D5                                            | Fynbos soil, South Africa                                |
|                                                  | CBS 137382      | DITO 181-D7                                            | Fynbos soil, South Africa                                |
| *Talaromyces ramulosus*                          | DAOM 241660^T   | DITO 184-B8                                            | Soil, Malmesbury, South Africa                           |
|                                                  | DITO 181-E3     | Mite, Stellenbosch, South Africa                        |                                                          |
|                                                  | DITO 181-F6     | *Protea repens* infructescence, Stellenbosch, South Africa |
|                                                  | DITO 182-A3     | *Protea repens* infructescense, Stellenbosch, South Africa |
|                                                  | DITO 182-A6     | Air, Malmesbury, South Africa                           |                                                          |
|                                                  | DITO 183-A7     | *Protea repens* infructescense, Malmesbury, South Africa |
| *Talaromyces rotundus*                           | CBS 369.48^T    | ATCC 10493 = IMI 040589 = NRRL 2107                    | Cardboard, Norway                                        |
| *Talaromyces ruber*                              | CBS 132704^T    | DITO 193-H6 = IBT 10703 = CBS 113137                    | Air craft fuel tank, United Kingdom                      |
|                                                  | CBS 196.88      | FRR 1714 = IBT 3951                                    | Unknown                                                  |
|                                                  | CBS 237.93      | ACC 828-81                                             | Unknown                                                  |
|                                                  | CBS 370.48      | ATCC 10520 = IMI 00036 = NRRL 1062 = IBT 4431 = IBT 3927 | Currency paper, Washington, USA                          |
|                                                  | ATCC 13217 = IMI 099723 = NRRL 3400 |                                      | Soil, Georgia                                             |
| *Talaromyces rubicundus*                         | CBS 342.59^T    | DITO 061-E8                                            | Type of *P. chrysitis*, air sample, beer producing factory, Kaulille, Belgium |
|                                                  | CBS 371.49^T    | ATCC 10128 = IMI 040041 = MUCL 31201 = NRRL 1045        | Roating potato tubers (*Solanum tuberosum*), USA         |
| *Talaromyces rugulosus*                          | CBS 137366      | DITO 061-E8                                            | Type of *P. echinosporum* Nehira, unknown, Japan         |
|                                                  | CBS 344.51      | IFO 6016                                               | Types of *P. echinosporum* Nehira, unknown, Japan        |
|                                                  | CBS 371.49^T    | ATCC 10128 = IMI 040041 = MUCL 31201 = NRRL 1045        | Roating potato tubers (*Solanum tuberosum*), USA         |
Table 1. (Continued).

| Species name | CBS no. | Other collections | Substrate and origin |
|--------------|---------|-------------------|----------------------|
| **Talaromyces rugulosus** | NRRL 1053 = FRR 1053 = IMI 028259 | Unknown | Type of P. tatum & P. elongatum, decaying twigs, France |
|               | NRRL 1073 = FRR 1073 = IMI 040034 = ATCC 10503 = Thom 4640.444 | Soil, Naha, Japan |
| **Talaromyces ryukyuensis** | NHL 2917T = DTO 176-A6 | House dust, Mexico |
| **Talaromyces sayulliensis** | CBS 138204 | House dust, Mexico |
|               | CBS 138205 | House dust, Mexico |
|               | CBS 138206 | House dust, Mexico |
| **Talaromyces scortetus** | CBS 233.60 | Decaying wood, Louisiana, USA |
|               | CBS 340.34T | Soil, Malmesbury, South Africa |
|               | CBS 499.75 | Unknown substrate, South Africa |
|               | CBS 500.75 | Bronchial lavage of patient after lung transplantation (subclinical), France |
| **Talaromyces siamensis** | CBS 475.88T | Forest soil, Thailand |
|               | CBS 340.34 | House dust, Thailand |
| **Talaromyces solicola** | CBS 133445T | Soil, Malmesbury, South Africa |
|               | CBS 133446 | Soil, Malmesbury, South Africa |
| **Talaromyces stipitatus** | CBS 375.48T | Decaying wood, Louisiana, USA |
| **Talaromyces stolii** | CBS 169.91 | Unknown, Nigeria |
|               | CBS 265.93 | Unknown, Sierra Leone |
|               | CBS 408.93T | Aedes aegypti, the Netherlands |
|               | CBS 581.94 | Unknown, Sierra Leone |
|               | CBS 624.93 | Ananas camosus cultivar, Martinique |
| **Talaromyces subinflatus** | CBS 652.95T | Copse soil, Japan |
| **Talaromyces tardifaciens** | CBS 250.94T | Paddy soil, Bhakatpur, Nepal |
| **Talaromyces thailandensis** | CBS 133147T | Soil, Thailand |
| **Talaromyces trachyspermus** | CBS 116556 | Pasteurised canned strawberries, Germany |
|               | CBS 118437 | Soil, Morocco |
|               | CBS 118438 | Soil, Morocco |
|               | CBS 373.48T | Unknown, USA |
| **Talaromyces tratensis** | CBS 133146T | Soil, Thai |
|               | CBS 137400 | House dust, Mexico |
|               | CBS 137401 | Carbonated beverage, Washington D.C., USA |
| **Talaromyces ucrainicus** | CBS 127.64 | Unknown, Ukraine |
|               | CBS 162.67T | ATCC 22344 = FRR 3462 = NHL 6086 |
|               | CBS 583.72A | IFO 8991 |
|               | CBS 583.72C | IFO 8991 |
| **Talaromyces udagawae** | CBS 579.72T | Soil, Misumigura, Japan |
| **Talaromyces unicus** | CBS 100535T | Soil from bank of creek flooding into Little river, New South Wales |
| **Talaromyces unicus** | CBS 100535T | Soil, Taiwan |
| **Talaromyces varians** | CBS 386.48T | Soil, Taiwan |
| **Talaromyces verruculosus** | CBS 254.56 | Unknown, Yangambi, Zaire |
|               | CBS 388.48T | Soil, Texas, USA |
| **Talaromyces viridulus** | CBS 114.72T | Soil, Australia |
| **Talaromyces viridulus** | CBS 252.87T | Soil from bank of creek flooding into Little river, New South Wales |

(continued on next page)
annealing temperature of 48°C was used with a step-up PCR that started with 5 cycles and used 35 cycles and had a 55°C annealing temperature for each medium were extracted as described in Nielsen et al. (2010). Generally, a standard thermal cycle was used, which ran 35 cycles and had a 55°C annealing temperature. The Internal Transcribed Spacer region (ITS) was amplified using primer pair V9G (de Hoog & Gerrits van den Ende 1998) and LS266 (Masclaux et al. 1995). For the DNA-dependent RNA polymerase II second largest subunit (RPB2), primer-pair RPB2-5F and RPB2-7CR (Liu et al. 1999) was used with a step-up PCR that started with 5 cycles and 50°C annealing temperature of 48°C, followed by 5 cycles at 50°C and a final 25 cycles at 52°C. β-tubulin (BenA) was generally amplified with primer pair Bt2a and Bt2b (Glass & Donaldson 1995), while primer pair T10 and Bt2b (Glass & Donaldson 1995) was used with a 52°C annealing temperature for section Islandici species. Sequencing reactions were set up using the BigDye Terminator v. 3.1 Cycle Sequencing Kit (Applied Biosystems, CA) with the same primer sets used for PCR amplification. Sequences were determined on an ABI PRISM 3730xl genetic analyser (Applied Biosystems, California, USA). Sequence contigs were assembled using Seqman Pro v. 9.0.4 (DNAstar Inc.) and newly generated sequences deposited into GenBank. Accession numbers are included in the phylogenetic trees, with accession numbers of ex-type sequences provided in the accepted species list.

### Data analysis

All data sets were aligned using Muscle software included with the MEGA v. 5.2.2 software package (Tamura et al. 2011). Aligned data sets were analysed using Maximum likelihood (ML). The best model for ML was selected based on the Akaike Information Criterion (AIC), which was calculated in MEGA. ML analysis was done by calculating an initial tree using BioNJ and the subsequent Heuristic search done with the Nearest-Neighbour-Interchange (NNI) option. Support in nodes was calculated using a bootstrap analysis of 1,000 replicates. For the multigene phylogeny, the aligned ITS, BenA and RPB2 data sets were concatenated in SeaView (Gouy et al. 2010) and analysed using both ML and Bayesian inference (BI). The most suitable model for BI was selected based on AIC, calculated in MrModeltest v. 2.3 (Nylander et al. 2004). The analysis was run in MrBayes v. 3.2.1 (Huelsenbeck & Ronquist 2001) with two sets of four chains (one cold, three heated), until an average deviation for split frequencies reached 0.01. The sample frequency was set at 100, with 25% of trees removed as burnin. In the presented phylogenies, thickened branches indicate supported branches with bootstrap support above 80% and/or a posterior probability above 0.95. Trees were visually prepared and edited using Adobe® Illustrator® CS6.

### Extrolites

Extrolites were extracted from fungal strains grown on CYA and YES. In some cases, extractions were made from strains also grown on MEA and OA at 25°C for 7 d. Three agar plugs of each medium were extracted as described in Nielsen et al. (2011) and Houbraken et al. (2012). The extracts were analysed by high performance liquid chromatography with diode-array detection (HPLC-DAD) (Frisvad & Thrane 1987). Analyses made after 2011, used UHPLC-DAD (Houbraken et al. 2012). Comparing retention time, retention index and UV spectra measured at 200–600 nm, the detected eluted compounds were identified. The UV spectra were compared to a database of UV spectra (Nielsen et al. 2011) and data from
RESULTS & DISCUSSION

Phylogeny of Talaromyces

Previous studies showed that *Penicillium* was a polyphyletic genus with the asexual *Penicillium* subgenus *Biverticillium* and the sexual *Talaromyces* forming a monophyletic clade distinct from *Penicillium sensu stricto* (LoBuglio et al. 1993, Berbee et al. 1995, Ogawa et al. 1997, Ogawa & Sugiyama 2000, Peterson 2000, Heredia et al. 2001, Wang & Zhuang 2007, Houbakten & Samson 2011, Samson et al. 2011). The move to single name nomenclature in the International Code of Nomenclature for algae, fungi and plants (McNeill et al. 2012) allows phylogenetically related species to be treated under the same generic name regardless of its sexual or asexual morphs. As such, Samson et al. (2011) recombined *Penicillium* subgenus *Biverticillium* species into *Talaromyces*. This means that *Talaromyces sensu stricto* now contains species, which can reproduce sexually (ascomata) and/or asexually (conidiophores). The generic description of *Talaromyces* is amended below.

In this study, we used sequence data of the ITS, BenA and RPB2 gene regions for defining relationships within *Talaromyces* (Fig. 1). The aligned concatenated data set, which includes a subset of species classified in *Talaromyces*, had a total length of 1368 bp (ITS, 494 bp; BenA, 336 bp; RPB2, 538 bp). The Kimura 2-parameter (K2) model with gamma distributed (+G) and invariant sites (+I) was the most suitable model for ML, while the general time reversible (GTR) model (+G+I) was most suitable for BI. *Trichocoma paradoxa* was selected as out-group. Topologies for ML and BI trees were identical and thus, the ML tree was used for illustrating the phylogeny, with bootstrap support (bs) above 80 % and/or posterior probabilities (pp) above 0.95 indicated above thickened branches. Based on this, and the ITS and BenA phylogenies shown below, we divided the 88 accepted *Talaromyces* species into seven clades and propose these as a new sectional classification for the genus. This is discussed below. *Talaromyces sensu stricto* also now contains species, previously classified in different genera, for example *T. cinnabarinus* is introduced for *Aphanoascus cinnabarinus* and *T. bohemicus* for *Sagenomella bohemia*, both phylogenetically belonging in *Talaromyces*.

Some species do in fact produce both the sexual and asexual forms. An example is *T. wortmannii*, which together with *T. sublevisporus*, *T. variabilis* and *Penicillium concavorugulosum*, forms a coherent clade (based on ITS, BenA, CaM and RPB2 sequence data) under Genealogical Concordance Phylogenetic Species Recognition (GCPKR; Taylor et al. 2010) and as a result are synonymised with *T. wortmannii* (data will be published elsewhere). This was also confirmed by our morphological studies, where conidiophores of *T. sublevisporus* and *T. wortmannii* (known for their teleomorphic states) are identical to that of *P. concavorugulosum* and *T. variabilis*. Additionally, extrolite data also supported this. Sexual *Talaromyces* species are generally homothallic; however, there are two species, which are heterothallic. *Talaromyces dextrii* was the first *Talaromyces* species to be described as heterothallic (Takada & Udagawa 1988). Recent studies have shown that species, which were previously thought to be asexual, could in fact produce ascomata. One of these heterothallic species is *T. flavovirens* (= *P. aureocephalum*) which produces ascomata only on damaged Oak leaf-litter in Catalonia, Spain, but never under laboratory conditions (Visagie et al. 2012). Other species shown to contain both the MAT-1 and MAT-2 loci in populations include *T. funiculosus*, *T. marneffei* and *T. pinophilus*, but a sexual state has not been induced in any of these (Woo et al. 2006, López-Villavicencio et al. 2010, Henk et al. 2012). Mating types in *Talaromyces* will be the focus of future studies.

The genus *Lasioderma* was described by Montagne (1845) with *L. flavovirens* as type. Visagie et al. (2012) showed that *P. aureocephalum* is a synonym of *L. flavovirens* and that it belongs in the *Talaromyces* clade. This created a problem where *Lasioderma* represented an older name than the more widely used *Talaromyces* and resulted in Seifert et al. (2012) proposing the conservation of *Talaromyces* over *Lasioderma*.

Generic diagnosis

The concept of *Talaromyces* was adapted in Samson et al. (2011) to accommodate the transfer of *Penicillium* subgenus *Biverticillium*. Here we further adapt the concept based on species transferred to *Talaromyces* below in the taxonomy section, as well as new characters observed for species.

*Talaromyces* C.R. Benj., Mycologia 47: 681. 1955.

= *Lasioderma* Mont. In Ann. Sci. Nat., Bot., sér. 3, 4: 364. 1845, nom. rej. prop.; = *Penicillium* Link subgenus *Biverticillium* Dierckx apud Bourge Cellule 33: 31. 1923.

= *Penicillium* subg. *Biverticillata*-Symmetrica Thom, The Penicillia: 158. 1930.

= *Sagenoma* Stolk & G.F. Orr, Mycologia 66: 676. 1974.

= *Erythrogymnotheca* Yaguchi & Udagawa, Mycoscience 35: 219. 1994.

= *Paratalaromyces* Matsush., Matsu., Mycol. Mem. 10: 111. 2003 (2001).

Typus: *T. vermiculatus* (P.A. Dang.) C.R. Benj. (= *Talaromyces flavus* (Klöcker) Stolk & Samson)

Colonies on CYA commonly produce yellow or red reverse and/or soluble pigments, on CYAS no growth to very restricted growth, sometimes determinate or indeterminate synnemata produced. *Conidiophores* having smooth or rough-walled elements, characteristically symmetrically biverticillate, with a minor proportion having subterminal branches (in some species with a single subterminal lateral branch that afterwards repeats the branching pattern of the main axis), some species mono-verticillate or with solitary phialides. Stipes usually hyaline, terminating in a whorl of metulae of 3–10, appearing symmetrical in face view. *Conidigenous cells* phialidic, approximately equal length to metulae, typically aceros, rarely flask-shaped. Conidia aseptate, green en masse, in basipetal chains, usually ellipsoid to fusiform, rarely globose to subglobose or ovoidal. *Ascomata* kleistochorial when produced, usually with a distinctly hyphal exterior soft wall, often yellow, occasionally white, creamish, pinkish, orange, reddish or green. *Asci* produced in chains, containing eight ascospores, rarely two. *Ascospores* one-celled, ellipsoid to globose, rarely smooth-walled, but often with spines and/or less commonly ridges, hyaline to yellow, occasionally red.

literature. Authentic standards of the different extrolites were available for most of the *Talaromyces* compounds (Klitgaard et al. 2014).
Fig. 1. Combined phylogeny of the ITS, BenA and RPB2 gene regions of species from Talaromyces. Trichcomata paradoxa was chosen as out-group. Support in nodes is indicated above thick branches and is represented by posterior probabilities (BI analysis) of 0.95 and higher and/or bootstrap values (ML analysis) of 80% and higher. Full support (1.00/100%) is indicated with an asterisk (*); support lower than 0.95/80 is indicated with a dash (–). T = ex type.
Sectional classification

Subgeneric classifications have traditionally been used for the taxonomy of *Talaromyces* and *Penicillium*. Stolk & Samson (1972) divided *Talaromyces* into four sections based on differences in their asexual states (Table 2). Pitt (1980) accepted this sectional classification and introduced different series for these sections. He did this also for *Penicillium* subgenus *Biverticillium*. At the time, classifications were generally based only on phenotypic characters. However, Yaguchi et al. (1996) used the ubiquinone systems for infragenic classification of *Talaromyces*. Ubiquinone Q-10(H2) was found in the majority of *Talaromyces* species; however, they found a mixture of ubiquinone Q-10(H2) and ubiquinone Q-10(H4) in *T. trachyspermus* and related taxa. Therefore Yaguchi et al. (1996) introduced *Talaromyces* section *Trachyspermi* [as ‘*trachyspermus*’]. In modern taxonomies, phylogenies often do not support classifications based on criteria such as morphology. Thus, similar to Houbraken & Samson (2011), we use a multigene phylogeny (Fig. 1) for defining a new sectional classification of *Talaromyces*. Species were resolved into seven distinct clades and we propose sections *Talaromyces, Helici, Purpurei, Trachyspermi, Bacillispori, Subinflati* and *Islandici* for these clades. These are discussed below. For each section, we include ITS and *BenA* phylogenies containing each species classified in the section, in order to show the use of these genes for sequence based identification. The results of this are summarised in the phylogenetic species recognition section below.

*Talaromyces* section *Talaromyces*. Figs 1, 2.

Subsections *Talaromyces*.

= *Penicillium* subgenus *Biverticillium* section *Simplicium* series *Miniolutea* Pitt, The genus *Penicillium*: 419. 1980.

= *Penicillium* subgenus *Biverticillium* section *Coremigenum* series *Duclauxii* Raper & Thom ex Pitt, The genus *Penicillium*: 404. 1980.

= *Talaromyces* section *Talaromyces* series *Flavi* Pitt, The genus *Penicillium*: 471. 1980.

Typus: *Talaromyces flavus* (Klöcker) Stolk & Samson, Stud. Mycol. 2: 10. 1972.

Stolk & Samson (1972) introduced *Talaromyces* section *Talaromyces* for species that produce yellow ascomata, which can occasionally be white, creamish, pinkish or reddish, and
have yellow ascospores. Conidiophores are usually of the biverticillate-symmetrical type, with some species that have reduced conidiophores with solitary phialides. Phialides are usually acerate, with a minor proportion of species having wider bases (Stolk & Samson 1972). Pitt (1980) used T. minioluteus (= P. minioluteum) for typifying Penicillium subgenus Biverticillium section Simplicium series Miniolutea Pitt. However, he used an incorrect strain for his description of T. minioluteus (CBS 196.88), which was correctly identified as T. ruber (Yilmaz et al. 2012) and belongs in Talaromyces section Talaromyces. As a result, the series Miniolutea Pitt is synonymised with Talaromyces section Talaromyces. Talaromyces duclauxii (type of Penicillium subgenus Biverticillium section Coremigenum series Duclauxii Pitt) is also resolved in section Talaromyces (Table 2).

Section Talaromyces species are commonly isolated from soil, indoor environments, humans with penicilliosis and food products. Common species include T. flavus, T. funiculosus, T. macrosporus, T. marneffei, T. pinophilus and T. purpureogenus. Talaromyces purpureogenus produces rubratoxin, which is a well-known hepaticarcinogenic toxin (Burnside et al. 1957; Kiraha et al. 2001). Talaromyces marneffei is the only thermal dimorphic Talaromyces species and is a pathogen of especially HIV patients mostly diagnosed in East Asia (Deng et al. 1988; Supparatpinyo et al. 1994, Chiang et al. 1998, Hien et al. 2001). Talaromyces pinophilus and T. funiculosus are important enzyme producers (Rao et al. 1983, Wood & McCrae 1986, Rando et al. 1997, Sukhacheva et al. 2004). Talaromyces cellulolyticus was recently introduced for Acremonium cellulolyticum (strains Y-94), an important cellulose-degrading species (Fuji et al. 2013). However, based on their sequence data (ITS: AB474749 and BenA: AB773823) we do not consider these species distinct from T. pinophilus and synonymise it with the latter. Delmas et al. (2014) and Lafond et al. (2014) have incorrectly linked the unpublished name T. versaltis (IMI 378536) as a “basonym” of Penicillium funiculosum (= T. funiculosus). Even though T. versaltis has not been validly published, the BenA sequence for IMI 378536 (KC992272) is distinct from all accepted Talaromyces species and is closely related to T. angelicus.

Accepted species:

Talaromyces aculeatus (Raper & Fennell) Samson et al., Stud. Mycol. 71: 174. 2011. [MB506039]. — Herb.: IMI 040588. Ex-type: CBS 289.48 = ATCC 10409 = IMI 040588 = NRRL 2129 = NRRL A-1474. ITS barcode: KF741995.

(Alternative markers; BenA = KF741929; CaM = KF741975; RPB1 = n.a.; RPB2 = KM022371).

Talaromyces amestolkiae Yilmaz et al., Persoonia 29: 48. 2012. [MB801358]. — Herb.: CBS H-21050. Ex-type: CBS 132969 = DTO 179-15-F5. ITS barcode: JX315660. (Alternative markers; BenA = JX315623; CaM = KF741937; RPB1 = JX315678; RPB2 = JX315668).

Talaromyces anguliculus S.H. Yu, T.-J. An & H. Sang, J. Microbiol. 51: 707. 2013. [MB046077]. — Herb.: KACC 46611. Ex-type: KACC 46611. ITS barcode: KF183638. (Alternative markers; BenA = KF741936; CaM = KJ885259; RPB1 = n.a.; RPB2 = n.a.).

Talaromyces apiculatus Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 174. 2011. [MB506041]. — Herb.: CBS H-20755. Ex-type: CBS 312.59 = ATCC 183151 = FRR 635 = IMI 068239. ITS barcode: JN999375. (Alternative markers; BenA = KF741916; CaM = KF741950; RPB1 = JN680293; RPB2 = KM022387).

Talaromyces aurantiacus (J.H. Mil., Giddens & A.A. Foster) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB506042]. — Herb.: No. 1736 (A.A. Foster). Ex-type: CBS 314.59 = ATCC 13216 = IMI 099722 = NRL 3398. ITS barcode: JN999380. (Alternative markers; BenA = KF741917; CaM = KF741915; RPB1 = JN680293; RPB2 = KM023311).

Talaromyces calidicanius (J.L. Chen) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB506045]. — Herb.: CBC-7 (isotype TNM F21246). Ex-type: CBS 112002. ITS barcode: JN999319. (Alternative markers; BenA = HQ156944; CaM = KF741934; RPB1 = JN680306; RPB2 = KM023329).
Fig. 2. ML phylogenies of ITS (left) and BenA (right) for species classified in Talaromyces sect. Talaromyces. Talaromyces dendriticus was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher.  

- ex type. Model selected: Tamura 3-parameter (T92) +G+I for ITS, K2+G for BenA, alignment 537 (ITS) and 458 (BenA) bp.
Talaromyces funiculosus (Thorn) Samson et al., Stud. Mycol. 71: 176. 2011. [MB560653]. — Herb.: IMI 193019. Ex-type: CBS 272.66 = IMI 193019. ITS barcode: JN899377. (Alternative markers; BenA = JX091383; CaM = KF741945; RPB1 = JN860288; RPB2 = KMO23293).  

Talaromyces galapagensis Samson & Mahoney, Trans. Brit. Mycol. Soc. 69: 158. 1977. [MB324417]. — Herb.: CBS H-7489. Ex-type: CBS 751.74 = IFO 31796. ITS barcode: JN899358. (Alternative markers; BenA = JX091388; CaM = KF741966; RPB1 = JN860321; RPB2 = n.a.).  

Talaromyces intermedius (Aphini) Stolk & Samson, Stud. Mycol. 2: 21. 1972. [MB324418]. — Herb.: CBS H-7828. Ex-type: CBS 152.65 = BDUN 267 = IFO 31752 = IMI 100534. ITS barcode: JN899331. (Alternative markers; BenA = JX091387; CaM = KJ885209; RPB1 = JN860276; RPB2 = n.a.).  

Talaromyces ilani (Kamynchko) Yılmaz, Frisvad & Samson. (this study). [MB809555]. — Herb.: unknown. Ex-type: CBS 225.66 = ATCC 18325 = ATCC 18331 = IMI 098480 = NRRL 3380 = VKM F-301. ITS barcode: JN899395. (Alternative markers; BenA = JX091380; CaM = KJ885257; RPB1 = JN860280; RPB2 = n.a.).  

Talaromyces macrosporus (Stolk & Samson) Frisvad, Samson & Stolk, Antonie van Leeuwenhoek 57: 186. 1990. [MB126704]. — Herb.: CBS H-7822. Ex-type: CBS 317.83 = FRR 404 = IMI 187478. ITS barcode: JN899333. (Alternative markers; BenA = JX091392; CaM = KF741952; RPB1 = JN860296; RPB2 = KMO23292).  

Talaromyces marneffei (Segretain, Capponi & Sureau) Samson et al., Stud. Mycol. 71: 176. 2011. [MB560656]. — Herb.: IMI 687944ii. Ex-type: CBS 388.87 = ATCC 18224 = CBS 334.59 = IMI 068794i = IMI 068794ii. ITS barcode: JN899344. (Alternative markers; BenA = JX091389; CaM = KF741958; RP1 = JN899298; RPB2 = KMO23283).  

Talaromyces panasensis (Samson, Stolk & Mycoscience) 35: 252. 1994. [MB362930]. — Herb.: CBS PH-1153. Ex-type: CBS 756.96 = PF 1153. ITS barcode: JN899351. (Alternative markers; BenA = KJ865727; CaM = KJ885274; RPB1 = n.a.; RPB2 = n.a.).  

Talaromyces oomae-annae Visagie et al., Stud. Mycol. 78: 130. 2014. [MB809187]. — Herb.: CBS H-21977. Ex-type: CBS 138208 = DTO 269.68. ITS barcode: KJ775720. (Alternative markers; BenA = KJ775723; CaM = KJ775425; RPB1 = n.a.; RPB2 = n.a.).  

Talaromyces oumae-annae 188 — JN899358 T. galapagensis CBS 751.74  

KJ775714 T. sayulliensis CBS 138205  

KJ775715 T. sayulliensis CBS 138206  

KJ775713 T. sayulliensis CBS 138204  

KM066204 T. pinophilus CBS 154.89  

JN899382 T. pinophilus CBS 631.68  

JN899347 T. pinophilus CBS 762.68  

JX091488 T. pinophilus DTO 193-B  

KM066205 T. pinophilus CBS 10780  

KM066206 T. pinophilus CBS 173.51  

KM066207 T. pinophilus CBS 266.73  

KM066208 T. iano CBS 116434  

KM066209 T. DTO 108-72  

KM066210 T. iano CBS 116885  

JN899367 T. iano CBS 225.66  

KJ741955 T. aculeatus CBS 289.48  

KJ741960 T. aculeatus CBS 136673  

KJ741961 T. aculeatus CBS 262.02  

KJ741986 T. aculeatus CBS 200.65  

KJ741984 T. aculeatus CBS 563.92  

AB176603 T. pseudoacris FM3616  

JN899384 T. indistinctus CBS 342.59  

JN899331 T. indistinctus CBS 100534  

JN899330 T. denticillus CBS 660.80  

Fig. 2. (Continued)
Fig. 3. ML phylogenies of ITS (left) and BenA (right) for species classified in Talaromyces sect. Helici. Talaromyces uranicius was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 90 % and higher. * = ex-type. Model selected: TS2 + G for ITS; K2+ for BenA. alignment 463 (ITS) and 510 (BenA) bp.

(Alternative markers; BenA = JX315833; CaM = JX315646; RPB1 = JX315893; RPB2 = JX315712).

Talaromyces thailandensis Manoch, Dethoup & Yilmaz, Mycosen. 54: 37. 2011. — Herb.: CBS H-21075. Ex-type: CBS 133147 = KUFC 3399. ITS barcode: JX988041. (Alternative markers; BenA = JX494294; CaM = KF741940; RPB1 = JX988043; RPB2 = KM023307).

Talaromyces verruculosus (Peyronel) Samson et al., Stud. Mycol. 71: 177. 2011. — Herb.: IMI 040039. Ex-type: CBS 10513 = DSM 2285 = IMI 040039 = NRRL 1050. ITS barcode: KF741994. (Alternative markers; BenA = KF749926; CaM = KF741944; RPB1 = n.a.; RPB2 = KM023306).

Talaromyces viridis (Stolk & G.F. Orr) Arx, Persoonia 13: 282. 1987. — Herb.: CBS H-7732 (isotype), CBS H-7733 (isotype), CBS H-7734 (isotype). Ex-type: CBS 114.72 = ATCC 22467 = NRRL 5575. ITS barcode: AF285782. (Alternative markers; BenA = JX494310; CaM = KF741935; RPB1 = JN121571; RPB2 = JN121430).

Talaromyces viridulus Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. — Herb.: FRR 1863. Ex-type: CBS 252.87 = FRR 1863 = IMI 040593. ITS barcode: AF285782. (Alternative markers; BenA = JX494310; CaM = JX898041; RPB1 = n.a.; RPB2 = KM023307).

Talaromyces section Helici Yilmaz, Frisvad & Samson, sect. nov. MycoBank MB809558. Figs 1, 3.

Typus: Talaromyces helicus (Raper & Fennel) C.R. Benj., Mycologia 47: 684. 1955.

Description: Conidiophores biverticillate, occasionally consisting of solitary phialides, with stipes generally pigmented, CYA reverse yellowish brown or dark green, species generally grow at 37 °C and do not produce acid on CREA, while some do not grow on this medium. Some species produce yellow to deep red or green ascomata.

Talaromyces section Helici is basal to section Talaromyces and includes a main clade containing T. helicus, T. boninensis and T. varians, which produce conidiophores with pigmented stipes, and the second clade containing T. cinnabarinus (≡ Paecilomyces cinnabarinus), T. aerugineus (≡ Paecilomyces aerugineus), T. bohemicus (≡ Sagenomella bohemica) and T. ryukyuensis (≡ Sagenoma ryukyuense) (Fig. 3).

Accepted species:

Talaromyces aerugineus (Samson) Yilmaz, Frisvad & Samson, (this study). [MB809553]. — Herb.: CBS H-7448. Ex-type: CBS 252.87 = FRR 1863 = IMI 28876. ITS barcode: JN999314. (Alternative markers; BenA = JX091385; CaM = KF741943; RPB1 = JN680824; RPB2 = JF417422).

Talaromyces bohemicus (Fassat & Pékiová) Yilmaz, Frisvad & Samson, (this study). [MB809554]. — Herb.: unknown. Ex-type: CBS 545.86 = CCF 2330 = IAM 14789. ITS barcode: JN999400. (Alternative markers; BenA = KJ865719; CaM = KJ885266; RPB1 = JN121699; RPB2 = JN121532).

Talaromyces boninensis (Yaguchi & Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB560643]. — Herb.: CBM PF-1103. Ex-type: CBS 650.95 = IBT 17516. ITS barcode: JN999356. (Alternative markers; BenA = KJ865721; CaM = KJ885263; RPB1 = JN680319; RPB2 = KM023267).

Talaromyces cinnabarinus (S.C. Jong & E.E. Davis) Yilmaz, Samson & Frisvad, (this study). [MB809557]. — Herb.: CBS H-6686. Ex-type: CBS 267.72 = ATCC 26215 = NHL 2673. ITS barcode: JN999376. (Alternative markers; BenA = KY753377; CaM = KJ885256; RPB1 = n.a.; RPB2 = JN121477).

Talaromyces helicus (Raper & Fennel) C.R. Benj., Mycologia 47: 684. 1955. — Herb.: CBS H-7448. Ex-type: CBS 252.87 = FRR 1863 = IMI 28876. ITS barcode: JN999314. (Alternative markers; BenA = JX091385; CaM = KF741943; RPB1 = JN680824; RPB2 = JF417422).

Talaromyces ryukyuensis (S. Ueda & Udagawa) Arx, Persoonia 13: 282. 1987. [MB560677]. — Herb.: CBS 28889. Ex-type: CBS 267.72 = ATCC 26215 = NHL 2673. ITS barcode: JN999376. (Alternative markers; BenA = KY753377; CaM = KJ885256; RPB1 = JN680319; RPB2 = KM023274).

Talaromyces purpureus (E. Müll. & Pacha-Aue) Stolk & Samson, Stud. Mycol. 2: 56. 1972. MycoBank MB39627. Figs 1, 4.

Typus: Talaromyces purpureus (E. Müll. & Pacha-Aue) Stolk & Samson, Stud. Mycol. 2: 56. 1972.

Description: Conidiophores biverticillate often with additional subterminal branches. Synnemata usually produced after two to three weeks of incubation. Colonies in general grow rapidly on CYA and MEA.

Talaromyces section Purpurea Stolk & Samson [as ‘Purpurea’], Stud. Mycol. 2: 56. 1972. MycoBank MB39627. Figs 1, 4.

= Penicillium subgenus Biverticillium sect. Coremigenum ser. Dendritica. Pitt, the genus Penicillium: 413. 1980.

Typus: Talaromyces purpureus (E. Müll. & Pacha-Aue) Stolk & Samson, Stud. Mycol. 2: 56. 1972.

Description: Conidiophores biverticillate with additional subterminal branches. Synnemata usually produced after two to three weeks of incubation, the exceptions being T. rademirici, T. purpureus and T. pycnochonidum (Fig. 4). Pitt (1980) used synnema production as a defining character for his section Coremigenum (type species Talaromyces dendriticus ≡ P. dendriticus), which we synonymise here with section Purpurea. In general, this group of species produces biverticillate conidiophores that have additional subterminal branches. Talaromyces purpureus is the exception, which...
produces conidiophores that can be monoverticillate or have solitary phialides. A number of species seems to be associated with very specific habitats. Talaromyces cicdicola was isolated from wasp insect galls (Seifert et al. 2004). T. dendriticus is commonly found in the presence of Eucalyptus (Pitt 1980, Seifert et al. 2004), while T. chloroloma and T. ramulosus are very common in Protea repens infuscetences and other substrates like apples grown in the Fynbos region of the Western Cape, South Africa (Visagie et al. 2009, Van der Walt et al. 2010, Visagie & Jacobs 2012).

Accepted species:

Talaromyces cicdicola (Seifert, Hoeckstra & Frisvad) Samson et al., Stud. Mycol. 71: 175. 2011. [MB560646]. — Herb.: DAO 233293. Ex-type: CBS 103.83. ITS barcode: JN899328. (Alternative markers; RPB1 = JX091496; RPB2 = KM023302).

Talaromyces chloroloma Visagie & K. Jacobs, Persoonia 28: 18. 2012. [JX091497]. — Herb.: CBS 475.71T. ITS barcode: JN899386. (Alternative markers; BenA = JX091629; CalM = JX091632; RPB1 = n.a.; RPB2 = KM023281).

Talaromyces cecidicola (Visagie & K. Jacobs) Samson, Persoonia 28: 18. 2012. [JX091498]. — Herb.: CBS 101419. ITS barcode: JN899323. (Alternative markers; RPB1 = JX091496; RPB2 = KM023302).
Fig. 5. ML phylogenies of ITS (left) and BenA (right) for species classified in Talaromyces sect. Trachysperm. Talaromyces purpurogenes was chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80 % and higher. \* = ex type. Model selected: T92+G1 for ITS, K2+G for BenA, alignment 495 (n.d.) and 376 (BenA) bp.

Accepted species:

**Talaromyces albobiverticillius** (H.-M. Hsieh, Y.M. Ju & S.Y. Hsieh) Samson et al., Stud. Mycol. 1: 174. 2011. [MB560683]. — Herb.: BCRC 34774. Ex-type: CBS 133440 = DTC 166-E = YM 1290. ITS barcode: HQ05705. (Alternative markers; BenA = KF114778, CaM = KJ885280, RPB1 = n.a.; RPB2 = KJ023310).

**Talaromyces assiutensis** Visagie & K. Jacobs, Persoonia 28: 20. 2012. [Image] Accepted species RPB2 = HQ156945; — 2011. [MB560612].

**Talaromyces atroroseus** Yilmaz et al., PLOS ONE 8: e84102-page 8. 2013. [MB560491]. — Herb.: CBS H-21790. Ex-type: CBS 133342 = IGT 32470 = DTC 178-A4. ITS barcode: KF114774. (Alternative markers; BenA = KF114779; CaM = KJ775418, RPB1 = n.a.; RPB2 = KM023388).

**Talaromyces auricomiformis** Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 245. 1993. [MB338112]. — Herb.: CBM-PP 1117. Ex-type: CBS 644.95 = IBT 17522. ITS barcode: JN899357. (Alternative markers; BenA = KJ865732; CaM = KJ885261; RPB1 = JN860316; RPB2 = n.a.).

**Talaromyces convolutus** Udagawa, Mycotaxon 48: 141. 1993. [MB560647]. — Herb.: CBM SUM-3018. Ex-type: CBS 100537 = IBT 14898. ITS barcode: JN899330. (Alternative markers; BenA = KF114773; CaM = n.a.; RPB1 = JN121553; RPB2 = JN121414).

**Talaromyces diversus** (Raper & Fennell) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB560649]. — Herb.: IMI 045759. Ex-type: CBS 320.48 = ATCC 10437 = DSM 2212 = IMI 040579 = IMI 040579i = NRRL 2121. ITS barcode: KJ865740. (Alternative markers; BenA = KJ865723; CaM = KJ865268; RPB1 = JN860297; RPB2 = KM023285).

**Talaromyces erythromellis** (Swift) C.R. Benj., [as *bacilliformis*] (Swift) C.R. Benj., [as *bacilliformis*], Mycologia 47: 682. 1955. Description: Restricted growth on CYA, DG18, YES and CREA. Some species produce creamish white to yellow ascocoma. Conidiophores mono- to bicelliverticate. The section is introduced for *T. bacilliformis* and its closely related species. Species typically produce creamish white to yellow ascocoma and generally grow restrictedly on CYA, DG18, YES and CREA, with the exception of *T. proteolyticus*, which grows relatively well and lacks a sexual state.

**Talaromyces trachyspermus** (Shear) Stolk & Samson, Stud. Mycol. 2: 32. 1972. [MB524241]. — Herb.: IMI 040043. Ex-type: CBS 373.48 = ATCC 10497 = IMI 04043 = NRRL 1028. ITS barcode: JN899354. (Alternative markers; BenA = KF114603; CaM = JX885281; RPB1 = JN121664; RPB2 = JF417432).

**Talaromyces ucrainicus** (Panas.) Udagawa, Trans. Mycol. Soc. Japan 7: 94. 1966. [MB449657]. — Herb.: unknown. Ex-type: CBS 162.67 = ATCC 22344 = FRR 3462 = NHL 6086. ITS barcode: JN899394. (Alternative markers; BenA = KF114771; CaM = JX885282; RPB1 = JX860277; RPB2 = KM023289).

**Talaromyces udagawae** Stolk & Samson, Stud. Mycol. 2: 36. 1972. [MB524242]. — Herb.: CBS H-7841. Ex-type: CBS 579.72 = FRR 1727 = IMI 040962. ITS barcode: JN899350. (Alternative markers; BenA = KF114796; CaM = n.a.; RPB1 = JX860310; RPB2 = n.a.).

**Talaromyces section Bacillispori** Yilmaz, Frisvad & Samson, sect. nov. MycoBank MB809642. Figs 1, 6.

**Talaromyces section Bacillispori** [Swift] C.R. Benj., [as *bacillisporus*], Mycologia 47: 682. 1955. Description: Restricted growth on CYA, DG18, YES and CREA. Some species produce creamish white to yellow ascocoma. Conidiophores mono- to bicelliverticate.
Talaromyces section Subinflati
Yilmaz, Frisvad & Samson, sect. nov. MycoBank MB809564. Figs 1, 7.

Typus: Talaromyces subinflatus Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 249. 1993.

Description: Poor growth on CREA and DG18. Sometimes indeterminate synnemata produced at colony margin after one to two weeks.

The section is introduced for T. subinflatus and T. palmae. Morphologically, T. subinflatus and T. palmae do not resemble each other, although both grow poorly on CREA and DG18. Talaromyces palmae produces indeterminate synnemata after one to two weeks, while T. subinflatus grows poorly on all media except MEA and OA.

Accepted species:

Talaromyces palmae (Samson, Stolk & Frisvad) Samson et al., Stud. Mycol. 71: 176. 2011. [MB560658]. — Herb.: CBS 442.88. Ex-type: CBS 442.88 = IMI 343660. ITS barcode: JN899396. (Alternative markers; BenA = HQ156947; CaM = KJ858291; RPB1 = JN860308; RPB2 = KM023300).

Talaromyces subinflatus Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 249. 1993. [MB361184]. — Herb.: CBF PF-1113. Ex-type: CBS 652.95 = IBT 17520. ITS barcode: JN869397. (Alternative markers; BenA = KJ857373; CaM = KJ858280; RPB1 = JN860301; RPB2 = KM023306).

Talaromyces section Islandici (Pitt) Yilmaz, Frisvad & Samson, comb. et stat. nov. MycoBank MB809565. Figs 1, 7.

Basionym: Penicillium sect. Simplicium ser. Islandica Pitt, The genus Penicillium. 445. 1980.

Typus: Talaromyces islandicus (Sopp) Samson et al., Stud. Mycol. 71: 176. 2011.

Description: Restricted growth on general media. Colonies have prominent yellow mycelia. Most species grow at 37 °C and some species produce yellow acomata.

The section is introduced for Penicillium sect. Simplicium ser. Islandica Pitt. Species typically produce restrictedly growing colonies and have prominent yellow mycelia. A four-genre phylogenetic analysis and extrolite data revealed that T. variabilis, P. concavorugulosum and T. sublevisporus are synonymous with T. wortmannii (Yilmaz et al. unpubl.). Section Islandica includes species, which are biotechnologically (e.g. T. variabilis and T. rugulosus) and medically important (e.g. T. piceus, T. columbinus and T. radicus) (Barthomeuf et al. 1991, Petruzzioli et al. 1999, Horre et al. 2001, de Vos et al. 2009, Peterson & Jurjevic 2013).

Accepted species:

Talaromyces alahabdensis (B.S. Mehrtra & D. Kumar) Samson et al., Stud. Mycol. 71: 174. 2011. [MB560640]. — Herb.: University of Allahabad P-26. Ex-type: CBS 453.93 = ATCC 15067 = CBS 304.63. ITS barcode: KF984873. (Alternative markers; BenA = KF984614; CaM = KF984768; RPB1 = JN860308; RPB2 = KF984906).

Talaromyces atrichus S.W. Peterson & Jurjevic, PLoS ONE 8: e78084-page 8. 2013. [MB804733]. — Herb.: unknown. Ex-type: CBS 255.35 = NRR 1052 = FRR 1052 = Thom 4640. ITS barcode: JN899366. (Alternative markers; BenA = KF984587; CaM = KF984668; RPB1 = n.a.; RPB2 = KF984948).

Talaromyces brunneus (Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. [MB560644]. — Herb.: NHL 6054. Ex-type: CBS 227.60 = ATCC 16229 = FRR 646 = IFO 6438 = IMM 3907 = IMI 078259 = MUCL 3118. ITS barcode: JN899356. (Alternative markers; BenA = KJ856722; CaM = KJ855264; RPB1 = JN860281; RPB2 = KM023272).

Talaromyces columbinus S.W. Peterson & Jurjevic, PLoS ONE 8: e78084-page 6. 2013. [MB804732]. — Herb.: BPI 892668. Ex-type: NRR 5811. ITS barcode: KJ856739. (Alternative markers; BenA = KF984566; CaM = KF984719; RPB1 = n.a.; RPB2 = KF984948).

Talaromyces islandicus (Sopp) Samson et al., Stud. Mycol. 71: 176. 2011. [MB560654]. — Herb.: IMI 040042. Ex-type: CBS 338.60 = ATCC 10127 = IMI 040042 = MUCL 3124 = NRR 1036. ITS barcode: KF984865. (Alternative markers; BenA = KF984655; CaM = KF984780; RPB1 = JN861268; RPB2 = KF985018).

Talaromyces loliensis (Pitt) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. [MB560655]. — Herb.: CBS 216901. Ex-type: CBS 643.80 = ATCC 52252 = FRR 1798 = IMI 216901 = MUCL 31325. ITS barcode: KF984888. (Alternative markers; BenA = KF984568; CaM = KF984783; RPB1 = JN860314; RPB2 = KF985021).

Talaromyces piceus (Raper & Fennell) Samson et al., Stud. Mycol. 71: 176. 2011. [MB560661]. — Herb.: IMI 040038. Ex-type: CBS 381.48 = ATCC 10519 = IMI 040038 = NRR 1051. ITS barcode: KF984792. (Alternative markers; BenA = KF984668; CaM = KF984860; RPB1 = n.a.; RPB2 = KF984899).

Talaromyces radicus (A.D. Hocking & Whetall) Samson et al., Stud. Mycol. 71: 177. 2011. [MB560669]. — Herb.: DAR 72374. Ex-type: CBS 100489 = FRR 4718. ITS barcode: KF984878. (Alternative markers; BenA = KF984599; CaM = KF984773; RPB1 = n.a.; RPB2 = KF985013).

Talaromyces rotundus (Raper & Fennell) C.R. Benj., Mycologia 47: 683. 1955. [MB306719]. — Herb.: IMI 040089. Ex-type: CBS 369.48 = ATCC 10495 = IMI
were chosen as out-group. Support in nodes is indicated above thick branches and is represented by bootstrap values of 80% and higher. T = ex type. Model selected: GTR+G for ITS, K2+G for

Fig. 7. Talaromyces tardifaciens = KJ865730; 040589 = NRRL 2107. ITS barcode: JN899353. (Alternative markers; [MB560672].—10128 = IMI 040047 = NRRL 1017. ITS barcode: KF984834. (Alternative markers; [MB809189].—CBS 652.95T = CBS 137397.

Talaromyces rugulosus (Thom) Samson et al., Stud. Mycol. 78: 134. 2014. [MB809189]. — Herb.: CBS H-2179. Ex-type: CBS 138209 = DTO 270-A6. ITS barcode: JN899397.

Talaromyces subinflatus (Bashkirov & Vrzhec) P. Cano, Mycoscience 54: 337. 2013. [MB801738]. — Herb.: CBS H-21074. Ex-type: CBS 133146 = JUFC 3383.

ITS barcode: KF984891. (Alternative markers; BenA = KF984559; CaM = KF984690; RPB1 = JX88042; RPB2 = KF984911). Talaromyces wortmannii (Küchler) C.R. Benj., Mycologia 47: 683. 1955. [MB344294]. — Herb.: IMI 040047. Ex-type: CBS 371.48 = ATCC 10517 = IMI 040047 = NRRL 1017. ITS barcode: KF984829. (Alternative markers; BenA = KF984648; CaM = KF984576; RPB1 = JN126696; RPB2 = KF984977).

Talaromyces yelensis Visagie et al., Stud. Mycol. 78: 134, 2014. [MB809189]. — Herb.: CBS H-2179. Ex-type: CBS 138209 = DTO 268-E5. ITS barcode: KJ775717. (Alternative markers; BenA = KF984556; CaM = KF984668; RPB1 = n.a.; RPB2 = n.a.).

Phylogenetic species recognition

The ITS rDNA region was recently accepted as the official DNA barcode for fungi (Schroth et al. 2012). It was chosen because of the universal primer sets available for PCR amplification and is
the most widely sequenced gene for fungi. The barcode does have its limitations and is often not sufficiently variable for making a species identification. For example, in section Talaromyces (Fig. 2), T. siamensis and T. cnidii have identical ITS sequences, while there is lack of support in most branches of the phylogeny. Another example is T. assiutensis and T. trachyspermus, classified in section Trachyspermii (Fig. 5), which also have identical ITS sequences. Overall ITS does, however, perform very well for species recognition in the genus, even though it should be used cautiously since variability is low in a few clades.

Previous studies on Penicillium and Talaromyces showed that BenA sequences have more variation compared to ITS (Seifert & Louis-Seize 2000, Samson et al. 2004, Visage et al. 2009, Visage & Jacobs 2012, Yilmaz et al. 2012, Frisvad et al. 2013). In our study, BenA easily distinguished between all species, also allowing for some infraspecific variation. The ITS and BenA phylogenies (Figs 2–7) cover the variation accepted in each species. Peterson & Jurjević (2013) mentioned problems with the amplification of BenA paralogs in section Islandici using primer pairs B12a and B12b or B12f and T22. We had similar results with these primers, with gel-electrophoresis showing one band after amplification, but subsequent sequences that have mixed electropherograms. As a result, we suggest primer pair T10 and Bt2b (Glass & Donaldson 1995), at annealing temperatures of 50 or 52 °C, for the amplification and sequencing of BenA in section Islandici.

Apart from ITS and BenA, several other genes have been used for phylogenetic comparisons in Talaromyces, including calmodulin, RPB1 and RPB2 (Yilmaz et al. 2012, Frisvad et al. 2013). These genes work well for species recognition, but amplification of these genes are often challenging. For example, RPB1 and RPB2 amplification is difficult across all sections of Talaromyces, while amplification of calmodulin often is difficult in section Trachyspermii using primer pairs CMD5 and CMD6 or CF1 and CF4. As a result, we propose the use of BenA as the secondary molecular marker for species identifications in Talaromyces.

**Morphological species recognition**

In aid of morphological species identification, tables (Table 3–9) are provided summarising the most important characters. Tables 3 & 4 contain all Talaromyces species and summarises general macro- (Table 3) and micromorphological characters (Table 4). Additional tables are provided for ascomata producers (Table 5), synnemata producers (Table 6), red soluble pigment producers (Table 7) and species that produce globose rough-walled conidia (Table 8). In Table 9 growth rates on CYA at 37 °C are given.

Table 3 provides a summary of the most important macro-morphological characters, including growth rates on CYA, MEA and CREA, reverse and soluble pigment colour on CYA, colony texture on MEA and acid production on CREA. Growth rates on especially CYA and MEA were taxonomically informative. For example, section Talaromyces species generally grow well on these media, species from section Trachyspermii grow poorly on CYA but well on MEA, while section Islandici species grow restrictedly on both CYA and MEA. Lack of and/or poor growth on CREA is characteristic of sections Trachyspermii and Subinflati. Acid produced on CREA is able to distinguish among closely related species. For example, T. allahadensis and T. radicus are closely related, but T. allahadensis produces acid in contrast to T. radicus, which lacks acid production. Species of medical importance includes T. amestolkiae, T. marnefei, T. helicus, T. piceus and T. stolii (Chiang et al. 1998, Horré et al. 2001, Tomlinson et al. 2011, Yilmaz et al. 2012), which are able to grow at 37 °C. As a result, Table 9 sorts species based on growth rates on CYA at 37 °C. Reverse colouration on CYA was taxonomically informative. For example, Talaromyces bacillisporus (especially at 30 and 37 °C), T. dextii, T. euchlorocarpus, T. viridis and T. aerugines all produce green CYA reverses. Colony texture on MEA was also useful for distinguishing species. For example, T. ruber produces velvety colonies compared to the loosely funiculose colonies of its closest relative T. amestolkiae, and T. rugulosus produces velvety colonies in contrast to its closest relative T. atricola, which has floccose colonies.

Micromorphological characters are summarised in Table 4 and illustrated in Fig. 8. A diverse range of conidiophore branching patterns are observed in Talaromyces and range from having solitary phialides (Fig. 8A) to monverticillate (Fig. 8B), biverticillate (Fig. 8C) and biverticillate conidiophores with additional subterminal branches (Fig. 8D, E). Phialide shape is a useful feature with most Talaromyces species having acerose phialides (Fig. 8F), while a small number of species have flask-shaped phialides (Fig. 8G). Conidial sizes and ornamentations were taxonomically informative characters. Talaromyces bacillisporus and T. viridulus produces rod-shaped conidia (Fig. 8H), a small group of species produces roughened globose conidia (Fig. 8I), but most species produce ellipsoidal conidia that are finely roughened (Fig. 8J, K). Ascomata are produced in a number of Talaromyces species and these are included in Table 5. Generally, ascomata are yellow, but some species produce green (T. dextii, T. euchlorocarpus and T. viridis) or creamish white ascomata (T. assiutensis and T. trachyspermus). Shape, size and ornamentation of ascosporas are also useful for distinguishing between species. Ascosporas are generally spiny. Ascosporas of T. stipitatus have single equatorial ridges, T. udagawae has numerous ornamented ridges on ascospores and T. helicus has smooth ascospores. In most species, ascosporas are broadly ellipsoidal, but T. bacillisporus and T. rotundus have spiny, globose ascospores and T. tardifaciens produces smooth globose ascosporas.

A number of species typically produces synnemata and is included in Table 6. Synnemata can be either determinate or indeterminate. Determinate synnemata have a terminal, non-elongated conidiogenous zone, in contrast to indeterminate synnemata, which have elongated fertile zones, sometimes covering the whole conidiom (Seifert 1985). Mostly, synnemata are produced after more than one week of incubation. However, T. panamensis and T. duclauxii produce them within one week. The length of synnemata is an important character. In T. ramulosus and T. flavovirens, synnemata are characteristically short (<1000 μm), whereas T. pseudostromaticus and T. calidicanus produce very tall synnemata (>6000 μm). Other characters distinguishing between synnemata producers, include growth rate on CYA and MEA at 25 and 30 °C and acid production on CREA.

Although red soluble pigment is not always consistently produced in strains from the same species, species such as T. albobverticillius, T. atroroseus, T. marnefei, T. minioluteus and T. purpurogenus typically produce these pigments. Table 7
Table 3. Overview of macro-morphological characters for the identification of *Talaromyces* species.

| Species name          | Ascomata | Growth rate (mm) | CYA reverse | CYA soluble pigment | MEA colony texture | Acid production on CREA |
|-----------------------|----------|------------------|-------------|---------------------|-------------------|-------------------------|
|                       |          | CYA | CYA (37 °C) | MEA       |                   |                   |                         |
| T. aculeatus          | Absent   | 25–35 | 15–20   | 30–35 | Light brown (7D4–7DS) at the centre fading into greyish yellow (4A3–4B3) | Absent | Floccose to funiculose | Weak                  |
| T. aeruginus          | Absent   | 26–27 | 35     | 49–50 | Dark green (26F5) centre fading into greyish green (20B5–26B5) | Absent | Loosely funiculose to velvety | Absent (no growth) |
| T. albobiverticillus  | Absent   | 15–20 | No growth | 25–28 | Greyish red to reddish brown (9C5–9F8) | Red (in some isolates absent) | Velvety | Absent                  |
| T. allahabadensis     | Absent   | 20–25 | 23–25   | 20–23 | Orange to greyish orange (5A6–5B6) in the centre fading into light yellow to greyish yellow (4A5–4B5) | Absent | Velvety | Present               |
| T. amstelodami       | Absent   | 30–32 | 8–15   | 30–45 | Violet brown (11E8–11F8) Very weak brownish red, in some strains absent | Absent | Floccose and overlaying funiculose | Weak                  |
| T. angeli             | Absent   | 25–27 | 25–27   | 33–35 | Greyish red (7B3) centre fading into yellowish white (4A2) | Absent | Floccose | Absent (in some isolates very weak) |
| T. apiculatus         | Absent   | 38–41 | 25–35   | 40–42 | Greyish yellow (3B3) to yellowish white (3A2) | Absent | Floccose to strongly funiculose | Weak                  |
| T. assittens          | Present  | 15–21 | 25–30   | 20–23 | Pale orange to brownish orange (5A3–5C5) | Absent | Floccose | Absent                  |
| T. atricola           | Absent   | 10    | No growth | 15   | Yellowish white to yellowish grey (4A2–4A3) | Absent | Floccose | Absent                  |
| T. atroroseus         | Absent   | 28–40 | 23–25   | 30–35 | Reddish brown (9E8) | Red | Velvety and floccose | Absent                  |
| T. aurantiacus        | Absent   | 30–32 | 19–21   | 38–40 | Pastel red (7A4) fading into orange white (6A2) | Absent | Floccose | Absent                  |
| T. austrocalifornicus | Present  | 10–11 | 10–11   | 16–18 | Orange white to pale orange (5A2–5A3) | Absent | Floccose | Absent (no growth)    |
| T. bacillisporus      | Present  | 10–15 | 33–37   | 15–20 | Dull green (28F4) fading into greyish yellow to olive brown (4C5–4D5) (at 30 and 37 °C reverse dark green (25F4)) | Absent | Floccose | Absent                  |
| T. bohemicus          | Absent   | Unknown | Unknown | 40 (after 10 d) | Unknown | Unknown | Floccose and loosely funiculose | Unknown                |
| T. boninensis         | Present  | 28    | Unknown | 30    | Yellowish brown (5E5) centre fading into golden yellow (5B7) | Absent | Velvety and floccose | Unknown                |
| T. brunneus           | Absent   | 19–20 | No growth | 17–19 | Yellowish brown (5E5) centre fading into golden yellow (5B7) | Absent | Velvety and floccose | Present                |
| T. calidicanius       | Absent   | 27–30 | No growth | 47–48 | Greyish yellow to olive brown (4C5–4D5) | Absent | Synnematous | Present                |
| T. cecidicola         | Absent   | 33–34 | 2–3     | 37–38 | Dark brown to violet brown (8F8–10F8) | Absent | Funiculose | Absent                  |
| T. chloroloma         | Absent   | 40–45 | 0–4     | 45–48 | Centre greyish orange (5B3), fading into dull greyish yellow (3B3) | Absent | Floccose and loosely funiculose | Moderate               |
| T. cinnabarinus       | Present  | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown                |
| T. cnidii             | Absent   | 25–30 | 20–28   | 38–40 | Violet brown (11E8) fading into vivid red (11A8) | Red to yellow | Velvety and floccose | Absent                  |
| T. coalescens         | Absent   | 32–34 | 2–4     | 43–45 | Dark brown to violet brown (8F8–10F8) | Red | Funiculose | Very weak              |

(continued on next page)
| Species name       | Ascomata | Growth rate (mm) | CYA | CYA (37 °C) | MEA | CYA reverse | CYA soluble pigment | MEA colony texture | Acid production on CREA |
|-------------------|----------|------------------|-----|-------------|-----|-------------|---------------------|---------------------|----------------------|
| T. columbinus     | Absent   | 13–14            | 42–43| 20–21       |     | Dark brown fading into beige (8F8) | Light brownish orange | Velvety and floccose | Absent |
| T. convolutus     | Present  | 10–12            | 6–8 | 13–15       |     | Orange white to pale orange (5A2–5A3) | Absent     | Floccose | Absent |
| T. dendriticus    | Absent   | 23–26            | 5–6 | 35–36       |     | Dark brown (6F6), fading into light brown (6D6) and light yellow (2A5) | Absent     | Funiculose and synnematous | Absent |
| T. denudii        | Present  | 38–40            | 35–38| 48–50       |     | Dark green (25F5) centre for both fading into light yellow (4A4) | Absent     | Floccose | Absent |
| T. diversus       | Absent   | 7–10             | 5–8 | 25–35       |     | Blond to brownish orange (4C4–5C4) | Absent     | Velvety | Absent (no growth) |
| T. duckiaii       | Absent   | 25–27            | 3–4 | 48–50       |     | Olive brown (4E8) fading into olive brown (4D7) and maize yellow (4A6) | Yellow | Synnematous | Weak |
| T. emodensis      | Present  | 8–10             | 4–6 | 8–10        |     | Brownish red to reddish brown (6C8–6D8) | Absent     | Floccose | Absent |
| T. erythromellis  | Absent   | 10–11            |     | 10–11       |     | Dark red to brownish red (10C8–10D8) | Absent     | Loosely funiculose | Absent |
| T. flavocarpius   | Present  | 15–18            |     | 38–40       |     | Reddish golden (6C7) centre fading into golden yellow (5B7) and deep yellow (4A8) | Yellow to orange yellow | Loosely funiculose and floccose | Absent |
| T. flavovirens    | Present  | 19–20            | 5–6 | 37–38       |     | Brown (7E8) centre fading into greyish yellow (2B6) | Yellow | Velvety after 2 wk, covered with yellow mycelia | Absent |
| T. flavus         | Present  | 9–10             | 19–20| 31–32       |     | Brownish orange (5C8) fading into light yellow (3A5) | Yellow | Floccose | Absent |
| T. funiculosus    | Absent   | (30–)38–45       | 38–50| 30–45       |     | Light orange to greyish orange (5A4–5B4) | Absent (in some isolates light red) | Stringly funiculose | Present |
| T. galapagensis   | Present  | 15–17            | 25–26| 25–28       |     | Brownish brown (6F6) centre fading into yellowish white (3A2) | Absent     | Floccose | Absent (no growth) |
| T. hachijoensis   | Present  | 3                | No growth | 8–10       |     | Brownish orange (5C6) | Unknown | Velvety to floccose | Unknown |
| T. helicus        | Present  | 13–23            | 10–18| 25–33       |     | Yellowish brown (5E4) centre fading into greyish orange (5B3) and yellowish white (4A2) | Absent     | Floccose | Absent (no growth) |
| T. indigoticus    | Present  | 20–21            | 20–22| 32–33       |     | Pale orange (5A3) centre fading into yellowish white (4A2) | Absent     | Floccose | Absent |
| T. intermedius    | Present  | 15–16            | No growth | 48–50       |     | Greyish yellow (3B4) | Absent     | Floccose | Absent (no growth) |
| T. islandicus     | Absent   | 20–27            | 8–17 | 21–26       |     | Reverse colouration brown (7E4) in the centre fading into light orange to light orange (4A4–5A4) | Absent     | Velvety and loosely funiculose | Present |
| T. iani           | Present  | 20–30            | 20–25| 35–45       |     | Light orange and light yellow (5A5–4A5) | Absent (in some isolates yellow) | Velvety and floccose | Absent (in some isolates very weak) |
| T. foliensis      | Absent   | 10–13            | No growth | 13–15       |     | Centre deep yellow to deep orange (4A8–5A8) fading into light yellow to yellow (3A5–3A6) | Weak yellow | Floccose and loosely funiculose | Absent to very weak |
| T. macrosorus     | Present  | 22–28            | 28–35| 40–50       |     | Yellowish brown (5E7–5F7) centre fading into brownish yellow to golden yellow (5C7–5B7) | Absent (at 30 and 37 °C brown soluble pigment) | Floccose | Absent |
| T. marneffei      | Absent   | 13–25            | 5–10 | 15–27       |     | Reddish brown (9E8) fading into red (9A6) | Red | Loosely funiculose and floccose | Absent |
| T. mimosinus      | Present  | 12–15            | 3–5 | 13–14       |     | Light yellow (3A5) | Absent     | Floccose | Absent (no growth) |
| Species name            | Ascomata | Growth rate (mm) | CYA reverse | CYA soluble pigment | MEA colony texture | Acid production on CREA |
|------------------------|----------|------------------|-------------|--------------------|--------------------|------------------------|
| T. minioluteus         | Absent   | 17–18            | No growth   | 21–22              | Brown (6E8) centre fading into brownish orange to light brown (6C8–6D8) | Weak brownish red       | Loosely funiculose and floccose | Absent |
| T. muroii              | Present  | 15–16            | 19–20       | 30–32              | Reddish brown (8E7) fading into brownish red (7C7–8C7) | Absent                 | Floccose | Absent (no growth) |
| T. omue-annae          | Absent   | 16–18            | 10–11       | 29–30              | Greyish green (29B6–29C6) | Yellow                | Velvety and floccose | Absent |
| T. palmae              | Absent   | 20–25            | No growth   | 22–26              | Pastel yellow to greyish yellow (2A4–2B4) | Absent                 | Velvety and in the margins synnematous | Weak   |
| T. panamensis          | Absent   | 23–24            | No growth   | 28–30              | Brownish orange to yellowish brown (5C6–5D6) | Absent                 | Synnematous | Present |
| T. paucisporus         | Present  | 15–18 (after 14d)| No growth   | 19–20 (after 14d)  | Violet brown (11E8) | Violet brown          | Velvety to tomentose | Unknown |
| T. piceus              | Absent   | 20–27            | 30–35       | 25–27              | Brown (8E6)          | Light brown           | Loosely funiculose to floccose | Absent |
| T. pinophillus         | Absent   | 18–25            | 25–40       | 30–40              | Greyish orange to orange (6B6–6B7) centre fading into pastel yellow (3A4) | Yellow, in some strains absent | Loosely funiculose to floccose | Moderate |
| T. pittii              | Absent   | 34–36            | No growth   | 42–44              | Reddish brown (8E7) at centre, fading into brownish red (8C5) | Red                    | Yeast like slimy colonies, after 2 wk floccose and synnematous | Absent |
| T. primulinus          | Absent   | 5–6              | No growth   | 20–25              | Some isolates brownish orange to reddish brown (7C5–8C5) and in some isolates greenish grey to greyish green (1D2–1D3) | Absent                 | Floccose after 2 wk covered with yellow mycelia | Absent |
| T. proteolyticus       | Absent   | 20–22            | No growth   | 20–21              | Centre greyish red (9B5) fading into between light yellow (4A4) and light orange (5A4) | Absent                 | Floccose | Moderate |
| T. pseudostromaticus   | Absent   | 25–34            | No growth   | 38–43              | Dark brown (7F8–8F8) | Absent                 | Velvety and loosely funiculose, after 2 wk synnematous | Absent |
| T. ptychoconidium      | Absent   | 8–16             | 5–12        | 12–23              | Centre light brown (5D4) fading into light yellow (3A5) | Absent                 | Loosely funiculose | Absent |
| T. purpureus           | Present  | 2–4              | No growth   | 15–16              | Creamish beige       | Absent                 | Floccose | Absent (no growth) |
| T. purpurigenus        | Absent   | 20–25            | 16–25       | 30–45              | Dark brown to violet brown (9F8–11F8) | Red                    | Velvety and floccose | Absent |
| T. rademini            | Absent   | 5–6              | 3           | 14–15              | Pigmentation yellowish white (4A2) | Absent                 | Floccose | Absent (no growth) |
| T. radicus             | Absent   | 15–22            | 25–30       | 15–25              | Yellowish brown (5E6–5F6) | Absent                 | Floccose | Absent (no growth) |
| T. ramulosus           | Absent   | 32–40            | 5–8         | 45–48              | Dark brown (6F4–6F7) | Absent                 | Floccose and synnematous | Absent |
| T. rotundus            | Present  | 9–11             | No growth   | 15–17              | Greyish green (27E5) circle at centre fading into greenish grey (1B2) | Absent                 | Floccose | Absent (no growth) |
| T. ruber               | Absent   | 20–35            | 14–18       | 35–40              | Brownish red (8E8–8F8) | Very weak red, in some strains absent | Very weak red | Absent |
| T. rubicundus          | Absent   | 30–32            | 34–35       | 38–39              | Brownish orange (5C5) centre fading into orange white (5A2) | Absent                 | Floccose | Absent |
| T. rugulosus           | Absent   | 15–17            | No growth   | 17–20              | Yellowish brown (5E4–5F4) fading into light yellow to greyish yellow (2A5–2B5 to 1A5–1B5) | Absent                 | Velvety  | Absent to very weak |

(continued on next page)
| Species name      | Ascomata | Growth rate (mm) | CYA CYA (37 °C) MEA | CYA reverse                                                                 | CYA soluble pigment               | MEA colony texture | Acid production on CREA |
|-------------------|----------|------------------|---------------------|----------------------------------------------------------------------------|-----------------------------------|-------------------|------------------------|
| T. ryukyuensis    | Present  | Unknown          | Unknown             | Unknown                                                                    | Unknown                           | Unknown           | Unknown                |
| T. sayulitensis   | Absent   | 24–29            | 32–40               | 37–40                                                                      | Brown (6E6) in the centre, fading into brownish orange (6C7) and light yellow (4A5) | Absent             | Loosely funiculose to floccose | Present               |
| T. scortetus      | Absent   | 8–16             | No growth           | 10–15                                                                      | Centre olive (2E4) centre fading into greyish yellow to olive (2C4–2D4) | Absent             | Velvety                | Absent                |
| T. siamensis      | Absent   | 20–22            | 15                  | 32–33                                                                      | Blond to greyish yellow (4C4)     | Absent             | Velvety                | Absent                |
| T. solicina       | Absent   | 12–13            | No growth           | 22–23                                                                      | Reddish brown to dark brown (9E6–9F6) | Absent             | Velvety and floccose   | Absent (no growth)    |
| T. stipitatus     | Present  | 32–38            | 28–32               | 45–48                                                                      | Dark brown (6F6), fading into reddish golden brownish orange to light brown (6C7–6D7) | Yellow to orangish yellow | Floccose               | Weak                  |
| T. stollii        | Absent   | 38–45            | 25–35               | 45–50                                                                      | Brownish red (8E8–8F8)            | Red, in some strains absent | Floccose and loosely funiculose | Present               |
| T. subinfalatus   | Present  | 3–4              | No growth           | 14–15                                                                      | Yellowish white (4A2)             | Absent             | Floccose               | Absent (no growth)    |
| T. tardifaciens   | Present  | 9–10             | No growth           | 13–15                                                                      | Centre light orange (5A5–5A6) fading into greyish yellow (4C4) | Absent             | Floccose               | Absent (no growth)    |
| T. thailandensis  | Present  | 33–35            | No growth           | 30–35                                                                      | Yellowish red to red (8A6–9A6) centre with red (9B7) dots | Absent             | Floccose               | Absent                |
| T. trachyspermus  | Present  | 13–24            | 32–40               | 17–25                                                                      | Light orange (5A5) fading into light yellow to yellow (3A5–3A6) | Absent             | Floccose               | Absent (no growth)    |
| T. tratensis      | Present  | 10–12            | No growth           | 15–20                                                                      | Greyish yellow (4A4–5A5) to brownish orange (6C8) | Yellow and in some isolates absent | Loosely funiculose to floccose | Absent               |
| T. ucrainicus     | Present  | 10–20            | 7–17                | 18–24                                                                      | Olive to olive brown to brownish orange (1F6–4E3–5C5) | Absent             | Floccose               | Absent (no growth)    |
| T. udagawae       | Present  | 6–8              | No growth           | 10–11                                                                      | Pale orange to light orange (5A3–5A4) | Absent             | Floccose               | Absent (no growth)    |
| T. unicus         | Present  | 10.5–16          | No growth           | 15–19.5                                                                     | Reddish white to violet brown (7A2–11E8) | Absent             | Floccose to funiculose | Unknown               |
| T. varians        | Absent   | 22–24            | 27–28               | 30–32                                                                      | Dark green (27F6) centre fading into dull green (7D3) fading into pale orange to light orange (5A3–5A4) | Absent             | Floccose               | Absent                |
| T. verruculosus   | Absent   | 32–35            | 25–26               | 35–36                                                                      | Greyish yellow to greyish orange (4C4–5C4) | Absent             | Floccose and loosely funiculose | Weak                  |
| T. viridis        | Present  | 9                 | 10–11               | 15                                                                          | Greyish green (1C3) centre fading into yellowish white (4A2) | Absent             | Floccose               | Absent (no growth)    |
| T. viridulus      | Absent   | 12–15            | 6–7                 | 37–38                                                                      | Brownish red (9C7) centre fading into pale yellow (3A3) | Absent             | Floccose               | Absent                |
| T. wortmannii     | Present  | 18–28            | 0–7                 | 15–25                                                                      | Reddish yellow (4A6) to greyish yellow (3B4–3C4) | Absent             | Velvety                | Absent to moderate     |
| T. yelensis       | Absent   | 20–22            | 25–26               | 15–16                                                                      | Yellowish white (2A2) to light yellow (3A5) to brown (5F6) | Absent             | Floccose               | Absent                |
| Species name          | Conidiophore branching                                      | Conidial ornamentation       | Conidial shape                           | Conidial size (μm)                           |
|----------------------|-------------------------------------------------------------|------------------------------|------------------------------------------|---------------------------------------------|
| T. aculeatus         | Biverticillate, minor proportion with subterminal branches | Rough to echinulate         | Globose                                  | 3–3.5 x 3–3.5                               |
| T. aerugineus        | Solitary phialides to monoverticillate                      | Smooth                      | Subglobose to ellipsoidal to fusiform    | 3–3.5 x 2.5–5                               |
| T. albovirens        | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough      | Globose to subglobose                    | 2.5–4.5 x 1.7–2.5                           |
| T. allahabadensis    | Biverticillate                                             | Smooth                      | Ellipsoidal to fusiform                  | 2–3 x 1.5–2.5                               |
| T. amestokiæae       | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough      | Ellipsoidal                              | 2.5–3.5 x 2–3                               |
| T. angelicus         | Mono- to biverticillate                                    | Finely rough                | Subglobose to ellipsoidal                | 2.5–4 x 1.5–2.5                             |
| T. apiculatus        | Biverticillate                                             | Rough to echinulate         | Globose                                  | 3–4(5–5.5) x 3–4(5–5)                       |
| T. assiutensis       | Mono- to biverticillate                                    | Smooth                      | Ovoidal to ellipsoidal                   | 2–4 x 1.5–2.5                               |
| T. atricola          | Biverticillate having symmetrical subterminal branches     | Smooth                      | Ellipsoidal to fusiform                  | 2–5 x 2–5                                   |
| T. atroroseus        | Biverticillate, minor proportion with subterminal branches | Finely rough to rough       | Ellipsoidal                              | 2–3.5 x 1.5–2.5                             |
| T. aurantiacus       | Biverticillate                                             | Smooth                      | Cylindrical to ellipsoidal               | 3–5 x 1.5–2.5                               |
| T. austrocalifornicus| Biverticillate                                             | Smooth                      | Subglobose                               | 1.5–3 x 1.5–2.5                             |
| T. bacillisporus     | Mono- to biverticillate                                    | Smooth                      | Cylindrical, rod shaped to ellipsoidal   | 3–5(6.5) x 1–2                              |
| T. bohemicus         | Monoverticillate, subterminal branching sometimes present  | Encrusted cell walls        | Fusiform                                 | 7–9 x 2.6–3                                 |
| T. bonensis          | Biverticillate                                             | Smooth                      | Ellipsoidal to fusiform                  | 2–4 x 1.5–2.5                               |
| T. brunneus          | Biverticillate, minor proportion with subterminal branches | Smooth                      | Globose to subglobose                    | 3–4(7) x 2–4                                |
| T. calidicanius      | Biverticillate, minor proportion with subterminal branches | Finely rough to rough with spiral striations | Ellipsoidal to fusiform | 2.5–4.5 x 2–3                               |
| T. cecidicola        | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough      | Ellipsoidal                              | 2.5–4 x 1.5–3                               |
| T. chloroloma        | Biverticillate, minor proportion with subterminal branches | Smooth                      | Ellipsoidal                              | 2.5–4(6) x 1.5–2.5                          |
| T. cinnabarinus      | Biverticillate                                             | Smooth                      | Cylindrical                              | 5.4–7.2 x 1.5–2                            |
| T. cridii            | Biverticillate, minor proportion with subterminal branches | Smooth                      | Ellipsoidal                              | 2.5–4 x 2–2                                 |
| T. coalescens        | Biverticillate, minor proportion with subterminal branches | Smooth                      | Ellipsoidal to fusiform                  | 2.5–3.5(5.5) x 1.5–3                        |
| T. columbinus        | Biverticillate                                             | Smooth                      | Ellipsoidal                              | 2.5–3.5 x 3–4.5                             |
| T. convolutus        | Mono- to biverticillate                                    | Smooth                      | Ellipsoidal                              | (2–3) x 4 x 1.5–2(–3)                       |
| T. dendriticus       | Biverticillate                                             | Smooth                      | Subglobose to ellipsoidal                | 2.5–3.5 x 2–2.5                             |
| T. derxii            | Mono- to biverticillate                                    | Smooth                      | Cylindrical to ellipsoidal, sometimes curved and fusiform | 4–8 x 1.5–3                                 |
| T. diversus          | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough      | Subglobose to ellipsoidal                | 2–3(5–5) x 2–3(–3.5)                        |
| T. duclauxii         | Biverticillate                                             | Smooth to finely rough      | Subglobose to ellipsoidal                | 3–4 x 1.5–3(5–4)                            |
| T. emodensis         | Monoverticillate, minor proportion with subterminal branches | Smooth                      | Ovoidal to ellipsoidal                   | 3–4 x 1.5–3                                 |
| T. erythromellis     | Biverticillate having symmetrical subterminal branches     | Smooth                      | Subglobose to ellipsoidal                | 2–3.5 x 1.5–2.5                             |
| T. euchlorocarpius   | Biverticillate                                             | Smooth                      | Subglobose to ellipsoidal                | 2–4 x 2–3                                   |
| T. flavovirens       | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough      | Ellipsoidal                              | 2.5–3.5(5–5) x 2–2.5(–4)                   |
| Species name         | Conidiophore branching          | Conidial ornamentation | Conidial shape             | Conidial size (μm)                      |
|---------------------|---------------------------------|------------------------|-----------------------------|----------------------------------------|
| T. flavus           | Monoverticillate                | Smooth                 | Ellipsoidal                 | 2–3 × 1.5–2.5                          |
| T. funiculosus      | Biverticillate, minor proportion with subterminal branches | Smooth                 | Ellipsoidal                 | 2–3(–5.5) × 1–2(–2.5)                  |
| T. galapagensis     | Mono- to biverticillate         | Smooth                 | Ovoid to ellipsoidal        | 2.5–5 × 1.5–3                         |
| T. hachijoensis     | Absent                          | Absent                 | Absent                      | Absent                                 |
| T. helicus          | Mono- to biverticillate         | Smooth                 | Globose to subglobose       | 2.5–3(–4.5) × 2.2–3.5                  |
| T. indigicus        | Mono- to biverticillate         | Smooth                 | Ovoidal to ellipsoidal      | 2.4–4 × 2–3.2                          |
| T. intermedius      | Solitary phialides to monoverticillate | Smooth                 | Ellipsoidal                 | 2.5–4.5 × 2.2–3.5                      |
| T. islandicus       | Biverticillate                  | Smooth                 | Ellipsoidal                 | 2.5–6 × 2–4.5                          |
| T. liari            | Mono- to biverticillate         | Smooth                 | Ellipsoidal                 | 2.5–4(–4.5) × 2–3.5                    |
| T. taliensis        | Biverticillate                  | Smooth, thick walled   | Subglobose to ellipsoidal   | 3–5 × 2.4–3.5                          |
| T. macrosporus      | Mono- to biverticillate         | Smooth                 | Subglobose to ellipsoidal   | 2–4 × 2–3.5                            |
| T. mameflei         | Mono- to biverticillate         | Smooth                 | Subglobose                  | 2.5–4 × 2–3                           |
| T. mimoainus        | Mono- to biverticillate         | Smooth                 | Globose to subglobose       | 2–3 × 2–2.5                            |
| T. minioluteus      | Biverticillate                  | Smooth                 | Ellipsoidal                 | 2.5–4 × 1.5–2.5                        |
| T. muroi            | Mono- to biverticillate, minor proportion with subterminal branches | Smooth                 | Globose to subglobose       | 2–3 × 1.5–3                            |
| T. omue-annae       | Biverticillate, minor proportion with subterminal branches | Rough                  | Ellipsoidal                 | 3–3.5 × 2.5–3                          |
| T. palmae           | Biverticillate, minor proportion with subterminal branches | Smooth                 | Subglobose to ellipsoidal   | 3–4.5 × 2–3.5                          |
| T. panamensis       | Biverticillate having subterminal branches | Smooth, thick walled   | Ellipsoidal to fusiform     | 3–5 × 2–3                             |
| T. paucisporus      | Absent                          | Absent                 | Absent                      | Absent                                 |
| T. piceus           | Biverticillate                  | Smooth                 | Ellipsoidal                 | 2–3.5 × 2–4                           |
| T. pirephilus       | Biverticillate, minor proportion with subterminal branches | Smooth                 | Globose to subglobose       | 2–3 × 2–3                             |
| T. pittii           | Mono- to biverticillate         | Smooth                 | Ellipsoidal                 | 2.5–4.5(–6.5) × 1.5–3.5                |
| T. primulinus       | Biverticillate                  | Smooth to finely rough | Ellipsoidal to fusiform     | 2–4 × 1.5–3                           |
| T. proteolyticus    | Biverticillate, minor proportion with subterminal branches | Smooth                 | Globose to subglobose       | 2–3 × 1.5–2.5                          |
| T. pseudostromaticus| Biverticillate, minor proportion with subterminal branches | Smooth                 | Subglobose to ellipsoidal   | 2.5–4 × 2–3                           |
| T. ptychoconidium   | Biverticillate                  | Rough with spiral ridges | Ellipsoidal                 | 3–4.5(–5) × 2–3                        |
| T. purpureus        | Solitary phialides and monoverticillate | Rough with spiral ridges | Subglobose to ellipsoidal   | 3–4 × 2–3                             |
| T. purpurogenus     | Biverticillate                  | Smooth                 | Ellipsoidal                 | 3–3.5 × 2–2.5                          |
| T. rademirici       | Mono- to biverticillate, minor proportion with subterminal branches | Smooth                 | Ellipsoidal                 | 2.5–4 × 1.5–2.5                        |
| T. radicus          | Biverticillate                  | Finely rough with ridges | Subglobose to ellipsoidal   | 2–3 × 2–2.5                           |
| T. ramulosus        | Biverticillate, minor proportion with subterminal branches | Smooth                 | Subglobose to ellipsoidal   | 2–3 × 1.5–2.5                          |
| T. rotundus         | Monoverticillate                | Smooth                 | Ellipsoidal to fusiform     | 3–5(–6.5) × 1.5–2.5                    |
| T. ruber            | Biverticillate, minor proportion with subterminal branches | Smooth                 | Ellipsoidal                 | 2.5–3.5 × 1.5–2                        |
| Species name       | Conidiophore branching                                      | Conidial ornamentation       | Conidial shape                              | Conidial size (μm)                  |
|-------------------|-------------------------------------------------------------|------------------------------|---------------------------------------------|------------------------------------|
| T. rubicundus     | Biverticillate, minor proportion with subterminal branches | Smooth                       | Subglobose to ellipsoidal                   | 2–3 × 1.5–2.5                     |
| T. rugulosus      | Biverticillate having symmetrical subterminal branches     | Smooth to finely rough       | Ellipsoidal to fusiform                     | 2.5–6 × 2.5–4                      |
| T. ryukyuensis    | Solitary phialides and monoverticillate                     | Rough, thick walled          | Cylindrical to fusiform to ellipsoidal      | 3.5–12–15 × 2.5–3.5               |
| T. sayulitensis   | Biverticillate, minor proportion with subterminal branches | Smooth                       | Subglobose to ellipsoidal                   | 2.5–3 × 2–2.5                     |
| T. scorteus       | Biverticillate having symmetrical subterminal branches     | Smooth                       | Ellipsoidal                                 | 3–5.5 × 2–3                       |
| T. siamensis      | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough       | Ellipsoidal to fusiform                     | 3–4 × 2–3                         |
| T. solicola       | Biverticillate                                              | Rough                        | Globose to subglobose                       | 2–3.5 × 2–2.5                     |
| T. stipitatus     | Mono- to biverticillate                                     | Smooth                       | Ovoidal to ellipsoidal                      | 2–7.5 × 2–4                       |
| T. stellii        | Biverticillate, minor proportion with subterminal branches | Smooth to finely rough       | Ellipsoidal                                 | 2.5–4 × 2–2.5                     |
| T. subinfatius    | Biverticillate                                              | Smooth                       | Ellipsoidal to fusiform                     | 2.5–4 × 1.5–2                     |
| T. tardiakens     | Solitary phialides and monoverticillate                     | Smooth                       | Cylindrical to ellipsoidal                  | 3–6 × 1.5–2.5                     |
| T. thailandensis  | Biverticillate                                              | Smooth                       | Broadly ellipsoidal to ovoidial             | 2–4 × 2–3                         |
| T. trachyspermus  | Mono- to biverticillate                                     | Smooth                       | Ellipsoidal                                 | 2–3.5(–5) × 1.5–2.5              |
| T. tratensis      | Biverticillate                                              | Smooth                       | Broadly ellipsoidal to ovoidial             | 2–2.5 × 3–3.5                     |
| T. ucraunicus     | Mono- to biverticillate                                     | Smooth                       | Broadly ellipsoidal to ovoidal              | 2–4(–5) × 1.5–2.5(–3)            |
| T. udagawae       | Biverticillate                                              | Smooth                       | Subglobose to ellipsoidal                   | 3–4 × 2–3                         |
| T. unicus         | Mono- to biverticillate, minor proportion with subterminal branches | Smooth                      | Ellipsoidal to ovoidal                     | 2.7–5 × 1.7–3.2                   |
| T. varians        | Mono- to biverticillate                                     | Smooth                       | Ellipsoidal to cylindrical                  | 2.5–4 × 1.5–2                     |
| T. verruculosus   | Biverticillate                                              | Rough to echinulate          | Globose                                     | 3–3.5 × 3–3.5                     |
| T. vindis         | Solitary phialides                                         | Smooth                       | Fusiform to ellipsoidal                     | 2.5–3.5(–4) × 1.5–2               |
| T. vindulus       | Biverticillate                                              | Smooth                       | Cylindrical to rod shaped                   | 3.5–6 × 1–2                       |
| T. wortmannii     | Biverticillate, minor proportion with subterminal branches | Smooth                       | Ellipsoidal                                 | 2.5–6 × 1.5–3.5                   |
| T. yelensis       | Biverticillate, minor proportion with subterminal branches | Rough                        | Subglobose to ellipsoidal                   | 2.5–3.5 × 2.5–3                    |
| Species name | Ascoma colour | Ridges | Ornamentation | Ascospores | Size (μm) | Conidiophore branching | Growth rate (mm) | CYA | MEA |
|-------------|--------------|--------|---------------|------------|-----------|------------------------|-----------------|-----|-----|
| T. assiutensis | Creamish white to pale yellow | Absent | Spiny | Ellipsoidal | 3.5–5 × 2–3 | Mono- to biverticillate | 15–21 | 20–23 |
| T. austrocalifornicus | Yellow | Finely spiny | Broadly ellipsoidal | 2.5–3.5 × 2–2.5 | Mono- to biverticillate | 10–11 | 16–18 |
| T. bacillisporus | Creamish white to pastel orange | Absent | Spiny | Globose | 3.5–5 × 3–5 | Biverticillate | 10–15 | 15–20 |
| T. boninensis | Creamish white to pastel orange | Absent | Spiny | Broadly ellipsoidal | (2.5–)3.5–(4.5) × 2–3 | Biverticillate | 28 | 30 |
| T. cinnabarinus | Yellow | Absent | Finely spiny | Broadly ellipsoidal, thick walled | 4–5 (–6) × 3–3.5 | Mono- to biverticillate | 8–10 | 8–10 |
| T. convolutus | Sulphur yellow | Present | Ornamented by irregular ridges | Broadly ellipsoidal, thick walled | (4–)4.5–(6–7) × 3–4 | Biverticillate, minor proportion with subterminal branches | 19–20 | 37–38 |
| T. derrxii | Greyish green to dark bluish green | Absent | Spiny | Spiny | 3.5–5 × 2.5–3 | Mono- to biverticillate | 9–10 | 31–32 |
| T. emodensis | Creamish white to sulphur yellow | Absent | Spiny | Broadly ellipsoidal | 7–10 × 5.5–8 | Mono- to biverticillate | 15–17 | 25–28 |
| T. euchlorocarpius | Deep green | Absent | Spiny | Ellipsoidal | 5.5–7 × 3.5–4.5 | Absent | 3 | 8–10 |
| T. flavovires | Golden yellow with a reddish pigment | Absent | Spiny | Ellipsoidal, thick walled | 4–5.5 × 3–3.5 | Biverticillate | 15–18 | 38–40 |
| T. flavus | Deep yellow | Absent | Spiny | Broadly ellipsoidal, thick walled | 4–6 × 2.5–4 | Mono- to biverticillate | 15–30 | 35–45 |
| T. galapagensis | Creamish white to yellow | Absent | Spiny | Broadly ellipsoidal | 7–10 × 5.5–8 | Mono- to biverticillate | 15–17 | 25–28 |
| T. hachijoensis | Yellow | Present | Ornamented by longitudinal, somewhat sinuous ridges | Ellipsoidal | 5.5–7 × 3.5–4.5 | Absent | 3 | 8–10 |
| T. helicus | Creamish white to yellow | Absent | Smooth (some with minute spines) | Ellipsoidal | 2.5–4 × 2–3 | Mono- to biverticillate | 13–23 | 25–33 |
| T. indigoticus | Yellow to orange | Absent | Spiny | Ellipsoidal | 3.5–5 × 2.5–3 | Mono- to biverticillate | 20–21 | 32–33 |
| T. intermedius | Creamish white to pastel pink | Absent | Spiny | Broadly ellipsoidal, thick walled | 4.5–7 × 3.5–5.5 | Solitary phialides to monoverticillate | 15–16 | 48–50 |
| T. iani | Yellow to orange red | Absent | Spiny | Broadly ellipsoidal | 4–6 × 2.5–4 | Mono- to biverticillate | 20–30 | 35–45 |
| T. macrosorpus | Yellow | Absent | Spiny | Subglobose to broadly ellipsoidal, thick walled | 5–6.5 × 4.5–5.5 | Mono- to biverticillate | 22–28 | 40–50 |
| T. mimosinus | Pure yellow to sulphur yellow | Present | Ornamented by conspicuous sinuous ridges | Globose to subglobose | 7–8 × 6–7 | Mono- to biverticillate | 12–15 | 13–14 |
| T. muroii | Pastel yellow to yellow | Absent | Spiny | Ellipsoidal, finely thick walled | 3.5–6 × 3–4 | Mono- to biverticillate, minor proportion with subterminal branches | 15–16 | 30–32 |
| T. paucisporus | Yellow (sometimes red) | Absent | Spiny | Subglobose to broadly ellipsoidal, thick walled | 14–18 × 12–16 | Absent | 15–18 (after 14 d) | 19–20 (after 14 d) |
| T. purpureus | Yellow | Absent | Spiny | Ellipsoidal, thick walled | 6.5–8 × 4.5–5.5 | Solitary phialides and monoverticillate | 2–4 | 15–16 |
| T. rotundus | Yellow to orange | Absent | Spiny | Broadly globose to ovoidal | 4–5 × 4–5.5 | Monoverticillate | 9–11 | 15–17 |
| T. ryukyuensis | Deep reddish | Absent | Spiny | Broadly ellipsoidal, thick walled | 4–5 × 3–4 | Solitary phialides and monoverticillate | Unknown | Unknown |
| T. stipitatus | Creamish white to yellow | Present | Smooth with single equatorial ridge | Flattened ellipsoidal | 3–5 × 2–3 | Mono- to biverticillate | 32–38 | 45–48 |
| Species name         | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Conidiophore branching | Shape                                      | Size (μm)                        | Ornamentation                        | Ridges | Ascospores               | Size (μm)                        | Shape                                      | Conidiophore branching | Ascoma colour                  | Growth rate (mm) | Condi
### Table 6. Morphological characters distinguishing *Talaromyces* species producing synnemata.

| Species               | Synnemata                        | Acid on CREA | Growth rate (mm) |
|-----------------------|----------------------------------|--------------|------------------|
|                       | Shape | Time of production | Length/height (μm) | CYA 25 °C | CYA 30 °C | MEA 30 °C | MEA | YES |
| *T. calidicanius*     | Determinate | Prolonged | Up to 6000 | Moderate | 27–30 | 33–35 | 30 | 47–48 | 40–41 |
| *T. cecidicola*       | Determinate | Prolonged | Up to 1250 | Absent | 33–34 | 37–38 | 38–39 | 37–38 | 30–31 |
| *T. chloroloma*       | Determinate | Prolonged | Up to 1200 | Weak to moderate | 40–45 | 50–55 | 55–60 | 45–48 | 35–40 |
| *T. coalescens*       | Determinate | Prolonged | Up to 1200 | Very weak | 32–34 | 40–41 | 45–46 | 43–45 | 34–35 |
| *T. dendriticus*      | Determinate | Prolonged | Up to 5000 | Absent | 23–26 | 15–16 | 20 | 35–36 | 15–27 |
| *T. duclauxii*        | Indeterminate | After 7 d | Up to 5000 | Weak | 25–27 | 34–35 | 40 | 48–50 | 43–44 |
| *T. flavovirens*      | Determinate, covered or masked by yellow mycelial covering | Prolonged | Up to 750 | Absent | 19–20 | 21–22 | 37–38 | 37–38 | 21–22 |
| *T. palmae*           | Indeterminate | Prolonged | Up to 8000 | Weak | 20–25 | 20–22 | 25–27 | 22–26 | 25–26 |
| *T. panamensis*       | Determinate | Prolonged | Up to 6800 | Strong | 23–24 | 20–21 | 27–28 | 28–30 | 30–32 |
| *T. pittii*           | Determinate, cone shaped and often sterile | Prolonged | Up to 1000 | Absent | 34–36 | 38–40 | 48–50 | 42–44 | 33–35 |
| *T. pseudoostromaticus* | Determinate, phototropic | Prolonged | Up to 8000 | Absent | 25–34 | 25–38 | 30–40 | 38–43 | 27–32 |
| *T. ramulosus*        | Determinate | Prolonged | Up to 500 | Absent | 32–40 | 39–50 | 48–52 | 45–48 | 40–43 |

### Table 7. Overview of morphological characters distinguishing soluble red pigment producers in the genus *Talaromyces*.

| Species name          | Growth rate (mm) | MEA texture | Acid CREA |
|-----------------------|------------------|-------------|-----------|
|                       | CYA 25 °C | CYA 30 °C | MEA | Absent |
| *T. albobiverticulus* | 15–20    | No growth | 25–28 | Velvety |
| *T. amestolkiae*      | 30–32    | 8–15       | 30–45 | Floccose and overlaying funiculose |
| *T. atrovosecens*     | 28–40    | 23–25      | 30–35 | Velvety and floccose |
| *T. cinidi*           | 25–30    | 20–28      | 38–40 | Velvety and floccose |
| *T. coalescens*       | 32–34    | 2–4        | 43–45 | Funiculose |
| *T. mannefiei*        | 13–25    | 5–10       | 15–27 | Loosely funiculose and floccose |
| *T. miniculete*       | 17–18    | No growth  | 21–22 | Loosely funiculose and floccose |
| *T. pittii*           | 34–36    | No growth  | 42–44 | Yeast like slimy colonies, after 2 wk floccose and synnematous |
| *T. purpurogenus*     | 20–25    | 16–25      | 30–45 | Velvety and floccose |
| *T. ruber*            | 20–35    | 14–18      | 35–40 | Velvety |
| *T. stalkii*          | 38–45    | 25–35      | 45–50 | Floccose and loosely funiculose |

### Table 8. Morphological characters distinguishing *Talaromyces* species which produce rough-walled and globose conidia.

| Species name          | Colony diameter (mm) | Acid on CREA | Colony reverse colour |
|-----------------------|----------------------|--------------|-----------------------|
|                       | CYA 25 °C | CYA 30 °C | CYA 37 °C | MEA | YES | MEA |
| *T. aculeatus*        | 25–35    | 30–40    | 15–20    | 30–35 | Moderate | Dark green (30F3) to greyish yellow (4C5) |
| *T. aculeatus*        | 25–35    | 30–40    | 15–20    | 30–35 | Moderate | Brownish orange (5C6) |
| *T. apiculatus*       | 38–41    | 35–45    | 25–35    | 40–42 | Weak | Light brown (7D5) to brownish grey (7E2) |
| *T. diversus*         | 7–10     | 6–10     | 5–8      | 25–35 | Absent | Light yellow (4A5–5A5) |
| *T. diversus*         | 7–10     | 6–10     | 5–8      | 25–35 | Absent | Brownish yellow (5C7–5C8) |
| *T. solcica*          | 12–13    | 13–15    | No growth | 22–23 | No growth | Reddish brown to dark brown (9E6–9F6) |
| *T. verruculosus*     | 32–35    | 37–38    | 25–26    | 35–36 | Weak | Greyish orange (5B5) |
| *T. verruculosus*     | 32–35    | 37–38    | 25–26    | 35–36 | Weak | Greyish orange (5C6) |
| Species name       | CYA 37°C (mm) | Species name       | CYA 37°C (mm) |
|-------------------|---------------|-------------------|---------------|
| *T. chloroloma*   | 0–4           | *T. varians*      | 27–28         |
| *T. wortmannii*   | 0–7           | *T. stipitatus*   | 28–32         |
| *T. cicidcola*    | 2–3           | *T. macrosporus*  | 28–35         |
| *T. coalescens*   | 2–4           | *T. piceus*       | 30–35         |
| *T. rademinici*   | 3             | *T. sayulitensis* | 32–40         |
| *T. duclauxii*    | 3–4           | *T. trachyspermus*| 32–40         |
| *T. mimosinus*    | 3–5           | *T. bacillisporus*| 33–37         |
| *T. emodensis*    | 4–6           | *T. rubicundus*   | 34–35         |
| *T. dendriticus*  | 5–6           | *T. aerugineus*   | 35            |
| *T. flavovirens*  | 5–6           | *T. dextii*       | 35–38         |
| *T. diversus*     | 5–8           | *T. funiculosus*  | 38–50         |
| *T. ramulosus*    | 5–8           | *T. columbinus*   | 42–43         |
| *T. mannefleii*   | 5–10          | *T. albobiverticillius* | No growth |
| *T. pychoconidium*| 5–12          | *T. atricola*     | No growth     |
| *T. viridulus*    | 6–7           | *T. Brunneus*     | No growth     |
| *T. convolutus*   | 6–8           | *T. calidicanius* | No growth     |
| *T. ucrainicus*   | 7–17          | *T. erythromellis*| No growth     |
| *T. amestolikiae* | 8–15          | *T. euchlorocarpus*| No growth     |
| *T. islandicus*   | 8–17          | *T. hachjoeinesis*| No growth     |
| *T. austrocalifornicus* | 10–11       | *T. intermedius*  | No growth     |
| *T. oumae-annae*  | 10–11         | *T. loliensis*    | No growth     |
| *T. viridis*      | 10–11         | *T. miniotelus*   | No growth     |
| *T. helicus*      | 10–18         | *T. palmae*       | No growth     |
| *T. ruber*        | 14–18         | *T. panamensis*   | No growth     |
| *T. siamensis*    | 15            | *T. paucisporus*  | No growth     |
| *T. aculeatus*    | 15–20         | *T. pittii*       | No growth     |
| *T. purpurogenus* | 16–25         | *T. primulinus*   | No growth     |
| *T. flavus*       | 19–20         | *T. proteolyticus*| No growth     |
| *T. muroii*       | 19–20         | *T. pseudostromaticus* | No growth |
| *T. aurantiacus*  | 19–21         | *T. purpureus*    | No growth     |
| *T. indicoticus*  | 20–22         | *T. rotundus*     | No growth     |
| *T. liani*        | 20–25         | *T. nugulosus*    | No growth     |
| *T. cnidii*       | 20–28         | *T. scortelus*    | No growth     |
| *T. allahabadensis* | 23–25       | *T. solicola*     | No growth     |
| *T. atroroseus*   | 23–25         | *T. subinflatius* | No growth     |
| *T. galapagensis* | 25–26         | *T. tardifaciens* | No growth     |
| *T. yeilensis*    | 25–26         | *T. thailandensis*| No growth     |
| *T. verruculosus* | 25–26         | *T. tratensis*    | No growth     |
| *T. angelicus*    | 25–27         | *T. udagawae*     | No growth     |
| *T. assiutensis*  | 25–30         | *T. unicus*       | No growth     |
| *T. radicus*      | 25–30         | *T. bohemicus*    | Unknown       |
| *T. apiculatus*   | 25–35         | *T. cinnabarinus* | Unknown       |
| *T. stolii*       | 25–35         | *T. ryukyuensis*  | Unknown       |
| *T. pinophilus*   | 25–40         | *T. boninensis*   | Unknown       |
summarises the characters needed for distinguishing species that produce red soluble pigments and include growth rates on CYA and MEA at 25 and 37 °C, colony texture on MEA and acid production on CREA.

*Talaromyces* species generally produce acerose phialides and ellipsoidal to fusiform conidia. Some species in *Talaromyces*, however, produce rough-walled, globose conidia and these species are listed in Table 8. Species, which produce rough-walled globose conidia include *T. aculeatus*, *T. apiculatus* and *T. verruculosus* (classified in sect. *Talaromyces*), *T. diversus* and *T. solicola* (classified in sect. *Trachyspermum*). All these species can be distinguished by using characters like growth rate on CYA at 25, 30 and 37 °C, acid production on CREA and reverse colour on YES and MEA (Table 5).

**Fig 8.** Micromorphological features of *Talaromyces*. A–E. Conidiophore branching: A. Solitary phialides. B. Monoverticillate. C. Biverticillate. D–E. Biverticillate with extra subterminal branching. F. Acerose phialides G. Flask-shaped phialides. H–K. Shapes of conidia: H. Cylindrical and rod-shaped. G. Globose. H, I. Ellipsoidal. Scale bars: F, G = 10 μm; A = 10 μm, applies B–E and H–K.

**Extrolite profiles**

Extrolite profiles are fundamental taxonomic criteria in filamentous fungi (Frisvad et al. 1990a, b). *Talaromyces* has unique and specific extrolites such as duclauxins, glauconic acids, mitorubrins, monascins, purpactins, rubratoxin, vermicellins, etc. (Samson et al. 2011). An overview of extrolites produced by *Talaromyces* is provided in Table 10. The extrolite profiles of each species are included
Table 10. An overview of extrolites produced by *Talaromyces* species (*"* Mycotoxins; + present; − absent).

| Species name | Alternaelii | Apolides | Asperphenenate | Austin | Bacilliporin | Batryodidin* | Cyclocorticols* & Elandin* | Duclauxin* | Epi-Australin | Falconesin | Gaunconic Acid | Luteoskyrin* | Mitrobiornis | Penicillides | Purpuracin & Vermiloxins | Peniscilin | Pentacellins | Thallidofides | Prugeratins & Ulaktones | Rubratoxins* | Rubropunctatin and other monascus pigments | Rubulosin* | Skrynin* | Rubusalin* | Saccharin D & F* | Secialic Acid | Stigmatatic Acid | Vermiloxin | Vermiladin & Fumicones (F-H) | Wortmanniactones | Wortmannin |
|--------------|-----------|---------|----------------|--------|-------------|-------------|-----------------------------|------------|--------------|------------|----------------|-------------|-------------|-------------|---------------------------------|------------|-------------|----------------|---------------------------------|-------------|-----------------------------|-------------|-----------|-----------|----------------|--------------|----------------|-----------|-----------------------------|-------------------|----------|
| *T. aculeatus* | +        |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. albobifurcatus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. alhambraicensis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. apiculatus* | +        | +      |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. assutusensis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. atricola* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. atroxolus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. austrocalifornicus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. bacilliporinus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. bruneus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. calicidicus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. cecidica* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. coalescens* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. colombinus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. convolutus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. dendriticus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. diversus* | +        | +      |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. duclauxii* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. emodensis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. erythromellis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. flavovires* |          | +      |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. flavus* |          | +      |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. funiculosus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. galapagensis* |          | +      |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. hachijogensis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. helicus* | +        | +      |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. islandicus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. loliensis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. macrosporus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. manneii* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. mimosinus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. minioluteus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. palme* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. panamensis* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. piceus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. pinophilus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. primulinus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. pseudostromaticus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |
| *T. purpurorogenus* |          |        |                |        |             |             |                              |            |              |            |                |             |             |             |                                |            |             |                |                                |             |                |             |            |            |               |                |              |                                     |

(continued on next page)
Table 10. (Continued).

| Species name | Alternariol | Apiculides | Asperphenamidine | Austin | Bacilliformin | Botryodiploidin* | Cyclochlorotine & Islanditoxin* | Duclauxin | Epiaudlidiol | Falcocinolide | Glauconic acid | Glauconic acid* | Luteoskyrin* | Mitorubrins | Penicillides/Purpactides/Vermixocins | Pentacleccides/Thalassoldides | Prugusenes/Ukulactones | Rubropunctatin and other monascus pigments | Rugulosin* | Rugulosine* | Secalonic acid D & F* | Stipilatic acid | Tetraplicin | Vermicellin | Vermiculin | Vermistanlactones (F-H) | Wortmanni | Wortmannin |
|--------------|-------------|------------|------------------|--------|-------------|------------------|-------------------------------|---------|-------------|---------------|----------------|-----------------|-------------|------------|----------------------|---------------------|-----------------|-----------------|----------------------|-----------------|---------------|-------------|-------------|----------------------|-----------------|-------------|
| T. radicus   |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. rotundus  |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. ruber     |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. rubicundus|            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. rugulosus |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. scorteus  |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. siamensis |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. stipitatus|            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. tardifaciens|           |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. thailandensis|          |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. trachyspermus|          |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. tratensis |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. ucrainicus|            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. udagawae  |            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. verruculosus|            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |
| T. wortmannii|            |            |                  |        |             |                  |                                |         |             |               |                |                 |             |           |                     |                     |                 |                 |                     |                 |               |             |             |                     |                 |

in the species description (see Taxonomy). Mitorubrins, penicillides, purpactins and vermoxocins are produced by all Talaromyces species in different ratios. Rugulosin and/or skyrin, which are known to be mycotoxins, are produced only by members of section Islandici. Some Talaromyces species produce other mycotoxins such as botryodiploidin (by T. coalescens and T. stipitatus), cyclochlorotine and islanditoxin (by T. islandicus), luteoskyrin (by T. islandicus and T. purpurogenus), rubratoxin (by T. purpurogenus), rugulovasine (by T. purpurogenus and T. wortmannii) and secalonic acid D & F (by T. dendriticus, T. flavovirens, T. funiculosis, T. miniolutes, T. pseudostromaticus, T. siamensis and T. stipitatus). Red pigment producers such as, T. marneffei, T. albobiverticillius, T. purpurogenus, T. albobiverticillus in sections Talaromyces and Trachyspermi produce rubropunctatin and other Monascus pigments. Species producing globose rough-walled conidia also produce alternariol (eg. T. verruculosus, T. apiculatus, T. diversus). Glaucanoid acid and glaucanic acid are specific for section Trachyspermi.

**In:** Talaromyces section Talaromyces

Typus: IMI 040588, culture ex-type CBS 289.48 = CBS 136670 = ATCC 10409 = IMI 040588 = NRRL 2129 = NRRL A-1474 = IBT 14259 = IBT 4185.

ITS barcode: KF741995 (alternative markers: BenA = KF741929; CaM = KF741975; RPBP2 = KM023271)

**Colony diam.** 7 d (mm): CYA 25–35; CYA 30 °C 30–40; CYA 37 °C 15–20; MEA 30–35; MEA 30 °C 40–42; DG18 15–17; CYAS 1–5; OA 28–33; CREA 15–20; YES 28–33.

**Colony characters:** CYA 25 °C, 7 d: Colonies moderately deep, radially and concentrically sulcate; margins low, narrow, entire; mycelia white, sometimes inconspicuously yellow; texture floccose; sporulation absent to sparse, conidia en masse greyish to dull green (27C4–27D4); soluble pigments absent; exudates minute red droplets; reverse light brown (7D4–7D5) at the centre, elsewhere pale to greyish yellow (4A3–4B3). MEA 25 °C, 7 d: Colonies moderately deep, plane to sometimes radially sulcate, raised at centre; margins low to somewhat subsurface, wide (up to 5 mm), entire; mycelia white and inconspicuously yellow; texture floccose to funiculose; sporulation sparse to moderately dense, conidia en masse greyish green (27E5); soluble pigments absent, exudates minute red droplets; reverse brownish orange (SC6). YES

**TAXONOMY (SPECIES LISTED IN ALPHABETICAL ORDER)**

*Talaromyces aculeatus* (Raper & Fennell) Samson et al., Stud. Mycol. 71: 174. 2011. MycoBank MB560639. Fig. 9. ≡ Penicillium aculeatum Raper & Fennell, Mycologia 40: 535. 1948.
Fig. 9. Morphological characters of *Talaromyces aculeatus* (CBS 289.48\textsuperscript{T}). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
25 °C, 7 d: Colonies moderately deep, irregularly sulcate, raised at centre; margins low, narrow, entire; mycelia white, yellow, red; texture floccose to lightly funiculo; sporulation absent to sparse; conidia en masse greyish green (27D5–27E5); soluble pigments absent; exudates absent; reverse greyish orange (5B5)

Micromorphology: Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 150–300 × 2.5–3.5 μm; branches 10–35 μm; metulae four to eight, divergent, 8.5–12 × 2.5–3.5 μm; phialides flask-shaped, tapering into very thin neck, three to five phialides per metulae, 9–11 × 2.5–3.5 μm; conidia rough to echinulate, globose, 3–3.5 × 3–3.5 μm. Ascomata not observed.

Extrolites: Altenusin, alternariol, alternariol momomethyl ether, cyclopeptin, MC-141, penicillide, purpactins, rubiginosin A, a rubropunctatin, secopenicillide C, vermicillin are produced by T. aculeatus (Fuska et al. 1979). Among the species treated here, T. aculeatus is the only species producing both cyclopeptin and MC-141. Strain NR 5165 = IFO 5689 = FAT 810 (not examined) produces the antibiotics penitricins (Okuda et al. 1984a, b, c).

Distinguishing characters: Talaromyces aculeatus produces flask-shaped phialides and rough-walled to echinulate, globose conidia (Fig. 9). These characters are similar to T. verruculosus and T. apiculatus. However, T. aculeatus grows slower than T. apiculatus on CYA (at 25 and 37 °C) and MEA, and grows slower than T. verruculosus on CYA at 37 °C.

Talaromyces aerugineus (Samson) Yilmaz, Frisvad & Samson, comb. nov. MycoBank MB809553. Fig. 10. Basionym: Paecilomyces aerugineus Samson, Stud. Mycol. 6: 20. 1974.

In: Talaromyces section Helici

Typus: CBS H-7448, culture ex-type CBS 350.66 = BDUN 276 = IMI 105412.

ITS barcode: AY753346 (alternative markers: BenA = KJ865736; CaM = KJ885258; RPB2 = KM023310)

Colony diam, 7 d (mm): CYA 27–26; CYA 30 °C 35–36; CYA 37 °C 35; MEA 49–50; MEA 30 °C 65–70; DG18 6–7; CYAS No growth; OA 45–50; CREA No growth; YES 29–30.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, sulcate, green appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse dark green (30F3), greyish yellow (4C5), pale yellow (4A3). DG18 25 °C, 7 d: Colonies have a reddish reverse. CREA 25 °C, 7 d: Weak acid produced.

Micromorphology: Conidiophores with solitary phialides or monoverticillate; stipes smooth walled, 20–75 × 2.5–5 μm; phialides acerose, one to three, 10–20 × 2.5–5 μm; conidia smooth, in various shapes subglobose to ellipsoidal to fusiform, 3–8.5 × 2.5–5 μm. Ascomata not observed.

Distinguishing characters: Talaromyces aerugineus is characterised by fast growing colonies on MEA at 25 and 30 °C. Conidiophores mainly have solitary phialides and sometimes monoverticillate conidiophores and produces large, smooth, globose to ellipsoidal conidia (3–8.5 × 2.5–5 μm) (Fig. 10).

Talaromyces albobiverticillius (H.-M. Hsieh, Y.M. Ju & S.Y. Hsieh) Samson et al., Stud. Mycol. 71: 174. 2011. MycoBank MB560683. Fig. 11.

In: Talaromyces section Trachyspermi

Typus: BCRC 34774, culture ex-type CBS 133440 = DTO 166-E5 = YMY 1292.

ITS barcode: HQ605705 (alternative markers: BenA = KF114778; CaM = KJ885258; RPB2 = KM023310)

Colony diam, 7 d (mm): CYA 15–20; CYA 30 °C 13–17; CYA 37 °C No growth; MEA 25–28; MEA 30 °C 20–25; DG18 12–18; CYAS generally no growth some isolates up to 3; OA 20–25; CREA 2–5; YES 20–25.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, sulcate, in some isolates sunken at centre and crateriforme; margins low, plane, entire (<1 mm); mycelia white and in some isolates yellow; texture velvety to floccose; sporulation moderately dense to dense, conidia en masse only in the ex-type strain reddish or pinkish white (8A2), the other strains greenish grey (26C2) to dull green (26E3); soluble pigments in some isolates red, in some lacking; exudates in some isolates red droplets; reverse in some isolates reddish brown (9F8) and in some isolates greyish red (9C5). MEA 25 °C, 7 d: Colonies slightly raised at centre, and in some isolates sunken in the centre, sulcate; margins low, plane, entire (1–2 mm); mycelia white and pastel yellow and also in some isolates yellow; texture velvety; sporulation moderately dense to dense, conidia en masse reddish or pinkish white (8A2) only in the ex-type strain, and for the other isolates greyish green (26D5–26D4); soluble pigments absent; exudates in some isolates red droplets; reverse in some isolates reddish brown (9E8) and in some lack of red reverse and brownish orange (5C6). YES 25 °C, 7 d:...
Fig. 10. Morphological characters of Talaromyces aerugineus (CBS 350.66T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B, C. Colony texture on MEA after 2 wk incubation. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–H.
Fig. 11. Morphological characters of Talaromyces albobiverticillius (CBS 206.89). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 1 wk incubation (CBS 113442T). C. Colony texture on MEA after 1 wk incubation (CBS 206.89). D–H Conidiophores. I. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–I.
Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white, pastel yellow and in some isolates yellow; texture velvety and floccose; sporulation moderately dense to dense, conidia en masse reddish or pinkish white (8A2) only in the ex-type strain, and for the other isolates greyish green (25D5–26D5); soluble pigments red (in some isolates absent); exudates in some isolates small red droplets; reverse in some isolates red (9B8), and in some isolates lacking of red reverse, greyish orange (5B5) centre, fading into brownish orange (5C3) and brownish grey (5C2). DG18 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white; texture velvety; sporulation sparse to moderately dense, conidia en masse reddish or pinkish white (8A2) only in the ex-type strain, and for the other isolates greyish green to dull green (26D2–26D3); soluble pigments in some isolates red, generally absent; exudates in some isolates slimy clear droplets, in some isolates small red droplets; reverse in some isolates reddish brown (9E8), in some isolates small red droplets; soluble pigment absent; reverse bright orange yellow and in some isolates yellowish green. CREA 25 °C, 7 d: Acid production absent.

*Micromorphology*: Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 200–400 × 2.5–4 μm; metulae three to eight, divergent, 8–13 × 1.5–4.5 μm; phialides acerose, three to eight per metulae, 8–13.5 × 2–3 μm; conidia smooth to finely rough, globose to subglobose and in some isolates fusiform, 2–3.5–(4) × 1.5–2.5 μm. Ascomata not observed.

*Extritolites*: Talaromyces albobiverticillius produces mitorubrin, mitorubrinic acid, mitorubrinol, masnin, monasnorubramin, penicillide, a purpactin, rubropunctatin, vermicillin (Frisvad et al. 2013).

**Distinguishing characters**: The ex-type culture of *T. albobiverticillius* has pinkish white conidia, which is unique to this species. However, some strains do produce green conidia (Fig. 11). Talaromyces albobiverticillius produces intense red soluble pigment on CYA. It differs from other red pigment producing species by restricted growth on CYA at 25 °C and no growth at 37 °C. It also has stipes up to 400 μm long, as wide as 4 μm and divergent metulae.

*Talaromyces allahabadensis* (B.S. Mehrotra & D. Kumar)

Samson et al., Stud. Mycol. 71: 174. 2011. MycoBank MB560640. Fig. 12.

≡ Penicillium allahabadense B.S. Mehrotra & D. Kumar, Can. J. Bot. 40: 1399. 1962.
≡ Penicillium zacinthae C. Ramirez & A.T. Martinez, Mycopathologia 74: 167. 1981.

In: Talaromyces section Islandici

**Typus**: University of Allahabad P-26, culture ex-type CBS 453.93 = ATCC 15067 = CBS 304.63 = NRRL 3397 = IBT 3926 = IBT 10824.

*ITS barcode*: KF984873 (alternative markers: *BenA* = KF984614; *CaM* = KF984768; *RPB2* = KF985006)

*Colony diam* 7 d (mm): CYA 20–25; CYA 30 °C 24–27; CYA 37 °C 23–25; MEA 20–23; MEA 30 °C 23–26; DG18 14–18; CYAS 14–18; OA 22–25; CREA 8–12; YES 22–23.

*Colony morphology*: CYA 25 °C, 7 d: Colonies 20–25 mm, slightly raised at centre, slightly sulcate; margins very narrow (1 mm), low, entire, plane; mycelium white and yellow; texture velvety and floccose; sporulation sparse to moderately dense; conidia *en masse* greyish green (27D5–27E5); exudates clear and yellow droplets; soluble pigment absent; reverse greyish orange (5A6–5B6) in the centre fading into light yellow to greyish yellow (4A5–4B5). MEA 25 °C, 7 d: Colonies 20–23 mm, slightly raised at centre, plane; margins narrow (1–2 mm), low, entire, plane; mycelium white and yellow; texture velvety; sporulation moderately dense to dense; conidia *en masse* dull green (26E4); exudates yellow droplets; soluble pigment absent; reverse dark brown (6F5) in the centre fading into light brown (6D5). YES 25 °C, 7 d: Colonies 22–23 mm, slightly raised at centre, sulcate; margins narrow (1 mm), low, in some isolates entire and in some isolates not entire, plane; mycelium white and yellow; texture velvety; sporulation sparse to moderately dense; conidia *en masse* dull green (26D4–26E4); exudates absent (except DTO 67–F7, clear exudates); soluble pigment absent; reverse brownish orange (5C5–5C6) centre fading into greyish orange (5B4–5B6). DG18 25 °C, 7 d: Colonies 14–18 mm, raised at centre, plane; margins narrow (1 mm), low, entire, plane; mycelium white (only CBS 137362 with yellow mycelia at centre); texture velvety and floccose; sporulation absent to dense (CBS 137362); conidia *en masse* greyish green to dull green (26D4–26D5); exudates clear and yellow droplets; soluble pigment absent; reverse greyish orange to orange (5A6–5B6) in the centre fading into light yellow to greyish yellow (4A5–4B5). OA 25 °C, 7 d: Colonies 22–25 mm, in some isolates raised at centre and in some isolates plane plane; margins wide (2 mm), low, entire, plane; mycelium white and yellow; texture velvety and in some isolates loosely funiculose; sporulation moderately dense to dense; conidia *en masse* greyish green (30C6–30D6) and in some isolates dull green (28D4–28E4); exudates absent; soluble pigment absent; reverse bright orange yellow and in some isolates yellowish green. CREA, 25 °C, 7 d: Colonies 8–12 mm, acid production.

*Micromorphology*: Conidiophores biverticillate; stipes smooth walled, 50–175 × 2.5–2.7 μm; metulae three to six, divergent, 8–11 × 2.4–3.2 μm; phialides acerose, three to six per metulae, 8.5–11 × 2–3 μm; conidia smooth, ellipsoidal to fusiform, 2.4–4.5 × 1.7–2.5 μm. Ascomata not observed.

*Extritolites*: Talaromyces allahabadensis produces prugosenes/ukulactones (Lang et al. 2007, Mori et al. 2011) and several azaphilones; mitorubrin, mitorubrinol, mitorubrin acetate, mitorubrinic acid, 6′-hydroxy-3′-methoxy-mitorubrin, 4′-hydroxy-3′-methoxy-(S)-mitorubrin and monomethyl-(S)-mitorubrin. Three isolates, IBT 12688, CBS 137937, CBS 441.89 also produced rugulosin A, while CBS 453.93 and CBS 178.81 did not. It seems that this species produces rugulosin A preferentially at 37 °C, and the latter two species were only examined for extritolite production at 25 °C. Talaromyces allahabadensis
Fig. 12. Morphological characters of Talaromyces allahabadensis (CBS 453.93T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale Bar: B = 10 μm, applies to C–H.
shares prugosenes with *T. rugulosus* and the three latter mitorubins listed above with *T. radicus*.

**Distinguishing characters:** *Talaromyces allahabadensis* is characterised by colonies with bright yellow mycelia and velvety texture on most media (Fig. 12). The species grows well at 37 °C. *Talaromyces allahabadensis* has ellipsoidal to fusiform conidia. Based on the multigene phylogeny, *T. allahabadensis* is closely related to *T. radicus* (Fig. 1). *Talaromyces allahabadensis* is distinguished from *T. radicus* by acid production on CREA, and denser sporulation on most media. Also, *T. allahabadensis* cannot grow at 40 °C.

**Notes:** Phylogenetically *Penicillium zacinthae* (CBS 178.81) is identical to *T. allahabadensis* (Fig. 7) and is considered a synonym.

**Talaromyces amestolkiae** Yilmaz et al., Persoonia 29: 48. 2012. MycoBank MB801358. Fig. 13.

In: Talaromyces section Talaromyces

**Typus:** CBS H-21050, culture ex-type CBS 132696 = DTO 179-F5.

**ITS barcode:** JX315660 (alternative markers: *BenA* = JX315623; *CaM* = KF741937; *RPB2* = JX315698)

**Colony diam 7 d (mm):** CYA 30–32; CYA 30 °C 30–36; CYA 37 °C 8–15; MEA 30–45; MEA 30 °C 45; DG18 18–19; CYAS 3–8; OA 45–52; CREA 15–25; YES 25–35.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (2–3 mm); mycelia white, pastel yellow and pastel red; texture floccose in the centre and loosely funiculose; sporulation moderately dense to dense, conidia *en masse* greyish green (26E6–26E7); soluble pigments very weak brownish red, in some strains absent (at 37 °C yellowish red); exudates absent; reverse violet brown (11E8–11F8). MEA 25 °C, 7 d: Colonies slightly raised at centre, plane, in some colonies black sclerotia produced in longer incubation; margins low, plane, entire (3–5 mm); mycelia white and pastel red; texture floccose in centre with overlaying loosely funiculose; sporulation moderately dense to dense, conidia *en masse* greyish to dull green (25D4–26D4); soluble pigments absent; exudates absent; reverse dark brown (9F8) centre fading into reddish brown (9E8) and greyish yellow to greyish orange (3C5–5C5) at margins. YES 25 °C, 7 d: Colonies slight raised at centre, sulcate; margins low, plane, entire (2–3 mm); mycelia white, pastel red and pastel orange; texture floccose and loosely funiculose; sporulation dense, conidia *en masse* greyish green (26E6–26E7); soluble pigments absent; exudates absent; reverse violet brown (11F8) to dark ruby (12F8). DG18 25 °C, 7 d: Colonies slightly raised at centre, plane, margins low, plane, entire (1–2 mm); mycelia white; texture floccose and loosely funiculose, aerial sterile hyphae at centre; sporulation dense, conidia *en masse* greyish green (26E6–26E7); soluble pigments absent; exudates red droplets; reverse dark brown (8F8) centre fading into brownish red (8C6) and margins greyish green (1C4). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (5–6 mm); mycelia white and in some isolates pastel yellow; texture velvety; sporulation dense, conidia *en masse* greyish green (25D4–25D6); soluble pigments absent; exudates small clear droplets; reverse red in centre fading into greyish green (in some isolates lack of red centre), CREA 25 °C, 7 d: Weak acid production.

**Micromorphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 90–180 × 2.5–3 μm; branches 15–50 μm; metulae three to six, divergent, 9–15 × 3–4 μm; phialides acerose, three to six per metulae, 9.5–12 × 2.5–3 μm; conidia smooth and sometimes finely rough, ellipsoidal, 2–3 × 1.5–2.5 μm. Ascomata not observed.

**Extrolites:** *Talaromyces amestolkiae* produces berkelic acid, mitorubin, mitorubinic acid, mitorubinol, *Monascus* red aza-phiophene pigments (not diffusing into the agar), pestalacin A, a purpactin and vermicellin (*Yilmaz et al. 2012*).

**Distinguishing characters:** Fast growth on CYA and MEA, production of berkelic acid, red mycelia, loosely funiculose texture and sclerotia production after 2 wk of incubation make *T. amestolkiae* a distinct species. Red soluble pigment and dark to violet brown reverses are also important characters however most of the time this species was confused with other red pigment producers such as *T. purpurogenus* (*Yilmaz et al. 2012*). *Talaromyces amestolkiae* is distinguished from *T. purpurogenus* by producing acid on CREA. Phylogenetically it is closely related to *T. ruber* and *T. stollii*. *Talaromyces ruber* differs from *T. amestolkiae* by its velvety texture and acid production similar to that of *T. purpurogenus*. *Talaromyces stollii* is distinguished from *T. amestolkiae* by faster growth at 37 °C.

**Talaromyces angelicus** S.H. Yu, T.-J. An & H. Sang, J. Microbiol. 51: 707. 2013. MycoBank MB804807. Fig. 14.

In: Talaromyces section Talaromyces

**Typus:** KACC 46611, culture ex-type KACC 46611.

**ITS barcode:** KF183638 (alternative markers: *BenA* = KF183640; *CaM* = KJ885259)

**Colony diam 7 d (mm):** CYA 25–27; CYA 30 °C 30–32; CYA 37 °C 25–27; MEA 33–35; MEA 30 °C 40–41; DG18 13–15; CYAS 2–3; OA 30–32; CREA 12–13; YES 30–32.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate, white sterile appearance; margins low, plane, entire (1–2 mm); mycelia white; texture floccose (after 2 wk funiculose); sporulation absent (after 2 wk dense sporulation); soluble pigments absent; exudates absent (at 30 °C clear droplets); reverse greyish red (7B3) centre fading into yellowish white (4A2), at 30 °C reverse centre violet brown (1E6) fading into brownish red to brownish violet (11C6–11D6). MEA 25 °C, 7 d: Colonies low, slightly sulcate, white and yellow sterile appearance; margins low, plane, entire (1–2 mm); mycelia white and yellow in the centre; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish orange (5B6). YES 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate, white sterile appearance; margins low, plane, entire (2–3 mm); mycelia white; sporulation absent; soluble pigments...
Fig. 13. Morphological characters of *Talaromyces amestolkiae* (CBS 132696T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 14. Morphological characters of *Talaromyces angelicus* (KACC 46611T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
absent; exudates absent; reverse pale orange (5A3) centre fading into pastel yellow (3A4). DG18 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate, yellow sterile appearance; margins low, plane, entire (1–2 mm); mycelia yellow; sporation absent; soluble pigments absent; exudates absent; reverse light orange (5A5–4C) centre fading into pastel yellow (3A4–3A5). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia yellow; texture funiculose; sporulation moderately dense, conidia en masse greyish green (27C5–28C5); soluble pigments absent; exudates absent; reverse pale yellowish beige. CREA 25 °C, 7 d: Acid production absent and in some isolates very weak acid production.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, 15–20 × 2–3 μm; metulae three to six, divergent, 8–15 × 2.5–3.5 μm; phialides acerose, three to six per metulae, 8–14 × 2–3 μm; conidia finely roughened, subglobose to ellipsoidal, 2.5–3.5 × 2–3 μm. Ascomata not observed.

Distinguishing characters: Talaromyces angicus is characterised by floccose colonies after 1 wk, which become funiculose with time (Fig. 14). Phylogenetically it is closely related to T. pinophilus, T. muroii and T. liani (Fig. 2). It differs from T. muroii and T. liani by lacking ascocarps. Morphologically, T. angicus is similar to T. pinophilus and differs from the latter species by lack of acid production on CREA.

Talaromyces apiculatus
Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 174. 2011. MycoBank MB560641. Fig. 15.

*Penicillium* aculeatum var. *apiculatum* Abe, S., 1956, J. Gen. Appl. Microbiol., Tokyo 2: 124. 1956 (nom. inval., Art. 36).

*In: Talaromyces* section Talaromyces

Typus: CBS H-20755, culture ex-typus: CBS 312.59 = ATCC 18315 = FRR 635 = IMI 068239 = ATCC 18315 = IFO 5728 = IBT 10894 = IBT 14261.

*ITS barcode*: JN899375 (alternative markers: BenA = KF741916; CaM = KF419950; RPB2 = KM023287)

**Colony diam. 7 (mm):** CYA 38–41; CYA 30 °C 35–45; CYA 37 °C 25–35; MEA 40–42; MEA 30 °C 52–57; DG18 19–22; CYAS 6–9; OA 36–40; CREA 20–22; YES 40–43.

**Colony characters:** CYA 25 °C, 7 d: Colonies moderately deep, radially and concentrically sulcate; margins low, narrow, entire; mycelia white; texture floccose; sporation absent to sparse, conidia en masse dull green (27D3–28D3); soluble pigments absent, exudates minute red droplets; reverse greyish yellow (3B3) to yellowish white (3A2) at margin. MEA 25 °C, 7 d: Colonies moderately deep, plane, slightly raised at centre; margins low to somewhat subsurface, wide (up to 5 mm), entire; mycelia white and yellow; texture floccose to strongly funiculose; conidiose sporulation sessile to moderately dense, conidia en masse greyish green (27D5–27E5); soluble pigments absent, exudates minute red droplets; reverse brownish orange (5C6). YES 25 °C, 7 d: Colonies moderately deep, irregularly sulcate, raised at centre; margins low, narrow, entire; mycelia white, yellow; texture floccose; sporation absent to sparse, conidia en masse greyish green (27D5–27E5); soluble pigments absent, exudates absent; reverse light brown (7D5), sometimes areas of brownish grey (7E2), pale yellow (4A3). DG18 25 °C, 7 d: Colonies have a bright orange reverse and produce abundant exudate. CREA 25 °C, 7 d: Weak acid produced.

**Extritols:** Talaromyces apiculatus produces the macrocyclic poly lactones (“apiculides”) NG-011 and NG-012 (Ito et al. 1992a, b), BK223A (=NG-012), BK-223B, BK-223C (Breinholt et al. 1993), 15G256δ, and 15G256α-2 (Gao et al. 2013). The latter five extritols have been reported as antifungal (Breinholt et al. 1993, Schlingmann et al. 2002), while NG-011 and NG-012 are potentiated of nerve growth factors (Ito et al. 1992a, b). Furthermore, by implication, T. apiculatus produces bioxanthracene 2 = ES-242-2 (Toki et al. 1992, Gao et al. 2013), penicillide, prepenicillide and prenxanthone (Gao et al. 2013). We detected altenusin (and alternariol & alternariol monomethyl ether in six strains, IBT 32315, IBT 13085, IMI 186297, IMI 191967, IMI 352119 & CBS 264.67), apiculides, bioxanthracene B, mitorubrins, purparicins, verrucillicin. Decapenic acid (Sakamoto et al. 2010) was tentatively identified in IMI 352119. Among the species treated here, *T. apiculatus* is the only species producing apiculides and bioxanthracene B.

Distinguishing characters: Talaromyces apiculatus produces flask-shaped phialides and rough-walled to echinulate, globose conidia (Fig. 15). These characters are also observed in *T. aculeatus* and *T. verruculosus*. However, *T. apiculatus* grows much faster than *T. aculeatus* on CYA (25 and 37 °C) and on MEA. Talaromyces apiculatus also grows faster than *T. verruculosus* on CYA and MEA at 25 °C.

Talaromyces assiutensis
Samson & Abdel-Fattah, Persoonia 9: 501. 1978. MycoBank MB324414. Fig. 16.

*Penicillium* assiutense *Samson & Abdel-Fattah,* (simultaneously published).

*Penicillium* gossypii Pitt. The genus *Penicillium*: 500. 1980 (≡*Penicillium* gossypii Pitt, The genus *Penicillium*: 500. 1980).

*In: Talaromyces* section Trachyspermi

Typus: CBS 147.78, culture ex-type CBS 147.78.

*ITS barcode*: JN899323 (alternative markers: BenA = KJ865720; CaM = KJ885260; RPB2 = KM023305)

**Colony diam. 7 (mm):** CYA 15–21; CYA 30 °C 27–33; CYA 37 °C 25–30; MEA 20–23; MEA 30 °C 33–35; DG18 5–7; CYAS No growth; OA 18–21; CREA No growth to micro-colonies; YES 17–21.

**Colony characters:** CYAA 25 °C, 7 d: Colonies low to moderately deep, raised at centre, plane; margins low, narrow, entire (2–3 mm); mycelia white, inconspicuously yellow; texture floccose; sporation absent to sparse, conidia en masse greenish grey (2B82); soluble pigments absent; exudates absent; reverse
Fig. 15. Morphological characters of *Talaromyces apiculatus* (CBS 312.59T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 16. Morphological characters of Talaromyces assiutensis (CBS 116554) A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on OA after 2 wk incubation. C. Ascomata D. Ascii and ascospores. E–G. Conidiophores. H. Ascospores. I. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–I.
pale orange to brownish orange (5A3–5C5). MEA 25 °C, 7 d: Colonies low to moderately deep, raised at centre, plane; margins low, narrow, entire (1 mm); mycelia white; texture floccose; sporulation absent to sparse, conidia en masse greenish grey (2B82); soluble pigments absent; exudates absent; reverse brownish yellow to brown (SC8–5E7). YES 25 °C, 7 d: Colonies low to moderately deep, raised at centre, plane; margins low, narrow, entire (2 mm); mycelia white; texture floccose; sporulation absent to sparse, conidia en masse greenish grey (2B82); soluble pigments absent; exudates absent; reverse greyish yellow to greyish orange (4C5–5B3). DG18 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire; mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse greyish yellow to greyish orange (5A5–5B5). DG18 25 °C, 7 d: Colonies low, plane; margins narrow (<1 mm), low, entire, plane; mycelium white; sporulation absent; soluble pigment absent; reverse light orange to greyish orange (5A5–5B5). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; soluble pigment absent; reverse greyish yellow to greyish orange (5A5–5B5).

**Notes:** Phyllogenetically, *T. gossypii* (CBS 645.80) is identical to *T. assiutensis* (Fig. 5) and is considered a synonym.

**Talaromyces atricola** S.W. Peterson & Jurjevic, PLoS ONE 8: e84102-page 8. 2013. MycoBank MB804901. Fig. 18.

≡ *Penicillum rugulosum* var. *aticolum* Thom, Penicillia: 474. 1930.

**In:** Talaromyces section Islandicic

**Typus:** Unknown, culture ex-type CBS 255.31 = NRRL 1052 = FRR 1052 = Thom 4640.439 = ATCC 52257 = DTO 278-F1 = IBT 4489.

**ITs barcode:** KF984859 (alternative markers: *BenA* = KF984566; *CaM* = KF984719; *RPB2* = KF984948)

** Colony diam, 7 d (mm):** CYA 10; CYA 30 °C 7–8; CYA 37 °C No growth; MEA 15; MEA 30 °C 5–6; DG18 15; CYAS 7; OA 15–17; CREA 8; YES 12.

**Colony characters:** CYA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white; texture velvety and

**Micromorphology:** Conidiophores biverticillate and also sometimes monovercillate; stipes smooth walled, 15–100 × 1.5–3.5 μm; metulae two to five, divergent, 12–17 × 1.5–3 μm; phialides acerose, three to six per metulae, 9.5–16 × 2–3 μm; conidia smooth, ovoid to ellipsoidal, 2–4 × 1.5–2.5 μm. Ascoma maturing after 1–2 wk of incubation on OA at 25 and 30 °C, creamish white to pale yellow, globose to subglobose, 250–600 × 250–550 μm, ascii 7–11 × 5.5–8.5 μm, ascopores ellipsoidal, spiny, 3.5–5 × 2–3 μm.

**Extrolites:** *Talaromyces assiutensis* produces gluaconic acid (Frisvad et al. 1990a).

**Distinguishing characters:** *Talaromyces assiutensis* produces creamish white ascomata with spiny, ellipsoidal ascopores (Fig. 16). *Talaromyces intermedius* also produces creamish white ascomata, but differs from *T. assiutensis* by faster growth at 25 °C and no growth at 37 °C. Also, ascopores of *T. intermedius* are bigger than *T. assiutensis*. Phylogenetically, *T. assiutensis* is closely related to *T. trachyspermus*. *Talaromyces assiutensis* differs from *T. trachyspermus* by slower growth at 37 °C.

**Notes:** Phylogenetically, *T. gossypii* (CBS 645.80) is identical to *T. assiutensis* (Fig. 5) and is considered a synonym.

**Talaromyces atricola** S.W. Peterson & Jurjevic, PLoS ONE 8: e84102-page 8. 2013. MycoBank MB804901. Fig. 18. **In:** Talaromyces section Trachyspermic

**Typus:** CBS H-21790, culture ex-type CBS 133442 = IBT 32470 = DTO 178-A4.

**ITs barcode:** KF114747 (alternative markers: *BenA* = KF114789; *CaM* = KJ775418; *RPB2* = KM023288)

** Colony diam, 7 d (mm):** CYA 28–40; CYA 30 °C 33–40; CYA 37 °C 23–25; MEA 30–35; MEA 30 °C 38–40; DG18 20–25; CYAS Generally no growth, in some isolates colonies up to 10; OA 20–25; CREA 2–5; YES 33–35.

**Colony characters:** CYA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white; texture velvety and
Fig. 17. Morphological characters of *Talaromyces atricola* (CBS 255.31T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 18. Morphological characters of *Talaromyces atroroseus* (CBS 133442T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bars: B = 50 μm; C = 10 μm, applies to D–H.
some parts floccose; sporulation dense, conidia en masse dark green (27E5); soluble pigments red; exudates absent; reverse reddish brown (9E8). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white; texture floccose and in some isolates velvety; sporulation moderately dense to dense, conidia en masse greyish green (25C5) to dark green (27E5) (at 30 °C dense and dark green); soluble pigments red (in some strains lacking at 25 °C but present at 30 °C); exudates red droplets (in some strains lacking); reverse reddish brown (9E8). YES 25 °C, 7 d: Colonies slightly raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white; texture velvety and floccose; sporulation dense, conidia en masse greyish green to dark green (25E5–25F5); soluble pigments red (in some isolates absent); exudates absent; reverse brownish red (10D8) centre fading into red (10B8). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white; texture velvety and floccose; sporulation moderately dense, conidia en masse dull green (25D4–26D4); soluble pigments absent; exudates absent; reverse greyish green (1C3) centre fading into greenish grey (1B2) and pale yellowish white (2A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white; texture velvety; sporulation moderately dense to dense, conidia en masse dark green (26F8); soluble pigments absent; exudates absent; reverse in some isolates centre red, in some isolates centre lacking and pale green. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 90–150 × 2.5–3 μm; branches 15–50 μm; metulae three to six, divergent, 8–15 × 3–4 μm; phialides acerose, three to six per metulae, 9.5–12.5 × 2.5–3 μm; conidia finely rough to rough, ellipsoidal, 2–3.5 × 1.5–2.5 μm. Ascomata not observed.

Extrolites: Talaromyces aurantiacus produces glauconic acid, glaucanic acid, Monascus red azaphilone pigments, purpactins A–C, purpurgenone and ZG-1494α (Frisvad et al. 2013).

Distinguishing characters: Talaromyces aurantiacus is characterised by soluble red pigment and very dark green conidia on OA (Fig. 18). Talaromyces aurantiacus produces glauconic acid, purpurgenone and ZG-1494α (Frisvad et al. 2013). Other species producing soluble red pigment include T. minioluteus, T. purpurgenus and T. albobiverticillus. Talaromyces aurantiacus grows well on CYA at 37 °C, in contrast to poor growth for T. albobiverticillus and T. minioluteus. Talaromyces aurantiacus resembles T. purpurgenus, but differs from the latter by finely rough to rough, dull to dark green, thick walled, ellipsoidal conidia.

Talaromyces aurantiacus (J.H. Mill., Giddens & A.A. Foster) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. MycoBank MB560642. Fig. 19.

≡ Penicillium aurantiacum J.H. Mill., Giddens & A.A. Foster, Mycologia 49: 797. 1957.

In: Talaromyces section Talaromyces

Typus: No. 1736 (A.A. Foster), culture ex-type CBS 314.59 = ATCC 13216 = IMI 099722 = NRRL 3398.

ITS barcode: JN899380 (alternative markers: BenA = KF741917; CaM = KF741951)

Colony diam, 7 d (mm): CYA 30–32; CYA 30 °C 43–45; CYA 37 °C 19–21; MEA 38–40; MEA 30 °C 50–52; DG18 4–5; CYAS No growth; OA 35–40; CREA 5–6; YES 10–12.

Colony characters: CYA 25 °C, 7 d: Colonies low, plane, sterile white aerial mycelia, pale red appearance because of reverse colouring; margins low, plane, entire (2–3 mm); mycelia white; texture floccose and funiculose; sporulation absent; soluble pigments absent; exudates absent; reverse pastel red (7A4) fading into orange white (6A2). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–4 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse greyish orange (5B5–5B6). YES 25 °C, 7 d: Colonies deep, raised, slightly sulcate, light orange fluffy appearance because of the reverse colour; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5A5–6A5) with pastel red (8A5) circle close to margins. DG18 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse orange (5A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (4–5 mm); mycelia white; texture floccose; sporulation absent to sparse, conidia en masse greyish green (27C4–27D4); soluble pigments absent; exudates absent; reverse pale orange. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores sporulation is best on OA after 2 wk incubation. Conidiophores biverticillate; stipes smooth walled, 50–100 × 2–3 μm; metulae two to five, divergent, 8–16 × 2.5–3.5 μm; phialides acerose, two to six per metulae, 10–17.5 × 2–3 μm; conidia smooth, cylindrical to ellipsoidal, 3–5 × 1.5–2.5 μm. Ascomata not observed.

Extrolites: Talaromyces aurantiacus produces duclauxin and mitorubrinic acid.

Distinguishing characters: Talaromyces aurantiacus was considered synonymous with T. funiculosus by Pitt (1980), who considered it as nutritionally deficient because of the poor growth on CYA. In our study we observed that T. aurantiacus grows restrictedly on YES and DG18. Micromorphologically, T. aurantiacus closely resembles T. funiculosus. However, acid production on CREA and strongly funiculose colonies on MEA and OA of T. funiculosus, distinguish T. funiculosus from T. aurantiacus.

Talaromyces austrocalifornicus Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 34: 245. 1993. MycoBank MB361182. Fig. 20.

≡ Penicillium austrocalifornicum Yaguchi & Udagawa, (simultaneously published).

In: Talaromyces section Trachyspermi

Typus: CBM-PF 1117, culture ex-type CBS 644.95 = IBT 17522.

ITS barcode: JN899357 (alternative markers: BenA = KJ865732; CaM = KJ885261).
Fig. 19. Morphological characters of *Talaromyces aurantiacus* (CBS 314.59T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 20. Morphological characters of Talaromyces austrocalifornicus (CBS 645.95T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
**Polyphasic Taxonomy of Talaromyces**

Colony characters: CYA 25 °C, 7 d: Colonies raised, sunken at centre, sulcate; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse orange white to pale orange (5A2–5A3). MEA 25 °C, 7 d: Colonies deep, plane, sterile white mycelia; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates orange droplets; reverse greyish orange (5B5–5B6). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate, white appearance; margins low, plane, entire (1–2 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse greyish yellow to olive brown (4C5–4D5) in some isolates lack of the centre colour; at 30 and 37 °C reverse dark green (25F4). MEA 25 °C, 7 d: Colonies raised at centre, slightly sunken at centre slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture floccose; sporulation sparse to moderately dense, conidia en masse dull green (25D4–25E4); soluble pigments absent; exudates absent; reverse brown (6E6) centre fading into carrot brown (6C6) and at 30 °C reverse dark green (25F4). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture floccose; sporulation sparse, conidia en masse greyish green (28C4); soluble pigments absent; exudates absent; reverse greyish yellow (4B5–4C5) centre fading into pale yellow (4A3). DG18 25 °C, 7 d: Colonies raised at centre, pale; margins low, plane, entire (1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates small clear droplets; reverse yellowish white (3A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–5 mm); mycelia white; sporulation absent; soluble pigments absent; exudates clear droplets; reverse brownish. CREA 25 °C, 7 d: No growth.

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 30–100 × 2–3 μm; metulae three to eight, divergent, 8–17 × 2–3 μm; phialides aceroso, three to eight per metulae, 7–12 × 1.5–2.5 μm; conidia smooth, subglobose, 1.5–3 × 1.5–2.5 μm. Ascomata not observed in our culture but *fide Yaguchi et al. (1993)* maturing after 2–3 wk of incubation, yellow, globose to subglobose, 360–480 μm, ascii 6–8 × 5–6 μm, ascospores broadly ellipsoidal, finely spiny, 2.5–3.5 × 2–2.5 μm.

**Extrolites:** *Talaromyces austrocalifornicus* produces altenuene, mitorubrin, mitorubric acid and a purpactin.

**Distinguishing characters:** *Talaromyces austrocalifornicus* is characterised by restricted growth on CYA and MEA, no growth on CREA, yellow ascomata that have small, broadly ellipsoidal, spiny ascospores and biverticillate conidiophores producing smooth subglobose conidia (Fig. 20). All these characters differentiate *T. austrocalifornicus* from other species that produce yellow ascomata with ellipsoidal, spiny ascospores. The ex-type strain of *T. austrocalifornicus* was investigated during our study. Unfortunately, the ex-type strain was degenerated and did not produce ascomata.

**Talaromyces bacillisporus** (Swift) C. R. Benj., [as ‘bacillisporus’], Mycologia 47: 682. 1955. MycoBank MB118745. Fig. 21. = *Penicillium bacillisporum* Swift, Bull. Torrey Bot. Club 59: 221. 1932.

**In:** Talaromyces section Bacillispori

**Typus:** CBS H-7813, culture ex-type CBS 296.48 = ATCC 10126 = IMI 040045 = NRRL 1025.

**ITS barcode:** KMO66182 (alternative markers: BenA = AY753368; CaM = KJ885262; RPB2 = JF417425)

**Colony diam, 7 d (mm):** CYA 10–15; CYA 30 °C 25–30; CYA 37 °C 33–37; MEA 15–20; MEA 30 °C 35–38; DG18 3–7; CYAS No growth; OA 18–22; CREA Generally no growth in some strains colonies up to 4; YES 10–15.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, slightly sulcate, colony appearance light green to yellowish green (30A5–30A6); margins low, plane, entire (1–2 mm); mycelia white and yellowish green; sporulation absent to sparse; soluble pigments absent; exudates absent; reverse centre dull green (28F4) fading into greyish yellow to olive brown (4C5–4D5) in some isolates lack of the centre colour; at 30 and 37 °C reverse dark green (25F4). MEA 25 °C, 7 d: Colonies raised at centre, slightly sunken at centre slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture floccose; sporulation sparse to moderately dense, conidia en masse dull green (25D4–25E4); soluble pigments absent; exudates absent; reverse brown (6E6) centre fading into carrot brown (6C6) and at 30 °C reverse dark green (25F4). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture floccose; sporulation sparse, conidia en masse greyish green (28C4); soluble pigments absent; exudates absent; reverse greyish yellow (4B5–4C5) centre fading into pale yellow (4A3). DG18 25 °C, 7 d: Colonies raised at centre, pale; margins low, plane, entire (1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse pale yellow (4A3). OA 25 °C, 7 d: Colonies low, plane, production of ascomata especially at 30 °C; margins low, plane, entire (2 mm); mycelia white and pale pastel yellow; texture floccose; sporulation sparse, conidia en masse dull green (26D4); soluble pigments absent; exudates absent; reverse pastel yellow. OA 25 °C, 7 d: Colonies low, plane, production of ascomata especially at 30 °C; margins low, plane, entire (2 mm); mycelia white and pale pastel yellow; texture floccose; sporulation sparse, conidia en masse dull green (26D4); soluble pigments absent; exudates absent; reverse pastel yellow (4A3). OA 25 °C, 7 d: Colonies low, plane, production of ascomata especially at 30 °C; margins low, plane, entire (2 mm); mycelia white and pale pastel yellow; texture floccose; sporulation sparse, conidia en masse dull green (26D4); soluble pigments absent; exudates absent; reverse pastel yellow (4A3). OA 25 °C, 7 d: Colonies low, plane, production of ascomata especially at 30 °C; margins low, plane, entire (2 mm); mycelia white and pale pastel yellow; texture floccose; sporulation sparse, conidia en masse dull green (26D4); soluble pigments absent; exudates absent; reverse pastel yellow (4A3).

**Extrolites:** *Talaromyces bacillisporus* produces pinselin and bacillisorpin A-E (Yamazaki & Okuyama 1980, Dethoup et al. 2006) and talarotoxin (Ishii et al. 1995).

**Distinguishing characters:** *Talaromyces bacillisporus* can easily be distinguished from other species by its globose, spiny ascospores, dark green reverse on CYA and MEA at 30 and 37 °C, rough-walled stipes and cylindrical, rod-shaped conidia (Fig. 21).

**Talaromyces bohemicus** (Fassat. & Pěčková) Yilmaz, Frisvad & Samson, comb. nov. MycoBank MB809554. *Basionym:* Sagenomella bohemiaca Fassat. & Pěčková, Ceská Mykol. 44: 240. 1990.

**In:** Talaromyces section Helici

**Typus:** Unknown, culture ex-type CBS 545.86 = CCF 2330 = IAM 14789.

**ITS barcode:** JN899400 (alternative markers: BenA = JK865719; CaM = JK885286; RPB2 = JN121532)

**Colony diam, 10 d (mm):** Fide Fassatičová & Pěčková (1990), MEA 40 mm.
Fig. 21. Morphological characters of *Talaromyces bacillisporus* (CBS 298.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B Colony reverse on CYA after 1 wk incubation at 30 °C. C. Colony texture and ascomata on OA after 2 wk incubation. D. Asci and ascospores. E–G. Conidiophores. H. Ascospores. I. Conidia. Scale bars: C = 500 μm; D = 10 μm, applies to E–I.
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**Talaromyces boninensis** (Yaguchi & Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 70: 175. 2011. MycoBank MB560644. Fig. 22.

≡ Penicillium brunneum Udagawa, J. Agric. Sci. Tokyo Nogyo Daig. 5: 16. 1959.

**In: Talaromyces section Islandici**

**Typus**: NHL 6054, culture ex-type CBS 227.60 = ATCC 18229 = FRR 646 = IFO 6438 = IHEM 3907 = IMI 078259 = MUCL 31318 = IBT 4490.

**ITS barcode**: JN899365 (alternative markers: BenA = KJ865722; CaM = KJ885263; RPB2 = KM023272)

**Colony diam, 7 d (mm)**: CYA 19–20; CYA 30 °C 18–20; CYA 37 °C No growth; MEA 17–19; MEA 30 °C 15–18; DG18 14–15; CYAS 6–10; OA 14–15; CREA 9–10; YES 24–25.

**Colony characters**: CYA 25 °C, 7 d: Colonies slightly raised, radially sulcate; margins low, plane, entire (1 mm); mycelia white and yellow; texture velvety and loosely funiculose and especially in the centre conidiophores born from sterile aerial hyphae; sporulation moderately dense, conidia en masse golden brown to yellowish brown (5D7–5E7); soluble pigments absent; exudates clear and yellow droplets; reverse yellowish brown (5E5) centre fading into golden yellow (5B7). MEA 25 °C, 7 d: Colonies slightly raised, sulcate; margins low, plane, entire (1 mm); mycelia white and yellow; texture velvety and in the centre floccose; sporulation moderately dense, conidia en masse golden brown to yellowish brown (5D7–5E7); soluble pigments absent; exudates absent; reverse brown (6D7). YES 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white and yellow; sporulation absent; soluble pigments absent; exudates very small clear droplets; reverse greyish orange (5BS). DG18 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white, yellow; sporulation absent; soluble pigments absent; exudates absent; reverse orange (5A7) centre fading into light yellow (4A5). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1 mm) it does not have the transparent zone; mycelia white and yellow; texture velvety; sporulation dense, conidia en masse yellowish brown (5E5) centre fading into golden yellow (5B7); soluble pigments absent; exudates orange and clear droplets; reverse light orange. CREA 25 °C, 7 d: Acid production.

**Micromorphology**: Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, it differs from *T. helicus* by the production of green ascomata and broadly ellipsoidal and spiny ascospores. Unfortunately the ex-type strain was unavailable and could not be investigated during our study. Based on Frisvad (unpublished data), *T. boninensis* (strain PF 1103 = IBT 17516); CYA 21–25 mm, no (poor) sporulation, cream yellow to light brown reverse (25 °C, 7 d); MEA 25–26 mm, cream yellow reverse; YES 23–27 mm, yellow cream reverse, CREA weak growth (12 mm), weak acid production; CYA (at 37 °C): 17–29 mm; OA (25 °C) 32–33 mm, ascomata and *T. boninensis* (strain PF 1110 = IBT 17521): CYA 20 mm; MEA 31 mm; YES 23 mm; OA 32 mm, ascomata; CREA weak growth (13 mm), some acid production; CYA at 37 °C 27 mm.

**Talaromyces brunneus** (Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 70: 175. 2011. MycoBank MB560644.

**Notes**: The ex-type strain of *Talaromyces bohemicus* was not in good condition and could not be described. The description is based on Fassatiova & Pěčková (1990).

**Talaromyces boninensis** (Yaguchi & Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. MycoBank MB560643.

≡ Talaromyces helicus var. boninensis Yaguchi & Udagawa, Trans. Mycol. Soc. Japan 33: 511. 1992.

**In: Talaromyces section Helici**

**Typus**: CBM PF-1103, culture ex-typus CBS 650.95 = IBT 17516.

**ITS barcode**: JN899356 (alternative markers: BenA = KJ865721; CaM = KJ885263; RPB2 = KM023276)

**Colony diam, 7 d (mm)**: Fide Yaguchi et al. (1992), CYA 28; MEA 30; OA 32.

**Colony characters**: Fide Yaguchi et al. (1992) colonies on CYA velvety, radially sulcate, consisting of a close basal felt in which ascomata slowly develop, reddish white to pastel green (7A2–29A4); sporulation limited; reverse light orange (5A4). At 37 °C, mycelial growth somewhat rapid, but ascomata and conidia less formed. Colonies on MEA floccose, more or less plane, consisting of a thin basal felt, white to orange white (6A2), then becoming green to grayish green (28A6); ascomata and conidia not sufficiently produced to influence the colony appearance within 7 d; reverse uncoloured. Colonies on OA floccose to funiculose, consisting of a rather thin basal felt, at first pale orange (5A3), then slightly greenish (28B6); ascomata abundantly produced, but conidia limited in number; reverse uncoloured to pale orange (5A3).

**Micromorphology**: Fide Yaguchi et al. (1992) conidiophores biverticillate; stipe finely rough, 25–260 × 2.5–4 μm; metulae four to ten, divergent, 10–16–(20) × 2.5–3(–3.5); phialides two to six, aceros, 10–15 × 2–3.5 μm; conidia ellipsoidal to fusiform, sometimes globoso, smooth, 2–4 × 1.5–2.5 μm. Ascomata ripening 14–21 d, grayish green, globoso to subgloboso, 280–550 × 240–480 μm; ascii 8–10(–12) × 7–8 μm; ascospores broadly ellipsoidal, spiny, (2.5–)3.5–4(4.5) × 2–3 μm.

**Extrarites**: Talaromyces boninensis produces talaroderxines.

**Notes**: Talaromyces boninensis was described as a variety of *T. helicus*. Molecular results show *T. boninensis* as a unique species. Its macromorphology is similar to *T. helicus* (Yaguchi et al. 1992), but...
Fig. 22. Morphological characters of Talaromyces brunneus (CBS 227.60T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
60–130 × 2.5–4 μm; sometimes extra branches 15–25 μm; metulae three to six, 8–15(–18) × 2–4 μm; phialides acerose, three to five per metulae, 9–14 × 2–3.5 μm; conidia smooth, globose to subglobose 3–4(–7) × 2–4. Ascomata not observed.

**Extrolites:** Talaromyces brunneus produces emodin, skyrin and (+)-rugulosin (Shibata & Ikekawa 1963, Shibata & Udagawa 1963, Sankawa et al. 1973, Seo et al. 1973). We detected rugulosin, skyrin, mitorubrin, mitorubrinol and mitorubrin acetate and one tetracyclic compound in CBS 227.60, and in addition to several specific not yet structure elucidated extrolites.

**Distinguishing characters:** Talaromyces brunneus is characterised by the production of golden brown to yellowish brown conidia on CYA, MEA and OA (Fig. 22). The species is unable to grow at 37 °C. These characters distinguish it from all Talaromyces species.

**Talaromyces calidicanius** (J.L. Chen) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. MycoBank MB560645. Fig. 23.

≡ Penicillium calidicanium J.L. Chen, Mycologia 94: 870. 2002.

In: Talaromyces section Talaromyces

*Typus:* CFC-7 (isotype TNM F12246), culture ex-type CBS 112002.

*ITS barcode:* JN899319 (alternative markers: BenA = HQ156944; CaM = KF741934; RPB2 = KM023311)

**Colony diam, 7 d (mm):** CYA 27–30; CYA 30 °C 33–35; CYA 37 °C No growth; MEA 47–48; MEA 30 °C 30; DG18 15; CYAS No growth; OA 45; CREA 18–20; YES 40–41.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, sulphate, young synnemata produced; margins low, plane, entire (<1 mm); mycelia white and pastel yellow; texture flocculose and floccose; sporulation moderately dense, conidia in masse greyish green (28D5–28E5); soluble pigments absent; exudates absent; reverse greyish yellow to olive brown (4C5–4D5). MEA 25 °C, 7 d: Colonies raised at centre, sulphate, synnemata at centre sporulate, and young synnemata at margins; margins low, plane, entire (3 mm); mycelia white; texture synnematous, loosely flocculose to floccose; sporulation sparse to moderately dense, conidia in masse dark grey (27F5) on the sporulated synnemata and on the rest of the colony greyish green (27D4); soluble pigments absent; exudates orange droplets; reverse golden brown to yellowish brown (5D7–5E7). YES 25 °C, 7 d: Colonies deep, raised at centre, sulphate, young synnemata formation; margins low, plane, entire (2 mm); mycelia white and yellow; texture flocculose; sporulation moderately dense, conidia in masse greyish green (27E5–28E5); soluble pigments absent; exudates absent; reverse olive brown (4D8–4E8) centre fading into golden brown (4C6–4D6). DG18 25 °C, 7 d: Colonies slightly raised at centre, sulphate; margins low, plane, entire (<1 mm); mycelia white; texture velvety; sporulation dense, conidia in masse greyish green (28E5–27E5); soluble pigments absent; exudates small orange droplets; reverse golden brown (4C6) fading into pale yellow (2A3). OA 25 °C, 7 d: Colonies low, plane, sporulated synnemata at centre and young synnemata at margins; margins low, plane, entire (4–5 mm); mycelia white; texture velvety; sporulation dense, conidia en masse dark green (28F5); soluble pigments absent; exudates small clear droplets; reverse pale brownish green. CREA 25 °C, 7 d: Moderate acid production.

**Micromorphology:** Synnemata 2000–6000 μm long. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 40–150(–250) × 2.8–4 μm; branches up to 20 μm; metulae two to six, divergent, 7–15 × 2.5–4 μm; phialides acerose, three to six per metulae, 8–13 × 2–3.5 μm; conidia finely rough to rough or spiral striate, ellipsoidal to fusiform, 2.5–4.5 × 2–3 μm. Ascomata not observed.

**Extrolites:** Talaromyces calidicanius produces duclauxin and related compounds.

**Distinguishing characters:** Talaromyces calidicanius produces synnemata after 1 wk of incubation (Fig. 23). It is characterised by fast growing colonies on MEA and grows well at 30 °C. Determinate synnemata, up to 6000 μm long, are produced after prolonged incubation. Talaromyces calidicanius produces conidia with spiral striations. Its morphology resembles T. panamensis, but T. panamensis grows slower at 30 °C on MEA and produces more acid on CREA.

**Talaromyces cevidicolia** (Seifert, Hoekstra & Frisvad) Samson et al., Stud. Mycol. 71: 175. 2011. MycoBank MB560646. Fig. 24.

≡ Penicillium cevidicola Seifert, Hoekstra & Frisvad, Stud. Mycol. 50: 520. 2004.

In: Talaromyces section Purpurei

*Typus:* DAOM 233329, culture ex-type CBS 101419 = DAOM 233329.

*ITS barcode:* AY787944 (alternative markers: BenA = FJ753295; CaM = KJ885287; RPB2 = KM023309)

**Colony diam, 7 d (mm):** CYA 33–34; CYA 30 °C 37–38; CYA 37 °C 2–3; MEA 37–38; MEA 30 °C 38–39; DG18 21–22; CYAS No growth; OA 31–33; CREA 6–8; YES 30–31.

**Colony characters:** CYA 25 °C, 7 d: Colonies low, raised at centre, plane; margins low, wide, entire (3–5 mm); mycelia white; texture flocculose and strongly flocculose; sporulation moderately dense, conidia in masse dark green (26F7); soluble pigments absent; exudates absent; reverse very dark red at centre, dark brown to violet brown (8F8–10F8). MEA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (5 mm); mycelia white; texture strongly flocculose with some velvety areas; sporulation moderately dense to dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates absent; reverse very dark red at
Fig. 23. Morphological characters of Talaromyces calidicanius (CBS 112002'). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 1 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 1000 μm; C = 50 μm; D = 10 μm, applies to E–G.
Fig. 24. Morphological characters of Talaromyces cecidicola (CBS 101419T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 1 wk incubation. C. Synnemata. D–F. Conidiophores. G. Conidia. Scale bars: B, C = 1000 μm; D = 10 μm, applies to E–G.
centre, dark brown to violet brown (8F8–10F8). DG18 25 °C, 7 d: Colonies slightly raised in the centre, plane; margins low, narrow, entire (2–3 mm); mycelia white; texture flocculose; sporulation moderately dense, conidia en masse dark green (26F5); soluble pigments absent; exudates absent; reverse brown (7E8) at centre, olive (3D3) near margin. OA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (3–4 mm); mycelia white; texture strongly flocculose, with some velvety areas; sporulation moderately dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates absent; reverse grey to brownish grey (7B1–7C2). CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Synnemata 250–1250 μm long. Conidiophores biverticillate with a minor proportion having sub-terminal branches; stipes smooth walled, 20–80(–200) × 2.5–4 μm; branches 8–25 μm; metulae three to eight, divergent, 9–15 × 2.5–3 μm; phialides acerose, three to six per metulae, 10–15 × 1.5–3 μm; conidia smooth to finely rough, ellipsoidal, 2.5–4 × 1.5–3 μm. Ascospora not observed.

**Distinguishing characters:** Talaromyces cecidicola is characterised by colonies with dark red reverses and synnemata up to 1250 μm long, which are produced after 1–2 wk of incubation (Fig. 24). It is most similar to T. coalescens. However, T. coalescens grows faster than T. cecidicola on MEA at 30 °C. This species was isolated from insect galls (Seifert et al. 2004).

**Talaromyces chloroloma** Visagie & K. Jacobs, Persoonia 28: 18. 2012. MycoBank MB564326. Fig. 25.

*In: Talaromyces section Purpurei*

**Typus:** PREM 60033, culture ex-type DAOM 241016 = CV 2802.

**ITS barcode:** FJ160273 (alternative markers: BenA = GU385736; CaM = KJ885265; RPB2 = KM023304)

**Colony diam., 7 d (mm):** CYA 40–45; CYA 30 °C 50–55; CYA 37 °C Generally no growth, sometimes colonies grow up to no 4; MEA 45–48; MEA 30 °C 55–60; DG18 20–25; CYAS 20–23; OA 40–48; CREA 15–20; YES 35–40.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, lightly sulcate; margins low, plane, entire (2 mm); mycelia white; texture floccose, with some funicles present; sporulation moderately dense to dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates in some isolates absent, in some isolates small clear droplets; reverse centre greyish orange (5B3), fading into dull greyish yellow (3B3). MEA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (4–5 mm); mycelia white; texture floccose and loosely flocculose (especially in the centre); sporulation dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates very small clear droplets; reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies low, radially sulcate; margins low, narrow, entire (1–2 mm); mycelia white; texture floccose; sporulation absent to sparse, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates absent; reverse in some isolates centre greyish red (9B6) to dull red (9B4) in some isolates lack of red centre, the rest pastel yellow (3A4). DG18 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire (2 mm); mycelia white; texture flocculose; sporulation absent to dense (no sporulation at centre, centre is slimy yeast like structure), conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates absent; reverse greyish green to dull green (27C4–27D4), in DTO 180–F3 margins orange red (8A6). OA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (5–6 mm); mycelia white, especially in the centre synnemata like aerial hyphae growing; texture velvety and flocculose; sporulation moderately dense to dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates clear droplets in centre; reverse pale light green. (1B3). CREA 25 °C, 7 d: Moderate acid production.

**Micromorphology:** Synnemata produced on CYA where the colony surface scraped away after 2–3 wk, 700–1200 μm long. Conidiophores biverticillate with a minor proportion having sub-terminal branches; stipes smooth walled, 10–75 × 2.5–5 μm; branches 5–20 μm; metulae three to six, divergent, 7.5–10(–13) × 2–4 μm; phialides acerose, three to six per metulae, 7–11 × 1.5–3 μm; conidia smooth, ellipsoidal, 2.5–4(–6) × 1.5–2.5 μm. Ascospore not observed.

**Distinguishing characters:** Talaromyces chloroloma grows rapidly on most media and produces synnemata after 2–3 wk, up to 1250 μm long and similar to those of T. cecidicola and T. coalescens. However, T. chloroloma grows much faster on MEA at 30 °C and produces acid on CREA, which is absent in its close relatives. Acid production also distinguishes T. chloroloma from T. rumulosus.

**Talaromyces cinnabarinus** (S.C. Jong & E.E. Davis) Yilmaz, Samson & Frisvad. comb. nov. MycoBank MB809557.

**Basionym:** Paecilomyces cinnabarinus S.C. Jong & E.E. Davis, Mycologia 67: 1144. 1975. = Aphanoascus cinnabarinus var. macrosporus Udagawa, Bull. Nat. Sci. Mus. Tokyo 16: 503. 1973.

*In: Talaromyces section Helici*

**Typus:** CBS H-6686, culture ex-type CBS 267.72 = ATCC 26215 = NHL 2873.

**ITS barcode:** JN899376 (alternative markers: BenA = AY753377; CaM = KJ885265; RPB2 = JN121477)

**Colony characters:** Fide Udagawa & Takada (1973) colonies on OA growing rapidly, plane, consisting of a thin mycelial felt in which scattered cleistothecia are embedded, surface appearing slightly flocculent, light orange to reddish orange, conidial structures not produced; reverse pale reddish orange to dark brown. On malt agar spreading, orange to reddish orange, more or less floccose, ripening process of cleistothecia extremely delayed; colony reverse dark green to dark blue-green with surrounding agar similarly coloured. At 37 °C grows slower than at 25 °C, with production of fructification much reduced and immature.
Fig. 25. Morphological characters of *Talaromyces chloroloma* (DAOM 241016T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–H.
**Micromorphology:** Fide Jong & Davis (1975) conidiophores short, smooth walled, up to 50 μm long; phialides two to four, 13.5–17.1 × 2.7–3.2 μm, smooth walled, consisting of a more or less cylindrical basal portion, tapering abruptly to a long thin neck 4.5–6.3 × 0.9–1.2 μm; conidia cylindrical with truncate ends, smooth walled, 5.4–7.2 × 1.5–2 μm. Fide Udagawa & Takada (1973) ascomata yellowish orange to orange red, subglobose to ovoidal, 350–600 μm; ascii 9.5–11 μm; ascospores broadly ellipsoidal, thick walled, ornamented by irregular ridges, 4–5.5(–6) × 3–3.5 μm.

**Distinguishing characters:** Fide Udagawa & Takada (1973) *T. cinnabarinus* is characterised by the production of its globose, red, non-ostiolate ascocarps, which are surrounded by loose wefts of encrusted hyphae and with a sclerotoid inner tissue, irregularly disposed globose ascii, and ellipsoid, hyaline to reddish orange ascospores, ornamented with several narrow ridges.

**Notes:** *Aphanoascus cinnabarinus* was described by Zukal (1890). The holotype and the ex-type strains were unavailable and Udagawa & Takada (1973) neotyphidied the species with CBS 267.72. However, this strain produced a *Paecilomyces* ana-morph, which was described by Jong & Davis (1975) as *Paecilomyces cinnabarinus*, whereas Zukal’s original description and illustrations clearly describes the structures of a *Chrysosporium* ana-morph (Stolk & Samson 1983). Stolk & Samson (1983) placed *Chromocleista cinnabaria* (as *A. cinnabarinus sensu Udagawa & Takada*) in the Eurotiales. However, Ogawa & Sugiyama (2000), Houbraken & Samson (2011) and our re-sults showed that *Aphanoascus cinnabarinus* belongs to *Talaromyces* and is classified here in *Talaromyces* section Helici. As such, we introduce the new combination *T. cinnabarinus* based on *Paecilomyces cinnabarinus* and consider *A. cinnabarinus* Zukal sensu Udagawa & Takada (J. Jpn. Bot. 48: 23. 1973) as a pseudonym. *Aphanoascus cinnabarinus* var. macrorosus is considered a synonym of *T. cinnabarinus* based on the original description by Udagawa et al. (1973). The ex-type strain (NHL 2704) was, however, not examined in our study.

**Talaromyces nidii** S.H. Yu, T.-J. An & H. Sang, J. Microbiol. 51: 707. 2013. MycoBank MB804809. Fig. 26.

**In:** Talaromyces section Talaromyces

**Typus:** KACC 46617, culture ex-type KACC 46617.

**ITS barcode:**KF183639 (alternative markers: *BenA* = KF183641; *CaM* = KJ885266; *RPB2* = KM023299)

**Colony diam, 7 d (mm):** CYA 25–30; CYA 30 °C 30–37; CYA 37 °C 20–28; MEA 38–40; MEA 30 °C 45–50; DG18 10–16; CYAS 3–4; OA 30–35; CREA 9–15; YES 25–30.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white and dull red; texture floccose; sporulation moderately dense to dense, conidia en masse greyish green (26C3–26C4) to dull green (26D3–26D4); soluble pigments red (DTO 270-B7 and DTO 303-E1) to yellow (DTO 270-A4 and DTO 270-A8) (at 30 °C yellow to orange); exudates in some isolates absent, in some isolates small red droplets (DTO 303-E1 and DTO 270-B7); reverse centre brownish violet (11D8) to violet brown (11E8) fading into vivid red (11A8) and orange red (8A8). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly concentrically sulcate; margins low, plane, entire (2–3 mm); mycelia white and in some isolates also yellow (DTO 303-E1); texture velvety and floccose especially at centre in some isolates just floccose; sporulation sparse (DTO 270-A8 and DTO 269-12) to dense, conidia en masse dull green (26D4–26E4); soluble pigments absent; exudates in some isolates red (DTO 303-E1) and orange (DTO 270-B7) droplets in some isolates absent; reverse violet brown (11E8–11F8) centre fading into orange red (8A8) and light orange (5A5) (in some isolates lack of the centre pigmentation). YES 25 °C, 7 d: Colonies raised at centre, in some isolates sunken at centre, slightly sulcate; margins low, plane, entire (2 mm); mycelia white (in some isolates red and yellow as well (DTO 270-B7); texture velvety and floccose; sporulation moderately dense to dense, conidia en masse dull green (26D4–26E4); soluble pigments in some isolates red (DTO 270-B7 and DTO 303-E1) and in some absent; exudates absent; reverse brownish red to violet red (10D8–10E8) centre fading into light yellow (4A4) and in some isolates centre reddish brown (8D6) to greyish red (8B6) and in some isolates brown (6E5). DG18 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white; texture velvety (DTO 303-E1) and in some isolates floccose; sporulation sparse and in some isolates dense (DTO 303-E1), conidia en masse dull green (26E4–27E4) (DTO 303-E1) and in some isolates greyish green (25D5–25E5); soluble pigments absent (except DTO 303-E1, red pigment); exudates absent (except DTO 303-E1 orange and red small droplets); reverse in some isolates (DTO 303-E1 and DTO 270-A4) violet brown (10E8) to reddish brown (10D8) centre fading into reddish orange (7A6) and in some isolates lack of centre colour and greyish red (8B5) (DTO 270-A8) and in some isolates pale orange (5A3). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white; texture velvety and in the centre floccose; sporulation moderately dense to dense, conidia en masse dull green (27E4); soluble pigments absent; exudates absent; reverse brownish orange. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 60–230 × 2–3 μm; branches 15–40 μm; metulae three to eight, divergent, 10–15 × 2.5–4 μm; phialides acerosus, three to six per metulae, 10–15 × 2–3.5 μm; conidia smooth, ellipsoidal, 2.5–4 × 2–2.5 μm. Ascomata not observed.

**Distinguishing characters:** *Talaromyces nidii* produces a red reverse on CYA and MEA (Fig. 26). It is phylogenetically closely related to *T. siamensis*. There are only minor morphological differences between these two species. *Talaromyces nidii* grows slightly faster at 25 °C and 37 °C, but *BenA* sequences are necessary for a definitive identification.

**Talaromyces coalescens** (Quintan.) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. MycoBank MB560647. Fig. 27.

≡ *Penicillium coalescens* Quintan., Mycopathologia 84: 115. 1984.

**In:** Talaromyces section Purpurei
Fig. 26. Morphological characters of *Talaromyces cnidii* (KACC 46617). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 27. Morphological characters of Talanomyces coalescens (CBS 103.83T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 2 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–H.
**Typos:** CBS 103.83, culture ex-type CBS 103.83.

**ITS barcode:** JN899366 (alternative markers: BenA = JX091390; CaM = KJ885267; RP2B = KM023277)

**Colonies diam, 7 d (mm):** CYA 32–34; CYA 30 °C 40–41; CYA 37 °C 2–4; MEA 43–45; MEA 30 °C 45–46; DG18 19–20; CYAS No growth; OA 35–38; CREA 5–6; YES 34–35.

**Colonies characters:** CYA 25 °C, 7 d: Colonies low to moderately deep, raised at centre, plane; margins low, wide, entire (3 mm); mycelia white and yellow; texture floccose and strongly fuscicole; sporulation moderately dense at centre, conidia en masse dark green (26F5); soluble pigments red; exudates absent; reverse dark brown to violet brown (8F8–10F8). MEA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (5 mm); mycelia white to beige; texture strongly fuscicole; sporulation moderately dense only at colony centre, conidia en masse dark green (26F5); soluble pigments red; exudates absent; reverse very dark red. YES 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (4 mm); mycelia white; texture fuscicole, with some floccose areas, abundant aerial hyphae; sporulation moderately dense at colony centre, conidia en masse dark green (26F5); soluble pigments red; exudates absent; reverse very dark red. DG18 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire (2 mm); mycelia white; texture loosely fuscicole; sporulation sparse, conidia en masse cannot be determined; soluble pigments red; exudates absent; reverse brown (7E7) at centre, fading into pale red (7A3). OA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (4 mm); mycelia white; texture strongly fuscicole, with some velvety areas; sporulation moderately dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates clear droplets at centre; reverse brownish grey to greyish brown (5C2–5D3). CREA 25 °C, 7 d: Very weak acid production.

**Micromorphology:** Synnemata 400–1200 μm long. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 30–140 × 2–5 μm; branches 10–45 μm; metulae three to six, divergent, 8–12–(16) × 2–3(–4) μm; phialides acerosus, three to six per metulae, 10–15 × 1.5–2.5(–3.5) μm; conidia smooth, ellipsoidal with pointed end to fusiform, 2.5–3.5(–5.5) × 1.5–3 μm. Ascomata not observed.

**Extrœlite:** Talaromyces coalescens produces (→) botryodiploid and related compounds (Cabedo et al. 2007). Botryodiploid has been called a mycotoxin and also has antifungal, antibacterial and insecticidal effects (Cabedo et al. 2007). A purpactin was also detected and several nonadrides related to gluaconic acid.

**Distinguishing characters:** Talaromyces coalescens produces colonies with dark red reverses with abundant red soluble pigment (Fig. 27). Synnemata, up to 1200 μm long, are produced after 2–3 wk incubation. It closely resembles T. cecidicola. However, T. coalescens grows faster than T. cecidicola on MEA at 30 °C.

**Talaromyces columbinus** S.W. Peterson & Jurjevic, PLoS ONE 8: e78084–page 6. 2013. MycoBank MB804732. Fig. 28.

In: Talaromyces section Islandici

**Typos:** BPI 892668, culture ex-tyrus NRRL 58811.

**ITS barcode:** KJ865739 (alternative markers: BenA = KF196843; CaM = KJ885288; RP2B = KM023270)

**Colonies diam, 7 d (mm):** CYA 13–14; CYA 30 °C 30–31; CYA 37 °C 42–43; MEA 20–21; MEA 30 °C 32–33; DG18 9–11; CYAS 2–3; OA 22–23; CREA 7–8; YES 18–20.

**Colonies characters:** CYA, 25 °C, 7 d: Colonies 11–12 mm, slightly raised in the centre, slightly sulcate; margins wide (2 mm), low, entire, plane; mycelium orange and white, colony appearance orange (6B7–6C7); sporulation absent; exudates absent; soluble pigment very pale light brownish orange around colonies; reverse dark brown fading into beige (8F8). MEA, 25 °C, 7 d: Colonies 23–25 mm, slightly raised in the centre, sulcate; margins very narrow (<1 mm), low, entire, plane; mycelium white and yellow; texture velvety and floccose; sporulation dense, especially in the centre; conidia en masse greyish green (26E5–26E6); exudates absent; soluble pigment absent; reverse brown centre fading into brownish orange (8F8). YES, 25 °C, 7 d: Colonies 18–20 mm, raised in the centre, concentrically sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white, pale yellow and orange; texture velvety and floccose; sporulation moderately dense; conidia en masse dull green (26E4); exudates absent; soluble pigment brownish; reverse dark brown (5F6). DG18, 25 °C, 7 d: Colonies 14–15 mm, raised in the centre, slightly concentrically sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and pale yellow in the centre; texture velvety; sporulation dense; conidia en masse greyish green to dark green (25E5–25F5); exudates absent; soluble pigment yellow around colonies; reverse olive green (2F6–3F6), light yellow margins (2A5). OA, 25 °C, 7 d: Colonies 23–25 mm, low, plane; margins narrow (1–2 mm), low, entire, plane; mycelium white; texture velvety; sporulation dense; conidia en masse greyish green to dark green (25E5–25F5); exudates small yellow droplets; soluble pigment yellow around colonies; reverse yellowish brown fading into pastel yellow (centre 5D5 and fading into 2A4). CREA, 25 °C, 7 d: Colonies 14–15 mm, acid production absent.

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 20–70 × 2–2.5 μm; terminating in vesicles up to 6 μm; metulae four to eight, 8–14 × 2–4 μm; phialides acerosae, three to six per metulae, 7–12 × 1.5–2.2 μm; conidia smooth, ellipsoidal, 2.5–3.5 × 3–4.5 μm.

**Extrœlite:** Talaromyces columbinus (isolate CBS 137393) produces rugulosin A, skyrin and series of tetracyclic compounds.

**Distinguishing characters:** Talaromyces columbinus is similar to T. piceus. Both species have biverticillate conidiophores with vesiculated stipes, grow fast at high temperatures and are able to grow at 40 °C. However, T. columbinus produces a brown soluble pigment on YES that is absent in T. piceus. In addition, T. columbinus grows slower on CYA at 25 °C.

**Talaromyces convolutum** Udagawa, Mycotaxon 48: 141. 1993. MycoBank MB360474. Fig. 29. = Penicillium convolutum Udagawa, (simultaneously published).

In: Talaromyces section Trachyspermi
Fig. 28. Morphological characters of Talaromyces columbinus (CBS 137393). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
Fig. 29. Morphological characters of *Talaromyces convolutus* (CBS 100537T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Ascomata from OA after 3 wk incubation. C. Initials. D–G. Conidiophores. H. Conidia. Scale bars: B = 500 μm; C = 10 μm; D = 10 μm, applies to E–H.
**Talaromyces convolutus** (Pitt) Samson et al., Stud. Mycol. 71: 175. 2011. MycoBank MB560648, Fig. 30. = Penicillium dendriticum Pitt, The genus Penicillium: 413. 1980.

*In: Talaromyces section Purpurei*

**Typus:** IMI 216897, culture ex-type CBS 660.80 = IMI 216897.

**ITS barcode:** JN899339 (alternative markers: BenA = JX091391; CaM = KF741965; RP2B = KM023266)

**Talaromyces dendriticus** (Pitt) Samson et al., Stud. Mycol. 71: 175. 2011. MycoBank MB560648, Fig. 30. = Penicillium dendthicium Pitt, The genus Penicillium: 413. 1980.

**Typus:** CBM SUM-3018, culture ex-type CBS 100537 = IBT 14989.

**Colony diam, 7 d (mm):** CYA 10–12; CYA 30 °C 15–16; CYA 37 °C 6–8; MEA 13–15; MEA 30 °C 17–20; DG18 3–5; CYAS No growth; OA 15–18; CREA 2–3; YES 12–13.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate, white sterile appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; exudates absent; reverse orange white to pale orange (5A2–5A3). MEA 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate, white sterile appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; exudates absent; reverse pale orange (SA3). DG18 25 °C, 7 d: Colonies low, plane, slimy yeast like colony; margins low, plane, entire (<1 mm); mycelia white; texture floccose; soluble pigments absent; exudates absent; reverse white (4A1). OA 25 °C, 7 d: Colonies low, plane, white sterile appearance; margins low, plane, entire (2 mm); mycelia white; texture floccose; soluble pigments absent; exudates absent; reverse pale orange (5A3). MEA 25 °C, 7 d: Colonies low, plane, white sterile appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; soluble pigments absent; exudates absent; reverse pale orange (5A3). CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate and monoverticillate; stipes smooth walled, 10–70 × 1.5–2.5 μm; metulae two to five, divergent, 8–12 × 1.5–3 μm; phialides acerose, three to five per metulae, 7.5–14 × 1.5–2.5 μm; conidia smooth, ovoidal to ellipsoidal, (2–)3–4 × 1.5–2(–3) μm. Ascomata not observed in our culture but fide Udagawa (1993) maturing slowly after 4 wk of incubation, sulphur yellow, globose to subglobose, 120–360 μm, ascomatal initials composed of short clavate ascogonia 15–20 μm long and 4 μm wide, asci 8–11 × 7.5–9 μm, ascospores globose to subglobose, spiny, 3–3.5 × 2.5–3(–3.5) μm.

**Extrolites:** *Talaromyces conivolutus* produces talaroconvolution A-D and ZG-1494α (Suzuki et al. 2000) and (α-)mitorubinal, (β-)mitorubinic acid and anhydroflovomannin-9,10-quione-6,6'-O-methyl ether (Suzuki et al. 1999). We also found a purpactin in this species. ZG-1494α is also produced by *T. atroroseus* (Frisvad et al. 2013).

**Distinguishing characters:** *Talaromyces convolutus* is characterised by its restricted growth, slowly maturing sulphur yellow ascoma, globose to subglobose, spiny ascospores and mono- to biverticillate conidiophores. These characters distinguish *T. convolutus* from its close relatives in section Trachysperm. The restricted growth of *T. convolutus* distinguishes it from other yellow ascoma producers such as *T. flavus*, *T. austrocalifornicus* and *T. tratensis*. Unfortunately, the available strains of *T. convolutus* were degenerated and no longer produced ascomata.
Fig. 30. Morphological characters of Talaromyces dendriticus (DTO 183-G3). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 2000 μm; D = 10 μm, applies to E–H.
Distinguishing characters: Talaromyces dendriticus is recognised by colonies producing synnemata up to 5.000 μm long after 1–2 wk of incubation. This species tends to be associated with Euca-
lyptus. Talaromyces dendriticus is distinguished from other synnema producers by its restricted growth on CYA at 25 and 30 °C.

**Talaromyces derxii** Takada & Udagawa, Mycotaxon 31: 418. 1988. MycoBank MB133755. Fig. 31.

≡ Penicillium derxii Takada & Udagawa, (simultaneously published).

In: Talaromyces section Talaromyces

Typus: NHL 2980, culture ex-type CBS 412.89 = NHL 2981.

ITS barcode: JN899327 (alternative markers: **BenA** = JX494305; **CaM** = KF741959; **RPB2** = KM023282)

Colony diam, 7 d (mm): CYA 38–40 (12–13); CYA 30 °C 43–45 (17–18); CYA 37 °C 35–38 (15–16); MEA 48–50 (20–22); MEA 30 °C 60–65 (30–32); DG18 14–15 (7–8); CYAS No growth; OA 10–20; CREA 2–6; YES 39–40 (15–16).

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, in some isolates (CBS 413.89) sunken at centre and crateriforme, slightly sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent to sparse; conidia en masse greyish green (25B–26B3); soluble pigments absent; exudates absent; reverse dark green (25F5) centre for both fading into light yellow (4A4). MEA 25 °C, 7 d: Colonies slightly raised at centre, in some isolates sunken at centre, low to deep, plane to sulcate; margins low, plane, entire (1–3 mm); mycelia white; texture floccose; sporulation absent to sparse, conidia en masse greyish green (25B–26B3); soluble pigments absent; exudates absent; reverse in some isolates (CBS 412.89 T) light brown to brown (6D6–6E6) centre fading into apricot (5B6) and in some isolates (CBS 413.89) greyish orange (5B5). YES 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulcate; margins low, plane, entire (1–3 mm); mycelia white; texture floccose; sporulation absent to moderate, dense, conidia en masse greyish green (25C5–25D5); soluble pigments absent; exudates absent; reverse in some isolates (CBS 412.89 T) golden yellow (5B7) rest dark green (27F7) and in some isolates (CBS 413.89) centre greyish green (27D6) fading into light orange (5A4) and light yellow (4A4) with brownish orange (5C6) circle. DG18 25 °C, 7 d: Colonies low to slightly raised at centre, plane to slightly sulcate, light orange appearance; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (6A5) to orange white (5A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white; texture velvety and floccose; sporulation sparse to moderately dense, conidia en masse greyish green (27D5–27E5); soluble pigments absent; exudates absent; reverse dull green. CREA 25 °C, 7 d: Acid production absent.

**Takada & Udagawa** (1993) heterothallic. Superficial, maturing within 1–2 wk at 37 °C, greyish green to dark bluish green, globose to subglobose, ascii 10–13 × 9–12 μm, ascospores ellipsoidal, spiny, 3.5–5 × 2.5–3 μm.

**Extrolites**: Talaromyces derxii produces talaroderxine A & B (Suzuki et al. 1992), 4-[3-methyl-2-butenyl]oxy]benzoic acid, 4-[[2,3-epoxy-3-methylbutyl]oxy]benzoic acid, (4E)-4-[[4-hydroxy-3-methyl-2-butenyl]oxy]benzoic acid (Nozawa et al. 1989), and penicillide and dehydroisopenicillide (Suzuki et al. 1991).

Distinguishing characters: Talaromyces derxii is a heterothallic species. It is characterised by a dark green reverse on CYA and cylindrical to ellipsoidal conidia (Fig. 31). These characters resemble *T. bacillisporus*. However, *T. bacillisporus* has globose, spiny ascospores whereas *T. derxii* produces green ascomata with spiny ellipsoidal ascospores. In addition, *T. derxii* has smooth walled stipes in contrast to the rough stipes of *T. bacillisporus*.

**Talaromyces diversus** (Raper & Fennell) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011. MycoBank MB560649. Fig. 32.

≡ Penicillium diversum Raper & Fennell, Mycologia 40: 539. 1948.

In: Talaromyces section Trachyspermi

Typus: IMI 040579, culture ex-type CBS 320.48 = ATCC 10437 = DSM 2212 = IMI 040579ii = NRRL 2121.

ITS barcode: KJ865740 (alternative markers: **BenA** = KJ865723; **CaM** = KJ855268; **RPB2** = KM023282)

Colony diam, 7 d (mm): CYA 7–10; CYA 30 °C 6–10; CYA 37 °C 5–8; MEA 25–35; MEA 30 °C 30–35; DG18 10–15; CYAS 2–5; OA 25–40; CREA No growth and sometimes up to 2; YES 8–10.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sunken at centre, slightly sulcate; margins low, plane, entire (<1 mm); mycelia white; texture velvety; sporulation moderately dense to dense, conidia en masse dull green (27D3–27D4); soluble pigments absent; exudates absent; reverse blue to brownish orange (4C4–5C4). MEA 25 °C, 7 d: Colonies slightly raised, sunken at centre, sulcate; margins low, plane, entire (2 mm); mycelia white; texture velvety and in some isolates floccose (DTO 231-A1); sporulation dense, conidia en masse dull green (27D3–27D4); soluble pigments absent; exudates in some isolates small clear droplets; reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies slightly raised at centre, sunken at centre, sulcate; margins low, plane, entire (<1 mm); mycelia white; texture velvety and in some isolates floccose; sporulation sparse to moderately dense, conidia en masse dull green (27D3–27D4); soluble pigments absent; exudates absent; reverse light yellow (4A5–5A5). DG18 25 °C, 7 d: Colonies raised at centre, sunken in the centre, sulcate; margins low, plane, entire (1 mm); mycelia white; texture velvety; sporulation moderately dense to dense, conidia en masse dull green (27D3–27D4); soluble pigments absent; exudates in some isolates clear droplets at centre; reverse in some isolates centre orange white to pale orange (5A2–5A3), in some isolates centre greenish grey (1B2), in the margins greyish green to olive
Fig. 31. Morphological characters of *Talaromyces derxii* (CBS 412.89T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. b. Colony texture of on OA after 2 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 μm; C = 10 μm, applies to D–G.
Fig. 32. Morphological characters of Talaromyces diversus (CBS 320.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
(1C4–1D4–1E4). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–4 mm); mycelia white; texture velvety; sporulation sparse to moderately dense, conidia en masse dull green (27D3–27D4); soluble pigments absent; exudates absent; reverse very pale light greenish beige. CREA 25 °C, 7 d: No growth.

**Micromorphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 200–300 × 2.5–4 μm; branches 10–35 μm; metulae three to eight, divergent, 7–14 × 2.5–3(–5) μm; phialides aceros, three to six per metulae, 8–12 × 2–3 μm; conidia smooth to verrucose, ellipsoidal to subglobose, 2–3(–5) × 2–3(–3.5) μm. Ascomata not observed.

**Extriletes: Talaromyces diversus** have been reported to produce diversonol, α- and β-diversonol esters, isoaustin, austinol, alternariol monomethyl ether and lichenanthone (Turner 1978, Simpson et al. 1982, Holker et al. 1983). We have detected the alternariol monomethyl ether, diversonol, austins and mitorubicin acid in this species.

**Distinguishing characters:** Talaromyces diversus is distinguished from other species by weak, restricted growth on CYA, dull green (27D3–27D4) conidia, velvety texture on MEA and lack of growth on CREA (Fig. 32). Its restricted growth on CYA resembles *T. rademirici*, *T. erythromelis* and *T. primulins*, however growth on CYA at 37 °C and colony size on MEA at 25 °C easily distinguish *T. diversus* from these species.

**Talaromyces duclauxii** (Delacr.) Samson et al., Stud. Mycol. 71: 175. 2011. MycoBank MB560650. Fig. 33.

≡ *Penicillium duclauxii* Delacr., Bull. Soc. Mycol. France 7: 107. 1891.

**In:** Talaromyces section Talaromyces

**Typus:** IMI 24312, culture ex-type CBS 322.48 = ATCC 10439 = IMI 040044 = MUCL 28672 = MUCL 29094 = MUCL 29212 = NRRL 1030.

**ITS barcode:** JN899342 (alternative markers: *BenA*= JX091384; *CaM*= KF741955; *RPB2*= JN121491)

** Colony diam, 7 d (mm):** CYA 25–27; CYA 30 °C 34–35; CYA 37 °C 3–4; MEA 48–50; MEA 30 °C 40; DG18 17–18; CYAS No growth; OA 48–50; CREA 18–20; YES 43–44.

** Colony characters:** CYA 25 °C, 7 d: Colonies deep, raised at centre, slightly sulcate; margins low, plane, entire (2–3 mm); mycelia white and pastel yellow; texture fluffy appearance, synnematus; sporulation absent to sparse, conidia en masse difficult to determine; soluble pigments yellow; exudates absent; reverse olive brown (4E8) centre fading into olive brown (4D7) and maize yellow (4A6). MEA 25 °C, 7 d: Colonies very deep, raised and sunken at centre, synnemata produced on the margins; margins low, plane, entire (2–3 mm); mycelia white; texture velvety; sporulation sparse, conidia en masse greyish green (2SB5–2SC5); soluble pigments absent; exudates absent; reverse brown (6E8) centre fading into brownish yellow (5C7). YES 25 °C, 7 d: Colonies slightly raised at centre, concentrically sulcate; margins low, plane, entire (1–2 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse olive brown (4D6–4E6) centre fading into greyish yellow (4B6–4C6). DG18 25 °C, 7 d: Colonies raised at centre, slightly deep, slightly sulcate; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates small clear and yellow droplets; reverse yellowish brown (5E6–5F6) and yellow (3A6). OA 25 °C, 7 d: Colonies deep, raised, plane, sporulated synnemata produced; margins low, plane, entire (2–3 mm); mycelia white; texture synnematus; sporulation only on synnemata densely, conidia en masse greyish green to dull green (26D3–26D4); soluble pigments absent; exudates absent; reverse brownish yellow. CREA 25 °C, 7 d: Weak acid production.

**Micromorphology:** Synnemata deep fluffy structure, 2000–5000 μm long. Conidiophores biverticillate; stipes smooth walled, 15–50 × 3–5(–5.5) μm; metulae two to six, divergent, 8.5–15 × 2.5–5 μm; phialides acero, three to eight per metulae, 9–15 × 2–3.5 μm; conidia smooth to finely rough, ellipsoidal, 3–4 × 1.5–3.5(–4) μm. Ascomata not observed.

**Extriletes: Talaromyces duclauxii** produces duclauxin, xeno-oglucin and cryptoclauixin and related compounds (Shibata et al. 1965, Oghara et al. 1966).

**Distinguishing characters:** Talaromyces duclauxii is characterised by its rapid growth, colonies that are deep and have fluffy texture on MEA and synnemata up to 5000 μm long (Fig. 33). *Talaromyces palmae* produces indeterminate synnemata like those of *T. duclauxii*. However, *T. duclauxii* grows faster on CYA at 30 °C.

**Talaromyces emodensis** Udagawa, Mycotaxon 48: 146. 1993. MycoBank MB360476. Fig. 34.

≡ *Penicillium emodense* Udagawa, (simultaneously published).

**In:** Talaromyces section Bacillispori

**Typus:** CBM SUM-3025, culture ex-type CBS 100536 = IBT 14990.

**ITS barcode:** JN899337 (alternative markers: *BenA*= KJ865724; *CaM*= KJ885269; *RPB2*= JN121552)

** Colony diam, 7 d (mm):** CYA 8–10; CYA 30 °C 12–14; CYA 37 °C 4–6; MEA 8–10; MEA 30 °C 10–12; DG18 4; CYAS 2–3; OA 9–10; CREA 3–4; YES 9–10.

** Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, sulcate, pastel yellow appearance; margins low, plane, entire (1 mm); mycelia white and pastel yellow; sporulation absent; soluble pigments absent; exudates absent; reverse brownish red to reddish brown (8C8–8D8). MEA 25 °C, 7 d: Colonies raised, plane, white fluffy appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse reddish golden brown (6C7). YES 25 °C, 7 d: Colonies raised at centre, sulcate, yellow and white fluffy appearance; margins low, plane, entire (1 mm); mycelia white and yellow; sporulation absent; soluble pigments absent; exudates absent; reverse greyish orange to brownish orange (5BS–5CS). DG18 25 °C, 7 d: Colonies low, plane, white appearance; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent;
Fig. 33. Morphological characters of *Talaromyces duclauxii* (CBS 322.48T). A. Colonies from left to right (top row) CYA, MEA, DG16 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 1000 μm; C = 10 μm, applies to D–G.
Fig. 34. Morphological characters of *Talaromyces emodensis* (CBS 100536T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D–E. Asci and ascospores F. Ascospores. Scale bars: B = 1000 μm; C = 500 μm; D = 10 μm, applies to E–F.
reverse yellowish white (4A2). OA 25 °C, 7 d: Colonies low, plane, white appearance (at 30 °C formation of pastel yellow ascomata); margins low, plane, entire (1–2 mm); mycelia white and yellow; sporulation absent; soluble pigments absent; exudates absent; reverse pastel yellow. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores not observed here, *fide* Udagawa (1993), monoverticillate with a minor proportion having subterminal branches; stipes smooth walled, 18–60 × 2–2.5 μm; branches 15–25 μm; phialides acerose, one to three, 10–17.5 × 2–3 μm; conidia smooth, ovoidal to ellipsoidal, 3.4 × 1–1.5 μm. Ascomata maturing slowly within 4 wk on MEA at 25 °C, 100–250 μm, sulphur yellow, pastel yellow and creamish white, globose to subglobose, asci 8.8–11 × 7–9.5 μm, ascospores globose to subglobose, spiny, 2.5–4 × 2.5–3.5 μm.

Extrolites: Talaromyces emodensis produces duclauxin and mitorubrin.

Distinguishing characters: Talaromyces emodensis grows restrictedly on all media, produces small, globose to subglobose, spiny ascospores and conidiophores with solitary phialides to monoverticillate conidiophores (Fig. 34). Its restricted growth resembles *T. tardifaciens*, however, *T. tardifaciens* has smooth ascospores. The typical characters of *T. emodensis* distinguish it from other species that produce globose to subglobose, spiny ascospores such as *T. baclilissporus* and *T. rotundus*. The assexual state was not observed in our study.

**Talaromyces erythromellis** (A.D. Hocking) Samson et al., Stud. Mycol. 71: 175. 2011. MycoBank MB560652. Fig. 35.

≡ Penicillum erythromellis A.D. Hocking, The genus *Penicillum*: 459. 1980.

In: Talaromyces section Trachyspermi

**Typus**: IMI 216899, culture ex-typus: CBS 644.80 = FRR 1868 = IMI 216899.

**ITS barcode**: JN899383 (alternative markers: *BenA* = HQ156945; *CaM* = KJ885270; *RPB2* = KM023290)

**Colony diam, 7 d (mm)**: CYA 10–11; CYA 30 °C 13–14; CYA 37 °C No growth; MEA 10–11; MEA 30 °C 12–13; DG18 5–6; CYAS No growth; OA 15–16; CREA 4; YES 9.

Colony characters: CYA 25 °C, 7 d: Colonies raised at margins, sunken in the middle, pinkish colour; margins low, irregular (1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates red small droplets; reverse dark red to brownish red (10C8–10D8). MEA 25 °C, 7 d: Colonies raised at centre, sulphate; margins low, plane, entire (<1 mm); mycelia white; texture loosely furinoculous; sporulation moderately dense, conidia en masse greyish green to dull green (26C3–26D3); soluble pigments absent; exudates small red droplets; reverse dark brown (7F7). YES 25 °C, 7 d: Colonies raised, sulphate, pinkish red colour; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates small red droplets; reverse greyish orange (6B3–6B4). DG18 25 °C, 7 d: Colonies slightly raised, plane; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates clear droplets; reverse orange white (5A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire, yeast like slimy texture (3–4 mm); mycelia white; texture velvety and loosely floccose; sporulation moderately dense, conidia en masse dull green (26D3–26D4); soluble pigments absent; exudates absent; reverse media colour, beige. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology**: Conidiophores biverticillate having symmetric subterminal branches; stipes smooth walled, 20–80 × 2–3 μm; branches 13–45 μm; metulae two to six, divergent, 9–20 × 1.5–3 μm; phialides acerose, three to six per metulae, 8.5–15 × 1.5–2.5 μm; conidia subglobose to ellipsoidal, 2.3–3.5 × 1.5–2.5 μm. Ascomata not observed.

**Extralites**: Talaromyces erythromellis produces rubropunctatin.

Distinguishing characters: Talaromyces erythromellis grows restrictedly on all media studied. It produces red exudates on MEA and biverticillate conidiophores with additional subterminal branches (Fig. 35). Its restricted growth on CYA resembles *T. rademirici*, *T. diversus* and *T. primulinus*, however restricted growth on MEA and conidiophore branching pattern easily distinguish *T. erythromellis* from *T. diversus* and *T. primulinus* and growth on CREA distinguishes it from *T. rademirici*.

**Talaromyces euchlorocarpius** Yaguchi, Somaya & Udagawa, Mycoscience 40: 133. 1999. MycoBank MB460481. Fig. 36.

≡ Penicillum euchlorocarpium Yaguchi, Someya & Udagawa, (simultaneously published).

In: Talaromyces section Talaromyces

**Typus**: PF 1203, culture ex-type PF 1203 = DTO 176-I3 = DTO 176-I4.

**ITS barcode**: AB176617 (alternative markers: *BenA* = KJ86573; *CaM* = KJ885271; *RPB2* = KM023303)

**Colony diam, 7 d (mm)**: CYA 15–18; CYA 30 °C 14–17; CYA 37 °C No growth; MEA 38–40; MEA 30 °C 25–32; DG18 12–13; CYAS No growth; OA 20–23; CREA 9–11; YES 20–25.

**Colony characters**: CYA 25 °C, 7 d: Colonies slightly raised at centre, sulphate, in some isolates sunken at centre; margins low, plane, entire (1 mm); mycelia white and pastel yellow, especially in the centre; texture velvety; sporulation dense, conidia en masse greyish green to dull green (25C3–25D3); soluble pigments yellow to orange yellow; exudates absent; reverse reddish golden (6C7) centre fading into golden yellow (5B7) and deep yellow (4A8). MEA 25 °C, 7 d: Colonies low, slightly sulphate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture loosely furinoculous and floccose; sporulation moderately dense (at 30 °C dense), conidia en masse greyish green (28B5–28C5); soluble pigments absent; exudates absent; reverse greyish orange (5B5–5B6) with red (987) dots. YES 25 °C, 7 d: Colonies raised at centre, sulphate; margins low, plane, entire (1 mm); mycelia white and yellow; texture velvety and floccose; sporulation moderately dense to dense, conidia en masse greyish green (25D4–26D4); soluble pigments absent; exudates absent; reverse brownish yellow (5C7) centre fading...
Fig. 35. Morphological characters of *Talaromyces erythromellicus* (CBS 644.80T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 36. Morphological characters of *Talaromyces euchlorocarpus* (PF 1203³). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on Hay infusion agar after 1 wk incubation. C. Ascomata. D. Asci and ascospores. E. Initials. F–H. Conidiophores. I. Conidia. Scale bars: B = 500 μm; C = 10 μm; D = 10 μm; applies to F–I.
into light yellow (4A5). DG18 25 °C, 7 d: Colonies low, plane, slimy yeast like sterile white mycelia. OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white; texture velvety; sporulation sparse, conidia en masse greyish green (25C4) and dull green (25E4); soluble pigments deep yellow; exudates absent; reverse deep yellow. CREA 25 °C, 7 d: Acid production absent.

* **Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 100–150 × 1.5–2 μm; metulae three to six, divergent, 9–13 × 2–3.5 μm; phialides acerose, three to six per metulae, 8–14 × 2–3 μm; conidia smooth, subglobose to ellipsoidial, 2–4 × 2–3 μm. Ascoma maturing after 1–2 wk of incubation on hay infusion agar at 25 °C and abundantly 30 °C, deep green, globose to subglobose, 150–300 μm, asci 8–10 × 5–8 μm, ascospores ellipsoidial, spiny, 3.5–5 × 2.5–3 μm.

**Distinguishing characters:** *Talaromyces euklorocarpius* is characterised by yellow soluble pigment on CYA and OA, deep green ascoma and biverticillate conidiophores (Fig. 36). Green ascoma resembles *T. dux* and *T. viridis*, however, lack of growth at 37 °C distinguishes *T.euklorocarpius* from both. In addition, *T. viridis* produces conidiophores with solitary phialides, whereas *T.euklorocarpius* produces biverticillate conidiophores.

**Talaromyces flavivirens** (Durieu & Mont.) Visagie, Límona & Seifert, Mycotaxon 122: 404. 2012. MycoBank MB800438. Fig. 37.

≡ Lasioderma flavivirens Durieu & Mont., Ann. Sci. Nat., Bot. 4: 364. 1845.
≡ Penicillium aureocephalum Munt.-Cvetk. et al., Fungal Divers. 7: 73. 2001.

**In:** Talaromyces section Talaromyces

**Typus:** Lectotype PC 0088796; epitype BCC 473 = BCN 473, culture ex-type CBS 102801 = IBT 27044.

**ITS barcode:** JN899392 (alternative markers: BenA = JX091376; CaM = KF741933)

**Colony diam, 7 d (mm):** CYA 19–20; CYA 30 °C 21–22; CYA 37 °C 5–6; MEA 37–38; MEA 30 °C 37–38; DG18 12–13; CYAS No growth; OA 38–40; CREA 15; YES 21–22.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white; texture velvety; sporulation dense, conidia en masse dull green (26D4–27D4); soluble pigments absent; exudates absent; reverse greyish red (9C5) centre fading into greyish yellow (4B3). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (4–5 mm); mycelia yellow; texture velvety and floccose, centre covered with yellow mycelia; sporulation moderately dense, conidia en masse greyish green to dark green (27E5–27F5); soluble pigments absent; exudates small yellow and clear droplets; reverse pale greyish red. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Synnemata up to 750 μm long, appearance to stipitate sporangia and covered with bright yellow layer. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 90–350 × 2–3 μm; branches 10–35 μm; metulae four to six, divergent, 9–15 × 2–3 μm; phialides acerose, three to eight per metulae, 8–12 × 2–3 μm; conidia smooth to finely rough, ellipsoidial, 2.5–3.5(–5.5) × 2–2.5(–4) μm. Ascoma production was reported by Visagie *et al.* (2012) from burned *Quercus suber* leaf litter. Ascoma golden yellow with a reddish pigment, only produced on *Quercus suber* leaf litter in nature, globose to subglobose, 150–380 μm, asci absent, ascospores ellipsoidial, thick walled, spiny, (4–)4.5–(6–)7 × 3–4 μm.

**Extrites:** Talaromyces flavivirens produces mitorubrin, mitorubrinol, mitorubrinic acid, a purpactin, secalonic acid D and vermicillin.

**Distinguishing characters:** *Talaromyces flavivirens* produces yellow ascoma with spiny, ellipsoidial ascospores on *Quercus suber* and rarely on *Q. ilex* and *Cistus salviifolius* leaf litter and all cultures originate from Catalonia, Spain. No ascoma were observed in uncrossed or crossed cultures on general media. Colonies produce characteristic yellow mycelial layers that resemble *T. marneffei* and *T. primulinus*. However *T. marneffei* produces red soluble pigment on MEA and CYA, and it produces a yeast phase at 37 °C. *Talaromyces primulinus* grows slower on all media studied.

**Notes:** Visagie *et al.* (2012) introduced *T. flavivirens*, describing it as the sexual state of *P. aureocephalum* and synonymising the latter.

**Talaromyces flavus** (Klöcker) Stolk & Samson, Stud. Mycol. 2: 10. 1972. MycoBank MB324416. Fig. 38.

≡ Gymnoascus flavus Klöcker, Hedwigia 41: 80. 1902.
≡ Penicillium vermiculatum P.A. Dang., Botaniste 10: 123. 1907 ≡ *Talaromyces vermiculatus* (P.A. Dang.) C.R. Berj., Mycologia 47: 684. 1955.
≡ Arachniotus indicus Chattop. & C. Das Gupta, Trans. Brit. Mycol. Soc. 42: 72. 1959.
≡ Arachniotus indicus Chattop. & C. Das Gupta var. major Chattop. & C. Das Gupta, Trans. Brit. Mycol. Soc. 42: 73. 1959.
≡ Penicillium dangeardii Pitt, The Genus *Penicillium*: 472. 1980.

**In:** Talaromyces section Talaromyces

**Typus:** CBS H–7820, culture ex-type CBS 310.38 = IMI 197477 = NRR 2098. 

**ITS barcode:** JN899360 (alternative markers: BenA = JX494302; CaM = KF741949; RP2B = J417426)
Fig. 37. Morphological characters of Talaromyces flavovirens (CBS 110280T). A. Colonies from left to right (top row) CYA, MEA, DG18 and QA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 3 wk incubation. C–F. Conidiophores. G. Conidia. Scale bars: B = 500 μm; C = 10 μm, applies to D–G.
Fig. 38. Morphological characters of Talarmyces flavus (CBS 310.38T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata D. Ascomata and asci. E. initials. F. Conidiophores. G. Asci and ascospores. H. Ascospores. Scale bars: B–D = 500 μm; E = 10 μm, applies to F–H.
Colony diam, 7 d (mm): CYA 9–10; CYA 30 °C 17–18; CYA 37 °C 19–20; MEA 31–32; MEA 30 °C 40–45; DG18 13; CYAS No growth; OA 30–32; CREA 7–9; YES 24–26.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (2 mm); mycelia white and bright yellow; texture floccose; sporulation absent; soluble pigments yellow; exudates absent; reverse brownish orange (5C6) fading into light yellow (3A5). MEA 25 °C, 7 d: Colonies low, plane, formation of yellow ascomata (at 30 °C more abundant); margins low, plane, entire (2–3 mm); mycelia white, yellow and red; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse greyish orange (5B6–5B6). YES 25 °C, 7 d: Colonies slightly raised at centre, sometimes sunken at centre, slightly sulcate; margins low, plane, entire (3–4 mm); mycelia white, yellow and red; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse orange (5A6) fading into reddish yellow (4A6). DG18 25 °C, 7 d: Colonies raised at centre, plane; margins low, plane, entire (1–2 mm); mycelia white; texture floccose and funiculose; sporulation absent; soluble pigments absent; exudates absent; reverse pale orange to greyish orange (5A3–5B3) centre fading into yellowish white (4A2). OA 25 °C, 7 d: Colonies low, plane, yellow ascomata formation; margins low, plane, entire (2 mm); mycelia white and yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish orange and fading into yellow. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores asexual state lacking, when present mononervicillate; stipes smooth walled, 15–20 × 1.9–20 μm; phialides acerosus, one to three, 11–12 × 2–2.5 μm; conidia smooth, ellipsoidal, 2–3 × 1.5–2.5 μm. Ascomata maturing after 1–2 wk of incubation on OA and MEA at 25 °C and abundantly 30 °C, deep yellow, globose to subglobose, 150–400 μm, asci 9.5–13.5 × 8–11.5 μm, ascospores broadly ellipsoidal, thick walled, spiny, 4–5.5 × 3–3.5 μm.

Extritites: Talaromyces flavus produces 3-hydroxymethyl-6,8-dimethyl-2,5-dimethyl-7-hydroxychromone, (--)trans-2,3-epoxyxycoumarin, 2,5-dimethyl-7-hydroxychromone, (--)trans-3,2,3-dihydroxy-5-methylphthalide, funiculosic acid, hydroxyfuniculosic acid, vermistatin = fijensin and related compounds, altenusin, dehydroaltenusin, desmethyldehydroaltenusin, talaroflavon, deoxytalaroflavon, (--)mitorubrin, (--)mitorubrinol, (--)mitorubrinic acid, (--)diazaphilonic acid, vermixocin A (= penicillide) & vermixocin B (= purpac tin A), vermiculine, vermiculic acid, 4-deoxyvermiculic acid, vermicillin, TAN-2177A & B (Proksa 2010). Talaromyces flavus also produces unique polysaccharides such as talaron, which is fungicidal and a series of enzymes (Proksa 2010). The species has been used for biological pest control (Proksa 2010). Distinguishing characters: Talaromyces flavus produces deep yellow ascomata and thick walled, spiny, broadly ellipsoidal ascospores (Fig. 38). It produces mononervicillate conidiophores that do not sporulate profusely. Colonies on CYA grow restrictedly (9–10 mm) after 7 d at 25 °C. This distinguishes it from T. macrosporus, T. muroii and T. liani. Talaromyces tratensis, T. convolutus, T. austrocalifornicus also grow restrictedly on CYA, but bigger ascospores (4.2–5.2 × 3–3.6 μm) easily distinguish T. flavus from the latter species.

Notes: Penicillium vermiculatum was described by Dangeard (1907) and transferred to Talaromyces by Benjamin (1955). Orr et al. (1963) considered Gymnoascus flavus and T. vermiculatus as synonyms and this was followed by Stolk & Samson (1972) and Pitt (1980). Ghosh et al. (1961) re-evaluated the type strains of Arachniotus indicus and A. indicus var. major and both isolates proved to represent Talaromyces vermiculatus and therefore they synonymised it with T. flavus. In our study we also concur with this.

Talaromyces funiculosus (Thom) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560653. Fig. 39.

In: Talaromyces section Talaromyces Typus: IMI 193019, culture ex-type CBS 272.86 = IMI 193019.

ITS barcode: JN899377 (alternative markers: BenA = JX091383; CaM = KF741945; RPB2 = KM023293)

 Colony diam. 7 d (mm): CYA (30–38)–45; CYA 30 °C (35–45)–55; CYA 37 °C 38–50; MEA 30–45; MEA 30 °C 40–55; DG18 13–20; CYAS 13–20, some strains no growth; OA 30–40; CREA (15–) 20–30; YES 35–45.

Colonial characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent to moderately dense, conidia en masse greyish green to dull green (26D3–26D4); soluble pigments only in DTO 60-E7 and DTO 50-F6 soluble light red pigment the rest absent; exudates clear droplets; reverse light orange to greyish orange (5A4–5B4) centre fading into greyish yellow (4B3), in some isolates, centre changes to greyish orange to brownish orange (5B5–5CS) and in red pigment producers brownish red (9C7) reverse. MEA 25 °C, 7 d: Colonies moderately deep, plane; margins low, plane, entire (2 mm); mycelia white; texture funiculose; sporulation sparse to dense, conidia en masse greyish green to dull green (26D3–26D4); soluble pigments absent; exudates absent; reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (2 mm); mycelia white; texture in some isolates sterile aerial mycelia grows like funiculose; sporulation absent; soluble pigments only in DTO 60-E7 light red; exudates in some isolates clear droplets; reverse greyish orange (5B5) centre fading into pastel yellow (3A4), and in red pigment producer (DTO 60-E7) greyish red (9B6) centre and in the margins red (9B7). DG18 25 °C, 7 d: Colonies moderately deep, plane; margins low, plane, entire (1 mm); mycelia white; texture in some isolates funiculose, in some isolates no sporulation slimy yeast like colonies; sporulation in some isolates absent, in some isolates dense, conidia en masse greyish green to dull green (26D3–26D4); soluble pigments absent; exudates small clear droplets; reverse in some isolates centre greyish green (26D3–26D4); in red isolates dense, conidia in some isolates slightly brownish to dull brown; in red isolates dense, conidia en masse greyish green to dull green
Fig. 39. Morphological characters of Talaromyces funiculosus (CBS 883.70). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 1 wk incubation. C–G. Conidiophores. H. Conidia. Scale bars: C = 50 μm; D = 10 μm, applies to E–H.
(26D3–26D4); soluble pigments absent; exudates in some isolates small clear droplets; reverse in some isolates greyish green, in some isolates brownish orange. CREA 25 °C, 7 d: Strong acid production.

**Micromorphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 15–100 × 2–3.5 μm; branches 8–18 μm; metulae three to six, divergent, 6.5–11 × 2–4 μm; phialides acerose, three to eight per metulae, 7.5–11 × 1.5–2.5 μm; conidia smooth, ellipsoidal, 2–3(–5.5) × 1–2(–2.5) μm. Ascomata not observed.

**Extrolves:** Strain NRRL 1033 = CBS 169.91 produces secalonic acid D and nonadride metabolites, while NRRL 1035 = CBS 171.91 produces pestalacin A, while all strains examined produce a specific extrolute, that has not been structure elucidated.

**Distinguishing characters:** Talaromyces funiculosus characteristically produces colonies that are strongly funiculose (Fig. 39). It shows fast growth on general media and at 37 °C, and produces strong acid on CREA. All these characters distinguish T. funiculosus from other Talaromyces species.

**Talaromyces galapagensis** Samson & Mahoney, Trans. Brit. Mycol. Soc. 69: 158. 1977. MycoBank MB324417. Fig. 40. ≡ Penicillium galapagensis Samson & Mahoney, (simultaneously published).

In: Talaromyces section Talaromyces

**Typus:** CBS H-7489, culture ex-type CBS 751.74 = IFO 31796. ITS barcode: JN899358 (alternative markers: BenA = JX091388; CaM = KF741966)

**Colony diam, 7 d (mm):** CYA 15–17; CYA 30 °C 23–27; CYA 37 °C 25–26; MEA 25–28; MEA 30 °C 33–35; DG18 4–5; CYAS No growth; OA 25–28; CREA No growth; YES 15–17.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, sulphate; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse dark brown (6F6) centre fading into yellowish white (3A2). MEA 25 °C, 7 d: Colonies low, sulphate; margins low, plane, entire (1–2 mm); mycelia white and pastel yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse dark brown (6F6) centre fading into light yellow to light orange (4A4–5A5). YES 25 °C, 7 d: Colonies raised, sulphate, pinkish red colour; margins low, plane, entire (1 mm); mycelia white and pale red; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse mustard brown (5E6) centre fading into brownish orange (5C5). DG18 25 °C, 7 d: Colonies no sporulation colonies up to 4 mm. OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish orange. CREA 25 °C, 7 d: No growth.

**Micromorphology:** Conidiophores biverticillate and monocentric; stipes smooth walled, (40–)70–100(–200) × 1.6–2.5 μm; metulae two to five, divergent, 8.5–12 × 2.5–3.5 μm; phialides acerose, three to five per metulae, 7.5–12(–15) × 2–3 μm; conidia smooth, ovoidal to ellipsoidal, 2.5–5 × 1.5–3 μm. Ascomata fide Samson & Mahoney (1977), abundantly produced on OA at 30 °C, within 2 wk, at first white to cream after prolonged incubation yellow or reddish, globose to subglobose, 150–400 μm, asci 15–19 × 15–19 μm, ascospores broadly ellipsoidal, spiny, 7–10 × 5.5–8 μm.

**Extrolves:** Apiculides have been found in T. galapagensis.

**Distinguishing characters:** Talaromyces galapagensis produces distinct ascospores, which are broadly ellipsoidal, thick walled and ornamented with ridges. Its ascospores are much bigger (7–10 × 5.5–8 μm) than ascospores of T. stipitatus, T. unicus, T. ucrainicus and T. mimosinus, which have similar ridges as T. galapagensis. The ex-type strain of T. galapagensis was degenerated and did not produce ascocoma.

**Talaromyces hachijoensis** Yaguchi, Someya & Udagawa, Mycoscience 37: 157. 1996. MycoBank MB416016.

In: Talaromyces section Proteolyticus

**Typus:** PF 1174, culture ex-type PF 1174 = IFM 53624.

**ITS barcode:** AB176620

**Colony diam, 7 d (mm):** Fide Yaguchi et al. (1996) CYA 3; CYA 37 °C No growth; MEA 8–10; OA: 5–8.

**Colony characters:** Fide Yaguchi et al. (1996) colonies on CYA growing very restrictedly, attaining a diameter of 3 mm in 7 d and 10–12 mm in 14 d at 25 °C, velvety to somewhat funiculose, almost plane, consisting of a compact basal felt, producing abundant ascocoma on the felt within 21 d, light yellow (3A5), overgrown by pigmented aerial hyphae; margins entire, narrow; sporulation absent; exudates small, clear; reverse brownish orange (5C6). Colonies on MEA growing restrictedly, attaining a diameter of 8–10 mm in 7 d and 17–20 mm in 14 d at 25 °C, velvety to floccose, centrally raised, consisting of a thick basal felt; mycelia white to light yellow (2A5); ascocoma very limited in number; sporulation absent; exudate abundant, clear to pale brown; margins entire; reverse greyish orange (5B4). Colonies on OA growing restrictedly, attaining diameter of 5–8 mm in 7 d and 15–17 mm in 14 d at 25 °C, radially sulphate, more or less zonate, consisting of a thin basal felt with funiculose aerial hyphae, granular due to abundant production of ascocoma within 21 d, pastel yellow (3A4); margins thin, broad, entire; sporulation absent; exudate abundant, clear, rather large; reverse greyish orange (5B4).

**Micromorphology:** Fide Yaguchi et al. (1996) asexual state not observed. Ascocoma discrete or often confluent, yellow, maturing slowly within 21 d, globose to subglobose, 300–350 μm in diam; asci globose to ovoidal, 10.5–12.5 × 9–11 μm, evanescent. Ascospores ellipsoidal, 5.5–7 × 3.5–4.5 μm, ridges bearing 12–15 longitudinal, somewhat sinus ridges about 0.5 μm wide, usually covering at the two end.

**Notes:** According to Yaguchi et al. (1996), the outstanding characters of T. hachijoensis are its extremely restricted growth on CYA, colony colouration on CYA and OA, production of yellow
Fig. 40. Morphological characters of Talaromyces galapagensis (CBS 751.74T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 2 wk incubation. C–G. Conidiophores. H. Conidia. Scale bars: B = 100 μm; C = 10 μm, applies to D–H.
ascomata with ellipsoidal, striate ornamented ascospores and absence of conidiophores.

**Talaromyces helicus** (Raper & Fennell) C.R. Benj., Mycologia 47: 684. 1955. MycoBank MB306715. Fig. 41.

≡ Penicillium helicum Raper & Fennell, Mycologia 40: 515. 1948.
= *Talaromyces helicus* var. major Stolk & Samson, Stud. Mycol. 2: 19. 1972.
= *Talaromyces bacinensis* Yaguchi & Udagawa Trans. Mycol. Soc. Japan 34: 15. 1993 ⩾ Penicillium bacinense Yaguchi & Udagawa Trans. Mycol. Soc. Japan 34: 15. 1993

In: *Talaromyces* section *Helici*

**Typus:** IMI 040593, culture ex-type CBS 335.48 = ATCC 10451 = DSM 3705 = IMI 040593 = NRRL 2106.

**ITS barcode:** JN899359 (alternative markers: *BenA* = KJ865725; *CalM* = KJ885289; *RPB2* = KM023273)

**Colony diam, 7 d (mm):** CYA 13–23; CYA 30 °C 18–28; CYA 37 °C 10–18 (DTO 56-A8 no growth); MEA 25–33; MEA 30 °C 35–40; DG18 5–12; CYAS No growth; OA 23–35; CREA No growth; YES 14–22.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1–2 mm); mycelia white and pale orange; texture floccose; sporulation absent to moderately dense, conidia *en masse* greyish green (25B3); soluble pigments absent; exudates absent; reverse in some isolates centre greyish red (9B6) and in some isolates yellowish brown (SE4) centre fading into greyish orange (SB3) and yellowish white (AA2), MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation moderately dense, conidia *en masse* greyish green (26B3); soluble pigments absent; exudates absent; reverse in some isolates brownish orange (6C6) and in some isolates yellowish brown (5D5) centre fading into brownish orange (5C5), YES 25 °C, 7 d: Colonies sunken at centre, sulcate, sterile white appearance; margins low, plane, entire (1 mm); mycelia white; sporulation absent to sparse; soluble pigments absent; exudates absent; reverse shades of dull green (27E4) fading into between pale yellow (4A3) and pale orange (5A3). DG18 25 °C, 7 d: Colonies low to slightly raised at centre, plane, white mycelia appearance; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (4A2). OA 25 °C, 7 d: Colonies low, plane, start to produce white and in some isolates yellow ascomata at 30 °C ascomata is more abundant; margins low, plane, entire (3–5 mm); mycelia white and bright yellow; texture floccose; sporulation sparse to moderately dense, conidia *en masse* greyish green (26B3); soluble pigments absent; exudates absent (at 30 °C clear droplets); reverse beige and pale yellow (at 30 °C bright orange), CREA 25 °C, 7 d: No growth.

**Micromorphology:** Conidiophores biverticillate and monoverticillate; stipes smooth walled, 30–60(–80) × 2–2.5 μm; metulae two to five, divergent, 12–15 × 2–2.5 μm; phialides acerose, two to four per metula, 8.5–12(–16) × 2.5–3 μm; conidia smooth, globose to subglobose, 2.5–3.5(–4.5) × 2.2–3.5 μm. Ascomata maturing within 1–2 wk on OA at 25 °C and at 30 °C abundantly, 100–300 μm, yellow, pastel yellow and creamish white, usually globose and sometimes subglobose, asci 6–9 × 4.5–6 μm, ascospores ellipsoidal, usually smooth, in some with minute spines, 2.5–4 × 2–3 μm.

**Extrolites:** *Talaromyces helicus* produces helicusins (Yoshida et al. 1995) and italinic acid.

**Distinguishing characters:** *Talaromyces helicus* is distinguished by its creamish white to yellow ascomata that are covered with yellow mycelia and produces smooth, ellipsoidal ascospores and mono- to biverticillate conidiophores with a green stipe (Fig. 41). It grows relatively fast on CYA and MEA and does not grow on CREA. Its smooth, ellipsoidal ascospores distinguish *T. helicus* from the other creamish white to yellow ascoma producers. Its green stipes resemble *T. varians*, however, *T. helicus* produces ascomata and *T. varians* does not. Also, *T. varians* produces cylindrical to ellipsoidal conidia, whereas *T. helicus* produces globose to subglobose conidia.

**Notes:** *Talaromyces bacinensis* (CBS 649.95) and *T. helicus* var. major (CBS 652.66) are phylogenetically identical to *T. helicus* (Fig. 1) and are considered synonyms.

**Talaromyces indicotigum** Takada & Udagawa, Mycotaxon 46: 129. 1993. MycoBank MB359290. Fig. 42.

≡ Penicillium indicotignum Takada & Udagawa, (simultaneously published).

**Holotypus:** CBM SUM-3010, culture ex-type CBS 100534 = IBT 17590.

**ITS barcode:** JN899331 (alternative markers: *BenA* = JX494308; *CalM* = KF741931)

**Colony diam, 7 d (mm):** CYA 20–21; CYA 30 °C 24–25; CYA 37 °C 20–22; MEA 32–33; MEA 30 °C 43–45; DG18 9–11; CYAS No growth; OA 15–17; CREA 13–15; YES 28–30.

**Colony characters:** CYA 25 °C, 7 d: Colonies low, plane, pinkish white appearance; margins low, plane, entire (1 mm); mycelia white and red pigmented (red crystal on mycelia); texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse pale orange (5A3) centre fading into yellowish white (4A2), MEA 25 °C, 7 d: Colonies deep, plane, has a characteristic smell, fluffy white appearance; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (10D8) centre fading into red (10B8). YES 25 °C, 7 d: Colonies deep to low, plane, has a characteristic smell, fluffy white and pale pink appearance; margins low, plane, entire (1 mm); mycelia white and pastel red; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse orange (5A3) centre fading into yellowish white (4A2). DG18 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation sparse, conidia *en masse* greyish green (25B4–25C4); soluble pigments absent; exudates absent; reverse pale yellow to light yellow (4A3–4A4). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent;...
Fig. 41. Morphological characters of *Talaromyces helicus* (CBS 335.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascospores. E. Initials. F–H. Conidiophores. I. Ascospores. J. Conidia. Scale bars: B = 500 μm; C = 250 μm; D = 10 μm, applies to E–J.
Fig. 42. Morphological characters of Talaromyces indogoticus (CBS 100534T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Initials. C–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
reverse creamish white, beige. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate and monoverticillate; stipes smooth walled, 10–75 × 2–3 μm; metulae two to four, divergent, 8–12 × 2–2.8 μm; phialides aceroso, three to five per metulae, 8–14.5 × 2–3 μm; conidia smooth, ovoidal to ellipsoidal, 2.4–4 × 2.3–3.2 μm. Ascomata not observed in our culture however, *fide Takada & Udagawa* (1993) maturing after 1–2 wk of incubation, yellow to orange, globose to subglobose, 350–550 μm, ascii 9–12.5 × 7.5–10 μm, ascospores indigo blue, ellipsoidal, spiny, 3.5–5 × 2.5–3 μm.

**Distinguishing characters:** *Talaromyces indigoticus* produces yellow to orange ascomata with indigo blue, spiny, ellipsoidal ascospores and mono- to biverticillate conidiophores with short stipes. It grows fast at 30 °C. Blue ascospores have never been reported in other *Talaromyces* species. The *T. indigoticus* strain available for this study, has lost its ability to produce ascomata.

*Talaromyces intermedius* (Apinis) Stolk & Samson, Stud. Mycol. 2: 21. 1972. MycoBank MB324418. Fig. 43. = Penicillium intermedium Stolk & Samson, (simultaneously published).

**In:** Talaromyces section Talaromyces

**Typus:** CBS H-7828, culture ex-type CBS 152.65 = BDUN 267 = IFO 31752 = IMI 100874.

**ITS barcode:** JN899332 (alternative markers: BenA = JX091387; CaM = KJ885290)

** Colony diam, 7 d (mm):** CYA 15–16; CYA 30 °C 7–8; CYA 37 °C No growth; MEA 48–50; MEA 30 °C 24–26; DG18 5–6; CYAS No growth; OA 34–35; CREA No growth; YES 28–30.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, plane, entire; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse greyish yellow (3B4). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (5 mm); mycelia white and pastel yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse apricot yellow (5B6). YES 25 °C, 7 d: Colonies sunken at centre, sulcate; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5AS) fading into yellowish white (4A2). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (4A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (5–8 mm); mycelia white; texture floccose, young ascomata produced; sporulation absent; soluble pigments absent; exudates absent; reverse pastel pinkish white. CREA 25 °C, 7 d: No growth.

**Micromorphology:** Conidiophores lacking or sparse on all media, best development on hay-infusion agar. When present monoverticillate or with solitary phialides; stipes smooth walled, 4–30 × 1.5–2 μm; phialides flask-shaped to aceroso, one to three, 12–20 × 1.5–2 μm; conidia smooth, ellipsoidal, 2.5–4.5 × 2.2–3.5 μm. Ascomata maturing within 1–2 wk on OA at 25 °C and at 30 °C abundantly, 300–1000 μm, at first creamish white and then becoming pastel pink, globose, ascii 11–16 × 10–14 μm, ascospores broadly ellipsoidal, thick walled, spiny, 4.5–7 × 3.5–5.5 μm.

**Distinguishing characters:** *Talaromyces intermedius* produces creamish white to pastel pink ascomata, grows restrictedly on CYA and DG18, has conidiophores with solitary phialides and does not grow on CREA (Fig. 43). It produces thick walled ascospores that are spiny and ellipsoidal. Its ascomata resemble *T. trachyspermus* and *T. assiutensis*, but *T. intermedius* differs from the latter species by conidiophores that have solitary phialides, as well as producing bigger ascospores (4.5–7 × 3.5–5.5 μm).

*Talaromyces islandicus* (Sopp) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560654. Fig. 44.

≡ Penicillium islandicum Sopp. Skr. Vidensk.-Selsk. Christiania, Math.-Naturvidensk. Kl. 11: 161. 1912.
≡ Penicillium aurantiocanum C. Ramirez, A.T. Martinez & Berer, Mycopathologia 72: 28. 1980.

**In:** Talaromyces section Islandici

**Typus:** IMI 040042, culture ex-type CBS 338.48 = ATCC 10127 = IMI 040042 = MUCL 31324 = NRRL 1036 = IBT 14884 = IBT 4476.

**ITS barcode:** KF984885 (alternative markers: BenA = KF984655; CaM = KF984780; RP2B = KF985018)

** Colony diam, 7 d (mm):** CYA 20–27; CYA 30 °C 20–28; CYA 37 °C 8–17; MEA 21–26; MEA 30 °C 20–28; DG18 15–25; CYAS 10–20; OA 20–30; CREA 7–11; YES 22–30.

**Colony morphology:** CYA 25 °C, 7 d: Colonies raised at centre, crateriforme; margins narrow (1–2 mm), low, entire, plane; mycelium white, yellow and orange; texture velvety and in some isolates loosely funiculose; sporulation sparse to dense; conidia *en masse* greyish green to dull green (26C3–26D3) (and for DTO 2-C7 dark green (26F4)); exudates big clear droplets in the strains which are not sporulating well; soluble pigment absent; reverse brown (7E4) in the centre fading into light yellow to light orange (4A4–5A4), in some isolates lack of reverse colour (CBS 338.48**).** MEA 25 °C, 7 d: Colonies slightly raised at centre, crateriforme; margins narrow (1–2 mm), low, entire, plane; mycelium white and orange; texture velvety and in some isolates loosely funiculose, especially in the centre conidiophores born from aerial hyphae; sporulation sparse to dense; conidia *en masse* greyish green to dull green (26C3–26D3) (and for DTO 2-C7 dark green (26F4)); exudates big clear droplets in the strains which are not sporulating well; soluble pigment absent; reverse brownish orange (6C7) and in some isolates brown (7E6) fading into brownish orange (7C7). YES 25 °C, 7 d: Colonies raised at centre, crateriforme; margins narrow (1–2 mm), low, entire, plane; mycelium white and orange; texture velvety to floccose; sporulation absent to dense; conidia *en masse* greyish green to dull green to dark green (26E4–26F4 to 26C3–26C4); exudates big clear and yellow droplets in the strains which are not sporulating well; soluble pigment absent; reverse brownish orange (6C7) and in some isolates brown (7E6) fading into brownish orange (7C7). YES 25 °C, 7 d: Colonies very raised at centre, slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and orange; texture velvety to floccose; sporulation absent to dense; conidia *en masse* greyish green to dull green to dark green (26E4–26F4 to 26C3–26C4); exudates big clear droplets in the strains which are not sporulating well; soluble pigment absent; reverse brownish orange (6C5–6C8). DG18 25 °C, 7 d: Colonies very slightly raised at centre, slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and orange; texture velvety to floccose; sporulation absent to dense; conidia *en masse* greyish green to dull green to dark green (26E4–26F4 to 26C3–26C4); exudates big clear droplets in the strains which are not sporulating well; soluble pigment absent; reverse brownish orange (6C5–6C8). DG18 25 °C, 7 d: Colonies very slightly raised at centre, slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and orange; texture velvety to floccose; sporulation absent to dense; conidia *en masse* greyish green to dull green to dark green (26E4–26F4 to 26C3–26C4); exudates big clear droplets in the strains which are not sporulating well; soluble pigment absent; reverse brownish orange (6C5–6C8).
Fig. 43. Morphological characters of *Talaromyces intermedius* (CBS 152.85). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CRE. B. Colony texture and ascomata on OA after 2 wk incubation. C–D. Ascomata. E. Conidiophores. F. Initials. G. Asci and ascospores. H. Ascospores. Scale bars: B, C = 500 μm; D = 100 μm; E = 10 μm, applies to F–H.
Fig. 44. Morphological characters of Talaromyces islandicus (CBS 338.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
velvety especially in the centre conidiophores born from aerial hyphae; sporulation sparse to dense; conidia en masse dark green (27F4); exudates absent; soluble pigment absent; reverse reddish brown (8ES) in the centre fading into golden yellow (5B7) to light yellow (4A4S). OA 25 °C, 7 d: Colonies low, plane; margins wide (2–3 mm), low, entire, plane; mycelium white and orange; texture velvety; sporulation dense; conidia en masse dull green to dark green (27F4 to 27D3–27D4); exudates big clear and yellow droplets in the strains which are not sporulating well; soluble pigment absent (except DTO 158-D6 and DTO 2-C7 weak red soluble pigment); reverse brownish orange (6C7) and in some isolates red and in some isolates reddish orange in the centre fading into green. CREA, 25 °C, 7 d: Strong acid production.

**Micromorphology:** Conidiophores biverticillate often additional branches occur; stipes smooth walled, 20–200 × 2.5–3.5 μm; with extra branches 13–30 μm; metulae three to six, divergent, 6–12 × 2.3–3.2 μm; phialides acerose, three to six per metulae, 7–10 × 1.5–3 μm; conidia smooth, ellipsoidal, 2.5–6 × 2.4–5 μm.

**Extriotics:** 3-hydrophthalic acid (Gatenbeck 1957), islandicin = 1,4,5-trihydroxy-2-methylanthraquinone (Howard 1948, Howard & Raistrick 1949); chrysophanic acid (Howard & Raistrick 1950); skyrin and flavoskyrin (Howard & Raistrick 1954a); indoskyrin and (−)-rubroskyrin (Howard & Raistrick 1954b, Takeda et al. 1973), endocorcin (Gatenbeck 1959), emodin (Gatenbeck 1958, Sankawa et al. 1984); (−)-luteoskyrin (Yamamoto et al. 1954a); iridoskyrin and (−)-luteoskyrin (Yamamoto et al. 1954a); chrysophanic acid (Howard & Raistrick 1950); skyrin and (−)-luteoskyrin (Yamaguchi et al. 1954a–b); (−)-luteoskyrin (Yamaguchi et al. 1954a–b); skyrinol, (−)-deoxyrubroskyrin, (−)-deoxyluteoskyrin, (−)-4a-oxyluteoskyrin (Ogihara et al. 1968, Takeda et al. 1973); islandic acid I & II (Fujimoto et al. 1982); pibasterol (Ghosh et al. 1978a); cyclochloritrin = islanditoxin = chlorine containing peptide = chloropeptide and simatoxin (Marumo & Sumiki 1955, Uraguchi et al. 1961, 1972, Ghosh et al. 1978b). Extriotics detected in this study (in CBS 338.48; NRRL 1036; CBS 165.81; IBT 12897; IBT 15605; FRR 3445; FRR 3606; CBS 189.68 and CBS 117284): erythroskyrin, islandicin, luteoskyrin, mitorubicin acid and other special mitorubrins, rugulosin & skyrin. UV spectra indicated that *T. islandicus* can also produce wortman-nilactone E-H, in addition to some extriotics unique to this species.

**Distinguishing characters:** *Talaromyces islandicus* is characterised by relatively fast growing colonies compared to other species in section *Islandici*. *Talaromyces islandicus* has bright orange mycelia and produces colonies with orange reverses on most media. Based on the *ITS* and *BenA* phylogenies, *T. islandicus* has *T. loliensis* as a close relative. *Talaromyces islandicus* differs from *T. loliensis* by the production of acid on CREA, its faster growth and wider conidiophores.

**Notes:** Phylogenetically *P. aurantioclaviformis* (CBS 165.81) is identical to *T. islandicus* (Fig. 7) and is considered a synonym.

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**Talaromyces liani** (Kamyschko) Yilmaz, Frisvad & Samson, **comb. nov.** MycoBank MB809555. Fig. 45. **Basionym:** Penicillium liani Kamyschko, Not. Syst. Crypt. Inst. bot. Acad. Sci. USSR 15: 86. 1962.

= *Talaromyces thermoclitinus* Subrahm. & Gopalkr., Ind. Bot. Reporter 35: 35. 1984 [as *thermoclitinus*].

**In:** *Talaromyces* section *Talaromyces*

**Typus:** Unknown, culture ex-type CBS 225.66 = ATCC 18325 = ATCC 18331 = IMI 098480 = NRRL 3380 = VKM F-301.

**ITS barcode:** JN899395 (alternative markers: *BenA* = JX091380; *CaM* = JX885257)

**Colonial diam.** 7 d (mm): CYA 20–30; CYA 30 °C 25–37; CYA 37 °C 20–25; MEA 35–45; MEA 30 °C 50–55; DG18 10–17; CYAS No growth; OA 35–40; CREA 10–20; YES 35–40.

**Colonial characters:** CYA 25 °C, 7 d: Colonies raised at centre, slightly sulcate, white and pastel yellow appearance; margins low, plane, entire; mycelia white and pastel yellow; texture; sporulation absent to sparse; soluble pigments absent (except CBS 118885 produces yellow soluble pigment also at 30 and 37 °C); exudates absent; reverse between light orange and light yellow (5A5–4A5), in some isolates (CBS 118885) pastel yellow (2D4) centre fading to greyish yellow to pale yellow (1B4 to 1A4). MEA 25 °C, 7 d: Colonies low, plane, formation of yellow ascomata (at 30 °C abundant yellow ascomata); margins low, plane, entire (2–3 mm); mycelia white and yellow; texture velvety to floccose; sporulation sparse to moderately dense, conidia *en masse* greyish green (26B4–26C4); soluble pigments absent; exudates absent; reverse brownish orange to greyish orange (5B6–5C6). YES 25 °C, 7 d: Colonies slightly raised at centre, sulcate; margins low, plane, entire (2–3 mm); mycelia white and pastel yellow; texture velvety to floccose; sporulation absent to dense (CBS 118885), conidia *en masse* dull green to greyish green (25D4–25D5); soluble pigments absent; exudates absent; reverse in some isolates between deep yellow and deep orange (4A8–5A8) fading to light yellow (4A5). DG18 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation moderately dense, conidia *en masse* greyish green to dull green (25D5–25E4); soluble pigments absent; exudates absent; reverse in some isolates dark green (28F5) centre fading into greyish green (28C5) and pastel green (28A4) and in some isolates (DTO 254-I1) light yellow (2A5). OA 25 °C, 7 d: Colonies raised at centre, plane, formation of yellow to orange red ascomata (abundant at 30 °C); margins low, plane, entire (2–3 mm); mycelia white and yellow; sporulation absent; soluble pigments absent; exudates absent; reverse pastel yellow. CREA 25 °C, 7 d: Acid production absent (except CBS 118885 very weak).

**Micromorphology:** Conidiophores monoveritcillate and biverticillate; stipes smooth walled, 20–130 × 2.5–3.5 μm; branches 5–25 μm; metulae three to six, divergent, 9–20 × 2.5–3 μm; phialides acerose, three to six per metulae, 9–20 × 2.5–3 μm; conidia smooth, ellipsoidal, 2.5–4(–4.5) × 2–3.5 μm. Ascomata maturing after 1–2 wk of incubation on OA and MEA at 25 °C, yellow to orange red, globose to subglobose, 150–550 × 150–545 μm, asci 9–13 × 7.5–11 μm, ascospores broadly ellipsoidal, spiny, 4–6 × 2.5–4 μm.
Fig. 45. Morphological characters of Talaromyces liani (CBS 118885). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascospores. E–G. Conidiophores. H. Ascospores. I. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–I.
Distinguishing characters: Talaromyces liani produces relatively fast growing colonies on MEA and CYA at 25, 30 and 37 °C. It produces yellow to orange red ascomata and spiny ellipsoidal ascosporas, similar to those of *T. flavus*, *T. convolutus*, *T. austrocalifornicus*, *T. flavovirens*, *T. tratenis*, *T. macrosporus* and *T. muroii*. Based on colony size at 25 °C on CYA and MEA after 7 d, *T. liani* is more similar to *T. muroii* and *T. macrosporus*. Talaromyces liani have ellipsoidal ascosporas, whereas *T. macrosporus* has more subglobose to broadly ellipsoidal ascosporas. Talaromyces muroii does not grow on CREA and produce yellow ascomata, whereas *T. liani* produces yellow to orange red ascomata.

Notes: Samson et al. (2011) speculated that *T. thermocrinus* might belong in the genus *Eurotium*. However, ITS and BenA sequences (unpublished data) from the ex-type strain are identical to *T. liani* strains and is considered to represent a synonym.

*Talaromyces loliensis* (Pitt) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. MycoBank MB560655. Fig. 46. ≡ Penicillium loliense Pitt, The genus Penicillium: 450. 1980.

In: Talaromyces section Islandici

**Typus**: IMI 216901, culture ex-type CBS 643.80 = ATCC 52252 = FRR 1798 = IMI 216901 = MUCL 31325 = IBT 4546.

*ITS barcode*: KF984888 (alternative markers: *BenA* = KF984658; CaM = KF984783)

Colony diam, 7 d (mm): CYA 10–13; CYA 30 °C 11–12; CYA 37 °C No growth; MEA 13–15; MEA 30 °C 12–13; DG18 13–15; CYAS 7–8; OA 13–14; CREA 4–8; YES 13–15.

Colony morphology: CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulphate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow (CBS 172.91 with orange mycelia); sporulation absent; exudates small clear droplets; soluble pigment very weak yellow around colonies; reverse centre deep yellow to deep orange (4A8–5A8) fading into light yellow to yellow (3A5–3A6). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulphate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; sporulation absent to sparse; texture floccose and loosely funicolous; conidia en masse greyish green to dark green (2BD4–2BF4); exudates small clear droplets; soluble pigment absent; reverse centre brownish orange to brown (6C7–6D8). YES 25 °C, 7 d: Colonies slightly raised at centre, slightly sulphate; margins narrow (1 mm), low, entire, plane; mycelium white (in margins) and yellow (in centre); sporulation absent; exudates few very small clear droplets; soluble pigment absent; reverse centre deep yellow to deep orange (4A8–5A8) fading into light yellow to pastel yellow (3A4–3A5). DG18 25 °C, 7 d: Colonies slightly raised at centre, slightly sulphate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; sporulation absent; exudates absent; soluble pigment very weak yellow around colonies; reverse centre deep yellow to deep orange (4A8–5A8) fading into light yellow to yellow (3A5–3A6). OA 25 °C, 7 d: Colonies deep, plane; margins narrow (1 mm), low, entire, plane, slimy yeast like; mycelium white and yellow; sporulation moderately dense; texture velvety and floccose; conidia en masse greyish green to dark green (2BD4–2BF4); exudates small orange and clear droplets; soluble pigment absent; reverse orange yellow. CREA, 25 °C, 7 d: In some isolates acid production absent and in some isolates very weak acid production.

**Micromorphology**: Conidiophores biverticillate; stipes smooth walled, 45–115 × 2.3–3.2 μm; metulae three to six, divergent, 6–12 × 2–3.6 μm; phialides acerose, three to six per metulae, 7–15 × 2–4 μm; conidia smooth, subglobose to ellipsoidal, some spores fusiform some spores just one ending has connections, 3.5–5 × 2.4–3.5 μm.

Extrolites: *Talaromyces loliensis* produces mitorubrins and sky-rin. No other known extrolites were detected, but two of the partly characterised extrolites were also found in other species in Talaromyces sect. Islandici.

Distinguishing characters: *Talaromyces loliensis* is characterised by restricted growth on most media. Colonies are fluffy and deep and have light yellow mycelia (Fig. 46). It resembles *T. tratenis*, however, *T. tratenis* produces yellow ascomata. Based on the ITS and BenA phylogenies, *T. loliensis* is closely related to *T. islandicus*. Talaromyces loliensis differs from *T. islandicus* by slower growth on most media.

*Talaromyces macrosporus* (Stolk & Samson) Frisvad, Samson & Stolk, Antonie van Leeuwenhoek 57: 186. 1990. MycoBank MB126704. Fig. 47. ≡ Penicillium macrosporum Frisvad et al. nom. illegit. Art. 53 (non Penicillium macrosporum Berk. & Broome 1882, Ann. Mag. Nat. Hist. 9: 183. 1882).

Colony diam, 7 d (mm): CYA 22–28; CYA 30 °C 33–40; CYA 37 °C 28–35; MEA 40–50; MEA 30 °C 55–65; DG18 15–22; CYAS No growth; OA 40–45; CREA 15–20; YES 35–40.

Colony characters: CYA 25 °C, 7 d: Colonies raised at centre, sulphate, pastel yellow and pinkish red appearance; margins low, plane, entire (1–2 mm); mycelia white, pastel yellow and pinkish red; sporulation absent to sparse; soluble pigments absent (at 30 and 37 °C brownish soluble pigment); exudates absent; reverse yellowish brown (5E7–5F7) centre fading into brownish yellow to golden yellow (5C7–5B7). MEA 25 °C, 7 d: Colonies low, plane, yellow ascomata formation (DTO 58-F4 & DTO 77-C5) (at 30 °C, abundant ascomata except (DTO 108-A8)); margins low, plane, entire (2–3 mm); mycelia white, yellow and pinkish red; sporulation absent; soluble pigments absent; exudates absent (except DTO 58-F4, small red droplets at centre); reverse dark brown (8F8) centre fading into reddish brown (8E8–8D8) in the margins golden yellow (5B7). YES 25 °C, 7 d: Colonies raised at centre, sulphate, light pinkish red and white appearance; margins low, plane, entire (3 mm); mycelia white and light pinkish red; sporulation absent; soluble pigments absent; exudates absent; reverse in some isolates centre dark brown (8F7) fading into orange.
Fig. 46. Morphological characters of *Talaromyces loliensis* (CBS 643.80T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 47. Morphological characters of *Talaromyces macrosporus* (CBS 317.63T). a. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D, E. Conidiophores. F. Conidia. G. Asci and ascospores. H. Ascospores. Scale bars: B = 1000 μm; C = 500 μm; D = 10 μm, applies to E–H.
(6B8), in some isolates centre brownish orange (5C4). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation moderately dense, conidia en masse dull green (25D4–25E4); soluble pigments absent; exudates absent; reverse in some isolates centre dark brown (6F5), fading into orange (6B7) to yellowish white (2A4). OA 25 °C, 7 d: Colonies low, plane, yellow and white ascomata formation (at 30 °C abundant ascomata except DTO 108-A8, yellow; orange in the centre and white in the margins); margins low, plane, entire (2–3 mm); mycelia white and yellow; sporulation absent; soluble pigments absent; exudates small clear and orange droplets; reverse pale brownish orange to orange and reddish orange. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate and monotrichous; stipes smooth walled, 30–100 × 2–3 μm; metulae three to five, divergent, 8–11 × 2–3(–4) μm; phialides acerose, three to six per metulae, (4–)8–12 × 2–3 μm; conidia smooth, subglobose to ellipsoidal, 2–4 × 2–3.5 μm. Ascomata maturing within 1–2 wk on OA at 25 °C and 30 °C abundantly, globose to subglobose, 100–400 × 100–350 μm, yellow, asci 13–15(–18) × 11.5–13.5 μm, ascospores subglobose to broadly ellipsoidal, thick walled, spiny, 5.5–6.5 × 4.5–5.5 μm.

**Extróites:** Talaromyces macrosporus produces duclauxin and mitorubric acid.

**Distinguishing characters:** Talaromyces macrosporus produces yellow ascomata, thick walled, spiny, subglobose to broadly ellipsoidal ascospores and rapid growth on MEA (Fig. 47). Its yellow ascomata and rapid growth resemble T. muroi and T. liani. Talaromyces muroi and T. liani colonies sporulate better on MEA compared to T. macrosporus. Talaromyces muroi does not grow on CREA. Talaromyces liani produces yellow to orange red ascomata, whereas T. macrosporus produces only yellow ascomata. Additionally, Talaromyces macrosporus produces slightly bigger, subglobose to broadly ellipsoidal ascospores (5–6.5 × 4.5–5.5 μm) compared to T. liani (4–6 × 2.5–4 μm) and T. muroi (3.5–6 × 3–4 μm). The species is a well-known heat-resistant spoilage organism in various food products and beverages.

**Talaromyces marneffei** (Segretain, Capponi & Sureau) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560656. Fig. 48.

≡ Penicillium marneffei Segretain, Capponi & Sureau, Bull. Soc. Mycol. France 75. 416. 1959 [1960].

**In:** Talaromyces section Talaromyces

**Typus:** IMI 68794ii, culture ex-type CBS 388.87 = ATCC 18224 = CBS 334.59 = IMI 068794ii = IMI 068794iii.

**ITS barcode:** JN899344 (alternative markers: BenA = JX091389; CaM = KF741958; RPB2 = KM023283)

**Colony diam, 7 d (mm):** CYA 13–25; CYA 30 °C 15–38; CYA 37 °C 5–10; MEA 15–27; MEA 30 °C 23–38; DG18 7–9; CYAS No growth; OA 20–25; CREA 8–15; YES 17–25.

**Colony characters:** CYA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white and in some isolates pastel red; texture loosely funiculose and floccose (at 37 °C yeast phase); sporulation moderately dense to dense, conidia en masse greyish green (25B4–26B4); soluble pigments red (in some isolates yellowish red in some isolates at 30 °C lack of red soluble pigment); exudates absent; reverse reddish brown (9E8) fading into red (9A6). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (2 mm); mycelia white, yellow and pastel red; texture loosely funiculose and floccose, covered with yellow mycelia; sporulation moderately dense to dense, conidia en masse greyish green (29C6–30C6); soluble pigments red (also at 30 °C); exudates absent; reverse dark brown (8F8). YES 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white; texture velvety and loosely funiculose; sporulation dense, conidia en masse greyish green (26B4–27B4); soluble pigments red; exudates absent; reverse reddish brown (8F8). DG18 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white and in some isolates yellow; texture velvety and loosely funiculose; sporulation dense, conidia en masse greyish green (26D3–26E3); soluble pigments red (in some isolates weak); exudates absent; reverse reddish brown (8F8). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white and yellow; texture loosely funiculose and floccose, colonies covered with yellow mycelia; sporulation sparse to moderately dense, conidia en masse greyish green (29B4–29C4); soluble pigments red (in some isolates lack); exudates absent; reverse brownish red. CREA 25 °C, 7 d: Acid production absent.

**Micro morphology:** Conidiophores generally biverticillate and sometimes monoverticillate; stipes smooth walled, 30–100 × 2.5–3 μm; metulae two to six, divergent, 7–11 × 2.5–3.5 μm; phialides acerose to flask-shaped, four to seven per metulae, 6–8(–12) × 2.5–3.5 μm; conidia smooth, subglobose, 2.5–4 × 2–3 μm.

**Extróites:** Talaromyces marneffei produces Monascus red pigments including rubropunctatin, monascin, mitorubrin, mitorubrino, mitorubrinic acid and a purpactin.

**Distinguishing characters:** Talaromyces marneffei is the only dimorphic species of Talaromyces which grows as a yeast phase at 37 °C (Fig. 48). It is a pathogen of immunocompromised patients, especially HIV positive individuals. It produces red soluble pigment on general media and conidiophores have flask-shaped to acerose phialides. After 7 d, colonies on MEA are covered with sterile yellow mycelia, which resemble T. flavovirens and T. primulinus. Talaromyces flavovirens differs from T. marneffei by rapid growth on MEA and lacks the reddish appearance of T. marneffei on MEA. After 2 wk of incubation, T. primulinus also produces a yellow mycelial layer that covers the colony. However T. primulinus grows restrictedly on general media and cannot grow at 37 °C.

**Talaromyces mimosinus** A.D. Hocking. The genus Penicillium 507. 1980. MycoBank MB116382. Fig. 49.

≡ Penicillium mimosinum A. D. Hocking. (simultaneously published).

**In:** Talaromyces section Bacillispori

**Typus:** IMI 223991, culture ex-type CBS 659.80 = FRR 1875 = IMI 223991. Typus: IMI 223991, culture ex-type CBS 659.80 = FRR 1875 = IMI 223991.

**ITS barcode:** JN899338 (alternative markers: BenA = KJ865726; CaM = KJ885272)
Fig. 48. Morphological characters of Talaromyces marneffei (CBS 549.77). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Mycelia. C. Yeast phase. D–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 49. Morphological characters of Talaromyces mimosinus (CBS 659.80T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
Colony diam, 7 d (mm): CYA 12–15; CYA 30 °C 17–18; CYA 37 °C 3–5; MEA 13–14; MEA 30 °C 20–21; DG18 8–10; CYA 4–5; OA 13–15; CREA No growth; YES 14–15.

Colony characters: CYA 25 °C, 7 d: Colonies raised at centre, slightly sunken at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white and pale pastel yellow; sporulation absent; soluble pigments absent; exudates absent; reverse light yellow (3A5). MEA 25 °C, 7 d: Colonies raised at centre, slightly sunken at centre, sulcate; margins low, plane, entire (1 mm); mycelia white and pale pastel yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5A6/C14). DG18 25 °C, 7 d: Colonies raised at centre, slightly sunken at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia yellow and white; texture loosely funiculose and floccose, conidiophores born from sterile aerial hyphae; sporulation dense, conidia en masse greyish green to dull green (27E4–27E6); soluble pigments absent; exudates absent; reverse brownish orange (6B8) centre fading into brownish orange to light brown (6C8–6D8). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia yellow and white; texture loosely funiculose and floccose, conidiophores born from sterile aerial hyphae; sporulation dense, conidia en masse greyish green to dull green (26D4–26D5); soluble pigments absent; exudates absent; reverse orange (6B8). DG18 25 °C, 7 d: Colonies slightly raised at centre, very slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia white; texture slimy hyphae; sporulation absent; soluble pigments absent; exudates absent; reverse pale pastel yellow. CREA 25 °C, 7 d: No growth.

Micromorphology: Conidiophores lacking on all media. After 3 wk incubation best development on OA. Conidiophores biverticillate and mononverticillate with a minor proportion having subterminal branches; stipes smooth walled, 15–50(–90) × 1.8–2.2 μm; branches 8–22 μm; metulae two to five, divergent, 7–10(–13) × 1.8–2.5 μm; phialides acerose, two to five per metulae, 7–9(–12) × 1.8–2.5 μm; conidia smooth, globose to subglobose, 2–3 × 2.5–5 μm. Ascomata not observed in our culture but fide Pitt (1980) maturing within 2–3 wk on MEA, pure yellow and sulphur yellow, 2.5 mm, asci 13–16 × 13–16 μm. Ascospores globose to subglobose, ornamented on all surfaces by conspicuous sinus ridges about 0.5 μm high, 7–8 × 6–7 μm.

Extröiles: Talaromyces mimosinus produces some mitorubrin-like extröiles.

Distinguishing characters: Talaromyces mimosinus produces big (2.5 mm) pure yellow to sulphur yellow ascomata; very big (7–8 × 6–7 μm), globose to subglobose ascospores, ornamented with ridges; mono- to biverticillate conidiophores with globose to subglobose conidia (Fig. 49). These characters distinguish it from all other species. Conidiophores were only observed on OA after 3 wk of incubation.

Talaromyces minioluteus (Dierckx) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560657. Fig. 50.
≡ Penicillium minioluteum Dierckx, Ann. Soc. Sci. Bruxelles 25: 87. 1901.
≡ Penicillium gaditanum C. Ramirez & A.T. Martinez, Mycopathologia 74: 165. 1981.
≡ Penicillium purpurogenum var. rubisclerotium Thom, Mycologia 7: 142. 1915.
≡ Penicillium samsonii Quintan, Mycopathologia 91: 69. 1985.

In: Talaromyces section Trachyspermi

Typus: CBS 642.68, culture ex-type CBS 642.68 = IMI 089377 = MUCL 28666.

ITS barcode: JN899346 (alternative markers: BenA = KF114799; CaM = KJ885273; RP2B = JF417443)

Colony diam, 7 d (mm): CYA 17–18; CYA 30 °C 10; CYA 37 °C No growth; MEA 21–22; MEA 30 °C 9–10; DG18 14–15; CYAS No growth; OA 22–23; CREA 2–3, YES 18.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia white; sporulation absent to sparse; soluble pigments weak brownish red; exudates absent; reverse brown (6E8) centre fading into brownish orange to light brown (6C8–6D8). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia yellow and white; texture loosely funiculose and floccose, conidiophores born from sterile aerial hyphae; sporulation dense, conidia en masse greyish green to dull green (26D4–26D5); soluble pigments absent; exudates absent; reverse orange (6B8). DG18 25 °C, 7 d: Colonies slightly raised at centre, very slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia white; texture slimy hyphae; sporulation absent; soluble pigments absent; exudates absent; reverse light pale orange. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, 80–300 × 2–3 μm; metulae three to five, divergent, 10–20 × 2–3.5 μm; phialides acerose, three to five per metulae, 10–17 × 2–3 μm; conidia smooth, ellipsoidal, 2.5–4 × 1.5–2.5 μm. Ascomata not observed.

Extröiles: Talaromyces minioluteus produces mitorubrin, mitourubricin acid, a purpactin, secaslonic acid D and vermicellin. It has also been reported to produce mitoinuletic acid and spiculosphoric acid (Birkshaw & Raistree 1934), 22-epoxyberkeleydione, minicoluteide A & B (Iida et al. 2008), HY559-1 (Haeyoung et al. 2004), NG-061 (Ito et al. 1999) and BE-31405 (Okada et al. 1998). Some of these metabolites may be produced by Penicillium minioluteum sensu Pitt (which can be Talaromyces amestolkiae or T. ruber). It is also an efficient producer of dextranase (Roca et al. 1996).

Distinguishing characters: Talaromyces minioluteus grows moderately on general media, produces weak acid on CREA and cannot grow at 37 °C. Both Penicillium samsonii and P. purpurogenum var. rubisclerotorum resemble T. minioluteus and ITS and BenA phylogenies also show that latter two species are synonyms of T. minioluteus.

Notes: van Reenen-Hoekstra et al. (1990) considered P. gaditanum (CBS 169.81) synonymous with T. minioluteus based on morphological and chemical data, which we follow here. Our ITS and BenA data show that P. samsonii (CBS 137.84) and P. purpurogenum var. rubisclerotium (CBS 270.35) are
Fig. 50. Morphological characters of Talaromyces minioluteus (CBS 642.68T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA, (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
Talaromyces muroii  
Yaguchi, Someya & Udagawa,  
Mycoscience 35: 252. 1994. MycoBank MB362930. Fig. 51.  

= Penicillium victoriae Szvinski, Arch. Hydrobiol. 14, (suppl. 3): 538. 1936.

**In:** Talaromyces section Talaromyces

**Typus:** CBM PF-1153, culture ex-type CBS 756.96 = PF 1153.

**ITS barcode:** JN899351 (alternative markers: BenA = KJ865727; CaM = KJ885274)

**Colony diam, 7 d (mm):** CYA 15–16; CYA 30 °C 20–22; CYA 37 °C 19–20; MEA 30–32; MEA 30 °C 37–40; DG18 10–13; CYAS 2–3; OA 27–30; CREA No growth; YES 25–26.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulcate; margins low, plane, entire (1 mm); mycelia white and pastel yellow; texture floccose; sporulation moderately dense, conidia en masse greyish green (25C3–25C4); soluble pigments absent; exudates absent; reverse reddish brown (8E7) fading into brownish red (7C7–8C7) and in some isolates also greyish green (1C3). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (3–5 mm); mycelia white and pastel yellow; texture floccose; sporulation moderately dense, conidia en masse greyish green (25C3–25C4); soluble pigments absent; exudates sticky clear droplets; reverse brownish orange (5G6) to light brown (5D6) and in some isolates reddish brown (9E7) dots. YES 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (2–3 mm); mycelia white, pastel yellow and pastel red; texture velvety and floccose; sporulation sparse to dense, conidia en masse dull green (26D4–26E4); soluble pigments absent; exudates clear and yellow droplets; reverse olive (2F3–2F4) reverse with shades (dots) of reddish brown (9E8). DG18 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulcate; margins low, plane, entire (1–2 mm); mycelia white; texture velvety; sporulation dense, conidia en masse dull green (26E3–27E3); soluble pigments absent; exudates small clear droplets; reverse greyish green (26E5–27E5). OA 25 °C, 7 d: Colonies slightly raised at centre, plane, yellow ascomata formation at (30 °C more abundant 1 wk later); margins low, plane, entire (2–3 mm); mycelia white; texture velvety and floccose; sporulation dense, conidia en masse greyish green (26D4–26E4); soluble pigments absent; exudates small clear droplets; reverse red. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate and monotricholobate with a minor proportion having subterminal branches; stipes smooth walled, 20–50(–100) × 2.5–3 μm; branches 5–20 μm; metulae three to six, divergent, 10–16 × 2–3 μm; phialides acerose, three to six per metulae, 11.5–15(–20) × 2–3 μm; conidia smooth, globose to subglobose, 2–3 × 1.5–3 μm. Ascomata maturing after 1–2 wk of incubation on OA at 25 °C and abundantly 30 °C, yellow and pastel yellow, globose to subglobose, 140–290 × 160–330 μm, asci 9.5–13 × 7.5–9.5 μm, ascospores ellipsoidal, finely thick walled, spiny, 3.5–6 × 3–4 μm.

**Distinguishing characters:** Talaromyces muroii produces relatively fast growth on CYA at 30 and 37 °C, MEA at 25 and 30 °C, and does not grow on CREA. It produces yellow ascomata and spiny, ellipsoidal ascospores (Fig. 51). Its yellow ascomata and rapid growth resemble T. macrosporus and T. liani. Talaromyces muroii produces ellipsoidal ascospores, whereas T. macrosporus has more subglobe to broadly ellipsoidal ascospores. Talaromyces liani grows on CREA and produces yellow to orange red ascomata.

**Notes:** Penicillium victoriae (CBS 274.26) is phylogenetically identical to T. muroii and is considered a synonym.

**Talaromyces oumae-annae** Visagie et al.,  
Stud. Mycol. 78: 130. 2014. MycoBank MB809187.

**In:** Talaromyces section Talaromyces

**Typus:** CBS H-21797, culture ex-type CBS 138208 = DTO 269-E8.

**ITS barcode:** KJ775720 (alternative markers: BenA = KJ775213; CaM = KJ775425)

**Colony diam, 7 d (mm):** CYA 16–18; CYA 30 °C 16–17; CYA 37 °C 10–11; MEA 29–30; MEA 30 °C 35–37; DG18 14–17; CYAS No growth; OA 30–35; CREA 5–6; YES 20–23.

**Colony characters:** *Fide Visagie et al. (2014)* CYA 25 °C, 7 d: Colonies low, slightly raised at centre, plane; margins low, narrow, entire; mycelia white; texture floccose and velvety; sporulation moderately dense to dense, conidia en masse dull green (25D4–25E4); soluble pigments yellow; exudates absent; reverse greyish green (29B6–29C6). MEA 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire; mycelia white and pastel yellow; texture velvety, centrally floccose with sterile aerial mycelia; sporulation dense, conidia en masse greyish green (27D5–27E5); soluble pigments absent; exudates absent; reverse light brown (7D6) in the centre fading into brownish orange (6C6). YES 25 °C, 7 d: Colonies low, raised at centre, lightly sulcate; margins low, narrow, entire; mycelia white to yellow; texture velutinous to floccose; sporulation dense, conidia en masse dull green (25D4–25E4); soluble pigments yellow; exudates absent; reverse centre light yellow to greyish yellow (2A5–2B5), at margins greyish green (27E5). DG18 25 °C, 7 d: Colonies moderately deep, lightly sulcate; margins low, narrow, entire; mycelia white to yellow; texture floccose; sporulation dense, conidia en masse greyish green (25E5–27E5); soluble pigments absent; exudates absent; reverse light orange (6A4–6A5). OA 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire; mycelia white; texture velvety; sporulation dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudates absent. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** *Fide Visagie et al. (2014)* conidiophores biverticillate, subterminal branches sometimes present; stipes smooth walled, 85–240 × 2.5–3.5 μm; branches up to 30 μm long; metulae appressed, 8–11(–12.5) × 2.5–3.5 μm; phialides acerose, 9–11.5 × 2–3 μm; conidia rough, ellipsoidal, 3–3.5 × 2.5–3 μm.

**Notes:** *Fide Visagie et al. (2014)* Talaromyces oumae-annae grows restrictedly on CYA and DG18, but grows moderately on...
Fig. 51. Morphological characters of Talaromyces muroii (CBS 756.96T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Ascii and ascospores. E–G. Conidiophores. H. Ascospores. I. Conidia. Scale bars: B = 500 μm; C = 250 μm; D = 10 μm, applies to E–I.
other media. It produces biverticillate conidiophores with some subterminal branches, smooth-walled stipes and has roughened, ellipsoidal conidia. It is phylogenetically resolved as a close relative to *T. verruculosus* and *T. viridulus* (Fig. 2). However, *T. oumae-annae* produces ellipsoidal conidia compared to spheroid conidia of *T. verruculosus*, which also grows faster on CYA at all temperatures (CYA 32–35; CYA 30 °C 37–38; CYA 37 °C 25–26). *Talaromyces viridulus*, originally described as *Geosmithia viridis* (Pitt & Hocking 1985), produces rod-shaped conidia, making identification of the species rather easy. For an illustration of the species, readers are referred to Visagie et al. (2014).

*Talaromyces palmae* (Samson, Stolk & Frisvad) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560658. Fig. 52.

Distinguishing characters: *Talaromyces palmae* characteristically produces indeterminate synnemata, especially at colony margins. Conidiophores typically have short stipes (up to 85 μm) and colonies grow restricted on DG18 and do not grow at 37 °C. *Talaromyces duclauxii* also produces indeterminate synnemata, but *T. palmae* grows slower on CYA at 30 °C.

**Talaromyces palmae** (Samson, Stolk & Frisvad) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560659. Fig. 53.

In: Talaromyces section Subinflati

Type: CBS 442.88, culture ex-type CBS 442.88 = IMI 343640.

*ITS barcode*: JN899396 (alternative markers: *BenA* = HQ156947; *CaM* = KJ858291; *RPB2* = KM023300)

Colonies raised at centre, sunken at centre and sometimes crateriforme, sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture velvety, early synnema formation; sporulation dense, conidia *en masse* dull green (28D4–29D4); soluble pigments absent; exudates absent; reverse pastel yellow to greyish yellow (2A4–2B4). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1 mm); mycelia white and yellow; texture velvety in centre aerial hyphae, production of synnema started; sporulation dense, conidia *en masse* dull green (28D4–29D4); soluble pigments absent; exudates absent; reverse brownish orange (5B5–5B6). YES 25 °C, 7 d: Colonies raised at centre, sunken at centre and sometimes crateriforme, sulcate; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture velvety, early synnema formation; sporulation dense, conidia *en masse* dull green (28D4–29D4); soluble pigments absent; exudates absent; reverse light yellow to yellow (3A5–3A6). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1 mm); mycelia white and light pastel yellow; sporulation dense, soluble pigments absent; exudates absent; reverse yellowish white (3A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white and yellow; texture velvety and in the margins early synnema production; sporulation moderately dense, conidia *en masse* dull green (28D4–29D4); soluble pigments absent; exudates absent; reverse pastel yellow. CREA 25 °C, 7 d: Weak acid production.

**Micromorphology**: Synnema formed at the edge of the colony on MEA up to 8,000 μm long after 1–2 wk. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 25–85 × 3–4 μm; branches 10–15 μm; metulae three to five, divergent, 10–17 × 2.5–4 μm; phialides acerose, three to six per metulae, 13–20 × 2–3.5 μm; conidia smooth, subglobose to ellipsoidal, 3–4.5 × 2–3.5 μm. Ascomata not observed.

**Extrolties**: *Talaromyces palmae* produces mitorubrin, mitorubrinol and mitorubrinol acetate (Samson et al. 1989).

In: Talaromyces section Talaromyces

Type: CBS 128.89, culture ex-type CBS 128.89 = IMI 297546.

*ITS barcode*: JN899362 (alternative markers: *BenA* = HQ156948; *CaM* = KF741936; *RPB2* = KM023284)

Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white; sporulation absent to sparse, conidia *en masse* difficult to determine; soluble pigments absent; exudates small clear droplets; reverse brownish orange to yellowish brown (5C6–5D6). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate, synnema at centre sporulate; margins low, plane, entire (1 mm); mycelia white, yellow and orange; texture synnematous; sporulation sporulation only on synnema densely, conidia *en masse* dark green (28F5); soluble pigments absent; exudates orange droplets; reverse yellowish brown (5E7) fading into golden brown to brownish yellow (5C7–5D7). YES 25 °C, 7 d: Colonies slightly raised at centre, concentrically sulcate; margins low, plane, entire (1–2 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse brown (5E7) with shades of golden brown (5D7) fading into brownish yellow (5C6) with dots of brownish red (9C8). DG18 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (<1 mm); mycelia white and yellow; texture velvety; sporulation dense, conidia *en masse* greenish grey (26D5–26E5); soluble pigments absent; exudates absent; reverse light brown (7D6) centre fading into brownish orange (6C7) and greyish orange (5B6). OA 25 °C, 7 d: Colonies low, plane, sporulated synnema at centre and young synnema at margins; margins low, plane, entire (2–3 mm); mycelia white, yellow, orange; texture synnematous; sporulation on synnema densely, conidia *en masse* dark green (28F5); soluble pigments absent; exudates small clear droplets; reverse red. CREA 25 °C, 7 d: Strong acid production.

**Micromorphology**: Synnema formed after 7 d on MEA 1800–5000 μm long and on OA 800–6800 μm long.
Fig. 52. Morphological characters of *Talaromyces palmae* (CBS 442.88T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–E. Conidiophores. F. Conidia. Scale bar: B = 10 μm, applies to C–F.
Fig. 53. Morphological characters of Talaromyces panamensis (CBS 128.89T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 1 wk incubation. C–E. Conidiophores. F. Conidia. Scale bar: C = 10 μm, applies to D–F.
Conidiophores biverticillate with a minor proportion having sub-terminal branches; stipes smooth walled, 40–85 × 3–4 μm; branches 15–25 μm; metulae three to six, divergent, 9.5–14 × 2.5–3.5(–4) μm; phialides aceroso, three to six per metulae, 9.5–13.5 × 2–3 μm; conidia smooth, thick walled, ellipsoidal to fusiform, 3–5 × 2–3 μm. Ascomata not observed.

**Exterolites**: *Talaromyces panamensis* produces mitorubrinic acid, mitorubrin and vermicillin (Samson et al. 1989).

**Distinguishing characters**: The most striking characteristic of *T. panamensis* is the production of determinate synnemata with yellow stalks up to 5,000 μm (MEA) and 6,800 μm (OA) in length after 7 d of growth (Fig. 53). It produces acid on CREA. Morphologically, *T. panamensis* resembles *T. calidicanius*. However, *T. calidicanius* grows faster at 30 °C on MEA and produces less acid on CREA.

**Talaromyces paucisporus** (Yaguchi, Someya & Udagawa) Samson & Houbraken, Stud. Mycol. 71: 176. 2011. MycoBank MB560684.

≡ *Erythrogymnotheca paucispora* Yaguchi, Someya & Udagawa, Mycoscience 35: 219. 1994.

**In**: *Talaromyces* section Islandici

**Typus**: PF 1150, culture ex-type PF 1150 = IFM 53616.

**ITS barcode**: AB176603

**Colony diam, 14 d (mm)**: CYA 15–18; CYA 37 °C No growth; MEA 19–20; OA 15–18.

**Colony characters**: *Fide* Yaguchi et al. (1994) colonies on CYA growing restrictedly, attaining a diam of 15–18 mm in 14 d at 25 °C, floccose, centrally convolute and raised, radially sulcate, more or less zonate, consisting of a compact basal felt, at first white, then becoming greyish yellow to pastel pink (1B4–11A3), producing abundant ascomata on the felt, with a thin irregular margin; exudate very abundant red; odour indistinct; reverse and agar violet brown (11E8). Colonies on MEA growing restrictedly, attaining a diam of 19–20 mm in 14 d at 25 °C, velvety to tomentose, almost plane, consisting of a thin basal felt, dull yellow to pastel pink (3B4–11A3), producing abundant ascomata on the felt, with a narrow entire margin; exudate lacking; reverse and agar ruby (11E8). Colonies on OA growing restrictedly, attaining a diam of 15–18 mm in 14 d at 25 °C, velvety, plane, consisting of a thin basal felt, becoming granular due to development of abundant ascomata, pale yellow (4A3); exudates small, pink; reverse and agar greyish green.

**Micromorphology**: *Fide* Yaguchi et al. (1994) asexual state lacking. Ascomata yellow to sometimes red, globose to subglobose, 200–500 μm in diam, maturing within 21 d; ascii 1–2(–4) spored, globose to subglobose, 22–25(–26) × 18–22(–25) μm, ascospores subglobose to broadly ellipsoidal, thick walled (up to 2 μm), spiny (spines up to 1.5 μm), 14–18 × 12–16 μm.

**Exterolites**: *Talaromyces paucisporus* produces monodictyphenone and purpuractins.

Notes: *Erythrogymnotheca paucispora* was described by Yaguchi et al. (1994) introducing the new genus *Erythrogymnotheca*. It produces ascii that have one to two and sometimes four ascospores, whereas *Talaromyces* generally produces ascii with eight ascospores. However, molecular studies show that *Erythrogymnotheca paucispora* belongs in *Talaromyces* (Samson et al. 2011). Unfortunately, the ex-type strain was not available for this study. Macro- and micromorphological characters are thus based on the original description (Yaguchi et al. 1994). According to Frisvad (unpublished data): Colony diameters (Strain IBT 17569): CYA 2–3 mm, cream reverse; MEA 8–10 mm orange red reverse and orange red exudate; YES 7–9 mm, cream yellow reverse; CYA at 37 °C: 0–1 mm; OA 8–11 mm; OA at 30 °C 32 mm, yellow mycelium and reddish reverse; OA at 37 °C 16 mm; CREA weak growth (13 mm), weak acid under colony.

**Talaromyces piceus** (Raper & Fennell) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560661, Fig. 54.

≡ *Penicillium piceum* Raper & Fennell, Mycologia 40: 533. 1948.

≡ *Penicillium ilerdanum* C. Ramírez & A.T. Martínez, Mycopathologia 72: 32. 1980.

**Colony morphology**: CYA, 25 °C, 7 d: Colonies raised in the centre, crateriforme; margins narrow (1–2 mm), low, entire, plane; mycelium white and pale yellow, in some strains also pale orange, colony has golden colour appearance; texture floccose; sporulation absent to sparse; conidia *en masse* greyish green (28B4–28C4); exudates clear and pale orange droplets in the centre; soluble pigment light brown; reverse brown (6E6). MEA, 25 °C, 7 d: Colonies slightly raised in the centre, slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and pale yellow, in some strains also orange; texture loosely funiculose and in some isolates floccose; sporulation sparse to dense; conidia *en masse* greyish green (28B4–28C4); exudates clear droplets in the centre; soluble pigment absent; reverse brown (6D7). YES, 25 °C, 7 d: Colonies low, sulcate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow, colonies with butter yellow to maize yellow (4B5–4B6) appearance; texture funiculose to floccose; sporulation absent to sparse; conidia *en masse* greyish green to dull green; exudates absent; soluble pigment absent; reverse orange to brownish orange in centre, fading into yellowish brown (5D5). DG18, 25 °C, 7 d: Colonies low, slightly sulcate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; texture loosely funiculose to floccose; sporulation absent to moderately dense; conidia *en masse* greyish green to dull green (28B4–28C4–28D4); exudates absent; soluble pigment absent; reverse yellowish brown in centre (5D5), fading into light yellow (2A5). OA, 25 °C, 7 d: Colonies low to slightly raised, plane;
Fig. 54. Morphological characters of Talaromyces piceus (CBS 137377). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
margins narrow (1–2 mm); low, entire, plane; mycelium white and yellow; texture velvety to loosely funiculose; sporulation sparse to dense; conidia en masse greyish green to dull green (29D3–29D4); exudates big clear droplets; soluble pigment absent, in some isolates around colonies light yellow to orange; reverse in the centre greyish yellow (2C3) fading into pale yellow in the margins (2A3). CREA, 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 10–65 × 2.5–3.5 μm; terminating in vesicles up to 5.5 μm; metulae four to eight, 8–14 × 2–4 μm; phialides aceros, three to six per metulae, 7–10 × 2.5–3.5 μm; conidia smooth, ellipsoidal, ranging in size from 2–3.5 × 2–4 μm.

**Extrolites:** Talaromyces piceus produces emodin, mitorubrin, mitorubirol, rugulosin A and other rugulosins, and skinr. It also produces diverse other anthraquinones and extrolites with chromophores suggesting tetracyclic compounds, citreosiscoumarin and restricticin.

**Distinguishing characters:** Talaromyces piceus is characterised by biverticillate conidiophores having vesiculated stipes (Fig. 54). The species is able to grow at high temperatures, growing faster on CYA at 37 °C than 25 °C. The species can also grow at 40 °C. These characters are very similar to its close relative T. columbinus (Fig. 7). Compared to T. columbinus, T. piceus grows faster on CYA and YES at 25 °C, but slower on CYA at 37 °C.

**Notes:** Penicillium ilerdanum is phylogenetically identical to T. piceus and is considered a synonym.

**Talaromyces pinophilus** (Hedgc.) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560662. Fig. 55.

≡ Penicillium pinophilum Hedgc. apud Thom, U.S.D.A. Bur. Animal Indstr. Bull. 118: 37. 1910.
≡ Penicillium korosum J.N. Rai, Wadhwani & J.P. Tewari, Antonie van Leeuwenhoek 35: 430. 1969.
≡ Acremonium cellulolyticus nom. nud. Leeuwenhoek 35: 430. 1969.
≡ Talaromyces cellulolyticus Hedgc.
≡ Talaromyces apiculatus T. Fujii et al., FEMS Microbiology Letters 351: 38. 2013.

In: Talaromyces section Talaromyces

**Typus:** IMI 114933, culture ex-type CBS 631.66 = ATCC 36839 = CECT 2809 = DSM 1944 = IAM 7013 = IMI 114933.

**ITS barcode:** JN899382 (alternative markers: BenA = JX091381; CaM = KF741964; RBP2 = KM023281)

**Colony diam, 7 d (mm):** CYA 18–25; CYA 30 °C 30–40; CYA 37 °C 25–40; MEA 30–40; MEA 30 °C 45–55; DG18 10–20; CYAS 3–7; OA 30–40; CREA 15–22; YES 25–40.

**Colony characters:** CYA 25 °C, 7 d: Colonies raised at centre, sulphate; margins low, plane, entire (2–3 mm); mycelia white, yellow and in some strains red; texture loosely funiculose and floccose especially in the centre; sporulation sparse to moderately dense, conidia en masse greyish green to dull green (26C3–26D4); soluble pigments only in DTO 60-C5 yellow soluble pigments at 37 °C except DTO 60-F4 they all produce yellow pigments; exudates small clear and red droplets; reverse greyish orange to orange (6B6–6B7) centre fading into pastel yellow (3A4). MEA 25 °C, 7 d: Colonies slightly raised, slightly sulphate; margins low, plane, entire (4–5 mm); mycelia white, yellow and red; texture loosely funiculose to floccose especially in the centre; sporulation sparse to dense, conidia en masse greyish green to dull green (27D4–29D4); soluble pigments absent; exudates in some isolates small red droplets; reverse brownish orange (5C6). YES 25 °C, 7 d: Colonies slightly raised at centre, sulphate; margins low, plane, entire (3–4 mm); mycelia white, yellow and in some isolates red; texture floccose; sporulation sparse to moderately dense, conidia en masse greyish green (28B5–28C4); soluble pigments absent; exudates in some isolates small clear droplets; reverse in some isolates centre dark brown to reddish brownish orange (6F6–6C7) fading into yellow (3A7) and in some isolates yellowish orange (4A7). DG18 25 °C, 7 d: Colonies raised at centre, plane; margins low, plane, entire (2–3 mm); mycelia white only in DTO 60-C7 yellow; texture loosely funiculose to floccose, especially in the centre conidiophores born from sterile aerial hyphae; sporulation moderately dense, conidia en masse dull green (26E3–26E4); soluble pigments absent; exudates absent; reverse olive (3F3) centre fading into pastel yellow to light yellow (3A4–3A5) and greyish yellow to greyish green (1B3–1C4). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–5 mm); mycelia white and yellow, texture funiculose and floccose, especially in the centre aerial mycelia; sporulation dense, conidia en masse greyish green (28D5–28E5); soluble pigments absent; exudates in some isolates small clear droplets; reverse 60F4 bright orange, the rest pale brownish orange to pale light brownish green. CREA 25 °C, 7 d: Acid production moderate (no acid production DTO 60-F4).

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 30–200 × 2–3 μm; metulae three to eight, divergent, 10–11 × 2.5–3 μm; phialides aceros, three to eight per metulae, 8.5–12 × 2–3 μm; conidia smooth, globose to subglobose, 2–3 × 2–3 μm. Ascomata not observed.

**Extrolites:** Talaromyces pinophilus has been reported to produce seccopenicillide C, penicillide, MC-141, pestalacin A and stromemycin (Nonaka et al. 2011), dinapinone A1 & A2 (Uchida et al. 2012), monoapinone A-E (Kawamoto et al. 1999a, b). We have found mitorubrin, mitorubrinic acid, vermisillin, a purpactin, penicillin, pestalacin A and Monascus red pigments in T. pinophilus.

**Distinguishing characters:** Talaromyces pinophilus grows relatively fast on general media at 25, 30 and 37 °C, produces weak acid on CREA. Colonies have white, yellow and red mycelia and floccose to loosely funiculose texture (Fig. 55). These characters resemble T. angelicus, T. aculeatus, T. apiculatus, T. verruculosus, T. amestolkiae and T. stollii. Talaromyces aculeatus, T. apiculatus and T. verruculosus produce flask-shaped phialides and rough-walled, globose conidia, which differ from T. pinophilus conidia. Talaromyces angelicus differs from T. pinophilus by lack of acid production on CREA. Talaromyces amestolkiae colonies have red reverses on CYA and MEA, black sclerotia after 2 wk of incubation and grows more restrictedly at 37 °C compared to T. pinophilus. Talaromyces pinophilus micro- and macro-morphologically closely resembles T. stollii. However T. stollii grows slightly faster than T. pinophilus on CYA. Sequence data is, however, needed for reliable identification of the species.
Fig. 55. Morphological characters of Talaromyces pinophilus (DTO 183-I6). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bars: B = 50 μm; C = 10 μm, applies to D–H.
since Visagie et al. (2014) introduced the phylogenetically distinct, but morphologically almost identical, *T. sayultensis*.

**Notes:** Strain Y-94, an important cellulase producer for biotechnology, was given the name *Acremonium cellulolyticus* in a patent application (Yamanobe et al. 1985a, b), but the species was never formally described. Fuji et al. (2013) subsequently described and introduced the name *T. cellulolyticus* for strain Y-94. However, sequence data (ITS: A474749; RPB1: AB856422; BenA: AB773823) show that the species is a synonym of *T. pinophilus*. *Penicillium korosum* (CBS 762.68) was also found to be identical to *T. pinophilus* (Fig. 2) and is considered a synonym.

**Talaromyces pittii** (Quintan.) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560663. Fig. 56.  
≡ *Penicillium pittii* Quintan., Mycopathologia 91: 69. 1985.

**In: Talaromyces section Purpurei**

**Typus:** CBS 139.84, culture ex-type CBS 139.84 = IMI 327871.

**ITS barcode:** JN899325 (alternative markers: BenA = KJ865728; CaM = KJ885275; RPB2 = KM023297)

**Colony diam, 7 d (mm):**
- MEA 25 °C: No growth; CYA 25 °C: No growth; OA 35 °C: 36; CREA 4 °C: Yes 8 – 10.

**Colony characters:**
- *Talaromyces pittii* grows fast on general media and colonies have a slimy texture and produce a typical red reverse. Synnemata are produced after 2 – 3 wk of incubation and have a greyish colour, are narrowly conical and often sterile. Conidiophores have short stipes up to 60 μm long (Fig. 56). These characters distinguish it from other species.

**Talaromyces primulinus** (Pitt) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. MycoBank MB560664. Fig. 57.

≡ *Penicillium diversum* var. *aureum* Raper & Fennell, Mycologia 40: 541. 1948 (nom. inval., Art. 39, no latin diagnosis).

**ITS barcode:** JN899317 (alternative markers: BenA = JX494305; CaM = KF741954; RPB2 = KM023294)

**Colony diam, 7 d (mm):**
- CYA 5 – 8; CYA 30 °C 5 – 6; CYA 37 °C No growth; MEA 20 – 25; MEA 30 °C 13 – 16; DG18 6 – 8; CYAS No growth; OA 22 – 25; CREA 2 – 3; YES 8 – 10.

**Colony characters:**
- *Talaromyces primulinus* is a synonym of *Penicillium primulinum* var. *aureum* Raper & Fennell, Mycologia 40: 541. 1948.

**Micromorphology:**
- Synnemata formed after 2 – 3 wk on MEA up to 1 000 μm long. Conidiophore biverticillate and monoverticillate: stipes smooth walled, 10 – 60 × 1.8 – 2.5 μm; metulae two to five, divergent, 9 – 15 × 1.8 – 3 μm; phialides aceroso, three to five per metulae, 11 – 15 × 2 – 3 μm; conidia smooth, ellipsoidal, 2.5 – 4.5 × (–6.5) × 1.5 – 3.5 μm. Ascomata not observed.

**Distinguishing characters:**
- *Talaromyces pittii* grows fast on general media and colonies have a slimy texture and produce a typical red reverse. Synnemata are produced after 2 – 3 wk of incubation and have a greyish colour, are narrowly conical and often sterile. Conidiophores have short stipes up to 60 μm long (Fig. 56). These characters distinguish it from other species.
Fig. 56. Morphological characters of *Talaromyces pittii* (CBS 139.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 3 wk incubation. C–G. Conidiophores. H. Conidia. Scale bars: B = 1000 μm; C = 10 μm, applies to D–H.
Fig. 57. Morphological characters of *Talaromyces primulinus* (CBS 321.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
acerate, three to eight per metula, 7.5–12 × 1.5–2.5 μm; conidia smooth to finely roughed, ellipsoidal to fusiform, 2–4 × 1.5–3 μm.

**Extr textiles: According to the literature** *T. primulinus* can produce sclerone, isocerone, juglone and herqueinone (Fujimoto et al. 1986). We detected herqueinone, mitorubrin, mitorubrinic acid in NRRL 1704 = IBT 3805.

**Distinguishing characters:** *Talaromyces primulinus* grows restrictively on all media and does not grow at 37 °C. After 2 wk of incubation, yellow mycelia cover the colony. This is also observed in *T. flavovires* and *T. mamefii*. However, *T. mamefii* grows at 37 °C as a yeast form and *T. flavovires* grows faster on all media. The restricted growth of *T. primulinus* on CYA resembles *T. rademirici, T. diversus* and *T. erythromelis*. *Talaromyces primulinus* differs from *T. erythromelis* by its biverticillate conidiophores. *Talaromyces diversus* grows faster on MEA, while *T. rademirici* grows slower on MEA. Also, *T. primulinus* has slightly vesiculated stipes. Both *T. primulinus* strains were nutritionally deficient (Pitt 1980).

*Talaromyces proteolyticus* (Kamyschko) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011. MycoBank MB560665. Fig. 58. In: *Talaromyces* section Bacilliospori

**Typus:** CBS 303.67, culture ex-type CBS 303.67 = ATCC 18326 = NRRL 3378.

**ITS barcode:** JN899387 (alternative markers: BenA = KJ865729; CaM = KJ885276; RP2B = KM023301)

**Colony diam, 7 d (mm):** CYA 20–22; CYA 30 °C 19–20; CYA 37 °C No growth; MEA 20–21; MEA 30 °C 20; DG18 10; CYAS 9–10; OA 20–22; CREA 15; YES 20–21.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white, pastel yellow and pastel orange; texture floccose; sporulation sparse, conidia en masse pastel green (25B4–26B4); soluble pigments absent; exudates small clear droplets; reverse centre greyish green (25E5); soluble pigments absent; exudates small clear droplets; reverse pale and light green. CREA 25 °C, 7 d: Acid production moderate.

**Micro morphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 150–250 × 2–3 μm; branches 13–26 μm; metulae three to eight, divergent, 9–15 × 2–3 μm; phialides acerate, three to eight per metulae, 8–11 × 1.8–2.6 μm; conidia smooth, globose to subglobose, 2–3 × 1.5–2.5 μm. Ascomata not observed.

**Extr textiles:** We detected monorden and compounds with the same chromophore as emodin, herqueinone and neosartonin in *T. proteolyticus* NRRL 3378 = IBT 4481 = IBT 14325. Chemically *T. proteolyticus* is very different from *T. verruculosus.*

**Distinguishing characters:** *Talaromyces proteolyticus* produces deep, yellow colonies and grows relatively fast on general media, except on DG18 and on CYA at 37 °C. It produces smooth, globose to subglobose conidia (Fig. 58). Pitt (1980) considered *T. proteolyticus* synonymous with *T. verruculosus.* However, *T. verruculosus* produces globose to subglobose, rough-walled conidia, flask-shaped phialides and grows at 37 °C.

*Talaromyces pseudostromaticus* (Hodges, G.M. Warner & Rogerson) Samson et al., Stud. Mycol. 71: 176. 2011. MycoBank MB560666. Fig. 59. In: *Talaromyces* section Purpurei

**Typus:** Warner 18 (NY), culture ex-type CBS 470.70 = ATCC 18919 = FRR 2039.

**ITS barcode:** JN899371 (alternative markers: BenA = HQ156950; CaM = KJ885277; RP2B = KM023298)

**Colony diam, 7 d (mm):** CYA 25–34; CYA 30 °C 25–38; CYA 37 °C No growth; MEA 38–43; MEA 30 °C 30–40; DG18 19–21; CYAS No growth; OA 35–37; CREA 4–6; YES 27–32.

**Colony characters:** CYA 25 °C, 7 d: Colonies low, slightly raised at centre, plane, red colour underneath sporulating areas; margins low, narrow, entire (2–3 mm); mycelia white, some yellow present; texture velvety; sporulation moderately dense to dense, conidia en masse dull green (26D3–27D3); soluble pigments absent; exudates small clear droplets; reverse pale and light green. CREA 25 °C, 7 d: Acid production moderate.
Fig. 58. Morphological characters of *Talaromyces proteolyticus* (CBS 303.67T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 59. Morphological characters of Talaromyces pseudostromaticus (CBS 470.70T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Synnemata. D–F. Conidiophores. G. Conidia. Scale bars: B, C = 2000 μm; D = 10 μm, applies to E–G.
Colonies low, slightly raised at centre, plane, having a reddish colour in non sporulating areas; margins low, wide, entire (4–5 mm); mycelia white; texture velvety; sporulation sparse, conidia en masse greyish green (25D5); soluble pigments inconspicuously yellow; exudates pink; reverse reddish brown (8D7) at centre, fading into greyish red (8B6). OA 25 °C, 7 d: Colonies low, plane, having a reddish colour underneath sporulating areas; margins low, wide, entire (4 mm); mycelia white; texture velvety; sporulation moderately dense, conidia en masse dull green (26E4); soluble pigments absent; exudates absent; reverse greyish red (8C5). CREA 25 °C, 7 d: Acid production absent.

**Micromorphology**: Synnemata phototropic and formed after 2–3 wk on MEA up to 8,000 μm long. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 30–180 × 2.5–4.5 μm; branches 16–50 μm; metulae two to six, divergent, 7.5–17 × 2.5–4.5 μm; phialides acerose, three to six per metulae, 10–16 × 2–3.5 μm; conidia smooth, subglobose to ellipsoidal, 2.5–4 × 2–3 μm. Ascomata not observed.

**Extrolites**: Talaromyces pseustomatricus produces mitorubricin acid and secalonic acid D (Samson et al. 1989). It also produces a Monascus red pigment (azaphilone).

**Distinguishing characters**: Talaromyces pseustomatricus grows relatively fast on general media, but does not grow on CYA: Distinguishing characters: Talaromyces ptychoconidium grows restrictedly on CYA and MEA. It produces slimy, clear exudates and synnema like structures after 2 wk of incubation (Fig. 60). It characteristically produces spirally roughened conidia and thus resembles T. purpureus. However, T. purpureus grows restrictedly, has vesiculated stipes and produces red soluble pigments on MEA and OA.

**Talaromyces purpureus** (E. Müll. & Pacha-Aue) Stolk & Samson, Stud. Mycol. 2: 57. 1972. MycoBank MB324420. Figs 61, 62.

- Arachniotus purpureus E. Müll. & Pacha-Aue, Nova Hedwigia 15: 552. 1968.
- Penicillium purpureum Stolk & Samson, Stud. Mycol. 2: 57. 1972.

**In**: Talaromyces section Purpurei

**Typus**: CBS H-7832, culture ex-type CBS 475.71 = ATCC 24069 = ATCC 52513 = FRR 1731 = IMI 181546.

**ITS barcode**: JN899328 (alternative markers: BenA = GU385739; CaM = KJ885292; RPB2 = KM023278)

**Colony diam, 7 d (mm)**: CYA 2–4; CYA 30 °C No growth (sometimes up to 3); CYA 37 °C No growth; MEA 15–16; MEA 30 °C 17–18; DG18 1–2; CYAS No growth; OA 18–20; CREA No growth; YES 7–8.

**Colony characters**: CYA 25 °C, 7 d: Colonies growing but sterile. MEA 25 °C, 7 d: Colonies growing but sterile. MEA 30 °C, 7 d: Colonies germinating but sterile. DG18 25 °C, 7 d: Colonies germinating but sterile. OA 25 °C, 7 d: Colonies growing but sterile.
Fig. 60. Morphological characters of Talaromyces ptychoconidium (DAOM 241017T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B, C. Colony texture on MEA after 2 wk incubation. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 500 μm; D = 100 μm; E = 10 μm, applies to F–H.
Fig. 61. Morphological characters of Talaromyces purpureus (CBS 475.71T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on MEA after 2 wk incubation. C. Colony texture on OA after 2 wk incubation. D. Initials. E–J. Conidiophores. K. Conidia. Scale bars: B = 500 μm; C = 100 μm; D = 10 μm, applies to E–K.
margins low, wide, entire (1–2 mm); mycelia red; sporulation absent; soluble pigments absent; exudates absent; reverse dark cherry red. CREA 25 °C, 7 d: No growth.

Micromorphology: Conidiophores with solitary phialides or monoverticillate; stipes smooth walled, sometimes vesiculate up to 4 μm, 7–22 × 2–2.5 μm; phialides flask-shaped and acerose, one to four, 4.5–8(–16) × 2–3 μm; conidia rough with spiral ridges, thick walled, subglobose to broadly ellipsoidal, 3–4 × 2–3 μm. Ascomata not observed in our culture however *Talaromyces ptychoconidium* (Stoll) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560667. *T. purpurogenus* (Stoll) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560667. Fig. 63.

Distinguishing characters: *Talaromyces purpureus* grows very restrictedly on general media and produces red soluble pigments on MEA and OA. It produces yellow ascomata with big, thick walled, spiny, ellipsoidal (6.5–8 × 4.5–5.5 μm) ascospores. Its conidiophores often have solitary phialides, but are mostly monoverticillate and have vesiculated stipes and spirally roughened conidia (Figs 61, 62). *Talaromyces ptychoconidium* also produces spirally roughened conidia, but produces biverticillate conidiophores.

*Talaromyces purpurogenus* (Stoll) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560667. Fig. 63.

≡ *Penicillium purpurogenum* Stoll, Beitr. Morph. Biol. Char. Penicill.: 32. 1904.
≡ *Penicillium sanguineum* Sopp, Skr. Vidensk.-Selsk. Christiana, Math.-Naturvidensk. Kl. 11: 175. 1912.
≡ *Penicillium crateriforme* J.C. Gilman & E.V. Abbott, Iowa State Coll. J. Sc. 1: 293. 1927.
≡ *Penicillium vanilliae* Bouriquet, Bull. Acad. Malgache 24: 68. 1941 (nom. inval., Art. 36).

*In: Talaromyces* section *Talaromyces*

Typus: IMI 091926, culture ex-type CBS 286.36 = IMI 091926.

ITS barcode: JN899372 (alternative markers: *BenA* = JX315639; *CaM* = KF741947; *RPB2* = JX315709)
Fig. 63. Morphological characters of Talaromyces purpurogenus (CBS 132707). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Colony diam, 7 d (mm): CYA 20–25; CYA 30 °C 18–27; CYA 37 °C 16–25; MEA 30–45; MEA 30 °C 50–52; DG18 10–15; CYAS 5; OA 28–35; CREA 7–15; YES 25–40.

Colony characters: CYA 25 °C, 7 d: Colonies moderately deep, radially sulcate; margins low, plane, entire (1 mm); mycelia white and pastel red; texture floccose; sporulation sparse to moderately dense, conidia en masse dull green (26D3–26D4); soluble pigments bright red (also at 30 °C); exudates absent; reverse dark brown to violet brown (9F8–11F8). MEA 25 °C, 7 d: Colonies raised at point of inoculation, plane; margins low, plane, entire (3–4 mm); mycelia white and light orange; texture velvety and floccose, especially in the centre; sporulation moderately dense to dense, in some isolates absent, conidia en masse dull green (26E4–26E5); soluble pigments absent; exudates absent; reverse brownish yellow to brownish orange (5C7–6C7). YES 25 °C, 7 d: Colonies low, sulcate; margins low, plane, entire (1–2 mm); mycelia white and light orange; texture floccose; sporulation moderately dense to dense, conidia en masse dull green to greyish green (26E4–26E5); soluble pigments absent; exudates absent; reverse centre brown (6D7) fading into light yellow (4A4), in some isolates dark red to dark brown (8F4). DG18 25 °C, 7 d: Colonies raised at the point of inoculation, slightly sulcate, fruity odour; margins low, plane, entire (1 mm); mycelia white and bright orange; texture velvety and in some isolates floccose; sporulation sparse to dense, conidia en masse dark green (27F5); soluble pigments absent; exudates absent; reverse light brownish orange (5A4–5C4). OA 25 °C, 7 d: Colonies low, plane, fruity odour; margins low, plane, entire (2–3 mm); mycelia white and light orange; texture velvety and in some isolates floccose; sporulation sparse to dense, conidia en masse dull green to dark green (26E4–27F5); soluble pigments absent; exudates absent; reverse dull red and in some isolates colour lacking. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores bverticillate; stipes smooth walled, 70–200 × 1.5–3 μm; metulae three to five, divergent, 12–15 × 2.5–4; phialides acerose, three to six per metulae, 12–14 × 3 μm; conidia smooth, 3–3.5 × 2.5–2.5 μm. Ascomata not observed.

Extröles: Talaromyces purpurogenus produces rugulovasine A & B, rubratoxin A & B, spicilisporic acid, mitorubin, mitorubinic acid, mitorubinol, purpactin A-C, Monascus red azaphilone pigments, including N-glutarylrubropunctamine and luteoskyrin (Yilmaz et al. 2012).

Distinguishing characters: Talaromyces purpurogenus colonies produce red soluble pigments on CYA at 25 and 30 °C and have orange mycelia on DG18 (Fig. 63). Talaromyces purpurogenus resembles T. atroroseus, but T. atroroseus has finely rough to rough, dull to dark green, thick walled, ellipsoidal conidia and produces darker conidia especially on OA.

Notes: Yilmaz et al. (2012) synonymised Penicillium crateriforme, P. sanguineum and P. vanilliae with T. purpurogenus and this is followed here.

Talaromyces rademirici (Quintan) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. MycoBank MB560668. Fig. 64.

≡ Penicillium rademirici Quintan., Mycopathologia 91: 69. 1985.

In: Talaromyces section Purpurei
typus: CBS 140.84, culture ex-type CBS 140.84 = CECT 2771 = IMI 282406 = IMI 327870.

ITS barcode: JN899386 (alternative markers: BenA = KJ865734; RPB2 = KM023302)

Colony diam, 7 d (mm): CYA 5–6; CYA 30 °C 5–7; CYA 37 °C 3; MEA 14–15; MEA 30 °C 14–16; DG18 4–5; CYAS No growth; OA 9–10; CREA No growth; YES 5–6.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (4A2). MEA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate, white appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish orange (5C6) centre fading into greyish orange (5B6). YES 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse pale yellow (4A3). DG18 25 °C, 7 d: Colonies low, plane, slimy yeast like colony appearance; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse white (4A1). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white; texture velvety; sporulation moderately dense, conidia en masse greyish green (27C5–27D5); soluble pigments absent; exudates absent; reverse dull beige. CREA 25 °C, 7 d: No growth.

Micromorphology: Conidiophores bverticillate and monoverticillate with a minor proportion having subterminal branches; stipes smooth walled, 25–95 × 1.5–2.5 μm; branches 10–15 μm; metulae two to five, divergent, 7–11 × 2–2.5 μm; phialides acerose, two to six per metulae, 7.5–11.5 × 1.5–3 μm; conidia smooth, ellipsoidal, 2.5–4 × 1.5–2.5 μm. Ascomata not observed.

Distinguishing characters: Talaromyces rademirici grows restrictedly on all media and does not grow on CREA (Fig. 64). Its restricted growth on CYA resembles T. erythromellis, T. diversus and T. primulinus. Talaromyces diversus grows much faster on MEA. Talaromyces erythromellis produces unusual biverticillate conidiophores with subterminal branches, whereas T. rademirici produces mono- to bverticillate conidiophores. Talaromyces primulinus grows slightly faster and has slightly vesiculated stipes. The ex-type strain of T. rademirici is nutritionally deficient.

Talaromyces radicus (A.D. Hocking & Whitelaw) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560669. Fig. 65.

≡ Penicillium radicum A.D. Hocking & Whitelaw, Mycol. Res. 102: 802. 1998.

In: Talaromyces section Islandici
Fig. 64. Morphological characters of Talaromyces rademirici (CBS 140.84T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 65. Morphological characters of Talaromyces radicus (CBS 100489T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–G. Conidiophores. H. Conidia. Scale bar: B = 10 μm, applies to C–H.
**Typus:** DAR 72374, culture ex-type CBS 100489 = FRR 4718 = IBT 14379.

**ITS barcode:** KF984878 (alternative markers: BenA = KF984599; CaM = KF984773; RPB2 = KF985013)

**Colonial diam., 7 d (mm):** CYA 15–22; CYA 30 °C 22–27; CYA 37 °C 25–30; MEA 15–25; MEA 30 °C 24–27; DG18 10–15; CVAS 14–20; OA 15–22; CREA 4–8; YES 22–25.

**Colonial morphology:** CYA 25 °C, 7 d: Colonies low, slightly sulphate; margins narrow (1–2 mm), low, entire, plane; mycelium white and yellow; texture velvety to loosely funiculose; sporulation absent to sparse; conidia en masse greyish green (30C7–30E7); exudes clear and yellow droplets; soluble pigment absent; reverse centre yellowish brown (5E6–5F6) in the centre fading into light brown (5D6) and pale yellow (4A3). MEA 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulphate; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; texture loosely funiculose to floccose; sporulation absent to sparse; conidia en masse greyish green (29C5–29E5) exudes in some colonies clear small droplets; soluble pigment absent; reverse yellowish brown (5F5) centre. YES 25 °C, 7 d: Colonies raised at centre, slightly sulphate; margins narrow (1 mm), low, entire, plane; mycelium white, yellow and pale orange; texture floccose; sporulation absent to sparse; conidia en masse dull green (26D4–26E4); exudes absent; soluble pigment absent; reverse light brown to olive brown (4D6–6D6) centre fading into reddish yellow to orange (4A6–6A6). DG18 25 °C, 7 d: Colonies raised at centre, plane; margins narrow (1 mm), low, entire, plane; mycelium white; texture floccose; sporulation absent to sparse; conidia en masse greyish green (29E5); exudes clear and yellow droplets; soluble pigment absent; reverse golden yellow (5B7) fading into olive brown (4D6). OA 25 °C, 7 d: Colonies raised at centre, plane; margins narrow (1–2 mm), low, entire, plane, in some isolates yeast like slimy margins; mycelium white and yellow; texture loosely funiculose; sporulation moderately dense to dense; conidia en masse greyish green (30C6–30D6) and in some isolates dull green (28D4–28E4); exudes clear small droplets in the centre; soluble pigment absent; reverse brownish orange centre fading into yellow. CREA, 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biseriellate with a minor pro-
portion having subterminal branches up to 15 μm; stipes smooth walled, 80–270 × 2–2.5 μm; metulae three to six, divergent, 9–12 × 2–3 μm; phialides acerosé, three to six per metulae, 8–11 × 2–2.5 μm; conidia finely rough-walled in ridges, globose to ellipsoidal, 2–3 × 2–2.5 μm.

**Extrolites:** *Talaromyces radicus* produces xanthoradone A, B & C (Yamazaki et al. 2009a, b, 2010a), which has only found in this species, and we also detected emodin, skyrin and rugulosin A and a series of azaphilones, including 6'-hydroxy-3'-methoxy-mitorubin, 4'-hydroxy-3'-methoxy-(S)-mitorubin and mono-
methyl-(S)-mitorubin in agreement with Yamazaki et al. (2010b). Furthermore CBS 137382 produced traces of one of the uku-
lactones. We detected two anti-MRSA antibiotics rugulosin A and C (Yamazaki et al. 2010c) and the latter authors also isolated rugulosin B. 6'-Hydroxy-3'-methoxy-mitorubin is a potentiat of miconazol activity (Yamazaki et al. 2010a).

**Distinguishing characters:** *Talaromyces radicus* is characterised by yellow fluffy colonies on CYA and MEA (Fig. 65). Colonies are deep and consist of bright yellow mycelia that form a fluffy texture, with the production of funicles on MEA (Hocking et al. 1998). It also has the ability to grow at 37 and 40 °C. Phylo-
genetically it is closely related to *T. allahabadensis*. However, *T. radicus* does not produce acid on CREA and weakly sporulates on general media, as well as growing faster at 37 °C, compared to *T. allahabadensis*.

**Talaromyces ramulosus** (Visagie & K. Jacobs) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560670. Fig. 66.

≡ *Penicillium ramulosum* Visagie & K. Jacobs, Mycologia 101: 890. 2009.

**ITS barcode:** EU795706 (alternative markers: BenA = FJ753290; CaM = JX140711; RPB2 = KMO23281)

**Typus:** PREM 59947, culture ex-type DAOM 241660 = CV 2837 = DTO 184-B8.

**In:** *Talaromyces* section Purpurei

**Colonial diam., 7 d (mm):** CYA 32–40; CYA 30 °C 39–50; CYA 37 °C 5–8; MEA 45–48; MEA 30 °C 48–52; DG18 23–25; CVAS 15–18; OA 40–45; CREA 10–14; YES 40–43.

**Colonial characters:** CYA 25 °C, 7 d: Colonies low, slightly raised at centre, radially sulphate; margins low, plane, entire (3–5 mm); mycelial white and in some isolates orange to red; texture funicle and exudates; sporulation sparse to moderately dense, conidia en masse greyish green (25D5–25E5); soluble pigments absent; exudes absent; reverse centre dark brown (6F4–6F7), in some isolates fading into greyish orange (6B6). MEA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (5–6 mm); mycelium white; texture funiculose (especially in the centre sterile aerial hyphae), formation of synnemata after 2 wk of incubation on scraped agar; sporulation dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudes very small clear droplets; reverse centre dark brown to reddish brown (7F7–8F7), in some isolates fading into orange red (8B7). YES 25 °C, 7 d: Colonies slightly raised at centre, radially sulphate; margins low, narrow, entire (3 mm); mycelial white and in some isolates orange red centre; texture floccose and exudates; sporulation sparse to moderately dense, conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudes absent; reverse centre dark brown (6F8–7F8), fading into greyish yellow to light blonde (4B3–4C3), in some isolates golden yellow (5B7). DG18 25 °C, 7 d: Colonies slightly raised in the centre, plane; margins low, narrow, entire (3–5 mm); mycelial white; texture funiculose; sporulation moderately dense to dense (no sporulation at centre, centre is slimy yeast like structure), conidia en masse greyish green to dark green (26E5–26F5); soluble pigments absent; exudes clear droplets at centre; reverse greyish green to olive (1C3–1E4), in some isolates (DTO 181-F6) greyish orange (5B6). OA 25 °C, 7 d: Colonies low, plane; margins low, wide, entire (5–6 mm); mycelial white; especially in the centre synnema like aerial hyphae growing, and there is an exudate in the centre makes a structure like synnema; texture velvety and funicelose; sporulation dense, conidia en masse greyish green to dark green (26E5–26F5);
Fig. 66. Morphological characters of *Talaromyces ramulosus* (DAOM 241660T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 3 wk incubation. C. Synnemata. D–G. Conidiophores. H. Conidia. Scale bars: B, C = 1000 μm; D = 10 μm, applies to E–H.
soluble pigments absent; exudates clear droplets in centre growing to air; reverse pale light green, DTO 183-A7 light red centre. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology**: Synnemata formed after 2 wk on MEA up to 50–250 μm long. Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 10–60 × 2.5–3.5 μm; branches 10–20 μm; metulae three to six, divergent, 8–11 × 2–3 μm; phialides acerose, three to six per metulae, 8.5–11 × 2–2.5 μm; conidia smooth, subglobose to ellipsoidal, 2.3–1.5–2.5 μm. Ascomata not observed.

**Distinguishing characters**: This species produces fast growing colonies on most media, with synnemata up to 500 μm long, produced after 2 wk incubation on MEA, similar to *T. cecidicola* and *T. chloroloma*. *Talaromyces ramulosus* and *T. chloroloma* grows faster on MEA than *T. cecidicola*, while *T. chloroloma* produces acid on CREA, which is absent in both *T. ramulosus* and *T. chloroloma*. Macromorphologically *T. ramulosus* resembles *T. pinophilus*, *T. amestolkiae* and *T. stolli*. However shorter stipes (up to 60 μm) and extra branches on the conidiophores can easily differentiate *T. ramulosus* from these species.

*Talaromyces rotundus* (Raper & Fennell) C.R. Benj., Mycologia 47: 683. 1955. MycoBank MB306719. Fig. 67.≡*Penicillium rotundum* Raper & Fennell, Mycologia 40: 518. 1948 ≡ *Penicillium sphærum* Pitt, Gen. Penicil.: 494. 1980.

**Colony characters**

- *T. pinophilus* and *T. chloroloma*.
- Produces acid on CREA, which is absent in both *T. cecidicola* and *T. chloroloma*. *Talaromyces ramulosus* produces acid on CREA, which is absent in both *T. ramulosus* and *T. chloroloma*. Macromorphologically *T. ramulosus* resembles *T. pinophilus*, *T. amestolkiae* and *T. stolli*. However shorter stipes (up to 60 μm) and extra branches on the conidiophores can easily differentiate *T. ramulosus* from these species.

*In: Talaromyces section Islandici*

**Typus**: IMI 040589, culture ex-typus CBS 369.48 = IMI 040589 ≡ NRRL 2107 = FRR 2107 = ATCC 10493 = IBT 4829.≡*Penicillium rotundum* Raper & Fennell, Mycologia 40: 518. 1948 ≡ *Penicillium sphærum* Pitt, Gen. Penicil.: 494. 1980.

**ITS barcode**: JN899353 (alternative markers: *BenA* = KJ865730; *CaM* = KJ885278; *RPB2* = KM023275)

**Colony diam, 7 d (mm)**: CYA 9–11; CYA 30 °C 12–15; CYA 37 °C No growth; MEA 15–17; MEA 30 °C 18–19; DG18 14–15; CYAS 2–3; OA 20; CREA No growth; YES 9–10.

**Colony characters**: CYA 25 °C, 7 d: Colonies slightly raised, sulphate; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse greyish green (27E5) circle at centre fading into greenish grey (1B2). MEA 25 °C, 7 d: Colonies slightly raised, slightly sulphate; margins low, plane, entire (<1 mm); mycelia white and yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies slightly raised at centre, sunken at centre, sulphate; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse light yellow (4A4). DG18 25 °C, 7 d: Colonies slightly raised at centre, sulphate; margins low, plane, entire (<1 mm); mycelia white; texture yeast like slimy hyphae; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (4A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white and orange yellow; sporulation absent; soluble pigments absent; exudates absent; reverse pale orange centre fading into pale light yellowish beige. CREA 25 °C, 7 d: No growth.

**Micromorphology**: Conidiophores irregular monoverticillate and biverticillate; stipes smooth walled, 20–80 × 1–2 μm; metulae one to three, divergent, 6–12 × 1–2 μm; phialides acerose, two to five, 5–17 × 1–2 μm; conidia smooth, ellipsoidal to fusiform, 3–(5–6.5) × 1.5–2.5 μm. Ascomata yellow to orange, globose to subglobose, ripening within 2–3 wk on OA at 25 °C, 100–300 μm, covering consisting of a few layers of well-developed networks of white and light yellow hyphae; asci broadly globose to ovoidal 11–17 × 9.5–13 μm; ascospores globose, spinose, 4.5–5.5 × 4–5.5 μm.

**Extrarites**: *Talaromyces rotundus* produces emodin, rugulosin and an extrorite with the same UV spectrum as talaroxanthone (Koolen et al. 2013).

**Distinguishing characters**: *Talaromyces rotundus* is characterised by restricted growth on general media. Colonies lack sporulation after 7 d of incubation at 25 °C and form irregular monoverticillate and biverticillate conidiophores (Fig. 67). Based on an ITS and *BenA* phylogeny, *T. rotundus* is consistently resolved in a separate clade, closely related to *T. tratensis* and *T. wortmannii* (Fig. 7). *Talaromyces rotundus* differs from the rest of the ascomata producers in this clade by the production of globose spinose ascospores. It resembles *T. bacillisporus* because of the ascospore shape and ornamentation, but *T. bacillisporus* produces cylindrical and rod-shaped conidia and has a dark green colony reverses on CYA at 30 and 37 °C.

*In: Talaromyces section Talaromyces*

**Typus**: CBS H-21052, culture ex-typus CBS 132704 = DTO 193-H6 ≡ IBT 10703 = CBS 113137.≡*Penicillium rubrum* Strain 5225.

**ITS barcode**: JX315662 (alternative markers: *BenA* = JX315629; *CaM* = KF741938; *RPB2* = JX315700)

**Colony diam, 7 d (mm)**: CYA 20–35; CYA 30 °C 25–35; CYA 37 °C 14–18; MEA 35–40; MEA 30 °C 45–48; DG18 14–18; CYAS 4–5; OA 40–45; CREA 8–15; YES 20–35.

**Colony characters**: CYA 25 °C, 7 d: Colonies sunken at centre, sulphate; margins low, plane, entire (2–3 mm); mycelia white, pastel yellow and pastel red; texture velvety; sporulation moderately dense to dense, conidia *en masse* olive green to greyish green (26D4–27D4); soluble pigments weak red (also at 30 °C), in some isolates lack of pigments; exudates absent; reverse brownish red (8B8–8F8). MEA 25 °C, 7 d: Colonies raised at point of inoculation, slightly sunken at centre; margins low, plane, entire (3–5 mm); mycelia white and yellow (especially at centre); texture velvety; sporulation dense, conidia *en masse* greyish green (26D4–26E4); soluble pigments absent; exudates absent; reverse brownish red to dark brown centre, in some isolates lack of centre pigmentation, greyish yellow to greyish orange (4B4–5B4). YES 25 °C, 7 d: Colonies raised at centre, sulphate; margins low, plane, entire (2–3 mm); mycelia white and yellow; texture velvety and floccose in some isolates; sporulation sparse to dense, conidia *en masse* greyish green (27C5–27E6–27E7); soluble pigments absent; exudates absent.
Fig. 67. Morphological characters of *Talaromyces rotundus* (CBS 369.48T). A. Colonies from left to right (top row) CYA, MEA, DG16 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Texture an ascocata on OA after 2 wk incubation. C. Asci and ascospores. D. Ascospores. E–H. Conidiophores. I. Conidia. Scale bar: C = 10 μm, applies to D–I.
Fig. 68. Morphological characters of *Talaromyces ruber* (CBS 132704T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
reverse greyish brown to brown (5F3–5F8) centre fading into orange to light brown (5C4–5D4). DG18 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation sparse to moderately dense, conidia en masse greyish green (27D4); soluble pigments absent; exudates small clear droplets; reverse greyish green (30D6–30E6) centre fading into greenish white (30A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (4–5 mm); mycelia white and light orange, in some isolates light yellow; texture velvety and in some isolates floccose; sporulation moderately dense to dense, conidia en masse greyish green (30D6–30E6); soluble pigments absent; exudates small clear droplets; reverse reddish orange. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 100–250 × 2.5–3 μm, branches 14–15 μm; metulae three to five, 7–12 × 2–3 μm; phialides acerose, three to six per metulae, 9–12 × 2–2.5 μm; conidia smooth, ellipsoidal, 2.5–3.5 × 1.5–2 μm; phialides 3.5 × 1.5–2 μm, branches 14–35; MEA 38 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–5 mm); mycelia white; texture floccose and funiculose; sporulation moderately dense to dense, conidia en masse dull green (27D4); soluble pigments generally absent in some isolates orange soluble pigments around colony; exudates absent; reverse brownish beige. CREA 25 °C, 7 d: Acid production absent.

**Extrolites:** Talaromyces rubicundus produces a compound with islandicin chromophore, mitorubrin, mitorubrinic acid and rubratoxins.

**Distinguishing characters:** Talaromyces rubicundus grows fast on general media and colonies are deep and have fluffy texture on MEA (Fig. 69). It has relatively short stipes up to 85 μm long. Pitt (1980) considered T. rubicundus, T. varians and T. aurantius as synonyms of T. fucinulosus. However, T. fucinulosus has a strongly funiculose texture and strong acid production on CREA, whereas T. rubicundus does not produce acid. Talaromyces varians has pigmented stipes and T. aurantius grows restrictedly on DG18 and YES, and produces cylindrical to ellipsoidal conidia.

**Talaromyces rugulosus** (Thom) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560672. Fig. 70.

≡ Penicillium rugulosum Thom, Penicillia: 485. 1930.
≡ Penicillium chrysitis Bainier, Bull. Trimest. Soc. Mycol. Fr. 23: 17. 1907 (non Dierckx).
≡ Penicillium rugulosum Thom, U.S.D.A. Bur. Animal Industr. Bull. 118: 60. 1910.
≡ Penicillium chrysitis Bouarge, Cellule 33: 252. 1923.
≡ Penicillium tardum Thom, Penicillia: 485. 1930.
≡ Talaromyces echinosporus (Nehira) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011 ≡ Penicillium echinosporum Nehira, J. Ferment. Technol., Osaka 11: 861. 1933.

**In:** Talaromyces section Islandici

**Talaromyces rubicundus** (J.H. Mill., Giddens & A.A. Foster) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560671. Fig. 69.

≡ Penicillium rubicundum J.H. Mill., Giddens & A.A. Foster, Mycologia 49: 797. 1957.

In: Talaromyces section Talaromyces

**Typus:** No. 2531 (A.A. Foster), culture ex-type CBS 342.59 = ATCC 13217 = IMI 099723 = NRRL 3400.

**ITS barcode:** JN899384 (alternative markers: BenA = JX494309; CaM = KF741956; RPB2 = KM023296)

**Colonies diam, 7 d (mm):** CYA 30–32; CYA 30 °C 38–40; CYA 37 °C 34–35; MEA 38–39; MEA 30 °C 50–52; DG18 15; CYAS 5–6; OA 40–45; CREA 17–18; YES 30–35.

**Colonies diam, 7 d:** Colonies raised at centre, concentrically sulcate; margins low, plane, entire (2 mm); mycelia white and pastel yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish orange (5C5) centre fading into orange white (5A2). MEA 25 °C, 7 d: Colonies deep, plane; margins low, plane, entire (2 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse coffee brown (5F7) centre fading into brownish orange (6C8). YES 25 °C, 7 d: Colonies low, slightly sulcate; margins low, plane, entire (2–3 mm); mycelia white, pastel red and pastel yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse light yellow (4A4) centre fading into light yellow (4A2). DG18 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose and funiculose; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish brown (5E8). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish beige. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 10–85 × 2–3 μm; branches 12–15 μm; metulae three to six, divergent, 8–17 × 2–3 μm; phialides acerose, three to six per metulae, 7.5–15.5 × 1.5–2.5 μm; conidia smooth, subglobose to ellipsoidal, 2–3 × 1.5–2.5 μm. Ascomata not observed.

**Extrolites:** Talaromyces rubicundus produces a compound with islandicin chromophore, mitorubrin, mitorubrinic acid and rubratoxins.

**Distinguishing characters:** Talaromyces rubicundus grows fast on general media and colonies are deep and have fluffy texture on MEA (Fig. 69). It has relatively short stipes up to 85 μm long. Pitt (1980) considered T. rubicundus, T. varians and T. aurantius as synonyms of T. fucinulosus. However, T. fucinulosus has a strongly funiculose texture and strong acid production on CREA, whereas T. rubicundus does not produce acid. Talaromyces varians has pigmented stipes and T. aurantius grows restrictedly on DG18 and YES, and produces cylindrical to ellipsoidal conidia.

**Talaromyces rugulosus** (Thom) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560672. Fig. 70.

≡ Penicillium elongatum Bainier, Bull. Trimest. Soc. Mycol. Fr. 23: 17. 1907 (non Dierckx).
≡ Penicillium rugulosum Thom, U.S.D.A. Bur. Animal Industr. Bull. 118: 60. 1910.
≡ Penicillium chrysitis Bouarge, Cellule 33: 252. 1923.
≡ Penicillium tardum Thom, Penicillia: 485. 1930.
≡ Talaromyces echinosporus (Nehira) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 175. 2011 ≡ Penicillium echinosporum Nehira, J. Ferment. Technol., Osaka 11: 861. 1933.

**In:** Talaromyces section Islandici

**Typus:** IMI 040041, culture ex-type CBS 371.48 = ATCC 10128 = IMI 040041 = MUCL 31201 = NRRL 1045 = IBT 4485.

**ITS barcode:** KF984834 (alternative markers: BenA = KF984575; CaM = KF984702; RPB2 = KF984925)

**Colonies diam, 7 d (mm):** CYA 15–17; CYA 30 °C (6–)10–15; CYA 37 °C No growth; MEA 17–20; MEA 30 °C (3–)13–15; DG18 13–15; CYAS 8–12; OA 15–16; CREA 8–10; YES 15–20.

**Colonies characters:** CYA 25 °C, 7 d: Colonies in some isolates slightly raised at centre and some isolates low, plane to slightly concentrically sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium generally only white, in some isolates in the centre very light yellow (DTO 225-I6, DITO 180-A4, DTO 254-A2, DTO 179-I3, DTO 278-E9) and in some pale light orange (14A2);
Fig. 69. Morphological characters of Talaromyces rubicundus (CBS 342.59T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 70. Morphological characters of Talaromyces rugulosus (DTO 180-A4). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
texture velvety; sporulation dense; conidia en masse dull green to dark green (2E6–2F4); exudates absent; soluble pigment absent; reverse centre yellowish brown (5E4–5F4) fading into light yellow to greyish yellow (2C6–2F4); mycelium generally only white, in some isolates slightly sulphate; margins narrow (1–2 mm), low, entire, plane; mycelium generally only white, in some isolates the centre very light yellow (CBS 137360, CBS 101423 and DTO 269-G4); texture velvety; sporulation dense; conidia en masse dull green to dark green (2E6–2F4); exudates absent; soluble pigment absent; reverse centre yellowish brown (5E6–6E6). YES 25 °C, 7 d: Colonies low, plane; margins narrow (1 mm), low, entire, plane; mycelium generally only white, in some isolates the centre very light yellow (1A4–2A5) and greyish green (1C5–1D5), in some isolates lack of centre colour. DG18 25 °C, 7 d: Colonies slightly raised at centre, slightly sulphate; margins narrow (1–2 mm), low, entire, plane; mycelium white; texture velvety; sporulation dense; conidia en masse dull green to dark green (2E6–2F4); exudates absent; soluble pigment absent; reverse centre yellowish brown (5E6–5F4) fading into light yellow to greyish yellow (2A5–2B5 to 1A5–1B5). OA 25 °C, 7 d: Colonies low, plane; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; texture velvety to loosely funiculose, especially at centre; sporulation dense; conidia en masse dull green to dark green (2E6–2F4); exudates clear, yellow and orange droplets; soluble pigment absent; reverse yellowish green and in some isolates brownish orange centre. CRE5 25 °C, 7 d: Colonies in some isolates acid production absent and in some isolates very weak acid production.

Micromorphology: Conidiophores biverticillate having symmetrical subterminal branches; stipes smooth walled, 40–110 × 2–3 μm; with extra branches 10–25 μm; metulae three to six, divergent, 7–15 × 2–3.5 μm; phialides acerose to flashe-shaped, three to six per metulae, 7–14 × 2–3.5 μm; conidia smooth to finely rough, ellipsoidal to fusiform, 2.5–6 × 2.5–4 μm.

Extrolites: *Talaromyces rugulosus* produces emodin, endocorcin and skyrin (Tatsuno et al. 1975); (+)-rugulosin = rugulosin A (Howard & Raistrick 1954a, b, Takeda et al. 1973), rugulin (Sedmera et al. 1978), OF4949-I, -II, III, IV, -D and -F (Sano et al. 1986a, b) and prugosin (prugosene = ukulactones) A1, A2, A3, B1, B2, C1, C2 (Lang et al. 2007, Mori et al. 2011). We detected berkelic acid, two mitorubrins, rugulosin, skyrin, one of the OF4949 compounds, and three prugosins (= ukulactones).

**Distinguishing characters:** *Talaromyces rugulosus* grows slow and produces compact and velvety colonies with dark green conidia (Fig. 70). Its conidiophores have acerose to flask-shaped phialides and additional symmetrical subterminal branches. Based on ITS and *BenA* phylogenies, *T. rugulosus* is resolved as a close relative of *T. atricola* (Fig. 7). In addition, *Penicillium chrysitis*, *P. tardum* and *T. echinosporus* are synonymous with *T. rugulosus* (Fig. 7). *Talaromyces rugulosus* differs from its close relatives by the production of dark green, compact and velvety colonies.

**Notes:** Samson et al. (2011), accepted *T. echinosporus* (CBS 344.51) as a valid species. However our ITS and *BenA* phylogenies show, that *T. echinosporus* (CBS 344.51), *P. tardum* (NRRL 1073), *P. chrysitis* (CBS 137366), and *P. elongatum* (NRRL 1073) are identical with *T. rugulosus* (Fig. 7) and are considered synonyms. A detailed study of this species complex is being prepared in a separate publication.

**Talaromyces ryukyuensis** (S. Ueda & Udagawa) Arx, Persoonia 13: 282. 1987. MycoBank MB132096. 
≡ Sagenoma ryukyuense S. Ueda & Udagawa, Mycotaxon 20: 499. 1984.

**In:** Talaromyces section Helici

**Typus:** Unknown, culture ex-type NHL 2917 = DTO 176-I6.

**ITS barcode:** AB176628

**Colony characters:** Fide Ueda & Udagawa (1984) colonies on OA spreading rapidly at 37 °C, attaining a diameter of 8.5 cm within 10 d, consisting of thin layer of numerous ascocoma coral to dark vinaceous (Rayner 1970) in colour; conidia limited; exudate lacking; odour faintly mouldy; reverse amber to coral (Rayner 1970). Colonies on malt agar spreading, 7.8 cm in 14 d at 37 °C, thin with reduced formation of ascocoma, showing a marked tendency to develop sectors; conidia abundantly produced, saffron to yellow-green or malachite green (Rayner 1970). Colonies on czapek agar growing restrictedly, very thin, vegetative mycelium submerged, pale luteous (Rayner 1970); ascocoma not produced.

**Micromorphology:** Fide Ueda & Udagawa (1984) conidiophores with solitary phialides or monoverticillate, stipe smooth, 12.5–50 × 3–4 μm; phialides four to six, acerose, 10–17.5(–20) × 2.5–5 μm; conidia formed in long chains, thick walled, usually rough sometimes smooth, cylindrical to fusiform, ellipsoidal or ovoidal, 3.5–12(–15) × 2.5–3.5 μm. Ascoma ripening within 2 to 3 wk, deep reddish, globose to subglobose, 80–350 μm in diam; ascii 8.5–10.5 μm in diam; ascospores yellowish orange, reddish in mass, broadly ellipsoidal, 4–5 × 3–4 μm, thick walled, usually spiny with spines up to 0.5 μm long.

**Notes:** *Talaromyces ryukyuensis* is a thermotolerant species (Ueda & Udagawa 1984) with an optimum growth temperature of 30–37 °C, while at 25 and 40 °C a reduction in sporulation occur (Ueda & Udagawa 1984). It was originally described as a Sagenoma species, but based on molecular results, it is classified in *Talaromyces*. Unfortunately, the ex-type strain was not available for our study, and data were taken from Ueda & Udagawa (1984).

**Talaromyces sayulitensis** Visagie et al., Stud. Mycol. 78: 132. 2014. MycoBank MB809188.

**In:** Talaromyces section Talaromyces

**Typus:** CBS H-21798, culture ex-type CBS 138204 = DTO 245-H1.

**ITS barcode:** KJ775713 (alternative markers: *BenA* = KJ775206; *CaM* = KJ775422)
Colony diam, 7 d (mm): Fide Visagie et al. (2014) CYA 24–29; CYA 30 °C 35–43; CYA 37 °C 32–40; MEA 37–40; MEA 30 °C 24–27; DG18 18–22; CYAS 5–8; OA 40–42; CREA 15–18; YES 37–40.

Colony characters: Fide Visagie et al. (2014) CYA 25 °C, 7 d: Colonies low, raised at centre, slightly sulcate; margins low, narrow, entire; mycelia white to yellow to red; texture floccose; sporulation absent; soluble pigments absent; exudates absent to clear in some isolates; reverse brown (6E6) in the centre, fading into brownish orange (6C7) and light yellow (4A4). MEA 25 °C, 7 d: Colonies low, slightly raised at centre, plane; margins low, narrow, entire; mycelia white, pastel yellow and pastel red; texture loosely funiculose to floccose; sporulation sparse, conidia en masse greyish green (27D5–E5); soluble pigments absent; exudates absent; reverse brownish orange (6C6–6C7). YES 25 °C, 7 d: Colonies low, raised at centre, sulcate; margins low, narrow, entire; mycelia white to yellow; texture loosely funiculose to floccose; sporulation sparse to moderately dense, conidia en masse greyish green (27D5–27E5); soluble pigments absent; exudates absent; reverse brownish orange (6C6–6C7). DG18 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire; mycelia white to yellow; texture floccose; sporulation moderately dense, conidia en masse greyish green (26D5–26E5); soluble pigments absent; exudates absent; reverse light yellow (3A5–4A5). OA 25 °C, 7 d: Colonies low, slightly raised at centre, plane; margins low, wide, entire; mycelia white to yellow; texture loosely funiculose and floccose, especially in the centre sterile aerial hyphae; sporulation dense, conidia en masse greyish green (27C5–27D5); soluble pigments absent; exudates absent. CREA 25 °C, 7 d: Acid strongly produced.

Micromorphology: Fide Visagie et al. (2014) conidiophores biverticillate, subterminal branches sometimes present; stipes smooth walled, (40–)85–300 × 2–3.5 μm; branches up to 40 μm long; metulae divergent, 8–11.5(–14) × 2.5–3 μm; phialides acerose, 8–11 × 2.5–3 μm; conidia smooth, subglobose to broadly ellipsoidal, 2.5–3 × 2.5–2.5.

Notes: Talaromyces sayulitensis is a close relative of T. pinophilus and T. liani. Talaromyces liani lacks the acid production observed in T. sayulitensis, produces larger conidia (2.5–4 μm) and typically produces a sexual state. Talaromyces pinophilus also produces acid on CREA. Other colony characters are very similar between T. pinophilus and T. sayulitensis with only minor differences observed in colony growth rates. However, this is not considered to be sufficient for morphological identification. As a result, sequence data is needed for making correct identifications. For an illustration of the species, readers are referred to Visagie et al. (2014).

Talaromyces scorteus (Nakazawa, Takeda & Suematsu) S.W. Peterson & Jurjevic, PLoS ONE e78084-page 8. 2013. MycoBank MB492647. Fig. 71.

≡ Penicillium scorteum Nakazawa, Takeda & Suematsu, J. Agric. Chem. Soc., Japan 10: 103. 1934.
≡ Talaromyces phialosporus (Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 176. 2011 ≡ Penicillium phialosporum Udagawa, J. Agric. Sci. Tokyo Nogyo Daig. 5: 11. 1959.

In: Talaromyces section Islandici

Typus: Unknown, culture ex-typus: CBS 340.34 = NRRL 1129 = FRR 1129.

ITS barcode: KF984892 (alternative markers: BenA = KF984565; CaM = KF984684; RP2′ = KF984916)

Colony diam, 7 d (mm): CYA 8–16; CYA 30 °C 8–9; CYA 37 °C No growth; MEA 10–15; MEA 30 °C 15–16; DG18 8–17; CYAS Generally no growth, in some isolates colonies up to 8; OA 8–16; CREA 4–10; YES 7–16.

Colony characters: CYA 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins narrow (12 mm), low, in some isolates entire and in some isolates not entire, plane; mycelium white and yellow; sporulation sparse to dense; texture velvety and in some isolates floccose in the centre; conidia en masse dark green (26F4–26F6); exudates absent; soluble pigment absent (except CBS 500.75 yellow soluble pigments around colonies); reverse centre olive (2E4) centre fading into greyish yellow to olive (2C4–2D4) (CBS 500.75 reverse reddish yellow (4A6)). MEA 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins narrow (1 mm), low, in some isolates entire and in some isolates not entire, plane; mycelium white and yellow; sporulation sparse to dense; texture velvety and in some isolates floccose in the centre; conidia en masse dark green (26F4–26F6); exudates absent; soluble pigment absent; reverse centre olive brown (5F6) fading into brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins narrow (1–2 mm), low, in some isolates entire and in some isolates not entire, plane; mycelium white and yellow; sporulation sparse to dense; texture velvety and in some isolates floccose in the centre; conidia en masse dark green (26F4–26F6); exudates absent; soluble pigment absent; reverse centre olive (2E4) centre fading into greyish yellow to olive (2C4–2D4) (except DTO 270-A6 and CBS 340.34 reverse orange (6A7) and light yellow (4A4–4A5), respectively). OA 25 °C, 7 d: Colonies low, plane; margins narrow (1 mm), low, entire, plane; mycelium white and yellow; sporulation sparse to dense; texture velvety and in some isolates floccose in the centre; conidia en masse dark green (26F4–26F6); exudates absent; soluble pigment absent; reverse centre olive (2E4) centre fading into greyish yellow to olive (2C4–2D4) (except DTO 270-A6 clear droplets); soluble pigment absent; reverse dark green to yellowish green. CREA, 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate having symmetrical subterminal branches; stipes smooth walled, 40–110 × 2.5–3 μm; with extra branches 10–25 μm; metulae three to six, divergent, 7–12 × 1.5–3.0 μm; phialides flask-shaped to acerose, three to six per metulae, 6–13 × 2–3.5 μm; conidia smooth, ellipsoidal, 3–5.5 × 2–3 μm.

Extritomes: Talaromyces scorteus produced mitorubin and compounds with a chromophore like rubiginosin.

Distinguishing characters: Talaromyces scorteus is characterised by restricted growth and deep, compact and densely sporulating colonies (Fig. 71). It cannot grow at 37 °C. Talaromyces scorteus is most similar to T. rugulosus, both having biverticillate
Fig. 71. Morphological characters of *Talaromyces scortea* (CBS 233.60). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
conidiophores, commonly with subterminally branches, and flask-shaped to acerose phialides. However, *T. scorteus* has shorter stipes, smaller colony sizes on most media and darker conidia.

Notes: We are following Peterson & Jurjević (2013) who considered that *T. phiolosporus* (CBS 233.60) is a synonym of *T. scorteus* (Fig. 7).

**Talaromyces siamensis** (Manoch & C. Ramírez) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. MycoBank MB560674. Fig. 72.

*Pencillium siamense* Manoch & C. Ramírez, Mycopathologia 101: 32. 1988.

In: Talaromyces section Talaromyces

**Typus:** CBS 475.88, cultures ex-type CBS 475.88 = IMI 323204.

**ITS barcode:** JN899385 (alternative markers: *BenA* = JX091379; *CaM* = KF741960; *RFP2* = KM023279)

Colony diam, 7 d (mm): CYA 20–22; CYA 30 °C 30–32; CYA 37 °C 15; MEA 32–33; MEA 30 °C 40–42; DG18 10–12; CYAS No growth; OA 30–32; CREA 7–8; YES 27–28.

Colony characters: CYA 25 °C, 7 d: Colonies sunken at centre, sulcate; margins low, plane, entire (<1 mm); mycelia white and pastel yellow; texture floccose; sporulation sparse, conidia en masse greyish turquoise (25D4–25D5); soluble pigments absent; exudates absent; reverse brownish grey (4C4) and at 30 °C centre reddish brown (9F7) fading into light yellow (4A5). MEA 25 °C, 7 d: Colonies slightly raised at centre, sulcate; margins low, plane, entire (2 mm); mycelia white; texture velvety; sporulation sparse, conidia en masse dull green (26D4–26E4); soluble pigments absent; exudates clear droplets at centre; reverse light brown (5D6) centre with an orange (5A7) circle and fading into greyish orange (5B5). YES 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulcate; margins low, plane, entire (2 mm); mycelia white and yellow; texture floccose; sporulation sparse, conidia en masse greyish green (25E5–26E5); soluble pigments absent; exudates absent; reverse yellowish brown (5E6) centre fading into greyish orange (5B6) to reddish yellow (4A6). DG18 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white; texture velvety; sporulation sparse, conidia en masse greyish green (25E5–26E5); soluble pigments absent; exudates clear droplets; reverse yellowish white (1A2) centre with greyish green (1C3) circle. OA 25 °C, 7 d: Colonies slightly raised at centre, plane, in centre yeast like colony appearance; margins low, plane, entire (3 mm); mycelia white; texture velvety; sporulation moderately dense, conidia en masse greyish green (26E5); soluble pigments absent; exudates absent; reverse brownish orange. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate with a minor proportion having subterminal branches; stipes smooth walled, 150–450 × 2.5–3.5 μm; branches 10–25 μm; metulae three to six, divergent, 11–16 × 2.5–4 μm; phialides acerose, three to eight per metulae, 10–13 × 2–3 μm; conidia smooth to finely rough, ellipsoidal to fusiform, 3–4 × 2–3 μm. Ascomata not observed.

**Extrolites:** Talaromyces siamensis produces mitorubrin, mitorubrinic acid, a purpactin, secalonic acid D and vermicillin.

**Distinguishing characters:** The ex-type strain of *T. siamensis* is deteriorated and no longer produces the reported characteristic purple red exudates and reverse (Manoch & Ramírez 1986). Talaromyces siamensis is closely related to *T. cnidii* and only minor morphological differences between these two species exist. Talaromyces cnidii grows slightly faster at 25 and 37 °C compared to *T. siamensis*, but for reliable identification, *BenA* should be sequenced.

**Talaromyces solicola** Visagie & K. Jacobs, Persoonia 28: 20. 2012. MycoBank MB564328. Fig. 73.

In: Talaromyces section Trachyspermi

**Typus:** PREM 60037, cultures ex-type DAOI 241015 = CV 2800 = CBS 13445 = DTO 180-D4.

**ITS barcode:** FJ160264 (alternative markers: *BenA* = GU385731; *CaM* = KJ885279; *RFP2* = KM023295)

Colony diam, 7 d (mm): CYA 12–13; CYA 30 °C 13–15; CYA 37 °C No growth; MEA 22–23; MEA 30 °C 24–26; DG18 11–12; CYAS No growth; OA 20; CREA No growth; YES 12–15.

Colony characters: CYA 25 °C, 7 d: Colonies slightly raised, crateriforme; margins low, plane; margins (1 mm); mycelia white and very pale light yellow; texture velvety and floccose in centre, with aerial sterile hyphae; sporulation dense, conidia en masse dark green (25F6–25F7); soluble pigments absent; exudates light red droplets; reverse centre dark brown (7F7), fading into brown (7E7). YES 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white and red; texture velvety; sporulation sparse, conidia en masse difficult to determine but greyish green (25C5); soluble pigments just around colonies red soluble pigments; exudates red droplets; reverse reddish brown to dark brown (9E6–9F6). MEA 25 °C, 7 d: Colonies slightly raised, crateriforme; margins low, plane entire (1 mm); mycelia white and very pale light yellow; texture velvety and floccose in centre, with aerial sterile hyphae; sporulation dense, conidia en masse dark green (25F6–25F7); soluble pigments absent; exudates light red droplets; reverse centre dark brown (7F7), fading into brown (7E7). YES 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (1 mm); mycelia white and red; texture velvety; sporulation sparse, conidia en masse difficult to determine but greyish green (25C5); soluble pigments just around colonies red soluble pigments; exudates red droplets; reverse reddish brown to dark brown (9E6–9F6). DG18 25 °C, 7 d: Colonies slightly raised at centre, very slightly sulcate; margins low, plane, entire (<1 mm); mycelia white; sporulation absent; soluble pigments absent; exudates big and small clear droplets; reverse orange white (25A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–4 mm); mycelia white; texture velvety; sporulation moderately dense to dense, conidia en masse dark green (27F4–27F5); soluble pigments absent; exudates very small clear droplets; reverse beige. CREA 25 °C, 7 d: No growth (Fig. 73).

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, 90–230 × 2.5–3.5 μm; metulae three to six, divergent, 8.5–11 × 2.5–3.5 μm; phialides acerose, three to eight per metulae, 9–11 × 2–2.5 μm; conidia rough, globose to sub-globose, 2–3.5 × 2–2.5 μm. Ascomata not observed.
Fig. 72. Morphological characters of *Talaromyces siamensis* (CBS 475.88T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 73. Morphological characters of Talaromyces solicola (CBS 133445T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
**Distinguishing characters: Talaromyces solicola** is characterised by its slow growth on CYA, YES and DG18, and no growth on CREA and CYA at 37 °C. Colonies typically produce red reverses on CYA and MEA, conidiophores are biverticillate and produce rough-walled globose to subglobose conidia (Fig. 73). Micromorphological characters resemble *T. veruculosus*, *T. aculeatus* and *T. apiculatus*. However, its slow growth, lack of growth at 37 °C and colony reverse colour distinguish *T. solicola* from the latter species.

**Talaromyces stipitatus** (Thom) C.R. Benj., Mycologia 47: 684. 1955. MycoBank MB306722. Fig. 74.  
≡ *Penicillium stipitatum* Thom, Mycologia 27: 138. 1935.

In: Talaromyces section Talaromyces

*Typus*: CBS H-7835, culture ex-type CBS 375.48 = ATCC 10500 = NRRL 1006 = IMI 39805.

*ITS barcode*: JN899348 (alternative markers: BenA = KM111288; CalM = KF741957; RP2B = KM023280)

**Colony diam, 7 d (mm)**: CYA 32–38; CYA 30 °C 36–41; CYA 37 °C 28–32; MEA 45–48; MEA 30 °C 65–70; DG18 10–15; CYAS No growth; OA 30–35; CREA 8–13; YES 40–45.

**Colony characters**: CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate, bright yellow appearance; margins low, plane, entire (2–3 mm); mycelia white and bright yellow; sporulation absent; soluble pigments yellow to orange yellow (also at 30 and 37 °C; exudates absent; reverse centre in some isolates brown (6E6) and in some isolates dark brown (6F6), fading into reddish golden brownish orange to light brown (6C7–6D7). MEA 25 °C, 7 d: Colonies slightly raised at centre, plane, light yellow appearance, start to produce yellow yellow ascomata at 30 °C more abundant; margins low, plane, entire (2–3 mm); mycelia bright yellow and white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brown (7E6) centre fading into brownish orange (7C6). YES 25 °C, 7 d: Colonies sunken at centre, sulcate, bright yellow appearance; margins low, plane, entire (3–4 mm); mycelia bright yellow and white; sporulation absent; soluble pigments yellow to orange yellow; exudates absent; reverse brown (7D7–7E7) centre fading into sunflower yellow (4A4). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white and pastel yellow; texture floccose; sporulation sparse to moderately dense in the centre, conidia en masse greyish green (3D05); soluble pigments absent; exudates absent; reverse centre light yellow to yellow (2A5–2A6), in some isolates with olive brown (4F4) dot and fading into pale yellow (2A3). OA 25 °C, 7 d: Colonies low, plane, formation of yellowish white ascomata (at 30 °C more abundant); margins low, plane, entire (2 mm); mycelia yellowish white and yellow; sporulation absent; soluble pigments absent (except DTO 108-A2 produces yellow soluble pigments); exudates absent; reverse brownish orange to brownish yellow. CREA 25 °C, 7 d: Acid production weak.

**Micromorphology**: Conidiophores asexual state lacking, *fide Stolk & Samson (1972)*, biverticillate and monoverticillate with a minor proportion having subterminal branches; stipes smooth walled, 10–100 × 2–2.5 μm; metulae two to five, divergent, 11–16 × 2.2–3 μm; phialides acerose, two to six per metulae, 12–15 × 2–3 μm; conidia ellipsoidal to ovoidal, 2–7.5 × 2–4 μm. Ascomata maturing after 1–2 wk of incubation on OA at 25 °C and abundantly 30 °C, creamish white, pastel yellow and yellow, globose to subglobose, 180–370 × 150–400 μm, asci 6–8.5 × 5–7 μm, ascospores flattened ellipsoidal with single equatorial ridge, smooth, 3–5 × 2–3 μm.

**Extrolites**: *Talaromyces stipitatus* produces botryodiploidin (Fuska et al. 1988), 7-epiaustidiol, 8-methoxy-epiaustidiol, duclauxin (Kuhr et al. 1973), compounds related to glauconic acid or rubratoxins, secalonic acid A, skyrin, stipitalide, stipitatic acid, stipitatic acid and triacetic acid lactone.

**Distinguishing characters**: *Talaromyces stipitatus* is distinguished by its smooth, flattened, ellipsoidal ascospores with single equatorial ridge (Fig. 74). It grows fast on general media, except on DG18. The asexual state was not observed during our study.

**Talaromyces stollii** Yilmaz et al., Persoonia 29: 52. 2012. MycoBank MB801359. Fig. 75.

In: Talaromyces section Talaromyces

*Typus*: CBS H-21053, culture ex-type CBS 408.93.

*ITS barcode*: JX315674 (alternative markers: BenA = JX315633; CalM = JX315646; RP2B = JX315712)

**Colony diam, 7 d (mm)**: CYA 38–45; CYA 30 °C 40–50; CYA 37 °C 25–35; MEA 45–50; MEA 30 °C 53–55; DG18 18–22; CYAS 4–5; OA 45–50; CREA 20–35; YES 35–45.

**Colony characters**: CYA 25 °C, 7 d: Colonies slightly raised at centre, sulcate; margins low, plane, entire (2–3 mm); mycelia white and pastel red; texture floccose; sporulation moderately dense, conidia en masse dull green (26E4–27E4); soluble pigments red and in some isolates absent; exudates absent; reverse brownish red (8E8–8F8) in the centre fading into greyish red (7B3). MEA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–5 mm); mycelia white, pastel yellow and pastel red; texture floccose and loosely funiculose; sporulation moderately dense, conidum en massa greyish to dull green (27C4–27D4); soluble pigments absent; exudates absent; reverse brownish orange to brownish yellow (5C6–6C7). YES 25 °C, 7 d: Colonies raised at centre, sulcate; margins low, plane, entire (3–4 mm); mycelia white; texture floccose; sporulation sparse, conidia en massa greyish green to dull green (27C4–27D4); soluble pigments absent; exudates absent; reverse melon yellow (5A6). DG18 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2–3 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5A4–5A5). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (5–6 mm); mycelia white and pale yellow; texture floccose and loosely funiculose, in the centre sterile aerial mycelia; sporulation moderately dense, conidia en massa greyish green to dull green (27C4–27D4); soluble pigments absent; exudates absent; reverse in some isolates reddish centre and green elsewhere, in some strain yellowish beige. CREA 25 °C, 7 d: Acid production.

**Micromorphology**: Conidiophores biverticillate with a minor proportion having subterminal branches, smooth walled, arising

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Fig. 74. Morphological characters of Talaromyces stipitatus (CBS 236.60). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D, E. Asci and ascospores. F. Ascospores. Scale bars: B = 1000 μm; C = 500 μm; D = 10 μm. Applies to E, F.
Fig. 75. Morphological characters of Talaromyces stolli (CBS 408.93T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
from aerial hyphae and overgrowing the ascomata, stipes narrow (<1 mm), low, plane; margins very narrow (<1 mm), low, not entire, plane; mycelium white; after 3 wk incubation white ascomata production; sporulation absent; exudates small bright orange droplets; soluble pigments absent; reverse centre orange (5A6) fading into greyish yellow (4C4). 

**Colony characters:** CYA, 25 °C, 7 d: Colonies 9–10 mm, slightly raised in the centre, plane; margins very narrow (<1 mm), low, not entire, plane; mycelium white; after 3 wk incubation white ascomata production; sporulation absent; exudates very small clear droplets; soluble pigment absent; reverse centre yellow to brownish yello (5B7–5C7) colour. YES, 25 °C, 7 d: Colonies 9–10 mm, slightly raised in the centre, plane; margins very narrow (<1 mm), low, not entire, plane; mycelium white and light yellow; sporulation absent; exudates very small bright orange droplets; soluble pigment absent; reverse deep orange to orange (5A8–5B8). DG18, 25 °C, 7 d: Colonies 7–8 mm, slightly raised in the centre, plane; margins very narrow (1 mm), low, not entire, plane; mycelium white and yellow; sporulation absent; exudates absent; soluble pigment absent; reverse centre orange (5A6) fading into butter yellow to maize yello (4A5–4A6). OA, 25 °C, 7 d: Colonies 13–15 mm, slightly raised in the centre, plane; margins narrow (1–2 mm), low, not entire, plane; mycelium white; after 3 wk incubation white ascomata production; sporulation absent; exudates very small clear droplets; soluble pigment absent; reverse centre light orange fading into light yellow and has a characteristic mouldy soil smell. CREA, 25 °C, 7 d: No growth.

**Distinguishing characters:** Talaromyces subinflatus grows very restrictedly on common media, MEA being the exception on which it reaches 15 mm, and does not grow on DG18, CREA or CYA at 37 °C (Fig. 76). These growth rates distinguish T. subinflatus from all other Talaromyces species. It produces large sulphur yellow ascomata and rather small, broadly ellipsoidal, spiny ascospores. When Yaguchi et al. (1993) described T. subinflatus they mentioned that it produced a Merimba-like conidiophore, with swollen apices of stipes and strongly divergent metulae. The ex-type strain of T. subinflatus is unfortunately deteriorated and we did not observe the Merimba-like conidiophores or ascomata.

**Talaromyces tardificiens** Udagawa, Mycotaxon 48: 150. 1993. MycoBank MB360478. Fig. 77.

≡ Penicillium tardificiens Udagawa, (simultaneously published).

**In:** Talaromyces section Islandici

**Typus:** CBM SUM 3017, culture ex-type CBS 250.94 = DTO 247-D6 = IBT 14986.

**ITS barcode:** JN899361 (alternative markers: BenA = KC202954; CaM = KF984682; RPB2 = KF984908)

**Colony diam. 7 d (mm):** CYA 9–10; CYA 30 °C 7–8; CYA 37 °C No growth; MEA 13–15; MEA 30 °C 10–13; DG18 7–8; CYAS No growth; OA 13–15; CREA No growth; YES 9–10.

**Colony morphology:** CYA, 25 °C, 7 d: Colonies low, plane; margins very narrow (<1 mm), low, not entire, plane; mycelium white; reverse centre orange (5A6) fading into greyish yellow (4C4). YES, 25 °C, 7 d: Colonies 9–10 mm, slightly raised in the centre, plane; margins very narrow (<1 mm), low, not entire, plane; mycelium white and light yellow; sporulation absent; exudates very small bright orange droplets; soluble pigment absent; reverse deep orange to orange (5A8–5B8). DG18, 25 °C, 7 d: Colonies 7–8 mm, slightly raised in the centre, plane; margins very narrow (1 mm), low, not entire, plane; mycelium white and yellow; sporulation absent; exudates absent; soluble pigment absent; reverse centre orange (5A6) fading into butter yellow to maize yello (4A5–4A6). OA, 25 °C, 7 d: Colonies 13–15 mm, slightly raised in the centre, plane; margins narrow (1–2 mm), low, not entire, plane; mycelium white; after 3 wk incubation white ascomata production; sporulation absent; exudates very small clear droplets; soluble pigment absent; reverse centre light orange fading into light yellow and has a characteristic mouldy soil smell. CREA, 25 °C, 7 d: No growth.
Fig. 76. Morphological characters of *Talaromyces subinflatus* (CBS 652.95T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 77. Morphological characters of Talaromyces tardifaciens (CBS 250.94T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Asci. C. Ascospores. D. Initials. E–H. Conidiophores. I. Conidia. Scale bar: B = 10 μm, applies to C–I.
Micromorphology: Conidiophores with solitary phialides or monoverticillate, smooth walled, arising from aerial hyphae and overgrowing the ascomata, stipes 15–40 × 2–2.5 μm; metulae absent; phialides one to three, acerose, 12.5–20 × 2.0–2.5 μm; conidia, smooth walled, cylindrical to ellipsoidal, 3–6 × 1.5–2.5 μm. Ascomata creamish white to white yellow, globose to subglobose, ripening within 3 wk or more, 200–400 μm. Covering consisting of a few layers of well-developed networks of white and light yellow hyphae. Ascii broadly globose to ovoidal, 6–8 × 6–7 μm. Ascospores, broadly ovoidal, smooth walled, 3–3.5 × 2–3 μm.

Extrólites: Talaromyces tardifaciens produces skyrin, 6'-hydroxy-3'-methoxy-mitorubrin related extrólites, and some extrólites that are unique for this species (structures not yet elucidated, but with characteristic UV spectra).

Distinguishing characters: Talaromyces tardifaciens is characterised by restricted growth on general media, with colonies that lack sporulation after 7 d of incubation at 25 °C. Based on the ITS and BenA phylogenies, T. tardifaciens is closely related to T. tratensis and T. wortmannii. Talaromyces tardifaciens and T. tratensis and some strains of T. wortmannii produce the sexual state; however, the latter two species differ from and some strains of T. wortmannii – fast maturing ascomata (1–2 wk), whereas T. tardifaciens ascomata maturation take 21 d (Udagawa 1993). Also, T. tardifaciens produces monoverticillate conidiophores and ascospores (2.5–3 × 2–3 μm), compared to the biverticillate conidiophores and bigger ascospores of T. tratensis (3–5 × 2.5–3.5 μm) and T. wortmannii (3.5–6 × 2.5–4.5 μm).

Talaromyces thailandensis Manoeh, Dethoup & Yilmaz, Mycologia 54: 339. 2013. MycoBank MB801737. Fig. 78.

In: Talaromyces section Talaromyces

Typus: CBS H-21075, culture ex-type CBS 133147 = KUFC 3399.

ITS barcode: JX898041 (alternative markers: BenA = JX494294; CaM = KF741940; RPB2 = KM023307)

Colony diam, 7 d (mm): CYA 33–35; CYA 30 °C 38–40; CYA 37 °C No growth; MEA 30–35; MEA 30 °C 35–36; DG18 16–20; CYAS No growth; OA 38–40; CREA 10–12; YES 35.

Colony characters: CYA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (1–2 mm); mycelia white and yellow; texture floccose; sporulation sparse, conidia en masse greyish turquoise to greyish green (24E5–25E5); soluble pigments absent; exudates absent (at 30 °C clear droplets); reverse yellowish red to red (8A6–9A6) centre with red (987) dots. MEA 25 °C, 7 d: Colonies low, plane, entire; margins low, plane, entire (1 mm); mycelia distinctly yellow and also white; texture floccose; sporulation sparse to moderately dense, conidia en masse greyish green (2SD5); soluble pigments absent; exudates absent; reverse greyish orange (5B6–6B6). YES 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulcate; margins low, plane, entire (1–2 mm); mycelia white, yellow and pink; texture floccose; sporulation sparse, conidia en masse greyish green (2SD5); soluble pigments absent; exudates absent; reverse orange (6A6) with a deep orange (6A8) circle in the margins. DG18 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates clear droplets; reverse light orange (5A4) centre with a pastel red (8A4) circle in the margins. OA 25 °C, 7 d: Colonies low, plane, formation of yellow and orange ascomata (30 °C more abundant); margins low, plane, entire (2–3 mm); mycelia dominantly yellow and also white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse orange yellow. CREA 25 °C, 7 d: Acid production absent (Fig. 78).

Mycorrhiza: Conidiophores biverticillate; stipes smooth walled, 200–400 × 2.5–3.5 μm; metulae three to six, divergent 9.5–17 × 2.5–3.5 μm; phialides acerose, three to six per metulae, 9–14 × 2–3.5 μm; conidia smooth, broadly ellipsoidal, sometimes ovoidal, 2–4 × 2–3 μm. Ascomata maturing after 1–2 wk of incubation on MEA and OA at 25 °C and abundantly 30 °C, yellow, globose to subglobose, 160–520 μm, ascospores broadly ellipsoidal, thick walled, spiny, 4–6 × 2.5–4.5 μm.

Extrólites: Talaromyces thailandensis produces asperphenate, thailandolide A & B, 3-methyl-6-hydroxy-8-methoxy-3,4-dihydroisocoumarin, penisimplicissin, vermicillin, and hydroylhydrovermistatin (Delhoup et al. 2007). We found mitorubrin, mitorubrinol, mitorubrinic acid, a purpurcin, vermicillin, and a compound with an emodin chromophore.

Distinguishing characters: Talaromyces thailandensis grows fast on general media and produces yellow ascomata with spiny, thick walled, broadly ellipsoidal ascospores (Fig. 78). Its characters resemble those of T. murai, T. macrosporus and T. liani. However, T. thailandensis is distinguished from these species by the absence of growth on CYA at 37 °C.

Talaromyces trachyspermus (Shear) Stolk & Samson, Stud. Mycol. 2: 32. 1972. MycoBank MB324421. Fig. 79. = Arachniotus trachyspermus Shear. Science 16: 138. 1902. = Penicillium spiculiforme (Lehman, 1920 = Talaromyces spiculiformis (Lehman) C.R. Benj., Mycologia 47: 683. 1955. = Talaromyces trachyspermus var. macrocarpus J.E. Wright & Love-wenb., Bol. Soc. Argent. Bot. 15: 100. 1973. = Penicillium lehmani Pilát. The genus Penicillium: 497. 1980.

In: Talaromyces section Trachyspermi

Typus: IMI 040043, culture ex-type CBS 373.48 = ATCC 10497 = IMI 040043 = NRRL 1028.

ITS barcode: JN899354 (alternative markers: BenA = KF114803; CaM = KJ885281; RPB2 = JF417432)

Colony diam, 7 d (mm): CYA 13–24; CYA 30 °C 30–40; CYA 37 °C 32–40; MEA 17–25; MEA 30 °C 32–40; DG18 Generally no growth some colonies up to 8; CYAS No growth; OA 20–24; CREA Generally no growth some colonies up to 4; YES 15–23.

Colony characters: CYA 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate; margins low, plane, entire (2–3 mm); mycelia white and yellow; texture floccose; sporulation
Fig. 78. Morphological characters of Talaromyces thailandensis (CBS 133147T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata D. Asci and ascospores. E–G. Conidiophores. H. Conidia. I. Ascospores. Scale bars: B, C = 1000 μm; D = 10 μm, applies to E–I.
Fig. 79. Morphological characters of Talaromyces trachyspermus (CBS 373.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata D. Asci and ascospores. E–G. Conidiophores. H. Ascospores. I. Conidia. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–I.
absent to sparse, conidia en masse greyish green to dull green (25C4–25D3); soluble pigments absent; exudates absent; reverse in some isolates centre yellowish brown (5D5–5E5) fading into pale orange to greyish orange (5A3–5B3), in some isolates centre light orange (5A6) fading into light yellow to yellow (3A5–3A6). MEA 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse centre brownish orange to light brown (6C6–6D6–6E6), fading into brownish orange (5C5–5C6). YES 25 °C, 7 d: Colonies raised at centre, slightly sulcate; margins low, plane, entire (5 mm); mycelia white; texture floccose; sporulation sparse; conidia en masse greyish green to dull green (25C4–25D3); soluble pigments absent; exudates absent; reverse light orange (5A5–5A6) centre fading into yellowish white (4A2). DG18 25 °C, 7 d: Colonies slightly raised in the centre, very slightly radially sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse yellowish white (4A2). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–4 mm); mycelia white; sporulation absent; soluble pigments absent; exudates absent; reverse beige only in DTO 228-D9 yellow. CREA 25 °C, 7 d: No growth (only DTO 56-A4 up to 4 mm).

**Micromorphology:** Conidiophores generally monoverticillate; stipes smooth walled, 15–45 × 1–2 μm; metulae two to three, divergent, 9–12 × 2–2.5 μm; phialides acerose, three to five per metulae, 10–15 × 1.3–2.5 μm; conidia smooth, ellipsoidal, 2–3.5(–)5 × 1.5–2.5 μm. Ascomata maturing after 1–2 wk of incubation on OA at 25 °C and abundantly 30 °C, creamish white, globose to subglobose, 190–650 × 170–650 μm, ascii 7.5–11.5 × 6.5–8 μm, ascospores broadly ellipsoidal, spiny, 3.5–5 × 2–3 μm.

**Extrolites:** *Talaromyces trachyspermus* produces trachyspic acid (Shiozawa et al. 1995), spiculisorpic acid (Clutterbuck et al. 1931) and gluconic acid.

**Distinguishing characters:** *Talaromyces trachyspermus* produces creamish white ascomata with spiny, ellipsoidal ascospores (Fig. 79) and closely resembles *T. intermedius* and *T. assimilens*. *Talaromyces intermedius* differs from *T. trachyspermus* by faster growth at 25 and 30 °C and no growth at 37 °C. Also, ascospores of *T. intermedius* are larger than *T. trachyspermus*. Phylogenetically and morphologically, *T. assimilens* is very similar to *T. trachyspermus*, with them having identical ITS sequences. However, *T. trachyspermus* grows slightly faster than *T. assimilens* on CYA at 37 °C and both species have unique BenA sequences.

**Notes:** *Talaromyces spiculisorpus* and *T. trachyspermus* var. *macrocarpus* were synonymised with *T. trachyspermus* by Stolk & Samson (1972) and Pitt (1980), and we concur with this.

**Talaromyces tratensis** Manoeh, Dethou & Yilmaz, Mycoscience 54: 337. 2013. MycoBank MB801738. Fig. 80.

*In: Talaromyces section Islandic*

**Typus:** CBS H-21074, culture ex-type CBS 133146 = KUFC 3383.

**ITS barcode:** KF984891 (alternative markers: BenA = KF984559; CaM = KF984690; RP2B = KF984911)

** Colony diam, 7 d (mm):** CYA 10–12; CYA 30 °C 13–20; CYA 37 °C No growth; MEA 15–20; MEA 30 °C 16–20; DG18 12–17; CYAS No growth; OA 15–20; CREA 4–8; YES 12–18.

** Colony characters:** CYA, 25 °C, 7 d: Colonies 10–12 mm, slightly raised in the centre, slightly plane; margins very narrow (<1 mm), low, entire, plane; mycelium white and very pale light orange yellow; sporulation sparse; texture loosely funiculose to floccose; conidia en masse greyish green to dull green (26C3–26D3 and in some isolates 29B5); exudates clear droplets; soluble pigment in some isolates very pale yellow, in some isolates absent; reverse greyish yellow (4A5–4A6) and in some isolates brownish orange (6C8) centre fading into beige. MEA, 25 °C, 7 d: Colonies 15–20 mm, raised in the centre, plane; margins narrow (1 mm), low, entire, plane; mycelium white and predominately orange yellow (3A6); formation of yellow ascomata; sporulation absent to sparse; exudates very small clear droplets; soluble pigment absent; reverse brownish yellow (5C7–5C8) and in some isolates brown centre (6E4). YES, 25 °C, 7 d: Colonies 12–18 mm, slightly raised in the centre, slightly sulcate; margins very narrow (<1 mm), low, not entire, plane; mycelium white and yellow; sporulation dense; texture floccose; conidia en masse greyish green (25C4–26C3); exudates in some isolates clear droplets (CBS 133146); soluble pigment absent; reverse greyish orange (5B5–5B6). DG18, 25 °C, 7 d: Colonies 12–17 mm, slightly raised in the centre, slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and yellow; sporulation dense; texture velvety to loosely funiculose; conidia en masse greyish green to dull green (26C3–26D3 and in some isolates 29B5); exudates absent; soluble pigment absent; reverse in centre greyish yellow (2C5) and in some isolates yellow (3A7) fading into greyish yellow (2B5). OA, 25 °C, 7 d: Colonies 15–20 mm, low, slightly sulcate; margins narrow (1–2 mm), low, entire, plane; mycelium white and predominantly yellow; formation of yellow to orange ascomata; sporulation sparse, difficult to determine; texture loosely funiculose, conidiophores raised at centre; exudates small yellow and orange droplets; soluble pigment absent; reverse pale to bright brownish orange. CREA, 25 °C, 7 d: Colonies 4–8 mm, generally acid production absent, in some isolates very weak acid production (CBS 137401).

**Micromorphology:** Conidiophores biverticillate, smooth walled stipes, arising from aerial hyphae and overgrowing the ascomata, stipes 120–200 × 2.5–3.5 μm; metulae three to six, divergent, 8.5–12.0 × 1.7–3.0 μm; phialides three to seven, acerose, 10–13.5 × 2.0–3.0 μm; conidia, smooth walled, ellipsoidal, 2.0–2.5 × 3.0–3.5 μm. Ascomata bright yellow, globose, ripening within 1–2 wk, covering consisting of a few layers of well-developed networks of yellow hyphae; ascii broadly globose to subglobose, 7.5–11 × 8–11 μm; ascospores ovoidal to broadly ellipsoidal, thick walled, finely rough, 3.5–5.0 × 2.5–3.5 μm.

**Extrolites:** *Talaromyces trachyspermus* produces mitorubrin, mitorubril, mitorubric acid, rugulosin, skyrin, vermicillin, wortmannin and a tetracyclic compound.
Fig 80. Morphological characters of Talaromyces tratensis (CBS 113146) a. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Texture and ascomata on OA after 2 wk incubation. C. Asci and ascospores. D. Ascospores. E–H. Conidiophores. I. Conidia. Scale bar: C = 10 μm, applies to D–I.
**Distinguishing characters:** Talaromyces tratensis is characterised by restricted growth on general media and cannot grow at 37 °C. Colonies are deep and consist of light yellow mycelia that form a fluffy texture (Fig. 80). It produces yellow ascomata with spiny, ellipsoidal ascospores. The characters most closely resemble *T. flavus*, *T. astrocorticalis* and *T. convolutus*. On MEA, *T. flavus* grows slightly faster than *T. tratensis*. *Talaromyces tratensis* ascospore size (3.5–5.0 × 2.5–3.5), yellow deep fluffy colony texture on MEA and lack of growth at 37 °C, distinguishes it from *T. convolutus* and *T. astrocorticalis*.

**Talaromyces ucrainicus** (Panas.) Udagawa, Trans. Mycol. Soc. Japan 7: 94. 1966. MycoBank MB449587. Fig. 81.

=/Penicillium ucrainicum* Panas., Mycologia 56: 59. 1964. = *Penicillium chienense* Pitt, *The genus Penicillium*: 502. 1980 = *Talaromyces chienense* Pitt, The genus *Penicillium*: 502. 1980. = *Talaromyces panasenkoii* Pitt, *The genus Penicillium*: 482. 1980 = *Penicillium panasenkoii* Pitt, *The genus Penicillium*: 482. 1980.

In: Talaromyces section Trachyspermi

**Typos:** Unknown, culture ex-type CBS 162.67 = ATCC 22344 = FRR 3462 = NHL 6086.

**ITS barcode:** JN899334 (alternative markers: *BenA* = KF114771; *CaM* = KJ885282; *RPB2* = KM023289)

**Colony diam, 7 d (mm):** CYA 10–20; CYA 30 °C 20–26; CYA 37 °C 7–17; MEA 18–24; MEA 30 °C 25–33; DG18 5–7; CYAS No growth; OA 15–20; CREA No growth; YES 13–19.

**Colony characters:** CYA 25 °C, 7 d: Colonies low to moderately deep, slightly raised at centre, plane; margins low, narrow, entire (1 mm); mycelia white, inconspicuously yellow; texture floccose; sporulation absent to sparse, conidia en masse greenish grey (28B2); soluble pigments absent; exudates absent; reverse olive to olive brown to brownish orange (1F6–45E–5C5). MEA 25 °C, 7 d: Colonies low to moderately deep, raised at centre, plane; margins low, narrow, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brown (6E6) at centre, greyish orange (5B5) elsewhere. YES 25 °C, 7 d: Colonies low to moderately deep, raised at centre, plane; margins low, narrow, entire (2 mm); mycelia white to inconspicuously yellow; texture floccose; sporulation absent to sparse, conidia en masse turqueise grey (24B2); soluble pigments absent; exudates absent; reverse olive to brownish orange (3F6–5C4). DG18 25 °C, 7 d: Colonies low, plane; margins low, narrow, entire; mycelia white; texture floccose; sporulation sparse, conidia en masse greenish grey (26C2); soluble pigments absent; exudates absent; reverse greyish green (1C4–29E5). OA 25 °C, 7 d: Colonies low, plane, young ascomata visible; margins subsurface, wide, entire (6 mm); mycelia white and yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse pale yellow (1A3). CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biterticillate and monovervictillate; stipites smooth walled, 14–80 × 1.5–2.6 μm; metulae three to six, divergent, 8–13 × 2–2.6 μm; phialides acerose, three to five per metulae, 8–13 × 1.5–3 μm; conidia smooth, broadly ellipsoidal to ovoidal, 2–4(–5) × 1.5–2.5(–3) μm. Ascomata maturing after 1–2 wk of incubation on OA at 25 °C and abundantly 30 °C, yellow, globose to subglobose, 430–490 × 400–410 μm, asci 6.5–9.5 × 5–7.5 μm, ascospores broadly ellipsoidal, ornamented with thin, somewhat jagged, irregular, for the greater part longitudinal ridges, 3–5 × 2–3 μm.

**Extralites:** Talaromyces ucrainicus produces spiculisporic acid (Fujimoto et al. 1988). Spiculisporic acid was claimed to be a mycotoxin by Fujimoto et al. (1988), as it was lethal to mice, but the toxicity of the compound was based on interperitoneal injection, and can there not be regarded as a real mycotoxin. In fact spiculisporic acid can be produced in a yield of 110 g/l of fermentation medium and can be used as a biosurfecant (Ishigami et al. 2000). We also found alternariol in CBS 118436 and glauconic acid in CBS 583.72C and NRRL 2103.

**Distinguishing characters:** Talaromyces ucrainicus grows restrictedly on general media and cannot grow on CREA. It produces yellow ascomata and ascospores, which are ornamented with thin and irregular ridges (Fig. 81). These characters easily distinguish *T. ucrainicus* from other species, which produce ascospores with ridges.

**Notes:** Phylogenetically *T. chienense* (CBS 127.64) is identical to *T. ucrainicus* (Fig. 5) and is considered a synonym.

**Talaromyces udagawae** Stolk & Samson, Stud. Mycol. 2: 36. 1972. MycoBank MB324424. Fig. 82.

=/Penicillium udagawae* Stolk & Samson, *Phylogenetically*.

In: Talaromyces section Trachyspermi

**Typos:** CBS H-7841, culture ex-type CBS 579.72 = FRR 1727 = IMI 197482.

**ITS barcode:** JN899350 (alternative markers: *BenA* = KF114796)

**Colony diam, 7 d (mm):** CYA 6–8; CYA 30 °C 7–8; CYA 37 °C No growth; MEA 10–11; MEA 30 °C 15–17; DG18 No growth; CYAS No growth; OA 12; CREAs No growth; YES 8–9.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (<1 mm); mycelia white and very pale light yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse pale orange to light orange (5A3–5A4). MEA 25 °C, 7 d: Colonies raised at centre, sulcate, yellow appearance after 3 wk of incubation yellow ascomata produced; margins low, plane, entire (1 mm); mycelia white and yellow; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies slightly raised at centre, sulcate; margins low, plane, entire (<1 mm); mycelia white and light orange (5A5); texture light orange appearance; sporulation absent; soluble pigments absent; exudates absent; reverse light orange (5A4) fading into pale orange (5A3). DG18 25 °C, 7 d: No growth. OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (2 mm); mycelia white and yellow; texture yellow appearance after 2 wk of incubation yellow ascomata is produced; sporulation absent; soluble pigments absent; exudates absent; reverse light yellow. CREA 25 °C, 7 d: No growth.
Fig. 81. Morphological characters of Talaromyces ucrainicus (CBS 583.72C). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on OA after 2 wk incubation. C. Ascomata. D. Asci and ascospores. E–G. Conidiophores. H. Conidia. I. Ascospores. Scale bars: B, C = 500 μm; D = 10 μm, applies to E–I.
Fig. 82. Morphological characters of *Talaromyces udagawae* (CBS 579.72T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture on OA after 1 wk incubation. C. Colony texture and ascomata on OA after 3 wk incubation. D. Initials. E. Asci and ascospores. F. Ascospores. Scale bars: B, C = 500 μm; D = 10 μm, applies to E, F.
**Micromorphology:** Conidiophores asexual state lacking, *fide Stolk & Samson (1972)*, abundantly developed on hay-infusion agar at the colony margin. Conidiophores biverticillate; stipes smooth walled, 50–200 × 2.5–3.5 μm; metulae two to five, divergent, 7.5–10 × 2–2.4 μm; phialides acerose, three to six per metulae, 12–15 × 2.2–2.5 μm; conidial smooth, subglobose to ellipsoidal, 3–4 × 2–3 μm. Ascomata maturing after 2–3 wk of incubation on OA at 25 °C and abundantly 30 °C, yellow, globose to subglobose, 200–400 μm, asci 8–13.5 × 6–9.5 μm, ascospores ellipsoidal, ornamented with 3 to 5 regularly transverse, nearly parallel ridges, 3.5–6 × 2.5–3.5 μm.

**Extrolites:** *Talaromyces udagawae* strain CBS 579.72 produces mitorubrin, mitorubrin acetate, mitorubrinic acid and a purpactin.

**Distinguishing characters:** *Talaromyces udagawae* is distinguished from the other *Talaromyces* species by its ascospores, which are ornamented with three to five regularly transverse, nearly parallel ridges (Fig. 82). It grows restrictively on general media and does not grow on CREA, DG18 or CYA at 37 °C. Conidiophores were not observed during our study. Pitt (1980) synonymised *T. udagawae* with *T. luteus*. However, Samson et al. (2011) showed that they are distinct species with *T. luteus* but ascospores of *T. unicus* do not belong in *Talaromyces* but is a close relative of *Thermomyces*. Further studies are needed on this species.

**Talaromyces unicus** Tzean, J.L. Chen & S.H. Shiu, *Mycologia* 84: 739. 1992. MycoBank MB560677. ≡ *Penicillium unicum* Tzean, J.L. Chen & S.H. Shiu, (simultaneously published).

**In:** *Talaromyces* section Bacillisperi

**Typus:** PPH 16, holotype Nat. Taiwan Univ., culture ex-type CBS 100535 = CCRC 32703 = IBT 18385.

**ITS barcode:** JN899336 (alternative markers: *BenA* = KJ865735; *CaM* = KJ885283)

**Colony diam. 7 d (mm):** *Fide Tzean et al. (1992)* CYA 10.5–16; CYA 37 °C No growth; MEA 15–19.5; OA: 23–28.

**Colony characters:** *Fide Tzean et al. (1992)* colonies on CYA restrictedly, dense, raised, floccose, white to reddish grey (10–11B2); mycelium white and reddish grey (10–11B2); sporulation not observed on CYA; soluble pigment pale greyish, pale red to reddish brown (8C–D5, 9D6); exudate absent; reverse reddish white, reddish orange, greyish red to reddish brown or violet brown or violet brown (7A2–6, 7B4–6, 8B–D4–6, 10–11E7–8). Colonies on MEA dense, floccose to funiculose; margins lower fibuliform; mycelium white to yellowish white (3–4A2); ascomata discrete or occasionally confluent; sporulation moderate, white; soluble pigment pale greyish red; exudate, clear to pale yellow; reverse pastel (light) yellow, yellow (3A4–6, 5A–B6–7) or light orange becoming dark orange (6A4–8, 6B7–8) to reddish orange (7A–B6) in age. Colonies on OA thin and flat, centre somewhat floccose, submargin to margin velvety, white; mycelium white; sporulation conspicuous; reverse white to yellowish white; exudate and soluble pigment absent; ascomata produced after 4 wk of incubation.

**Micromorphology:** *Fide Tzean et al. (1992)* conidiophores on MEA, monoverticillate to biverticillate with a minor proportion having subterminal branches; stipes finely rough to rough, 35–180 × 2.6–4.2 μm; metulae finely rough to rough, two to five, divergent, 8.3–27.4 × 2.1–3.3 μm; phialides acerose, two to seven; smooth to finely rough, 6.7–22 × 2.1–3 μm; conidia mostly ellipsoidal to ovoidal, sometimes subglobose, smooth, 2.7–5 × 1.7–3.2 μm. Ascomata soft, absent on MEA, usually discrete, globose, subglobose, or ellipsoidal, pastel yellow or yellow (3A4–3A6), 280–450 × 270–410 μm, maturing mostly in 8 wk; asci 8.5–10.8 × 7.3–9.2 μm; ascospores ellipsoidal, 3.3–6.7 × 2.8–4.2 μm, very rough to spiny; usually with a single ridge up to 1.3 μm wide.

**Extrolites:** *Talaromyces unicus* produces an extrolite with a chromopore similar to talarodexine.

**Distinguishing characters:** *Talaromyces unicus* grows restrictedly on CYA and does not grow at 37 °C. Its most striking feature is its rough-walled ascospores that have a single ridge. Ascomata mature in 4 wk. Its single equatorial ridge resembles *T. stipitatus*, but ascospores of *T. unicus* are rough, whereas *T. stipitatus* ascospores are smooth. The ex-type strain of *T. unicus* was badly degraded and did not produce its characteristic features as originally described and as a result macro- and micromorphological characters were taken from Tzean et al. (1992).

**Talaromyces varians** (G. Sm.) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011. MycoBank MB560677. Fig. 83. ≡ *Penicillium varians* G. Sm., Trans. Brit. Mycol. Soc. 18: 89. 1933.

**In:** *Talaromyces* section Helici

**Typus:** IMI 040586, culture ex-type CBS 386.48 = ATCC 10509 = IMI 040586 = NRRL 2096.

**ITS barcode:** JN899368 (alternative markers: *BenA* = KJ865731; *CaM* = KJ885284; *RPB2* = KM023274)

**Colony diam. 7 d (mm):** CYA 22–24; CYA 30 °C 26–30; CYA 37 °C 27–28; MEA 30–32; MEA 30 °C 40–43; DG18 8–12; CYAS 2–4; OA 25–28; CREA 9–10; YES 27–28.

**Colony characters:** CYA 25 °C, 7 d: Colonies slightly raised at centre, slightly sulcate; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation moderately dense, conidia *en masse* greyish green (25B3); soluble pigments absent; exudates absent; reverse dark green (27F6) centre fading into dull green (7D3) fading into pale orange to light orange (5A3–5A4). MEA 25 °C, 7 d: Colonies slightly raised at centre, plane; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation moderately dense, conidia *en masse* greyish green (25C4); soluble pigments absent; exudates absent; reverse dark green (26F6) centre fading into between light yellow (4A5) and light orange (5A5). YES 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate; margins low, plane, entire (2 mm); mycelia white; texture floccose; sporulation moderately dense, conidia *en masse* pastel green (25A4); soluble pigments absent; exudates absent; reverse shades of dull green (27E4) fading into between pale yellow (4A3) and pale orange (5A3). DG18 25 °C, 7 d: Colonies raised at centre, slightly concentrically sulcate; margins low, plane,
Fig. 83. Morphological characters of *Talaromyces varians* (CBS 386.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
entire (<1 mm); mycelia white; sporulation absent to sparse; soluble pigments absent; exudates absent; reverse yellowish white (4A2) with shades of olive brown (4F4). OA 25 °C, 7 d: Colonies low, plane; margins low, plane, entire (3–4 mm); mycelia white; texture floccose; sporulation moderately dense, conidia en masse greyish green to dull green (26C3–26D3); soluble pigments absent; exudates absent; reverse dark green. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Conidiophores biverticillate and monoverticillate; stipes smooth walled, pigmented, 35–65 × 1.5–3 μm; metulae two to four, divergent, 9–12 × 1.5–2.5 μm; phialides acerose, three to five per metula, 10–16.5 × 1.5–2.5 μm; conidia smooth, ellipsoidal to cylindrical, 2.5–4 × 1.5–2 μm. Ascomata not observed.

**Distinguishing characters:** Talaromyces varians characteristically produces a strongly pigmented, smooth walled stipe (Fig. 83). It grows relatively fast at 30 and 37 °C. Pitt (1980) considered T. varians synonymous with T. funiculosus, but its colony texture is not funiculose and its pigmented stipe can easily distinguish T. varians from T. funiculosus.

**Talaromyces verruculosus** (Peyronel) Samson et al., Stud. Mycol. 71: 177. 2011. MycoBank MB560678. Fig. 84. = Penicillium verruculosum Peyronel, Germi Atmosf. Fung. Micel.: 22. 1913.

**In:** Talaromyces section Talaromyces

**Typus:** IMI 040039, culture ex-type CBS 388.48 = CBS 136671 = ATCC 10513 = DSM 2263 = IMI 040039 = NRRL 1050 = FRR 1050 = IBT 10891 = IBT 32644.

**ITS barcode:** KF741994 (alternative markers: BenA = KF741928; CaM = KF741974; RPB2 = KM023306)

** Colony diam, 7 d (mm):** CYA 32–35; CYA 30 °C 37–38; CYA 37 °C 25–26; MEA 35–36; DG18 15–16; CYAS 11–12; OA 38–40; CREA 24–26; YES 36–38.

** Colony characters:** CYA 25 °C, 7 d: Colonies moderately deep, radially sulphate; margins low, narrow, entire; mycelia white and yellow; texture floccose; sporulation moderately dense, conidia en masse greyish green (26D5–27D5); soluble pigments absent, exudates absent; reverse greyish yellow to greyish orange (4C4–5C4) at centre, pale elsewhere. MEA 25 °C, 7 d: Colonies moderately deep, plane; margins low to somewhat subsurface, narrow, entire; mycelia white and yellow; texture floccose, with some loosely funicoluse areas; sporulation moderately dense, conidia en masse greyish green (26D5–27D5); soluble pigments absent, exudates absent; reverse greyish orange (5C6). YES 25 °C, 7 d: Colonies moderately deep, irregularly sulphate, raised at centre; margins low, narrow, entire; mycelia white, yellow and pink; texture floccose; sporulation absent; soluble pigments absent, exudates absent; reverse greyish orange (5B5) at centre, pale elsewhere. DG18 25 °C, 7 d: Colonies consist of white mycelium and produce clear exudate. CREA 25 °C, 7 d: Weak acid produced.

**Micromorphology:** Conidiophores biverticillate; stipes smooth walled, (50–)150–300 (–400) × 2.5–3 μm; metulae four to eight, divergent, 8.5–12.5 × 2.5–3.5 μm; phialides flask-shaped, tapering into very thin neck, three to five per metulae, 8.5–10.5 × 2.5–3–3.5 μm; conidia echinulate, globose, 3–3.5 × 3–3.5 μm.

**Extrolites:** Altenuene, altenuin, alternariol, berkelic acid, hypomillin, MC-141, mitorubrin, mitorubinic acid, penicillide, pestalacn A (only detected in IMI 193912), purpactins, rubiginosin A, vermicillin.

**Distinguishing characters:** Talaromyces verruculosus produces flask-shaped phialides and rough to echinulate, globose conidia (Fig. 84). These characters are also observed in T. aculeatus and T. apiculatus. Talaromyces verruculosus grows slower than T. apiculatus on CYA and MEA at 25 °C. Compared to T. aculeatus, T. verruculosus grows faster on CYA at 37 °C.

**Talaromyces viridis** (Stolk & G.F. Orr) Arx, Persoonia 13: 2821. 1987. MycoBank MB132097. Fig. 85. = Sagenoma viride Stolk & G.F. Orr, Mycologia 66: 677. 1974.

**In:** Talaromyces section Talaromyces

**Typus:** CBS H-7732 (isotype), CBS H-7733 (isotype), CBS H-7734 (isotype), culture ex-type CBS 114.72 = ATCC 22467 = NRRRL 5575.

**ITS barcode:** AF285782 (alternative markers: BenA = JX494310; CaM = KF741935; RPB2 = JN121430)

** Colony diam, 7 d (mm):** CYA 9; CYA 30 °C 10; CYA 37 °C 10–11; MEA 15; MEA 30 °C 16–17; DG18 6–7; CYAS 3; OA 14–15; CREA No growth; YES 9.

** Colony characters:** CYA 25 °C, 7 d: Colonies low, slightly sulphate; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates absent; reverse greyish green (1C3) centre fading into yellowish white (4A2). MEA 25 °C, 7 d: Colonies slightly raised at centre, sulphate, with a soilly smell; margins low, plane, entire (1 mm); mycelia white and yellow; texture floccose; sporulation sparse, conidia en masse greyish green to dull green (26C4–26D4); soluble pigments absent; exudates absent; reverse brown (6E7) centre fading into reddish golden (6C7). YES 25 °C, 7 d: Colonies raised at centre, sunken at centre, sulphate; margins low, plane, entire (<1 mm); mycelia white; texture floccose; sporulation dense, conidia en masse greenish grey (26B2–26C2); soluble pigments absent; exudates absent; reverse greyish green (1D3 fading into 1C3). DG18 25 °C, 7 d: Colonies sunken at centre, sulphate, with a greyish green appearance; margins raised, plane, entire (1 mm); mycelia white; texture floccose; sporulation absent; soluble pigments absent; exudates clear droplets; reverse greyish green (1C4–1D4). OA 25 °C, 7 d: Colonies low, plane, formation of yellow ascoma (at 30 °C more abundant); margins low, plane, entire (3–4 mm); mycelia white and yellow; texture velvety; sporulation moderately dense, conidia en masse greyish green (27C5) (at 30 °C greyish green to dark green (27E5–27F5)); soluble pigments absent; exudates absent; reverse greyish yellow. CREA 25 °C, 7 d: No growth.

**Micromorphology:** Conidiophores with solitary phialides; phialides usually solitary, 10–25 × 1.5–2.5 μm; conidia smooth, fusiform to ellipsoidal, 2.5–3.5 (–4) × 1.5–2 μm. Ascomata maturing after 1–2 wk of incubation on MEA and OA at 25 °C.
Fig. 84. Morphological characters of *Talaromyces verruculosus* (CBS 388.48T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 85. Morphological characters of Talaromyces viridis (CBS 114.72T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and synnemata on MEA after 2 wk incubation. C. Ascomata. D–E. Asci and ascospores. F. Peridial hyphae. G–I. Conidiophores. J. Conidia. K. Ascospores. Scale bars: B = 500 μm; C = 50 μm; D = 10 μm, applies to E–K.
and abundantly 30 °C, dark green, globose to subglobose, 200–400 μm; texture yellow; texture brownish orange to light brown (5C6–6B6). YES 23–25.

Colony characters: CYA 25 °C, 7 d: Colonies raised at centre, slightly sulcate, white sterile appearance; margins low, plane, entire (1 mm); mycelia white; texture floccose; sporulation abundant; reverse orange brown to light brown (5C6–5D6). YES 25 °C, 7 d: Colonies slightly raised, deep, plane, sterile white and red appearance; margins low, plane, entire (3–4 mm); mycelia white, pastel red and dull red; texture floccose; sporulation abundant; reverse red (9B8) fading into orange red (8B8) and pale red (8A3). DG18 25 °C, 7 d: Colonies low, slightly sulcate; margins low, plane, entire (1–2 mm); mycelia white; texture floccose; sporulation moderately dense, conidia en masse greyish green (25C4); soluble pigments absent; exudates absent; reverse reddish brown (9B8) fading into pastel red (9A5). OA 25 °C, 7 d: Colonies low, plane, margins low, plane, entire (3–4 mm); mycelia white; texture velvety and in the centre floccose; sporulation moderately dense to dense, conidia en masse dull green (27D4); soluble pigments absent; exudates absent; reverse beige. CREA 25 °C, 7 d: Acid production absent.

Micromorphology: Conidiophores biverticillate; stipes smooth walled, 25–80 × 2.5–3 μm; metulae three to six, divergent, 9–15 × 2–3 μm; phialides acerose, two to six per metula, 8–12 × 1.5–3 μm; conidia smooth, cylindrical, rod-shaped, 3.5–6 × 1–2 μm. Ascomata not observed.

Distinguishing characters: Talaromyces viridulus grows restrictively on general media, except on MEA, OA and YES. It produces deep colonies with a white, pastel yellow and pastel red appearance. Its most striking character is its smooth, cylindrical, rod-shaped conidia (Fig. 86). Similar conidia are observed in T. bacillisporus, but T. bacillisporus produces dark green colony reverses on CYA at 30 °C, and globose, spiny ascospores.

Talaromyces wortmannii (Klöcker) C.R. Benj. Mycologia 47: 683. 1955. MycoBank MB344294. Fig. 87.

≡ Penicillium wortmannii Klöcker, Compt. Rend. Lab. Carlsberg, Physiol. 6: 100. 1903.
≡ Penicillium kloeckeri Pitt, The genus Penicillium. 491. 1980.
=
Talaromyces sublevisporus (Yaguchi & Udagawa) Samson, Yilmaz & Frisvad, Stud. Mycol. 71: 177. 2011 ≡ Talaromyces wortmannii var. sublevisporus Yaguchi & Udagawa, Mycoscience 35: 63. 1994.
Talaromyces variabilis (Sopp) Samson et al., Stud. Mycol. 71: 177. 2011 ≡ Penicillium variable Sopp, Skr. Vidensk.-Selsk. Christiania, Math.-Naturvidensk. Kl. 11: 169. 1912.
= Penicillium concavoverruculosum S. Abe, J. Gen. Appl. Microbiol., 2: 127. 1956 (nom. inval., Art. 36).

In: Talaromyces section Islandici

Talaromyces wortmannii (Klöcker) C.R. Benj. Mycologia 47: 683. 1955. MycoBank MB344294. Fig. 87.

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Talaromyces variabilis (Sopp) Samson et al., Stud. Mycol. 71: 177. 2011 ≡ Penicillium variable Sopp, Skr. Vidensk.-Selsk. Christiania, Math.-Naturvidensk. Kl. 11: 169. 1912.
= Penicillium concavoverruculosum S. Abe, J. Gen. Appl. Microbiol., 2: 127. 1956 (nom. inval., Art. 36).

In: Talaromyces section Islandici
Fig. 86. Morphological characters of *Talaromyces viridulus* (CBS 252.87T). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B–F. Conidiophores. G. Conidia. Scale bar: B = 10 μm, applies to C–G.
Fig. 87. Morphological characters of Talaromyces wortmannii (CBS 319.63). A. Colonies from left to right (top row) CYA, MEA, DG18 and OA; (bottom row) CYA reverse, MEA reverse, YES and CREA. B. Colony texture and ascomata on MEA after 2 wk incubation. C. Asci and ascospores. D–G. Conidiophores. H. Conidia. Scale bar: C = 10 μm, applies to D–H.
greyish green to dull green (25D4–25E4); in some isolates yellow ascomata production with the longer incubation (up to 9 d) (CBS 319.63, CBS 137376); exudates absent (except CBS 319.63, CBS 100258, yellow droplets); soluble pigment absent; reverse in some isolates centre yellow (1E5) fading into brownish orange to brown (6C8–6D6), in some isolates lack of reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies 20–30 mm, raised at centre, some isolates crumferome and some isolates sulcate; margins narrow (up to 2 mm), low, entire, plane; mycelium generally only white, in some isolates yellow dominant (CBS 319.63, CBS 391.48T, CBS 137376); texture velvety and crusty; sporulation absent (CBS 293.53, CBS 391.48T) 1 to dense; conidia en masse greyish green to dull green (25D4–25E4); exudates absent; soluble pigment absent; reverse in some isolates centre yellow to greyish orange (4A5–5B6) fading into greyish yellow to olive yellow (2C4–2D4) (DTO 127-I4, DTO 189–200, DTO 127-I4, CBS 137384, NRRL 2125), in some isolates olive (2F4) in the centre fading into greyish yellow to olive yellow (2C4–2D4) (CBS 100258, CBS 137394), in some isolates centre orange to yellow (5A6–5B6) fading into yellow (2A6). DG18 25 °C, 7 d: Colonies 13–18 mm, raised at centre, sulcate; margins very narrow (up to 1 mm), low, entire, plane; mycelium generally only white, in some isolates yellow dominant (CBS 293.53; CBS 319.63, CBS 137376); texture velvety; sporulation absent (CBS 391.48T, CBS 393.53) to dense; conidia en masse greyish green to dull green (25D4–25E4); exudates absent; soluble pigment absent (except CBS 100258, CBS 137378, CBS 319.63 yellow); reverse in some isolates centre yellow to greyish green to dull green (25D4–25E4); exudates absent; soluble pigment absent; reverse in some isolates centre yellow (1E5) fading into brownish orange to brown (6C8–6D6), in some isolates lack of reverse brownish yellow (5C7–5C8). YES 25 °C, 7 d: Colonies 20–25 mm, low, plane; margins wide (2–4 mm), low, entire, plane; mycelium generally only white and pale yellow, in some isolates bright yellow dominant (CBS 319.63, CBS 391.48T, CBS 137376, CBS 100258), in some isolates olive (3E4) centre fading into dull green (3B3) (CBS 319.63, CBS 391.48T) to dense; conidia en masse yellowish white (2A2–2A6–2A8) (CBS 293.53, CBS 319.63, CBS 137376, CBS 100258), in some isolates olive (3E4) centre fading into dull yellow (3B3) (CBS 137394) and in some isolates pale yellow (3A3) (CBS 391.48T). OA 25 °C, 7 d: Colonies 20–25 mm, low, plane; margins wide (2–4 mm), low, entire, plane; mycelium generally only white and pale yellow, in some isolates bright yellow dominant (CBS 319.63, CBS 391.48T, CBS 137376); texture velvety in some isolates centre occose; sporulation sparse (CBS 137376, CBS 391.48T, DTO 108-A4, CBS 293.53) to dense; conidia en masse greyish green to dull green (25D4–25E4); in some isolates yellow ascomata production with the longer incubation (up to 9 d) (CBS 319.63, CBS 137376, CBS 391.48T, CBS 293.53); exudates absent and in some isolates yellow and clear droplets; soluble pigment absent; reverse in some isolates orange brown centre fading into orange (NRRL 2125, CBS 391.48T, CBS 137376, CBS 319.63), in some very pale orange pink (5A3, CBS 293.53) and rest pale green to beige. CREA, 25 °C, 7 d: Colonies 5–15 mm, in some isolates acid production absent and in some isolates moderate production (NRRL 2125, CBS 137384, CBS 319.63).

**Micromorphology:** Conidiophores biverticillate, sometimes with additional branches, smooth walled stipes, arising from aerial hyphae and overgrowing the ascomata, stipes 100–400 × 2.5–4 μm, extra branches 15–30 μm; metulae three to six, divergent, 7–15 × 12.5–40 μm; phialides three to six, acerose to almost flask-shaped, 7–15 × 2–3.5 μm; conidia, smooth walled, ellipsoidal, 2.5–6 × 1.5–3.5 μm. Ascomata bright yellow, to orange globose, ripening within 1 to 2 wk, covering consisting of a few layers of well-developed networks of yellow hyphae; asci broadly globose to subglobose, 8–14 × 7–11 μm; ascospores, broadly ellipsoidal, 3.5–6.0 × 2.5–4 μm, thick walled, spiny, to smooth (DTO 176-I6).

**Extrolites:** Talaromyces wortmannii is reported to produce wortmanniactones E–H (Dong et al. 2009), closely related to the pruginosins/prugosenes/ukulactones produced by *T. allahabads* and *T. rugulosus*. Furthermore it produces rugulovasine A and B (Abe et al. 1969, Yamatodani et al. 1970, Zhestikova et al. 2006, 2010, Antipova et al. 2008), chanoclavine-I (Abe et al. 1969); wortmanniactones A–D (Dong et al. 2006); mitorubrin acetate (Suzuki et al. 1999); β-caryophyllene (Yamagishi et al. 2011); Talaromin A and B (Bara et al. 2013); atrovirin B1 and B2 (Gill & Morgan 2004); We detected rugulosin, skyrin, rugulovasine A, wortmanniactones E, F, G, H, mitorubrin, mitorubril, mitorubrin acetate and other mitorubrins, and a tetracyclic compound. Wortmannin, virone and wortmannolone have been reported to be produced by *T. wortmannii* (Brian et al. 1957, Blight & Grove 1986), but we did not detect these compounds in any *T. wortmannii sensu stricto* isolates.

**Distinguishing characters:** Talaromyces wortmannii is characterised by velvety colonies that sporulate densely. Many strains also produce ascocata with ascospores (Fig. 87). Acid production and growth at 37 °C varies among strains of *T. wortmannii*. Talaromyces wortmannii was previously believed to be closely related to *T. rugulosus*. However, *T. wortmannii* grows faster on most media and some strains produce yellow to orange ascomata (CBS 319.63, CBS 137376, CBS 293.53). Conidiophores are also often much wider. Ascomata and ascospores of *T. wortmannii* closely resemble those of *T. tratesinis*. However, *T. tratesinis* produces dense floccose colonies and conidiophores are more appressed than *T. wortmannii*.

**Notes:** Samson et al. (2011) accepted *T. variabilis* (CBS 385.48) and *T. sublevisporus* (CBS 137376) as valid species. However, based on ITS, BenA, CaM and RP2 phylogenies, *P. cavarugulosum*, *T. sublevisporus* (CBS 137376) and *T. variabilis* (CBS 385.48) form a coherent clade with *T. wortmannii* (Yilmaz et al., unpubl.).

**Talaromyces yelenensis** Visagie et al., Stud. Mycol. 78: 134. 2014. MycoBank MB809189.

**In:** Talaromyces section Islandici

**Typus:** CBS H-21799, culture ex-type CBS 138209 = DTO 268-E5.

**ITS barcode:** KJ775717 (alternative markers: BenA = KJ775210)

**Colony diam., 7 d (mm):** Fide Visagie et al. (2014) CYA 20–22; CYA 30 °C 25–26; CYA 37 °C 14–16; MEA 15–16; MEA 30 °C 21–22; DG18 16–17; CYAS 13–14; OA 18–20; CREA 9–10; YES 20–21.

**Colony characters:** Fide Visagie et al. (2014) CYA 25 °C, 7 d: Colonies moderately deep; margins low, narrow, entire; mycelia white to yellowish to orange; texture floccose; sporulation absent; soluble pigments absent; exudates clear and sticky; reverse yellowish white (2A2) to light yellow (3A5) to brown (5F6). MEA
25 °C, 7 d: Colonies very deep, plane; margins deep, narrow, entire; mycelia white to yellow to orange; texture floccose; sporulation absent; soluble pigments absent; exudates yellow; reverse brownish yellow to yellowish brown to brown (5C8–E8). YES 25 °C, 7 d: Colonies very deep, plane; margins long, narrow, entire; mycelia white to yellow to orange; texture floccose; sporulation absent; soluble pigments absent; exudates yellow; reverse yellowish white to greyish orange (5B5). DG18 25 °C, 7 d: Colonies deep, plane; margins long, narrow, entire; mycelia white to yellow; texture floccose; sporulation sparse, conidia en masse greyish green (26C3); soluble pigments absent; exudates yellow and sticky; reverse yellowish white to greyish orange (5B5). OA 25 °C, 7 d: Colonies moderately deep, plane; margins long, narrow, entire; mycelia white to yellow; texture floccose; sporulation moderately dense, conidia en masse dark green (26F6); soluble pigments absent; exudates clear and sticky. CREA 25 °C, 7 d: Acid production absent.

**Micromorphology:** Fide Visagie et al. (2014) Conidiophores biverticillate, subterminal branches sometimes present; stipes smooth walled, 60–190 × 2.5–3.5 μm; branches up to 30 μm long; metulae appressed, 8–11 × 2.5–3.5 μm; phialides flask-shaped, ending in a fine apical pore, 8–10 × 2.5–3 μm; conidia rough, subgibbose to broadly ellipsoidal, 2.5–3.5 × 2.5–3 μm.

**Distinguishing characters:** Talaromyces yelensis produces very dense, deep and yellow colonies on general media. Colonies closely resemble those produced by T. tratensis. However, T. tratensis typically produces ascomata with roughened ascospores and conidiophores that produce ellipsoidal smooth walled conidia, in contrast to T. yelensis that lacks ascocoma and produces subgibbose to broadly ellipsoid conidia that have rough walls. For an illustration of the species, readers are referred to Visagie et al. (2014).

**EXCLUDED SPECIES LIST**

**Penicillium resedanum** McLenman & Ducker, Aust. J. Bot. 2: 360. 1954. [MB302422]. — Herb.: IMI 062877. Ex-type: CBS 181.71 = ATCC 22366 = FRR 578 = IMI 062877 = NRRL 578. Note: ITS sequence data (AF033398) show that this species belongs in Talaromyces, and is not related to any section we accept here. Unfortunately CBS 181.71 is not viable and the species will be re-examined in a future study.

**Talaromyces lagunensiis** Udagawa, Uchý & Kamiya, Mycoscience 35: 403. 1994. [MB414250]. — Herb.: CMB BF-49341. Ex-type: Unknown. Note: This culture is not examined in our study.

**Talaromyces malagensis** (Thüm.) Stalpers & Samson, Stud. Mycol. 24: 69. 1984. [MB107328]. — Herb.: Unknown. Ex-type: Unknown. Note: No type culture information is available and we can not determine its taxonomic position.

**Talaromyces retardatus** Udagawa, Kamiya & Osada, Trans. Mycol. Soc. Japan 34: 9. 1993. [MB360062]. — Herb.: CBF-24811. Ex-type: Unknown. Note: We have not examined authentic material for this species and did not treat it in this study.

**Talaromyces versatilis** P.F. Cannon, Bridge & Buddle nom. inval., Art. 38.1(a). Note: Talaromyces versatilis was never published. However, Delmas et al. (2011) and Lafond et al. (2014) have incorrectly used this name, based on IMI 378536, in their publication as a ‘basionym’ of Penicillium funiculosum (≡ T. funiculosus). We did not examine this strain, but based on the BenA sequence for IMI 378536 (KC992272), it is distinct from all accepted Talaromyces species and is closely related to T. angelicus. Further studies are needed for this taxon.

**Paecilomyces tenuis** Y.F. Yan & Z.Q. Liang, Mycotaxon 102: 54. 2007. [MB510919]. — Herb.: GZUIFR-C43-1. Ex-type: Not available. Note: This strain has an ITS sequence (EU004612) identical to T. asatinus and T. trachyspermus. No strain is available for examination and thus its correct classification cannot be determined.
Talaromyces ceqii (Milko) van Novostí, Nizík: Rast. 208. 1964 ≡ Dichotomomyces ceqii (Milko) D.B. Scott in Trans. Brit. Mycol. Soc. 55: 313. 1970 ≡ Aspergillus ceqii (Milko) Samson et al., Stud. Mycol. 78: 141. MycoBank MB609582. — Herb.: CBS H-7011. Ex-type: CBS 157.86. Note: Houbraken & Samson (2011) showed that this species is phylogenetically in Aspergillus and is transferred in Samson et al. (2014).

Talaromyces eburneus Yaguchi et al., Mycological Science 35: 249. 1994 ≡ Geosmithia eburnea Yaguchi et al. ≡ Rasamsonia eburnea (Yaguchi et al.) Houbraken & Frisvad, Antonie van Leeuwenhoek 90: 533. 1998. Program on the Microbiology of the Built Environment. We thank James Swezey for the assistance.

This research was partly supported by grants from the Alfred P. Sloan Foundation to J.A. Stolk, Antonie van Leeuwenhoek 31: 262. 1986 ≡ Paecilomyces leyceettanii (Stolk) Houbraken & Frisvad, Antonie van Leeuwenhoek 101: 416. 2011. [MB362928].

This research was partly supported by grants from the Alfred P. Sloan Foundation to J.A. Stolk, Antonie van Leeuwenhoek 101: 416. 2011. [MB362928]. — Herb.: CBS H-7011. Ex-type: CBS 157.86. Note: Houbraken & Samson (2011) showed that this species is phylogenetically in Aspergillus and is transferred in Samson et al. (2014).

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